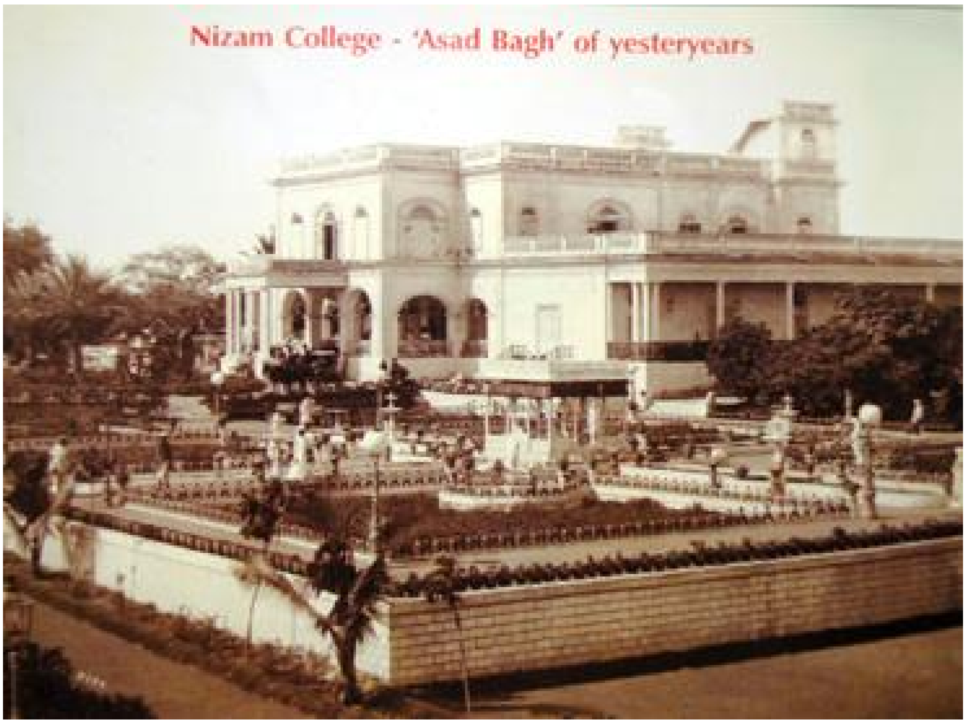
E A P C E T
P H Y S I C S



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E A P C E T
P H Y S I C S

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E A P C E T

(Engineering, Agriculture & Medicine Common Entrance Test)

PHYSICS

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PREFACE

Taking competitive examinations has became the order of the day for any educated young man who is desirous of seeking any coveted job, a seat in any prestigious college. The approach required for such competitive examination is different from that of taking an academic examination.

It was observed that most of the minority candidates do not fare well at these competitive examinations not because they lack in talents but because they can neither afford to join the private coaching centres nor could purchase the required study material.

In order to improve the participation and performance of the candidates belonging to minorities in such competitive examinations, the Minorities Welfare Department, State Government sponsored a project to Osmania University. The University in turn established Centre for Educational Development of Minorities (CEDM) in 1994 in Nizam College. Since then, the Centre has been offering free coaching for the benefit of candidates belonging to minority communities appearing for various job seeking and admission seeking competitive examinations at Hyderabad and other minority concentrated districts of the state. In respect of job-seeking examinations, the Centre is providing free coaching and study material for TS TRT, TS TET etc. and for admission oriented examinations such as NEET, EAPCET, ICET, ECET, EdCET, DEECET and POLYCET etc. In addition to these coaching programmes, the Centre is also providing free coaching and study material to X class Urdu medium minority students in minority concentrated districts of the state to strengthen their educational foundation and to improve their performance in SSC Public Examination.

We wish to place on record the pains the compilers have taken to summarize and arrange the important questions. The Centre gratefully acknowledges their services.

If these study materials are of any help to the candidates, we feel immensely rewarded for the humble efforts we have put in.

Hyderabad
April 2024

Prof. S. A. Shukoor,
DIRECTOR

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I YEAR

CHAPTER 1
PHYSICAL WORLD

Systematic and organized knowledge obtained through observations and Experiments in defined as SCIENCE

Physics deals with nature and natural Phenomena.

Forces in nature

a) Gravitational Force b) Strong Nuclear force
c) Electromagnetic force d)weakForce

Conservation laws

a) Law of conservation of Energy b) Law of Conservation of Mass-Energy
c) Law of conservation of Charge

1. Quantum Statistics proposed by
a) Bohr b) Einstein c) Bose d) Wein
2. Force which binds protons and neutrons in a nuclear is
a) Nuclear force b) Electromagnetic force
c) Gravitational force d) none of them
3. James Chadwick discovered
a) Electron b) proton c) Neutron d) X-Rays
4. Which of the following is not a branch of physics?
a) Mechanics b) Optics
c) Cytogenetics d) Electrodynamics
5. Sir C. V. Raman got Nobel Prize in physics for
a) Refraction of light b) Reflaction of light
c) Scattering of light d) dispersion of light
6. Aeroplane is based on
a) Bernoullis Theorem b) Faradays Laws c) Pascal's Law d) None of these
7. Sonar emits which of the following waves?
a) radiowaves b) microwaves c) ultrasonic waves d) gamma rays
8. Physics involves the study of
a) plants b) animals
c) birds & animals d) nature and natural phenomenon
9. Arrange the following basic forces the increasing order of relative strength
(1) Gravitational force (2) Electromagnetic force
(3) Weak nuclear force (4) Strong nuclear force
(a) 1, 2, 3, 4 (b) 1, 3, 2, 4 (c) 4, 3, 2, 1 (d) 4, 1, 2, 3
10. Innerse law of distance is followed by
(a) Gravitational force (b) Electromagnetic force
(c) both (a) and (b) (d) neither (a) nor (b)

Key 1. c 2. a 3. c 4. c 5. c 6. a 7. c 8. d 9. d 10. c

CHAPTER 2

UNITS AND MEASUREMENTS

Any measurable quantity is called physical quantity. If "n" is the number of times the unit is contained by the quantity (q) and u is the unit, product 'nu' is constant
$n_1u_1=n_2u_2$, so $n \propto 1/u$ E.g. 1000m=1km, $n_1>n_2$ & $u_1 <u_2$
Fundamental quantities:--
According to MKS & CGS – system, length mass and time are fundamental quantities and their units are fundamental units and thermodynamic temperature, electric current ,luminous intensity and quantity of matter are also fundamental quantities according to SI system all other physical quantities except the fundamental quantities are known as derived quantities and their units as derived units.

S. No.	Physical quantity	Unit (SI system)	Symbol
1	Length	Metre	m
2	Mass	Kilogram	kg
3	Time	Second	s
4	Temperature	Kelvin	K
5	Luminous intensity	Candela	Cd
6	Strength of electric current	Ampere	A
7	Quantity of matter	Mole	Mol

Supplementary Quantities: -

1	Plane angle	Radian	rad
2	Solid angle	Steradian	sr

Sr. No.	Dimension	Fixed value	Type of quantity
1	√	√	Dimensional constants E.g. Planck ,gravitational constant.
2	√	X	Dimensional variables E.g. force, work etc.
3	X	√	Dimension less constant e.g. 3.,Π
4	X	X	Dimension less variable e.g., specific gravity, sin θ, strain

<u>Principle of Homogeneity of dimensions</u>:- The physical quantities having same dimensions can only be added or subtracted or equated.

<u>Dimension formulae of some physical quantities</u>: -

S.No.	**Physical quantity**	**Formula**	**Dimensional formula**	**Unit in SI system**
1	Density	Mass / volume	ML^{-3}	Kg/m^3
2	Linear density	Mass / length	ML^{-1}	Kg /m
3	Velocity	Displ /time	LT^{-1}	m/s
4	Acceleration	ΔV/time	LT^{-2}	m/s^2
5	Momentum	Mass x velocity	MLT^{-1}	Kg m s^{-1}
6	Force	Mass x acc	MLT^{-2}	Newton
7	Impulse	Force x time	$ML^{-1}T^{-1}$	N.sec

S.No.	Physical quantity	Formula	Dimensional formula	Unit in SI system
8	Stress	Force / area	$ML^{-1}T^{-2}$	Pa
9	Young's modulus	Stress / liner strain	$ML^{-1}T^{-2}$	Pa
10	Angular displacement	Are length /radius	$M^0L^0T^0$	Radian
11	Moment of force or torque or moment of of couple (T)	Force x distance	ML^2T^{-2}	newton metre
12	Universal gravitational	$G=Fd^2/m_1m_2$	$M^{-1}L^2T^{-2}$	Nm^2 /kg^2
13	Planck's constant	$h=E/\nu$	ML^2T^{-1}	J-sec
14	Surface tension	Force / length	MT^{-2}	Nm^{-1}
15	Co-efficient of viscosity.	Force / area x Velocity	$ML^{-1}T^{-1}$	$NS.m^2$
16	Quantity of heat	Energy	ML^2T^{-2}	J
17	Temperature	-	K	K
18	Mechanical equivalent of heat	J=W/Q	$M^0L^0T^0$	J/cal
19	Electric current	-	A or I	Amp
20	Electric charge	Q=it	TA	Coulomb
21	Magnetic flux	$\varnothing$ =BA	$ML^2T^{-2}A^{-1}$	Wb

<u>Set of quantities with the same dimensions</u>

1. Speed, velocity – LT^{-1}
2. Momentum, impulse – MLT^{-1}
3. Force ,thrust – MLT^{-2}
4. Work, energy, heat, moment of force, K.E., P.E., torque – $ML^{-2}T^{-2}$
5. Pressure, stress, young's modulus, bulk moduolus, rigidity modulus – $ML^{-1}T^{-2}$
6. Angular velocity , frequency, velocity gradient – T^{-1}
7. Angular momentum, Planck's constant, angular impulse – ML^2T^{-1}
8. Surface tension, surface energy , spring constant – MT^{-2}
9. Gravitational potential, latent heat – L^2T^{-2}
10. Thermal capacity, entropy, universal gas constant, Boltzman constant $ML^2T^{-2} K^{-1}$

$\Rightarrow$ fermi = 10^{-15}m

$\Rightarrow$ $A^0 = 10^{-10}$m

$\Rightarrow$ Astronomical unit = 1.5 x 10^{11}m

$\Rightarrow$1 per sec = 3.26 light year
(parallectic second) = 3.084 x 10^{16}m

Measurement of Physical Quantities

- The measurement of Physical quantities depend on the measuring instruments, methods of measurement surroundings and the skill of the individual who measures them. When the Physical quantities are measured number of times these exist accuracy and precision

Constant error: The error repeats itself in all the measurements
Theoretical error: The error due to the approximate
Parallax error: These errors due to the limitations of the human senses
Random errors: The errors caused by the uncontrolled disturbances which influence the physical quantity and instrument are called the random errors
Ex: The errors due to line voltage changes and back lash error
Gross error: The errors due to faulty adjustments or improper usage of the instrument are called gross errors
Arithmetic Mean: A particular physical quantity is measured 'N' number of times, its value are x_1, x_2, x_3,------x_n

Arithmetic Mean = $\dfrac{x_1 + x_2 + ------ + x_n}{N} = \dfrac{\sum x}{N} = \bar{x}$

Combination of Errors:

- **In sum**: If Z = A +B, then ΔZ = ΔA + ΔB
  i.e., when two physical quantities are added then the maximum absolute error in the result is the sum of the absolute errors of the individual quantities
- **In difference**: If Z = AB then $\dfrac{\Delta Z}{Z} = \dfrac{\Delta A}{A} + \dfrac{\Delta B}{B}$

  Where $\dfrac{\Delta Z}{Z}$ is known as fractional error or relative error
- **In division**: If Z = $\dfrac{A}{B}$ then maximum fractional error is $\dfrac{\Delta Z}{Z} = \dfrac{\Delta A}{A} + \dfrac{\Delta B}{B}$
- **In power**: If Z = A then $\dfrac{\Delta Z}{Z} = n\dfrac{\Delta A}{A}$
- In more general form

  Z = $\dfrac{A^x B^y}{C^q}$, Then the maximum fractional error in Z is $\dfrac{\Delta Z}{Z} = x\dfrac{\Delta A}{A} + y\dfrac{\Delta B}{B} + q$
  $\dfrac{\Delta C}{C}$

Significant Figures:

- The digits to express a physical quantity correctly, are called significant figures.
- If there is zero value before decimal point, then the zeros immediately after the decimal point are not significant figures. Ex: 0.000030204, number of significant
- If there is some value before decimal point then the zeros immediately after decimal are also counted as significant figures. Ex: 100.002053

- If there is decimal point in a quantity then the zeros at the end (right most zeros) are also counted as significant figures. Ex: 4207.2000
- If there is no decimal point in a quantity the right most zeros are ambigious
  Ex: 34300 we can't say the exact number of significant figures
  3.4300×10^4 the number of significant figures are 5
  3.430x104 the number of significant figures are 4

Round of the significant figures:

- If the last digit of the number is less than 5, that can be ignored
  Ex: $20.0354 \rightarrow 20.035$
- If the last digit is more than 5, then the preceding digit have to be raised by adding 1 and the last digit has to be omitted. Ex: $304.238 \rightarrow 304.24$
- When the value of last digit is exactly 5
  If the preceding digit is even then it cannot be changed but last digit '5' had to be ignored
  If the preceding digit is odd then it should be increased by adding 1 and last digit '5' has to be ignored
  $2.35 \rightarrow 2.4$, $2.65 \rightarrow 2.6$
- **Addition or Subtraction**: In addition or subtraction, the number of decimal places which are significant in the result is the same as smallest number of significant decimal places in any number used in the addition or subtraction
- **Multiplication or Division**: The product or quotient should contain the same number of significant figure as the number which has less number of significant figures

Question Bank:

1) The numerical value of a physical quantity is
   1) Independent of the unit chosen
   2) Directly proportional to the unit chosen
   3) Inversely proportional to the unit chosen
2) Which of the following is not the name of a physical quantity
   1) Kilogram 2) impulse 3) energy 4) density
3) Unit of energy can be written as
   1) gm cms^{-2} 2) gm cms^{-1} 3) gm cm^2 s^{-2} 4) $gmcm^{-1}$ s^{-2}
4) Which of the following is not a unit of length
   1) micron 2) parsec 3) angstrom 4) steradian
5) Which of the following is not a unit of energy
   1) electron volt 2) kilowatt hour 3) watt sec. 4) Kilowatt
6) If 1 KWH= N ev then N=
   1) 2.25×10^{20} 2) 2.25×10^{25} 3) 2.25×10^{30} 4) 2.25×10^{35}
7) The velocity of a certain body is $V= at^2+b$. Then the unit of a is
   1) ms^{-2} 2) ms^{-1} 3) ms 4) ms^{-3}
8) The unit of permittivity of free space $\in_0$ is
   1) C/N-m 2) $N\text{-}m^2/c^2$ 3) $C^2/N\text{-}m^2$ 4) $C^2/N^2\text{-}m^2$
9) Nkg^{-1} – is the unit of
   1) velocity 2) momentum 3) angular momentum 4) acceleration
10) If a ms^{-1} = b km/h, then a/b
    1) 5/18 2) 18/5 3) 1 4) None

11) One torr is equal to

1) ``1cm Hg pressure 2) 1 atm 3) $1Nm^{-2}$ 4) 1m Hg pressure

12) Volt per meter is the unit of

1) Potential 2) resistively 3) permittivity 4) electric intensity

13) Ampere-hour is a unit of

1) electric charge 2) strength of electric current 3) power 4) energy

14) The unit of nuclear does given to a patient is

1) Fermin 2) Ruther ford 3) curie 4) roentgen

15) Out of the following, the dimensional constant which is invariable is

1) Velocity of light in vacuum 2) resistance of a wire
3) young's modulus of copper 4) acceleration due to gravity

16) The dimension of planck's constant are same as those of

1) power 2) energy 3) angular momentum 4) linear momentum

17) The pair of physical quantities of which one is scalar and the other is vector but possess same dimensional formulae are

1) Work and energy 2) impulse and linear momentum
3) speed and velocity 4) force and energy

18) Select the physical constant that has dimensions

1) strain 2) refractive index 3) gas constant 4) all

19) The dimensions of strength of electric current in resistively

1) 3 2) 1 3) -3 4)-2

20) Force and surface tension have different dimensions in

1) Mass 2) Length 3) time 4) Temperature

21) Which none of the following has negative dimensions for mass

1) Heat capacity 2) pressure
3) universal gravitational constant 4) Angular momentum

22) The dimensional formula of universal gravitational constant is

1) ML^2T^{-1} 2) $ML^{-1}\ T^{-2}$ 3) $ML^{-1}\ T^2$ 4) $M^{-1}\ L^3\ T^{-2}$

23) The dimensional formula of stefan's constant is

1) $MT^{-2}\ K^{-3}$ 2) $MT^{-3}\ K^{-4}$ 3) $MLTK^{-4}$ 4) $ML^2\ T^{-3}\ K^{-4}$

24) The dimensional formula for compressibility is

1) $M^{-1}L^2\ T^{-2}$ 2) $M^{-1}L^3T^2$ 3) $M^{-1}L^{-2}T^2$ 4) $M^{-1}\ LT^2$

25) The dimensional formula for capacitance is

1) $M^{-1}\ L^{-2}T^4\ I^2$ 2) $ML^{-2}T^4I^{-2}$ 3) $M^{-1}L^2T^{-4}I^2$ 4) $M^{-1}\ L^2\ T^4I^2$

26) If μ_0 is permeability and $\in_0$ is the permittivity of free space, which physical quantity is represented by the dimensional formula of $\sqrt{\mu_0 \in_0})^{-1}$

1) density 2) volume 3) Mass 4) Velocity

27) If F is the force, S is the displacement and V is the velocity of the particle, the dimensions of the ratio FS/V^2 will be

1) $M^0\ L^0T^2$ 2) ML^0T^0 3) M^0L^0T 4) $M^oL^0T^0$

28) If L and R denote inductance and resistance, the dimensions of R/L are

1) $M^0L^0T^0$ 2) ML^0A^{-1} 3) M^0L^0T 4) $M^0L^0T^{-1}$

29) Linear density M=X/Y where X is force. Then the dimensions of y will be

1) same as that of pressure 2) same as that of work 3) same as that of momentum
4)same as that of latent heat

30) If L represents angular momentum and E represents the energy, $L^2/2E$ represents

1) Moment of inertia 2) Moment of force 3) Angular momentum 4) inertia

31) The velocity of a body moving in viscous medium is given by $V=P/Q (1-e^{Qt})$ where t is the time, p and Q are constant. Then the dimensions of P are
1) $M^0 LT^{-2}$ 2) $M^0L^0T^{-2}$ 3) MLT^{-1} 4) $ML^0 T^{-1}$

32) The work done by a body w varies with displacement 'S' as $W=aS+b/(c-S)^2$
1) M 2) L 3) ML^4T^{-2} 4) MLT^{-2}

33) The refractive index μ and wavelength of the light λ are related by μ $A+B/\lambda+C/\lambda^2$ where A,B and C are constants. Dimensions of C are
1) $M^o L^2T^0$ 2) $M^0L^0T^0$ 3) ML^0T^2 4) MLT^{-2}

34) In the formula $V^2=Ag\lambda$, v is the velocity, A is the amplitude and g is acceleration due to gravity and λ is the wavelength. Then the formula is
1) Incorrect 2) correct 3) may be correct 4) none

35) Velocity of sound in a medium is $v = \sqrt{y}/d$ where y is the young's modulus of the material and d is its density. Then this equation is dimensionally
1) Correct 2) incorrect 3) may be correct or not 4) none

36) The volume of a liquid (V) flowing per second through a cylindrical tube depends upon the pressure gradient (p/l), radius of the tube r, coefficient of viscosity (n) of the liquid . by dimensional method, the correct formula is
1) $V \alpha Pr^4/nl$ 2) $V\alpha Pr/nl^4$ 3) $V\alpha Pl^4/nr$ 4) none

37) The time period of a soap double it T which depends on pressure P, density d and surface tension S. ten the relation for T is
1) $T\alpha Pd S$ 2) $T\alpha P^{-3/2} d^{1/2} S$ 3) $T\alpha Pd^{-2}S^{3/2}$ 4) $T \alpha Pd^2S^{1/3}$

38) The wavelength associated with a particle in motion depends upon mass 'm' velocity 'v' and h'. then relation for wavelength λ is
1) $\lambda \alpha m v h$ 2) $\lambda \alpha 1/ m v h$ 3) $\lambda \alpha h/m v$ 4) $\lambda \alpha h v/m$

39) If young's modulus y, surface tension S and time T are the fundamental quantities, then dimensional formula of density is
1) $S^2Y^3T^{-2}$ 2) $S^3Y^2T^{-2}$ 3) $S^{-2}y^3t^2$ 4) $S^{-2} Y^2T^3$

40) If force F, velocity V and acceleration A are chosen as fundamental quantities angular momentum can be expressed as
1) FVA 2) FV^3A^{-2} 3) FV^2A^{-3} 4) None

41) If energy E, velocity V and time T are taken as fundamental units, the dimensional formula of intensity of radiation is
1) $Ev^{-2} T^{-3}$ 2) $EV^{-1} T^{-1}$ 3) $EV^{-1} T^{-2}$ 4) $EV^{-2} T^{-2}$

42) If V, A and F denote the units of fundamental quantities velocity, acceleration and force, the dimensions of young's modulus in that system are
1) $F A^2V^{-4}$ 2) $F^2A^4V^{-1}$ 3) $F^4A^2V^{-1}$ 4) $F^{-1} A^4V^2$

43) If the speed of light in vacuum is taken as unity and light takes 8 minutes and 20 seconds to cover the distance between the sun and the earth, then this distance in terms of the new unit will be
1) 200 units 2) 250 units 3) 400 units 4) 500 units

44) If the units of length , mass and time are doubled then the unit of work will be
1) halved 2) doubled 3) tripled 4) quadrupled

45) The work done by a force is 400 units. If the units of mass, length and time are doubled, the numerical value of work is
1) 800 units 2) 400 units 3) 200 unit 4) 100 units

46) If the units of force and displacement in the direction of force are increased by 4 times then the new unit of energy increases by
1) 2 times 2) 4 times 3) 8 times 4) 16 times

47) If the unit of mass is 1kg, unit of time is one minute and unit of acceleration is $10ms^{-1}$, then unit of energy is
1) 36×10^6J 2) 3.6×10^6J 3) 0.36×10^6J 4) 0.036×10^6J

48) If m is mass, q is charge and B is magnetic induction, m/BQ has the same dimension as
1) Frequency 2) $(frequency)^{-1}$ 3) velocity 4) acceleration

49) The S.I unit of moment of inertia is
1) Kg/m^2 2) kg m^2 3) N/m^2 4) Nm^2

50) The dimensional formula for latent heat is
1) MLT^{-2} 2) ML^2T^{-2} 3) $M^0L^2T^{-2}$ 4) MLT^{-1}

*KEY: -----

1)3 2)1 3)3 4)4 5)4 6)2 7)4 8)3 9)4 10)1 11)4 12)4 13)1
14)4 15)1 16)3 17)3 18)3 19) 4 20)2 21)3 22)4 23)2 24)4
25)1 26)4 27)2 28)4 29)4 30)1 31)1 32)3 33)1 34)1 35)1
36)1 37)2 38)3 39)3 40)2 41)1 42)1 43)4 44)2 45)3 46)4
47)3 48)2 49)2 50)3

New Type Questions:

1) Match the following physical quantities with correct dimensional formula

List-I	List-II
I) Coefficient of Viscosity	A) ML^2T^{-1}
II) Gas constant	B) $ML^{-1}T^1$
III) Plank's constant	C) $L^2T^2q^1$
IV) Specific heat	D) ML^2T^2 mol 'q'

1) I-B, II-D, III-A, IV-C 2) I-C, II-A, III-B, IV-D
3) I-D, II-A, III-B, IV-D 4) I-A, II-C, III-D, IV-B
Key:1

2) Match the following physical quantities with same dimensional formula

List-I	List-II
I) Angular velocity	A) Angular momentum
II) Pressure	B) Frequency
III) Plank's constant	C) Latent heat
IV) Gravitational Potential	D) Modulus of elasticity

1) I-C, II-A, III-B, IV-D 2) I-A, II-B, III-C, IV-D
3) I-B, II-D, III-A, IV-C 4) I-D, II-C, III-B, IV-A
Key:3

3) The velocity 'v' of a particle is given in time by the equation v=at+h/t+c. Match the dimensions of a,b, c and v respectively

List-I	List-II
I) a	A) L
II) b	B) LT^{-1}

III)c C) LT^{-2}
IV) v D) T

1) I-A, II-C, III-B, IV-D 2) I-D, II-A, III-C, IV-B
3) I-B, II-A, III-C, IV-D 4) I-C, II-A, III-D, IV-B

Keys: 4

Question Bank:

1) The measured mass and volume of a body are 22.42 gm and $4.7cm^3$ respectively with possible errors 0.01 gm and 0.1c. The maximum error in density is about
1) 0.2% 2) 2% 3) 5% 4) 10%

2) The heat generated in a circuit is dependent on the resistance, current and time of flow of electric current. If the errors measured in the above are 1%, 2% and 1% respectively, the maximum % error in measuring the heat is
1) 2% 2) 3% 3) 6% 4) 1%

3) A student finds out volume and surface area of a cube by measuring its side length in which he commits 0.3% error, then % error in volume and surface area are
1) 0.9, 18 2) 0.9, 0.6 3) 0.3, 0.6 4) 0.6, 0.9

4) A student measures density of a cube by measuring its side length and mass in which % error is 0.2% and 0.1% respectively, then the maximum % error in density is
1) 0.3 2) 0.1 3) 0.2 4) 0.7

5) The least count of an instrument is 0.01cm, then error in measurement is
1) >0.01 2) >0.01cm 3) <0.01 4) $\leq$0.01

6) The length of the rod is measured as (75$\pm$0) cm. The percentage error is
1) 0.1% 2) 0.33% 3) 0.133% 4) 0.75%

7) The resistance of a wire is measured as (3$\pm$0.4%) ohm. The absolute error is
1) 0.12ohm 2) 0.012ohm 3) 0.4ohm 4) 0.04ohm

8) The maximum and minimum temperatures of a body are $(19\pm0.2)^0$ C and $(32\pm0.4)^0$C respectively. The maximum rise of temperature of the day is
1) $(13+0.2)^0$C 2) $(13\pm0.4)^0$C 3) $(13\pm0.3)^0$C 4) $(13\pm0.6)^0$c

9) The measure of length of a simple pendulum is (100$\pm$0.5) cm, the percentage error is
1) 0.5% 2) 0.1% 3) 1% 4) 0.05%

10) Two resistances R_1 = (150$\pm$2) ohm and R_2 = (50$\pm$1) ohm are connected in series the equivalent resistance is
1) 150$\pm$2 2) 200$\pm$1 3) 200$\pm$3 4) 200$\pm$2

11) The number of significant figures in 0.004821 is
1) 6 2) 5 3) 4 4) 7

12) The number of significant figures in 7.0015 is
1) 3 2) 5 3) 4 4) 2

13) 7.8787 is rounded off to three significant figure is
1) 7.87 2) 7.88 3) 8.00 4) 7.879

14) The value of 37.156 –4.21 to correct significant figures is
1) 32.946 2) 32.95 3) 32.9 4) 33.0

15) The value of 4.21x3.412 to correct significant figures is
1) 14.36452 2) 14.36 3) 14.4 4) 14.0

16) The value of $\frac{78}{3.412}$ to correct significant figures is

1) 22.86 2) 22.9 3) 23 4) 23.0

17) The mass of mercury is 141.8 gm and the volume is 10.4 c.c. The density of mercury is calculated as 13.6346 $gmcm^{-3}$. Density of mercury correct to significant figures is

1) 13.63$gmcm^{-3}$ 2) 13.6$gmcm^{-3}$ 3) 13.634$gmcm^{-3}$ 4) 13.6346$gmcm^{-3}$

18) The radius of a circle is 1.2m and the value of π =3.142. The area of the circle is calculated as 4.52448cm^2. Area of the circle correct to significant figures is

1) 4.52448m^2 2) 4.5244m^3 3) 4.5m^2 4) 4.524m^2

Keys

1)2	2)3	3)2	4)4	5)4	6)3
7)2	8)4	9)1	10)3	11)3	12)2
13)2	14)2	15)3	16)3	17)2	18)3

Previous Eamcet Questions:

1. If Force (F), work (W) and velocity (V) are taken as fundamental quantities, then the dimensional formula of time (T) is (2007M)

1) $W^1F^1V^1$ 2) $W^1F^1V^{-1}$ 3) $W^{-1}F^{-1}V^1$ 4) $W^1F^{-1}V^{-1}$

2. Some physical constants are given in List –I and their dimensional formulas are given in List –II

Match the following

List –I	List –II
a) Plank's constant	e) $ML^{-1}T^{-2}$
b) Gravitational constant	f) $ML^{-1}T^{-1}$
c) Bulk modulus	g) ML^2T^{-1}
d) Coefficient of Viscosity	h) $M^{-1}L^3T^{-2}$

1) a→h; b→g; c→f; d→e 2) a→f; b→e; c→g; d→h

3) a→g; b→f; c→e; d→h 4) a→g; b→h; c→e; d→f

3. If C, R, L and I denote capacity, resistance inductance and electric current respectively, the quantities having the same dimensions of time are (2006 E)

a) CR b) L/R c) $\sqrt{LR}$ 4) LI^2

1) a & b are only 2) a and c only 3) a and d only 4) a, b and c only

4. According to Bernoulli's theorem $\frac{p}{d}+\frac{v^2}{2}+gh=\text{constant}$. The dimensional formula of the constant is (P = pressure, d = density, h = height, V = velocity, g = acceleration due to gravity) (2005M)

1) $M^0L^0T^0$ 2) M^0LT^0 3) $M^0L^2T^{-2}$ 4) $M^0L^2T^{-4}$

5. Names of units of some physical quantities are given in List –I and their dimensional formulae are given in List –II. Match the following correct pairs in the list s: (2005E)

List –I	List –II
a) Pas	e) $L^{-2}T^{-2}K^{-1}$

b) NmK^{-1}	f) $MLT^{-3}K^{-1}$
c) $Jkg^{-1}K^{-1}$	g) $ML^{-1}T^{-1}$
d) $Wm^{-1}K^{-1}$	h) $ML^{2}T^{-2}K^{-1}$

1) a→h; b→g; c→e; d→e 2) a→g; b→f; c→h; d→e
3) a→g; b→e; c→h; d→f 4) a→g; b→h; c→e; d→f

6.The correct order in which the dimensions of "Length" increases in the following physical quantities is: (2004M)
a) Permittivity b) Resistance c) Magnetic permeability d) Stress
1) a, b, c, d 2) d, c, b, a 3) a, d, c, b 4) c, b, d, a

7.The position of a particle at time 't' is given by the equation: $x(t) = \frac{v_0}{a}(1- e^{At})$ v_0 = constant and A>0. Dimension of v_0 and A respectively are (2004E)
1) M^0LT^0 and T^{-1} 2) M^0LT^{-1} and LT^{-2} 3) M^0LT^{-1} and T 4) M^0LT^{-1} and T^{-1}

8. The dimensional equation for magnetic flux is (2003M)
1) $ML^2T^{-2}I^{-1}$ 2) $ML^2T^{-2}I^{-2}$ 3) $ML^{-2}T^{-2}I^{-1}$ 4) $ML^{-2}T^{-2}I^{-2}$

9.The dimensional formula of coefficient of Kinematic viscosity of (2002M)
1) $M^0L^{-1}T^{-1}$ 2) $M^0L^2T^{-1}$ 3) ML^2T^{-1} 4) $ML^{-1}T^{-1}$

10.The van der Waals equation for a gas is $\left(p+\frac{a}{v^2}\right)(V-b) = nRT$ Where P, V, R, T and n represent the pressure, volume universal gas constant, absolute temperature and number of moles of a gas respectively. 'a' and 'b' are constants. The ratio $\frac{b}{a}$ will have the following dimensional formula (2002E)
1) $M^{-1}L^{-2}T^2$ 2) $M^{-1}L^{-1}T^{-1}$ 3) ML^2T^2 4) MLT^{-2}

Keys

1)4	2)4	3)4	4)3
5)4	6)3	7)4	8)1
9)1	10)1		

CHAPTER 3
MOTION IN A STRAIGHT LINE

FORMULAE

1. Speed = distance / time → $V= s/t$ ms^{-1}
2. Velocity = displacement/ time → $V= s/t$. ms^{-1}
3. Average speed = total distance/ total time
4. Average velocity = total displacement / total time
5. Acceleration = change in velocity / time → $a= v-u/t$ ms^{-2}
6. Average acceleration = total change in velocity / total time
7. Let S_1, S_2,S_3 ……… be the displacements of a particle in the same direction traveling with velocities v_1,v_2 V_3 …….. in time intervals t_1,t_2,t_3,……………. respectively .
   →Total displacement $S= S_1+S_2+S_3+$………… ,→Total time $t= t_1+t_2+t_3+$………………

→Average velocity $V= S_1+S_2/ t_1+t_2 = (S_1+S_2) (V_1V_2) / S_1V_2+S_2V_1$

→IF $S_1=S_2$ then $V_{avg} = 2V_1V_2/ V_1+V_2$

(i.e. average velocity of a body covers first half of the displacement with velocity V_1 and second half with velocity V_2).

8. If a body travels with velocity V_1 for a time t_1 and with a velocity V_2 for a time t_2 then average velocity is $V_{avg} = V_1t_1+v_2t_2 / t_1+t_2$

9. When a body covers each of the 1/N th of the distance with different velocities V_1,V_2,V_3,… V_n then average velocity V is given by
   $1/V = 1/N (1/v_1 +1/v_2+1/v_3+ \ldots 1/v_n)$
10. When a body travels with velocities V_1,V_2,V_3,….. V_n for each 1/Nthe interval of time the average velocity is $V=(V_1+V_2+V_3 + \ldots +V_n) / N$
11. If a car moving with a velocity 'v' comes to rest after traveling a distance 's' when breaks are applied, then a car moving with velocity 'nv' comes to rest after traveling 'n^2s' distance when same breaking force is applied.
12. If V_1 is initial velocity and V_2 is final velocity then change in velocity
    $\Delta v = v_2 - v_1$ $|\Delta v| = \sqrt{V_1^2 + V_2^2 + 2 V_1 V_2 \text{Cos}}\ \theta$
13. If V_1 and V_2 are the two velocities acting on a body simultaneously and θ be the angle between them then resultant velocity is $|v| = \sqrt{V_1^2 + V_2^2 + 2 V_1 V_2 \text{Cos}\ \theta}$
    $V= V_1+V_2$(if $\theta=0^0$) $V= \sqrt{V_1^2 + V_2^2}$ (if $\theta=90^0$)
14. Relative velocity :- Let V_A be the velocity of a body A and V_B be the velocity of a body B. The relative velocity of A w.r.t B is $V_{AB} = V_A-V_B$
    The relative velocity of B w.r.t A is $V_{BA} = V_B-V_A$
    The relative velocity is zero if $V_B=V_A$
    The magnitude of relative velocity is $V= \sqrt{V_A^2+V_B^2 +2V_AV_B\cos\theta}$

MOTION UNDER GRAVITY

- The acceleration acquired by a freely falling body towards the center of earth is called acceleration due to gravity. It is denoted by 'g' value of g is g= 980 cms^{-2} = 9.8 ms^{-2} The value of g changes from place to place . maximum at poles and minimum at equator. 'g' is a vector and independent of mass of body.

- In the case of a freely falling body initial velocity u=o , acceleration a=+g and displacement s=h
- In the case of a body projected vertically upwards acceleration a=-g, displacement s=h and final velocity V=0
- For a body projected vertically upwards, the magnitude of velocity at any point on its path is same whether the body is moving upwards or downwards.

Equations of Motion under gravity

STANDARD EQUATION	Equation for freely falling body U=0, a=g, s=h	Equation for a body projected vertically up. U=u, a=-g, s=h	Equation for a bod projected vertically down . u=u, a=g, s=h
1. v= u+at	V=gt	V=u-gt	V=u+gt
2. $S=ut+1/2at^2$	$H=1/2gt^2$	$H=ut-1/2gt^2$	$H=ut+1/2gt^2$
3. $V^2-u^2=2as$	$V^2=2gh$	$V^2-u^2=-2gh$	$V^2-u^2=2gh$
4.S=1/2 (U+v)t	H=1/2 vt	H=1/2 (u+v) t	H=1/2 (u+v) t
5. Sn=u+a(n-1/2)	Hn=g(n-1/2)	Hn=u-g(n-1/2)	Hn= u+g(n-1/2)

Freely falling body :

- If a body is dropped freely from a height 'h' then time of its free fall t= $\sqrt{2h/g}$
- Velocity with which it reaches the ground v=$\sqrt{2gh}$
- For a freely falling body s α t^2 , vαt and v α √s.
- For a freely falling body the ratio of its displacements in 1st , 2nd , 3rd ,…….nth seconds is 1:3: 5:…………. (2n-1)
- For a freely falling body the ratio of displacements in 1,2,3,4,…..n seconds is 1:4:9:16:……:n^2
- For a freely falling body the ratio of times to cover 1st, 2nd, 3rd, 4th , …nth meter of distance is (√1- √0): (√2-√1) : (√3-√2) : ….. : (√n- √n-1)
- If a particle starts from rest and moves with uniform acceleration a such that it travels distances s_m and s_n in m th and n th seconds respectively then a= S_m-S_n /m-n.
- If a body starts from rest and moves with acceleration α for certain time and then deceleration at the rate β. Until it stops and 't' is the total time.
  Max. velocity V= αβt / (α+β) Average velocity = v/2
  Distance traveled s= $\alpha\beta t^2 / 2(\alpha+\beta)$
- If a body falls freely from a height 'h' on to a sandy surface and buries into sand to a depth 'x' then (h+x)g=ax where a is retardation produced by sand .

Body projected vertically upwards :-

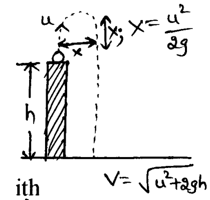
- If a body is projected vertically upwards with a velocity u, then

i) time of ascent = time of decent= u/g
ii) time of flight t= 2u/g
iii) Maximum height reached H= $U^2/2g$

- If a body is projected vertically up with velocity u and if it can reach a maximum height h in T sec then
  i) its velocity = u/2 at height 3h/4 ii) its velocity =u/2 after T/2 seconds
  iii) at a height h/2 its velocity is $u/\sqrt{2}$
- A body is projected vertically up with velocity u. the distance traveled by it in last second of upward journey is g/2.
- A body is projected vertically up reaches a point at a height 'h' while going up in t_1 seconds and reaches ground in t_2 seconds. Total time of flight $T= t_1+t_2=2u/g$
  Height $h= 1/2\ gt_1t_2$ Max. height reached by the body $= 1/8\ g(t_1+t_2)^2$

Body projected vertically upwards from the top of a tower :-

- Max. height reached by the body $= H+u^2/2g$
- Total distance traveled on reaching foot of tower $= H+u^2/g$.
- Velocity on reaching the ground $V= \sqrt{u^2+2gh}$
- Time taken to reach the ground $t= u+\sqrt{u^2+2gh}\ /g$
- If a body is projected vertically up from the top of a tower with velocity, u and it strikes the foot of the tower with velocity nu then height of the tower $h= u^2/2g(n^2-1)$.

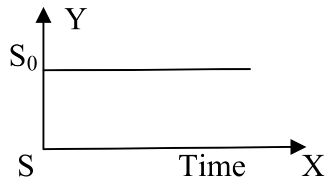


ith

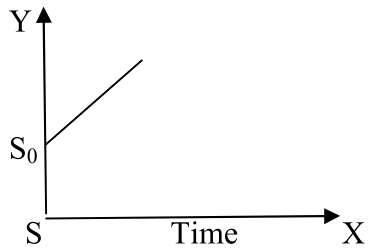
- A body is projected vertically upwards from the top of a tower of height h and it reaches the ground in t_1 seconds. If another body is projected vertically downwards with same velocity from the same point it reaches in ground in t_2 seconds. If a third body is dropped freely at the same point it reaches the ground in t_3 seconds. then $t_3= \sqrt{t_1t_2}$,$t_1-t_2=2u/g$ and $h=1/2\ gt_1t_2$.

Graphs:

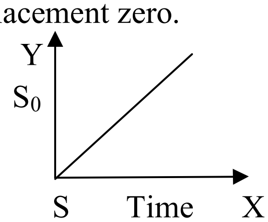
- While plotting graphs an independent variable will be taken on x-axis and a dependent variable on y-axis.
- For a freely falling body
  $V = gt$ $\frac{1}{2} gt^2$
  $V^2 = 2gs$ $s_n = g/2(2n-1)$
  If a graph is plotted between
  a) Velocity and time it is a straight line passing through origin and its slope is g.
  b) Displacement and time is a parabola.
  c) Displacement and square of the time is a straight line and its slope is g/2.
  d) Velocity and displacement is a parabola.
  e) Square of velocity and displacement is a straight line and its slope is 2g.
  f) Displacement in nth second and n is a straight line, its slope is g and negative y-axis intercept is g/2.
- Time displacement graphs: slope of the time displacement graph gives the velocity.
  a) The graph is a straight line parallel to time axis, this shows that the body is at rest. When the time is reckoned it has some initial displacement.



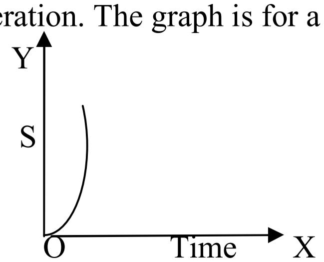
b) The graph shows that the body is moving with uniform velocity. The body starts somewhere and attains some displacement when the time is reckoned.



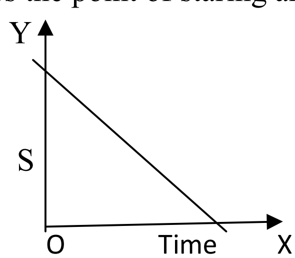
c) The graph is for a body moving with uniform velocity, having initial displacement zero.



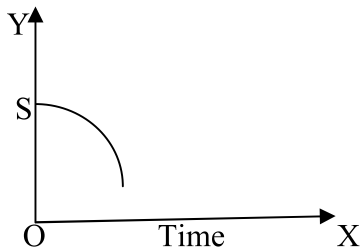
d) The graph is a parabola. It is for a body staring from rest moving with uniform acceleration. The graph is for a freely falling body also.



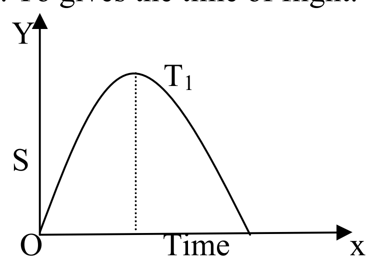
e) The graph shows that the body is moving in opposite direction to the initial direction of motion. The point 'p' represents the instant when the body occupies the point of staring and it moves future.



f) The graph is a parabola. It shows that the body is moving with uniform acceleration the body is moving in opposite direction to the initial direction and reaches the starting point which is at infinite.



g) The graph is a parabola. It shows that the body starts form rest and moves with decreasing velocity (decreasing slope) and comes to rest momentarily when $t=t_1$. This is the position of maximum height then the body moves in opposite direction with increasing velocity and comes to the starting point when $t=t_2$. To gives the time of flight.

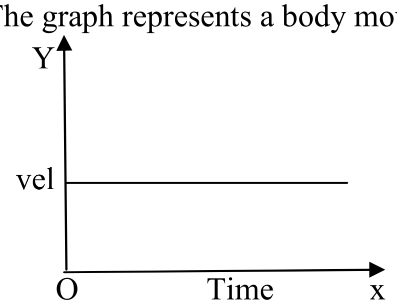


Graphs shows that the body is moving with uniform acceleration. This shows a body projected vertically upwards.

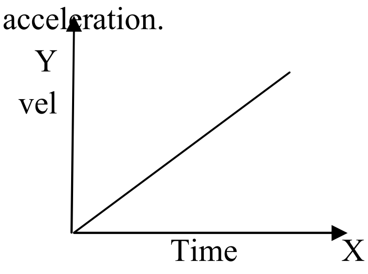
- Time velocity graph: the slope of the time velocity graph gives the acceleration.
- The area of time velocity graph and time axis gives the displacement.

Graphs:

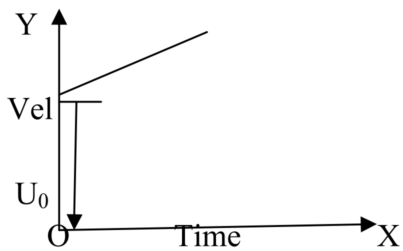
a) The graph represents a body moving with uniform velocity.



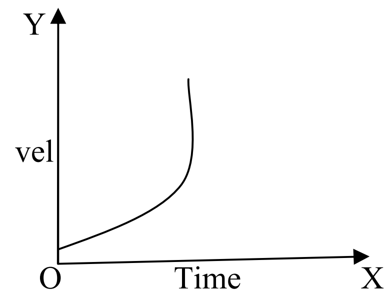
b) The graph shows that a body starts from rest and moves with uniform acceleration.



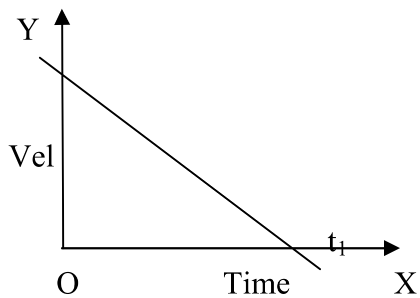
c) The graphs show that a body is moving with uniform acceleration and possesses an initial velocity.



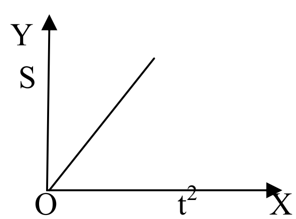
d) The graph is for body staring from rest and moving with increasing acceleration.



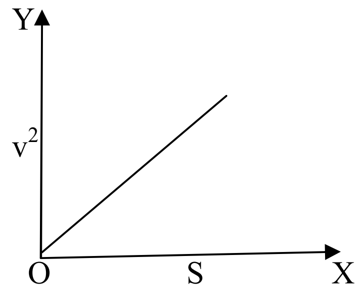
e) The graph is for body moving with uniform retardation the body comes ti rest momentarily when $t=t_1$ and then moves with uniform acceleration in opposite direction to initial direction of motion.



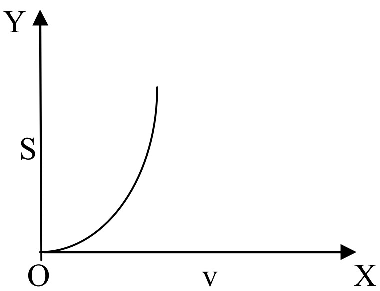
- a) A graph between t^2 and s for a body staring from rest and moving with uniform acceleration is a straight line.
  b) The slope of the adjacent graph is equal to **a/2**.



- a) A graph drawn between s and v^2 for a body staring from rest and moving with uniform acceleration is a straight line.
  a) The slope of the above graph is equal to **a**.

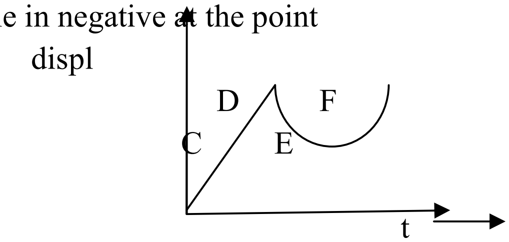


- A graph between v and s for a body moving with uniform acceleration is a parabola.

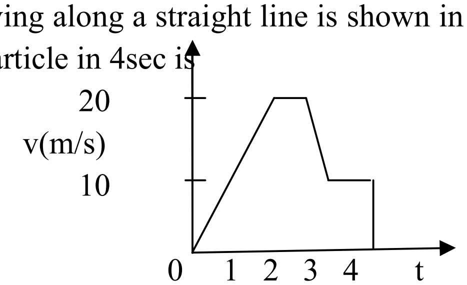


MOTION IN ONE DIMENSION

1. The displacement time graph of moving particles is shown below. The instantaneous velocity of the particle in negative at the point
   a) C
   b) D
   c) E
   d) F

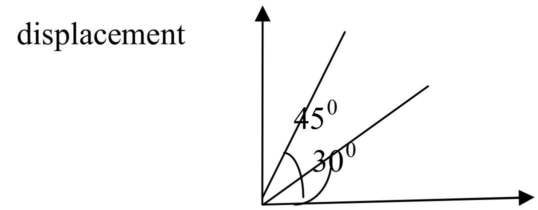


2. The variation of velocity of a particle moving along a straight line is shown in the figure. The distance travelled by the particle in 4sec is
   a) 25cm
   b) 30cm
   c) 55cm
   d) 60cm

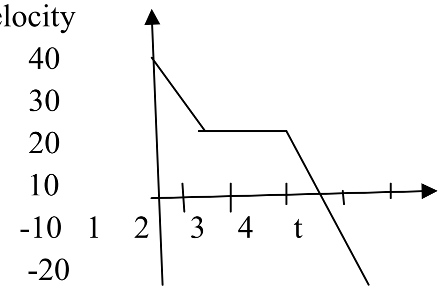


3. The displacement – time graphs of two moving particle make angles of 30^0 and 45^0 with the x- axis. The ratio of the two velocities is

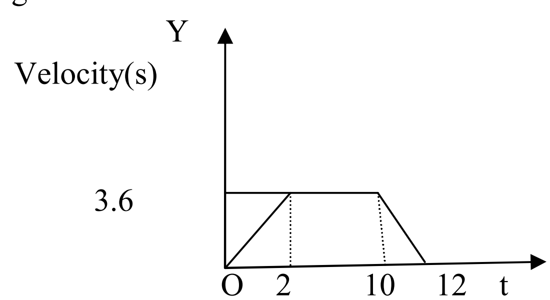
a) Γ3 : 1
b) 1:1
c) 1:2
d) 1:Γ3



4. In the given velocity – time graph displacement of a body in 5second will be
   a) 20m
   b) 40m
   c) 80m
   d) 100m



5. In the above velocity-time graph, displacement of a body in 5sec will be
   a) 20m
   b) 40m
   c) 80m
   d) 100m
6. In question (4) the average velocity of the body in 5second is
   a) 4m/s
   b) 8m/s
   c) 16m/s
   d) 20m/s
7. An elevator is going up. The variation in the velocity of the elevator is as given in the graph. What is the height to which the elevator takes the passengers?
   a) 3.6m
   b) 28.8m
   c) 36m
   d) 72m

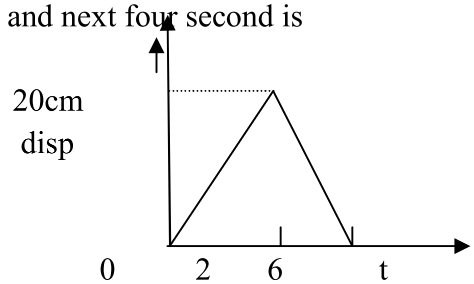


8. In question no (7) what will be the average velocity of the elevator?
   a) 1m/s
   b) 3m/s
   c) 2.88m/s
   d) 3.24m/s

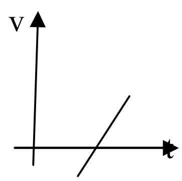
9. In question no (7) the average acceleration of the elevator is
   a) Zero

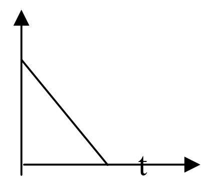
b) $0.3 m/s^2$
c) $-1.8 m/s^2$
d) $1.8 m/s^2$

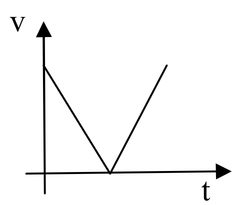
10. For the displacement- time graph shows is figure, the ratio of the magnitude of the speeds during the first two second and next four second is
    a) 1:1
    b) 2:1
    c) 1:2
    d) 3:2

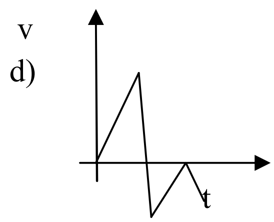


11. Which of the following curves represent the v-t graph of an object falling on a metallic surface and bouncing back?

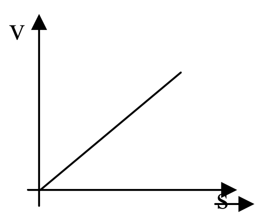
a) 

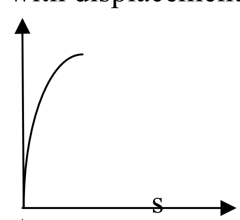
b) v 

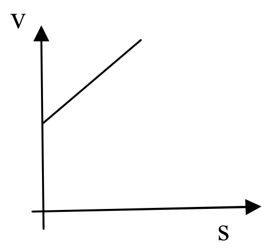
c) 

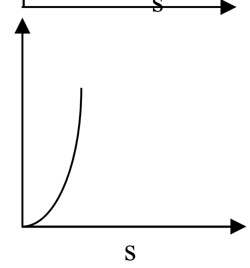
d) 

12. A particle starts from rest and moves along a straight line with constant acceleration. The variation of velocity 'v' with displacement is

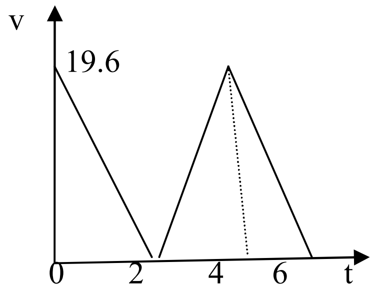
a) 

b)v 

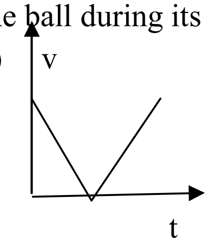
c) 

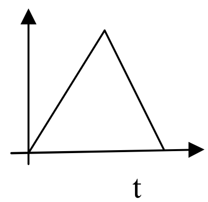
d)v 

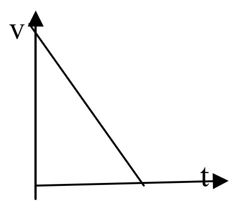
13. The velocity – time graph of a particle is as shown in figure
    a) It moves with a constant acceleration throughout
    b) It moves with an acceleration of constant magnitude
    c) The displacement of the particle is zero
    d) The velocity becomes zero at t=4 second

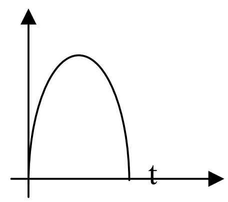


14. A ball is projected vertically upwards which graph represented the velocity of the ball during its flight when air resistance is ignored.

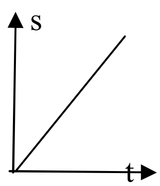
a) 

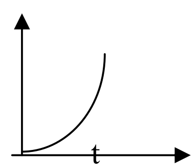
b) 

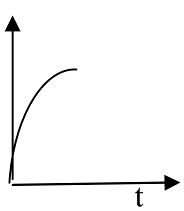
c) 

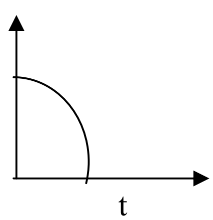
d) 

15. Which of the following graphs represents the distance time variation of a body released from the top of a building?

a) 

b) 

c) 

d) 

16. The velocity time graph of a uniformly accelerated body is a
    a) Circle b) parabola c) straight line d) hyperbola
17. The velocity time graph of a body projected vertically upwards is
    a) Circle b) parabola c) straight line d) hyperbola
18. A body covers distance in proportion to the square of time. The acceleration of the body is
    a) Constant b) decreasing c) increasing d) zero

key

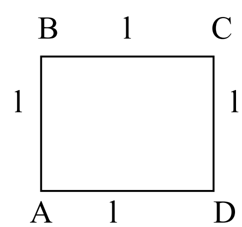
1) c	2) c	3) d	4) d	5) c	6) c	7) c	8) b	9) a
10) b	11) d	12) b	13) b	14) c	15) b	16) c	17) c	18) a

QUESTION BANK:

Numerical Problems:

Linear Motion:

1) An aeroplane moves. 400m towards north, 300m towards west and then 1200m vertically upwards. Then its displacement from the initial position is
   1) 1300m 2) 1400m 3) 1500m 4) 1600m
2) A bus travels the first one third distance at a speed of 10 kmph. The next one third distance at a speed of 20kmph and the last one third distance at a speed of 60 kmph. The average speed of the bus is
   1) 16kmph 2) 18kmph 3) 9kmph 4) 48kmph
3) A body moving in a straight line, covers half the distance with a speed V, the remaining part of the distance was covered with a speed V_1 for half the time and with a speed V_2 for other half of the time. What is the average speed of the body?
   1) $\frac{2V(V_1+V_2)}{(2V+V_1+V_2)}$ 2) $\frac{V(V_1+V_2)}{(2V+V_1+V_2)}$ 3) $\frac{2V_1V_2}{V+V_1+V_2}$ 4) $\frac{V_1V_2}{V+V_1+V_2}$
4) A particle moves along the side of a square of length ‘l’ starting from A and reaches the opposite corner C by traveling from A to B and from B to C. If the time taken is ‘t’, the average velocity of the particle is



   1) 2l/t 2) $\sqrt{2}$l/t 3) zero 4) 1/ $\sqrt{2}$t
5) A particle moving with velocity equal to $0.4ms^{-1}$ is subjected to an acceleration of $0.15ms^{-1}$ for 2s in a direction at right angle to its direction of motion, what is the magnitude of resultant velocity?
   1) $0.3ms^{-1}$ 2) $0.5 ms^{-1}$ 3) $0.27 ms^{-1}$ 4) $0.55ms^{-1}$
6) The motion of a particle along X-axis is given by the equation $X= 9+5t^2$, where X is distance in cm and t is time in sec. Average velocity during the interval from t = 3 second to t =5 second is
   1) $40cms^{-1}$ 2) $30 cms^{-1}$ 3) $35cms^{-1}$ 4) $50cms^{-1}$
7) A bus starts to move with an acceleration of $1ms^{-2}$. A man who is 48m behind the bus runs with constant velocity of $10 ms^{-1}$ to catch it. In how much time he will catch the bus?
   1) 6sec 2) 8sec 3) 10sec 4) 12sec
8) A train starts to move with an acceleration of $2ms^{-2}$. A man who is 9m behind the train runs with uniform speed and just manages to get into the train in 7.5sec. The speed of the train is

1) $9ms^{-1}$ 2) $8.7ms^{-1}$ 3) $4.5ms^{-1}$ 4) $18ms^{-1}$

9) Two cars traveling towards each other on a straight road at velocity $10ms^{-1}$ and $12ms^{-1}$ respectively. When they are 150m apart, drivers apply their breaks and each can decelerates at $2ms^{-1}$ until it stops. How far apart will they be when they have both come to a soap.

1) 97m 2) 61m 3) 36m 4) 89m

10) A person walks up a stalled escalator in 90 second. When standing on the same escalator, now moving he is carried up in 60second. How much time would it take

1) 75s 2) 36s 3) 30s 4) 60s

11) The displacement of a particle moving in one dimension under the action of a constant force is related to the time t by the equation $t = \sqrt{x}+3$, where X is in meter and t is in second. The displacement of the particle when the velocity is zero is

1) 2m 2) 3m 3) 4m 4) 0m

12) The displacement of a body at any time t after starting is given by $S = 10t-0.1t^2$. The velocity of the body is zero after

1) 100s 2) 50s 3) 25s 4) 200s

13) A body moving with uniform acceleration covers 100m in the first 100seconds and 150m in the next 10 seconds. The initial velocity of the body is

1) $15ms^{-1}$ 2) $7.5ms^{-1}$ 3) $5 ms^{-1}$ 4) $2.5ms^{-1}$

Keys

1) 1 2) 2 3) 1 4) 2 5) 2 6) 1 7) 2 8) 2 9) 4 10) 2
11) 4 12) 2 13) 2

Freely – Falling Body:

14) Two bodies one held 10m vertically above the other, are released simultaneously. After falling freely for 3 seconds under gravity , their relative seperation is

1) 10m 2) 5m 3) 1m 4) none

15) A freely falling body travels a distance X in the n^{th} second. In the next second if the travels a distance, Y,

1) X+Y=g 2) X-Y=g 3) Y-X=g 4) X=Y

16) A body released from certain height above the ground describes 9/25 of the total height in the last second of its fall. Then it is falling from a height equal to

1) 100m 2) 122.5m 3) 200m 4) 400m

17) A body is released from height h above the ground which takes 't' seconds to reach the ground. The position of the body after t/2 seconds is

1) h/2 above the ground 2) 3h/4 above the ground
3) h/4 above the ground 4) depends upon the size of the body

18) If a body is released from certain height above the ground, in the last second of its fall it covers half of the total distance travelled by it. Then total time of it fall is

1) $(2-\sqrt{2})$s 2) $(2+\sqrt{2})$s 3) 2s 4) 4s

19) S_1 and S_2 are the distances travelled by a freely falling body in the x^{th} second and y^{th} second respectively. Then

1) $\frac{S_1+S_2}{x+y} = g$ 2) $\frac{S_2-S_1}{x+y} = g$ 3) $\frac{S_2-S_1}{x-y} = g$ 4) $\frac{S_2-S_1}{y-x} = g$

20) A freely falling body has velocity V after falling through a distance 'h'. The distance it has to fall further for its velocity to be doubled is

1) 3h 2) 4h 3) 6h 4) 8h

21) On a planet a freely falling body describes 10m, 40m, 90m in 1 second, 2 seconds and 3 seconds respectively. Acceleration due to gravity on that planet is

1) 20 ms^{-2} 2) 10 ms^{-2} 3) 9.8 ms^{-2} 4) 4.9ms^{-2}

22) A freely falling body describes a distance X in the first 2 seconds and a distance Y in the next 2 seconds. Then

1) Y=X 2) Y=2X 3) X=2Y 4) Y=3X

23) A body released from certain height reaches the ground after 't' seconds. The time taken to reach half this height is

1) t/2 2) $\frac{t}{\sqrt{2}}$ 3) $t\sqrt{2}$ 4) $2t$

24) A body is released from height 'h' above the ground. Exactly as the midway if g vanishes suddenly, its total time of fall is

1) $\sqrt{\frac{h}{g}}$ 2) $2\sqrt{\frac{h}{g}}$ 3) $\frac{1}{2}\sqrt{\frac{h}{g}}$ 4) $\frac{3}{2}\sqrt{\frac{h}{g}}$

25) The average velocity of freely falling body is 7ms^{-1}. Then it is released from a height equal to

1) 5m 2) 10m 3) 20m 4) none

26) A particle falling from the top of a tower has descended X meter when another is let fall from a point Y meter below the top. If they reach the ground together, height of the tower is

1) $\frac{(X+Y)^2}{4Y}$ 2) $\frac{(X-Y)^2}{4X}$ 3) $\frac{(X+Y)^2}{4X}$ 4) $\frac{(X-Y)^2}{4Y}$

27) A body falling for 2 seconds covers a distance y equal to that covered in the next second. If g = 10ms^{-2}, the value of y is

1) 20m 2) 10m 3) 30m 4) 60m

28) A parachutist drops freely from an aeroplane for 10 seconds before the parachute opens out. Then he descends with a net retardation of 2.5ms^{-2}. If he bails out of the plane at a height of 2495m and g= 10ms^{-2}, the velocity on reaching the ground will be

1) 5ms^{-1} 2) 10ms^{-1} 3) 15ms^{-1} 4) 20ms^{-1}

29) A body is released from a certain height above the ground. After t seconds if g vanishes distance travelled by it in the next t seconds and distance travelled by it in the first 't' seconds will be in the ratio equal to

1) 1:1 2) 1:2 3) 2:1 4) 1:4

30) A stone dropped from certain point crosses the top and bottom ends of a vertical pole of length 20m in one second. The distance of top end of the pole from the initial point of release will be (g = 10ms^{-2})

1) 22.5m 2) 12.5m 3) 11.25m 4) 7.5m

31) A body is released from certain height above the ground. At the same moment another body at a height h above the previous point of release is projected vertically down with velocity u. If both reach the ground simultaneously time of fall of each is

1) 2h/u 2) h/u 3) h/2u 4) $\sqrt{2}$h/u

Keys

14) 1 15) 3 16) 2 17) 2 18) 2 19) 4 20) 1 21) 1 22) 4 23) 2
24) 4 25) 2 26) 3 27) 3 28) 1 29) 2 30) 3 31) 2

Body Projected Vertically Up:

32) A boy throws a stone vertically up and catches it after time 't' seconds. Then maximum height reached by the stone is

1) $gt^2/2$ 2) $gt^2/4$ 3) $gt^2/8$ 4) $gt^2/16$

33) An object is thrown vertically upwards. When it reaches half of its maximum height, its velocity is 10 ms^{-1}. If g = 10ms^{-2}, how high does it rise?

1) 10m 2) 20m 3) 5m 4) 25m

34) A body projected vertically up reaches a maximum height of 9.8m. Its time of flight is

1) 4s 2) 2s 3) $\sqrt{2}$s 4) $2\sqrt{2}$s

35) If a particle occupies x seconds less and acquires a velocity y ms^{-1}more at one place than at another in falling through the same distance. If g_1 and g_2 are accelerations due to gravity at those two places, then x:y is equal to

1) g_1/g_2 2) g_2/g_1 3) $\sqrt{g_1 g_2}$ 4) $1/\sqrt{g_1 g_2}$

67)If a body is projected vertically up, its velocity decreases to half of its initial velocity at a height 'h' above the ground. Then maximum height reached by it is

1) 3h 2) 4h 3) 2h 4) 4h/3

36) When a body is projected vertically up, it crosses points P and Q with velocities V_1 and V_2. If R is the mid point of PQ, its velocity at R is

1) $\frac{V_1+V_2}{2}$ 2) $\sqrt{\frac{V_1+V_2}{\sqrt{2}}}$ 3) $\frac{V_1^2+V_2^2}{V_1+V_2}$ 4) $\sqrt{\frac{V_1^2+V_2^2}{\sqrt{2}}}$

37) In order to keep a body in air above the earth for 't' a body is projected with certain velocity. If S is the total distance travelled by the body during the motion, then

1) $t=\sqrt{2s/g}$ 2) $t=\sqrt{4s/g}$ 3) t=2s/g 4) t=4s/g

38) A particle is projected vertically upwards is at a certain height at time t_1 and again at time t_2. If t_1=4s, t_2=6s and g=10ms^{-2}, then velocity of projection is

1) 50ms^{-1} 2) 40ms^{-1} 3) 20ms^{-1} 4) 10ms^{-1}

39) A body projected up and it reaches a point in its path at the end of 8 and 12s. If g= 10ms^{-2}, height of that point above the ground is

1) 480m 2) 960m 3) 240m 4) 120m

40) The velocity with which a ball is to be projected vertically up so that the distance covered in 5^{th} second is twice that covered in 6^{th} second is (g= 10ms^{-2})

1) 20ms^{-1} 2) 60ms^{-1} 3) 50ms^{-1} 4) 65ms^{-1}

41) A boy sees a ball going up and then back down through a window 2.45m high. If the total time the ball is in sight for up and down motion is 1 sec. The height above the window that the ball rises is

1) 0.98m 2) 0.49m 3) 0.245m 4) 0.306m

42) A body is projected vertically up from ground. Just before the last second of its ascent its velocity will be numerically

1) g/2 2) g 3) 2g 4) 4g

43) A body is projected vertically up from a ground . In the last second of its total journey distance travelled by it is h. Then its initial velocity of projection is numerically

1) (h+g) 2) (h-g) 3) (h+g/2) 4) (h-g/2)

44) A body is projected vertically up and the total distance travelled by it is S. Then total time of its flight will be

1) $\sqrt{S/g}$ 2) $\sqrt{2S/g}$ 3) $\sqrt{4S/g}$ 4) $\sqrt{8S/g}$

45) A body is projected vertically up from ground with a velocity so as to reach maximum height 'h'. At half of the maximum height its velocity will be

1) $\sqrt{gh/2}$ 2) $\sqrt{2gh}$ 3) $\sqrt{gh}$ 4) $\sqrt{4gh}$

46) A body projected vertically up with velocity from the ground reaches a maximum height h_1. If the same is projected with velocity u_2, it reaches a maximum height h_2.To reach the maximum height (h_1+h_2) it should be projected up with a velocity equal to

1) u_1+u_2 2) $\sqrt{u_1^2+u_2^2}$ 3) $\sqrt{u_1+u_2}$ 4) $\sqrt{u_1u_2}$

47) When a body is projected vertically up from the ground. Its velocity reduces to half of the initial velocity after time 't'. Then total time of its flight is

1) 2t 2) 3t 3) $(\sqrt{2}+1)t$ 4) 4t

48) A boy has projected a body vertically up with a velocity of $50ms^{-1}$. After two seconds he projected another body with a velocity of 100 ms^{-1}.($g= 10ms^{-2}$). They meet 't' seconds after the first one is projected then t=

1) 11/7sec 2) 22sec 3) 22/7sec 4) 7 sec

Key

32) 3	33) 1	34) 4	35) 4	36) 4	37) 1	38) 1	39) 3	40) 4	41) 4
42) 2	43) 3	44) 3	45) 3	46) 2	47) 4	48) 3			

Body Projected Vertically up from a Tower:

49) A body projected vertically up from the top of a tower with $19.6ms^{-1}$takes 5s to reach the ground. Then height of the tower is

1) 44.1m 2) 24.5m 3) 39.2m 4) 19.6m

50) From the top of a tower a stone is projected vertically upwards when it reaches a distance h below that point, its velocity is double that of its velocity when it was at a height h above the top of the tower. Then greatest height attained by the stone above the top of the tower is

1) 2h 2) h/3 3) 5h/3 4) 4h

51) A balloon is ascending up with a velocity of $4ms^{-1}$. An object is dropped from it when it is at a height of 100m above the ground. The distance between the object and balloon after
2 seconds is ($g = 10\ ms^{-2}$)

1) 10m 2) 20m 3) 30m 4) 40m

52) A body is dropped from a height h and second body is thrown vertically up from the ground with a velocity $\sqrt{gh}$. They meet at a point at this height above the ground.

1) h/4 2) h/3 3) 3h/4 4) h/2

53) A food packet is released from a helicopter which is rising at $4ms^{-1}$. Then velocity of the packet after 2 seconds is

1) $15.6ms^{-1}$ up 2) $15.6ms^{-1}$ down 3) $17.6ms^{-1}$ up 4) $17.6ms^{-1}$ down

54) A ball is projected vertically up with a velocity of 40 ms^{-1} from ground. At the same time another ball is dropped from a height of 100m. The magnitude of their velocities are equal after this time ($g= 10ms^{-2}$)

1) 1s 2) 2s 3) 3s 4) 4s

55) A balloon is going vertically up with a velocity of $10ms^{-1}$. When it is at 75m above the ground, a stone is released the height of balloon above the ground when the stone reaches the ground is ($g = 10ms^{-2}$)

1) 25m   2) 100m   3) 125m   4) 150m

56) From a balloon moving down at $10ms^{-1}$ an object is dropped when it is at an altitude of 40m. The object strikes the ground with a velocity equal to ($g = 10ms^{-2}$)

1) $20ms^{-1}$ 2) $10\sqrt{7}ms^{-1}$ 3) $30ms^{-1}$ 4) $40ms^{-1}$

Keys

49) 2   50) 3   51) 2   52) 4   53) 2   54) 2   55) 3   56) 3

CHAPTER 4

MOTION IN A PLANE

INTRODUCTION: Physical quantities are mainly divided into two types. They are

1) **Scalar:** A physical quantity which has only magnitude is called a scalar .
   Eg:- Mass, Time, Area, Volume, density, work, power, Energy , temperature, electric charge, electric current, electric potential, resistance, etc.

→ It is specified by unit and number. Addition and subtraction of scalars is same as in algebra.

2) **Vector :-** A physical quantity which has both magnitude and direction and which obeys vector law of addition is called a vector.

Eg:- Displacement, Velocity, Acceleration, force, Momentum, Angular Momentum, impulse, etc.

3) All the quantities that have magnitude and direction are not vectors. E.g.: (Electric current)
4) A vector can be represented by an arrow (→). The length of the arrow is proportional to magnitude of the physical quantity, where as the arrow head represents its direction ($\vec{A}$ or $|\vec{A}|$). Vectors are specified by unit, number and direction.

TYPES OF VECTORS :-

5) Unit Vector :- A vector having unit magnitude is called unit vector. If A is given vector then unit vector in its direction is given by
   $\hat{A} = \vec{A} / |\vec{A}|$
6) Null vector (or) Zero vector :- A vector whose magnitude is zero and does not have specified direction is called null vector (or) zero vector . it is represented by $\vec{O}$. The initial point and terminal point of a null vector coincide.
7) NEGATIVE VECTOR (OR) OPPOSITE VECTOR :- A vector having the same magnitude but opposite in direction to a given vector is called negative vector .

   Ex: If $\vec{A} + \vec{B} = 0$ then $\vec{B} = -\vec{A}$

8) Equal Vectors :- if two vectors have same magnitude and direction then they are said to be equal vectors.
9) Like vectors : If two vectors have same direction but different magnitudes, then they are said to be like vectors.
10) Unlike vectors : if two vectors have opposite directions and different magnitudes then they are said to be unlike vectors .
11) Parallel vectors :- if two vectors have same direction then they are said to be parallel vectors. The angle between two parallel vectors is O^0 .
12) Anti parallel vectors :- if two vectors have opposite direction they are said to be anti-parallel vectors . the angle between two anti parallel vectors is 180^0.
13) Perpendicular (or) Orthogonal vectors :- Two vectors are said to be orthogonal vectors if the angle between them is 90^0 .

14) Collinear vectors :- Vectors drawn along the same line are called collinear vectors.
15) Coplanar vectors : vectors lying in the same plane are called coplanar vectors.
16) Basic unit vectors :- unit vectors along the three mutually perpendicular axes are called basic unit vectors .
($\hat{i}$ along x –axis , $\hat{j}$ along y-axis, $\hat{k}$ along z –axis).
17) Position vector :- The vector which specifies the position of a point w.r.t some fixed point (like origin) is called position vector.

If P(x,y,z) be the position of a point w.r.t origin then $\vec{OP} = \vec{r} = x\hat{i}+y\hat{j}+z\hat{k}$
Magnitude $|\vec{r}| = \rightarrow \sqrt{x^2+y^2+z^2}$
In three dimensional if $A(x_1,y_1,z_1)$ and $B(x_2,y_2z_2)$ are two point then

displacement vector is $\vec{AB} = (x_2-x_1)\hat{i} + y_2+y_1)\hat{j}\,(z_2-z_1)\hat{K}$.

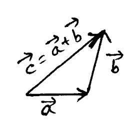
$|\vec{AB}| = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2}$

18) Polar vectors (or) Real vectors :_ The vector which possess direction by virtue of their nature are called polar vectors (or) real vectors.
Ex:- displacement, velocity acceleration, force, etc.
19) Pseudo (or) Axial vectors :- The vectors whose direction does not depend upon their nature but associated with some convention are called pseudo (or) axial vectors.

or

If the direction of a vector changes with the change of reference frame (from right handed to left handed frame) is called pseudo (or) axial vectors.
Ex:- Angular velocity, angular momentum, angular displacement angular acceleration etc.
Addition of vectors: - Two vectors are added by using triangle law of vectors, polygon law of vector, parallelogram law of vectors, if the vectors are more in number

20) Triangle law of vector addition :- If two vectors are represented both in magnitude and direction by the two adjacent sided of a triangle taken in an order, then their resultant is given by the third side taken in the reverse order.



21) Law of vector addition :-
→ Vector addition is commutative . $\vec{A}+\vec{B} = \vec{B}+\vec{A}$

→ Vector addition is associative $(\vec{A}+\vec{B})+\vec{C} = \vec{A}+(\vec{B}+\vec{C})$

→ Vector addition is distributive

$m(\vec{A}+\vec{B}) = m\vec{A}+m\vec{B}$ (m,n are scalars) $(m+n)\,A = mA + nA$

→ When a vector is multiplied by a scalar, the resultant is also a vector
→ vector multiplication obeys commutative law SA = AS (S → scalar)

→ Vector multiplication obeys associative law

$m(nA) = mnA$ (m,n are scalars)

→ vector multiplication obeys distributive law.

$S(A + B) = SA + SB$ (S → scalar)

22) Subtraction of vectors :- The subtraction of vector B from vector A is same as addition of vector – B to vector A . i.e., $A - B = A + (-B)$.

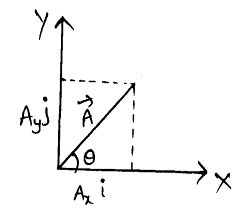
→ The vector subtraction does not obey commutative law

$A - B \neq B - A$

→ The vector subtraction obeys distributive law $m(A - B) = mA - mB$

→ vector subtraction is useful to find the change in velocity of a particle .

23) Rectangular components of a vector :- If a vector A in x-y plane makes an angle θ with x-axis, it can be resolved into two rectangular components along x and y axis .



Along x – axis $A_x = A\cos\theta$

Along y-axis $A_y = A\sin\theta$

$\tan\theta = Ax / Ay$; A: $\sqrt{A_x^2 + A_y^2}$

24) Resolution of vectors (in three dimensions) :-

If vector A makes angles α , β , γ respectively with x,y and z axis then

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$$

$$|A| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

unit vector along $\vec{A}$ is $\frac{A}{|A|} = \frac{A_x i + A_y j + A_z k}{\sqrt{A_x^2 + A_y^2 + A_z^2}}$

→ If α, β, γ are the angles made by $\vec{|A|}$ with x,y,z axis respectively then the direction cosines of α, β , and γ are given by

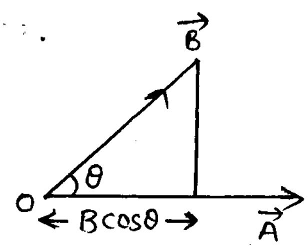
$l = \cos\alpha = A_x / |A|$, $m = \cos\beta = A_y / |A|$

l,m,n are direction cosines of A, $n = \cos\gamma = A_z / |A|$

→ $\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

25) Dot Product (Or) Scalar Product :-

The dot product of two vectors A and B is defined as the productof the magnitudes of the vectors and the cosine of the angle between them.



$$\vec{A} \cdot \vec{B} = |\vec{A}|\ |\vec{B}| \cos\theta$$

→ The scalar product of two vectors is a scalar quantity

→ Workdone is the dot product of force and displacement

$$W = \vec{F} \cdot \vec{S} = Fs\cos\theta$$

→ Power is the dot product of force and velocity $P = \vec{F}.\vec{V} = Fv \cos\theta$

→ Angle between $\vec{A}$ and $\vec{B}$ is given by

$$\cos\theta = \vec{A}\,.\,\vec{B} \,/\, |\vec{A}|\,|\vec{B}|$$

26) Characteristics of scalar product:-

i) Scalar product is commutative

$$\vec{A}\,.\,\vec{B} = \vec{B}\,.\,\vec{A}$$

ii) Scalar product is distributive

$$\vec{A}.\,(\vec{B}+\vec{C}) = \vec{A}.\,\vec{B} + \vec{A}.\,\vec{C}$$

iii) The scalar product of two parallel vectors is maximum

$\vec{A}.\,\vec{B} = |A||B| \cos 0^{0} = AB \quad (\theta=0^{o})$

iv) The scalar product of two opposite vectors is negative

$\vec{A}.\vec{B} = AB \cos\theta = -AB \quad (\theta = 180^{0})$

v) The scalar product of two perpendicular vectors is zero.

$\vec{A}.\vec{B} = AB \cos\theta = 0 \quad \theta = 90^{0}$

vi) When dot product is taken with same vector, the magnitude of vector is determined as.

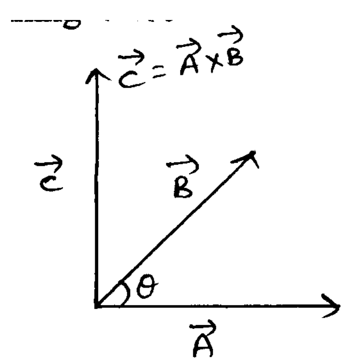
$$\vec{A}.\,\vec{A} = |A|\,|A| \cos 0^{0} = AA = A^{2}$$

vii) In the case of unit vectors

$$\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1 \text{ and}$$

$$\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 0$$

27) Vector product (or) cross product :
Cross product of two vectors is a vector whose magnitude is equal to the product of those two vectors and the sine of angle between them. Direction of this vector is perpendicular to the plane containing those two vectors.



$$\vec{A} \times \vec{B} = |A|\ |B| \sin\theta\ \hat{n}$$

Where n is unit normal vectors

→ Torque $\tau = \vec{r} \times \vec{f}$
→ Velocity $v = \omega \times r$

→Area of parallelogram $= |\vec{A} \times \vec{B}|$

→ Area of triangle $= 1/2 \, |\vec{A} \times \vec{B}|$

→ $\vec{L} = \vec{r} \times \vec{p}$; $\vec{F} = \vec{Q} \, (\vec{V} \times \vec{B})$

28) Characteristics of cross product :-

i) Cross product does not obey commutative law.

$\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$

But $\vec{A} \times \vec{B} = -(\vec{B} \times \vec{A})$

ii) Cross product obeys distributive

$\vec{A} \times (\vec{B} + \vec{C}) = (\vec{A} \times \vec{B}) + (\vec{A} \times \vec{C})$

iii) Cross product of two parallel vectors is equal to zero

$\vec{A} \times \vec{B} = |A| \, |B| \sin 0^0 = 0 \quad (\theta = 0^0)$

iv) Cross product of two anti – parallel vectors is equal to zero

$\vec{A} \times \vec{B} = |A| \, |B| \sin 180^0 = 0 \quad (\theta = 180^0)$

v) The product of two perpendicular vectors is maximum.

$\vec{A} \times \vec{B} = |\vec{A}| \, |B| \sin 90^0 \quad AB \quad (\theta = 90^0)$

vi) Cross product of two collinear vectors is a null vector $\vec{A} \times \vec{B} = 0$ (if $\theta = 0^0$ or 180^0)

vii) In the case of unit vector

$\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0$

$\hat{i} \times \hat{j} = \hat{k}$ and $\hat{j} + \hat{i} = -\hat{k}$

$\hat{j} \times \hat{k} = \hat{i}$ and $\hat{k} + \hat{j} = -\hat{i}$

$\hat{k} \times \hat{i} = \hat{j}$ and $\hat{i} \times \hat{k} = -\hat{j}$

viii) Cross product of a vector with itself gives null vector $A \times A = 0$

ix) If $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$ and $\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$ then

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$A \times B = \hat{i}(A_y B_z - B_y A_z) - \hat{j}(A_x B_z - B_x A_z) + \hat{k}(A_x B_y - B_x A_y)$$

29) If $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$ and $\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$ are parallel vectors then.

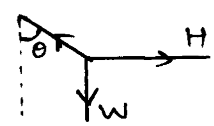
Ax/ Bx = Ay / By = Az/Bz = k
If they are anti parallel then
Ax / Bx = Ay/By = Az/Bz =- k

30) Vector of magnitude C which is perpendicular to both A and B

is $\vec{C} = C \dfrac{\vec{A} \times \vec{B}}{|A \times B|}$

31) Cross product of two real vector gives pseudo vector. Cross product of polar vector and pseudo vector is a polar vector. Cross product of two pseudo vectors is a pseudo vector.

32) Tangent law :- if a load w attached to a string is drawn by a horizontal force H., so that the string makes an angle θ with the vertical . Then Tan θ = H/ w



33) Relative velocity :- If $\vec{V}_A$ and $\vec{V}_B$ are the velocities of A and B

then relative velocity of A w.r.t B is $\vec{V}_A - \vec{V}_B$ and relative velocity of B w.r.t A is $V_B - V_A$

i) If θ is angle between $\vec{V}_A$ and $\vec{V}_B$ then
$|V_A - V_B|$ or $|V_B - V_A| = \sqrt{V_A^2 + V_B^2 - 2V_AV_B \cos\theta}$

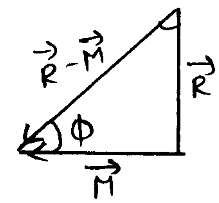
ii) If $\theta = 0^0$ $\vec{V}_A // \vec{V}_B$; $|\vec{V}_A - \vec{V}_B| = V_A - V_B$ and $|\vec{V}_B - \vec{V}_A| = |V_B - V_A|$

iii) If $\theta = 180^0$ $\vec{V}_A // -\vec{V}_B$; $|\vec{V}_A - \vec{V}_B| = V_A + V_B$ and $|\vec{V}_B - \vec{V}_A| = V_B + V_A$

iv) If $\theta = 90^0$; $\vec{V}_A$ perpendicular $\vec{V}_B$

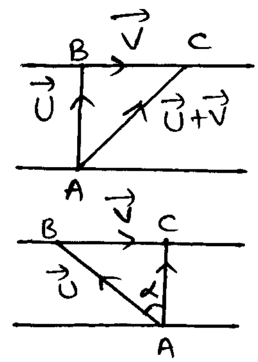
$|\vec{V_A}-\vec{V_B}|$ or $|\vec{V_B}-\vec{V_A}| = \sqrt{V_A^2+V_B^2}$

34) Rain – umbrella problem :- When it is raining vertically downwards with a velocity $\vec{R}$, a man moving with a velocity $\vec{M}$ velocity M rain should hold his umbrella in the direction of relative velocity of rain. That is given by $\varnothing = \tan^{-1}$ (R/M).



$|\vec{R}-\vec{M}| = \sqrt{R^2+M^2}$. the velocity of rain observed by man is $\vec{R}-M$

37) Motion of boat in a river: _ Let $\vec{U}$ be the velocity of boat in still water. V is Velocity of water in river. If boat moves in that river, its resultant velocity is $|U+V| = \sqrt{U^2+V^2+2uV\cos\theta}$



i) If boat moves in down stream $|\vec{U}+\vec{V}|$ = U + V.Time taken to cover a distance d is $t_1 = d/ U+V$

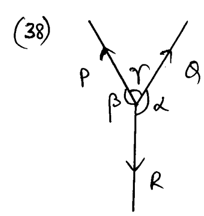
ii) If boat moves in up stream $|\vec{U}+\vec{V}| = \vec{U}$ - V time taken to cover a distance d is t_2=d/U-V

iii) If boat moves at right angles to the stream $|\vec{U}+\vec{V}| = \sqrt{U^2+V^2}$

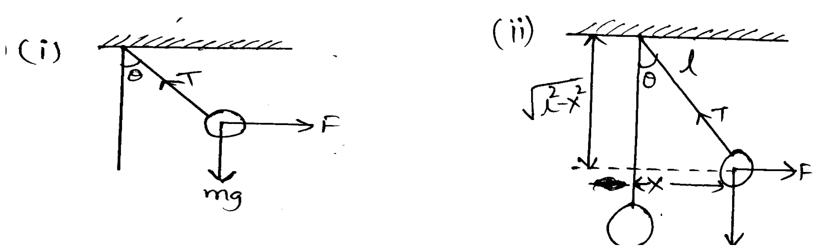
iv) Shortest time to cross the river t=d/U (d is width of the river)

v) Time taken by the boat to cross the river is $T= d/ \sqrt{U^2-V^2}$ (d is width of the river

35) Lami's Theorem :- If three coplanar vectors acting simultaneously on a particle be in equilibrium, then the ratio of magnitude of vector and the sine of the angle between the other two vectors is constant $P/\sin\alpha = Q/\sin\beta = R/\sin\gamma$



39) If the bob of a pendulum is pulled to a side such that the string makes an angle θ with the vertical, F= mg tanθ. Where F is horizontal force applied. Tension in the string i) $T= \sqrt{(mg)^2 + F^2}$ ii) $T/l = mg / \sqrt{l^2-x^2} = F/x$



QUESTION BANK

Elements of Vectors

Numerical Problems:

I-Resultant:

1. Two forces 3 and 4N act on a body of mass 5kg at right angles. The acceleration of the body
   1) $7/5ms^{-2}$ 2) $1ms^{-2}$ 3) $1/5ms^{-2}$ 4) $5/7ms^{-2}$
2. A and B are two unit vectors and θ is the angle between them. Then A+B is a unit vector if
   1) $\theta = \pi/3$ 2) $\theta = \pi/4$ 3) $\theta = \pi/2$ 4) $\theta = 2\pi/3$
3. Two forces 60N and 80N act on a body making angles of 30^0 and 150^0 respectively with X-axis . Find their resultant nearly?
   1) 72N 2) 120N 3) 20N 4) 70N
4. At what angle should the two forces 2P and √2P act so that the resultant force is √10
   1) 45^0 2) 60^0 3) 90^0 4) 120^0
5. Two equal forces act a point. The square of their resultant is three times their product. Then angle between those vectors is
   1) 60^0 2) 30^0 3) 15^0 4) 90^0
6. The resultant of two forces of magnitudes 4N and 4√2N makes 90^0 with the smaller force. Then angle between those two forces is
   1) 90^0 2) 120^0 3) 135^0 4) 150^0
7. Two forces whose magnitudes are in the ratio 3:5 give a resultant 35N. When they are inclined at 60^0 to each other. Magnitudes of those two forces are
   1) 10N, 25N 2) 6N, 10N 3) 30N, 50N 4) 15N, 25N
8. The resultant of two forces at right angles is 5N. When the angle between them is 120^0, the resultant is √13N. Then magnitudes of those two forces are
   1) 2N, 3N 2) √10N, √15N 3) √10N, √20N 4) 4N, 3N
9. If A = 4i-2j+6k and B = i-2j-3k , the angle which the A+B makes with X-axis is
   1) $\cos^{-1}(3/\sqrt{50})$ 2) $\cos^{-1}(5/\sqrt{50})$ 3) $\cos^{-1}(4/\sqrt{50})$ 4) $\cos^{-1}(12/\sqrt{50})$
10. Two forces of magnitude 20N and 25N respectively act at a point. If the resultant force is 39N, the angle between the forces has to be
    1) 60^0 2) 45^0 3) 90^0 4) 30^0
11. The resultant of two vectors (P+Q) and (P-Q) , when they act right angles to each other is
    1) $2\sqrt{P^2+Q^2}$ 2) $\sqrt{2(P^2+Q^2)}$ 3) $\sqrt{P^2-Q^2}$ 4) $\sqrt{(P^2-Q^2)}-2$
12. A blind person after walking 10 steps in one direction, each of length 80cm, turns randomly to the left or to the right by 90^0. After walking a total of 40 steps the maximum displacement of the person from his starting position could be
    1) 320m 2) 32m 3) 16√2m 4) 160√2m
13. Resultant of (3i+4j)N and another force is 5√2N in magnitude. Then the other force could be
    1) (2i+j)N 2) 5kN 3) (i-j+5k)N 4) Any of these
14. Four forces (-5i+3j-5k), (2i+j+3k), (i-3j+3k) and (4i-2j-2k) act at a point simultaneously. Then the angle between those two vectors is
    1) √3 2) √14 3) √12 4) √6

15. Two vectors of magnitudes 7 and 24 combine to give a resultant of magnitude 25. Then the angle between those vectors is

1) 30^0 2) 60^0 3) 90^0 4) 120^0

16. An insect moves 3cm towards north, 4m towards east and then 5m vertically up. Then its resultant displacement is

1) 12m 2) 10m 3) $5\sqrt{2}$m 4) none

17. The resultant of two forces at right angles is 17N. If the maximum resultant is 23N, the greater force is

1) 15N 2) 8N 3) 7N 4) 23N

18. Ratio of the magnitude of maximum and minimum resultants of two forces is 7:3. Then ratio of the magnitudes of those forces is

1) 2:5 2) 1:5 3) 1:7 4) none

19. The resultant of two forces at right angles is 5N when the angle between them is 120^0, the resultant is $\sqrt{13}$N. The forces are

1) 1N, 4N 2) 2.5N, 2.5N 3) 2N, 3N 4) 3N, 4N

20. The angle between the forces (x+y) and (x-y) if their resultant is $2\sqrt{(x^2+y^2)}$

1) 0^0 2) 30^0 3) 60^0 4) 90^0

II-Position Vector:

21. A force F making an angle of 60^0 with +ve X-axis has a component of 20N along X-axis. Write the force in vector form

1) 20i+j 2) $40i+20\sqrt{3}j$ 3) $20i+20\sqrt{3}j$ 4) 20i+20j

22. The direction cosines of a vector are $1/\sqrt{5}$, $1/2\sqrt{5}$, $-2/\sqrt{5}$. Its vector equation is

1)i+j-2k 2) 2i+j-2k 3) 2i+j-4k 4) i+j+2k

23. If A= 2i+j and B= j-k then magnitude of 2A+3B is

1) $\sqrt{10}$ 2) $\sqrt{5}$ 3) $5\sqrt{2}$ 4) $\sqrt{20}$

24. A vector PQ has the initial point P(1,2,-1) and terminal point Q(3,2,2). Write the vector PQ and its magnitude

1) 3i+2j;$\sqrt{13}$ 2) 2i+3k;$\sqrt{13}$ 3) 6i+5j; $\sqrt{20}$ 4) 3i+3k; $\sqrt{26}$

25. Length of 2i-3j+4k in the XY plane

1) $\sqrt{13}$ 2) $\sqrt{20}$ 3) 5 4) zero

26. The direction cosines of a vector are $\cos\alpha = 3/5\sqrt{2}$, $\cos\beta= 4/5\sqrt{2}$, $\cos\gamma= 1/\sqrt{2}$. Then that vector is

1) 3i+5j+4k 2) 3i+4j-5k 3) 3i+4j+5k 4) none

27. Angle made by 5i-3j+4k with X-axis is

1) 45^0 2) 60^0 3) 90^0 4) 0^0

28. Vector parallel to 3i+4j and magnitude same as that of j+k is

1) $\frac{5(3i+4j)}{\sqrt{2}}$ 2) $\frac{\sqrt{2}(3i+4j)}{5}$ 3) $5\sqrt{2}(3i+4j)$ 4) $\frac{(3i+4j)}{5\sqrt{2}}$

29. If 0.2i+0.3j+zk is unit vector then z^2=

1) 0.27 2) 0.4 3) 0.87 4) none

30. If $|2i+yj+3k| =5$, then y=

1) $\sqrt{6}$ 2) $\sqrt{12}$ 3) $\sqrt{15}$ 4) none

31. If the position of a particle changes from (1,2,3) m to (5,4,2)m, then displacement vector is

1) 4i-2j+k 2) (4i+2j+k) 3) (4i-2j-k) 4) (4i+2j-k)

32. If 2i-yj+3k is parallel to 8i+3j+12k, then y =

1) 4/3 2) ¾ 3) –4/3 4) –3/4

33. If A= 3i+4j and B= 7i+24j then the vector having the same magnitude as B and parallel to A is

1) 15i+20j 2) 15i-20j 3) 20i+15j 4) 20i-15j

34. If A= 3i+5j and B= 5i+12j are the vectors having the same magnitude as B and parallel to A

1) $\frac{13(3i+4j)}{5}$ 2) $\frac{5(3i+4j)}{13}$ 3) $\frac{8(3i+4j)}{5}$ 4) $\frac{5(3i+4j)}{8}$

35. The angle made by i+j with z axis

1) 0^0 2) 45^0 3) 90^0 4) 180^0

36. A body initially at rest, is acted upon by four forces F_1=i+k, F_2= 2j+3k, F_3= 3iand F_4=3j-4i. In which plane will the body move?

1) X-Y 2) X-Z 3) Y-Z 4) none of these

III-Components:

37. The rectangular components of a force 17newton can be

1) 10N, 7N 2) 8N, 15N 3) 9N, 8N 4) 8N, 25N

38. The maximum and minimum resultants of two forces are in the ratio 7:3 . The ratio of the forces is

1) 5:2 2) √7: √5 3) 49:9 4) 4:1

39. If the X component of a vector in X-Y plane is √3 times its Y component, angle made by it with X-direction is

1) 30^0 2) 45^0 3) 60^0 4) 90^0

40. A vector is inclined at θ to the vertical and its horizontal component is H. Then its vertical component is

1) Hsinθ 2) Hcosθ 3) HTanθ 4) HCotθ

41. Two balls are moving on a table. One has the velocity components U_x= 2ms^{-1} Uy=√3ms^{-1}and the other has components Vx=2ms^{-1} V_y= 2ms^{-1}. If both start moving from the same point, angle between their directions of motion is

1) 15° 2) 30° 3) 60° 4) 90°

42. One of the two rectangular components of a force is 25N and it makes an angle of 60^0. With the force. The magnitude of the other component is

1) 25N 2) 50√3N 3) 25√3N 4) 25√2N

43. If a vector is along the horizontal , its vertical component is

1) maximum 2) minimum 3) zero 4) none

44. Given A= 2i+3j and B=i+j. The component of vector A along vector B is

1) $\frac{1}{\sqrt{2}}$(i+j) 2) $\frac{3}{\sqrt{2}}$(i+j) 3) $\frac{5}{\sqrt{2}}$(i+j) 4) $\frac{7}{\sqrt{2}}$(i+j)

45. Given A= 2i+3j and B=i+j, what is the component of vector A perpendicular to vector B and in the same plane as B?

1) $\frac{1}{\sqrt{2}}$(j-i) 2) $\frac{3}{\sqrt{2}}$(j-i) 3) $\frac{5}{\sqrt{2}}$(j-i) 4) $\frac{7}{\sqrt{2}}$(i+j)

IV-Dot Product:

46. The vector A= i+4j+3k and B= 4i+2j-4k are

1) perpendicular 2) parallel 3) inclined at 45^0 4) inclined at 60^0

47. If A = 4i+5j-6k and B= 2i-3j+4k then (A+B) .(A-B) is
1) 6 2) 48 3) 67 4) 13

48. A point of application of a force F= 5i-3j+2k is moved from r_1=2i+7j+4k to r_2= 5i+2j+3k. The work done is
1) 28 units 2) 22units 3) 11 units 4) 0 units

49. A force of (-3i-j+2k) N displaced the body from a point (4, -3, -5) m to a point (-1, 4, 3)m . The work done is
1) 12J 2) 14J 3) 24J 4) 36J

50. The work done is moving an object along a vectors S= 2i+3j+5k, if the applied force is F=2i+3j+7k
1) 12 2) 24 3) 36 4) 48

51. A body of mass 5kg moves from (6i+5j-3k)m to (10i-2j+7k)m under the action of force of (10i-3j+6k)N. Then work done is
1) 11J 2) 121J 3) 61J 4) none

52. If i+2j+nk is perpendicular to 4i+2j+2k, then n=
1) 4 2) 2 3) –4 4) –2

53. When a force (8i+4j)N displaces a particle through (3i-3j)m, the power is 0.6w. The time of action of force is
1) 10s 2) 20s 3) 15s 4) none

54. A force of (2i+3j+4k) N acts on a body for 4 seconds and produces a displacement of (3i+4j+5k)m. Then power=
1) 18W 2) 19W 3) 19.5W 4) 9.5W

55. Angle between –4i+2j and 9k is
1) 0^0 2) 30^0 3) 60^0 4) 90^0

56. Angle between i+2j-k and –i+j-2k is
1) 0= 2) 30^0 3) 60^0 4) 90^0

57. Angle between 3i+2j+k and 6i+4j+2k is
1) 0^0 2) 30^0 3) 45^0 4) 60^0

58. The magnitudes of two vectors are 3 and 4 units and their scalar product is 6 units. The angle between the vectors is
1) π/3 2) π/6 3) π/2 4) π/4

59. The power is given by P=F.V .A force of F = 6i+5j+3k N make the body move on a rough surface with uniform velocity of (2i-3j+2k)ms^{-1}. Find the power in watt.
1) 6 2) 9 3) 3 4) 8

60. Angle between 6i+3j+2k and 2i-2j-k is
1) $\sin^{-1}$(4/21) 2) $\cos^{-1}$(4/21) 3) $\cos^{-1}$(4/21) 4) none

61. If A= 2i+3j, its component along B= 2j+3k is
1) 6 2) 1/6 3) 6/3 4) 6/√13

62. If (3i-2j+2k).(2i-xj+3k) = - 12, the value of ‘x’ is
1) 6 2) –6 3) 12 4) –12

63. The magnitude of two vectors are 6 and 4. Their dot products is equal to 12. Then angle between those vectors is
1) 0^0 2) 30^0 3) 60^0 4) 90^0

64. Component of A along B is √3 times that of the component of B along A. Then A:B=
1) 1: √3 2) √3:1 3) 2: √3 4) √3:2

V-**Cross Product**:

65. (i+j+k)x(2i+3j+k)=
   1) –2i-j-k 2) –2i+j+k 3) 2i-j-k 4) 2i+j+k

66. If the diagonals of a parallelogram are represented by the vectors P=5i-4j+3k and Q=3i+2j-k. Find the area of the parallelogram
   1) 13.4units 2) 4.0 units 3) 8.0 units 4) 13.1 units

67. If the linear momentum and the radius vectors are 2i-3j+2k, 3i+4j+2k respectively, then the angular momentum is
   1) 5i+j+4k 2) i-7j+0k 3) 14i-2j-17k 4) 6i-12j+4k

68. Cross product of A= 2i-3j+k and B= -i+3j+k
   1) 6i+3j-6k 2) –6i+3j-6k 3) 6i-3j+6k 4) –6i-3j+2k

69. Area of a parallelogram formed by vectors 3i-2j+k and i+2j+3k is
   1) $3\sqrt{8}$ sq units 2) 24 sq units 3) $8\sqrt{3}$ sq units 4) none

70. Area of a triangle formed by A= 2i-6j+3k and B = 3i-4j+k is
   1) $\sqrt{45}$ units 2) $\sqrt{90}$ units 3) $\frac{\sqrt{45}}{2}$ units 4) $\frac{\sqrt{185}}{2}$ units

71. Area of the triangle enclosed by the vectors i+3j+2k, 2i-j+k and –i+2j+3k is
   1) $\sqrt{107}$ units 2) $\sqrt{107}/2$ units 3) $\frac{\sqrt{107}}{\sqrt{2}}$ units 4) none

72. Three vectors A, B and C satisfy the relation A.B=0 and A.C=0. The vector A is parallel to
   1) B 2) C 3) B.C 4) BxC

73. In a clock wise system
   1) jxk=1 2) j.i=0 3) jxk=i 4) k.i=1

74. If the magnitude of cross product of two vectors is $\sqrt{3}$ times their dot product , then angle between those vectors is
   1) 30^0 2) 45^0 3) 60^0 4) 90^0

75. $|A.B|^2+|AxB|^2=$
   1) AB 2) A^2B 3) AB^2 4) A^2B^2

76. (AxB)+(BxA)=
   1) 0 2) A+B 3) A-B 4) AB

77. A proton of velocity $(3i+2j)10^5ms^{-1}$enters a magnetic field (2i+3k) $webm^{-2}$.If the specific charge is $9.6x10^7C\ Kg^{-1}$, the acceleration of the proton in ms^{-2} is
   1) $(6i+9j+4k)x9.6x10^{12}$ 2) $(6i-9j+4k)x9.6x10^{12}$
   3) $(6i-9j+4k)x6.6x10^{12}$ 4) $(6i-9j-4k)x9.6x10^{12}$

VI-**Equilibrium, Lami's Theorem:**

78. A body of 10Kg is suspended by a rope and is pulled to a side by means of a horizontal force so that the rope makes an angle of 60^0 with the vertical. The tension in the rope is
   1) 20 Kg-wt 2) 10 Kg-wt 3) 30 Kg-wt 4) $10\sqrt{3}$ Kg-wt

79. A body of mass 10Kg is suspended by a rope and is pulled to a side by means of a horizontal force so that the rope makes an angle of 60^0 with the vertical. The horizontal force is
   1) 10 Kg-wt 2) 30 Kg-wt 3) $10\sqrt{3}$ Kg-wt 4) $30\sqrt{3}$ Kg-wt

80. A body of mass 20Kg is suspended vertically by means of a string of length 10cm. The horizontal force required to pull the mass horizontally through 6cm.

1) 20 Kg-wt 2) 15 Kg-wt 3) 10 Kg-wt 4) none

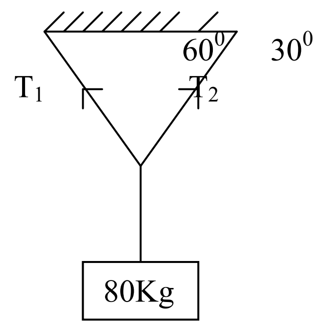
81. A body of mass √3Kg is suspended by a string from roof. It is pulled horizontally by a force until the string makes an angle of 60^0 with the vertical . Then that horizontal force is

1) 9.8N 2) 19.6N 3) 29.4N 4) none

82. A body of 10Kg is suspended by a rope and is pulled to a side by means of a horizontal force 10√3Kg-wt. Then the angle made by the rope to the vertical is

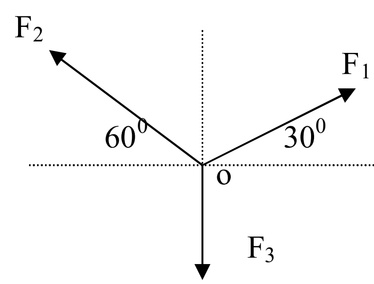
1) 30+ 2) 45^0 3) 60^0 4) 90^0

83. A man 80Kg is supported by two cables as shown in the fig. Then tensions T_1 and T_2 respectively are



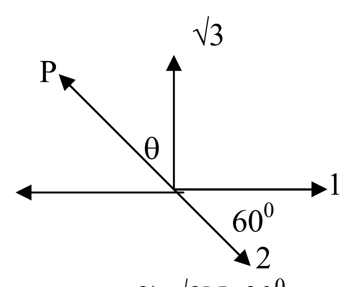
1) 40√3Kg-wt, 40Kg-wt 2) 40Kg-wt, 40Kg-wt
3) 40√3Kg-wt, 40√3Kg-wt 4) 40Kg-wt, 40√3Kg-wt

84. Forces F_1, F_2 and F_3 act O as shown. If $F_2 = 5\sqrt{3}$ and 'O' is in equilibrium , values of F_1 and F_2 are



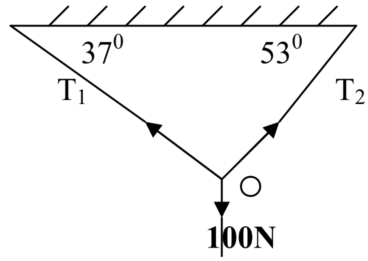
1) 5N, 10N 2) 10N, 5√3N 3) 10N, 10N 4) none

85. Four concurrent coplanar forces in Newton are acting at a point and keep it in equilibrium. Then values of P and θ are



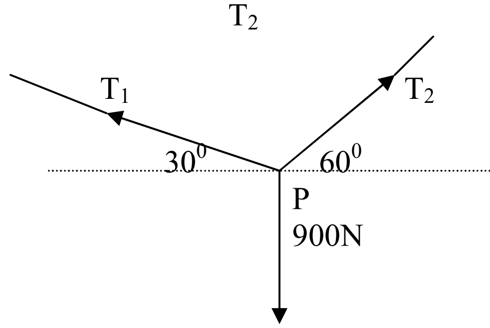
1) 1N, 90^0 2) 2N, 60^0 3) √2N, 90^0 4) 2N, 90^0

86. If 'O' is in equilibrium, then tensions T_1 and T_2 are numerically ($\sin 37^0 = 3/5$)



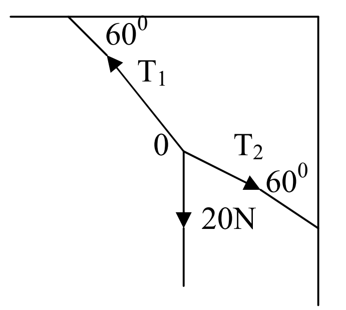
1) 30N, 50N 2) 60N, 80N 3) 80N, 60N 4) none

87. If P is in equilibrium, then tensions $\frac{T_1}{T_2}$ =



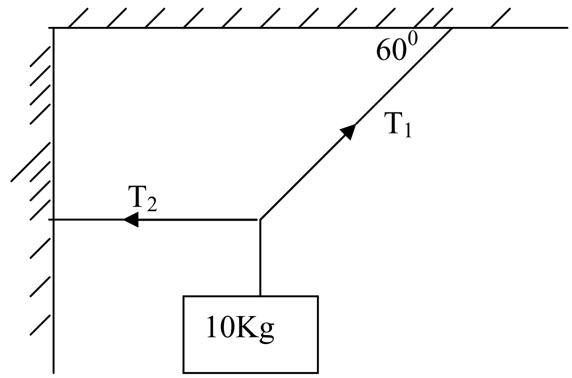
1) $\sqrt{3}$ 2) 2 3) $1/\sqrt{3}$ 4) ½

88. If 'O' is in equilibrium, then values of T_1 and T_2 are



1) 20N, 20N 2) $20\sqrt{3}$N, 20N 3) $20\sqrt{3}$N, $20\sqrt{3}$N 4) none

89. Tensions T_1 and T_2 in the cords of the given system in equilibrium are



1) 20Kg-wt, 20√3Kg-wt 2)10Kg-wt, 10√3Kg-wt
3) 20/√3Kg-wt, 10√3Kg-wt 4) 20/√3Kg-wt, 10/√3Kg-wt

90. A body of weight √3N suspend vertically using a rope is pulled horizontally such that rope makes an angle 30^0 to the vertical. Then tension in that rope is
1) 1N 2) 3N 3) 2N 4) 4N

VII- **Resultant Velocity**:

91. A boat takes hours to travel 8Km and back in still water lake. If the velocity of water is 4Kmph the time taken for going upstream of 8Km and coming back is
1) 2 hours 20 minutes 2) 2 hours 40 minutes
3) 1 hour 20 minutes 4) 3 hours 20 minutes

92. A boat has a speed of 5Kmph in still water. It crosses a river of width 1Km along the shortest possible path in 15 min. The velocity of the river is
1) 3Kmph 2) 4Kmph 3) 5Kmph 4) 6Kmph

93. A man rowing a boat in a river making on angle of 45^0 with the straight course reaches the opposite point from the straight point. If velocity of water is V, then velocity of the boat
1) V/√2 2) √2V 3) 2V 4) V/2

94. Velocity of boat in still water is $(2i+3j)ms^{-1}$. If it moves in a river flowing with a velocity of $(3i+2j)ms^{-1}$. Then the resultant velocity of boat is
1) $(i+j)ms^{-1}$ 2) $(3i+3j)ms^{-1}$ 3) $(2i+2j)ms^{-1}$ 4) $(5i+5j)ms^{-1}$

95. A boat is rowed with 10Kmph straight across a river which flows at 4Kmph . Breadth of the river is 80Km. Straight from one bank boat finally reaches the other bank. On reaching the other bank its drift is
1) 29Km 2) 16Km 3) 24Km 4) 32Km

96. A man can swim in still water at 15Kmph . The river flows at 10Kkmph. If he wants to cross the river along shortest path, he should swim along a direction making an angle θ with the direction of the stream. Then θ=
1) $\sin^{-1}(2/3)$ 2) $\sin^{-1}(90^0+2/3)$ 3) $90^0+\sin^{-1}(2/3)$ 4) zero

97. A river flows at $3ms^{-1}$ and 300m wide. A man swims across the river with a velocity of $20ms^{-1}$ directed always perpendicular to the flow of current. The time taken by the man to cross the river is
1) 100s 2) 150s 3) $\frac{300}{\sqrt{13}}$ s 4) $\frac{300}{\sqrt{5}}$ s

98. A man can swim in still water with 4Kmph. The time taken by him to cross a 1Km wide river flowing at 3Kmph if he moves normal to the river current is

1) 10min 2) 15min 3) 30min 4) 45min

99. A man can swim in still water at 10Kmph. The river flows at 5Kmph. If he crosses the river in shortest time, his resultant velocity is

1) 15kmph 2) 5kmph 3) $5\sqrt{5}$kmph 4) none

VIII- **Change in Velocity and Relative Velocity**:

100. A particle moves along a circle with uniform speed V. When it has moved through an angle60^0, change in its velocity is

1) zero 2) $\sqrt{3}$V 3) 3V 4) V

101. A man is walking on a road with velocity V. Velocity of rain relative to the man appears to be 2V and the rain is falling down vertically. Then actual velocity of the rain is

1) V/$\sqrt{3}$ 2) $\sqrt{3}$V 3) $\sqrt{3}$V/2 4) none

102. A particle moves along a circle with a constant speed $10ms^{-1}$ from A to B which are the ends of its diameter. Then change in its velocity is

1) $10ms^{-1}$ 2) $20ms^{-1}$ 3) $10\sqrt{2}ms^{-1}$ 4) zero

103. A man is walking due east at the rate of 4Kmph and the rain is falling at an angle of 30^0 east of vertical with a velocity of 6Kmph. The velocity of the rain relative to the man will be

1) 8.718Kmph 2) 10Kmph
3) 7.718Kmph 4) 5Kmph

104. A particle is moving eastwards with a velocity $10ms^{-1}$. In 5 seconds the velocity changes to $10ms^{-1}$ south wards. Then average acceleration during this time is

1) zero 2) $2\sqrt{2}ms^{-2}$ towards S-E
3) $2\sqrt{2}ms^{-2}$ towards N-W 4) $2\sqrt{2}ms^{-2}$ towards S-W

105. A monkey is climbing a vertical pillar with a velocity of $5ms^{-1}$ and a boy is running towards the pillar with a velocity of $5\sqrt{3}ms^{-1}$. Velocity of boy relative to the monkey is

1) $10ms^{-1}$ at 30^0 with the horizontal 2) 10 ms^{-1} at 60^0 with the horizontal
3) $8\sqrt{3}ms^{-1}$ at 30^0 with the horizontal 4) $8\sqrt{3}$ ms^{-1} at 60^0 with the horizontal

106. A car is moving towards east with a speed of 20Kmph. To the driver of the car a truck appears to move towards north with a speed of $20\sqrt{3}$ Kmph. Then actual speed of the truck is

1) 40Kmph, 30^0east of north 2) $40\sqrt{3}$Kmph, 30^0 east of north
3)40Kmph, 30^0 west of north 4) $40\sqrt{3}$Kmph, 30^0 west of north

107. A 100 m train is moving North at a speed of $16ms^{-1}$. A bird flying at $4ms^{-1}$ towards South crosses the train in

1) 5s 2) 10s 3) 12s 4) 20s

108. A man is walking due east at 5Kmph. Rain appears to fall vertically downwards at 12Kmph for him. Then true velocity of the rain in Kmph is

1) $\sqrt{119}$ 2) 17 3) 14 4) none

109. Rain is falling vertically with a speed of 4ms-1. After some time, wind starts blowing with a speed of $3ms^{-1}$ in the north to south direction. In order to protect himself they move a man standing on the ground should hold his umbrella at an angle θ given by

1) θ= $\tan^{-1}$(3/4)with the vertical towards south
2) θ=$\tan^{-1}$(3/4) with the vertical towards north
3) θ=$\cot^{-1}$(3/4) with the vertical towards south
4) θ=$\cot^{-1}$(3/4) with the vertical towards north

110. To a man walking at 2kmph, rain appears to fall vertically. When he doubles his speed, it appears to fall at 30^0 to the vertical. Then actual velocity of the rain is
1) 2kmph, 30^0 to the vertical 2) 2kmph, 60^0 to the vertical
3) 4kmph, 30^0 to the vertical 4) 4kmph, 60^0 to the vertical

111. Rain drops are falling vertically downwards at $5\sqrt{2}ms^{-1}$. A man runs horizontally in the rain at $5\sqrt{2}$ ms^{-1}, The magnitude and direction of relative velocity of the rain drops with respect to the person is
1) $5ms^{-1}$, 45^0 with vertical 2) $10ms^{-1}$, 45^0 with vertical
3) $15ms^{-1}$, 30^0 with vertical 4) none of these

112. To a person going east in a car with a velocity of 25kmph, a train appears to move towards north with a velocity of $25\sqrt{3}$kmph. Then actual velocity of the train is
1) 25kmph 2) 50kmph 3) 5kmph 4)$5\sqrt{3}$kmph

IX-**Previous Eamcet Questions**:

113. A proton of velocity $(3i+2j)ms^{-1}$ enters a field of magnetic induction (2j+3k) tesla. The acceleration produced in the proton in ms^{-2} is (specific charge of proton = $0.96x10^8CKg^{-1}$) (2002E)
1) $2.8x10^8$(2i-2j) 2) $2.88x10^8$(2i-3j+2k)
3) $2.8x10^8$(2i+3k) 4) $2.88x10^8$(i-3j+2k)

114. A boat which has a speed of 13kmph in still water crosses a river of width 1km along the shortest possible path in 12 minutes. The velocity of the river water in Kmph is (2002M)
1) 12 2) 10 3) 8 4) 6

115. Two particles having position vectors r_1= (3i+5j)m and r_2= (-5i+3j)m are moving with velocities V_1= $(-4i+3j)ms^{-1}$ and V_2=$(-ai+3j)ms^{-1}$. If they collide after 2 seconds, the value of 'a'is (2003E)
1) 2 2) 4 3) 6 4) 8

116. A stationary body of mass 3kg explodes into three equal pieces Two of the pieces fly off at right angles to each other, one with a velocity $2ims^{-1}$ and the other with a velocity $3jms^{-1}$ .If the explosion takes place in 10^{-5}s, the average force acing on the third place in newtons is (2003M)
1) $(2i+3j)x10^{-5}$ 2) $-(2i+3j)x10^5$ 3) $(3j-2i)x10^5$ 4) $(2i-3j)x10^{-5}$

117. At given instant of time two particles are having the position vectors 4i-4j+7km and 2i+2j+5k m respectively, If the velocity of the first particle is $0.4ims^{-1}$, the velocity of second particle in ms^{-1} if they collide after 10sec is (2004E)
1) $6(i-j+\frac{1}{\sqrt{5}}k)$ 2) $0.6(i-j+\frac{k}{3})$ 3) $0.6(i+j+\frac{k}{3})$ 4) $0.6(i+j-\frac{k}{3})$

118. A vector Q has a magnitude of 8is added to the vector P which lies along the X-axis. The resultant of these two vectors is a third vector R which lies along the Y-axis and has a magnitude twice that of P. The magnitude of P is (2004M)
1) $6/\sqrt{5}$ 2) $8/\sqrt{5}$ 3) $12/\sqrt{5}$ 4) $16/\sqrt{5}$

Keys

1) **2**	2) **4**	3) **1**	4) **1**	5) **1**	6) **3**	7) **4**	8) **4**	9) **2**	10) **1**
11) **2**	12) **3**	13) **4**	14) **4**	15) **3**	16) **3**	17) **1**	18) **1**	19) **4**	20) **4**
21) **3**	22) **3**	23) **3**	24) **2**	25) **1**	26) **3**	27) **1**	28) **2**	29) **3**	30) **2**
31) **4**	32) **4**	33) **1**	34) **1**	35) **3**	36) **3**	37) **2**	38) **1**	39) **1**	40) **4**
41) **1**	42) **3**	43) **3**	44) **3**	45) **1**	46) **1**	47) **2**	48) **1**	49) **3**	50) **4**
51) **2**	52) **3**	53) **2**	54) **4**	55) **4**	56) **3**	57) **1**	58) **1**	59) **3**	60) **3**
61) **4**	62) **4**	63) **3**	64) **2**	65) **2**	66) **1**	67) **3**	68) **4**	69) **3**	70) **4**
71) **2**	72) **4**	73) **3**	74) **3**	75) **4**	76) **1**	77) **4**	78) **1**	79) **3**	80) **2**
81) **3**	82) **3**	83) **1**	84) **1**	85) **4**	86) **2**	87) **3**	88) **2**	89) **4**	90) **3**
91) **2**	92) **1**	93) **2**	94) **4**	95) **4**	96) **3**	97) **2**	98) **2**	99) **3**	100) **4**
101) **1**	102) **2**	103) **1**	104) **4**	105) **1**	106) **1**	107) **1**	108) **3**	109) **2**	110) **3**
111) **2**	112) **2**	113) **2**	114) **1**	115) **4**	116) **2**	117) **2**	118) **2**		

1) Given two vectors $\bar{A} = \hat{i} - 2\hat{j} - 3\hat{k}$ and $\bar{B} = 4\hat{i} - 2\hat{j} + 6\hat{k}$. The angle made by ($\bar{A} + \bar{B}$) with x –axis is (2007M)
1) 30^0 2) 45^0 3) 60^0 4) 90^0

2) Velocity and acceleration vectors of charged particle moving perpendicular to the direction of a magnetic field at a given instant of time $\vec{V} = 2\hat{i} + c\hat{j}$ and $\vec{a} = 3\hat{i} + 4\hat{j}$ respectively. Then the value of 'c' is (2007E)
1) 3 2) 1.5 3) –1.5 4) –3

3) Of the vectors given below, the parallel vectors (2006M)
$\bar{A} = 6\hat{i} + 8\hat{j}$ $\bar{B} = 210\hat{i} + 280\hat{j}$ $\bar{C} = 5.1\hat{i} + 6.8\hat{j}$ $\bar{D} = 3.6\hat{i} + 8\hat{j} + 48\hat{k}$
1) $\bar{A}$ & $\bar{B}$ 2) $\bar{A}$ & $\bar{C}$ 3) $\bar{A}$ & $\bar{D}$ 4) $\bar{C}$ & $\bar{D}$

4) When a man is standing, rain drops appears to him falling at 60^0 from the horizontal from his front side. When he is travelling at 5km per hour on a horizontal road they appear to him falling at 30^0, from the horizontal from his front side. The actual speed of the rain is (in km per hour) (2006M)
1) 3 2) 4 3) 5 4) 6

5) Angle (in rad) made by the vector $\sqrt{3}\,\hat{i} + \hat{j}$ with the X –axis (2005M)
1) $\frac{\pi}{6}$ 2) $\frac{\pi}{4}$ 3) $\frac{\pi}{3}$ 4) μ

6) At a given instant of time the position vector of a particle moving in a circle with 9 velocity $3\hat{i} - 4\hat{j} - 5\hat{k}$ is $\hat{i} + 9\hat{j} - 8\hat{k}$. Its angular velocity at that time is (2005E)
1) $\frac{(13\hat{i} - 29\hat{j} - 31\hat{k})}{\sqrt{146}}$ 2) $\frac{(13\hat{i} - 29\hat{j} - 31\hat{k})}{146}$
3) $\frac{(13\hat{i} + 29\hat{j} - 31\hat{k})}{\sqrt{146}}$ 4) $\frac{(13\hat{i} + 29\hat{j} + 31\hat{k})}{146}$

7) A vector $\bar{Q}$ which has a magnitude of 8 is added to the vector $\bar{P}$ which lies along the X –axis. The resultant of these two vectors is a third vector $\bar{R}$ which lies along the Y-axis and has a magnitude twice that of $\bar{P}$. The magnitude of $\bar{P}$ is (2004M)

1) $\frac{6}{\sqrt{5}}$ 2) $\frac{8}{\sqrt{5}}$ 3) $\frac{12}{\sqrt{5}}$ 4) $\frac{16}{\sqrt{5}}$

8) At a given instant of time two particles are having the position vectors $4\hat{i}-4\hat{j}+7\hat{k}$ and $2\hat{i}+2\hat{j}+5\hat{k}$ meters respectively. If the velocity of the first particle be $0.4\bar{i}\,ms^{-1}$, the velocity of second particle in meter per second of they collide after 10 sec is (2004E)

1) $6\left(\bar{i}-\bar{j}+\frac{1}{3}\bar{k}\right)$ 2) $0.6\left(\bar{i}-\bar{j}+\frac{1}{3}\bar{k}\right)$

3) $6\left(\bar{i}+\bar{j}+\frac{1}{3}\bar{k}\right)$ 4) $0.6\left(\bar{i}+\bar{j}-\frac{1}{3}\bar{k}\right)$

9) A boat which has a speed of 13kmph in still water crosses a river of width 1km along the shortest possible path in 12 minutes. The velocity of river water in kmph is (2002M)

1) 12 2) 10 3) 8 4) 6

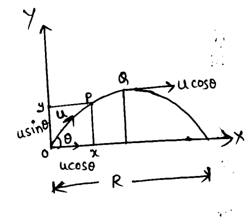
10) A proton of velocity $(3\hat{i}+2\hat{j})ms^{-1}$ enters a field of magnetic induction $(2\hat{j}+2\hat{k})$ tesla. The acceleration produced in the proton in ms^{-2} is (sp of charge of proton = $0.96\times10^{8}Ckg^{-1}$) (2002M)

1) $2.8\times10^{8}(2\hat{i}-3\hat{j})$ 2) $2.88\times10^{8}(2\hat{i}-3\hat{j}+2\hat{k})$

3) $2.8\times10^{8}(2\hat{j}+3\hat{k})$ 4) $2.88\times10^{8}(\hat{i}-3\hat{j}+2\hat{k})$

1)2	2)3	3)2	4)3	5)1
6)2	7)2	8)2	9)1	10)2

Motion in a plane (projectile motion) (or) Projectiles:-



⇒ Projectile : A body projected into air with certain velocity making an angle other than 90^0 to the horizontal is known as projectile

⇒ The path of a projectile is called trajectory and is a parabola

⇒ If a body is projected at an angle θ to the horizontal with an initial velocity 'u' its horizontal component u cosθ remains constant throughout its motion and the vertical component u sinθ will be subjected to gravity.

⇒ In the case of a projectile velocity varies both in magnitude and direction but acceleration remains constant both in magnitude and direction.

⇒ When a body is thrown into air, at highest point of its motion its velocity need not be equal to zero.
Eg: projectile. At maximum height it posses horizontal component of velocity.

⇒ Depending on angle of projection, projectiles are divided into three types. They are horizontal projectiles, vertical projectiles and oblique projectiles.

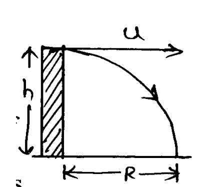
- Body A is projected horizontally from certain height. Body B is released from the same point simultaneously. Both will reach the ground at after the same time with different velocities.
- When a projectile is thrown into air at an angle θ to the horizontal, the angle between its velocity and acceleration change from (90+θ) to (90-θ) during its time of flight
- For a given velocity of projection, horizontal range of a projectile is same for angles of projection θ_1 and θ_2 such that $\theta_1+\theta_2 = \Pi/2$ [i.e, ($\Pi/2$ -θ) and θ].
- Horizontal displacement of a body projected at an angle θ x= u cosθ t
- Vertical displacement $y= u \sin\theta.t - 1/2\, gt^2$
- Equation of projectile $y=\tan\theta.x - gx^2/2u^2\cos^2\theta$
- Velocity of the body after time't' is v_x=ucosθ y= usinθ -gt .

⇒ $V= v_x i+v_y j$

⇒ $V= \sqrt{V_x^{\,2}+v_y^{\,2}} = \sqrt{(u\cos\theta)^2 + (u \sin\theta-gt)^2}$

- If α is angle between them $\tan\alpha = v_y/v_x$.
- Velocity of the body when it is at a height 'h' above the ground is vx= ucosθ, v_y= usinθ-2gh Time of ascent = Time of descent t=usinθ/g
- Time of flight T= 2usinθ/g , Maximum height $H=u^2\sin^2\theta/2g$
- Horizontal range $R= u^2 \sin2\theta/g$, tanθ =4H/R → R=4Hcotθ→$H=gT^2/8$
- Maximum height $H=u^2/2g$, Maximum range $R=u^2/g$. when $\theta=45^0$

HORIZONTAL PROJECTILES :-



- When a body is projected horizontally with a velocity from a point above the ground level, it is called horizontal projectile.
- The horizontal distance travelled by the projectile during the time of flight is called horizontal range.

- Horizontal component of velocity 'u' remains constant throughout its motion. In vertical component it is same as freely falling body.
- A body projected horizontally form a height reaches the ground after a time 't' then
  t= $\sqrt{2H/g}$
- Horizontal range R=ut=u/$\sqrt{2H/g}$,Velocity with which it hits the ground
  $V = \sqrt{u^2 + 2gh}$
- If E is the K. E of the projectile at the time of projection on reaching the maximum height its P.E. = $E\sin^2\theta$, K.E= $E\cos^2\theta$
- If a body projected horizontally with velocity u from a height 'h'
- Time taken to reach the ground t=$\sqrt{2h/g}$
- Horizontal distance at which it strikes the ground is x=ut = u.$\sqrt{2h/g}$
- Horizontal component = u , Vertical component =gt or $\sqrt{2gh}$
- Velocity with which strikes the ground = $\sqrt{u^2+(gt)^2} = \sqrt{u^2+2gh}$
- If the angle at which the body reaches ground is α then $\tan\alpha$ =gt/u = $\sqrt{2gh}$/u
- A body is dropped from the top of a tower of height h and another body is thrown up simultaneously with velocity u from foot of the tower. Both of them would meet after a time t=h/u in their paths.

Oblique Projection:

1) A projectile is fired at an angle of 45^0 and reaches the highest point in its path in $2\sqrt{2}$s. If air resistance is neglected, maximum height reached by it is
   1) g 2) 2g 3) 3g 4) 4g
2) The speed of a projectile at its maximum height is 6m/s. If it stays in the air for a total time of 8 seconds, its horizontal range is
   1) 12m 2) 24m 3) 36m 4) 48m
3) Two stones are thrown each with a velocity of g from the same point in opposite directions on the ground. If each has the greatest horizontal range, their separation on reaching the ground
   1) g 2) 2g 3) 4g 4) 8g
4) A particle is projected with a velocity u. So that its horizontal range and maximum height reached are equal. The maximum height reached is
   1) $2u^2/3g$ 2) $4u^2/5g$ 3) u^2/g 4) $8u^2/17g$
5) A body projected at angle 'θ' with the horizontal. If remains for a time T in air. Its horizontal range is R, then Tanθ=
   1) gT/2R 2) $g^2T/2R$ 3) $gT^2/2R$ 4) $gT/2R^2$
6) A particle is projected with a certain velocity. So as to have the same horizontal range 'R'.If t_1 and t_2 are the times taken to reach this point in the two possible way.
   1) $t_1/t_2=2R/g$ 2) $t_1t_2=2R/g$ 3) $t_1+t_2=2R/g$ 4) $t_1-t_2=2R/g$
7) A shell is fired vertically upwards with a speed of V_1 from the deck of a shop travelling at a speed of V_2.A person on the shore observe the motion of the shell as parabola whose horizontal range is given by
   1) $2V_1^2V_2/g$ 2) $2V_1V_2^2/g$ 3) $2V_1V_2/g$ 4) $2V_1^2V_2^2/g$
8) The equation of trajectory of a projectile thrown from a point on the ground is $y=(x-x^2/40)$m. If $g=10ms^{-2}$. The maximum height reached is
   1) 6m 2) 8m 3) 10m 4) 12m

9) The velocity of a projectile when it is at half of the maximum height is $\sqrt{\frac{5}{2}}$ times its velocity when it is at the heighest point. The angle of projection is

1) 15^0 2) 30^0 3) 45^0 4) 60^0

10) A body is projected with a velocity of 40m/s, and at an angle 30^0. The time it takes to be at a height of 20 m is (g = 10 ms^{-2})

1) 6s 2) 3s 3) 2s 4) none

11) The K.E of a projectile at the highest point of the trajectory is 75% of its K.E at the point of projection. The angle of projection is

1) 45^0 2) 60^0 3) 30^0 4) 15^0

12) Two bodies are projected at angle θ and (90-θ) to the horizontal with the same speed . The ratio of their times of flight is

1) 1:1 2) tanθ:1 3) 1:tanθ 4) $\tan^2\theta$:1

13) A ball thrown by a boy is caught 2 seconds later by another at some distance away on the same level. If the angle of projection is 30^0. The velocity of projection is

1) 19.6m/s 2) 9.8m/s 3) 4.9m/s 4) none

14) A cannon ball has the same range R on a horizontal plane for two different angles of projection. If h_1 and h_2 are the maximum heights in two paths for which this is possible, then

1) $R=h_1h_2$ 2) $R=\sqrt{h_1h_2}$ 3) $R=2\sqrt{h_1h_2}$ 4) $R=4\sqrt{h_1h_2}$

15) A stone is projected from the ground with a velocity of 20m/s. Its maximum height is 5m, then the angle of projection is (g = 10m/s^2)

1) 5^0 2) 30^0 3) 45^0 4) 60^0

16) If a projectile at 30^0 to the horizontal reaches the ground two seconds after its projection, the change in velocity in that interval of time is

1) 9.8ms^{-1} 2) 14.7ms^{-1} 3) 19.6ms^{-1} 4) 29.4ms^{-1}

17) A grass hopper on a horizontal straight road leaps forward at an angle of 45^0 and during its flight reaches a maximum height of 0.2m. It continues to leap forward at the same rate without wasting any time. Then its average horizontal velocity is (g = 10ms^{-2})

1) 1ms^{-1} 2) 2ms^{-1} 3) 4ms^{-1} 4) 0.5ms^{-1}

18) The horizontal range of a projectile is $R= gT^2/2$ where T is its time of flight. Then angle of projection to the horizontal is

1) 30^0 2) 45^0 3) 60^0 4) 90^0

19) A body is projected from the ground with velocity (ai+bj)ms^{-1}. If the range is twice the maximum height attained, then

1) b=a/2 2) b=a 3) b=2a 4) b=4a

20) A player kicks a foot ball at a speed of 20ms^{-1} so that the horizontal range is Maximum. Another player 24m away in the direction of kick starts running in the same direction at the same instant of hit. If he has to catch the ball just before it reaches the ground. He should run with a velocity equal to (g = 10ms^{-2})

1) 4ms^{-1} 2) 5ms^{-1} 3) 10ms^{-1} 4) 12ms^{-1}

21) A stone is projected into air at an angle 300 to the horizontal with a speed 20ms^{-1} from the top of a tower of height 120m. The time after which it reaches the ground is (g=10ms^{-2})

1) 2s 2) 3s 3) 4s 4) 6s

Keys

1) 4	2) 4	3) 2	4) 4	5) 3	6) 2	7) 3	8) 3	9) 4	10) 3
11) 3	12) 2	13) 1	14) 4	15) 2	16) 3	17) 2	18) 2	19) 3	20) 1
21) 4									

Horizontal Projection:

22) A body is projected horizontally from the top of a tower with $30ms^{-1}$. If $g=10ms^{-2}$, the velocity of that body after 4 seconds

1) $40ms^{-1}$ 2) $30ms^{-1}$ 3) $50ms^{-1}$ 4) $20ms^{-1}$

23) From the top of a building 20m high, a ball is projected horizontally. If the line joining the point of projection to the point where it hits the ground makes an angle 45^0 with the horizontal , then the initial velocity of the stone is ($g = 10ms^{-2}$)

1) $5ms^{-1}$ 2) $10ms^{-1}$ 3) $15ms^{-1}$ 4) $20ms^{-1}$

24) An Aeroplane flying horizontally at a height 1.96km with a velocity of $300ms^{-1}$ drops a bomb when it is exactly above a point A on the earth. The bomb strikes a target at a point B on the earth. Then distance between A and B is

1) 3Km 2) 6Km 3) 9Km 4) 12Km

25) A body is projected horizontally with a velocity of 10 ms^{-1} from the tower of height 19.6m. The distance at which it falls from the foot of the tower is

1) 10m 2) 15m 3) 20m 4) 25m

26) A body is thrown horizontally from the top of a tower 40m high and strikes the ground at an angle 45^0 with the horizontal. The speed with which it was thrown from the top is

1) $7ms^{-1}$ 2) $14ms^{-1}$ 3) $28ms^{-1}$ 4) none

27) An Aeroplane flying horizontally at a height of 0.49Km with a velocity $98ms^{-1}$ released a bomb. On reaching the ground velocity of the bomb is

1) $49ms^{-1}$ 2) $49\sqrt{2}ms^{-1}$ 3) $98ms^{-1}$ 4) $98\sqrt{2}ms^{-1}$

28) Two stones A and B are thrown with velocities $10ms^{-1}$ ands $20ms^{-1}$ from the top of a tower horizontally. If they reaches the ground after times t_1 and t_2 respectively

1) $t_1=2t_2$ 2) $t_2=2t_1$ 3) $t_1=t_2$ 4) $t_1^2=2t_2^2$

29) When a body is projected horizontally with velocity u from certain height, it reaches the ground with velocity 4u. Then height from which it is thrown is

1) $4u^2/2g$ 2) $15u^2/2g$ 3) $16u^2/5g$ 4) $4u^2/5g$

30) From the top of a building 78.4m high , a ball is thrown horizontally which hits the ground at a distance . The line joining the top of the building to the point where the ball hits the ground makes an angle of 45^0 with the horizontal. Then initial velocity of the ball is

1) $9.8ms^{-1}$ 2) $19.6ms^{-1}$ 3) $9.8\sqrt{2}ms^{-1}$ 4) $19.6\sqrt{2}ms^{-1}$

31) A body projected horizontally with a velocity u from the top of a tower strikes the ground with a velocity 2u. Then height of that tower is

1) $3u^2/2g$ 2) $u^2/2g$ 3) u^2/g 4) $3u^2/4g$

32) From the top of a tower of height h a body is projected horizontally with velocity u. On reaching the ground, magnitude of change in its velocity is

1) $\sqrt{u^2+2gh}$ 2) $\sqrt{2gh}$ 3) $u-\sqrt{2gh}$ 4) $u+\sqrt{2gh}$

Keys

22) 3 23) 2 24) 2 25) 3 26) 3 27) 4 28) 3 29) 2 30) 2 31) 1 32) 2

Previous Eamcet Questions:

33) A body is thrown horizontally from the top of a tower of 5m height. It touches the ground at a distance of 10m from the foot of the tower. Then initial velocity of the body is ($g = 10\ ms^{-2}$) (Eamcet 2000E)
   1) $2.5ms^{-1}$ 2) $5\ ms^{-1}$ 3) $10ms^{-1}$ 4) $20ms^{-1}$
34) A body is thrown vertically upwards with initial velocity 'u' reaches maximum height in 6 seconds. The ratio of distances travelled by the body in the first second and seventh second is (Eamcet 2000E)
   1) 1:1 2) 11:1 3) 1:2 4) 1:11
35) For a projectile the ratio of maximum height reached to the square of flight time is ($g = 10\ ms^{-2}$) (Eamcet 2000M)
   1) 5:4 2) 5:2 3) 5:1 4) 10:1
36) A stone projected with a velocity u at an angle θwith the horizontal reaches a maximum height H_1.When it is projected with velocity u at an angle($\pi/2-\theta$) with the horizontal reaches maximum height H_2. The relation between the horizontal range R of the projectile , H_1 and H_2 is (Eamcet 2000M)
   1) $R= 4\sqrt{H_1H_2}$ 2) $R= 4(H_1-H_2)$
   3) $R= 4(H_1+H_2)$ 4) $R=(H_1/H_2)^2$
37) An object is projected with a velocity of $20ms^{-1}$ making an angle of 450 with horizontal. The equation for the trajectory is $h=Ax-bx^{2,}$ where 'h' is height, x is horizontal distance, A and B are constants. The ratio of A and B is ($g=10ms^{-2}$)
   1) 1:5 2) 5:1 3) 1:40 4) 40:1 (2001 E)
38) It is possible to projectile a particle with a given speed in two possible ways so that it has the same horizontal range 'R'. The product of time taken by it in the two possible ways is (Eamcet 2001 M)
   1) R/g 2) 2R/g 3) 3R/g 4) 4R/g
39) A body of mass m1 projected vertically upwards with an initial velocity 'u' reaches a maximum height 'h'. Another body of mass m2 is projected along an inclined plane making an angle 30^0 with the horizontal and with speed 'u'. The maximum distance travelled along the incline is (Eamcet 2001M)
   1)2h 2) h 3) h/2 4) h/4
40) The horizontal and vertical displacement of projectile at time 't' are x=36t and $y=48t-4.9t^2$ respectively. Initial velocity of the projectile in ms^{-1} is (2002 E)
   1) 15 2) 30 3) 45 4) 60
41) A projectile has initially the same horizontal velocity as it would acquire if it had moved from rest with uniform acceleration of $3ms^{-2}$ for 0.5 minutes . If the maximum height reached by it is 80m then the angle of projection is ($g=10ms^{-2}$)
   1) $Tan^{-1}(3)$ 2) $Tan^{-1}(3/5)$ 3) $Tan^{-1}(4/9)$ 4) $sin^{-1}(4/9)$ (2002M)
42) The equations of motion of a projectile are given by x=36t metre and $2y=96t - 9.8t^2$metre. The angle of projection is (2003E)
   1) $sin^{-1}(4/5)$ 2) $sin^{-1}(3/5)$ 3) $sin^{-1}(4/3)$ 4) $sin^{-1}(3/4)$
43) Two stones are projected with the same speed but making different angles with the horizontal. Their horizontal ranges are equal. The angle of projection of one is $\pi/3$

and the maximum height reached by it is 102 meters. Then the maximum height reached by the other in metres is (2003 M)

1) 336 2) 224 3) 56 4) 34

44) The horizontal and vertical displacement X and Y of a projectile at a given time 't' are given by X=6t meters and $Y=8t-5t^2$ metres. The range of projectile in metres is (2004 E)

1) 9.6 2) 10.6 3) 19.2 4) 88.4

45) The maximum height reached by a projectile is 4 meters. The horizontal range is 12 meters. Velocity of projection in ms^{-1} is (g is acceleration due to gravity) (2004M)

1) $5\sqrt{g/2}$ 2) $3\sqrt{g/2}$ 3) $\frac{1}{3}\sqrt{g/2}$ 4) $\frac{1}{5}\sqrt{g/2}$

Keys

33) 1 34) 2 35) 3 36) 4 37) 1 38) 3 39) 4 40) 2 41) 3 42) 3
43) 4 44) 1 45) 2

Match the following Questions:

46)

List-I	List-II
a) A body covers first half distance with speed V_1 and second half of distance with a speed V_2	e) Average speed is $\sqrt{gh}/2$
b) A body covers first half of a time with a speed V1 and second of time with a speed V_2	f) Average speed is $\frac{V_1+V_2}{2}$
c) A body is projected vertically up from ground with a speed $\sqrt{gh}$. Considering its total motion	g) Average speed is $\frac{2V_1V_2}{V_1+V_2}$
d) A body freely released from a Height h	h) Average speed is $\sqrt{gh/2}$

1) a→f;b→g;c→e;d→h 2) a→g;b→f;c→h;d→e

3) a→h;b→g;c→h;d→e 4) a→e;b→f;c→h;d→g

47) Study the following

List-I	List-II
a) Constant speed and varying velocity	I) At height point of body projected vertically up
b) Zero displacement and finite distance	II) Uniform circular motion
c) Zero velocity and finite acceleration	III) At any intermediate point of freely falling body
d) Non-zero velocity and non-zero acceleration	IV) Body on reaching point of projection

	A	B	C	D
1)	IV	II	III	I
2)	II	IV	I	III
3)	III	I	IV	II
4)	I	III	II	IV

48) Study the following

List-I	List-II
a) Maximum height	I) $\frac{u^2 \sin 2\theta}{g}$
b) Range	II) $\frac{2u \sin\theta}{g}$
c) Maximum Range	III) u^2/g
d) Time of flight	IV) $\frac{u^2 \sin^2\theta}{g}$

	A	B	C	D
1)	III	I	II	IV
2)	I	III	IV	II
3)	IV	I	III	II
4)	II	IV	III	I

49) Angle between velocity and acceleration vectors in the following cases.

List-I	List-II
a) Vertically projected body	e) 90^0
b) For freely falling body	f) changes from point to point
c) For projectile	g) zero
d) In uniform circular motion	h) 180^0

The correct match is

1) a→h;b→g;c→f;d→e 2) a→f;b→g;c→h;d→e

3) a→e;b→f;c→h;d→g 4) a→g;b→h;c→e;d→f

50) For a projectile relation between range, velocity of projection and angle of projection ($g = 10\ ms^{-2}$)

List-I	List-II
a) $u=20ms^{-1}$; $\theta=30^0$	e) $45\sqrt{3}$m
b) $u=30ms^{-1}$, $\theta=60^0$	f) 40m
c) $u=30ms^{-1}$, $\theta=45^0$	g) $20\sqrt{3}$m
d) $u=20ms^{-1}$, $\theta=45^0$	h) 90m

1) a→e;b→g;c→h;d→f 2) a→g;b→h;c→g;d→f

3) a→f;b→h;c→g;d→e 4) a→g;b→e;c→h;d→f

51) Study the following

List-I	List-II
a) Horizontal motion of a projectile	e) zero velocity
b) Freely falling body from a small height	f) retarded motion
c) Parachutist descending down from an aeroplane	g) uniform acceleration
d) Maximum height of a body thrown vertically up	h) uniform velocity

1) a→g;b→f;c→h;d→e 2) a→h;b→g;c→f;d→e

3) a→e;b→h;c→f;d→g 4) a→f;b→e;c→g;d→h

52) For a projectile 'R' is range and H is maximum height, then match the following

List-I	List-II
a) R=H	e) angle of projection $\tan^{-1}(1)$
b) R=2H	f) angle of projection $\tan^{-1}(4)$
c) R=3H	g) angle of projection $\tan^{-1}(2)$
d) R=4H	h) angle of projection $\tan^{-1}(4/3)$

1) a→g;b→h;c→e;d→f 2) a→h;b→g;c→e;d→f
3) a→f;b→g;c→h;d→e 4) a→e;b→g;c→f;d→h

53) Study the following

List-I	List-II
a) One-dimensional motion with uniform acceleration	e) Y=kx2. Where k is constant
b) Equation of trajectory of horizontal projection	f) Y=Bx-Cx2 where B &C are constants
c) Equation of trajectory for oblique projection	g) Velocity =k√displacement where k is constant
d) Relation between maximum height(H), Range (R) and angle of projection (θ)	h) R=4Htanθ
	i) R=Rhcotθ

1) a→e;b→g;c→f;d→i 2)a→e;b→g;c→f;d→h
3) a→g;b→e;c→f;d→i 4) a→g;b→e;c→f;d→h

54) Match ListI and ListII for a projectile

List-I	List-II
a) For two angle θ and (90-θ) with same magnitude of velocity of projection	e) Pi-Pi/g
b) Equation of parabola of a projectile $y=Px-Qx^2$	f) Maximum height 25%of P^2/Q
c) Radius of curvature of a body projected	g) Range = Maximum height with velocity (Pi+Qj)ms^{-1} at heighest
d) Angle of projection $\theta=\tan^{-1}(4)$	h) Range is same

1) a→f;b→h;c→g;d→e 2) a→h;b→f;c→e;d→g
3) a→e;b→g;c→f;d→h 4) a→e;b→g;c→h;d→f

Keys

46) 2 47) 2 48) 3 49) 1 50) 4 51) 2 52) 3 53) 3 54) 2

Order Arranging Type Questions:

55) The velocity of a body as a function of time is $V=t^3-6t^2+10t+4$.Set the accelerations of a body in increasing order at given times
a) t=0sec b) t=1sec c) t=5sec
1) b,a,c 2) a,b,c 3) c,b,a 4) c,a,b

56) Three bodies are projected in three ways with the same speed from top of a tower. Set the times of reaching ground by them in increasing order
a) vertically up b) vertically down c) horizontally
1) b,a,c 2) c,a,b 3) b,c,a 4) a,b,c

57) From the top of a tower two bodies are projected with the same initial speed of $40ms^{-1}$, first body vertically upwards and second body vertically downwards. A third body is freely released from the top of the tower. If their respective times of flights are T_1 ,T_2 and T_3. Identify the correct descending order of the times of flights.

1) T_1,T_2,T_3 2) T_2,T_3,T_1 3) T_2,T_1,T_3 4) T_1,T_3,T_2

58) Set the ranges for following projectiles in increasing order for the same velocity of projection

1) $\theta=15^0$ 2) $\theta=45^0$ 3) $\theta=55^0$ 4) $\theta=85^0$

Keys

55) 1	56) 3	57) 4	58) 1

Assertion And Reason Type Questions:

Directions:

These Questions consist of two statements as Assertion and reason. While answering these Questions you are required to choose any of the following four responses.

A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B) If both Assertion and Reason are true, but Reason is correct explanation of the Assertion

C) If Assertion is true, but the Reason is false.

D) If Assertion is false, but the Reason is true.

59) A: The numerical ratio of displacement to distance is equal to one or less than one .
R: Displacement is a vector quantity and distance is a scalar quantity
1) A 2) B 3) C 4) D

60) A: If the distance travelled by body is directly proportional to the square of time
R: The speed is equal to the increasing with time
1) A 2) B 3) C 4)D

61) A:The displacement –time graph of a body moving with uniform acceleration is a straight line.
R: The displacement is proportional to time.
1)A 2)B 3)C 4)D

62) A: Average velocity of the body may be equal to its instantaneous velocity
R: The body is having uniform motion in one dimension.
1) A 2)B 3)C 4)D

63) A: A body may have acceleration even when its velocity is zero
R: Acceleration is rate of change of velocity
1)A 2)B 3)C 4)D

64) A: A body can have acceleration even if its velocity is zero at a given instant of time.
R: A body is momentarily at rest when it reverses its direction of motion.
1) A 2) B 3) C 4)D

65) A: The equation of motion can be applied only if acceleration is along the direction of velocity and is constant.
R: If the acceleration of a body is constant that its motion is known as uniform motion

1) A 2)B 3)C 4)D

66) A: A hydrogen filled balloon stops rising after it has attained a certain height in the sky.
R: The atmospheric pressure decreases with height and becomes zero when maximum height is attained.
1)A 2)B 3)C 4)D

67) A: The size of a hydrogen balloon increases at it rises in air.
R: The material of the balloon can be easily stretched.
1) A 2)B 3)C 4)D

68) A: A metal ball and a wooden ball of same radius are dropped from the height in vacuum reach the ground same time.
R: In Vacuum all the bodies dropped from same height take same time to reach the ground.
1) A 2)B 3)C 4)D

69) A: The displacement of a freely falling body in successive seconds is in the ratio 1:3:5
R: Because it is moving with uniform velocity
1)A 2) B 3) C 4) D

70) A: When a body is dropped of thrown horizontally from the same height. It would reach the ground at the same time.
R: Horizontal velocity has no effect in the vertical direction.
1) A 2) B 3) C 4) D

71) A: For a body projected horizontally from the top of a tower, the velocity on reaching the ground depends both on velocity of projection and height of the tower.
R: For a projectile velocity varies both in horizontal and vertical directions.
1) A 2) B 3) C 4) D

72) A: If a bomb is dropped from an aerplane moving horizontally with constant velocity then the bomb appears to move along a vertical straight line for the pilot of the plane.
R: Horizontal component of velocity of the bomb remains constant and same as the velocity of the plane during the motion under gravity.
1) A 2) B 3) C 4) D

73) A: Time taken by the bomb to reach the ground from a moving aeroplane depends on height of aeroplane only.
R: Horizontal component of velocity of bomb remains constant and vertical component of velocity of bomb changes due to gravity
1) A 2) B 3) C 4) D

74) A: Path of a body moving under gravity is a parabola or a straight line depending on the velocity of projection.
R: Gravitational force on the body is always towards the earth.
1) A 2) B 3) C 4) D

75) A: Only vertical component of velocity of a projectile is known, time of flight can be calculated but horizontal range cannot be calculated.
R: Time of flight depends on horizontal component and range depends on vertical component of velocity projection.
1) A 2) B 3) C 4) D

76) A: In projectile motion, the angle between the instantaneous velocity and acceleration at the heighest point is 180^0.
R: At the highest point, velocity of projectile will be horizontal direction only.
1) A 2) B 3) C 4) D

77) A: The path followed by one projectile as a observed by another projectile is a straight line.
R: The relative velocity between two projectiles at a given place does not change with time.
1) A 2) B 3) C 4) D

78) A: When a range of projectile is maximum, its angle of projection may be 45^0 or 135^0.
R: Horizontal range = $\frac{u^2 \sin 2\theta}{g}$. When $\theta=45^0$ or 135^0 the value of horizontal range remains the same, only the sign changes
1) A 2) B 3) C 4) D

79) A: When a body is projected at an angle 45^0, its range is maximum.
R: For maximum of range, the value of $\sin 2\theta$ should be equal to one.
1) A 2) B 3) C 4) D

80) A: When a body is projected at an angle 45^0, its maximum height is half than that of horizontal range.
R: Horizontal range = $\frac{u^2 \sin 2\theta}{g}$ and maximum height = $\frac{u^2 \sin^2\theta}{2g}$
1) A 2) B 3) C 4) D

81) A: The horizontal displacement of a projectile varies linearly with time.
R: Projectile motion is uniform motion along horizontal and accelerated motion along vertical.
1) A 2) B 3) C 4) D

82) A: Horizontal range is same for angle of projection θ and $(90-\theta)$
R: Horizontal range is independent of angle of projection.
1) A 2) B 3) C 4) D

Keys

59) 2	60) 1	61) 4	62) 1	63) 2	64) 2	65) 2	66) 2	67) 2	68) 1
69) 3	70) 1	71) 1	72) 1	73) 1	74) 1	75) 2	76) 3	77) 4	78) 1
79) 1	80) 1	81) 4	82) 1						

Previous Eamcet Questions:

1. A body is thrown vertically up with certain up with certain initial velocity. The potential and kinetic energies of the body are equal at a point 'P' in its path. If the same body is thrown with double the velocity upwards. The ratio of potential and kinetic energies of the body when it crosses energies of the body when it crosses the same point is (2007M)
1) 1:1 2) 1:4 3) 1:7 4) 1:8
2. An object is projected with a speed of $100ms^{-1}$ at an angle $\theta = \sin^{-1}(3/5)$ to the horizontal. At the highest point, the object breaks into two pieces of matter m_1 and m_2 ($m_1:m_2 = 1:3$) and the smaller one comes to rest. The distance between the point of

projection and the point of landing of the bigger piece (in meters) is ($g = 10ms^{-2}$)
(2007E)

1) 3840 2) 1280 3) 1120 4) 960

3. A body of mass 2kg is projected from the ground with a velocity $20ms^{-1}$ at an angle 30^0 with the vertical. If t_1 is the time, in seconds at which the body is projected and t_2 is the time in seconds at which it reaches the ground, the changes in momentum in kg ms^{-1} during the time ($t_2 - t_1$) is (2006M)

   1) 40 2) $40\sqrt{3}$ 3) $50V^3$ 4) 60

4. A particle is moving in a circle of radius 'r' with a constant speed 'u'. The change in velocity after the particle has travelled in velocity after the particle has travelled a distance equal to (1/8) of the circumference of the circle is (2006M)

   1) Zero 2) 0.500V 3) 0.5765V 4) 0.125V

5. A body is projected vertically upwards with a velocity 'u'. It crosses a point in its journey at a height 'h' twice, just after 1 and 7 seconds. The value of u in ms^{-1} is: ($g=10ms^{-2}$) (2006M)

   1) 50 2) 40 3) 30 4) 20

6. A body is projected from the earth at angle 30^0 with the horizontal with same initial velocity. If its range is 20m, the maximum height reached by it in meters (2006E)

   1) $5\sqrt{3}$ 2) $5/\sqrt{3}$ 3) $10/\sqrt{3}$ 4) $10\sqrt{3}$

7. Two balls are projected simultaneously in the same vertical plane from the same point with velocities V_1 and V_2 with angles θ_1 and θ_2 respectively with the horizontal. If $V_1\cos\theta_1 = V_2\cos\theta_2$ the path of one ball as seen from the position of other ball is

   1) Parabola 2) Horizontal straight line
   3) Vertical straight line 4) Straight line making 45^0 with the vertical (2005M)

8. A body projected vertically upwards crosses a point twice in its journey at a height 'h' just after t_1 and t_2 seconds. Maximum height reached by the body is (2005 E)

   1) $\frac{g}{4}(t_1+t_2)^2$ 2) $g\left(\frac{t_1+t_2}{4}\right)^2$ 3) $2g\left(\frac{t_1+t_2}{4}\right)^2$ 4) $\frac{g}{4}(t_1t_2)$

9. The equation of trajectory of a projectile is $y = 10x-(5/7)x^2$. If we assume $g = 10ms^{-2}$. The range of projectile (in meters) is (2005 E)

   1) 36 2) 24 3) 18 4) 9

Key: 1) 3 2)3 3)2 4)3 5)2 6)2 7)3 8)3 9)3

CIRCULAR MOTION:

1. i) Angular velocity of seconds hand = $2\prod /60$ rad s^{-1}
   ii) Angular velocity of minutes hand = $2 \prod / 60x60$ rad s^{-1}
   iii) Angular velocity of hours hand = $2\prod/ 12x60x60$ rad s^{-1}.
   iv) Angular velocity of self rotation of earth = $2\prod/ 24x 60x60$ rads^{-1}
2. centripetal (or) radial (or) normal acceleration $a_N=V^2/r=r\omega^2$
3. Tangential acceleration $at=r\alpha = r\ (\omega_2-\omega_1/t)$
4. For a body in non-uniform circular motion resultant acceleration
   $a= \sqrt{a_N^2+a_t^2}= \sqrt{(r\omega^2)^2+(r\alpha)^2}$
5. Centripetal force $F_N= mv^2/r = mr\omega^2$
6. Tangential force $F_t=mr\alpha$
7. For a body in non-uniform circular motion resultant force $F= \sqrt{F_N^2+F_t^2}$

$F= \sqrt{(mr\omega^2)^2 + (mr\alpha)^2}$

Problems of Circular Motion:

1. The shaft of a motor car rotates at constant frequency of 3000 revolutions/min. The angle through which it has turned in one second in radians is
   1)100π 2)50π 3) 25π 4)125π
2. A point moves along a circle of radius 20 cm with a constant tangential acceleration of $5cms^{-2}$. The time after which the normal acceleration of that point will be equal to the tangential acceleration is
   1)1s 2)2s 3)4s 4)6s
3. A wheel starts from rest and acquires an angular velocity of $60rads^{-1}$ in half a minute. Then its angular acceleration is
   1)4 rad s^{-2} 2) 2 rad s^{-2} 3)1 rad s^{-2} 4)0.5 rad s^{-2}
4. The wheel of a car makes 10 rev/sec.It is stopped in 14 sec. Find the number of revolutions it makes before it stops
   1)10 2) 20 3)40 4)70
5. A flywheel is revolving at 150 revolutions per minute. If it decelerates at a constant rate of 2π rad s^{-2} , then time required to stop it is
   1)10s 2) 5s 3)2.5s 4)1.25 s
6. A motor car is traveling at 30m/s on a circular road of radius 500m. It is increasing its speed at a rate of 2m/s. What is its acceleration
   1)2.69m/s^{-2} 2)3.69 m/s^{-2} 3)4.69 m/s^{-2} 4)5.69 m/s^{-2}
7. Initial angular velocity of awheel is 2 rad s^{-1}. It rotates with a constant angular acceleration of 3.5 rad s^{-2} . Its angular displacement in 2 seconds is
   1)4rad 2)7 rad 3)7 rad 4)11 rad
8. The angular velocity of a wheel increases from 120 to 480rpm rate in 10s.The number of revolutions made during this time is
   1)10 2)50 3)50 4)100
9. The angular velocity of a disc is increasing at a constant rate. At an instant its angular velocity is 40 rad s^{-1}. After 2 seconds its angular velocity is 48 rad s^{-1}.Then three seconds before that instant its angular velocity was

1)28 rad s^{-1} 2)30 rad s^{-1} 3)32 rad s^{-1} 4)36 rad s^{-1}

10. A disc of radius 0.1 m starts from rest with an angular acceleration of 4.4 rad s^{-2} Then linear velocity of the point on its rim after 5s is
 1)0.22ms^{-1} 2)2.2 ms^{-1} 3)4.4 ms^{-1} 4)1.1 ms^{-1}
11. Starting form rest a disc rotates with a constant angular acceleration. In 2 seconds it completes 5 revolutions . Then in the next second it completes.
 1)5 revolution 2)10 revolution 3)15 revolution 4)20 revolution
12. A disc starts from rest an angular acceleration completes 10 revolution in 2 seconds. The time taken by it to complete 10 more revolution from that instant is
 1)2s 2)($\sqrt{2}$ -1)s 3)2($\sqrt{2}$ -1)s 4)2$\sqrt{2}$ s
13. A wheel starts from rest and moves with uniform angular acceleration . In 3 seconds its angular displacement is θ. Then in the 3rd second its angular displacement is
 1) $\frac{4\theta}{9}$ 2) $\frac{5\theta}{9}$ 3) $\frac{4\theta}{5}$ 4) $\frac{\theta}{3}$

1)1	2)2	3)2	4)4	5)3
6)1	7)4	8)3	9)1	10)2
11)3	12)3	13)2		

CIRCULAR TURNINGS AND BANKING OF ROADS

When vehicles go through turnings, they travel along a nearly circular arc. There must be some force which will produce the required acceleration. If the vehicle goes in a horizontal circular path, this resultant force is also horizontal. Consider the situation as shown in figure. A vehicle of mass *M* moving at a speed υ is making a turn on the circular path of radius *r*. The external forces acting on the vehicle are:

(i) Weight *Mg.*

(ii) Normal contact force $\mathcal{N}$

(iii) Friction f_8

If the road is horizontal, the normal force $\mathcal{N}$ is vertically upward. The only horizontal force that act towards the centre is the friction f_8. This is static friction and is self adjustable. The tyres get a tendency to skid outward and the frictional force which opposes this skidding acts towards the centre. Thus, for a safe turn we must have

$$\frac{\upsilon^2}{r} = \frac{f_8}{M}$$

Or $$f_8 = \frac{Mv^2}{r}$$

However, there is a limit to the magnitude of the frictional force. If μ_8 is the coefficient of static friction between the tyres and the road, the magnitude of friction cannot exceed $\mu_8 \mathcal{N}$. For vertical equilibrium $\mathcal{N} = Mg$, so that

$$f_8 s\ \mu_8\ Mg$$

Or, $$\mu_8 \geq \frac{Mv^2}{rg}$$

Friction is not always reliable at circular turns of high speeds and sharp turns are involved. To avoid dependence on friction, the roads are banked at the turn so that the outer part of the road is somewhat lifted up as compared to the inner part.

The surface of the road makes an angle θ with the vertical. At the correct speed, the horizontal component of is sufficient to produce the acceleration towards the centre and the self adjustable frictional force keeps its value zero. Applying Newton's second law along the radius and the first law in the vertical direction. $\mathcal{N} \sin\theta \frac{Mv^2}{r}$

and $\mathcal{N} \cos\theta = Mg$

These equations give $\tan\theta = \frac{Mv^2}{rg}$ ....(7.13)

The angle θ depends on the speed of the vehicle as well as on the radius of the turn. Roads are banked for the average expected speed of the vehicles. If the speed of a particular vehicle is a little less or a little more than the correct speed, the self adjustable static friction operates between the tyres and the road and the vehicle does not skid or slip.

PROBLEMS

1. A car has to move on a level turn of radius 45m. If the coefficient of static friction between the tyre and the road is μ_8 = 2.0, find the maximum speed the car can take without skidding.
   (1) 108 km / hr (2) 208 km / hr (3) 308 km/hr (4) 508 km / hr
2. A circular trackof radius 600 m is to be designed for cars at an average speed of 180 km/hr. What should be the angle of banking of the track?
   (1) 16.6° (2) 22.6° (3) 32.6° (4) 42.6°
3. A scooter weighing 150 Kg together with its rider moving at 36 km/hr is to take a turn of radius 30 m. What horizontal force on the scooter is needed to make the turn possible?
   (1) 500N (2) 600 N (3) 700 N (4) 800 N
4. A part has a radius of 10m. If a vehicle goes round it at an average speed of 18 km/hr, what should be the proper angle of banking?
   (1) $tan^{-1/4}$ (2) $\tan^{3/4}$ (3) $\tan^{1/2}$ (4) none of these
5. A circular road of radius 50m has the angle of banking equal to 30°. At what speed should a vehicle go on this road so that, the friction is not used:
   (1) 11 m/sec. (2) 15 m / sec (3) 21 m / sec (4) 17 m/sec,

Key: 1) 1 2) 1 3) 1 4) 1 5) 4

CHAPTER 5
LAWS OF MOTION

Newton's First law:

- Newton's First law is known as law of inertia
- Inertia is the property of a body by which it is unable to change of inertia
- Mass is a measure of inertia. Inertia of a body depends only on mass
- Inertia of three types a) inertia of rest b) inertia of motion c) inertia of direction
- The inability of a body to change its state of rest by itself is known as inertia of rest

Newton's Second law:

- The rate of change of momentum of a body is directly proportional to the external force acting on it and takes place in the direction of the force
- Newton's Second law gives the formula for force
- This law is known as law of motion
- According to this law force is rate of change of momentum

Newton's Third law:

- For every action, there is an equal and opposite reaction
- Action and reaction act on different bodies
- Action = – Reaction
- Mathematical treatment of Newton's third law gives law of conservation of linear momentum
- Newton's third law is not applicable for pseudo forces

Connected Bodies:

- Mass m_1 is on smooth table. A string attached to it passes over a light pulley and carries m_2. for m_1:$T = m_1a$, for m_2: $m_2g - T = m_2a$

  Acceleration of the system $a = \frac{m_2 g}{m_1 + m_2}$, Tension in the string $T = \frac{m_1 m_2 g}{(m_1 + m_2)}$

  Thrust on pulley = $\sqrt{2}$ T
- When two bodies are connected by a light string passing over a light pulley, for m1:T –m1g = m1a, for m2: m2g –T =m2a

  Acceleration of each body $a = \left[\frac{m_2 - m_1}{m_1 + m_2}\right] g$, $T = \frac{2m_1 m_2 g}{(m_1 + m_2)}$

  Thrust on the pulley = 2T

Contact Forces:

- A system consists of the bodies of different masses as shown which are in contact. A force F is applied as shown. All the bodies move with the same acceleration 'a'.

  For m_1: $F - f_{12} = m_1a$, for m_2: $f_{12} - f_{23} = m_2a$, for m_3: $f_{13} = m_3a$

  $a = \frac{F}{(m_1 + m_2 + m_3)}$

  Contact force between m_1 and m_2 is $f_{12} = \frac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$

Contact force between m_2 and m_3 is $f_{23} = \dfrac{m_3F}{(m_1 + m_2 + m_3)}$

7. Angular momentum = moment of inertia x angular velocity $L=I\omega$
   Or $L=mvr$ $L=m(r\omega)r = mr^2\omega$
   $L= r \times p$ (r is $\perp$ distance . p is linear momentum)
   $L=m (r \times v)$,$L=mvr \sin\theta$

8. Angular impulse (J) = torque x time $J=\tau t = I\alpha t$
   $= I (\omega_2-\omega_1)/ t \times t = I \omega_2-I \omega_1$
   $J= L_2-L_1$ or Angular impulse = change in angular momentum

9. Law of conservation of angular momentum :
   $L=I\omega$=constant
   $I_1\omega_1=I_2\omega_2$
   $I_1n_1=I_2n_2$ (n_1,n_2 are frequencies)
   $I_1/T_1=I_2/T_2$ (T_1,T_2 are time periods)

QUESTION BANK:

Numerical Problems:

1) Two particles with inertial masses 3kg and 9kg are acted upon by the same force. If the acceleration of the 9kg particle is $3m/s^2$, the acceleration of the 3kg particle is
   1) $1m/s^2$ 2) $9m/s^2$ 3) $0.9m/s^2$ 4) $0.1m/s^2$
2) A train reduces its speed uniformly from 75 to 15 kmph in 40s in a straight line. To come to rest, traveling at the same rate it will take a further time of
   1) 40s 2) 20s 3) 15s 4) 10s
3) The horizontal and vertical components of a force 30N and 40N. If the force acts on a body of mass 5kg, acceleration produced is
   1) $5m/s^2$ 2) $0.5m/s^2$ 3) $1m/s^2$ 4) $10m/s^2$
4) A 5gm bullet acquires a speed of 120m/s in a gun with barrel 2.0m. The average force exerted on the bullet is
   1) 3.6N 2) 18N 3) 36N 4) 72N
5) A force of 100N stops a body moving with a velocity of $20ms^{-1}$. The force required to stop the same body when moving with $30ms^{-1}$ in the same distance is
   1) 550N 2) 225N 3) 112.5N 4) 65N
6) A body of mass 5kg is dropped from the top of a tower. The force acting on the body during motion
   1) 0 2) 9.8N 3) 5kg-wt 4) none
7) A body of mass 40kg, moves with a uniform velocity under the action of a force 50N on a surface. If a force of 70N now acts on the same body in the same direction as that of 50N, moving on the same surface, the acceleration of the body is
   1) $1.75m/s^2$ 2) $1.5m/s^2$ 3) $1.0m/s^2$ 4) $0.5m/s^2$
8) A body moving wit h constant velocity is brought to rest in 0.25sec by applying retarding force 100N. The initial momentum of the body
   1) 25kgm/s 2) 50 kgm/s 3) 100kg m/s 4) 125 kg m/s

9) A constant force acts on a body of mass 50 gm at rest 2 seconds. If the body moves through 27m during that time, impulse of the force is

1) 1.35kg m/s 2) 13.5Ns 3) 135Ns 4) 2.7kg m/s

10) Two stones of masses m_1 and m_2 are let fall from heights 2h and h, their momenta on reaching the ground are in the ratio.

1) 1:1 2) m_1: $\sqrt{2}m_2$ 3) $2m_1$:m_2 4) $\sqrt{2}m_1$:m_2

11) A 1.5kg hammer moving with velocity $10ms^{-1}$ strikes a nail for 0.005, seconds. Average force exerted on the nail is

1) 1000N 2) 1500N 3) 750N 4) 3000N

12) A 0.6kg ball strikes a wall with a velocity $5ms^{-1}$ at an angle of 30^0 with the wall and rebounds at the same angle with the same speed. The change in the momentum of the ball perpendicular to the wall is:

1) 15 kg ms^{-1} 2) 10 kg ms^{-1} 3) 5 kg ms^{-1} 4) 3 kg ms^{-1}

13) A ball moving with momentum 10 kg ms^{-1} strikes a wall at an angle 45^0 and is reflected at the same angle with the same magnitude of momentum. The magnitude of change in momentum

1) 0 2) 20kg ms^{-1} 3) $20\sqrt{2}$ kg ms^{-1} 4) $10\sqrt{2}$ kg ms^{-1}

14) A body of mass 100kg is moving with a velocity 1m/s the frictional force offered by the surface is 5kgwt. If the body is pushed by a force of 50N for one minute, velocity of the body after one minute is

1) 0.16m/s 2) 16m/s 3) 1.6m/s 4) 3.2m/s

15) A body of mass 1.5kg falls vertically downwards with an acceleration of $29.4m/s^2$. The force on the body in addition to force of gravity is

1) 9.8N 2) 19.6N 3) 29.4N 4) 49N

16) A body of mass 5kg started from rest with an acceleration of $4ms^{-2}$. Its momentum after 5s is

1) 20 kg ms^{-1} 2) 100 kg ms^{-1} 3) 4 kg ms^{-1} 4) 25 kg ms^{-1}

17) A 6kg balls strikes a vertical wall with a velocity $34ms^{-1}$ and rebounds with a velocity of $26ms^{-1}$. The change in momentum is

1) 60Ns 2) 180Ns 3) 48Ns 4) 360Ns

18) A block of mass 4kg is sliding on a smooth inclined plane of inclination 30^0. Its momentum after 2 sec is

1) 0 2 39.2kg ms^{-1} 3) 19.6 kg ms^{-1} 4) 9.8kg ms^{-1}

19) A force of 6i-8j+10k Newton produces an acceleration of $1ms^{-2}$ in a body. The mass of the body is

1) 200kg 2) 20kg 3) $10\sqrt{2}$kg 4) $6\sqrt{2}$kg

20) A ball of mass 10 gm hits vertically a hard surface with a speed of 5 ms^{-1} and rebounds with the same speed. The ball remains in contact with the surface for 1/100sec. The average force exerted by the surface on the ball is

1) 5N 2) 10N 3) 20N 4) zero

21) A ball of mass 100gm is moving with a velocity of $10ms^{-1}$ and hits a bat and rebounds with a velocity of $10ms^{-1}$. The force of the blow by the bat acts for 0.01 seconds. The average force exerted on the ball by the bat is

1) 100N 2) 200N 3) 50N 4) zero

Connected Bodies:

1) Two bodies having masses m_1 = 30kg, m_2 = 40kg are attached in the ends of a string of negligible mass and suspended by a light friction less pulley. If g = 9.8m/s^2 . Find the acceleration of the system

1) 0.07m/s^2 2) 1.4m/s^2 3) 2.8m/s^2 4) none

2) Two masses 2kg and 3kg are attached to the ends of the string passed over a pulley fixed at the top. The tension and acceleration in the string in terms of 'g' are

1) $\frac{7}{8}g$, $\frac{g}{8}$ 2) $\frac{21}{8}g$, $\frac{g}{8}$ 3) $\frac{21}{8}g$, $\frac{g}{5}$ 4) $\frac{12}{5}g$, $\frac{g}{5}$

3) Two masses 2kg and 0.5kg are tied to the ends of a light string over a smooth pulley fixed at the edge of the tab le. The larger mass resting on smooth horizontal table and the smaller mass hanging vertically. Find the tension in the strength g = 9.8m/s^2

1) 2N 2) 0.5N 3) 2.5N 4) 3.92N

4) Two masses 1kg and 3kg are connected by massless string. The string passes over a frictionless pulley. The lighter mass is resting on table. Calculate the force required to keep this mass on table. (g= 9.8m/^{2})

1) 9.8N 2) 19.6N 3) 32.5N 4) 50N

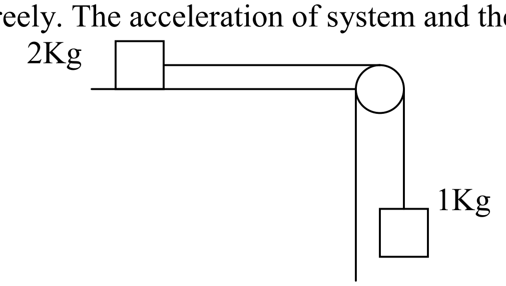
5) A force of F = 10kgwt is exerted horizontally against a 60kg block which in turn pushes a 40kg block. If the blocks are on a frictionless surface, what force does one block exert on the second g = 10m/s^2

1) 20N 2) 40N 3) 60N 4) 80N

6) A 1000kg lift is supported by a cable that can support by 2000kg. The shortest distance in which the lift can be stopped when it is descending with a speed of 2.5m/s is (g = 10m/s^2)

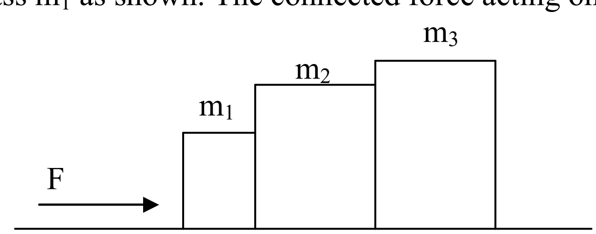
1) S = $\frac{5}{16}$m 2) S = $\frac{3}{16}$m 3) S = $\frac{7}{16}$m 4) None

6) A mass 2kg is placed on a smooth horizontal table and connected by a light inextensible string passing over a small smooth pulley at the edge of the table to a mass of 1kg hanging freely. The acceleration of system and the tension in the string



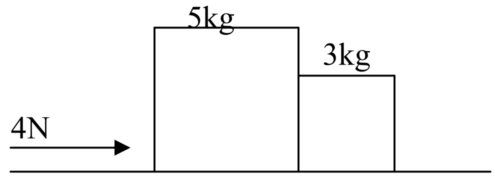
1) $\frac{g}{3}$, $\frac{2g}{3}$ 2) $\frac{g}{3}$, $\frac{g}{3}$ 3) $\frac{2g}{3}$, $\frac{g}{3}$ 4) $\frac{2g}{3}$, $\frac{2g}{3}$

7) Three blocks of masses m_1 = 1kg, m_2 = 2kg and m_3 = 3kg are connected by massless string and placed on horizontal frictionless surface as shown in fig. A force F = 12N is applied to mass m_1 as shown. The connected force acting on mass m_3 is



1) 12N 2) 10N 3) 8N 4) 6N

8) Two blocks of masses 5kg and 3kg are placed in contact on horizontal and frictionless surface of shown in fig. A force of 4N is applied on mass 5kg as shown. The acceleration of mass 3kg will be

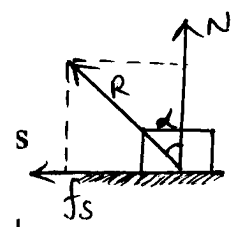


1) $\frac{4}{5}ms^{-2}$ 2) $\frac{4}{3}ms^{-2}$ 3) $2ms^{-2}$ 4) $0.5ms^{-2}$

Key

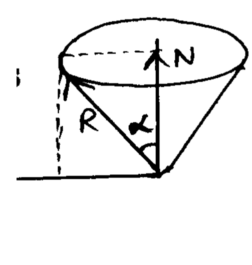
1)1	2)4	3)4	4)2	5)2	6)1	7)1	8)4	9)4

1) **FRICTION:** It is the tangential force acting between the contact surfaces of two bodies. Preventing one body sliding over the other.
2) Properties of frictional force:-
   1) Frictional force acts a direction opposite to the direction of motion of the bodies.
   2) it is independent of the area of contact surfaces of the bodies
   3) it depends upon the nature of the materials in contact and normal reaction i.e. $f \alpha N$
3) Frictional force exerted by the fluids is called viscous forces.
4) Friction is of three kinds.
   1) static friction or limiting friction
   2) kinetic or sliding or dynamic friction c) rolling friction.
5) Frictional force is independent of velocities of bodies provided the velocity is small.
6) Normal Reaction(N):-When Two bodies are in contact the contact force which either body exerts on the other normal to the contact surface is called Normal Reaction.i.e $N = mg$.
7) Static friction (fs) The maximum force of friction when the body is just on the point of motion is called static friction or limiting friction (fs)
   * Coefficient of static friction (μs): it is defined as the ratio of the maximum force of static friction to the normal reaction $\mu s=fs/N$.



8) *Kinetic Friction (f_k): The friction that acts when there is relative motion between two surfaces is called Kinenetic Friction(f_k).
9) Rolling Friction:-(f_r)When one ody rolls over another body, the friction that acts between those bodies is rolling friction. (f_r).
10) Angle of friction (α) :- The angle which the resultant of static friction (fs) and normal reaction (N) makes with normal reaction is called the angle of friction $\mu s= \tan (\alpha) =fs/N$
11) Force applied at angle θ with the horizontal case(i) :- force applied upwards let the force (f) applied make and angle (θ) upwards form the horizontal when the body is just on the point of sliding. Then
    i) $F \cos \theta = fs = \mu_s N$ ii) $F \sin \theta+N =W$
    iii) $F=\mu_s mg / \cos \theta+\mu_s \sin\theta]$ iv)$\mu_s= F\cos\theta/mg-F\sin\theta$

   case (ii) : Force applied downwards



let the force (F) applied makes and angle(θ) downwards from the horizontal when the body is just on the point of sliding then

i) $F\cos\theta = f_s = \mu_s N$ ii) $N = mg + F\sin\theta$

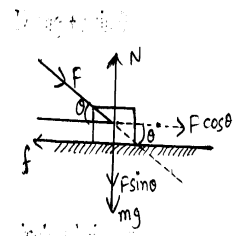
iii) $F = \mu_s mg/\cos\theta - \mu\sin\theta$ iv) $\mu_s = f_s \cos\theta / mg + f_s \sin\theta$

12) The angle of inclination of inclined plane to the horizontal so that the body placed on it just tends to slide is called angle of repose.

I. Cone of friction :_ angle made by R with N is α which is equal to angle of friction is called cone of friction.

HORIZONTAL SURFACE

A. Pushing and pulling



1) If F is a pulling force, then $mg = N + \sin\theta$

$N = mg - F\sin\theta$

2) $F\cos\theta = fs = \mu_s N$

$F\cos\theta = \mu s\,(mg - F\sin\theta)$

$F = \mu_s mg / (\cos\theta + \mu_s \sin\theta)$

$F = mg\sin\alpha / \cos(\theta - \alpha)$ $(\mu_s = \tan\alpha)$

3) $F_{min} = \dfrac{\mu_s mg}{\sqrt{1+\mu_s^{\,2}}}$

B .If F is a pushing force then normal force $N = mg + F\sin\theta$

$F\cos\theta = fs = \mu sN$

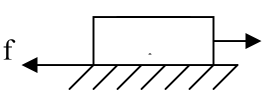
$F\cos\theta = \mu s(mg + F\sin\theta)$

$F = (\mu_s mg)/(\cos\theta - \mu_s in\theta)$

If body moves with uniform velocity, then $F = \dfrac{\mu_k mg}{(\cos\theta - \mu_k \sin\theta)}$.

$F = mg\sin\alpha / \cos(\theta + \alpha)$

Motion of Body on Rough Horizontal Surface



1. If F is horizontal force applied on a body
   a) Frictional force f =F (if F<f) and (if F< f) and body does not move.
   b) $f_s = \mu_S mg = F$, body just tends to move..
   c) If we continue to apply a force $F = f_s$ the block slides with an acceleration..

      $a = (\mu_S - \mu_k)g$.
   d) If the body moves with uniform acceleration 'a' then

      $F_R = F - f_k,\ ma = F - \mu_k mg$

      $a = \dfrac{F - \mu_k mg}{m}$, or $F = m(a + \mu_k g)$
   e) If body moves with uniform velocity $F = f_k = \mu_k mg$.
2. Minimum horizontal force applied on a body to move it

   $F = f_s = \mu_s mg = mg\tan\alpha$.
3. A body moving with velocity v on a rough horizontal surface is brought to rest in a rough horizontal surface is brought to rest in a distance S, (in time t)

   $S = \dfrac{V^2}{2\mu g}$; $t = \dfrac{V}{\mu g}$
4. Two blocks of masses m_1, and m_2 are connected by a spring. They are composed and released

on a rough horizontal surface. If coefficient of friction is same for both, S_1 and S_2 are the distances traveled by the blocks before coming to rest, then

$$\frac{S_1}{S_2} = (\frac{m_2}{m_1})^2 .$$

If t_1 and t_2 are the times after which they stop; $\frac{t_1}{t_2} = \frac{m_2}{m_1}$.

5. A stationary block of mass M at rest on a rough horizontal surface explodes into two fragments. Mass of one fragment is m_1 If s1 and s2 are the distances traveled by the fragment of mass m and (M-m) before coming to rest, then

$$\frac{s_1}{s_2} = (\frac{v_1}{v_2})^2 = (\frac{M-m}{m})^2$$

6. An ice block of mass M moving with velocity u on a rough horizontal surface is brought to rest after some time , the amount of ice which melts due to friction is

   m = $\frac{\mu Mgd}{L}$ where μ is coefficient of friction, d is distance traveled,

   L is latent heat of ice.

7. A chain of uniform length 'L' is placed on a rough horizontal table. The coefficient of friction between the chain and the table is μ then the maximum fractional length of chain can be bung freely from the edge of the table is $\frac{X}{L} = \frac{\mu}{1+\mu}$.

   Minimum fraction of length of chain that can be on the table is $\frac{1}{1+\mu}$.

8. On an unbanked curved road , friction between the road tyres of a vehicle provides centripetal force

   $\therefore \quad \frac{mv^2}{r} = \mu mg$, Safe maximum Speed of vehicle V = $\sqrt{\mu gr}$

ROUGH INCLINED PLANE: -

I. Body Sliding down:

1. If θ<α then the body does not slides
2. If θ=α then the body just tends to slide
3. If θ=α then the body slides with some acceleration
   a = g(sinθ - μ_k cosθ).
4. Time taken by the body to move from top to
   bottom of the inclined plane is t= √2l / g(sinθ-μ_k cosθ)
5. Velocity of the body on reaching the bottom is V= √2gh (sinθ-$\mu_k$cosθ)
6. Work done by gravitational force = (mgsinθ) l . work done against frictional force = (μmgcosθ)l.
7. If P is the applied force parallel to the inclined plane in downward direction a= P+mg(sinθ-μ_k cosθ)/m
8. If the body is pushed up with some initial velocity, body will be subjected to retardation then,
   a =g (sinθ+ μ_k cosθ) /m
9. If a force p is applied on the body parallel to the inclined plane in the upward direction. then
   a= P-mg (sinθ + μ_k cosθ) and a=0 .
10. Normal reaction on the body N = mgcosθ.
11. The force with which body slides down inclined plane is F = mg(sinθ-μ_k cosθ).

12. If the inclination is maintained at α, the block slides down with an acceleration equal to

$$a = \frac{(\mu_s - \mu_k)g}{\sqrt{\mu^2{}_s + 1}}$$

13. If the block slides down with uniform velocity then $\mu_k = \tan\theta$.

II. <u>Body pushed upwards.</u>

1. Force needed to be applied parallel to the plane to move the block up with constant velocity is $F = mg(\sin\theta + as\mu_k \cos\theta)$.
2. Force needed to be applied parallel to the plane to move the block up with an acceleration a is $F = mg(\sin\theta - \mu_k \cos\theta) + ma$

3. The velocity traveled by the body up the plane before the velocity becomes zero is

$$l = \frac{u^2}{2g(\sin\theta + \mu_k \cos\theta)}$$

5. Time taken by the body to move up the plane is time of ascent and is given by

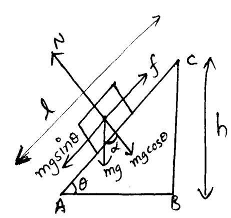
$$t = \sqrt{\frac{2l}{g(\sin\theta + \cos\theta)}}$$

6. If time of descent is 'n' times the time of ascent then

$$\mu_k = \left[\frac{n^2 - 1}{n^2 + 1}\right]\tan\theta.$$

SMOOTH INCLINED PLANE:-

I. **<u>Body sliding downwards</u>**:



1. Normal reaction on the body $N = mg\cos\theta$.
2. The force with which body slides down freely is $F = \sin\theta$
3. Acceleration with which it slides down freely is $a = g\sin\theta$.
4. As it slides down work done by gravitational force $W = mgl\sin\theta$.
5. Velocity of the body on reaching to bottom (if released from top) is $V = \sqrt{2gl\sin\theta} = \sqrt{2gh}$
6. Time taken to travel from top to the bottom; of inclined plane $t = \sqrt{\frac{2l}{g\sin\theta}}$

II. **<u>Body pushed upwards</u>**

1. The force with which body pushed upwards is ; $F = -mg\sin\theta$.
2. Acceleration with which the body pushed upwards is ; $a = -g\sin\theta$.
3. Velocity with which it should be pushed from bottom so just reaches the top most point is ; $u = \sqrt{2gl\sin\theta} = \sqrt{2gh}$
4. Distance traveled up before its velocity becomes zero is ; $l = \frac{u^2}{2g\sin\theta}$.
5. Time taken to travel from bottom to top of inclined plane is ; $t = \sqrt{\frac{2l}{g\sin\theta}}$.

6. From top of inclined plane a body is released to slide down. At the same moment another is pushed up with velocity 'u' from the bottom. They meet after time; $t=\frac{l}{u}$.
7. A body dropped from height 'h' reaches the ground after time t_1 with velocity v_1. If the same body is released from the top[of an inclined plane with its top most point at height h, it reaches the ground after time t_2 with velocity v_2.

$$\text{Then } t_2 = \frac{t_1}{\sin\theta}, \text{ when } V_1 = V_2$$

QUESTION BANK

Conceptual Questions:

1) Frictional force between two surface in contact is due to
   1) Adhesive forces between the molecules
   2) Cohesive forces between the molecules
   3) Repulsive forces between the molecules 4) Both 2 & 3
2) Friction is always
   1) opposes the motion of the body 2) perpendicular to the surface of contact
   3) tangential to the surface of contact 4) inclined to the surface of contact
3) A body lies on a table. Its weight is balanced by the
   1) frictional force 2) normal force
   3) force causes motion on the body 4)surface of the table
4) with increase of temperature, friction
   1) increases 2) decreases 3) remains unchanged 4) may increases or decreases
5) Limiting friction depends upon the
   1) nature of the surfaces of the contact and their state of polish
   2) weight of the body lying on a surface
   3) the shape of the body 4) dimensions of the body
6) Coefficient of static friction depends on
   1) normal reaction 2) nature of the surface in contact
   3) both normal reaction and nature of the surfaces in contact
   4) none of these
7) The force of friction that comes into action after the motion has started is known as
   1) limiting friction 2) static friction 3) dynamic friction 4) none of these
8) The coefficient of static friction is
   1) always negative 2) always greater than one
   3) always less than one 4) usually less than one
9) If the normal force is doubled, frictional force is
   1) halved 2) doubled 3) not changed 4) zero
10) If the normal force is doubled, coefficient of friction is
    1) halved 2) doubled 3) not changed 4) zero
11) A good lubricant must be
    1) highly viscous 2) low viscous
    3) volatile in nature 4) highly viscous and low volatile in nature
12) The tangent of angle made by the resultant of limiting friction and normal reaction with the normal reaction gives
    1) Kinetic friction 2) Static friction
    3) Coefficient of kinetic friction 4) coefficient of static friction

13) If the external force applied in the horizontal direction on a block which is on table is balanced by the frictional force. Then such friction is called
1) maximum friction 2) sliding friction 3) static friction 4) rolling friction

14) Pulling of lawn roller is easier than pushing because
1) weight of the roller gets decreased when it is pulled
2) vertical component of the pulling force acts downwards and there by decrease the frictional force during pulling
3) the vertical component of the pulling force acts upwards and there by decrease the frictional force during pulling
4) the frictional force acts in the direction of motion of the roller and there by making the pulling easier

15) Angle of repose is
1) greater than angle of friction 2) less than angle of friction
3) equal to angle of friction 4) equal to half of the angle of friction

Key

1)1	2) 3	3)2	4)2	5)1	6)2	7)3	8)4	9)2	10)3
11)4	12)4	13)3	14)3	15)3					

Numerical Problems

Body on a Horizontal Surface:

16) A block of weight 100kg is kept on the horizontal plane of coefficient of friction 0.5. The amount of work done is dragging it with a velocity of 10 ms^{-1} for 10s is
1) $49x10^3$J 2) $4.9x10^3$J 3) $98x10^3$J 4) $9.8x10^3$J

17) A 100Kg body is resting on horizontal plane having coefficient of friction 0.2. A force of 196N is required to pull the body horizontally. The acceleration developed by the body is
1) $10ms^{-2}$ 2) $2ms^{-2}$ 3) $4ms^{-2}$ 4) $6ms^{-2}$

18) A force of 20kg wt is required to just slide a wooden box weighing 50kg over ice.Then coefficient of static friction between the surface in constant is
1) 0.2 2) 0.4 3) 0.8 4) 0.1

19) A body of mass 10kg is on a rough horizontal surface. If the coefficient of kinetic friction between the surfaces in contact is 0.3, the force which can keep it moving with uniform velocity is
1) 9.8N 2) 19.6N 3) 29.4N 4) 39.2N

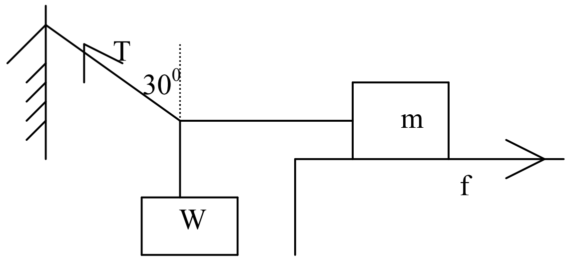
20) A body of mass 5kg moving with a velocity $10ms^{-1}$ on a rough horizontal surface is stopped after a distance of 10m. Then frictional force acting on it is
1) 25N 2) 50N 3) 100N 4) 200N

21) A block of weight 20N rests on the horizontal surface. A force of 8N is required before the block begins to move. A force of 7N will keep the block in uniform motion. Then coefficient of kinetic friction is
1) 0.35 2) 0.70 3) 0.175 4) 0.275

22) A gun of mass 50kg fires a bullet of mass 0.5kg with velocity of $200ms^{-1}$. If the gun moves through 1m back before coming to rest, the frictional force on the gun is
1) 50N 2) 100N 3) 200N 4) zero

23) The horizontal force required to drag a wooden cube of a side 'a' on a rough horizontal surface is F. Another cube of the same wood but of side '2a' is dragged on the same surface. Then the force required if the cube is dragged with constant speed in both the cases
1) F 2) 2F 3) 8F 4) 16F

24) A block of mass m is placed on a horizontal surface with μ as the coefficient of static friction between the body and the surface. It is kept in equilibrium by a weight W and the tension T in a string. Then the tension T is



1) μmg 2) 2μmg 3) 3μmg 4) μmg/2

25) Two blocks of masses in the ratio 5:6 connected by a spring of negligible mass are compressed and released. They move off in opposite directions and comes to rest traveling distances S_1 and S_2. If the coefficient of friction is same for both the bodies, S_1:S_2 is

1) 25:36 2) 6:5 3) 36:25 4) 5:6

26) A block weighing 30N is at rest on a horizontal table. The coefficient of static friction between the block and the table is 0.5. Then magnitude of pulling force that can act an angle 45^0 to the horizontal on the body which will just move it

1) 10N 2) 15N 3) 10√2N 4) none

27) A body is at rest on a rough horizontal surface. The coefficient of static and kinetic friction are 0.8 and 0.6. A force equal to limiting friction is applied on the body and continued to act. Then acceleration produced in the body is

1) $0.98ms^{-2}$ 2) $1.96ms^{-2}$ 3) $9.8ms^{-2}$ 4) $19.6ms^{-2}$

28) A cannon of mass 500 kg fires a shell of mass 1kg horizontally with a velocity $100ms^{-1}$. After firing if the cannon moves back through 0.1m and comes to rest, coefficient of friction between the ground and the cannon is

1) 1/2g 2) 1/4g 3) 1/5g 4) None

29) A box is placed on the floor of a truck moving with an acceleration of $7ms^{-2}$. If the coefficient of kinetic friction between the box and surface of the truck is 0.5, acceleration of the box relative to the truck is

1) $1.1ms^{-2}$ 2) $2.1ms^{-2}$ 3) $3.1ms^{-2}$ 4) $4.1ms^{-2}$

30) A body is placed at the middle of a plank of length *'l'* coefficient of friction between the body and the plank is μ. If the body starts with an acceleration 'a', the time after which the body leaves the plank is

1) $\sqrt{\frac{l}{(a-\mu g)}}$ 2) $\sqrt{\frac{l}{(a+\mu g)}}$ 3) $\sqrt{\frac{2l}{(a-\mu g)}}$ 4) $\sqrt{\frac{2l}{(a+\mu g)}}$

31) A force equal to the weight of the body acts on a body for 't' seconds. If the frictional force is equal to half the weight of the body the distance travelled in 't' seconds is

1) $s= g^2t^2/4$ 2) $S = gt^2/4$ 3) gt/4 4) $g^{-1}t^{-1}/4$

32) A chain is kept on a table such that 1/3 of the length of the chain is hanging down. The coefficient of static friction between the chain and the table is

1) ¼ 2) ½ 3) ¾ 4) 2/3

33) When a block of mass 2kg is pulled on a rough horizontal surface with a force of 20N, the acceleration of the block is $3ms^{-2}$. Then force required to increase the acceleration of the block to $5ms^{-2}$ is

1) 40N 2) 32N 3) 24N 4) 20N

34) A block of mass 4kg is at rest on a rough horizontal surface. A horizontal force of 20N when applied on the body increases its velocity to $5ms^{-1}$ in 4 seconds. Then the frictional force acting on the block

1) 10N 2) 15N 3) 20N 4) 0

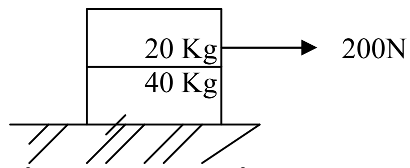
35) A block of mass 2kg is at rest on a rough horizontal surface. A horizontal force of 25N when applied on the body increases its velocity to $10ms^{-1}$ in traveling through 5m. Then the frictional force on the block is

1) 5N 2) 10N 3) 20N 4) 15N

36) A block slides with an initial velocity of $10ms^{-1}$ on a rough horizontal surface. It is brought to rest after covering a distance of 50m. Then coefficient of kinetic friction is ($g = 10\ ms^{-2}$)

1) 0.1 2) 0.2 3) 0.3 4) 0.4

37) A 40kg slab rests on a frictional less floor. A 20kg block rests on the top of the slab. The coefficient of static friction between the block and the slab is 0.6 and the coefficient of kinetic friction is 0.4. The 20 kg block is acted upon is acted upon a horizontal force of 200N. Then resulting acceleration of slab is ($g = 10ms^{-2}$)



1) $0.5ms^{-2}$ 2) $1\ ms^{-2}$ 3) $2\ ms^{-2}$ 4) None

38) When a block of weight 40N is pushed by a force $20\sqrt{3}$ N making an angle 30^0 with the vertical, the frictional force is 14N. The coefficient of kinetic friction is

1) 0.5 2) 0.2 3) 0.3 4) 0.4

39) A bullet of mass $1x10^{-2}$kg moving horizontal with a velocity of $2x10^2ms^{-1}$ strikes the block and gets embedded into it. If the coefficient of kinetic friction of the block and the horizontal surface is 0.25, Then the distance moved by the block with the bullet is before coming to rest is

1) 20.4m 2) 40.8m 3) 61.2m 4) 10.2m

40) Two trolleys of masses m_1 and m_2 are connected by a spring. They are compressed towards each other and released . They move off in opposite directions and come to rest after traveling distances d_1 and d_2 respectively. If coefficient of friction is the same for both, $m_1:m_2$ is equal to

1) $d_1:d_2$ 2) $d_2:d_1$ 3) $d_1^2:d_2^2$ 4) $d_2^2:d_1^2$

41) A body of mass m is thrown vertically up with velocity u. If the resistance force due to air is f_1 the time of ascent of the body is

1) $\frac{u}{g+f}$ 2) $\frac{mu}{mg+f}$ 3) $\frac{u}{g-f}$ 4) $\frac{mu}{mg-f}$

42) A lift is moving down with on acceleration equal to the acceleration due to gravity. A body of mass M kept on the floor of the lift is pulled horizontally. If the coefficient of friction is μ then the frictional resitance offered by the body is

1) μ Mg 2) Mg 3) Zero 4) $\frac{\mu Mg}{2}$

43) A train consisting of 40 Wagons of 20 ton each is pulled by an engine with velocity of $20ms^{-1}$. The powered by an engine is 160 Kw. The frictional fore offered per ton of the train is

1) 1N 2)5N 3)10N 4) 20N

44) The relation between coefficient of static friction μ and angle of friction λ is

1) $\lambda = \cot^{-1}(\mu)$ 2) $\lambda = \cos^{-1}(\mu)$

3) $\lambda = \tan^{-1}(\frac{1}{\mu})$ 4) $\lambda = \sin^{-1}(\frac{\mu}{\sqrt{1+\mu^2}})$

45) A block of mass 6kg is lying on a rough horizontal surface. The angle of limiting and kinetic friction are 53° and 37° respectively.(g = 10m/s^2). A horizontal force enough to apply the force , by how much must the force be reduced to move the block with must the force be reduced to move the block with uniform velocity on the surface ?

1) 20N 2)45N 3)80N 4)35N

46) Pushing force making an angle θ to the horizontal is applied on a block of weight W placed on a horizontal table. If the angle of friction is Φ, the magnitude of the force required to move the body is equal to

1) $\frac{w\sin\phi}{\cos(\theta-\phi)}$ 2) $\frac{w\sin\phi}{\cos(\theta+\phi)}$ 3) $\frac{w\tan\phi}{\cos(\theta-\phi)}$ 4) $\frac{w\cos\phi}{\cos(\theta+\phi)}$

47) A wooden box is placed on the back part of a lorry moving with an acceleration of 6ms^{-2}, if μ = 0.5 , the acceleration of the box relative to lorry is

1) 1.1 ms^{-2} 2)1 ms^{-2} 3)1.5 ms^{-2} 4) 0

48) The maximum speed with which a car can be driven round a curse of radius 18m without Skidding (when g = 10 ms^{-2} and coefficient of friction between rubber and roadway is 0.2) is…in Kmph.

1) 36 2)18 3)21.6 4)14.4

49) A heavy uniform chain lies on horizontal table top. If the coefficient of friction between the chain and the table surface is 0.25, the maximum percentage of length of chain that can hang over one edge of the table is

1)20% 2)25% 3)35% 4)15%

Key

16) 1	17) 1	18) 2	19) 3	20) 1	21) 1	22) 2	23) 3	24) 2	25) 3
26) 3	27) 2	28) 3	29) 2	30) 1	31) 2	32) 2	33) 3	34) 2	35) 1
36) 1	37) 3	38) 2	39) 1	40) 4	41) 2	42) 3	43) 3	44) 4	45) 4
46) 2	47) 1	48) 3	49) 1						

Body On An Inclined Plane:

50) A cube of 10N rests on plane of coefficient of friction 0.6. The slope of the plane is 3 in 5. The minimum force required to start the cube moving up the plane is

1) 10.8N 2) 100.8N 3) 0.8N 4) 1.8

51) A body of weight 20N rests on a rough inclined plane of angle of inclination 60^0 and coefficient of friction 0.4. The minimum force parallel to the plane to be applied to make the body up the plane is

1) 21.3N 2) 13.22N 3) 20N 4) 42.6N

52) When a mass slides down a smooth inclined plane it moves back on smooth surface because of this force (N- normal reaction, mg is weight of the body , Mg wt of plane)

1) $N\cos\theta$ 2) $N\sin\theta$ 3) $mg\cos\theta$ 4) $mg\tan\theta$

53) A body slides down a rough inclined plane of angle of inclination 30^0 with constant velocity. If it is projected up the plane with velocity 9.8ms^{-1}, the distance travelled by it is before coming to rest is

1) 4.9m 2) 9.8m 3) 19.6m 4) $4.9\sqrt{2}$m

54) If the coefficient of static friction is 0.75, the angle through which an inclined plane must be raised so that a block placed on it may begin to slide is ($\sin 37^0 = 3/5$)

1) 53^0 2) 37^0 3) 45^0 4) None

55) An inclined plane rises 7 in 25. A block placed on this plane is just about to slide down. Then coefficient of static friction between the block and the inclined plane is

1) 7/24 2) 7/25 3) 24/25 4) 18/25

56) A block slides down an inclined plane of inclination 30^0 with constant velocity. It is then projected up the same plane with velocity $9.8ms^{-1}$. Before coming to rest, it will move through a distance of

1) 19.6m 2) 14.7m 3) 9.8m 4) 4.9m

57) An engine of 1000kg is moving up an inclined plane 1 in 2 at the rate of $20ms^{-1}$. If the coefficient of friction is $1/\sqrt{3}$, power of the engine is

1) 98KW 2) 196KW 3) 392KW 4) 49KW

58) An object takes k times as much time to slide down 45^0 rough inclined plane as it takes to slide down a perfectly smooth 45^0 incline. The coefficient of kinetic friction between the object and the incline is

1) $1-1/k^2$ 2) $1/1-k^2$ 3) $\sqrt{1-1/k^2}$ 4) $\sqrt{1/1-k^2}$

59) A body released from certain height reaches the ground in time 't'. If the same body is released from the top of smooth inclined plane at the same height, it reaches the ground after time 2t. Then inclination of that inclined plane to the horizontal is

1) 30^0 2) 45^0 3) 60^0 4) 90^0

60) A block of ice slides down a 45^0 smooth inclined plane in time 't'. The same block of ice slides down a rough inclined plane of same inclination. If the coefficient of kinetic friction is ¾, then time taken in this case is

1) 4t/3 2) 3t/4 3) t/2 4) 2t

61) A smooth inclined plane of length 4m is making an angle 30^0 with the rough horizontal plane. A body is released from the top of the smooth inclined plane travels a distance of 8m on the horizontal surface and comes to rest. The coefficient of friction is

1) 0.025 2) 0.0025 3) 0.25 4) 0

62) A body is pushed up on a rough inclined plane making an angle 30^0 to the horizontal .If its time of ascent on the plane is half the time of its descent, coefficient of friction between the body and the plane is

1) $\frac{\sqrt{5}}{3}$ 2) $\frac{\sqrt{3}}{5}$ 3) $\sqrt{\frac{5}{3}}$ 4) $\sqrt{\frac{3}{5}}$

63) Length of an inclined plane is 5m and it is inclined at 30^0 to the horizontal. Work done to move the block up the plane with uniform velocity is 100J. Then work done to move the block up the plane with uniform acceleration of 4 ms^{-2} is

1) 200J 2) 400J 3) 300J 4) 100J

64) The force required just to move a body up an inclined plane of angle of inclination 'θ' is doubled the force required just to prevent the body sliding down it, the coefficient of friction is

1) $\tan\theta$ 2) $\frac{1}{2}\tan\theta$ 3) $3\tan\theta$ 4) $\frac{1}{3}\tan\theta$

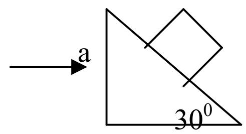
65) A block slides down an inclined plane of inclination θ with constant velocity. It is then projected up the same plane with an initial velocity 'u'. How far up the incline will it move before coming to rest?

1) $u^2/2g\sin\theta$ 2) $u/2g\sin\theta$ 3) $u^2/4g\sin\theta$ 4) $u/4g\sin\theta$

66) A body of mass 2kg is on an inclined plane inclined at 30^0 to the horizontal. The force applied on it parallel to the plane so that it moves up that slope with acceleration of $2ms^{-2}$ against a frictional force of 5N

1) 5N 2) 9N 3) 14N 4) 18.8N

67) A block is kept on a wedge of inclination 30^0 to the horizontal as shown. With what acceleration the wedge should be moved so that the block does not move relative to the wedge?



1) g 2) $g/\sqrt{3}$ 3) $\sqrt{3}g$ 4) $g/\sqrt{2}$

68) A block slides down a slope of angle θ with constant velocity. It is then projected up with a velocity of $10ms^{-1}$, $g = ms^{-2}$ and $\theta = 30^o$. The maximum distance it can go up the plane before coming to stop is

1) 10m 2)5m 3)4m 4)15m

69) A block of mass 2Kg is lying on a rough inclined plane .The force needed to move the block up the plane with uniform velocity by applying a force parallel to the plane is 100N.The force needed to move the block up with an acceleration of $2ms^{-2}$ is

1)100N 2) 200N 3)96N 4)104N

70) A body is allowed to slide from the top along smooth inclined plane of length 5m at an angle of inclination 30^o. If $g = 10ms^{-2}$, time taken by the body to reach the bottom of the plane is

1) $\frac{\sqrt{3}}{2}s$ 2)1.414 s 3) $\frac{1}{\sqrt{2}}s$ 4) 2s

71) An object takes 1 second to slide down a rough 45^o inclined plane .The time taken to slide down a smooth 30^o inclined plane having the same slope length is (μ = 0.5).

1) $\sqrt{2}s$ 2) $\frac{1}{\sqrt{2}}s$ 3) $\frac{1}{2\sqrt{2}}s$ 4)$2^{-1/4}$s

72) The length of smooth and rough inclined planes of 45^0 inclination is same. Time of sliding of a body an two surfaces is t_1,t_2 and μ =0.75 then $t_1 : t_2$ =

1)2:1 2)2:3 3)1:2 4)3:2

Keys

50) 1	51) 1	52) 2	53) 1	54) 2	55) 1	56) 4	57) 2	58) 1	59) 1
60) 4	61) 4	62) 2	63) 1	64) 4	65) 3	66) 4	67) 3	68) 2	69) 4
70) 2	71) 4	72) 3							

previous Eamcet Questions

73) A block of weight 200N is pulled along a rough horizontal surface at a constant speed by a force of 100N cutting an angle 30° above the horizontal .Then coefficient of friction is (Eamcet 2001M)

1) 0.43 2) 0.58 3) 0.75 4) 0.83

74) A body is moving up an inclined plane of angle θ with an initial kinetic energy E. The coefficient of friction between the plane and the body is 'μ'. The work done against friction before the body comes to rest is (Eamcet 2002 E)

1) μcosθ/Ecosθ+sinθ 2) 2μEcosθ

3) μEcosθ/μcosθ-sinθ 4) μEcosθ/μcosθ+sinθ

75) A body is sliding down a rough inclined plane. The coefficient of friction between the body and the plane is 0.5. The ratio of the net force required for the body to slide down and the normal reaction on the body is 1:2. Then the angle of the inclined plane is (Eamcet 2002E)
1) 15^0 2) 30^0 3) 45^0 4) 60^0

76) The horizontal acceleration that should be given to a smooth inclined plane of angle $\sin^{-1}(1/l)$ to keep an object stationary on the plane, relative to the inclined plane is (Eamcet 2003E)

1) $\frac{g}{\sqrt{l^2-1}}$ 2) $g\sqrt{l^2-1}$ 3) $\frac{\sqrt{l^2-1}}{g}$ 4) $\frac{g}{\sqrt{l^2+1}}$

77) A horizontal force, just sufficient to move a body of mass 4kg lying on a rough horizontal surface is applied on it. The coefficient of static and kinetic friction between the body and the surface are 0.8 and 0.6 respectively. If the force continues to act even after the block has started moving, the acceleration of the block in ms^{-2} is ($g = 10\ ms^{-2}$) (Eamcet 2003 E)
1) ¼ 2) ½ 3) 2 4) 4

78) The minimum force required to move a body up an inclined plane of inclination 30^0 is found to be thrice the minimum force required to prevent it from sliding down the plane. The coefficient of friction between the body and the plane is (Eamcet 2004 M)
1) $1/\sqrt{3}$ 2) $1/2\sqrt{3}$ 3) $1/3\sqrt{3}$ 4) $1/4\sqrt{3}$

79) Consider the following statements A & B and identify the correct answer:
A: When a person walks on a surface the direction of frictional force exerted by the Surface on the person is opposite to the direction of his motion.
B: When a cycle is in motion, the force of friction exerted by the ground on the front whell is in backward direction. (2004E)
1) A and B are correct. 2) A is correct , B is wrong.
3) A and B are wrong. 4) A is wrong , B is correct.

80) A cannon of mass 1000Kg located at the base of an inclined plane fires a shell of mass 100kg in a horizontal direction with a velocity 180 Kmph.The angle of inclination of the inclined plane with the horizontal is 45^0.The coefficient of friction between the cannon and the inclined plane is 0.5 . The height in metres, to which the cannon ascends the inclined plane as a result of recoil is ($g = 10 m/s^2$) [2004M]

1) $\frac{7}{6}$ 2) $\frac{5}{6}$ 3) $\frac{2}{6}$ 4) $\frac{1}{6}$

81) The minimum fprce required to move a body up an inclined plane us three times the minimum force reuired to prevent it from sliding down the plane. If the coefficient of friction between the the body and the inclined plane is $\frac{1}{2\sqrt{3}}$, the angle of inclined plane is [2005E]
1) 60^0 2) 45^0 3) 30^0 4) 15^0

82) A cubical block of mass 'm' rest on a horizontal surface 'μ' is coefficient of static frilction between the block and the surface. A force mg acting on the cube at an angle 'θ' with the vertical side if the cube pulls the block. If the block is to be pulled along the surface then the value of $\cot(\frac{\theta}{2})$ is [2005 M]
1) Less than μ 2) Greater than μ 3) Equal to μ 4) Not dependent on μ

83) When jthe angle of anclination of an inclined plane is θ, an obeject slides down with uniform velocity. If the same object is pushed up with an initial velocity μ on the same

inclined plane , it goes up the plane and stops at a certain distance on the plane. There after j the body. [2006E]

1) Slides down the inclined plane and reaches the ground with velocity 'u'
2) Slides down the inclined plane and reaches the ground with velocity less than 'u'.
3) Slides down the inclined plane and reaches the ground lwith velocity greater than 'u'.
4) Stays at rest on the inclined plane and will not slide down

84) A block of wood resting on an inclined plane of angle 30^0, just starts moving down. If the coefficient of friction is 0.2, its velocity (in ms^{-1}) after 5seconds is ($g = m/s^{-2}$)

1) 12.75 2) 16.35 3)18.25 4)20 [2006 M]

85) A man slides down on a telegraphic pole with an acceleration equal to one- fourth of acceleration due to gravity . The frictional force between man and pole is equal to in terms of man's weight W: [2007 E]

1) $\frac{W}{4}$ 2) $\frac{W}{2}$ 3) $\frac{3W}{4}$ 4)W

86) A block of mass 2Kg is placed on the surface of a trolley of mass 20Kg which os on smooth surface. The coefficient of friction between the block and the surface of the trolley is 0.25. If a horizontal force of 2N acts on the block, the acceleration of the System in ms^{-2} is ($g = 10\ m/s^2$). [2007M]

1)1.8 2)1.0 3)0.9 4) 0.09

Key

73) 2	74) 4	75) 3	76) 1	77) 3	78) 2	79) 1	80) 2	81) 3	82) 2
83) 4	84) 2	85) 3	86) 4						

Matching Type Questions

87) Match ListI with ListII from the combinations below.

List-I	List-II
a) non-conservative force	e) depends on mass
b) conservative force	f) work done independent of path
c) deceleration due to friction on rough horizontal surface	g) work done depends on path
d) accelerating force on a smooth inclined surface	h) independent of mass

The correct match is

1) a→g;b→h;c→f;d→e 2) a→f;b→e;c→h;d→g
3) a→g;b→f;c→h;d→e 4) a→e;b→g;c→h;d→f

88) Match the following

List-I	List-II
a) Static friction	e) constant for given pair of surfaces
b) Limiting friction	f) independent of area of constant
c) Kinetic friction	g) self adjusting
d) Rolling friction	h) has the least magnitude for a given normal reaction

The correct match is

1) a→e;b→f;c→g;d→h 2) a→h;b→f;c→e;d→g
3) a→g;b→e;c→f;d→h 4) a→g;b→h;c→f;d→e

89) Study the following

List-I	List-II
a) Frictional force	e) Zero
b) Gravitational force	f) Electromagnetic force
c) When a body on rough inclined plane is just to move, then the net force acting on the body is	g) mg sinθ
d) The force acting on a body placed on a smooth inclined plane is	h) conservative force

The correct match is

1) a→h;b→f;c→g;d→e 2) a→f;b→h;c→e;d→g

3) a→e;b→g;c→f;d→h 4) a→g;b→e;c→h;d→f

90) Study the following

List-I	List-II
a) Frictional force	e) reduction of friction
b) rolling friction	f) adhesive force
c) ball bearing	g) deformation at the point of contact
d) excessive polishing	h) increase of friction
	i) conservative force

The correct match is

1) a→i;b→e;c→h;d→f 2) a→h;b→f;c→e;d→g

3) a→f;b→g;c→e;d→h 4) a→i;b→f;c→h;d→e

91) Study the following

List-I	List-II
a) Static friction	e) less friction
b) angle of repose	f) self-adjusting force
c) Lubrication	g) non-conservative force
d) frictional force	h) angle of friction

The correct match is

1) a→f;b→h;c→e;d→g 2) a→e;b→g;c→h;d→f

3) a→g;b→h;c→e;d→f 4) a→g;b→h;c→f;d→e

Key

87) 3 88) 3 89) 2 90) 3 91) 1

<u>Assertion and Reason Type Question</u>

These Questions consist of two statements as Assertion and Reason. While answering these questions you are required to choose any of the following four responses.

A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion

B) If both Assertion and Reason are true, but Reason is not correct explanation of the Assertion.

C) If Assertion is true, but the Reason is false.

D) If Assertion is false, but the Reason is true.

92) A: Friction is a self adjusting force

R: The magnitude of static friction is equal to the applied force and its direction is Opposite to that of the applied force.

1) A 2) B 3) C 4)D

93) A: Force of friction increases when surfaces in contact are too smooth.

R: Smoothness decreases friction.

1) A 2) B 3)C 4)D

94) A: On polishing the surface the friction decreases upto certain limit but increases Beyond that

R: On polishing the surface, the irregularities are cut off.

1) A 2) B 3) C 4)D

95) A: when a bicycle is being pedalled the friction on the front wheel is in a direction opposite to the motion of bicycle.

R: The rear wheel while being pedalled, pushed the front wheel on rough road due to Which the friction opposes the relative motion.

1) A 2)B 3)C 4)D

96) A: It is difficult to move a bike with its breaks on.

R: Sliding friction its greater than rolling friction.

1) A 2) B 3) C 4) D

97) A: A larger brake on a bicycle wheel is more effective than a small one.

R: Force of friction is independent of the surface area of contact.

1) A 2) B 3) C 4) D

98) A: On a rainy day, it is difficult to drive a car or bus at high speed.

R: The value of coefficient of friction is lowered on wetting the surface.

1) A 2) B 3)C 4)D

99) A: When a wheel is rolling forward on a level road, frictional force between the wheel and the road acts backwards.

R: Friction always opposes the motion

1) A 2) B 3)C 4)D

100) A: A horse has to pull a cart harder during the first few steps of his motion.

R: The first few steps are always difficult.

1) A 2) B 3)C 4)D

101) A: Pulling a lawn roller is easier than pushing it.

R: Pulling increases the apparent weight as the vertical component of the pulling force acts upward.

1) A 2) B 3) C 4)D

102) A: More force is required to push up a rough inclined plane than that to move the same body down the same plane.

R: The friction always acts parallel to inclined plane downwards.

1) A 2) B 3) C 4) D

103) A: When a body tends to slide down an inclined plane, force of friction acts up the plane.

R: Friction always opposes the relative motion.

1) A 2) B 3) C 4) D

104) A: A body on an inclined plane just tends to slide down if the angle of inclination is equal to angle of friction.

R: When the angle of inclination is equal to the angle of friction, the component of weight parallel to the plane is just sufficient to overcome the frictional force

1) A 2) B 3) C 4) D

105) A: An object projected with same velocity on the paths of different rough surfaces are brought to rest in different distances.

R: The work done against the friction depends on the path travelled by the object.

1) A 2) B 3) C 4) D

106) A: Frictional force is independent of the velocity of the body.

R: Friction is due to the surface irregularities.

1) A 2) B 3) C 4)D

Key

92) 4 93) 2 94) 2 95) 1 96) 1 97) 4 98) 1 99) 4 100) 3 101) 3
102) 2 103) 1 104) 1 105) 1 106) 2

CHAPTER 6
WORK, ENERGY AND POWER

WORK: - 1) work is the product of displacement and the component of the force in the direction of the displacement

A) if the force(f) and the displacement (s) are in the same direction W= Fx s
B) if the force(f) and the displacement (s) are inclined to each other at an angle θ w= f cosθs
C) if the force and the displacement are perpendicular to each other, $w = f \cos 90^0 \times s = 0$
   E.g., the work done in carrying a suitcase over a smooth horizontal floor is zero, because the weight of the suitcase and the displacement are at right angles to each other.
D) If the body is to be raised up along an inclined plane, then the force f work against the component mg sin θ along the plane in the down ward direction W = mg sinθs

1) Work done is independent of the path and the time taken to do the work (if there is no friction), if there is friction work done depends on the path followed by the body
2) The area under the force – displacement graph is equal to the work done
3) If the force or the component of the force is in the direction of the displacement the work done is "positive" other wise if displacement is in opposite direction work done negative
4) Work done against to gravity w = mgh
5) Work done against to friction w = μ mgs
6) Work done in moving up a rough inclined plane $w = mg(\sin\theta + \mu \cos\theta)\, s$
7) Work done in moving up a smooth incline plane, $w = mg \sin \theta x\ s$
8) Work done in projecting a body with a velocity v, $w=1/2\ mv^2$
9) Work done in compressing or extending a spring $w= 1/2\ kx^2$ where k is the spring constant and x is the compression or extension
10) Work done in pulling the bob of a simple pendulum of length l through and angle θ from the vertical $w = mg (1-\cos\theta)$
11) Work done in pulling the metal rod of length l through an angle θ from the vertical $w = ½\ mgl (1-\cos\theta)$
12) Work done in expanding a gas $w = p \times \Delta v$ where p is the pressure and Δ vi s the change in volume
13) Work done by the resultant force acting on a body $w= 1/2mv^2-1/2\ mu^2$ where v is the final velocity and u is the initial velocity. it is also known as work energy theorem.
14) SI or MKS unit of work done is joule and in CGS system erg. And 1 joule = 10^7erg
15) When a body is revolving round in a circular path due to a centripetal force, the work done by the centripetal force is zero
16) If work is performed by the body there is loss of energy and the workdone is said to be negative
17) If work is performed by another external force the energy of the body increases and the work is taken to be positive

18) Workdone in rotating a magnet of moment M suspended in a magnetic field B, form θ_1 to θ_2 is MB(cos θ_1–cos θ_2)
19) Energy and work are scalar quantities and having same units
20) The energy possessed by a body by virtue of its motion is known as kinetic energy K.E.=1/2 $mv^2=p^2/2m$ ∴ P= $\sqrt{2mE}$ Where p= mv= linear momentum
21) A body cannot have momentum without energy but can have energy without momentum
22) The energy possessed by a body by virtue of its position, configuration or internal mechanism is called potential energy
23) P.E.. = mgh is known as gravitational potential energy (G.P.E) the exact formula for G.P.E. = mgRH / (R+h) (when h is not very small)
24) According to law of conservation of energy ,the total amount of energy is always constant
25) In the case of freely falling body its P.E. decreases and its K.E. increases but its total amount of energy is constant and when the body touches the ground mgh= ½ mv^2
26) In the case of a body projected vertically up the K.E. at the time of projection is equal to its P.E. at the maximum height $H_{max} = v^2/2g$
27) When a body is projected horizontally on a rough inclined surface if its comes rest with a distance s, the $\mu mgs=1/2\ mv^2$, $\mu = v^2/2gs$
28) Stopping distance = kinetic energy / retarding force
29) The minimum stopping distance for a car of mass 'm' moving with a speed v, along a level road, if the coefficient of static friction between tyres and the road is μs will be $S= v^2/ 2\mu sg$
30) Then energy is expended it converts into work done
31) If a body is under the influence of force of attraction or force of repulsion it possesses the potential energy
32) A body under the influence of gravitational force of attraction has negative P.E
33) As the body moves away from the earth its P.E. increases and becomes zero when it is infinite distance.
34) The gain in the P.E. of a body when the body is taken to a height "R" from the surface of the earth is mgR/2
35) To get rid of the excess P.E. :-
    1) A body situated at a height above the ground always falls to the ground
    2) Water always flows from higher level to lower level
    3) Electron always transits from higher level to lower level.
36) In the absence of loss of energy in any form the temperature of waterfall is greater at the bottom than at top. This is due to conversion of P.E into heat energy
37) A block of mass M is suspended by a string and a bullet t of mass m is fired into the block with a velocity v. if the bullet embeds in the block, then
    i) the initial common velocity of the system x= mv/M+m)
    ii) The system rises to a minimum height $h= x^2/2g\ (mv/M+m)^2\ 1/2g$
    iii) The velocity of the bullet v= (M+m/m) $\sqrt{2gh}$
38) If a bullet of mass m fired into a stationary large wooden block with velocity v penetrates a distance x before coming to rest then the resistance offered by the block f= ½ mv^2/x

39) When a retarding force is applied time taken to come to rest 't'= p/f

40) Ascending a steep hill is easier for a cyclist if he goes by zigzag path than by straight path

41) The elastic potential energy of a spring increases whether the spring is stretched or compressed.

42) Rate of doing work is known as power. Or the dot product of force and velocity is known as power. In SI system its unit is watt and CGS system its unit is erg/sec and in fps system horse power note that 1 horse – power = 746 watt

43) If a machine gun fires 'n' bullets per second each of mass 'm' with a speed 'v' then the power of the gun $p = n\,mu^2/2$

44) A block of mass 'm' is pulled up an inclined plane of angle θ with constant velocity then the power extended $p = fxv = mg\sin\theta xv$

45) For a given spring , greater the number of turns greater will be work done

$W \alpha\, n$ or $w_1 / w_2 = n_1 / n_2$

46) When a vehicle is moving with uniform velocity v the power developed is (frictional force x velocity) P= F.V

Variable mass system:

22) Water coming out of a hose pipe strikes a wall normally with a velocity 40m/s and then trikles down the wall. If the area of cross-section of the pipe $1cm^2$, force acting on the wall is

1) 80N 2) 160N 3) 40N 4) 120N

23) A 500kg rocket has to be fired vertically. Exhaust velocity of the gases is 1.96km/s. Minimum mass of the fuel to be released in kg per second is

1) 250kg 2) 25 kg 3) 2.5 kg 4) 50 kg

24) A 400 kg rocket is set for vertical firing. Exhaust speed of the gases is 490 m/s. The rate at which gas is to be ejected to give an upward acceleration of 'g' to the rocket

1) 160kg/s 2) 16kg/s 3) 1.6kg/s 4) 80 kg/s

25) A target of mass M is moving with a velocity u. Lead shots, each of mass m, are fired at it in opposite direction.with velocity v the number of bullets required to stop it is

1) Mu/mv 2) mv/Mu 3) (M+m)u/v 4) mu/(M+m)v

26) A machine gun fires 10 bullets per second. If the force to hold the gun is 10N, mass of each bullet 10gm, speed of each bullet will be

1) $100ms^{-1}$ 2) $300ms^{-1}$ 3) $750ms^{-1}$ 4) $1kms^{-1}$

27) A balloon has 5 gm of air. A small hole is pierced into it. The air escapes at a uniform rate with a velocity of 4 cm/s. If the balloon shrinks, completely in 5 seconds, then the mean force acting on the balloon is

1) 2 dyne 2) 4 dyne 3) 8 dyne 4) 8 newton

Apparent weight and normal reaction:

28) A body is moving with an acceleration 'a' under the action of a force 'g' . The weight of the body is

1) g/a 2) $-g^2/a$ 3) g^2/a 4) a^2/g

29) A 60 kg man stands on an elevator floor. The elevator is going up with constant acceleration of $1.96\ m/s^2$.Percentage change in the apparent weight of the person is

1) 10 2) 15 3) 20 4) 25

30) A spring balance suspended from the roof of a elevator indicates 90kg as the weight of a 120kg body. Acceleration of the elevator
1) g/4 upwards 2) g/4 downwards
3) g/2 upwards 4) g/2 downwards

31) A lamp hangs vertically from a cord in a descending lift. The lift has retardation of $5.2m/s^2$ before coming to a halt. If the tension in cord is 30N, mass of the lamp is
1) 2kg 2) 1kg 3) 9.8kg 4) 4.9kg

32) A lift of mass 500kg is descending with an acceleration of $2ms^{-2}$. If $g = 10ms^{-2}$, the tension in the cable is
1) 4000N 2) 8000N 3) 2000N 4) 6000N

33) The weight of a person in a stationary lift is 70kg. If the lift moves with a constant velocity of 7 ms^{-1} his weight in the moving lift is
1) 75kg 2) 70kg 3) 64kg 4) 60kg

34) A person of 70 kg weight is being lifted by a helicopter with a rope rising up with an acceleration of $4m/s^2$. Tension is
1) 966N 2) 100 Kgwt 3) 400N 4) 280N

35) Ina tug of war each team is pulling the rope with a force of 400N. Tension in the rope is
1) 800N 2) 0 3) 400N 4) 200N

Key

1) 2	2) 4	3) 4	4) 2	5) 2	6) 3	7) 4	8) 1	9) 1	10) 4
11) 4	12) 4	13) 4	14) 3	15) 3	16) 2	17) 4	18) 2	19) 3	20) 2
21) 2	22) 2	23) 3	24) 2	25) 1	26) 1	27) 2	28) 3	29) 3	30) 2
31) 1	32) 1	33) 2	34) 1	35) 3					

Work:

36) A body moves a distance of 10m along a straight line under the action of a force of 5N. The work done is 25J. The angle which the force makes with the direction of motion of the body
1) 0^0 2) 30^0 3) 60^0 4) 90^0

37) A man holds a 10kg suit-case 0.5m above the ground for 2 minutes. The work done is
1) 49J 2) 98J 3) 9.8J 4) 0

38) A body constrained to move along z-axis of a coordinate system is subjected to a constant force F given by F=(2i-4j+3k)N. Work done by the force in moving the body by a distance of 6m along the z-axis
1) 18ergs 2) $6x\sqrt{29}$joule 3) 18 joule 4) 30 joule

39) A man pushes a 60kg block by 30m along a smooth level floor with a force 3N directed 60^0 above the horizontal. The work done is
1) 150 joule 2) 50 joule 3) 40 joule 4) 45 joule

40) A block of mass 10 kg is to be raised from the bottom to the smooth incline of inclination 30^0 and length 5m. Work done is
1) 245 joule 2) 250 joule 3) 240 joule 4) 975 joule

41) A can of water 10 kg is raised from a depth of 20m. When the can rises by 10m its velocity is 1m/s. Work done is
1) 980joule 2) 985 joule 3) 990 joule 4) 975 joule

42) Water is lifted from a well of depth 50m. If mass of water is 20kg and that of the rope is 0.2kg per meter the amount of work done is
1) 15250J 2) 12520J 3) 12250J 4) 1252J

43) A uniform chain of mass M and length L is held on a smooth table with $1/5^{th}$ of length hanging over its edge. Work to be done to pull the hanging part back on to the table is
1) MgL/5 2) MgL/10 3) MgL/6 4) MgL/50

44) The work done in lifting a stone of mass 10kg and specific gravity 3 from the bottom of a lake to a height of 6m in water is
1) 0.392J 2) 3.92J 3) 39.2J 4) 392J

45) The work done in lifting 4 cement bags each of mass 50kg to the top of a building of eight 20m is
1) 39.2KJ 2) 3.92KJ 3) 0.392KJ 4) 392KJ

46) A force F=5i-3j+2k moves or particle from r_1 = 2i+7j+4k to r_2 = 5i+2j+8k. Then work done by that force is
1) 18 units 2) 28 units 3) 38 units 4) 48 units

47) A ladder of mass 5kg and length 2m carries a 2.5kg at its top end. When the ladder is moved from the ground to vertical position, its potential energy is
1) 147J 2) 98J 3) 49J 4) 140J

48) A box is dragged along a smooth horizontal floor by a rope. The rope makes an angle of 60^0 with the horizontal. If the tension in the rope is 200N and the box is moved through distance of 20m, work done is
1) 500J 2) 1000J 3) $1000\sqrt{3}$J 4) 2000J

49) A person of mass 50kg carrying a load of 20kg on his head moves up stairs. The height of the each step is 0.25m and the total number of steps is 20. The amount of work done by him against gravity is
1) 5J 2) 100J 3) 343J 4) 3430J

50) A drop of water of volume $5x10^{-8}$ m^3 falls from a height of 100m. If g = $10m/s^2$, the work done by gravitational force is
1) $5x10^{-6}$J 2) $5x10^{-4}$J 3) $5x10^{-3}$J 4) $5x10^{-2}$J

51) If 12J of work is done in raising one end of a rod from its horizontal position through 37^0, the extra work required to raise it to vertical position is (sin 37^0 = 3/5)
1) 12J 2) 48J 3) 20J 4) 3J

Power:

52) A train is travelling with a uniform velocity of 2i-j+4k m/s on a level track. The engine has to exert a force of i-3j+2k N to overcome friction. The power of the engine is
1) 7W 2) 10W 3) 13W 4) 15W

53) A boy whose mass is 50 kg climbs, with constant speed, a vertical rope 6m long in 10s. Boy power output during the climb is
1) 294W 2) 300W 3) 30W 4) 29W

54) Sand drops at the rate of 4kgs-1 on to a conveyor belt moving horizontally with a velocity $0.4ms^{-1}$. The extra power required to keep the belt moving is
1) 0.32W 2) 0.64W 3) 1.6W 4) zero

55) A motor car needs an engine 8KW to keep it moving at a constant velocity $16ms^{-1}$ on a level rough road. The frictional force between the tyres and the road is

1) 1280N 2) 500N 3) 200N 4) 128N

56) A machine gun fires 360 bullets per minute. Each bullet moves with a velocity of $600ms^{-1.}$ If the power of the gun is 5.4KW, mass of each bullet is

1) 5Kg 2) 0.5Kg 3) 0.05Kg 4) 0.005Kg

57) From a water fall water is pouring down at the rate of 100kg per second on the blades of a turbine. If height of fall is 100m, the power delivered to the turbine is approximately

1) 100KW 2) 10KW 3) 1KW 4) 100W

58) A trailer of mass 4000 metric tons is moving with a velocity 36 kmph on a rough road. If the frictional force due to air and road are 100N per 500 metric tons, power of the engine is

1) 800W 2) 80W 3) 8KW 4) 2KW

59) A bus of mass 6 metric tons is pulled at a speed of 18kkmph on a smooth incline of inclination 1 in 20. Power of the engine

1) 14.7KW 2) 147W 3) 147KW 4) 1470W

60) A pump of 200W power is lifting 2kg water from an average depth of 10m per second. Velocity of the water delivered by the pump is.

1) 4m/s 2) 2.5m/s 3) 3m/s 4) 2m/s

61) An electric motor creates a tension of 4500N in a cable and reels it at the rate of 2m/s. The power of the electric motor is

1) 4.5KW 2) 9KW 3) 13.5KW 4) 18KW

62) A motor is used to lift water from a well 60m below to fill a tank 4m x 5m x 10m in 50 minutes. Power of the motor is

1) 3.92W 2) 39.2W 3) 392W 4) 3920W

63) A man carries a load of 50 Kg through a height of 40m in 25s. If the power of the man is 1568 W, mass of the mass is

1) 20Kg 2) 50Kg 3) 25Kg 4) 40Kg

64) The power of a motor used to lift water from a water pond is 3KW. The mass of water that can be lifted to a height of 10m in one minute is ($g = 10ms^{-2}$)

1) 450Kg 2) 900Kg 3) 1200Kg 4) 1800Kg

Energy:

65) A meter stick of mass 2kg is pivoted at one end and the other end is displaced through 60^0 from the vertical. The increase in its P.E is

1) 4.9J 2) 9.8J 3) 98J 4) 49J

66) A wooden block is suspended by light rope of length 0.9m vertically. The block is pulled aside through an angle 60^0 to the vertical and then released. The maximum velocity the block can attain is ($g = 10\ ms^{-2}$)

1) $3ms^{-1}$ 2) $3\sqrt{2}\ ms^{-1}$ 3) $3/\sqrt{2}\ ms^{-1}$ 4) $1.4ms^{-1}$

67) Two identical simple pendulums are swinging in a vertical plane. The ratio of their potential energies when they make angles 30^0 and 60^0 with the verticals is

1) $\sqrt{3}:1$ 2) $1:\sqrt{3}$ 3) $(2-\sqrt{3}):1$ 4) $1:(2-\sqrt{3})$

68) A ladder of mass 5kg and length 2m carries a 2.5kg at its top end. When the ladder is moved from the ground to vertical position, its potential energy is

1) 147J 2) 98J 3) 49J 4) 140J

69) A person is swinging over a string such that his lowest and highest positions are at heights of 2m and 4.5m respectively. The velocity at the lowest point is

1) 2.5m/s 2) 7 m/s 3) 14 m/s 4) 20 m/s

70) Two spheres of different materials are in motion. If their densities are in the ratio 1:2 radii are in the ratio 1:2 and velocities are in the ratio 2:1 their kinetic energies are in the ratio

1) 1:4 2) 4:1 3) 1:1 4) 8:1

71) Two identical perfectly elastic spheres moving with velocities u_1 and u_2 under go collisions 20 times successively. The final K.E of the system is

1) 19 times the initial K.E of the system 2) 20 times the initial K.E of the system
3) 21 times the initial K.E of the system 4) same as the initial K.E of the system

72) A river is flowing at a speed $4ms^{-1}$. The K.E of a cubic meter of water is

1) 8J 2) 800J 3) 1600J 4) 8000J

73) A force of 8N is applied on a body of mass 2kg at rest for 10s. Its K.E is

1) 1600J 2) 800J 3) 400J 4) 200J

74) The height from which an automobile would have to fall to gain the kinetic energy equivalent to what it would have when going at a speed of 14m/s is

1) 7m 2) 8m 3) 9m 4) 10m

75) A particle of mass 2kg starting from rest moves with an acceleration $2m/s^2$ for 2s. The gain in K.E of the body is

1) 16J 2) 8J 3) 4J 4) 2J

76) A ball is released along the wall of a hemispherical bowl of diameter 0.2m. The velocity of the ball at the bottom of the bowl is

1) 0.1m/s 2) 0.98m/s 3) 1.4m/s 4) 2.8m/s

77) Two identical bodies of equal masses undergo to perfectly elastic collision. If the K.E of one body increases by 50 joule. K.E of the other body is

1) zero 2) increases by 50 J 3) decreases by 50J4) decreases by 25J

78) A projectile with an angle of projection 30^0 to the horizontal has an initial kinetic energy of 40J. Its kinetic energy at the highest point of projection is

1) 10J 2) 20J 3) 30J 4) 40J

79) When a spring is stretched by 2cm, its P.E is U. If the spring is stretched by 10cm, P.E stored in it will be

1) U/25 2) U/5 3) 5U 4) 25U

Work – Energy – Theorem:

80) A force 'F' stops a body of mass 'm' moving with a velocity 'v' in a distance 's'. The force required to stop a body of triple the mass, moving with double the velocity in half the distance is

1) 3F 2) 6F 3) 8F 4) 24F

81) A body of mass 5kg initially at rest, is moved by a horizontal force of 2N on a smooth horizontal surface. The work done by the force in 10s is

1) 4J 2) 16J 3) 32J 4) 40J

82) A body of mass 0.5kg is moving with a constant velocity of 2m/s. In order to bring it to rest in a distance of 2m, the work to be done is

1) 0.5J 2) 1J 3) 2J 4) 4J

83) A body of mass 20Kg is at rest. A force of 5N is applied on it. The work done in first second will be

1) 5/8J 2) 8/5J 3) 5/4J 4) 4/5J

84) Two identical 5kg blocks are moving with the same speed of 2m/s towards each other along a frictionless horizontal surface. The two blocks collide and stick together to come to rest. The work done by the external force in one second is

1) 20J 2) 10J 3) 5J 4) 0

85) The work done against friction in moving a body of mass 2kg with uniform velocity of 5m/s for 10s on a surface of coefficient of friction 0.4 is

1) 294J 2) 392J 3) 490J 4) 784J

86) A body falls from a height of 10m and rebounds from a hard surface to a height of 8m. The percentage loss of energy during the collision is

1) 100% 2) 50% 3) 40% 4) 20%

87) A perfectly elastic sphere moving with some velocity collides with an identical sphere at rest. The percentage of K.E transferred to the sphere at rest is

1) 0 2) 25% 3) 50% 4) 100%

88) The percentage of K.E of a moving particle imparted to a stationary particle of mass 3 times the first particle during an elastic collision is

1) 25% 2) 50% 3) 75% 4) 0

89) A bullet traveling with a velocity 240m/s when passes through a plank of thickness 18 inches gets its velocity reduced to half. The thickness of the plank that can just stop the bullet is

1) 36 inches 2) 24cm 3) 2.4 inches 4) 24 inches

90) A 30 gm bullet traveling with 500 ms^{-1} penetrates 12.5 cm into a wooden block. The average force exerted by the block on the bullet is

1) 300N 2) $3x10^4$N 3) $6x10^5$N 4) $4.5x10^4$N

91) A bullet of mass 10gm strikes a fixed target and penetrate 8cm into it. If the average resistance offered by the target to the bullet is 100N, the velocity with which the bullet hits the target is

1) 20m/s 2) 25m/s 3) 40m/s 4) 4.5m/s

Momentum- Kinetic Energy:

92) Two masses of 1gm and 4gm are moving with equal K.E. The ratio of the magnitudes of their linear momenta is

1) 4:1 2) √2:1 3) 1:2 4) 1:16

93) Two masses of 2kg and 8kg are moving with linear momenta in the ratio 1:2. The ratio of their K.E is

1) 2:1 2) 1:4 3) 4:1 4) 1:1

94) The momentum of two bodies are in the ratio 2:3 and their K.E are in the ratio 8:27. Their masses are in the ratio of

1) 3:2 2) 2:3 3) 4:9 4) 3:4

95) A gun of mass 'M' fires a bullet of mass 'm' with a velocity 'u'. The kinetic energies of the bullet and the gun are in the ratio

1) m:M 2) M:m 3) 1:4 4) m/M+m

96) When K.E of a body is increases by 300% . The momentum of the body is increases by

1) 20% 2) 50% 3) 100% 4) 200%

97) The mass of a body is halved and velocity is doubled . Percentage increase in the K.E of the body is

1) 400% 2) 300% 3) 200% 4) 100%

98) The K.E of a body is twice its momentum. Velocity of the body is

1) $4ms^{-1}$ 2) $1m^{-1}$ 3) $2ms^{-1}$ 4) $\sqrt{4}ms^{-1}$

99) The momentum of a body is 0.4N.s K.E of the body is 4/5 joule. Mass of the body is

1) 1kg 2) 0.1kg 3) 0.5kg 4) 0.2kg

100) A body of mass 5kg has a linear momentum of 10 gm/s. A constant force of 0.2N is applied on it for a time of 10s. The change in kinetic energy of the body is

1) 1.1J 2) 2.2J 3) 3.3J 4) 4.4J

Keys

36) 3	37) 4	38) 3	39) 4	40) 1	41) 2	42) 3	43) 4	44) 4	45) 1
46) 3	47) 2	48) 4	49) 4	50) 4	51) 2	52) 4	53) 1	54) 2	55) 2
56) 4	57) 1	58) 3	59) 1	60) 4	61) 2	62) 2	63) 2	64) 4	65) 1
66) 1	67) 3	68) 2	69) 4	70) 1	71) 4	72) 4	73) 1	74) 4	75) 1
76) 3	77) 3	78) 3	79) 4	80) 4	81) 4	82) 2	83) 1	84) 1	85) 3
86) 4	87) 4	88) 3	89) 4	90) 2	91) 3	92) 3	93) 4	94) 1	95) 2
96) 3	97) 4	98) 1	99) 2	100) 4					

New Type Questions:

1) Match the following

List-I	List-II
a) elastic collision	e) along the original parabolic path
b) when the bodies stick together the collision is	f) momentum alone
c) A bullet hits and gets embedded in solid served block resting on a horizontal frictionless table then conserved Quantity is	g) both momentum and K.E are const
d) When an explosive shell travelling in a parabolic path under the influence of gravity explodes, the centre of mass of the fragments will move	h) completely inelastic

1) a-g, b-h, c-f, d-e 2) b-g, a-h, c-e, d-f 3) c-g, b-e, a-f, d-h 4) e-h, a-g, d-c, b-f

Key:1

2) A small metal sphere falls freely from a height h upon a fixed horizontal plane. If e is the coefficient of restitution , match the column A with column B

A	B
a) The height to which it rebounds after n collisions	e) $\sqrt{\frac{2h}{g}}\frac{[1+e]}{[1-e]}$
b) The velocity with which it rebounds from the ground after n^{th} collision	f) $e^{2n}h$
c) The total distance traveled by it before it slop rebounding	g) $e^n\sqrt{2gh}$
d) The time taken by it before it comes to rest	

1) a-g, b-f, c-e, d-h 2) a-f, b-g, c-h, d-e

3) a-h, b-e, c-f, d-g 4) a-e, b-h, c-g, d-f Key:2

3) Assertion: The relative velocity between two bodies can be equal to sum of the velocities of the two bodies.

Reason: Some times relative velocity between two bodies is equal to difference in velocities of the two.

1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A

3) A is true but R is false
4) A is false, but R is true Key:2

4) Assertion: Force is required to move a body uniformly along a circle.
Reason: When the motion is uniform acceleration is zero
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true, but R is false
4) A is false, but R is true Key:3

5) Let v and 'a' denote the velocity and acceleration respectively of a body
a) 'a' can be zero when v=0
b) 'a' must be zero when v=0
c) 'a' may be zero when $v \neq 0$
d) 'a' and v may be $\perp$ to each other
1) a & c are true
2) a, c & d are true
3) all are true
4) a & d are true Key:2

6) Assertion: The path of a projectile is a parabola
Reason: Because the particle moves in a plane with constant acceleration in a direction different from its initial velocity.
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A and R are false Key: 1

7) Assertion: Two bodies of different masses are dropped simultaneously from the top of a tower . If air resistance is proportional to the mass of the body, then heavier body reaches the ground earlier.
Reason: Because the net force on the heavier body is more
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A and R are false Key: 1

8) Assertion: To reach the same height on the moon as on the earth, a body must be projected up with lesser velocity on the moon
Reason: Because the acceleration due to gravity on moon is less than that on the earth.
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A and R are false Key:1

9) Assertion: Acceleration of a body can be nonzero when its velocity is zero
Reason: when a body is projected vertically up at any point in its path force acting on the body is equal to its weight.
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A and R are false Key:2

Previous Eamcet Questions:

1. A body of mass 2kg is thrown up vertically with kinetic energy of 490 J. If g = $9.8 m/s^2$, the height at which the kinetic energy of the body becomes half of the original value, is
   1) 50m 2) 25m 3) 12.5m 4) 19.6m (2007M)
2. The apparent weight of a person inside a lift is w_1 when lift moves up with a certain acceleration and is w_2 when lift moves down with same acceleration. The weight of the person when lift moves up with constant speed is (2007M)
   1) $\frac{w_1 + w_2}{2}$ 2) $\frac{w_1 - w_2}{2}$ 3) $2w_1$ 4) $2w_2$
3. A rifle of 20kg mass can fire 4 bullets per second. The mass of each bullet is 35×10^{-3}kg and its final velocity is $400 ms^{-1}$. Then what force must be applied on the rifle so that it does not move backwards while firing the bullets? (2007E)
   1) 80N 2) 28N 3) –112N 4) –56N
4. A motor is used to deliver water at a certain rate through a given horizontal pipe. To deliver n times the water through the same pipe in the same time the power of the motor must be increased as follows (2006E)
   1) n –times 2) n^2 –times 3) n^3 –times 4) n^4 –times
5. A bullet of mass 10gm is fired horizontally with a velocity $1000 ms^{-1}$ from a rifle situated at height 50m above the ground. If the bullet reaches the ground with a velocity $500 ms^{-1}$, the work done against air resistance in the trajectory of the bullet is (in joules) (2006E)
   1) 5005 2) 3755 3) 3750 4) 17.5
6. A man of 50kg is standing at one end on a boat of length 25m and mass 200kg. If he starts running and when he reaches the other end he was a velocity $2 ms^{-1}$ with respect to the boat. The final velocity of the boat is (in ms^{-1}) (2006E)
   1) $\frac{2}{5}$ 2) $\frac{2}{3}$ 3) $\frac{8}{5}$ 4) $\frac{8}{3}$
7. A body of density 'D' and Volume 'V' is lifted through height 'h' in a liquid of density 'd' (<D). The increase in potential energy of the body is: (2005M)
   1) V(D –d)hg 2) VDgh 3) Vdgh 4) V(D+d)gh
8. A machine gun fires 240 bullets per minute. If the mass of each bullet is 10g and the velocity of the bullets is $600 ms^{-1}$ the power (in kW) of the gun is (2005E)
   1) 43200 2) 432 3) 72 4) 7.2
9. A block of mass 2kg is initially at rest on a horizontal frictionless surface. A horizontal force $\bar{F} = (9 - x^2)\, l$ newtons acts on it, when the block is at x = 0. The maximum kinetic energy of the block between x = 0 and x =3 m in joules is:
   1) 24 2) 20 3) 18 4) 15 (2004E)
10. A body of mass 'm' has a kinetic energy equal to one-fourth kinetic energy of another body of mass $\frac{m}{4}$. If the speed of the heavier body is increased by 4 m/s, its new kinetic energy equals the original kinetic energy of the lighter body. The original speed of the heavier body in m/s is (2003M)
    1) 8 2) 6 3) 4 4) 2

Key: 1)3 2)1 3)4 4)3 5)2 6)1 7)1 8)4 9)3 10)3

1. **COLLISIONS:-** collision is an interaction between two or more bodies in which sudden changes of momentum takes place.
2. Collisions are of two types (a) Elastic b) Inelastic
3. a) In perfect Elastic collisions K.E. and linear momentum are conserved, total energy is constant, bodies will not be deformed, and the temperature of the system does not change.
4. In an inelastic collision, liner momentum is conserved, K.E. is not conserved, total energy is conserved, temperature changes and the bodies may be deformed.
5. The collision between a bullet and a target is perfectly inelastic if the bullet remains embedded in the target.
6. For on dimensional collision between two bodies total momentum before collision=total momentum after collision.
7. the ratio between relative velocity of separation after collision and relative velocity of approach before collision is called coefficient of restitution.
8. In most of the inelastic collisions there will be a loss in K.E. of the system.
9. when perfect elastic collision takes place between two bodies in one dimension, the two bodies interchange their velocities after collision.
10. When a lighter body collides with a stationary heavy body elastically, the second body starts moving with the velocity of the first body and the first body comes to rest.
11. When a heavy body collides elastically with a stationary lighter body, then heavy body continues to move with same velocity but the lighter body starts moving with double the velocity of the heavy body.
12. When a lighter body collides with a heavy body at rest, then it returns with the same velocity but heavy body remains at rest.
13. A ball is dropped from certain height . if the collision is perfectly elastic, it rebounds to the same height.
14. Ballistic pendulum is used to measure the velocity of the bullet in the case of inelastic collision.
15. The ability or tendency of a body to impart motion to other bodies is its linear momentum.
16. if the energy lost in one direction is regained in the reverse direction, then the force acting on the body is called a conservative force.
    Ex:- Gravitational, Electrical force etc.
17. If the energy lost in one direction cannot be regained in the reverse direction, then the force acting on the body is called a non-conservative force. Ex:- Frictional force.

FORMULAE

18. Linear momentum $\vec{p} = m\vec{v}$
19. The amount of force required to hold the gun in position is F= nmv/t
    where n is the number of bullets fired. In 't' seconds and 'm' is the mass of each bullet.
20. Force = Rate of change of momentum .
    i) $\vec{F} = d\vec{p}/dt = d/dt(mv)$
    ii) $\vec{F} = m\,d\vec{v}/dt$ (for constant mass system)

iii) $\vec{F} = [dm/dt]\, \vec{v}$ (for variable mass system)

21. Force required to stop a car of mass 'm' moving with a velocity 'v' in a distance 's' is $f= mv^2/2s$. if the car is stopped in time 't' then $f= mv/t$.
22. For one dimensional collision between two bodies having masses m_1 and m_2 traveling in the same direction with initial velocities u_1 and u_2 respectively.
    i) The conservation of linear momentum is $m_1u_1+m_2u_2=m_1v_1+m_2v_2$
    ii) If the bodies are moving in opposite directions then $m_1u_1-m_2u_2=m_1v_1+m_2v_2$
    iii) After the collision if the two bodies travel with a common velocity 'v' then $m_1u_1+m_2u_2=(m_1+m_2)V$
    iv) If the second body is at rest then $m_1u_1=m_1v_1+m_2v_2$. where $v_1$and v_2 are the initial and final velocities after collision.
23. If M is the mass of the gun and V recoil velocity ,m is the mass of the bullet and v its velocity after firing $M\vec{V}=mv$. $\Rightarrow Mv-mv=0$
    (-ve sign indicates V and v are in opposite direction)
24. Even though the momentum of the gun and the bullet are equal, their K.E., are not equal
    i) for bullet K.E. is $K_1= ½\, mv^2$
    ii) For gun K.E. is $K_2 = ½\, Mv^2$
25. Coefficient of restitution for one dimensional collision between two bodies. $e =V_2– V_1/ u_1-u_2$
    i) e=1 for perfectly elastic collision
    ii) e=0 for perfect inelastic collision iii) $0<e<1$ for semi elastic collision
26. When a body be dropped from a height 'h' then $v^2=2gh \Rightarrow h=v^2/2g$. if e is the coefficient of restitution, it rebounds to a height e^2h. After hitting the ground n th time it rebounds to a height $h_n=e^{2n}h$. While it rebounds its velocity from ground is $e^n.\sqrt{2gh}$
27. A ball is dropped from a height h_1 after hitting the ground if it rebounds to a height h_2 then $e=\sqrt{h_2/h_1}$
28. for perfect elastic collision between two bodies which is head on .
    i) $m_1u_1+m_2u_2=m_1v_1+m_2v_2$ and $½\, m_1u_1^2+1/2m_2u_2^2=1/2m_1v_1^2+1/2m_2v_2^2$
29. $V_1 = \left(\frac{m_1-m_2}{m_1+m_2}\right)u_1 + \left(\frac{2m_2}{m_1+m_2}\right)u_2$

30. $V_2 = \left(\frac{m_2-m_1}{m_1+m_2}\right)u_2 + \left(\frac{2m_1}{m_1+m_2}\right)u_1$

31. If $m_1=m_2=m$; $v_2=u_1$ and $v_1=u_2$ 32) If the second body is at rest ; $u_2=0$

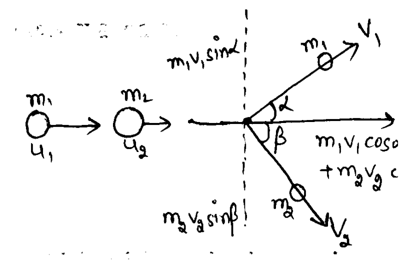
33) If $m_1=m_2=m$, then $v_2=u_1$ and $v_1=0$ 34) if $m_2>> m_1$, then $v_1=-u_1$ and $v_2=0$

35) if $m_1> m_2$, then $v_1=-u_1$ and $v_2=-2u_1$

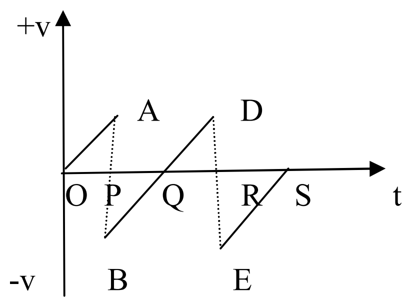
1) For perfect elastic collision between a moving body m1 and stationary body m2 fraction of k.E. transferred to second body is $4m_1m_2 / (m_1+m_2)^2$

   Fraction of k.E. retained by the first body is $\left(\frac{m_1-m_2}{m_1+m_2}\right)^2$

1. If a body of mass m_1 collides with a body of mass m_2 at rest and the collision is perfectly inelastic final K.E / initial K.E. $= m_1/m_1+m_2$
2. If K is initial K.E. of m_1; then loss in K.E. $= K\,[m_2/m_1+m_2]$
   Fractional loss in K.E. is $[\ 1/1+m_1/m_2]$
3. For two dimensional collision. (oblique) from conservation of momentum
   $m_1u_1+m_2u_2=m_1v_1 \cos \propto +m_2V_2\cos \beta$
   $m_1u_1+m_2u_2= m_1v_1\sin\alpha-m_2V_2\sin_\beta$



- a) the velocity – time graph of a ball freely falling from a height and undergoing elastic collisions with the floor is as follows:



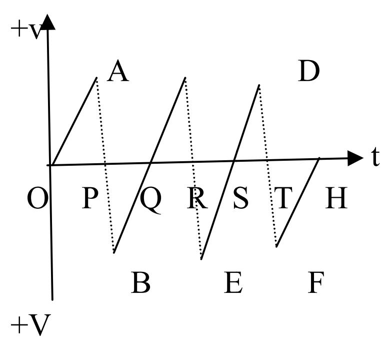
OA, QD: Desent, BQ, ES: Ascent

OP, QR: Time of Desent

PQ, RS: Time of Ascent

AB, DE: during collision with the floor any direction of the velocity charges, without charge in magnitude.

b) In elastic collisions with the floor:



After successive collisions, the ball comes to rest in the case of in elastic collisions.

QUESTION BANK

Numerical Problems

1) A sphere of mass 2Kg strikes another sphere of mass 3Kg at rest with a velocity of $5ms^{-1}$. If they move together after collision, then common velocity is
   1) $1ms^{-1}$ 2) $2ms^{-1}$ 3) $4ms^{-1}$ 4) 0
2) Two bodies of masses 2kg and 8kg have kinetic energies 16J and 9J respectively, when they are moving in the same direction. They collide each other. The total momentum after collision is
   1) $20Kgms^{-1}$ 2) $2Kgms^{-1}$ 3) $40Kgms^{-1}$ 4) $4Kgms^{-1}$
3) A moving body with mass ' m_1'collides another body of mass ' m_2' elastically. After collision the velocity of first body becomes 2/3 of its initial value. Then the ratio of m_1 and m_2 is
   1) 1:5 2) 5:1 3) 25:1 4) 1:25
4) A bullet moving with a speed of 200 ms^{-1} strikes a bag of sand and remains in it. The masses of bag and bullet are 4.5Kg and 500g respectively. If the sand bag is free to move, its speed is
   1) $5ms^{-1}$ 2) $10ms^{-1}$ 3) $20ms^{-1}$ 4) $40ms^{-1}$
5) A 6kg mass collides with a body at rest. After collision they travel together with a velocity equal to one third of the velocity of 6Kg mass. The mass of second body is
   1) 6kg 2) 3kg 3) 12kg 4) 18kg
6) A body of mass 2Kg moving with uniform velocity of $40ms^{-1}$ collides with another body at rest. If the two bodies move together with a velocity of $25ms^{-1}$, mass of the other body is
   1) 0.6Kg 2) 0.9Kg 3) 1.2Kg 4) 1.5Kg
7) A body of mass 6Kg travelling with a velocity of $10ms^{-1}$ collides elastically with a body of mass 4kg travelling at a speed of $5ms^{-1}$ in opposite direction and comes to rest. Then velocity of the second body is
   1) 0 2) $6ms^{-1}$ 3) $8ms^{-1}$ 4) $10ms^{-1}$
8) A body of mass 20Kg moving with a velocity of $20ms^{-1}$ collides with another body of mass 40Kg moving in the same direction with a velocity of 10ms-1. After collision, if they move together , their common velocity is
   1) 10/3 ms^{-1} 2) 20/3 ms^{-1} 3) 40/3 ms^{-1} 4)50/3 ms^{-1}
9) A sphere of mass '2m' gm collides with a stationary sphere of '3m' gm and sticks to it. Then the loss in Kinetic energy during collision is
   1) 80% 2) 60% 3) 40% 4) 20%
10) A body of mass 20gm moving with $20cms^{-1}$ collides and coalesces with another body moving in the same direction with a velocity of $5cms^{-1}$. After the collision the combined mass moves with a velocity of $10cms^{-1}$, then mass of the second body is
    1) 10gm 2) 20gm 3) 30gm 4) 40gm
11) Two spheres of masses 2kg and 3kg travelling in opposite direction with velocities $8ms^{-1}$ and $6ms^{-1}$ collide. If the collision is perfectly elastic, then final velocities are
    1) $-8.8ms^{-1}$, $2.5ms^{-1}$ 2) $-8.8ms^{-1}$, $5.2ms^{-1}$
    3) $8.8ms^{-1}$, $-5.2ms^{-1}$ 4) $-8.8ms^{-1}$, $-5.2ms^{-1}$
12) A ball with a mass of 0.4kg travelling with a velocity of $3ms^{-1}$ collides a stationary ball of mass $6ms^{-1}$ collide. If the collision is perfectly elastic, then final velocities are
    1) $2.4ms^{-1}$, $2.5ms^{-1}$ 2) $-2.4ms^{-1}$, $0.6ms^{-1}$

3) $0.6ms^{-1}$, $2.4ms^{-1}$ 4) $0.6ms^{-1}$, $-2.4ms^{-1}$

13) A block of mass 200Kg approaches a man with a velocity of $10ms^{-1}$. He fires bullets each of mass 10gm with a velocity of $200ms^{-1}$. The number of bullets he must fire at it make the block just turn back is

1) 1000 2) 100 3) 10 4) 1

14) A body of mass 'm_1' moves with a velocity of $40ms^{-1}$ hits another body of mass 'm_2' which is at rest . After the impact both the bodies move with common velocity of $30ms^{-1}$. The ratio of their masses is

1) 1:3 2) 2:1 3) 3:1 4) 9:1

15) A body of mass m_1 moving at a constant speed undergoes an elastic collision with a body of mass m_2 initially at rest. The ratio of the kinetic energy of mass m_1 after the collision to that before the collision is

1) $[m_1-m_2/m_1+m_2]^2$ 2) $[m_1+m_2/m_1-m_2]^2$

3) $[2m_1/m_1+m_2]^2$ 4) $[2m_2/m_1+m_2]^2$

16) A body of mass m_1 moving at a constant speed undergoes an elastic collision with a body of mass m_2 initially at rest. The ratio of the kinetic energies of masses m_2 and m_1 after the collision is

1) $m_1m_2/(m_1-m_2)^2$ 2) $\sqrt{2}m_1m_2/(m_1-m_2)^2$

3) $2m_1m_2/(m_1-m_2)^2$ 4) $4m_1m_2/(m_1-m_2)^2$

17) A 50gm ball collides with another ball of mass 150gm moving in its direction of motion. After collision the two balls move at an angle 300 with their initial direction. Ratio of their velocities after collision is

1) 3:1 2) 1:3 3) 2:3 4) 1:1

18) A ball moving with a velocity $12ms^{-1}$ strikes an identical ball at rest. After collision both balls move in direction making 30^0 with original direction of motion. Speeds of the balls after collision are (in ms^{-1})

1) $4\sqrt{3}$, $3\sqrt{5}$ 2) $4/\sqrt{3}$, $3/\sqrt{5}$ 3) $5\sqrt{3}$, 3 4) $4\sqrt{3}$, $4\sqrt{3}$

19) A target of mass M is moving with a velocity U. Shots each of mass m are fired at it in opposite direction with velocity V. The number of bullets required to stop it is

1) MU/mV 2) mV/Mu 3) (M+m)U/V 4) mU/(M+m)V

20) A body of mass 2Kg moving with a velocity (i+2j-3k)ms^{-1} collides with another body of mass 3Kg moving with a velocity (2i+j+k) in ms^{-1}. If they stick together, the velocity in ms-1 of the composite body is

1) $\frac{1}{5}$ (8i+7j-3k) 2) $\frac{1}{5}$ (-4i+J-3k)

3) $\frac{1}{5}$ (8i+j-k) 4) $\frac{1}{5}$ (-4i+7j-3k)

21) A sphere of mass 3kg having a velocity of $4ms^{-1}$ hits another sphere of mass 4Kg moving with a velocity of $2ms^{-1}$ in the opposite direction. After the collision they stick each other, and move with common velocity. Their total initial momentum of the system is

1) $4x10^{-2}Kgms^{-1}$ 2) $4Kgms^{-1}$ 3) $4x10^{11}Kgms^{-1}$ 4) $4x10^{2}Kgms^{-1}$

22) A ball moving with a speed of $9ms^{-1}$ strikes an identical stationary ball such that after collision the direction of each ball makes an angle of 30^0 with the original line of motion. The speeds of the two balls after collision are respectively

1) $3\sqrt{3}ms^{-1}$, $3ms^{-1}$ 2) $3ms^{-1}$, $3\sqrt{3}ms^{-1}$ 3) $3ms^{-1}$, $3ms^{-1}$ 4) $3\sqrt{3}ms^{-1}$, $3\sqrt{3}ms^{-1}$

23) A moving particle of mass m makes a head on elastic collision with a particle of mass2m which is initially at rest. The fraction of the initial kinetic energy lost by the colliding particle

1) 1/9 2) 2/9 3) 4/9 4) 8/9

24) A bullet of mass $4x10^{-2}$Kg fired with a speed of $802ms^{-1}$ hits a block of 16Kg which is at rest. The loss in kinetic energy if the common speed of the block and the bullet is $2ms^{-1}$

1) 1283.2J 2) 128.32J 3) 12.832J 4) 12832J

25) A tennis ball is thrown from a height 'h' with an initial downward velocity 'u' . It rebounces back to the same height after losing half of its K.E . The value of 'u' is

1) $\sqrt{gh}$ 2) $\sqrt{3gh}$ 3) $\sqrt{2gh}$ 4) $\sqrt{4gh}$

26) A neutron travelling with a certain velocity and K.E E collides perfectly elastically head on with the nucleus of an atom of mass number A at rest. The fraction of the initial energy retained by neutron is

1) $[A-1/A+1]^2$ 2) $[A+1/A-1]^2$ 3) $[A-1/A]^2$ 4) $[A+1/A]^2$

27) In the above problem, the fraction of energy lost by neutron (or transferred to the nucleus) is

1) $4A/(A-1)^2$ 2) $(A-1)^2/4A$ 3) $4A/(A+1)^2$ 4) $(A+1)^2/4A$

28) A gun of mass 10Kg fires a bullet of 10gm mass with a muzzle velocity of $200ms^{-1}$. Recoil velocity of the gun is

1) $0.1ms^{-1}$ 2) $0.2ms^{-1}$ 3) $0.4ms^{-1}$ 4) $0.8ms^{-1}$

29) A proton and a neutron of equal masses collide elastically together to form deutron. The initial velocities of proton and neutron in the opposite directions are $7x10^6ms^{-1}$ and $4x10^6ms^{-1}$ respectively. The velocity of deutron is

1) $3x10^8ms^{-1}$ 2) $3x10^{10}ms^{-1}$ 3) $3x10^6ms^{-1}$ 4) $3x10^4ms^{-1}$

30) A neutron of mass $1.67x10^{-27}$kg moving with a speed of $3x10^6ms^{-1}$ collides with a deutron of mass $3.34x10^{-27}$Kg at rest. After collision they both stick together and form a triton. Velocity of triton is

1) 10^6ms^{-1} 2) 10^5ms^{-1} 3) 10^4ms^{-1} 4) 10^7ms^{-1}

31) 5 bullets each of mass 200gm are fired with a velocity of $10ms^{-1}$ into a block of mass 3kg at rest in quick succession. If the bullets are embedded in it, the block moves with a velocity of

1) $10ms^{-1}$ 2) $20ms^{-1}$ 3) $2.5ms^{-1}$ 4) $2ms^{-1}$

32) Five bodies of masses m, 2m, 3m, 4m, 5m moving with velocities V, 2V, 3V, 4V, 5V in the same direction collide among themselves and stick together. Their common velocity is

1) $11/3\ ms^{-1}$ 2) $11V/3\ ms^{-1}$ 3) $22V/3\ ms^{-1}$ 4) $22/3\ ms^{-1}$

33) A man and a cart approach each other. Mass of the man is 64Kg and his velocity is 5.4Kmph. Mass of the cart is 32Kg and its velocity is 1.8Kmph. If the man jumps into the cart, the velocity of the cart becomes

1) 3Kmph 2) 30Kmph 3) 1.8Kmph 4) 5.4Kmph

34) A ball of mass 2Kg is fired from a canon of mass 198Kg. Velocity of ball relative to cannon is $50ms^{-1}$. Then recoil velocity of the canon is

1) $2ms^{-1}$ 2) $1ms^{-1}$ 3) $0.5ms^{-1}$ 4) $0.25ms^{-1}$

35) A body of mass 10Kg collides elastically with a stationary body of mass of 4Kg. The initial kinetic energy of the first body is E. The amount of K.E left over with the first body is

1) 3/7 E 2) 4/7 E 3) 9/49 E 4) 40/49 E

36) A neutron moving with a speed of $108ms^{-1}$ suffers, a head on collision with a nucleus of mass number 80. The fraction of energy retained by nucleus is

1) $(79/81)^2$ 2) $(81/79)^2$ 3) (79/81) 4) 89/71

37) A bullet of mass m is fired with a velocity V_1 at a body of mass M moving in opposite direction with velocity V_2. The bullet perforates the body and emerges with a velocity V. The subsequent velocity of the body is

1) V_2-m(V_1-V)/M 2) V_2+M(V_1-V)/m

3) (V-V_1)m/M-V_2 4) V_2+(V-V_1)M/m

Keys

1) 2	2) 1	3) 2	4) 3	5) 3	6) 3	7) 4	8) 3	9) 2	10) 4
11) 2	12) 3	13) 1	14) 3	15) 1	16) 4	17) 1	18) 4	19) 1	20) 1
21) 2	22) 4	23) 4	24) 4	25) 3	26) 1	27) 3	28) 2	29) 3	30) 1
31) 3	32) 2	33) 1	34) 3	35) 3	36) 1	37) 3			

Coefficient of Restitution

38) A body of mass 4Kg having with a velocity of $9ms^{-1}$ collides directly with a body of 8Kg at rest The coefficient of restitution is 0.33. After collision the velocity of the body having mass 4Kg is

1) $1ms^{-1}$ 2) $4ms^{-1}$ 3) $6ms^{-1}$ 4) $9ms^{-1}$

39) A block of mass$2x10^3$gm moving at $2x10^2$ ms^{-1} collides with another block of same mass at rest. If actual loss of K.E is one fourth of the maximum then the coefficient of restitution is

1) √2 2) 1/√2 3) 2 4) ½

40) A body falls from a height 'h' on a horizontal surface and rebounds. Then it falls again and again rebounds and so on. If the restitution coefficient is 1/3, the total time taken by the body to come to rest is

1) √2h/g 2) 2√2h/g 3) 3√2h/g 4) 4√2h/g

41) A body of mass 1Kg moving with velocity $5ms^{-1}$ collides with another of mass 2Kg moving with velocity $1.5ms^{-1}$ in opposite direction. If the coefficient of restitution is 0.8, their velocities after collision is

1) $-2.8ms^{-1}$, $2.4ms^{-1}$ 2) $-1.4ms^{-1}$, $1.2ms^{-1}$ 3) $-3ms^{-1}$, $3.5ms^{-1}$ 4) 0, $6.5ms^{-1}$

42) A ball of mass 4Kg moving with a velocity $3ms^{-1}$ collides with another ball of mass 10Kg moving in the same direction with $1ms^{-1}$. The loss in the K.E when coefficient of restitution is 0.5 is

1) 4.286J 2) 0.4286J 3) 42.86J 4) 428.6J

43) Two balls have masses in ratio 2:1. Their velocities are in the ratio of 1:2. The coefficient of restitution is 5/6. Then the final velocity of each ball is

1) 5/6 of its initial velocity 2) 6/5 of its initial velocity

3) 25/36 of its initial velocity 4) 36/25 of its initial velocity

44) A ball is dropped from a height H on the ground. If the coefficient of restitution is e, the height to which the ball goes up after it rebounds for the n^{th} time is

1) He^{2n} 2) He^n 3) e^{2n}/H 4) H/e^{2n}

45) A ball is dropped from a height 10m above the ground. If the coefficient of restitution between the ground the ball is 0.7, the height to which the ball rebounds

1) 7m 2) 4.9m 3) 3m 4) 5.1m

46) A ball is dropped from a height of 1m. If the coefficient of restitution is 0.6, the ball rebounds to a height of

1) 0.6m 2) 0.4m 3) 0.16m 4) 0.36m

47) A sphere of mass m moving with a constant velocity hits another stationary sphere of the same mass. If e is the coefficient of restitution, then the ratio of the velocities of the two spheres after collision will be

1) 1-e/1+e 2) 1+e/1-e 3) e/1-e 4) e/1+e

48) A ball A moving with a speed u, collides directly with another similar ball B moving with a speed V in the opposite direction. A comes to rest after the collision. If the coefficient of restitution is e then u/v is

1) 1-e/1+e 2) 1+e/1-e 3) e/1-e 4) e/1+e

49) A 1kg ball falls vertically onto the floor with a speed of $25ms^{-1}$. It rebounds with a speed of $10ms^{-1}$. Then coefficient of restitution is

1) 0.8 2) 0.6 3) 0.5 4) 0.4

50) A ball is dropped from a height H. After striking the ground n^{th} time it rebounds to height h. Then coefficient of restitution is

1) $(h/H)^{1/n}$ 2) $(H/h)^{1/n}$ 3) $[\sqrt{H/h}]^{1/n}$ 4) $[\sqrt{h/H}]^{1/n}$

51) A ball of mass 0.2Kg is dropped from height h and after hitting the ground it rebounds to 0.64m. If coefficient of restitution is 0.8, the value of h=

1) 1.2m 2) 1m 3) 0.81m 4) 0.9m

Key

38) 1 39) 2 40) 2 41) 1 42) 1 43) 1 44) 1 45) 2 46) 4 47) 1
48) 1 49) 4 50) 4 51) 2

Explosion

52) A bomb shell explodes into 3 pieces having masses 1kg , 2kg and m kg respectively. The 2kg and 1kg masses fly off with velocities $8ms^{-1}$ and $12ms^{-1}$ along Y and X-axes respectively. The third one flies off with speed of $40ms^{-1}$. The total mass of the shell is

1) 0.35Kg 2) 3.5Kg 3) 45Kg 4) 0.45Kg

53) A bomb of mass 9Kg initially at rest, explodes into two pieces of massess 3Kg ands 6Kg. Kinetic energy of 3Kg mass is 216J. Then kinetic energy of the 6Kg mass is

1) 216J 2) 108J 3) 432J 4) 54J

54) A bomb of mass 5Kg explodes into two pieces. A piece of mass 2Kg flies of with a velocity $60ms^{-1}$. The second piece of mass 3Kg flies off with a velocity 'V' in

1) $80ms^{-1}$ 2) $40ms^{-1}$ 3) $8ms^{-1}$ 4) $4ms^{-1}$

55) A stationary body of mass m explodes into 3 parts having masses in the ratio 1:3:3. Its two fractions having equal mass move at right angles to each other with $15ms^{-1}$. Then velocity of the third piece is

1) $\sqrt{2}ms^{-1}$ 2) $5ms^{-1}$ 3) $5\sqrt{32}ms^{-1}$ 4) $45\sqrt{2}ms^{-1}$

56) A ball of mass 10Kg moving with velocity of $10ms^{-1}$ suddenly bursts into two pieces. One piece of mass 6Kg moves in the same direction with a velocity of $18ms^{-1}$. The other piece moves with a velocity of

1) $2ms^{-1}$ 2) $-2ms^{-1}$ 3) $-1ms^{-1}$ 4) $4ms^{-1}$

57) A body of mass 1Kg at rest explodes and breaks into three fragments of masses in the ratio 1:1:3. Two pieces of equal mass fly off perpendicular to each other with a speed of $30ms^{-1}$ each. The velocity of the heavier fragment is

1) $10ms^{-1}$ 2) $10\sqrt{2}ms^{-1}$ 3) $20ms^{-1}$ 4) $30ms^{-1}$

Key

52) 2	53) 2	54) 2	55) 4	56) 2	57) 2

Previous Eamcet Questions

58) A body of mass m_1 moving with a velocity $10ms^{-1}$ collides with another body at rest of mass m_2. After collision the velocities of the two bodies are $2ms^{-1}$ and $5ms^{-1}$ respectively along the direction of motion of m_1. The ratio m_1/m_2 is (Eamcet 2000E)

1) 5/12 2) 5/8 3) 3/5 4) 12/5

59) A gun of mass 10Kg fires four bullets per second. The mass of each bullet is 20g and the velocity of the bullet when it leaves the gun is $300ms^{-1}$. The force required to hold the gun while fringe is (Eamcet 2000M)

1) 6N 2) 8N 3) 24N 4) 240N

60) A particle falls from a height 'h' upon a fixed horizontal plane and rebounds. If 'e' is the coefficient of restitution, the total distance travelled before rebounding has stopped is (Eamcet 2001E)

1) $h[1+e^2/1-e^2]$ 2) $h[1-e^2/1+e^2]$

3) $\frac{h}{2}[1-e^2/1+e^2]$ 4) $\frac{h}{2}[1+e^2/1-e^2]$

61) A body 'A' experiences perfectly elastic collision with a stationary body 'B'. If after collision the bodies fly apart in the opposite directions with equal velocities, the mass ratio of 'A' and 'B' is (Eamcet 2001M)

1) ½ 2) 1/3 3) ¼ 4) 1/5

62) A body of mass 2Kg and 10gm moving of $6ms^{-1}$ strikes inelastically another body of same mass at rest. The amount of heat evolved during collision is (Eamcet 2002M)

1) 36J 2) 18J 3) 9J 4) 3J

63) Two bullets of masses 5gm and 10gm moving with velocities $10ms^{-1}$ and $5ms^{-1}$ respectively strike and penetrate into a fixed wooden block and come to rest. Then the ratio of their respective distances moved in the block before coming to rest is (Eamcet 2002M)

1) 1:2 2) 1:4 3) 4:1 4) 2:1

64) A 2kg ball moving at $24ms^{-1}$ undergoes inelastic head –on collision with a 4kg ball moving in the opposite direction at $48ms^{-1}$. If the coefficient of restitution is 2/3, (Eamcet 2004E)

1) –56, -8 2) –28, -4 3) –14, -2 4) –7, -1

65) A body 'x' with a momentum 'P' collides with another identical stationary body 'y' one dimensionally . During the collision 'y' gives an impulse 'j' to the body 'x'. Then the coefficient of restitution is (Eamcet 2004 M)

1) $\frac{2J}{P} - 1$ 2) $\frac{J}{P} + 1$ 3) $\frac{J}{P} - 1$ 4) $\frac{J}{2P} - 1$

Key

58) 2 59) 3 60) 1 61) 2 62) 2 63) 4 64) 1 65) 1

Matching Type Questions

66) Match the following:

List-I	List-II
a) Impulse	e) elastic collision
b) coefficient of restitution	f) change in momentum
c) conservation of momentum	g) $\frac{\text{relative velocity of seperation}}{\text{relative velocity of approach}}$
d) conservation of kinetic energy	h) internal forces

The correct match is

1) a→h; b→g; c→f; d→e 2) a→f; b→g; c→h; d→e
3) a→e; b→f; c→g; d→h 4) a→e; b→g; c→f; d→h

67) Match the following:

List-I	**List-II**
a) Rocket propulsion	e) oxyaccetalyne
b) Subatomic particles	f) conservation of momentum
c) collision between billiard balls	g) collision
d) momentum transfer	h) elastic collision

The correct match is

1) a→h; b→g; c→f; d→e 2) a→f; b→g; c→h; d→e
3) a→e; b→h; c→f; d→g 4) a→e; b→g; c→f; d→h

68) Match the following

List-I	List-II
a) Elastic collision	e) e=0
b) Inelastic collision	f) 0<e<1
c) Explosion	g) e=1
d) Plastic collision	h) Final K.E>Initial K.E

The correct match is

1) a→e; b→f; c→g; d→h 2) a→g; b→e; c→f; d→h
3) a→h; b→g; c→f; d→e 4) a→g; b→f; c→h; d→e

69) Match the following

List-I	List-II
a) When m_1=m_2	e) The smaller body moves with a velocity
b) Heavier body moving a velocity 'U' collides a smaller body at rest	f) Inelastic collision
c) Smaller body moving with a velocity 'U' collides heavier body at rest.	g) Coefficient of restitution 0.5
d) Explosion of a bomb at rest	h)Smaller body rebounds with same velocity
	i)They exchange their velocities

The correct match is

1) a→e; b→i; c→h; d→f 2) a→i; b→e; c→f; d→g
3) a→i; b→e; c→h; d→f 4) a→g; b→i; c→f; d→g

70) Match the following

List-I	List-II
a) Impulse	e) Area under f-t graph
b) $[m_1-m_2/(m_1+m_2)]^2$	f) elastic collision between similar bodies
c) $4m_1m_2/(m_1+m_2)^2$	g) fraction of K.E retained in an elastic
d) Interchange of velocities	h) fraction of K.E transfer in an elastic collision

The correct match is

1) a→h; b→g; c→f; d→e 2) a→f; b→g; c→h; d→e
3) a→e; b→f; c→h; d→g 4) a→e; b→g; c→h; d→f

71) Match the following

List-I	List-II
a) $\frac{m_1m_2}{(m_1+m_2)^2}(1+e)^2$	e) Perfectly inelastic collision
b) $[m_1-m_2/m_1+m_2]^2$	f) Ratio of final velocities if $m_1=m_2$ and m_2 is at rest initially.
c) Two bodies move together after collision	g) Perfectly elastic collision and energy retained by m_1 if m_2 is at rest initially.
d) 1-e/1+e	h) Energy retained by m_1 when m_2 is at rest
	i) Fraction of energy transferred to m_2 if it is initially at rest

The correct match is

1) a→i; b→g; c→e; d→f 2) a→h; b→g; c→e; d→f
3) a→g; b→i; c→e; d→f 4) a→g; b→h; c→f; d→e

Key

66) 2	67) 3	68) 4	69) 3	70) 4	71) 1

Order Arranging Type Questions

72) Arrange the coefficient of restitution in following cases in ascending order.

a) Collision between atomic and rests atomic particles
b) Bullet embedded in the wooden block in case of ballistic pendulum.
c) A body dropped from a height of 4m rises to a height of 1m after collision.
d) A body moving with initial velocity $10ms^{-1}$ strikes with another identical body at rest. After collision first body comes to rest and second body moves with a velocity of $20ms^{-1}$.

1) $b<c<a<d$ 2) $c<b<a<d$ 3) $a=d<c<b$ 4) $b<c<a=d$

73) Write the ascending order of loss of K.E during collision from the following cases.

a) A ball dropped from a height h rises to same height after collision.
b) A ball dropped from a height h rises to height h/2.
c) A ball dropped from a height h rises to height h/4.

1) $c<a<b$ 2) $b<a<c$ 3) $a<c<b$ 4) $b<c<a$

Key

72) 2 73) 3

Assertion And Reason Type Questions

Directions:

These Questions consist of two statements as Assertion and Reason. While answering these questions you are required to choose any of the following four responses.

A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B) If both Assertion and Reason are true, but Reason is correct explanation of the Assertion.

C) If Assertion is true, but the Reason is false.

D) If Assertion is false, but the Reason is true.

74) A: Collision between two particles is not necessarily associated with physical contact between them.
R: Only in physical contact momentum transfer takes place.
1) A 2) B 3) C 4) D

75) A: In any collision momentum is conserved.
R: Collision is associated with internal forces only.
1) A 2) B 3) C 4) D

76) A: Collision between two fundamental particles is elastic.
R: Fundamental particles lose their shape in collision.
1) A 2) B 3) C 4) D

77) A: Usually the collisions between macroscopic bodies are partially elastic.
R: Perfectly rigid bodies are absent in nature.
1) A 2) B 3) C 4) D

78) A: A quick collision between two bodies is more violent than slow collision, even when initial and final velocities are identical.
R: The rate of change of momentum determine that force is small or large.
1) A 2) B 3) C 4) D

79) A: For any collision, coefficient of restitution lies between 0 and 1.
R: Collision may be elastic or inelastic.
1) A 2) B 3) C 4) D

80) A: In an inelastic collision K.E is not conserved.
R: For an inelastic collision body permanently deforms.
1) A 2) B 3) C 4) D

81) A: In an elastic collision K.E is also conserved along with momentum.
R: There is almost no deformation during elastic collision.
1) A 2) B 3) C 4) D

82) A: If two bodies of equal masses undergo elastic collision in one dimension, then after the collision, the bodies will exchange their velocities.
R: In elastic collision velocity of approach is equal and opposite to velocity of separation.
1) A 2) B 3) C 4) D

83) A: Linear momentum is conserved in both elastic and inelastic collisions.
R: Total energy is conserved in all such collisions.
1) A 2) B 3) C 4) D

Key

74) 3 75) 1 76) 3 77) 1 78) 1 79) 1 80) 1 81) 1 82) 2 83) 2

Previous Eamcet Questions:

1. A sphere of mass 'm' moving with constant velocity u, collides with another sphere of same mass. If 'e' is the coefficient of restitution, the ratio of final velocities of the first and second spheres is (2007M)

   1) $\frac{1+e}{1-e}$ 2) $\frac{1-e}{1+e}$ 3) $\frac{e}{1-e}$ 4) $\frac{1+e}{e}$

2. In two separate collisions, the coefficient of restitutions e_1 and e_2 are in the ratio 3:1. In the first collision the relative velocity of approach is twice the relative velocity of separation, then the ratio between relative velocity of approach and the relative velocity of separation in the second collision is (2007E & 2006M)

   1) 1:6 2) 2:3 3) 3:2 4) 6:1

3. For a system to follow the law of convation of linear momentum during a colllision, the condition is
   a) total external force acting on the system is zero
   b) total external force acting on the system is finite and time of collision is negligible
   c) total internal force acting on the system is zero

   1) a only 2) b only 3) c only 4) a or b

4. Consider the following statements A & B and identify the correct answer:

   A) Coefficient of restitution varies between 0 and 1

   B) In elastic collision, the law of conservation of energy is satisfied

   1) A and B are true 2) A and B are false

   3) A is true but B is false 4) A is false but B is true

5. A nucleus of mass 218 amu in free state decays to emit an α -particle. Kinetic energy of the α -particle emitted is 6.7MeV. The recoil energy (in MeV) of the daughter nucleus is (2005M)

   1) 1.0 2) 0.5 3) 0.25 4) 0.125

1)2	2)4	3)1	4)1	5)4

Additional Problems

1. An object has a displacement from position rector $\vec{r_1}=(2\vec{i}+3\vec{j})m$ to $\vec{r_2}=(4i+6j)m$ under a force $\vec{F}=(3x^2i+2y\vec{j})N$ work done by the force is ( )

   a) 43J b) 53J c) 83J d) 93J

2. Force acting on a particle is $(2\vec{i}+3\vec{j})N$ work done by this force is zero, when a particle is moved along the line $3y+kx=5$, the value of K is. ( )

   a) 2 b) 4 c) 6 d) 8

3. Under the action of force, 2kg body mines such that its position x as a function of time it is given by $x=\frac{t^3}{3}x$ is in meter and t is in scored the work done by the force first 2 second is. ( )

   a) 8J b) 4J c) 2J d) 16J

4. A force of $(4x^1 + 3x)N$ acts on a particle which displaces it from x=2m to x=3m the work done by the force is. ( )

   a) 32.8J b) 3.28J c) 0.328J d) Zero

5. A block of mass m moving with speed V collides with another block of mess 2m at rest. The lighter block comes to rest after the collision be coefficient if restitution is. ( )

   a) $\frac{1}{2}$ b) $\frac{1}{3}$ c) $\frac{1}{4}$ d) $\frac{1}{5}$

6. A spring is stretched 10cm. the work done is K kj. The Extra work done to stretch the spring 10cm more in ( )

   a) K kj b) 2K kj c) $k/8$ kj d) 3K kj

7. A meter stick whose mess is 0.2kg is pivoted at one end and displaced through an angle of 60^0 increase in potential energy is. ( )

   a) 0.49J b) 0.98J c) 1.47J d) 1.96J

8. A solid of mess 2kg Moring with a velouty 10m/sec strikes an idea weightless spring and produces a compression of 25cm in it. Four content of the spring in.( )

   a) 4200N/M b) 3200N/M c) 5200N/M d) 6200N/M

9. A ball Moving with speed of 9m/sec strikes an identical ball at rest, such that after the collision the direction of each ball makes an angle of 30* with the original line of Motion. The speed of the two balls after collision is. ( )

   a) $\sqrt[6]{6}m/\sec$ b) $\sqrt[5]{5}m/\sec$ c) $\sqrt[3]{3}m/\sec$ d) $\sqrt[7]{7}m/\sec$

Key: 1) c 2) a 3) d 4) a 5) a 6) d 7) b 8) b 9) c

CHAPTER 7
SYSTEMS OF PARTICLES AND ROTATIONAL MOTION

CENTER OF MASS

1. The point at which the whole mass of the body may be supposed to be concentrated is called its center of mass.
2. The center of mass of a body is a point at which an applied force produces translatory motion but no rotation.
3. Newton's laws of motion apply only to the center of mass of the body which is a system of particles. In an uniform gravitational field the center of mass and center of gravity coincide.
4. If there is no external force acts on the system the velocity of the (system) center of mass remains constant and its acceleration becomes zero.
5. The internal forces in the system have no effect on the motion of center of mass.
6. If an object explodes in air during its motion, different particles will follow different paths, but the centre of mass continues to follow the original parabolic path.
7. The position of centre of mass depends on the shape of the body and the distribution of mass.
8. The centre of mass may lie within or outside the body.
9. The position of centre of mass is independent of the coordinate system chosen.
10. The position of centre of mass remains unchanged in rotatory motion.
11. The centre of mass of a circular ring is at its centre where there is no matter.
12. For symmetrical bodies with homogenous distribution of mass, centre of mass coincides with the geometric centre.
13. The motion of centre of mass depends on the total external forces acting on the system.
14. The algebirc sum of the moments of masses of the system about the centre of mass is zero.
15. Centre of gravity of a body is the point through which its weight acts.
16. In the case of small and regular bodies centre of mass coincide with centre of gravity.
17. In case of very large bodies centre of mass and centre of gravity does not coincide.
18. In whatever position the body may be placed the centre of gravity remains fixed.
19. In circus, a person walking on a stretched horizontal rope changes his orientation such that the line of action of the total weight passes vertically within the base area.
20. When an Indian club is projected into air as a projectile, the centre of mass of the ball follows a parabolic path. All the remaining points will have complex motions.
21. If two particles move towards each other due to their mutual force of attraction then velocity of center of mass of that system does not change.
22. A body is heated uniformly keeping it on a smooth surface. The position of centre of mass with respect to that body does not change in position.
23. The centre of mass of a uniform square plate lies at the intersection of the diagonals of the plate.

24. The centre of mass of a sphere lies at its centre and that of a cone on the axis of the cone.
25. The centre of mass of earth and moon lies within the earth itself.
26. The centre of mass of all planets and the sun lie within the sun.
27. Matter need not be present at the centre of mass.
    Ex: Hollow sphere, ring.
28. The motion of a body or system of particles can be obtained by its centre of mass.
29. If the motion of the body is represented by anyone of the particle in it, then the motion of the body is transnational.

FORMULAE

30. If two particles of masses m_1 and m_2 are separated by a distance 'r' then distance of centre of mass from m_1 is m_2r / m_1+m_2 and distance of centre of mass from m_2 is $m_1 r/m_1+m_2$
31. If r_1 and r_2 are distances of centre of mass from m_1 and m_2 respectively then $m_1r_1=m_2r_2$
32. If a system consists of particles of masses m_1, m_2, m_3,…. Whose coordinates are (x_1,y_1,z_1) , (x_2,y_2,z_2) , (x_3,y_3,z_3) ….. then the coordinates of centres of mass(x_{cm}, y_{cm}, z_{cm}) are given by
    $X_{cm} = m_1x_1+m_2x_2+m_3x_3+ / m_1+m_2+m_3$ ………….. $= 1/M \Sigma m_i; x_i$
    $Y_{cm} = m_1y_1+m_2y_2+m_3y_3 / m_1+m_2+m_3$ …………… $=- 1/M \Sigma m_i y_i$
    $Zcm = m_1Z_1+m_2Z_2 +m_3Z_3 +….. / m_1 +m_2 +m_3 = 1/M \Sigma m_i z_i$
    Where M is the total mass of the system i.e. $M= m_1 +m_2+m_3+….$
33. If $\vec{r1}, \vec{r2}, \vec{r3}$,…… are the position vectors of particles of masses m_1, m_2, m_3,…. Of a system, then position vector of centre of mass is
    $\vec{r}_{cm} = m_1r_1 +m_2r_2 +…….. / m_1+m_2 = 1/M \Sigma m_i r_i$
    $\vec{r}_{cm} = X_{cm} \hat{i} + Y_{cm} \hat{j} + Z_{cm} \hat{K}$
34. If particles of masses m_1,m_2,m_3,……….. are moving with velocities V_1,V_2,V_3 ,….. respectively velocity of centre of mass is
    $\vec{V}_{cm} = m_1\vec{v}_1 +m_2\vec{v}_2+…….. /m_1+m_2+…… = m_1v_1 +m_2\vec{v}_2 + /\vec{M}$

$M\vec{V}_{cm} = m_1\vec{v}_1 +m_2\vec{v}_2 +………$ $\vec{P}_{cm} = \vec{P}_1+\vec{p}_2 +$ ………………
Where $\vec{P}_{cm}$ is linear momentum of centre of mass of the system
35. If particles of masses m_1, m_2, m_3………. are moving with
acceleration $\vec{a}_1, \vec{a}_2, \vec{a}_3$,………… respectively then acceleration of centre of mass is

    $\vec{A}_{cm} = m_1\vec{a}_1+m_2\vec{a}_2+m_3\vec{a}_3 / m_1+m_2+m_3 = F_1+\vec{F}_2+ \vec{F}_3 / M$

    $M \vec{a}_{cm} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3+$………..

    $\vec{F}_{ext} = \vec{F}_1+\vec{F}_2+ \vec{F}_3$
    $\vec{F}_{ext}$ is resultant external force.
36. When no external force acts on a system, its linear momentum is constant.
    $F_{ext} = 0 \Rightarrow M a_{cm} = 0$
    $M d\vec{v}_{cm}/dt = 0$ i.e $d/dt (M \vec{Vcm}) = 0 \Rightarrow \vec{P}_{cm}$ is constant it means velocity of centre of mass does not change

37. Two skaters of masses m_1 and m_2 initially separated by a distance 'd' pull a rope such that they approach each other. They will meet at a distance $m_2 d/ m_1+m_2$ from m_1
38. A boy of mass 'm' is at one end of a flat boat of mass M and length l which floats on water. If the boy moves to the other end, the boat moves through a distance 'd' in opposite direction such that $d= ml /(M+m)$
39. From a solid sphere of radius R, a sphere of radius R/2 is removed. Then distance of centre of mass of remaining part from the centre of mass of original sphere is R/14 .
40. From a uniform circular disc of radius R a disc of radius R/2 is removed. Then distance of centre of mass of remaining part from the centre of mass of original disc is R/6.

QUESTION BANK

Conceptual Questions:

1) Centre of mass is a
   1) point 2) mass 3) vector 4) scalar
2) Centre of mass does not depend on
   1) Masses of particles 2) Position of particles 3) Internal forces 4) External forces
3) The centre of mass of a body
   1) Lies always outside the body 2) May be within, outside or on the surface.
   3) Lies always inside the body. 4) Lies always on the surface of the body.
4) A bomb traveling in a parabolic path under the effect of gravity explodes in mid air. The centre of mass of fragments will
   1) Move in irregular path 2) Move in parabolic path
   3) Move in regular path 4) Move in circular path
5) If a hollow cylinder is half filled with water, then its centre of mass will be shifted
   1) to the side 2) upwards 3) downwards 4) None
6) The total linear momentum of a system of particles about the centre of mass is
   1) Maximum 2) Constant 3) 0 4) None
7) In the absence of external force, velocity of centre of mass of a system of particles is
   1) Maximum 2) Constant 3) 0 4) None
8) When the earth revolves around the sun, the centre of mass of the earth and moon describes
   1) parabolic path 2) circular path
   3) straight line 4) Elliptical path
9) When a bomb shell is dropped from some height above the ground, it explodes into fragments which move randomly . Here the centre of mass of those fragments moves
   1) towards the heavier fragments 2) towards the lighter fragment
   3) Along a vertical straight line 4) Along a parabolic path
10) Two bodies coupled by a spring is at rest on a frictionless horizontal surface. When they are released and released. How does the centre of mass of the system move?
   1) It moves towards heavier mass 2) It moves towards lighter mass
   3) It moves at right angles 4) It does not move

Numerical Problems

11) What is the centre of mass of 4 particles located at (1,1) ,(2,2), (3,3), (4,4) and of masses 4kg, 3kg, 2kg and 1kg respectively
1) (2,2) 2) (1,) 3) (3,3) 4) (4,4)

12) The positions of the particle of masses 1kg and 2kg is given by (2i+3j+4k) and (5i+7j-8k) . The position of centre of mass is
1) 1/3 (2i+3j+4k) 2) 1/3 (12i-17j+12k) 3) 1/3 (12i+17j-12k) 4)1/3 (12i-12k)

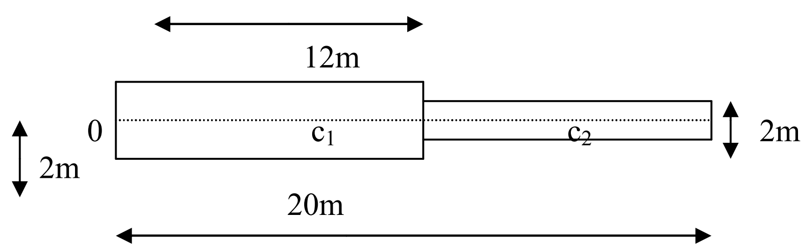
13) The acceleration of centre of mass of a 3 particle system of masses 5kg, 10kg, 15kg with respective accelerations of $1m/s^2$, $2m/s^2$ and $3m/s^2$ is
1) $2m/s^2$ 2) $3m/s^2$ 3) $4m/s^2$ 4) $2.3m/s^2$

14) If the coordinates axes are along two adjacent sides of a square, the centre of mass of 4 particles of equal masses 1kg at 4 corners of the square of 4 meters side is
1) 2,2 2) 2, $(2)^{1/2}$ 3) 2, $(2)^{-1/2}$ 4) ½, -1/2

15) The mass of earth is 81 times the mass of moon , and the distance between the centre of earth and moon is 60 times the earth radius R. The distance of the centre of mass of earth-moon system from the of the earth is
1) (30/41) R 2) (20/27) R 3) (2/3) R 4) (9/10) R

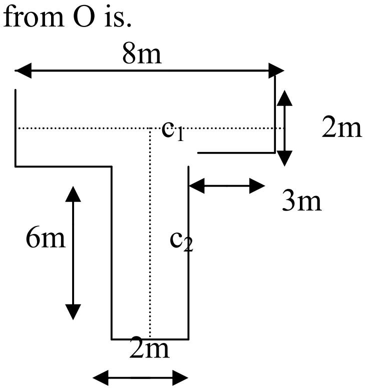
16) A discrete system consists of three masses of 1kg, 2kg and 3kg . The masses are situated at (2,1) , (3,4) and (4,2) respectively. Compare the velocity of centre of mass if all the masses start moving with velocity of 8m/s due west.
1) 8m/s due west 2) 4m/s due west
3) 8m/s due east 4) 4m/s due east

17) A machine part consists of two homogeneous solid cylinders coaxially. Then the distance of centre of mass from O is



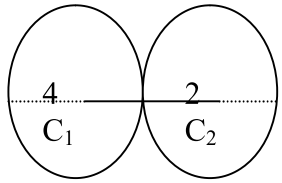
1) $\frac{1}{7}$ m 2) $\frac{2}{7}$ m 3) $\frac{52}{7}$ m 4) none

18) A uniform metal sheet is cut in the form of letter T as shown. The distance of centre of mass of this plate from O is.



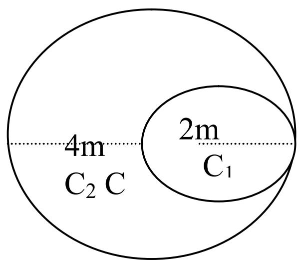
1) $\frac{2}{7}$ m 2) $\frac{4}{7}$ m 3) $\frac{19}{7}$ m 4) $\frac{27}{7}$ m

19) Two discs of radii 4cm and 2cm respectively are attached as shown. Where is the new centre of mass of the system from C_1



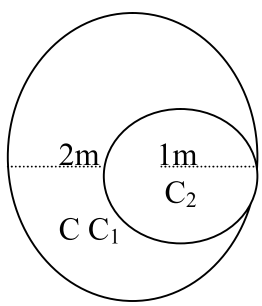
1) 1cm 2) 1.2cm 3) 1.3cm 4) 1.4cm

20) From a circular disc of radius 4cm a circular portion of radius 2m just passing through the centre of disc is cut off. Find the centre of mass of the remainder from the original centre of mass



1) $\frac{1}{3}$ m 2) $\frac{2}{3}$ m 3) $\frac{3}{2}$ m 4) 2m

21) From a solid sphere of radius 2m a sphere of radius 1m is removed . Find the new centre of mass from first

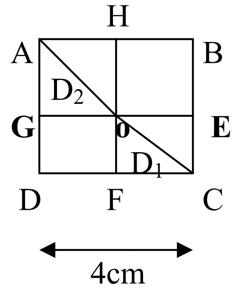


1) $\frac{1}{7}$ m 2) $\frac{2}{7}$ m 3) $\frac{3}{7}$ m 4) $\frac{4}{7}$ m

22) A square of side 'a' and uniform thickness is divided into 4 equal squares. If one of them is cut-off , the distance of centre of gravity of the remaining part from the centre of the original square is

1) a/12 2) a/8 3) a/16 4) $\sqrt{2}$a/12

23) A square of side 4cm and of uniform thickness is divided into four equal squares. If one of them is cut-off (OECF), find the centre of mass of the remaining portion from O.



1) $\frac{1}{3}$ cm 2) $\frac{2}{3}$ cm 3) $\frac{\sqrt{2}}{3}$ cm 4) $\frac{\sqrt{4}}{3}$ cm

24) The distance x_1 and x_2 of the particles of masses m1 and m2 respectively from their centre of mass bears a relation

1) $\frac{m_1}{m_2} = \frac{x_1}{x_2}$ 2) $\frac{m_1}{m_2} = \frac{x_2}{x_1}$ 3) $\frac{m_1^2}{m_2^2} = \frac{x_2}{x_1}$ 4) $\frac{m_1}{m_2} = \frac{x_1^2}{x_2^2}$

25) Three masses 3,4 and 5kg are placed at the centres of an equilateral triangle of side 1m. Located its centre of mass.

1) 1.5m, 1m 2) 0.54m, 0.36m 3) 1m, 0.5m 4) 1.5m, 0.3m

26) Find the centre of mass of carbon monoxide molecule (CO) relative to carbon atom if the distance between the centres of the carbon and oxygen atoms is 1.13×10^{-10}m

1) 6.45×10^{-11}m 2) 5.45×10^{-11}m 3) 7.45×10^{-11}m 4) None

27) If two identical particles are at (2,3,4) and (6,3,2) then coordinates of centre of mass of the system are

1) (3,4,4) 2) (4, 3,4) 3) (4,3,3) 4) (3,4, 3)

28) If the centre of mass of three particles 10kg, 20kg be at (1,-2, 3) , then where should a fourth particle of mass 40Kg placed so that the combined centre of mass may be At (1, 1, 1)

1) (1, 2, -11/2) 2) (1, -2, 11/2) 3) (11/2, -2, 1) 4) (1, 11/2, -2)

29) A 2kg mass 4kg mass are placed along the x-axis at distances of 2m and 4m from the origin. A third mass of 5kg is placed on the X-axis such that the centre of mass of the system lies at the origin. The position of that 5kg is

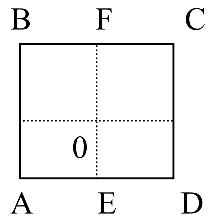
1) 4m 2) –4m 3) 3m 4) –3m

30) Two particles of masses 100gm and 300gm have at a given time velocities (10i-7j-3k) and (7i-9j+6k) cms^{-1} respectively. Then velocity of centre of mass of the system in cms^{-1} is

1) $\frac{1}{4}$ (34i-31j+15k) 2) $\frac{1}{4}$ (15i-34j+31k)

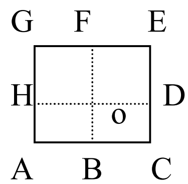
3) $\frac{1}{3}$ (31i-15j–34k) 4) $\frac{1}{4}$ (31i-34j+15k)

31) A uniform square plate has a mass of 4kg . Two masses of 2kg are placed at corners B and C as shown in fig. Then centre of mass of the system gets shifted.



1) to the mid point of OC 2) to the mid point of OB
3) to the mid point of OE 4) to the mid point of OF

32) Masses 1kg each are placed at the corners G and E of a uniform square plate ACEG. A mass of 2kg is to be placed on the plate so that the centre of mass of the system should be at the centre O. Then the mass should be placed at



1) B 2) D 3) F 4) H

33) Two bodies of masses 2kg and 3kg move along X-axis . At a particular instant the first body has a velocity of $3ms^{-1}$ ands the other body has $-1ms^{-1}$. Then velocity of centre of mass that system is
1) $1.2ms^{-1}$ 2) $-1.2ms^{-1}$ 3) $0.6ms^{-1}$ 4) $-0.6ms^{-1}$

34) Two persons of masses m and 2m are standing on a horizontal smooth surface of ice. They are initially separated by a distance 'd'. They are pulling each other holding a rope. They meet at a distance
1) 2d/3 from heavier person 2) d/3 from heavier person
3) 2d/4 from lighter person 4) d/3 from lighter person

35) Two particles of masses 1kg and 3kg have position vectors (2i+3j+4k) and (-2i+3j-4k) respectively. The centre of mass has a position vector
1) i+3j-2k 2) –i-3j-2k 3) –i+3j+2k 4) –i+3j-2k

36) The centre of mass of two particles with masses 4kg and 2kg located at (1,0,1) (2,2,0) respectively has the coordinates
1) (2/3, 2/3, 4/3) 2) (4/3, 4/3, 2/3) 3) (2/3, 4/3, 2/3) 4) (4/3, 2/3, 2/3)

37) The algebraic sum of the moments of the masses about the centre of mass of the system is
1) Positive 2) Negative 3) 0 4) None

38) Three identical particles each of same mass are placed touching each other with their centers on a straight line. Their centers are at A, B and C respectively. Then distance of centre of mass of the system from A is
1) AB+AC+BC/3 2) AB+AC/3 3) AB+BC/3 4) AC+BC/3

39) A thin mass less meter scale has point masses 30gm, 70gm at 20cm and 60cm divisions respectively . Then centre of mass of the system will be at
1) 50cm division 2) 40cm division 3) 52cm division 4) 48cm division

40) A boy of mass 20kg is at one end of a flat boat of mass 80kg and length 10m which floats on water. If the boy moves to the other end, the boat moves through a distance
1) 2m in the same direction 2) 2m in the opposite direction
3) 2.5m in the same direction 4) 2.5m in the opposite direction

Key

1)1	2)3	3)2	4)2	5)3	6)3	7)2	8)4	9)3	10)4
11)1	12)3	13)4	14)1	15)1	16)1	17)3	18)3	19)2	20)2
21)1	22)4	23)3	24)2	25)2	26)1	27)3	28)4	29)2	30)4
31)4	32)1	33)3	34)2	35)4	36)4	37)3	38)2	39)4	40)2

Previous Eamcet Questions:

41) The velocities of three particles of masses 20g, 30g and 50g are 10i, 10j and 10k respectively. The velocity of the centre of mass of the three particles is(2001 E)
   1) 2i+3j+5k 2) 10(i+j+k) 3) 20i+30j+5k 4) 2i+30j+50k

42) A uniform rod of length one metre is bent at its midpoint to make 90^0 angle. The distance of the centre of mass from the centre of the rod is (2001 E)
   1) 36.1cm 2) 25.2cm 3) 17.7cm 4) 0

43) Particles of masses m, 2m, 3m ------ n m grams are placed on the same line at distances l, 2l, 3l----- nl cm from a fixed point. The distance of centre of mass of the particles from the fixed point in centimeter is (Eamcet 2002 E)
   1) $\frac{(2n+1)l}{3}$ 2) l/n+1 3) $\frac{n(n^2+1)l}{2}$ 4) $2l/n(n^2+1)$

44) A system consists of two identical particles one particle is at rest and the other particle has an acceleration "a". The centre of mass of the system has an acceleration of (2002 E)
   1) 2a 2) a 3) a/2 4) a/4

45) Two objects of masses 200g and 500g possess velocities $10ims^{-1}$ and $3i+5jms^{-1}$ respectively. The velocity of their centre of mass in ms^{-1} is (Eamcet 2003 E)
   1) 5i-25j 2) $\frac{5}{7}$ i- 25j 3) 5i+$\frac{25}{7}$ j 4) 25i-$\frac{5}{7}$ j

46) One end of a thin uniform rod of length L and mass M_1 is rivetted to the centre of a uniform circular disc of radius 'r' and mass M_2 so that both are coplanar. The centre of mass of the combination from the centre of the disc is (Assume that the point of attachment is at the origin) (Eamcet 2003 M)
   1) $L(M_1+M_2)/2M_1$ 2) $LM_1/2(M_1+M_2)$
   3) $2(M_1+M_2)/LM_1$ 4) $2LM_1/(M_1+M_2)$

47) Two particles of equal mass have velocities V_1=4i and $V_2=4jms^{-1}$, First particle has an acceleration a_1= $(5i-5j)ms^{-2}$ while the acceleration of other particle is zero. What is the path followed by centre of mass (Eamcet 2004 E)
   1) straight line 2) parabola 3) circle 4) ellipse

48) Four particles each of mass 1kg , are placed at the corners of a square of side one metre in the XY-plane. If the point of intersection of the diagonal of the square is taken as a origin, the coordinates of the centre of mass are : (Eamcet 2004M)
   1) (1,1) 2) (-1,1) 3) (1,-1) 4) (0,0)

Key

41)1 42)3 43)1 44)3 45)3 46)2 47)1 48)4

Matching Type Questions:

49) Match the following

List-I	List-II
a) Position of centre of mass	e) is zero
b) The algebraic sum of moments Of all the masses about centre Of mass	f) in non uniform gravitational field.
c) Centre of mass and centre of gravity coincide	g) is independent of frame of reference
d) Centre of mass and centre of Gravity do not coincide	h) in uniform gravitational field.

The correct match is

1) a→e; b→g; c→f; d→h
2) a→g; b→e; c→f; d→h
3) a→g; b→e; c→h; d→f
4) a→h; b→e; c→f; d→g

50) Study the following:

List-I	List-II
a) Centre of mass of ring	e) mass is present
b) Centre of mass of non-uniform rod	f) coincides with centre of gravity
c) Centre of mass of small funnel	g) on the heavier side
d) Centre of mass of uniform disc	h) at geometric centre

The correct match is

1) a→f; b→e; c→g; d→h
2) a→g; b→h; c→e; d→f
3) a→h; b→g; c→f; d→e
4) a→e; b→f; c→h; d→g

51) Study the following:

List-I	**List-II**
a) Position of centre of mass of a triangle	e) at one fourth of maximum height from the base
b) Position of centre of mass of a square	f) at the point of intersection of medians
c) Position of centre of mass of a sphere	g) at the point of intersection of diagonals
d) Position of centre of mass of a cone	h) at the centre

The correct match is

1) a→f; b→g; c→h; d→e
2) a→g; b→h; c→e; d→f
3) a→g; b→h; c→f; d→e
4) a→g; b→f; c→e; d→h

Key 49)3 50)3 51) 1

Assertion and Reason Type Questions:

Directions:

These Questions consist of two statements as Assertion and Reason. While answering these Questions you are required to choose any of the following four responses.

A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B) If both Assertion and Reason are true, but Reason is not correct explanation of the Assertion.

C)If Assertion is true, but the Reason is false

D)If Assertion is false, but the Reason is true

52) A: The centre of mass of a body may lie where there is no mass.
R: Centre of mass of a body is a point, where the whole mass of the body is supposed to be concentrated.
1) A 2) B 3) C 4) D

53) A: At the centre of earth , a body has centre of mass, but no centre of gravity.
R: This is because g = 0 at the centre of earth.
1) A 2) B 3) C 4) D

54) A: Position of centre of mass of a body is independent of coordinate system
R: Internal forces do not effect the motion of central of mass.
1) A 2) B 3) C 4) D

55) A: Two particles (starting from rest) move towards each other under a mutual force of attraction. The velocity of centre of mass is zero.
R: Internal forces do not alter the state of motion of centre of mass.
1) A 2) B 3) C 4) D

56) A: The centre of mass of a two particle system lies on the line joining them, being closer to the heavier particle.
R: The centre of mass is a point where whole mass of the system is supposed to be Concentrated.
1) A 2) B 3) C 4) D

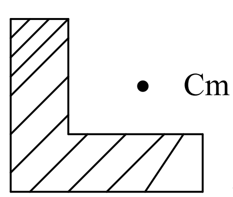
57) A: A particle in the system of particles has a complex motion. But its centre of mass has translatory motion.
R: The centre of mass is a point where whole mass of the system is supposed to be concentrated.
1) A 2) B 3) C 4) D

58) A: the centre of mass of an isolated system has a constant velocity
R: If the centre of mass of an isolated system is already at rest, it remains at rest.
1) A 2) B 3) C 4) D

59) A: The centre of mass of a proton and an electron released from their respective position remains at rest.
R: The proton and electron attract and move towards each other. No external force is applied, therefore their centre of mass remains at rest.
1) A 2) B 3) C 4) D

60) A: The centre of mass of a circular disc lies always at the centre of the disc.
R: Circular disc is a symmetrical body.
1) A 2) B 3) C 4) D

61) A: For the body shown in the figure, the centre of mass lies outside the body.
R: Centre of mass of a body may or may not lie with in the body.



1) A 2) B 3) C 4) D

62) A: When a person walks on a stationary boat in still water, centre of mass of person and boat system is not displaced.
R: Internal forces cannot alter the position of centre of mass.
1) A 2) B 3) C 4) D

63) A: When an external force is applied at the centre of mass of a free system of particles then it undergoes translatory motion only.
R: The torque of the force acting at centre of mass about that centre of mass is zero.
1) A 2) B 3) C 4) D

64) A: The position of centre of mass of a body depends on its shape and size.
R: Centre of mass of a body is a point where the whole mass of the body is supposed to be concentrated.
1) A 2) B 3) C 4) D

65) A: A shell moving in a parabolic path explodes in mid air.
R: Explosion is due to internal forces, which cannot alter the state of motion of a body.
1) A 2) B 3) C 4) D

66) A: When a body dropped a height in mid air, the pieces fly in such a way that their centre of mass keeps moving vertically downwards.
R: Explosion occurs under internal forces only. External forces = 0
1) A 2) B 3) C 4) D

Keys

52) 2 53)1 54) 1 55) 1 56)2 57)2 58)2 59)1 60)4 61)1
62)1 63)2 64) 1 65) 1 66)1

New Type Question:

1) Match the following

List-I (The motion of the bodies)	List-II (The path of the centre of mass)
a) A wheel rolls without slipping	e) at rest
b) Indian dub is thrown in to air from the ground	f) elliptical
c) The earth and moon revolves around the sun	g) parabola
d) A bullet is fired from a rifle	h) straight line

1) a-h, b-g, c-f, d-e 2) a-h, b-e, c-f, d-g
3) a-g, b-h, c-e, d-f 4) a-h, b-f, c-e, d-g Key:1

2) The centre of the mass of the system of the particles
a) Depends on the position of the particles
b) Depends on the masses of the particles
c) Independent of the coordinate system
d) Independent of the forces acting on the particles
1) Only ‘a’ and ‘b’ are correct 2) Only ‘c’ and ‘d’ are correct
3) All the above are false 4) All the above are correct Key:4

3) A non zero external force acts on a system of particles. The velocity and acceleration of the centre of mass are found to be V_o and a_o at an instant l. It is possible that
a) $V_0=0$ $a_0=0$ b) $V_0=0$ $a_0\neq0$ c) $V_0\neq0$ $a_0=0$ d) $V_0\neq0$ $a_0\neq0$

1) ‘a’ and ‘b’ are correct   2) ‘a’ and ‘c’ are correct
3) ‘b’ and ‘d’ are correct   4) ‘b’ and ‘c’ are correct   Key:3

4) Assertion: The position of centre of mass of two particles moving towards each other from rest due to gravitational force does not change
Reason: The internal force does not change the position of the centre of mass
1) A and Rare true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) Both A and R are false
4) A is correct and R is not correct explanation   Key: 1

5) Assertion: For a uniform triangular plate, centre of mass lies at its centroid.
Reason: For symmetric bodies centre of mass lies at their respective geometric centers.
1) Both A and R are true and R is the not the correct explanation of A
2) Both A and R are true and R is the correct explanation of A
3) A is true but R is false
4) A is false and R is the true   Key:2

Previous Eamcet Questions:

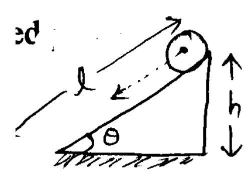
1. Two bodies of 6kg and 4kg masses have their velocity $5\hat{i}-2\hat{j}+10\hat{k}$ and $10\hat{i}-2\hat{j}+5\hat{k}$ respectively. Then the velocity of their center of mass is (2007E)
1) $5\hat{i}+2\hat{j}-8\hat{k}$ 2) $7\hat{i}+2\hat{j}-8\hat{k}$ 3) $7\hat{i}-2\hat{j}+8\hat{k}$ 4) $5\hat{i}-2\hat{j}+8\hat{k}$
2. Four particles, each of mass 1kg are placed at the corners of a square OAB C side 1m. ‘O’ is at the origin of the coordinate system. OA and OG are aligned along positive x –axis and positive Y –axis respectively. The position vector of the center of mass is (in ‘m’)   (2006M)
1) $(\hat{i}+\hat{j})$ 2) $\frac{1}{2}(\hat{i}+\hat{j})$ 3) $(\hat{i}-\hat{j})$ 4) $\frac{1}{2}(\hat{i}-\hat{j})$
3. Three particles each of 1kg mass, are placed at the corners of a right angled triangle AOB, O being the origin of the coordinate system (OA & OB along positive X –direction and positive Y –direction). If OA = OB =1m, the positive vector of the center of mass (in meters)   (2005M)
1) $\frac{\hat{i}+\hat{j}}{3}$ 2) $\frac{\hat{i}-\hat{j}}{3}$ 3) $\frac{2(\hat{i}+\hat{j})}{3}$ 4) $(\hat{i}-\hat{j})$
4. The center of mass of three particles of masses 1kg, 2kg and 3kg is at (2,2,2). The position of the fourth mass of 4kg to be placed in the system so, that the new center of mass is at (0, 0, 0) is: (2005E)
1) (-3, -3, -3)   2) (-3, 3, -3)   3) (2, 3, -3)   4) (2, -2, 3)

1)3	2)2	3)1	4)1

ROTATORY MOTION

Formulae

10. Torque (or) Moment of force
    $\vec{\tau} = \vec{r} \times \vec{F} \Rightarrow \tau = rF\sin\theta \quad \Rightarrow \tau = Fd$
11. Torque = rate of change of angular momentum
    $\tau = dl/dt = d/dt\,(I\omega)$ (.. $L=I\omega$)
12. Torque = Moment of inertia x angular acceleration $\tau = I\alpha$
    (.. $\tau = dI\omega/dt = I.d\omega/dt = I\alpha$)
13. Workdone by torque in rotational motion is $W = \tau\theta$
14. Power $p = \tau.\omega$
15. Moment of inertia of a particle is $I=mr^2$ (m=mass of particle)
    (r= $\perp$distance of particle from axis of rotation)
16. Moment of inertia of group or system of particles.
    $I = m_1r_1^2+m_2r_2^2+m_3r_3^2+\ldots\ldots\ldots.+m_nr_n^2$, $I=\Sigma mr^2$
    Where $m_1,m_2,m_3\ldots.m_n$ are masses of particles and $r_1,r_2,\ldots\ldots.r_n$ are $\perp$ distances from axis of rotation.
17. Moment of inertia of rigid body is $I=Mk^2$
    (M = mass of rigid body) K = radius of gyration
    Or $k = \sqrt{I/M}$
    Or $k = \sqrt{r_1^2+r_2^2+\ldots.+r_n^2/n}$
    n is total number of particles $r_1,r_2\ldots r_n$ are their $\perp$r distances from axis of rotation.
18. K.E. of a rolling body :
    $K.E._{rot} = 1/2\, I\omega^2 = L^2/2I$ $(L=I\omega)$
    $K.E._{Trans} = 1/2\, Mv^2$ (v is velocity of centre of mass)
    Total K.E. $= 1/2Mv^2+1/2\, I\omega^2$
    Or $K.E_{tot.} = 1/2Mv^2 + 1/2MV^2(K^2/R^2) = 1/2Mv^2(1+k^2/R^2)$
    $\rightarrow$ Ratio between translational and rotational K.E. is R^2/k^2



19. Motion of rolling body on an inclined plane:
    If θ is the inclination to the horizontal,
    'l' is the length of inclined plane h is the height, then
    i) Acceleration of the body
    $a = g\sin\theta / 1+(k^2/R^2)$
    ii) velocity of the body on reaching the bottom of the inclined plane is

$V = \sqrt{2gh/ 1+(k^2/R^2)} = \sqrt{2gl\sin\theta/ 1+(k^2/R^2)}$

iii)Time taken by the body to reach the bottom of the inclined plane is

$t = \sqrt{2l\,(1+k^2/R^2)/g\sin\theta} = \sqrt{2h(1+(k^2/R^2)/ g\sin^2\theta)}$

20. If radius of the earth shrinks to 1/nth of the present radius without change in its mass, duration of the new day is $(24/n^2)$ hrs.
21. If radius of the earth shrinks to $1/n^{th}$ of the present radius without any change in the mean density, duration of the new day is $(24/n^5)$ hrs.
22. work done = change in rotational K.E. $W = 1/2\, I\omega_2^2 - 1/2\, I\omega_1^2$
23. Banking angle of road or rail track θ is $\tan\theta = v^2/rg$
24. When a body slides along an inclined plane of height 'h' describes a vertical circle of radius 'r' on reaching the bottom then $h = 5r/2$.

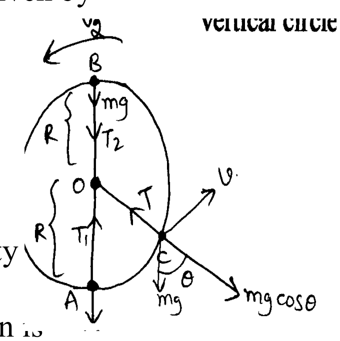
25. A particle begins to slide without any friction from the top of a hemisphere of radius R. its leaves the surface of hemisphere at height h above the centre. Such that h= 2r/3 and cos $\theta = 2/3$.

26. Motion in vertical circle:

1) if a stone of mass m is tied to one end of a string is rotated in a vertical circle of radius 'r'

i) Tension in the string T_1 when the body is at lowest point is given by

$T_1 = (mv_1^2/R) + mg$



ii) Tension in the string T_2 when the body is at highest point is given by $T_2 = (mv_2^2/R) - mg$

(R is radius of vertical circle)

iii) The minimum velocity at lowest point A is (R is radius of vertical circle) $V_1 = \sqrt{5gR}$

iv) The minimum velocity at highest point B called as critical velocity

$V_2 = \sqrt{gR}$ (R is radius of vertical circle)

v) Tension in the string T_3 when the body is at 'c' horizontal direction is

$T = (mv^2/r) + mg\cos\theta$

vi) The minimum velocity at horizontal position 'c' is $v = \sqrt{3gR}$

vii) $V_1^2 - v_2^2 = 4gR$ viii) $T_1 - T_2 = 6mg$

27. Safe maximum speed to avoid toppling or overturning is $V = \sqrt{gar/h}$ where 'h' is height of centre of gravity , 2a is the distance between the wheels or wheel base.

28. 'l' is length of ballistic pendulum m_2 is mass of block. A bullet of mass m_1 strikes the block in horizontal direction and the bullet is embedded in the block, such that the combined mass describes vertical circle of radius equal to length of pendulum l. if u is minimum striking velocity of bullet, then $m_1 u = (m_1 + m_2)\sqrt{5gl}$

Expression for moments of inertia of some regular shape rigid bodies

Rigid body	Axis of Rotation	Moment of Inertia (I)	Radius of gyration(k)
1. Thin circular ring of mass M and radius R.	a) passing through the centre and perpendicular to its plane.	MR^2	R
	b)passing through diameter of ring	$MR^2/2$	$R/\sqrt{2}$
	c)About any tangent perpendicular to its plane	$2MR^2$	$\sqrt{2}$ R
	d)About any tangent in its plane	$3/2MR^2$	$\sqrt{3/2}$ R
2. Circular disc of mass M and radius R	a) Passing through the centre and perpendicular to its plane	$MR^2/2$	$R/\sqrt{2}$
	b) About diameter	$MR^2/4$	R/2
	c) About any tangent perpendicular to its plane	$3MR^2/2$	$\sqrt{3/2}$ R

	d) passing through any tangent	$5MR^2/4$	$\sqrt{5/4}$ R
3. Annular ring or disc of outer and inner radii R and r.	a) passing through the centre and perpendicular to its plane	$M(R^2+r^2)/2$	$\sqrt{R^2+r^2/2}$
	b) About diameter	$M(R^2+r^2/4$	$\sqrt{R^2+r^2/2}$
	c) About a tangent in its plane	$M(5R^2+r^2)/4$	$\sqrt{5R+r^2/2}$
4. solid cylinder of mass M length L, radius R	a) About the axis of symmetry	MR^2	R
	b) Passing through centre and perpendicular to its length	$M[L^2/12+R^2/4]$	$\sqrt{L^2/12+R^2/4}$
	c) passing through centre and parallel to its length	$MR^2/2$	$R/\sqrt{2}$
	d) passing through edge and parallel to its length	$3MR^2/2$	$\sqrt{3/2}$ R
5.Hollow cylinder of mass 'm' length 'l' and radius R.	a) Parallel to the length of cylinder and passing through its center	MR^2	**R**
	b) parallel to the length of cylinder and passing through its edge	$2MR^2$	$\sqrt{2}$ R
	c) Perpendicular to length of cylinder and passing through its center	$M[l^2/12+R^2/2]$	$\sqrt{L^2/12+R^2/2}$
6. Thin uniform rod of mass M length L	a) Perpendicular to the length of rod and passing through its centre	$ML^2/12$	$L/2\sqrt{3}$
	b) perpendicular to the length of rod and passing through its end	$ML^2/3$	$L/\sqrt{3}$
7. solid sphere of mass M radius R.	a) about diameter b) About tangent	$2/5MR^2$ $7/5\ MR^2$	$\sqrt{2/5}$ R. $\sqrt{7/5}$ R.
8. Hollow sphere of mass M radius R	a) passing through its centre or any diameter	$2/3MR^2$	$\sqrt{2/3}$ R
	b) passing through its edge or about any tangent	$5/3\ MR^2$	$\sqrt{5/3}$ R
9. Thin rectangular lamina of length 'l' and breadth 'b'.	a) Through its centre and perpendicular to its plane	$M[l^2/12+b^2/12]$	$\sqrt{l^2+b^2}\ /\ 2\sqrt{3}$
	b) Through its centre and parallel to breadth in its plane	$Ml^2/12$	$L/2\sqrt{3}$

	c) Through its centre and parallel to length in its plane	$Mb^2/12$	$b/2\sqrt{3}$
	d) through its edge and parallel to its breadth.	$Ml^2/3$	$L/\sqrt{3}$
	e) Through its edge and parallel to its length	$Mb^2/3$	$b\sqrt{3}$
10. Thin square lamina of side 'a'	a) Through its centre and perpendicular to its plane	$Ma^2/6$	$a/\sqrt{6}$
	b) Through its centre and parallel to any side in its plane	$Ma^2/12$	$a/2\sqrt{3}$
	c) About diagonal	$Ma^2/12$	$a/2\sqrt{3}$
	d) Through its edge in its plane	$Ma^2/3$	$a/\sqrt{3}$
	e) Through its corner and perpendicular to its plane	$2Ma^2/3$	$\sqrt{2/3}\ a$

Angular displacement (θ): the angular through which the radius representing the position of particular rotates is called angular displacement. It is no dimensions. Its dimensions formula is $M^0T^0L^0$.

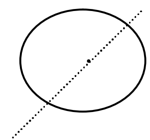
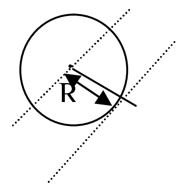
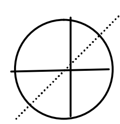
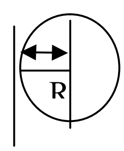
Angular velocity (ω): the rate of charge of angular displacement of a particle is called angular velocity. **ω = θ/t**. its dimensions formula is $M^0L^0T^{-1}$. Its S.I. unit is $rads^{-1}$.

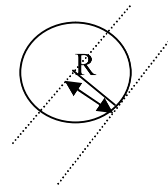
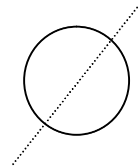
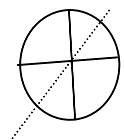
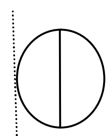
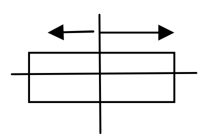
$$\omega = \frac{\theta}{t} = \frac{2\pi n}{t} \quad n=1 \text{ for one complete rotation}$$

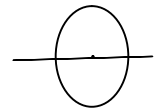
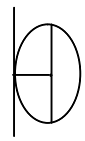
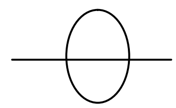
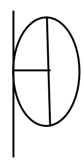
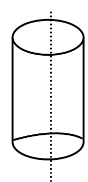
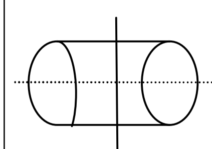
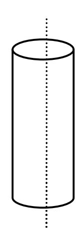
Angular acceleration (α): the rate of charge of angular velocity of a particle is called angular acceleration. Its dimension formula is $M^0L^0T^{-2}$. Its S.I unit is $rads^{-2}$.

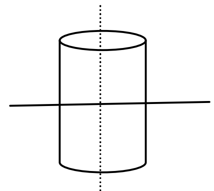
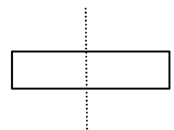
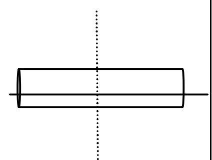
$$\alpha = \frac{\omega-\omega_0}{t} = \frac{d\omega}{dt}$$

Moment of inertia and Radius of gyration for different bodies about different axes:

S.No:	Name of the body	Axis of rotation	Figure	Moment ofinertia (M.I)	Radius of gyration(K)
1.	Circular Ring	a) About an axis passing though its center and perpendicular to its plane or transverse axis		MR^2	R
		b) About a tangent in the perpendicular plane		$2MR^2$	$\sqrt{2}R$
		c) About a Diameter		$\frac{MR^2}{2}$	$\frac{R}{2}$
		d) About a Tangent in its plane		$\frac{3MR^2}{2}$	$\sqrt{3/2}\ R$

2.	Circular Disc	a) About an axis passing though its center and perpendicular to its plane or transverse axis		$\frac{MR^2}{2}$	$\frac{R}{\sqrt{2}}$
		b) About a tangent in the perpendicular plane		$\frac{3MR^2}{2}$	$\sqrt{\frac{3}{2}}\,R$
		c) About a Diameter		$\frac{MR^2}{4}$	$\frac{R}{2}$
		d) About a Tangent in its plane		$\frac{5MR^2}{4}$	$\frac{\sqrt{5}\,R}{2}$
3.	Rectangular plate or bar	a) passing through its center and perpendicular to its length		$\frac{Ml^2}{12}$	$l/\sqrt{3}$
		b) passing through its center and perpendicular to its breadth		$\frac{Mb^2}{12}$	$b/2\sqrt{3}$
		c) passing through its center and perpendicular to its plane		$M\left(\frac{l^2+b^2}{12}\right)$	$\sqrt{l^2+b^2}\,/\,2\sqrt{3}$

4.	Solid Sphere	a) About an axis passing through its diameter b) About an axis passing through its tangent	 	$\frac{2}{5}MR^2$ $\frac{7}{5}MR^2$	$\sqrt{\frac{2}{5}}R$ $\sqrt{7/5}\,R$
5.	Hollow Sphere	a) About an axis passing through its diameter b) About an axis passing through its tangent	 	$\frac{2}{3}MR^2$ $\frac{5}{3}MR^2$	$\sqrt{\frac{2}{3}}R$ $\sqrt{\frac{5}{3}}R$
6.	Solid cylinder	a) About its own axis i.e., axis of symmetry b) passing through its center and perpendicula r to its own axis	 	$\frac{MR^2}{2}$ $M\left(\frac{l^2}{12}+\frac{R^2}{4}\right)$	$\frac{R}{\sqrt{2}}$ $\sqrt{L^2/12+R^2/2}$
7.	Hollow cylinder	a) About its own axis i.e., axis of symmetry		MR^2	**R**

		b) passing through its center and perpendicular to its own axis		$M\left[\frac{l^2}{12}\ \frac{R^2}{2}\right]$	$\sqrt{L^2/12+R^2/2}$
8.	Thin Rod	a) About an axis passing though its center and perpendicular to its plane b) About an Axis passing through one end of the Rod and perpendicular to its Length	 	$\frac{Ml^2}{12}$ $\frac{Ml^2}{3}$	$\frac{L}{\sqrt{12}}$ $\frac{L}{\sqrt{3}}$

Analogy between Linear Motion and Rotation about Axis Quantities:

Linear motion		Rotational motion		Relationship
Linear displacement	S	Angular displacement	θ	$S = r\theta$
Linear velocity	$V = \frac{ds}{dt}$	Angular velocity	$\omega = \frac{d\theta}{dt}$	$V = r\omega$
Linear acceleration	$a = \frac{dv}{dt}$	Angular Acceleration	$\alpha = \frac{d\omega}{dt}$	$a = r\alpha$
Mass	m	Moment of inertia	I	$I = \Sigma mr^2$
Linear momentum	$p = mv$	Angluar Momentum	$l = I\omega$	$\vec{l} = \vec{r} \times \vec{p}$
Force	F	Torque	τ	$\tau = \vec{r} \times \vec{F}$

New type question:

1.A particle moves around a circular path in the xy-plane with angular velocity ω and angular acceleration α

Assertion (A): α lies along the z-axis.

Reason (R): The direction of α must be same as the direction of $d\omega$

The correct answer is

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is not the correct explanation of A

c) A is true, R is false

d) A is false but R is true

2. (A): a coin placed on a rotating horizontal disc, appears to be at rest for an observer on the disk itself.

(R): the necessary centripetal force is provided by friction between coin and disc.

The correct answer is

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is not the correct explanation of A

c) A is true, R is false

d) A is false but R is true

3. (A): Parallel to a given direction the moment of inertia of a rigid body reduces to its minimum value, when the axis of rotation passes through its centre of gravity.

(R): Sum of moments of weights of all the particles of the body about center of gravity is zero.

The correct answer is

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is not the correct explanation of A
c) A is true, R is false
d) A is false but R is true

4. Match the Moment of inertia for the given objects and indicated axes.

Object	Moment of inertia
a) Circular ring	e) 7/5 MR^2 about Tangent
b) Circular disc	f) 5/4 MR^2 about Tangent
c) Solid sphere	g) $2MR^2$ about tangent perpendicular to plane.

a) a-g, c-f, d-e b) a-e, c-f, d-e
c) a-g, b-e, c-f d) a-g, c-f, d-f

5. (A): a particle in non uniform circular motion has both radial and tangential acceleration
(R): In non uniform circular motion velocity charges both in magnitude and direction.
The correct answer is
a) Both A and R are true and R is the correct explanation of A
b) Both A and R are true and R is not the correct explanation of A
c) A is true, R is false
d) A is false but R is true

6. (A): a solid sphere and hollow sphere when released from the top of a smooth and fixed inclined plane, reach the ground simultaneously.
(R): Acceleration while sliding is independent of mass and dimension of the body.
The correct answer is
a) Both A and R are true and R is the correct explanation of A
b) Both A and R are true and R is not the correct explanation of A
c) A is true, R is false
d) A is false but R is true

7. (A): the speed of particle remains constant in uniform circular motion.
(R): No force is acting on the particle.
The correct answer is
a) Both A and R are true and R is the correct explanation of A
b) Both A and R are true and R is not the correct explanation of A
c) A is true, R is false
d) A is false but R is true

8. (A): Centripetal force does not work.
(R): Force and displacement are perpendicular to each other.
The correct answer is
a) Both A and R are true and R is the correct explanation of A
b) Both A and R are true and R is not the correct explanation of A
c) A is true, R is false
d) A is false but R is true

9. (A): The angular momentum of a particle w.r.t. origin moving parallel to x-axis with constant velocity is constant.

(R): There is no charge in the perpendicular distance of the particle from the origin.

The correct answer is

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is not the correct explanation of A

c) A is true, R is false

d) A is false but R is true

10. The angular velocity of the seconds hand in a watch is

a) 0.053 rad/sec b) 0.02 rad/sec c) 0.150 rad/sec d) 0.42 rad/sec

11. (A): A disc released from the top of a fixed inclined plane rolls down without slipping if the inclined plane is rough only.

(R): friction does not work in pure rolling.

The correct answer is

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is not the correct explanation of A

c) A is true, R is false

d) A is false but R is true

12. Match list-I with list-II

a) Centrifugal force	e) along the axis of rotation
b) Centripetal force	f) towards the centre of rotations
c) Tangential force	g) Away from the center of rotation
d) Angular velocity	h) Changes the angular velocity

a) a-h, b-g, c-f, d-e b) a-g, b-f, c-h, d-e

c) a-f, b-g, c-h, d-e d) a-e, b-h, c-e, d-f

13. (A): A ball connected to a string is in circular motion on a frictionless horizontal table and is in equilibrium.

(R): Magnitude of the centripetal force is equal to the magnitude of the tension in the string

The correct answer is

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is not the correct explanation of A

c) A is true, R is false

d) A is false but R is true

14. Match list-1 with list-11

List-1	List -11
a) Centripetal force	e) earth’s rotation
b) Centrifugal force	f) steam governors
c) Conical pendulum	g) tides
d) Foucault’s pendulum	h) tension in the string of a simple pendulum

a) a-e, b-h, c-f, d-g   c) a-f, b-h, c-e, d-g
b) a-e, b-g, c-f, d-e   d) a-g, b-f, c-e, d-g

15. Match list-1 with list-11

List-1	List -11
a) Moment of inertia	e) ML^2T^{-1}
b) Torque	f) mr^2
c) Angular momentum	g) ½ $I\omega^2$
d) Rotational K.E. of solid sphere	h) rxF

Key:

1. a	2. a	3. a
4. a	5. a	6. a
7. c	8. a	9. a
10. c	11. d	12. b
13. d	14. b	15. c

QUESTION BANK

Conceptual Question:

1.In a uniform circular motion
1) Both velocity and acceleration are constant 2) Both acceleration and velocity change
3) Both acceleration and speed are constant 4) Both acceleration and speed change

2.For all particles in rotatory motion
1) linear velocity is same 2) linear displacement is same
3) angular velocity is same
4) square root of angular velocity equal to linear velocity

3.A body is moving along a curved path with changing magnitude of velocity, It has
1) Tangential acceleration 2) Radial acceleration
3) Both tangential and radial acceleration
4) Square root of angular velocity equal to linear velocity

4.A stone tied to one end of a rope and rotated in circular path. If the string breaks the stone travels
1) along circular path 2) away from center
3) towards center 4) along tangential direction

5.A particle is moving in a vertical circle. At the top of the circle, velocity of the particle is critical. Then which of the following is not true
1) Tension in the string at the top most point is mg
2) Tension in the string at the top most point is zero
3) Tension in the string at the lowest portion is equal to six times its weight
4) All the above

6.When a bucket filled with water is rotated in a vertical circle, water does not fall at the top most point because

1) Water has high adhesive force with bucket
2) Cohesive forces of water molecules are very strong
3) Centrifugal force balance the gravitational force 4) None of these

7.A wheel rotates with constant angular velocity. Then
1) Its angular displacement is proportional to time
2) Its angular acceleration is zero 3) Both 1 &2 4) Neither 1 nor 2

8.Moment of inertia of rigid body does not depend upon its
1) Mass 2) Distribution of mass about the axis
3) Angular velocity of the body 4) All of these

9.Moment of inertia of a rigid body depends up on
1) Mass of the body 2) Distribution of mass of the body about the axis
3) Both 1 &2 4) Neither 1 nor 2

10. With the increase in temperature, moment of inertia of a solid sphere about the diameter
1) Decreases 2) Increases 3) Does not change 4) None

11. If all a sudden the radius of the earth increases, then
1) the angular momentum of the earth will become greater than that of the sun
2) the orbit speed of the earth will increase
3) the periodic time of the earth will increase
4) the energy and angular momentum will remain constant

12. A person can balance easily on a moving bicycle but cannot balance on stationary bicycle. This is possible because of law of
1) conservation of mechanical energy 2) conservation of mass
3) conservation of angular momentum 4) conservation of linear momentum

13. When the torque acting on a system is zero, which of the following is conserved?
1) Linear momentum 2) Angular momentum
3) Moment of inertia 4) Angular velocity

14. The gymnast sitting on a rotating disc with his arms out stretched, suddenly lowers his arms
1) His angular velocity decreases 2) His moment of inertia decreases
3) His angular velocity remains constant 4) His angular momentum decreases

15. The angular momentum of a projectile in X –Y plane about point of projection at time ‘t’ has
1) only Z –component 2) only X and Y components
3) only X –component 4) only Y component

16. When a particle is rotating in a plane about a fixed point, its angular momentum is directed along
1) The radius 2) The tangent to the orbit
3) The axis of rotation 4) Circumference of that circle

17. A person is originally standing on a rotating wheel. If he sits on the wheel, the angular momentum
1) increases 2) decreases 3) remains same 4) doubles

18. Two rigid bodies have same angular momentum about their central axes. Then which will have greater kinetic energy?
1) body having more moment of inertia 2) body having less moment of inertia
3) body will have same kinetic energy 4) we cannot decide

1)2	2)3	3)3	4)4	5)1	6)3
7)3	8)3	9)3	10)2	11)2	12)3
13)2	14)2	15)1	16)3	17)3	18)2

Moment of inertia

1. Two particles of masses 2kg and 3kg are separated by 5m. Then moment of inertia of the system about an axis passing through the centre of mass of the system and perpendicular to the line joining them is
   1) 10 kgm^2 2)20 kgm^2 3)30 kgm^2 4)40 kgm^2
2. If moment of inertia of a solid sphere of mass 5kg about its diameter is 50 kg m^2. Its moment of inertia about its tangent in kg m^2 is
   1)260 2)250 3)240 4)175
3. The moment of inertia of a thin rod of linear density λ and length l about an axis passing through one end and perpendicular to length is
   1) $\frac{\lambda l^2}{12}$ 2) $\frac{\lambda l^2}{3}$ 3) $\frac{\lambda l^3}{12}$ 4) $\frac{\lambda l^3}{3}$
4. Moment of inertia of a ring about an axis passing through its diameter is I. Then moment of inertia of that ring about an axis passing through its centre and perpendicular to its plane is
   1)2I 2)I 3) $\frac{I}{2}$ 4) $\frac{I}{4}$
5. Two sphere each of mass m & radius R are placed touching each other. The moment of inertia of system about common tangent through their point of contact is
   1) $\frac{14mR^2}{5}$ 2) $\frac{4mR^2}{5}$ 3) $\frac{mR^2}{5}$ 4) $\frac{8mR^2}{5}$
6. Four particles each of mass m are kept at the four corners of a square of side 'l' moment of inertia about a line perpendicular plane passing through its centre is
   1)$4ml^2$ 2)ml^2 3)$2ml^2$ 4)$16ml^2$
7. Three particles each of mass m are at three vertices of an equilateral triangle of side a . Then moment of inertia of the system about an axis passing through its centre and perpendicular to its plane is
   1) $\frac{ma^2}{3}$ 2)ma^2 3) $3ma^2$ 4) $\frac{ma^2}{\sqrt{3}}$
8. Two discs have the same masses and thickness. Their materials are of densities D_1 and D_2 . Then ratio of their moments of inertia about axes passing through the centre and perpendicular to their planes is
   1) $D_1:D_2$ 2)$D_2:D_1$ 3)1: D_1D_2 4) $D_2\,D_1$::1

9. Two identical and thin discs are put in contact side by side such that their planes are perpendicular to each other and the same line passes through their diameters at the point of contact. If M and R denote mass and radius of each disc, moment of inertia of the system about that line passing through there centers is

1) $2MR^2$ 2) $\frac{3MR^2}{2}$ 3) $\frac{MR^2}{2}$ 4) MR^2

10. The moment of inertia of two spheres of equal masses about their diameters are the same. One is hollow, then ratio of their diameters

1)1:5 2)$1:\sqrt{5}$ 3)3:1 4) $\sqrt{5}:\sqrt{3}$

11. From a disc of mass M and radius R, a concentric disc of mass $\frac{M}{2}$ is removed. Then moment of inertia of the remaining part about the central axis perpendicular to its plane is

1) $\frac{3MR^2}{4}$ 2) $\frac{MR^2}{8}$ 3) $\frac{MR^2}{4}$ 4) $\frac{3MR^2}{8}$

12. The moment of inertia of a disc about an axis passing through its centre and perpendicular to its plane is I kgm^2 . Its moment of inertia about an axis coincident with the tangent to it is

1)I 2)$\frac{5}{4}I$ 3) $\frac{5}{2}I$ 4) $\frac{3}{2}I$

13. Moment of inertia a thin uniform rod about an axis passing through one end and perpendicular to its length is *I*. Then moment of inertia of the same rod about the central axis perpendicular to its plane is

1) $\frac{I}{4}$ 2)2I 3)4I 4)3I

14. The moments of inertia of a solid sphere and a hollow sphere of same mass about their diameters are equal. Then the ratio of their diameters is

1)1:1 2)3:5 3)$\sqrt{3}:\sqrt{5}$ 4) $\sqrt{5}:\sqrt{3}$

15. Three point masses m_1,m_2 and m_3 are located at the vertices of an equilateral triangle of side 'a' . the moment of inertia of the system about the axis parallel to the attitude of the triangle and passing through m_1 is

1)$(m_1+m_2)\frac{a^2}{2}$ 2) $(m_2+m_3)\frac{a^2}{4}$ 3) $(m_2+m_3)\frac{a^2}{2}$ 4) $(m_2+m_3)\,a^2$

16. The radius of gyration of a thin rod of mass m and length l about an axis perpendicular to its length and passing through the centre is

1)$\frac{l}{2\sqrt{3}}$ 2)$\frac{l\sqrt{3}}{2}$ 3) $\frac{l}{\sqrt{3}}$ 4) $\frac{2l}{\sqrt{3}}$

17. Radius of gyration of solid sphere about its tangent and its radius bear this ratio.

1) $\sqrt{5}:\sqrt{7}$ 2) $\sqrt{7}:\sqrt{2}$ 3) $\sqrt{2}:\sqrt{5}$ 4) $\sqrt{5}:\sqrt{2}$

18. The radius of gyration of a disc of radius R about central axis normal to its plane is

1)$\frac{R}{\sqrt{2}}$ 2) $\sqrt{2}$ R 3) $\frac{R}{2}$ 4)2R

19. The moment of inertia of a circular disc about its diameter is 500 kg m^2.

Key

1)3	2)4	3)4	4)1	5)1
6)3	7)2	8)2	9)3	10)4
11)4	12)3	13)1	14)4	15)2
16)1	17)2	18)1	19)1	20)4
21)3	22)3	23)4	24)1	25)3
26)2	27)4	28)1	29)1	30)3

Motion in a vertical circle

1. A motor cyclist of total mass is 200kg performing vertical circular motion inside a globe of diameter 8m.The reaction experienced by him at the lowest point is
   1)1000kg.wt 2) 1200 kg.wt s3)1400 kg.wt 4)1600 kg.wt
2. The velocity of a body revolving in a vertical circle of radius 'r' at the lowest point is $\sqrt{7gr}$ .The ratio of the maximum and minimum tensions in the string is
   1)8:1 2) 4:1 3) $\sqrt{7}$:1 4)1: $\sqrt{7}$
3. The minimum speed for a body at the lowest point such that it just completes a vertical circle 'r' when tied to a string of length 'l' .If the string length is reduced to $\frac{1}{4}$ th the body should have at lowest point of vertical circle minimum speed of
   1) $\frac{V}{4}$ 2) $\frac{V}{2}$ 3)V 4) $\frac{4}{V}$
4. A 2Kg stone at the end of a string 1m long is whirled in a vertical circle at a constant speed. The tension in the string is $52N$ when the stone is at the bottom of the circle . Then speed of the stone is (g = 10ms^{-2})
   1)2ms^{-1} 2)4m s^{-1} 3)6m s^{-1} 4)8ms^{-1}
5. A point mass of 100grams is whirled at the end of a string in a vertical circle of radius 1m at a constant speed of 6m s^{-1} . The tension in the string at the highest point of its path will be(g = 10ms^{-2})
   1)1.6N 2)2.6N 3)3.6N 4)0.6N
6. A 1kg stone at end of 1m long string is whirled in a vertical circle at a constant speed of 4ms^{-1}.The tension in the string is 6N,when the stone is (g = 10ms^{-2})
   1) At the top of the circle 2) At the bottom of the circle
   3)Half way done 4)None
7. The bob of a pendulum of mass m and length is pulled to a side till the string is horizontal and released. Then tension in the string when the bob passes through the lowest point is
   1)1mg 2)2mg 3)3mg 4)4mg
8. A wooden ball of mass M hangs from a string of length *'l'* . A bullet of mass m flying horizontally hits the ball and stickes to it. The minimum velocity of the bullet so that the ball makes a complete revolution in the vertical plane is

1) $\frac{(m+M)\sqrt{5gl}}{m}$ 2) $\frac{(m+M)\sqrt{gl}}{m}$

3) $\frac{(m+M)\sqrt{5gl}}{M}$ 4) $\frac{(m+M)\sqrt{gl}}{m}$

1)2	2)2	3)2	4)2
5)2	6)1	7)3	8)1

Torque, Momentum & Energy:

1. A rod of mass 'm' and length 'l' rotates about an axis passing through its end and perpendicular to its length. If its angular velocity is decreased from 4ϖ to 2ϖ in 3 seconds, the torque applied on it.
   1) $\frac{ml^2\varpi}{6}$ 2) $\frac{2ml^2\varpi}{3}$ 3) $\frac{2ml^2\varpi}{9}$ 4) $\frac{ml^2\varpi}{9}$
2. A disc of mass 16kg and radius 25 cm is rotated about its axis. What torque will increase its angular velocity from 0 to 8 π rads^{-1} in 8 seconds
   1) π Nm 2) π/2 Nm 3) π/4 Nm 4)2π Nm
3. A torque of magnitude 100 Nm acting on a rigid body produces an angular acceleration of 2rad s^{-2} . Then moment of inertia of that body is
   1)50kgm^2 2)100 kgm^2 3)200 kgm^2 4)25 kgm^2
4. A shaft rotating at 6000 rpm is transmitting a power of 2π KW. Then magnitude of the driving torque is
   1)10 Nm 2)5 Nm 3)1 Nm 4)0.1Nm
5. Kinetic energy of a wheel rotating a\bout its central axis is E. Then kinetic energy of another wheel having twice the moment of inertia and half the angular momentum as that of the first wheel is
   1)8E 2)4E 3)E/8 4)E/4
6. Torque of equal magnitude are applied on a solid sphere and a hollow sphere both having the same mass and radius. They are free to rotate about their central axes perpendicular to their planes. Then ratio o f the angular velocities acquired by then after a given time if they initially at rest.
   1)3:5 2)5:3 3)9:25 4)25:9
7. A stone is whirled along a circle with a constant angular velocity and its angular momentum is L.If the radius of its circular path is halved while keeping the angular velocity same, its new angular momentum would be
   1)L/4 2)L/2 3)L 4)2L
8. Angular momentum of a solid sphere about its diameter is L .If it rotates about its tangent with the same angular velocity as that in the first case, now its angular momentum will be
   1)2L /7 2)7L /5 3)5L /2 4)7L/2
9. when 50 j of work is done on a wheel, its angular speed is increased from 1rps to 2 rps.Then moment of inertia of that wheel is
   1) $\frac{25}{8\pi^2}$ kgm^2 2) $\frac{25}{4\pi^2}$ kgm^2 3) $\frac{25}{2\pi^2}$ kgm^2 4)None

10. A solid sphere is rotating with a constant angular velocity ϖ about its diameter. Its rotational kinetic energy is same as the kinetic energy acquires by it if the same falls through a distance h under gravity. Then radius of the sphere is

1) $\frac{\sqrt{gh}}{\varpi}$ 2) $\frac{\sqrt{2gh}}{\varpi}$ 3) $\frac{\sqrt{3gh}}{\varpi}$ 4) $\frac{\sqrt{5gh}}{\varpi}$

11. A hollow sphere and solid sphere of same mass and radius rotate about their diameters with the same rotational kinetic energy. Then ratio of their angular velocities is

1)3:5 2)5:3 3) $\sqrt{3}:\sqrt{5}$ 4) $\sqrt{5}:\sqrt{3}$

12. A thin circular ring of mass M is rotating about its axis with an angular velocity ϖ .Two objects each of mass M/2 are attached gently to the opposite ends of a diameter of that ring. Then the new angular velocity of the ring system would be

1) 2ϖ 2) 4ϖ 3) $\varpi/2$ 4) $\varpi/4$

13. If the angular momentum of body about an axis is increased by 10% its kinetic energy increases by

1)20% 2)21% 3)10% 4)-21%s

14. Mass remaining constant if the earth suddenly contracts to one third of its present radius the length of the day would be shorted by

1) $\frac{8}{3}$ 2)12hours 3)8hours 4) $\frac{64}{3}$ hours

15. If the density of the earth is to remain constant and earth contracts to half of its present radius, duration of then day will be

1)45minutes 2)80 minutes 3)6hours 4)18 hours

16. A uniform disc of mass M and radius R is rotating in a horizontal plane about an axis perpendicular to its plane with an angular velocity ϖ Another disc of mass $\frac{M}{3}$ and radius R/2 is placed gently on the first disc coaxially. Then final angular velocity of the system.

1) $\frac{12\varpi}{13}$ 2) $\frac{13\varpi}{12}$ 3) $\frac{3\varpi}{12}$ 4) $\frac{11\varpi}{12}$

17. A dancer spins about himself with an angular speed ϖ . With his arms extended. When he draws his hands in, his moment of inertia reduces by 40%.Then his new angular velocity would be

1) $\frac{3\varpi}{5}$ 2) $\frac{4\varpi}{5}$ 3) $\frac{5\varpi}{4}$ 4) $\frac{5\varpi}{3}$

18. A disc if mass 2kg and radius 0.2m is rotating about an axis passing through its centre and perpendicular to its plane with an angular velocity 50rads^{-1}.Another disc of mass 4kg and radius 0.1m rotates about an axis passing through its centre and perpendicular to its plane. If the two discs are coaxially coupled, angular velocity of the coupled system would be

1)150 rads^{-1} 2)120 rads^{-1} 3)100/3 rads^{-1} 4)50rads^{-1}

19. A dancer spins about a vertical axis at 60 rpm with her arms closed. If she now stretches her hands, her moment of inertia increases by 50%. Her new speed of revolution is

1)90 rpm 2)80 rpm 3)40 rpm 4)30rpm

20. Rotational kinetic energy of a disc of mass 1kg and radius 0.2m is 8j. then velocity of its centre of mass is

1)2 ms^{-1} 2)$2\sqrt{2}$ ms^{-1} 3)4 ms^{-1} 4)$4\sqrt{2}$ ms^{-1}

21. A hollow sphere rolls on a horizontal surface without slipping. Then percentages of rotational and transnational kinetic energy in total energy is

1)40%,60% 2)60%,40% 3)28%,72% 4)72%,28%

22. A solid sphere of mass M rolls without slipping on a horizontal surface with a linear velocity V. Then its total kinetic energy is

1) $\frac{5MV^2}{7}$ 2) $\frac{7MV^2}{5}$ 3) $\frac{10MV^2}{7}$ 4) $\frac{7MV^2}{10}$

23. A ring and a disc having the same mass roll without slipping with the same linear velocity. If the kinetic energy of the ring is 8j,then kinetic energy of the disc must be

1)2J 2)4J 3)6J 4)12J

Key

1)3	2)2	3)1	4)1	5)3	6)2
7)1	8)4	9)1	10)4	11)3	12)3
13)2	14)4	15)1	16)1	17)4	18)3
19)3	20)4	21)1	22)4	23)3	

NEW TYPES OF QUESTION

1) Match the following

List-I	List-II
a) Work	e) Non conservative force
b) Friction	f) eV
c) The position of centre of mass	g) Coefficient of friction
d) The tangent of angle of repose	h) Independent of coordinate system

1) a-c, b-f, c-g, d-h 2) a-f, b-e, c-h, d-g

3) a-f, b-e, c-h, d-g 4) a-f, b-g, c-e, d-h Key:3

2) Match the following

List-I	List-II
The angle between the force and displacement is	The work done is
a) acute	d) zero
b) right angle	e) Negative
c) obtuse	f) Positive

1) a-f, b-d, c-e 2) a-f, b-e, c-d

3) a-d, b-e, c-f 4) a-e, b-d, c-f Key: 1

3) A block of mass 10kg on a rough horizontal surface. A horizontal force 4N is applied on it. If the coefficient of friction between the surface is 0.5 then after two seconds

a) The acceleration of the particle is $0.1ms^{-2}$
b) The displacement of the particle is 0.2m
1) a and b are correct   2) a,b and c are correct
3) b and d are correct   4) All the above are false   Key:3

4) Assertion: Circular wheels are preferable than square wheels
Reason: Rolling friction is greater than kinetic friction.
1) A is true R is false   2) A is false but R is true
3) Both A and R are false   4) Both A and R are true   Key:1

5) A ring, disc and solid sphere are made up of steel with same radius are moving on a rough horizontal surface. If their sliding friction are R,D,S respectively then
1) $R>D<S$ 2) $R<S<D$ 3) $S<D<R$ 4) $R<D<S$ Key: 4

6) Assertion: A body rests on rough horizontal surface when no external force is applied on it.
Reason: Its weight is balanced by the static friction
1) A is correct R is not correct explanation   2) A is false R is correct
3) Both A and R are correct   4) Both A and R are false   Key: 1

7) When a bicycle is in motion the force of friction exerted by the ground on the two wheels such that it may act
a) In the backward direction on the front wheel and In the forward direction on the rear wheel
b) In the forward direction on the front wheel in the backward on the rear wheel
c) In the backward direction on both front and the rear wheel
d) In the forward direction on both the front and the rear wheel
1) a and b are correct   2) a and c are correct
3) b and c are correct   4) b and d are correct   Key:2

8) Assertion: A car with flattened tyres stop sooner when pushed than a car with un flattened tyres
Reason: Greater the deformation on the tyre, the greater will be the rolling friction
1) A is true R is false   2) A is false R is true
3) Both A and R are true   4) Both A and R are false   Key: 3

9) About natural axis of rotation, the ratio of radius gyration and radius for following bodies

List-I	List-II
a) Circular ring	e) 2:5
b) hollow sphere	f) 1:1
c) circular plate	g) 2:3
d) solid sphere	h) 1:2

	a	b	c	d		a	b	c	d
1)	h	e	g	f	2)	f	g	h	e
3)	f	e	h	g	4)	e	h	g	f

Key:2

10) Match the following analogous physical quantities:

List-I	List-II
a) mass	e) angular momentum
b) force	f) moment of couple
c) linear momentum	g) torque

d) couple h) moment of inertia

	a	b	c	d		a	b	c	d
1)	e	f	h	g	2)	g	h	e	f
3)	h	g	e	f	4)	h	e	g	f

Key: 3

11) Assertion: A vehicle that travels along an unbanked curved path may skid or overturn from curvature

Reason: The vehicle skids when velocity of vehicle is $F>\sqrt{\mu rg}$ and overtimes $V>\sqrt{rgb/2h}$ where r is radius curvature , h is height of centre of gravity .b is of vehicle and μ is coefficient of friction

1) Both A and R are true and R is correct explanation of A
2) Both A and R are true and R is not correct explanation of A
3) A is true but R is false
4) A is false but R is true Key: 1

12) A string of length l is suspended from fixed point and a body of mass m is attached at the lower of that string. The body is made to move along a horizontal circle of radius r with an angular velocity ω such that the string makes an angle θ with vertical. If T is tension in the string then

a) $\omega=\sqrt{g/l\cos\theta}$ b) centripetal force (F) = $\sqrt{T^2-(mg)^2}$

c) T/mg = l/r d) centripetal force is the resultant of T and

1) both a and c are correct 2) both a and d are correct

3) a, b and d are correct 4) a, b, c and d are correct

PREVIOUS EAMCET QUOTIONS

1. The radius of gyration of a rod of length 'L' and mass 'M' about an axis perpendicular to its length and passing through a point at a distance $\frac{L}{3}$ from one of its ends is (2007M)

   1) $\frac{\sqrt{7}}{6}L$ 2) $\frac{L^2}{9}$ 3) $\frac{L}{3}$ 4) $\frac{\sqrt{5}}{2}L$
2. A ball of mass 0.6kg attached to a light inextensible string rotates in a vertical circle of radius 0.75m such that it has a speed of $5ms^{-1}$ when the string is horizontal. Tension in the string when it is horizontal on other side is ($g = 10ms^{-2}$) (2007M)

   1) 30N 2) 26N 3) 20N 4) 6N
3. A bucket filled with water is tied to a rope of length 0.5m and is rotated in a circular path in vertical plane. The least velocity it should have at the lowest point of circular so that water does not spill is ($g = 10ms^{-2}$) (2007E)

   1) $\sqrt{5}$ m/s 2) $\sqrt{10}$ m/s 3) 5m/s 4) $2\sqrt{5}$ m/s
4. Two solid spheres (A and B) are made of metals of different densities P_A and P_B respectively. If their masses are equal, the ratio of their moment of inertia $\left(\frac{I_A}{I_B}\right)$ about their respective diameter is (2007E)

1) $\left(\frac{P_B}{P_A}\right)^{\frac{2}{3}}$ 2) $\left(\frac{P_A}{P_B}\right)^{\frac{2}{3}}$ 3) $\frac{P_A}{P_B}$ 4) $\frac{P_B}{P_A}$

5. A uniform circular disc of radius R lies in the X –Y plane with its center coinciding with the origin of inertia about an axis lying in a plane perpendicular to X –Y plane passing through a point on the X –axis at a distance x = d is I_2. $I_1 = I_2$, the value of 'd' is (2006M)

   1) $\frac{\sqrt{19}}{2}R$ 2) $\frac{\sqrt{17}}{2}R$ 3) $\frac{\sqrt{15}}{2}R$ 4) $\frac{\sqrt{13}}{2}R$

6. The kinetic energy of a body rotating at 300 revolutions per minute is 62.8J. Its angular momentum (in kg m^2 s^{-1}) is approximately (2006M)

   1) 1 2) 2 3) 4 4) 8

7. A uniform rod of length '8a' and mass '6m' lies on a smooth horizontal surface. Two point masses 'm' and '2m' moving in the same plane with speed 2v and v respectively strike the rod perpendicularly at distance 'a' and '2a' from the mid point of the rod in the opposite directions and stick to the rod. The angular velocity of the system immediately after the collision is (2006E)

   1) $\frac{6v}{32a}$ 2) $\frac{6v}{33a}$ 3) $\frac{6v}{40a}$ 4) $\frac{6v}{41a}$

8. A uniform cylindrical rod of mass M and length L is rotating with an angular speed 'ω'. The axis of rotation is perpendicular to its axis of symmetry and passes through one of its end faces. If the room temperature increases by 't' and the coefficient of linear expansion of the rod is 'α', the magnitude of the change in its angular speed is)

   1) $2\omega\alpha t$ 2) $\omega\alpha t$ 3) $\frac{3}{2}\omega\alpha t$ 4) $\frac{\omega\alpha t}{2}$ (2005M)

9. Assertion: I_S and I_H are the moments of inertia about the diameters of a solid and thin walled hollow sphere respectively. If the radii and the masses of the above spheres are equal, $I_H > I_S$.

   Reason: In solid sphere, the mass is continuously and regularly distributed about the center; whereas the mass, to a large extent is concentrated on the surface of hollow sphere (2005M)

   1) Both A & R are true and R is the correct explanation of A
   2) Both A & R are true and R is not the correct explanation of A
   3) A is true but R is false 4) A is false but R is true

10. A constant power is supplied to a rotating disc. The relationship of the angular velocity (ω) of the disc and the number of rotations (n) made by the disc is governed by (2005E)

    1) $\omega \propto n^{1/3}$ 2) $\omega \propto n^{2/3}$ 3) $\omega \propto n^{3/2}$ 4) $\omega \propto n^2$

11. Identify the increasing order of the angular velocities of the following (2005E)

    a) Earth rotating about its own axis b) Hour's hand of a clock
    c) Second's hand of a clock d) Flywheel of radius 2m making 300 rpm

    1) a, b, c, d 2) b, c, d, a 3) c, d, a, b 4) d, a, b, c

12. A uniform circular disc of radius 'R' lies in the X –Y plane with the center coinciding with the origin. Its moment of inertia about an axis passing through a point of the X –

axis at a distance x =2R and perpendicular to the X –Y about an axis passing through a point on the Y –axis a distance Y = d and parallel to the X –axis is the X –Y plane. The value of ‘d’ is (2004M)

1) $\frac{4R}{3}$ 2) $\sqrt{17}\left(\frac{R}{2}\right)$ 3) $\sqrt{15}\left(\frac{R}{2}\right)$ 4) $\sqrt{13}\left(\frac{R}{2}\right)$

13. Assertion: If a body moving in a circular path has constant speed, then there is no force acting on it
Reason: The direction of the velocity vector of a body moving in a circular path is changing (2004M)
1) Both A & R are true and R is the correct explanation of A
2) Both A & R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

14. A thin uniform square lamina of side ‘a’ is placed in the XY –plane with its sides parallel to X and Y –axis and with its center coinciding with the origin. Its moment of inertia about an axis passing through a point on the Y –axis at a distance Y =2a and parallel to X-axis is equal to its moment of inertia about an axis passing through a point on the X –axis at a distance x =d and perpendicular to XY –plane. Then value of ‘d’ is (2003E)

1) $\frac{7}{3}a$ 2) $\sqrt{\frac{47}{12}}a$ 3) $\frac{9}{5}a$ 4) $\sqrt{\frac{51}{12}}a$

15. A particle of mass 1kg is projected with an initial velocity $10ms^{-1}$ at an angle of projection 45^0 with the horizontal. The average torque acting on the projectile, between the time at which it is projected and the time at which it strikes the ground, about the point of projection in newton –meter is (2004E)
1) 25 2) 50 3) 75 4) 100

1)3	2)3	3)3	4)2	5)3
6)3	7)3	8)1	9)1	10)1
11)1	12)2	13)4	14)2	15)2

Additional Problems

(1) A solid cylinder (SC), a hollow cylinder (HC) and solid sphere (S) of the some mess and riddles are released simuthemourly from the some height. The order in which these bodies reach the bottom of the incline is.
( )
a) SC, HC, S b) SC, S HC c) S, SC HC d) HC, SC, S

(2) The mass of the earth is 6.0x10 24kg, its radius is 6.4x10 6m and it has an angular speed of 1 rac / day. Assuring the earth to be uniform slyer, the rotational kinetic energy is.
( )
a) $2.6\times10^{29}J$ b) $3.5\times10^{8}J$ c) $4.8\times10^{27}J$ d) $1.2\times10^{30}J$

(3) A uniform spherical shell rolls down a fixed inflamed plane without slipping. The nitro of rotational kinetic energy to the translational kinetic energy as it reaches lowest point of the incline. ( )

a) 3/2 b) 2/3 c) 5/2 d) 7/3

(4) A solid cylinder of radius R and mass M rolls without slipping an inclined plane angle θ the combatant acceleration is. ( )

a) $\frac{2}{3} g \sin\theta$ b) $\frac{1}{3} g \sin\theta$ c) $\frac{3}{4} g \sin\theta$ d) $\frac{1}{2} g \sin\theta$

(5) A solid sphere and a spherical shell roll down an incline from rest from same height. The nitro of times taken by them is. ( )

a) $\sqrt{\frac{25}{21}}$ b) $\sqrt{\frac{25}{23}}$ c) $\sqrt{\frac{21}{25}}$ d) $\sqrt{\frac{23}{25}}$

(6) A drop rolls down an inclined plane. The fraction of its total kinetic energy that is associated with the rotational motion is. ( )

a) 1:2 b) 1:3 c) 1:4 d) 2:3

(7) Two identical cylinders are released from the top of two identical included planes, if one rolls without slipping and the other slips without rolling, they. ( )

a) Rolling cylinder reaches the bottom first with greater speed
b) Sliding cylinder reaches the bottom first with greater speed
c) Both reach the bottom simultaneity and the some speed.
d) Both reach the bottom simultaneity but with different speeds.

CHAPTER 8
OSCILLATIONS

1. Periodic Motion : the motion which repeats itself at regular intervals of time is called periodic motion.
   Ex. The motion of the earth round the sun, the motion of the hand of a clock are periodic motions but they are not S.H.M.
2. Simple harmonic motion (SHM) : if a body moves along a straight line with its acceleration always directed towards a fixed point on the line and the magnitude of acceleration is directly proportional to the displacement of the body measured with respect to that fixed point, then the body is said to be in SHM.
3. simple harmonic motion may also be described as the projection of uniform circular motion on a fixed diameter of the circle.
4. Simple harmonic motions are of two types
   i) Linear simple harmonic motion : if the particle executes SHM along a straight line, then it is said to be in linear simple harmonic motion.
   Ex: i) The to and from motions of a simple pendulum
   ii) the up and down motions of a mass suspended form a spring.
   ii) Angular simple harmonic motion :_ the angular motion of a particle in which the restoring torque is proportional to angular displacement and is opposite in direction to it is called angular simple harmonic motion
   Ex.(1) The twisting and untwisting motion of a disc when suspended by a wire.
   (2) Oscillation of magnet in vibration magnetometer.
5. Displacement: it is the distance of the particle in SHM from the mean equilibrium at any instant of time.
6. Amplitude : the maximum displacement of the particle from the mean position is called amplitude
7. Frequency: it is the number of oscillations made by the particle in SHM per second.
8. Phase: Phase is that which gives the position and direction of motion at the given instant.
9. Restoring force:- the force which acts on a particle in a direction opposite to the direction of its displacement is called restoring force.
10. in simple harmonic motion this restoring force is directly proportional to the $F=- -Kx$, where k is a constant called the force constant.
11. Equation of simple harmonic motion :
    i) if a particle under go SHM starting from mean equilibrium position, its displacement (x) at any time t can be represented by
    $x=A \sin \omega t$ where A is the amplitude and $\omega$is the angular frequency
    ii) If a particle undergoing SHM starting from one extreme position, its displacement can be represented by
    $X=A \cos \omega t$
    iii) Generally if motion starts from any position. Its displacement can be represented $x=A \sin \omega t + \phi$
    Where $\omega t + \phi$ is called phase angle and ϕ is called initial phase or "epoch"
12. Velocity of a particle executing SHM : the velocity of the particle undergoing SHM at any instant 't' can be represented by $V=\omega \sqrt{A^2-x^2}$

13. Acceleration of a particle executing SHM. : The acceleration of the particle undergoing SHM at any instant t can be represented by
Acceleration (a) = $- \omega^2 x$
14. The average velocity of a particle in SHM during one complete oscillation is equal to zero.
15. Time period of a particle executing SHM. The time taken by a particle to complete one oscillation is called time period. The period of oscillation of a body in SHM is given by $T= 2\Pi/\omega = 2\Pi \sqrt{x/a}$
16. Frequency of a particle executing SHM. : the frequency of oscillation of a particle in SHM is given by
$n= 1/T = \omega /2\Pi= 1/2\Pi\sqrt{a/x}$
17. Phase of a particle executing SHM : it represents the initial position of a vibrating particle at the instant when the counting of time is begun.
    i) If the SHM of the particle starts from mean position in positive x-direction then its phase is given by $\phi= 0$
    ii) If the SHM of the particle starts from the extreme position in positive y – direction the its phase is given by $\phi=\Pi/2$
    iii) If the SHM of the particle starts from the extreme position in negative Y direction then its phase is given by $\phi=3\Pi/2$
18. Phase changes in SHM.
    i) The phase difference between displacement and velocity = $\Pi/2$ (or) 90^0
    ii) The phase difference between velocity and acceleration = $\Pi/2$ (or) 90^0
    iii) The phase difference between displacement and acceleration = Π(or) 180^0
19. P.E. of a particle executing SHM. : the potential energy of SHM at any instant of time can be represented by
$P.E.=1/2\ mw^2A^2 \sin^2 (\omega t+\phi)$
20. K.E. of a particle executing SHM : at any instant of time, the K.E. of a particle executing SHM is given by
$K.E.=1/2\ m.\omega^2A^2\cos^2(\omega t+\phi)$
21. Total energy of a particle executing SHM : the total energy of the particle , undergoing SHM is equal to the sum of its P.E. and K.E. it always remains constant
Total energy $E= P.E.+K.E= 2m\ \Pi^2A^2n^2$
22. For a particle in SHM with frequency n, its P.E. and K.E. changes with a frequency 2 n.
23. For a particle executing SHM with a time period T its P.E. and K.E. changes with a period of T/2 .
24. Path length of a particle executing SHM =2A (Where 'A" is amplitude)
25. Oscillations of a loaded spring : if a mass m, attached to the free end of a mass –less spring is pulled down and released it undergoes SHM if k is the spring constant or force constant, its time period is given by .
    i) $T= 2\Pi \sqrt{m/k}=2\Pi \sqrt{x/g}$
    ii) Its frequency is given by $n= 1/2\Pi \sqrt{k/m}$
    iii)If a mass M is suspended from a spring of mass m its time period is given by $T= 2\Pi \sqrt{M+m/3/ k}$

26. If two springs of spring constants k1 and k2 are connected in series the effective spring constant (k) is given by
$1/k = 1/k_1 + 1/k_2$ (or) $K = k_1k_2/k_1+k_2$
27. IF two springs of spring constant k_1 and k_2 are connected in parallel as shown in the effective spring constant (K) is given by , $K=K_1+K_2$
Time period $T=2\Pi \sqrt{m/K1+K2}$
28. Simple pendulum : The time period of a simple pendulum of length l is given by, $T=2 \Pi \sqrt{l/g}$.
29. The period of oscillation is independent of the size, shape, mass and the material of the bob. (when its length remains constant)
30. The period of oscillation of a simple pendulum of constant length is independent of the amplitude of oscillation provided it is small (up to 6^0)
31. Laws of simple pendulum:
    i) The time period (T) of a simple pendulum is directly proportional to the square root of its length. $T_1/T_2 = \sqrt{l_1/l_2}$
    ii) The time period (T) of a simple pendulum is inversely proportional to the square root of acceleration due to gravity(g) $T1/T2 = \sqrt{g2/g1}$
32. Pendulum in a lift : if a pendulum is suspended form the ceiling of a lift its time period changes when the lift is in motion.
    i) When the lift is stationary, its time period is given by , $T= 2\Pi \sqrt{l/g}$
    ii) When the lift is moving up with an acceleration 'a', its time period is given by , $T= 2\Pi \sqrt{l/g+a}$
    iii) When the lift is moving down with an acceleration 'a', its time period is given by $T= 2\Pi \sqrt{l/g-a}$
    iv) When the lift is falling freely its time period is given by $T= 2\Pi \sqrt{L/g-g} = \infty$
33. Simple Pendulum in a cart :
    i) When the cart is moving in horizontal direction with an acceleration 'a' the time period of the pendulum is given by
    $T= 2\Pi \sqrt{l}/ \sqrt{a^2+g^2}$
    ii) When the cart is sliding down an inclined plane of angle of inclination 'θ' the time period of the pendulum is given by
    $T= 2\Pi \sqrt{l/g\cos\theta}$
    iii) if simple pendulum itself is sliding down. If its time period is T then new time period $T^1 = T/\sqrt{\cos\theta}$
34. The time period of a simple pendulum in a car moving on a circular road of radius R with a constant speed v is given by
$T= 2\Pi \sqrt{1 / g^2+v^4/R^2)^{1/2}}$
35. If a hole is made along the diameter of the earth and a body is dropped into it the body executes SHM its time period is given by
$T=2 \Pi \sqrt{R/g}$ = 84.5 minutes where R= radius of earth=$6.4X10^6$ m
36. The time period of a pendulum whose length is equal to the radius of the earth is given by
$T=2 \Pi \sqrt{R/2g}$ = 59 minutes 45 seconds
37. The time period of a pendulum whose length is very large is given by

$T= 2\Pi \sqrt{LR / g(L+R)}$

38. Pendulum in electric field :
    Let q= charge on bob and E= Intensity of electric field
    i) When the direction of electric field E and force F is same $T= 2\Pi \sqrt{l/g-Eq/m}$
    ii) When the direction of e & f is opposite $T= 2\Pi \sqrt{l/g+Eq/m}$
39. Oscillations of a spring: if a spring is suspended vertically from rigid support is pulled down slightly and released, it began to oscillate. Its time period is given by , $T= 2\Pi\sqrt{e/g}$
40. If two spring oscillation with the time periods T1 and T2 are connected in parallel the new time period of the combination is given by,
    $T= T_1T_2 / \sqrt{T^2{}_{1+}T^2{}_2}$
41. If a spring of force constant k is cut into n equal parts the force constant of each part=nk If a mass m is suspended to one of the piece its time period $T=2 \Pi \sqrt{m/nk}$
42. If a spring having time period T is cut into n equal parts, the time period of each part is given by $T^1=T/\sqrt{n}$ (without mass attached)
43. If metal sphere of density d_s is hung as the bob of a simple pendulum of length (l) and tsime period (T) and the sphere is now immersed in a non –viscous liquid of density d_l (d_s>d_L) . its new period of oscillation is given by $T= 2\Pi \sqrt{ld_s / g(d_s-d_l)}$.
44. The time period of the simple pendulum on surface of earth is T.
    a) its time period at a depth d below the surface of the earth
    $T^1 = T \sqrt{R/R-d}$
    b) Its time period at a height h above the surface of the earth
    $T^1=T (R+h/R)$

QUESTION BANK

CONCEPTUAL QUESTIONS

1. A particle is moving in a circle with uniform speed. Its motion is
   1)Periodic and simple harmonic 2)Periodic but not simple harmonic
   3)a periodic 4)none of the above
2. In S.H.M, there is always a constant ratio between the displacement of the body and its
   1)Velocity 2)Acceleration 3)ass of the particle 4)All of the above
3. A body executing simple harmonic motion has maximum acceleration
   1)At the mean positions 2)At the two extreme position
   3)At any position 4)The question is irrelevant
4. Which of the following is a necessary and sufficient condition for simple harmonic motion.
   1)Constant period 2)constant acceleration
   3)Proportionality between acceleration and restoring force
   4)Proportionality between restoring force and displacement from equilibrium position
5. Which of the following expression does not represent SHM
   1)Acosωt 2)A sin2ωt 3)A sinωt+Bcosωt 4)$A\sin^2 t$
6. A particle moves on the x-axis according to the equation $x=x^0 \sin\omega t$. The motion is simple harmonic.

1)with amplitude x_0 2)with amplitude $2x_0$ 3)with time period π/ω 4)with time period $2\pi/\omega$

7. A particle moves on the x-axis according to the equation $x=A+B \sin\omega t$. The motion is simple harmonic with amplitude
   1)A 2)B 3)A+B 4)A^2+B^2
8.. The ratio of maximum acceleration to maximum displacement of a simple Harmonic Motion is equal to
   1)Square of its angular velocity 2)Square of its time period
   3)its time period 4)its angular velocity
9. A particle is executing S.H.M. Then the graph of acceleration as a function displacement is
   1)A sine curve 2)A circle 3)A straight line 4)Frequ3ncy
10. At the equilibrium position of a particle executing S.H.M
    1)Restoring force acting on the particle is zero
    2)The velocity of the particle is maximum
    3)Potential energy is minimum 4) All the above
11. For a particle executing S.H.M along x-axis force is given by
    1)-kx 2)A coskx 3)A e-kx 4)Akx
12. If the maximum acceleration of a S.H.M. is α and the maximum velocity is β then amplitude of vibration is given by
    1)$\beta^2\alpha$ 2)$\alpha^2\beta$ 3)β^2/α, 4)α^2/β
13. An oscillating simple pendulum is arranged in a vacuum jar, then
    1)It stops oscillating 2)It continues to oscillate
    3)It oscillates with slightly more time period
    4)It oscillates with slightly less time period
14. The bob of a simple pendulum is hollow. Now its time period is T. If it is filled with water the time period will be
    1)More than T 2)Less than T 3)Equal to T 4)Zero
15. The amplitude of a simple harmonic oscillator is doubled. Which of the following is also doubled?
    1)Its frequency 2)Its period 3)Its maximum velocity 4)Its total energy
16. In simple harmonic motion, when the displacement is minimum then
    1)K.E is maximum and P.E is minimum 2)P.E is maximum and D.K is minimum
    3)Both K.E and P.E are maximum 4)Both P.E and K.E are minimum
17. A bob is hung from an elastic spring to a support and set in motion is a vertically place in a way similar to the oscillations of a simple pendulum. Its length will be maximum
    1)At its left extreme position 2)At its right extreme position
    3)At its mean position 4)Will remain the same at all positions
18. A seconds pendulum is taken from the surface of the earth to that of the moon. In order to maintain the period constant.
    1)Length of the pendulum has to be deceased
    2)Length of the pendulum has to be increased.
    3)Amplitude of the pendulum has to be increased
    4)Amplitude of the pendulum has to be increased

19. The period of a simple pendulum suspended from the ceiling of a car it T when the car is at rest. If the car moves with a constant acceleration the period of the pendulum
1)Unaltered 2)Decreases 3)Increases 4)None
20. If iron sphere is replaced by wooden sphere of same mass, time period
1)Increases 2)Decreases 3)Remains same 4)None of the above

KEY

1) 2	2) 2	3) 2	4) 4	5) 3	6) 3	7) 2	8) 1	9) 3	10) 4
11) 1	12) 3	13) 2	14) 3	15) 3	16) 1	17) 3	18) 1	19) 2	20) 1

1) What is phase difference between displacement and acceleration of a particle executing SHM in radians
1)Π/2 2)Π 3)3Π/2 4)2Π
2) Amplitude of oscillation of a particle that executes SHM is 2 cm what is the displacement from its mean position in a time equal 1/6th of its time period
1)√2 cm 2) √3cm 3)1/√2cm 4)1/√3cm
3) A simple harmonic oscillator starts from extreme position and covers a displacement half of its amplitude in a time ‘t’, in what further time it reaches mean position
1)2t 2)t 3)t/√2 4)t/2
4) The velocity of a particle that executes SHM at its mean position is 0.866m/s. what will be its velocity at a displacement half of its amplitude from mean position
1)1m/s 2)1.414m/s 3)0.5m/s 4)0.75m/s
5) Displacement of a particle executing SHM is given by X=0.01Sin100Π(t+0.005x) where X is in meter and t is in seconds. What is its velocity when t=0
1)Π m/s 2) Π /2m/s 3)2Π m/s 4)zero
6) The time period of oscillation of a particle executes S.H.M IS 1.2sec. in what time starting extreme position, its velocity will be half of its velocity at mean position
1) 0.1sec 2)0.2sec 3)0.4sec 4)0.6sec
7) The time period of oscillation of a particle in S.H.M is Π sec. if its acceleration at extreme position is $1m/s^2$, its velocity at mean position
1)0.5m/s 2)2m/s 3) Π/2m/s 4) Π m/s
8) A particle executing S.H.M has velocity 20cm/s, 16cm/s at a displacement 4cm/s,5cm/s from its mean position respectively. Its time period is
1)Π/2sec 2)Πsec 3)2Πsec 4)Π/4sec
9) The displacement equation of two simple harmonic oscillator are given by $X_1=A_1$ Cosωt ; $X_2=A_2$ Sin(ωt+Π/6) the phase difference between them in degrees
1)30 2)60 3)90 4)120
10) The maximum speed of a particle in S.H.M. is found to be 62.8cm/s. If the amplitude is 20cm its period of oscillation is
1)1sec 2)2sec 3)3sec 4)4sec

For a body in S.H.M. the velocity is given by the relation $V = \sqrt{144 - 16x^2}$ m/s. The maximum acceleration is
1)12m/s 2)16m/s 3)36m/s 4)48m/s

12. The periods of pendulum on two planets are in the ratio 4:3. The acceleration due to gravity on them are in the ratio
1)9:16 2)3:4 3)4:3 4)16:9
13. The motion of a particle executing S.H.M. is represented by Y=Sint, where Y is in meter. The amplitude of motion is
1)1m 2)√2m 3)1/2m 4)2m
14. Two S.H.M's are represented by the relations X=4Sin(80t+Π/2) and Y=2Cos(60t+Π/3).the ratio of their time periods is
1)2:1 2)1:2 3)4:3 4)3:4
15. A horizontal platform is executing S.H.M. up and down with period 1sec. Find the maximum amplitude with which it can vibrate so that a small object placed on the platform does not leave it .(take Π =g)
1) 0.25m 2) 0.5m 3)1m 4)1.25m
16. At t=0,the displacement of the particle in S.H.M is half of its amplitude. Its initial phase is
1) Π/6 rad 2) Π /3 rad 3)2Π /3 rad 4) Π/2 rad
17. The time period of oscillation of a S.H.O. is Π/2sec. its acceleration at a phase angle Π/3 rad from extreme position is $2m/s^{-2}$ what is its velocity at a displacement equals to half of its amplitude from mean position
1)0.707m/s 2) 0.866m/s 3)√2m/s 4) √3m/s
18. The velocity of a particle in SHM at the instant when it is 0.6cm away from the mean position is 4cm/s. if the amplitude of vibration is 1cm then its velocity at that instant when it is 0.8cm away from the mean position is
1) 2.25cm/s 2) 2.5cm/s 3) 3cm/s 4) 3.5cm/s
19. When a body is suspended to a spring its length is increased by 0.2 m, then the same body is further pulled by 5cm and released. What is its time period of oscillation
1) Π /7sec 2)2Π /7sec 3)7/Π sec 4)7/2Π sec
20. If the length of the simple pendulum is decreased by 75% what will be % variation of its time period
1) Decreases by 25% 2) Increases by 25%
3) Increases by 50% 4) Decreases by 50%
21. The length of seconds pendulum is 1m. what should be decrease in its length to decrease its time period of oscillation by 1 second
1)0.75m 2)0.5m 3)0.414m 4)0.25m
22. The time periods of oscillation of two simple pendulums are 1sec and 1.2sec. initially both are in same phase . After what minimum number of oscillations made by longer pendulum they will be again in same phase
1) 5 2) 6 3) 10 4)12
23. A pendulum is taken 1Km inside the earth from sea level. Then the pendulum
1) looses 13.5 sec per day 2)gains 13.5 sec per day
3) looses 7 sec per day 4) gains 7 sec per day
24. The period of oscillation of a particle in SHM is 4sec and its amplitude of vibration is 4cm. How far away is the particle 1/3sec after passing the mean position
1) 1.33cm 2) 1.66cm 3) 2cm 4) 2.33cm
25. A particle executes SHM along a straight line 4cm long. When the displacement is 1cm its velocity and acceleration are numerically equal. The time period of SHM is

1) 2Π sec 2) $2\Pi/\sqrt{3}$sec 3) $2\Pi/\sqrt{5}$sec 4) $2\Pi/\sqrt{7}$sec

26. The period of oscillation of a particle in SHM is Πsec and its amplitude of vibration is 10cm. The acceleration of the particle $\Pi/12$sec after passing the mean position is
1) $20\sqrt{3}cm/s^2$ 2) $20cm/s^2$ 3) $20/\sqrt{3}cm/s^2$ 4) $20\sqrt{3}m/s^2$

27. A boy swings from a rope 4.9m long. His approx. period of oscillation is
1) 0.55sec 2) 3.14sec 3) 4.45sec 4) 12.5sec

28. The time period of oscillation of a simple pendulum is 2sec, if its length is decrease to half of its initial length, what will be its new time period
1) 1sec 2) 0.707sec 3) 0.414sec 4) 0.5sec

29. The length of seconds pendulum is 1m. what is length of simple pendulum at the point of intersection of l-T graph and l-T^2graph
1) 25cm 2) 50cm 3) $25\sqrt{2}$cm 4) $50\sqrt{2}$cm

30. A seconds pendulum is suspended from the roof of a lift. If the lift is moving up with an acceleration $9.8m/s^2$, what is its time period
1) 1sec 2) $\sqrt{2}$sec 3) $1/\sqrt{2}$sec 4) $2\sqrt{2}$sec

31. A seconds pendulum is shifted from a place where $g=9.8m/s^2$ to another place where $g=9.78m/s^2$. what should be change in its length so that its time period of oscillation does not change
1) should be decreased by $2/\Pi^2$cm 2) should be increased by $2/\Pi^2$cm
3) should be increased by $2/\Pi$cm 4) should be decreased by $2/\Pi$cm

32. Two simple harmonic oscillator with amplitudes in the ratio 1:2 are having the same total energy . the ratio of their frequencies is
1) 1:4 2) 1:2 3) 2:1 4) 4:1

33. The period of simple pendulum in a stationary lift is T. If the lift is accelerates upwards with an acceleration g/4, period will be
1) T/4 2) T 3) $2T/\sqrt{5}$ 4) $2T/\sqrt{3}$

34. The acceleration due to gravity on a planet is 3/2times that on the earth. If length of seconds pendulum on earth is 1m, length of seconds pendulum on planet is
1) 0.7m 2) 1m 3) 1.7m 4) 1.5m

35. A seconds pendulum is suspended from a roof of a bus. What is its time period of oscillation when bus is moving along a straight horizontal road with uniform acceleration
1) 2sec 2) <2sec 3) >2sec 4) None

36. If the radius of the earth is shrinks by 0.2% without change in its mass, what will be % change in its time period of oscillation of simple pendulum
1) Increases by 0.2% 2) Decreases by 0.2%
3) Increases by 0.1% 4) Decreases by 0.1%

37. A simple pendulum is oscillating with an angular amplitude $30^{0.}$ if mass of its bob is 50g. what is the tension in the string at its mean position ($g=10m/s^2$)
1) 0.634N 2) 0.317N 3) 1.268N 4) 0.433N

38. Two simple pendulums of lengths 100cm and 121cm start swinging together. They will swing together again after
1) the longer pendulum makes 10 oscillations 2) the shorter pendulum makes 10 oscillations
3) the longer pendulum makes 11 oscillations 4) the shorter pendulum makes 11 oscillations

39. The mass and diameter of a planet are twice that of earth. What will be the period of oscillation of a pendulum on this planet if it is a seconds pendulum on earth

1) 2√3sec 2) 2√2sec 3)2sec 4)4sec

40. A simple pendulum of length 81cm takes 3 minutes to execute 100 oscillations. The time that a simple pendulum of length 121cm takes to make the same number of oscillations is

1) 2 min 2) 3.66 min 3) 4.2 min 4) 4.67 min

41. A simple pendulum with a brass bob has a period T. The is now immersed in a non-viscous liquid and oscillated. If the density of liquid is $1/8^{th}$ of brass, the time period of same pendulum is

1)√8/7 T 2)8/7T 3)64/49 T 4)T

42. Two simple pendulums of identical bobs have their lengths in the ratio 1:4. both are given the same angular displacement and are allowed to oscillate. Their energies of oscillation are in the ratio

1) 1:1 2) 1:4 3) 4:1 4) 1:16

43. The length of seconds pendulum is changed from 1m to 1.21m. The percentage change in its period is

1) 20% 2) 21% 3) 10% 4) 11%

44. A body of mass 0.5Kg is performing S.H.M. with a time period Π/2sec. if its velocity at mean position 1m/s, what is the restoring force acts on the body at a phase angle 60^0 from extreme position

1) 0.5N 2) 1N 3) 2N 4) √6N

45. A 1Kg weight is suspended to a mass less spring and it has a period T. if now a 4Kg is suspended from same spring the new period will be

1) 4T 2)2T 3)T 4)T/2

46. A body is executing SHM. If the force acting on the body is 6N when the displacement is 2cm, then the force acting on the body when the displacement is 3cm is

1) 6N 2) 9N 3) √4N 4) √6N

47. A block of mass M is attached to an ideal spring oscillates with time period 2 seconds. If an additional mass 2Kg is attached to this block then the time period is increases by 1sec. what is the value of M

1) 1.2Kg 2) 1.6Kg 3) 2Kg 4) 2.4Kg

48) A body of mass 0.25Kg is in SHM . its displacement is given by Y=0.05 Sin(20t+Π/2)m. the maximum force acting on the particle is

1) 5N 2)2.5N 3) 10N 4) 0.25N

49. Along spring when stretched by X cm has a potential energy V on increasing the stretching to nX cm, the potential energy stored in the spring will be

1) $n^2/2V$ 2) n^2V 3)V/n^2 4)nV^2

50. A mass m, attached to a spring, oscillate with a period of 3 sec. if the mass is increases by 1Kg, the period is increases by 1s. the initial mass m is

1) 9/7 Kg 2) 7/9 Kg 3) 9/16Kg 4)16/9Kg

51. An oscillating mass spring system has a mechanical energy 1 Joule when it has an amplitude 0.1m and maximum speed of 1m/s then the force constant of the spring is

1) 100 N/m 2) 200 N/m 3) 300 N/m 4) 50 N/m

52. A spring of natural length 80cm with a load has a length 100cm. If it is slightly pulled down and released its period will be

1) 3sec   2) 0.9sec   3) 0.81sec   4) 2sec

53. A simple spring has length l and force constant K it is cut into two springs of lengths l_1 and l_2 such that l_1=nl_2. the force constant of the spring of length l_1 is

1) K(1+n)   2) K(1+n)/n   3) K   4) K/(n+1)

54. The average kinetic energy of a simple harmonic oscillator is 2 joule and its total energy is 5joule . what is its minimum potential energy

1) 1J   2) 1.5J   3) 2J   4) 3J

55. Potential energy of a simple oscillator at its mean position is 0.4J. If its kinetic energy at a displacement half of its amplitude from mean position is 0.6J, what is its total energy

1) 1J   2) 1.2J   3) 1.4J   4) 1.6J

56. E is the energy of a simple harmonic oscillator at its mean position. At what phase angle from mean position its kinetic energy is E/2

1)Π /5rad   2)Π/4rad   3)Π/3rad   4)None

57. The K.E. of a particle in SHM is 8J at its mean position . if its mass is 4Kg and amplitude is 1m, then its time period is

1) Π sec   2) 2Π sec   3) Π/2sec   4) 4Π sec

58. The amplitude of oscillation of particle in S. H.M. is √3cm.At what displacement from mean position its potential and kinetic energies are in the ratio 1:2

1) 1cm   2) 0.866cm   3) 1/√3cm   4)√2cm

59. The frequency of a particle executing simple harmonic motion is 10hertz. What is the frequency of variation of its kinetic energy?

1) 20Hz   2) 10Hz   3) 5Hz   4) 15Hz

60. What should be the displacement of a simple pendulum whose amplitude is A at which potential energy is 1/4th of total energy.

1) A/√2   2) A/2   3) A/4   4) A/5

KEY

1)2 2)2 3)4 4)2 5)4 6)1 7)1 8)1 9)2 10)4 11)4
12)4 13)1 14)4 15)1 16)1 17)2 18)3 19)2 20)4 21)1
22)1 23)3 24)3 25)2 26)2 27)3 28)1 29)1 30)2 31)1
32)3 33)3 34)4 35)2 36)2 37)1 38)1 39)2 40)2 41)1
42)3 43)3 44)2 45)2 46)2 47)2 48)1 49)2 50)1 51)2
52)2 53)2 54)1 55)2 56)2 57)1 58)1 59)1 60)2

PREVIOUS EAMCET QUESTIONS

1. If the displacement (x) and velocity(v) of a particle executing SHM are related through the expression $4v^2=25-x^2$ then its time period is (2002 E)

1) Π   2) 2Π   3) 4Π   4) 6Π

2. A body executes SHM under the action of force F_1 with a time period 4/5sec. If force is changed to F_2 its time period changes to 3/5sec. If both the forces act simultaneously in the same direction of the body. Its time in seconds is (2002 E)

1) 12/25   2) 24/25   3) 25/24   4) 25/12

3. The mass and diameter of a planet are two those of earth. If a seconds pendulum is taken to it the time period of the pendulum in seconds is (2002 M)

1) 1/√2   2) 1/2   3) 2   4) 2√2

4. The elongation of a spring of length L and of negligible mass due to a force is X. The spring is cut into two pieces of lengths in ratio 1:n. The ratio of spring constants is (2002 M)

1) n:1 2) 1:n 3) n^2:1 4) 1:n^2

5. Two springs of force constants 1000N/m and 2000N/m are stretched by same force. The ratio of their potential energies is

1) 2: 1 2) 1:2 3) 4:1 4) 1:4

6) The time period of a particle in simple harmonic motion is 8seconds. At t=0 it is at the mean position. The ratio of the distances traveled by it in the first and second is (2003M)

1) ½ 2) $1/\sqrt{2}$ 3) $1/\sqrt{2}-1$ 4) $1/\sqrt{3}$

7) A body of mass 'm' is tied to one end of a spring and whirled round in a harmonic plane with a constant angular velocity. The elongation in the spring is one centimeter. If the angular velocity is doubled , the elongation in the string is 5cm. The original length of the spring is (2003M)

1) 16cm 2) 15cm 3) 14cm 4) 13cm

8) An object is attached to the bottom of a light vertical spring and set vibrating. The maximum speed of the object is 15 cm^{-1} and the period is 62j8 milli – seconds. The amplitude of the motion in centimeters is (2003 E)

1) 3.0 2) 2.0 3) 1.5 4) 1.0

9) When a body of mass 1.0Kg is suspended from certain light hanging vertically, its length increases by 5cm. By suspending 2.0Kg block to the spring and if the block is pulled though 10cm and released, the maximum velocity in it in ms^{-1} is (g = $10ms^{-2}$) (2003E) 1) 0.5 2) 1 3) 2 4) 4

10) Two springs of force constants 1000Nm-1 and 2000Nm-1 are stretched by same force. The ratio of their respective potential energies is (2003 E)

1) 2:1 2) 1:2 3) 4:1 4) 1:4

11) The equation of nation of a particle executing SHM is, $a+16\pi^2x=0$.In the equation, 'a' is the linear acceleration in m/s^2,of the particle at a displacement x in metre. The time of SHM_1 in seconds, is: (2004 M)

1) ¼ 2) ½ 3) 1 4) 2

12) The time period of a simple pendulum is T. When the length is increased by 10cm, its period is T_1. When the length is decreased by 10 cm, its period is T_2. Then relation between T, T_1 and T_2 is: (2004Eamcet)

1) $\frac{2}{T^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$ 2) $\frac{2}{T^2} = \frac{1}{T_1^2} - \frac{1}{T_2^2}$

3) $2T^2 = T_1^2+T_2^2$ 4) $2T^2 = T_1^2- T_2^2$

KEY

1)3 2)1 3)4 4)2 5)1 6) 3 7) 2 8) 3 9) 2 10) 1
11) 2 12) 3

NEW TYPES OF QUESTIONS

1) Assertion: If a pendulum falls freely, then its time period becomes infinite.
Reason: Freely falling body has acceleration equal to 'g'
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true Key: 1

2) Assertion: The period of simple pendulum is independent of the mass of the bob
Reason: Inertial and gravitational masses are equal
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true Key: 2

3) Assertion: One of the two clocks on the earth is controlled by a pendulum and the other by a spring these clocks be taken to the moon, then spring based clock shows accurate time
Reason: Time period of clock controlled by a spring is independent on acceleration due to gravity
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true Key: 1

4) Assertion: The bob of a simple pendulum is a ball full of water. If a fine hole is made in the ball then the time period will not remain constant
Reason: Time period of a pendulum depends in the length of the pendulum
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true Key: 1

5) A person measures the time period of a simple pendulum inside a stationary lift and finds it to
Match the following

List-I	List-II
I) Lift accelerates downwards with an acceleration g/3	a) infinity
II) Lift accelerates upwards with an acceleration g/3	b) T
III) Lift falling freely	c) $\frac{\sqrt{3}}{2}$ T
IV) Lift moves upwards with uniform velocity	d) $\frac{\sqrt{3}}{\sqrt{2}}$ T

1) I-c, II-d, III-a, IV-b 2) I-b, II-c, III-a, IV-d
3) I-d, II-b, III-c, IV-a 4) I-a, II-d, III-c, IV-d Key:3

6) The total energy of the body executing SHM is E and amplitude a. Then match the following

List-I	List-II
I) Displacement y=a/2	a) Kinetic energy is zero
II) Displacement y=a/√2	b) Total energy = E
III) Displacement y=a	c) KE=PE
IV) Displacement y=0	d) KE=3E/4

1) I-a, II-b, III-c, IV-d   2) I-d, II-c, III-a, IV-b
III) I-b, II-a, III-d, IV-c   4) I-c, II-d, III-b, IV-a   Key:2

7) Identify the decreasing order in time period of a simple harmonic oscillator varies with time according to the differential equations given in the following cases.

I) $\frac{d^2x}{dt^2}+4x=0$ (where x is displacement)   II) $\frac{d^2x}{dt^2}+x=0$

II) $\frac{d^2x}{dt^2}+9x=0$ IV) $\frac{d^2x}{dt^2}+16x=0$

1) I, II, III, IV   2) IV, III, II, I   3) II, I, III, IV   4) I, IV, III, II   Key: 3

8) The time period of a spring system executing simple harmonic motion depends upon

a) Amplitude   b) force constant   c) total energy   d) mass

1) Both a and b are correct   2) Both b and c are correct
3) Both b and d are correct   4) Both a and d are correct   Key:3

9) Match the following

Column-I	Column-II
a) Time period of simple pendulum in an artificial satellite	e) 2s
b) Time period of seconds pendulum	f) ∞
c) Period of pendulum of infinite length	g) 0
d) Frequency of simple pendulum in an artificial satellite	h) 84 minutes

1) a-e, b-f, c-g, d-h   2) a-f, b-e, c-h, d-g
3) a-h, b-g, c-f, d-e   4) a-g, b-f, c-h, d-g   Key: 2

10) Match the following

If the maximum velocity and maximum acceleration of the particle is SHM are I_0 and a_0 then

Column-I	Column-II
a) angular velocity	e) $\frac{1}{2\pi}\frac{a}{V_0}$
b) Time period	f) a_0/V_0
c) Frequency	g) V_0^2/a_0
d) Amplitude	h) $2\pi\frac{V_0}{a_0}$

1) a-e, b-f, c-g, d-h   2) a-f, b-h, c-e, d-g
3) a-h, b-g, c-e, d-f   4) a-g, b-e, c-h, d-f   Key:2

Previous eamcet quitions

1) The displacement of a particle of mass 3gm executing SHM is given by y = 3sin (0.2t) in SI units. The kinetic energy of the particle at a point which is at a distance equal to $\frac{1}{3}$ of its amplitude from its mean position   (2007M)

1) $12x10^{-3}$J   2) $25x10^{-3}$J   3) $0.48x10^{-3}$J   4) $0.24x10^{-3}$J

2) The magnetic of maximum acceleration is π times that of maximum velocity of a simple harmonic oscillator. The time period of the oscillator in seconds is   (2007E)

1) 4   2) 2   3) 1   4) 0.5

3) The simple harmonic motion of a particle is represented by the equation x = 4cos $\left[88\,t+\frac{\pi}{4}\right]$. The frequency (in Hz) and the initial displacement (in m) of the particle are (2006M)

1) 14: $2\sqrt{2}$ 2) 16; $2\sqrt{2}$ 3) 14; $3\sqrt{2}$ 4) 16; $3\sqrt{2}$

4) A body executing SHM has a maximum velocity of $1ms^{-1}$ and a maximum acceleration of $4ms^{-2}$. Its amplitude in meters is (2005)

1) 1 2) 0.75 3) 0.5 4) 0.25

1)3	2)2	3)1	4)4

ADDITIONAL HINTS AND PROBLEMS:

Damped Harmonic oscillator

Equation: $\frac{d^2x}{dt^2}+2b\frac{dx}{dt}+\omega^2 x=0$

Where $\frac{r}{m}=2b$ and $\frac{k}{m}=\omega^2$

Where k= Force constant

r=Frictional force per unit velocity

b=damping constant

Energy of the damped oscillator : $E=\frac{1}{2}KA^2e^{-bt/m}$

Power Dissipation: P=2bE

Forced Vibrations: 2t is defined as the vibration in which the body vibrated with a frequency other than its natural frequency under the action of an extended periodic force

Resonance: the phenomenon of making a body vibrate with its natural frequency under the influence of another vibrating body with the same frequency is called resonance.

(1) A point is executing damped osculation's in accordance with the law, $x=ae^{-kx}$ sin ωt. the oscillation amplitude and the velocity of the point at zero time is( )

a) aω, a b) a, aω c) ω,a d) a, ω

(2) The differential equation for a certain system is $\frac{d^2x}{dt^2}+2k\frac{dx}{dt}+\omega^2 x=0$, if ω>>k, the time in which amplitude falls to 1/e time the initial value is, ( )

a) K sec b) K^2Sec c) 1/k sec d) 2k sec

(3) Earth quacks sometimes causes disasters, the Phenomenon involved in the is ( )

a) Beats b) Echo c) Resonance d) None of them

(4) A spring of force Constant 1.0N/M is joined end to end to a spring of force constant 2.0 N/M. the force constant of the Combination is ( )

a) 0.67 N/M b) 1.5 N/M c) 1.0 N/M d) 3.0 N/M

(5) A 1kg mess rests on a smooth incline plane of angle Q = 30^0 supported by a spring. The spring stretches 2 cm. the force constant of the spring is( )

a) 225 N/M b) 245 N/M c) 340 N/M d) 440 N/M

KEY

1) a 2) d 3) c 4) a 5) b

Chapter 9
GRAVITATION
FORMULAE

1. KEPLER'S LAWS:

1) Law of orbits :-

Centripetal force for the revolution of the planet = sun's gravitational force of attraction on the planet

$\frac{MV^2}{R} = \frac{GMm}{R^2} \Rightarrow mR\omega^2 = \frac{GMm}{R^2}$ Where m= mass of planet

M=mass of sun ω= angular velocity of planet

R= Average distance between sun and planet.

2) Law of Areas :- If the line joining sun and planet sweeps areas a_1, a_2 during time intervals t_1,t_2 respectively then $a_1/t_1 = a_2/t_2$

or $dA/dt = 1/2\ R^2 d\theta/dt = 1/2\ R^2\omega$

3) Law of periods :- $T^2 \propto R^3$ or T^2/R^3 = constant = $4\prod^2/GM$, $\frac{T_1^2}{R_1^3} = \frac{T_2^2}{R2^3}$

Where T_1,T_2 are time period of revolutions of two planets and R R_1,R_2 are their average distances from sun.

4) Newton's universal law of gravitation:-

Where m_1,m_2 are the masses of two bodies sperated by distance 'r' and G is universal gravitational constant. G= 6.67 $x10^{-11}\ Nm^2kg^{-2}$ $F= Gm_1m_2/r^2$

5) Relation between g and G:-

$g=GM/R^2$ and $M= 4/3\ \prod R^3\ \rho$, Where g is acceleration due to gravity G is universal gravitational constant. M is the mass of the earth And R is the radius of the earth ρ is the density of the earth.

6) Variation of g:-

i) with altitude 'h': $g_h=GM/(R+h)^2$ $g^1=g[1-2h/R]$

ii) with depth d: $g_d= 4/3\ \prod(R-d)\ G\rho$ G⇒Gravitational const.

ρ⇒density of earth R⇒Radius of earth

g`=g[1-d/R]

iii) with latitude 'θ'

Due to the rotation of the earth, the value of acceleration due to gravity is

$g_\theta = g[1-\frac{R\varpi^2\cos^2\theta}{g}]$ g=acceleration due to gravity

ω=angular velocity

R= Radius of earth

At equator $\theta=0^0 \Rightarrow \cos o^o =1$

At poles $\theta= 90^0 \Rightarrow \cos 90^0=0$

$g_\theta = g\ [1-R\omega^2/g\ ] = g-R\omega^2$

$g_\theta = g[1-0] =g.$

7) if the earth stops rotating then'g' increases by $R\omega^2$= 0.0335 ms^{-2} at equator. At poles there is no change.

8) The fractional change of 'g' at altitude 'h' is

$$\frac{\Delta g_h}{g} = \frac{2h}{R}$$ (if h<<R).

9) The fractional change of ‘g’ at depth ‘d’ is $\frac{\Delta g_d}{g} = \frac{d}{R}$

10) Orbital velocity of satellite (V_0):-

i) The orbital velocity of a satellite near the earth’s surface is

$$V_0 = \frac{\sqrt{GM}}{R} = \sqrt{\frac{GM}{(R+h)}} = \sqrt{\frac{gR^2}{(\sqrt{R+h})}}$$ ($\therefore$ R=R+h and GM = gR^2)

$$V_o = \sqrt{gR} = \frac{\sqrt{GM}}{R}$$ ($\therefore$ g=GM/R^2 and h=0)

ii) For two satellites revolving around the earth in different circular orbits of radii r_1,r_2 at heights h_1,h_2

$$\frac{V_1}{V_2} = \sqrt{\frac{r_2}{r_1}} = \sqrt{\frac{(R+h_2)}{(R+h_1)}}$$

iii) Orbital angular velocity of the satellite z

$$\omega_0 = \frac{V_0}{(R+h)} = \sqrt{\frac{GM}{(R+h)^3}} = \sqrt{\frac{g^1}{(R+h)}}$$

for surface satellite $\omega_0 = \sqrt{\frac{GM}{(R)^3}} = \sqrt{\frac{g}{R}}$

11) Escape velocity (V_e) :- (i) Escape velocity of a satellite from the surface of the earth is $V_e = \sqrt{2gR} = \sqrt{\frac{2GM}{R}}$ (M is mass of earth R is radius of earth)

$$V_e = \sqrt{\frac{2GM}{(R+h)}} = \sqrt{\frac{2gR^2}{(R+h)}}$$ (h is the height above earth surface)

ii) if ρ is the mean density of earth . $V_e = \sqrt{\frac{8\pi G\rho R^2}{3}}$

iii) If V_e and V_e are escape velocities on two different planets.

$$\frac{V_e}{V_e^1} = \sqrt{\frac{M_1R_2}{M_1R_1}} = \sqrt{\frac{g_1R_1}{g_2R_2}} = \sqrt{\frac{\rho_1R_1}{\rho_2R_2}}$$

12) Relation between V_e and V_o: -

$Ve=\sqrt{2}.V_o$ V_e = Escape velocity V_o = Orbital Velocity.

13) Time period of statellite :- Time period of satellite revolving around the earth is

$$T = 2\Pi\sqrt{\frac{r^3}{GM}} = 2\Pi\sqrt{\frac{(R+h)^3}{GM}} = 2\Pi\sqrt{\frac{r}{g^1}} = 2\Pi\sqrt{\frac{(R+h)}{g^{1`}}}$$

For surface satellite $T = 2\Pi\sqrt{\frac{R^3}{GM}} = 2\Pi\sqrt{\frac{R}{g}}$ ($\therefore$ h =0)

For two satellites $\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{R+h_1}{R+h_{22}}\right)^3$

14) Gravitational potential :- " It is defined as numerically equal to the work done in taking a unit mass from infinity to the given point. On the surface of the earth gravitational potential is

V= - GM/R = - gR. Where M ⇒ Mass of the earth
R⇒Radius of the earth G⇒Universal gravitational constant .
g⇒acceleration due to gravity

15) Gravitational potential energy of a body :- if 'm' is the mass of a body 'M' is mass of the earth and 'R' radius of earth,

i) U =- GMm/R =-mgR. (on the surface of earth)
ii) At altitude 'h' above the surface of earth

$U = -\frac{GMm}{R+h}$ = -mg (R+h). iii) At the center of the earth U=- 3GMm/2R

iv) If three particles of masses m_1,m_2 and m_3 are at the three vertices of an equilateral triangle of side'a', then gravitational potential energy is

$$U = \frac{-G}{a}(m_1m_2 + m_2m_3 + m_3m_1)$$

16) Energy of a satellite :- A satellite of mass m orbiting close to the earth has

P.E. =-GMm/R K.E. = ½ mv_0^2 = ½ m.GM/R = GMm/2R

Total energy = P.E+K.E.

T.E. = $\frac{-GMm}{R} + \frac{GMm}{2R}$, T.E. =- $\frac{GMm}{2R}$ Binding energy = GMm/2R

17) Gravitational intensity produced by a point mass M at a distance 'r' from it is

I= GM/r^2.

18) If two bodies of masses m_1 and m_2 are separated by a distance 'r' then the distance null point from m_1 on the line joining the bodies is

$$x = \frac{r}{\sqrt{\frac{m_2}{m_1}+1}}$$

19) If r_1 and r_2 are the distance of null point from m_1 and m_2 then $\frac{m_1}{r_1^2} = \frac{m_2}{r_2^2}(r_1 + r_2 = r)$.

20) If the same body is dropped from the same height on two different planets or two different places on the earth where acceleration due to gravity are g_1 and g_2 then

i) velocity on reaching the ground v ∝ √g ⇒ $\frac{V_1}{V_2} = \sqrt{\frac{g_1}{g_2}}$

ii) Time of fall t . t ∝ $\sqrt{\frac{1}{g}} \Rightarrow \frac{t_1}{t_2} = \sqrt{\frac{g_2}{g_1}}$.

21) If w_1 and w_2 are the weights of a body at two different places or on two different planets, then $w_1/w_2 = g_1/g_2$

22) i) if a man jumps to a maximum height h_1 on the surface of one planet and h_2 on another planet then $h_1/h_2 = g_2/g_1$ ($h=u^2/2g$ and $h \propto 1/g$)

ii) If it is a long jump and man jumps through a maximum horizontal distance R_1 on the first planet and through R_2 on the second planet, then

$R_1/R_2 = g_2/g_1$ ($R = \dfrac{u^2 \sin 2\theta}{g}$ and $R \propto 1/g$)

23) weight of a body at an attitude 'h' above the earth is $w^1=mg^1$ where $g^1 = \dfrac{GM}{(R+h)^2}$.

weight of a body on the surface of the earth is w=mg. where

$g = GM/R^2$. $w^1/w = g^1/g = \dfrac{R^2}{(R+h)^2}$.

24) Angular momentum of the satellite or planet

i) If m is mass of the planet orbiting around the sun of mass M in an orbit of radius 'r'.then angular momentum of the planet

$$L=mvr=mr\sqrt{\frac{GM}{r}} = \sqrt{GMm^2r}.$$

ii) If a satellite of mass m is revolving around a planet of mass M in a circular orbit of radius 'r' then angular momentum of satellite is

$$L=mv_0r = mr\sqrt{\frac{GM}{r}} = \sqrt{GMm^2r} = \sqrt{GMm^2(R+h)}.$$

$$L = \sqrt{gR^2m^2(R+h)}.$$

iii) for surface satellite of a planet $L = mR\sqrt{gR} = \sqrt{gR^3m^2}$.

QUESTION BANK

Theory Questions

1. Gravitational force is
   1)Mass and charge dependent 2) Mass and charge independent
   3)mass dependent and charge independent 4)mass independent and charge dependent
2. Newton's laws of motion fialed bodies exists
   1) the existence of gravity between bodies
   2) the non dependence of the intervening medium between the bodies on the gravitational field
   3) the reason for the variation of gravitational force with square of distance between the bodies
   4) all the above.
3. According to Einstein, gravitation is
   1)distortion to matter due to presence of space]
   2)distortion of space due to presence of matter
   3)distortion of matter due to absence of space
   4)distortion of space due to absence of matter.
4. Read the following statements and select the correct option

A) According to Einstein's theory of relativity, whenever mass particles are accelerated the gravitational fields around them undergo rapid changes.

B). According to Planck's modern theory, all fields are considered to have quantum nature.

1)only A is true 2) only B is true 3)both are true 4)both are false.

5. The radius of magic sphere around dense objects such that when light enters into that sphere cannot come out is known as
1)Newton radius 2)Einstein radius 3)Schwarzscild radius 4)Black hole
6. A red gaint star blows away by releasing material particles present in it and form
1)Red dwarf star 2)Blue gaint stage 3)White dwarf star
4)White giant star
7. Chandra Sekhar limit is
1)more than 1.4 times the solar 2)less than 1.4 times the solar mass
3)equal to 1.4 times the solar mass 4)equal to solar mass
8. If m is mass of a massive star,C is speed of light and G is universal gravitational constant, Schwarzchild radius is given by
1) GM/C^2 2) 2GM/C 3)2 GM/C^2 4) GM/C
9. For a body moving with high speed
1)inertial mass and gravitational mass both increase
2)inertial mass and gravitational mass both remain constant
3)inertial mass increase and gravitational mass remain constant
4)gravitational mass increase and inertial remains constant.
10. This following theory is based on the principle of equivalence of inertial and gravitational mass
1)Quantum theory 2)General theory of relativity
3)Kepler's theory 4) Newton's theory.
11. The first Indian satellite was
1)Apple 2)Bhaskara 3)Angular momentum 4)None.
12. If the earth stops rotating about its axis, then acceleration due to gravity remains Unchanged at
1)The equator 2)The poles 3)Latitude45^0 4)Latitude 60^0
13. If R is radius of the earth ω is present angular velocity about its axis, the value of g at the equator varies like this on stopping the rotation of the earth.
1)Decreases by ω^2R 2)Remains same 3)Increases by ω^2R 4)Becomes zero
14. The weight of a body at the center of the earth is
1)Zero 2)Same as on the surface of the earth
3)Infinite 4)Same as that at the equator
15. The unit of quantity g/G in SI will be
1)kgm-^{2} 2)mKg^{-2} 3)$m2Kg^{-1}$ 4)Kg^2m^{-1}
16. Two artificial satellites are revolving in the same circular orbit. Then they must have the same
1)Mass 2)Angular momentum 3)Kinetic energy 4)Period of revolution.
17. A man inside an artificial satellite feels weightlessness because the force of attraction due to earth on him is
1) Zero at that place 2) Equal to the necessary centripetal force

3) Balanced by the force of repulsion   4) None

18. If an astronaut comes out of the artificial satellite
    1) He flies off tangentially   2) He falls to the earth
    3) He performs SHM
    4) He continues to move along the satellite in the same orbit
19. If S_1 is surface satellite and S_2 is geostationary satellite, with time periods T_1 and T_2 orbital velocities V_1 and V_2,
    1) $T_1>T_2;V1>V_2$ 2) $T_1>T_2;V_1<V_2$ 3) $T_1<T_2;V_1<V_2$ 4) $T_1<T_2;V_1>V_2$
20. There is no atmosphere on moon because
    1) It is closer to earth   2) It revolves round the earth
    3) It gets light form the earth   4) None of these
21. When a satellite is orbiting round a planet in a circular orbit, work done by the gravitational force acting on the satellite is
    1) Zero on completing one revolution only   2)Zero   3)Infinite   4)Negative
22. The value of G depends upon
    1)The masses of bodies   2)The medium between the bodies
    3)The temperature of bodies   4)None of these
23. A satellite in vacuum
    1)Is kept in orbit by solar energy   2)Derives energy from gravitational field
    3)Is kept in an orbit by remote control   4)Does not require any enrgy for revolving
24. A satellite is revoling around the earth in a circular orbit with a uniform speed. If the gravitational force suddenly disappears, the satellite will
    1)Continue to move in the same orbit with that speed.
    2)Move tangentially to the orbit with that speed
    3)Move away from the earth normally to the orbit
    4)Fall down on to the earth.

MATCHING TYPE QUESTIONS

25. Match the following.

List-I	**List-II**
a) Gravitational force	e) Constant
b) Time period of satellite	f) Varies inversely with r^2
c) Orbital velocity	g) Varies directly with r^3
	h) Varies inversely with M
d) Areal velocity	i) Varies directly with $\sqrt{M}$

The correct match is
1) $a\to f;b\to g;c\to h;d\to e$ 2) $a\to h;b\to g;c\to f;d\to g$
3) $a\to f;b\to h;c\to i;d\to g$ 4) $a\to f;b\to h;c\to i;d\to e$

26. Match the following.

List-I	**List-II**
a) Universal gravitational constant	e) g at equator if earth stops rotating
b) Increases by $R\omega^2$	f) scalar
c) G does not change at poles	g) gravitational force
d) Central force	h) if earth stops rotating

1) $a\to e;b\to f;c\to g;d\to h$ 2) $a\to f;b\to e;c\to h;d\to g$
3) $a\to e;b\to g;c\to f;d\to h$ 4) $a\to f;b\to h;c\to e;d\to g$

27. Match column I with column II

Column-I	Column-II
a) Geostationary satellite	e) orbital radius 6400km
b) Gravitational force	f) Conservation of angular Momentum
c) Planetary motion	g) exploded mass
d) Supernova	h) orbital radius 36000km
	i) conservative force

1) $a \to e; b \to g; c \to f; d \to g$　　2) $a \to h; b \to i; c \to f; d \to g$

3) $a \to f; b \to i; c \to g: d \to e$　　4) $a \to g; b \to f; c \to e; d \to h$

28. Study the following.

List-I	List-II
a) White dwarf	e) 1.4solar masses
b) Northen star	f) mass of star must be greater than 10 solar
c) Black holes	g) mass of the star must be less than 10 solar
d) Chandrasekhar limit	h) mass of the remaining star is greater than 3 solar masses

1) $a \to g; b \to f; c \to h; d \to e$　　2) $a \to f; b \to g; c \to e; d \to h$

3) $a \to g; b \to f; c \to e; d \to h$　　4) $a \to f; b \to e; c \to g; d \to h$

29. Study the following.

List-I	List-II
a) sun	e) Black hole
b) Schwartzchild	f) Nuclear fusion
c) Gravitational field strength	g) Acceleration due to Gravity
d) Degenerate electron pressure	h) White dwarf
	i) Nuclear fission

1) $a \to f; b \to e; c \to g; d \to h$　　2) $a \to e; b \to h; c \to f; d \to g$

3) $a \to i; b \to f; c \to g; d \to h$　　4) $a \to g; b \to h; c \to e; d \to i$

ASSERTION AND REASON NTYPE QUETIONS

DIRECTINS :

These questions consists of two statements as Assertion and reason .While answering these questions you are required to choose any of the following four responses.

- **A) If both Assertion and reason are true and Reason is correct explanation of the Assertion.**
- **B) If both Assertion and reason are true, but Reason is not correct explanation of the Assertion.**
- **C) If Assertion is true, but the Reason is false.**
- **D) If Assertion is false, but the reason is true.**

30. A: When distance between two masses is doubled and each mass is also doubled, gravitational force between them remains the same.

1)A　　2)B　　3)C　　4)D

31. A: The coulomb force is dominating force in the universe.

R: The coulomb force is weaker than the gravitational force.

1)A　　2)B　　3)C　　4)D

32. A: Value of ‘g’ is maximum at the surface of earth.

R: 'g' decreases with height above and depth below the surface of earth.
1)A 2)B 3)C 4)D

33. A: 'g' is maximum at the poles and poles and minimum at the equator.
R: 'g'varies with rotation of earth.
1)A 2)B 3)C 4)D

34. A: At pole value of acceleration due to gravity (g) is greater than that of equator.
R: Earth rotates on its axis in addition to revolving round the sun.
1)A 2)B 3)C 4)D

35. A: The value of acceleration due gravity (g) does not depend upon mass of body.
R: This follows from $g = \frac{GM}{R^2}$, where M is mass of planet (earth)and R is radius of planet (earth).
1)A 2)B 3)C 4)D

36. A: If earth were to stop rotating about its axis, 'g' would increase
R: This is because, $g1 = g - R\omega^2 \cos^2\lambda$ were the symbols have standard meaning
1) A 2) B 3) C 4) D

37. A: if the earth stops suddenly its rotation, then the weight of the body at the equator at equal to its weight at poles (assume earth is a perfect sphere.)
R: The centrifugal force is zero at equator.
1)A 2)B 3)C 4)D

38. A: Gravitational fields propagate with the velocity of light.
R: Electromagnetic and gravitational fields are large scale manifestations of a quantum field.
1)A 2)B 3)C 4)D

39. A: An object would be black hole of all of its mass is inside a sphere with a radius equal to schwarzchild radius.
R: At the schwarzchild radius, escape velocity is equal to the speed of light.
1)A 2)B 3)C 4)D

40. A: Stationary railway platform is non – inertial frame of reference.
R: Newton's laws are invalid in the case of non inertial frame of reference.
1)A 2)B 3)C 4)D

41. A: Inertial and gravitational masses differ when the speed of the particle (u) is comparable to the speed of tight(c).
R: Gravitational mass is measured when the body is at rest and inertial mass is measured when the body is in motion. Relativistic variation of mass is significant when "u' is comparable to c.
1)A 2)B 3)C 4)D

42. A: The greater the altitude of a satellite , the greater is its orbital velocity.
R: The orbital velocity of a satellite is inversely proportional to the square root of its distance from the center ot the earth.
1)A 2)B 3)C 4)D

43. A: Orbital velocity of as teliite is greater than its escape velocity.
R: Orbit of a satellite is within the gravitational field of earth whereas escaping is beyond the gravitational field of earth.
1)A 2)B 3)C 4)D

44. A: The time period of pendulum, on a satellite orbiting the earth is infinity,

R: Time period of pendulum is inversely proportional $\sqrt{g}$.

1)A 2)B 3)C 4)D

Key

1)3	2)4	3)2	4)3	5)3	6)3	7)3
8)3	9)3	10)2	11)4	12)2	13)3	14)1
15)1	16)4	17)2	18)4	19)4	20)4	21)2
22)4	23)4	24)2	25)4	26)2	27)2	28)1
29)1	30)1	31)4	32)1	33)2	34)1	35)1
36)1	37)1	38)1	39)1	40)4	41)1	42)4
43)4	44)1					

Numerical Questions:

Newton's universal law of gravitation:

Key

1)3	2)1	3)2	4)3	5)2	6)4	7)3	8)1	9)4	10)4	11)3
12)4	13)1	14)3	15)1	16)2	17)3	18)3	19)3	20)4	21)4	22)2
23)1	24)3	25)4	26)4	27)3	28)1	29)4	30)3	31)1	32)1	33)3
34)2	35)3	36)2	37)1	38)2	39)1	40)2	41)4	42)2	43)3	44)4
45)1	46)3	47)2	48)2	49)4	50)1	51)2	52)1	53)2	54)3	55)1

NEW TYPES OF QUESTIONS

1) If the shape of the orbit of an artificial satellite depends upon its velocity, then match the following (V= velocity of satellite; V_0= Orbital Velocity; V_e = escape velocity)

Column-I	Column-II
A) $V>V_e$	a) Parabolic
B) $V=V_0$	b) Hyperboic
C) $V=V_e$	c) Circular
D) $V>V_0$	d) Spiral
	g) Elliptical

1) A-c, B-b, C-a, D-e 2) A-b, B-c, C-d, D-e
3) A-b, B-c, C-a, D-e 4) A-e, B-a, C-b, D-c Key:3

2) Assertion: For the planets orbiting round the sun, the angular speed, linear speed, K.E change with time but angular momentum remains constant.
Reason: This is because no torque is acting on the rotating planet
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true, but R is false
4) A is false, but R is true Key: 1

3) Assertion: Gravitational potential of earth at every point on it is negative
Reason: Every body on earth is not bound by attraction of earth.
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true Key: 2

4) A) If radius of planet increases by n% acceleration due to gravity will increase by 2n% (m = constant)
B) If mass of planet increases by n% acceleration due to gravity on it increases by n% (R= constant)
C) If density of planet decreases by n% acceleration due gravity decreases by n%
1) A, B & C are true 2) A is true and B,C are false
3) A & B are true & C is false 4) A, B & C are false Key:1

Previous Eamcet Questions:

1) A body of mass 'm' is raised from the surface of the earth to a height 'nR' (R –radius of earth). Magnitude of the change in the gravitational potential energy of the body is (g = acceleration due to gravity on the surface of earth) (2007M)
1) $\left(\frac{n}{n+1}\right)mgR$ 2) $\left(\frac{n-1}{n}\right)mgR$ 3) $\frac{mgR}{n}$ 4) $\frac{mgR}{(n-1)}$

2) The mass of a planet is half that of the earth and the radius of the planet is one fourth that of earth. If we plan to send an artificial satellite from the planet, the escape velocity will be, (escape velocity of earth $V_e = 11kms^{-1}$) (2007E)
1) $11kms^{-1}$ 2) $5.5kms^{-1}$ 3) $15.55kms^{-1}$ 4) $7.78kms^{-1}$

3) How many times more, the mass of the original star is to be larger than that of the sun for the formation of 'Black Hole'? (2006M)
1) 2 2) 6 3) 8 4) 10

4) Assume the earth's orbit around the sun as circular and the distance between their centers as 'D'. Mass of the earth is 'M' and its radius is R. If earth has an angular velocity 'ω_0' with respect to its center and 'ω' with respect to the center of the sun, the total kinetic energy of the earth is (2006E)
1) $\frac{Mr^2\omega_0^2}{5}\left[1+\left(\frac{\omega}{\omega_0}\right)^2+\frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$ 2) $\frac{Mr^2\omega_0^2}{5}\left[1+\frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$
3) $\frac{5}{2}MR^2\omega_0^2\left[1+\frac{5}{2}\left(\frac{D\omega}{R\omega_0}\right)^2\right]$ 4) $\frac{5}{2}MR^2\omega_0^2\left[1+\left(\frac{\omega}{\omega_0}\right)^2+\frac{5}{2}\left(\frac{D\omega^2}{R\omega_0}\right)^2\right]$

5) Assertion: A particular of mass 'm' dropped into a hole made along the diameter of the earth from one end to the other end possesses simple harmonic motion
Reason: Gravitational force between any two particles is inversely proportional to the square of the distance between them (2006E)
1) Both A & R are true and R is the correct explanation of A
2) Both A & R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

6) According to the size, identify the correct decreasing order in: (2005M)
a) Original star b) Red giant c) White dwarf
1) a, b, c 2) b, c, a 3) c, a, b 4) b, a, c

7) Degenerate electron pressure will not be sufficient to prevent core collapse of white dwarf if its mass becomes 'n' times of our solar mass. Value of 'n' is: (2005E)
1) 0.5 2) 0.8 3) 1 4) 1.4

8) The escape velocity of a body on the earth's surface is v_e. A body is thrown up with a speed $\sqrt{5}\, v_e$. Assuming that the sun and planets do not influence the motion of the body, velocity of the body at infinite distance is (2004E)

1) 0 2) v_e 3) $\sqrt{2}\, v_e$ 4) $2v_e$

9) A space ship is launched into a circular orbit of radius R close to the surface of earth. The additional velocity to be imparted to the space ship in the orbit to overcome the earth's gravitational pull is (g = acceleration due to gravity)

1) 1.414Rg 2) $1.414\sqrt{Rg}$ 3) 0.414Rg 4) $0.414\sqrt{Rg}$ (2004M)

10) In planetary motion the areal velocity of position vector of a planet depends on angular velocity (ω) and the distance of the planet from Sun (r). If so the correct relation for areal velocity is (2003 E)

1) $\frac{dA}{dt} \alpha\ \omega r$ 2) $\frac{dA}{dt} \alpha\ \omega^2 r$ 3) $\frac{dA}{dt} \alpha\ \omega r^2$ 4) $\frac{dA}{dt} \alpha\ \sqrt{\omega r}$

11) A satellite is launched into a circular orbit of radius R around earth while a second satellite is launched into an orbit of radius 1.02R. The percentage difference in the time periods of the two satellites is (2003E)

1) 0.7 2) 1.0 3) 1.5 4) 3

12) The radius in kilometers to which the present radius of the earth (R = 6400km) is to be compressed so that the escape velocity is increased 10 times is (2003M)

1) 6.4 2) 64 3) 640 4) 4800

13) The mass and diameter of a planet are two times those of earth. If a seconds pendulum is taken to it the time period of the pendulum in seconds is (2002M)

1) $\frac{1}{\sqrt{2}}$ 2) $\frac{1}{2}$ 3) 2 4) $2\sqrt{2}$

14) Two satellites S_1 and S_2 are revolving round a planet in coplanar and concentric circular orbits of radii R_1 and R_2 in the same direction respectively. Their respective periods of revolution are 1 hr and 8 hr. The radius of the orbit of satellite S_1 is equal to 10^4 km. Their relative speed when they are closest, in kmph is (2002M)

1) $\frac{\pi}{2} x 10^4$ 2) $\pi x 10^4$ 3) $2\pi x 10^4$ 4) $4\pi x 10^4$

15) If A is the areal velocity of planet of mass M its angular momentum is (2002E)

1) $\frac{M}{A}$ 2) 2MA 3) A^2M 4) AM^2

1)1	2)3	3)4	4)1,2	5)1
6)4	7)4	8)4	9)4	10)3
11)4	12)2	13)4	14)2	15)2

SATELLITES

Earth Satellites: Earth satellites ate the objects which resolve around the earth. Moon is the only natural satellite of the earth.

Time period for such satellites; $T_0 = 2\pi\sqrt{RE/g}$

R_E =Radius of the earth,=6400km

$g = 9.8m/\sec^2$

$$KE = \frac{G_M M_E}{2(R_E + h)}$$

$$PE = \frac{G_M M_E}{(R_E + h)}$$

$\underline{Energy\ of\ an\ orbiting\ Satellite}$

$$E = KE + PE = \frac{G_M M_E}{2(R_E + h)}$$

Geostationary Satellite: It revolves in the equatorial plane from went to east with a time period of 24 hours. It height from the surface of the earth is nearly 3600km and ram of the circular orbit is really 4000km. The orbital velocity of this satellite is nearly 3.08km.

Polar Satellites: These are low alt tube satellites (n=500 to 800km). They go around the poles of the earth in a north – sound direction whereas earth retiles around the axis is an east – west direction. Its time period is 100 minutes; such satellites are useful for remote sensing metrology as well as environmental studies of the earth.

Weight lessness: When an object is in free-fall, it is mirthless and this phermerin is called weightlessness. An astrumant experiences weightlessness in a satellite. It is because both the instrument and the satellite are in free fall towards the Earth.

Value of Gravitational Content G can be determined by **CAVENDISH METHOD**

Areal Velocity of a Planet $= \frac{1}{2} R^2 W$

<u>Gravitational Potential Energy</u>

It is defined as work done in bringing the body from infinity to a point.

Grantational energy "U" of a body of mess "M" at distance "r" from the center of Earth is $U^1 = -\frac{GMm}{r}$ resign shows the energy is due to attractive forces of earth on the body.

<u>Problems</u>

(1) Let "A" be the area swept ou by the line joining the earth and the sun during Feb, 1991. The area swept ant by the line during a typical week is Feb, 1991 is. (   )

a) A b) 2A c) 4A d) A/4

(2) An earth satellite is moved from one stable circular orbit the farther stable circular orbit. Which one of the following increases?

(   )

a) Linear orbital speed b) Grantational force

c) Centripetal accelentan   d)   Granitational Potential Energy.

(3) Time period of an earth satellite is circular orbit is independent of ( )

a) Mass the satellite   b)   Radius of the orbit

c) Both mass of satellite and radius the orbit

d) Neither the mass of satellite or the radius of its orbit.

(4) If A is the areal velocity of a planet of mass M the angular momentum. ( )

a) $\frac{M}{A}$ b)   2MA   c) A^2M d) AM^2

(5) The planet Naptune travels round the sun with a period of 165 years. The retro of its orbit radius to that of the earth is approximately.   (   )

a) 10:1   b)   20:1   c)   30:1   d)   40:1

(6) Reason of weightlessness is satellite is   (   )

a) Zero gravity   b)   Centre of mess

c)   Zero gravitational force by satellite surface   d)   None

(7) The intently of grantational field at the center of a spherical shell is ( )

a) Gm/r^2 b)   g   c)   O   d)   None of these

(8) A remote sensing satellite of the earth resolves is a circular orbit at a height of 250km above the earth surface. Its orbit speed and period of the resolution is (Radius of the earth = $6.38x10^6$ (   )

a) 7.76km/sec, T=5370sec   b)   6.66km/sec,T=8360sec

c)   9.76km/sec, T=3390sec   d)   4.76km/sec T=2390sec

(9) The mass of the earth is $6\times10^{24}kg$. Its grantational potential, at a distance of $3.35\times10^{10}m$ from the center of the earth is.   (   )

a) $-24\times10^6 J/kg$ b) $-12\times10^3 J/kg$ c) $36\times10^9 J/kg$ d) $48\times10^8 J/kg$

(10)   If V is the grantational potential on the surface of the earth then its value at the center of the earth is   (   )

a) 2V   b)   3V   c)   3/2V   d)   2/3V

KEY

1) d 2) d 3) a 4) b 5) c 6) c 7) c 8) a 9) b 10) c

CHAPTER -10

MECHANICAL PROPERTIES OF SOLIDS

Elasticity & Plasticity:

- When the external forces do not produce any deformation in the body, such body is called as rigid body
  There is no perfectly rigid body. But the nearest approach to it is diamond or carborundum
- The force which changes or ties to change the shape or size of a body without moving it as a whole is called deforming force
- When the deforming forces are removed, the body may regain its original shape and dimension. This is because of the restoring forces acting in the body, which opposite changes in the shape or dimensions of the body
- The property of a body by virtue of which it tends to regain its original size and shape after the removal of deforming forces is called **elasticity**
  No material is perfectly elastic. Quartz can be taken as perfectly elastic body (nearest approach)
- The property of a body by virtue of which it cannot be regain its original shape or size after the removal of deforming forces is called **plasticity**
  The nearest approach to be perfectly plastic body is putty. Chewing gum, wax, wet clay, lead solder etc., are plastic bodies
- Steel is more elastic than rubber. Water is more elastic than air
- When a body regains its original size and shape completely after the removal of the deforming forces, it is said to be perfectly elastic body
- Steel is more elastic than rubber. Water is more elastic than air
- When a body regain its original size and shape completely after the removal of the deforming forces, it is said to be perfectly elastic body
- If a body does not regain its original shape or size even after the removal of deforming forces, then it is said to be a plastic body
- Decreasing order of elasticity of certain substances: Tungsten, Nickel, Steel, Iron, Copper, Phosphor, Bronze, German silver, Brass, Aluminium

Stress & Strain:

Stress: It is restoring force per unit area (measured as the applied force per unit area)

$$\text{Stress} = \frac{\text{Restoring force}}{\text{area}}$$

Units: dy cm^{-2} (CGS), Nm^{-2} or pascal (SI)

Its dimensional formula is $ML^{-1}T^{-2}$.

- If the stress is normal to the surface, it is called normal stress. If the stress is tangential to the surface, it is called tangential stress.
- $\text{Stress} = \dfrac{\text{Restoring force}}{\text{Area of cross section}} = \dfrac{F}{A}$
- $\text{Normal stress} = \dfrac{\text{Restoring force per normal area}}{\text{Area of cross –Section}}$

  $\text{Shearing stress} = \dfrac{\text{Restoring force per parallel area}}{\text{Area of cross –section}}$

- Longitudinal stress: When a force is applied on a body such that there is a change in the length of the body, the longitudinal force per unit area is called longitudinal stress. A loaded wire or rod develops longitudinal stress
- Longitudinal stress is called tensile stress when there is an increase in length and compressive stress when there is a decrease in length
- Bulk stress: If a body is subjected to the same force normally on all its faces such that there is a change in its volume, the normal force per unit area is called bulk stress or volume stress
- Bulk stress is equal to pressure or change in pressure
- Shearing stress or Tangential stress: When a tangential force is applied on a body such that there is change in shape of the body only, then the tangential force per unit area is called tangential stress
- Stress is tensor quantity as it has different values in different directions
- **Strain**: The deformation or change produced per unit dimension of the body is called strain. As strain is a ratio, it has no units and no dimensions.
- Longitudinal strain: It is the change in length per unit original length or it is the fractional change in length
  If there is an increase in length, it is called tensile strain. If there is a decrease in length, it is called compressive strain
- Volume strain: It is the change in volume per unit original volume or it is the fractional change in volume
- Shearing strain: It is the ratio of relative displacement between two layers of the body to the normal distance between those two layers
  It can be expressed as the angle through which the line originally normal to the fixed surface is turned
- Shearing strain = 2 x longitudinal strain
- Strain = $\frac{\text{Change in dimension}}{\text{Original dimension}}$

  Longitudinal strain = $\frac{\text{change in length}}{\text{original length}} = \frac{\Delta l}{l}$

  Bulk strain = $\frac{\text{change in volume}}{\text{original volume}} = \frac{\Delta V}{V}$

  Shearing strain = $\frac{\text{relative displacement of a layer}}{\text{distance between layers}} = \frac{x}{d}$ or θ

  Lateral strain of a wire stretched = $\frac{\text{Change in radius}}{\text{original radius}} = \frac{\Delta r}{r}$
- Longitudinal and Bulk strains do not change the shape of the body. The cause change in magnitude of volume or length. Shearing strain causes change only in the shape of the body

Hooke's Law: Within the elastic limit, stress is directly proportional to strain

i.e Stress $\propto$ Strain

or $\frac{\text{Stress}}{\text{Strain}} = E$

E is a constant known as modulus of elasticity or coefficient of elasticity of the body

- The value of E depends upon the nature of material and the manner in which the body is deformed. There are three types of modulii corresponding to three types of strains

  a) Young's modulus b) Bulk modulus c) Rigidity modulus
- Units of E are dyne cm^{-2} (CGS) and Nm^{-2} or Pa (SI)
- The maximum value of stress upto which a body retains its elastic property is known as elastic limit
- Carbon becomes plastic when heated. But for rubber elastic property increases with increase of temperature
- To increase the elastic property; carbon is added to iron. Similarly potassium is added to increase elasticity of gold
- Quartz and phosphor bronze are used for suspension wires of moving coil galvanometers. These two have high tensile strength and low rigidity modulus. Elastic after effect least for these two
- The area under stress-strain diagram gives the work done per unit volume
- If stress is plotted on Y-axis and strain on X-axis, within elastic limit slope of the graph gives E

Young's Modulus:

- The ratio of longitudinal stress of longitudinal strain within the elastic limit is called Young's modulus (Y)

  $Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}}$
- If a wire of length '*l*' is fixed at one end and loaded at the other end by a mass M, then Longitudinal stress = $\frac{F}{A} = \frac{Mg}{\pi r^2}$ (r is radius)

  If e or Δl is elongation of the wire, then longitudinal or linear strain = $\frac{e}{l}$

  Young's modulus $Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{Mg/\pi r^2}{e/l} = \frac{Mgl}{\pi r^2 e}$
- elongation $e = \frac{Mgl}{\pi r^2 Y}$
- $e \propto 1/r^2$ (same stretching force in applied to different wires of same material)
- $\frac{l_1}{r_1^2} = \frac{l_2}{r_2^2}$ (for same elongation in the above case)
- $e \propto F$ or Mg (different stretching forces on the same wire)
- $e \propto \frac{1}{Y}$ (same stretching force on wires of different material having same dimensional)
- When a mass is suspended from a wire, its elongation is e. Then
  a) if same mass is suspended form a wire of same length, material but half the radius of cross section, its extension is 4e
  b) if same mass is suspended form a wire of same material but half the length, its extension is e/2

c) if the mass is a sphere, and now sphere of same material with double the radius is suspended its new extension is 8e

d) if the suspended mass is completely immersed in a nonviscous liquid, its new extension is $e\left(1-\frac{d_2}{d_1}\right)$ where d1 and d2 are the densities of liquid and the suspended mass

e) If e_1 is the extension when the suspended mass in air and e_2 is the extension when that mass is completely immersed in a liquid (water), then its relative density is

$$\frac{d_1}{d_2} = \frac{e_1}{e_1 - e_2}$$

- Two rods or wires of the same material and same volume are subjected to same stretching force. Then ratio of their elongations is given by

$$\frac{e_1}{e_2} = \left[\frac{r_2}{r_1}\right]^4 \text{ (} r_1, r_2 \text{ are radii of cross section)}$$

$$\frac{e_1}{e_2} = \left[\frac{l_1}{l_2}\right]^2 \text{ (} l_1, l_2 \text{ are length of cross section)}$$

- Thermal stress: If the ends of a rod are rigidly fixed so as to prevent expansion or contraction and the temperature of rod is changed, tensile or compressive stress produced is called thermal stress developed within that rod
  Thermal stress does not depend on the original length of the rod
- Thermal stress $\frac{F}{A} = Y\alpha\ (\Delta\theta)$

  Force required to prevent the rod from expansion is $F = YA\alpha\ (\Delta\theta)$
  Here thermal strain = $\alpha\ (\Delta\theta)$
  $Y = \frac{\text{Thermal stress}}{\text{Thermal strain}}$
  Here Y is Young's modulus, α Coefficient of linear expansion
  $\Delta\theta$ is change in temperature

Note: For the same change in temperature, if same thermal stress is produced in two different rods, $Y_1\alpha_1 = Y_2\alpha_2$

- If a wire of length l is suspended, its elongation due to its own weight is $e = \frac{l^2 dg}{2Y}$

  Here d is density of the material of wire, Y is Young's modulus
- The length of a wire l_1 when the tension in it is T_1 and l_2 when the tension is T_2.

  Then natural length of the wire is $\frac{l_1 T_2 - l_2 T_1}{T_2 - T_1}$

Poisson's Ratio (σ):

- When a force is applied on a wire to increase its length, its radius decreases. So two strains are produced by a single force
  " The ratio of lateral strain to longitudinal strain is called poisson's ratio".
- Poisson's ratio $\sigma = \frac{(-\Delta r/r)}{(e/l)}$

- Poisson's ratio has no units and dimensions. Theoretically σ lies between –1 and 0.5. But in actual practice it lies between 0 and 0.5.
- For most of solids σ value lies between 0.2 and 0.4 σ for rubber is nearly 0.5.
- If there is no change in the volume of a wire undergoing long extension, the poisson's ratio must be 0.5
- Practically no substance has been found for which σ is negative

Force Constant:

- Force constant of a spring which obeys Hooke's law is $K = \frac{YA}{l}$

  (Y is Young's modulus, A is area of cross section, l is length)

Bulk Modulus (K)

- **Bulk Modulus (K)**: The ratio of Bulk stress to bulk strain within the elastic limit is called bulk modulus (K) or coefficient of volume elasticity
- If the volume V of a body diminishes by ΔV. When the pressure on it is increased uniformly by ΔP then, volume stress = ΔP

  and Volume strain = $\frac{-\Delta V}{V}$ (-ve sign suggests that with increase in pressure, volume decreases)

  Bulk modulus $K = \frac{\text{Volume stress}}{\text{Volume of strain}}$ or $K = \frac{\Delta P}{\left(\frac{-\Delta V}{V}\right)} = -V\left(\frac{\Delta P}{\Delta V}\right)$

  Adiabatic bulk modulus = γP

  Isothermal bulk modulus = P (P is pressure and $\gamma = C_P/C_V$)

  Compressibility (C) = $\frac{1}{K} = \frac{-1}{V}\left(\frac{\Delta V}{\Delta P}\right)$

Rigidity Modulus (n)

- Rigidity Modulus (n): The ratio of tangential stress to shearing strain within the elastic limit is called rigidity modulus (n) or coefficient of tensile elasticity
- Strain energy per unit volume = $\frac{1}{2}$ x stress x strain

  Elastic strain energy = $\frac{1}{2}$ x stress x strain x volume

  Strain energy per unit volume = $\frac{1}{2} \times \frac{(\text{Stress})^2}{Y} = \frac{Y}{2}(\text{strain})^2$

Strain Energy and Work done:

- When a body is deformed, the work done is stored in the form of P.E. in the body. This potential energy is called strain energy. When the force applied is removal, the stress vanishes and the strain energy appears as heat
- Strain energy per unit volume = $\frac{1}{2}$ x stress x strain

  Elastic strain energy = $\frac{1}{2}$ x stress x strain x volume

  Strain energy per unit volume = $\frac{1}{2} \times \frac{(\text{strain})^2}{Y} = \frac{Y}{2}(\text{strain})^2$

- If a force F acts along the length of the wire and stretches it by x, then work done is equal to $W = \frac{1}{2} Fx = \frac{1}{2} Mgx$ (if F = Mg).
- If a wire or rod extends longitudinally by an amount while the stretching force increases in value from F1 to F2 then within elastic limit work done $W = \frac{1}{2}(F_1+F_2)e$

  Where 'e' is the extension
- If one end of a wire or rod is clamped and to the other end of the wire hanging freely, a torque τ is applied so that it experience a twist of θ radian, then the work done on the wire is $\frac{1}{2}\tau\theta$

Breaking Stress:

- Breaking stress = $\frac{\text{Breaking force}}{\text{Area}} = \frac{F}{A}$, Breaking force (F) ∞ Area (A)

$$F \propto A \quad \text{or} \quad \frac{F_1}{F_2} = \frac{A_1}{A_2} = \frac{r_1^2}{r_2^2}$$

Elastic Fatigue:

- The state of temporary loss of elastic nature of a body due to repeated stresses over a long time intervals is called elastic fatigue

  Ex: When a copper wire is bent once, it may not break. But it breaks when bent repeatedly at the same time

Conceptual questions:

1) If stress is equal to young's modulus the change in length is equal to
   1) original length 2) Half of the original length
   3) twice the original length 4) 1/4 of the original length
2) The effect of temperature on the value of modulus of elasticity for various substances in general is
   1) it increases with increase in temperature 2) remains constant
   3) decreases with rise in temperature 4) sometimes increase and sometimes decreases
3) Hooke's law states that
   1) stress /strain = coefficient of elasticity
   2) coefficient of elasticity /stress = strain
   3) coefficient of elasticity /strain = stress
   4) stress /coefficient of elasticity = change of length
4) Young's modulus $Y = 21 \times 10^{11} D/cm^2$. It is equal to
   1) 210 G Pa 2) 2100 G Pa 3) 21000 G Pa 4) 210000 G Pa
5) Young's modulus of a substance depends on
   1) its length 2) its area 3) acceleration due to gravity 4) none
6) The property of metals where by they could be drawn into thin wires beyond their elastic limit without breaking is
   1) ductability 2) malleability 3) elasticity 4) hardness

7) The substance which shows practically no elastic after effect is
1) quartz 2) copper 3) silver 4) rubber

8) In the stress-strain graph, if the distance between yield point and breaking point is less, then the metal is
1) rigid 2) brittle 3) ductile 4) malleable

9) A spiral spring is stretched by a weight attached to it. The strain is
1) shearing strain 2) elastic strain 3) tensile strain 4) bulk strain

10) The Young's modulus for a liquid is
1) 0 2) 1 3) ∞ 4) finite, non-zero constant

11) Graph plotted within elastic limit between applied force and corresponding change in length will be
1) a curve 2) a straight line passing through origin
3) a zig-zag curve 4) a circle

12) The strain produced in crystals is due to
1) non-movement of molecules 2) movement of molecules
3) neither 1 nor 2 4) crystals produce to strain

13) Volumetric strain is ------ times linear strain
1) 2 times 2) 3 times 3) 4 times 4) 5 times

14) For a gas, elastic limit
1) exists 2) does not exist
3) exists only at absolute zero 4) exists for a perfect gas

15) The temperature of a body is increased by t^0C. Now the product of Young's modulus, coefficient of linear expansion and temperature difference gives
1) volume coefficient 2) force 3) linear strain 4) stress

16) If a metal wire is stretched a little beyond its elastic limit and released it will
1) lose its elastic property completely 2) not constant
3) contract but final length is greater than initial length 4) contract only at elastic limit

17) A wire is shortened to half of its original length. The maximum load the wire can support within the elastic limit
1) remains unaffected 2) first increases then decreases
3) increases 4) decreases

18) When impurities are added to a substance, elasticity may
1) increase 2) decrease 3) increase or decrease 4) none

19) Match the following questions:

List –I	List –II
a) Elastic fatigue b) Bulk strain c) Shearing strain d) Hooke's law	e) 3 times linear strain f) tangential strain g) proportional limit h) temporary loss of elastic property i) yield point

The correct match is
1) a→h; b→e; c→f; d→g 2) a→e; b→h; c→g; d→f
3) a→f; b→e; c→g; d→i 4) a→e ;b→f; c→h; d→i

20) Match the following lists:

List –I	List –II
a) Isothermal bulk modulus of a gas b) Adiabatic bulk modulus of a gas c) Bulk modulus of a perfect rigid body d) Compressibility of a perfect rigid body	I) Infinity II) γP III) P IV) zero

The correct match is

1) a→h; b→g; c→e; d→f 2) a→e; b→f; c→h; d→g
3) a→g; b→f; c→e; d→h 4) a→g ;b→h; c→f; d→e

21) Study the following:

List –I	List –II
a) Young's modulus b) Rigidity modulus c) Shear modulus d) stress	e) resistance to change in shape f) resistance to change in linear dimension g) resistance to change in volume h) resistance to against defarmation forces

The correct match is

1) a→f; b→g; c→e; d→h 2) a→g; b→h; c→e; d→f
3) a→f; b→e; c→g; d→h 4) a→g ;b→e; c→h; d→f

22) Match the following:

A spring of Young's modulus $2x10^{11}$Pa is suspended vertically and subjected to a load of 5Kg and elongation is 2mm when the load is doubled. ($g = 9.8m/s^2$)

List –I	List –II
a) Elongating force b) Stress c) Elongation d) Young's modulus	e) 4mm f) unchanged g) 98N h) doubled

The correct match is

1) a→h; b→g; c→f; d→e 2) a→g; b→h; c→e; d→f
3) a→e; b→f; c→g; d→h 4) a→f ;b→e; c→g; d→h

23) Study the following:

List –I	List –II
a) Brittle metals b) Ductile metals c) Tangential force d) Normal force	e) only change in shape f) drawn into wires g) only change in size h) can't be drawn into wire

The correct match is

1) a→h; b→f; c→g; d→e 2) a→h; b→f; c→e; d→g
3) a→f; b→h; c→g; d→e 4) a→e ;b→g; c→f; d→h

24) Match the following:

List –I	List –II
a) Poisson's ratio	e) $\frac{(3K-2n)}{2(3K+n)}$
b) Young's modulus	f) $\frac{9Kn}{(2K+n)}$

c) Elastic energy density	g) $\frac{\text{Shearing stress}}{\text{shearing strain}}$
d) Rigidity modulus	h) $\frac{1}{2}Y\ (\text{strain})^2$
	i) $\frac{Y}{2n}+1$

1) a→i; b→e; c→g; d→h2) a→e; b→i; c→g; d→f
3) a→e; b→f; c→h; d→g 4) a→i ;b→g; c→f; d→e

25) Assertion: Steel is more elastic than rubber
Reason: Under a given deforming force, steel is deformed less than rubber
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

26) Assertion: Lead is more elastic than rubber
Reason: If the same load is attached to lead and rubber wires of the same cross-sectional area, the strain of lead is very much less than that of rubber
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

27) Assertion: Two identical solid balls, one of ivory and the other of wet-clay are dropped from the same height on the floor. Both the balls will rise to same height after bouncing
Reason: Ivory is more elastic than wet-clay
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

28) Assertion: With increase of temperature, elastic property of a substance decreases
Reason: Elasticity is due to intermolecular forces which decrease with the increase of intermolecular distance
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

29) Assertion: Addition of carbon to iron increases the elastic property
Reason: Carbon and iron belong to the same group of elements
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

30) Assertion: Stress is the internal force per unit area of the body
Reason: Rubber is more elastic than steel
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

31) Assertion: Stress is restoring force per unit area
Reason: Interatomic forces in solids are responsible for the property of elasticity
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A

3) A is true but R is false 4) A is false but R is true

32) Assertion: Young's modulus for a perfectly plastic body is zero
Reason: For a perfectly plastic body, restoring force is zero
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

33) Assertion: Rigidity modulus of a liquid is infinity
Reason: Liquids have no shape of their own
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

34) Assertion: Silver is a ductile material
Reason: For a ductile material yield point and breaking point are separated by larger distance than for brittle materials on the stress-strain curve
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

Numerical Exercise:

Young's Modulus:

35) If the stress in a wire is 1/200th of young's modulus, the strain produced is
1) 1/100 2) 1/200 3) 1/10 4) 1/20

36) If Y is the young's modulus of a wire of cross sectional area A, the force required to increase its length of 0.1% is
1) AY 2) AY/100 3) AY/1000 4) 1000AY

37) If same tensile force is applied on two wires there will an extension of $1x10^{-3}$m in them. The Young's modulii and radii of these wires are $10x10^{10}Nm^{-2}$ and $20x10^{10}Nm^{-2}$ and R_1 and R_2 respectively then
1) $R_2 = \sqrt{2}R_1$ 2) $R_2 = R_1/\sqrt{2}$ 3) $R_2 = 4R_1$ 4) $R_2 = R_1/4$

38) Two persons pull a rope towards themselves. Each person exerts a force of 100N on the rope. Original length of the rope is 2m and the area of cross-section is 2cm2. If it extends in length by 1cm then the Young's modulus of the material of the rope is
1) $1x10^5Nm^{-2}$ 2) $1x10^6Nm^{-2}$ 3) $1x10^{-7}Nm^{-2}$ 4) $1x10^8Nm^{-2}$

39) The length of a metal wire is l when the tension in it is F and xl when the tension is yF. Then the natural length of the wire is
1) $\frac{(x-y)l}{(x-1)}$ 2) $\frac{(y-x)l}{(y-1)}$ 3) $\frac{(x-y)l}{(x+1)}$ 4) $\frac{(y-x)l}{(y+1)}$

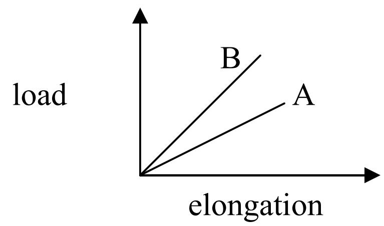
40) A mass 'm' is whirled in a vertical plane by tyring it at the end of a flexible wire of length l and area of cross section A. When the mass is at its lowest position, the strain produced in the wire is (Y is Young's modulus)
1) AY/6mg 2) 6mg/AY 3) 5mg/AY 4) AY/5mg

41) Two wires of the same length and radius are joined end to end and loaded. If the Young's modulii of the wires are Y_1 and Y_2 the combination behaves as a single wire of Young's modulus
1) (Y_1+Y_2) 2) $\sqrt{Y_1Y_2}$ 3) (Y_1-Y_2) 4) $\frac{2Y_1Y_2}{(Y_1+Y_2)}$

42) A tensile force of 4000N doubles the length of a rubber cord of cross –sectional area $4cm^2$. Then young's modulus of rubber is
1) 10^{10}Pa 2) 10^9Pa 3) 10^8Pa 4) 10^7Pa

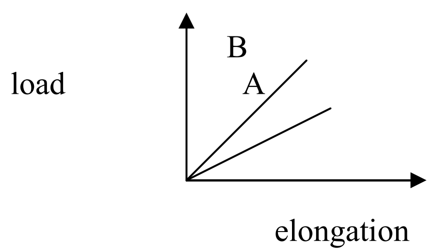
43) Two exactly similar wires of steel ($Y= 20x10^{11}dy\ cm^{-2}$) and copper ($Y=12x10^{11}dycm^{-2}$) are stretched by equal forces. If the total elongation is 1cm, elongation of copper wire is
1) $\frac{3}{5}$ cm 2) $\frac{5}{3}$ cm 3) $\frac{3}{8}$ cm 4) $\frac{5}{8}$ cm

44) The dimensions of wires A and B are the same but materials are different. If the graphs for load versus elongation for those two wires are as shown. Young's modulus is less for



1) A 2) B 3) Same for both 4) None

45) Load-extension graph for two different wires of same material are as shown in the graph. If their lengths are the same which of these two is thin wire?
1) A 2) B 3) Same for both 4) None



46) Two wires of different materials each of length l and cross sectional area 'A' are joined in series to form a composite wire. If their young's modulii are Y and 2Y, the total elongation produced by applying a force F to stretch the composite wire
1) $3FA/2Yl$ 2) $2Fa/3Yl$ 3) $2FA/3AY$ 4) $3Fl/2AY$

47) A metal ring of inner radius r_1 and cross sectional area A is fitted onto a wooden disc of radius $r_2 (r_2>r_1)$. If Y is the young's modulus of the metal, then the tension in the ring is
1) $\frac{AYr_2}{r_1}$ 2) $\frac{AY(r_2-r_1)}{r_1}$ 3) $\frac{Y}{A}\frac{(r_2-r_1)}{r_1}$ 4) $\frac{Yr_1}{Ar_2}$

48) The length of a wire is l_1 when tension is 4F and l_2 when the tension is 5F. Then its length when the tension is 9F would be
1) $9l_1-8l_2$ 2) $5l_1-4l_2$ 3) $5l_2-4l_1$ 4) $9l_2-8l_1$

Breaking Stress & Thermal Stress:

49) A breaking force a given wire is 'F'. The breaking force for the wire having double the thickness is
1) 4F 2) 2F 3) F 4) F/2

50) The breaking stress of a wire is 10^4Nm^{-2} and the radius is $1x10^{-3}$m. If the radius is

$2x10^{-3}$m the breaking stress is

1) $4x10^4Nm^{-2}$ 2) $40x10^4Nm^{-2}$ 3) $0.4x10^4Nm^{-2}$ 4) $0.04x10^4Nm^{-2}$

51) A cable breaks if stretched by more than 2mm. It is cut into two equal parts. By how much either part can be stretched with out breaking?

1) 0.25mm 2) 0.5mm 3) 1mm 4) 2mm

52) A wire is made of material of density 10,000kgm^{-3} and breaking stress $4x10^8Nm^{-2}$. Then the minimum length of wire which will break under its own weight when suspended vertically is (g = 10ms^{-2})

1) $4x10^4$m 2) $4x10^3$m 3) 400m 4) 40m

53) A lift is tied with thick wires and the mass of the lift is one metric ton. If the maximum acceleration of the lift is 1ms^{-2}, and the maximum stress of the wire is $1.4x10^8$ Nm^{-2}.

If g =10ms^{-2}, the minimum diameter of that wire is

1) 10m 2) 10^{-1}m 3) 10^{-2}m 4) None

54) The breaking stress of a wire is $7.2x10^8Nm^{-2}$ and density is $78x10^2kgm^{-3}$. The wire is held vertically to the rigid support. The maximum length so that the wire does not break is

1) $0.94x10^3$m 2) $9.4x10^3$m 3) $94x10^3$m 4) $940x10^3$m

55) A steel rod of length 25cm has a cross sectional area of 0.8cm^2. The force required to stretch this rod by the same amount as the expansion produced by heating it through 10^0C is ($\alpha = 10^{-5 0}C^{-1}$ and Y = $2x10^{10}Nm^{-2}$)

1) 40N 2) 80N 3) 120N 4) 160N

56) At 0^0C a square steel bar of 2cm side is rigidity clamped at both ends so that its lengths cannot increase. Young's modulus of steel is $20x10^{10}Nm^{-2}$ and coefficient of linear expansion is $12x10^{-6}C^{-1}$. When the temperature is increased to 10^0C, the force exerted on the clamps is

1) 1200N 2) 2400N 3) 4800N 4) 9600N

Bulk modulus & rigidity modulus:

57) A solid cube of 4m is subjected to a pressure of $20x10^6$pascal.Its bulk modulus is $125x10^9$ pascal. The change in the volume of the cube is

1) $-10x10^{-3}m^3$ 2) $-20 x10^{-3}m^3$ 3) $-30x10^{-3}m^3$ 4) $-40x10^{-3}m^3$

58) The change in the density of water in ocean at a depth of 400m below the surface. If the density of water at surface is 1030kgm^{-3} and bulk modulus of water = $2x10^9Nm^{-2}$

1) 0.5kgm^{-3} 2) 1.0kgm^{-3} 3) 1.5kgm^{-3} 4) 2.0kgm^{-3}

59) A steel plate of face area 4cm^2 and thickness 0.5cm is fixed rigidity at the lower surface. A tangential force of 10N is applied on the upper surface. The lateral displacement of the upper surface with respect to the lower surface is

(rigidity modulus of steel = $8.4x10^{10}$ Nm^{-2})

1) $1.5x10^{-6}$m 2) $1.5x10^{-7}$m 3) $1.5x10^{-8}$m 4) $1.5x10_{-9}$m

60) Two parallel forces of 4000N are applied tangentially in opposite direction to the opposite faces of a metallic cube of side length 0.25m. The shear modulus of the material is $80x10^9$Pa. The displacement of the upper surface relative to the lower surface is

1) $2x10^{-5}$m 2) $2x10^{-6}$m 3) $2x10^{-7}$m 4) $2x10^{-8}$m

61) A cube is shifted to a depth of 200m in a lake. The change in volume is 0.1%. Then bulk modulus of the material is (g = 10ms^{-2})

1) 10^9Pa 2) $2x10^9$Pa 3) $0.5x10^9$Pa 4) None

62) The compressibility of water is $5x10^{-10}m^2N^{-1}$. The decrease in volume of 100ml of water when subjected to a pressure of 15MPa

1) 0.25m*l* 2) 0.50m*l* 3) 0.75m*l* 4) 1m*l*

63) A cube is subjected to a uniform volume compression. If the side of the cube is decreased by 1%, bulk strain produced is

1) 0.01 2) 0.03 3) 0.02 4) 0.08

64) Bulk modulus of elasticity of rubber is 10^9Nm^{-2}. If it is taken down to a 100m deep lake, decrease in its volume is ($g = 10ms^{-2}$)

1) 0.1% 2) 0.2% 3) 1% 4) 2%

65) On a perfect cube of side 10cm, a shearing force is applied. If its top surface is displaced through 0.3mm with bottom surface unmoved, magnitude of shearing force applied is ($n = \frac{100}{3}$GPa)

1) 10^3N 2) 10^4N 3) 10^5N 4) 10^6N

66) If a shear force of 3000N is applied on a cube of side 40cm, displacement of the top surface of the cube when bottom surface is fixed ($n = 5x10^{10}Nm^{-2}$)

1) $15x10^{-6}$m 2) $15x10^{-7}$m 3) $15x10^{-8}$m 4) $15x10^{-9}$m

67) A 2cm cube on a table is subjected to a shearing force of 1N, its upper surface is displaced by ($n = 10^4$Pa)

1) 0.1mm 2) 1mm 3) 0.1cm 4) 1cm

Strain Energy:

68) A wire is stretched by $2x10^{-2}$m due to the force of 10N. Then the amount of work done to stretch the wire to a displacement of $4x10^{-2}$m is

1) 0.04J 2) 0.4J 3) 40J 4) 400J

69) The Young's modulus of the material of a rod is $20x10^{10}Nm^{-2}$. When the longitudinal strain is 0.04%. What is the energy stored per unit volume?

1) $16x10^3Jm^{-3}$ 2) $8x10^3Jm^{-3}$ 3) $16x10^2Jm^{-3}$ 4) $0.8x10^3Jm^{-3}$

70) The ratio of the lengths of the two wires of same Young's modulus and same diameter is 5:3. They are stretched by the same force. Then the ratio of the work done on the two wires to stretch is

1) 5:3 2) 3:5 3) 8:5 4) 5:8

71) A long wire hangs vertically with its upper end clamped, when a torque of 2 Nm is applied to the free end, it is twisted through an angle 30^0. Then the potential energy of the twisted wire is

1) π joules 2) π/3 joules 3) π/6 joules 4) π/4 joules

72) Two wires of the same material and length but radii in the ratio 2:3 are stretched by the same force. Then the ratio of work done in the two cases is

1) 2:3 2) 3:2 3) 4:9 4) 9:4

73) The work done is stretching a wire of cross-section 1sqcm and length 2m through 0.1mm is ($Y = 2x10^{11}Nm^{-2}$)

1) $5x10^{-2}$J 2) $5x10^{-3}$J 3) $5x10^{-4}$J 4) $5x10^{-5}$J

74) A rod of length 150cm and a cross section 3 sq.cm is compressed through 4mm by applying a force of 400N. Then the work done is

1) 0.1J 2) 0.2J 3) 0.3J 4) 0.4J

75) A metal wire 4m long and $2x10^{-7}$ sq.m in cross section is stretched by a force of 30N. If the work done is stretching that wire is $4.5x10^{-2}$J, the young's modulus of the wire is
1) $2x10^{11}$Pa 2) $4x10^{11}$Pa 3) $2x10^{12}$Pa 4) $4x10^{12}$Pa

76) A metal rod of length 2.5m and area of cross-section $2.5x10^{-4}m^2$ is elongated by $2.5x10^{-3}$m by a force of 600N. Then energy stored in the rod is
1) 75J 2) 0.75J 3) 25J 4) None

77) The work done to stretch a wire through $1x10^{-3}$m is 2J. Then the work done to stretch another wire of same material having half length and double the area of the cross section by $1x10^{-3}$ m is
1) $\frac{1}{4}$ J 2) 4J 3) 8J 4) 16J

78) A wire of length *l* and cross-sectional area A is made up of a material of young's modulus Y. If the wire is stretched by 'e' then work done is
1) YAe/l 2) YAe^2/l 3) YAe^2 4) $YAe^2/2l$

79) In a wire stretched by hanging a weight from its end, the elastic potential energy per unit volume in terms of longitudinal strain σ and modulus of elasticity is
1) $Y^2\sigma/2$ 2) $Y\sigma/2$ 3) $Y\sigma^2/2$ 4) $2Y\sigma^2$

Keys

1)1	2)3	3)1	4)1	5)4	6)1	7)1	8)2	9)3
10)1	11)2	12)2	13)2	14)2	15)4	16)3	17)1	18)3
19)3	20)1	21)4	22)4	23)4	24)3	25)1	26)1	27)4
28)1	29)3	30)2	31)1	32)1	33)4	34)1	35)2	36)3
37)2	38)4	39)2	40)2	41)4	42)4	43)4	44)2	45)1
46)4	47)2	48)3	49)1	50)1	51)3	52)2	53)3	54)2
55)4	56)3	57)1	58)4	59)4	60)3	61)2	62)3	63)2
64)1	65)4	66)3	67)4	68)2	69)1	70)1	71)3	72)4
73)3	74)4	75)1	76)2	77)3	78)4	79)3		

Elasticity previous eamcet questions

1) Bulk modulus of water is $2x10^9$ Nm^{-2}, the pressure required to increase the density of water by 0.1% in Nm^{-2} is [2003E]
1) $2x10^9$ 2) $2x10^8$ 3) $2x10^6$ 4) $2x10^4$

2) Consider the statements A and B, identify the correct answer given below:
(A): If the volume of a body remains unchanged, when subjected to tensile strain, the value of poisson's ratio is ½. [2003M]
(B): Phosphor bronze has low Young's modulus and high rigidity modulus.
1) A and B are correct 2) A and B are wrong
3) A is correct, B is wrong 4) A is wrong and B is right.

3) A metallic ring of radius 'r' and cross sectional area A is fitted into a wooden circular disc of radius R (R> r). If the Young's modulus of the material of the ring is Y, the force with which the metal expands is [2004E]
1) $\frac{AYR}{r}$ 2) $\frac{AY(R-r)}{r}$ 3) $\frac{Y(R-r)}{Ar}$ 4) $\frac{YR}{Ar}$

4) The increase in the length of a wire on stretching is 0.025%. If its Poisson's ratio is 0.4, then the percentage decrease in the diameter is [2004M]
   1) 0.01 2) 0.02 3) 0.03 4) 0.04
5) The radii and Young's modulii of two uniform wires A and B are in the ratio 2 : 1 and 1 : 2 respectively. Both wires are subjected to the same longitudinal force. If the increase in length of wire 'A' is one percent, the percentage increase in length of wire 'B' is [2005E]
   1) 1 2) 1.5 3) 2 4) 3
6) Two wires of same material and same diameter have lengths in the ratio 2 : 5. They are stretched by same force. The ratio of work done in stretching them is [2005M]
   1) 5 : 2 2) 2 : 5 3) 1 : 3 4) 3 : 1
7) Assertion (A): Ductile metals are used to prepare thin wires.
   Reason (R): In the stress-strain curve of ductile metals, the length between the points representing elastic limit and breaking point is very small. [2006E]
   1) Both (A) and (R) are true and (R) is the correct explanation of (A).
   2) Both (A) and (R) are true but (R) is not the correct explanation of (A).
   3) (A) is true but (R) is false. 4) (A) is false but (R) is true.
8) A mass of 6.5kg is hanging from the end of a 60cm long steel wire ($Y = 2 \times 10^{11}$ Pa) with area of cross-section $0.05cm^2$. When it is revolving in vertical circle it has an angular velocity of 2 revolutions per second, at the bottom of the circle. Approximate elongation of the wire (in meters) when the mass is at lowest point of the trajectory is [2006M]
   1) 8×10^{-4} 2) 4×10^{-4} 3) 8×10^{-5} 4) 4×10^{-5}
9) When a wire of length 10m is subjected to a force of 100N along its length, the lateral strain produced is 0.01×10^{-3}m. The poisson's ratio was found to be 0.4. If the area of cross-section of wire is $0.025m^2$, its young's modulus is [2007E]
   1) 1.6×10^8 Nm^{-2} 2) $2.5 \times 10^{10} Nm^{-2}$
   3) $1.25 \times 10^{11} Nm^{-2}$ 4) $16 \times 10^9 Nm^{-2}$
10) A body subjected to strain several times will not obey Hooke's law due to [2007M]
   1) Yield point 2) permanent state
   3) Elastic fatigue 4) Breaking stress.

Keys:

1) 3 2) 3 3) 2 4) 1 5) 3 6) 2 7) 3 8) 2 9) 1 10) 3

Applications of Elasticity

(1) Metallic parts loses their elastic properties with time & one never subjected to a stress beyond the elastic limit of the material of the machines.

(2) The thickness of metallic ropes used in cranes to lift heavy loads is decided from the knowledge of the elastic limit of the material of rope. For the purpose of flexibility and strength, the rope is made of number of them wires braided together.

(3) in designing a bridge knowledge of elasticity is used such that bridge should not bend or break under its own weight, load of traffic and force of winds

(4) In the design of building the beams and columns are used. Both these problems involve the bending of breaks under a load the depression of breaks of length *l,* breadth *b*, and thickness d fixed at ends under a load *w* applied at the centre given by $\delta = {wl^3}/{4ybd^3}$

(5) The maximum height of mountain on earth depends upon shear modulus.

(6) The elastic limit of a typical rock is 3×10^8 N / m^2

CHAPTER 11
MECHANICAL PROPERTIES OF FLUIDS

FLUID MECHANICS:

- The property of a fluid by virtue of which it offers a resistance to relative motion between its different layers is called "Viscosity" .
  Viscosity of fluid resembles friction of solids
  viscous force f=n A dv/dx, where n=coefficient of viscosity
  A= surface area of the layer. dv/dx = velocity gradient
- The coefficient of viscosity (n) of a liquid is the tangential force per unit area required to maintain units velocity gradient normal to the direction of flow. Its unit in CGS system is poise and in MKS system Nsm^{-2} or pascal second
- the variation of velocity with transverse distance is called velocity gradient velocity gradient = dv/dx
- the coefficient of viscosity of a liquid is also defined as the ratio of the tangential stress to the velocity gradient
- the dimensional for coefficient of viscosity or simply viscosity is $ML^{-1}\ T^{-1}$
- Following are the examples of viscosity: -
  A) When water in a beaker is stirred with a rod at its center, the layer of water in the layers near the walls of the beaker remain stationary. The intermediate layers will move with intermediate speeds.
  B) The viscosity of sea water makes the water wave subside
  C) Raindrops fall with less uniform velocity
  D) If the velocity of the liquid at any point inside the liquid is independent of time, such a flow is called stream line flow or steady or laminar flow.
- If the velocity of the liquid at any given point varies with time, the flow is called turbulent flow
- The minimum velocity at which the flow changes from streamline to turbulent state is called critical velocity of that liquid.
- Critical velocity has higher values for highly viscous liquids
- In the case of gases viscosity increases with increase of temperature
- in the case of liquids viscosity decreases with increase of temperature
- viscosity of gases is independent of pressure (at ordinary pressure)
- Viscosity of gases is directly proportional to the pressure (at low pressures only)
- 1 Pascal second = 10^{-1} poise
- Note that E= "n" is called coefficient. A (dv / dx) of dynamic viscosity and η/p is termed as the coefficient of kinematics viscosity and it is measured in " stokes ". and dimensional formula of kinematics viscosity is $\eta/p = L^2\ T^{-1}$unit is $m^2\ s^{-1}$
  1 stoke = $10^{-4}\ m^2s^{-1}$
- According to stokes law the viscous force acting on a spherical body moving in a fluid is proportional to radius of the body, velocity of the body and coefficient of viscous of the fluid , F= 6 π nrv where v=velocity
- The steady final velocity reached by a body falling through a fluid when resultant force on it is zero is called terminal velocity & it is given as
  $V= 2r^2\ (d-\sigma)g\ /9n$

Where d= density of the body, σ =density of the fluid and n = coefficient of viscosity

- Poiseuilles expression given the volume of the fluid v following through a capillary tube of length l and radius r
  As v= $\pi r^4 P / 8nl$ where p is difference between the two ends of the tube = hdg
- Where h= the average difference of levels between the two ends of the capillary tube.
- Equation of continuity is in accordance with the law of conservation of mass, AV = Constant.
- Following are the examples of equation of continuity
  When a household tap is opened so the stream becomes narrow as it falls,
  When the outlet of a water hose is closed partially the water gushes out with greater velocity
- Pressure in a fluid at rest at any point depends on the depth and density of fluid.
- According to Pascal law the external pressure applied to a fluid transmits equally in all directions.
- In general normal atmospheric pressure is given as 76cm of Hg or 10.33m of water column.
- When a body is immersed in a fluid at rest, the bottom surface experience greater pressure then the top surface. So the body experiences a resultant force acting vertically upwards. This upward force is called buoyant force or buoyancy
- when the buoyancy of a fluid is greater than the weight of the body it floats in the fluid. If it is less than the weight of the body, the body sinks in the fluid.
- A fluid in motion possess three type of energy
  1) Kinetic energy =$1/2\ mv^2$, and thus kinetic energy per unit volume =$1/2\ \rho v^2$ where p is the density.
  2) potential energy = mgh and thus P.E. /volume =ρgh
  3) Pressure energy:- the energy possessed by a fluid by virtue of the pressure is the pressure energy and pressure energy= Pa Δ x where P is the pressure applied, a is the area of piston and Δx is the distance traveled by the piston and thus pressure energy/mass = P/ρ and pressure energy / volume =P
- Bernoulli's theorem:- the sum of the pressure energy, kinetic energy and potential energy at any point in a steady flow of a fluid is constant thus P/P + ½ V2+gh=const
  Where P/ρ = pressure energy /mass , ½ v^2=K.E./mass and gh= P.E. /mass
  Note that: A) P/Pg is called pressure head B) $1/2\ V^2/g$ is called velocity head
  C) H is called gravitational head D) 1/2 Pv2 is called dynamic pressure
  E) (P + pgh) is called static pressure
- From Bernoulli's thermo we can conclude that pressure is less at a point where the velocity of flow is more
- Following are applications of Bernoulli's theoremic
  1) Aerodynamic lift 2) motion of spinning hall (Magnus effect) 3) Aerofoil or aeroplane wing 4) Blow of roof of a house 5) Attraction of two suspended balls
- due to Bernoulli's effect only
  Two steamers moving in water in the same direction separated by a shorter distance come close
  A cyclist is drawn towards a truck moving part him in the same direction
- For a horizontal tube of variable cross section the pressure difference is

$P_2 - P_1 = 1/2\ \rho(V^2_2 - V^2_1)$

- Critical velocity $V_c = R\eta/pr$ where , A) R is the Raynolds number and it is given as R= $2VPr/\eta$ values lies between 'o' and 2000 for streamline flow & for bulent B) η = coefficient of viscosity , C) r= radius of the tube

QUESTION BANK
CONCEPTUAL QUESTIONS

1.viscosity is the property of liquids by virtue of which
1) Liquids molecules attract each other 2) Liquid become conducting
3) Liquids oppose relative motion of its parts 4) None

2.The force acting tangential to the layers of the liquid is called
1) Buoyant force 2) Viscous drag 3) Frictional force 4) Gravitational force

3.The property of viscosity in gas is due to
1) Cohesive forces between the molecules 2) Collision between the molecules
3) Not having a definite volume 4) Not having a definite size

4. Atomizer works on the
1) principle of continuity 2) Bernoulli's theorem 3) Stokes law 4) Archimedes principle

5. When the wind blows with high speeds, the roof of houses blown off because
1) Pressure under the roof increases 2) Pressure above the roof increases
3) Pressure above the roof decreases 4) Pressure under the roof decreases

6.When water flows from a narrow pipe into a broader pipe,
1) pressure decreases, rate of flow increases 2) pressure increases velocity increases
3) rate of flow does not change but velocity increases
4) pressure increases, velocity decreases, rate of flow remains same

7. For body falling with terminal velocity, the net force on it is
1) Buoyant force 2) Weight of the body
3) Difference of viscous drag and weight of the body 4)None

8. Bernoulli's theorem is a consequence of
1) Law of conservation of energy 2)Law of conservation of mass
3) Law of conservation of momentum 4) None

9. Rain drops strike the earth with
1) Same acceleration 2) Same constant velocity
3) Different constant 4) Different acceleration velocities

10. As the temperature increases; the viscosity of
1) Gases and liquids increases 2) Gases and liquids decreases
3) Gases increase and liquids decrease 4) Gases decrease and liquids increase

11. A body is floating in a liquid weight of the body
1) Equal to weight of the body
2) Equal to weight of the liquid displaced by the body
3) Less than the weight of body 4) None

12. If the weight of the body and up thrust on the body are equal, then the body
1) Sinks 2) Floats 3)Just completely immersed in the liquid
4) Completely lies out side the liquid

13. A physical balance is counterpart. The air is blown with a straw under one of the pan. Then that pan
1) Rises up 2) Remains in the same position 3) Lowers down 4) None
14. Liquid is flowing through a non-uniform tube. The rate of flow is more at
1) Narrow region 2) Wider region 3) Same through out 4)None
15. To reduce friction between the moving parts of a machine, the liquid used must have
1) High viscosity 2)Low viscosity 3) Low density 4) low boiling point
16. The clouds float in air due to
1) Viscosity of air 2) Clouds are heavier
3) At higher altitude density of air is more 4) None
17. For liquids, the graph between temperature and coefficient of viscosity is
1) Straight line 2) Parabola 3)Rectangular hyperbola 4)Ellipse
18. At normal pressure, for gases as pressure increases, the viscosity
1) Remains same 2) Increases 3)Decreases 4) None
19. The viscosity of water is
1) More in deep water 2) More in shallow water 3) Same throughout 4) None
20. The buoyant force is equal to
1) Weight of the body 2)Weight of liquid displaced by body
3)Difference of weight of body and liquid displace 4) None

KEY

Conceptual questions :
1)3 2)2 3)2 4)2 5)3 6)4 7)4 8)1 9)3 10)3
11)2 12)3 13)3 14)3 15)1 16)1 17)3 18)1 19)1 20)2

Numerical Questions:

Viscous Force:

1) A metal plate of area $10^{-2}m^2$ is placed on a liquid layer of thickness $2x10^{-3}$m. If the liquid has coefficient of viscosity 2 S.I units the force required to move the plate with a velocity of $3cms^{-1}$ is
1) 0.3N 2) 0.03N 3) 3.3N 4) 30N
2) A metal plate of area $400cm^2$ is placed on a glycerine layer of thickness 5mm. ($\eta_{glycerine} = 2 Pa\ s$) The horizontal force required to move the plate with a velocity of $5cms^{-1}$ is ---- newton
1) 1 2) 0.8 3) 0.5 4) 8
3) The velocity of water in a river is 18 kmph near the surface. If the river is 4m deep, the shearing stress between horizontal layers of water in Nm-2 is ($\eta_{water} = 1x10^{-3} Pa\ s$)
1) $2.5x10^{-3}$ 2) $1.25x10^{-3}$ 3) $0.75x10^{-3}$ 4) zero
4) If the shearing stress between the horizontal layers of water in a river is 1.5 milli newton/m^2 and $\eta_{water} = 1x10^{-3} Pa\ s$, The velocity gradient is ----s^{-1}
1) 1.5 2) 3 3) 0.7 4) 1
5) A force of 10N is required to draw rectangular glass plate on the surface of a liquid with some velocity. Force needed to draw another glass plate of 3 times length and 2 times width is
1) $\frac{5}{3}$N 2) 10N 3) 60N 4) 30N

6) Two flat plates are separated by a layer 4mm thick liquid. The upper plate is moved by force of 400dynes with a velocity of 10cm/s. If the area of the upper plate is $5cm^2$, the coefficient of viscosity of the liquid is

1) 3.2 poise 2) 1.6 poise 3) 32 poise 4) 16 poise

Poiseuille's Equation:

7) The vein of a person is horizontal and its length is 0.314m. It has an internal radius of 1mm. The average blood flow through the vein is $5cms^{-1}$. The rate of flow of blood in $10^7 m^3 s^{-1}$ is

1) 1.57 2) 0.157 3) 15.7 4) 0.0157

8) Water is flowing through a capillary tube at the rate of $20x10^{-6} m^2 s^{-1}$. If an identical tube is connected in series, the rate of flow of water in $m^3 s^{-1}$ is

1) $20x10^{-6}$ 2) $40x10^{-6}$ 3) 0 4) $10x10^{-6}$

9) Water is flowing through a capillary tube at the rate of $20x10^{-6} m^3/s$. Another tube of same radius and double the length is connected in series to the first tube. Now the rate of flow of water in $m^3 s^{-1}$ is

1) $10x10^{-6}$ 2) $3.33x10^{-6}$ 3) $6.67x10^{-6}$ 4) $20x10^{-6}$

10) The total area of cross section is $0.25m^2$. If blood is flowing at the rate of $100cm^3 s^{-1}$, then the average velocity of flow of blood through the capillaries, in mms^{-1} is

1) 0.4 2) 4 3) 25 4) 400

11) Water flows through a capillary tube at the rate of 10cc per minute. If the pressure difference across the same tube is doubled, the rate of flow of water through the tube will be (in cc per minute)

1) 20 2) 5 3) 40 4) 2.5

12) An artery in a certain person has been widened $1\frac{1}{2}$ times the original diameter. If the pressure difference across the artery is maintained constant, the blood flow through the artery will be increased

1) $\frac{3}{2}$ times 2) $\frac{9}{4}$ times 3) no change 4) $\frac{81}{16}$ times

13) The rate at which water flows through a capillary of length 0.5m with an internal diameter of 1mm, coefficient of viscosity $1.3x10^{-3} kgm^{-1} s^{-1}$ and pressure head 20cm of water in c.c per second is

1) $7.4x10^{-2}$ 2) $3.7x10^{-2}$ 3) $74x10^{-2}$ 4) 7.4

14) Water flowing from a house pipe fills at 15 litre container in one minute. The speed of water from the free opening of radius 1 cm is (in ms^{-1})

1) 2.5 2) $\frac{\pi}{2.5}$ 3) $\frac{2.5}{\pi}$ 4) 5π

15) Water flows with a velocity V in a tube of diameter d and the rate of flow is Q. Another tube of diameter 2d is coupled to the first one. The velocity of water flowing out and rate of flow in the second tube are respectively

1) $\frac{V}{4}$ and Q 2) $\frac{V}{2}$ and $\frac{Q}{2}$ 3) 2V and 2Q 4) $\frac{V}{2}$ and 2Q

16) Water flows through capillary tube of length 20cm and radius of 1mm under a constant pressure difference of 14cm of water level If $\eta_{water} = 1x10^{-3}$ $Pa\ s$; g = $10ms^{-2}$, the rate of flow of water through the tube in m^3s^{-1} is

1) $27.5x10^{-7}$ 2) $275x10^{-7}$ 3) 275 4) $2.75x10^{-7}$

17) Two liquids are allowed to flow through two capillary tubes of lengths in the ratio 1:2 and radii in the ratio 2:3 under the same pressure difference. If the volume rates of flow of the liquids are in the ratio 8:9, the ratio of their coefficients of viscosity is

1) 1:3 2) 3:1 3) 4:9 4) 9:4

18) The factor by which the pressure across a capillary tube is to be changed, so that the rate of flow of a liquid is doubled, when the length and the radius of the tube are doubled is

1) 4 2) 8 3) $\frac{1}{8}$ 4) $\frac{1}{4}$

19) The pressure exerted by water in a vessel at its bottom is $32x10^2Nm^{-2}$. A capillary tube of length 0.25m and radius 1mm is fixed near the bottom of the vessel to the side of the vessel. If volume of water flown out of the tube is 70 sec is $44x10^{-6}m^3$, the coefficient of viscosity of water is

1) $8x10^{-3}$Pa–s 2) $0.8x10^{-3}$Pa –s 3) $560x10^{-3}$Pa –s 4) $0.56x10^{-3}$Pa –s

20) Three horizontal capillary tubes of same radii and lengths L_1, L_2 and L_3 are fitted side by side a little above the bottom, to the wall of a tank that is filled with water. The length of a single capillary tube of same radius that can replace the three tubes such that the rate of flow of water through the single tube equals the combined rate of flow through the these tubes is

1) $\frac{L_1L_2L_3}{L_1+L_2+L_3}$ 2) $\frac{L_1L_2L_3}{L_1L_2+L_2L_3+L_3L_1}$

3) $\frac{L_1+L_2+L_3}{L_1L_2L_3}$ 4) $\frac{L_1L_2+L_2L_3+L_3L_1}{L_1L_2L_3}$

Poiseuille's Equation:

21) When a capillary tube is connected to a pressure head, V c.c. of water flows per second. If a tube of same length but half the radius is connected to the same pressure head, the quantity of water flowing through the tube per second will be (in c.c)

1) $\frac{V}{4}$ 2) V 3) $\frac{V}{16}$ 4) $\frac{V}{8}$

22) When a capillary tube is connected to a pressure head V.c.c of water flows per second. If a tube of same length but half the radius is connected to the same pressure head, the quantity of water flowing through the tube per second will be (in c.c)

1) $\frac{V}{16}$ 2) $\frac{V}{17}$ 3) $\frac{17V}{16}$ 4) V

23) When a capillary tube is connected to a pressure head V.c.c of water flow per second. If another tube of same length but half the radius is connected parallel to the first one, the quantity of water flowing through them per second will be (in c.c)

1) $\frac{V}{17}$ 2) $\frac{V}{16}$ 3) $\frac{16\,V}{17}$ 4) $\frac{17\,V}{16}$

Bernoulli's Theorem & Equation of Continuity:

24) Two water pipes of diameters 4cm and 8cm are connected with main supply line. The velocity of flow of water in the pipe of 8cm diameter is ----- times that of 4cm diameter pipe

1) 4 2) $\frac{1}{4}$ 3) 2 4) $\frac{1}{2}$

25) A liquid is flowing in a cylindrical pipe of internal diameter 4cm with a velocity of $5ms^{-1}$. If this tube is joined with another tube of internal diameter 2cm then the velocity of flow of liquid in the smaller tube will be (in ms^{-1})

1) 10 2) 40 3) 5 4) 20

26) A horizontal pipe of non uniform cross section has water flow through it such that the velocity is $2ms^{-1}$ at a point where the pressure is 40 kpa. The pressure at a point where the velocity of water flow is $3ms^{-1}$ (in Kilopascal)

1) 27 2) 60 3) 37.5 4) 40

27) The velocity of the wind over the surface of the wing of an aeroplanes is $80ms^{-1}$ and under the wing $60ms^{-1}$. If the area of the wing is $40m^2$, the dynamic lift experienced by the wing is [density of air = 1.3 kgm^{-3}]

1) 3640N 2) 7280N 3) 14560N 4) 72800N

28) In a horizontal pipe line of uniform cross-section, pressure falls by 5Pa between two points separated by 1km. The change in the kinetic energy per kg of the oil flowing at these points is (Density of oil = $800kgm^{-3}$)

1) $6.25x10^{-3} Jkg^{-1}$ 2) $5.25x10^{-4} Jkg^{-1}$
3) $3.25x10^{-5} Jkg^{-1}$ 4) $4.25x10^{-2} Jkg^{-1}$

29) Water flows through a non-uniform tube of area of cross sections A, B and C whose values are 25, 15 and 35 cm^2 respectively. The ratio of the velocities of water at all the sections A, B and C is

1) 5:3:7 2) 7:3:5 3) 21:35:15 4) 1:1:1

Bernoulli's Theorem:

30) A room has a window of area 'A'. Out side of the room wind is blowing parallel to the window with a velocity 'v'. If the density of air is 'ρ', then the force acting on the window is

1) $\frac{1}{2}\frac{\rho v^2}{A}$ 2) $\frac{1}{2}\rho v^2 A$ 3) $\rho v^2 A$ 4) $2\rho v^2 A$

31) Water flowing steadily through a horizontal pipe of non-uniform cross section.If pressure of water is $4x10^4Nm^{-2}$ at a point where cross section is $0.02m^2$ and velocity of flow is $2ms^{-1}$, the pressure at a point of cross sectional area $0.01m^2$ in Nm^{-2} is

1) $4.6x10^4$ 2) $3.4x10^4$ 3) $4x10^4$ 4) $2x10^4$

32) At a point P in a water pipe line the velocity is $1ms^{-1}$ and the pressure is $3x10^5 Pa$. At another point Q the area of cross section is half that of at P and the pressure is $5x10^5 Pa$. The difference of heights between P and Q in metre is (g = $10ms^{-2}$)

1) 10.5 2) 20.15 3) 4.5 4) zero

33) An aeroplane of mass 5000kg is flying at an altitude of 3km. If the area of the wings is $50m^2$ and pressure at the lower surface of wings is $0.6x10^5 Pa$, the pressure on the upper surface of wings is (in pascal) ($g = 10ms^{-2}$)

1) $59x10^3$ 2) $2x10^4$ 3) $6x10^4$ 4) 59

34) In a horizontal oil pipe line of constant cross sectional area the decrease of pressure between two points 100 km apart is 1500 Pa. The loss of energy per unit volume per unit distance is ----- Joule

1) 15 2) 0.015 3) 0.03 4) zero

35) The reading of a manometer fitted to a closed tap is $3.5x10^5Nm^{-2}$. If the value is opened the reading of the manometer falls to $3x10^5Nm^2$. The velocity of water is

1) $0.1ms^{-1}$ 2) $1ms^{-1}$ 3) $10ms^{-1}$ 4) $100ms^{-1}$

36) The pressure at the top of a building of height 200m is 500k Pa. The minimum pressure required at the base of the building to pump water to a closed tank on the top of the building ($g = 10m/s^2$)

1) $2.5x10^4 Pa$ 2) $2.5x10^5 Pa$ 3) $2.5x10^6 Pa$ 4) $2.5x10^3 Pa$

Buoyancy & Pressure:

37) A balloon contains $1000m^3$ of Hydrogen. If the mass of the balloon without gas is 100kg the net lifting ability of the balloon is (in Kgwt)
(given density of Hydrogen is $0.09kgm^{-3}$ and that of air is $1.3kgm^{-3}$)

1) 2220 2) 1300 3) 190 4) 1110

38) Two blocks A and B float in water. If block A floats with $\frac{1}{4}$th of its volume immersed and block B floats with $\frac{3}{5}$th of its volume immersed, the ratio of their densities is

1) 5:12 2) 12:5 3) 3:20 4) 20:3

39) A cube of side 20cm is floating on a liquid with 5cm of the cube outside the liquid. If the density of liquid is 0.8gm/c.c then the mass of the cube is

1) 4.2kg 2) 4.8kg 3) 5kg 4) 5.2kg

40) If a body floats with $(m/n)^{th}$ of its volume above the surface of water, then the relative density of the material of the body is

1) $\frac{(n-m)}{n}$ 2) $\frac{m}{n}$ 3) $\frac{n}{m}$ 4) $\frac{(n-m)}{n}$

41) An air tight container having a lid with negligible mass and an area of $8cm^2$ is partially evacuated. If a 48N force is required to pull the lid off the container and the atmospheric pressure is $1.0x10^5$ Ps, the pressure in the container before it is opened must be

1) 0.6atm 2) 0.5 atm 3) 0.4 atm 4) 0.2 atm

42) When a body lighter than water is completely submerged in water, the buoyant force acting on it is found to be ‘n’ times its weight. The specific gravity of the material of the body is

1) $\frac{1}{1+n}$ 2) $\frac{1}{n}$ 3) n 4) $n+\frac{1}{n}$

Buoyancy:

43) A sphere of density d is let fall in a liquid of density $\frac{d}{4}$. The acceleration of the body will be

1) $\frac{g}{4}$ 2) $\frac{3g}{4}$ 3) $\frac{g}{2}$ 4) g

44) A boat having length 2m and width 1m is floating in a lake. When a man stands on the boat, it is depressed by 3cm. The mass of the man is

1) 50kg 2) 55kg 3) 60kg 4) 70kg

Key

1)1	2)2	3)2	4)1	5)3	6)1	7)1
8)4	9)3	10)1	11)1	12)4	13)1	14)3
15)1	16)1	17)3	18)4	19)1	20)2	21)3
22)2	23)4	24)1	25)4	26)3	27)2	28)1
29)3	30)2	31)2	32)2	33)1	34)2	35)3
36)3	37)4	38)1	39)2	40)1	41)3	42)2
43)2	44)3					

previous eamcet problems

1. When temperature is increased (2004 M)

a) viscosity of a gas increases **b**) viscosity of a gas decreases
c) viscosity of a liquid decreases **d**) viscosity of a liquid increases
1) a and b are true 2) b and c are true
3) b and d are true 4) a and d are true

3. Water in a river 20m deep is flowing at a speed of 10m/s. The shearing stress between the horizontal layers of water in the river in Nm^{-2} is (Coefficient of viscosity of water is 10^{-3}SI unit) (2004 E)

1) $1x10^{-2}$ 2) $0.5x10^{-2}$ 3) $1x 10^{-3}$ 4) $0.5x10^{-3}$

4. There are two holes one each along the opposite sides of a water tank. The cross section of each hole is 0.01 m^2 and the vertical distance between the holes is one meter. The net force on the tank is in Newton when the water flows out of the holes is (ρ of water is 1000 Kg/m^3) (2004E)

1)100 2) 200 3) 300 4) 400

5. A square plate of 0.1m side moves parallel to a second plate with a velocity 0.1m/s both plates being immersed in water. If the viscous force is 0.002 N and the coefficient of viscosity of 0.01 poise. Distance between the plates in meters is (2003 M)

1)0.1 2) 0.05 3) 0.0005 4) 0.005

6. In a planet a sucrose solution of coefficient of viscosity $0.0015Nm^2S$ is driven at a velocity of 10^{-3}m/s through xylem vessels of radius 2 m and 5 m . the hydrostatic pressure difference across the length of xylem vessels in $Nm^{-2}$is (2002M)

1) 5 2) 8 3) 10 4) 15

7. Tanks A and B open at the top contains two different liquids upto certain height in them. A hole is made to the wall of each tank at a depth h from the surface of

the liquid. The area of the hole in A is twice that of in B. if the liquid mass flux through each hole is equal, then the ratio of the densities of the liquids is (2002E)

1) 2/1 2) 3/2 3) 2/3 4) 1/2

KEY: 1)1 3)4 4)2 5)4 6)4 7)4

1) The pressure on the top surface of an aeroplane wing is $0.8x10^5$Pa and the pressure on the bottom surface is $0.75x10^5$Pa. If the area of each surface is $50m^2$, the dynamic lift on the wing is (2007M)

1) $25x10^4$N 2) $0.5x10^4$N 3) $5x10^4$N 4) $0.25x10^5$N

2) A horizontal pipe of non –uniform cross section allows water to flow through it with a velocity $1ms^{-1}$ when pressure is 50kpa at a point. If the velocity of flow has to be $2ms^{-1}$ at some other point, the pressure at that point should be (2007E)

1) 50kpa 2) 100kpa 3) 48.5kpa 4) 24.25kpa

3) The speeds of air-flow on the upper and lower surfaces of a wing of an aeroplane are V_1 and V_2 respectively. If A is the cross –sectional area of the wing and 'ρ' is the density of air, then the upward lift is (2006M)

1) $\frac{1}{2\rho A(V_1 - V_2)}$ 2) $\frac{1}{2}\rho A(V_1+V_2)$

3) $\frac{1}{2}\rho A(V_1^2 - V_2^2)$ 4) $\frac{1}{2}\rho A(V_1^2 + V_2^2)$

4) An air bubble of radius 1cm rises from the bottom portion through a liquid of density 1.5g/cc at a constant speed of $0.25cms^{-1}$. If the density of air is neglected the coefficient of viscosity of the liquid is approximately, (in Pas) (2006E)

1) 13,000 2) 1,300 3) 130 4) 13

5) Two rain drops reach the earth with their terminal velocities in the ratio 4:9. The ratio of their radii is (2005M)

1) 4:9 2) 2:3 3) 3:2 4) 9:4

6) An iron sphere of mass $20x10^{-3}$kg falls through a viscous liquid with terminal velocity $0.5ms^{-1}$. The terminal velocity (in ms^{-1}) of another iron sphere of mass $54x10^{-2}$kg is (2005E)

1) 4.5 2) 3.5 3) 2.5 4) 1.5

Key: 1)1 2) 3 3) 3 4) 3 5) 2 6) 1

Mechanical Properties of fluids

Pressure: $P = F / A \ N/m^2$ parcel

Pressure exacted by higuid column: $P = \ell hg$

Pascal's law: Statement: A change in Pressure applied to an enclosed fluid is transmitted equally to every point of the fluid and the walls of the containing vessel.

Pascal's Law: Effect of Gravity

$$\boxed{P_2 - P_1 = \ell hg}$$

Application:

a) Hydraulic lift b) Hydraulic Breaks

Atmospheric Pressure: Pressure exacted by the atmospheres is called atmospheric **pressure. Atmospheric** pressure at see land in 76cm or 760mm of Hg

Absolute Pressure: The actual pressure at a point is called absolute pressure

Gauge Pressure: it is the difference between the actual pressure at a point and the atmosphere pressure.

Sphygmomanometer measures the Gauge pressure of the blood

Bernoulli's Principle

$$P + \frac{1}{2}\rho v^2 + \rho hg = \text{Constant}$$

Application:

(1) **Venturimeter** : Used for measuring the rate of flow of liquid through pipes

Rate of flow: $V = a_1 a_2 \sqrt{\frac{2hg}{a_1^2 - a_2^2}}$

A, $a_1 a_2$ areas of cross section, h=height

(2) **Torricelli's Theorem (Speed of efflux)**

Speed of efflux is save as that acquired by a body falling through a height h

$V = \sqrt{2gh}$

(3) **Dynamic lift (Lift of an Air craft)**

According to Bernoulli's principle, the pressure on the upper surface is less than that below the wing; the difference in pressure provides an upward lift to the aircraft

(4) **Spinning of a Ball (Magnus effect)**

(5) **Bernoulli's Principle helps in explaining blood flow in artery**

Problems

(1) The Velocity with which the water emerges from an orifice in a tank in which gauge pressure is $3 \times 10^5 N/M^2$ before the flow starts is ( )

(Density of water = 1000kg/ m^3)

a) 34.495m/sec b) 44.495m/sec c) 24.495m/sec d) 54.495m/sec

(2) The diameter of a pipe at two points, where a venturimeter is connected is 8cm and 5cm and the difference of levels in it is 4cm. the Volume of water flowing through the pipe sec second is ( )

a) $1599 cm^3/sec$ b) $1889 cm^3/sec$ c) $1499 cm^3/sec$ d) $1299 cm^3/sec$

(3) A Barrel is filled with water up to 60cm height. A hole is punched 50cm above the bottom of the barrel. The efflux velocity of water will be ( )

a) 14cm/Sec b) 7cm/Sec c) 7m/sec d) 1.4m/sec

(4) Reynolds's number is low for ( )

a) Low velocity b) low density c) high viscosity d) all the above

(5) Hydraulic brakes work on the principle of ( )

a) Pascal's law b) Thomson's law
c) Newton's law d) Bernoulli's Theorem

KEY:

1) c 2) b 3) a 4) a 5) a

SURFACE TENSION:

The attraction between the molecules of a substance is called **cohesion**

- Cohesive force is maximum in the case of solids, lesser in the case of liquids and the least in the case of gases
- The attraction between the molecules of different substances is called **adhesion**
- The elongation, at constant temperature, in a liquid surface does not obey Hooke's law
- **Surface tension** is due to cohesion (intermolecular attraction) between the molecules of a liquid
- The maximum distance upto which the cohesive force between two molecules exists is called the **molecular range** and it is of the order of 10^{-9}m or 1nm
- An imaginary sphere drawn around a molecule with a radius of molecular range is called the **sphere of influence** of that molecule
- Surface tension is the force per unit length of a line drawn on the liquid surface and acting perpendicular to it. Unit is Nm^{-1} or dynes cm^{-1}.
- A sphere has minimum surface area for a given volume
- Rain drops or small droplets of mercury are spherical in shape due to surface tension while big drops flatten out due to weight
- The work done is extending the free surface of a liquid through unit area is called **surface energy**
- At a constant temperature, the surface energy = coefficient of surface tension (T)
- Work done = surface tension x increase in surface area
- The work done (W) is blowing a soap bubble of radius r is $W = 8\pi r^2 T$.
- Work done is increasing the radius of a bubble from r_1 to r_2 is given by
  $W = 8\pi(r_2^2 - r_1^2)T$
- The work done by an agent to split a liquid drop of radius R into 'n' identical drops is $W = 4\pi R^2(n^{1/3}-1)$ where T is surface tension
- The amount of energy evolved when 'n' droplets of a liquid of radius 'r' combine to forma large drop is $E = 4\pi r^2 T(n-n^{2/3})$
- **Factors which influence surface tension of a liquid**:
  1) It decreases with increase of temperature
  2) It increases when an inorganic substance is dissolved
     ex: NaCl solution:84 dynes/cm
- The angle of contact depends on solid-liquid pair, temperature and impurities
- The angle of contact is not altered by the amount of inclination of solid object in the liquid
- Angle of contact increases with increase in temperature
- For pure water and glass, the angle of contact is zero
- Angle of contact decreases on adding soluble impurity, detergent and welting agent to a liquid
- For mercury and glass, angle of contact is about 140^0

- If a liquid wets the solid, then the angle of contact is less than 90^0 and if the liquid doesn't wet the solid, then the angle of contact is greater than 90^0
- **Capillarity**: The action by which the surface of a liquid where it comes in contact with a solid, is elevated or depressed, because of the relative attraction of the molecules of the liquid for each other and for those of the solid, is known as capillarity
- The addition of a detergent decreases the surface tension and angle of contact
- Wetting agents are used in detergents in order to clean clothes
- The addition of a water proofing agent like waxy substance to a liquid increases angle of contact
- If the angle of contact (θ) is acute ($\theta<90^0$), there will be capillarity rise
  Ex: Water in glass capillarity
- If the angle of contact (θ) is obtuse ($\theta>90^0$), there will be capillarity depression
  Ex: Mercury in capillarity
- If the angle of contact is 90^0, there will be neither rise nor fall
  Ex: Water in silver capillarity
- Rise of liquid in tubes of insufficient length: If a liquid can rise upto a height 'h' in the tube but its total length outside the water surface is less than 'h', the liquid will not overflow out of the tube instead of it, the liquid will rise to the top of the tube
- Excess pressure in a drop of liquid is given by P = 2T/r
- Excess pressure in a soap bubble is given by P = 4T/r
- Excess pressure inside a soap bubble present in a liquid P = 2T/r. Where r is radius and T is surface tension
- When a charge either positive or negative is given to a soap bubble, it expands due to repulsions among the charges
- Surface tension by capillary rise method T = $\frac{rdg(h+r/3)}{2\cos\theta} = \frac{r\,h\,dg}{2\cos\theta}$ If h>>r

  In the case of pure water, T = $\frac{r\,h\,dg}{2}$
- **Critical temperature**: The temperature at which surface tension of the liquid becomes zero is known as critical temperature
- $r = r_0(1-\alpha T)$ where r is surface tension at t^0C, r_0 the surface tension at 0^0C and α the coefficient of surface tension
- When two soap bubbles of radii a and b in vacuum coalesce under isothermal condition, the resultant bubble has a radius R such that R = $\sqrt{a^2+b^2}$
- If two soap bubbles of radii a and b coalesce (a>b), then the radius of curvature of the interface between the two bubbles will be $\left(\frac{ab}{a-b}\right)$

- A spherical soap bubble of radius r_1 is formed inside another of radius r_2. The radius of the single soap bubble which maintains the same pressure difference as inside the smaller and outside the larger soap bubble is $\left(\frac{r_1 r_2}{r_1 + r_2}\right)$

QUESTION BANK

Surface Tension

Conceptual Question:

1) The range of attraction between molecules is of the order of
   1) 10^{-6}m   2) 10^{-9}m   3) 10^{-12}m   4) 10^{-15}m
2) Surface tension of a liquid
   1) surface phenomenon 2) exists throughout the liquid 3) both 4) none
3) When the surface of a liquid is increased
   1) surface tension increases 2) surface energy increases
   3) surface tension does not change 4) 2 and 3
4) The main difference between liquid surface and an elastic membrane is
   1) Hook's law is not obeyed by liquid surface   3) Both
   2) Surface tension increases with increase of surface area 4) None
5) In the absence of an external force, the shape of liquid drop is determined by
   1) surface tension of the liquid 2) density of liquid
   3) viscosity of liquid 4) temperature of air only
6) An iron needle slowly placed on the surface of water floats on it because
   1) when inside in water it will displace water more than its weight
   2) the density of the material of needle is less than that of water
   3) of surface tension 4) of his shape
7) Soap helps in cleaning the clothes because
   1) it reduces the surface tension of solution 2) it gives strength to solution
   3)it absorbs the dirt 4) None of the above
8) Which of the following has the same dimensional formula as that of surface tension
   1) force constant   2) planks constant
   3) gravitational constant   4) none of the above
9) A drop of kerosene oil placed on water
   1) remains as a drop   2) shrinks
   3) spreads on the surface of water   4) none
10) Two needles are floating on the surface of water. A hot needle when touches water surface between the needles, then they move
    1) closer 2) away 3) surface tension 4) all of the above
11) If the cohensive and adhesive forces between solid and liquid are equal, shape of the meniscus of the liquid in that capillary tube is
    1) horizontal   2) concave   3) convex   4) none
12) More liquid rises into a thin capillary tube because
    1) surface tension decreases   2) surface tension increases
    3) rise of liquid is inversely proportional to radius of bore
    4) surface tension is proportional to radius of bore
13) When a soap water bubble is given a positive charge it expands. If it is given a negative charge, then it

1) expands 2) contracts 3) remains same 4) does not hold negative charge

14) In a gravity free surface, shape of a large drop of liquid is
1) spherical 2) cylindrical
3) neither spherical nor cylindrical 4) nearly spherical

15) The sap in the trees rises up to the branches . this phenomenon is due to
1) Viscosity 2) Surface tension 3) elasticity 4) all the above

16) A liquid does not wet the surface of a solid if the angle of contact is
1) 0 2) $< 90^0$ 3) 45^0 4) $>90^0$

17) Meniscus of mercury in a capillary glass tube is
1) plane 2) convex up 3) concave 4) cylindrical

18) If the diameter of a capillary tube is doubled, the rise of water in the tube will be
1) doubled 2) half 3) remain the same 4) four times

19) When two capillary tubes of different diameters are dipped vertically, the rise of the liquid is
1) same in both the tubes 2) more in the tube of large diameter
3) less in the smaller diameter 4) more in the tube of smaller diameter

20) When rises to height of 15.0cm in a capillary tube of height 20cm above the water Level. If the tube is cut at a height of 10cm
1) water will come as a fountain from the tube
2) water will stay at a height of 10cm in the tube
3) water will flow down along the walls of the tube 4) none

Keys

1)2	2)1	3)4	4)1	5)1
6)3	7)1	8)1	9)3	10)2
11)1	12)3	13)1	14)1	15)2
16)4	17)2	18)2	19)4	20)2

Numerical Problems

Pull Due To Surface Tension

21) A needle of 12cm long is on the surface of water. The extra force required, over its weight, to take it out from the surface of water is (surface tension = 72 dyne cm^{-1})
1) 72N 2) 0.864N 3) 0.0173N 4) 7.2N

22) A needle of length 5cm is floating on water of surface tension $0.07Jm^{-2}$ and is not wetted by water. Then the weight of the needle will be
1) $7x10^{-3}$kgwt 2) $0.7x10^{-3}$kgwt 3) $5.2x10^{-2}$N 4) $4x10^{-2}$N

23) A wire of ring of diameter 14cm is gently lowered on a liquid surface and then pulled up. The force applied is 0.0616N. The surface tension of the liquid is
1) $7x10^{-2}Nm^{-1}$ 2) $7x10^{-3}Nm^{-1}$ 3) 70 Nm^{-1} 4) $1.7Nm^{-1}$

24) A thin walled glass tube of radius 0.5cm is dipped vertically in the water of surface tension 70 dyne cm^{-1}. The force required to take it out from the water is
1) $44x10^{-5}$N 2) $44x10^{-4}$N 3) $4.4x10^{-4}$N 4) $0.44x10^{-5}$N

25) A thin film of water of thickness 1mm and area of $20cm^2$ is formed between two plane glass plates.The normal force required to pull them apart is (surface tension of water 70 dyne cm^{-1})
1) 0.14N 2) 0.28N 3) 0.32N 4) 0.42N

26) A uniform wire of 20cm long is bent into a circle. It is placed gently on the surface of water of surface tension. $0.07Nm^{-1}$. The extra force than its weight required to pull it out of the water is

1) 0.014N 2) 0.028N 3) 0 4) 0.0035N

27) The additional force required to lift a flat circular disc of radius 5cm from the surface of water with surface tension 75 dyne cm^{-1} will be

1) 750 dyne 2) 750π dyne 3) 30 dyne 4) 60 dyne

Capillary Rise

28) The force required to take out a circular plate of circumference 100cm from the surface of water is (surface tension of water 0.07 Nm^{-1})

1) 0.07N 2) 0.14N 3) 0.035N 4) 0.28N

29) Two capillary tubes of same material dipped are placed vertically in the same liquid. If their radii are in the ratio 2:3, the ratio of rise of liquid in the tubes is

1) 2:3 2) 3:2 3) 4:9 4) 9:4

30) Two capillary tubes of glass of radii 3mm and 2mm, are placed vertically in water, ratio of height of water in the tube is

1) 3:2 2) 4:9 3) 9:4 4) 2:3

31) Two capillaries of same materials are dipped into a liquid. If the heights of liquid risen in them are 2.2cm and 6.6cm then the ratio of their radii is

1) 3:1 2) 1:3 3) 9:1 4) 1:1

32) Two similar capillary tubes of sufficiently long are placed in water. One is placed vertically and the other is placed at 60^0 with the vertical . The length of the liquid rised into tubes is in the ratio

1) 1:3 2) $\sqrt{3}$: $\sqrt{2}$ 3) 3:2 4) 1:2

33) When a capillary tube is dipped in water vertically water rises to a height of 10 mm. The tube is now tilted and makes an angle 60^0 with vertical. Now length of water column in tube is

1) 10mm 2) 5mm 3) 20mm 4) 40mm

34) Water rises upto a height of 12cm into a capillary tube when placed vertically. If it is now tilted through 45^0 from the vertical, length of the water in the capillary tube is

1) 12cm 2) $6\sqrt{2}$cm 3) $12\sqrt{2}$cm 4) 6cm

35) Water rises in a capillary upto a height of 2cm. If the radius of some different capillary is one fourth that of the first tube then to what height water will rise in it?

1) 6cm 2) 8cm 3) 2cm 4) 1cm

36) If a capillary tube is titled to 45^0 and 60^0 from the vertical then the ratio of length l_1, l_2 of liquid columns in it will be

1) 1: $\sqrt{2}$ 2) $\sqrt{2}$:1 3) 2:1 4) 1:2

37) The force required to separate two glass plates of area $10^{-2}m^2$ with a film of water between them is $70x10^{-3}N\ m^{-1}$, the thickness of water film is

1) 0.5cm 2) 0.05mm 3) 0.5mm 4) 0.025mm

38) Water rises to a height of 10cm in a capillary tube and mercury falls to a depth of 3.42cm in the same capillary tube. If the density of mercury is 13.6gm/cc and the angle of contact is 135^0, ratio of surface tension for water and mercury is

1) 1:0.5 2) 1:3 3) 1:6.5 4) 1.5:1

39) A tube of 0.8mm radius is dipped into a liquid and $900Kg/m^3$ respectively . If the tube is kept vertical, the height of liquid rises in it will be (g = $10ms^{-2}$)

1) 0.017m 2) 0.17m 3) 1.7m 4) 17m

40) Water rises in a capillary tube of diameter $0.2x10^{-2}$m, upto a height of 1.5cm. The surface tension of water is

1) $73.5x10^{-3}$ Nm^{-1} 2) $73.5x10^{-3}$ dyne cm^{-1} 3) $35.7x10^{-3}$ Nm^{-1} 4) $43.5x10^{-3}$ Nm^{-1}

41) A vessel has a small hole of radius 0.4mm at its bottom. The height to which water can be poured inside the vessel without leakage is (g = $10m/s^2$, surface tension of water $72dycm^{-1}$)

1) 0 2) 0.36cm 3) 0.36m 4) 3.6m

42) A vessel has a small hole at its bottom. If water can be poured into it upto a height of 7cm without leakage g = $10ms^{-2}$, the radius of the hole is (surface tension of water $0.07Nm^{-1}$)

1) 2mm 2) 0.2mm 3) 0.1mm 4) 0.4mm

43) To take out a pin from the surface of water an extra force of 1296 dynes is to be applied . If the surface tension of water is 0.072 Nm^{-1}, length of the pin is

1) 6cm 2) 9cm 3) 4.5cm 4) 18cm

44) A small hole is made at the bottom of a hollow sphere. The water enters into it when it is taken to a depth of 40cm under water. If the surface tension of water is 0.07 Nm^{-1}, diameter of the hole is

1) 10/7mm 2) 10/14mm 3) 2/15mm 4) 1/14mm

Excess Pressure

45) The surface tension of soap water is $0.04Nm^{-1}$. The excess of pressure inside a soap of water bubble of radius 5cm is

1) 0.2Pa 2) 1.6Pa 3) 3.2Pa 4) 0.16Pa

46) Two bubbles of radii 2mm and 3mm when tough each other, the radius of curvature of their interface is

1) 1.7mm 2) 0.017cm 3) 6mm 4) 0.17cm

47) The excess of pressure inside the first soap bubble is three times that inside the second bubble. Then ratio of volume of the first to second bubble is

1) 1:3 2) 1:9 3) 1:27 4) 3:1

48) Two bubbles of radii 2cm and 4cm touch each other. The radius of their interface is

1) 3cm 2) 1.5cm 3) 4cm 4) 2.5cm

49) A drop of mercury is broken into 8 droplets. Then its surface tension

1) increases by 8 times 2) decreases by 8 times 3) halved 4) does not change

50) A soap bubble of radius 3cm and another bubble of 4cm coalesce under isothermal conditions in vacuum. The radius of the new bubble is

1) 3cm 2) 4cm 3) 5cm 4) 7cm

51) Two liquids drops of same oil have diameters of 1cm and 1.5cm . Ratio of excess of pressures inside them is

1) 3:2 2) 2:3 3) 1:15 4) 15:1

52) An air bubble inside the water at the surface has an extra pressure of 7 Nm^{-2}. If the radius of the bubble is 2cm, the surface tension of water is

1) $0.07Nm^{-1}$ 2) $0.7Nm^{-1}$ 3) 7 Nm^{-1} 4) $70Nm^{-1}$

53) Two soap bubbles have radii in the ratio of 2:1. The ratio of excess of pressure in side them is

1) 2:1 2) 4:1 3) 8:1 4) 1:2

54) The volumes of two air bubbles inside the water are in the ratio of 27:8 the ratio of excess of pressures inside them is:

1) 8:27 2) 27:8 3) $\sqrt{27}$: $\sqrt{8}$ 4) 2:3

55) What will be the value of excess of pressure inside a soap bubble of radius $2x10^{-3}$m, If the surface tension of soap solution is 0.03 Nm^{-1}?

1) $20Nm^{-2}$ 2) $60Nm^{-2}$ 3) $30Nm^{-2}$ 4)0

56) The ratio of excess pressures in two soap bubbles is 3:1, The ratio of their volumes will be

1) 9:1 2) 1:9 3) 27:1 4) 1:27

57) The ratio of radii of two bubbles is 1:4, then the ratio excess of pressures in them will be

1) 4:1 2) 1:4 3) 1:16 4) 16:1

58) Two soap bubbles of radii 4cm and 5cm coalesce to form a common surface. The radius of curvature of this common surface will be

1) 20cm 2) 1cm 3) 1.25cm 4) $\sqrt{41}$cm

59) The surface tension of a liquid is $0.5Nm^{-1}$. If a liquid film is formed on a ring of area $0.02m^2$ then its surface energy will be

1) 0.01J 2) 0.02J 3) 0.03J 4) 0.04J

60) The pressure in air bubble just below the water surface is (surface tension of liquid is 72 dyne cm^{-1} and atmospheric pressure = $1.0x10^5Nm^{-2}$, Radius of bubble = 0.1mm)

1) $1.0144x10^5Nm^{-2}$ 2) $2.0274x10^5Nm^{-2}$

3) 0 4) $3.0274x10^5Nm^{-2}$

Work Done And Surface Energy

61) The work done to blow a bubble is W. The extra work to be done to double its radius is

1) W 2) 2W 3) 3W 4) 4W

62) A drop of radius 1mm is sprayed into 1000 droplets of same size. If surface tension of the liquid is 40 dyne (cm^{-1}) , the amount of work done in the process is

1) 4.53erg 2) 4.53J 3) $4.53x10^{-6}$J 4) $9.06x10^{-6}$J

63) The area of the surface of water in a vessel is 40 cm^2. It is transferred into a cylindrical vessel of area of cross section $220cm^2$. If the surface tension of water is $0.07Nm^{-1}$, the work done in the transfer of water is

1) 12.6erg 2) 1.26erg 3) $12.6x10^4$J 4) $1.26x10^{-4}$J

64) The work done in blowing a soap bubble of radius a under isothermal conditions is (the surface tension of soap film is T)

1) $4\pi a^2T$ 2) $8\pi a^2T$ 3) $16\pi a^2T$ 4) $2\pi a^2T$

65) The work done in forming a soap film of size 10cmx10cm will be , if the surface tension of soap solution is $3x10^{-2}$N/m

1) $3x10^{-4}$J 2) $3x10^{-2}$J 3) $6x10^{-4}$J 4) $6x10^{-2}$J

66) The work done in blowing a spherical soap bubble of diameter 2cm will be (the surface tension of soap solution is $2x10^{-2}Nm^{-1}$)

1) $50.2x10^{-6}$J 2) 50.2J 3) $50.2x10^{-6}$erg 4) 0

67) A liquid drop of diameter 'D' is split into 27 droplets. If T is surface tension of the liquid the change in energy is

1) $2\pi D$ 2) $2\pi D^2$ 3) $2\pi D^2T$ 4) 0

68) A film of water is formed between two straight parallel wires 10cm long and at separation 5mm. To increase the distance between them to 6mm, the work done is $144x10^{-7}$J. The surface tension of water is

1) $7x10^{-3}Nm^{-1}$ 2) $7.2x10^{-3}Nm^{-1}$ 3) $0.72Nm^{-1}$ 4) $0.072Nm^{-1}$

69) The work done in splitting a drop of water of 1mm radius into 10^6 droplets is (S.T of water $72x10^{-3}$ J/m^2)

1) $9.98x10^{-5}$J 2) $8.95x10^{-5}$J 3) $5.89x10^{-5}$J 4) $5.98x10^{-5}$J

70) Water is filled into a container with hexagonal cross section of side 6cm. If the surface tension of water is $0.075Nm^{-1}$ then the surface energy of water will be

1) $8.5x10^{-4}$J 2) $2.8x10^{-4}$J 3) $6.4x10^{-4}$J 4) $7x10^{-4}$J

Key

21) 3	22) 2	23) 1	24) 2	25) 2	26) 2	27) 2	28) 1	29) 2	30) 4
31) 1	32) 4	33) 3	34) 3	35) 2	36) 1	37) 2	38) 3	39) 1	40) 1
41) 4	42) 2	43) 2	44) 2	45) 3	46) 3	47) 3	48) 3	49) 4	50) 3
51) 1	52) 1	53) 4	54) 4	55) 2	56) 4	57) 1	58) 1	59) 1	60) 1
61) 3	62) 3	63) 3	64) 2	65) 3	66) 1	67) 3	68) 4	69) 2	70) 3

SURFACE TENSION Previous Eamcet questions

1. Two spherical soap bubbles of radii r_1 and r_2 in vacuum combine under isothermal conditions. The resulting bubble has a radius equal to

   1) $\frac{r_1+r_2}{2}$ 2) $\frac{r_1r_2}{r_1+r_2}$ 3) $\sqrt{r_1r_2}$ 4) $\sqrt{r_1^2+r_2^2}$ [2003E]

2. The rate of steady volume flow of water through a capillary tube of length 'l' and radius 'r' under a pressure difference of P is V. This tube is connected with another tube of same length but half the radius in series. Then the rate of steady volume flow through them is (pressure across the combination is P) [2003E]

   1) $\frac{V}{16}$ 2) $\frac{V}{17}$ 3) $\frac{16V}{17}$ 4) $\frac{17V}{16}$

3. Water rises to a height of 10cm in a capillary tube and mercury falls to a depth of 3.5cm in the same capillary tube. If the density of mercury is 13.6gm/c.c and its angle of contact is 135^0 and density of water is 1gm/c.c and its angle of contact is 0^0, then the ratio of surface tensions of two liquids is [$\cos135^0 = 0.7$] [2003E]

   1) 1: 14 2) 5: 34 3) 1:5 4) 5:27

4. One end of a uniform glass capillary tube of radius r = 0.025cm is immersed vertically in water to a depth h = 1cm. The excess pressure in Nm^{-2} required to blow an air bubble out of the tube (surface tension of water = $7x10^{-2}Nm^{-1}$, density of water = 10^3kgm^{-3}, acceleration due to gravity = $10ms^{-2}$) [2004E]

   1) $0.0048x10^5$ 2) $0.0066x10^5$ 3) $1.0018x10^5$ 4) $1.0033x10^5$

5. The radii of the two columns in a U tube are 'r_1'& 'r_2' when a liquid of density ρ [angle of contact is 0^0] is filled in it, the difference of the liquid in the two arms is 'h'. The surface tension of the liquid is [g = acceleration due to gravity] [2004M]

1) $\frac{\rho g h r_1 r_2}{2(r_2 - r_1)}$ 2) $\frac{\rho g h (r_2 - r_1)}{2 r_2 r_1}$ 3) $\frac{2(r_1 - r_2)}{\rho g h r_1 r_2}$ 4) $\frac{\rho g h}{2(r_2 - r_1)}$

6. A wire ring of 3cm radius rests flat on the surface of a liquid. The pull required to raise the ring before the film breaks is 30.14 x 10^{-3}N more than it is after. The surface tension of the liquid (in Nm^{-1}) is [2005E]
   1) 80 x 10^{-3} 2) 87 x 10^{-3} 3) 90 x 10^{-3} 4) 98 x 10^{-3}
7. The pressure inside two soap bubbles are 1.01 and 1.02 atmospheres respectively. The ratio of their respective volumes is: [2005M]
   1) 16 2) 8 3) 4 4) 2
8. Two soap bubbles combine to form a single bubble. In this process, the change in volume and surface area are respectively 'V' and 'A'. If 'P' is the atmospheric pressure, and 'T' is the surface tension of the soap solution, the following relation is true: [2006E]
   1) 4PV + 3TA = 0 2) 3PV - 4TA =0 3) 4PV – 3TA = 0 4) 3PV + 4TA = 0
9. A wire of length '*l*' meters, made of a material of specific gravity 8 is floating horizontally on the surface of water. If it is not wet by water, the maximum diameter of the wire (in millimeters) upto which it can continue to float is (surface tension of water is T = 70 x $10^{-3}Nm^{-1}$) [2006M]
   1) 1.5 2) 1.1 3) 0.75 4) 0.55
10. A liquid does not wet the solid surface if the angle of contact is
    1) zero 2) equal to 45^0 3) equal to 90^0
    4) greater than 90^0 [2007E]
11. A liquid drop of radius 'R' breaks into 64 tiny drops each of radius 'r'. If the surface tension of liquid is 'T', then the gain in energy is
    1) $48\pi R^2 T$ 2) $12\pi r^2 T$ 3) $96\pi R^2 T$ 4) $192\pi r^2 T$ [2007M]

KEY:

1) 4 2) 2 3) 2 4) 2 5) 1 6) 1 7) 2 8) 4 9) 1 10) 4 11) 4

Chapter -12
THERMAL PROPERTIES OF MATTER

TEMPERATURE AND HEAT

- The temperature is a measure of the hotness or coldness of a body. It is the thermal state of a body which determines whether it will give heat to (or) receive heat from other bodies

Scales of Temperature:

Celsius Scale:

- On this scale melting point of ice is taken as the lower fixed point (0^0C) and the boiling point of water is taken as the upper fixed point (100^0C)

Fahrenheit Scale:

- On this scale 32^0F is the lower fixed point and 212^0R as the upper fixed point

Absolute Scale or Kelvin Scale:

- On this scale -273^0C is taken as 0^0A. Any temperature t^0C is equal to $273 + t = T^0$A

Conversion of Scale Temperature:

- If the temperature of a body is C, F and R on the Celsius. Fahrenheit and Reaumur scales, respectively $\frac{C-0}{100} = \frac{F-32}{180}$

Faulty Thermometer:

- If x^0 is the reading shown and y^0 is the lower fixed point and z^0 is the upper fixed point of a faulty thermometer and the correct readings are C and F on the Celsius and Fahrenheit scales

$\frac{C}{100} = \frac{F-32}{100} = \frac{x-y}{z-y}$ from which the correct readings can be obtained

THERMAL EXPANSION

I. EXPANSION OF SOLIDS:

- $\alpha = \frac{l_2 - l_1}{l_1(t_2 - t_1)}$
- Linear expansion $= l_1\alpha(t_2-t_1)$ or $\Delta l = l\alpha\Delta t$
- For anisotropic solid of α_x, α_y, α_z denote the coefficient of linear expansion along X, Y and Z directions, then $\alpha_{av} = \frac{\alpha_x + \alpha_y + \alpha_z}{3}$ and $\gamma = \alpha_x + \alpha_y + \alpha_z$

`

- If r_1 and r_2 are the radii of a disc or circular plate or a ring at t_1^0C and t_2^0C, then
  $r_2 = r_1 \{1+\alpha(t_2-t_1)\}$
  $D_2 = D_1 \{1+\alpha(t_2-t_1)\}$ (D₁ and D₂ are diameters)
- A wire is bent in the form of a ring with a small gap of length x_1 at t_1^0C. On heating to t_2^0C, if the gap increases to x_2 in length then coefficient of linear expansion of the wire material $\alpha = \frac{X_2 - X_1}{X_1(t_2 - t_1)}$

- The ratio of increase in area per degree rise of temperature to the original area of a solid (lamina) is known as coefficient of areal or superficial expansion (β)
- Coefficient of superficial expansion depends upon nature of the material and scale of temperature only. It is independent of the initial area, initial temperature and unit of area
- $\beta = \dfrac{a_2 - a_1}{a_1(t_2 - t_1)}$ /^{o}c
- Areal expansion = $a_1\beta(t_2-t_1)$ or $\Delta a = a\beta\, \Delta t$
- The ratio of the increase in volume per degree rise of temperature to the orginal volume of the solid is known as coefficient of volume expansion (γ)
- Coefficient of cubical expansion depends upon nature of the material and scale of temperature only. It is independent of the initial volume, temperature and unit of volume
- $\gamma = \dfrac{V_2 - V_1}{V_1(t_2 - t_1)}$ /^{o}c
- Volume expansion = $V_1\gamma(t_2-t_1)$ or $\Delta V = V\gamma\, \Delta t$
  Fractional change in volume $\dfrac{\Delta V}{V} = \gamma\, \Delta t$
- $\alpha : \beta : \gamma = 1 : 2 : 3$ or $\alpha + \beta + \gamma$ (for isotropic solid)
- $\dfrac{\Delta V}{V} = \dfrac{3\Delta l}{l}$ and $\dfrac{\Delta a}{a} = \dfrac{2\Delta l}{l}$
- For all isotropic substances $\alpha : \beta : \gamma = 1 : 2 : 3$ or $\gamma = \alpha + \beta$
- The numerical value of α and β or γ expressed per ^{0}C = 9/5 times numerical value expressed per ^{0}F
- A metal plate has two holes at certain separation. On heating the plate, the distance between the centres of holes increases
- Two rods of same material and same mass have different lengths. When they are heated
  a) Through same rise in temperature, longer rod expands more
  b) If same quantity of heat is supplied, longer rod expands more

Metal Tapes, Pendulum & Barometer

- Fractional change in the time period of a pendulum due to change in temperature , is
  $\dfrac{\Delta T}{T} = \dfrac{1}{2}\alpha\, \Delta t$
  Time lost or gained by pendulum clock in a day is
  $\dfrac{\Delta T}{T} \times 86400 = \dfrac{1}{2}\, \alpha\, \Delta t \times 86400$ seconds
  % time lost or gained = $\dfrac{1}{2}\, \alpha\, \Delta t \times 100$

Thermal Stress:

- If a metal rod is prevented from expansion on heating, stress will be developed which is known as thermal stress

- If the ends of a rod of length *l*, Young's modulus Y, area of cross section A and coefficient of linear expansion α are rigidly fixed, to prevent the expansion or contraction on heating or cooling, the tension or force developed in the rod is given by
  $F = YA\,\alpha\,\Delta t$ (Δt is change in temperature)
- Thermal stress = $\frac{F}{A} = Y\,\alpha\,t$
  For same thermal stress in two different rods heated through the same rise in temperature,
  $Y_1\alpha_1 = Y_2\alpha_2$
- Thermal stress is independent of length of the rod

II-EXPANSION OF LIQUIDS

Real & Apparent Expansions:

- On, heating liquid expands. The expansion of liquids is more when compared to that of solids
- Liquids do not possess any definite shape. So they experience volume expansion
- The ratio of apparent increase in volume per degree rise of temperature to its initial volume of the liquid is known as coefficient of apparent expansion (γ_a).
- The ratio of real increases in volume per degree rise in temperature to its initial volume of the liquid is known as coefficient of real expansion (γ_r)
- Coefficient of real expansion = Coefficient of apparent expansion + Coefficient of cubical expansion of material of the vessel
  $\gamma_r = \gamma_a + \gamma_g$
- $\gamma_a = \frac{\text{apparent increase in volume}}{\text{0riginal volume x rise in temperature}}$
- $\gamma_r = \frac{\text{real increase in volume}}{\text{original volume x rise in temperature}}$
- A vessel of volume is filled with a liquid of volume V*l* and volume of empty space above the liquid remains constant at all temperature if $\gamma V = \gamma_1 V_1$.Here γ and γ_1 denote the coefficients of cubical expansion of vessel and liquid

Determination of γ_a and γ_r:

Using specific gravity bottle method

$$\gamma_a = \frac{\text{weight of liquid expelled}}{\text{Weight of remaining liquid x rise in temperature}}$$

$$\gamma_a = \frac{W_2 - W_3}{(W_3 - W_1)\ (t_2 - t_1)}$$

W_1 is weight of empty specific gravity bottle
W_2 is weight of specific gravity bottle filled with water at $t_1{}^0C$
W_3 is weight of specific gravity bottle with remaining liquid at $t_2{}^0C$

- Using Dulong and Petit's method,

$\gamma_a = \dfrac{h_2 - h_1}{h_1(t_2 - t_1)}$, h_1, h_2 are the heights in the limbs of U tube at $t_1{}^0C$ and $t_2{}^0C$ resply.

- Using Regnault's method, $\gamma_r = \dfrac{h}{(H-h)\quad(t_2 - t_1)}$

  h is difference in the liquid levels in the inverted U tube
  H is height of liquid in the vertical tube
- If the same liquid is heated in two vessels x and y then $\gamma_r = \gamma_{ax} + 3\alpha_x = \gamma_{ay} + 3\alpha_y$
  or $\gamma_{ax} - \gamma_{ay} = 3(\alpha_y - \alpha_x)$
  Here γ_{ax}, γ_{ay} denote coefficients of apparent expansion in x and y
  α_x and α_y are coefficients of linear expansion

Variation of Density:

- If d_0 and d_t are the densities at 0^0C and t^0c, then
  $d_0 = d_t(1+\gamma_r t)$
  $d_t = \dfrac{d_0}{(1+\gamma_r t)}$; $d_t = d_0(1-\gamma_r t)$ (approximate formula)
  then $\gamma_r = \dfrac{d_1 - d_2}{d_1 t_2 - d_2 t_1}$
- The temperature at which density of a liquid is n% less than 0^0C is $\dfrac{n}{(100-n)\gamma_r}$
- The temperature at which density of a liquid is n% of the density at 0^0C is $\dfrac{100-n}{n\gamma_r}$
- The temperature at which density of a liquid is $\dfrac{1}{n}th$ of its density at 0^0C is $\dfrac{n-1}{\gamma_r}$

III-EXPANSION OF GASES

Expansion Coefficients:

- Volume coefficient of a gas is the ratio of the increase in its volume per degree rise of temperature to its volume at 0^0C at constant pressure
- Pressure coefficient of a gas is the ratio of the increase in its pressure per degree rise of temperature to its pressure at 0^0C at constant volume
- Volume coefficient of a gas is $\alpha = \dfrac{V - V_0}{V_0 t}$ (P constant)

  $V = V_0(1+\alpha t)$; V_0, V are volumes at 0^0C and t^0C
- If V_1, V_2 are the volumes of a gas at temperatures $t_1{}^0C$ and $t_2{}^0C$ and pressure is constant, then $\alpha = \dfrac{V_2 - V_1}{V_1 t_2 - V_2 t_1}$
- Pressure coefficient of gas is $\beta = \dfrac{P - P_0}{P_0 t}$ (V constant) $\Rightarrow P = P_0(1+\beta_t)$

P_0, P are pressures at 0^0C and t^0C

- If P_1, P_2 are the pressures of gas at temperatures $t_1{}^0C$ and $t_2{}^0C$ and its volume is constant, then $\beta = \frac{P_2 - P_1}{P_1 t_2 - P_2 t_1}$
- For an ideal gas pressure coefficient (β) or volume coefficient (α) = $\frac{1}{273}$ = $0.0036/^0C$
- If a gas is heated at constant volume from 0^0C, for every 1^0C rise in its temperature its pressure increases by 0.36 % of its pressure at 0^0C
- If a gas is heated at constant pressure from 0^0C, for every 1^0C rise in its temperature, its volume increases by 0.36 of its volume at 0^0C
- The range of gas thermometers is -260^0C to 1600^0C

Absolute Temperature:

- At -273^0C, pressure or volume of a gas = 0
- The scale of temperature on which the zero corresponds to -273^0C and width of each division same as that of centigrade division is known as absolute scale of temperature
- At absolute zero i.e. at -273^0C or 0^0A,
  a) Pressure and volume of any gas become zero
  b) Molecular velocities become zero c) K.E of molecules become zero
  c) No heat is radiated by the body e) The product PV =0
- The temperature t^0C is equal to (273+t) = T on the absolute scale

Boyle's Law:

- At constant temperature, the pressure of a given mass of a gas is inversely proportional to its volume. $P \propto \frac{1}{V}$ or PV = C (at constant temperature). Value of constant 'C' depends on the mass, temperature of the gas and the system of units
- PV = Constant; $P_1V_1 = P_2V_2$ (at constant temperature)
- $\frac{P}{d}$ = constant; $\frac{P_1}{d_1} = \frac{P_2}{d_2}$ (at constant temperature)
- In a Quill tube experiment, Pl = constant $\Rightarrow P_1 l_2 = P_2 l_2$ is pressure of enclosed air and l is length of air column. If H is atmospheric pressure (mercury barometer) and h is length of air column, pressure P is different cases is as shown in the figure
- If l_1 is length of air column in the quill tube with its open end vertically upwards and l_2 with its open end downwards, then atmospheric pressure H can be calculated as below
  $(H+h)l_1 = (H-h)l_2$
  and $H = \frac{h(l_1 + l_2)}{(l_2 - l_1)}$
  From the graph between h and $\frac{1}{l}$, H can be calculated

- An air bubble rises from bottom to surface of the lake. If V_1 and V_2 are the volumes of air bubble at the bottom and at the top of the lake and temperature is assumed to be constant, then ;$(H+h)V_1 = HV_2$
  Where h is depth of the lake and H is atmospheric pressure on water barometer
  a) If $V_2 = nV_1$ then $n = \left[1 + \frac{h}{H}\right]$
  b) If $V_2 = nV_1$ then $h = H(n-1)$
  c) If r_1 and r_2 are the radii of the bubble at the bottom and top then $(H+h)r_1^3 = Hr_2^3$
  d) If $r_2 = nr_1$ then $n = \left[1 + \frac{h}{H}\right]^{\frac{1}{3}}$
  e) If $r_2 = nr_1$ then $h = H(n^3 - 1)$
  f) In the above case if T_1 and T_2 are temperatures at the bottom and top of the lake then
  $$\frac{(H+h)V_1}{T_1} = \frac{HV_2}{T_2}$$
- If an air bubble rises from the bottom of a liquid column to the top at the constant temperature and its volume becomes n times, then depth of the liquid column $= \frac{76 \times 13.6}{d}(n-1)$ where d is density of that liquid in CGS units

Charles Laws:

- **Charles I Law**: At constant pressure, the volume of a given mass of gas is directly proportional to its absolute temperature
- At constant pressure, the density of a given mass of gas is inversely proportional to its absolute temperature
- $\frac{V}{T}$ = constant (P constant) $\Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}$
  Td = constant $T_1d_1 = T_2d_2$ (P constant)
- **Charles II Law or Gay-Lussac's Law**: At constant volume, the pressure of a given mass of gas is inversely proportional to its absolute temperature
- $\frac{P}{T}$ = constant $\Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$ (at constant volume)

Ideal Gas Equation:

- On combining Boyle's law with Charles law we arrive at an equation of state for the ideal gas. According to it $\frac{PV}{T}$ = constant which is known as gas equation
- For unit mass of gas, $\frac{PV}{T} = r$
  The constant 'r' is known as gas constant. Its value depends upon the nature of gas and amount of gas.
  Units of r: Cal $gm^{-1} K^{-1}$ or $JKg^{-1} K^{-1}$

Dimensional formula of r: $L^2T^{-2}K^{-1}$

If 'm' is mass of the gas, $\frac{PV}{T} = mr$

- For one mole of gas $\frac{PV}{T} = R$

  The constant R is known as universal gas constant. It is same for all gases.

  R = 8.31J/gm mol/K = $8.31x10^7$erg/gm mol/K = 2cal/gm mol/K

  For 'n' moles of the gas $\frac{PV}{T} = nR = \frac{m}{M}R$

  So, $mr = \frac{m}{M}R \Rightarrow r = \frac{R}{M}$

- PV = mrT (for a gas of mass m)
- PV = nRT (for n moles of gas)
- $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ (for the same gas)
- $\frac{P_1}{d_1T_1} = \frac{P_2}{d_2T_2}$ (for same mass)
- $\frac{PV}{T} = nNK$ (N is avagadros number)
- If n_1 moles of a non reactive gas in state (P_1, V_1, T_1) is mixed with n_2 moles of another non reactive gas at (P_2, V_2, T_2) and the resultant mixture is at (P, V, T) then $n_1+n_2 = r$

  $\Rightarrow \frac{P_1V_1}{T_1} + \frac{P_2V_2}{T_2} = \frac{PV}{T}$

  a) If $V_1 = V_2$ then $\frac{P}{T} = \frac{P_1T_2 + P_2T_1}{T_1T_2}$

  b) If $T_1 = T_2$, then $P = \frac{P_1V_2 + P_2V_2}{V}$

Ideal gas & Real gas:

- A gas that obeys laws at all pressures and temperatures is called ideal or perfect gas. No such gas exists
- Molecules of an ideal gas must be point masses occupying no finite volume. There will be no mutual forces of attraction between them
- Molecules of a gas have finite size and there are inter molecular attractions. A gas for which these two are considered is called a real gas. The inter molecular forces though negligible under ordinary conditions, become effective under high pressure and low temperatures
- Real gases approximate to ideal gases under low pressures and high temperatures

<u>Numerical Exercise:</u>

1. Convert -10^0C into Fahrenheit scale.
   1) 14^0 F 2) 28^0 F 3) 36^0 F 4) 46^0 F
2. Convert the normal temperature of human body 98.4^0 F into Celsius scale.

1) 36.9^0C 2) 43.3^0C 3) 21.4^0C 4) 63.4^0C

3. Show that -40^0 measure the same temperature on Celsius and Fahrenheit scales.
   1) 30^0 2) 40^0 3) 55^0 4) -40^0
4. The coefficient of linear expansion of gold is 14×10^{-6} $/^0C$. Find the coefficient of linear expansion on Fahrenheit scale.
   1) $7.778/^0$ F. 2) 3.44 $/^0$ F 3) $2.31/$ ^{0} F 4) $9.34/^0$ F
5. The volume of a gas is 210 c.c. at a temperature of 27^0C. Find its volume if its temperature is increased to 127^0C at constant pressure.(Assume that absolute zero corresponds to -273^0C)
   1) 280c.c 2) 340c.c 3) 170c.c 4) 862c.c
6. Express 200 K on the Fahrenheit scale.
   1) -23.23K 2) -45.23K 3) -99.68K 4) 42.22K
7. The triple points of neon and carbon dioxide are 24.57K and 216.55K respectively. Express this temperature on the Celsius scales.
   1) -248.58^0C and -24 ^0C 2) – 248.58^0C and 43 ^0C
   3) -248.58^0C and -56.6^0C 4) 64.23^0C and -56.65 ^0C
8. From above in term of Fahrenheit scales is
   1) 248.58^0C and -24 ^0F 2) – 248.58^0F and 43 ^0C
   3) -248.58^0F and -56.6^0F 4) -415.26^0F and -69.88^0F
9. What is the temperature for which the reading on Kelvin and Fahrenheit scales are same?
   1) 574.6 2) 234.3 3) 216.4 4) 123.7
10. A faulty thermometer has its fixed points marked as 5^0 and 95^0, the temperature of a body as measured by the faulty thermometer is 59^0. Find the correct temperature of the body on Celsius scale.
    1) 60 ^0C 2) 45 ^0C 3) 23^0C 4) 15^0C
11. Find the increases in temperature of aluminum rod if its length is to be increased by 1%.(α for aluminium = $25 \times 10^{-6}/^0C$)
    1) 400^0C 2) 300^0C 3) 250^0C 4) 853^0C
12. At what temperature on the Fahrenheit scale will be double of the reading on the Celsius scale?
    1) 320^0 F 2) 438^0 F 3) 263^0 F 4) 342^0 F

Key

1) 1	2) 1	3) 4
4) 1	5) 1	6) 3
7) 3	8) 4	9) 1
10) 1	11) 1	12) 1

I-Expansion of Solids
Question Bank:

Numerical Exercise

Coefficients of Expansions:

1) A man wishes to fit an aluminium ring on steel rod of 1cm diameter and found it is 0.001cm smaller in a diameter. How much should the temperature be raised before it just slips on (α_{Al} = 25x10^{-6}; α_S= 10x10^{-6}/^{0}C)
   1) 40^{0}C 2) 50^{0}C 3) 25^{0}C 4) 60^{0}C
2) The length of each rail is 10m while constructing the track. If the temperature in summer may increase by 15^{0}C, the gap that should be left between two successive rails is (α = 12x10^{-6}/^{0}C)
   1) 0.0018m 2) 0.018m 3) 0.00018m 4) 0.18m
3) Length of each rail at 20^{0}C is 10m. Maximum temperature in summer is 40^{0}C. At 20^{0}C, if the gap left between two successive rails is 0.22cm, coefficient of linear expansion of rail material
   1) 11x10^{-4}/^{0}C 2) 11x10^{-5}/^{0}C 3) 11x10^{-6}/^{0}C 4) 11x10^{-7}/^{0}C
4) On heating a block its volume increases by 0.30% for a rise of 100^{0}C in its temperature. Then coefficient of real expansion of that metal is
   1) 2x10^{-4}/^{0}C 2) 2x10^{-5}/^{0}C 3) 2x10^{-6}/^{0}C 4) 2x10^{-7}/^{0}C
5) A crystal has coefficient of linear expansion 10x10^{-7}/^{0}C in one direction and 220x10^{-7}/^{0}C in every direction at right angles to it. Then coefficient of cubical expansion of that material is
   1) 45x10^{-7}/^{0}C 2) 45x10^{-6}/^{0}C 3) 45x10^{-5}/^{0}C 4) 45x10^{-4}/^{0}C
6) A thin metal wire of length l increases in length by 0.1% on heating it from temperature θ_1 to θ_2. If a plate of same material is heated from θ_1 and θ_2, which has dimensions 2l x 3l then percentage increase in its area is
   1) 0.1% 2) 0.05% 3) 0.2% 4) 0.6%
7) In the above problem, if a block of dimensions 3l x 2l x l is heated form θ_1 to θ_2 percentage increase in its volume is
   1) 0.1% 2) 0.033% 3) 0.15% 4) 0.3%
8) On heating area of a plane increase by 0.08%. If the rise in its temperature in this case is 80^{0}C, coefficient of cubical expansion of that material is
   1) 15x10^{-6}/^{0}C 2) 15x10^{-5}/^{0}C 3) 15x10^{-4}/^{0}C 4) 15x10^{-3}/^{0}C
9) The diameter of a metal ring is D and the coefficient of linear expansion is α. If the temperature of the ring is increased by 1^{0}C, the circumference of the ring will increase by
   1) $\frac{\pi D\alpha}{2}$ 2) $2\pi D\alpha$ 3) $\pi D\alpha$ 4) $\pi D^2\alpha$
10) In the above case, area of the ring increases by
   1) $2\pi D\alpha$ 2) $\pi D^2\alpha$ 3) $\frac{\pi D\alpha}{2}$ 4) $\frac{\pi D^2\alpha}{2}$
11) The change in length of a rod of length 1m, when it is heated through 1^{0}F is (α = 10^{-6}/^{0}C)
   1) $\frac{5}{9}$x10^{-6}m 2) $\frac{9}{5}$x10^{-6}m 3) $\left[\frac{5}{9}\text{x}10^{-6}\text{ m}\right]$ 4) $\left[\frac{9}{5}+32\right]$x10^{-6}m

12) Coefficient of linear expansion of a material is $0.000018/^0C$. Then coefficient of cubical expansion of that material expressed ^0F is

1) $3x10^{-5}/^0F$ 2) $3x10^{-6}/^0F$ 3) $3x10^{-7}/^0F$ 4) $3x10^{-8}/^0F$

13) Two rods have their initial lengths in the ratio 2:3 and coefficients of linear expansion in the ratio 3:2. When both are heated from 0^0C to 100^0C, the ratio of their expansions is

1) 1:1 2) 10:1 3) 4:9 4) 9:4

Equal Expansion:

14) A rod of brass and that of iron differ by 5cm in length at all temperatures, the length of iron rod at 0^0C is ($\alpha_I = 11x10^{-6}/^0C$ and $\alpha_B = 18x10^{-6}/^0C$)

1) 7.85cm 2) 12.85cm 3) 20.7cm 4) 5cm

15) The length of iron rod whose expansion would be equal to the brass rod 80cm long if the two were heated the same range of temperature is
($\alpha_{Brass} = 19x10^{-6}/^0C$ and $\alpha_I = 12x10^{-6}/^0C$)

1) 46.67cm 2) 126.67cm 3) 80cm 4) 120cm

16) In order to have a difference of 25cm in their lengths at all temperature, lengths of iron and copper rods at 0^0C are
(α of iron = $12x10^{-6}/^0C$, α of copper = $17x10^{-6}/^0C$)

1) 85cm, 110cm 2) 50cm, 25cm 3) 85cm, 60cm 4) 60cm, 85cm

17) Coefficients of linear expansion of two metal rods are on $2.4x10^{-5}/^0C$ and $3.2x10^{-5}/^0C$. At all temperature if they differ in lengths by a fixed amount, ratio of their lengths at 0^0C is

1) 4:3 2) 3:4 3) 2:3 4) 3:2

18) α of aluminium = $23x10^{-6}/^0C$ and α of brass = $19x10^{-6}/^0C$ and the difference in their lengths at all temperature is 10cm. Then the ratio of their lengths at 0^0C is

1) 4:19 2) 4:23 3) 23:19 4) 19:23

Pendulum Clocks:

19) A pendulum clock keeps correct time at 0^0C. Mean coefficient of linear expansion is α per ^0C. If the temperature of the room rises by a small amount of t^0C, then the clock loses per day by

1) α t sec 2) $\frac{1}{2}\alpha$ t sec 3) αt x 86,400 sec 4) $\frac{1}{2}\alpha$t x 86,400 sec

20) The fractional change in the period of a pendulum clock is

1) $\frac{1}{2}\alpha\,(t_2-t_1)^2$ 2) $2\alpha(t_2-t_1)$ 3) $\frac{1}{2}\alpha\,(t_2-t_1)$ 4) $2\alpha\,(t_2-t_1)^2$

21) A clock keeps correct time at 10^0C. If it looses 17.28 seconds per day. Then the temperature of the day is ($\alpha = 20x10^{-6}/^0C$)

1) 20^0C 2) 30^0C 3) 40^0C 4) 15^0C

22) A clock with a metal pendulum beating seconds shows correct time at 10^0C. If it loses 10 seconds a day at 30^0C, coefficient of linear expansion of material of that pendulum is

1) $11.5x10^{-4}/^0C$ 2) $1.15x10^{-6}/^0C$ 3) $5.65x10^{-6}/^0C$ 4) $11.5x10^{-6}/^0C$

Thermal Stress:

23) A steel beam with cross section $60cm^2$ is fixed between two rigid clamps at 10^0C.When the beam is heated to 35^0C, the force exerted on the ends of the beam by the clamps is ($Y = 2x10^{11}Pa$, $\alpha = 12x10^{-6}/^0C$)

1) 3.6×10^6N 2) 36×10^7N 3) 36×10^5N 4) 3.6×10^5N

24) A steel rod 25cm long has a cross sectional area of $0.8cm^2$. The force required to stretch the rod by the same amount as the expansion produced by heating it through 10^0C is ($\alpha = 10^{-5}/^0C$, $Y = 20 \times 10^{11}$ $dycm^{-2}$)
1) 16×10^7dy 2) 16×10^6dy 3) 16×10^5dy 4) 16×10^4dy

25) A steel rod of length 5m is fixed rigidly between two supports. α of steel = $12 \times 10^{-6}/^0C$, $Y = 2 \times 10^{11} Nm^{-2}$. With the increase in its temperature by 400C, the stress developed in the rod is
1) $9.6 \times 10^5 Nm^{-2}$ 2) $9.6 \times 10^6 Nm^{-2}$
3) $9.6 \times 10^7 Nm^{-2}$ 4) $9.6 \times 10^8 Nm^{-2}$

26) A metal rod of $Y = 2 \times 10^{12}$ dyne cm^{-2} and $\alpha = 16 \times 10^{-6}/^0C$ has its temperature raised by 20^0C. Then the linear compressive stress to prevent the expansion of the rod is
1) $6.4 \times 10^5 dyne/cm^2$ 2) $6.4 \times 10^6 dyne/cm^2$
3) $6.4 \times 10^7 dyne/cm^2$ 4) $6.4 \times 10^8 dyne/cm^2$

Variation of density:

27) The density of a substance at 0^0C is 10gm cm^{-3} and its density at 100^0C is $9.4gmcm^{-3}$. Then the coefficient of linear expansion
1) $2 \times 10^{-4}/^0C$ 2) $2 \times 10^{-3}/^0C$ 3) $6 \times 10^{-4}/^0C$ 4) $6 \times 10^{-3}/^0C$

28) The density of copper at 0^0C is $9gmcc^{-1}$. If α of copper = $17 \times 10^{-6}/^0C$, its density at 20^0C is
1) $9.1gmcc^{-1}$ 2) $8.99gmcc^{-1}$ 3) $8.19gmcc^{-1}$ 4) $9.99gmcc^{-1}$

29) Density of gold at 800^0C is $18.68gmcc^{-1}$. When it is cooled to 0^0C, its density would be ($\alpha = 14 \times 10^{-6}/^0C$)
1) $18gmcc^{-1}$ 2) $18.42gmcc^{-1}$ 3) $17gmcc^{-1}$ 4) $19.3gmcc^{-1}$

30) If α of a material is $10 \times 10^{-6}/^0C$, ratio of its densities at 20^0C and 40^0C is
1) 1.006 2) 1.0006 3) 1.06 4) 0.9998

Keys

1) 1	2) 1	3) 3	4) 2	5) 2	6) 3	7) 4
8) 1	9) 3	10) 4	11) 1	12) 1	13) 1	14) 2
15) 2	16) 3	17) 1	18) 4	19) 4	20) 3	21) 2
22) 4	23) 4	24) 1	25) 3	26) 4	27) 1	28) 2
29) 4	30) 2					

Question Bank:

1) Find the temperature at which the Centigrade and Fahrenheit thermometers show the same reading
1) -40^0 2) 40^0 3) -20^0 4) 20^0

2) Express the value of 59^0F in ^{0}C
1) 10^0 2) 15^0 3) 30^0 4) 35^0

3) Find the reading of the Fahrenheit scale corresponding to 40^0C
1) 90^0 2) 96^0 3) 104^0 4) 110^0

4) Normal human body temperature which is 98.4^0F. Express it in ^{0}C
1) 7 2) 17 3) 27 4) 37

5) The higher and lower fixed points on a thermometer are separated by 160mm. When the length of the mercury thread above the lower points is 40mm. Find the temperature reading

1) 100^0 2) 75^0 3) 50^0 4) 25^0

6) A faculty thermometer has 90.5^0C and 0.5^0C marked as the upper and lower fixed points respectively. What is the correct temperature if this faulty thermometer reads 15.5^0C?

1) $\left(\frac{101}{3}\right)^0 C$ 2) $\left(\frac{81}{3}\right)^0 C$ 3) $\left(\frac{50}{3}\right)^0 C$ 4) $\left(\frac{41}{3}\right)^0 C$

7) The reading of a contact volume gas thermometer at 0^0C and 100^0C are 0.6m and 0.85m of mercury respectively. What will be the temperature when the reading of the thermometer is 0.925m?

1) 200^0C 2) 130^0C 3) 100^0C 4) 50^0C

8) The resistance of a coil in a platinum resistance thermometer at 0^0C is 3 ohm and at 100^0C is 3.75 ohm. Its resistance at an unknown temperature is 3.15 ohm. Calculate the unknown temperature

1) 20^0C 2) 40^0C 3) 60^0C 4) 80^0C

Key

1) 1	2)2	3)3	4)4
5)4	6)3	7)2	8)1

Expansion of solids Previous Eamcet Questions

2) Two uniform metal rods of lengths l_1 and l_2 and linear coefficients of expansions α_1 and α_2 respectively are connected to form a single rod of length ($l_1 + l_2$). When the temperature of the combined rod is raised by t^0C, the length of each rod increases by the same amount, then $\left(\frac{\alpha_2}{\alpha_1+\alpha_2}\right)$ is [2005M]

1) $\frac{l_1}{l_1+l_2}$ 2) $\frac{l_1+l_2}{l_1}$ 3) $\frac{l_2}{l_1+l_2}$ 4) $\frac{l_1+l_2}{l_2}$

3) Two rods of different materials and identical cross-sectional areas are joined face to face at one end and their free ends are fixed to the rigid walls. If the temperature of the surroundings is increased by 30^0C, the magnitude of the displacement of the joint of the rods is, (length of the rods $l_1 = l_2 = 1$unit, ratio of their Young's modulii $Y_1/Y_2 = 2$, coefficient of linear expansion are α_1 and α_2). [2006E]

1) $5(\alpha_2 - \alpha_1)$ 2) $10(\alpha_1 - \alpha_2)$ 3) $10(\alpha_2 - 2\alpha_1)$ 4) $5(2\alpha_1 - \alpha_2)$

4) The temperature of a thin uniform circular disc of one meter diameter is increased by 10^0C. The percentage increase in moment of inertia of the disc about an axis passing through its centre and perpendicular to the circular face (linear coefficient of expansion = $11 \times 10^{-6}/^0C$).

1) 0.0055 2) 0.011 3) 0.022 4) 0.044 [2006E]

5) A pendulum clock gives correct time at 20^0C at a place where $g = 10m/s^2$. The pendulum consists of a light steel rod connected to a heavy ball. If it is broken to a different place where $g = 10.01m/s^2$, at what temperature the pendulum gives correct time? (α of steel is $10^{-5}/^0C$). [2007E]
1) 30^0C 2) 60^0C 3) 100^0C 4) 120^0C

6) Two rods of different materials with coefficients of linear thermal expansion α_1 α_2 and Young's modulii Y_1 and Y_2 respectively are fixed between two rigid walls. They are heated to have the same increase in temperature. If the rods do not bend and if $\alpha_1 : \alpha_2 = 2:3$, then the thermal stresses developed in the two rods will be equal when $Y_1 : Y_2$ is
1) 2 : 3 2) 2 : 5 3) 3 : 2 4) 5 : 2 [2007M]

KEY:

1) 1 2) 3 3) 3 4) 4 5) 3

II – Expansion of Liquids

Question Bank:

Theory Questions:

1) By increasing temperature of liquid, its
1) Volume and density decreases 2) Volume and density increases
3) Volume increases and density decreases 4) Volume decreases and density increases

2) If the coefficient of apparent expansion of liquid is greater than absolute coefficient expansion of the liquid then the vessel should have on heating appeared
1) contracted 2) falls on heating
3) remains same 4) first expanded and later contracted

3) Real expansion of liquid does not depend up on
1) Nature of the liquid 2) Colour of the liquid 3) Initial volume of the liquid
4) Pressure of liquid exerted on the walls of the container

4) A liquid with coefficient of volume expansion γ is filled in a container of a material having the coefficient of linear expansion 'α'. If the liquid over flows on heating, then
1) $\gamma = 3\alpha$ 2) $\gamma < 3\alpha$ 3) $\gamma > 3\alpha$ 4) $\gamma = 3\alpha^2$

5) The coefficient of expansion of water is negative between
1) 0^0C to 4^0C 2) 4^0C to 10^0C 3) 10^0C to 34^0C 4) none

6) A glass jar is full of water, when it kept in a freezing mixture, the jar breaks because
1) water expands from 4^0C to 0^0C 2) ice expands while melting
3) water expands due to freezing 4) none

Match the following Questions:

7) Study the following:

List –I	List –II
a) Apparent expansion depends on b) Real expansion depends on c) Coefficient of apparent expansion	e) nature of vessel and liquid f) nature of liquid g) nature of vessel, and rise of

depends on	temperature
d) Coefficient of real expansion depends on	h) nature of liquid and rise of temperature

The correct match is

1) a→e; b→f; c→g; d→h   2) a→f; b→g; c→h; d→e
3) a→g; b→h; c→e; d→f   4) a→h; b→e; c→f; d→g

8) Study the following:

List –I	List –II
a) γ_g is +ve and $<\gamma_r$ b) γ_g is –ve c) $\gamma_g = \gamma_r$ d) $\gamma_g > \gamma_r$	e) liquid level does not change f) liquid level increases continuously g) liquid level decreases h) liquid level first decreases and then increases

The correct match is

1) a→g; b→e; c→f; d→h   2) a→h; b→f; c→e; d→g
3) a→e; b→f; c→g; d→h   4) a→f; b→g; c→h; d→e

9) Study the following:

List –I	List –II
a) γ_a is determined with the help of b) γ_r is determined with the help of c) Anamalous expansion of water is determined with the help of d) Maximum density of water is determined with the help of	e) Regnault's method f) Dialometer g) Hope's apparatus h) Specific gravity bottle

The correct match is

1) a→f; b→g; c→h; d→e   2) a→g; b→h; c→e; d→f
3) a→h; b→e; c→f; d→g   4) a→e; b→f; c→g; d→h

10) Match the following lists:

List –I	List –II
a) It is not possible to construct a glass thermometer with water between the temperature range 0^0C to 8^0C b) It is possible to construct a platinum resistance thermometer c) A platinum wire is generally sealed to a glass rod d) In cold countries the aquatic animals survives	e) due to anomalous expansion of water f) as platinum is a bad conductor of heat g) as resistance of platinum increases uniformly with temperature h) as glass is bad conductor of heat

1) a→e; b→g; c→f; d→h   2) a→e; b→g; d→e
3) a→e; d→e   4) c→g; b→f

Assertion & Reason Type Questions:

11) Assertion: Real expansion of liquid does not depend upon material of container

Reason: Liquids have no definite shape. They acquire the shape of the containers in which they are taken

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false   4) A is false but R is true

12) Assertion: A vessel is filled with water up to brim at 4^0C. It over flows when the system is cooled or heated

Reason: Water has minimum volume at 4^0C

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false   4) A is false but R is true

13) Assertion: Aquatic animals at bottom of water lake survive in cold countries even when surface is frozen

Reason: Due to anomalous expansion, the density of water is minimum at 4^0C

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false   4) A is false but R is true

14) Assertion: A wooden block is floating on a liquid. When the temperature of the liquid is increased the volume of the block immersed in the liquid increases

Reason: As temperature increases the density of the liquid decreases

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false   4) A is false but R is true

15) Assertion: When a liquid in a container is heated first the level of the liquid falls down then rises

Reason: When the liquid in a container is heated first the container undergoes expansion then the liquid undergoes expansion and generally the expansion of the liquid is greater than that of solid

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false   4) A is false but R is true

Numerical Exercise:

16) The coefficient of linear expansion of glass is $10x10^{-6}/^0$C and the coefficient of real expansion of mercury is $18x10^{-5}/^0$C then the coefficient of apparent expansion of mercury with respect to the glass is $/^0$C

1) $15x10^{-5}$ 2) $183x10^{-5}$ 3) $181x10^{-5}$ 4) $15x10^{-6}$

17) If the coefficient of real expansion of liquid is equal to the cubical coefficient of the container. Then the coefficient of apparent expansion of the liquid is

1) zero   2) +ve   3) –ve   4) infinity

18) The coefficient of real expansion of a liquid is $0.00027/^0$C. The coefficient of linear expansion of the container is $0.00009/^0$C. Then the coefficient of apparent expansion of the liquid is

1) infinity   2) positive   3) negative   4) zero

19) If the coefficient of real expansion γ_r is 1% more than coefficient of apparent expansion, linear expansion coefficient of the material is

1) $\frac{\gamma_r}{303}$ 2) $\frac{100\gamma_r}{101}$ 3) $\frac{101\gamma_r}{300}$ 4) $\frac{100\gamma_r}{100}$

20) If the apparent change in volume of a liquid per 1000C rise in 4%, its coefficient of apparent expansion is

1) $2x10^{-4}/^0C$ 2) $4x10^{-4}/^0C$ 3) $8x10^{-4}/^0C$ 4) $16x10^{-4}/^0C$

21) If the coefficient of absolute expansion of a liquid is 7 times the coefficient of cubical expansion of the vessel, then ratio of coefficients of absolute and apparent expansion of the liquid is

1) $\frac{1}{7}$ 2) $\frac{6}{7}$ 3) $\frac{7}{6}$ 4) 7

Coefficient of apparent expansion:

22) When a specific gravity bottle is heated from $t_1{}^0C$ to $t_2{}^0C$, x gms of liquid is expelled and m gms of liquid remained. Then the coefficient of real expansion is

1) $\frac{x}{m(t_2 - t_1)}$ 2) $\frac{x}{m(t_2 - t_1)} + 3\alpha$ 3) $\frac{x}{m(t_2 - t_1)} - 3\alpha$ 4) $\frac{x}{m(t_2 - t_1)} - 3\alpha$

23) A vessel contains 105gm of a liquid at 0^0C. The vessel is heated to 1000C when 5gm of the liquid is expelled, then the coefficient of real expansion of the liquid is $10^{-4}/^0C$ (α of vessel = $9x10^{-6}/^0C$)

1) 5.27 2) 5.17 3) 4.92 4) 4.83

24) If 52gm of a liquid is heated in a vessel from 0^0C to 100^0C. 2gm of the liquid is expelled. If 104gm of the same liquid taken in the same vessel and heated from 0^0C to 50^0C. Then the mass of the liquid expelled is

1) 4gm 2) 3gm 3) 2gm 4) 1gm

25) In an experiment with the specific gravity bottle, the mass of the liquid expelled is $\frac{1}{50}$ of the mass liquid remaining for a temperature difference of 20^0C. Then the coefficient of apparent expansion of the liquid is -----$/^0C$

1) 10^{-1} 2) 10^{-2} 3) 10^{-3} 4) 10^{-4}

26) A specific gravity bottle weights 40g when empty and 1040g when filled with mercury at 0^0C on heating to 100^0C 10g of mercury over flows. If the coefficient of real expansion of mercury $0.0002/^0C$. Then the coefficient of volume expansion of glass is

1) $3x10^{-4}/^0C$ 2) $2x10^{-4}/^0C$ 3) $1x10^{-4}/^0C$ 4) None

27) A specific gravity bottle contains 104gm of a liquid at 0^0C. When it is heated to 200^0C, 4gm of the liquid is expelled. The coefficient of apparent expansion of the liquid is

1) $0.002/^0C$ 2) $0.0002/^0C$ 3) $0.00002/^0C$ 4) $0.02/^0C$

28) An empty specific gravity bottle weights 20gm. When it is filled with a liquid at 40^0C, its weight is 32gm. On heating to 100^0C. Weight of the specific gravity bottle with the remaining liquid is 30gm. Then coefficient of apparent expansion of that liquid is the

1) $3.3x10^{-3}/^0C$ 2) $6.6x10^{-3}/^0C$ 3) $4.4x10^{-3}/^0C$ 4) $5.5x10^{-5}/^0C$

29) A specific gravity bottle contains m grams of a liquid of coefficient of apparent expansion γ at 0^0C. When it is heated to t^0C, mass of the liquid expelled is

1) $\frac{1+\gamma t}{\gamma mt}$ 2) $\frac{\gamma m}{1+\gamma t}$ 3) $\frac{\gamma mt}{1+\gamma t}$ 4) $\frac{\gamma mt}{1-\gamma t}$

Coefficient of real expansion:

30) A liquid of 50cc in a container is being heated through 40^0C and the apparent expansion $9x10^{-6}/^0C$. Find the coefficient of real expansion of the liquid
1) $27x10^{-6}/^0C$ 2) $14x10^{-6}/^0C$ 3) $50.27x10^{-6}/^0C$ 4) $5.27x10^{-4}/^0C$

31) A flask contains 100cc of liquid at 10^0C. When it is heated to 110^0C increase in volume of the liquid appears to be 2cc. The coefficient of real expansion of the liquid is [α of flask = $11x10^{-6}/^0C$]
1) $2.43x10^{-1}/^0C$ 2) $2.33x10^{-2}/^0C$ 3) $2.33x10^{-3}/^0C$ 4) $2.33x10^{-4}/^0C$

32) A column of mercury at 100^0C is balanced by a column of mercury at 0^0C. The respective heights of mercury are 76.35cm and 75cm. Then the coefficient of real expansion of mercury is ----
1) $1.2x10^{-4}/^0C$ 2) $1.6x10^{-4}/^0C$ 3) $1.76x10^{-4}/^0C$ 4) $2x10^{-4}/^0C$

33) In an experiment performed by Dulong and Petit's method, the height of cold (0^0C) and hot (100^0C) columns of mercury are 0.5m and 0.509m respectively. Then the coefficient of real expansion of mercury is
1) $1.6x10^{-4}/^0C$ 2) $1.76x10^{-3}/^0C$ 3) $2.0x10^{-4}/^0C$ 4) $2.2x10^{-4}/^0C$

34) The heights of the liquid columns on the two sides of a U-tube are 20 and 20.2cm. The temperatures, on the two sides are 0^0C, 100^0C respectively. The absolute coefficient of expansion of liquid is
1) $182x10^{-6}/^0C$ 2) $1x10^{-4}/^0C$ 3) $1x10^{-3}/^0C$ 4) $101x10^{-5}/^0C$

35) Calculate the difference in the heights of liquid column if they are at 0^0C and 100^0C respectively and the height of the column at 0^0C is 100cm and $\gamma_R = 18x10^{-5}/^0C$
1) 1.8cm 2) 18cm 3) 9cm 4) 90cm

36) A solid floats in a liquid at 20^0C with 75% of it immersed in a liquid. When the liquid is heated to 100^0C the same body floats with 80% of it immersed in the liquid. Find the coefficient of real expansion of the liquid
1) $8x10^{-4}/^0C$ 2) $8.33x10^{-4}/^0C$ 3) $8.33x10^{-5}/^0C$ 4) $8x10^{-5}/^0C$

37) In an experiment with Dulong and Petit's apparatus, the column of the liquid stood at 60cm at 0^0C and 5cm higher at 100^0C. Then coefficient of real expansion of that liquid is
1) $\frac{6}{5000}/^0C$ 2) $\frac{3}{5000}/^0C$ 3) $\frac{5}{6000}/^0C$ 4) $\frac{5}{3000}/^0C$

Compensating expansion of a liquid:

38) A glass tube of length 98cm is closed at one end. What length of it should be filled with mercury so that the level of mercury may remain the same at all temperatures. ($\gamma_R = 1.8x10^{-4}/^0C$; $\gamma_g = 2.7x10^{-5}/^0C$)
1) 4.9 of glass tube 2) 3.9 of glass tube 3) 2.9 of glass tube 4) 1.9 of glass tube

39) A vessel is filled with a liquid such that 20% of the vessel volume is empty. It is found that at all temperatures that volume of the empty space above the liquid surface emains the same. Then the ratio of cubical expansion coefficients of vessel and liquid is
1) 4:5 2) 5:4 3) 2:5 4) None

40) A vessel contains a liquid filled with $\frac{1}{10}^{th}$ of its volume. Another vessel contains same liquid $\frac{1}{8}^{th}$ of its volume. In both the cases volume of empty space remains constant at all temperatures. Then the ratio of the cubical expansion coefficients of those two vessels is

1) 2:5   2) 5:2   3) 4:5   4) 5:4

41) The coefficient of linear expansion of glass is $8x10^{-6}/^{0}C$ and the coefficient of cubical expansion of mercury is $1.8x10^{-4}/^{0}C$. The volume of mercury to be placed in the bottle in order that the volume of bottle not occupied by mercury should be the same at all temperature

1) $\frac{1}{7}^{th}$ volume   2) $\frac{2}{15}^{th}$ volume   3) $\frac{3}{22}^{th}$ volume   4) $\frac{4}{29}^{th}$ volume of the vessel

42) A vessel filled with a liquid upto $\frac{1}{8}^{th}$ volume is observed to have the volume of empty space above it is constant at all temperatures. If the same vessel is filled with another liquid upto $\frac{1}{12}^{th}$ volume, same is observed. Then ratio of the coefficients of linear expansion of those two vessels is

1) 2:3   2) 3:2   3) 1:2   4) 2:1

Variation of density with temperature:

43) The density of a liquid at $t^{0}C$ to 0.1% of its density at $0^{0}C$. Then coefficient of its absolute expansion is

1) $\frac{9}{t}$ 2) $\frac{99}{t}$ 3) $\frac{999}{t}$ 4) $\frac{1}{999t}$

44) If γ is coefficient of real expansion of a liquid, the temperature at which density of a liquid is 1% of its density at $0^{0}C$ is

1) $\frac{99}{\gamma}$ 2) $\frac{1}{99\gamma}$ 3) $\frac{100}{\gamma}$ 4) $\frac{1}{100\gamma}$

45) The temperature at which density of a liquid is 1% less than that of density at $0^{0}C$ (is coefficient of absolute expansion)

1) $\frac{99}{\gamma}$ 2) $\frac{1}{99\gamma}$ 3) $\frac{100}{\gamma}$ 4) $\frac{1}{100\gamma}$

46) If d_1 and d_2 are densities of a liquid at $t_1{}^{0}C$ and $t_2{}^{0}C$ then $\frac{d_1}{d_2}$ is about (γ is coefficient of real expansion) (use formula $d = \frac{d_0}{(1+\gamma t)}$)

1) $\frac{1+\gamma t_1}{1+\gamma t_2}$ 2) $\frac{1-\gamma t_1}{1-\gamma t_2}$ 3) $\frac{1+\gamma t_2}{1+\gamma t_1}$ 4) $\frac{1-\gamma t_2}{1-\gamma t_1}$

47) If d_0 is density of a liquid at 0^0C and its coefficient of real expansion is $10^{-3}/^0$C, then its density at 100^0C is

1) $\frac{11d_0}{10}$ 2) $\frac{10d_0}{11}$ 3) $\frac{9d_0}{10}$ 4) $\frac{10d_0}{9}$

1)3	2)1	3)4	4)2	5)1	6)1	7)3
8)2	9)3	10)2	11)2	12)1	13)3	14)1
15)1	16)1	17)1	18)4	19)1	20)2	21)3
22)2	23)1	24)3	25)3	26)3	27)2	28)4
29)3	30)4	31)4	32)3	33)2	34)2	35)1
36)2	37)3	38)1	39)1	40)3	41)2	42)2
43)3	44)1	45)2	46)3	47)2		

Expansion of liquids Previous Eamcet Questions

48) The relation between the coefficient of real expansion (γ_r), and coefficient of apparent expansion (γ_a) of a liquid and the coefficient of linear expansion (α_g) of the material of the container is : [2005E]

1) $\gamma_r = \alpha_g + \gamma_a$ 2) $\gamma_r = \alpha_g + 3\gamma_a$ 3) $\gamma_r = 3\alpha_g + \gamma_a$ 4) $\gamma_r = 3(\alpha_g + \gamma_a)$

49) What fraction of the volume of a glass flask must be filled with mercury so that the volume of the empty space may be the same at all temperatures?
($\alpha_{glass} = 9 \times 10^{-6}/^0C$, $\gamma_{Hg} = 18.9 \times 10^{-5}/^0C$) [2007M]

1) 1/2 2) 1/7 3) ¼ 4) 1/5

KEY: 48) 3 49) 2

III-Expansion of Gases
Question Bank:

Theory Questions:

1) Boyle's law holds good for an ideal gas during
   1) Isobaric changes 2) Isothermal changes 3) Isochoric changes 4) Isotopic changes
2) An ideal gas is that which
   1) Can not be liquified 2) Can be easily liquified
   3) Has strong inter molecular forces 4) Has a large size of molecules
3) The product of pressure and volume has the same units as
   1) Temperature 2) Work 3) Force 4) Power
4) At constant pressure density of a gas is
   1) Directly proportional to absolute temperature
   2)Inversely proportional to absolute temperature
   3) Independent of temperature 4) None
5) In an air bubble rises from the bottom to surface of a lake at constant temperature, its volume
   1) Decreases 2) Increases 3) Remains same 4) Is zero
6) The volume expansivity at constant pressure expansivity at volume
   1) are equal for any gas 2) both of them are equal and equal for any gas
   3) their values increases with increase of atomic number of the gas

4) their values decreases with increase of atomic number of the gas

7) A graph between temperature is 0^0C and pressure of perfect gas keeping volume constant Is

1) a straight line parallel through origin

2) a straight line with positive intercept of Y-axis 3) a hyperbola

4) a straight line parallel to pressure axis intercepting temperature axis at -273^0C

8) Match the following:

List –I	List –II
a) Boyle's law b) Charle's law c) Ideal gas equation d) Dalton's law	e) $P = P_1+P_2+P_3$ f) $\frac{P}{dT}$ = constant g) $P \propto$ density f) $T \propto \frac{1}{\text{density}}$

The correct match is

1) a→h; b→e; c→f; d→g 2) a→g; b→e; c→h; d→f

3) a→h; b→g; c→e; d→f 4) a→g; b→h; c→f; d→e

9) Study the following:

List –I	List –II
a) Boyle's law b) Charle's law c) Ideal gas d) Anamalous expansion	e) pressure constant f) surviving of aquatic animals g) temperature constant h) laws obeys at all temperatures and pressures

The correct match is

1) a→h; b→e; c→f; d→g 2) a→h; b→f; c→g; d→e

3) a→e; b→g; c→f; d→h 4) a→f; b→h ; c→e; d→g

10) Match the following lists:

List –I	List –II
a) P –V graph (T is constant) b) P –T graph (V is constant) c) V –T graph (T is constant) d) PV –P graph (T is constant)	e) A straight line cutting temperature axis at -273^0C f) Rectangular hyperbola g) A straight line parallel to pressure axis h) Straight line passing through origin

The correct match is

1) a→g; b→e; c→h; d→f 2) a→h; b→f; c→g; d→e

3) a→e; b→g; c→f; d→h 4) a→f; b→h; c→e; d→g

11) Assertion: Pressure coefficient and volume coefficient of a gas are equal

Reason: Pressure coefficient of a gas can be determined using Regnault's apparatus

1. A and R are true and R is the correct explanation of A
2. A and R are true and R is not the correct explanation of A
3.A is true but R is false 4.A is false but R is true

12) Assertion: Gases obey Boyle's law at high temperature and low pressure only

Reason: At low pressure and high temperature gases would behave like ideal gases

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

13) Assertion: When the volume of given mass of gas is increased by 4 times at constant temperature its pressure becomes $\frac{1}{4}^{th}$ of the original values

Reason: According to Boyle's law, pressure of the given mass of gas is inversely proportional to its volume at constant temperature

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is t rue but R is false 4) A is false but R is true

14) Assertion: The value of $\frac{PV}{T}$ for one-gram mole of an ideal gas is 8.4 J $mole^{-1}K^{-1}$.

Reason: $\frac{PV}{T}$ = R = universal gas constant for 1 gram mole of the gas, whose standard value is 8.4 J $mole^{-1}$ K^{-1}.

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

15) Assertion: $\frac{PV}{T}$ = constant for gram of gas. This constant varies from gas to gas

Reason: 1 gram of different gases at N.T.P occupy different volumes

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

16) Assertion: $\frac{PV}{T}$ = constant for 1 mole of gas. This constant is same for all gases.

Reason: 1 mole of different gases at N.T.P occupy same volume of 22.4 liters

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

17) Assertion: A hydrogen filled balloon stops rising after it has attained a certain height in the sky

Reason: The atmospheric pressure decreases with height and becomes zero when maximum height is attained

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

18) Assertion: The earth without its atmosphere would be inhospitably cold

Reason: All heat would escape in the absence of atmosphere

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

19) A gas has pressures 100cm and 136cm Hg at temperatures 0^0C and 100^0C under constant volume. Then pressure coefficient of the gas is
1) $0.036/^0C$ 2) $0.0036/^0C$ 3) $0.36/^0C$ 4) $3.6/^0C$

20) Volume of a gas at 0^0C is 300cc. Keeping the pressure constant, if the gas is heated to 100^0C, its volume is (volume coefficient = $\frac{1}{300}/^0C$)
1) 240cc 2) 400cc 3) 2500cc 4) 450cc

21) The pressure of a gas at 0^0C is 50cm Hg. At constant volume, when it is heated to 80^0C, its pressure is 64cm Hg. Then pressure coefficient of the gas is
1) $0.0035/^0C$ 2) $0.0175/^0C$ 3) $0.0070/^0C$ 4) $0.0036/^0C$

22) At constant volume, when a gas is heated from 0^0C, for every 1^0C rise in temperature, its pressure increases by $\frac{1}{3}\%$ then, pressure coefficient of gas is
1) $\frac{2}{300}/^0C$ 2) $\frac{1}{300}/^0C$ 3) $\frac{3}{1000}/^0C$ 4) None

23) The volume of gas at 27^0C and 1 atm pressure is 1 lit. If the pressure is doubled and absolute temperature is made half, what will be the volume of the gas
1) 0.5 lit 2) 0.25 lit 3) 0.75 lit 4) 1.6 lit

24) The pressure of gas at 100^0C is 2 atm. When the gas is heated keeping volume constant at what temperature the pressure raises to 3 atm?
1) 286.5^0C 2) 380.7^0C 3) 420.2^0C 4) 227.4^0C

25) An open mouthed bottle contains a gas at 60^0C. The temperature to which the bottle should be heated so that 1/4of the mass of the gas may leave it is
1) 171^0C 2) 250^0C 3) 300^0C 4) None

26) The readings of a faulty barometer are 72 and 73 cm of Hg when the atmospheric pressures are 75.4 and 76.6 cm of Hg. When the faulty barometer shows 74cm of Hg, the atmospheric pressure is
1) 76.25cm of Hg 2) 76.675 cm of Hg
3) 77.825 cm of Hg 4) 76 cm of Hg

27) A vessel containing air of mass 8 gm at 400^0K is provided with a hole on the vessel so that some amount of air leaks out. After some time, the pressure is halved and temperature is changed to 300^0K. The mass of air that has escaped is
1) 2.7 gm 2) 3.7 gm 3) 1.7 gm 4) 2 gm

28) A small bulb is filled with air at 41^0C and sealed. When it is heated slowly in an oil bath upto 198^0C, it is found to be broken. Find the pressure at which the bulb is broken
1) 2.5 atm 2) 1.5 atm 3) 3 atm 4) 1.3 atm

29) The pressure of a gas is 80cm of mercury, Now 25% of the gas is also introduced in the same vessel at the same temperature, the final pressure of the gas is
1) 105 cm of Hg 2) 55 cm of Hg 3) 100 cm of Hg 4) 80 cm of Hg

30) A vessel filled with a gas at a pressure of 72 cm of Hg. If $\frac{1}{3}^{rd}$ of mass air is leaked out at same temperature its new pressure is

1) 54 cm of Hg 2) 36 cm of Hg 3) 48 cm of Hg 4) 64 cm of Hg

31) If the volume of an ideal gas decreased by 5% at constant temperature, the increase of pressure is
1) 5% 2) 5.18% 3) 5.26% 4) 5.41%

32) The volume of a given mass of air at temperature 27^0C is 100cc. If its temperature is raised to 57^0C maintaining the pressure constant, the increase in its volume is
1) 110 cc 2) 130 cc 3) 10cc 4) 30cc

33) A vessel has 6 gm of oxygen at pressure P and temperature 400K. A small hole is made in it so that the gas leaks out. How much oxygen leaks out if the final pressure is $\frac{P}{2}$ and final temperature is 300K
1) 2 gm 2) 3 gm 3) 4 gm 4) 5 gm

34) A given amount of gas is heated till the volume and pressure are each increased by 1%. Then the temperature increases by
1) 0.5% 2) 1% 3) 2% 4) 4%

35) The lengths of air column is quill tube are 33 cm and 43 cm. When open end of the tube is vertically upwards and downwards. If the length of the Hg column is 10cm then atmospheric pressure is
1) 32 cm of Hg 2) 71.5 cm of Hg 3) 68 cm of Hg 4) 72.5 cm of Hg

36) 8 gm of oxygen and x gm of hydrogen possess same pressure, volume and temperature. Then x =
1) $\frac{1}{2}$ 2) 16 3) 32 4) 2

37) A gas at temperature of 250K is contained in a closed vessel. If the gas is heated through 1^0C the percentage increase in the pressure is
1) 0.4% 2) 0.6% 3) 0.85% 4) 1%

38) The pressure of gas is 80cm of Hg. Now 25 percentage of the gas is removed from the vessel at the same temperature. The final pressure of the gas in the vessel will be
1) 55 cm of Hg 2) 20 cm of Hg 3) 60 cm of Hg 4) None

39) Two bulbs of volume V and 4V contain gas at a pressures of 5 atm, 1 atm and at temperatures of 300K and 400K respectively. When the bulbs are joined by narrow tube keeping their temperatures at their initial values. The pressure of the system is
1) 1 atm 2) 2 atm 3) 2.5 atm 4) 3 atm

40) A closed vessel contains 8gm of oxygen and 7gm of nitrogen. Total pressure is 10 atm, at given temperatures. If all the oxygen be removed from the system with out permitting any change in temperature, the pressure now will be
1) 5 atm 2) 10 atm 3) 7.5 atm 4) 4 atm

Keys

1)2	2)1	3)2	4)2	5)2	6)2	7)2
8)4	9)3	10)4	11)3	12)1	13)2	14)1
15)1	16)1	17)2	18)1	19)2	20)2	21)1
22)2	23)2	24)1	25)1	26)3	27)1	28)2
29)3	30)3	31)3	32)3	33)1	34)3	35)2
36)1	37)1	38)3	39)2	40)1		

Expansion of Gases Previous Eamcet Questions

1) The difference between volume and pressure coefficients of an ideal gas is
   1) 1/273 2) 273 3) 2/273 4) zero [2005E]

2) The tyre of a motor car contains air at 15^0C. If the temperature increases to 35^0C, the approximate percentage increase in pressure is (ignore the expansion of tyre).
   1) 7 2) 9 3) 11 4) 13 [2005E]

3) Equation of a gas in terms of pressure (P), absolute temperature (T) and density (d) is 1) $\frac{P_1}{T_1 d_1} = \frac{P_2}{T_2 d_2}$ 2) $\frac{P_1 T_1}{d_1} = \frac{P_2 T_2}{d_2}$ 3) $\frac{P_1 d_2}{T_2} = \frac{P_2 d_1}{T_1}$ 4) $\frac{P_1 d_1}{T_1} = \frac{P_2 d_2}{T_2}$ [2005M]

4) At a certain temperature, radius of an air bubble is doubled when it comes to the top from the bottom of a mercury column of height 'h'. If the pressure at the top is two atmospheres, the value of 'h' in meters is:
   1) 5.5 2) 10.64 3) 12.45 4) 15.00 [2006M]

5) The temperature of a gas contained in a closed vessel increases by 2^0C when the pressure is increased by 2%. The initial temperature of the gas is:
   1) 200K 2) 100K 3) 200^oC 4) 100^0C [2006M]

6) Two gases A and B having same pressure P, volume V and absolute temperature T are mixed. If the mixture has the volume and temperature as V and T respectively, then the pressure of the mixture is [2007E]
   1) 2P 2) P 3) P/2 4) 4P

KEYS:

1) 4 2) 1 3) 1 4) 2 5) 2 6) 1

Heat & Temperature

- Heat is a form of energy that flows between two bodies due to difference in their temperatures
- Heat flows from a body at higher temperature to a body at lower temperature until then attain same temperature
- A body at low temperature may possess more heat energy than body at high temperature
- Heat is a scalar with dimensions ML^2T^{-2}
  Units: calorie (CGS) or practical unit Joule (SI).
- Calorie is the quantity of heat required to raise the temperature of 1gm of water through 1^0C
- Mean calorie or standard calorie is the amount of heat required to raise the temperature of 1gm of water from 14.5^0C to 15.5^0C

Specific Heat:

- The quantity of heat required by one gram of a substance to raise its temperature by 1^0C is called its specific heat (s).
  Units: Cal $gm^{-1}\ {}^0C^{-1}$ (CGS) , J $Kg^{-1}\ K^{-1}$ (SI)
  Dimensions: $M^0L^2T^{-2}K^{-1}$
- Of all solids and liquids water has the highest specific heat
  Its value is 1 cal $gm^{-1}\ {}^0C^{-1}$ or 4180 J $Kg^{-1}\ K^{-1}$ (J = 4.18*J/Cal*).
- Specific heat of ice is 0.5 cal $gm^{-1}\ {}^0C^{-1}$ or 2090 J $Kg^{-1}\ K^{-1}$
  Specific heat of steam is 0.45 cal $gm^{-1}\ {}^0C^{-1}$ or 1881 J $Kg^{-1}\ K^{-1}$
  Specific heat of copper is 0.1 cal $gm^{-1}\ {}^0C^{-1}$ or 418 J $Kg^{-1}\ K^{-1}$
  Specific heat of lead is 0.03 cal $gm^{-1}\ {}^0C^{-1}$ or 125.4 J $Kg^{-1}\ K^{-1}$
- Of all gases hydrogen has the highest specific heat (3.5 cal $gm^{-1}\ {}^0C^{-1}$)
- Specific heat of a substance depends on temperature and nature of material. (In general for heavier materials it is less)
- Heat lost or gained by a substance is $Q = m\,s\,\theta$
  m is mass, s is specific heat and θ is change in temperature
  Specific heat $s = \frac{Q}{m\theta}$ (or) $s = \frac{1}{m}\left(\frac{dQ}{d\theta}\right)$
- If two substances of masses m_1, m_2 specific heats s_1, s_2 at initial temperatures θ_1 and θ_2 are mixed then final temperature of the mixture is $\frac{m_1s_1\theta_1 + m_2s_2\theta_2}{m_1s_1 + m_2s_2}$ (no heat losses)
- If two liquids of specific heats s_1, s_2 having masses m_1, m_2 are mixed at the same temperature, effective heat of the mixture is $s = \frac{m_1s_1 + m_2s_2}{m_1 + m_2}$

  If $m_1 = m_2$ then $s = \frac{s_1 + s_2}{2}$

  If V_1, V_2 are volumes and d1, d2 are their densities, $s = \frac{d_1V_1s_1 + d_2V_2s_2}{d_1V_1 + d_2V_2}$

Here if $V_1 = V_2$ then $s = \dfrac{d_1 s_1 + d_2 s_2}{d_1 + d_2}$

- If same quantity of heat is given to two different substances and θ_1 and θ_2 are the changes in their temperatures, $m_1 s_1 \theta_1 = m_2 s_2 \theta_2$

Thermal Capacity & Water Equivalent:

- The quantity of heat required to raise the temperature of a given substance by 1^0C is called its thermal capacity or heat capacity
  Units: cal $^0C^{-1}$, JK^{-1}, Dimensions: $ML^2T^{-2}K^{-1}$
- The mass of water in grams which would require the same amount of heat to raise its temperature through 1^0C as the body when heated through the same temperature is called water equivalent
- Thermal capacity = $ms = \dfrac{Q}{\theta}$ (or) $\left(\dfrac{dQ}{d\theta}\right)$

Principle of Method of Mixtures:

- If there are not heat loses, the quantity of heat gained by the cold body is equal to the quantity of heat at lost by the hot body
- If steam at 100^0C is mixed with ice at 0^0C is mixed with ice at 0^0C such that mass of each is m grams

  a) resultant temperature of the mixture is 100^0C b) mass of steam condensed is $\dfrac{1}{3}$ gram c) mass of water is $\dfrac{4m}{3}$ gram at 100^0C d) $\dfrac{2}{3}$ grams of steam remains uncondensed
- If X grams of ice at 0^0C is mixed with Y grams of steam at 100^0C, the temperature of the resulting final mixture is $\dfrac{80(8X - Y)}{(X + Y)}$

Equivalence between Heat & Work:

- The amount of work performed is directly proportional to the amount of heat produced $W \propto H$ or $W = JH$
  J is Mechanical equivalent of heat or Joule's constant
  $J = 4.2$ Joule/cal or $4.2\text{x}10^7$ erg/cal
- If a body of mass *m* falls from height *h* and its P.E converts into heat then
  $mgh = J\,(ms\theta)$ ($ms\theta$ is calories mgh in joules or ergs)

  then $\theta = \dfrac{gh}{Js}$

  If that body falls from height h_1 and rebounds to height h_2, then $mg\,(h_1 - h_2) = J\,ms\theta$

  $\theta = \dfrac{g(h_1 - h_2)}{Js}$

  If the body falls from height h and only $\dfrac{1}{n}^{\text{th}}$ of its PE converts into heat

  then $\dfrac{mgh}{n} = J\,(ms\theta)$ and $\theta = \dfrac{gh}{nJs}$

  $Q = mL$ where *L* is the latent heat.

a) Latent heat of fusion of ice = 336×10^3 J/kg or 80 calories / gram
b) Latent heat of steam = 226×10^4 J/kg or 540 caloreis / gram
c) Specific heat of water = 1000 kg / m^3 per K or 1 calories per gram per centigrate

- If an ice block of ice is dropped from a height h which completely melts on reaching the ground then $mgh = JmL$
  or $h = \frac{JL}{g}$ (mL is in calories)
- When a body of mass 'm' moving with velocity V (ex: bullet) is stopped and still its K.E is converted into heat energy then
  $\frac{1}{2}mV^2 = J(ms\theta)$, $\theta = \frac{V^2}{2Js}$
- If an ice block of mass M is dragged on a rough horizontal surface with a constant velocity V, through a distance d, and work done against friction is used as heat which melts ice of mass m then $\mu Mgd = JmL$
  $m = \frac{\mu Mgd}{JL}$, Here d = Vt
- An ice block of mass M moving with velocity ν is stopped, before coming to rest the amount of ice melted is m. Then $\frac{1}{2}M\nu^2 = JmL$ and $m = \frac{M\upsilon^2}{2JL}$

Internal Energy (U):

- Internal energy of a gas is independent of pressure and volume. It depends only on temperature
- If temperature is constant internal energy is constant (dU = 0). The internal energy increases or decreases as temperature of gas increases or decreases respectively.
- The change in internal energy of an ideal gas is $dU = mC_v dT$ interms of molar specific heat $dQ = nC_v dT$.
- For an ideal gas change in internal energy $dU = \frac{3}{2}KT$ (for each molecule)

Work done by a System:

- Work is defined as the energy that is transferred from one body to the other due to a force that acts between them
- If the volume of a system increases in process then work is done by the system. Here work done by the system is taken as positive
- If the volume of a system decreases in a process then work is done on the system. Here work done by the system is taken as negative
- The amount of work done by a system as it expands or contracts is given by
  $\int dW = \int_{V_1}^{V_2} PdV$
- In a cyclic process work done is equal to the area under the PV graph. It is positive at the cyclic is clockwise and negative if the cycle is anticlockwise

QUESTION BANK

Conceptual Questions

1) When mechanical energy is converted to heat energy
   1) it is lost for ever   2) it can be completely recovered
   3) part of it can be recovered   4) it always makes the object hotter
2) Heat capacity expressed in grams is
   1) water equivalent 2) specific heat 3) latent heat 4) mechanical equivalent of heat
3) The substance which has maximum specific heat among solids, liquids and gases
   1) water   2) hydrogen   3) silver   4) germanium

4) In free expansion of a gas
   1) internal work is done   2) internal work is not done
   3) temperature increases   4) total change in energy is not zero
5) A monatomic gas molecule has
   1) four degrees of freedom   2) three degrees of freedom
   3) five degrees of freedom   4) six degrees of freedom
6) If the temperature scale is changed from 0^0 to ^0F the numerical value of specific heat Will
   1) remain unchanged   2) increase   3) decrease   4) none of the above
7) If a cylinder containing a gas at high pressure explodes, the gas undergoes
   1) irreversible adiabatic change and rise of temperature
   2) irreversible adiabatic change and fall of temperature
   3) reversible adiabatic change and fall of temperature
   4) reversible adiabatic change and rise of temperature
8) During an isothermal process, which of the following is not true.
   1) Internal energy does not change   2) Temperature remains constant
   3) No heat enters or leaves the system   4) None of the above
9) The internal energy of a gas will increase when it
   1) expands adiabatically   2) expands isothermally
   3) is compressed isothermal   4) is compressed adiabatical
10) Water is used to cool the radiators of engine in motor car because of
    1) its high specific heat   2) its lower density
    3) its easily availability   4) its low temperature
11) Can two isothermal curves cut each other?
    1) they will cut when temperature is 0^0C
    2) yes, when the pressure is critical pressure   3) never   4) yes
12) The physical property of the system that does not change in reversible adiabatic process is
    1) temperature   2) disorder state   3) volume   4) internal energy
13) During adiabatic process the specific heat of a gas is
    1) 0   2) infinite   3) finite   4) none
14) To increase the internal energy of system, energy can be transferred to a system
    1) by mechanical method   2) by a non-mechanical method
    3) by both mechanical and non-mechanical method   4) by none of the above the methods

15) During the free expansion there is no internal work done by the molecules against the force of attraction. This is in accordance with the
1) Joule's law 2) Mayer's hypothesis
3) Avogadro's hypothesis 4) Joule's law or Mayer's hypothesis

16) The gas law (PV/T) = constant is true for
1) adiabatic change only 2) isothermal change only
3) adiabatic and isothermal changes 4) neither isothermal nor adiabatic changes

17) The molar heat capacity of an ideal gas at constant pressure is greater than that at constant volume because
1) work has to be done against intermolecular forces at the gas expands
2) work has to be done against external pressure as the gas expands
3) molecules rotate more easily when the gas expands 4) none of these

18) The work done in an isothermal expansion of a gas depends upon
1) temperature only 2) expansion ratio only
3) neither temperature nor expansion ratio
4)both temperature and expansion ratio

19) "It is impossible to convert total heat into work". This was enunciated by
1) Kelvin-Planck 2) Clausis 3) Joule and Thomson 4) Einstein

20) A process in which the temperature and pressure of a gas change at constant volume, is known as
1) Isothermal 2) Isochoric 3) Isobaric 4) adiabatic

21) Two samples A and B of a gas initially of the same temperature and pressure are compressed from a volume V to a volume V/2 such that A is compressed isothermally and B adiabatically. The final pressure of
1) A is less than that of B 2) A is greater than that of B
3) A is twice the pressure of B 4) A is equal to that of B

22) The best container for the gas during adiabatic process is
1) thermos flask 2) wooden vessel 3) glass vessel 4) adiabatic expansion

23) If γ denotes the ratio of the two specific heats of a gas, the ratio of the slope of adiabatic and isothermal
1) γ 2) $1/\gamma$ 3) $\gamma+1$ 4) $\gamma-1$

24) In which process P-V diagram is a straight line parallel to the volume axis?
1) Isothermal 2) Isochoric 3) adiabatic 4) isobaric

25) Which entinguishes a fire most quickly
1) cold water 2) boiling water 3) hot water 4) ice

26) When a gas expands adiabatically
1) no energy is required for expansion
2) internal energy of the gas is used in doing the work
3) energy is required and it comes from the wall of the container of the gas
4) law of conservation of energy does not hold good

27) Ships in the sea cannot be sailed by utilising large amount of heat from sea water because
1) high surface tension 2) low temperature 3) high atmospheric pressure
4) it is not possible to convert total heat energy into mechanical energy.

28) During change of state
1) the heat may be absorbed 2) the heat may be liberated

3) there is no absorption or emission of heat 4) heat may be absorbed or liberated

29) During melting the specific heat of a substance is

1) constant 2) changes 3) 0 4) infinite

30) In a cyclic process

1) work is done by the system 2) work done is zero

3) work done depends upon the quantity of heat given to the system or taken

4) work done on the system

Keys

1) 3	2) 1	3) 2	4) 2	5) 2	6) 3	7) 2	8) 3	9) 4	10) 1
11) 3	12) 2	13) 1	14) 3	15) 4	16) 3	17) 2	18) 4	19) 1	20) 2
21) 1	22) 1	23) 1	24) 4	25) 2	26) 2	27) 4	28) 4	29) 4	30) 3

Numerical Problems

Heat And Energy:

31) 30Kcal of heat is required to raise the temperature of 15kg of substance from 20^0C to 40^0C then thermal capacity of the substance

1) 1.5Kcal/^{0}C 2) 3Kcal/^{0}C 3) 2Kcal/^{0}C 4) 4Kcal/^{0}C

32) Two spheres of radii in the ratio 2:3, have specific heats in the ratio 3:4. Their densities are in the ratio 4:5. Their water equivalents are in the ratio

1) 2:5 2) 4:15 3) 8:45 4) 45:8

33) A bullet moving with a velocity of $42ms^{-1}$ strikes a wall and gets stopped. If its kinetic energy is converted into heat and it is taken by the bullet, rise in temperature of the bullets is (specific heat of lead is $126Jkg^{-1}k^{-1}$)

1) 7^0C 2) 14^0C 3) 28^0C 4) 0.7^0C

34) A body of mass 21kg is dragged on a horizontal rough road with a constant speed of 20Km/hr. If the coefficient of friction is 0.5. Find the heat generated in one hour (g = $10m/s^2$, J = 4200J/Kcal)

1) 50 2) 500 3) 10 4) 1000

35) A piece of lead is dropped from a height of 210m. If 50% of its striking energy is converted into heat calculate the rise in temperature. Specific heat of lead = 0.03Kcal/Kg J = 4200J/Kcal and g = 10 m/s^2

1) 30^0C 2) 21^0C 3) $(25/3)^0$C 4) none

36) A body of mass 2kg is drawn with a velocity of 2m/s on a horizontal table. If the coefficient of kinetic friction is 0.3 then calculate the heat produced in 5sec. g= $9.8m/s^2$

1) 5 2) 10 3) 14 4) 28

37) A man releases 270Kcal of heat in 1 hour during physical exercise. Then the amount of sweat evaporated from his body is (Assume , L= 540cal/gm)

1) 0.54kg 2) 0.5kg 3) 0.27kg 4) 0.1kg

38) A bullet of mass moving with a velocity of 500m/s strikes a wall and all its energy is converted into heat. The temperature raises by 20^0C.If the same bullet strikes the same wall the velocity of 1Km/s, the temperature will be -----0^0C.

1) 80 2) –10 3) 60 4) 50

39) A 0.1kg steel ball falls from a height of 10m and becomes to a height of 7m. The rise in temperature of the ball is (S = 0.1 Kcal/Kg/^{0}C)

1) 0.05^0C 2) 0.064^0C 3) 0.06^0C 4) 0.07^0C

40) A body moves through a distance of 30m against a frictional force of 100N. If the work is completely converted into heat the rise in temperature if the specific heat of the material of the body is 600J $kg^{-1}k^{-1}$

1) 5^0C 2) 2.5^0C 3) 0.25^0C 4) 10^0C

41) Water falls from a height of 10m assuming that the whole of the energy due to fell is converted into heat calculate rise in temperature of water (g = $10m/s^2$, J = 4200J/Kcal)--^0C

1) 0.1 2) 0.2 3) 0.5 4) 0.7

42) A man gets 100Kcal heat by eating a bread. His efficiency is 28% and his mass is 60Kg. How high he can rise after eating the bread? [g = $9.8m/s^2$]

1) 20Km 2) 2Km 3) 20m 4) 200m

43) A body of mass 200g requires 252J for 10^0C rise of temperature its thermal capacity is

1) $126Jk^{-1}$ 2) $504Jk^{-1}$ 3) $0.126Jk^{-1}$ 4) $25.2Jk^{-1}$

44) If two substances have specific heats in the ratio 2:3 and densities in the ratio 6:5, their thermal capacities per unit volume are in the ratio

1) 4:5 2) 5:4 3) 5:9 4) 9:5

45) A mass of 300gm falls a height of 3m (g= $9.8m/s^2$). Assuming that the whole energy is converted into heat calculate the amount of heat produced.

1) 2cal 2) 2.1cal 3) 4cal 4) 4.2cal

46) Two spheres A and B of masses in the ratio 1:2, specific heats in the ratio 2:3 fall from heights h_1:h_2. On reaching the ground the increase in temperature are the same. Then h_1/h_2=

1) 3:2 2) 9:4 3) 2:3 4) 4:9

47) A metallic ball moving with a velocity of $60ms^{-1}$ comes to rest after striking a target. If 75% of heat generated remains in the ball, the rise of temperature of the ball is ($S=120Jkg^{-1}k^{-1}$)

1) 11.25^0C 2) 11.50^0C 3) 11.75^0C 4) 20^0C

48) In a water fall the temperature of water rises by 0.98^0C on reaching the bottom. Then height of that water fall is

1) 210m 2) 2100m 3) 420m 4) 4200m

49) The time taken by an electric heater to rise the temperature of 100cc of water through 10^0C is 7s.

1) 420KW 2) 42KW 3) 4.2KW 4) 0.42KW

50) An ice block is projected vertically up with a velocity 20ms-1 . Find the amount of ice that melts when it reaches the ground if the mass of ice block is 4.2kg

1) 2.5gm 2) 2.5kg 3) 0.25kg 4) 0.25gm

Keys

31) 1	32) 3	33) 1	34) 2	35) 3
36) 3	37) 2	38) 1	39) 4	40) 1
41) 3	42) 4	43) 4	44) 1	45) 2
46) 3	47) 1	48) 3	49) 4	50) 1

Calorimetry

51) 200gm of water at 30^0C is mixed with an equal amount of water at 60^0C. Then resultant temperature of the mixture is

1) 45^0C 2) 90^0C 3) 50^0C 4) 48^0C

52) A body absorbs 1000calories of heat when it is heated from 20^0C to 70^0C. The water equivalent of that body is

1) 10gm 2) 20gm 3) 15gm 4) 25gm

53) If a gm of substance at $t_1{}^0C$ rise of temperature requires as much heat of 'b' gm of water at $t_2{}^0C$ rise of temperature , the specific heat of the substance is

1) bt_1/at_2 2) bt_2/at_1 3) at_1/bt_2 4) at_2/bt_1

54) If there no heat losses, the heat released by the condensation of x gm of steam at 100^0C into water at 100^0C can be used to convert y gm of ice at 0^0C into water at 100^0C. Then the ratio y:x is

1) 3:1 2) 1:1 3) 1:3 4) 2:1

55) The amount of water of mass 20gm at 0^0C mixed with 40gm of water at 10^0C. Find temperature of the mixture is

1) 20^0C 2) 6.66^0C 3) 5^0C 4) 0^0C

56) It takes 15 minutes for an electric kettle to heat certain quantity of water from 0^0C to the boiling point 100^0C into steam. Then latent heat of steam is

1) 533.33cal/gm 2) 533cal/gm 3) 529.33cal/gm 4) 532.33cal/gm

57) How much of liquid at 200^0C must be added to 50gm of the same liquid at 20^0C so that the temperature of the mixture becomes 70^0C

1) 19.2gm 2) 18.2gm 3) 17.2gm 4) 16.2gm

58) Heat required to convert 2Kg of ice at -10^0C into steam at 100^0C is (S.P heat of ice =0.5, L for ice = 80 Kcal/Kg)

1) 1450Kcal 2) 145Kcal 3) 14.5Kcal 4) 1.45Kcal

59) The densities of two substances are in the ratio 3:4 and their SP .heats are in the ratio 2:3. The ratio of the thermal capacities of equal volumes of the substances is

1) 1:2 2) 2:1 3) 8:9 4) 9:8

60) A copper calorimeter weighing 0.1kg contains 0.2kg of water at 20^0C. The mass of the ice that should be added to the water in the calorimeter so that the temperature falls to 10^0C is
(specific heat of copper =$420Jkg^{-1}k^{-1}$; Latent heat of fusion of ice=$336000Jkg^{-1}$)

1) 2.33kg 2) 0.02333kg 3) 0.233kg 4) 3.233kg

61) A 20 gm of ice of originally at -20^0C.How much steam at 100^0C should be passed so that ice is changed to water and the resultant temperature becomes 45^0C?
(SP.heat of ice = 0.5) ------gm.

1) 3gm 2) 4gm 3) 4.53gm 4) 5.96gm

62) A liquid of specific heat 0.5 at 60^0C is mixed with another liquid of specific heat 0.3 at 20^0C. After mixing the temperature of the mixture becomes 30^0C . In what proportion by masses are the liquids mixed?----

1) 1:1 2) 1:2 3) 1:5 4) 1:7

63) 5gm of steam at 100^0C is passed into 50gm of ice at 0^0C, If the latent heat of ice is 80cal/gm and the latent heat of steam is 540cal/gm the resultant temperature is ----

1) 10^0C 2) 50^0C 3) 0^0C 4) -10^0C

64) Two liquids A and B are at temperature of 75^0C and 15^0C respectively. Their masses are in the ratio 2:3 and their specific heat are in the ratio 3:4 . The resultant temperature of the mixture if the liquids A and B mixed -----is

1) 35^0C 2) 75^0C 3) 80^0C 4) none

65) The amount of heat required to convert 10gm of ice into water at 20^0C is
1) 80cal 2) 100cal 3) 1000cal 4) 1Kcal

66) Boiling water at 100^0C and cold water at t^0C are mixed in the ratio 1:3 to give a mixture at 37^0C. Then t =
1) 10^0C 2) 12^0C 3) 13^0C 4) 16^0C

67) 540gm of ice at 0^0C is mixed with 540gm of water at 80^0C. The temperature of the mixture will be
1) 0^0C 2) 40^0C 3) 50^0C 4) 120^0C

68) Heat required to convert 1gm of ice at 0^0C into steam at 100^0C is
1) 100cal 2) 720cal 3) 0.01Kcal 4) 1Kcal

69) If 1gm of ice at 0^0C and 1gm of water 100^0C are mixed. What is the resultant temperature of that mixture?
1) 0^0C 2) 10^0C 3) 30^0C 4) 100^0C

70) If x gm of steam at 1000C converts y gm of ice at 0^0C into water at 100^0C, they x:y=
1) 1:3 2) 3:1 3) 1:2 4) 2:1

Keys

51) 1	52) 2	53) 3	54) 1	55) 2
56) 1	57) 2	58) 1	59) 3	60) 2
61) 3	62) 4	63) 3	64) 2	65) 3
66) 1	67) 1	68) 2	69) 2	70) 1

TRANSMISSION OF HEAT:

Thermal Conduction & Convection: **Methods of Heat Transmission**:

- There are three methods of heat transmission
- **Conduction**: The process of heat transfer through a medium from molecule to molecule through their vibrations without any change in their mean positions. It takes mainly in solids
- **Convection**: The process of heat transfer from one part of the fluid to another part by the actual motion of the particles of the fluid. It takes place in fluids
- **Radiation**: The process of heat transfer from one place to another place without heating the intervening medium (if present). Heat transfer from the sun to the earth is by radiation

Thermal Conduction:

- The process of heat transfer in a body without the actual movement of the particles of the body is called thermal conduction
- Materials like silver, copper are good conductors of heat whereas wood, glass etc, are poor conductors
- In general, metals are good conductors of heat

Thermal Conductivity:

- $Q = \frac{KA(\theta_1 - \theta_2)t}{l}$

- The quantity of proportionality known as coefficient of thermal conductivity of the side, which are maintained at a temperature difference of one degree is known as coefficient of thermal conductivity
- The rate of flow of heat across the material of the block between its parallel faces is given by $\frac{dQ}{dt} = -KA\left(\frac{d\theta}{dx}\right)$

  Here $\left(\frac{d\theta}{dx}\right)$ is known as temperature gradient. Here negative sign indicates that the temperature decreases as the distance increases in the direction of flow of heat
- The rate of flow of heat per unit area unit temperature gradient is known as coefficient of thermal conductivity
- The unit of K is $Js^{-1}\ m^{-1}\ K^{-1}$ or $Wm^{-1}\ K^{-1}$ (SI) and cal $s^{-1}\ cm^{-1}\ {}^{0}C^{-1}$ in CGS system. The dimensions of K are $MLT^{-3}\theta^{-1}$.

Thermal Resistance:

- R_{Th} is known as thermal resistance of the conductor R_{Th}.

  $$R_{Th} = \frac{(\theta_1 - \theta_2)}{\left(\frac{dQ}{dt}\right)} = \frac{1}{KA}$$

Junction or Slabs in Series:

- If two rods are in series, heat flowing per second is same in each rod.

Rods or Slabs in Parallel:

- When two rods of same length are connected in parallel

  $$K = \frac{K_1 + K_2 + K_3 + ------ + K_n}{n}$$

- Two rods of different materials have different dimensions and different conductions. If the flow rate of heat through those two rods is to be same, (for the same temperature difference between the ends)

  $$\frac{Q}{t} = \frac{K_1A_1(\theta_1 - \theta_2)}{l_1} = \frac{K_2A_2(\theta_1 - \theta_2)}{l_2}$$

  $$\Rightarrow \frac{l_1}{K_1A_1} = \frac{l_2}{K_2A_2}, \quad \Rightarrow \frac{l_1}{K_1} = \frac{l_2}{K_2} \text{ if } A_1 = A_2$$

  $K_1A_1 = K_2A_2$ if $l_1 = l_2$

  $K_1r_1^2 = K_2r_2^2$

Convection:

- It is the heat transfer by the actual displacement of the particles of the medium
- Convection is of two types a) Natural convection and b) Forced convection
- In natural convection, particles of the fluid move by healing (i.e, it takes place in the still fluid)
- In forced convection particles of the fluid are forced to move by a blower or fan etc.

Radiation & its Features:

- The process by which heat is transferred from one body to another without requiring any medium is called radiation
- Thermal radiation travels through vacuum with the same velocity as light

- Thermal radiation undergoes, reflection and refraction like light
- Thermal radiation exhibits interference, diffraction and polarisation like light
- Intensity of heat radiation varies inversely with square of the distance from the source.

  $I \propto \frac{1}{r^2}$

Prevost's Theory of Heat Exchanges:

- Every body emits heat radiations to its surroundings and at the same time it receives heat radiation from the surroundings
- All bodies radiate temperature heat radiations at all temperatures above absolute zero
- When the body is in thermal equilibrium with the surroundings, then heat radiated by the body is equal to the heat absorbed from the surroundings
- The fall or rise in temperature of a body is the net result of the exchange of heat between the body and the surroundings
- At absolute zero, this law is not applicable

Emissive & Absorptive Powers:

- The amount of radiation emitted by a body per second per unit area is known as its emissive power (e).

  SI unit of e is Wm^{-2}
- If Q is the radiant heat emitted by a body of surface area A n time t,

  $e = \frac{Q}{At}$ and $e_\lambda = \frac{e}{d\lambda}$
- e_λ depends on temperature of the body, nature of surface of the body and wavelength. For a perfect black body $e_\lambda = 1$.
- Absorptive power of a body at a given temperature and wavelength is the ratio of the amount of heat energy absorbed to the amount of heat energy incident on it is wavelength range from λ to λ+dλ. It is denoted by a_λ.
- If dQ is the amount of heat energy between the wavelengths λ and λ+dλ incident per unit area of the surface of the absorber, then the amount of heat energy absorbed per unit area of surface per sec and per unit wave length at a particular temperature is d Q_λ, then

  $a_\lambda = \frac{dQ_\lambda}{dQ}$
- For an ideal black body a_λ=1
- Ratio between emissive power of a surface and emissive power of a black body at the same temperature is known as emissivity (∈ or e). ∈or e = $\frac{e_\lambda}{E_\lambda}$

Black Body Radiation:

- A black body is one that absorbs all the radiations incident on it. It neither reflects nor transmits any radiation incident on it
- For an ideal black body absorptive power is unity
- The body which when heated to high temperature emits radiations of all wavelengths is known as ideal black body
- For an ideal black body reflectance and transmittance are zero

Kirchhoff's law:

- The ratio of the emissive power to the absorptive power of a given wave length is the same for all bodies at the same temperature and is equal to the emissive power of a perfectly blackbody at all temperature

  $\frac{e_\lambda}{a_\lambda} = E_\lambda$

- Kirchoff's law suggests that good absorbs of heat are good emitters also
- The emissive power of a surface is directly proportional to the absorptive power

  $\Rightarrow e_\lambda = a_\lambda$

- Since E_λ increases with temperature, the ratio $\frac{e_\lambda}{a_\lambda}$ also increases with the temperature
- Emissivity of a body is equal to its absorptive power

Applications of Kirchoff's law:

- Explains the existence of dark lines in the solar spectrum (Fraunhoffer lines)
- When a piece of decorated china disc is heated to a high temperature and suddenly placed in the dark room, the decorated portion containing black spot appears brighter

Stefan's law:

- The radiant energy emitted by a perfectly black body per unit area per second is directly -+\.bvgftr54proportional to the fourth power of its absolute temperature

$E \propto T^4$ or $E = \sigma T^4$

σ is proportionality constant called Stefan's constant ($\sigma = 5.6x10^{-8} Wm^{-2} K^{-4}$)

If the body is not a perfectly black body,

$E = \in\sigma T^4$, $\in$ is emissity or relative emittance ($0<\in<1$)

Stefan-Boltzmann's law:

- If a black body at absolute temperature T is surrounded by another black body or enclosure at temperature T_0, then the heat radiated by the body per second per unit area is given by

  $E = \sigma (T^4 - T_0^4)$, (T is absolute temperature of the body &T_0 is absolute temperature of the surroundings)

  $E = \in\sigma(T^4 - T_0^4)$ (if not a perfectly black body)

- From Stefan-Boltzmann's law we can deduce Newton's law of cooling
- The heat energy radiated per second from the surface of a body is $\frac{Q}{t} = \in A(T^4 - T_0^4)$

Newton's Law of Cooling:

- The rate of loss of heat by a hot body is proportional to the difference between the temperature of the body and its surroundings provided this difference is small

  $\frac{dQ}{dt} \propto (\theta - \theta_0)$, [$\theta$ is temperature of the body & θ_0 is temperature of surroundings]

- If a body cools by radiation from θ_1 to θ_2^0 C in time t, then

  $\frac{d\theta}{dt} = \frac{\theta_1 - \theta_2}{t}$ and $\theta = \left(\frac{\theta_1 + \theta_2}{2}\right)$ $\Rightarrow \left(\frac{\theta_1 - \theta_2}{t}\right) = K\left[\left(\frac{\theta_1 - \theta_2}{2}\right) - \theta_0\right]$

- When a body cools, the rate of fall of temperature is proportional to the excess of its temperature over the surroundings
- Newton's law of cooling is applicable when the lost of conduction is negligible and the heat lost by the body is mainly by radiation
- Newton's law of applicable if every part of the body is at the same temperature

Wien's displacement law:

- For a black body the wavelength corresponding to maximum energy of emission is inversely proportional to the absolute temperature of the black body

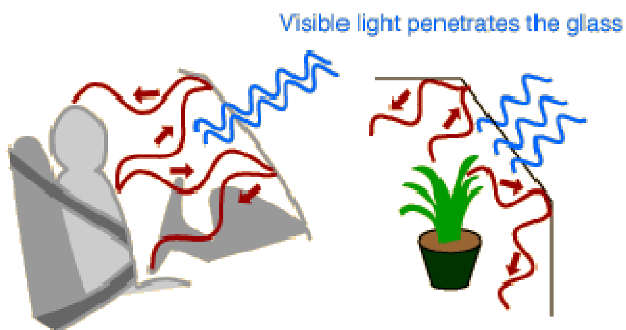
  $\lambda_m \propto \frac{1}{T}$ or $\lambda_m T$ = constant , λ_m is wavelength corresponding to maximum energy

  $\lambda_m T = b$, b is a constant and $b = 2.9\text{x}10^{-3}$mK

  $\lambda_1 T_1 = \lambda_2 T_2$

Greenhouse Effect

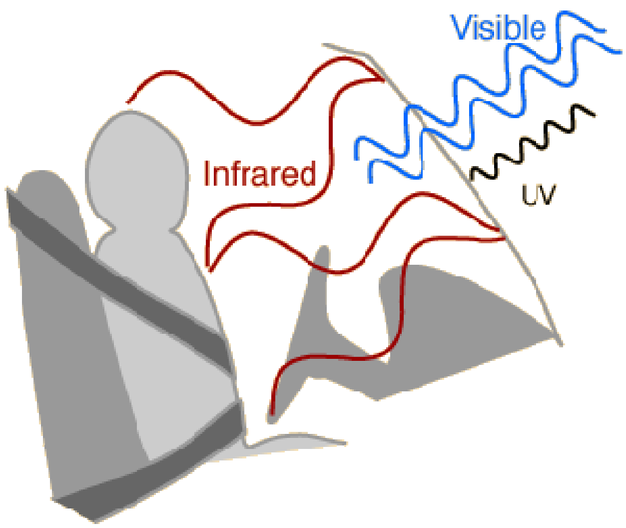
The greenhouse effect refers to circumstances where the short wavelengths ofvisible light from the sun pass through a transparent medium and are absorbed, but the longer wavelengths of the infrared re-radiation from the heated objects are unable to pass through that medium. The trapping of the long wavelength radiation leads to more heating and a higher resultant temperature. Besides the heating of an automobile by sunlight through the windshield and the namesake example of heating the greenhouse by sunlight passing through sealed, transparent windows, the greenhouse effect has been widely used to describe the trapping of excess heat by the rising concentration of carbon dioxide in the atmosphere. The carbon dioxide strongly absorbs infrared and does not allow as much of it to escape into space.



A major part of the efficiency of the heating of an actual greenhouse is the trapping of the air so that the energy is not lost by convection. Keeping the hot air from escaping out the top is part of the practical "greenhouse effect", but it is common usage to refer to the infrared trapping as the "greenhouse effect" in atmospheric applications where the air trapping is not applicable.

Greenhouse Effect Example

Bright sunlight will effectively warm your car on a cold, clear day by thegreenhouse effect. The longer infrared wavelengths radiated by sun-warmed objects do not pass readily through the glass. The entrapment of this energy warms the interior of the vehicle. The trapping of the hot air so that it cannot rise and lose the energy by convection also plays a major role.



Short wavelengths ofvisible light are readily transmitted through the transparentwindshield.

Shorter wavelengths of ultraviolet light are largely blocked by glass since they have greater quantum energies which have absorption mechanisms in the glass.

QUESTION BANK

Conceptual Questions:

1) In the solids, the substance which has maximum thermal conductivity
   1) copper 2) aluminum 3) silver 4) gold
2) Dimensional formula of coefficient of thermal conductivity is
   1) $ML^2T^{-2}K^{-1}$ 2) $MLT^{-3}K^{-1}$ 3) $M^{-1}L^{-1}T^{-2}K$ 4) $M^2L^2T^{-2}K$
3) The fall in temperature per unit length of material in steady state is called
   1) conduction 2) thermal conductivity 3) variable state 4) none
4) Two different metal rods of equal lengths and equal cross sectional area have their ends kept at same temperature, Q_1 & Q_2. If K1 and K2 are thermal conductivities, ρ_1, ρ_2 are their densities and S_1, S_2 are specific heats, then the rate of flow of heat in two rods will be same if
   1) $\frac{K_1}{K_2} = \frac{\rho_1 S_1}{\rho_2 S_2}$ 2) $\frac{K_1}{K_2} = \frac{\rho_1 S_2}{\rho_2 S_1}$ 3) $\frac{K_1}{K2} = \frac{\theta_2}{\theta_1}$ 4) $K_1=K_2$
5) The coefficient of thermal conductivity of a metal depends on
   1) the density of thermal conductivity 2) thickness of the metal
   3) area of plate 4) material of metals

6) A slab consists of two series layers of two different materials of same thickness ands having thermal conductivities K1 and K2. The eqvalent thermal conductivity of the slab is

1) K_1+K_2 2) K_1K_2 3) K_1+K_2/K_1K_2 4) $2K_1K_2/K_1+K_2$

7) Two rods of same length and areas of cross-section A_1 and A_2 have their ends at same temperature. K_1 and K_2 are thermal conductivities of two rods, the rate of flow of heat is same in both the rods if

1) $\frac{A_1}{A_2} = \frac{K_1}{K_2}$ 2) $\frac{A_1}{A_2} = \frac{K_2}{K_1}$ 3) $A_1A_2= K_1K_2$ 4) placed in hot air

8) On heating one end of rod, the temperature of whole rod will be uniform when

1) K=1 2) K=0 3) K=100 4) K=infinity

9) When thermal conductivity is determined , the rod must be heated

1) at one end 2) at both ends 3) throughout 4) at middle and at end

10) Before steady state the flow of heat is regulated by

1) thermal diffusivity 2) thermal equilibrium
3) thermal conductivity 4) temperature

11) Which of the following is a good emitter

1) black and polished 2) white and rough
3) white and polished 4) black and rough

12) When the temperature of black body rises, the wavelength corresponding to the maximum intensity (λ_m)

1) decreases 2) increases
3) it may increase or decrease depending upon the nature of the black body
4) it may increase or decrease depending upon the scale of temperature

13) The substance which are transparent to thermal radiation's are

1) athermanous 2) diathermanous 3) water vapour 4) none of these

14) A mechanism of equalization of temperature of a body by thermal radiation's, with that of its surroundings was proposed by

1) Newton 2) Stefan 3) Kirchhoff 4) Prevost

15) According Prevost's theory of exchanges

1) every body above zero Kelvin radiates energy
2) the rate of emission increases with the temperature of the body
3) the radiation does not depend upon the surroundings and surrounding temperature
4) all the above

16) In the following which statements is correct?

1) a hot body emit hot radiation's only
2) a cold body absorbs radiation's only
3) a cold body emits cold radiation's only
4) all bodies emit and absorb radiation's simultaneously

17) Heat radiation's cannot exhibit the following phenomenon. That is

1) interference 2) diffraction 3) polarisation 4) beats

18) When a piece of yellow glass is heated in a dark room it appears in

1) yellow colour 2) Blue colour 3) Red colour 4) Green colour

19) The prominent lines in frunhoffer lines in a solar spectrum are due to

1) hydrogen is Sun's atmosphere 2) helium is Sun's atmosphere
3) nitrogen is Sun's atmosphere 4) carbon in Sun's atmosphere

20) When a piece of Blue glass is heated in a dark room it appears in
1) Yellow colour 2) Blue colour 3) Red colour 4) Green colour

21) A red coloured body is kept in yellow light. The which colour does it appear?
1) Red 2) Yellow 3) Black 4) White

22) If the temperature of the sun is doubled then
1) emission of energy will be doubled
2) 2) emission of energy will become four times
3) mostly ultra violet radiation's will be emitted
4) mostly infrared radiation's will be emitted

23) Newton's law of cooling is also applicable to
1) forced convection losses 2) convection losses
3) natural convection losses 4) none

24) The radiation emitted by a perfectly black body is proportional to
1) temperature on ideal gas scale
2) fourth root of temperature on ideal gas scale
3) fourth power of temperature on ideal gas scale
4) square of temperature on ideal gas scale

25) An electric heater, kept in vacuum is heated continuously by passing electric current, Its temperature will
1) go on rising with time
2) stop rising after some time as it will lose heat to surroundings by conduction
3) will rise for some time and there after will start falling
4) will become constant after some time due to loss of heat by radiation

26) Three identical spheres of different materials iron, gold and silver are at the same temperature. The one that radiates more energy is
1) gold 2) silver 3) iron 4) all radiates equally

27) The spectrum from a black body radiation is
1) line spectrum 2) band spectrum
3) continuous spectrum 4) line and band spectrum

28) The absorption coefficient of the perfectly black body is
1) 0 2) <1 3) unity 4) more than 1

29) At 0^0C body emits
1) no radiation 2) electromagnetic radiation of single wavelength
3) electromagnetic radiation of all wave lengths that are emitted by it at room temperature
4) electromagnetic radiation of fewer wavelength than that are emitted by it at room temperature

30) A perfectly black body is one whose emissive power is
1) 0 2) unity 3) maximum 4) minimum

Keys

1)3	2)2	3)2	4)4	5)4
6)4	7)2	8)4	9)3	10)1
11)4	12)1	13)2	14)4	15)4
16)4	17)4	18)2	19)1	20)3
21)3	22)3	23)1	24)3	25)4
26)4	27)3	28)3	29)1	30)3

Numerical Problems

31) One end of metal bar 25cm in length is in steam, other in contact with ice. If 12gms of ice melt per minute, conductivity of the metal is in cal/cm/sec/^{0}C(A= 5cm^2, latent heat of ice =80 cal/gm)
1) 0.8 2) 0.4 3) 0.5 4) 0.6

32) Two cylindrical rods of lengths l_1, l_2 and radii r_1,r_2 have thermal conductivity K_1 and K_2 respectively. The ends of rods are maintained at same temperature difference. If $l_1=2l_2$, $r_1=r_2/2$. The rate of heat flow in them will be same if K_1/K_2 is
1) 1 2) 2 3) 4 4) 8

33) A rod of 40cm length and has temperature difference of 80^{0}C two ends. Another rod B is of 60cm length and has temperature difference of 90^{0}C, but has same area of cross-section . If the rate of flow of heat is same, then the ratio of thermal conductivities are
1) 3:4 2) 4:3 3) 1:2 4) 2:1

34) Two cylindrical rods of same material have the same temperature difference between their ends. The ratio of rates of flow of heat through them is 1:8. The radii of the rods are in 1:2, what is the ratio of their lengths
1) 2:1 2) 4:1 3) 1:8 4) 1:32

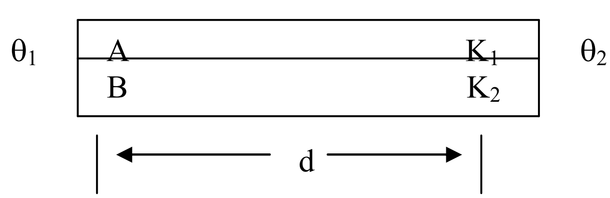
35) The ratio of thermal conductivity coefficients are different materials 5:3. If thermal resistance of rods of same thickness of these materials is same, then the ratio of lengths of these rods is
1) 3/5 2) 5/3 3) 2/7 4) 7/2

36) One end of a 0.25m long metal bar with area of cross section 5x10^{-2}m^2 is in steam and the other in contact with ice. If 2x10^{-3}Kg of ice melts per minute, what is thermal conductivity of the metal (L_{ice} = 80Kcal/Kg)
1) 20CGS units 2) 40 CGS units 3) 80 CGS units 4) 100 CGS units

37) Two metal rods are joined end to end. The lengths of the rods are in the ratio 1:2 and cross sectional areas are in the ratio 2:3. The free ends are maintained at 100^{0}C and 0^{0}C respectively. At the steady state it is found that the temperature difference across the ends of first rod is equal to that across the second rod. Find the ratio of coefficient of thermal conductivity of the two rods?
1) 1:3 2) 3:1 3) 2:3 4) 3:4

38) The ends of a metal rod of length 40cm are maintained at temperature 100^{0}C and 20^{0}C respectively. At steady state condition, what is the temperature at a point at a distance 30cm form the hot end of the rod?
1) 10^{0}C 2) 20^{0}C 3) 30^{0}C 4) 40^{0}C

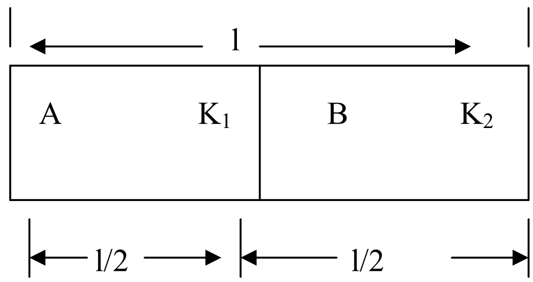
39) Two rods A and B of different materials are welded together in fig. If their thermal conductivities are K_1 and K_2 the thermal conductivity of the composite rod will be



1) $2(K_1+K_2)$ 2) $\underline{3}$ (K_1+K_2) 3) (K_1+K_2) 4) $\underline{1}$ (K_1+K_2)

2 2

40) Two slabs A and B of different materials, but of same thickness are joined as shown in fig. The thermal conductivities of A and B are K_1 and K_2 respectively. The thermal conductivity of composite bar will be



1) K_1+K_2 2) $\frac{1}{2}(K_1+K_2)$ 3) $\sqrt{K_1K_2}$ 4) $2K_1K_2/K_1+K_2$

Keys

31) 1	32) 4	33) 1	34) 1	35) 2
36) 3	37) 4	38) 4	39) 4	40) 4

Stefan's Law

41) A black body at 227^0C radiates energy at the rate of 10^5Jsec^{-1}cm^{-2}. To what temperature , it is to be heated so that it can emit the radiation at the rate of 10^9J/sec-cm^2.
1) 2270^0C 2) 4727^0C 3) 5000^0C 4) 2543^0C

42) At what rate is the energy radiated by a sphere of radius 5cm at 3000K and with an emissivity of 0.3? ($\sigma = 6x10^{-8}$ Wm^{-2} K^{-4})
1) 43.53x10^3W 2) 4.353x10^3W 3) 435.3x10^3W 4) 4353x10^3W

43) An electric heater emits 1000 watt of thermal radiation. The coil has a surface area of 0.020m^2. Assuming that the radiates like a black body , find its temperature (σ=6x10^{-8} Wm^{-2} K^{-4})
1) 1235K 2) 1124K 3) 737K 4) 955K

44) Two black bodies A and B 427^0C and 227^0C respectively are kept in evacuated chamber at 27^0C. The ratio of heat loss from A and B is nearly
1) 1:2 2) 2:1 3) 4:1 4) 1:4

45) Two spheres of the same material have radii 2m and 3m and temperatures 2000K and 1000K respectively. Then ratio of the energies radiated by them per second is
1) 64:9 2) 8:3 3) 1:36 4) 36:1

46) Two stars are at temperatures 2000K and 4000K then ratio of energy radiated per second per unit area from those is
1) 1:4 2) 4:1 3) 1:16 4) 16:1

47) A black body at 727^0C emits heat radiation. Then the heat energy emitted by unit area of its surface in one second (σ =5.67x10-5 Wm^{-2} K^{-4})
1) 5.7x10^{-8}Wm^{-2} 2) 5.7x10^{-4} Wm^{-2} 3) 5.7x10^{-2} Wm^{-2} 4) 5.7x10^4 Wm^{-2}

48) Calculate the energy radiated per minute from the filament of an incandescent lamp at 2000K , if the surface area is 5.0x10^{-8}m^{-2} and its relative emittance is 0.85
1) 1896J 2) 2.314J 3) 2456J 4) 1298J

49) A sphere 3cm radius acts like a black body. It is in equilibrium with its surroundings and absorbs 30KW of power radiated to it from the surroundings. What is the temperature of the sphere?

1) 3200K 2) 2200K 3) 2500K 4) 2600K

50) Two bodies A and B are placed in an evacuated vessel maintained at a temperature of 27^0C. The temperature of A is 327^0C and that of B is 227^0C. Find the ratio of heat loss from A and B

1) 1:3 2) 2:3 3) 3:1 4) 3:2

51) The energy emitted per second by a body at 1227^0C is E. Then the energy emitted per second by another body at 2727^0C is

1) E/16 2) 16E 3) 8E 4) E/8

Keys

41) 2	42) 1	43) 4	44) 3	45) 1
46) 3	47) 4	48) 2	49) 4	50) 3
51) 2				

Newton's Law of Cooling

52) The temperature of a liquid in a beaker falls from 95^0C to 90^0C in 6 minutes. If the room temperature is 70^0C. The temperature of the liquid after 15 minutes is

1) 77.5^0C 2) 75^0C 3) 80^0C 4) 82.5^0C

53) A body initially at 80^0C cools to 64^0C in 5 minutes and to 52^0C in 10 minutes. Then temperature of the surrounding is

1) 48^0C 2) 36^0C 3) 24^0C 4) 30^0C

54) A body cools from 60^0C to 50^0C in 5 minutes in a room at 30^0C. It cools from 50^0C to 40^0C in

1) 5 minutes 2) 7.5 minutes 3) 25/3 minutes 4) 10 minutes

55) A copper ball cools from 62^0C to 50^0C in 10 minutes and to 42^0C in the next 10 minutes. Then temperature of the surroundings is

1) 20^0C 2) 26^0C 3) 30^0C 4) 36^0C

56) The ratio of water equivalents of the liquids with calorimeters is 3:5. The ratio of the times taken to cool through same temperature difference for them if they cool under same conditions is

1) 3:5 2) 5:3 3) 3:8 4) 2:3

57) An object is cooled from 75^0C to 65^0C in 2 minutes in a room at 30^0C. The time taken to cool the same object from 55^0C to 45^0C in the same room in minutes is

1) 4 2) 5 3) 6 4) 7

58) A bucket full of hot water is kept in a room and it cools from 80^0C to 75^0C in time t_1, from 75^0C to 70^0C in time t_2 and from 70^0C to 65^0C in t_3 . Then

1) $t_1=t_2=t_3$ 2) $t_1<t_2<t_3$ 3) $t_1>t_2>t_3$ 4) $t_1<t_3<t_2$

59) In a room where the temperature is 30^0C a body cools from 61^0C to 59^0C in 4 minutes. The time in minutes taken by it cool from 51^0C to 49^0C is

1) 4 2) 6 3) 5 4) 8

60) The ratio of the masses of water and liquid is 4:5. The ratio of the times taken to cool to same temperature difference is 8:3. The specific heat of the liquid

1) 0.3 2) 0.6 3) 0.1 4) 0.8

61) The tea in a cup cools from 75^0C to 70^0C in 4 minutes. If the surroundings temperature is 30^0C, then time taken by it to cool from 70^0C to 65^0C is

1) 9 minutes 2) 8 minutes 3) 19 minutes 4) 4.5 minutes

62) The temperature of a liquid in a beaker falls from 77^0C to 73^0C in 3 minutes and from 73^0C to 69^0C in 4 minutes. Then room temperature is

1) 70^0C 2) 61^0C 3) 50^0C 4) 48^0C

63) Two liquids of masses in ratio 3:2 are cooled under similar conditions. The ratio of times taken by them to cool to same temperature difference is ¼. The ratio of their specific heats

1) 1:6 2) 3:8 3) 8:3 4) 6:1

Keys

52) 3	53) 3	54) 3	55) 2	56) 1
57) 1	58) 2	59) 2	60) 1	61) 4
62) 2	63) 1			

Wein's Displacement Law

64) A body at 1500K emits maximum energy at a wavelength $20,000A^0$. If the sun emits maximum energy at a wavelength of $5000A^0$, the temperature of the sun is

1) 375K 2) 24,000K 3) 12,000K 4) 6000K

65) A black body has a temperature of 2900K. When it cools, wavelength corresponding to maximum energy density changes by 9 micron. Then the temperature to which the body is cooled would be

1) 290K 2) 322K 3) 100K 4) 200K

66) If the wavelength corresponding to maximum emission of energy by a furnace is 2.9micsron then temperature of the furnace is ($b = 2.9x10^{-3}$ mK)

1) 727K 2) 727^0C 3) 1000^0C 4) None

67) A body A at a temperature of 5000K emits maximum radiation of wavelength $6000A^0$ what is the temperature of another body B which is emitting maximum radiation at wavelength $4000A^0$?

1) 266.6K 2) 7500K 3) 300K 4) 450K

68) Two stars A and B radiate maximum energy at $3600A^0$ and $4800A^0$ respectively. Then the ratio of the absolute temperatures of A and B is

1)4:3 2) 3:4 3) 81:256 4) 256:81

69) The temperature of furnace is 2324^0C and the intensity is maximum in its radiation spectrum nearly at $12000A^0$. If the intensity of spectrum of a star is maximum at $4800A^0$ nearly, then surface of temperature of that star is

1) 8400^0C 2) 7200^0C 3) 6500^0C 4) 6220^0C

70) The ratio of maximum wavelength of radiation emitted by the sun to the maximum wavelength emitted by the earth if surface temperatures of the sun and the earth are 6000K and 300K

1) 1:5 2) 5:1 3) 20:1 4) 1:20

Key:

64) 4	65) 1	66) 2	67) 2	68) 1	69) 4	70) 4

Previous Eamcet Questions

71) The radiation emitted by a star "A" is 10, 000 times that of the sun. If the surface temperature of the sun and the star A are 6000K and 2000K respectively, the ratio of the radii of the star A and the sun is (Eamcet 2003 E)

1) 300:1   2) 600:1   3) 900:1   4) 1200:1

72) A particular star (assuming it as a black body) has a surface temperature about $5x10^4$K.The wavelength in nano-meters at which its radiation becomes maximum (Eamcet 2003 M)

1) 48   2) 58   3) 60   4) 70

73) A black body of mass 34.38gm and surface area $19.2cm^2$ is at an initial temperature of 400K. It is allowed to cool inside an evacuated enclosure kept at constant temperature 300K. The rate of cooling is 0.04^0C per sec. The specific heat of the body in $Jkg^{-1}k^{-1}$ is (Eamcet 2004 E)

1) 2800   2) 2100   3) 1400   4) 1200

74) The absolute temperature of a body A is four times that of another body B. For the two bodies, the difference in wavelengths, at which energy radiated is maximum is two bodies, the difference in wavelengths, at which energy radiated is maximum is 3.0μm. Then the wave length at which the body B radiates maximum energy in micrometer is (Eamcet 2004 M)

1) 2   2) 2.5   3) 4.0   4) 4.5

Keys

71) 3   72) 2   73) 3   74) 3

Transmission of heat Previous Eamcet Questions

1) Two identical bodies have temperature 277^0C and 67^0C. If the surroundings temperature is 27^0C, the ratio of loss of heats of the two bodies during the same interval of time is (approximately):

1) 4:1   2) 8:1   3) 12:1   4) 16:1   [2005E]

2) Two bodies of same shape, same size and same radiating power have emissivities 0.2 and 0.8. The ratio of their temperatures is: [2005M]

1) $\sqrt{3}:1$ 2) $\sqrt{2}:1$ 3) $1:\sqrt{5}$ 4) $1:\sqrt{3}$

3) Two solid spheres A and B made of the same material have radii r_A and r_B respectively. Both the spheres are cooled from the same temperature under the conditions valid for Newton's law of cooling. The ratio of rate of change of temperatures of A and B is [2006E]

1) $\frac{r_A}{r_B}$ 2) $\frac{r_B}{r_A}$ 3) $\frac{r_A^2}{r_B^2}$ 4) $\frac{r_B^2}{r_A^2}$

4) A black body radiates energy at the rate of 'E' watt/m^2 at a high temperature T^0K, when the temperature is reduced to $(T/2)^0$K, the radiant energy is [2007E]

1) E/2   2) 2E   3) E/4   4) E/16

5) The power of a black body at temperature 200K is 544 watt. Its surface area is ($\sigma = 5.67 \times 10^{-8} Wm^{-2}K^{-4}$). [2007M]

1) $6 \times 10^{-2}m^2$ 2) $6m^2$ 3) $6 \times 10^{-6}m^2$ 4) $6 \times 10^2m^2$

KEYS: 1) 4   2) 2   3) 2   4) 4   5) 2

Matching Type Questions

1) Study the following

List-I	List-II
a) Method of transfer of heat without the movement of the particles	e) Radiation
b) Method of transfer of heat with the movement of the particles	f) conduction
c) Method of transfer of heat without any medium	g) thermal conductivity
d) Ability to conduct heat in a medium	

1) a→f; b→h; c→e; d→g 2) a→h; b→e; c→g; d→f
3) a→e; b→g; c→h; d→f 4) a→g; b→e; c→f; d→h

2) Column I consists three physical quantities. Select the appropriate formula for these from the choice given in column II.

List-I	List-II
a) Coefficient of thermal conductivity	d) KV/ms
b) Thermal resistance	e) $Ql/A(\theta_1-\theta_2)t$
c) Diffusivity	f) $(\theta_1-\theta_2)/(dQ/dt)$

1) a→e; b→f; c→d 2) a→e; b→d; c→f
3) a→d; b→f; c→e 4) a→f; b→e; c→d

3) Study the following

List-I	List-II
a) Pyrometry	e) Resistance
b) Bolometer	f) convection
c) Searle's apparatus	g) Thermo electricity
d) uniform temperature enclosure	h) thermal conductivity
	i)black body

1) a→g; b→e; c→h; d→i 2) a→e; b→g; c→h; d→i
3) a→g; b→e; c→i; d→h 4) a→f; b→e; c→h; d→I

Keys

1)1 2)2 3)1

Assertion And Reason Type Questions

Directions:

These questions consist of two statements as Assertion and Reason. While answering these questions you are required to choose any of the following four.

A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B) If both Assertion and Reason are true, but Reason is not correct explanation of the Assertion.

C) If Assertion is true, but the Reason is false.

D) If Assertion is false, but the Reason is true.

1) A: The SI unit of thermal conductivity is watt m^{-1} K^{-1}.

R: Thermal conductivity is a measure of ability of the material to allow the passage of heat through it.

1) A 2) B 3) C 4) D

2) A: Coefficient of thermal conductivity of a metal rod is a function of length of the rod.

R: Longer the rod, smaller is the amount of heat conducted.

1) A 2) B 3) C 4) D

3) A: Two bodies at different temperatures , if brought in thermal contact do not necessary settle to the mean temperature.

R: The two bodies may have different thermal capacities.

1) A 2) B 3) C 4) D

4) A: Greater is the coefficient of thermal conductivity of a material, smaller is the thermal resistance of a rod of that material.

R: Thermal resistance is the ratio of temperature difference between the ends of the conductor and the rate of flow of heat.

1) A 2) B 3) C 4) D

5) A: The material of cooking utensils should have low specific heat and high conductivity.

R: Low specific heat means low absorption of heat and high conductivity means faster flow of heat.

1) A 2) B 3)C 4) D

Keys

1)2 2)4 3)1 4)2 5)3

CHAPTER 13
THERMODYNAMICS

Zeroth Law of Thermodynamics:

- If two systems A and B are seperately in thermal equilibrium with a third system then the first two systems must be in thermal equilibrium with each other

First Law of Thermodynamics:

- If heat is supplied to a system which is capable of doing work, then quantity of heat absorbed by the system will be equal to the sum of the external work done by the system and the increase in its internal energy i.e $dQ = dU + dW$
- If heat is given to a system it is +ve
  If heat is given out by a system it is –ve
  If work is done by the system it is +ve
  If work is done on the system it is -ve
- This law defines the internal energy as a thermodynamical function of state which though depends on initial and final position of the state, is path independent
- This law is a statement of conservation of energy in thermodynamic process
- First law of thermodynamics cannot explain why the entire heat cannot be converted into work. It cannot explain why heat cannot flow from a cold body to a hot body. Second law of thermodynamics explains these two
- This law does not indicate the direction of heat flow
- This law does not explain the limitations under which heat is converted into mechanical work.

Second Law of Thermodynamics:

- **Kelvin's Statement**: It is impossible to get a continuous supply of work from a body by cooling it to a temperature lower than that of surroundings.
  This means a working substance can do work only if its temperature is higher than that of the surroundings
- Second law of thermodynamics gives the direction of flow of heat. First law of thermodynamics only gives the relation between the work done and heat produced. But the second law of thermodynamics gives the conditions under which heat can be converted into work
- Heat engine is a device which converts heat energy into mechanical work

Reversible & Irreversible Process:

- A process which can be retraced back in the opposite direction in such a way that the system passes through the same states as direct process is known as reversible process
- For a process to be irreversible there should be no loss of energy and the system must always be in thermal equilibrium with the surroundings
- Fusion of ice, vapourisation of water etc are examples of reversible processes
- The process which cannot be retraced back in the opposite direction is known as irreversible process
- Work done against friction, Joule heating effect, diffusion of gases etc, are examples for irreversible processes

Specific heats of gas:

- The quantity of heat required to raise the temperature of unit mass of the gas through 1^0C at constant pressure is known as specific heat at constant pressure (C_p)
- The quantity of heat required to raise the temperature of one mole of gas through 1^0C at constant pressure is known as molar specific heat at constant pressure (C_p)
  The quantity of heat required to raise the temperature of one mole of gas through 1^0C at constant volume is known as molar specific heat at constant volume (C_v)
- C_p = M x C_p and C_v = M x C_v
  Where M is molecular weight
- C_p -C_v = R (for 1 mole). This is known as Mayer's relation
- C_p-C_v = γ (C_p>C_v as γ >1)
- The number of independent variables that must be known to describe the state or the position of the system completely is known as degrees of freedom
- Cp = $\frac{\gamma R}{\gamma - 1}$ and C_v = $\frac{R}{\gamma - 1}$
- If the temperature of n moles of a gas is increased at constant volume by dT, then increase in internal energy dU = $nC_v dT$
- If the temperature of n moles of gas is increased at constant pressure by dT, then external work done is dW = nRdT

Isothermal change:

- If the temperature of a thermodynamic process remains constant throughout that process. It is called isothermal process
- In this process internal energy remains constant (dU = 0) but there will be change in pressure and volume
- This process takes place very slowly
- Boyle's law holds good for this process (Pressure x Volume = Constant)
- In an isothermal change, dU = 0 and dQ = dW (ie) dQ = PdV
- Work done is isothermal process is

  $$W = nRT \log_e\left(\frac{V_2}{V_1}\right) = nRT \log_e\left(\frac{P_1}{P_2}\right)$$

  $$\text{(or) } W = 2.303\ nRT \log_{10}\left(\frac{V_2}{V_1}\right) = 2.303\ nRT \log_{10}\left(\frac{P_1}{P_2}\right)$$

Adiabatic change:

- If the system exchanges no heat with the surroundings during a process, then it is known as Adiabatic change or process
- In this process internal energy and temperature of the system change
- In this process there will be no exchange of heat between system and surroundings, (dQ =0)
- This is a quick process
- For this process (Pressure x Volume)$^\gamma$ = Constant
- Work done in adiabatic process

  $$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{nR(T_1 - T_2)}{(\gamma - 1)}$$

- In an adiabatic process,

  a) PV^{γ} = constant $\Rightarrow P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ b) $TV^{\gamma-1}$ = constant $\Rightarrow T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

  c) $\frac{T^{\gamma}}{P^{\gamma-1}}$ = constant $\Rightarrow \frac{T_1^{\gamma}}{P_1^{\gamma-1}} = \frac{T_2^{\gamma}}{P_2^{\gamma-1}}$

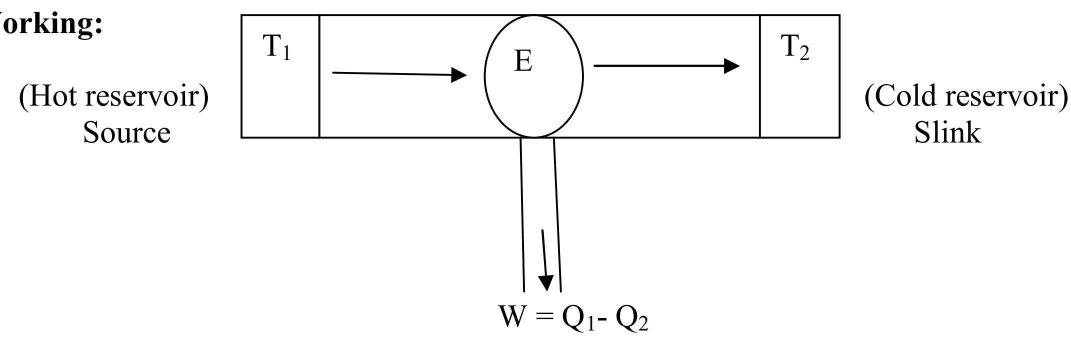
  Isochoric Process:
- If volume of the system remains constant throughout the process, then such process is called isochoric process or constant volume process

Isobaric process:
- If the pressure of a gas remains constant throughout a process then it is called isobaric process or constant pressure process

Cyclic Process:
- A process in which the system after passing through various stages (of pressure, volume and temperature changes) returns to its initial state is defined as a cyclic process
- In a cyclic process, the total heat absorbed by the system equals the work done by the system

Heat Engines and Refrigerators:

Heat Engines: A device used to convert heat energy into work (or mechanical energy) is called a heat engine
- For conservation of heat into work with the help of a heat engine the following conditions have to be met with:
- There should be body at higher temperature T_1 from which heat is extracted. It is called the source.
- Body of the energy containing working substance.
- There should be a body at lower temperature T_2 to which heat can be rejected this is called the sink.
- **Working:**



- Schematic diagram of heat engine
- Engine devices and amount Q_1 of heat from the source.
- A part of this heat is converted into work "W".
- Remaining Q_2 is rejected to the slink

$$Q_1 = W + Q_2$$

OR
- The work done by the engine is given by

$$W = Q_1 - Q_2$$

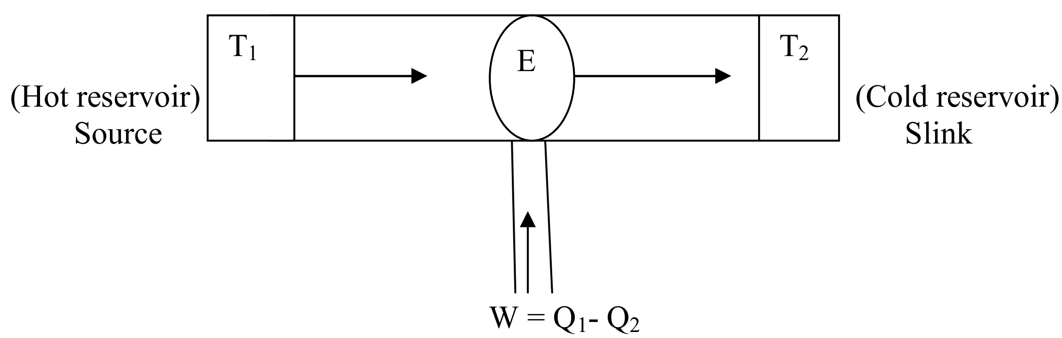
- A body at a higher temperature T_1. Heat Q_1 is extracted from this body and hence it is called a 'source' (or hot reservoir)
- A body at a lowest temperature T_2. Heat Q_2 is rejected by the working substance to this body and hence it is called a 'sink (or cold reservoir)
- The difference in heat absorbed (Q_1) and heat rejected (Q_2) is equal to the work done by the system (W). This is because the engine is operated in a cyclic process. $W = Q_1 - Q_2$
- **Efficiency of heat engine:**
- Efficiency of heat (η) is defined as the fraction of total heat supplied to the engine which is converted into work.
- Efficiency (η) = $\frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$
- **Efficiency of carnot engine:**
- The efficiency (η) of a heat engine is defined as the ratio of the work done (W) by the engine to the amount of heat absorbed (Q_1) by the engine

  Efficiency (η) = $\frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$

  $$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

Refrigerators:

- The refrigerator is just the reverse of a heat engine
- In a refrigerator the working substance extracts an amount of heat Q_2 from the cold reservoir (sink) at a lowest temperature T_2.
- An amount of external work W is done on the working substance and finally an amount of heat Q_1 is rejected to the hot reservoir at a higher temperature T_1.



Reversible & Irreversible Processes:

Reversible Process: A process that can be retraced back in the opposite direction in such a way that the system passes through the same states as in the direct process, and finally the system and the surroundings return to their original states, with no other change any where else in the universe is called a reversible process

- The changes must take place at an infinitesimally slow rate
- The system must always be in thermal and mechanical (thermodynamic) equilibrium with the surroundings

- There should be no loss of energy due to conduction, convection or dissipation of energy against any resistance like friction, viscosity etc
- No amount of heat is to be converted into electric or magnetic forms of energy

Example of reversible processes are:

- A quasi – static isothermal expansion of an ideal gas in a cylinder fitted with a frictionless movable piston
- Peltier effect and Seebeck effect
- Fusion of ice and vaporisation of water

Irreversible Process:

- A process that cannot be retracted back in the opposite direction is called an irreversible process. In an irreversible process the system does not pass through the same intermediate states as in the direct process

Examples of irreversible process are:

- Work done against friction
- Joule heating –heat produced in a conductor by passing a current through it
- Diffusion of gases
- Magnetization of a material

Importance of Reversibility:

- Out of all the heat engines working between the given temperatures of source (T_1) and sink (T_2). The engine working in a reversible process will have the highest efficiency.

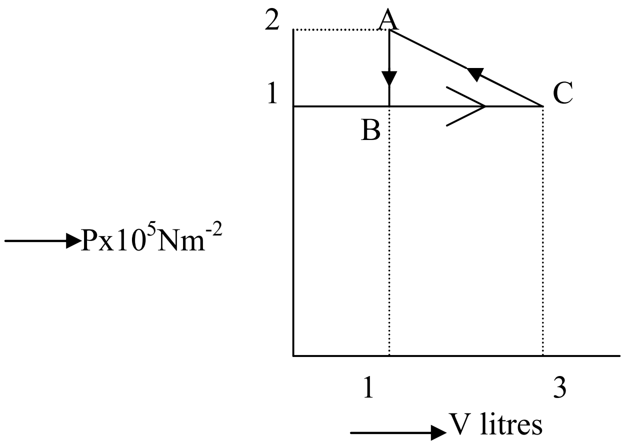
First Law of Thermodynamics

71) Considering 1g of water of volume $1cm^3$ becomes $1681cm^3$ of steam when boiled at 1atm pressure. What is the external work done? (1 atm = 10^5Pa)
    1) 168J   2) 268J   3) 368J   4) 468J
72) When 1gm of water 0^0C and 1x105Nm^{-2} pressure is converted into ice of volume $1.091cm^3$, the external work done will be
    1) 0.0091J   2) 0.091J   3) –0.0091J   4) 1.091J
73) A gas expands from 75 litre to 125 litre at constant pressure of 4 atmosphere. If 1 atm =$10^5 N/m^2$, the work done by the gas during this expansion is
    1) 20KJ   2) 30KJ   3) 40KJ   4) 50KJ
74) In a process, 500cal of heat is given to a system and 100 Joules of work is done by the system. If J = 4.2 J/cal the increase its internal energy is nearly
    1) 600cal   2) 600 Joules   3) 476cal   4) 942cal
75) Find the change in the internal energy of the system which absorbs 2Kcal of heat and at the same time it does 500J of work (J=4.2J/cal)
    1) 9000J   2) 8000J   3) 7900J   4) 7500J
76) The volume of a gas under atmospheric pressure is 2 litres. On giving 300Joules of heat of the gas its volume increases to 2.5litres at the same pressure. Determine the change in the internal energy of the gas [atm pressure =$10^5 N/m^2$]
    1) 250J   2) 150J   3) 100J   4) 50J
77) A gas expands from 40 litres to 90 litres at a constant pressure of 8 atmospheres work done by the gas during the expansion.
    1) $4x10^{-4}$J   2) $4x10^4$J   3) $4x10^3$J   4) $4x10^2$J

78) 2000J of heat is given to a gas, when its volume increases by $3x10^{-3}m^3$ at a constant pressure of 10^5Pa. The increase in the internal energy of the gas is

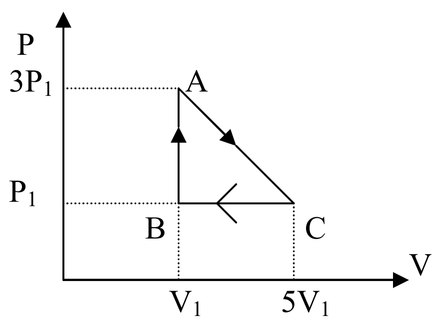
1) 1500J 2) 1600J 3) 1700J 4) 1800J

79) A system is taken along the path ABCD as shown in P-V diagram. The heat released by the system in Jouless



1) 300 2) 100 3) 150 4) 200

80) An ideal gas is taken through series of changes represented in the diagram. The net work done by the gas at the end of the cycle is equal to

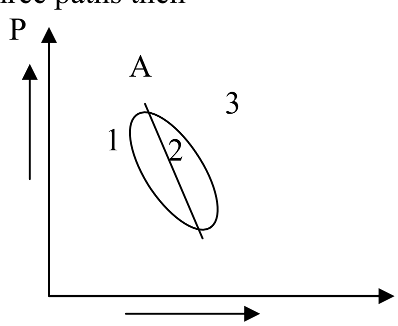


1) $4P_1V_1$ 2) $5P_1V_1$ 3) $3P_1V_1$ 4) $15P_1V_1$

81) A gas is compressed at a constant pressure of $20Nm^{-2}$ from a volume of $10m^3$ to a volume of $5m^3$. Later energy of 100J is added to the gas by heating it. What is the change in internal energy

1) 100J 2) 200J 3) 300J 4) 400J

82) A given mass of gas expands from the state A to the state B by three paths 1,2 and 3 as shown in the figure. If W_1, W_2 and W_3 respectively be the work done by the gas along the three paths then



V

1) $W_1>W_2>W_3$ 2) $W_1<W_2<W_3$ 3) $W_1=W_2=W_3$ 4) $W_1<W_2$; $W_1<W_3$

Keys

71) 1	72) 2	73) 1	74) 3	75) 3	76) 1
77) 2	78) 3	79) 2	80) 1	81) 2	82) 2

<u>Specific Heat of Gases</u>

83) Find the quantity of heat given to 20g of helium is rising the temperature through 10^0C at constant volume is
1) 600J 2) 500J 3) 400J 4) 300J

84) What are the values of the molar specific heats for a diatomic gas in cal $mole^{-1}k^{-1}$ (R=2cal $mole^{-1}k^{-1}$)
1) 5,7 2) 3.9 3) 9,3 4) 6,3

85) At a temperature of 27^0C , oxygen of mass 0.32grams occupies a volume of 2.5litres. The gas expands at a constant temperature to a final volume 25litres. How much work is done by the gas
1) 69.09R 2) 6.909R 3) 2.303R 4) 23.03R

86) The temperature of 5 moles of a gas which was held at constant volume was changed from 100^0C to 120^0C. The change in internal energy was found to be 80J. The total heat capacity of the gas at constant volume will be equal to
1) $8Jk^{-1}$ 2) $0.8Jk^{-1}$ 3) $4.0Jk^{-1}$ 4) $0.4Jk^{-1}$

87) A diatomic gas undergoes same change of temperature by two different process i)at constant volume ii) at constant pressure. Then the ratio's of heat supplied in the two cases and ratio of change in internal energies are
1) 1:1;1:1 2) 3:5;5:3 3) 7:5;5:7 4) 5:7;1:1

88) The molar specific heats of an ideal gas to constant pressure and volume are denoted by Cp and C_v respectively. Further $Cp/Cv=\gamma$ and R is the gas constant for 1gm mole of a gas. Then Cv is equal to
1) R 2) γ R 3) $R/\gamma-1$ 4) $\gamma R/\gamma-1$

89) For a gas the difference between the two specific heats is $5000Jkg^{-1}k^{-1}$. Find the two specific heats of gas if the ratio of specific heats is 1.6
1) $1333.33Jkg^{-1}k^{-1}$ 2) $13333.3Jkg^{-1}k^{-1}$
3) $133333Jkg^{-1}k^{-1}$ 4) $1333333.3Jkg^{-1}k^{-1}$

90) The ratio of specific heats of a gas is 1.4. If the value of Cv is $20.8Jmole^{-1}k^{-1}$, find Cp in cal $mole^{-1}k^{-1}$
1) 3.93cal $mole^{-1}k^{-1}$ 2) 4.93 cal $mole^{-1}$ k^{-1}
3) 5.93 cal $mole^{-1}$ $k^{-}1$ 4) 6.93cal $mole^{-1}$ k^{-1}

Keys

83) 1	84) 1	85) 2	86) 2	87) 4	88) 3	89) 2	90) 4

Isothermal Process And Adiabatic Process

91) One mole of O_2 gas having a volume equal to 22.4 litres at 0^0C and 1 atmospheric pressure is compressed isothermally so that its volume reduces to 11.2litres. The work done in this process is

1) 1672.5J 2) 1728J 3) –1728J 4) –1572.5J

92) A mono atomic gas (γ=5/3) is suddenly compressed to 1/8 of its original volume adiabatically, the pressure of the gas will change to

1) 24/5 2)8
3) 40/3 4) 32 times its initial value

93) Assume that you have an ideal gas for which γ=1.50, initially at 1.0 atm pressure. The gas is compressed to one half of its original volume. The final pressure if the compression is isothermal, is

1) 4.0atmp 2) 2.8atm 3) 2.0atm 4) 6.0atm

94) A polyatomic gas (γ=4/3) is compressed to $1/8^{th}$ of its volume adiabatically. If its initial pressure is P_0, its new pressure will be

1) $8P_0$ 2) $16P_0$ 3) $32P_0$ 4) $4P_0$

95) A gas at NTP is suddenly compressed to $1/n^{th}$ of its original volume (γ=3/2). If final pressure is 8atm, then n=

1) 4 2) ¼ 3) 2 4) ½

96) An ideal gas is compressed adiabatically to (8/27) of its original volume. If γ=5/3 and rise in its temperature is 375^0C, its initial temperature is

1) 127^0C 2) 225^0C 3) 27^0C 4) 75^0C

97) A mono atomic ideal gas initially at 17^0C is suddenly compressed to 1/8 of its original volume. The temperature after compression becomes

1) 17^0C 2) 136^0C 3) 887^0C 4) None

98) If R is universal gas constant and the temperature of a diatomic gas changes from 4T to T in an adiabatic process. Work done is

1) 15RT/3 2) 15RT/2 3) 3RT/15 4) 12RT/5

99) A polyatomic gas (γ =4/3) is compressed to 1/8 of its volume adiabatically. If its initial pressure is P_0, its new pressure is

1) $8P_0$ 2) $16P_0$ 3) $32P_0$ 4) $4P_0$

100) The pressure in tyre of a car is 2 times the atmospheric pressure at 300K. If this tyre suddenly bursts, its new temperature is (γ=1.4)

1) $300\ (2)^{0.4/1.4}$ 2) $300(1/4)^{0.4/1.4}$ 3) $300(4)^{-0.4/1.4}$ 4) $300(4)^{1.4/0.4}$

Keys

91) 4	92) 4	93) 3	94) 2	95) 1
96) 3	97) 3	98) 2	99) 2	100) 1

Previous Eamcet Questions

101) The temperature of 5 moles of a gas at constant volume is changed from 100^0C to 120^0C. The change in internal energy is 80J. The total heat capacity of the gas at constant volume will be in Joule/kelvin is (Eamcet 2003 E)

1)8 2) 4 3) 0.8 4) 0.4

102) During an adiabatic process, the pressure of a gas is proportional to the cube of its adiabatic temperature. The value of Cp/Cv for that gas is (Eamcet 2003M)

1) 3/5 2) 4/3 3) 5/3 4) 3/2

103) The pressure and density of a given mass of a diatomic gas (γ = 7/5) change adiabatically from (P, d) to (P_1, d_1). If d_1/d =32, then P_1/P is (γ = ratio of specific heat) (Eamcet 2004 E)

1) 1/128 2) 1/64 3) 64 4) 128

104) If 4 moles of an ideal gas monoatomic gas at temperature 400K is mixed with 2 moles of another ideal monoatomic gas at temperature 700K, the temperature of the mixture is (Eamcet 2004 E)

1) 550^0C 2) 500^0C 3) 550K 4) 500K

105) When a heat of Q is supplied to one mole of a monoatomic gas (γ =5/3) , the work done by the gas is (Q/3) . Then the molar heat capacity of the gas at constant volume (Eamcet 2004 M)

1) 3R/4 2) 5R/4 3) 7R/4 4) 4R/4

106) The sample of the gas x,y and z for which the ratio of specific heats is γ = 8/2, have initially the same volume. The volume of the each sample is doubled by adiabatic process in the case of x, by isobaric process in the case of y and y and by isothermal process in the case of z. If the initial pressure of the sample of x,y and z are in the ratio $2\sqrt{2}$:1:2; then the ratio of their final pressures is

(Eamcet 2004 M)

1) 2:1:1 2) 1:1:1 3) 1:2:1 4) 1:1:2

Keys

101) 2 102) 4 103) 4 104) 4 105) 4 106) 2

Heat engines and refrigerators

107) A Carnot engine works between a source and a slink maintained at constant temperatures T_1 and T_2. For efficiency to be the greatest:
1) T_1 and T_2 should be high
2) T_1 and T_2 should be low
3) T_1 should be low and T_2 should be high
4) T_1 should be high and T_2 should be low

108) By opening the door of a refrigerator which is inside a room:
1) You can cool the room to a certain degree
2) You can cool it to the temperature inside the refrigerator
3) You ultimately warm the room
4) None of the above

109) A heat engine operates by the extracting heat from a source at high temperature T_1 and
1) Converting the whole of it into work
2) Converting some of it into work and rejecting the rest at a lower T_2
3) Converting some of it into work and rejecting the rest at a some T_1
4) Converting some of it into work and rejecting the rest at a higher than T_1

110) An ideal refrigerator has a freezer at a temperature of -13^0C. The coefficient of performance of the engine is 5. The temperature of the air(to which heat is rejected) is:

1) 320^0c 2) 39^0c 3) 325K 4) 325^0K

111) A Carnot engine working between 300k and 600k has a work output of 80J per cycle. The amount of heat energy supplied to the engine from the source in each cycle is:

1) 800J 2) 1600J 3) 3200J 4) 6400J

112) A Carnot engine works as a refrigerator between 250K and 300K. if it receives 750calories of heat from the reservoir at the lower temperature. The amount of heat rejected at the higher temperature is:

1) 900 calories 2) 625 calories 3) 750 calories 4) 1000 calories

113) A heat engine operates on cartons cycle between 227^0c and 27^0c. if it absorbs $15x10^4$ J of heat energy, Then amount of heat converted into work is equal to

1) 5×10^4 J 2) 6×10^4 J 3) $7 X 10^4$ J 4) 8×10^4 J

114) A Carnot engine works first between 200^0c and 0^0c and then between -200^0c and 0^0c. the ratio of its efficiency in these two cases is:

1) 1 2) 0.72 3) 0.57 4) 0.34

115) A refrigerator is working between temperature T_1K and T_2K ($T_1 > T_2$). The coefficient of performance is:

1) T_1/ T_2 2) T_2/ T_1 3) $\left(\frac{1}{\frac{T_1}{T_2}-1}\right)$ 4) $\left(\frac{T_1}{T_2}-1\right)$

116) Even Carnot engine cannot give 100% efficiency because we cannot

1) Prevent radiation 2) Find ideal sources
3) Reach absolute zero temp 4) Eliminate friction

117) Heat given to a body which raises its temperature by 1^0c is

1) Water equivalent 2) Thermal capacity
3) Specific heat 4) Temperature gradient

118) A Carnot engine takes 3×10^6cal of heat from a reservoir at 625^0c, and gives it to a sink at 27^oc. the work done by the engine is

1) Zero 2) $4.2 x10^6$ J 3) $8.4 x10^6$ J 4) 16.8×10^6 jJ

119) Find the efficiency of a heat engine if its temperature of the source is 100^0c and sink is 27^0C.

1) 0.1957 2) 2.444 3) 3.35 4) 0.92

120) A Cannot engine takes 1000kilocalaries of heat from a reservoir of 627^0C and exhaust it to a sink at 27^0C the efficiency at the engine will be

1) 22.2% 2) 33.3% 3) 44.4% 4) 66.6%

121) If the temperature of a source increases then efficiency of a Carnot engine is

1) Increases 2) Decreases 3) Remains uncharged 4) None of the above

122) A Carnot engine can be 100% efficient if its sink is at

1) 0K 2) 273K 3) 0^0 F 4) 0^0 C

123) A Carnot engine has an efficiency of 40% when the sink temperature is 27^0 the source temperature will be

1) 100k 2) 300k 3) 500k 4) 700k

124) A device used to convert heat energy into mechanical energy is called a heat engine.
1) Heat engine 2) refrigerators 3) Adiabatic 4) None of these above

Key

107) 4	108) 3	109) 2	110) 2	111) 2	112) 1	113) 2	114) 3	115) 3	116) 3
117) 2	118) 3	119) 1	120) 4	121) 1	122) 1	123) 3	124) 1		

Thermodynamics Previous Eamcet Questions

1) The ratio of specific heats of a gas is γ. The change in internal energy of one mole of the gas when volume changes from V to 2V at constant pressure is [2005E]

1) $\frac{\gamma-1}{PV}$ 2) PV 3) $\frac{PV}{\gamma-1}$ 4) $\frac{PV}{\gamma}$

2) A 42kg block of ice moving horizontal surface stops due to friction, after some time. If the initial velocity of the decelerating block is $4ms^{-1}$, the mass of ice (in kg) that has melted due to the heat generated by the friction is: (Lice= $3.36 \times 10^5 Jkg^{-1}$) [2005M]

1) 10^{-3} 2) 1.5×10^{-3} 3) 2×10^{-3} 4) 2.5×10^{-3}

3) consider the statement (A) and (B) and identify the correct answer:

A: First law of thermodynamics specifies the conditions under which a body can use its heat energy to produce the work.

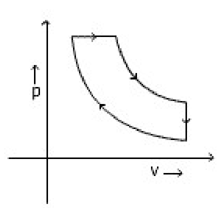
B: second law of thermodynamics states that heat always flows from hot body to cold body by itself. [2005M]

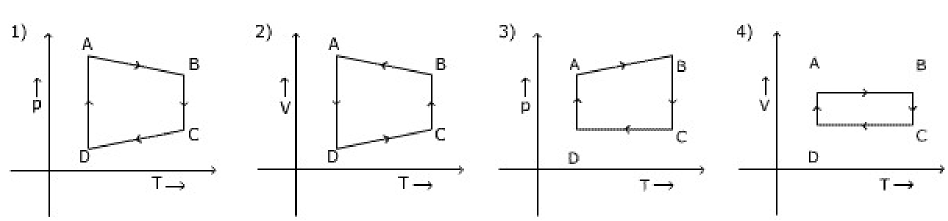
1) Both (A) and (B) are true.
2) Both (A) and (B) are false.
3) (A) is true but (B) is false.
4) (A) is false but (B) is true.

4) A given mass of a gas is compressed isothermally until its pressure is doubled. It is then allowed to expand adiabatically until its volume is restored and its pressure is then found to be 0.75 of its initial pressure. The ratio of the specific heats of the gas is approximately: [2006E]

1) 1.20 2) 1.41 3) 1.67 4) 1.83

5) A cyclic process ABCD is shown below in the given P-V diagram. In the following answers the one that represents the same process as in PV diagram. [2006E]





6) An ideal gas after going through a series of four thermodynamic states in order, reaches the initial state again (cyclic process). The amounts of heat (Q) and work (W) involved in these states are Q_1 = 6000J; Q_2 = -5500J; Q_3 = -3000J; Q_4 = 3500J; W_1=2500J; W_2 = -1000J; W_3 = -1200J; W_4 = x Joules. The ratio of net work done by the gas to the total heat absorbed by the gas is η. The value of x and η are nearly. [2006M]

1) 500; 7.5 2) 700; 10.5 3) 1000; 21 4) 1500; 15

7) 'm' grams of a gas of molecular weight 'M' is flowing in an isolated tube with velocity V. If the gas flow is suddenly stopped the rise in its temperature is: (γ = ratio of specific heats ; R= Universal gas constant; J=mechanical equivalent of heat) [2006M]

1) $\frac{MV^2(\gamma-1)}{2RJ}$ 2) $\frac{m}{M}\frac{V^2(\gamma-1)}{2RJ}$ 3) $\frac{mV^2\gamma}{2RJ}$ 4) $\frac{MV^2\gamma}{2RJ}$

8) A bullet of mass $10x10^{-3}$Kg moving with a speed of $20ms^{-1}$ hits an ice block(0^0C) of 990g kept at rest on a frictionless floor and gets embedded in it. If ice takes 50% of K.E. lost by the system, the amount of ice melted (in grams) approximately is: (J= 4.2 J/cal; L_{ice}= 80cal/gm). [2006M]

1) 6 2) 3 3) $6x10^{-3}$ 4) $3 x10^{-3}$

9) The temperature of the system decreases in the process of [2007E]

1) Free expansion 2) Adiabatic expansion
3) Isothermal expansion 4) Isothermal compression

10) Two cylinders A and B fitted with pistons; contain equal number of moles of an ideal monoatomic gas at 400K. The piston A is free to move while that of B is held fixed. Same amount of heat energy is given to the gas in each cylinder. If the rise in temperature of the gas in A is 42K, the rise in temperature of the gas in B is (γ = 5/3) [2007E]

1) 21K 2) 35K 3) 42K 4) 70K

11) For an adiabatic process, the relation between V and T is given by

1) TV^{γ} = constant2) T^{γ} = constant [2007M]
3) $TV^{1-\gamma}$ = constant 4) $TV^{\gamma-1}$ = constant

12) Consider the following two statements and choose the correct answer:

A: If heat is added to a given to a system its temperature must always increase.
B: If positive work is done by a system in thermodynamic process, its volume must increase. [2007M]

1) Both (A) and (B) are correct. 2) (A) is correct, but (B) is wrong
3) (B) is correct, but (A) is wrong. 4) Both (A) and (B) are wrong.

KEYS

1) 3 2) 1 3) 4 4) 2 5) 1 6) 2 7) 1 8) 4 9) 2 10) 4 11) 4 12) 3

Assertion And Reason Type Questions
Directions:

These questions consist of two statements as Assertion and Reason. While answering these questions you are required to choose any of the following four responses.

A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B) If both Assertion and Reason are true, but Reason is not correct explanation of the Assertion.

C) If Assertion is true, but the Reason is false.

D) If Assertion is false, but the reason is true.

1) A: First law of thermodynamics is a restatement of the principle of conservation of energy
   R: Energy is something fundamental.
   1) A 2) B 3) C 4) D
2) A: Internal energy of an ideal gas depends only on temperature and not on volume.
   R: Temperature is more important than volume.
   1) A 2) B 3) C 4) D
3) A: Change of state is an example of isothermal process.
   R: Change of state from solid to liquid occurs only at melting point of solid, and change of state from liquid to gas occurs only at boiling point of liquid. Thus, change of state from liquid to gas occurs at boiling point of liquid. Thus, there is no change of temperature during change of state.
   1) A 2) B 3) C 4) D
4) A: During an isothermal process, specific heat of a substance is infinity.
   R: Isothermal process is a constant temperature process.
   1) A 2) B 3) C 4) D
5) A: During change of state of a substance internal energy of a substance remains constant.
   R: During isothermal process of an ideal gas change in internal energy is zero.
   1) A 2) B 3) C 4) D
6) A: Specific heat of a substance during change of state is infinite.
   R: During change of state $\Delta Q=mL$, specific heat does not come in.
   1) A 2) B 3)C 4) D
7) A: During an adiabatic process, an ideal gas expands by decrease in its internal energy only.
   R: During an adiabatic process, heat cannot be exchanged between a system and its surroundings.
   1) A 2) B 3) C 4)D
8) A: Work done by a gas in isothermal expansion is more than the work done by the gas in the same expansion, adiabatically.
   R: Temperature remains constant in isothermal expansion, and not in adiabatic expansion.
   1) A 2) B 3) C 4) D
9) A: When a bottle of cold carbonated drink is opened, a slight fog forms around the opening.
   R: Adiabatic expansion of the gas causes lowering of temperature and condensation of water vapours.
   1) A 2) B 3) C 4) D

10) A: Amount of heat required to raise the temperature of 1kg of water through 1^0C is 1 gram of water through 1^0C.
R: By definition, 1 calorie is the amount of heat required to raise the temperature of 1 gram of water through 10C.
1) A 2) B 3) C 4) D

11) A: Work required to produce 1 calorie of heat is 4.2Joule.
R: This is the standard value of Joule's mechanical equivalent of heat.
1) A 2)B 3) C 4)D

12) A: The ratio Cp/Cv for a diatomic gas is more than that for a monoatomic gas.
R: The molecules of a monoatomic gas have more degree of freedom than those of a diatmoic gas.
1) A 2) B 3) C 4) D

13) A: At room temperature water does not sublimate from ice to steam.
R: The critical point of water is much above the room temperature.
1) A 2) B 3) C 4)D

14) A: It is possible to transfer heat energy from body at lower temperature to body at higher temperature by using external agency.
R: External agency extracts larger heat from colder body by doing work rejects smaller heat to hotter heat, hence transfer is possible.
1) A 2) B 3) C 4)D

15) A: It is not possible for a system, unaided by an external agency to transfer heat from a body at a lower temperature to another at a higher at a higher temperature.
R: It is not possible to violate the second law of thermodynamics.
1) A 2) B 3)C 4)D

Keys

1) 3	2) 3	3) 1	4) 1	5) 4
6) 2	7) 2	8) 2	9) 1	10) 1
11) 1	12) 4	13) 3	14) 3	15) 1

ADDITIONAL TOPICS AND PROBLEMS:

Heat Engine:

(i) Peirce which converts heat into work continuously through a cynic process

Efficiency of a Heat engine, $\eta \frac{work\ done}{heat\ absorbed} = \frac{w}{Q^1}$

$$\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

A perfect heat engine in one which convert all heat into work

$[W = Q_1\ so\ that\ Q_2 = 0\ and\ \eta = 1]$

Refrigerator or heat pump:

(i) A refrigerator or heat pump is basically a heat engine run in reverse direction. It transfers heat from cold to hot body at the expenses of mechanical energy supplied to it by an external agent. Coefficient of performance of a refrigerator is defined as

$$\beta = \frac{heat\ extracted\ from\ the\ reservior\ at\ low\ temprature T_2}{work\ done\ to\ transfer\ the\ heat}$$

$$\beta = \frac{Q_1}{w} = \frac{Q_2}{Q_1 - Q_2}$$

A perfect refrigerator is one which transfer heat from cold to a heat body without doing any work w=o, so that Q1=Q2 .: $\beta = \infty$.

Carnot's heat engine:

Efficiency of the engine $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{Q_2}{Q_1}$

The working substance goes through a closed cycle is a cant's heat engine, concerning four operations called cant's cycle.

Problems

(1) An ideal heat engine excavating heat at $77^o c$ is have a 30% efficiency. It must take heat it ( )

a) $127^o c$ b) $227^o c$ c) $327^o c$ d) $673^o c$

(2) A carnot engine takes in 3000k call of heat from a reservoir at _____ and given it to a sink at $627^o c$. The work done by the engine is ( )

a) $4.2\times10^6 J$ b) $16.8\times10^6 J$ c) $P.4\times10^6 J$ d) Zero

(3) A carnot engine works first between $200^0 C$ and $0^0 C$ and then between $0^0 C$ and $-200^0 C$. The ratio of its efficiency is these two cases is. ( )

a) 1.0 b) 0.721 c) 0.577 d) 0.34

(4) A refrigerator has to transfer a energy of 263J of heat per second from temperature $-10^{'} c$ to $-25^{'} c$. The average power uvoumed assuming no energy loss in the process is ( )

a) 35W b) 45W c) 55W d) 65W

(5) The efficiency of a cannot engine working between 800k and 500k is( ).

a) 0.625 b) 0.375 c) 0.4 d) 0.5

(6) A carnot engine operator between $327^o c$ and $27^o c$. The heat (in Joules) does it take from the $327^o c$ reservoir for every 100J of work done is ( )

a) 100J b) 200J c) 300J d) 400J

(7) γ of a gas in 7/5. Then the gas may be ( )

a) He b) H_2 c) argon d) Ne

(8) If one mole of a monoatomic gas (γ=5/3) is mixed with one mole of a diatomic gas (γ=7/5). The value of γ for the mixture is. ( )

a) 1.5 b) 1.53 c) 1.60 d) 1.52

(9) A sink, that is a system where heat is rejected, is essential for the conversion of heat into work. The above inference follows which law ( )

a) Zero b) First c) Secondd) Third

(10) In a cannot cycle, order of process is ( )

a) Isothermal expansion, adiabatic expansion and adiabatic compression.

b) Isothermal Experian, adiabatic compression, and adiabatic expansion

c) Adiabatic expansion, Iso thermal expansion and adiabatic compression

d) None of these.

(11) The efficiency of a Carnot engine is 1/6. In reducing the sink temperature by 65K, the efficiency become 1/36. The initial and final temperature between which the engine works are ( )

a) $117^o c, 52^o c$ b) $271^o c, 52^o c$ c) $317^o c, 52^o c$ d) $17^o c, 52^o c$

KEY b 2) c 3) c 4) a 5) b 6) b 7) b 8) a 9) c 10) b 11) a

CHAPTER 14
KINETIC THEORY

Brief Review

I. Assumptions of kinetic theory of gases:

(i) A gas consists of a large number of identical, tiny spherical, natural and elastic particles, ting.

(ii) In a gas molecules are moving in all possible direction with all possible speeds in accordance with Maxwell's distribution law.

(iii) The space occupied by the molecules is much smaller than the volume of the gas.

(iv) There is no force of attraction among the molecular.

(v) The pressure of a gas is due to elastic Collision of gas molecule with the wells of the container.

(vi) The time of contract of moving molecule with the wells of the container is negligible as compared to the time internal between two successive collections on the same wall of the container.

II. *Pressure exacted by an ideal gas and not means sequence speed*.

a. $P = \frac{1}{3}\frac{mN}{V}\overline{V^2}$ where V^{-2} is the mean sequence velocity$\left(=\frac{V_1^2 + V_2^2 + ...}{N}\right)$,m, mass of each molecule and N, the total number of molecules in the vessel having volume V

b. $P = \frac{1}{3}\rho \overset{-2}{v}$ as mN=mass of the gas

$= \frac{mN}{V} = \rho =$ dent of gas

c. Root Mean sequence Speed as, $V_{rm} = \sqrt{\overset{-2}{v}} = \sqrt{(V_1^2 + V_2^2 - ....)/N}$

$V_{rm} = \sqrt{3p/p} \rightarrow$ (Graham's law of diffusion)

d. K.E/Volume , $E = \frac{1}{2}\frac{mN}{V}\overset{-2}{v} = \frac{1}{2}\rho\overset{-2}{v}$

$E = \frac{1}{2}(\frac{1}{2}\rho\overset{-2}{v}) = \frac{2}{3}E$

e. $V_{rms} = \sqrt{\frac{3PN}{mN}}$

f. If M be the molecular weight of Gas;
Mass, the gas=nM and PV=nRT

$V_{rms} = \sqrt{\frac{3RT_x}{M}} = \sqrt{\frac{3RT}{M}}$

g. $M = N_A M \; and \; R = N_A K$

Where K=Baltzman constant
N_A=Avagadw's numbers

h. $V_{rms} = \sqrt{\frac{3N_A KT}{N_A M}} = \sqrt{\frac{3KT}{M}}$

III. Difficult types of needs of gas noleles..

a. $\underline{Root\,mean\,squance\,Speed:(V_{ms})}$

$$V_{rms} = \sqrt{(\frac{V_1^2 + V_2^2 + \ldots\ldots}{N}} = \sqrt{\bar{v}^2}$$

b. Most Probable Speed: $V_{mp} = V_{mp} = \sqrt{\frac{2RT}{M}}$

$$V_{mp} = \sqrt{\frac{2}{3}} V_{rms} = 0.816 V_{rms}$$

<u>Law of Equipatition of Energy:</u>

Average energy mean energy per molele = 1/2KT where K is the Biltynum content & T temperature of the gas in kelvin

<u>For Monoatomic gas</u> : Mean energy = 3/2KT

<u>For Diatomic Gas</u> : Mean energy = 5/2KT

<u>For Polyatomic Gas</u> : Mean energy = 6/2KT

(i) Bole's Law : $V \propto \frac{1}{p}$ at content temperature

M=Control

(ii) Charle's Law : $V \propto T$ m&p=content[T=absolute temp]

(iii) Gay-lussais Law : $p \propto T$ m&p=content[T=Absolute temp]

(iv) **Avagadro's Law**: According to the law, at same temperature and pressune, equal volume of all the gases contain equal number of moleuler.

$N_1 = N_2$ P,V & T are same

(v) **Graham's Law:** According to the law, at content pressure and temperature, the rate of diffusion of gas is inversely proportional to the square root of its density.

(vi) **Dalton's Law**: According to the law, pressure exerted by a gaseous mixture is equal to the sum of partial pressure of each component present in the mixture:

$p = p_1 + p_2 + p_3 + \ldots\ldots$

Brownian Motion:

Robert Brown discerned that pollen-grains suspended in water move following zig-zag patters when viewed through under a microscope. The phenomena is called Brownian Motion.

Mean free path:

it is the average distance travelled by a gas molecular between two successive collisions.

Mean free path $\lambda = \frac{1}{\sqrt{2\pi d^2 n}}$

When d in the diameter of the molecular, n is the number of molecular per unit volume.

At NTP the mean free path for air molecular is 0.01/4m

$$\lambda = \frac{1}{\sqrt{2}} \frac{kT}{\pi d^2 p}$$

Average Speed: V_{av} $, V_{av} = \sqrt{\frac{8RT}{\pi M}}$

$$V_{av} = (\sqrt{\frac{8}{3\pi}})V_{rms} = 0.92V_{rms}$$

$$V_{rms} > V_{av} > V_{mp}$$

A planet or satellite will have atmosphere only and only if $V_{rms} < V_{esc} = \sqrt{2gR}$

IV. **Kinetic interpretation of temperature:**

Mean kinetic energy per molure, $E = \frac{3}{2}KT$

E, Mean K.E. per gm mole is grain by

Emole: $(\frac{1}{2}m\overline{v}^2)N_A = \frac{3}{2}KTN_A = \frac{3}{2}RT$

V. Kinetic interpretation of pressure.

$$P = \frac{1}{3}\frac{mN}{v}\overline{v}^2 \; with \; \overline{v}^2 \propto T$$

a) $p \propto mN$ b) $p \propto \frac{1}{v}$ c) $p \propto \overline{v}^2$

VI. Degrees of Freedom:

a) Degrees of freedom refresh to the possible independent motors of a system can have. The independent motion of a system can be translational, Rotational or vibrational or any combination of thes.
b) A monatomic has 3 degrees of freedom (all translational) ex: He, Ar A diatomic molecule has 5 degrees of freedom (3 translational and 3 rotational) ex: H_{21} O_2
c) A polyatomic molecule has 6 degrees of freedom (3 translational, 3 rotational) ex: (Co_2, H_2o)

VII. **A gas has two specific heats:**

Specific heat has constent volume (C_v) and specific heat has pressure (C_p).

For Ideal gas: Molar specific heat at content volume (C_v) and molar specific heat at content pressure (C_p) is considered.

C_p - C_v =R ; $C_p / C_v = \gamma$

Table

	Monatomic	Diatomic	Triatomic or Polyatomic
Degrees of freedom	3	5	6
C_v	$\frac{3}{2}$R	$\frac{5}{2}$R	3R
C_p	$\frac{5}{2}$R	$\frac{7}{2}$R	4R
γ	1.66	1.4	1.33
E_{mole}	$\frac{3}{2}$RT	$\frac{5}{2}$RT	3RT

General Formula for *f*, the number of degrees of freedoms

$$\gamma = 1 + \frac{2}{f}$$

Problems

(1) The temperature of an ideal gas is increased from $27^o c$ to $927^o c$. The rms speed of its molecular becomes. ( )

a) Twice b) half c) four times d) one fourth

(2) Hydrogen has maximum rms speed at NTP because ( )

b) it is the lightest gas b) it is a good conductor of heat

c) it abs abs heat rapidly d) it has only one electron it its atom.

(3) At what temperature the molecules of nitrogen will have the same rms velocity as the molecule of oxygen at $127^o c$ ( )

a) $37^o c$ b) $350^o c$ c) $273^o c$ d) $77^o c$

(4) At absolute zero temperature, the kinetic energy of the molecules. ( )

a) becomes maximum b) becomes zero

c) becomes minimum d) Remains content.

(5) For a gas the difference between the two specific heats is 4150/kg/k. What is the specific heat at content volume of gas if the specific heats ratio is 1.4

a) 8475j/kg/k b) 5186 j/kg/k c) 10375 j/kg/k d) 1660 j/kg/k

(6) A vessel has 6 gm of hydrogen at pressure and temperature 500KJ. A small hole is made in it so that hydrogen leaks out much if the final pressure is P/2 and temperature falls to 300K. ( )

a) 2gm b) 3gm c) 4gm d) 1gm

(7) The root mean sequence velocity of the molecules in a sample of helium is (5/7) the that of the molecules is a sample of hydrogen. If the temperature of hydrogen sample is $0^o c$ that of helium sample is about. ( )

a) $0^o c$ b) 283k c) Ok d) $100^o c$

(8) The Value of γ for air is ( )

a) 1.6 b) 1.3 c) 1.4 d) 1.2

(9) The root mean square velocity, V_{rms} . the average velocity V_{av}, the most probable velocity V_{mp} of the molecules of the gas in the order. ( )

a) $V_{mp} > V_{av} > V_{rms}$ b) $V_{rms} > V_{av} > V_{mp}$

c) $V_{av} > V_{mp} > V_{rms}$ d) $V_{mp} > V_{rms} > V_{av}$

(10) Average speed and rms speed of four molecules of a gas have speeds 2,4,6 and 8 km/sec respectively are ( )

a) $V_{av} = 5km/sec, V_{rms} = 5.48km/sec$ b) $V_{av} = 7km/sec, V_{rms} = 7.48km/sec$

c) $V_{av} = 5.48km/sec, V_{rms} = 3km/sec$ d) $V_{av} = 9km/sec, V_{rms} = 10km/sec$

(11) The total K.E. of all the molecules of helium heaving a volume V exerting pressure P is 1500J. The total K.E. in jarles of all the molecules of N2 having the same volume V and exerting a pressure if is. ( )

a) 6000 b) 5000 c) 4000 d) 3000.

(12) If P is the pressure of the gas then the K.E per unit volume of the gas is.( )

a) P/2 b) P c) 3 P/2 d) 2P

(13) Two vessels A and B having equal volume contain equal messes of hydrogen is A and helium in B at 300K. Then mark the correct statement. ()

a) The pressure exerted by h2 is half that exerted by helium
b) the pressure exerted by h2 is equal that exerted by helium
c) the pressure exerted by h2 is twice that exerted by helium
d) None of these.

(14) Equal volume of monotonic and diatomic gases at the same temperature are given equal quantities of heat. Then ( )

a) the temperature of diatonic gas will be more
b) the temperature of monotonic will be more
c) the temperature of both will be zero
d) Nothing can be said.

(15) Oxygen and hydrogen gases are at the same temperature T, the K.E of oxygen molecules will be equal to. ( )

a) 16 times the K.E of hydrogen molecules
b) 4 times the K.E of hydrogen molecules
c) The K.E of hydrogen molecules
d) One fourth the K.E of a hydrogen molecules

(16) If the pressure in a closed vessel in reduced by drawing out some of the gas, the mean free path of two molecules ( )

a) Increased
b) Is decreased
c) Remains unchanged
d) Increases or decreases according to the nature of the gas

(17) Some gas at 300k is enclosed in a container. Now the container is in motion, the temperature of the gas ( )

a) Rises above 300k b) falls below 300k

c) Remains unchanged d) becomes unsteady

II YEAR

Chapter – 15
WAVES

- The Mechanical wave energy which can be heard by human ear is known as sound
- Sound is propagated in the form of longitudinal mechanical waves
- A material medium is necessary for the propagation of sound
- Medium must possess elasticity and inertia
- Velocity of sound in air at STP is $330ms^{-1}$ (approximately)
- Velocity of sound depends on nature of the medium and temperature of the medium
- Velocity of sound depends is maximum in solids, intermediate in liquids and minimum in gas

Audible Sound:
- Only those sound whose frequency is greater than 20Hz and less than 20,000Hz are audible
- Audible wave length range varies with temperature of the medium (nature of the medium)

Ultrasonics:
- The sound waves of frequency greater than 20,000Hz are known as ultrasonic

Free Vibrations:
- When a body is excited and left free to itself, it begins to vibrate and the vibration of the body are called free or natural vibration

The frequency of vibrations depends upon on the dimensions of the body and the elastic constant of the material of the body

Forced Vibration:
- When a body vibrate under the influence of external periodic impulses whose frequency is not equal to its natural frequency

Resonance:
- It is the phenomenon in which system vibrates with max amplitude (theoritically infinite amplitude)
- Ex: Soldiers are advised to go out of steps while crossing a bridge to avoid breakage of bridge due to resonance

Transverse wave along stretched string:
- When a string stretched between two ends is plucked at right angles to it and released, a plucked at right angles to it and released, a transverse wave travels along the length of string
- Velocity of transverse wave along stretched string

$V = \sqrt{\frac{T}{m}}$ T = tension, m = linear density

- Linear density: $m = \frac{\text{mass}}{\text{length}} = \frac{Ald}{l} = Ad = \pi r^2 d$, Where d is density of the material of wire

$V = \sqrt{\frac{T}{Ad}} = \sqrt{\frac{T}{\pi r^2 d}} = \frac{1}{r}\sqrt{\frac{T}{\pi d}} = \sqrt{\frac{\text{stress}}{d}}$

- Tension may arise due to load, elastic force, thermal force
- $T = Mg$, $V = \sqrt{\frac{Mg}{m}}$
- When load is immersed in a liquid, effective weight decreases, hence tension decreases and therefore velocity decreases

$V^1 = \sqrt{\frac{Mg(1-\frac{d_l}{d_b})}{m}}$, d_l = density of liquid

- When tension arises due to electric force

$V = \sqrt{\frac{Ye}{l\,d}}$ M = mass of the string

- When tension arises due to thermal force

$V = \sqrt{\frac{Y\alpha\alpha}{d}}$ y = young's modulus, d = density of material of string

α = coefficient of material of string, θ = rise in temperature

Formation of a stationary wave on a stretched string:

- When a stretched string is plucked at the midpoint and released, a transverse wave travels along its length, it gets reflected at other end the superposition of incident and reflected wave forms stationary wave
- **Fundamental frequency**:
- Vibrates in one loop
- The point of plucking is antinode distance between two nodes $\frac{\lambda}{2} = l$ and

$\lambda = 2l$, $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$ n = fundamental frequency

Harmonics:

- The frequencies which are integral multiples of the fundamental frequency are called Harmonics

Overtones:

- All possible higher frequencies other than fundamental are called overtones

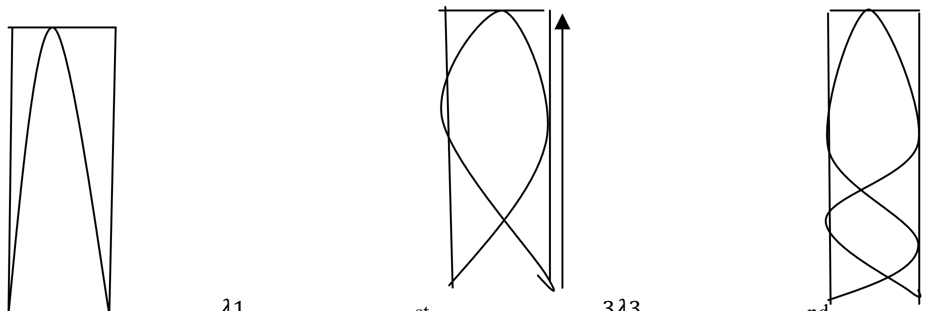
VIBRATIONS OF AIR COLUMS

VIRATIONS OF ORGAN PIPES:

1. The waves in vibrating air columns are **longitudinal stationary waves.**

   Closed Pipe:
2. In a closed organ pipe closed end is an always a node and the open end is always an antinodes.
3. In a simple mode of vibrations, a node will be formed at the closed end and antinodes are formed at the open end.
4. The length of the air column is then equal to $L = \frac{\lambda 1}{4}$

L



(i)Fundamental $L=\frac{\lambda 1}{4}$ (ii) I[st] overtone $L=\frac{3\lambda 3}{4}$; (iii)II[nd] overtone $L = \frac{5\lambda 5}{4}$

5. **The fundamental frequency of the closed air column is given by**

   $\mathbf{n_1} = \frac{V}{4L} = \frac{V}{\lambda 1}$;

6. In the next mode of vibrations, the length of the air column is equal to

   $L=\frac{3\lambda 3}{4}$; $\lambda_3 = 4L/3$;

   This frequency is known as third harmonic or the first overtone $n_3 = \frac{v}{\lambda_3} = \frac{3.v}{4L} = 3n_1$;
7. In this mode of vibration, the length of the air column is equal to

   $L = \frac{5\lambda 5}{4}$; $\lambda_5 = 4L/5$;

   This frequency is known as fifth harmonic or the second overtone $n_3 = \frac{v}{\lambda_5} = \frac{5.v}{4L} = 5n_1$;
8. Thus in a **closed pipe only odd harmonics are present.** Even harmonics are absent.
9. **The maximum possible wavelength is 4L and the other wavelength are given by** $\frac{4L}{(2K-1)}$**;**

   Where K= 1, 2, 3, 4………….. The overtone is given by (2k+1) $= \frac{V}{4L}$;

10. The mode of vibration of closed end organ pipes is identical to that of a rod clamped at one end and a string fixed at one end and free at the other. In the pipes waves are always longitudinal, in rods waves may be longitudinal or transverse and is strings waves are always transverse stationary waves.

Open pipe :

1. In open air column, antinodes will be formed at either end.
2. In a simple mode of vibrations, an antinode will be formed at the either end with a node in between them.

The maximum possible wavelength is given by $\frac{\lambda}{2} = L$; $\lambda = 2L$;

3. **The fundamental frequency of the open pipe is given by**
   $n_1 = \frac{V}{2L} = \frac{V}{\lambda 1}$; this is also known as first harmonic.

4. In the next mode of vibrations, the length of the air column is equal
   $L = \frac{2\lambda 2}{2}$; $\lambda_2 = \frac{2L}{2}$;

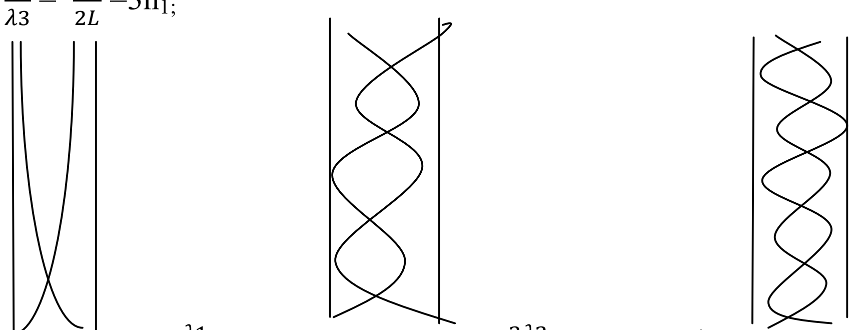
This frequency is known as **second harmonic or the first overtone**

$n_2 = \frac{V}{\lambda 2} = \frac{2V}{2L} = 2n_1$;

5. In this mode of vibration, the length of the air column is equal
   $L = \frac{3\lambda 3}{2}$; $\lambda_3 = \frac{2L}{3}$;

This frequency is known as **third harmonic or the second overtone**

$n_3 = \frac{V}{\lambda 3} = \frac{3V}{2L} = 3n_1$;



(i)Fundamental $L = \frac{\lambda 1}{2}$ (ii) I[st] overtone $L = \frac{2\lambda 2}{2}$; (iii)II[nd] overtone $L = \frac{3\lambda 3}{2}$

6. **Thus in a open pipe all harmonics are present**.
7. **The maximum possible wavelength is 2L and the other wavelength are given by $\frac{2L}{2K}$;**

Where K= 1, 2, 3, 4…

8. **The overtone is given by (k+1) $= \frac{V}{4L}$; where K=1, 2, 3, 4………**

9. The mode of vibration of open end organ pipes are identical with that of a rod clamped in the middle.

PROBLEMS:

1. Two organs pipes of same length open at both ends produce sound of different pitch if their radii are different pitch if their radii are different. Since for a given length.
   a) The frequency will be more for a pipe of smaller radius.
   b) The frequency will be less for a pipe of smaller radius.
   c) The frequency will not be depend on the radius of the pipe.
   d) None of above.
2. Find the frequency of the first three harmonics of an pipe of length 1.65m, given that the velocity of sound in air is equal to 330 s^{-1}. What will be the first three frequencies if the pipe is closed at one end?
   a) 50Hz, 150Hz, 250Hz b) 120Hz, 180Hz, 350Hz
   c) 190Hz, 200Hz, 210Hz d) 50Hz, 150Hz, 200Hz
3. The frequency of the fundamental note of a tube closed at one end is 200Hz. What will be the frequency of the fundamental note of a similar tube of same length but open at both ends?
   a) 400Hz b) 200Hz c) 120Hz d) 100Hz
4. Fundamental frequency of an open pipe 0.5m is equal to the frequency of the first overtone of a closed pipe of length l. the value l_c is
   a) 1.5m b) 0.75m c) 2m d) 1m
5. 5. An open pipe and closed pipe are in resonance with each other with their first overtones. Find the ratio of their lengths.
   a) 2:1 b) 3:6 c) 4:3 d) 5:7
6. The quality of sound from an open pipe is different from a closed pipe of fundamental frequency since
   a) The number of overtones in a closed pipe are more than in an open pipe.
   b) The number of overtones in a closed pipe are same than in an open pipe.
   c) The number of overtones in an open pipe are more than in an closed pipe.
   d) None of the above.
7. An open tube resonates to a frequency of 256Hz when it is dipped so that ¼ th of its length is under water the frequency to which it resonates is
   a) 256Hz b) 512Hz c) 170.6Hz d) 128Hz
8. An open organ pipe is suddenly closed with the result the second overtone of the closed pipe is formed to be higher is frequency by 100 vibrations per second than the first overtone of the original pipe. The fundamental frequency of the open pipe is
   a) 100Hz b) 400Hz c) 50Hz d) 200Hz
9. Two tuning forks A and B give 6 beats per second. A resonates with a closed column of air 15cm long and B with an open column 30.5cm long in their fundamental harmonics. Calculate their frequencies.
   a) n_A = 366Hz n_B = 360Hz
   b) n_A = 366Hz n_B = 320Hz
   c) n_A = 266Hz n_B = 360Hz
   d) n_A = 366Hz n_B = 260Hz

10. An open pipe resonates to a frequency n_o and a closed pipe to a frequency n_c . if they are joining to form a longer tube, it will resonates to a frequency of
    a) $\frac{n_o n_c}{2n_c + n_o}$ b) $\frac{n_o n_c}{2n_o + n_c}$ c) $\frac{2n_o + n_c}{n_o n_c}$ d) $\frac{2n_c + n_o}{n_o n_c}$
11. A rod is fixed between two points and is vibrating. The length of the rod for the first harmonic will be
    a) λ b) λ/2 c) 2λ d) λ/4
12. Sound waves in air are
    a) Transverse b) Longitudinal c) De-Broglie d) None of the above
13. Speed of sound depends on
    a) Pressure b) Density of gas c) Above both d) None of the above
14. Resonance is an example of
    a) tuning fork b) Forced vibration c) Free vibration d) Damped vibration
15. If the velocity of sound in air is 350m/s, then fundamental frequency of an open pipe of length 50cm will be
    a) 175cm b) 350cm c) 700cm d) 980cm
16. the velocity of sound is maximum at
    a) water b) air c) vacuum d) metal
17. Two open pipes 80 and 81cm long are found to give 26 beats in 10sec, when each is sounding with its fundamental frequency. The velocity of sound in air is
    a) $334ms^{-1}$ b) $335ms^{-1}$ c) $336ms^{-1}$ d) $337ms^{-}$
18. An organ pipe p_1 closed at one end vibrating in its first overtone and another pipe p_2. Open at both ends vibrating in its third overtone are in resonance with a given tuning fork. Then the ratio of lengths p_1 and p_2 is given by
    a) 1:2 b) 2: 1 c) 3:8 d) 3:4
19. The length of the closed pipe whose frequency is equal to that of pipe open of 60cm length is
    a) 45cm b) 15cm c) 60cm d) 30cm
20. The fundamental frequency of a closed pipe is 220Hz. If ¼ th of the pipe is filled with water, the frequency of the 1^{st} overtone of the pipe now is
    a) 220Hz b) 440Hz c) 880Hz d) 1760Hz
21. An open pipe of length 'ι' vibrates in fundamental mode. The pressure variation is Maximum at
    a) ¼ th from ends. b) The middle of pipe.
    c) The ends of pipe. d) at 1/8 th from ends of pipe.

key

1) c	2)a	3) a	4)b	5)c	6)c	7)c
8)b	9) a	10)b	11)b	12)b	13)d	14)b
15)b	16)d	17)d	18)c	19) d	20)c	21)b

Laws of transverse vibrations:

- Laws of length $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$, $n_1 l_1 = n_2 l_2$
- Laws of tension $\frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}}$
- Laws of mass $n \alpha \frac{1}{r}$ (T, l, d constants)

Sonometer experiment:

- First law verified directly, $n \alpha \frac{1}{l}$ (law of length)
- Second, third laws are verified by showing $\frac{\sqrt{T}}{l}$ = constant

(same tuning fork, same wire) (n, m constant)

- Law of mass is verified by showing $l\sqrt{m}$ = constant (n, T are kept constant)

Uses of Sonometer:

- To determine velocity of transverse wave along a stretched string
- To determine unknown frequency of tuning fork
- To determine frequency in A.C circuits
- To verify laws of transverse vibrations in stretched strings

Echo:

- When an observer produces a sound and receives its reflection from an obstacle, the reflected sound is called echo of the original sound
- Suppose a person standing between two parallel cliffs fires a bullet. If echoes are heard from the cliffs after $t_1$and t_2 seconds after firing distance between the cliffs x = $\frac{(t_1 + t_2)v}{2}$
- An observer at a distance d from an obstacle 'a' produces a sound and receives its echo after t_1 sec. If he walks through a distance x away from the obstacle produces a sound and receives its echo

$v = \frac{2x}{t_2 - t_1}$, If he moves towards the obstacle $v = \frac{2x}{t_1 - t_2}$

Case:

- When a truck approaches a cliff with velocity v_t blows a horn (when the truck is at a distance d from the cliff) the echo is heard after a time t = $\frac{2d}{v + v_1}$, where v is the velocity of sound

- If truck moving away from the cliff t = $\dfrac{2d}{v - v_1}$
- A car moving with velocity 'u' on a road running parallel to a row of buildings. The distance between row of buildings and road is 'd'. The driver sounds the horn; He receives the echo after a time,

t = $\dfrac{2d}{\sqrt{v^2 - u^2}} = \dfrac{AB + BC}{v} = \dfrac{AC}{u}$

- Same can be applied to determine the height of aeroplane t = $\dfrac{2h}{\sqrt{v^2 - u^2}}$
- If the car runs mid way between parallel rows of buildings t= $\dfrac{d}{\sqrt{v^2 - u^2}}$
- A person standing between two cliffs fires a bullet. He receives first echo after t_1 sec and second echo t_2 sec later d = $\dfrac{v}{2}(2t_1+t_2)$

Uses of Echo:

- It can be used to determine the velocity of sound
- To determine height of aeroplane and depth of ocean.
- SONAR (sound navigation and ranging) principles can be used for determining position and speeds of submarines
- In SONAR – ultrasonics are used because ordinary sounds are highly absorbed by water
- Mega phone, ear trumpet, hydrophone, fathometer, stethoscope are based on principle of reflection of sound

Beats:

- Beats: When two sound waves of slightly different frequencies travelling in same direction superiomose together, the resultant sound waxes and wanes at regular intervals of time. This waxing and waning of sound is called beats
  - Beat frequency = number of maxima heard per second = number of minima heard per second = number of beats per second = $n_1 \sim n_2$

  n_1, n_2 frequencies of parent sounds
  - Because persistence of hearing is 0.1 sec, max number of beats that can be heard per second is 10
  - If n_1 and n_2 are the frequencies of the two sound waves combined to produce beats, the combined wave has a frequency $\dfrac{n_1 + n_2}{2}$
  - Beat frequency = $n_1 \sim n_2$

- Beat period = $\frac{1}{n_1 \sim n_2}$ = Time interval between two consecutive maxima (or) minima
- Time interval between one maxima and one minima is $\frac{1}{2(n_1 \sim n_2)}$

Uses of Beats:

- It can be used to determine unknown frequency of a tuning fork
- To tune a musical instrument to a given note
- To detect poisonous gases in mines

Dopper Effect:

- Apparent change in frequency due to relative motion between the source and observe is called Dopper effect

v_0 = Velocity of observer, v_S = Velocity of source, v = Velocity of sound
w = Velocity of wind, n = actual frequency of sound,
n^1 = apparent frequency of sound, $n^1 = \left(\frac{v - v_0}{v - v_S}\right)n$

Sign Conventions:

.Direction of velocity of sound is always from source to observer irrespective of their directions of motions

- v_0 and v_S are positive if they are in the direction of sound
- v_0 and v_S are –ve if they are opposite to the direction of sound

Indirect approach:

- The relative velocity between source and the observer is always taken along the line of sight of the source by the observer

$n^1 = \left(\frac{v}{v - v_S\cos\theta}\right)n$

- There is no Dopper effect, means

Apparent frequency = actual frequency, apparent change in frequency = 0

$n_A = \left(\frac{v}{v - v_S\cos\theta}\right)n$; $n_B = n$; $n_C = \left(\frac{v}{v + v_S\cos\theta}\right)n$

- A source is at origin and observer moves, with constant velocity V_0 on the line x = k $\quad n_A = \left(\frac{v + v_0\cos\theta_1}{v}\right)n$, $n_C = \left(\frac{v - v_0\cos\theta_2}{v}\right)n$, $n_B = n$
- In both cases, shown below there is no Dopper effect because one is moving at right angles to the line of sight and the other is at rest

Observer is crossing a stationary source:

- $n_{\text{approaching observer}} = \left(\frac{v + v_0}{v}\right) n$, $n_{\text{receeding observer}} = \left(\frac{v - v_0}{v}\right) n$

$\frac{n_{\text{app obs}}}{n_{\text{receeding observer}}} = \frac{v + v_0}{v - v_0}$, Drop in frequency $\Delta n = \frac{2 v_0 n}{v}$

Source crossing a stationary observer:

- $n_{\text{approaching source}} = \left(\frac{v}{v - v_S}\right) n$
- $n_{\text{receeding source}} = \left(\frac{v}{v + v_S}\right) n \xrightarrow{v_s} \frac{n_{\text{app source}}}{n_{\text{receeding source}}} = \frac{v + v_S}{v - v_S}$
- Drop in frequency $\Delta n = \frac{2 v_S n}{v}$
- If the observer is standing outside the circular track,

$n_A = n_{max} = \left(\frac{v}{v - v_S}\right) n$, $n_B = n$, $n_C = n_{min} = \left(\frac{v}{v + v_S}\right) n$

Doppler effect + Echo → Beats:

- A source is moving towards a wall with speed v_S. The observer is standing behind the source. $n_{direct} = \left(\frac{v}{v + v_S}\right) n$, $n_{reflected} = \left(\frac{v}{v - v_S}\right) n$, Number of beats $= n_d - n_r \approx \frac{2 n v_S}{v}$
- Source is moving towards wall and observer standing between source and wall.
- $n_d = \left(\frac{v}{v - v_S}\right) n$, $n_r = \left(\frac{v}{v - v_S}\right) n$,

Δn = number of beats heard = difference in frequencies = 0

- Source and observer both are moving towards a wall, with same speed u,

$n_d = n$, $n_r = \left(\frac{v + u}{v - u}\right) n$, $\Delta n = \frac{2 n u}{v - u}$

Sabine: It is the sound absorbed by one square foot of an open window

Stationary wave method:

- Absorption coefficient of a surface is measuring by stationary wave method using formula $a = \frac{4 i_1 i_2}{(i_1 + i_2)^2}$

Question Bank:

Conceptual Questions:

Wave Motion:

1) The maximum distance through which a vibrating particle is displaced from its mean position is
   1) frequency 2) amplitude 3) wavelength 4) phase
2) The phase difference between particle velocity and wave velocity is
   1) zero 2) $\frac{\pi}{4}$ 3) $\frac{\pi}{2}$ 4) $\frac{\pi}{6}$
3) Which of the following is not a characteristic of sound waves?
   1) sound requires a material medium for propagation
   2) sound is transmitted through solid, liquids and gases
   3) velocity of sound is different for different media
   4) velocity of sound is independent of temperature
4) Sound waves can diffract easily because
   1) The wavelength is very very small 2) The wavelength is more
   3) It can refract 4) It can reflect

Free, forced, damped vibrations and resonance:

5) The frequency of natural vibrations of a body is determined by
   1) elasticity of body 2) inertia 3) both elasticity and inertia 4) none
6) Resonance is a special case of
   1) forced oscillations 2) damped oscillations
   3) free oscillations 4) natural oscillations
7) Which are in resonance?
   1) a fork of frequency 20Hz and a simple pendulum of length 20cm
   2) a pendulum of length 1m and a loaded spring of force constant $9.8 Nm^{-1}$ with a load of 1kg
   3)a communication satellite and a stone dropped into a tunnel dug in the earth from pole to pole 4) all the above

Superposition of waves:

8) To demonstrate the phenomenon of beats, we need
   1) two sources which emit radiation of nearly the same frequency
   2) two sources which emit radiation of exactly the same frequency
   3) two sources which emit radiation of exactly the same frequency and have a definite phase relationship
   4) two sources which emit radiation of exactly the same wavelength

9) When two tuning forks of nearly same frequency are sounded together, they produce beats. The velocity of the propagation of beats

1) is greater than the velocity of sound 2) is smaller than the velocity of sound
3) depends on the relative frequencies 4) the same as the speed of sound

10) In a Stationary wave

1)all the particles of the medium vibrate in phase
2) all the antinodes vibrate in phase
3) all alternate antinodes vibrate in phase
4) all the particles between consecutive nodes are in phase
1) 1 & 2 2) 3 & 4 3) 1 & 4 4) 2 &3

11) At anti –nodes

1) pressure is maximum and velocity is minimum
2) pressure is minimum and velocity is maximum
3) pressure and velocity both are maximum
4) pressure and velocity both are minimum

12) Energy is not carried by

1) transverse progressive waves 2) longitudinal progressive waves
3) stationary waves 4) electromagnetic waves

Vibrations of strings:

13) A sitar wire is replaced by another wire of same length and material, but of triple radius If the tension in the wire remains the same, the frequency will become

1) nine times 2) three times 3) one –third 4) one – ninth

14) A sonometer is plucked at $\frac{1}{4}$ th of it length. The most prominent harmonic would be

1) eight 2) fourth 3) third 4) second

Reflection and refraction of sound:

15) The echo and original sound will have same

1) Frequency 2) Amplitude 3) Intensity 4) All the above

Dopper effect and musical sound:

16) When a source of sound is in motion towards a stationary observer, the effect observed is

1) increase in velocity of sound only 2) the velocity of sound in air increases
3) increase in frequency of sound only 4)decrease in frequency of sound only

Order Arranging Type Questions:

17) A stretched string of length *l* and radius *r* fixed at both ends, is under a tension of *T* Vibrates in fundamental frequency. Identify the correct choice in the increasing order of harmonics

a) Length of the string is quadrapled keeping tension and radius are constant
b) Radius of the wire is halved keeping tension and length are constant
c) Tension increases by 9 times keeping tension and length are constant

1) b, c & a   2) a, b & c   3) c, b & a   4) b, a & c

18) Identify the correct order in which the values of apparent frequency decreases for the following cases

a) Both source and observer are moving away from each other with equal velocities

b) Both source and observer are moving towards each other with equal velocities

c) Both source and observer are moving with equal velocities as sourceis behind the observer

1) a, b & c   2) c, b & a   3) b, c & a   4) c, a & b

Assertion & Reason Type Questions:

Directions: These questions consists of two statements as Assertion and Reason. While answering these questions you are required to choose any of the following four responses.

A) If both A & R are true and R is the correct explanation of A

B) If both A & R are true and R is not the correct explanation of A

C) A is true but R is false   D) A is false but R is true

19) Assertion: When the temperature of a stretched string which is fixed between two rigid supports is increased, its fundamental frequency decreases

Reason: The wavelength of the waves remain unchanged

1) A   2) B   3) C   4) D

20) Assertion: Beats are produced when two sound waves of nearly equal frequencies are moving in opposite direction, superimpose

Reason: The maximum number of beats that can be identified by a person is ten

1) A   2) B   3) C   4) D

21) Assertion: The apparent frequency remains same as the source of sound approaches a stationary observer

Reason: The dopper effect does not depend on the distance between the source and observer

1) A   2) B   3) C   4) D

Key

1)2	2)3	3)4	4)1	5)3	6)1	7)2	8)1	9)4	10)2
11)2	12)3	13)3	14)4	15)1	16)3	17)1	18)3	19)2	20)4
21)1									

Numerical Questions:

Wave Motion:

1) The angular frequency of a particle in a progressive wave is an elastic medium is 100π rads^{-1} and it is moving with a velocity of 200ms^{-1}. The phase difference between two particles separated by a distance of 20m is

1) 31.4 rad   2) π rad   3) $\frac{3\pi}{4}$ rad   4) 36 rad

2) The maximum particle velocity in a progressive wave is 4 times of the wave velocity. If the amplitude of the particle is "a". The propagation constant is

1) $\frac{4}{a}$ 2) $\frac{2}{a}$ 3) $\frac{a}{4}$ 4) $\frac{a}{2}$

3) A transverse wave is represented by the equation $y = 2\sin(30t - 4x)$ and the measurements of distance are in metres then the velocity of propagation is

1) $15ms^{-1}$ 2) $7.5ms^{-1}$ 3) $3.75ms^{-1}$ 4) $30ms^{-1}$

4) A wave of length 2m is superposed on its reflected wave to form a stationary wave. A node is located at x = 3m. The next node will be located at x =

1) 3.25m 2) 3.50m 3) 3.75m 4) 4m

5) Which of the following expressions represents simple harmonic stationary wave

1) $A \sin\omega t + B \cos \omega t$ 2) $A \sin\omega t + B \cos kx$

3) $A \sin \omega t\, B \cos kx$ 4) $A \sin (\omega t - kx)$

6) The wavelength of a wave represented by equation $y = 0.03 \sin\pi (2t - 0.01x)$, where x and y are in metres and t in seconds is

1) 50m 2) 100m 3) 150m 4) 200m

7) The time lag between two particles vibrating in a progressive wave separated by a distance 20m is 0.02s. The wave velocity if the frequency of the wave is 500Hz, is

1) $1000ms^{-1}$ 2) $500ms^{-1}$ 3) $2000ms^{-1}$ 4) $250ms^{-1}$

8) The wave length of a progressive wave moving with a velocity $200ms^{-1}$ is 1m. The time lag between two particles separated by a distance of 10m is

1) 0.5s 2) .05s 3) 0.005s 4) 0.1s

9) A transverse wave is represented by $y = 2\sin 2\pi \left(100t + \frac{x}{3}\right)$. Velocity of propagation is

1) $300ms^{-1}$ 2) $30ms^{-1}$ 3) $3ms^{-1}$ 4) $600ms^{-1}$

10) The equation of a wave motion is given by (measurements in metres and seconds) $y = 7\sin \left(7\pi t - 0.4\pi x + \frac{\pi}{3}\right)$ the wave velocity bears a ratio with the maximum particle velocity equal to

1) 44:5 2) 22:7 3) 44:7 4) 22:5

11) For a stationary wave $y = 4\sin \left(\frac{\pi x}{15}\right) \cos (96\pi t)$ meters. The distance between a node and the next antinode is

1) 7.5m 2) 15m 3) 22.5m 4) 30m

12) The equation of a stationary wave is $y = 5 \sin \frac{\pi x}{3} \cos\pi t$ where x and y are in cm and t is in seconds. The separation between two adjacent nodes is

1) 1.5cm 2) 3cm 3) 6cm 4) 4cm

13) A standing wave is represented by $y = A \sin 100t \cos \frac{X}{100}$ where y and A in millimeter, t in seconds and x is in meter. Velocity of wave is
1) $10^4 ms^{-1}$ 2) $1ms^{-1}$ 3) $10^{-4} ms^{-1}$ 4) none

Vibration in Strings:

14) The fundamental frequency of a stretched string is n. If the tension and diameter are doubled its new fundamental frequency will be equal to
1) $\sqrt{2}$ n 2) $\frac{n}{\sqrt{2}}$ 3) $\frac{n}{2}$ 4) 4n

15) A sonometer wire is to be divided into three segments having fundamentals frequencies in the ratio 1:2:3. What should be the ratio of their lengths?
1) 6:3:2 2) 4:3:2 3) 4:2:1 4) 3:2:1

16) Two strings A and B made of the same material have same thickness. The length of A is twice that of B. The ratio of the frequencies of vibrations
1) $\sqrt{2}$:1 2) 2:1 3) 1: $\sqrt{2}$ 4) 1:2

17) The tension in the string is changed by 2% what is the change in the transverse wave velocity
1) 1% 2) 2% 3) 3% 4) 4%

18) The linear density of a stretched wire is increased by 1% the transverse wave velocity
1) decreases by 1% 2) increases by 1%
3) decreases by 0.5% 4) increases by 0.5%

19) If tension in the string is increased from 1kN to 4kN, other factors remaining unchanged the frequency of the second harmonic is
1) halved 2) unchanged 3) doubled 4) quadrupled

20) The frequency of a vibrating wire is ‘n’. When the area of cross section of the wire is halved and tension doubled the frequency becomes
1) n 2) 2n 3) 3 4) $\sqrt{2}$ n

21) A stretched string 0.25m long has a fundamental frequency 600Hz. The velocity of transverse waves in the strings is
1) 75m/s 2) 150m/s 3) 300m/s 4) 1200m/s

22) A wire of density $7x10^3 kg/m^3$, length 1m and diameter 1mm is stretched by weight of 11kg. Calculate the frequency of the fundamental note
1) 35Hz 2) 140Hz 3) 280Hz 4) 70Hz

23) The length of a sonometer wire tuned to a frequency of 256Hz is 0.6m. Calculate the frequency of the tuning fork with which the vibrating wire will be in tune when the length is made 0.4m
1) 78Hz 2) 512Hz 3) 384Hz 4) 126Hz

24) When a load of 8kg is added to the hanger of a sonometer wire the fundamental frequency of wire becomes 3 times of its initial value.

The initial load in the hanger was

1) 0.5kg wt 2) 1kg wt 3) 2 kg wt 4) 4 kg wt

25) String B has twice the length, twice the diameter, twice the tension and twice the density of string. The overtone of B that will be unison with A is

1) 1^{st} 2) 2^{nd} 3) 3^{rd} 4) 4^{th}

26) The distance between two consecutive nodes on a stretched string is 10cm. It is resonance with a tuning fork of frequency 256Hz what is the velocity of the progressive wave in the string?

1) 51.2m/s 2) 25.6m/s 3) 12.8m/s 4) 6.4m/s

27) The fundamental frequency of a string stretched with a weight of 4kg is 256Hz. The weight required to produce it octave is

1) 4 kg wt 2) 12 kg wt 3) 16 kg wt 4) 24 kg wt

28) Transverse waves are generated in two uniform wires A and B of the same material by attaching their free ends to a vibrating source of frequency 200Hz. The cross section of A is half that of B while tension on A is twice than on B. The ratio of wavelengths of the transverse waves in A and B is

1) $1:\sqrt{2}$ 2) $\sqrt{2}:1$ 3) 1:2 4) 2:1

29) If n_1, n_2 and n_3 be the frequencies of the segments of stretched string. Find out the frequency n of the string itself in terms of n_1, n_2 and n_3

1) $\frac{n_1+n_2+n_3}{n_1+n_2+n_3}$ 2) $\frac{n_1n_2+n_2n_3+n_3n_1}{n_1n_2n_3}$

3) $\frac{n_1n_2n_3}{n_1n_2+n_2n_3+n_3n_1}$ 4) $\frac{n_1n_2n_3}{n_1n_1+n_2n_2+n_3n_3}$

30) The string of a sonometer is divided into two parts with the help of a wedge. The total length of the string is 1m and the two parts differ by 2mm. When sounded together they produce two beats. The frequencies of the notes emitted by the two parts are

1) 499 & 497Hz 2) 501 & 499Hz 3) 501 & 503 Hz 4) None

Beats:

31) The number of beats produced by two tuning forks when sounded together is 4. One of them has a frequency of 250Hz. The frequency of the other cannot

1) be less than 246Hz 2) be more than 254Hz
3) lie between 246 & 254Hz 4) all the above

32) Two tuning forks of frequencies 256 and 258 Hz are sounded together. Then the time interval between two consecutive maxima is

1) 2 sec 2) 0.5 sec 3) 250 sec 4) 252 sec

33) Two waves are $y_1 = 0.25\sin 316t$, $y_2 = 0.25\sin 310t$

1) 6 2) 3 3) $\frac{3}{\pi}$ 4) 3π

34) Two sounds waves of wavelengths 2 ms and 2.02m produced 15 beats in 3 seconds in a medium. The velocity of sound in that medium is

1) 330m/s 2) 1010m/s 3) 1450m/s 4) 1600m/s

35) Two stretched wires of same length, diameter and same material are in unison. The tension in one is increased by 2% and 2 beats per second are heard. What was the frequency of the note produced when they were in unisions

1) 100Hz 2) 200Hz 3) 300Hz 4) 400Hz

36) A tuning fork produces 5 beats with sonometer wires of 40cm as well has 44cm, other factors remaining constant, then frequency of the tuning fork is

1) 80Hz 2) 88Hz 3) 105Hz 4) 160Hz

37) Two tuning forks when sounded together produce 5beats per second. The first tuning fork is in resonance with 16.0cm of a sonometer wire and the second is in resonance with 16.2cm wire of same sonometer wire. The frequency of the tuning forks are

1) 100Hz & 105Hz 2) 200Hz & 205Hz 3) 300Hz & 305Hz 4) 400Hz & 405Hz

38) A tuning fork of frequency 340Hz produces 5 beats per second with a sonometer wire. IF the tension is slightly increased the number of beats becomes 4. The frequency of sonometer wire is

1) 335Hz 2) 345Hz 3) 330Hz 4) 350Hz

39) 41 tuning forks are arranged such that every fork gives 5 beats with the next. The last fork has frequency that is double of the first .The frequency of the first fork is

1) 50Hz 2) 100Hz 3) 200Hz 4) 400Hz

40) Tuning fork A of frequency 258Hz gives 8 beats with a tuning fork B. When prongs of B are cut and again A and B are sounded the number of beats heard remains same. The frequency of B is

1) 250Hz 2) 264Hz 3) 258Hz 4) 242Hz

41) Two tuning forks x and y produce tones of frequencies 256Hz and 262Hz respectively. An unknown tone sounded with x produces, beats. When it is sounded with y the number of beats produced is doubled. The unknown frequency is

1) 254Hz 2) 258Hz 3) 264Hz 4) 259Hz

42) Two tuning forks when sounded together produce 5 beats per second. The frequency of one of them is 250Hz. When the other is slightly loaded, they produce 7 beats per second, the frequency of the other tuning fork without loading is

1) 243Hz 2) 245Hz 3) 255Hz 4) 257Hz

43) A given length of a sonometer wire is in resonance with tuning fork. If the length the wire is reduced by 4%, the wire vibrating with the fork produces
5 beats per second. What is the frequency of the tuning fork?

1) 240Hz 2) 200Hz 3) 400Hz 4) 800Hz

44) The frequency of a tuning fork A is 5% greater than that of a standard fork K. The frequency of another fork B is 3% less than that of K. When A and B are vibrated simultaneously 4 beats per second are heard. Find the frequencies of A and B

1) 52.5Hz, 48.5Hz 2) 63.5Hz, 79.5Hz
3) 10.5Hz, 101Hz 4) 124Hz, 120Hz

45) A tuning fork produces 7 beats/s with a tuning fork of frequency 248Hz. Unknown fork is now loaded and 7 beats/s are still heard. The frequency of unknown fork was

1) 241Hz 2) 248Hz 3) 255Hz 4) 234Hz

Echo's:

46) A man fires a gun towards a hillock and hears the echo after 2s. The distance of hillock from him is (velocity of sound $340ms^{-1}$)

1) 170m 2) 340m 3) 680m 4) 34m

47) A person stands at a distance of 850m from a hillock and howled. If he hears the echo after 5sec the velocity of sound is

1) $330ms^{-1}$ 2) $360ms^{-1}$ 3) $340ms^{-1}$ 4) None

48) A man fires a shot and hears the echo from a cliff after 2s. He walks 85m towards the cliff and the echo of a second shot is now heard after 1.5sec. Velocity of sound in air is

1) 85m/s 2) 170m/s 3) 340m/s 4) 680m/s

49) A person moving in a car with a velocity of 36kmph towards a fort wall blows a horn. If he hears the echo after 3s, the distance of wall from him when he blows, the horn (velocity of sound $340ms^{-1}$)

1) 340m 2) 1050m 3) 700m 4) 525m

50) A man standing between two parallel cliffs produces sound and heard the first echo after 4 sec and next echo after 2 sec later v = $330ms^{-1}$. The distance between the cliffs is

1) 1650m 2) 1000m 3) 200m 4) 1050m

51) A rifle is fired in a valley formed between two parallel mountains. The echo from one mountain is heard after 1.5s and from the other is heard 3s later. What is the width of the valley? (velocity of sound = $340ms^{-1}$)

1) 1080m 2) 1060m 3) 1040m 4) 1020m

52) A man is driving at 36km/hr on a straight road towards a hill. He sounds the horn and hears its echo after 4s. At what distance from the hill was the horn sounded. (Velocity of sound = 340m/s)

1) 680m 2) 700m 3) 720m 4) 350m

Doppler Effect:

53) When both source and listner move in the same direction with a velocity equal to half the velocity of sound, the change in frequency of the sound as detected by the listner is (frequency of sound n)

1) zero 2) n 3) $\frac{n}{2}$ 4) $\frac{n}{3}$

54) An engine gives off whistle is moving towards a stationary observer with 50m/s speed. What will be the ratio of the frequencies of the whistle heard 0 when engine is approaching and receding from the observer? (speed of sound = 350m/s)

1) 2:1 2) 4:5 3) 4:3 4) 3:4

55) A train running at 108km/hr towards east whistles at a frequency of 800Hz. The frequencies heard by a passenger sitting in the train and a person standing near the track whom the train has just passed (Speed or Sound = 330m/s)
1) 800Hz, 740Hz 2) 740Hz, 800Hz 3) 800Hz, 870Hz 4) 800Hz, 750Hz
56) The velocity of sound in air is $330ms^{-1}$. To increase the apparent frequency of the sound by 50%, the source should move towards the stationary observer with a velocity equal to
1) $330ms^{-1}$ 2) $220ms^{-1}$ 3) $165ms^{-1}$ 4) $110ms^{-1}$
57) The wave length of the sound produced by a source is 0.8m. If the source moves towards the stationary listner at $32ms^{-1}$, what is the apparent wave length of sound if the velocity of sound is $320ms^{-1}$
1) 0.32m 2) 0.4m 3) 0.72m 4) 0.80m
58) A source of sound is moving with a constant speed of $20ms^{-1}$, emitting a tone of fixed frequency. The ratio of the frequencies observed by a stationary observer when the source is approaching him and after it has crossed him is, if the velocity of sound is $340ms^{-1}$
1) 9:8 2) 8:9 3) 10:9 4) 9:10
59) Two trains move towards each other with the same speed. The speed of sound is $340ms^{-1}$. If the height of the tone of the whistle of one of them heard on the other is $\frac{9}{8}$ times the actual frequency, then the speed of each train should be
1) $20ms^{-1}$ 2) $2ms^{-1}$ 3) $200ms^{-1}$ 4) $2000ms^{-1}$
60) A car is travelling at $\frac{v}{10}ms^{-1}$ and sounds horn of frequency 990Hz. The apparent frequency heard by a police chasing the car at $\frac{v}{9}ms^{-1}$ where V is velocity of sound
1) 990Hz 2) 900Hz 3) 1000Hz 4) 0
61) The frequency of a source of sound as measured by an observer when the source is moving towards him with a speed of 30m/s is 720Hz. The apparent frequency when the source is moving away after crossing the observer is ---- (velocity of sound is 330m/s)
1) 500Hz 2) 600Hz 3) 864Hz 4) 648Hz
62) If to a stationary observer the apparent frequency appears to be $\frac{6}{5}$ times the actual frequency of the moving source, then the speed and direction of the sound source is (Velocity of sound = 360m/s)
1) 60m/s towards the observer 2) 60m/s away from the observer
3) 55m/s towards the observer 4) 55 m/s away from the observer
63) A circular platform is making 10 revolution per second about its axis. A siren is fitted at 70cm distance from the axis and is giving off a sound of frequency 900Hz. To an

observer standing at some distance in front of the platform, the maximum frequency of the sound heard will be (velocity of sound 344m/s)

1) 932Hz 2) 1000Hz 3) 1032Hz 4) 850Hz

64) A person is listening to two trains one approaching him while the other moving away from him. The speed of both the trains is 5m/s. If both trains give off whistle of their natural frequency of 280Hz then the observer will hear ----- no of beats/s (velocity of sound = 350m/s)

1) 6 2) 7 3) 5 4) 8

65) Two sources A and B are sounding notes of frequency 700Hz. A listener moves from A to B with constant velocity u. If the speed of sound is 350m/s, what must be the value of u so that 8 beats/s are heard

1) 2m/s 2) 1.5m/s 3) 2.5m/s 4) 4m/s

66) The driver of a car moving towards a vertical wall notices that the frequency of his car's horn changes from 440Hz to 480Hz. Find the speed of the car if that of the sound is 345m/s

1) 15m/s 2) 680m/s 3) 620m/s 4) 660m/s

67) A source and a detector move away from each other, each with a speed of 10m/s with respect to ground with no wind. If the detector detects a frequency 1650Hz of the sound coming from the source, what is the original frequency of the source? (speed of sound = 340m/s)

1) 750Hz 2) 1750Hz 3) 2000Hz 4) 1800Hz

68) Two tuning forks with natural frequency 340Hz each move relative to a stationary observer. One fork moves away from the observer while the other moves towards him at the same speed. The observer hears beats of frequency 3Hz. Find the speed of the forks (speed of sound in air is 340m/s)

1) 3m/s 2) 1.5m/s 3) 6m/s 4) 1.75m/s

69) A person is standing between two tuning forks each vibrating at 240Hz. If both the forks move towards right at a speed of 5.5m/s find the number of beats heard by the person (speed of sound = 330m/s)

1) 3 2) 6 3) 8 4) 9

70) A source is moving with a constant speed of 10m/s on a circular track of 200m. It emits a sound of frequency 200Hz. A listener stands at the center of the circular track. The frequency received by the listener is (velocity of sound = 340m/s)

1) zero 2) 200Hz 3) 190Hz 4) 210Hz

71) A car travelling at a speed of 54km/hr towards a large wall horns a sound of frequency 400Hz. A person standing between the car and the wall receives sounds one directly from the car and the other reflected from the wall. The number of beats heard by him per second are

1) 8 2) 6 3) 3 4) zero

72) In the above problem what is the frequency of the reflected sound received by the driver of the car? (speed of sound = 335m/s)

1) 420Hz 2) 437.5Hz 3) 380Hz 4) 410Hz

73) In problem number 71 if the person stands behind the car such that the car receding from him approaches the wall the difference in frequencies of the two sounds one received directly from the car and the other reflected from the wall (speed of sound is 335m/s)

1) 35.9Hz 2) 20Hz 3) 70Hz 4) 30Hz

Keys

1)1	2)1	3)2	4)4	5)3	6)4	7)1	8)2	9)1	10)1	11)1
12)2	13)1	14)1	15)1	16)4	17)1	18)3	19)4	20)1	21)3	22)4
23)3	24)2	25)4	26)1	27)3	28)4	29)3	30)2	31)4	32)2	33)3
34)2	35)2	36)3	37)4	38)1	39)3	40)1	41)2	42)2	43)2	44)1
45)3	46)2	47)3	48)3	49)4	50)1	51)4	52)2	53)1	54)3	55)1
56)4	57)3	58)1	59)3	60)3	61)2	62)1	63)3	64)4	65)1	66)1
67)2	68)2	69)3	70)2	71)4	72)2	73)1				

Previous Eamcet Question:

1) Two uniform strings A & B made of steel are made to vibrate under the same tension. If the first overtone of A is equal to the second overtone of B and if the radius of A is twice that of B, the ratio of the lengths of the strings is (2003E)

1) 1:2 2) 1:3 3) 1:4 4) 1:5

2) If the length of a stretched string is shortened by 40% and the tension is increased by 44% then the ratio of the final and initial fundamental frequencies is (2003E)

1) 2:1 2) 3:2 3) 3:4 4) 1:3

3) Two uniform wires of vibrating simultaneously in their fundamental modes. The tensions, lengths, diameters and the densities of the two wires are in the ratio's 8:1, 36:35, 4:1 and 1:2 respectively. If the note of the higher pitch has a frequency 360Hz, the number of beats produced per second is (2003M)

1) 5 2) 10 3) 15 4) 20

4) A radar sends a radio signal of frequency $9x10^9$Hz towards an aircraft approximately the radar. If the reflected wave shows a frequency shift of $3x10^3$Hz, the speed with which the aircraft is approaching the radar in ms^{-1}[Velocity of the radio signal $=3x10^8 ms^{-1}$] (2003M)

1) 150 2) 100 3) 50 4) 25

5) An iron load of 2kg is suspended in air from the free end of a sonometer wire of length one meter. A tunning fork of frequency 256Hz, is in resonance with $\frac{1}{\sqrt{7}}$ times the length of the sonometer wire. If the length is immersed in water, the length of the

wire in meter that will be resonance with the same tuning fork is [specific gravity of iron =8]

1) $\sqrt{8}$ 2) $\sqrt{6}$ 3) $\frac{1}{\sqrt{6}}$ 4) $\frac{1}{\sqrt{8}}$ (2004E)

6) Two identical strings of the same material, same diameter and same length are in unison when stretched by the same tension. If the tension on one string is increased by 21%, the number of beats heard per second is 10. The frequency of note in Hertz. When the strings are in unison is (2004M)

1) 210 2) 200 3) 100 4) 100

7) A vehicle sounding a whistle of frequency 256Hz is moving on a straight road towards a hill with velocity $10ms^{-1}$. Number of beats/second absorbed by a person traveling in the vehicle is velocity of sound = 330m/s (2005E)

1) 0 2) 10 3) 14 4) 16

8) Transverse propagating on a stretched string of linear density $3x10^{-1}$kg/m is represent by the equation y = 0.2sin(1.5x+60t) where x in meters tension in the string is (2005M)

1) 0.24N 2) 0.48N 3) 1.2N 4) 1.8N

9) Frequency of tuning fork is 256Hz velocity of sound is 344m/s. Distance travelled by the sound during the time in which tuning fork completes 32 vibrations is (2006E)

1) 21m 2) 43m 3) 86m 4) 129m

10) A uniform of string of length 1.5m has two successive harmonics of frequency 70Hz and 84Hz. The speed of wave in the string is (2006E)

1) 84m/s 2) 42m/s 3) 21m/s 4) 10.5m/s

11) Two strings A & B of lengths 80cms and X cms are used separately in a sonometer the ratio of their densities is 0.81. Diameter of B is half that of A. If the strings have same tension and fundamental frequency. The value of X is (2006M)

1) 33 2) 102 3) 144 4) 130

12) An observer is standing 500meters away from a hill. Starting between observer and hill a police van sounding horn of frequency 1000Hz moves towards the hill with uniform speed. If the frequency of sound heard directly from horn is 970Hz the frequency of sound heard after reflection from the hill is (V = 330m/s)(2006M)

1) 1042 2) 1032 3) 1022 4) 1012

13) A whistle of frequency 540Hz rotates in a Horizontal circle of radius 2m at an angular speed 15 rad/s the highest frequency heard by a listener at rest with respect to center of circle. V = 330m/s (2007E)

1) 590Hz 2) 594Hz 3) 598Hz 4) 602Hz

14) A segment of wire vibrates with a fundamental frequency of 450Hz under a tension of 9kgwt. Then tension at which fundamental frequency of the same wire becomes 900Hz

1) 36kgwt 2) 27kgwt 3) 18kgwt 4) 72kgwt (2007E)

1) 2	2) 1	3) 2	4) 3	5) 4	6) 4	7) 4
8) 2	9) 2	10) 2	11) 3	12) 2	13) 2	14) 1

Chapter - 16

RAY OPTICS & OPTICAL INSTRUMENTS

About Light:

- Light is a form of energy which makes the objects visible to eye
- Light propagates as electromagnetic waves. It does not require medium for its propagation
- In the electromagnetic spectrum, it lies between $4000A^0$ and $7000A^0$
- All colours of light travel with same speed in vacuum. In a medium different colours of light travel with different speeds. Speed of light is maximum for red and minimum for violet in a medium
- When light travels from one medium to the other, velocity and wavelength change but frequency or colour of light does not change. Amplitude may decrease or remain constant in this case.

Refraction:

- When a light ray passes obliquely from one medium into another, it bends at the interface. This bending of light is called refraction
- The ratio of sine of angle of incidence to the sine of angle of refraction is a constant for a given pair of media and for a given colour of light. This law is called as Snell's law

$\frac{\sin i}{\sin r} = {}_1\mu_2 = \frac{\mu_2}{\mu_1}$ = constant, Where ${}_1\mu_2 = \frac{\mu_2}{\mu_1}$ is called as the refractive index of second medium with respect to the first medium

Refractive index:

- The refractive index of a medium,

$$\mu_m = \frac{\text{velocity of light in vaccum or air}}{\text{velocity of light in medium}} = \frac{C_0}{C}$$

- Different colours travel with different velocities in a medium. Velocity or wavelength of the light. It is maximum for violet and minimum for red
- An object in a denser medium appears nearer as seen from rarer medium

The object at O appears to at I

$$\frac{\sin i}{\sin r} = {}_2\mu_1, \quad {}_1\mu_2 = \frac{PA/PI}{PA/PO} = \frac{PO}{PI} = \frac{\text{real distance}}{\text{apparent distance}} = \frac{t}{t^1}$$

- The shift in the position of object is

$$\left(t - \frac{t}{\mu}\right) = t\left[1 - \frac{1}{\mu}\right]$$

This shift is not affected by the position of eye in the rarer medium

- The object in rarer medium is seen from denser medium

The object appears to be at I

$_1\mu_2 = \frac{\sin i}{\sin r} = \frac{\tan i}{\tan r}$, for small angles of i & r $_1\mu_2 = \frac{PA/PO}{PA/PI} = \frac{PI}{PO}$

$_1\mu_2 = \mu = \frac{t^1}{t}$, Shift = $t^I = t$, Shift = $t\,(\mu - 1)$

Critical Angle – Total Internal Reflection:

Critical Angle:

- When a light ray is travelling from denser medium to rarer medium, the angle of incidence for which the angle of refraction is 90^0 is called the critical angle for that interface

Total internal reflection:

- When angle of incidence of a ray travelling from denser medium to a rarer medium is greater than the critical angle, the incident ray is reflected back in the same medium. This phenomenon is called total internal reflection

Important Points:

- The critical angle "C" depends upon pair of media, colour of light and temperature.
- As temperature increases "C" also increases. (Since μ decreases)

Microscope and telecsope

- **Magnifying power of a simple microscope** is the ratio of the angle subtended by the image at the eye when formed at the near point to the angle subtended by the object at the eye when imagined to be the near point.

- **Magnifying power of a simple microscope,** $m = 1 + \frac{D}{f}$ at the near point and $m = \frac{D}{f}$ at far point where D is the least distance of the distinct vision.

- **Magnifying power of a compound microscope,** $m = m_0 \times m_c$ where m_0 and m_c are the magnifying powers of the objective and eyepiece respectively. It is also given by
- $m = \frac{+Vo}{u}\left(1 + \frac{D}{fe}\right) = \frac{-L}{fo}\left(1 + \frac{D}{fe}\right)$

  Where v_0 is the distance due to the objective and D is the least distance vision which is 25cm for normal eye. If the final image is at infinity, m = - LD.

$f_o f_e$

- **Magnifying power of a telescope** is defined as the ratio of the subtended by the image at the eye when formed at infinity to the angle subtended by the object at the eye when imagined to be at infinity.

- **Magnifying power of an astronomical or terrestrial telescope,** $m = -f_o/f_e$,for normal adjustment or when the image forms at infinity. It is equal to = $\frac{-fo}{fe}\left(1+\frac{fe}{D}\right)$ when the image

Forms at the least distance of distinct vision.

- The length of the Astromical telescope = $f_o + u_e = f_o + \frac{Dfe}{fe+D}$
- The length of the terrestrial telescope = $f_o + f_e + 4f$.
- Comparison between Microscope and Telescope

Microscope	Telescope
1. It is used to see very small objects 2. Its objective is of small focal length and of small aperture. 3. Its eyepiece is of large focal length and of larger aperture. 4. It produces linear magnification i.e., size of the image is larger than that of the object.	1. It is used to see distance objects. 2. Its objective is of larger focal length and of larger aperture. 3. Its eyepiece is of smaller focal length and of smaller aperture. 4. It produces linear magnification i.e., size of the image is nearest but the size does not increases.

- **An eyepiece** is used to increase the field of view and to minimize spherical and chromatic.
- **Dispersive power of the material of a prism** is the ratio of the angular dispersion of two extreme colours to their mean deviation.

$$\omega = \frac{\delta_V - \delta_R}{\frac{\delta_V - \delta_R}{2}} = \frac{\delta_V - \delta_R}{\delta_y} = \frac{\mu_V - \mu_R}{\mu - 1} \left(\quad \right)$$

Problems:

1) Find the magnifying power of a compound microscope whose objective has a focal power of 100D and eyepiece has a focal power of 16D when the object is placed at a distance of 1.1cm from the objective. Assume that the final image is formed at the least distance of distinct vision, 25cm.
   a) -50 b) -60 c) -40 d) -30
2) An astronomical telescope consists of two thin lenses set 52cm apart. Its magnifying power is 25cm for normal adjustment. Find the focal length of the lenses.
   a) 45cm b) 55cm c) 65cm d)50cm
3) A telescope objective of focal length 1m forms a real image of the moon 0.92cm in diameter. Calculate the diameter of the moon taking its mean distance from the earth to be $38*10^4$. If the telescope uses an eyepiece of 5cm focal length, what would be the distance between the two lenses for the final image to be formed at infinity
   a) 106cm b) 108cm c) 105cm d) 108cm

4) From the above problems find the final image (virtual) at 25cm from the eye.
a) 103..4cm b) 104.2cm c) 106.2cm d) 109.3cm

5) In an astronomical telescope, the focal length of the objective and the eye piece are 100cm and 5cm respectively. If the telescope is focused on a scale 2m from the objective, the final image is formed at 25cm from the eye. Calculate the magnification
a) -5 b) -6 c) -4 d) -7

6) Form the above problems find the distance between the objective and the eyepiece.
a) 202.3cm b) 240cm c) 204.2cm d) 205.3cm

7) The refraction indicates of flint glass prism for C, D and F lines are 1.790, 1.795 and 1.805 respectively. Find the dispersive power of the flint glass prism.
a) 0.666 b) 0.564 c) 0.1887 d) 0.999

8) A microscope consists of two convex lenses of focal lengths 2.0cm and 6.25cm placed 15.0cm apart. Where the object must be placed so that the final virtual image is at a distance of 25cm from the eye?
a) 3.5cm b) 2.5cm c) 2.9cm d) 3.8cm

9) A compound microscope is of magnifying power 100. The magnifying power of its eyepiece is 4.
Find the magnification o f its objective.
a) -28 b) -35 c) -25 d)-45

10) The two lenses of a compound microscope are of focal length 2cm and 5cm. if an object is placed at a distance of 2.1cm from the objective of focal length 2cm the final image forms at the least distance of distinct vision of a normal eye. Find the image distance of the image formed by the objective.
a) 42cm b) 48cm c) 44cm d)56cm

11) From the above problem find the magnification of the objective.
a) - 20 b) -39 c) -10 d) 20

12) From the above problem find the distance between the objective and eyepiece and also find the magnifying power of the microscope.
a) 48.32cm ; -110 b) 46.17cm; -120 c) 41.12cm;-114 d) 48.26cm; 120

13) The focal lengths of the eyepiece and the objective of an astronomical telescope are 2cm and 100cm respectively. Find the magnifying power of the telescope for normal adjustment and the length of the telescope.
a) -20; 102cm b) -50; -102cm c) -50; 112cm d) -50; 102cm

14) The focal length of the objective and eyepiece of a telescope are 60cm and 5cm respectively. The telescope is focused on an object 360cm from the objective and the final image is formed at distance of 30cm form the eye of the observer. Calculate the length of the telescope.
a) 76.3cm b) 75.3cm c) 0 d) 78.2cm

15) The magnifying power of an astronomical telescope for normal adjustment is 10 and the length of the telescope is 110cm. find the magnifying power of the telescope when the image is formed at the least distance vision for normal eye.
a) -7 b) -14 c) -21 d) -28

Key

1) a	2) d	3) c	4) b	5) b
6) c	7) c	8) b	9) c	10) a
11) a	12) b	13) d	14) a	15) b

Resolving power of optical instruments

1) The resolving limit of Healthy eye is ( )
   a) $1'$ b) $1''$ c) 1^o d) none of these
2) A telescope having larger diameter will have ( )
   a) High resolving power b) medium resolving power
   c) Lower resolving power d) none of these
3) The smallest object details can be resolved with a certain microscope with light of wavelength $6000A^o$ is $3.5\times10^{-5}cm$. The numerical aperture of the objective when used dry is
   ( )
   a) 0.26 b) 0.46 c) 0.86 d) 0.36
4) The criterion of resolution for resolving power was given by ( )
   a) Newton b) Huygen c) Rayleigh d) Ramsden

Key:

1) a 2) a 3) c 4) b

Optical Fibre:

- It is a thin of diameter 2 micron made up of pure quartz or glass of high quality known as light guiding core
- It is coated with a material of less refractive index called the cladding
- The refractive index of the core is 1.7 and that of cladding is 1.5 to 1.6
- The angle of incidence on one end of the fibre is called lauching angle
- The angle of incidence on the cladding is greater than critical angle of the core with respect to the cladding. Hence total internal reflection takes place several times at the cladding and finally emerges out

Time taken by Light to Travel in a given Medium:

- If "C" is the velocity of light in air or vacuum, then the time taken "t" by light to travel a medium of thickness "d" and refractive index μ is $t = \frac{\mu d}{c}$
- If light takes a time of t_1 and t_2 to travel two different media of same thickness "d" and refractive indices μ_1 and μ_2 then $\frac{d}{C} = \left[\frac{t_2 - t_1}{\mu_2 - \mu_1}\right]$

Relation between Critical Angle & Velocity of Light:

- If v_1 and v_2 are the velocities of light in two media of refractive indices μ_1 and μ_2 ($\mu_1 > \mu_2$). If "C" is the critical angle for the pair of media then $\frac{\mu_1}{\mu_2} = \frac{v_2}{v_1}$
- If C_1 and C_2 are the critical angles for two different media in which velocities of light are v_1 and v_2 respectively then $\frac{\sin C_1}{\sin C_2} = \frac{v_1}{v_2}$

Lens Makes Formula of Thin Lens Formula:

- Lens placed in air $\frac{1}{f} = \left[\frac{\mu_2}{\mu_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

Where μ_2 is refractive index of lens medium and μ_1 is refractive index of surrounding medium and R_1, R_2 radii of curvature of the surface.

- When lens is used in air, $\mu_1 = 1$ and $\mu_2 = \mu$. Then $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$
- For double concave lens, R_1 is +ve and R_2 is –ve

For double concave lens R_1 is –ve and R_2 is +ve

- Lens placed in a liquid of refractive index $\mu 1$, $\frac{1}{f^1} = \left[\frac{\mu_g}{\mu_l} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$
- $\frac{f^1}{f} = \frac{\mu_l(\mu_g - 1)}{\mu_g - \mu_l}$

A Few Formula Relating to u, v f and m:

- The focal length of a lens is given by $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

Where *u* is the object distance and *v* is the image distance

Sign convention:

- All distances are measured from the optic centre of a lens
- Distances of real objects, real images are positive

Focal Power:

- The reciprocal of the focal length (expressed in meters) of a lens is called its power.

Power, P = $\frac{1}{f}$ (in metes) (or) P = $\frac{100}{f}$ (in cms)

- Unit of power is dioptres
- The power of a converging lens is positive
- The power of a diverging lens is negative

Combination of Lenses:

- When two lenses of focal lengths f_1 and f_2 are kept in contact, then

1) focal length of the combination is $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

2) power of the combination is $P = P_1 + P_2$

- When two lenses of focal lengths f_1 and f_2 are separated by a distance 'd' then

1) focal length of the combination is $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

2) power of the combination is $P = P_1 + P_2 - dP_1P_2$

Aberrations:

- The defects in the optical images is known as aberration
- There are two types of aberrations

1) Chromatic aberration 2) Spherical Aberration:

Chromatic Aberration:

- Formation of several images with different colours of an object that give white light is called chromatic aberration
- It is due to the fact that the focal length varies with wavelength (colour)
- Violet rays meet first and red rays at a farthest point from the lens (i.e. $f_R > f_v$)
- The longitudinal chromatic aberration = $f_R - f_v$ (when object is at infinity)
- The distance x measures longitudinal chromatic aberration and the distance y measures the lateral chromatic aberration

Elimination of Chromatic Aberration:

Achromatic combination of two lenses seperated by a distance:

- Chromatic aberration is eliminated by using a pair of thin lenses of focal lengths f_1 and f_2 separated by a distance 'd' such that

$d = \frac{\omega_1 f_1 + \omega_2 f_2}{\omega_1 + \omega_2}$, Where $\omega = \frac{\mu_v - \mu_r}{\mu - 1} = \frac{d\mu}{\mu - 1}$ is called dispersive power

If the two lenses are made of same material then $d = \frac{f_1 + f_2}{2}$

- Chromatic aberration can be eliminated by an achromatic doublet. An achromatic doublet is the combination of a bi-convex lens (usually crown glass) and a plano concave lens (usually flint glass) kept in contact
- The condition to be satisfied by an achromatic doublet is $\frac{\omega_1}{\omega_2} = \frac{-f_1}{f_2}$

Where ω_1 and ω_2 are the dispersive powers of the lens. Negative sign shows that one of the lens is concave

Spherical Aberration:

- The inability of the lens to form a point image of an axial point object is called spherical aberration
- It is due to the fact that the marginal rays suffer greater deviation that the paraxial rays. Therefore the marginal rays are focussed nearer than paraxial rays. So the image formed by the marginal rays is nearer than the image formed by paraxial rays

Elimination of Spherical Aberration:

- The spherical aberration can be minimised by using stops.
- If deviations produced in a light ray are equal at the two refracting surfaces of a lens then spherical aberration becomes minimum. Such a lens which produced equal deviations at the two surfaces is called a 'crossed lens'

A lens satisfying any one of the following conditions acts as crossed lens

$\mu = 1.5.,\ \frac{R_1}{R_2} = \frac{1}{6}$

- By a suitable combination of convex and concave lenses the spherical aberration can be minimised
- The spherical aberration can be minimised by using two plano-convex lenses of the same material placed at a distance equal to the difference of their focal lengths

i.e. $a = f_1 - f_2$

The convex surfaces of the lenses must be towards the incident rays

Huygen's Eyepiece:

- It consists of two plano convex lenses of focal length $3f$ and f separated by a distance of $2f$.
- The focal length of the field lens is $3f$ and focal length of eye lens is f.
- Convex surfaces of both the lenses will be towards incident light
- The effective focal length is $F = \frac{3f}{2}$
- The distance of the equivalent lens from field lens is $3f$.
- It is a negative eyepiece, since the image due to the objective is formed behind the field lens
- It is not possible to provide cross wires in this eye piece. As the cross wires should be kept at the position of the image due to the objective

- The virtual image formed by the objective is at a distance of $\frac{3f}{2}$ form the field lens
- The real image formed by the field lens is at a distance of "f" from the field lens
- This eye piece is free from chromatic and spherical aberrations
- It is used in biological instruments in which the cross wires are not required

Ramsdens Eye Piece:

- It consists of two plano convex lenses of same focal length "f" separated by a distance $\frac{2f}{3}$
- Convex surfaces of the lenses face each other. So either lens can be used as field lens or eye lens
- The effective focal length of the eye piece is $F = \frac{3f}{4}$
- The distance of the equivalent lens from field lens is $\frac{f}{2}$
- It is a positive eyepiece because the image due to objective is formed inform of the field lens
- The cross wires are fixed infront of the field lens at the same position where the image due to objective is formed
- The distance of the cross wires before the field lens is $\frac{f}{4}$
- The distances of the cross wires from the eye lens is $= \frac{2f}{3} + \frac{f}{4} = \frac{11f}{12}$
- The virtual image formed by the field lens is at a distance of $\frac{f}{3}$ from the field lens and at a distance of "f" from the eye lens
- It is not completely free from chromatic and spherical aberrations
- The eyepiece is used in measuring instruments like travelling microscope and spectrometer

Dispersion:

- The splitting of white light into constituent colours is called dispersion and the band of colours is called spectrum
- Dispersion of light was discovered by Newton

Angular Dispersion:

- The difference in deviation between any two colours (generally violet and red) is called angular dispersion
- The angular dispersion = $d_V - d_R = (\mu_V - \mu_R) A$

[Since for small angled prism, $d_V = (\mu_V - 1)$ and $d_R = (\mu_R - 1)A$]

Dispersive Power:

- Dispersive power, $\omega = \frac{\text{angular dispersion}}{\text{mean deviation}}$ $\quad \omega = \frac{d_V - d_R}{d}$, where d = (μ -1)A the mean deviation (i.e. for yellow colour) $\quad \therefore \quad \omega = \frac{\mu_V - \mu_R}{\mu - 1}$

Question Bank:

Theory Questions:

1) Which of the following statements is wrong?
 1) Light travels faster in vacuum than in air
 2) Wavelength of light is longer than the wavelength of sound
 3) Wavelength of sound is greater than the wavelength of light
 4) Speed of sound is much less than speed of light in air
2) The direction of light ray and its wave front are
 1) Parallel 2) Perpendicular 3) Opposite 4) None
3) Velocity of electromagnetic waves in a medium depends upon
 1)Thermal properties of the medium
 2)Mechanical and electrical properties of medium
 3)Electrical and magnetic properties of medium
 4)Mechanical and magnetic properties of medium
4) When a ray of light enters into air from a glass slab
 1) its wavelength decreases 2) its wavelength increases
 3) its frequency increases 4) its frequency decreases
5) In case of refraction of light
 1) frequency changes 2) phase changes
 3) speed changes 4) wavelength constant
6) The ratio of the refractive index of red light to blue light in glass is
 1) <1 2) >1 3) =1 4) can be >1 or <1
7) Monochromatic light of wavelength λ gets refracted from vacuum to a medium of refractive index μ. The ratio of wavelength of the incident and refracted wave is
 1) 1: μ 2) 1:1 3) μ :1 4) μ^2:1

8)Total internal reflection is possible when a ray of light passes from
 1) air into water 2) air into glass 3) glass into water 4) water into glass

9) The critical angle for a ray of light suffering total internal reflection will be smallest for light travelling from
 1) water to air 2) glass to air 3) glass to water 4) water to glass

10) Optical fibres are based on
 1) total internal reflection 2) less scattering
 3) refraction 4) less absorption coefficient

11) In an optical fibre, the refractive index of inner region must be

1) greater than outer region 2) equal to outer region
3) less than outer region 4) either less or more

12) The focal length of a lens depends on
1) refractive index 2) radii of curvature 3) medium outside the lens 4) all

13) f_v and f_R are the focal lengths of a convex lens for violet and red light respectively and F_v and F_R are the focal lengths of concave lens for violet and red light respectively. Then we must have
1) $f_v<f_R$ and $F_v>F_R$ 2) $f_v<f_R$ and $F_v<F_R$
3) $f_v>f_R$ and $F_v>F_R$ 4) $f_v>f_R$ and $F_v<F_R$

14) The cause of chromatic aberration is
1) Marginal rays 2) Central rays
3) Difference in radii of curvature of its surfaces
4) Variation of focal length of lens with colour

15) An Achromatic combination is to be obtained using a convex lens and a concave lens, the two lenses selected should have
1) Their powers equal 2) Their refractive indices equal
3) Their dispersive powers equal
4) The product of their powers and dispersive powers equal

16) A plano convex lens is effectively used in decreasing spherical aberration
1) with its plane surface towards the incident rays
2) with its curved surface towards the incident rays
3) with its surface having less radius of curvature towards spherical aberration
4) both 2 & 3

17) In Ramsden eyepiece, which aberration is removed?
1) spherical 2) chromatic 3) both 4) neither

18) Cross wires can be used in
1) Huygen's eyepiece 2) Ramsden's eyepiece 3) both 1 & 2 4) none of the above

19) The angular dispersion produced by a prism
a. increases if the average refractive index increases
b. increases if the average refractive index decreases
c. remains constant with out depending on refractive index
d. no relation with average refractive index

20) The dispersive power of a material is
1) positive only 2) negative only
3) both positive and negative at the same time
4) some times positive and sometimes negative

21) Dispersive power depends upon
1) shape of prism 2) refracting angle of prism
3) material of prism 4) both material and angle of prism

22) The dispersive power of a prism is

1) same for all pairs of colours 2) independent of refracting angle
3) changes with pair of colours 4) 2 & 3

23) Dispersion of light occurs due to
1) site of the prism 2) wavelength 3) angle of incidence 4) angle of prism

24) Liquids at high temperature gives
1) line spectrum 2) band spectrum 3) continuous spectrum 4) none

25) High pressure gases at high temperature gives
1) line spectrum 2) continuous spectrum
3) band spectrum 4) absorption spectrum

26) Which of the following does not give continuous spectrum?
1) Hot charcoal 2) Hot iron 3) Photosphere 4) Carbondioxide

27) The spectra used to identify the elements in the mixture is
1) emission 2) absorption 3) emission and absorption 4) none

28) The nature of line spectra is
1) electronic 2) vibrational 3) rotational 4) oscillatory

29) The spectra given out by hydrogen subjected to an electric discharge is
1) continuous 2) line 3) band 4) absorption

30) The nature of band spectra
1) electronic 2) vibrational 3) rotational 3) both vibrational and rotational

31) Solar spectrum is
1) emission spectrum 2) absorption spectrum
3) continuous spectrum 4) band spectrum

32) The nature of sun's spectrum is
1) line spectrum 2) band spectrum
3) continuous spectrum 4) continuous spectrum with a few absorption

33) The element helium was discovered first with the help of
1) continuous spectrum 2) line spectrum
3) band spectrum 4) solar spectrum

34) Fraunhofer lines is example for
1) line emission spectrum 2) band emission spectrum
3) band absorption spectrum 4) line absorption spectrum

35) Emission of light stops as soon as the incident light is cut off in
1) phosphorescence 2) flourescence
3) luminescence 4) efforescence

Match the Following Questions:

36) Match the following Lists:

List –I	List –II
a) chromatic aberration b) spherical aberration c) effective focal length of Huygen's eye piece	e) the image of a point object can't be of point size f) $3f/2$ g) $3f/4$

d) effective focal length of Ramsden's eyepiece	h) focal length of lens changes with the colour of light

The correct match is

1) a→e; b→h; c→g; d→f 2) a→h; b→e; c→f; d→g

3) a→g; b→f; c→h; d→e 4) a→f; b→g; c→e; d→h

37) Match the following lists:

List –I	List –II
a) chromatic aberration b) spherical aberration c) Achromatism (condition) d) Lens makers formula	e) $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$ f) $f_1 - f_2 = d$ g) $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ h) $\frac{\omega_1 f_1 + \omega f_2}{\omega_1 + \omega_2}$ i) $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

1) a→e; b→g; c→f; d→h 2) a→f; b→h; c→e; d→g

3) a→g; b→i; c→e; d→f 4) a→f; b→e; c→h; d→i

Order Arranging Question:

38) It is wished to prepare 4 lenses, double convex, convexo-concave, double concave and concavo-convex by the two curved surfaces of radii of curvature +20cmand +30cm of refractive index 1.5. What are the values of their focal lengths in the given order?

1)+20cm, –20cm, +120cm, –120cm 2) –20cm, –120cm, –20cm, +120cm

3) +120cm, –120cm, –20cm, +20cm 4) –120cm, +20cm, –20cm, +120cm

Assertion & Reason Type Questions:

Directions: **These questions consist of two statements as Assertion and reason. While answering these questions you are required to choose any of the following four responses**

A)If both Assertion and Reason are true and the Reason is correct explanation of the Assertion

B) If both Assertion and Reason are true but R is not correct explanation of the Assertion

C) If Assertion is true, but the Reason is false

D) If Assertion is false, but the Reason is true

39) Assertion: Corpuscular theory fails in explaining the velocities of light in air and water
Reason: According to corpuscular theory, light should travel faster in denser media than in rarer media
1) A 2) B 3) C 4) D

40) Assertion: According to Huygen's wave theory, light requires a material medium for its propagation
Reason: Mechanical waves can travel in a medium having elasticity and inertia
1) A 2) B 3) C 4) D

41) Assertion: A single lens produces a coloured image of an object illuminated by white lightReason: The refractive index of the material of lens is different for different wavelengths of light
1) A 2) B 3) C 4) D

42) Assertion: Critical angle of light passing from glass to air in minimum for violet colour
Reason: The wavelength of blue light is greater than the light of other colours
1) A 2) B 3) C 4) D

43) Assertion: Optical fibres are used to transmit light without any loss in its intensity over distance for several kilometers
Reason: Optical fibres are very thick and all the light is passed through it without any loss
1) A 2) B 3) C 4) D

44) Assertion: Optical fibres are widely used in communication net work
Reason: Optical fibres are small in size, light weight, flexible and there is no scope for interference in them
1) A 2) B 3) C 4) D

45) Assertion: Spherical aberration of a lens can be reduced by blocking the central portion or peripheral portion of the lens
Reason: Spherical aberration arises on account of inability of the lens to focus central and peripheral rays at the same point
1) A 2) B 3) C 4) D

46) Assertion: For an achromatic combination, sum of products of power and dispersive powers of the two lenses must be zero
Reason: Condition for achromatism is $\frac{\omega_1}{f_1}+\frac{\omega_0}{f_0}=0$, where symbols have standard meaning
1) A 2) B 3) C 4) D

47) Assertion: Ramsden's eyepiece can not be used for measuring purpose in optical instruments whereas Huygen's eyepiece can be used
Reason: Cross wires can be placed in Ramsden's eyepiece but in Huygen's eyepiece they cannot be placed

1) A 2) B 3) C 4) D

48) Assertion: Dispersion of light occurs because velocity of light in a material depends upon its colour
Reason: The dispersive power depends only upon the material of the prism, not upon the refracting angle of prism
1) A 2) B 3) C 4) D

49) Assertion: A tube light emits white light
Reason: Emission of light in a tube takes place at a very high temperature
1) A 2) B 3) C 4) D

Key

1) 2	2) 2	3) 3	4) 2	5) 3	6) 1
7) 3	8) 3	9) 2	10) 1	11) 1	12) 4
13) 1	14) 4	15) 4	16) 4	17) 4	18) 2
19) 1	20) 1	21) 3	22) 4	23) 2	24) 3
25) 2	26) 4	27) 1	28) 1	29) 2	30) 4
31) 2	32) 4	33) 4	34) 4	35) 2	36) 2
37) 2	38) 2	39) 1	40) 1	41) 1	42) 3
43) 3	44) 1	45) 1	46) 4	47) 3	48) 2
49) 2					

Refraction of Light, Tir – Optical Fibre:
Numerical Questions:

1) V_W and V_g are velocities of light in water and glass respectively. Refractive index of water w.r.t glass is
1) $\frac{V_W}{V_g}$ 2) $\sqrt{V_W V_g}$ 3) $\frac{V_g}{V_W}$ 4) $V_g V_W$

2) The refractive index of glass is 1.5. The velocity of light in that glass in ms^{-1} is
1) $3x10^8$ 2) $2x10^8$ 3) $1.5x10^8$ 4) $\frac{2}{8}$ $x10^8$

3) If refractive indices of glass and water are respectively $\frac{3}{2}$ and $\frac{4}{3}$, refractive index of glass w.r.t water is
1) 2 2) $\frac{8}{9}$ 3) $\frac{9}{8}$ 4) $\frac{1}{2}$

4) A ray of light passes normally through a slab (μ =1.5) of thickness 't'. If the speed of light in vacuum be C, then time taken by the ray to go across the slab will be

1) $\frac{t}{C}$ 2) $\frac{3t}{2C}$ 3) $\frac{2t}{3C}$ 4) $\frac{4t}{9C}$

5) A ray of light is incident on the surface of a slab of refractive index 1.5 and of thickness 't' so that the ray of light has angle of refraction 60^0, then the time taken to cross the slab will be

1) $\frac{3t}{C}$ 2) $\frac{3t}{2C}$ 3) $\frac{2t}{3C}$ 4) $\frac{4t}{3C}$

6) Light of wavelength 7200^0A in air has a wavelength in glass equal to (μ =1.5)

1) 7200^0A 2) 4800^0A 3) 10800^0A 4) 7201.5^0A

7) The velocity of light in glass whose refractive index with respect to air is 1.5 is $2x10^8ms^{-1}$. In a certain liquid the velocity of light is found to be $2.5x10^8$m/s. The refractive index of the liquid with respect to air is

1) 0.64 2) 0.80 3) 1.20 4) 1.44

8) A ray of light incidents at an angle of incidence 60^0 on a refracting surface. If the reflected and refracted rays are perpendicular to each other, the refractive index of the medium is

1) $\sqrt{3}$ 2) $\frac{\sqrt{3}}{2}$ 3) $2\sqrt{3}$ 4) $\sqrt{2}$

9) The same colour of light takes t_1 seconds and t_2 seconds to travel the same distance 'x' in two media A and B respectively. Refractive index of medium A w.r.t B is

1) $\frac{xt_1}{t_2}$ 2) $\frac{t_2}{t_1x}$ 3) xt_1t_2 4) $\frac{t_1}{t_2}$

10) A ray of light is travelling from medium A into rarer medium B. The angle of incidence is 45^0 and the angle of deviation is 45^0. The refractive index of medium A w.r.t B is

1) $\sqrt{\frac{3}{2}}$ 2) $\frac{\sqrt{3}}{2}$ 3) $\frac{1}{\sqrt{2}}$ 4) $\sqrt{\frac{2}{3}}$

11) Absolute refractive index of a medium is 'x'. Refractive index of the same medium is y and absolute refractive index of air is z. Then, the relation between them is

1) $x = \frac{y}{z}$ 2) $y = \frac{x}{z}$ 3) $z = \frac{y}{x}$ 4) $y = \frac{1}{xz}$

12) If the angle of incidence is twice the angle of refraction, find the angle of incidence (the refractive index of the medium is μ)

1) $\cos^{-1}(\mu/2)$ 2) $\sin^{-1}(\mu/2)$ 3) $2\sin^{-1}(\mu/2)$ 4) $2\cos^{-1}(\mu/2)$

13) Refractive indices of glass and water are respectively $\frac{3}{2}$ and $\frac{4}{3}$. The critical angle between them is $\sin^{-1}$

1) $\frac{9}{8}$ 2) $\frac{8}{9}$ 3) $\frac{2\sqrt{2}}{3}$ 4) $\frac{3}{\sqrt{8}}$

14) A bird in the air sees a fish in the water vertically below it. 'x' is the depth of the fish and 'y' is the height of the bird above the water. If 'μ' is the refractive index of water, then the distance of the fish as observed by the bird is

1) $y+\frac{x}{\mu}$ 2) $x+\frac{y}{\mu}$ 3) $\frac{x+y}{\mu}$ 4) $\mu(x+y)$

15) Monochromatic light is refracted from air into glass of refractive index μ. The ratio of wavelengths of incident and refracted waves is

1) 1: μ 2) 1: μ^2 3) μ : 1 4) μ^2 :1

16) Velocity of light in air is $3x10^8ms^{-1}$. If it takes $2.66x10^{-6}$ sec to travel in a medium of refractive index 1.33, the distance is travels in that medium is

1) 400m 2) 600m 3) 500m 4) 1000m

17) Air has refractive index 1.0003. The thickness of air column, which will have one more wave length of yellow light (6000^0A) than in same thickness of vacuum is

1) 2mm 2) 2cm 3) 2m 4) 2km

18) A glass slab of thickness 4cm contains the same number of waves as 5cm of water when both are traversed by the same monochromatic light. If the refractive index of water is 4/3 then that of glass is

1) 5/3 2) 5/4 3) 16/15 4) 1.5

19) A ray of light is incident on a rectangular glass plate at an angle of incidence of 60^0. The light ray suffers a deviation which is 25% of the angle of incidence. The refractive index of the glass plate iss

1) $\sqrt{3}$ 2) $\sqrt{2}$ 3) $\sqrt{\frac{3}{2}}$ 4) 1.5

Lens Maker's Formula:

20) If R_1 and R_2 are the radii of curvature of double convex lens, the lens with more power is

1) R_1 = 20cm, R_2 = 10cm 2) R_1 = 20cm, R_2 =20cm 3) R_1 = R_2 = 10cm 4) R_1 = R_2 = 5cm

21) An equiconvex lens of focal length 'f ' is cut into two equal parts normal to the axis. If they are arranged as shown, their respective focal lengths of the combination will be

1) f and 2f 2) f/2 and f/2 3) f and 2f 4) 2f and f

22) A convex lens of focal length 'f ' is placed in a transparent medium of double the refractive index. Then focal length of the lens becomes index. Then focal length of the lens becomes

1) 2f 2) f/2 3) nature of the lens changes and focal length increases

4) f but acts as concave lens

23) The focal power of diverging lens of focal length 25cm is
1) 2D 2) –4D 3) 4D 4) 0.25D

24) The radius of curvature of the convex surface is 18cm. If its refractive index is 1.6, focal length of the plano convex lens is
1) 18cm 2) 24cm 3) 36cm 4) 30cm

25) A double convex lens of refractive index 3/2 is placed in a liquid of refractive index 4/3. If the focal length of the lens in air is 25cm, in water it will be
1) 12.5cm 2) 60cm 3) –100cm 4) 1m

26) An object is placed at a distance of 20cm from a concave lens of focal length 20cm. Position of the image is
1) 20cm, virtual 2) 10cm real 3) 10cm, virtual 4) 12cm, virtual

27) The rays of light are coming to focus at a point P.A convex lens of focal length 10cm is placed before they meet, at a distance of 20cm from P. The new position of P from the lens is
1) 6.67cm 2) 30cm 3) 10cm 4) P itself

28) A diverging meniscus of radii of curvature 25 cm and 50 cm has a refractive index 1.5. Its focal length is
1) –50cm 2) –100cm 3) –75cm 4) 20cm

29) A thin liquid convex lens is formed in glass. Refractive index of liquid is 4/3 and that of glass is 3/2. If 'f' is the focal length of the liquid lens in air, its focal length and nature in the glass is
1) f, convex 2) f, convex 3) 2f, convex 4) 3f, convex

30) A plano convex lens of focal length 100cm has a convex surface of radius of curvature 60cm. The refractive index of the lens is
1) 1.5 2) 1.6 3) 1.7 4) 1.3

31) A thin double convex lens is cut into two equal pieces A and B by a plane containing the principle axis. The piece B is further cut into two more equal pieces C and D by another plane perpendicular to the principal axis. If the focal power of the original lens is 'P', then those of A and C are respectively
1) P and P/4 2) P and P/2 3) P/2 and 2P 4) P/2 and P/4

32) A lens of power +3.5 diopters is placed in contact with a lens of power –2.5diopter. The combination will behave like
1) a convergent lens of focal length 100cm 2) a divergent lens of focal length 100cm
3) a convergent lens of focal length 200cm 4) a divergent lens of focal length 200cm

33) A double convex lens has –radii of curvature of 1m and 2m. What should be the refractive index of the medium so that the focal length of the lens is 50cm
1) $3\frac{1}{3}$ 2) $2\frac{1}{3}$ 3) $4\frac{1}{3}$ 4) 1.33

34) A plano convex lens of refractive index 'μ' has radius of curvature 'R' for its curved surface. When its curved surface is silvered. The focal length of the silvered lens is

1) $\frac{R}{2(\mu-1)}$ 2) $\frac{R}{\mu}$ 3) $\frac{R\mu}{2(\mu-1)}$ 4) $\frac{R}{2\mu}$

35) A double convex lens of refractive index 1.5 has radii of 20cm. Incident rays of light parallel to the axis will come to converge at a distance from the lens is
1) 20cm 2) 10cm 3) 40cm 4) 30cm

36) A plano convex lens of refractive index 1.5 and radius of curvature 24cm is placed on a plano glass plate with its curved surface on the glass plate. A liquid of refractive index 1.6 is placed between lens and the glass plate. The focal length of liquid lens is
1) 15cm convex 2) 30cm concave 3) 7.5cm convex 4) 7.5cm concave

37) Two equi-convex lenses, each of radius of curvature 20cm and refractive index 1.5 are placed in contact. If water of refractive index 4/3 is placed in between the lenses, the focal length of the combination is
1) 15cm convex 2) 30cm concave 3) 7.5cm convex 4) 7.5cm concave

38) A thin convex lens of refractive index 2 has a focal length of 20cm in air. When the lens is cut into two halves, perpendicular to its principal axis and if one of the pieces is placed in a medium of refractive index 4/3, then the focal length of the piece will be
1) 10cm 2) 20cm 3) 80cm 4) 40cm

39) The distance of the image formed by the objective to the eye lens of the Ramsden's eye piece is
1) 11f/12 2) 12f/11 3) 3f/4 4) 2/3f

40) The effective focal length of the Ramsden's eye piece with lenses of 12cm focal length each is
1) 6 cm 2) 24cm 3) 9cm 4) None

41) The image due to the objective is made to form at a distance of E from the field lens of focal length 16cm
1) 4cm 2) 8cm 3) 12cm 4) 2cm

42) The ratio of the distance of the image formed due to the objective to field lens to the effective focal length in Huygens eye piece is
1) 1:1 2) 2:1 3) 2:3 4) 3:1

43) If the equivalent focal length of Ramsden eye piece is 'x', distance of cross wires from field lens is
1) x 2) 3x 3) x/3 4) 11x/4

44) In Huygen's eye piece, the focal length or field lens is 'f '. The distance of image (I_1) formed due to objective from the eye lens is
1) f 2) f/4 3) 11f/12 4) f/2

45) If distance of the cross wire from eye lens is 22/3 cm, then the equivalent focal length of Ramsden's eye piece is
1) 12cm 2) 6cm 3) 4cm 4) 8cm

46) In Huygen's eye piece, the ratio between equivalent focal length and the distance between the lenses is

1) 3:4 2) 2:3 3) 1:1 4) 4:1

47) The ratio of focal lengths of eye lens used in Ramsden's and Huygen's eyepiece is 1:1. The ratio of equivalent focal lengths of Ramsden and Huygen's eyepiece is

1) 3:2 2) 2:1 3) 1:1 4) 4:1

48) The equivalent focal length of Huygen's eye piece is f. The focal lengths of the field lens and eye lens are respectively

1) 2f and 2f/3 2) f and f/3 3) 3f and f 4) 6f and 2f

49) The focal length of eye lens in Huygen's eye piece is 'f '. It is used that the position of image formed by the objective lens is at distance of

1) ' f ' behind the field lens 2) f/4 behind the field lens
3) 3f/2 behind the field lens 4) 2f/3 behind the field lens

50) The equivalent focal length of lenses used in Ramsden's eye piece is 6cm. If they are put in contact with their flat surfaces together, the focal length of new arrangement becomes

1) 8cm 2) 12cm 3) 3cm 4) 4cm

51) Two thin lenses of focal lengths f_1 and f_2 are separated by a distance d between them. If the combination satisfies the condition for no chromatic and no spherical aberration then, f_1:f_2 is

1) 3:1 2) 1:2 3) 2:3 4) 4:1

52) For flint glass prism the refractive indices for red, yellow and violet light, are 1.613, 1.620 and 1.632 respectively. Its dispersive power is about

1) 0.031 2) 0.019 3) 0.620 4) 0.471

53) If the refractive indices of crown glass for red, yellow and violet colours are 1.5140, 1.5170 and 1.5318 respectively and for flint glass these are 1.6434, 1.6499 and 1.6852 respectively, then the dispersive power for crown and flint glass are respectively

1) 0.034 and 0.064 2) 0.064 and 0.034
3) 1.3 and 0.064 4) 0.034 and 1.0

54) The refractive indices of violet and red light are 1.54 and 1.52 respectively. If the angle of prism is 10^0, the angular dispersion is

1) 0.02^0 2) 0.2^0 3) 3.06^0 4) 30.6^0

55) An achromatic convergent lens of focal length +20cm is made of two lenses (in contact) of materials having dispersive powers in the ratio of 1:2 and having focal lengths f_1 and f_2. Which of the following is true?

1) f_1 = 10cm, f_2 = 20cm 2) f_1 = 20cm, f_2 = 10cm
3) f_1 = -10cm, f_2 = 20cm 4) f_1 =20cm, f_2 = -10cm

56) The dispersive powers of the materials of convex lens and concave lens placed in contact are in the ratio 1:2. For achromatic combination, the focal lengths of the arrangement is 200cm. The focal lengths of the lenses respectively are

1) 100 cm, -200cm 2) –100cm, 200cm
3) 200cm, -200cm 4) 50cm, -150cm

Key

1)3	2)2	3)3	4)2	5)1	6)2	7)3
8)1	9)4	10)1	11)2	12)4	13)2	14)1
15)3	16)2	17)1	18)1	19)3	20)4	21)1
22)3	23)2	24)4	25)4	26)3	27)1	28)2
29)4	30)2	31)2	32)1	33)2	34)4	35)1
36)4	37)1	38)3	39)1	40)3	41)1	42)1
43)3	44)4	45)2	46)1	47)1	48)1	49)3
50)4	51)1	52)1	53)1	54)2	55)1	56)1

Previous Eamcet Questions:

1) A ray of light is incident on the hypotenuse of a right angle prism after travelling parallel to the base inside the prism. If 'μ' is the refractive index of the material of the prism, the maximum value of the base angle for which light is totally reflected from the hypotenuse is (2003E)

1) $\sin^{-1}\left[\frac{1}{\mu}\right]$ 2) $\tan^{-1}\left[\frac{1}{\mu}\right]$ 3) $\sin^{-1}\left[\frac{\mu-1}{\mu}\right]$ 4) $\cos^{-1}\left[\frac{1}{\mu}\right]$

2) A prism of refractive index 'μ' and angle 'A' is placed in the minimum deviation position. If the angle of minimum deviation is 'A', then the value of 'A' interms of 'μ' (2003E)

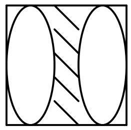
1) $\sin^{-1}\left[\frac{1}{\mu}\right]$ 2) $\sin^{-1}\left[\sqrt{\frac{\mu-1}{2}}\right]$ 3) $2\cos^{-1}\left[\frac{\mu}{2}\right]$ 4) $\cos^{-1}\left[\frac{\mu}{2}\right]$

3) Assertion: Propagation of light through an optical fiber is due to total internal reflection taking place at the core cladding interface
Reason: Refractive index of the material of the core of optical fiber is greater than that of air (2005E)
   1) Both A & R are true and R is the correct explanation of A
   2) Both A & R are true and R is not the correct explanation of A
   3) A is true but R is false 4) A is false but R is true

4) The focal length of an equiconvex lens is greater than radius of curvature of any of the surfaces. Then refractive index of material of lens is (2005E)
1) Greater than zero but less than 1.5 2) Greater than 1.5 but less than 2
3) Greater than 2 less than 2.5 4) Greater than 2.5 but less than 3

5) Fraunhoffer lines are produced by the absorption of light in (2005M)
1) Chromo sphere of sun 2) Photosphere of sun
3) Atmosphere of earth 4) Ionosphere of earth

6) The effective focal length of lens combination in the figure is -60cm the radii of curvature of the curved surfaces of plano convex lenses are 12 cm each and refractive index of material of lens is 1.5. Then refractive index of liquid is (2006M)



1) 1.33 2) 1.42 3) 1.53 4) 1.6

7) In Ramsden eye piece two plano convex lenses each of focal length f are separate by a distance 12cm equivalent focal length of eye lens in cm is (2006M)
1) 10.5 2) 12 3) 13.5 4) 15.5

8) A light ray travelling between two media as given below. The angle of incidence on the boundary in all the cases is 30^0 identify the correct sequence of increasing order of angle of refraction. a) air to water b) water to glass c) glass to water (2006M)
1) a, b, c 2) b, c, a 3) c, a, b 4) a, c, b

9) Two surfaces of a bi convex lens has radii of curvature. This lens is made of glass of refractive index 1.5 and has a focal length 10cm in air. Lens is cut into two equal halves along a plane perpendicular to its principal axis. The two pieces are glued such that convex surfaces touch each other if this combination is immersed in water (μ = 4/3) its focal length is (2006E)
1) 5cms 2) 10cms 3) 20cms 4) 40cms

10) Dispersive power depends on the following (2006E)
1) material of prism 2) shape of prism
3) size of prism 4) size, shape, material of prism

11) Refractive index of material of double convex lens is 1.5 and its focal length is 5cm. If the radii of curvature are equal the value of radius of curvature in cm is (2007E)
1) 5 2) 6.5 3) 8 4) 9.5

1)4	2)3	3)2	4)1	5)1	6)4	7)3
8)1	9)4	10)1	14)1			

Reflection of Light by spherical Mirrors and Refraction at spherical surfaces

Introduction

Light is a form of radiant energy, that is, energy emitted by excited atoms or molecules which can cause the sensation of vision in a normal human eye.

The branch of Physics which deals with the phenomena concerning light is called Optics. There are two branches of Optics :

(a) Geometrical Optics : This branch of optics deals with the formation of images purely by ordinary geometrical methods and the laws of reflection and refraction.

(b) Physical Optics : It deals with the theories regarding the nature of light and provides an explanation for the different phenomena in light, such as reflection, refraction, interference, diffraction, polarisation and rectilinear propagation.

Some Definitions

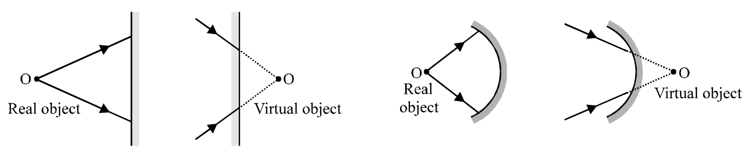
(i) A ray : The 'path' along which light travels is called a ray. They are represented by straight lines with arrows directed towards the direction of travel of light.

(ii) **A beam** : A bundle of rays is called a beam. A beam is parallel when its rays are parallel; divergent when its rays spread out from a point and convergent when its rays meet at a point.

(iii) **A pencil** : A narrow beam is called a pencil of light.

Object and Image

If the rays from a point on an object actually diverge from it and fall on the mirror, then the object is said to be real object. If the rays incident on the mirror do not start from a point but appear to converge at a point, then that point is the virtual object for the mirror.



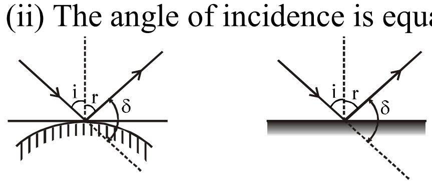
Definition

When light falling on a surface is turned back into the same medium, it is said to be reflected. The angle made by the incident ray with the normal to the reflecting or refracting surface is called the angle of incidence and the angle made by the reflected or refracted ray with the normal is called the angle of reflection or refraction.

Laws of Reflection

(i) The incident ray, the reflected ray and the normal to the reflecting surface at the point of incidence lie in the same plane called the plane of incidence.

(ii) The angle of incidence is equal to the angle of reflection.



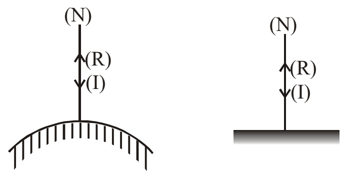
Deviation of Ray

Deviation is defined as the angle between directions of the incident ray and the reflected ray (or, the emergent ray). It is gneratlly denoted by δ.

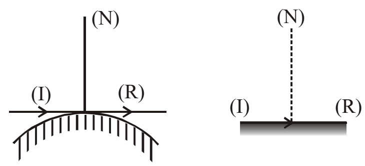
Here,

or, $\delta = 180° - 2i$

Normal Incidence :



Grazing Incidence :



4. IMAGE FORMATION BY PLANE MIRROR

If an object is placed in front of a mirror as shown we get its image in the mirror due to reflection of light.

(a) Distance of object from the mirror = Distance of image from the mirror.

(b) The line joining the object point with its image is normal to the reflecting surface.

(c) The image is laterally inverted. (left right inversion)

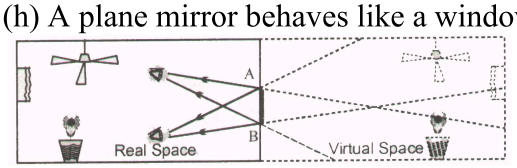
(d) The size of the image is the same as that of the object.

(e) For a real object the image is virtual and for a virtual object the image is real.

(f) For a fixed incident light ray, if the mirror be rotated through an angle θ the reflected ray turns through an angle 2θ. If plane mirror is rotated through about an axis perpendicular to plane of mirror then reflected ray image, spot do not rotate.

(g) The minimum size of a plane mirror, required to see the full size image of a person by himself is half the size of that person.

(h) A plane mirror behaves like a window to virtual world.



Velocity of image formed by a plane mirror :

$X_{OM} \rightarrow$ x co-ordinate of object relative to mirror

$X_{IM} \rightarrow$ x co-ordinate of image relative to mirror

Here, $x_{IM} = -x_{OM}$

differentiating,

⇒ $v_{IM} = - v_{OM}$

⇒ velocity of image relative to mirror = – velocity of object relative to mirror.

5. SPHERICAL MIRROR

Spherical mirrors are part of polished spherical surface

Important Terms for Spherical Mirror

(i) **Pole (P)**, is the mid point of reflecting surface.

(ii) **Centre of curvature (C)**, is the centre of the sphere of which the mirror is a part.

(iii) **Radius of Curvature**, is the radius of the sphere of which the mirror is a part. Distance between P and C.

(iv) **Principal Axis** is the straight line connecting pole P and centre of curvatrue C

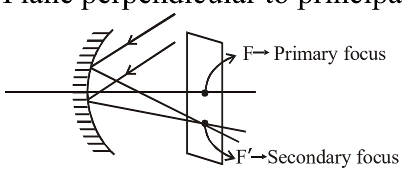
(v) **Principal focus (F)**, is the point of intersection of all the reflected rays which strikes the mirror parallel to the principal axis. In concave mirror it is real and in the convex mirror it is virtual.

(vi) **Focal Length (f)**, is distance from pole to focus.

(vii) **Aperture**, the diameter of the mirror is called aperture of the mirror.

Focal Plane :

Plane perpendicular to principal axis and passing through focus is known as focal plane.



Rules for Image Formation (For small aperture)

(i) If incident ray is parallel to principal axis, then reflected ray passes through the foucs.

(ii) If incident ray is passing through focus then reflected ray passes parallel to the principal axis.

(iii) If incident ray is passing through centre then it will be reflected back through centre.

Sign Convention

We follow cartesian co-ordinate system conventions according to which

(a) The pole of mirror is the origin.

(b) The direction of the incident rays is considered as positive x-axis.

(c) Vertically up is positive y-axis.

Mirror Formula

u = distance of object, v = image distance, f = focal length

and f = R/2;   R = radius of curvature.

Magnification

(a) Linear Magnification :

h_1 = y co-ordinate of the object h_2 = y co-ordinate of image

(h_1 and h_2 both are perpendicular to the principal axis of mirror)
Note that if the image is upright or erect with respect to the object then m is positive. And m is negative if the image is inverted with respect to the object.
(b) Longitudinal magnification [for small sized object]
⇒ V_{IM} ⇒ velocity of image w.r.t. mirror
⇒ V_{OM} ⇒ velocity of object w.r.t. mirror
$V_{IM} = -m^2 V_{OM}$

6. REFRACTION OF LIGHT AND LAWS OF REFRACTION

The phenomenon of deviation or bending of light rays from their original path while passing from one medium to another is called refraction. It is due to change in speed of light in other medium.
(a) If the refracted ray bends towards the normal with respect to the incident ray, then the second medium is said to be ***DENSER*** as compared to the first medium. Speed will reduce.

(b) If the refracted ray bends away from the normal, then the second medium is said to be ***RARER*** as compared to the first medium. The speed will increase.
Deviation due to refraction
$\delta = i - r$
Note : Deviation is zero if medium is same on both sides of slab.

Laws of Refraction
(i) The incident ray (AB), the normal (NN') to the refracting surface (SS') at the point of incidence (B), and the refracted ray (BC) all lie in the same plane called the plane of incidence or plane of refraction.

(ii) **Snell's Law** :
For any two given media and for light of a given wave length.
= constant

${}_1n_2$ = Refractive index of the second medium with respect to the first medium.
n_1 = R. I. of the 1st medium with respect to air or absolute R. I. = c/v_1
n_2 = R. I. of the 2nd medium with respect to air or absolute R. I. = c/v_2
v_1, v_2 are speed of light in first and second medium respectively.
λ_1, λ_2 are wavelength of the light in 1st and 2nd medium respectively.
c = speed of light in air (or vacuum) = 3×10^8 m/s.
Note :
(a) Higher the value of R. I. denser (optically) is the medium.

(b) Frequency of light does not change during refraction.
(c) Refractive index of the medium relative to air =
Lateral Shift Due to Slab

Note : Emergent ray is parallel to the incident ray. Emergent ray will not be parallel to the incident ray if the medium on both the sides are different.
Critical Angle
O = Object NN¢ = Normal to the interface
SS′ = Interface C = Critical angle
If i = C then r = 90°. For a given pair of media
Critical angle
for air-medium combination
Conditions of T. I. R.

(b) Angle of incidence should be greater than the critical angle (i > C).

7. IMAGE FORMATION DUE TO REFRACTION

Image formation due to Refraction at Plane Surface

Apparent Depth and Apparent Shift
(a) Object in denser medium
Apparent depth
Apparent shift [towards observer]
(b) Object in rarer medium
Apparent depth
Apparent shift [away from observer]

Image formation due to Refraction at Spherical Surface
(i) When refraction of light takes place from a spherical surface separating two media, the object distance u, image distance v and the radius of curvature of the spherical surface r satisfy the following relation :

μ_1 = Refractive index of the medium in which the incident ray travels.
μ_2 = Refractive index of the medium in which light travels after refraction.

8. LENSES

Lens : A lens is a transparent medium bounded by two refracting surfaces such that at least one of the refracting surfaces is curved.
If the thickness of the lens is negligibly small in comparison to the object distance or the image distance, the lens is called thin. Here we shall limit ourself to thin lenses.

Questions

1. Two plane mirrors are inclined to each other at an angle 60^0. If a ray of light incident on the first mirror is parallel to the second mirror, it is reflected from the second mirror
(A) Perpendicular to the first mirror (B) Parallel to the first mirror
(C) Parallel to the second mirror (D) Perpendicular to the second mirror

2. Two mirrors are inclined at an angle θ as shown in the figure. Light ray is incident parallel to one of the mirrors. The ray will start retracing its path after third reflection if :
(A) $\theta = 45°$ (B) $\theta = 30°$ (C) $\theta = 60°$ (D) all three

3. Two plane mirrors are parallel to each other and spaced 20 cm apart. An object is kept in between them at 15 cm from A. Out of the following at which point(s) image(s) is/are not formed in mirror A (distance measured from mirror A):
(A) 15 cm (B) 25 cm (C) 45 cm (D) 55 cm

4. A point object is kept in front of a plane mirror. The plane mirror is doing SHM of amplitude 2 cm. The plane mirror moves along the x-axis and x- axis is normal to the mirror. The amplitude of the mirror is such that the object is always infront of the mirror. The amplitude of SHM of the image is
(A) zero (B) 2 cm (C) 4 cm (D) 1 cm

5. A person's eye level is 1.5 m. He stands in front of a 0.3m long plane mirror which is 0.8 m above the ground. The length of the image he sees of himself is:
(A) 1.5m (B) 1.0m (C) 0.8m (D) 0.6m

6. A person is standing in a room of width 200 cm. A plane mirror of vertical length 10 cm is fixed on a wall in front of the person. The person looks into the mirror from distance 50 cm. How much width (height) of the wall behind him will he be able to see:
(A) 30 cm (B) 40 cm (C) 50 cm (D) none of these

7. An unnumbered wall clock shows time 04: 25: 37, where 1st term represents hours, 2nd represents minutes & the last term represents seconds. What time will its image in a plane mirror show.
(A) 08: 35: 23 (B) 07: 35: 23 (C) 07: 34: 23 (D) none of these

8. A plane mirror is moving with velocity. A point object in front of the mirror moves with a velocity. Here is along the normal to the plane mirror and facing towards the object. The velocity of the image is:
(A) (B) (C) (D)

9. Images of an object placed between two plane mirrors whose reflecting surfaces make an angle of 90^0 with one another lie on a :
(A) straight line (B) zig-zag curve (C) circle (D) ellipse

10. A concave mirror of radius of curvature 20 cm forms image of the sun. The diameter of the sun subtends an angle 1° on the earth. Then the diameter of the image is (in cm):
(A) $2\pi/9$ (B) $\pi/9$ (C) 20 (D) $\pi/18$

11. A candle is kept at a distance equal to double the focal length from the pole of a convex mirror. Its magnification will be:
(A) – 1/3 (B) 1/3 (C) 2/3 (D) – 2/3

12. An object is kept perpendicular to the principal axis of a convex mirror of radius of curvature 20 cm. If the distance of the object from the mirror is 20 cm then its magnification will be:

(A) + 1/3 (B) – 1/3 (C) – 1 (D) none of these

13. An object of height 1 cm is kept perpendicular to the principal axis of a convex mirror of radius of curvature 20 cm. If the distance of the object from the mirror is 20 cm then the distance between tips of the image and the object will be:

(A) (B) (C) (D) none of these

14. An object is kept between a plane mirror and a concave mirror facing each other. The distance between the mirrors is 22.5 cm. The radius of curvature of the concave mirror is 20 cm. What should be the distance of the object from the concave mirror so that after two successive reflections the final image is formed on the object itself: [Consider first reflection from concave mirror]

(A) 5 cm (B) 15 cm (C) 10 cm (D) 7.5 cm

15. A square ABCD of side 1mm is kept at distance 15 cm infront of the concave mirror as shown in the figure. The focal length of the mirror is 10 cm. The length of the perimeter of its image will be :

(A) 8 mm (B) 2 mm (C) 12 mm (D) 6 mm

16. In the figure shown find the total magnification after two successive reflections first on M_1 & then on M_2

(A) + 1 (B) – 2 (C) + 2 (D) – 1

17. A luminous point object is moving along the principal axis of a concave mirror of focal length 12 cm towards it. When its distance from the mirror is 20 cm its velocity is 4 cm/s. The velocity of the image in cm/s at that instant is

(A) 6, towards the mirror (B) 6, away from the mirror
(C) 9, away from the mirror (D) 9, towards the mirror.

18. A particle is moving towards a fixed spherical mirror. The image:

(A) must move away from the mirror
(B) must move towards the mirror
(C) may move towards the mirror
(D) will move towards the mirror, only if the mirror is convex.

19. A point object on the principal axis at a distance 15 cm in front of a concave mirror of radius of curvature 20 cm has velocity 2 mm/s perpendicular to the principal axis. The velocity of image at that instant will be:

(A) 2 mm/s (B) 4 mm/s (C) 8 mm/s (D) none of these

20. A point object at 15 cm from a concave mirror of radius of curvature 20 cm is made to oscillate along the principal axis with amplitude 2 mm. The amplitude of its image will be

(A) 2 mm (B) 4 mm (C) 8 mm (D) none of these

21 The distance of an object from the focus of a convex mirror of radius of curvature ' a ' is
' b '. Then the distance of the image from the focus is:

(A) $b^2 / 4a$ (B) a / b^2 (C) $a^2 / 4b$ (D) none of these

22. A concave mirror cannot form:

(A) virtual image of virtual object (B) virtual image of a real object
(C) real image of a real object (D) real image of a virtual object

23. The largest distance of the image of a real object from a convex mirror of focal length 20 cm can be:
(A) 20 cm (B) infinite (C) 10 cm (D) depends on the position of the object

24. Which of the following can form erect, virtual, diminished image?
(A) plane mirror (B) concave mirror
(C) convex mirror (D) none of these

25. I is the image of a point object O formed by spherical mirror, then which of the following statement is incorrect :
(A) If O and I are on same side of the principal axis, then they have to be on opposite sides of the mirror.
(B) If O and I are on opposite sides of the principal axis, then they have to be on same side of the mirror.
(C) If O and I are on opposite side of the principal axis, then they can be on opposite side of the mirror as well.
(D) If O is on principal axis then I has to lie on principal axis only.

26. An object is placed at a distance u from a concave mirror and its real image is received on a screen placed at a distance of v from the mirror. If f is the focal length of the mirror, then the graph between 1/v versus 1/u is
(A) (B) (C) (D)

27. A real inverted image in a concave mirror is represented by (u, v, f are coordinates)
(A) (B) (C) (D)

28. When a wave is refracted:
(A) its path must change (B) its amplitude must change
(C) its velocity must change (D) its frequency must change

29. The wavelength of light in vacuum is 6000 0A and in a medium it is 4000 0A. The refractive index of the medium is:
(A) 2.4 (B) 1.5 (C) 1.2 (D) 0.67

30. A ray of light passes from vacuum into a medium of refractive index n. If the angle of incidence is twice the angle of refraction, then the angle of incidence is:
(A) cos–1 (n/2) (B) sin–1 (n/2)
(C) 2 cos–1 (n/2) (D) 2 sin–1 (n/2)

31. A ray of light is incident on a parallel slab of thickness t and refractive index n. If the angle of incidence q is small, than the displacement in the incident and emergent ray will be:
(A) (B) (C) (D) none

32. A ray of light travelling in air is incident at grazing angle on a slab with variable refractive index,
n (y) = [k y3/2 + 1]1/2 where k = 1 m -3/2 and follows path as shown. What is the total deviation produced by slab when the ray comes out.

(A) 60º (B) 53º (C) sin -1 (4/9) (D) no deviation at all

33. A ray incident at a point at an angle of incidence of 600 enters a glass sphere of m = Ö3 and it is reflected and refracted at the farther surface of the sphere. The angle between reflected and refracted rays at this surface is

(A) 500 (B) 900 (C) 600 (D) 400

34. How much water should be filled in a container of 21 cm in height, so that it appears half filled (of total height of the container) when viewed from the top of the container ?

(Assume near normal incidence and mw=4/3)

(A) 8.0 cm (B) 10.5 cm (C) 12.0 cm (D) 14.0 cm

35. A beam of light is converging towards a point. A plane parallel plate of glass of thickness t, refractive index m is introduced in the path of the beam. The convergent point is shifted by (assume near normal incidence):

(A) away (B) away (C) nearer (D) nearer

36. Given that, velocity of light in quartz = 1.5 ´ 108 m/s and velocity of light in glycerine

= (9/4) ´ 108 m/s. Now a slab made of quartz is placed in glycerine as shown. The shift of the object produced by slab is

(A) 6 cm (B) 3.55 cm (C) 9 cm (D) 2 cm

37. An object is seen through a glass slab of thickness 36 cm and refractive index 3/2. The observer, object and the slab are dipped in water (n = 4/3). The shift produced in the position of the object is:

(A) 12 cm (B) 4 cm (C) cannot be calculated (D) 9/2 cm

38. The critical angle of light going from medium A to medium B is q. The speed of light in medium A is v. The speed of light in medium B is:

(A) (B) v sin q (C) v cot q (D) v tan q

39. A ray of monochromatic light is incident on one refracting face of a prism of angle 750. It passes through the prism and is incident on the other face at the critical angle. If the refractive index of the material of the prism is Ö2, the angle of incidence on the first face of the prism is

(A) 300 (B) 450 (C) 600 (D) 00

40. A prism having refractive index and refracting angle 30º, has one of the refracting surfaces polished. A beam of light incident on the other refracting surface will retrace its path if the angle of incidence is:

(A) 0º (B) 30º (C) 45º (D) 60º

41. A ray of light is incident at angle i on a surface of a prism of small angle A & emerges normally from the opposite surface. If the refractive index of the material of the prism is m, the angle of incidence i is nearly equal to:

(A) A/m (B) A/(2 m) (C) m A (D) m A/2

42. A beam of monochromatic light is incident at i = 500 on one face of an equilateral prism, the angle of emergence is 400, then the angle of minimum deviation is:

(A) 300 (B) < 300 (C) £ 300 (D) ³ 300

43. A prism of refractive index has refracting angle 60º. In order that a ray suffers minimum deviation it should be incident at an angle :

(A) 450 (B) 900 (C) 300 (D) none

44. For a glass prism (m=) the angle of minimum deviation is equal to the refracting angle of the prism. The angle of the prism is:

(A) 800 (B) 450 (C) 600 (D) 900

45. The maximum refractive index of a material of a prism of apex angle 900 for which light will be transmitted is:
(A) (B) 1.5 (C) (D) None of these

46. A prism having an apex angle of 40 and refractive index of 1.50 is located in front of a vertical plane mirror as shown. A horizontal ray of light is incident on the prism. The total angle through which the ray is deviated is
(A) 40 clockwise (B) 1780 clockwise
(C) 20 clockwise (D) 80 clockwise

47. There is a small black dot at the centre C of a solid glass sphere of refractive index m. When seen from outside, the dot will appear to be located:
(A) away from C for all values of m (B) at C for all values of m
(C) at C for m = 1.5, but away from C for m ¹ 1.5
(D) at C only for £ m £ 1.5.

48. A fish is near the centre of a spherical water filled fish bowl . A child stands in air at a distance 2 R (R is radius of curvature of the sphere) from the centre of the bowl . At what distance from the centre would the child's nose appear to the fish situated at the centre (R.I. of water = 4/3)
(A) 4R (B) 2R (C) 3R (D) R

49. The image for the converging beam after refraction through the curved surface is formed at:

(A) x = 40 cm (B) x = cm (C) x = - cm (D) x = cm

50. A planoconcave lens is placed on a paper on which a flower is drawn. How far above its actual position does the flower appear to be?
(A) 10 cm (B) 15 cm (C) 50 cm (D) none of these

51. A beam of diameter ‘ d ‘ is incident on a glass hemisphere as shown. If the radius of curvature of the hemisphere is very large in comparison to d, then the diameter of the beam at the base of the hemisphere will be:
(A) d (B) d (C) (D) d

52. The power (in diopters) of an equi convex lens with radii of curvature of 10 cm & refractive index 1.6 is:
(A) + 12 (B) - 12 (C) + 1.2 (D) - 1.2

53. A convexo - concave diverging lens is made of glass of refractive index 1.5 and focal length 24 cm. Radius of curvature for one surface is double that of the other. Then radii of curvature for the two surfaces are (in cm):
(A) 6, 12 (B) 12, 24 (C) 3, 6 (D) 18, 36

54. Two symmetric double convex lenses A and B have same focal length, but the radii of curvature differ so that, RA = 0.9 RB. If nA = 1.63, find nB.
(A) 1.7 (B) 1.6 (C) 1.5 (D) 4/3

55. When a lens of power P (in air) made of material of refractive index m is immersed in liquid of refractive index m0. Then the power of lens is:
(A) P (B) P (C). (D) none of these

56. A lens behaves as a converging lens in air and a diverging lens in water. The refractive index of the material is (refractive index of water = 1.33)
(A) equal to unity (B) equal to 1.33
(C) between unity and 1.33 (D) greater than 1.33

57. The diameter of the sun subtends an angle of 0.50 at the surface of the earth. A converging lens of focal length 100 cm is used to provide an image of the sun on to a screen. The diameter in mm of the image formed is about
(A) 1 (B) 3 (C) 5 (D) 9

58. A thin lens of focal length f and its aperture diameter d, forms a real image of intensity I. Now the central part of the aperture upto diameter (d/2) is blocked by an opaque paper. The focal length and image intensity would change to
(A) f/2, I/2 (B) f, I/4 (C) 3f/4, I/2 (D) f, 3I/4

59. A thin symmetrical double convex lens of power P is cut into three parts, as shown in the figure. Power of A is:
(A) 2 P (B) (C) (D) P

60. In the figure given below, there are two convex lens L1 and L2 having focal length of f1 and f2 respectively. The distance between L1 and L2 will be

(A) f1 (B) f2 (C) f1 + f2 (D) f1 - f2

61. An object is placed at a distance u from a converging lens and its real image is received on a screen placed at a distance of v from the lens. If f is the focal length of the lens, then the graph between 1/v versus 1/u is:
(A) (B) (C) (D)

62. A virtual erect image by a diverging lens is represented by (u, v, f are coordinates)
(A) (B) (C) (D)

63. What should be the value of distance d so that final image is formed on the object itself. (focal lengths of the lenses are written on the lenses).
(A) 10 cm (B) 20 cm (C) 5 cm (D) none of these

64. A thin linear object of size 1 mm is kept along the principal axis of a convex lens of focal length 10 cm. The object is at 15 cm from the lens. The length of the image is:
(A) 1 mm (B) 4 mm (C) 2 mm (D) 8 mm

65. A biconvex lens is used to project a slide on screen. The slide is 2 cm high and 10 cm from the lens. The image is 18 cm high. What is the focal length of the lens?
(A) 9 cm (B) 18 cm (C) 4.5 cm (D) 20 cm

66. The minimum distance between a real object and its real image formed by a thin convex lens of focal length f is
(A) 4f (B) 2f (C) f (D) f/2

67. A plano-convex lens, when silvered at its plane surface is equivalent to a concave mirror of focal length 28 cm. When its curved surface is silvered and the plane surface not silvered, it is equivalent to a concave mirror of focal length 10 cm, then the refractive index of the material of the lens is:
(A) 9/14 (B) 14/9 (C) 17/9 (D) none

68. In the above question the radius of curvature of the curved surface of plano-convex lens is :
(A) cm (B) cm (C) cm (D) cm

69. Two plano-convex lenses each of focal length 10 cm & refractive index are placed as shown. In the space left, water is filled. The whole arrangement is in air. The optical power of the system is (in diopters):
(A) 6.67 (B) - 6.67 (C) 33.3 (D) 20

70. The focal length of a plano-concave lens is - 10 cm, then its focal length when its plane surface is polished is:
(A) 20 cm (B) - 5 cm (C) 5 cm (D) none of these

71. A convex lens of focal length 25 cm and a concave lens of focal length 20 cm are mounted coaxially separated by a distance d cm. If the power of the combination is zero, d is equal to
(A) 45 (B) 30 (C) 15 (D) 5

72. The dispersion of light in a medium implies that :
(A) lights of different wavelengths travel with different speeds in the medium
(B) lights of different frequencies travel with different speeds in the medium
(C) the refractive index of medium is different for different wavelengths
(D) all of the above.

73. Critical angle of light passing from glass to air is minimum for
(A) red (B) green (C) yellow (D) violet

74. A plane glass slab is placed over various coloured letters. The letter which appears to be raised the least is:
(A) violet (B) yellow (C) red (D) green

75. A medium has nv = 1.56, nr = 1.44. Then its dispersive power is:
(A) 3/50 (B) 6/25 (C) 0.03 (D) none of these

76. All the listed things below are made of flint glass. Which one of these have greatest dispersive power (w).
(A) prism (B) glass slab (C) biconvex lens (D) all have same w

77. A thin prism P1 with angle 40 made of glass of refractive index 1.54 is combined with another thin prism P2 made of glass of refractive index 1.72 to produce dispersion without deviation. The angle of the prism P2 is :
(A) 30 (B) 2.60 (C) 40 (D) 5.330

78. Light of wavelength 4000 Å is incident at small angle on a prism of apex angle 4º. The prism has nv = 1.5 & nr = 1.48. The angle of dispersion produced by the prism in this light is:
(A) 0.2º (B) 0.08º (C) 0.192º (D) none of these

79. An object is placed 30 cm (from the reflecting surface) in front of a block of glass 10 cm thick having its farther side silvered. The image is found to be at 23.2 cm behind the silvered face, by an observer infront of the block. The refractive index of glass is :
(A) 1.41 (B) 1.46 (C) 200/ 132 (D) 1.61

80. A ray of light strikes a plane mirror at an angle of incidence 45º as shown in the figure. After reflection, the ray passes through a prism of refractive index 1.50, whose apex angle is 4º. The angle through which the mirror should be rotated if the total deviation of the ray is to be 90º is :
(A) 10 clockwise (B) 10 anticlockwise
(C) 20 clockwise (D) 20 anticlockwise

(KEY)

1. B	2. B	3. C	4. C	5. D	6. C	7. C	8. B	9. C	10. D
11. B	12. A	13. A	14. D	15. C	16. C	17. C	18. C	19. B	20. C
21. C	22. A	23. A	24. C	25. C	26. B	27. A	28. C	29. B	30. C
31. A	32. D	33. B	34. D	35. A	36. A	37. B	38. A	39. B	40. C
41. C	42. B	43. A	44. D	45. C	46. B	47. B	48. C	49. A	50. A
51. D	52. A	53. A	54. A	55. C	56. C	57. D	58. D	59. D	60. C
61. B	62. D	63. A	64. B	65. A	66. A	67. B	68. A	69. A	70. C
71. D	72. D	73. D	74 C	75. B	76. D	77. A	78. D	79. C	80. B

CHAPTER.17

WAVE OPTICS

SYNOPSIS

1. Physical optics deals with the nature of light and explanation of different phenomena.
2. Corpuscular theory is put forth by Newton according to this theory:-
   A) Light consists of smallest particles called corpuscles moving with the velocity of light.
   B) They move in a straight line.
   C) According to this theory the velocity of light in denser medium is more than in rarer medium.
   D) This theory unable to explain interference, diffraction and polarization where light shows wave nature (Draw back of theory).
   E) Practically it is observed that velocity of light in a rarer medium is more than in denser medium(Draw back)
3. ***Huygen's wave theory*** :-
   A) Light is propagated in a medium in the form of mechanical wave.
   B) For the propagation of light huygen proposed a medium called ether existing in the universe.
   C) Light waves travel with the velocity of 3x 10^8 m/s
   D) The colour of light depends upon the wavelength of waves.
   E) Red colour has maximum and violet has minimum wavelengths in the visible region.
   F) Velocity of light is more in rarer medium than in denser medium.
   G) Interference and diffraction phenomena can be explained by this theory.
   H) The photoelectric effect and Compton effect could not be explain by this theory where light shows particle nature. Draw back.
   I) Theory could not explain propagation of light in vacuum. Draw back).
   J) It is observed that ether medium which this theory has proposed is not existing anywhere. (Draw back)
4. ***ELECTROMAGNETIC THEORY***:- According to this theory :-
   A) Light is a electromagnetic wave but not a mechanical wave.
   B) Electromagnetic waves do not require medium for their propagation.
   C) As electric and magnetic field can exist in vacuum, hence light can propagate through vacuum.
   D) Electromagnetic wave consists of variable electrical and magnetic field, which are mutually perpendicular. These variations are propagated in perpendicular direction to both the fields.
   E) Electromagnetic wave is a transverse wave.
   F) This theory can explain polarization.

G) This theory unable to explain photoelectric effect and comption effect. (Draw back).

5. ***PLANCKS QUANTUM THEORY***: - Max Planck put forth this theory. According to this theory
   A. Light is radiated in quantum.
   B. A quantum of light is called photon
   C. Photon has dual nature particle and wave nature
   D. Light could not exhibit its dual nature simultaneously.
6. The locus of all points of wave, which are in phase, is called wave front.
7. The line drawn perpendicular to the wave front represents the light ray.
8. A point source forms a spherical wave front.
9. A parallel beam of light ray forms a plane wave front .
10. Narrow illuminated slit forms a cylindrical wave front.
11. According to huygne's principle, every point on the wave front behaves as a source of secondary waves.
12. The displacement and amplitudes of a particle in a progressive wave is considered as a vectors
13. The phase difference between the two particles at the point of super position is considered as the angle between the two vectors.
14. If A1 and A2 are the amplitudes resulting amplitude is given by

$A=\sqrt{A_1^2+A^2{}_2+2A^1A^2\cos\theta}$

15. The coherent sources of light produce light waves of same frequency wavelength and of same phase or having constant phase difference.
16. According to principle of super position of waves, the resultant displacement produced at a point due to different waves reaching at that point is vector sum of displacement s produced by each wave taken such that no any another wave is acting there.
17. LASER (Light Amplification by stimulated emission of radiation) has following characteristics:-
    A) High coherence B) Monochromatic C) High intensity D) Highly directional
18. lasers are used in eye surgery holography , printing and metal cutting
19. The superimpose of two or more coherent light waves is known as interference.
20. ***Conditions for interference***:-
    A) The two light waves must be monochromatic B) They must be coherent
21. If the sources are not coherent interference takes place but we cannot observe. The phase difference between the waves continuously changes rapidly and hence interference maxima and minima changes rapidly so that the eye cannot follow the changes. So a uniform average intensity is observed.
22. In young's double slit experiment the coherent sources are real
23. In fresnels biprism the coherent sources are both virtual.
24. In young double slit experiment coherence is obtained by division wavefornt.

25. The intensity I is proportional to $(\text{amplitude})^2$ or $I=Ka^2$ where k is a constant .
26. If 'x' is the path difference and ϕ is the corresponding phase difference then $\phi = 2\Pi/\lambda$ x x
27. In interference if crest of one wave falls on crest of another wave or similar is the case for trough then such type of interference is known as constructive interference and on screen bright point is obtained.
28. In interference if crest of one wave falls on trough of another wave or vice – versa then such type of interference is knows as destructive interference and on screen dark point is obtained.
29. If the path difference is $n\lambda$ then amplitude becomes (A_1+A_2) and the intensity becomes maximum. n can take any integral value from zero.
30. If the path difference is $(2n-1)\ \lambda/2$ which is the odd multiples of half wave length the amplitude becomes (A_1-A_2) and the intensity becomes minimum .
31. When the amplitudes are equal $I\ max\ \alpha\ 4\ a^2$
32. The maximum intensity at interference is 4 times that of the intensity one of the coherent source.
33. In young's double slit experiment if path difference = $xd/D=0$
    A bright band is formed at the central point '0'
34. If $x_1 d/D = 1\ \lambda$, first bright band is formed.If $d/D = n\lambda$, nth bright band is formed .
35. If $x_1\ d/D = \lambda/2$, first dark band is formed. If $nd/D = (2n-1)\ \lambda/2$, first dark band is formed
36. The distance between two successive bright or dark band is called band width , and it is equal to $(\beta) = \lambda D/d$
37. Bandwidth β changes with the wavelength of light used. And $\beta_1/\beta_2 = \lambda_1/\lambda_2$
38. If the experiment is conducted in a medium of refractive index the equivalent path difference become $\mu xd/D$ and band width becomes $\beta_1 = D\lambda/\mu d$
39. If β_1 band width with medium refractive index μ
    β_0 band width with air or vacuum then $\beta_1 = B_o/\mu$ (thus the band width decreases and fringes shrink)
40. When a thin transparent film of refractive index μ and thickness 't' is introduced in one of the interference beams, following changes occurs.
    A) The extra path difference introduced is $(\mu-1)\ t$
    B) The fringe system displaces towards the side in which the film is introduce
    C) The shift(s) is equal to 'n' bands. If the path difference added = $(\mu-1)\ t = n\lambda$, $s = D/d(\mu-1)\ t$
    D) Band width does not changes
41. The intensity of light from a slit is proportional to the are of the slit
42. The effective amplitude of the light wave emitted by a slit is proportional to the width of slit.
    $A_1/A_2 = [a_1/a_2]$ A $\rightarrow$ Area of slit a$\rightarrow$ Amplitude

43. Inter ferometer work on the principle of interference.
44. Michelsons interferometer is used to determine the wavelength of light, refractive index of material in the form of thin film, and its thickness.
45. During rainy day if oil leak on roads it forms a thin layer over water and no.of colours are seen. This is due to interference same is the reason for colours seen on a soap bubble.
46. in the formation of colours in thin films the coherent sources are derived from the division of amplitude. This type of interference is called interference due to division of amplitude.
47. Bending of light round the edges is called diffraction.
48. Grimilidi first observed diffraction
49. fresnel gave successful explanation for the diffraction
50. Following are the examples of diffraction :-
    A) The silver lining surrounding the profile of a mountain or cloud just before sunrise or sunset.
    B) Some times colours are seen where viewed a distant object through a cloth.
    C) When a street light bulb is seen through a polyester cloth, a number of images are observed.
    D) Hold the two fingers close so that there is a narrow slit formed between the fingers and look at an glowing bulb. Dark lines are seen.
51. A razor blade held at a distance from the eye with its edge parallel to the glowing tube light, alternate bright and dark lines are seen.
52. ***FRESNEL'S DIFFRACTION***
    1) The source and plane of observation are at finite distances.
    2) The diffraction pattern is studied on the screen placed at a finite distance from the obstacle.
    3) The wave fronts may be spherical, plane or cylindrical.
    4) Fresnel suggested that secondary wavelets also interfere just as in the same manner as the light waves from coherent sources.
    5) The wavefront is divided into small areas called fresnels zones or half period zones.
    6) A zone is a small area on a wave front with reference to a point of observation, so that all the waves from the area reach the point without any path difference.
    7) Different zones contribute different amplitudes at the point p.
       The amplitude contributed by a zone depends on, a) area of the zone from the point b) distance of the zone from the point c) the obliquity
    8) As area of the half period zone is proportional to the number of secondary waves generated and the resultant amplitude "d" contributed by the zone changes accordingly.
    9) Area of half-period zone on a plane wave front is equal to $\Pi P\lambda$ and same for all zones.

10) As the number of half period zone increases its distance from point "P" increases. So intensity decreases (intensity is inversely proportional to the square of the distance). So the amplitude contributed by the zone is less.
11) As the obliquity increases the intensity decreases.
12) Obliquity is the angle made by the direction of the point p from the normal to the wave front.
13) Maximum amplitude contributed by the zone in the direction perpendicular to it is d_o.
14) 'd' is the amplitude contributed by the zone in a direction θ with the normal is d= d0/2 (1+cosθ)
15) Obliquity is the angle made by the direction of the point p from the normal to the wave front.
16) Maximum amplitude contributed by the zone in the direction perpendicular to it is d_o .
17) 'd' is the amplitude contributed by the zone in a direction θ with the normal is d= $d_o/2$ (1+cosθ)
18) When θ= 90 the amplitude = $d_o/2$
19) When $\theta=180^0$ the amplitude becomes zero. The part of wave front does not contribute any light in backward direction.

53. Fesnels zones of plane wave front are of equal area and equal to πPλ. Where P is the perpendicular distance of the reference point from the wave front.
54. The amplitudes contributed by all the zones are equal.
55. Due to the path difference of λ/2 between two successive zones the amplitude term gets a negative sign during the calculation of resultant amplitude. So the amplitude contributed by even numbered half period zone becomes negative.
56. Cylindrical wave front is produced by an illuminated slit.
57. The line joining the source and point of observation divides the wave front into two parts. One is upper half and the other is lower half.
58. The widths of half period zones decrease as the order of the zone increases.
59. if the part of the wave front exposed to the point consists of odd number of half period zones the point becomes bright (Maximum brightness) And if the part of the wave front exposed to the point consist of even number of the half period zones the point becomes less bright (minimum brightness).
60. ***DIFFRACTION AT STRAIGHT EDGE(FRESNEL'S EXPLANATION)***
    1) A straight edge is kept parallel to the illuminated slit.
    2) The intensity decreases gradually and becomes dark within the geometrical shadow.
    3) Above the geometrical shadow alternate bright and less bright bands are formed.
    4) The band widths are not equal. Band widths decrease with increase order of the bands.

5) The intensity of maximum decreases gradually.
6) The intensity of minimum brightness increases gradually
7) Hence the contrast between the maximum and minima decreases and attains uniform illumination.

61. ***FRAUNHOFFER'S DIFFRACTION***

1. The source and the plane of observation are effectively at infinite distance from the obstacle.
2. The plane wave front produces this type of diffraction.
3. The diffracted rays are brought to converge on the plane of observation with help of converging lens s
4. The diffracted rays interfere to produce diffraction pattern.
5. This type of diffraction pattern is found in the optical instruments.
6. The diffraction at the circular aperture contains a central maximum with alternate bright and dark rings around it.

62. POLARISATION:--

1) Huygen considered the light wave to be longitudinal.
2) The properties of light are explained by considering the electrical vector only.
3) These vectors are resolved into two mutually perpendicular components, one in the plane of incidence (μ-component) and the other is perpendicular to the plane of incidence (σ components) , with same amplitude .
4) σ components are in perpendicular to the plane of paper.
5) Calcite, quartz and tourmaline crystals act as a polarizers and analyzers. They are said to be optically active.

63. When an unpolarised light is incident on any active crystal, the light having vibrations along the optic axis are transmitted through.
64. An active crystal does not transmit light possessing electrical vibrations perpendicular to its optic axis.
65. the light which consists of the electrical vibrations confined to a plane, is called plane polarized light
66. The plane containing the electrical vibrations and the direction of propagation is called the plane of vibration.
67. The plane, which does not contain electrical vibrations, is called the plane of polarization.
68. Refraction, refraction and double refraction can produce polarized light.
69. Brewster's law $I=\tan^{-1}\mu$
70. When the light is incident at the Brewster angle the reflected and refracted rays are polarized.
71. The reflected light is strongly polarized.
72. The refracted light is not completely polarized. It contains polarized and unpolarised light
73. The reflected light contains vibrations perpendicular to the plane of incidence.

74. The refracted ray contains vibrations in the plane of incidence
75. Pile of plates is used to produce transmitted light, which is also polarized with a little unpolarised light.
76. The monochromatic light splits into two light rays when it is transmitted thorough a crystal. This process is called double refraction.
77. The two rays are polarized in mutually perpendicular planes. They are called ordinary ray and extraordinary ray.
78. Ordinary ray follows the laws of refraction where as the extraordinary ray does not obey the laws of refraction.
79. the velocity of ordinary ray is same in any direction in the crystal. So the refractive index is constant in any direction of propagation in the crystal
80. The velocity of extraordinary ray is different in different directions. So the refractive index has different values along different directions of propagation.
81. Along the optic axis the ordinary and extraordinary ray has the same velocity .
82. The refractive indices of ordinary and extraordinary ray along the perpendicular direction to the optic axis have maximum difference.
83. There exists two types of crystals called positive and negative crystals
84. For negative crystals $\mu_0 > \mu_e$. μ_e is minimum when the extraordinary light ray moves along the perpendicular direction to the optic axis. $(\mu_0 - \mu_e)$ is Maximum . $\mu_0 -= \mu_e$ along optic axis.
85. For positive crystals $\mu_e > \mu_0$. μe is maximum when the extraordinary light ray moves along the $\perp$ to the optic axis . $(\mu_e - \mu_0)$ = maximum $\mu_e - \mu_0$ along the optic axis.
86. Quartz and ice crystals are positive crystal

QUESTION BANK

CONCEPTUAL QUESTIONS

1. Which of the following statements are true for light waves but not for sound waves?
   I)The speed of waves is greater in vacuum than in a medium
   II)Waves of different frequencies travel with different speeds in a medium
   III)Waves travel with different speeds indifferent media.
   Choose your answer according to the code given below.
   1)(I) and (II) 2)(I) and (III) 3)(II) and (III) 4)(I),(II) and (III)
2. A plane wave front falls on a convex lens. The emergent wave front is
   1)Plane 2)Cylindrical 3)Spherical diverging 4)Spherical converging
3. When two light waves meet at a place
   1)their displacement add up 2)their intensities add up
   3)both will add up 4)Energy becomes zero
4. When interference of light takes place
   1)Energy is create in the region of maximum intensity.

2)Energy is destroyed in the region of maximum intensity
3)Conservation of energy doesn't hold good

5. Which of the following can give sustained interference?
   1)Two independent laser sources 2)Two independent light bulbs
   3)Two sources must be far away from one other
6. In young's double slit experiment if one of the slits is covered with a thin transparent sheet.
   1)at maximum, intensity increases: at minimum, intensity increases
   2)at maximum, intensity decreases, at minimum, intensity decreases
   3)at maximum intensity increases, at minimum, intensity decreases
   4)at maximum intensity decreases, at minimum intensity increases
7. When viewed in white light, soap bubble show colours because of
   1)Interference 2)Scattering 3)Diffraction 4)Dispersion
8. Interference is produced with two coherent sources of same intensity. If one of the sources is covered with a thin film so as to reduce the intensity of light coming out of it to half, then
   1)Bright fringes will be less bright and dark fringes will be less dark
   2)Bright fringes will be more bright than the dark fringes will be more dark
   3)Brightness of both types of the fringes will remain the same
   4)Dark region will spread completely.
9. For the sustained interference of light, the necessary condition is that the two sources should
   1)have constant phase difference 2)be narrow 3)be close to each other
   4)of same amplitude with constant phase difference
10. Laser light is considered to be coherent because it consists of
    1)many wavelengths 2)uncoordinated wavelengths
    3)coordinated waves of exactly the same wavelength 4)divergent beams
11. In young's double slit experiment, the intensity at the center of screen is
    1)equal the intensity of each source 2)equal to twice the intensity of each source
    3)half the intensity of each source 4)four times the intensity of each source
12. Interference fringes in young's double slit experiment are
    1)always equispaced 2)always unequally spaced
    3)both equally and unequally spaced 4)formed by apportion of the wave front.
13. In young's experiment with white light central fringe is white. If now a transparent film is introduced in the upper beam coming from the top slit, the white fringe
    1)moves down ward 2)Moves upward
    3)remains at the same place 4)totally disappears
14. In young's double slit experiment
    1)only interference occurs 2)only diffraction occurs
    3)both diffraction occurs 4)polarization occurs
15. Four different independent waves are represented by

1)$y_1=a_1 \sin\omega_1 t$ 2)$y_2=a_2\sin\omega_2 t$ 3)$y_3=a_3\sin\omega_3 t$ 4)$y_4=a_4\sin(\omega t+\pi/3)$
The interference is possible due to
1)1&3 2)1&4 3)3&4 4)not possible with any combination

16. In young's double slit experiment the slits are of different length and widths. The amplitude of the light waves is directly proportional to
1)length of the slits 2)distance between the slits 3)area of the slits 4)width of slits
17. The bending of light about corners of an obstacle is called
1)Dispersion 2)Refraction 3)Deviation 4)Diffraction
18. The diffraction of light by an aperture cab become more pronounced.
1)If the wavelength of light is either increased or decreased
2)If the aperture is made narrower
3)If the aperture is made wider 4)All the above
19. The class of diffraction in which the incident and diffracted wave fronts are spherical is called
1)Fraunhoffer diffraction 2)fresnel diffraction
3)Huygen's diffraction 4)Newton's diffraction
20. To observe diffraction, the size of an obstacle
1)Should be of the same order as wave length
2)should be much larger than the wave length 3)Has no relation to wave length
4)May be greater or smaller than the wave length
21. The class of diffraction in which incident and diffracted wave fronts are planar is called
1) fresnel diffraction 2)Fraunhoffer diffraction
3)Huygen's diffraction 4)Newton's diffraction
22. In diffraction pattern
1)The fringe widths are equal 2)The fringe widths are not equal
3)The fringes can not be produced 4)The fringe width may or may not equal
23. According to Fresnel's assumptions in diffraction pattern,
1)Light propagates in the form of transverse waves
2)Light propagates in the form of stationary waves
3)Rectilinear propagation of light is approximately true
4)Rectilinear propagation of light is absolutely true
24. Sun light filtering through a tree leaves often makes circular patches on the ground because
1)The sun is round 2)The space through which light penetrates is round
3)Light is transverse in nature 4)Of diffraction effects
25. In studying diffraction pattern of different obstacles, the effect of
1)full wave front is studied 2)portion of a wave front is studied
4)waves from one of the coherent source is studied.
26. Crystalline structure of solids can be studied by using the method of
1)Diffraction 2)Interference 3)Polarization 4)Refraction

27. One of the following statements is correct. Pick out the one
    1)Diffraction can not take place without interference
    2)Interference will not take place with out diffraction.
    3)Interference and diffraction are the result of polarization
    4)The fringe width in young's double slit experiment does not depends on the wave length.
28. Waves that cannot be polarized are
    1)Longitudinal 2)Transverse 3)Electromagnetic 4)Light
29. Human eye
    1)Can detect polarized light 2)can not detect polarization of light
    3)can detect only circularly polarized light 4)can detect only linearly [polarized light
30. Polarization of light was first successfully explained by
    1)Corpuscular theory 2)Huygens' wave theory
    3)Electromagnetic wave theory 4)Planck's theory
31. Plane of polarization is
    1)The plane in which vibrations of the electric vector takes place
    2)A plane perpendicular to the plane in which vibrations of the electric vector takes place
    3)is perpendicular to the plane of vibration 4)2 and3
32. The Polaroid is
    1)Celluloid film 2)Big crystal 3)Cluster of small crystal arranged in a regular way
    4)Cluster of small crystals arranged in a haphazard way.
33.A pile of plates to produce polarized light by refraction contains the glass plates kept incline to the axis of the tube at an angle
    1)57.5^0 2)67^0 3)90^0 4)32.5^0
34. Pile of plates can be used to produce completely polarized light due to
    1)Reflection 2)refraction 3)Double refraction 4)1 and 2
35. In double refraction, the stationary image can be produced by
    1)O-ray 2)E-ray 3)Both O-ray and E-ray combined together 4)None

Numericals.

1. The ratio of phase difference and the corresponding path difference is
   1)λ/Π 2)Π/λ 3)$2\lambda/\Pi$ 4)$2\Pi/\lambda$
2. Ratio of intensities of two waves are given by 4:1. Then ratio of the amplitudes of the two waves is
   1)2:1 2)1:2 3)4:1 4)1:4
3. The displacements of the two interfering light waves are
   Y_1=4Sin(wt) and Y_2=3Cos(wt).The amplitude of resultant wave is
   1)5cm 2)7cm 3)1cm 4)zero
4. The displacements of the two interfering light waves are
   Y_1=2Sin(wt) and Y_2=5Sin(wt+Π/3).The amplitude of resultant wave is

1) 39cm 2)$\sqrt{39}$cm 3)7cm 4)29cm

5. Waves of same amplitude and same frequency from two coherent sources overlap at a point. The ratio of resultant intensity when they arrive in phase to that when they arrive 90^0 phase difference
   1) 1:1 2)$\sqrt{2}$:1 3)2:1 4)4:1
6. Light from two coherent sources of same wave length illuminates the screen. The intensity of the central maximum is I.If the sources were incoherent the intensity at the same point will be
   1)I/2 2)I 3)I/$\sqrt{2}$ 4)4I
7. Yong's double slit experiment is conducted with light of wave length λ. The intensity of bright fringe is I. The intensity at a point where the path difference is 3λ/4 is
   1)zero 2)I/8 3) I/4 4)I/2
8. The intensity ratio two waves is 9:1. If they produce interference, the ratio of the maximum to the minimum intensity is
   1)4:1 2)2:1 3)9:1 4)3:2
9. The intensity ratio two waves is 16:9. If they produce interference, the ratio of the maximum to the minimum intensity is
   1)The ratio of maximum to minimum amplitudes are 9:5
   2)The intensities of individual waves will be in ratio 4:3
   3) The amplitudes of individual waves will be in ratio 7:1
   4)none of the above is true
10. Two narrow slits separation by a distance of 4mm are illuminated by a source of light. If the band width is 0.06mm on a screen placed at a distance of 40cm from the slits, the wavelength of the light is
    1)5800A^0 2)6000A^0 3)4500A^0 4)4200A^0
11. Two narrow slits separation by a distance of 0.08mm are illuminate by a source of light of wavelength 5460A^0.If the fringes are measured with a micrometer eyepiece it is found that 2 fringes occupy a distance of 10.92mm. The distance of the eyepiece from the slits is
    1)0.8m 2)1.6m 3)0.4m 4)0.5m
12. In Yong's double slit experiment the separation between the slits is double and the screen is halved. Then the fringe width is
    1)Doubled 2)Quadrupled 3)Unchanged 4)decreased by a factor 1/4
13. Two narrow slits separation by a distance of 1mm are illuminate with light of wave length 6000A^0.The interference fringes are observed on a screen placed 1m from the slits. The distance between the third dark fringe and fifth bright fringe is
    1)0.6mm 2)1.5mm 3)3mm 4)4.5mm
14. In Yong's double slit experiment the phase difference between the waves reaching central fringe and fourth bright fringe will be
    1)Zero 2)4Π 3)6Π 4)8Π

15. If the intensity of the central bright fringe is I, the intensity at a point distant one fourth of the distance between two successive bright fringes will be
1)I/4 2)I/2 3)I/√2 4)Zero
16. In Yong's double slit experiment the angular fringe width is 0.4^0.If the experiment is shifted to water of refractive index 4/3 the angular fringe width becomes
1)0.3^0 2)0.4^0 3)0.53^0 4)0.45^0
17. When mica plate of thickness 0.1mm is introduced in one of the interfering beams, the central fringe is displaced by a distance equal to 100 fringes. If the wave length of the light is $6000A^0$, the refractive index of the mica is
1)1.6 2)0.6 3)2.4 4)1.2
18. The maximum resultant amplitude due to a Fresnel's zone at a point is A.If P is a point such that the line joining it to the given zone makes an angle 60^0 with the normal to the zone, the resultant amplitude at p is
1)A/2 2)3A/2 3)3A/4 4)3A/√2
19. The polarization angle of a surface is 57^0. The angle of incidence so that the reflected light from it is plane polarized is
1)33^0 2)114^0 3)57^0 4)90^0
20. An unpolarized light is incident on a plate of refractive index √3 and the reflected light is found to be completely plane polarized.The angles of incidence and refraction are respectively
1)60^0,30^0 2)30^0,60^0 3)Sin^{-1}[1/ 3],45^0 4)Tan^{-1}[3/2],30^0
21. If the critical angle of medium is 45^0, its angle of polarization is
1)Tan^{-1}[1/√2] 2)Tan^{-1}[√2] 3)45^0 4)57^0
22. Two nicol prisms are inclined to each other at an angle 30^0.If I is the intensity of ordinary light incident on the first prism, then the intensity of light emerging from the second prism will be
1)3I/4 2)I/2 3)I/4 4)3I/8
23. The polarizer and analyzer are inclined to each other at an angle 60^0 . If the intensity of the polarizer light emerging from the polarizer is I, the intensity of the unpolarised light incident on the polarizer is
1)8I 2)2I 3)4I 4)I
24. The amplitude of the unpolarized light incident on a polarizer is A. The amplitude of the polarized light transmitted through it is
1)A/2 2)A/√2 3) 3/2 A 4)3A/4
25. The axis of the polarizer and analyzer are inclined to each other at 45^0. If the amplitude of the unpolarised light incident on the polarizer is A, the amplitude of the light transmitted through the analyzer is
1)A/2 2)A/√2 3) 3A/2 4)3A/4

PREVIOUS EAMCET QUESTION

1. Assertion (A) : In young's interference experiment the incident used is white. When one slit is covered with red filter and other with blue filter, the phase difference at any point on the screen will continuously change producing uniform illumination.
   Reason (R): Two independent sources of light would no longer act as coherent sources.
   1)Both A and R are true and R is correct explanation of A (2004 M)
   2) Both A and R are true and R is not correct explanation of A
   3) A is true R is false 4) A is false R is true
2. Consider the following statements A and B
   A) Fresnals diffraction pattern occurs when the source of light or screen on which diffraction pattern is seen are when both are at finite distance from the aperture.
   B) Diffracted light can be used to estimate the helical structure of nucleic acid. (2004E)
   1)A & B are true 2)A & B are false
   3) A is true B is false 4) A is false B is true
3. In Yong's double slit experiment, is obtained on a screen by a light of wave length $6000A^0$ coming from coherent sources S_1 & S_2. At a point P on the screen third dark fringe is formed. The path difference S_1P-S_2P in microns is (2003 E)
   1)0.75 2)1.5 3)3.0 4)4.5
4. Consider the following statements A and B (2003 M)
   A) Polarized light can be used to study the helical structure of nucleic acids
   B) Optic axis is a direction and not any particular line in the crystal
   1)A & B are true 2)A & B are false 3) A is true B is false 4) A is false B is true
5. Consider the following statements A and B
   A: when light falls on two polarized sheets having their axes mutually perpendicular, it is completely extinguished
   B: when polyvinyl alcohol is subjected to large strain the molecules get oriented parallel to the direction of strain and material becomes double refractive (2002 M)
   1)A & B are true 2)A & B are false
   3) A is true B is false 4) A is false B is true
6. When two coherent monochromatic light beams of intensity I and 4I are superimposed, the ratio between maximum and minimum intensities in the resultant beam is (2002M)
   1) 9:1 2)1:9 3)4:1 4)1:4
7. Consider the following statements A and B
   A: The refractive index of the extraordinary ray depends on the angle of incidence in double refraction.
   B: The vibrations of light waves acquire one sidedness for both ordinary and extraordinary rays in double refraction.(2002 E)

1)A and B are wrong 2)A and B are correct
3)A is correct is wrong 4)A is wrong B is correct

8. In Young's double slit interference experiment the wavelength of light used is 6000 A^0. If the path difference between waves reaching a point P on the screen is 1.5 microns, then at point P
1) Second bright band occurs 2) Second dark band occurs (2002 E)
3) Third dark band occurs 4) Third bright band occurs
9. Both light and sound waves produce diffraction. It is more difficult to observe the diffraction with light waves because (2001 M)
1) Light wave do not require medium 2) Wavelength of light waves is far smaller
3) Light waves are transverse 4) Speed of light is far greater
10. A wave front is an imaginary surface (2001 M)
1) Phase is same for all points
2) Phase changes at constant rate at all points along the surface
3) Constant phase difference continuously changes between the points
4) Phase changes all over the surface
11. Light ray of wavelength λ is passing through a pin hole of diameter D and the effect is observed on a screen placed at a distance L from the pin hole the approximations of geometrical optics are applicable if (2005E)
1) $D \geq \lambda$ 2) $\frac{L\lambda}{D^2} = 1$ 3) $\frac{L\lambda}{D^2} << 1$ 4) $\frac{L\lambda}{D^2} >> 1$
12. In Young's double slit experiment first slit has width 4 times the width of second slit. The ratio of maximum intensity to the minimum intensity in the interference fringe system is
1) 2:1 2) 4:1 3) 9:1 4) 8:1 (2006E)
13. Two coherent monochromatic light sources are located at two vertices of an equilateral triangle if the intensity of each source is 1 Wm^{-2} at the third vertex the resultant intensity due to both the sources at that point is (2006M)
1) 0 2) $\sqrt{2}$ Wm^{-2} 3) 2 Wm^{-2} 4) 4 Wm^{-2}

KEY

CONCEPTUAL QUESTIONS :

1)1 2)4 3)1 4)3 5)1 6)4 7)1 8)1 9)4 10)3 11)4
12)1 13)2 14)3 15)4 16)3 17)4 18)2 19)2 20)1
21)2 22)2 23)3 24)4 25)2 26)1 27)1 28)1 29)2
30)3 31)4 32)3 33)4 34)2 35)1

NUMERICAL QUESTIONS

1)4 2)1 3)1 4)2 5)3 6)1 7)4 8)1 9)3 10)2 11)1 12)3
13)2 14)4 15)3 16)1 17)1 18)3 19)3 20)1 21)2
22)4 23)2 24)2 25)1

PREVIOUS EAMCET QUESTIONS

1)1 2)3 3)2 4)1 5)2 6)1 7)2 8)3 9)2 10)1
11)3 12)3 13)4

Chapter -18

ELECTRIC CHARGES AND FIELDS

- **Electric charge**: It is a fundamental property of matter and never found free
- **Properties of electric charge**:

1) There are two types of electric charges, namely positive and negative charges

Ex: Charge carried by electron is negative & charge carried by photon is positive

2) In S.I system the unit of charge is coulomb. Electron charge e = $1.6 x 10^{-19}$ coulomb.
3) Charge is quantised. The smallest charge is associated with electron (−) and proton (+) is $1.6 x 10^{-19}$ coulomb.
4) All charges in nature exist as integral multiples of electron charge q = n.e. n → Integer

- Electric chare is acquired by a body due to transfer of electrons only

1) Body that loses electrons becomes positively charged
2) Body that gains electrons becomes negatively charged
3) Mass of the body slightly changes

- Charge produced by friction is called frictional electricity

Ex: 1) When a glass rod is rubbed with silk cloth, glass acquires positive charge and silk cloth acquires negative charge

Electrons are removed from glass rod and are added to silk cloth

2) When an ebonite rod is rubbed with fur cloth. Ebonite rod acquires negative charge and fur cloth acquires positive charge

Electrons are transferred from fur cloth to ebonite cloth

Induction:

- Separation of +ve and –ve charge in the uncharged (neutral) body under the influence of a near by charged body is called electrostatic induction

1) Induction always preceeds attraction
2) Opposite charge is induced at the near end and similar charge at the farther end
3) The induced +ve and –ve charges are also equal in magnitude

- Charge residing on unit area of charged body is called surface density of charge

$$\sigma = \frac{Q}{A} \text{ Cm}^{-2}$$

1) σ increases with curvature of the surface or inversely proportional to the square of the radius of curvature of the surface
2) So charge accumulates at the pointed ends, edges, and corners of the surface. (Action of points)
3) Lightning conductors work on action of points

- Coulomb's inverse square law

1) $F = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{d^2}$

q_1, q_2 – Charges in coulomb, d – distance in metres, F – Electrostatic force in newton
ε_0 – Permittivity of free space or vacuum or air
ε_r –Relative permittivity or dielectric constant of the medium in which the charges are situated

2)$\varepsilon_0 = 8.85 \times 10^{-12}$ farad/meter $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2/C^2$

1) The relative permitivity of a material

$$\varepsilon_r = K = \frac{\text{Force between two charges in air}}{\text{Force between the same charges in the medium at same distance}} = \frac{Fa}{Fm}$$

2) For air K =1

- The space around a charged body where its influence can be experienced is called electric field, Intensity or strength of electric field (E)

1) Intensity is the force on unit +ve charge $E = \frac{F}{q}$
2) It is a vector, Field is uniform if $\vec{E}$ is same at all points
3) S.I unit is newton/coulomb or volt/metre
4) Intensity at any distance due to a charge q in air $E = \frac{1}{4\pi\varepsilon_0} \frac{q}{d^2}$

- **Electric lines of force**

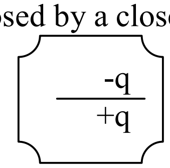
1) Line of force is the path along which a unit +ve charge, accelerates in electric field
2) The tangent at any point to the line of force gives the direction of the field at that point
3) Two lines of force never intersect
4) Number of lines of force passing normally through unit area around a point is numerically equal to E, the strength of the field at that point
5) Lines of force always leaves or end normally on a charged conductor
6) Electric lines of force can never be closed loops
7) Lines of force have tendency to contract longitudinally
8) If in a region of space there is no electric field, there will be no lines of force. Inside a conductor there cannot be any line of force
9) Number of lines of force passing normally through unit area around a point is numerically equal to E
10) In uniform field, lines of force are parallel to one another

Gauss's law:

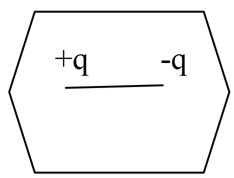
1. Gauss's law or gauss's theorem in electrostatics states that "**the total electric flux through any closed surface is equal to $1/\varepsilon_0$ times the net charge enclosed by the surface**". Here $\boldsymbol{\varepsilon_0}$ is the permittivity of free space. Mathematically the gauss's law or gauss's theorem can be stated as

$$\oint \boldsymbol{E.ds} = \frac{\mathbf{q}}{\boldsymbol{\epsilon o}}.$$

2. $\Phi = \oint \boldsymbol{E.ds} = \frac{q}{\epsilon o}$. = E.4πr2. = 4πKq. Here q is the algebraic sum of the charge enclosed by the closed surface.
3. The value of Φ does not depend on the shape, size or area of the surface rather it depends upon the total quantity of charge enclosed by the surface.
4. This law is valid of symmetric charge distribution and for all vector fields obeying inverse square law.
5. The value of Φ is Zero in the circumstances.
   a) If a dipole is enclosed by a closed surface.



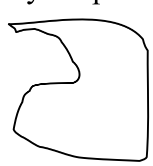
   b) If a magnitudes of positive and negative charges are equal inside a closed surface.



   c) If a no charge is enclosed by the closed surface

   i) conductor of any shape

+q
S



   ii) Cubical conductor

+++++++

Gauss'

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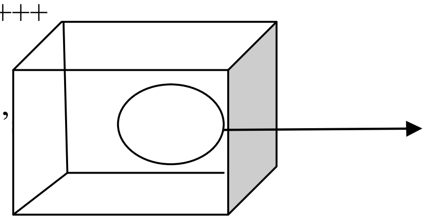
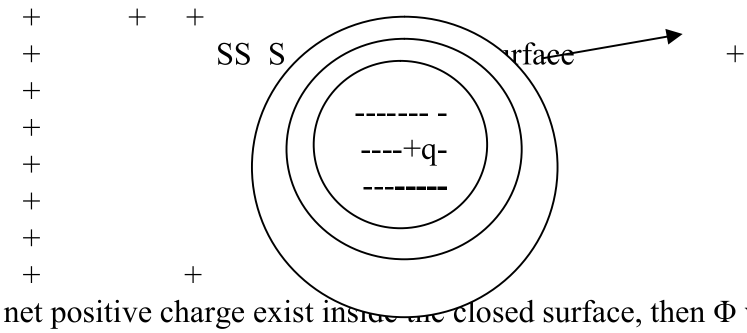


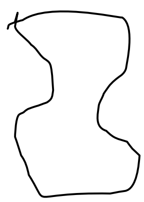
d) If the charge is enclosed in a cavity as shown in the figure.



6. If net positive charge exist inside the closed surface, then Φ will be positive i.e., flux will be coming out.

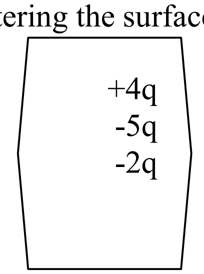
+3q
+q

-2q



7. If net charge inside a closed surface is negative then Φ will be negative i.e., flux will be entering the surface.

+



8. a) If a charge q is the situated at the center of the cube. Then the flux emerging out of the cube will be **q/ε_0.**
b) If a charge q is situated at one corner of the face of the cube. Then the flux coming out of the cube will be **$q/8\varepsilon_0$.** Because only q/8 charge will contribute to this cube.
c) If a charge q is the situated at the center of the face of the cube. Then the flux coming out of the cube **$q/2\varepsilon_0$.** Because only q/2 charge contributes to this cube.
9. If a charge q is the situated at the center of the square then
a) The flux coming out of each side of the square will be
$\Phi = \frac{q}{4\varepsilon_0}$.
b) The flux coming out of one of the sides will be
$\Phi = \frac{q}{2\varepsilon_0}$.

Application of gauss's law to continuous charge Distribution:

There are three kinds of charge distributions, namely linear, surface and volume charge distributions; we have three kinds of charge densities.

a) **Linear charge density(λ):**

It is defined as the charge per unit length and it is given by

$$\lambda = \frac{dq}{dl} = \frac{q}{l}$$

Where dq is the charge in an infinitesimal length dl.

Units of λ are coulomb/meter and its dimensions are MTL^{-1} .

It is used in formulae for charged ring, linear charge distributions.

b) **Surface charge density(σ):**

It is defined as the charge per unit area.

$$\sigma = \frac{dq}{ds} = \frac{q}{A}$$

Where dq is the charge in an infinitesimal surface ds.

Units of σ are coulomb/meter^2 and its dimensions are MTL^{-2}.

It is used in formulae for charged disc, charge conductor and infinite sheet of charge.

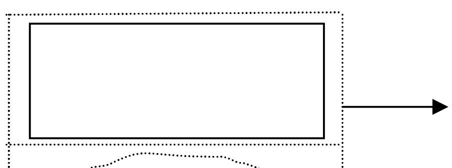
$\sigma \propto \frac{1}{r^2}$ i.e., $\frac{\sigma_1}{\sigma_2} = \frac{r_2^2}{r_1^2}$

σ maximum at pointed surfaces for plane surfaces it is minimum

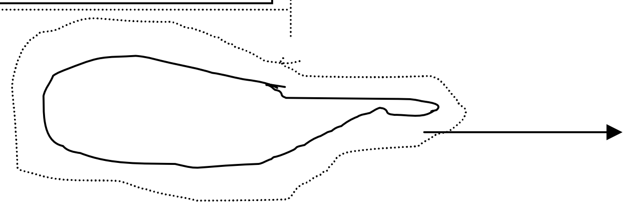
σ depends on the shape of the conductors and presence of their conductors and insulators in the vicinity of the conductor.

σ maximum at the corner of rectangular laminas and at the vertex of conical conductor.

σ- max



σ - max



c) **Volume charge density(ρ):**

It is defined as the charge per unit volume.

$$\rho = \frac{dq}{dv} = \frac{q}{v}$$

Where dq is the charge in an infinitesimal volume dv.

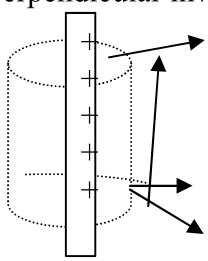
Units of σ are coulomb/meter^3 and its dimensions are MTL^{-3}.

It is used in formulae for surface charged distributions.
For spherical conductor $\rho = \frac{q}{4/3\pi r^3}$

10. **Electric Intensity and Potential due to an Infinite Long Straight Charged Wire.**
$\oint E.ds = \frac{q}{\epsilon o}$. Where **q = λl**, is the total charge enclosed within the surface.
The surface area S= (2πr)l
If **λ is positive**, that is if the wire is positively charged, the direction of **E** will be radically perpendicular outwards (away from the wire)
If **λ is negative,** that is if the wire is negatively charged, the direction of **E** will be radically perpendicular inwards (towards the wire)

ds_1
A
l

E C

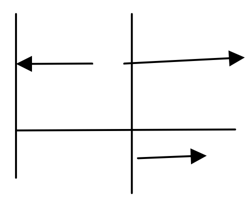


ds_2

Gaussian surface long straight charted conductor

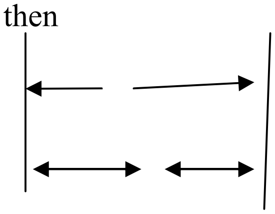
a) Direction of E is at right angles to the linear charge.
b) If the point of observation lies at infinity then E = 0.
c) The value of E due to two parallel linear charges.
d) If the point of observation lies on one side of both wires. Then E =0.
$E = 2K \left(\frac{\lambda_1}{r_1} + \frac{\lambda_2}{r_2} \right)$
r1 P
λ_1 λ_2

r_2



e) If the point of observation lies between two wires, then
$E = 2K \left(\frac{\lambda_1}{r_1} - \frac{\lambda_2}{r_2} \right)$
λ_1 . λ_2

r p r



Brief Synopsis and Important Formulae

1. If the sizes of charged bodies are very small as compared to the distance between them, are called point charges.

2. Quantisation of electric charge means that total charge (q) of a body is always an integral multiple of a basic quantum of charge (e) i.e., Q = ne, where n = 0, ± 1 ± 2 ± 3.

3. Coulomb's law gives us the force acting between two stationary charges placed at a given distance It is called inverse square law as the electrostatic force is inversely proportional to the square of the distance between the charges. Coulombs law in SI in medium is

$F = \frac{1}{4\pi\varepsilon} \cdot \frac{q_1 q_2}{r^2}$, where ε is the permitivity of the medium

4. Dielectric constant of the medium, $K = \frac{\varepsilon}{\varepsilon_0}$

5. The superposition principle is based on the fact that the electrostatic force between any two charges is not affected by the presence of other charges.

6. Electric field intensity at a point is the force experienced per unit positive test charge at that point.

7. A line of force is a curve, the tangent to which at any point gives the direction of electric field at that point. Electrostatic lines of force are not closed curves.

8. Electric flux, $\Phi_E = \int_s E.dS$. Area of an element dS is also a vector and is directed

along the outward drawn normal to the area. Electric flux is a scalar quantity

9. Gauss's law states that the total electric flux through any closed surface is equal to

$\frac{1}{\varepsilon_0}$ times the total charge enclosed by the surface.

$$\Phi_E = \int_s E.dS = \frac{q}{\varepsilon_0}$$

10. Work done per unit positive test charge in bringing it from infinity to a point against the electrostatic force is the potential (V) at that point. It is a scalar quantity.

11. Electric field E due to a point charge 'q' at a distance 'r' in free space

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

12. Electric potential 'V' due to a charge 'q' at a distance 'r' in free space =

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

13. A pair of equal and opposite point charges q and –q, separated by a distance 2a is called an electric dipole.
14. In non-polar molecules, the centres of position charges and of negative charges coincides their dipole moment is zero. Eg.: CO_2, CH_4
15. In polar molecules, the cetres of positive charges and of negative charges do not coincide, they have a permanent dipole moment. Eg. H_2O
16. Charge per unit surface area of a body is called charge density, $\sigma = \frac{-\Delta Q}{\Delta S}$
17. Charge per unit length of a wire is called linear charge density, $\lambda = \frac{\Delta Q}{\Delta l}$
18. Charge per unit volume of a body is called volume charge density $\rho = \frac{\Delta Q}{\Delta V}$.
19. Field due to an infinitely long straight uniformly charged wire, $E = \frac{\lambda}{2\pi\varepsilon\varepsilon_0}$
20. Field due to a uniformly charged infinite plane sheet E, $= \frac{\sigma}{2\pi\varepsilon_{0y}r}$
21. Thin spherical shell of uniform surface charge density σ,
    (i) E, $= \frac{q}{4\pi\varepsilon_0 r^2}$ $(\geq R)$ (ii) E = 0 (r < R)
22. Field of an electric dipole in its equatorial plane at a distance r from the centre,

$$E = \frac{-P}{4\pi\varepsilon_0} \quad \frac{1}{(a^2 + r^2)^{3/2}}$$

$$E = \frac{-P}{4\pi\varepsilon_0 r^3} \text{ for } r >> a.$$

23. Dipole electric field on the axis at a distance r from the centre

$$E = \frac{2Pr}{4\pi\varepsilon_0 (r^2 - a^2)^2} \equiv \frac{2P}{4\pi\varepsilon_0 r^3} \text{ for } r >> a.$$

24. In uniform electric field E, a dipole experience a torque t, given by $\tau = P \times E$.

IMPORTANT FORMULAE

1. Coulombs law $\vec{F} = \frac{1q_1q_2}{4\pi\varepsilon_0 r^2}\hat{r}$ or $\vec{F} = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1q_2}{|\vec{r}|^3} \times \vec{r}$

2. Principle of superposition, $\vec{E} = \frac{q}{4\pi\varepsilon_0} \sum_{r_1} \frac{q_i}{2}\hat{ri}$

3. Dielectric constant of relative permittivity K or $\varepsilon_r = \frac{F_{vac}}{F_{medi}}$

4. Coulomb's law in vector form is $\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$ r12

$$= \frac{1}{4\pi\varepsilon_0} \times \frac{q_1q_2}{|\vec{r}2 - \vec{r}_1|^2}\left(\vec{r}_2 - \vec{r}_1\right)$$

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2} \text{ r21} = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1q_2}{|\vec{r}2 - \vec{r}_1|^3}\left(\vec{r}_1 - \vec{r}_2\right)$$

5. Electric field intensity at any point on the axis of a uniformly charged ring is

$$E = \frac{q}{4\pi\varepsilon_0}\frac{qx}{(x^2 + a^2)3/2}$$

If x >> a, then $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}$

6. Electric dipole moment is $\vec{P}_e = q\,(2\vec{a})$

7. Intensity of electric field (i) on axial line, it is $\vec{E}_a = \frac{2\vec{p}.r}{4\pi\varepsilon_0}\frac{qx}{(r^2 - a^2)\ \ 2}$

(ii) on equatorial line or Neutral axis, it is

$$\vec{E}_{eq} = \frac{\vec{p}}{4\pi\varepsilon_0(r^2 - a^2)3/2}$$

8. Torque on an electric dipole placed in a uniform electric field τ = PE sin θ

In vector form $\vec{\tau} = \vec{P} \times \vec{r}$, if $\vec{E}$ is uniform

9. Potential energy of an electric dipole in uniform electric field is

U = PE cos θ = $-\vec{P}.\vec{E}$

10. Gauss's theorem is $\oint \vec{E}.\vec{d}s = \frac{q}{\varepsilon_0}$

11. Electric field intensity at any point

(i) due to a line charge $E = \frac{1}{2\pi\varepsilon_0}.\frac{\lambda}{r}$

(ii) due to an infinite sheet of charge of density, $E = \frac{\sigma}{2\varepsilon_0}$

(iii) due to an infinite plane conductor having finite thickness, $E = \frac{\sigma}{\varepsilon_0}$

12. Electric field intensity due to two infinite parallel sheet of charges.

(i) In the region between the sheets, $E = \frac{1}{2\varepsilon_0}(\sigma_A - \sigma_B)$

(ii) In the region outside the sheets, $E = \frac{1}{2\varepsilon_0}(\sigma_A + \sigma_B)$

13. Electric field due to a charged spherical shell

(i) When point of observation lies inside the shell $E = 0$

(ii) When point of observation lies outside the shell $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

(iii) On the surface of the shell $E = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2}$

14. Electric field due to a charged sphere

(i) outside the charged sphere $E = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2} = \frac{p}{\varepsilon_0}.\frac{R^3}{r^2}$

(ii) On the surface of the charged sphere $E = \frac{1}{4\pi\varepsilon_0}.\frac{q}{R^2} = \frac{p^R}{3\varepsilon_0}$

(iii) Inside the sphere $E = \frac{1}{4\pi\varepsilon_0}.\frac{q^r}{R^3} = \frac{p^R}{3\varepsilon_0}$

Questions on Gauss's Law and its pplication:

1. The Gauss Law in a dielectric medium is
   (a) $\oint KE.ds = \frac{q}{\epsilon o}$. (b) $\oint E.ds = \frac{q}{\epsilon o}$ (c) zero (d) $\oint E.ds = 0$.
2. If a conducting medium is placed between two charges, then the electric force between then will becomes
   (a) Zero (b) Infinity (c) 1N (d) 1dyne
3. The electric flux entering and emanating out of a closed surface are $2 * 10^3$ and $8 * 10^3$ volt-meter respectively. The charge enclosed by the closed surface is
   (a) Zero (b) 1coloumb (c) 0.53 μC (d) 0.053 μC
4. A cube is arranged such that its length, breath and height are along x, y and z directions. One its corners are situated at the origin. Length of each side of the cube is 25cm. the components of electric field are $E_x = 400\sqrt{x}$ N/c, $E_y = 0$ and $E_z = 0$ respectively. The total flux coming out of the cube will be
   (a) 12.5 N-m^2/c (b) Zero (c) 12.5 (d) 1
5. A square frame of side 10cm is lying in an electric field of intensity 20v/m. the unit normal to the square makes an angle of 60^0 with the direction of electric flux through the surface enclosed by the frame will be
   (a) 0.2 volt-m (b) 0.1 volt-m (c) Zero (d) 0.4 volt-m

6. A positively charge of 17.7 μC is lying at the center of a hollow sphere of radius 0.5m. the flux density emanating out of the sphere will be
   (a) 5.89×10^2 N/c (b) 3.21×10^3 N/c (c) 2.93×10^4 N/c (d) 6.93×10^5 N/c
7. The electric flux through an area $5 * 10^{-3}$ j m^2 lying in an electric field of intensity (20i +30j) will be
   (a) 50 volt-m (b) 15volt-m (c) 0.15 volt-m (d) Zero
8. The electric charge on an infinite plane $1.6 * 10^{-19}$ coulomb per square Angstrom. The intensity of electric field near the plane will be
   (a) 10^3 (b) 9.04×10^{11} v/m (c) 10^{11}v/m (d) 10^{-11}v/m
9. The linear charge density on an infinite line of charge is 4Mc/m. the field intensity at a point situated at a distance of 20cm will be
   (a) 36×10^{-4} v/m (b) 6×10^{-4} v/m (c) 36×10^4 v/m (d) Zero
10. Two parallel conducting plates, each of area 10^4 cm^2, are given equal and opposite charge of $8.8 * 10^{-6}$ coulomb. Dielectric medium is partially filled between the plates. If the electric field inside the dielectric is $1.4 * 10^5$ v/m then the electric field in vaccum will be
    (a) Zero (b) 10^5 v/m (c) 9.94×10^5 v/m (d) 1.94×10^5 v/m
11. A point charge of 1μC is situated just above a square of side 1m. the electric flux emanating out of the square surface will be
    (a) Zero (b) 1.884×10^4 v/m (c) 10^6 (d) 10^7 v/m
12. The intensity of electric field of 10N/c is dielectric at an angle of 60^0 from the normal to a rectangular surface 2m long and 4m wide. The electric flux coming out of it will be
    (a) $40\frac{N\text{-}m^2}{Colu}$ (b) $20\frac{N\text{-}m^2}{Colu}$ (c) Zero (d) $80\frac{N\text{-}m^2}{Colu}$
13. A charge q is lying above the center of a square of side α at a distance of a/2 from the center. This electric flux emanating out of the square will be
    (a) $q/8\varepsilon_0$ (b) $q/6\varepsilon_0$ (c) $q/2\varepsilon_0$ (d) q/ε_0
14. Two metallic plates, each of area A and bearing charges +q and -q respectively. Are placed at distance d apart. The electric field between the plates will be
    (a) $q/A\varepsilon_0$ (b) $q/2A\varepsilon_0$ (c) $3q/A\varepsilon_0$ (d) $q/6A\varepsilon_0$
15. two electrons are lying at two points P and Q between the plates of a parallel plate condenser the ratio of forces acting on two electrons F_p/F_Q
    (a) 1 (b) >1 (c) <1 (d) Infinity

1.a	2.a	3.d	4. a	5.b
6.d	7.c	8.b	9.c	10.c
11. b	12.a	13.b	14.a	15.a

Question Bank:

Conceptual Questions:

1) In induction charge induced in the near surface of the conductor is
   1) similar 2) dissimilar 3) not related 4) zero

2) When charge is given to a body
1) more charge accumulates at regions of small curvature
2) more charge accumulates at regions of large curvature
3) charge is distributed uniformly irrespective of curvature
4) none of the above is true

3) An electric charge is uniform motion produce
1) an electric field only   2) a magnetic field only
3) both electric and magnetic field   4) cannot be predicted

4) A charge q_1 exerts some force on a second charge q_2. If a third charge q_3 is brought near, the force exerted by q_1 on q_0
1) decreases   2) increases   3) remains unchanged
4) increases if q_3 is of same sign as q_1 and decreases if q_3 is of opposite sign

5) Two charges are placed at a distance apart. If a glass slab is introduced between them the mutual force between the charges
1) increases   2) decreases   3) remains same   4) becomes zero

6) The charge density on a surface varies in the following way with increase of curvature
1) increases   2) remains constant   3) decreases   4) becomes zero

7) Electric lines of force from a negative point charge are
1) circular anticlockwise   2) circular clockwise
3) radial outward   4) radial inward

8) As one penetrates a uniformly charged conducting sphere, the electric field strength 'E'
1) increases   2) decreases
3) remains the same as the surface   4) is zero at all points

9) The path of a charged particle projected into a uniform transverse electric field is
1) circle   2) hyperbola   3) parabola   4) ellipse

10) Choose the correct statement
1)only positive charges have electric field
2) Electric field can exist only in material medium
3) The direction of electric field is that in which an electron is attracted
4) Field lines are continuous in a medium

11) Electric lines of force always leave an equipotential surface
1) at any angle to the surface   2) parallel to the surface
3) perpendicular to the surface   4) none

12) A unit charge is taken from one point to another over an equipotential surface, then
1) work is done on the charge   2) work is done by the charge
3) work on the charge is constant 4) no work is done

13) Inside a hollow spherical conductor, the potential
1) is constant   2) varies directly as the distance from the centre
3) varies inversely as the distance from the centre
4) varies inversely as the square of the distance from the centre

14) Choose the wrong statement
1) An equipotential surface is normal to electric field lines
2) Potential increases in the direction of electric field
3) We may have zero potential but non zero electric field at a point in space
4) Potential is a scalar quantity

15) Out of the following two statements
A) As we move in the direction of the field potential goes on decreasing
B) If a charge body is moved with in the field work must be done
1) A is correct and B is wrong 2) A is wrong and B is correct
3) Both A and B are correct 4) Both A and B are wrong

16) Out of the following two statements
A) In case of a charged spherical conductor the field inside is zero
B) Charge resides only on the surface of a solid conducting body and on the outer surface of a hollow body due to repulsion
1) A is correct and B is wrong 2) B is correct and A is wrong
3) Both A and B are wrong 4) Both A and B are correct

17) Out of the following two statements:
A) Two like charge can only produce a null point
B) Due to two opposite charges infinite number of zero potential points are formed
1) A is correct and B is wrong 2) A is wrong and B is correct
3) Both A and B are wrong 4) Both A and B are correct

18) Out of the following two statements:
A) Three charge system cannot have zero mutual potential energy
B) The mutual potential energy of a system of charges is only due to positive charges
1) A is wrong and B is correct 2) A is correct and B is wrong
3) Both A and B are correct 4) Both A and B are wrong

19) If two conducting spheres are seperately charged and then brought into contact
1) The total energy of the spheres is conserved
2) The total charge on the spheres is conserved
3) Both the total energy and charge are conserved
4) The final potential is always the mean of the original potential of the two spheres

20) Electric potential some point in space is zero. Then at that point
1) electric intensity is necessarily zero 2) electric intensity is necessarily non zero
3) electric intensity may or may not be zero 4) electric intensity is necessarily infinite

21) A condenser is charged connecting to a battery then the battery is disconnected. If a dielectric slab is introduced between the plates
1) potential decreases 2) capacity decreases
3) potential increases 4) charge increases

22) Two conductors when connected by a wire, charge flows if they have
1) different charges 2) different potentials
3) different capacities 4) different charge densities

23) The capacitance of a parallel plate condenser depends upon
1) area of the plates 2) medium between the plates
3) distance between the plates 4) all the above

24) The capacity of a spherical conductor is independent of its
1) volume 2) surface area 3) material 4) none of the above

25) The condenser used in the tuning circuit of radio receiver is
1) paper condenser 2) electrolytic condenser 3) leyden jar 4) Gang condenser

Key

1)2	2)1	3)3	4)3	5)2	6)1	7)4	8)4
9)3	10)3	11)3	12)4	13)1	14)2	15)3	16)1
17)2	18)4	19)2	20)3	21)1	22)2	23)4	24)3
25)4							

Coloumbs Law:

1) In 1gram of solid, there are $5x10^{21}$ atoms. If one electron is removed from every one of 0.1% of atoms of the solid, the charge gained by the solid is
1) +0.08C 2) +0.8C 3) +8.0mC 4) –0.08C

2) The number of electrons in 1 coulomb of charge is
1) $6.25x10^{19}$ 2) $6.25x10^{18}$ 3) $1.6x10^{19}$ 4) $9x10^{31}$

3) The ratio of the forces between two small spheres with constant charges (a) in air (b) in a medium of dielectric constant k respectively
1) 1:K 2) K:1 3) $1:K^2$ 4) $K^2:1$

4) A negatively charged bob of a seconds pendulum is made to vibrate on a positively charged metal plate. Then its time period is
1) 2s 2) >2s 3) <2s 4) zero

5) Three identical charges are placed at the corners of an equilateral triangle. If the force between any two charges is F, the net force on each charge will be
1) F 2) 2F 3) $\sqrt{3}$ F 4) 3F

6) Two charges 40μC and -40μC are placed at the corners A and B of an equilateral triangle ABC of side 20cm. The force on a charge 10μc placed at C is
1) $\sqrt{3}$ x90N 2) 90N 3) $\sqrt{2}$ x90N 4) 180N

7) Two charges $4x10^{-9}$C and $-16x10^{-9}$C are separated by a distance 20cm in air. The position of the neutral point from the smaller charge is
1) $\frac{40}{3}$ cm 2) $\frac{20}{3}$ cm 3) 20cm 4) $\frac{10}{3}$ cm

8) Two charges 9μC and 16μC are separated by 42cm in air. The distance of a charge 25μC to be placed on the line joining the charges for it alone to be in equilibrium is
1) 18cm from 9μC 2) 18cm from 16μC

3) 21cm from 16μC 4) 24cm from 9μC

9) Two positive charges separated by a distance 2m each other with a force of 0.36N. If the combined charge is 26μC, the charges are

1) 20μC, 6μC 2) 16μC to 10μC 3) 18μC, 8μC 4) 13μC, 13μC

10) A charge Q is to be divided into two parts so that the force between the parts will be maximum. The parts are

1) $\frac{Q}{2}, \frac{Q}{2}$ 2) $\frac{Q}{4}, \frac{Q}{4}$ 3) $\frac{Q}{3}, \frac{Q}{3}$ 4) $\frac{Q}{6}, \frac{5Q}{6}$

11) Two point charges +4C and +6C repel each other with a force F. If a charge –5C is given to each of these charges, the force becomes

1) repulsive force of $\frac{F}{24}$ 2) attractive force of $\frac{F}{24}$

3) repulsive force of 24F 4) attractive force of 24F

12) Two charges +8μC and +8μC are separated by a certain distance. A third charge to be placed at the mid point of the line joining the first two charges so that all the three charges are in equilibrium is

1) +2μc 2) -2μc 3) +4μc 4) -4μc

13) Two metal balls each of 1kg are suspended by silk threads from the same point. When they are given identical charges each ball is deflected through 45^0 from the equilibrium position having distance of seperation 0.4m, the charge on each ball is (g = $10ms^{-2}$)

1) 13.3μc 2) 1.33μc 3) 0.75μc 4) 1μc

14) Two identical metal spheres carrying charges Q and –5Q separated by a distance d experience a mutual force of attraction F. If they are made to touch each other and separated to a distance 3d, then the force between them will be

1) Repulsive force of $\frac{4F}{45}$ 2) Repulsive force of $\frac{4F}{45}$

3) Attractive force of 4F 4) Repulsive force of 4F

Electric Field Intensity:

15) A particle of mass 'm' carrying a charge 'q' is projected up with a velocity 'u' at an angle 'α' to the horizontal. An electric field 'E' is directed downwards vertically. The time of flight of the particle is

1) $\frac{2\,u\sin\alpha}{g - \frac{qE}{m}}$ 2) $\frac{2\sin\alpha}{g} + \frac{qE}{m}$ 3) $\frac{2\,u\sin\alpha}{g + \frac{Eq}{m}}$ 4) $\frac{(2\,u\sin\alpha s\,m}{Eq}$

16) The mass of the sphere is $3.2x10^{-14}$kg and it carries a net charge equal to that of 10 electrons. If the electronic charge is $–1.6x10^{-19}$C and the acceleration of free fall g is $10m/sec^2$, the field required to keep the sphere stationary is

1) $5x10^{-6}$V/m 2) $5x10^{-5}$V/m 3) $2x10^{5}$V/m 4) $2x10^{-4}$V/m

17) The force ‘f’ experienced by a charge ‘q’ placed in a electric filed of intensity $200Vm^{-1}$ is 1 milli newton. The charge is

1) 5μC 2) 5C 3) 10μC 4) 20μC

18) Two charges $10^{-8}C$ and $-10^{-8}C$ are placed at two corners of an equilateral triangle of side 20cm. Electric intensity at the third corner is

1) $\sqrt{3}$ x2250NC^{-1} 2) $\sqrt{2}$ x2250NC^{-1} 3) 450NC^{-1} 4) 2250NC^{-1}

19) Two electric charges Q and 4Q are separated by certain distance. If the electric intensity at Q is E, the electric intensity at the other charge is

1) 4E 2) $-\frac{E}{4}$ 3) $\frac{E}{2}$ 4) 2E

20) Four charges $5x10^{-9}C$, $5x10^{-9}C$, $5x10^{-9}C$ and $5x10^{-9}C$ are placed at the corners A, B, C and D of a square ABCD of side 1m. The electric intensity at the centre of the square is

1) 90NC^{-1} 2) 180NC^{-1} 3) 45NC^{-1} 4) zero

21) Two charges +Q and –Q are separated by a distance d. The electric intensity at the mid point of the line joining them is

1) $\frac{2Q}{\pi\varepsilon_0 d^2}$ towards negative charge 2) $\frac{2Q}{\pi\varepsilon_0 d^2}$ towards positive charge

3) $\frac{Q}{4\pi\varepsilon_0 d^2}$ towards negative charge 4) zero

22) A sphere of radius 10cm contains $2x10^{-9}C$ of charge. Electric intensity at a distance of 90cm form its surface is

1) 18NC^{-1} 2) 36NC^{-1} 3) 9NC^{-1} 4) 27NC^{-1}

23)A sphere of mass 50gm is suspended by a string in an electric field of intensity 5NC^{-1} acting vertically upward. If the tension in the string is 520millinewton, the charge on the sphere is (g = 10ms^{-2})

1) $4x10^{-3}C$ 2) $-4x10^{-3}C$ 3) $8x10^{-3}C$ 4) $-8x10^{-3}C$

24)Two concentric hollow conducting spheres of radii R_1 and R_2 charges Q_1 and Q_2 respectively. If $R_1>R_2$, then the electric intensity at a distance r from the common centre ($R_1>r>R_2$) is

1) $\frac{1}{4\pi\varepsilon_0}\frac{Q_1}{r^2}$ 2) $\frac{1}{4\pi\varepsilon_0}\frac{Q_2}{r^2}$ 3) $\frac{1}{4\pi\varepsilon_0}\frac{Q_1+Q_2}{r^2}$ 4) Zero

25) A solid metal sphere A is placed concentrically inside a hollow spherical conductor B. Positive charge Q is given to A and B is earthed. The electric intensity

1) inside A is zero 2) on the surface of B is zero

3) between A and B is not zero 4) all the above are true

26)A simple pendulum having bob of mass m is suspended in a uniform horizontal electric field of intensity E. When the bob is given a charge Q, the string of the pendulum deflects through an angle θ and comes to rest. Then the tension in the string of the pendulum is

1) $\frac{mg}{Cos\theta}$ 2) $\sqrt{Q^2E^2+m^2g^2}$ 3) both of the above 4) none of the above

27) Two charges $+5x10^{-9}C$ and $+5x10^{-9}C$ are placed at the corners B and C of an equilateral triangle of side 10cm. The electric intensity at the corner A is

1) $0.45NC^{-1}$ 2) $\frac{\sqrt{3}}{2}$ $x0.45NC^{-1}$ 3) $\sqrt{3}$ $x0.45NC^{-1}$ 4) $\sqrt{2}$ $x0.45NC^{-1}$

28) At the corners A, B, C of a square ABCD, charges 10μC, -20μC and 10μC are placed. The electric intensity at the centre of the square to become zero, the charge to be placed at the corner D is

1) -20μC 2) +20μC 3) 30μC 4) -30μC

29) Two charges 10μC and 40μC are separated by a distance 21cm. At a distance 7cm from 10μC in between them

1) the net electric potential is zero 2) the resultant electric intensity is zero
3) both of the above 4) none of the above

Electric Intensity:

30)Two charges 2 nano coulombs and –2 nano coulombs are separated by a distance 40cm in air. The resultant electric intensity at the zero potential point which lies in between them and on the line joining them is

1) 450N/C 2) 900N/C 3) 225N/C 4) zero

31) A bob of a simple pendulum of mass 40gm with a positive charge $4x10^{-6}c$ is oscillating with time period 'T_1'. An electric field of intensity $3.6x10^4N/c$ is applied vertically upwards now time period is T_2. The value of $\frac{T_2}{T_1}$ is ($g = 10m/s^2$)

1) 0.16 2) 0.64 3) 1.25 4) 0.8

32) A pendulum of 80cm-wt and carrying charge $2x10^{-8}c$ is at rest in a horizontal uniform electric field of 20,000v/m. The tension is the pendulum string will be

1) $2.2x10^{-4}N$ 2) $8.8x10^{-4}N$ 3) $4.4x10^{-4}N$ 4) $1.76x10^{-4}N$

1)2	2)2	3)2	4)3	5)3	6)2	7)3
8)1	9)2	10)1	11)2	12)2	13)1	14)2
15)3	16)3	17)1	18)4	19)2	20)2	21)1
22)1	23)2	24)2	25)4	26)3	27)3	28)1
29)2	30)2	31)3	32)2			

ELECTRIC DIPOLE

1. A system of electric charges in which two equal and opposite electric charges are separated by a small distance is called an electric dipole.

Dipole moment = electric charge × distance between them

It is a vector directed from –ve charge to +ve charage

If two charges of q and $-q$ are separated by a distance of 2ℓ, dipole moment

$P = q \times 2\ell$

[It is measured in coulomb × m]

A special unit of electric dipole moment is debye.

1 debye = 1D = $\frac{1}{3} \times 10^{-29}$ coulomb × m

2. AT the point (r, θ) at a distance of r making an angle θ with dipole moment vector. Electric potential $V = \frac{P\cos\theta}{4\pi\epsilon^2}$

Electric field Intensity $E = \frac{P}{4\pi\epsilon^3}\sqrt{3\cos^2\theta + 1}$

If $\propto$ be the angle between $\vec{E}$ & $\vec{r}$, then $\tan \propto = \frac{1}{2}\tan\theta$

Angle between $\vec{E}$ & $\vec{r}$ is $\beta = (\theta + \alpha) = \theta + \tan^{-1}\left(\frac{1}{2}\tan\theta\right)$

Special cases

3. (i) If the point is on the axis of dipole (θ = 0° or 180°) [axial point or end side on position]

$V_a = \frac{\pm P}{4\pi\epsilon r^2}$ and $E_a = \frac{2P}{4\pi\epsilon r^3}$ $\overrightarrow{E_a} \,||\, \vec{P}$

(+) for the point closer to $+q$ charge & (-) for point closer to $-q$ charge

(ii) If the point is on perpendicular bisector of dipole (θ = 90° or 270°)

(Broad side on position)

$V_b = 0$ *and* $E_b \frac{P}{4\pi\epsilon r^3}$, $\vec{E}_b \,||\, \vec{P}$

4. (i) Potential energy of electric dipole in electric field is

U = PE (1- cos θ) where θ is angle between $\vec{P}$ & $\vec{E}$ [zero level of potential energy is the position when P || E]

(ii) If the position $\vec{P} \perp \vec{E}$ be taken as zero level of potential energy, U = -PE cos θ

$U = \vec{P} \cdot \vec{E}$

(iii) If an electric dipole is kept in a uniform electric field of strength E, making an angle θ, the dipole experience a torque.

$\vec{\tau} = \vec{P} \times \vec{E}$ $\therefore \tau = \text{PE} \sin\theta$

PROBLEMS

1. An electric dipole has dipole moment of 3 debye. What is the potential at a point on its axis at a distance of 100 Å?

Ans: 9×10^{-4} volt.

$$V = \frac{P}{4\pi\epsilon_0 r^2} = \frac{9\times10^9 Nm^2C^{-2}\times3\times\frac{1}{3}\times10^{-29}C\times m}{(100\times10^{-10})^2 m^2}$$

$V = 9\times 10^{-4} NmC^{-1} = 9 \times 10^{-4} V$

2. What is the intensity at a point at a distance of 300 Å lying on the axis of an electric dipole of moment of 6 debye?

Ans: 133×10^{-4} volt/m. in the direction of dipole moment vector

$$E_a = \frac{2P}{4\pi\epsilon_0 r^3} = \frac{9\times10^9\times2\times6\times\frac{1}{3}\times10^{-2}}{(300\times10^{-10})^3} \frac{volt}{m}$$

$E_a = 133 \text{ x } 10^{-4}$ volt/m

3. It is the field intensity at a point on axis of an electric dipole is 8 KV/m, what will be the field intensity at a point at the same distance on the normal bisector of dipole?

Ans: 4 KV/m anticipated to dipole moment vector

4. A charge experience force F parallel to x-asis when it is on normal bisector of an electric dipole along x-asis. What force will the same charge experience if dipole is rotated by 90° about an axis perpendicular to plane containing dipole axis and position vector?

Ans: **2** F parallel to y-axis.

5. An α particle is moved through a distance of 0.2Å on the normal.

bisector of an electric dipole of moment 2 debye. What is the work done by agent?

Ans: Zero. [because potential at all points on normal bisector is zero and hence p.d. is zero]

6. At what point the intensity is normal to dipole axis?

Ans: $\sqrt{2} \cong 55° \left[\tan(90° - \theta = \frac{1}{2}\tan\theta\right]$

7. If can electric dipole is subjected to a uniform electric field, what is the effect on the dipole?

Ans: The dipole experiences a torque (a system of two equal parallel and opposite forces) which produces rotational motion unless dipole becomes parallel to field intensity.

8. What is the electric potential at a point 10 cm away from the mind-point of an electric dipole of moment 500 cgs unit making an angle of 60°?

Ans: 2.5 statvolt.

$$V = \frac{\text{Pcos}}{r^2} = \frac{500 \times \cos 60°}{10^2}\ \text{statvolt} = \frac{500 \text{ x } 0.5}{100}\ \text{stalvolt}$$

V = 2.5 statvolt.

9. What is the electric field intensity at a point 20 cm away from an electric dipole of moment 1000 cgs units on its axis?

Ans: 0.25 statvolt/cm parallel to dipole moment vector

$$E = \frac{P}{r^3}\ \sqrt{3\cos^2\theta + 1} = \frac{1000}{20^3}\sqrt{3\cos^2 0° + 1}\ \text{stalvolt/cm}$$

$$E = \frac{1}{8}\ \sqrt{3+1}\ \frac{\text{statvolt}}{\text{cm}} = 0.25\,\frac{\text{statvolt}}{\text{cm}}$$

10. An electric dipole of moment 6 debye is held normal to an uniform electric field of intensity 1000 V/cm. What is the torque on dipole?

Ans: 2×10^{-24} N × m [$\tau = PE \sin\theta$]

11. An electric dipole of moment 12 debye is held anti=-parallel to an uniform electric field of intensity 100 V/cm. What is its potential energy?

Ans: 8×10^{-25} joule [W = PE(cos θ)]

12. An electric dipole is along a uniform electric field. If it is deflected by 60°, work done by agent is 2×10^{-19} J. What will be the work done by agent if it deflected 30° further?

Ans: 2×10^{-19} J

$$PE(\cos 0° - \cos 60°) = W = 2 \times 10^{-19}\ J$$

$$PE[\cos 60° - \cos(60°+30°)] = ?$$

13. An electric dipole held normal to a uniform electric field is released. What will be its kinetic energy (E_k) and potential energy (E_p) when it passes the line of E-field during its oscillation?

Ans: $E_k = PE$ & $E_p = 0$

14. In which position of electric dipole in E-field its potential energy is maximum?

Ans: 180° ($\vec{P} \| - \vec{E}$)

15. If the potential at a point (r, θ) due to an electric dipole is 100V, what will be the potential at ($2r$, θ)?

Ans: 25 volt.

16. If field intensity at a point (r, θ) due to an electric dipole is 400 Vm^{-1}, what will be the field intensity at the point ($2r$, θ)

Ans: 50 Vm^{-1}

Chapter 19
ELECTRO STATIC POTENTIAL AND CAPACITANCE

• **Electric potential (V)**

1) Electric potential at a point in a field is the amount of work done in bringing unit +ve charge from infinity to the point
2) It is equal to the Electric potential energy of unit +ve charge a that point
3) It is a scalar, SI unit is volt
4) Potential at a distance 'd' due to a point charge q in air or vacuum is

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{d}$$

5) Work done is moving a charge q through a potential difference V.

W = q V Joule

1 ev = 1.6×10^{-19} joule

• In the case of a hollow charged sphere

1)Intensity at any point inside the sphere is zero

2)Intensity at any point on the surface is same and it is maximum $W = \frac{1}{4\pi\varepsilon_0}\frac{q}{d^2}$

1) Outside the sphere , $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{d^2}$, d = distance from the centre
2) It behaves as if the whole charge is at its centre

• In the case of a hollow charged sphere

1) The potential at any point inside the sphere is same as that at any point on its surface

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

2) Outside the sphere, the potential varies inversely as the distance of the point from the centre $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{d}$

• **Null points or Neutral points**:

1) At the null point or neutral point the resultant and electric intensity is zero

2) The distance x of the null point from Q_1 is given by $\frac{Q_1}{x^2} = \frac{Q_2}{(d-x)^2}$

• **Zero potential point**:

1) Two unlike Q_1 and $-Q_2$ are separated by a distance d. The net potential is zero at two points on the line joining them, one in between them and the other outside them

$\frac{Q_1}{x} = \frac{Q_2}{(d-x)}$, $\frac{Q_1}{y} = \frac{Q_2}{(d+y)}$ (Here Q_2 is the numerical value of the charge)

• **Electrical Potential Energy**:

1) The electric potential energy of a system of charges is equal to the work done in bringing the charges from infinity to form the system

2) If two charges q_1 and q_2 are separated by a distance d, the P.E of the system is

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{d}$$

3) If three charges q_1, q_2 and q_3 are situated at the vertices of a triangle (as shown in the figure), the PE of the system is

$$U = U_{12}+U_{23}+U_{31} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{d_1}+\frac{q_2q_3}{d_2}+\frac{q_3q_1}{d_3}\right]$$

• **Electric capacity**:

1) It is the ratio of the charge (Q) on a conductor to its potential (V) $C = \frac{Q}{V}$

2) SI Unit farad (F)

3) It depends upon the size and shape of the conductor but is independent of charge and potential

4) Capacity of a spherical conductor

$C = 4\pi\varepsilon_0 R$ (R = Radius)

5) Energy of a charged conductor

$$E = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}$$

• When 'n' identical charged small drops are combined to form a Big drop

S. No	Quantity	For each charged small drop	For the big drop
1	Radius	r	$R = n^{1/3}$ r
2	Charge	q	Q = n x q
3	Capacity	E	$C^1 = n^{1/3}$ x C
4	Potential	V	$V^1 = n^{2/3}$ x V
5	Energy	W	$W^1 = n^{5/3}$ x W
6	Surface Density of charge	σ	$\sigma = n/^{13}\sigma$

• **Capacity of a spherical condenser**:

1) $C = 4\pi\varepsilon_0 \frac{R_1R_2}{R_1 - R_2}$, Inner sphere is charged and outer sphere is earthed

2) $C = 4\pi\varepsilon_0 \frac{R_1^2}{R_1 - R_2}$, Inner sphere is earthed and outer sphere is charged

• Parallel plate condenser

1) Capacity of a parallel plate condenser without medium between the plates $C_0 = \frac{\varepsilon_0 A}{d}$

A = Area of each plate

2) With a medium of dielectric constant K completely filling the space between the plates

$C = K \frac{\varepsilon_0 A}{d}$

3) $K = \frac{C}{C_0} = \frac{\text{Capaacity of the condenser with dielectric medium}}{\text{Capacity of the same condenser with air}}$

4) When a dielectric slab of thickness is introduced between the plates

$$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{k}} = \frac{\varepsilon_0 A}{d - t(1 - \frac{1}{k})}$$

In this case the distance of separation decreases by $t(1 - \frac{1}{k})$ and hence the capacity increases

To remove the capacity to original value the distance of separation is to be increased by $t(1 - \frac{1}{k})$

- If a metal slab of thickness t is introduced between the plates

$C = \frac{\varepsilon_0 A}{d - t}$ because for metals K is infinity

- Electric field between the plates is uniform Electric intensity $E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0} = \frac{Q}{Cd}$

Here σ is the surface charge density on the plates $\frac{Q}{A}$

- Potential difference between the plates $V = E.d = \frac{Q}{\varepsilon_0 A}.d$
- Force on each plate

$$F = \frac{1}{2} EQ = \frac{1}{2}\frac{Q^2}{Cd} = \frac{1}{2}\frac{CV^2}{d} = \frac{1}{2}\frac{Q^2}{\varepsilon_0 A} = \frac{1}{2}\varepsilon_0 A E^2$$

- Energy stored per unit volume of the medium = $\frac{1}{2}\varepsilon_0 E^2$
- When condensers are connected in series

1) All plates have the same charge in magnitude

2) Potential differences between the plates are different $V_1:V_2:V_3 = \frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3}$

3) Equivalent capacity of a combination, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

4) Energies of the condensers $E_1:E_2:E_3 = \frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3}$

- When condensers are connected in parallel

1) P.E across each condenser is same
2) Charge of each condenser is different $Q_1:Q_2:Q_3 = C_1:C_2:C_3$
3) Equivalent capacity of the combination $C = C_1+C_2+C_3$
4) Energies of the condensers $E_1:E_2:E_3 = C_1:C_2:C_3$

- When the space between the plane of a parallel plate condenser is completely filled with two slabs of dielectric constants K_1 and K_2 and each slab having area $\frac{A}{2}$ and thickness equal to distance of separation d
- When the space between the plates of a parallel plate condenser is completely filled with two slabs of dielectric constants K_1 and K_2 and each slab having area A and thickness equal to $\frac{d}{2}$ as shown in the figure 1) Capacity of the upper half = $C_1 = 2K_1 = \frac{\varepsilon_0 A}{d}$

2) Capacity of the lower half = $C_2 = 2K_2 = \frac{\varepsilon_0 A}{d}$

3) C_1 and C_2 may be supposed to be connected in series

4) Effective capacity $C = \frac{C_1 C_2}{C_1 + C_2} = \frac{\varepsilon_0 A}{d}\left(\frac{2K_1K_2}{K_1+K_2}\right) = C_0 . \left(\frac{2K_1K_2}{K_1+K_2}\right)$

Here C_0 is the capacity of the condenser with air medium

- Effect of introducing a dielectric slab between the two plates of a parallel plate charged capacitor
- When two conductors or condensers of capacities C_1 and C_2 charged to potentials V_1 and V_2 are connected parallel,

1) Charge flows from condenser of high potential to low potential till common potential is reached

2) Common potential $V = \frac{Q_1 + Q_2}{C_1 + C_2} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

3) Loss of energy= $\frac{1}{2} C_1V_1^2 + \frac{1}{2} C_2V_2^2 - \frac{1}{2}(C_1+C_2)V^2 = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1 - V_2)^2$

- When two condensers of capacities C_1 and C_2 charged to potentials V_1 and V_2 are connected antiparallel as shown in the figure.

1) Common potential $V = \dfrac{Q_1 - Q_2}{C_1 + C_2} = \dfrac{C_1V_1 - C_2V_2}{C_1 + C_2}$

2) Loss of energy $= \dfrac{1}{2} C_1V_1^2 + \dfrac{1}{2} C_2V_2^2 - \dfrac{1}{2}(C_1+C_2)V^2 = \dfrac{1}{2}\dfrac{C_1C_2}{C_1 + C_2}(V_1+V_2)$

f) Electrostatic potential:

$V = -\dfrac{\lambda}{2\pi\varepsilon_0} \log_e r + k$

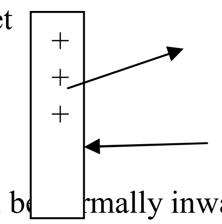
Here k is a constant integration.

11. Electric intensity and potential due to an infinite plane sheet of charge (non-conducting):

a) If the sheet is positively charged then direction of E will be normally outwards and the value of E will be same at all point near the sheet

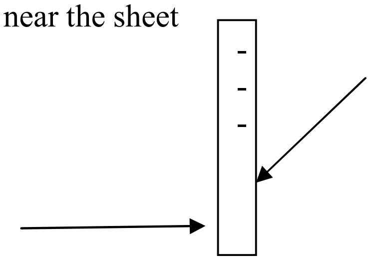
$E = \dfrac{\sigma n}{2\varepsilon_0}$

P



b) If the sheet is positively charged then direction of E will be normally inwards and the value of E will be same at all point near the sheet

$E = \dfrac{\sigma n}{2\varepsilon_0}$



P E E

c) The electric intensity due to an infinite plane sheet of charge:

$\mathbf{E = \dfrac{\sigma}{2\varepsilon_0}}$

ds_3 Y

ds_2 A

E

O X

ds_4

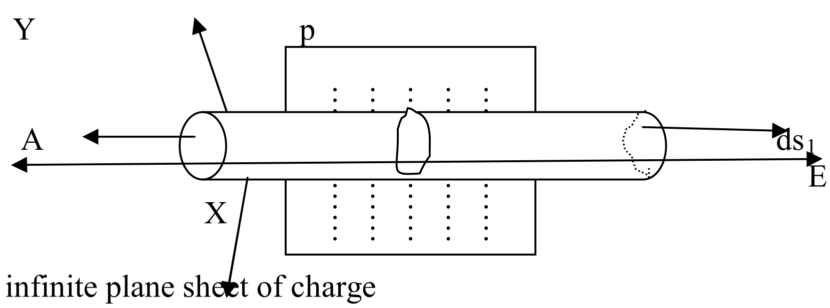


fig (i) an infinite plane sheet of charge

d) Intensity due electric field due to two parallel sheets of charge

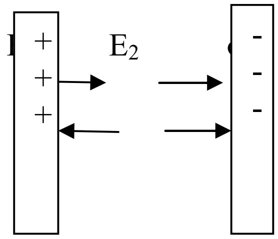
i) If the point lies between two oppositely charged sheets, then

$$E = \frac{\sigma}{\varepsilon_0} n$$

σ

P

d



ii) The value of E does depend upon the positive of p. hence E is uniform at all points between the sheets and where as E is negligible near the edges of the sheets.

iii) If the points of observation lies outside the sheets, then E=0.

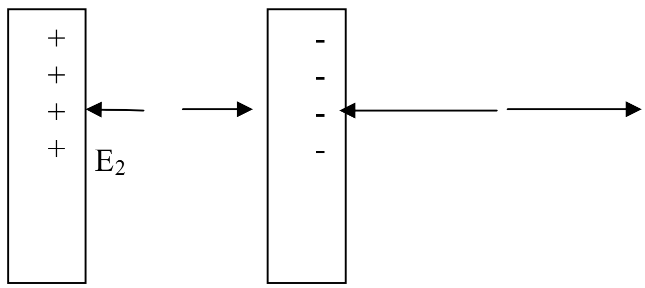
iv) The potential difference between sheets

$$V = \frac{\sigma d}{\varepsilon_0}$$

σ
E_1
D

P

σ

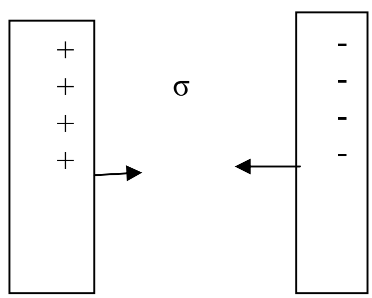


v) If the point between the similarly charged sheets then the intensity of electric field is

E=0.

σ

p



$E_1 = E_2$

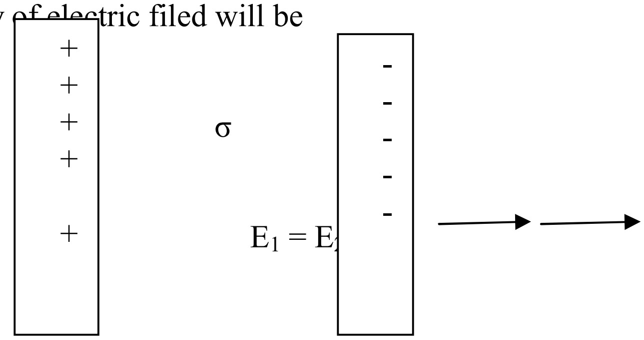
vi) If the point lies on one side of the similarly charged sheets then the intensity of electric filed will be

$E = \frac{\sigma}{\varepsilon_0}$

σ

P

E_1



vii) Electrostatic potential:

$V = -\frac{\sigma}{2\varepsilon_0} \log_e r + k$

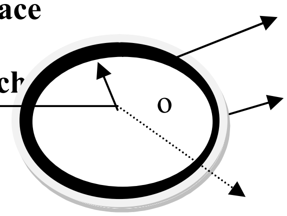
Here k is a constant integration.

12. Electric intensity and potential due to charged spherical shell:

Gaussian surface

Total surface ch

E ds



r

fig (ii) charged spherical shell

let us consider a uniformly charged thin spherical of radius R and total charge q. as it is thin spherical shell, it will have surface charge density ,

$\sigma = \frac{q}{4\pi R^2}$

From spherical symmetry it can be said that the electric field at any point, either outside the shell or within the shell, will depend only on the radial distance 'r' from the center of the shell to the point concerned. The direction of E will be along the radius (outwards for positively charged spherical shell and inwards for negatively charged shell).

i) Electric intensity and potential at a point outside the shell :

$\mathbf{E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}}$

For points outside a uniformly charged spherical shell, the shell behaves as if the entire charge on it were concentrated at the centre of the shell.

For points outside the conducting spherical shell(r>R)

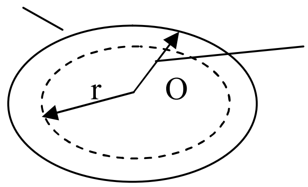
$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$

ii) Electric intensity and potential at a point in the shell:

$E = 0$

P

R



Inside charged spherical shell

There is no charge inside the spherical shell, hence the charge q inside the Gaussian surface is zero and consequently,

i.e., $E = 0$ inside the charged shell

Electric potential inside the shell is given by $V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{R}$.

iii) Electric intensity and potential at a point on the shell :

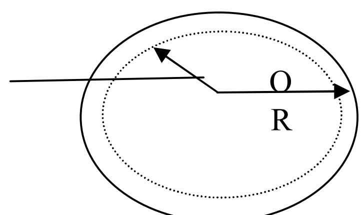
$$\mathbf{E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{R^2}}$$

The direction of E will be again radial- outward normal to the surface.

On the surface of the sphere,

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \left(\frac{q}{R}\right)$$

r



A point on the shell

Van de Graff Generator: It is a machine that produces high voltages of the order of million volts, to accelerate electrons and ions.

Potential Difference between the sphere and the shell is

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{r} + \frac{Q}{R}\right) - \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

Potential difference between the sphere and the shell is independent of the change on the shell

Electric Potential:

1) A charge of 4 coulombs moves through a potential difference of 2.5v. The work done
   1) 10J 2) 5J 3) 20J 4) 2.5J
2) An electric cell does 5 joules of work in carrying 10 coulombs of charge around a closed circuit. The emf of the cell is
   1) 2V 2) $\frac{1}{2}$V 3) 4V 4) 1V
3) Two positive charges Q and Q are placed at the diagonally opposite corners of a square and two negative charges –Q and –Q are placed at the other two corners of the square. Then at the centre of the square the resultant electric intensity E and the net electric potential V are
   1) $E\neq 0, V=0$ 2) $E=0, V\neq 0$ 3) $E=0, V=0$ 4) $E=0, V\neq 0$
4) A is a spherical conductor of radius R_1 placed concentrically inside a hollow spherical conductor B of radius R_2. The charge of A is Q_1 and that of B is Q_2. The electric potential at a distance d such that $R_1<d<R_2$ is
   1) $\frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{R_1}+\frac{Q_2}{R_2}\right]$ 2) $\frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{d}+\frac{Q_2}{R_2}\right]$ 3) $\frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{d}\right)$ 4) $\frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{R}\right)$
5) Electric potential on the surface of a hollow conducting sphere is V. The electric potential is $\frac{V}{2}$ at a distance
   1) $\frac{R}{2}$ inside the sphere 2) $\frac{R}{2}$ from the surface of the sphere and outside it
   3) 2R from the centre of the sphere 4) 2R from the surface of the sphere and outside it
6) Two charges 20μC and -60μC are separated by a distance of 16cm. The net electric potential is zero on the line joining them
   1) at a distance of 4cm from 20μc in between the charges
   2) at a distance of 8cm from 20μc outside the charges
   3) both of the above 4) none of the above
7) Two charges +Q and –Q are separated by a distance in air. A unit charge is moved through a distance d on the perpendicular bisector of the line joining the charges. Work done is

1) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d}$ 2) $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{d}$ 3) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d^2}$ 4) None

8) Charges 5μC, -2μC and -9μC are placed at the corners A, B, C and D of a square ABCD of side 1m. The net electric potential at the centre of the square is

1) $27\sqrt{2}$ KV 2) -$27\sqrt{2}$ KV 3) $\frac{27}{\sqrt{2}}$ KV 4) zero

9) Eight liquid drops are charged to the same potential 2volt. If all the drops combine to form a single large drop, its potential will be

1) 4V 2) 64V 3) 16V 4) 8V

10) Three charges each 20μC are placed at the corners of an equilateral triangle of side 0.4m. The potential energy of the system is

1) $18x10^{-6}$J 2) 9J 3) $9x10^{-6}$J 4) 27J

11) A and B are two points at distances 2m and 3m from a charge $12x10^{-9}$C. Work done in moving a charge of 4μC from B to A is

1) 36μJ 2) 72μJ 3) 54μJ 4) 18μJ

12) An infinite number of charges each equal to Q are placed along the X-axis at X =1, X =2, X= 4, X =8 and so on. The potential at the point X =0 due to this set of charges

1) $\frac{2Q}{4\pi\varepsilon_0}$ 2) $\frac{Q}{3\pi\varepsilon_0}$ 3) $\frac{1}{4\pi\varepsilon_0} = \frac{2Q}{3}$ 4) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{3}$

13) A charge -2μC at a origin, 1μC at +7cm and 1μC at –7cm are placed on X-axis. The mutual potential energy of the system is

1) –0.51J 2) –0.45J 3) 0.45J 4) zero

14) It requires 4 Joules of work to move a charge of 20C from point A to point B separated by a distance of 0.2m. The potential difference between the points A and B is

1) 80V 2) 16V 3) 5V 4) 0.2V

15) An electron starting from rest moves between two points having potential difference of 18kV. Gain in its velocity is

1) $3x10^8ms^{-1}$ 2) $8x10^3ms^{-1}$ 3) $8x10^7ms^{-1}$ 4) $4x10^7ms^{-1}$

16) At the corners of an equilateral triangle of side 25cm charges 1μC, 2μC and 3μC are placed. The electrostatic potential energy of the system is

1) $396x10^{-3}$J 2) $132x10^{-3}$J 3) $396x10^3$J 4) $132x10^3$J

17) Two conducting spheres of radii 8cm and 14cm have surface charge densities in the ratio 1:2. Then their surface potentials are in the ratio of

1) 8:7 2) 1:2 3) 4:7 4) 2:7

Electric Potential:

18) A charged spherical conductor of radius R_1 is connected to another uncharged spherical conductor of radius R_2 by a thin conducting wire. Then, the ratio of surface charge densities of the first conductor to the second conductor is

1) $\frac{R_1}{R_2}$ 2) $\frac{R_2}{R_1}$ 3) $\frac{R_1^2}{R_2^2}$ 4) $\frac{R_2^2}{R_1^2}$

19) Three charges each q are placed at the corners of an equilateral triangle. The fourth charge to be placed at the centre of the triangle so that electrostatic potential energy of the system is zero is

1) $\frac{q}{\sqrt{3}}$ 2) $\frac{-q}{\sqrt{3}}$ 3) q 4) $\frac{-q}{\sqrt{2}}$

20) Three charges Q, +q and +q are placed at the vertices of a right –angled isosceles triangle as shown. The net electrostatic energy of the configuration is zero. If Q is equal to

1) $\frac{-q}{1+\sqrt{2}}$ 2) $\frac{-2q}{1+\sqrt{2}}$ 3) –2q 4) +q

Keys

1)1	2)2	3)3	4)2	5)3	6)1	7)4
8)2	9)4	10)4	11)2	12)1	13)2	14)4
15)3	16)1	17)4	18)1	19)2	20)2	

Capacitance:

1) Three condensers of capacity 4μF, 2μF and 3μF are connected such that 2μF and 3μF are in series and 4μF is parallel to them. The equivalent capacity of the combination is

1) 9μF 2) 2.6μF 3) 5.2μF 4) 10μF

2) Two conducting spheres of radii r_1 and r_2 are at the same potential. Their charges are in the ratio of

1) $\frac{r_2}{r_1}$ 2) $\left(\frac{r_1}{r_2}\right)^2$ 3) $\frac{r_1}{r_2}$ 4) $\left(\frac{r_2}{r_1}\right)^2$

3) Three condensers of capacities 8, 12, 16 μF are connected in series. If the potential on 12μF is 60V, the p.d between the ends of the combination is

1) 390V 2) 195V 3) 210V 4) 220V

4) The capacity of a parallel plate capacitor is 2μF. The distance between the plates is increased 3/2 times and a slab of relative permittivity 6 is placed between them. The new capacity is

1) 12μF 2) 6μF 3) 8μF 4) 2μF

5) A parallel plate capacitor is connected to a battery. The quantities charge, voltage, electric field and energy associated with the capacitor are given by Q_0, V_0, E_0 and U_0 respectively. A dielectric slab is now introduced between the plates with battery still in connection. The corresponding quantities now given by Q, V, E and U are related to previous ones are

1) $V>V_0$ 2) $U>U_0$ 3) $E>E_0$ 4) $Q=Q_0$

6) Two capacitors rated 6μF –110V and 12μF –110V are connected in series to a 220V source
1) Both are likely to be damaged 2) 12μF is likely to be damaged
3) 6μF is likely to be damaged 4) Both are safe

7) 6 capacitors each of capacity 6μF are joined in 2 rows, each of 3 capacitors. The capacity of the combination is
1) 1μF 2) 2μF 3) 3μF 4) 4μF

8) Two spheres of radii 12cm and 16cm have equal charge. The ratio of their energies is
1) 3:4 2) 4:3 3) 2:1 4) 1:2

9) A condenser is charged to an energy of 0.5J. After disconnecting from the battery the space between the two plates of the condenser is filled with a dielectric slab of $\varepsilon_r = 5$. Its new energy is
1) 0.1J 2) 0.5J 3) 2.5J 4) Zero

10) If two condensers of capacities 2μF and 3μF are connected in parallel with a battery, the charge and energy of 2μF condenser are Q and E respectively. Then the charge and energy of 3μF condenser are
1) $\frac{3Q}{2}, \frac{2E}{3}$ 2) $\frac{2Q}{3}, \frac{3E}{2}$ 3) 3Q, 2E 4) $\frac{3Q}{2}, \frac{3E}{2}$

11) Two identical condensers are first connected in series and then in parallel. If the equivalent capacity in parallel grouping is 40μF, equivalent capacity in series grouping is
1) 1μF 2) 5μF 3) 10μF 4) 15μF

12) The work done is increasing the potential of a capacitor from 4V to 6V is W. The further work done is increasing the p.d from 6V to 8V is
1) 7W/5 2) 5/7W 3) W 4) 2W/5

13) A parallel plate capacitor with a dielectric slab (k =3) filling the space between the plates is charged to potential 250V and isolated. The slab is drawn out and another dielectric of equal thickness but k =4 is introduced between the plates. The ratio of the energy stored in the capacitor (second case to first case)
1) 4:3 2) 3:4 3) 9:16 4) 16:9

14) Two identical parallel plate capacitors are joined in series to 100V battery. Now a dielectric with k =4 is introduced between the plates of second capacitor. The potential difference on capacitors are
1) 60V, 40V 2) 70V, 30V 3) 75V, 25V 4) 80V, 20V

15) A parallel plate condenser has initially air medium between the plates. If a slab of dielectric constant 5 having thickness half the distance of separation between the plates is introduced, the percentage increase in its capacity is
1) 33.3% 2) 66.7% 3) 50% 4) 75%

Keys

1)3	2)3	3)2	4)3	5)2	6)3	7)4
8)2	9)1	10)4	11)3	12)1	13)2	14)4
15)2						

PREVIOUS EAMCET QUESTIONS

1) A parallel plate capacitor of capacity C_0 is charged to a potential V_0.
A) The energy stored in the capacitor when the battery is disconnected and the plate separation is doubled is E_1.
B) The energy stored in the capacitor when the battery is kept connected and the separation between the capacitor plates is doubled is E_2. Then $\frac{E_1}{E_2}$ value is [2003E]
1) 4 2) 3/2 3) 2 4) ½

2) An infinite number of electric charges each equal to 5 nano coulombs (magnitude) are placed along X- axis at x = 1cm, x = 2cm, x = 4cm, x = 8cm…….. and so on. In this set up if the consecutive charges have opposite sign, then the electric field in Newton/coulomb at x = 0 is $\left(\frac{1}{4\pi\varepsilon_0} = 9\times10^9\frac{Nm^2}{C^2}\right)$ [2003E]
1) 12×10^4 2) 24×10^4 3) 36×10^4 4) 48×10^4

3) Between the plates of a parallel plate capacitor of capacity C, two parallel plates of the thickness of these plates is equal to $1/5^{th}$ of the distane between the plates of the original capacitor, then the capacity of the new capacitor is [2003M]
1) $\left(\frac{5}{3}\right)C$ 2) $\left(\frac{3}{5}\right)C$ 3) $\left(\frac{3}{10}\right)C$ 4) $\left(\frac{10}{3}\right)C$

4) A charged sphere of diameter 4cm has a charge density of 10^{-4} cou/cm^2. The work done in joules when a charge of 40 nano-coulombs is moved from infinite to a point which is at a distance of 2cm from the surface of the sphere, is [2003M]
1) 14.4π 2) 28.8π 3) 144π 4) 288π

5) The plates of a parallel plate capacitor are charged up to 200 volts. A dielectric slab of thickness 4mm is inserted between its plates. Then to maintain the same potential difference between the plates of the capacitor, the distance between the plates is increased by 3.2mm. The dielectric constant of dielectric slab is [2004E]
1) 1 2) 4 3) 5 4) 6

6) Three point charges 1C, 2C, -2C are placed at the vertices of an equilateral triangle of side one meter. The work done by an external force to increase the separation of the charges to 2 meters in joules is (ε_0 is permittivity of air). [2004E]

1) $\frac{1}{4\pi\varepsilon_0}$ 2) $\frac{1}{8\pi\varepsilon_0}$ 3) $\frac{1}{16\pi\varepsilon_0}$ 4) 0

7) Capacitance of a capacitor becomes 7/6 times its original value if a dielectric slab of thickness, t = (2/3)d is introduced in between the plates. 'd' is the separation between the plates. The dielectric constant of the dielectric slab is [2004M]

1) 14/11 2) 11/14 3) 7/11 4) 11/7

8) A parallel plate capacitor filled with a material of dielectric constant K is charged to a certain voltage. The dielectric material is removed. Then

a) The capacitance decreased by a factor K. [2004M]

b) The electric field reduces by a factor K.

c) The voltage across the capacitor increases by a factor K.

d) The charge stored in the capacitor increased by a factor K.

1) (a) and (b) are true. 2) (a) and (c) are true.

3) (b) and (c) are true. 4) (b) and (d) are true.

9) A 4 μF capacitor is charged by a 200V battery. It is then disconnected from the supply and is connected to another uncharged 2 μF capacitor. During the process, loss of energy (in J) is : [2005E]

1) zero 2) 5.33×10^{-2} 3) 4×10^{-2} 4) 2.67×10^{-2}

10) Two charges 2C and 6C are separated by a finite distance. If a charge of -4C is added to each of them, the initial force of 12×10^3N will change to

1) 4×10^3N repulsion 2) 4×10^2N repulsion [2005E]

3) 6×10^3N attraction 4) 4×10^3N attraction

11) Three identical charges of magnitude 2 μC are placed at the corners of a right angled triangle ABC whose base BC and height BA are respectively 4cm and 3cm. Forces on the charge at the right angled corner B due to the charges at A and C are respectively F_1 and F_2. The angle between their resultant force and F_2 is :[2005M]

1) $\tan^{-1}(9/16)$ 2) $\tan^{-1}(16/9)$ 3) $\sin^{-1}(16/9)$ 4) $\cos^{-1}(16/9)$

12) Energy 'E' is stored in a parallel plate capacitor C_1. An identical uncharged capacitor C_2 is connected to it, kept in contact with it for a while and then disconnected. The energy stored in C_2 is: [2005M]

1) E/2 2) E/3 3) E/4 4) zero

13) The bob of a simple pendulum is hanging vertically down from a fixed identical bob by means of a string of length 'l'. If both bobs are charged with a charge 'q' each, time period of the pendulum is (ignore the radii of the bobs): [2006E]

1) $2\pi\sqrt{\frac{l}{g+\left(\frac{q^2}{l^2 m}\right)}}$ 2) $2\pi\sqrt{\frac{l}{g-\left(\frac{q^2}{l^2 m}\right)}}$ 3) $2\pi\sqrt{\frac{l}{g}}$ 4) $2\pi\sqrt{\frac{l}{g-\left(\frac{q^2}{l}\right)}}$

14) Along the x-axis, three charges $\frac{q}{2}$, -q and $\frac{q}{2}$ are placed at x = 0, x = a and x = 2a respectively. The resultant electric potential at x = a+r (if a<<r) is (ε_0 is permittivity of free space). [2006&2007E]

1) $\frac{qa}{4\pi\varepsilon_0 r^2}$ 2) $\frac{qa^2}{4\pi\varepsilon_0 r^3}$ 3) $\frac{q(a^2/4)}{4\pi\varepsilon_0 r^3}$ 4) $\frac{q}{4\pi\varepsilon_0 r}$

15) The electric potential on the surface of a sphere of radius 'r' due to a charge 3×10^{-6}C is 500V. The intensity of electric field on the surface of the sphere is $\left(\frac{1}{4\pi\varepsilon_0} = 9\times10^9 \frac{Nm^2}{C^2}\right)$(in NC^{-1}) [2006M]

1) <10 2) >20 3) Between 10 and 20 4) <5

16) Two unit negative charges are placed on a straight line. A positive charge 'q' is placed between these unit charges. If the system of three charges is in equilibrium the value of 'q' (in C) is: [2006M&2007E]

1) 1.0 2) 0.75 3) 0.5 4) 0.25

17) The equivalent capacity between the points X and Y in the circuit with C = 1 μF. [2007M]

1) 2 μF 2) 3 μF 3) 1 μF 4) 0.5 μF

18) Three charges 1 μC, 1 μC and 2 μC are kept at the vertices A, B and C of an equilateral triangle ABC of 10cm side, respectively. The resultant force on the charge at C is [2007M]

1) 0.9N 2) 1.8N 3) 2.72N 4) 3.12N

KEYS

1) 1	2) 3	3) 1	4) 1	5) 3	6) 4	7) 1	8) 2	9) 4	10) 4
11) 2	12) 3	13) 3	14) 2	15) 1	16) 4	17) 1	18) 4		

CHAPTER.20

CURRENT ELECTRICITY

- When two bodies at different potentials are connected by a conductor, electric changes flow from one body to the other depending on potential. The flow of electric charges constitutes electric current.
- Direction of current is taken as the direction in which positive charges would move. Conventionally, the direction of current is taken as opposite to the direction of electron flow
- Net change flowing across the cross section of the conductor in one second is called electric current

a) $i = \frac{Q}{t}$ or Q = it b) S.I Unit of current; ampere c) 1 ampere = $\frac{1\,\text{coulomb}}{1\,\text{second}}$

Electric Cell:

- Cell is a source of EMF (Electro Motive Force)
- When connected between the ends of a conductor, it maintains potential difference between the ends of a conductor
- It is a device which converts chemical energy into electrical energy

Internal resistance of a cell:

- It is the resistance offered by the electrolytic of the cell
- It depends on i) $r \propto \frac{1}{a}$, a→area ii) $r \propto d$, d→distance iii) nature of electrolyte

iv) area of cross section of the electrolyte through which the current flows

v) concentration ($r \propto c$) vi) temperature of electrolyte ($r \propto \frac{1}{t}$)

vii) $r = \left(\frac{E-V}{V}\right)$

- Internal resistance of ideal cell is zero

EMF of a cell:

- The work done in carrying a unit positive charge once in the circuit including the cell is defined as the electron motive force. $E = \frac{w}{q}$
- It is equal to the work done in moving unit charge through a circuit
- It is a fixed quantity and it depends only on the nature of electrolyte used in the cells. It depends on 1) nature of electrolyte concentration 2) nature of electrodes
- EMF does not depends on 1) area of electrodes 2) distance between the electrodes

3) quantity of electrolyte 4) size of the cell

Terminal Pd of cell:

- Terminal P.D of cell when cell being discharged is $V = E - ir$

$PD = iR = \frac{ER}{R + r}$

i = circuit current ; r = Internal resistance of cell ; R = External resistance

- Terminal P.D of cell during charging is $V = E + ir$

Cells in series:

- If R<<nr; $i = \frac{E}{r}$, current due to a single cell
- If R>>nr; $i = \frac{nE}{R}$, n times the current due one cell

Cells in Parallel:

$$i = \frac{E}{R + \frac{r}{n}} = \frac{nE}{nR + r}$$

- If nR<<r; $i = \frac{nE}{r}$, n times the current due to single cell. If r<<R; $i = \frac{E}{r}$, current due to single cells. Parallel combination is preferred (when R<<r) to get more current at cell

Mixed grouping:

- N idented cells in series, and m such rows in parallel are connected as shown.

Emf = nE effective internal resistance = $\frac{nr}{m}$

resultant external resistance $R + \frac{nr}{m} = \frac{mR + nr}{m}$

total current $i = \frac{nE}{\left[\frac{mR + nr}{m}\right]} \Rightarrow i = \frac{mnE}{mR + nr}$

- Mixed grouping is preferred when more power is needed

a) Of two cells connected current flows in the direction of higher emf. If $E_1 > E_2$, current flows in anticlock wise direction

b) If two cells are connected in parallel current

$i_1 = \frac{E_1}{r_1}$; $i_2 = \frac{E_2}{r_2}$

$i = i_1 + i_2 = \frac{E_1}{r_1} + \frac{E_2}{r_2} = \frac{E_1 r_2 + E_2 r_1}{r_1 r_2}$; Effective internal resistance = $\frac{r_1 r_2}{r_1 + r_2}$

EMF of equivalent source or effective P.d

Wrongly connected cells in series:

- N cells each of emf 'E' are to be connected in series. If n cells of them are wrongly connected, the resultant emf = (N –2n)E, resultant internal resistance = Nr

Ohm's law:

- At constant temperature, the current 'i' through a conductor is proportional to P.D. 'V' across its ends V = iR (or) $R = \frac{V}{i}$
- Ohms law is obeyed by metals and allowys. They are called ohmic conductors. Graph drawn between i –V for ohmic conductors is straight line

<u>Resistance: R</u>

- It is the property by virtue of which a conductor opposes the flow of charge in it.
- It depends on length, area of cross section, nature of material and temperature
- It does not depend upon current and potential difference
- S.I unit of resistance = ohm; $1 \text{ ohm} = \frac{1\,\text{volt}}{1\,\text{ampere}}$
- Reciprocal of resistance is conductance. $G = \frac{1}{R}$; S.I Unit = siemen (S)

Specific resistance :

- $R \propto \frac{l}{A}$ or $R = \frac{sl}{A}$ or $s = \frac{RA}{l}$
- It is equal to resistance of the conductor of unit length and unit area of cross section
- S.I Unit: ohm – metre
- It depends only on the material of the conductor, and temperature
- It is independent of dimensions of the conductors

Conductivity: (or) specific conductance (σ):

- It is reciprocal of resistivity $\sigma = \frac{1}{s} = \frac{l}{RA}$
- S.I Unit: siemen /m; For Insulators σ = 0; For perfect conductors, σ = Infinity

Variation of resistance with temperature:

- $R_t = R_0(1+\alpha t)$ or $\alpha = \frac{R_t - R_0}{R_0 t} = \frac{R_2 - R_1}{R_1 t_2 - R_2 t_1}$; R_1 = Resistance at t^0C

R_0 = Resistance at 0^0C, α = Temperature coefficient of resistance

- α is positive for metals. Hence resistance of metals increases with increase of temperature
- α is negative for carbon, mica, India rubber, Thermistor, electrolytes, semiconductors and insulators. Their resistance decreases with increase of temperature
- For constantan, manganin α is negligible. Their resistances remains constant with change of temperature

- Manganin wires are used in Resistance boxes, meter bridge, and potentiometer since their α is small
- For fuse wire α should be more

Comparision of resistances:

- If 2 wires are made of different materials

$$\frac{R_1}{R_2} = \left(\frac{s_1}{s_2}\right)\left(\frac{l_1}{l_2}\right)\left(\frac{A_2}{A_1}\right)$$

- If 2 wires are made of same material

$$\frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)\left(\frac{A_2}{A_1}\right)$$

- If 2 wires made of same material have lengths l_1, l_2 and masses m_1, m_2

$$\frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)^2\left(\frac{m_2}{m_1}\right)$$

- If 2 wires made of same material have equal masses (or) when a wire is stretched from length l_1 to l_2

$$\frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)^2 = \left(\frac{A_{21}}{A_1}\right)^2 = \left(\frac{r_2}{r_1}\right)^2$$

Thermistor :

- A Thermistor is a heat sensitive non-ohmic device
- This is made of semi-conductor compounds as oxides of Ni, Fe, Cobalt, Cn etc
- This will have high (+)ve or (-)ve temperature coefficient
- Thermistors with (-)ve temperature coefficient are used as resistance thermometer. Which can measure low temperature in the order of 10K, and small changes in the order of 10^{-3}K

Kirchoff's laws:

- Laws of current (or) junction Theorem (or) Law of conservation of charges: Algebraic sum of currents at any junction in a circuit is zero i.e. $\sum i = 0$
- Laws of voltages (or) Loop Theorem (or) Law of conservation of energies: (1) In any closed circuit, algebraic sum of products of currents and resistances is equal to algebraic sum of emfs While applying second law P.D (iR) is taken +ve, if 'i' is in clockwise direction and EMF 'E' is taken positive, if the source drives the current in clockwise direction

Wheat Stone's Bridge:

- Bridge is balanced when galvanometer current is zero or Galvanometer deflection is zero

- Condition for balance is $\frac{P}{Q} = \frac{R}{S}$ or PS = QR
- Equivalent resistance of the balance bridge across the ends of battery = $\frac{(P+Q)(R+S)}{P+Q+R+S}$

Meter Bridge:

- By any reason, if resistance in the left gap increases or resistance in the right gap decreases, balancing point shifts towards right side by the reason, if resistance in the left gap decreases or resistance in the right gap increases, balancing point shifts towards left
- Used to find resistance of unknown wire, specific resistance of wire and to compare resistance
- In balanced Bridge $\frac{resistance \quad in \quad the \quad left \quad gap}{resistance \quad in \quad the \quad right \quad gap} = \frac{l}{100-l}$
- A high resistance is connected in series to galvanometer to protect it from high currents

Sensitivity :Potentiometer is said to be more sensitive if it measure less potential difference more accurately i.e. lower the potential gradient higher will be the sensitivity and vice versa

- 12 wires each of resistance 'r' are connected in the form of 12 sides of a cube. Effective resistance across

a) Diagonally opposite corners = $\frac{5r}{6}$ b) Face diagonal = $\frac{3r}{4}$

c) 2 adjacent corners = $\frac{7r}{12}$

- Three equal resistance of each 'r' are connected to form a triangle. Equivalent resistance across any two verticles is $\frac{2r}{3}$
- Four equal resistances of each 'r' are connected to form a square. Equivalent resistance between

a) Adjacent corners is $\frac{2r}{3}$ b) Ends of diagonals is r

- A wire of resistance 'r' is bent into a circle. The effective resistance across any two vertices is $\frac{r}{4}$

- A wire of resistance 'r' is bent into a triangle. Equivalent resistance across any two vertices is $\frac{2r}{9}$
- If n wires of equal resistances are given, the number of combinations they can be made to give different resistances is 2n –1
- If n wires of unequal resistances are given, the number of combinations they can be made to give different resistances is 2^n (if n>2)

Question Bank:

Conceptual Questions:

1) For making standard resistance, wire of following material is used
   1) Nichrome 2) Copper 3) Silver 4) Manganin
2) Material used for heating coils is
   1) Nichrome 2) Copper 3) Silver 4) Manganin
3) The resistance of a conductor is
   1) Inversely proportional to the length
   2) Directly proportional to the square of the radius
   3) Inversely proportional to the square of the radius
   4) Directly proportional to the square root of the length
4) A piece of silver and another of silicon are heated from room temperature. The resistance of
   1) each of them increases 2) each of them decreases
   3) silver increases & silicon decreases 4) silver decrease & silicon increase
5) Ohms law is applicable to
   1) Ohmic conductors only 2) Non Ohmic conductors only
   3) Both Ohmic & Non Ohmic conductors 4) Vacuum tubes only
6) With the increase of temperature, the ratio of conductivity to resistivity of a metal conductor
   1) Decreases 2) Remains same 3) Increases 4) Many increase Hence

Cells:

7) Choose the correct statement
   1) The difference of potential between the terminals of a cell in closed circuit is called emf of the cell
   2) Electromotive force and accelerating force have the same dimensions
   3) The internal resistance of an ideal cell is infinity
   4) The difference between the emf of a cell and potential difference across the ends of the cell is called 'lost volts'
8) For a cell, which is discharging, in a circuit (V→(Terminal pd) d & E→ emf)
   1) V = E 2) V < E 3) V > E 4) None
9) For a cell which is charging in a circuit
   1) V = E 2) V <E 3) V > E 4) None

10) If two identical cells of emf E & internal resistance r are connected in paralled, the terminal voltage of battery is

1) E 2) $\frac{E}{2}$ 3) 2E 4) $\frac{E}{r}$

11) Back emf of a cell is due to

1) Electrolytic polarization 2) Pettier effect 3) Magnetic effect of current 4) All

12) The internal resistance of cell depends on

1) Concentration of electrolyte 2) Distance between the electrodes
3) Area of electrode 4) All of the above

13) The direction of current in a cell is

1) (−)ve pole to (+)ve pole during discharging
2) (+)ve pole to (−)ve pole during charging
3) Always (−)ve pole to (+)ve pole 4) Both 1 & 2

14) To reduce the electrolytic polarization, the depolarizer used is

1) Copper sulphate solution 2) Manganese dioxide
3) Dil Sulphuric acid 4) Zinc

15) When an electric cell drives current through load resistance, its Back emf,

1) Supports, the original emf 2) Opposes the original emf
3) Supports if internal resistance is low 4) Opposes if load resistance large

16) When cells are connected in parallel, then

1) Current decreases 2) Current increases
3) Emf increases 4) Emf decreases

17) Choose the correct statement:

A) Series combination of cells is preferred when external resistance is large compared to internal resistance of cells
B) Parallel combination of cells, is preferred when external resistance is small compared to the internal resistance of each cell

1) Both A & B are true 2) Both A& B are false
3) A is true but B is false 4) A is false but B is true

18) Wheat stone bridge is most sensitive when the arms ratio is

1) equal to one 2) less than one 3) more than one 4) zero

Metre Bridge:

19) In meter bridge experiment, the known and unknown resistances in the 2 gaps are interchanged. The error so removed is

1) end correction 2) index error 3) due to temperature effect 4) random error

20) In a meter bridge, metal wire is connected in the left gap, standard resistance is connected in the right gap and balance point is found. If the metal wire in the left gap is heated, the balance point

1) shifts towards left 2) shifts towards right
3) does not shift 4) depends on thickness of metal wire

21) A series high resistance is preferable than shunt resistance in the galvanometer circuit of meter bridge or potentiometer, Because

1) shunt resistances are costly 2) shunt resistance damage the galvanometer
3) series resistance reduces the current through galvanometer in an unbalanced meter bridge 4) high resistances are easily available

22) Metal wire is connected in the left gap, Germanium, connected in the right gap of meter bridge and balancing point is found at 50cm. Metal wire is heated and Germanium is cooled so that variations of resistances in them are equal. Then the balancing point

1) will not shift 2) shifts towards left
3) shifts towards right 4) depends on change of temp

Potentiometer:

23) The value of potential gradient in a potentiometer experiment in balanced state is due to

1) primary and secondary circuits 2) only by primary circuit
3) only by secondary circuit 4) nothing can be said

24) The sensitiveness of potentiometer wire can be increased by

1) decreasing the length of potentiometer wire
2) increasing potential gradient on its wire
3) increasing emf battery in the primary circuit
4) decreasing the potential gradient on its wire

25) Potentiometer is an ideal instrument, because

1) no current is drawn from the source of unknown emf
2) Current is drawn from the source of unknown emf
3) It gives deflection even at null point 4) It has variable potential gradient

26) On increasing the resistance of the primary circuit of potentiometer its potential gradient

1) become more 2) become less 3) no change 4) become infinite

27) In potentiometer experiment, the unknown potential difference is compared with

1) unknown resistance 2) known resistance
3) known standard resistance 4) internal resistance of cell

28) At the moment when the potentiometer is balanced

1) Current flows only in the primary circuit 2) Current flows only in the secondary circuit
3) Current flows both in primary and secondary circuits
4) Current does not flow in any circuit

29) Temperature coefficient of resistance ‘α’ and resistivity ‘r’ of a potentiometer wire must be

1) high & low 2) low & high 3) low & low 4) high & high

30) Choose the correct option from the following statements:

a) Ohm’s law is applicable at constant temperature

b) When temperature is raised, resistance of copper decreases and resistance of germanium decreases

c) Potentiometer is sued to measure emf of a cell

d) Closed mesh law obeys the law of conservation of charge

1) a, b and c 2) a, b and d 3) c and d 4) a and c

31) Choose the correct from the following statements:

a) In potentiometer experiment using balancing length gives the potential difference across the secondary cell

b) The shunt resistance between the terminals of cell in the secondary circuit of potentiometer increases, the balancing length increases

c) In potentiometer experiment the emf of the cell in the secondary circuit may be greater than the emf of cell in the primary circuit

d) Potentiometer is used to measure thermo emf

1) b and c are correct 2) c and d are correct

3) a and d are correct 4) a and b are correct

32) Choose the correct option using the following statements:

a) Coefficient of resistance of carbon is positive

b) At constant temperature, V –i graph of aluminium is a straight line

c) Resistance of mercury at 4.2K temperature is zero

d) With increase in temperature the conductivity of silicon decreases

1) a and b are correct 2) b and c are correct

3) c and d are correct 4) a and d are correct

33) The following table gives the lengths of three copper rods, their diameters. The resistances between the two ends of the rod arranged in ascending order

Rod	Length	Diameter
A	l	d
B	$2l$	$\frac{d}{2}$
C	$\frac{l}{2}$	d
D	l	$\frac{d}{2}$

1) A, B, C, D 2) C, A, B, D 3) C, A, D, B 4) C, B, D, A

Match the following Questions:

34) Match the following Lists:

List –I	List –II
a) Thermister b) Carbon c) Nichrome d) Constantan, manganin	e) High positive ‘α’ f) α almost zero g) either positive is negative ‘α’ h) Negative ‘α’

1) a→g; b→h; c→e; d→f   2) a→h; b→g; c→e; d→f
3) a→e; b→f; c→g; d→h   4) a→e; b→g; c→h; d→f

35) Match the following Lists:

List –I	List –II
a) Charging cell	e) V = 0
b) Discharging cell	f) V = E
c) Cell short circuited	g) V<E
d) Cell is open circuit	h) V>E

1) a→g; b→h; c→e; d→f 2) a→g; b→e; c→h; d→f
3) a→f; b→g; c→h; d→e 4) a→h; b→g; c→e; d→f

In each of the following questions, a statement of Assertion (A) is given followed by a corresponding statement of reason (R) just below it. Of the statement mark the correct answer:
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false   4) A is false but R is true

36) Assertion: Terminal P.D of a cell decreases, if current is drawn from that cell
Reason: During discharging, Terminal P.D , V = E –ir
1) 1   2) 2   3) 3   4) 4

37) Assertion: When cells, each of internal resistance r and arbitrarily connected in series, the told internal resistance of cells may be zero
Reason: A potentiometer draws no current while measuring emf of a cell
1) 1   2) 2   3) 3   4) 4

38) Assertion: A voltmeter is better than a potentiometer for measuring emf of a cell
Reason: A potentiometer draws no current while measuring emf of a cell
1) 1   2) 2   3) 3   4) 4

39) Assertion: In a metrebridge; copper wire is connected in the left gap and silica is connected in the right gap, when the temperature of both wires increases, balancing point shifts to right
Reason: Temperature coefficient of copper is (–) and that of silicon is (+) ve
1) 1   2) 2   3) 3   4) 4

40) Assertion: When current is drawn from a cell, the terminal potential difference is lesser than the emf of the cell
Reason: When current is drawn from a cell, energy is dispated due to the internal resistance of the cell
1) 1   2) 2   3) 3   4) 4

Key

1)4	2)1	3)3	4)3	5)1	6)2	7)4	8)2	9)3
10)1	11)1	12)4	13)1	14)2	15)2	16)2	17)1	18)1
19)1	20)2	21)3	22)1	23)2	24)4	25)1	26)2	27)3
28)1	29)2	30)1	31)3	32)2	33)2	34)1	35)4	36)1
37)4	38)4	39)3	40)1					

Numerical Questions:

1) If the electron in H_2 atom makes 6.25 x10^{15} rev/sec, the current is
   1) A 2) 10^{-1}A 3) 1mA 4) 1μA
2) Resistance of a wire is 2 Ohm. It is drawn in such a way that it experiences a longitudinal strain of 200%. Its new resistance is
   1) 6 ohm 2) 8 ohm 3) 12 ohm 4) 18 ohm
3) 2 wires made of same material have their electrical resistance in the ratio 1:4. If their lengths are in the ratio of 1:2, the ratio of their masses is
   1) 1:1 2) 1:2 3) 1:4 4) 2:1
4) A wire of resistance R is cut into 4 equal parts and they are bundled together side by side to form a thicker wire. The resistance of the bundle is
   1) $\frac{R}{16}$ 2) 0.5R 3) 2R 4) 4R
5) A carbon filament has resistance of 120Ω at 0^0C. What must be the resistance of a copper filament connected in series with carbon so that the combination has same resistance at all temperatures
   1) 120Ω 2) 21Ω 3) 60Ω 4) 210Ω
6) A wire of resistance 12 ohm is bent in the form of a circle. The effective resistance between the ends of any diameter
   1) 3 ohm 2) 6 ohm 3) 4 ohm 4) 24 ohm
7) Four conductors of same resistance connected to form a square. If the resistance between diagonally opposite corners is 8 ohm, the resistance between any two adjacent corners is
   1) 32 ohm 2) 8 ohm 3) $\frac{1}{6}$ ohm 4) 6 ohm
8) A wire of resistance 18 ohm is bent to form equilateral triangle. The resistance across any two vertices of the triangle is
   1) 12 ohm 2) 6 ohm 3) 4 ohm 4) 9 ohm
9) You are given 'mn' wires of equal resistance. If 'm' wires are in series and 'n' such combination are in parallel the resultant resistance is R_1, If 'n' wires are in series and 'm' such combinations are in parallel, the resultant resistance is R_2, R_1/R_2 is
   1) 1:1 2) m:n 3) m^2:n^2 4) n^2:m^2

Cells:

10) A cell of emf E is connected across a resistance R. The P.D between the terminals of the cell is found to be V. The internal resistance of the cell is

1) $\frac{2(E-V)V}{R}$ 2) $\frac{2(E-V)R}{E}$ 3) $\left[\frac{E-V}{V}\right]R$ 4) (E –V) R

11) If the external resistance is equal to the internal resistance of a cell of emf E, the P.D across its terminals is

1) $\frac{E}{2}$ 2) E 3) 2E 4) Zero

12) When two identical cells are connected either in series in parallel across a 4 ohm resistor, they send the same current through it. The internal resistance of the cells is – ohm

1) 1.2 2) 2 3) 4 4) 4.8

13) The p.d cross the terminals of a battery is 50V when 6A of current is drawn and 60V when 1A is drawn. The emf and internal resistance of the battery are

1) 62V, 2 ohm 2) 63V, 1 ohm 3) 61V, 1 ohm 4) 64V, 2 ohm

14) The emf of a Daniel cell is 1.08V. When the terminals are connected to a resistance of 3 ohm, the P.D across the terminals is found to be 0.6V. Then the internal resistance of the cell is – ohm

1) 1.8 2) 2.4 3) 3.24 4) 0.2

15) A cell of emf 2V and internal resistance 0.5Ω is charged with a current 3A. During charging, the terminal P.D of the cell is

1) 3V 2) 0.5V 3) 3.5V 4) Zero

16) 12 Cells of each emf 2V are connected in series. Among them if 3 Cells are connected wrongly. Then effective emf of the combination is

1) 18V 2) 12V 3) 24V 4) 6V

17) 20 Cells each of 6V are connected in series. The emf of the combination is found to be 96V. How many cells are connected wrong?

1) 2 2) 4 3) 6 4) 12

18) Two cells of emf 2V and 6V having internal resistance of 0.25Ω and 1Ω are connected in parallel. Then the terminal Voltage is

1) 2V 2) 6V 3) 3.8V 4) 4V

19) A cell of emf 6V and resistance 1Ω is connected to 9Ω bulb. The percentage of energy released by the cell which is useful is

1) 100% 2) 50% 3) 25% 4) 90%

20) 2 Cells of emf 3V and 5V and internal resistances r_1 and r_2 respective in series with an external resistance R. If the p.d across 1st cell is zero, Then R =

1) $r_1 - r_2$ 2) $\frac{r_1 + r_2}{2}$ 3) $\frac{5r_1 - 3r_2}{3}$ 4) $\frac{3r_1 + 5r_2}{2}$

Metre Bridge:

21) When an unknown resistance and a resistance of 6Ω are connected in the left and right gaps of a meter bridge, the balancing point is obtained at 50cm. If 3Ω resistance is connected in parallel to resistance in right gap, the balance point

1) decreases by 25cm 2) increases by 25 cm
3) decreases by 16.7cm 4) increases by 16.7cm

22) The resistances in the left and right gaps of a balanced meter bridge are R_1 and R_2 and the balance points is 40cm from left. If 10 ohm resistance is connected in series with R_1,then the balance point is 60cm. The values of R_1 and R_2 are

1) 8Ω, 12Ω 2) 12Ω, 16Ω 3) 16Ω, 20Ω 4) 20Ω, 24Ω

23) A resistance of 4 ohm is connected in the left gap and a resistance of 12 ohm is connected in the right gap of meter bridge. The position of balance point is

1) 33.3cm 2) 66.6cm 3) 25cm 4) 20cm

24) 6 ohm is connected in the left gap, 3ohm and 6ohm coils in parallel is connected in right gap. The balancing point is

1) 25cm 2) 50cm 3) 66.6cm 4) 22cm

25) In a meter bridge, the balancing point is obtained at 40cm. If a resistance equal to that in the left gap in shunted across it, the new balancing point is

1) 55cm 2) 50cm 3) 25cm 4) 33.3cm

26) When two resistances P and Q are kept in the left and right gaps of a meter bridge, the null point is obtained at 60cm. If P is shunted by a resistance equal to half of its value, the shift in null point is

1) 10cm to the left 2) 10cm to the right
3) 26.7cm to the left 4) 26.7cm to the right

27) In a meter bridge, the left and right gaps are closed by resistances 2 ohm and 3 ohm respectively. The value of shunt to be connected to 3 ohm resistor to shift the balancing point by 22.5cm is

1) 3 ohm 2) 1 ohm 3) 2 ohm 4) 2.5 ohm

28) In meter bridge when P is kept in left gap, Q is kept in right gap, the balancing length is 40cm. If Q is shunted by 10Ω, the balance point shifts by 10cm. Resistance Q is

1) $\frac{10}{3}\Omega$ 2) 5Ω 3) 10Ω 4) 6Ω

29) A battery of negligible internal resistance is connected with 10m long wire. A standard cell gets balanced on 6m length of this wire. On increasing the length of potentiometer wire by 2m, the null point with the same standard cell in the secondary will be

1) increased by 2m 2) decreased by 2m
3) increased by 1.2m 4) decreased by 1.2m

30) Two equal resistances are an connected in the gaps of meter bridge. If the resistance in the left gap is increased by 10%, the balancing point shift

1) 10% to right 2) 10% to left 3) 9.6 to right 4) 4.8 to right

31) A constant resistance is kept in the left gap of a meter bridge. For two different resistances separately in right gap, the balancing length are 40 & 60cm. If these two are connected in series in right gap, the balancing length is

1) 20cm 2) 30cm 3) 40cm 4) 80cm

32) Two resistances X & Y are in the left and right gaps of a meter bridge. The balancing point is 40cm from left. Two resistances of 10Ω each are connected in series with X & Y separately. The balance point is 40cm. The X & Y are

1) 2 & 8 Ohms 2) 4Ω & 6Ω 3) 8Ω & 12Ω 4) 12Ω & 26Ω

33) In a meter bridge experiment, when the resistance in the gaps are interchanged the balance point is shifted by 10cm. The ratio of the resistance is

1) 15:5 2) 12:8 3) 11:9 4) 10:9

Potentiometer:

34) A 10m long wire of resistance 15ohm is connected in series with a battery of emf 2V (no internal resistance) and a resistance of 5ohm. The potential gradient along the wire is

1) $0.15Vm^{-1}$ 2) $0.45Vm^{-1}$ 3) $1.5Vm^{-1}$ 4) $4.5Vm^{-1}$

35) In a potentiometer experiment, when two cells are joined in series to support each other and then joined to oppose each other balancing points are obtained at 6m and 2m respectively. The ratio of their e.m.f.s is

1) 1:1 2) 2:1 3) 3:1 4) 4:1

36) A cell in the secondary circuit given balancing length for 1.5m length in potentiometer of length 10m. If the length of potentiometer is increased by 1m without changing the cells in primary or secondary, balancing length becomes

1) 1.5m 2) 1.65m 3) 3m 4) 3.5m

37) A standard resistance of 1 ohm and a small resistance 'r' are connected in series. The balancing length on potentiometer wire corresponding to this combination is 630 cm where as the balancing length corresponding to 1 ohm resistance is 600cm. The value of 'r' will be

1) 0.5Ω 2) 1Ω 3) 2Ω 4) 0.05Ω

38) A potentiometer wire of 10m length and 20ohm resistance is connected in series with a resistance of 80 ohm and a battery of emf 2V, negligible internal resistance. Potential gradient on the wire in milivolt/centimetre will be

1) 0.4 2) 0.16 3) 2 4) 4

39) A cell connected in the secondary circuit of potentiometer gives null point at 325cm. When another cell is connected in series with the cell, the null point is obtained at 550cm. Ratio of e.m.f. s of the 2 cells is

1) 13:22 2) 13:9 3) 325:550 4) 65:43

40) The resistance of the potentiometer wire is $0.9\Omega m^{-1}$. The potential gradient is $0.0081LVcm^{-1}$. Then the current in the wire is

1) 1A 2) 0.9A 3) 0.5A 4) 0.1A

41) In a potentiometer experiment, 2 cells of emf's E_1 and E_2 balances for a length of 800cm when they are in series. If the terminals of the cell of E_2 in reversed then the balancing length is 200cm. If $E_1>E_2$, the ratio $E_1:E_2$ is

1) 4:1 2) 2:1 3) 5:3 4) 3:2

42) In a potentiometer experiment, a standard cell of 1.2V emf gets balanced at 260cm length of potentiometer wire. If a current of 0.2A flows through 3 ohm resistance, the balancing length will be

1) 80cm 2) 130cm 3) 520cm 4) 260cm

43) A potentiometer wire of length 10m and resistance 30Ω is connected in series with a battery of emf 2.5V, internal resistance 5Ω and external resistance R. If the fall of potential along the potentiometer wire is 50m V/m, the value of R in ohm is

1) 115 2) 80 3) 50 4) 100

44) A student finds the balancing length as 'I' with a cell of constant emf in the secondary circuit. Another student connects the same cell in the secondary circuit of potentiometer of half the length but with a cell of double of emf in the primary circuit than used in the primary of circuit of first case. Then the balancing length will be

1) $\frac{1}{4}$ 2) $\frac{1}{2}$ 3) 41 4) 1

45) A potentiometer wire of length 10m and resistance 9.8Ω is connected in series with a battery of 3mf 2V and internal resistance 0.2Ω. The balancing length 1st cell of emf north potentiometer is 4m. Where 2V resistance is connected in series with the potentiometer wire, the charge in belonging length is

1) Decreases by 0.8m 2) Increases by 1m

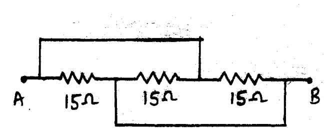
3) Decreases by 1m 4) Increases by 0.8m

Key

1)4	2)4	3)1	4)1	5)2	6)1	7)4	8)3	9)2
10)3	11)1	12)3	13)1	14)2	15)3	16)2	17)2	18)3
19)4	20)3	21)2	22)1	23)3	24)4	25)3	26)3	27)2
28)2	29)3	30)4	31)2	32)3	33)3	34)1	35)2	36)2
37)4	38)1	39)1	40)2	41)3	42)2	43)1	44)1	45)4

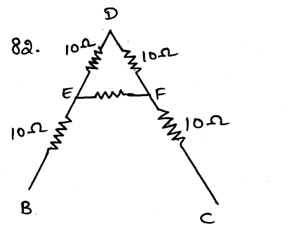
1. The equivalent resistance between A and B is

   1) 5Ω 2) 15 Ω 3) zero 4) 10Ω 81.

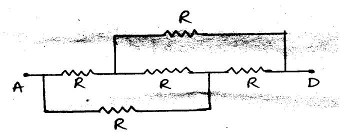


2. Find the effective resistance between B and C of letter A . containing resistance as shown in fig

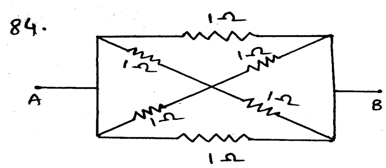
1) 60 Ω 2) 40Ω 3) 80/3 Ω 4) 160/9 Ω



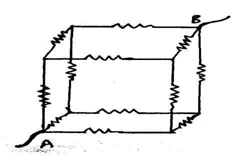
3. Find the equivalent resistance between A and D.
   1) R 2) 2R 3) 3R 4) 4R



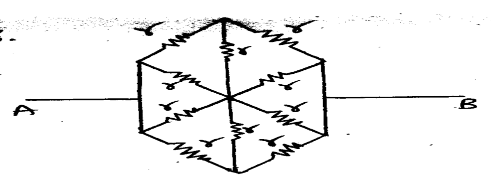
4. What is the total resistance between A and B in the following circuit ?
   1) 3 Ω 2) 3/2 Ω 3) 2/3 Ω 1/3 Ω



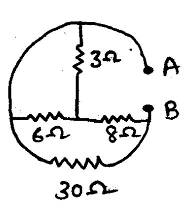
5. Twelve identical wires each of resistance ‘r’ are connected in the form of a cube. What is the effective resistance R between diagonally opposite corners.
   1) r 2) 3r/4 3) 5r/6 4) 7r/3



6. Find the effective resistance between A and B of hexagonal circuit .
   1) r 2)0.5r 3) 2r 4) 0

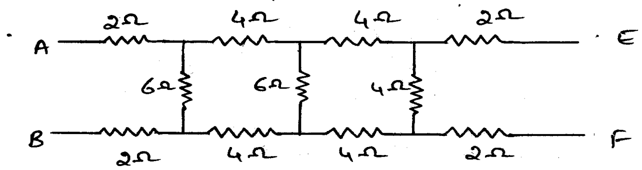


7. Find the eq
   1)6Ω 2)



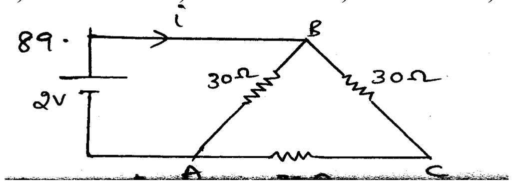
8. Find the equivalent resistance between A and B

1) 4 Ω 2) 8Ω 3) 12Ω 4) 16Ω



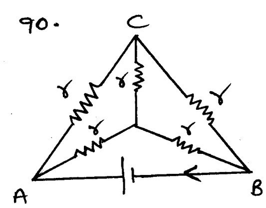
9. Find the current 'i' in the circuit

1) 1/45 A 2) 1/15 A 3) 1/10A 4) 1/5A



10. Find the effective resistance between A and B in the circuit shown

1) r/2 Ω 2) rΩ 3) 2rΩ 4) 3r/2 Ω



11. In the giv) reading is same with both switches S_1 and S_2 are closed or opened. What is the value of resistance R.

1) 100 Ω 2) 200 Ω 3) 400 Ω 4) 600 Ω

12. Two cells are connected across an external resistance as shown. Find the current s i_1 and i_2

1) [-16/13]A, [11/13]A 2) -2A,3A 3) [-13/11]A, 2A 4) [-16/13]A, 3A

13. In the given network equivalent resistance between A and B is

1) 5Ω 2) 10Ω 3) 10/3Ω 4) 20/3Ω

14. The resistance between A and B is

1) 2 Ω 2) 18Ω 3) 6Ω 4) 3.6Ω

15. The current from the battery in the network shown below

1)1A 2) 1.5A 3) 2A 4) 2.5A

Key

1)1	2)3	3)1	4)4	5)3
6)2	7)2	8)2	9)3	10)3
11)4	12)1	13)3	14)4	15)2

CURRENT ELECTRICTY Previous Eamcet questions

1) Two resistances of $400\,\Omega$ and $800\,\Omega$ are connected in series with 6 volt battery of negligible internal resistance. A voltmeter of resistance $10{,}000\,\Omega$ is used to measure the potential difference across $400\,\Omega$. The error in the measurement of potential difference in volts approximately is
1) 0.01 2) 0.02 3) 0.03 4) 0.05 [2003E]
2) Three unequal resistors in parallel are equivalent to a resistance $1\,\Omega$. If two of them are in the ratio 1:2 and if no resistance value is fractional, the largest of the three resistances in ohms is [2003E]
1) 4 2) 6 3) 8 4) 12
3) In a potentiometer experiment, the balancing length with a cell is 560cm. When an external resistance of 10 ohms is connected in parallel to the cell, the balancing length changes by 60cm. The internal resistance of the cell in ohms is [2003M]
1) 3.6 2) 2.4 3) 1.2 4) 0.6
4) Two cells with the same e.m.f 'E' and different internal resistances $r_1$and r_2 are connected in series to an external resistance R. The value of R so that the potential difference across the first cell be zero is [2003M]
1) $\sqrt{r_1 r_2}$ 2) $r_1 + r_2$ 3) $r_1 - r_2$ 4) $\frac{r_1 + r_2}{2}$
5) "n" conducting wires of same dimensions but having resistivities 1, 2, 3, ……..n are connected in series. The equivalent resistivity of the combination is [2004E]
1) $\frac{n(n+1)}{2}$ 2) $\frac{n+1}{2}$ 3) $\frac{n+1}{2n}$ 4) $\frac{2n}{n+1}$
6) Two cells A and B are connected in the secondary circuit of a potentiometer one at a time and the balancing length are respectively 400cm and 440cm. The e.m.f of the cell A is 1.08 volt. The e.m.f of the second cell B in volts is [2004E]
1) 1.08 2) 1.188 3) 11.8 4) 12.8
7) An electrical meter of internal resistance 20Ω gives a full scale deflection when one milliampere current flows through it. The maximum current that can be measured by using three resistors of resistance 12Ω each, in milliamperes is [2004M]
1) 10 2) 8 3) 6 4) 4
8) The temperature coefficient of resistivity of material is 0.0004/K. When the temperature of the material is increased by 50^0C, its resistivity increases by $2x10^{-8}$ohm-meter. The initial resistivity of the material in ohm-meter is [2004M]
1)$50x10^{-8}$ 2) $90x10^{-8}$ 3) $100x10^{-8}$ 4) $200x10^{-8}$
9) A 6V cell with 0.5 Ω internal resistance, a 10V cell with 1 Ω internal resistance and a 12 Ω external resistance are connected in parallel. The current (in amperes) through the 10V cell is [2005E]
1) 0.60 2) 2.27 3) 2.87 4) 5.14

10) In a meter bridge a 30 Ω resistance is connected in the left gap and a pair of resistances P and Q in the right gap. Measured from the left, the balance point is 37.5cm when P and Q are in series and 71.4cm when they are parallel. The values of P &Q are

1) 40Ω ; 10Ω 2) 35Ω ; 15Ω 3) 30Ω ; 20Ω 4) 25Ω; 25Ω [2005E]

11) Two wires A and B, made of same material and having their lengths in the ratio 6:1 are connected in series. The potential differences across the wires are 3V and 2V respectively. If r_A and r_B are the radii of A and B respectively, then $\frac{r_B}{r_A}$ is: [2005M]

1) 1/4 2) 1/2 3) 1 4) 2

12) For a chosen non-zero value of voltage, there can be more than one value of current in:

1) copper wire 2) Thermistor 3) Zener diode 4) Manganin wire. [2005M]

13) One end each of a resistance 'r' capacitance 'C' and resistance '2r' are connected together. The other ends are respectively connected to the positive terminals of the batteries P, Q, R having respectively emf's E, E and 2E. The negative terminals of the batteries are then connected together. In this circuit, with steady current the potential drop across the capacitance is [2006E]

1) E/3 2) E/2 3) 2E/3 4) E

14) Twelve cells, each having emf 'E' Volts are connected in series and are kept in a closed box. Some of these cells are wrongly connected with positive and negative terminals reversed. This 12 cell battery is connected in series with an ammeter, an external resistance 'R' ohms and a two-cell battery (two cells of same type used earlier, connected perfectly in series). The current in the circuit when the 12-cell battery and 2-cell battery aid each other is 3A and is 2A when they oppose each other. Then the number of cells in 12-cell battery that are connected wrongly is: [2006E]

1) 4 2) 3 3) 2 4) 1

15) Consider the following statements A and B and identify the correct answer:

A: Thermistors can have only negative temperature coefficients of resistances.

B: Thermistors with negative temperature coefficients of resistance are used as resistance thermometers, to measure low temperatures of the order of 10K.[2006M]

1) Both A and B are true. 2) Both A and B are false.

3) A is true, but B is false. 4) A is false, but B is true.

16) A teacher asked a student to connect 'N' cells each of emf 'e' in series to get a total emf of 'Ne'. While connecting the student, by mistake, reversed the polarity of 'n' cells. The total emf of the resulting series combination is [2006M]

1) $e\left[N-\frac{n}{2}\right]$ 2) e(N-n) 3) e(N-2n) 4) eN

17) In a meter bridge experiment, the ratio of the left gap resistance to right gap resistance is 2:3, the balance point from left is [2007E]
1) 60cm 2) 50cm 3) 40cm 4) 20cm

18) An aluminium (resistivity $\rho = 2.2 \times 10^{-8}\,\Omega\,m$) wire of a diameter 1.4mm is used to make a $4\,\Omega$ resistor. The length of the wire is [2007E]
1) 220m 2) 1000m 3) 280m 4) 1m

19) Two unknown resistances X and Y are connected to left and right gaps of a meter bridge and the balancing point is obtained at 80cm from left. When a $10\,\Omega$ resistance is connected in parallel to X, the balancing point is 50cm from left. The values of X and Y respectively are
1) $40\,\Omega, 9\,\Omega$ 2) $30\,\Omega, 7.5\,\Omega$ 3) $20\,\Omega, 6\,\Omega$ 4) $10\,\Omega, 3\,\Omega$
[2007M]

20) The current in a circuit containing a battery connected to $2\,\Omega$ resistance is 0.9A. When a resistance of $7\,\Omega$ is connected to the same battery, the current observed in the circuit is 0.3A. Then the internal resistance of the battery is [2007M]
1) $0.1\,\Omega$ 2) $0.5\,\Omega$ 3) $1\,\Omega$ 4) zero.

KEYS

1) 4	2) 2	3) 3	4) 3	5) 2	6) 2	7) 3	8) 3	9) 3	10) 3
11) 2	12) 2	13) 1	14) 4	15) 4	16) 3	17) 3	18) 3	19) 2	20) 2

Chapter 21

MOVING CHARGES AND MAGNETISM

Magnetic Effects of Electric Current:

- A current carrying conductor produces a magnetic field in the surroundings space. This was first discovered by oested
- The direction of magnetic field depends on the direction of current and magnitude of magnetic field depends on the magnitude of current
- Moving electric charge produce both electric and magnetic field

Biot Savart Law:

- The magnitude induction produced at a point due to a small element of current carrying conductor (dB) is

$$dB \propto \frac{idl\sin\theta}{r^2} \Rightarrow dB = \frac{\mu_0}{4\pi}\frac{idl\sin\theta}{r^2}$$

Ampere's Swimming Rule:

- If a man is imagined to swim along the wire in the direction of current with his face towards a magnetic needle placed below the conductor, the north pole of the needle is deflected towards his left side

If the man swims along a direction opposite to the direction of current, south pole of the needle deflects towards his left hand

Magnetic field due to a Straight conductor carrying current:

- If a conductor of finite length carries current, magnetic field at any point near it is given by

$$B = \frac{\mu_0}{4\pi}\frac{i}{r}(\sin\alpha + \sin\beta) \quad = \frac{\mu_0}{4\pi}\frac{i}{r}(\cos\alpha + \cos\beta)$$

If the conductor is infinite long, $\alpha = \beta = 90^0$

$$\Rightarrow B = \frac{\mu_0}{4\pi}\frac{i}{r}(2) = P \quad = \frac{\mu_0}{2\pi}\frac{i}{r}$$

Direction of magnetic field is given by right hand thumb rule

- If the point is near one end of an infinitely long wire at a perpendicular distance 'r' from it, at that point, $B = \frac{\mu_0}{4\pi}\frac{i}{r}$
- If the wire is of finite length and the point is at a perpendicular distance 'r' form it at the point, $B = \frac{\mu_0}{4\pi}\frac{i}{r}\sin\alpha$;Where $\sin\alpha = \frac{1}{\sqrt{l^2 + 4r^2}}$

In this case if the point is at a distance 'r' from one end, at that point

$B = \frac{\mu_0}{4\pi}\frac{i}{r}\sin\alpha$;Where $\sin\alpha = \frac{1}{\sqrt{l^2 + r^2}}$ (l is length of the conductor or wire)

Ampere's Law: **(Circuital law)**

- The line integral of magnetic induction around a closed path in a magnetic field is equal to the μ_0 times total current enclosed by the closed path

$\Rightarrow \oint \vec{B} \cdot d\vec{l} = \mu_0 \sum i$

Hence $\mu_0 \sum i$ gives the work done to move a unit north pole along that ϕ closed path

Special Cases:

- At the central of current carrying wire bent in the form of equilateral of side a, magnetic induction is $B = 18 \frac{\mu_0}{4\pi} \frac{i}{a}$
- At the centre of current carrying wire bent in the form of square of side 'a' magnetic induction is $B = 8\sqrt{2} \frac{\mu_0}{4\pi} \frac{i}{a}$
- Two straight and infinite long parallel wires separated by a distance 'r' carry currents i_1 and i_2 as shown. At P, resultant induction

is $B = \frac{\mu_0}{4\pi} \left\{ \frac{i_1}{x} - \frac{i_2}{(r-x)} \right\}$, if $\left\{ \frac{i_1}{x} - \frac{i_2}{(r-x)} \right\}$ and B is normally into the page

- At P, resultant magnetic field

$$B = \frac{\mu_0}{4\pi} \left\{ \frac{i_1}{x} + \frac{i_2}{(r-x)} \right\}$$

Magnetic Field due to circular coil carrying current:

- A circular coil of radius 'r' with n turns carries current *i*. At a point on the axis of the loop,

$$B = \frac{\mu_0}{2} \frac{nir^2}{(r^2 + x^2)^{3/2}} = \frac{\mu_0}{2} \frac{nir^2}{d^3}$$

Here direction of $\vec{B}$ is along the axis of the coil. At the centre of the coil, x = 0

$\Rightarrow$ at the centre $B = \frac{\mu_0}{2} \frac{ni}{r}$

- A wire of length *l* is bent in the form of a circular loop with n turns ands carries a current *i* then at its centre $B = \frac{\mu_0 n^2 \pi i}{l}$
- A wire length '*l*' carrying current *i* is first bent in the form of a circular loop with n_1 turns and then with n_2 turns. In these two cases, magnetic inductions at the centre of the loops are B_1 and B_2, then

$$\frac{B_1}{B_2} = \frac{n_1^2}{n_2^2}$$

- If the wire is bent in the form an arc subtending an angle 'θ' at the centre of curvature 'O' the magnetic induction is

$B = \frac{\theta}{2\pi}\frac{\mu_0}{2}\frac{i}{r}$ (Here θ is an radians)

$\rightarrow$
(B is normal to plane of paper downwards. If current is in the anticlock wise direction B is normally outwards)

If $\theta = \pi$, it is semicircle, and $B = \frac{\mu_0}{4}\frac{i}{r}$, If $\theta = \frac{\pi}{2}$ it is quadrant and $B = \frac{\mu_0}{8}\frac{i}{r}$

Special cases:

- At the centre of the loop 'O' for straight wire and loop arrangement

$B = \frac{\mu_0 i}{2r}\left[1 + \frac{1}{\pi}\right]$ (normally outwards)

- At the centre of loop 'O' for straight wire and loop arrangement

$B = \frac{\mu_0 i}{2r}\left[1 - \frac{1}{\pi}\right]$(normally outwards)

- At the centre of the loop 'O' B = 0
- At the common centre of the concentric loops

$B = \frac{\mu_0 i}{2}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$(normally inwards)

- At the centre 'O' of semi circle, $B = \frac{\mu_0}{4}\frac{i}{r}$ (normally inwards)
- At the centre 'O' resultant magnetic field $B = \frac{\mu_0 i}{4}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$ (normally outwards)
- At the centre 'O' resultant magnetic field is

$B = \frac{\mu_0 i}{4}\left[\frac{1}{r_1} + \frac{1}{r_2}\right]$(normally inwards)

- At the centre of curvature 'O' resultant magnetic field is

$B = \theta\frac{\mu_0 i}{2\pi}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$ (normally outwards)

- At 'O' resultant magnetic induction field is $B = \frac{\mu_0 i}{4\pi r}[\pi + 4]$ (normally inwards)

- At 'O' resultant magnetic induction is $B = \frac{\mu_0 i}{4r}\left[1+\frac{1}{\pi}\right]$ (normally inwards)
- If a charged ring of radius *r* rotates with a frequency '*f*' at the centre of the ring

$B = \frac{\mu_0}{2}\frac{qf}{r}$

- If electron is revolving around the nucleus in a circular path of radius 'r' at the centre of that circle or at nucleus,

$B = \frac{\mu_0 e v}{4\pi r^2}$ (v is speed of electron)

- If two loops are inclined at 90^0, at the common centre $B = \sqrt{B_1^2 + B_2^2}$

$B_1 = \frac{\mu_0}{2}\frac{i_1}{r_1}$ and $B_2 = \frac{\mu_0}{2}\frac{i_2}{r_2}$,If $i_1 = i_2$ and $r_1 = r_2$ then $B = \sqrt{2}\,\frac{\mu_0 i}{2r} = \frac{\mu_0 i}{\sqrt{2}\,r}$

Field on the axis of a Solenoid:

- If the point is inside the solenoid of infinite length $B = \mu_0 ni$
- If the solenoid is infinite length and the point is near one end, $B = \frac{\mu_0 ni}{2}$

(here n is number of turns per unit length)

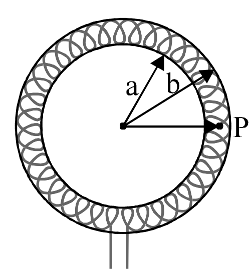
Magnetic Field due to Toroid :

Toroid is a structure formed by joining solenoid end to end.

The magnetic field at a point P at a distance 'r' from the centre is given by

$B = \frac{\mu_0 Ni}{2\pi r}$

$N \rightarrow$ Total number of turns.



Magnetic Moment of a Loop Carrying Current:

- If a loop of Area A with n turns carries current i its magnetic moment is

$\vec{M} = i\, n\, A\, \hat{N}$, Here $\hat{N}$ is unit vector normal to surface area of the coil

Numerically $M = n\, i\, A$

- If the loop is circular, $M = ni\pi r^2$, If the loop is square, $M = nia^2$

• A wire of length l is bent in the form of a circular loop with n turns and carries current i. Then its magnetic moment is $M = \frac{l^2 i}{4\pi n}$

For a given length l of a wire carrying a current i, the number of circular turns which would produce the maximum magnetic moment is 'one' (n = i)

Maximum magnetic moment $M_{max} = \frac{il^2}{4\pi}$

Force on a Moving charge in Magnetic field:

• Force on a moving charge in uniform magnetic field is given by $\vec{F} = q(\vec{v} \times \vec{B})$

Magnitude of force is $F = Bqv\sin\theta$

• When the charged particle moves at right angles to the magnetic field, $\theta = 90^0$ and $F = Bqv$ (maximum)

1) This force acts at right angles to both $\vec{B}$ and $\vec{v}$. The path of the particle will be circular
2) The momentum of the particle will remain constant in magnitude but its direction will constantly be changing
3) Kinetic energy of the particle remains constant. $K.E = \frac{q^2B^2r^2}{2m}$
4) The magnetic force acting on the particle provides the necessary centripetal force for its circular motion

$$Bqv = \frac{mv^2}{r}$$

• Radius of the circular path $r = \frac{mv}{Bq} = \frac{P}{Bq} \frac{\sqrt{2mK}}{Bq}$

(Here P is momentum and K is Kinetic energy)

• Angular velocity of the charged particle is $\omega = \frac{Bq}{m}$

• Time period of charged particle is $T = \frac{2\pi m}{Bq}$

Lorentz Force:

• When a charge enters into a region where there are both electric and magnetic fields,

$$\vec{F} = \vec{F}_e + \vec{F}_m = q[\vec{E} + (\vec{v} + \vec{B})]$$

Force Between Two Parallel Current Carrying Conductors:

- When the currents in both the wires is in the same direction, then mutual force between the wires is attractive. When the currents in the wires are in opposite directions. The mutual force between the wires is repulsive.
- Mutual force between the wires is $F = \frac{\mu_0}{2\pi}\frac{i_1 i_2}{r} l$

Force per unit length on each wire is $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{i_1 i_2}{r}$

- A straight and very long wire carries current i_1. A rectangular wire loop carrying

  Force on the loop is $F = \frac{\mu_0 i_1 i_2 l}{2\pi}\left\{\frac{1}{a} - \frac{1}{b}\right\}$ (attractive)

Torque on a Current Loop in Uniform Magnetic Field:

- When a coil carrying current is placed in a uniform magnetic field, the net force on it always is zero. Here different parts experience forces in different directions so that the loop may experience a torque or couple
- A rectangular coil of area A having N turns and carrying current *i* is placed in a uniform magnetic field of induction $\vec{B}$

If θ is the angle between the normal to the plane of the coil and the magnetic field, then torque acting on the coil is $\tau = NiAB \sin\theta = MB \sin\theta$

- If α is the angle between the plane of the coil and the magnetic field, then torque acting on the coil is $\tau = NiAB \cos\alpha = MB \cos\alpha$

Moving Coil Galvanometer:

- **Principle**: A rectangular coil carrying current placed in a uniform magnetic field such that plane of the coil is parallel to the field direction experiences maximum torque. This deflecting torque is balanced by restoring couple in the phosphor bronze wire.
- In MCG, current (*i*) passing through the coil is directly proportional to its deflection (θ).

$NiAB = C\theta,\ i = \left(\frac{C}{BAN}\right)\theta \Rightarrow i = K\theta$

K is galvanometer constant (C is restoring couple per unit twist)

- Current sensitivity of MCG is the deflection per unit current

$\Rightarrow \left(\frac{\theta}{i}\right) = \frac{BAN}{C},\ \left(\frac{\theta}{i}\right) \propto N;\ \left(\frac{\theta}{i}\right) \propto B;\ \left(\frac{\theta}{i}\right) \propto A;\ \left(\frac{\theta}{i}\right) \propto \frac{1}{C}$

⇒ For more current sensitivity, B, A, N should be more and C should be small.

- Voltage sensitivity of MCG is the deflection per unit potential difference or voltage

$\frac{\theta}{V} = \frac{\theta}{iG}$ where G is galvanometer coil.

Tangent Galvanometer:

- Working principle of tangent galvanometer is tangent law.
- If $\vec{B}$ is the magnetic induction at the centre of current carrying coil, which is perpendicular to the direction of $\vec{B}_H$. If the needle deflects through an angle θ in equilibrium position, $B = B_H \tan\theta$

Here $B = \frac{\mu_0}{2}\frac{ni}{r} \Rightarrow \frac{\mu_0}{2}\frac{ni}{r} = B_H \tan\theta$

$\Rightarrow i = \left(\frac{2rB_H}{\mu_0 n}\right)\tan\theta \Rightarrow i = K\tan\theta$ Here K is known as reduction factor

Shunt:

- A low resistance connected in parallel to a galvanometer to protect it form large current is known as shunt.

Uses:

- Current through galvanometer $i_g = i\left(\frac{S}{G+S}\right)$
- Current through shunt $i_g = i\left(\frac{G}{G+S}\right)$
- Fractional current passing through the galvanometer $\frac{i_g}{i} = \left(\frac{G}{G+S}\right)$
- Fractional current passing through the shunt $\frac{i_g}{i} = \left(\frac{S}{G+S}\right)$
- Power of the shunt = $\frac{i_g}{i} = i\left(\frac{G+S}{S}\right)$
- If the range of the galvanometer is increased to n times, then $\frac{1}{n}$th of the main current passes through the galvanometer

$\Rightarrow \frac{i_g}{i} = \frac{1}{n}$ or $\frac{S}{G+S} = \frac{1}{n} \Rightarrow S = \frac{G}{n-1}$

Ammeter:

- Ammeter is a device used for measuring currents in electrical circuits
- A galvanometer can be connected into an ammeter by connecting a suitable shunt across it
- The value of shunt resistance to be connected to convert galvanometer into ammeter is

S = $\frac{i_g G}{i - i_g} = \frac{G}{n-1}$ where $\frac{i_g}{i} = \frac{1}{n}$

Here $\frac{i_g}{i}$ is known as sensitivity of ammeter. $\frac{i_g}{i} = \frac{S}{G+S}$

Voltmeter:

- It is a device used for measuring potential difference between any two points in a circuit
- A galvanometer can be connected into a voltmeter by connecting high resistance in series
- The value of series resistance 'R' to be connected to convert galvanometer into a voltmeter is R = $\frac{V}{i_g} - G$
- If voltage range of a galvanometer is increased to n times by connecting a series resistance R, then R = G ($n - 1$)

Theory Questions:

1) Oersted experiment with current carrying conductor established that
   1) the weight of the conductor increases 2) the weight of the conductor decreases
   3) magnetic field is created round the conductor 4) the conductor is heated
2) If a copper wire carries a direct current, the magnetic field associated with the current will be
   1) only inside the rod 2) only outside the rod
   3) both inside and out side the rod 4) neither inside nor outside the rod
3) A certain wire of length *L* carries a current *I*. It is bent to form a circle of one turn. The magnetic field at the center of the loop is *B*. The same wire now is made to form a circular loop of two turns. The magnetic field now at center is
   1) $2B$ 2) $4B$ 3) $\frac{B}{2}$ 4) $\frac{B}{4}$
4) A current I flows along the length of an infinitely long, straight thin-walled pipe. Then
   1) the magnetic field at all points inside the pipe is same but not zero
   2) the magnetic field at any point inside the pipe is zero
   3) the magnetic field is zero only on the axis of the pipe
   4) the magnetic field is different at different points inside the pipe
5) A long solenoid has n turns per meter and current IA is flowing through it. The magnetic field at the ends of the solenoid is
   1) $\frac{\mu_0 nI}{2}$ 2) $\mu_0 nI$ 3) Zero 4) $2\mu_0 NI$
6) If current is passed in a spring with a weight hung on it, then the spring
   1) will be compressed 2) will expand

3) compression and expansion both will occur
4) there will be no change in state of compression

7) Two beams of electrons traveling in the same direction
1) attract each other 2) repel each other
3) spin in same direction 4) either 1 or 3

8) A soft iron cylinder is used in a moving coil galvanometer because without it in galvanometer
1) magnetic field will not be radial and strong
2) magnetic field will be radial but weak
3) magnetic field will be radial and strong
4) magnetic field will not be radial and weak

9) The restoring couple in the moving coil galvanometer is because of
1) magnetic field 2) material of the coil
3) twist produced in the suspension 4) current in the coil

Galvanometer, ammeter, voltmeter and tangent galvanometer:

10) When a current is passed in moving coil galvanometer, the coil gets deflected because
1) current in the coil produces an electric field 2) a couple acts on coil
3)the current deflects any thing 4) current in the oil produces magnetic field

11) The current that must flow through a galvanometer to have a deflection of 1 division on its scale is called
1) meter sensitivity 2) micro sensitivity
3) figure of merit 4) voltage sensitivity

12) To convert a moving coil galvanometer into an ammeter, one has to connect
1) a small resistance in series 2) a small resistance is parallel
3) a high resistance in series 4) a high resistance in parallel

13) Which of the following is likely to have the largest resistance?
1) moving coil galvanometer 2) ammeter of range 1 A
3) voltmeter of range 10 V 4) a copper wire of length 1ma and diameter 3mm

Match the following Questions:

14) Match the following lists:

List –I	List –II
a) right hand thumb rule	e) magnitude of magnetic field
b) Biot-Savart law	f) direction of induced current
c) Fleming's left hand rule	g) direction of magnetic field
d) Fleming's right hand rule	h) direction of force due to magnetic fields

The correct match is
1) a→g; b→e; c→h; d→f 2) a→f; b→g; c→h; d→e
3) a→g; b→e; c→h; d→f 4) a→e; b→g; c→f; d→h

15) Match the following lists:

List –I	List –II
a) magnetic induction due to straight conductor b) magnetic induction at the center of a circular coil c) magnetic induction on the axis of a circular coil d) magnetic induction at the center due to a circular arc	e) $B = \frac{\mu_0 i\theta}{4\pi r}$ f) $B = \frac{\mu_0 n i r^2}{2(x^2 + r^2)^{\frac{3}{2}}}$ g) zero h) $B = \frac{\mu_0 n i}{2\pi r}$ i) $B = \frac{\mu_0 n i}{2r}$

The correct match is

1) a→i; b→e; c→f; d→g   2) a→g; b→f; c→h; d→i
3) a→h; b→i; c→f; d→e   4) a→h; b→g; c→f; d→e

16) Match the following lists:

List –I	List –II
a) moving coil galvanometer b) ammeter c) voltmeter d) shunt	e) always connected in parallel f) highly sensitive g) always connected in series h) high resistance connected in parallel to MCG i) small resistance connected in parallel to MCG

The correct match is

1) a→e; b→g; c→h; d→f   2) a→g; b→h; c→f; d→i
3) a→h; b→f; c→g; d→e   4) a→f; b→g; c→e; d→i

Assertion & Reason Type Questions:

17) Assertion: Magnetic field interacts with a moving charge and not with a stationary charge
Reason: A moving charge produces a magnetic field
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false   4) A is false but R is true

18) Assertion: When current is represented by a straight line, the magnetic field will be circular
Reason: According to Fleming's left hand rule, direction of force is parallel to the magnetic field
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A

3)A is true but R is false 4) A is false but R is true

19) Assertion: If an electron and proton enter an electric field with equal energy, then path of electron is more curved than that of proton
Reason: Electron has a tendency to form curve
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4)A is false but R is true

20) Assertion: For a given charged particle moving in a given magnetic field, the radius of circular path is directly proportional to the momentum of particle
Reason: The effect of magnetic field on a charge particle, change only its path from linear to circular
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4) A is false but R is true

21) Assertion: Two long parallel conductors carrying currents in the same direction experience a force of attraction
Reason: The magnetic fields produced in the space between the conductors are in the same direction
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4) A is false but R is true

22) Assertion: The energy of charged particle moving in a uniform magnetic field does not change
Reason: Work done by the magnetic field on the charge is zero
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4) A is false but R is true

23) Assertion: Torque on the coil is maximum when coil is suspended in radial magnetic field
Reason: Torque depends upon the magnitude of the applied magnetic field
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4) A is false but R is true

24) Assertion: A soft iron cylinder is arranged in the space of the coil suspended between the pole pieces of the magnet
Reason: Iron, having permeability, decreases the sensitivity of the galvanometer
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4) A is false but R is true

25) Assertion: An ammeter connected in parallel with a given resistance may get damaged

Reason: Resistance of ammeter is low
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4)A is false but R is true

26) Assertion: The resistance of an ideal voltmeter is infinity
Reason: This is because an ideal voltmeter should drawn no current
1)A and R are true and R is the correct explanation of A
2)A and R are true and R is not the correct explanation of A
3)A is true but R is false 4)A is false but R is true

Numerical Problems:

27) The magnetic induction field strength at a distance of 1cm by the side of an infinitely long straight conductor carrying current is $2x10^{-5}$T in magnitude. Find the strength of current through the conductor?
1) 1A 2) 2A 3) 3A 4) 4A

28) A horizontal over head power line carries a current of 50A in west to east direction What is the magnitude of the magnetic field, 1.5m below the line?
1) $5.7x10^{-6}$T 2) $6.7x10^{-6}$T 3) $7.7x10^{-6}$T 4) $8.7x10^{-7}$T

29) A current of 2A is flowing through a conductor of length 22m bent in an arc of radius 5cm. Find the magnetic induction field strength at the center of curvature of the arc
1) $1.76x10^{-3}$T 2) $1.76x10^{-4}$T 3) $1.76x10^{-5}$T 4) $1.76x10^{-6}$T

30) What current should be passed through a flat circular coil of 20cm diameter and having 100 closely wound turns to produce a magnetic induction of $3.142x10^{-4}$T at its center
1) 2A 2) 1.5A 3) 1A 4) 0.5A

31) An infinitely long straight conductor is bent into the shape as shown. It carries a current 'i' ampere and the radius of the circular loop 'r' meter. Then the magnetic induction at the center of the circular part is
1) zero 2) infinite 3) $\frac{\mu_0}{2\pi}\frac{2i}{r}(\pi+1)$ 4) $\frac{\mu_0}{2\pi}\frac{2i}{r}(\pi-1)$

32) A metal wire of length 1m is bent in the form of a circle and a current of 2A is made to pass through it. At the center of the circle the magnetic induction is
1) $8\pi^2$ x 10^{-7}T 2) $2\pi^2$ x 10^{-7}T 3) 4π x 10^{-7}T 4) 8π x 10^{-7}T

33) A conducting wire is bent in the form of a semi circle of radius 10 cm carries a current of 2A. At the center of the semicircle the magnetic induction is
1) 4π x 10^{-6}T 2) 8π x 10^{-7}T 3) 6π x 10^{-6}T 4) 2π x 10^{-6}T

34) Compare the strengths of the fields produced at the centers of two coils carrying the same current if their radii 6 and 9cm and their number of turns 10 and 20 respectively.
1) 3:4 2) 4:3 3) 1:3 4) 3:1

35) An infinite straight conductor carrying current 2*I* is split into a loop of radius r as shown in the figure. The magnetic field at the center of the coil is

1) $\frac{\mu_0}{2\pi}\frac{2(\pi+1)}{r}$ 2) $\frac{\mu_0}{2\pi}\frac{2(\pi-1)}{r}$ 3) $\frac{\mu_0}{4\pi}\frac{(\pi+1)}{r}$ 4) zero

36) A wire loop PQRS formed by joining two semi circular wires of radii R_1 and R_2 carries a current *i* as shown in the figure. The magnetic induction at the center O is

1) $\frac{\mu_0}{4\pi}\pi\frac{i}{R_1}$ 2) $\frac{\mu_0}{4\pi}\pi\frac{i}{R_2}$

3) $\frac{\mu_0}{4\pi}\pi i\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$ 4) $\frac{\mu_0}{4\pi}\pi i\left[\frac{1}{R_1}+\frac{1}{R_2}\right]$

37) In the figure shown there are two semi circles of radii r_1 and r_2 in which a current I is flowing. The magnetic field induction at the center 'O'

1) $\frac{\mu_0 i}{4}(r_1+r_2)$ 2) $\frac{\mu_0 i}{4}(r_1-r_2)$ 3) $\frac{\mu_0 i}{4}\left[\frac{r_1+r_2}{r_1r_2}\right]$ 4) $\frac{\mu_0 i}{4}\left[\frac{r_2-r_1}{r_1r_2}\right]$

38) An equilateral triangle of side length '*l*' is formed a piece of wire of uniform resistance. The current *l* is fed as shown in the figure. The magnitude of the magnetic field at its center *O* is

1) $\frac{\sqrt{3}\mu_0 I}{2\pi l}$ 2) $\frac{3\sqrt{3}\mu_0 I}{2\pi l}$ 3) $\frac{\mu_0 I}{2\pi l}$ 4) zero

39) Calculate the force experienced by a wire of length 10 cm kept at an angle 30^0 to a field of 0.5T and carrying a current of 6 A

1) 0.5N 2) 1N 3) 0.15N 4) 0.2N

40) Two long wires are kept parallel at 0.2 cm apart in a vertical plane. Equal currents flow in both wires in the same direction. The linear density of the lower wire is $0.05kgm^{-1}$. If the lower wire appears wieghtless. Find the current in each wire

1) 50A 2) 70A 3) 90A 4) 110A

41) A proton enters a magnetic field of flux density 1.5T with a velocity of $2x10^7ms^{-1}$ at an angle of 30^0 to the field. Find the force experienced by the proton

1) $2.4x10^{-12}$N 2) $3.4x10^{-12}$N 3) $4.4x10^{-12}$N 4) $5.4x10^{-12}$N

42) An alpha particle with a velocity of $3x10^5\,\vec{i}\,ms^{-1}$ enters a region where the magnetic field has a magnetic induction of $1.2\,\vec{k}$ T. Find the magnitude of force on the α – particle

1) $1.152x10^{-13}\vec{J}$ N 2) $11.52x10^{-13}\vec{J}$N 3) $115.2x10^{-13}\vec{J}$N 4) $1152x10^{-13}\vec{J}$N

43) A conductor 10cm long remains suspended vertically below a long conductor carrying 200A at a distance of 5cm. If the mass per unit length of the conductor is 0.2g/cm, calculate the current in the conductor

1) 145A 2) 245A 3) 345A 4) 445A

44) An electron revolves in a circular orbit in a plane perpendicular to a uniform magnetic field of induction 6x10-15wb/m^2. Then the time period of revolution is
1) 5.96x10^{-5}sec 2) 5.96x10^{-7}sec 3) 5.96x10^{-9}sec 4) 5.96x10^{-11}sec

45) An electron of mass 0.90x10^{-30}kg under the action of a magnetic field moves in a circle of 2.0 cm radius at a speed of 3.0x106 ms^{-1}. If proton of mass 1.8x10^{-27}kg were to move in a circle of the same radius in the same magnetic field, then its speed will be
1) 3.0x$10^6$$ms^{-1}$ 2) 1.5x$10^3$$ms^{-1}$
3) 6.0x$10^3$$ms^{-1}$ 4) cannot be estimated from the given data

46) A charged particle of mass 10^{-3}kg and charge 10^{-5}kg coulomb enters a magnetic field of induction one tesla. If g = 10ms^{-2} for what value of velocity it will pass straight through it without deflection?
1) $10^{-3}$$ms^{-1}$ 2) $10^3$$ms^{-1}$ 3) $10^6$$ms^{-1}$ 4) 1ms^{-1}

Torque on the wire loop:

47) A square coil of side 10cm consists of 20 turns and carries 12A. The coil is suspended vertically and the normal to the plane makes an angle of 30^0 with the direction of uniform magnetic field 0.8T. The torque acting on the coil is
1) 0.69N –m 2) 0.96 N –m 3) 0.096 N –m 4) 0.069 N –m

48) The coil in a moving coil galvanometer has an area of 8cm^2 and 250 turns. The intensity of magnetic induction is 1T. When a current of 2x10^{-4}A is passed through it, the deflection is 10^0. The couple per unit twist is
1) 4x10^{-6}Nm/degree 2) 4x10^{-7}Nm/degree
3) 4x10^{-8}Nm/degree 4) 4x10^{-9}Nm/degree

49) A rectangular coil of arc a 2.5 cm x 1.5 cm has 100 turns, when a current of 2 mA is passed through it, the deflection was 30^0. The couple per unit twist of the suspended wire is 1.44x10^{-4}Nmrad^{-1}. The intensity of magnetic induction is
1) 1.6T 2) 1.06T 3) 1.006T 4) 1.0006T

50) A vertical rectangular coil of sides 0.1m and 5x10^2m has 20 turns and carries a current of 4 amp. Calculate the torque on the coil when it is placed in a uniform horizontal magnetic field of induction 0.1 wb/m^2.
1) 4x10^{-2}N –m 2) 3x10^{-2} N –m 3) 2x10^{-2} N –m 4) 1x10^{-2} N –m

51) A wire of length 'l' is formed into a circular loop of one turn only and is suspended in a magnetic field B. When a current I is passed through the loop, the torque experienced by it is
1) $\frac{1}{4\pi}$ 8I l 2) $\frac{1}{4\pi}$ l^2I B 3) $\frac{1}{4\pi}$ B^2I l 4) $\frac{1}{4\pi}$ BI^2 l

Galvanometer, ammeter and voltmeter:

52) A galvanometer has a resistance of 100Ω. A potential difference of 500mV between its terminals gives full scale deflection. Calculate the shunt required which will enable it to read upto 5A?
1) 0.1Ω 2) 0.01Ω 3) 0.001Ω 4) 1Ω

53) Find the value of shunt to be used to pass $\frac{1}{10}$th of the total current through a galvanometer of resistance 100Ω

1) 41.11Ω 2) 31.11Ω 3) 21.11Ω 4) 11.11Ω

54) A galvanometer has a resistance of 196Ω. If 2% of the main current is to be passed through the meter, what should be the shunt?

1) 1Ω 2) 2Ω 3) 3Ω 4) 4Ω

55) A galvanometer is of resistance 100Ω. It is shunted to reduce the sensitivity of $\frac{1}{99}$. What is the shunt resistance?

1) 1.02Ω 2) 1.04Ω 3) 1.06Ω 4) 1.08Ω

56) A galvanometer has a sensitivity of 10 divisions per milliampere. Its resistance is 50Ω. Calculate from ohm's law the shunt required to change the sensitivity to 2 divisions/milliampere

1) 42.5Ω 2) 32.5Ω 3) 22.5Ω 4) 12.5Ω

57) A galvanometer of resistance 500Ω has a sensitivity of 5×10^{-4}A per division. If the sensitivity is to be increased to 10A/division, then what must be the shunt?

1) 0.025Ω 2) 0.05Ω 3) 0.075Ω 4) 0.01Ω

58) How you would change a galvanometer which has a resistance of 20Ω and gives a deflection of 1 division for 0.001 ampere into an ammeter reading 1 ampere for every 10 divisions

1) $\frac{20}{99}$Ω in series 2) $\frac{20}{99}$Ω in parallel

3) $\frac{99}{20}$Ω in series 4) $\frac{99}{20}$Ω in parallel

59) A galvanometer has a coil of resistance 5Ω and requires 15mA for full scale deflection. How will you convert it into a voltmeter of range 0 –15V?

1) by connecting 995Ω in series 2) by connecting 995Ω in parallel

3) by connecting 599Ω in series 4) by connecting 599 Ω in parallel

Key

1)3	2)2	3)2	4)2	5)1	6)1	7)2	8)1
9)3	10)2	11)3	12)2	13)3	14)1	15)3	16)4
17)1	18)3	19)3	20)2	21)2	22)1	23)2	24)3
25)2	26)1	27)1	28)2	29)1	30)4	31)4	32)1
33)4	34)1	35)4	36)3	37)3	38)4	39)3	40)2
41)1	42)1	43)2	44)2	45)2	46)2	47)2	48)1
49)3	50)1	51)2	52)2	53)4	54)4	55)1	56)4
57)1	58)2	59)1					

Previous Eamcet Questions

1) A wire of length 'l' is bent into a circular coil of one turn of radius R_1. Another wire of the same material and same area of cross section and same length is bent into a circular coil of two turns of radius R_2. When the same current flows through the two coils, the ratio of magnetic induction at the centres of the two coils is [2004E]
1) 1:2 2) 1:1 3) 1:4 4) 3:1
2) A circular coil of radius 2R is carrying current i. The ratio of magnetic fields at the centre of the coil and at a point at a distance 6R from the centre of the coil on the axis of the coil is
1) 10 2) $10\sqrt{10}$ 3) $20\sqrt{5}$ 4) $20\sqrt{10}$ [2004M]
3) An electrical meter of internal resistance $20\,\Omega$ gives a full scale deflection when one milliampere current flows through it. The maximum current, that can be measured by using three resistors of resistance $12\,\Omega$ each, in milliamperes is [2004M]
1) 10 2) 8 3) 6 4) 4
4) Two parallel rails of a railway track insulated from each other and with the ground are connected to a millivoltmeter. The distance between the rails is one meter. A train is traveling with a velocity of 72kmph along the track. The reading of the millivoltmeter (in mv) is: (vertical component of the earth's magnetic induction is 2 x 10^{-5}T). [2005E]
1) 1.44 2) 0.72 3) 0.4 4) 0.2
5) Magnetic field induction at the centre of a circular coil of radius 5cm carrying a current 0.9A is (in S.I units), (ε_0 = absolute permittivity of air in S.I units; velocity of light = 3 x 10^8ms^{-1}). [2005E]
1) $\frac{1}{\varepsilon_0 10^{16}}$ 2) $\frac{10^{16}}{\varepsilon_0}$ 3) $\frac{\varepsilon_0}{10^{16}}$ 4) $10^{16}\varepsilon_0$
6) A current carrying circular coil, suspended freely in a uniform external magnetic field orients to a position of stable equilibrium. In this state
1) The plane of the coil is normal to the external magnetic field.
2) The plane of the coil is parallel to the external magnetic field.
3) Flux through the coil is minimum.
4) Torque on the coil is maximum. [2005M]
7) A proton is projected with a velocity 10^7ms^{-1}, at right angle to a uniform magnetic field of induction 100mT. The time (in seconds) taken by the proton to transverse 90^0 arc is: (mass of proton = 1.65 x 10^{-27}kg and charge of proton = 1.6 x 10^{-19}C). [2005M]
1) 0.81 x 10^{-7} 2) 1.62 x 10^{-7} 3) 2.43 x 10^{-7} 4) 3.24 x 10^{-7}
8) When a positively charged particle enters a uniform magnetic field with uniform velocity, its trajectory can be: [2006E]
a) a straight line b) a circle c) a helix
1) (a) only 2) (a) or (b) 3) (a) or (c) 4) any one of (a),(b) and (c).

9) A rectangular loop of length 'l' and breadth 'b' is placed at a distance of 'x' from an infinitely long wire carrying current 'i' such that the direction of current is parallel to breadth. If the loop moves away from the current wire in a direction perpendicular to it with a velocity 'v' the magnitude of the emf in the loop is: (μ_0 = permeability of free space). [2006E]

1) $\frac{\mu_0 iv}{2\pi x}\left(\frac{l+b}{b}\right)$ 2) $\frac{\mu_0 i^2 v}{4\pi^2 x}\log\left(\frac{b}{l}\right)$ 3) $\frac{\mu_0 i l bv}{2\pi x(l+b)}$ 4) $\frac{\mu_0 i l bv}{2\pi}\log\left(\frac{x+l}{x}\right)$

10) A long horizontal rigidly supported wire carries a current i_a = 96A. Directly above it and parallel to it at a distance, another wire of 0.144N weight per metre carrying a current i_b = 24A, in a direction opposite to that of i_a. If the upper wire is to float in air due to magnetic repulsion, then its distance (in mm) from the lower wire is: [2006M]

1) 9.6 2) 4.8 3) 3.2 4) 1.6

11) Two wires A and B are of lengths 40cm and 30cm. A is bent into a circle of radius r and B into an arc of radius r. A current i_1 is passed through A and i_2 through B. To have same magnetic induction at the centre, the ratio of $i_1 : i_2$ is [2007M]

1) 3 : 4 2) 3 : 5 3) 2 : 3 4) 4 :3

KEY

1) 3 2) 2 3) 3 4) 3 5) 1 6) 1 7) 2 8) 4 9) 3 10) 3 11) 1

Chapter 22

MAGNETISM AND MATTER

synopsis

1.A material which attracts substance like iron, cobalt, nickel, steel.. etc is called a magnet.

2.Magnets are of two types. they are

i) Natural magnets: magnets which are available in nature are called natural magnets . magnetite is a natural magnet. It is the magnetic oxide or iron. Its formula is Fe_3O_4

ii) Artificial magnets : magnets which are made by artificial methods are called artificial magnets.

Ex: Bar magnets, horse shoe magnets, Robinson magnets, etc.

Note: Natural magnets have no regular shape. They have less magnetic power. Artificial magnets have regular shape. Their magnetic power is more.

3.***Properties of magnets*** :

i) Attractive property : Magnets attract material like iron, cobalt, nickel, steel etc (ferromagnetic substances). This is called attractive property.

ii) Directional property : when a magnet is suspended freely it always comes to rest in geographic north and south. This is called directional property.

Because of its directional property magnet is also called as 'load stone'.

i) Inductive property : when a magnetic material is brought near a magnet it induces a magnetism in it. This property is known as inductive property.

4) ***Magnetic poles*** :

1. The magnetism of a magnet is mostly concentrated at two points near the ends of the magnet. These are called magnetic poles.
2. Isolated magnetic poles (single poles) do not exist Magnetic poles always occur in pairs.
3. The two poles of a magnet are of equal strength.
4. Like poles repel each other and unlike poles attract each other.this is called dufey's law
5. Pole strength is a scalar quantity . Units :

i) The S.I. unit of pole strength =amp-metre.

ii) Rationalized MKS. Unit of pole strength is weber.

iii) CGS unit of pole strength is ab.amp-cm. iv) 1 ab.amp-cm =10-1 amp-metre.

5) ***Magnetic axis*** : the line passing through the two poles of a magnet is known as magnetic axis or axial line.

6) ***Magnetic equator***: the line passing through the centre of the magnet and perpendicular to its axis is called magnetic equator or equatorial line.

7) ***Magnetic length*** : the shortest distance between the two poles of a magnet is called magnetic length . Its is denoted by 2L

The relation between geometric length and magnetic length is given by magnetic length = 5/6 x geometric length 2L = 5/6xL (or) Magnetic length is about 84% of its geometric length.

8) Magnetic field : The space around a magnet where-ever the influence of the magnet is felt is called the magnetic field. It is a vector quantity

9) ***Magnetic lines of force*** : A line of force in a magnetic field is the path or the curve along which a free unit north pole travels .

10) ***Characteristics of magnetic lines of force*** :

i) Magnetic liens of force starts from north-pole and ends on the south-pole out-side the magnet.

ii) Inside the magnet magnetic lines of force run from South Pole to North Pole.

iii) They are closed loops.

iv) No two magnetic lines of force intersect each other.

v) They have a tendency to repel each other laterally (they have lateral elongation).

vi) They contract longitudinally.

vii) The tangent drawn to the magnetic line of force at any point gives the direction of magnetic field at that point.

vii) In uniform magnetic field magnetic lines of force will be straight and parallel lines.

viii)The number of lines of force at a region represents the intensity of magnetic field at that region.

ix) For an isolated north –pole the liens of force are radial, pointing away.

x) For an isolated South Pole, the lines of force are radial, pointing in wards.

11) ***Magnetic permeability (μ)*** : the property by virtue of which materials allow magnetic lines of force to pass through them is called magnetic permeability. It is a characteristics property of medium.

12) ***Relative permeability***: the ratio of permeability of a medium to the permeability of a free space is called relative permeability. $\mu = \mu/\mu_0$, Where μ_0 is the absolute permeability of a free space

i) value of $\mu_0 = 4\Pi \times 10^{-7}$ Henry/meter

ii) Units of 'μ_0 = henry/metre (or) weber/amp-m (or) Newton /(ampere)^2

iii) Dimensional formula of $\mu_0 : MLT^{-2} A^{-2}$

iv) For air or vacuum $\mu_r = 1$

v) For diamagnetic substances $\mu_{r<1}$

vi) For paramagnetic substances $\mu_r > 1$

vii) For ferromagnetic substances $\mu_{r>>>1}$

13) ***Coulomb's inverse square law***: the force of attraction between two point magnetic pole is directly propositional to the product of their pole strengths and inversely proportional to the square of the distance between them. $F \alpha m_1 m_2/d^2$

where m1,m2 are pole strengths 'd' is the distance between the magnetic poles

(or) $F = \mu/4\Pi , m_1 m_2 / d^2$ (in S.I. system)

But $\mu = \mu_0 \mu_r$ where $\mu_0 = 4\Pi \times 10^{-7}$ H/m and for air or vaccum $\mu_r = 1$

$F = \mu_0/4\Pi \ m_1 m_2/d^2 = 10^{-7} \times m_1 m_2/d^2$ **(for air)**

14) Unit pole : unit pole is one which when placed at a distance of one meter apart from a similar pole in air or vacuum repels it with a force of 10-7 newton.

15) ***Magnetic moment*** : the product of the length of the magnet and its pole strength is called the moment of a magnet.

If m is the pole strength and 2l is the length of the magnet then, the moment of the magnet is given by , M=mx2l

i) Magnetic moment is a vector quantity, with its direction from south pole to north pole along its axial line.
ii) Units of magnetic moment : SI unit is amp-m^2 (or) Joule/tesla
iii) Dimensional formula : [$M^0L^2T^0A$]

16) When a bar magnet of pole strength 'm' and magnetic moment 'M'is cut in two equal parts along its axial line, then

i) Pole strength of each piece = m/2
ii) Magnetic moment of each piece = M/2

17) When a bar magnet of pole strength 'M' and magnetic moment 'M" is cut into two equal parts along its equatorial line, then i) Pole strength of each piece = m. ii) magnetic moment of each piece = M/2.

18) When a bar magnet of pole strength m and magnetic moment M is cut into n equal parts along its breadth then, I) pole strength of each piece = m ii) magnetic moment of each piece = M/n

19) When a bar magnet of pole strength m and magnetic moment 'm' is cut into n equal parts along its length, then

i) pole strength of each piece = m /n
ii) magnetic moment of each piece = M /n^2

20) If a long thin magnetic needle of moment M is bent at the middle so that the angle at the bent is θ then its new magnetic moment is given by $M^1 = M \sin \theta/2$

21) If a thin magnetic needle of magnetic moment M is bent at the middle so that the two parts are mutually, perpendicular to each other then its new magnetic moment is given by M1= M/√2

22) If a thin magnet of magnetic moment M is bent into the form of an arc of a circle such that it suspends an angle θ at the centre, then its new magnetic moment is given by, M1= 2M sin θ/2 / θ (θ will be in radians)

23) If a long thin magnet of magnetic moment M is bent into a semicircle then new magnetic moment is given by M1= 2M/∏ (or M1= 7M/11)

Resultant magnetic moment of two bar magnets:--

I) If two bar magnets of magnetic moment of M1 and M2(M1>M2) are arranged co-axially such that their unlike poles are in contact with each other, then the resultant magnetic moment of the combination is given by $M_1=M_1+M_2$

ii) In the above case if their like poles are in contact with each other, the resultant magnetic moment of the combination in given by $M_1= M_1-M_2$

iii) If two bar magnets of magnetic moments of M1 and M2 are placed one over the other with like poles are on the same side, then the resultant magnetic moment of the combination is given by $M=M_1+M_2$

iv) In the above case if their unlike poles are on the same side then the resultant magnetic moment is given by $M_1= M_1-M_2$

v) If two bar magnets of magnetic moments of M1 and M2 are arranged so that the angle between their axis is θ, and their like poles touching each other, then the magnetic moment of the system is given by

$M_1 = \sqrt{M_1^2 +M_2^2+2M_1M_2 \cos \theta}$

VI) In the above case if their unlike poles touching each other, then the resultant magnetic moment of the system is

given by $M1= \sqrt{M_1^2 +M_2^2 -2M_1M_2 COS\theta}$

vii) If the two magnets are arranged such that they are right angles to each other (i.e. they form + or T or L) the resultant magnetic moment, the system is given by $M_1= \sqrt{M_1^2+M_2^2}$

i) If there identical magnets are arranged to form a triangle with unlike poles at each corner, the resultant magnetic moment of the system is zero.

ii) If four identical magnets are arranged to form a square with unlike poles at each corner, the resultant magnetic moment of the system is zero.

25) ***Magnetic flux***: I) it is defined as the number of magnetic lines of force passing through a given surface when a surface is perpendicular to the lines of force. It is denoted by ϕ . it is a scalar quantity.

Units : Maxwell (or) gauss – cm2 (C.G.S. system) Weber (S.I. system)

ii) Positive magnetic flux : when the magnetic induction B and the unit normal vector n are in the same direction them ϕ is called the positive magnetic flux. $\phi=BA$

iii) Negative magnetic flux: when the magnetic induction B and unit normal vector are mutually in opposite directions then ϕ is called negative magnetic flux $\phi=-BA$

iv) Flux density (or) Magnetic induction (B): the number of magnetic lines of force passing through unit area normal to the surface is called magnetic flux density.

Magnetic induction (or) flux density B= Magnetic flux /Area → $B= \phi/A$.

B is a vector quantity .

v) Magnetic induction : it is defined as the force experience by a unit north pole placed at a point in a magnetic field . $B= F/m$

Unit of B is Newton/ampere-meter (or) weber/m^2

vi) Magnetic induction due to an isolated pole: the magnetic induction (B) at any point at a distance 'd' from a magnetic pole of strength 'm' is given by . $B = \mu_0/4\Pi \ m/d^2$.

vii) Magnetic induction at the mid point of the line joining the pole of an horse –shoe magnet: if m is the pole strength and 'd' is the distance between the poles of a horse –shoe magnet, the magnetic induction at the mid point of N,S is given by $B= B_1+B_2$

→ $B= \mu_0/4\Pi \, . \, m/(d/2)^2 + \mu_0/4\Pi \ m/(d/2)^2$, $B= 8\mu_0/4\Pi . m/d^2$ along NS

<u>Relation between B and H</u> :

If B is the magnetic induction field and H is the intensity of magnetic field at the sane point then they are related as follows. $B= \mu H$

Where μ = permeability of the medium and is equal to $\mu_0\mu_r$

$B= \mu_0\mu_r H$ (for any other media) & For air or vacuum $\mu_r=1$, $B= \mu_0 H$ (for air or vacuum)

<u>Magnetic intensity (H):</u> it is defined by the relation

$H= B/\mu = B/\mu_0\mu_r$, In air or vacuum, $H= B/\mu_0$

The magnetic intensity (H) at a point which is at a distance d from a magnetic pole of strength 'm' is given by $H =B/\mu_0 =1/4\Pi, m/d^2$

H is a vector quantity. Its CGS unit is oersted. S.I. unit is amp/m

Note that :- 1 amp/m = $4 \Pi \times 10^{-3}$ oersted.

24) *<u>Magnetic induction at a point on the axial line of a bar magnet:--</u>* Let 'p' is a point which is at a distance 'd' from the centre of a bar magnet on its axial line.

i) The magnetic induction field at point 'p' is given by ,

$$B_{axial} = \frac{\mu_0}{4\Pi} \frac{2Md}{(d^2-l^2)^2}$$

ii) For a short bar magnet $l^2 <<< d^2$. hence l^2 can be neglected

$$B_{axial} = \frac{\mu_0}{4\Pi} \frac{2M}{d^3}$$

iii) the direction of B is from south to north along the axial line .

iv) B || M

25) ***<u>Magnetic induction at a point of the equatorial line of a bar magnet</u>*** : Let p is a point on the equatorial line of a bar magnet which is at a distance 'd' form the centre of the bar magnet.

The magnetic induction field at point 'p' is given by

$$B_{eqi} = \frac{\mu_0}{4\Pi} \frac{M}{(d^2+l^2)^{3/2}}$$

i) for a short bar magnet, $B_{eqi} = \frac{\mu_0}{4\Pi} \frac{M}{d^3}$

ii) The direction of B is from north to south parallel toits axis .

iii) B || -M

26)Magnetic meridian : An imaginary vertical plane passing through the north and south poles of a freely suspended magnet at rest is called the magnetic meridian.

27)Geographical meridian : an imaginary vertical plane passing through the north and south poles of the earth at a place is called the geographical meridian.

28)*Horizontal component* (B_H): the component of the total induction of the earth's magnetic field (B) along the horizontal direction is called the horizontal component (B_H).

29) ***Dip or inclination*** (θ): it is the angle between the horizontal component (B_H) and the total magnetic induction (B) of the earth's magnetic field.

30)***Declination*** (ϕ): it is the angle between the magnetic meridian and the geographical meridian at a given place.

S.NO	Dia magnetism	Para magnetism	Ferro magnetism
	Substances are feebly repelled by the magnet.	Substances are feebly attracted by the magnet.	Substances are strongly attracted by the magnet.
2.	Magnetization I is small, negative and varies linearly With the field.	I is small, positive and varies linearly with field.	I is very large, positive and varies non-linearly with field.
3.	Susceptibility χ_m is small, negative and temperature independent.	Susceptibility χ_m small, positive and varies inversely with temperature, i.e., χ_m α (1/T)	Susceptibility χ_m very large, positive and temperature dependent.
4.	Relative permeability μ_r is slightly lesser than unity. i.e., $\mu < \mu_o$.	μ_r slightly greater than unity, i.e., $\mu > \mu_o$.	μ_r is much greater than unity. i.e., $\mu >> \mu_o$.
5.	In it lines of forces are expelled from the substance, i.e., $B < B_o$.	In it lines are 'pulled in' by the substances, i.e., $B > B_o$.	In it lines are pulled in strongly by the substances, i.e., $B >> B_o$.
6.	It is practically independent of temperature.	It is decreases with rise in temperature.	It is decreases with rise in temperature and above curie temperature becomes para magnetic.
7.	Atoms do not have any paramagnet dipole moment.	Atoms have permanent dipole moments Which are randomly oriented.	Atoms have permanent dipole moments Which are organised in domains.
8.	Exhibited by solids, liquids and gases.	Exhibited by solids, liquids and gases.	Exhibited by solids only, that too crystalline.
9.	Bi, Cu, Ag, Hg, Pb, Water Hydrogen, He, Ne etc diamagnetic.	Na, K, Mg, Mn, Al, Cr, Sn and liquid Oxygen are paramagnetic.	Fe, Co, Ni and their alloys are ferromagnetic.

Breif Synopsis and Important Formulae

1. Load stone is a natural magnet. It is ore of Iron magnetite. Load stone means leading stone.
2. The magnetic field lines of a magnet (or a solenoid) from continuous closed loops.
3. Magnetic dipole moment m associated with a current loop is m = NIA where N is the number of turns in the loop, I is the current and A is the are vector.
4. Magnitude of the magnetic moment of the solenoid is m = n (2l) I (πa^2).
5. Axial magnetic field of a bar magnet $B_A = \frac{\mu 0}{4\pi}\frac{2m}{r3}$
6. Torque on the dipole (needle) in a uniform magnetic field is $\tau = m \times B$.
7. Equatorial field of a bar magnet $B_E = \frac{\mu 0}{4\pi}\frac{2m}{r3}$.
8. Gauss's Law in Magnetism: The net magnetic flux through any closed surface is

   zero. $\int_s B1 = 0$
9. Magnetic meridian of a place as the vertical plane which passes through the imaginary line joining the magnetic north and the south poles.
10. The angle between the true geographic north and the north shown by a compass needle is called declination.
11. The angle between the direction of the total earth's magnetic intensity and the horizontal line in the magnetic meridian is known as the angle of dip or the angle of inclination.
12. Magnetic moment per unit volume is called magnetisation. $M = \frac{m_{net}}{V}$. Its unit is Am^{-1} and its dimensions $L^{-1}A$.

13. At 300k, negative dia magnetic substances are Bismuth, Copper, Diamond, Gold, Lead, Mercury, Nitrogen (STP), Silver, Silicon.

14. At 300k, positive paramagnetic substances are Aluminum, Calcium, Chromium, Lithium, Magnesium, Niobium, Oxygen (STP), Platinum, Tungsten. ◇

15. For Diamagnetic substances, $-1 \leq \chi < 0; 0 \leq \boldsymbol{\mu_r} < 1; < \boldsymbol{\mu_0}$.

16. For paramagnetic substances, $0 < \chi < \boldsymbol{\varepsilon}; \mathbf{1} < \boldsymbol{\mu_r} < \mathbf{1} + \boldsymbol{\varepsilon}; \boldsymbol{\mu} > \boldsymbol{\mu_0}$.

17. For Ferromagnetic substances $\chi \gg \mathbf{1}; \boldsymbol{\mu_r} \gg \mathbf{1}; \boldsymbol{\mu} \gg \boldsymbol{\mu_0}$.

18. The magnetization of a paramagnetic material is inversely proportional to the absolute temperature T.

$M = \frac{CB_0}{T}$ or equivalently, $\chi = C\frac{\mu_0}{T}$

19. As the field is increased or the temperature is lowered on the paramagnetic sample, the magnetization increases until it reaches the saturation value M_s, at which point all the dipoles are perfectly aligned with the field.

20. Macroscopic volume of a ferromagnetic material from 10^{-6} cm^3 to 10^{-2} cm^3 is called domain. ◇

21. The domain size is 1mm and the domain contains about 10^{11} atoms.

22. In some ferromagnetic materials the magnetization persists. Such materials are called hard magnetic materials or hard ferromagnetic. For ferromagnetic materials, $\mu r > 1000$.

23. The temperature of transition from ferromagnetic to paramagnetism is called the curie temperature T_C.

24. The lagging of I and G behind H is called, hysteresis.

25. The value of I for which H = 0 is called retentivity.

26. The value of magnetizing force required to reduce I is zero in reverse direction of H is called coercivity.

27. Electromagnets are used in electric bells, loudspeakers and telephone diaphragms.

IMPORTANT FORMULAE

1. Coulombs Law, $F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2} = 10^{-7}\, x\, \frac{m_1 m_2}{r^2}$
2. Magnetic dipole $\vec{M} = m\,(2\vec{l})$
3. Magnetic moment of current loop is $\vec{M} = I\vec{A}$
4. *Magnetic moment due to orbital motion* $\chi\mu_l = n\left(\frac{eh}{4\pi m_e}\right)$
5. *Bohr magneton* $\mu_B = \frac{eh}{4\pi m_e}$
6. $\vec{B}_{axial} = \frac{\mu_0}{4\pi}\frac{\vec{m}r}{(r^2 - l^2)^2}$
7. For a short dipole, $B_{axial} = \frac{\mu_0}{4\pi}\frac{2m}{r^3}$
8. $B_e = \frac{\mu_0}{4\pi}\frac{\vec{m}}{(r^2 + l^2)\,3/2}$ for short magnet $B_e = \frac{\mu_0}{4\pi}\frac{m}{r^3}$
9. Magnetic field at any point due to short magnetic dipole is $B = \frac{\mu_0}{4\pi}\frac{M\sqrt{3\cos^2\theta + 1}}{r^3}$
10. Torque $\vec{\tau} = \vec{m} \times \vec{B}$
11. P.E. of a bar magnet placed in a magnetic field is $U = -mB\cos = -\vec{m} \times \vec{B}$
12. Gauss's law in magnetism $\oint B.\,d\vec{s} = 0$
13. Magnetic intensity $H = \frac{B_0}{\mu_0}$
14. Intensity of magnetization is $I = \frac{M}{V} = \frac{m \times 2l}{A \times 2l} = \frac{m}{A}$
15. Magnetic flux $\phi = \vec{B}\,.\,\triangle\vec{S}$
16. Magnetic susceptibility $x_m = \frac{I}{H}$
17. Magnetic permeability $\mu = \frac{B}{H}$

18. $\mu = \mu_0 (1 + x_m)$

Also $\mu_r = 1 + x_m$

19. Curies law is $x_m \propto \frac{I}{T}$

$x_m T = \text{constant}$

PROBLEM BASED ON MAGNETIC MATERIALS:

1. The magnetic susceptibility of para magnetic materials
   a) Will increase with temperature
   b) Will decrease with temperature
   c) Is independent of temperature
   d) Sometimes increase and Sometimes decrease
2. Which of the following has the highest magnetic susceptibility
   a) Brass b) Steel c) Soft iron d) Zinc
3. Which of the following has highest retentively?
   a) Cobalt b) Nickel c) Steel d) Soft iron
4. The susceptibility of a paramagnetic substance is
   a) Positive b) Negative c) Zero d) None of the these
5. Curie temperature is that temperature at which ferromagnetic material
   a) Has maximum susceptibility
   b) Has zero susceptibility
   c) Loses its ferromagnetism
   d) d) Develops reverse polarity
6. The permeability of a material is 0.9998. it is
   a) Dia magnetic b) Para magnetic c) ferro magnetic d) Non-magnetic
7. Permeability of a diamagnetic materials is
   a) Greater that one b) Less than one c) Equal to one d) May be any of above
8. Which of the following is ferro magnetic?
   a) Aluminum b) Quartz c) Nickel d) Bismuth
9. Which of the following statements is true?
   a) Para magnetic ceases to exit below a certain temperature.
   b) Ferro magnetic requires the presence of magnetic monopoles.
   c) Para magnetic requires the presence of permanent magnetic dipoles.
   d) Ferro magnetic ceases to exit below a certain temperature.
10. Materials getting magnetised by orientation of atomic magnetic moments in external magnetic field are
    a) Ferro magnetic b) Para magnetic c) Dia magnetic d) All of these
11. Which of the following substance is non-magnetic?
    a) Ebonite b) Cobalt c) Nickel d) Iron

12. T he ratio of the intensity of magnetization to the magnetizing field is known as
   a) Permeability b) Magnetic susceptibility
   b) c) magnetic intensity d) magnetic induction

Key

1. d	2. b	3.c	4.a	5.c	6.a
7.b	8.c	9.d	10.b	11.a	12.b

QUESTION BANK

Conceptual Questions:

1) An isolated magnetic pole
   1) Is an imagination 2) Is made of atom 3) Made of an e^- 4) Exists only in space
2) The North pole of the earth's magnet is near
   1) Geographical north 2) Geographical south 3) At the center of the earth
   4) Does not exist
3) The lines of force of a bar magnet are
   1) Parallel and straight 2) Concentric circles 3) Curved lines 4) Curved closed loops
4) Magnetic lines of force
   1) Do not intersect 2) Are closed loops 3) Are imaginary 4) All of these
5) Two bar magnets are placed on a piece of cork which floats on water. The magnets are so placed that their axis are mutually perpendicular. Then the cork
   1) Rotates 2) moves a side 3) oscillates 4) rotates and oscillates
6) A bar magnet of magnetic moment M is placed in a uniform field B. The torque experienced by the magnet is
   1) M.B 2) –M.B 3) MxB 4) BxM
7) The resultant magnetic induction at a point on the perpendicular bisector of the magnet is
   1) Zero 2) Parallel to the axis of the magnet
   3) Perpendicular to the axis of the magnet
   2) Anti parallel to the axis of the magnet
8) The magnetic induction due to an isolated pole at a distance r is proportional to
   1) r^2 2) r^3 3) r^{-2} 4) r^{-3}
9) The magnetic induction due to a short bar magnet at a distance r is proportional to
   1) r^2 2) r^3 3) r^{-2} 4) r^{-3}
10) The direction of magnetic moment is
   1) along $\overrightarrow{SN}$ 2) along $\overrightarrow{NS}$
   3) Perpendicular to $\overrightarrow{SN}$ 4) Cannot be detected
11) The dimentional formula for magnetic moment is
   1) $M^0L^2T^0A^1$ 2) $M^0L^1T^0A^2$ 3) $M^0L^2T^0A^2$ 4) $M^0L^0T^1A^1$

12) When a bar magnet of magnetic moment M is placed in a magnetic field of induction field strength B, each pole experienced a force of F then the distance between the South and North pole of the magnet measured inside it is

1) MBF 2) MB/F 3) F/MB 4) FB/M

13) The time period of a freely suspended magnetic needle does not depend upon

1) Length of the magnet 2) Pole strength

3) Horizontal component of earth's magnetic field 4) Length of the suspension

14) A magnetic needle is kept in a non uniform magnetic field. It experiences

1) A force and a torque 2) A force but not a torque

3) Torque but not a force 4) Neither a torque nor a force

15) A very long magnet is held vertically with its south pole on a table. A single neutral point is located on the table to the

1) East of the magnet 2) North of the magnet

3) West of the magnet 4) South of the magnet

16) In working with the direction magnetometer , the proportional error will be minimum when the deflection is

1) 90^0 2) 60^0 3) 30^0 4) 45^0

17) A magnet is kept fixed with its length parallel to the magnetic meridian. An identical magnet is parallel to this such that its center lies on perpendicular bisector of both. If the second magnet is free to move, it will have,

1) Translatory motion only 2) Rotational motion only

1) Both Translatory and Rotational motion 4) Vibrational motion only

18) The electric and magnetic field differ in that ----

1) Electric lines of force are closed curves while magnetic field lines are not
2) Magnetic field lines are closed while electric lines are not
3) Electric lines of force can give direction of the electric field while magnetic lines can not
4) Magnetic lines can give direction of magnetic field while electric lines can not

19) A magnetic field is produced and directed along y-axis. A magnet is placed along x-axis. The direction of the torque on the magnet is

1) in the x-y plane 2) Along z-axis 3) Along y-axis 4) torque will be zero

20) If a diamagnetic gas is placed between the poles of a magnet. The gas spreads

1) Along the field 2) Perpendicular to the field 3) Below 4) towards the weak regions

21) The best method to demagnetize a magnet is

1) To heat it 2) To drop it from a height

3) To send AC through the coil around it 4) To send DC through the coil around it

22) Robinson's single pole method can be done

1) In TanB position only 2) In TanA position only

3) Both in TanA and TanB 4) in any direction

Key

1)1 2)2 3)4 4)4 5)4 6)3 7)4 8)3 9)4 10)1
11)1 12)2 13)4 14)1 15)2 16)4 17)3 18)2 19)2 20)4
21)3 22)2

Numerical Problems

Magnetic Moment

23) The length of a magnet is 16cm. Its pole strength is 250milli.amp.m.When it is cut into four equal pieces parallel to its axis, the magnetic length, pole strength and moments of each piece are:(respectively)
   1) 4cm; 62.5milli amp.m; 250 milli amp.cm^2
   2) 8cm; 500 milli amp m; 400 milli amp cm^2
   3) 16 cm; 250 milli amp m; 4000 milli amp cm^2
   1) 16cm; 62.5 milli amp m; 0.01 A.m^2
24) The length of a bar magnet is 16cm. Its pole strength is 250 milli amp m. When it is cut into four equal parts parallel to its equitorial line, the magnetic length, pole strength moment of each piece are ---- respectively
   1) 4cm, 62.5 milli amp m; 250 milli amp cm^2
   2) 4cm, 250 milli amp m; 0.01 A.m^2
   3) 4cm, 250 milli amp m; 2000 A.m^2
   4) 8cm, 500 milli amp m; 2000 A m^2
25) The magnetic moment of a bar magnet is 3.6x10^{-3} A.m^2.Its pole strength is 120milli amp. Its magnetic length is ---cm
   1) 3 2) 0.3 3) 33.33 4) 3x10^{-2}
26) A steel wire of length 0.28m is magnetised and is found to have moment of 0.308 A.m^2.If it is bent into a semi circle, its new magnetic moment is --- amp m^2
   1) 0.196 2) 0.308 3) 0.392 4) 0.09
27) The geometric length of a bar magnet of pole strength 80 A.m and magnetic moment 4amp m^2.is 6cms .the distance between the two poles of the magnet is
   1) 6cm 2) 5cm 3) 5/6 cm 4) 6/5 cm
28) The length of a magnet is 25cm.Its magnetic moment is 0.75x10^{-2} Am^2. The pole strength of the magnet is ---- A.m.
   1) 0.15 2) 0.03 3) 0.3 4) 0.3x10^{-2}
29) A thin bar magnet of leng5h 'L' and magnetic moment M is bent at the mid-point so that the two parts are at right angles. The new magnetic length and magnetic moment are respectively.
   1) √2L, √2M 2) L, M 3) √2L, M/√2 4) L , √2M
   √2 √2 √2
30) A magnet of magnetic moment M is the form of a quadrant of a circle. If it is straightened , its new magnetic moment will be

1) $\frac{M\pi}{\sqrt{2}}$ 2) $\frac{M}{\sqrt{2}}$ 3) $\frac{\sqrt{2}M}{\pi}$ 4) $\frac{M\pi}{2\sqrt{2}}$

31) The magnetic moment of a bar magnet of length 20cm is $3.6\times10^{-6}Am^2$. The magnetic length is 90% of its geometric length. The pole strength is
1) 2×10^{-5}Am 2) 1.8×10^{-4}Am 3) 7.2×10^{-8}Am 4) 0.55×10^{-4}Am

32) Three identical bar magnets , each of pole strength 10 A-m and length 10cm are placed in a uniform field of induction $0.05wb/m^2$. If the three magnets are fastened end to end along the same axis with opposite poles touching each other, resulting magnetic moment 1) 3 Am^2 2) 9 Am^2 3) 6 Am^2
4) 8 Am^2

33) A long thin magnet of moment M is bent into a semi circle. The decrease in the Magnetic moment is
1) $2M/\pi$ 2) $\pi M/2$ 3) $M(\pi-2)/\pi$ 4) $M(2-\pi)/2$

34) Two magnets have their pole strengths in the ratio 4:5 and lengths in the ratio 3:4. The ratio of their magnetic moment is ---
1) 7:11 2) 7:9 3) 5:3 4) 3:5

Force & Field

35) The force of repulsion between two similar magnetic poles each of strength 2 amp m at a distance 2 meter from each other in vacuum is ---- N
1) 10^{-5} 2) 10^{-7} 3) 10^{-3} 4) 2×10^{-7}

36) Two magnetic poles of equal pole strengths each of 1.732amp m should be placed at -- cms apart so that the force of attraction between then is 0.5 dynes
1) 6 2) 2.45 3) 24.5 4) $\sqrt{3}$

37) When the magnetic poles placed in air repel each other with a force of 4×10^{-6}N. When the space between them is filled with a medium the repulsive force becomes 2.24×10^{-5}N. The relative permeability of the medium is
1) $\frac{5}{28}$ 2) 5.6 3) 8.96×10^{-11} 4) 56

38) A magnet has a pole strength of 1000 milli amp m . The magnetic field intensity at a distance of 10cm from a North pole is ----(A/m)
1) $\frac{25}{\pi}$ 2) $\frac{\pi}{25}$ 3) $\frac{100}{\pi}$ 4) $\pi/100$

39) The magnetic field intensity due to magnet is $\frac{100}{4\pi}$ A/m. The induction field strength due it is ----- Tesla.
1) 1×10^{-5} 2) $4\pi/10^3$ 3) $\frac{10^3\times100}{4\pi}$ 4) $\frac{10^{-5}}{4\pi}$

40) The magnetic field intensity at a distance of 20cm from a pole strength 40A.m in air is -----A/m; The induction field strength at that point is -----tesla.
1) $\frac{10^3}{4\pi}$; 10^{-4} 2) $\frac{4\pi}{10^3}$; 10^{-4}

3) 10^{-4}; $\frac{10^3}{4\pi}$ 4) 10^4; $\frac{4\pi}{10^3}$

41) The magnetic induction at distance of 0.1m from a strong magnetic pole strength 1200A.m is
1) $12x10^{-3}$T 2) $12x10^{-4}$T 3) $1.2x10^{-3}$T 4) $24x10^{-3}$T

42) P and Q are two unlike magnetic poles. Induction due to 'P' at the location of 'Q' is B, and induction due to 'Q' at the location of P is B/2.The ratio of pole strengths of P & Q is
1) 1:1 2) 1:2 3) 2:1 4) 1:$\sqrt{2}$

43) The dimensions of a bar magnet are 10cmx2cmx1cm . Its pole strength is 200A.m. Its intensity of magnetisation is ----A/m
1) 10^{-4} 2) $2x10^{-4}$ 3) $2x10^{-6}$ 4) 10^6

44) A bar magnet of pole strength 50 A.m is cut into 10 equal parts parallel to its axial line. The intensity of magnetisation of each piece will be----
1) $1/10^{th}$ of initial value 2)10 times initial value 3) Does not change 4) Become half

45) In the above problem 53, the pole strength of each piece will be---
1) $1/10^{th}$ of original pole strength 2) 10 times of original pole strength
3)same as that of original 4) Becomes 1/5

46) The magnetic field intensity due to a bar magnet is 100 Am^{-1}. The magnetic induction field strength due to it is,
1) $4\pi/10^7$ 2) $4\pi/10^5$ 3) $10^3/4\pi$ 4) $10^5/4\pi$

47) The mass of iron rod is 110gm, its magnitude moments is $20Am^{-2}$. The density of iron is $8gm/cm^3$.The intensity of magnetization is
1) $2x10^5Am^{-1}$ 2) $2.26x10^6Am^{-1}$ 3) $1.6x10^6Am^{-1}$ 4) $1.4x10^6Am^{-1}$

48) A magnet has a dimensions of 25cmx10cmx5cm ands pole strength of 200milli amp m. The intensity of magnetisation due to it is ----A/m
1) 6.25 2) 62.5 3) 160 4) 4

49) The magnetic induction field strength due to a short bar magnet at a distance 0.20 m on the equtorial line is $20x10^{-6}$tesla. The magnetic moment of the bar magnet is --- Am^2
1) 3.2 2) 6.4 3) 1.6 4) 16

50) A short bar magnet produces a field of induction $160x10^{-6}$T at a certain point on the axial line. The induction field strength on the same line at a point twice the distance of the first is
1) $20x10^{-5}$ T 2) $2x10^{-5}$T 3) $20x10^{-4}$T 4) $2x10^{-7}$T

51) The pole strength of a horse magnet is 90Am and distance between the poles is 6cm. The magnetic induction at mid point of the line joining the poles is,
1) 10^{-2}***T*** 2) Zero 3) $2x10^{-2}$***T*** 4) 10^{-4}***T***

52) The ratio of magnetic fields on the axial line of a long magnet at distances of 10cm and 20cm is 12.5:1. The length of the magnet is
1) 5cm 2) 10cm 3) 10m 4) 15m

53) The magnetic induction field strength due to a short bar magnet of moment 3.6A.m^2.at a distance of 0.2m on the equatorial line is ----T.
1) $4.5x10^{-4}$ 2) $9x10^{-4}$ 3) $9x10^{-5}$ 4) $4.5x10^{-5}$

54) In problem 62, the induction field strength at a distance 0.2m on the equatorial line is -- T
1) $4.5x10^{-4}$ 2) $9x10^{-4}$ 3) $9x10^{-5}$ 4) $4.5x10^{-5}$

55) If area vector A=3i+2j+5k m^2 flux density vector B =5i+10j+6k(web/m^2). The magnetic flux linked with the coil is -----weber.
1) 31 2) 9000 3) 65 4) 100

56) A magnetic pole of pole strength 9.2Am. is placed in a field of induction $50x10^{-6}$tesla. The force experienced by the pole is N
1) 46 2) $46x10^{-4}$ 3) $4.6x10^{-4}$ 4) 460

57) If each pole of bar magnet of magnetic moment 7.8Am2 experiences a force of $15.6x10^{-5}$N. When placed in a magnetic field of induction $0.4x10^{-5}$ tesla. Then the length of the magnet is 1) 20m 2) 2m 3) 0.2m 4) 0.10m

58) Two magnetic poles of pole strengths 324 milli amp m and 400 milli amp m are kept at a distance of 10cm in air. The null point will be at a distance of ----cm on the line joining the two poles, from the weak pole if they are like poles.
1) 4.73 2) 5 3) 6.2 4) 5.27

59) The force acting on a pole of strength of 20Am is $8x10^{-4}$N. When placed in a magnetic field. The magnetic induction field strength is
1) $4x10^{-5}$tesla 2) $0.4x10^{-4}$T 3) 0.4 gauss 4) All

60) The force acting on each pole of a magnet when placed in a uniform magnetic field of 7A/m is $4.2x10^{-4}$N. If the distance between the poles is 10cm . the moment of the magnet is ----.
1) $15/\pi$ amp m^2 2) $\pi/15$ amp m^2 3) $7.5x10^{-12}$ amp m^2 4) $6x10^{-6}$ amp m^2

61) The moment of a bar magnet is 400CGS units. It is placed in a uniform magnetic field of 0.32oerdynes. The force acting on each pole is 5.12dynes. The distance between the poles of the magnet is ----cms
1) 25 2) 2.5 3) 10 4) 0.25

62) The absolute permeability of a medium is $8.792x120^{-6}$henry/m. Its relative permeability is ---
1) 0.7 2) 7 3) 70 4) $6x10^{-8}$

63) The susceptibility of a magnetic material is 49. Its relative permeability is---
1) 50 2)48 3) 49 4) 1/49

64) The relative permeability of a substance is 101. Its susceptibility is---
1) 101 2) 102 3) 100 4) 1/100

65) The permeability of the material of the rod is $6.25x10^4$web/ampm. The susceptibility of its material is
1) 496.3 2) 498.3 3) $5x10^{-3}$ 4) $3x10^{-3}$

Moment Of Couple & Potential Energy

66) A bar magnet of length 16cm has a pole strength of 500 milli amp m. The angle at which it should be placed to the direction of external magnetic field of induction 2.5 gauss so that it may experienced a torque of $\sqrt{3}x10^{-5}$ N.m

1) π 2) $\pi/2$ 3) $\pi/3$ 4) $\pi/6$

67) A magnet of length 10 cm and pole strength 4x10-4A.m is placed in a magnetic field of induction $2x10^{-5}$weber m^{-2}. Such that the axis of the magnet makes an angle 30^0 with the lines of induction . The moment of the couple acting on the magnet is ---N m

1) $4x10^{-10}$ 2) $8x10^{-10}$ 3) $4x10^{-6}$ 4) $\sqrt{3}x10^{-11}$

68) A bar magnet of moment 0.2 A m^2 is placed in a uniform magnetic field of induction $25x10^{-5}$ S.I units at an angle 90^0 to the direction of the field. The couple acting on the magnet is

1) 0 2) Maximum of $5x10^{-5}$T 3) $2.5x10^{-5}$T 4) Minimum of $5x10^{-5}$T

69) In the Problem 77 , if the magnet is placed at an angle 30^0 to the direction of the field. The couple acting on the bar magnet is ----N m.

1) $2.5x10^{-5}$ 2) $5x10^{-5}$ 3) $\frac{\sqrt{3}}{2}x10^{-5}$ 4) $\sqrt{3}x10^{-5}$

70) The force between two poles, when separated by a distance 0.04m in vacuum is $1.6x10^{-4}$N. If the distance between them is reduced by half, then the force between them is ---- N

1) $1.6x10^{-4}$ 2) $3.2x10^{-4}$ 3) $0.4x10^{-4}$ 4) $6.4x10^{-4}$

71) A short bar magnet placed in a uniform magnetic field experiences a maximum couple of $4x10^{-5}$N-m. The magnet is turned through 45^0. The couple acting in the new position is --1) $2x10^{-5}$ N-m 2) $2.828x10^{-5}$ N-m 3) $1.414x10^{-5}$ N-m 4) None

72) A magnet of magnetic moment 0.6A-m^2 placed at an angle of 30^0 with a uniform magnetic field experiences a moment of couple of $6x10^{-5}$N-m. The magnetic induction field strength is

1) 10^{-4}T 2) $2x10^{-4}$T 3) $4x10^{-4}$T 4) $0.2x10^{-4}$T

73) The maximum moment of couple on the bar magnet placed in a uniform magnetic field of induction $80x10^{-6}$ tesla is $6x10^{-5}$ N-m. If the distance between the poles of the magnet is 0.05 m. Then the pole strength of the magnet in A-m is

1) 20 2) 40 3) 50 4) 37.5

74) A bar magnet of length 0.4m and pole strength 5 A.m is kept in a uniform magnetic field of induction 8 web m^{-2}, making an angle 45^0 with the field. The couple acting as it is --- N-m

1) 1.131 2) 113.1 3) 11.31 4) 22.62

75) A bar magnet of length 10cm and pole strength 2A.m is making an angle 60^0 with a uniform field of strength 50A/m the couple acting on it is ----N-m

1) $20x\sqrt{3}x10^{-7}$ 2) $20\sqrt{3}x\pi x10^{-7}$ 3) $10\sqrt{3}x\pi x10^{-7}$ 4) $2\sqrt{3}x\pi x10^{-7}$

76) A dipole of magnetic moment $2A\text{-}m^2$ is deflected through 30^0 from magnetic meridian. If earth's horizontal component of magnetic field H = 30A/m. The deflecting couple is

1) $3.8x10^{-5}$N-m 2) $38x10^{-5}$N-m 3) $1.9x10^{-5}$ 4) $38x10^{-7}$N-m

77) A bar magnet of 5cm long having a pole strength of 20A.m is deflected through 30^0 from magnetic meridian If H=$\frac{320}{4\pi}$ A/m, the deflecting couple is --- N-m

1) $1.6x10^{-4}$ 2) $3.2x10^{-5}$ 3) $1.6x10^{-5}$ 4) $1.6x10^{-2}$

78) A bar magnet has pole strength of 48A.m. The poles are 25 cm apart in the magnet. The couple required to hold the magnet at an angle 30^0 with an uniform field of the density 0.15T(tesla) is ----N-m.

1) 90 2) 9 3) 0.15 4) 0.90

79) A bar magnet is at right angles to a uniform magnetic field. The couple acting on the magnet is to be one fourth by rotating it from the position. The angle of rotation is

1) $\sin^{-1}(0.25)$ 2) $90^0-\sin^{-1}(0.25)$
3) $\cos^{-1}(0.25)$ 4) $90^0-\cos^{-1}(0.25)$

80) The magnetic moment of a bar magnet is $0.4x10^{-3}$ amp-m^2.It is kept at right angles to the direction of external magnetic field of induction B so as to be free to rotate and the torque experienced by it is 0.2 dyne cm. Then the value of B is ----tesla

1) $0.5x10^{-4}$ 2) $0.5x10^{4}$ 3) $1.25x10^{-4}$ 4) 0.8

81) A short bar magnet placed with its axis at 30^0 with a uniform external magnetic field of 0.16T experience a torque of magnitude 0.032Nm. If the bar magnet is free to rotate its potential energies when it is in stable and unstable equilibrium are respectively.

1) –0.128J, +0.064J 2) –0.032J, + 0.032J 3) +0.064J, -0.128J 4) 0.032J, -0.032J

Key

26) 4	27) 2	28) 1	29) 1	30) 2	31) 2	32) 2	33) 4	34) 1	35) 1
36) 3	37) 4	38) 2	39) 3	40) 2	41) 1	42) 1	43) 1	44) 1	45) 3
46) 4	47) 3	48) 1	49) 2	50) 4	51) 3	52) 3	53) 2	54) 3	55) 1
56) 4	57) 3	58) 3	59) 3	60) 3	61) 1	62) 4	63) 1	64) 1	65) 2
66) 1	67) 3	68) 1	69) 3	70) 1	71) 2	72) 1	73) 1	74) 4	75) 2
76) 2	77) 2	78) 3	79) 2	80) 1	81) 3	82) 4			

Previous Eamcet Questions:

1) The magnetic susceptibility of a material of a rod is 499. Permeability of vacuum is $4\pi x10^{-7}Hm^{-1}$. Absolute permeability of the material of the rod is henry/meter is

1) $\pi\ x10^{-4}$ 2)$2\pi\ x10^{-4}$ 3) $3\pi\ x10^{-4}$ 4) $4\pi\ x10^{-4}$ (2003E)

2) The period of oscillation of a magnet at a place is 4 seconds. When it is remagnetised, so that the pole strength becomes 4 times the initial value, the period of oscillation in seconds is (2003M)

1) $\frac{1}{2}$ 2) 1 3) 2 4) 4

3) Two short bar magnets of magnetic moments 'M' each are arranged at the opposite corners of a square of side 'd', such that their centers coincide with the corners and their axes are parallel. If the like poles are in the same direction, the magnetic induction at any of the corners of the square is (2003M)

1) $\frac{\mu_0}{4\pi}\frac{M}{d^3}$ 2) $\frac{\mu_0}{4\pi}\frac{2M}{d^3}$ 3) $\frac{\mu_0}{4\pi}\frac{M\sqrt{5}}{d^3}$ 4) $\frac{\mu_0}{4\pi}\frac{3M}{d^3}$

4) The magnetic induction and the intensity of magnetic field inside an iron core of an electromagnet are $1wbm^{-2}$ and $150Am^{-1}$ respectively. The relative permeability of iron is ($\mu_0 = 4\pi x10^{-7}Hm^{-1}$) (2004E)

1) $10^6/4\pi$ 2) $10^6/6\pi$ 3) $10^5/4\pi$ 4) $10^5/6\pi$

5) Two magnetic isolated north poles each of strength "m" Ampere –meter are placed one at each of the two vertices of an equilateral triangle of side "a". The resultant magnetic induction at the third vertex is (μ_0 is permeability of free space) (2004M)

1) $\frac{\mu_0}{4\pi}\frac{m}{a^2}$ 2) $\frac{\mu_0}{4\pi}\frac{\sqrt{2}\,m}{a^2}$ 3) $\frac{\mu_0}{4\pi}\frac{\sqrt{3}\,m}{a^2}$ 4) $\frac{\mu_0}{2\pi}\frac{m}{a^2}$

6) With a standard bar magnet of length *l*, breadth b (b<<*l*) and magnetic moment M, the time period of the magnet in vibration magnetometer is 4 seconds if the magnet is cut normal to its length into four equal pieces, the time period of any one piece is

1) 16s 2) 2s 3) 1s 4) 4s (2005E)

7) Two identical bar magnets each of length *l* and pole strength m, magnetic moment M are placed perpendicular to each other with their unlike poles in contact, the magnetic moment of the combination is (2005E)

1) $\frac{M}{\sqrt{2}}$ 2) $lm\sqrt{2}$ 3) $2lm\sqrt{2}$ 4) 2M

8) The effect due to uniform magnetic field on a freely suspended magnetic needle is as follows (2006E)

1) both torque and net force are present 2) torque is present but not net force
3) both torque and net force are absent 4) net force is present but no torque

9) Two short magnets AB and CD are in X –Y plane and are parallel to X –axis and the coordinates of their centers are (0, 2) and (2,0). Line joining north south poles of CD is opposite to AB and lies along the positive X –axis. The resultant field induction due to AB and CD at a point (2,2) is $100x10^{-7}$ T. When the poles of magnet CD are

reversed the resultant field induction is $50x10^{-7}$T. The values of magnetic moments of AB and CD are

1) 300, 200 2) 600, 400 3) 200, 100 4) 300, 150 (2006E)

10) Two short bar magnets P & Q are arranged such that their centers are on X –axis and separated by large distance. Axis of P & Q are along X & Y axes . At a point R midway between their centers if B is induction due to Q the magnitude of total induction at R due to both magnets is (2006M)

1) 3B 2) $\sqrt{5}$ B 3) $\frac{\sqrt{5}}{2}$B 4) B

11) A bar magnet of moment of inertia $49x10^{-2}$ kgm^2 vibrates in a field of induction $0.5x10^{-4}$T. The time period of vibration is 8.8seconds. The magnetic moment of bar magnet is (2007E)

1) 350 Am^2 2) 490 Am^2 3) 3300 Am^2 4) 5000 Am^2

12) A bar magnet of moment M and moment of inertia I is freely suspended such that axial line is in the direction of magnetic meridian. If the magnet is displaced by a small angle θ The angular acceleration is (2007E)

1) $\frac{MB_H\theta}{I}$ 2) $\frac{IB_H\theta}{M}$ 3) $\frac{MI\theta}{B_H}$ 4) $\frac{\theta I}{MB_H}$

1)2	2)3	3)1	4)4	
5)3	6)3	7)2		
8)2	9)1	10)2	11)4	12)1

Chapter 23

ELECTROMAGNETIC INDUCTION

- The number of lines of force passing through any area in a magnetic field is known as magnetic flux
- When magnetic field makes and angle θ with the normal to the plane then, the magnetic flux linked with coil is $\phi = \vec{B} \cdot \vec{A}$ = BA cosθ
- When a coil of area A and number of turns N is placed in a uniform magnetic field then ϕ = BAN cosθ; Where θ = Angle between direction of B and normal to ($\hat{n}$)

1) If the plane of the coil is parallel to the magnetic field then $\theta = 90^0$ in this condition ϕ= 0 (minimum)
2) If the plane of the coil is perpendicular to magnetic field then $\theta = 0^0$, in this condition ϕ = BAN (maximum)

- When the plane of coil makes an angle α with the magnetic field then flux passing through it ϕ = B BAN sinα, where as if the normal to the plane of coil makes an angle θ with the magnetic filed then flux crossing the coil will be ϕ = BAN cosθ
- If the conductor moves at right angles to its length and perpendicular to the field direction, magnetic flux linked is $\phi = Blvt$ ($\because$ A = lvt)

Where v is velocity of rod and t is time to its motion

- If the conductor moves at an angle θ with the length in this case, flux linked is

$\phi = Blv\sin\theta$

- If a uniform conducting rod is rotated about one end in the field such that its plane of rotation is perpendicular to the field direction, flux linked is

$\phi = \frac{1}{2} Bt^2\theta$ ($\because A = \frac{1}{2} l^2\theta$)

Where θ is angular displacement in time 't' $\Rightarrow \phi = \frac{1}{2} Bl^2\omega t$ Where ω is angular velocity

- A coil of area and N turns is placed in a uniform magnetic field B.

1) If the plane of the coil is perpendicular to the field, flux linked ϕ = NBA
2) If the coil is rotated through π or180^0, change in flux linked is

$d\phi$ = NBA – (–NBA) = 2NBA

3) If the coil is rotated through $\frac{\pi}{2}$ or 90^0, change in flux linked is $d\phi$ = NBA
4) If the coil is rotated through an angle θ, change in flux is $d\phi$ = NBA (1-cosθ)

Faraday's Laws of Electromagnetic Induction:
First Law

- When the magnetic flux is linked with a closed circuit changed then emf will be induced in the circuit
- If the circuit is closed then an induced electric current also flows in the circuit on account of induced emf. Which depends on the rate of change of magnetic flux(i.e $\frac{d\varphi}{dt}$)

Second law: The magnitude of induced emf is directly proportional to the rate of change of magnetic flux linked with circuit, i.e., $e \propto \frac{d\phi}{dt}$

- If the number of turns in the coil is N, then $e \propto \frac{d}{d\phi}(N\phi)$ or $e \propto \frac{Nd\phi}{dt}$, where $N\phi$ is

In SI units $e = N\left(\frac{d\phi}{dt}\right) = \frac{N(\phi_2 - \phi_1)}{t}$

- If the area of coil of N turns is A and angle between $\vec{B}$ and $\vec{A}$ is θ. Then

$e = \frac{d}{dt}(NBA\cos\theta) = \frac{d}{dt}(NBA\cos\omega t)$

1) If only B is changing, then $e = NA\cos\theta\left(\frac{dB}{dt}\right)$
2) If only A is changing then $e = NB\cos\theta\left(\frac{dA}{dt}\right)$
3) If only θ is changing, then $e = NAB\frac{d}{dt}(\cos\theta)$, $\Rightarrow e = -NAB\omega\sin\omega t$.

Lenz's Law:

- The direction of induced emf or induced current in any circuit or coil such that it opposes the very cause which is responsible for its own production

$\Rightarrow e = -N\frac{d\phi}{dt}$

- Induced current $i = \frac{e}{R} = \frac{N}{R}\frac{d\phi}{dt}$, where R is the total resistance of the circuit
- As $i = \frac{dq}{dt}$, there is induced charge in the closed circuit due to electromagnetic induction

$\Rightarrow \frac{dq}{dt} = \frac{e}{R} = \frac{N}{R}\frac{d\phi}{dt}$ $\Rightarrow q = \frac{Nd\phi}{R} = \frac{N(\phi_2 - \phi_1)}{R}$

Induced charge is independent of time in which the flux changes

- Induced power is P = ei (i.e induced emf x induced current)

$\Rightarrow P = \dfrac{e^2}{R}$ or $P = i^2R \Rightarrow P = \dfrac{N^2}{R}\left(\dfrac{d\phi}{dt}\right)^2$

Induced power depends on change in time

Various Formulae of Induced EMF:

- The induced emf generated due to the rotation of a conducting rod in a perpendicular magnetic field is $e = \dfrac{d\phi}{dt}$

$\Rightarrow e = \dfrac{d}{dt}(\dfrac{1}{2}Bl^2\theta)$ or $e = \dfrac{1}{2}Bl^2\omega$

- $e = BAf$, where f = Frequency of rotation and $A = \pi l^2$, ω = Angular velocity,

l = Length of conducting rod

- Induced emf generated in a disc rotating with a constant angular velocity in a perpendicular magnetic field is $e = \dfrac{1}{2}Br^2\omega$, r is radius of the disc.
- $E = \pi r^2 f B$, where f is frequency of rotation

EMF induced due to the motion of a conducting rod in Perpendicular uniform magnetic field:

- If the rod moves with velocity v along a direction making an angle θ, emf induced at its ends is $e = Blv\sin\theta$
- If the rod moves along a direction perpendicular to its length, emf induced at its ends is $e = Blv$ (maximum induced emf)
- If the rod rotates about one end with a constant angular velocity, emf induced between its ends is $e = \dfrac{1}{2}Bl^2\omega$

Self Induction:

- The property of a conductor or coil which enables to induce an emf due to change of current in the same coil
- Magnetic flux linked with coil is directly proportional to the current

$\Rightarrow \phi \propto i$ or $\phi = L\, i$ For n turns $N\phi = L\, i$

Here L is the proportionality constant known as coefficient of self induction or self-inductance of the coil

- From Faraday's law, self induced emf is given by $e_s = \dfrac{-d\phi}{dt} = -L\dfrac{di}{dt}$
- Self inductance of a coil $L = \dfrac{\mu_0 N^2 R}{2}$
- Self inductance of a solenoid = $\mu_0 n^2 Al$ (n is turns per unit length, l is the length)

- Energy stored in a coil is U = $\frac{1}{2}$ L i^2

This energy is magnetic potential energy which is not localised but is distributed in the field associated with the current carrying coil

- When coils are in series, coefficient of coupling = 0

Equivalent self inductance $L_S = L_1 + L_2 +$---------

When coils are in parallel, equivalent self inductance L_P is given by

$$\frac{1}{L_P} = \frac{1}{L_1} + \frac{1}{L_2} + \text{-------------}$$

Mutual Induction:

- When two coils are placed near each other such that the current flowing in one changes, emf is induced in the second coil, such phenomenon is known as mutual induction
- Flux linked with secondary coil is directly proportional to the current flowing in primary coil

$\Rightarrow \phi_2 \propto i_1$ or $\phi_2 = M\, i_1$

For N turns $N\phi_2 = M\, i_1$

M is the proportionality constant known as coefficient of mutual induction

- From Faraday's law, mutually induced emf is e = $-M \frac{di_1}{dt}$
- In case of circular coils the coefficient of mutual induction is M = $\frac{\mu_0 N_1 N_2 \pi R_2^2}{2R_1}$
- Mutual inductance M of two coils of circuits having self inductances L_1 and L_2 is given by M = K $\sqrt{L_1 L_2}$ K is called coefficient of coupling

Eddy Currents: Eddy currents are the electric currents induced in a relatively large piece of conducting material when it is linked with a changing magnetic flux

Eddy currents are commonly put to use in speedometer, induction furnace, deed beet galvanometer and electromagnetic shielding.

AC Generator: It operator on the principle of electromagnetic induction. It converts mechanical energy to electrical energy.

Total induced emf $\varepsilon = NBA \sin wt$

B – Magnetic field, N = No. of turns, A = Area of coil

The peak of maximum emf $\varepsilon_m = NBA\omega$

Which occurs when wt = 90℃ or 270℃

emf in zero when wt – 0 or 180℃

$w = 2\pi f$. For commercial generators the usual frequency is 50 Hz.

Theory Questions:

Magnetic flux; Faraday's law & Lenz's law

1) If a coil carrying an electric current is placed in a uniform magnetic field, then
   1) emf is produced 2) torque is produced
   3) both 1 & 2 4) torque is not produced
2) A conducting loop is placed in a uniform magnetic field with its plane perpendicular to the field an emf is induced in the loop it
   1) is translated 2) is rotated about its axis
   3) is rotated about a diameter 4) all of these
3) If the magnetic field is parallel to a surface, then the magnetic flux through the surface is
   1) zero 2) small but not zero 3) infinite 4) large but not infinite
4) A resistance coil is held horizontally and a magnet is allowed to fall vertically through it. Then the acceleration of the magnet is
   1) equal to g 2) less than g
   3) more than g 4) some times less and some times more than g
5) Lenz's law is based on the law of conservation of
   1) charge 2) energy 3) mass 4) momentum
6) The direction of the induced current is such that it opposes the cause to which it is due. This is
   1) consistant with observed facts 2) a statement of lenz's law
   3) a consequence of law of conservation of energy 4) all of these
7) When two mutually perpendicular alternating magnetic fields superimpose to each other, the resulting field is
   1) linear 2) stationary 3) rotating 4) alternating
8) Two circuits consisting of a loop of wire are placed in the proximity of one another and one of them is carrying a current. The current is them suddenly stopped. Then
   1)there will be an induced emf in the other circuit
   2)there will be no induced emf
   3)there will be an induced emf in both of the circuits 4)none

Self induction:

9) The role of self-inductance in a circuit is equivalent to
   1) momentum 2) force 3) energy 4) inertia
10) When number of turns o coil is doubled, its self inductance (Length of the coil is constant)
   1) is doubled 2) is halved 3) become one quarter 4) becomes four times
11) The self inductance of a straight wire is
   1) zero 2) infinity 3) negative 4) positive
12) What should be the rate of variation of current in a circuit of self-inductance one henry to generate induced emf equal to one volt?
   1) less than one ampere per second 2) one ampere per second

3) two ampere per second 4) more than two ampere per second

Mutual induction:

13) Two circular coils of radii R_1 and R_2 ($R_2 > R_1$) are placed on a plane. The smaller coil is placed at the center of the larger coil. If a current is set up in the larger coil, the mutual inductance of smaller coil with respect to larger coil depends upon

1) R_1R_2 2) $\frac{1}{R_1R_2}$ 3) $\frac{R_1^2}{R_2}$ 4) $\frac{R_2^2}{R_1}$

Match the following Questions:

14) Match List-I and List-II

List –I	List –II
a) Lenz's law	e) Coefficient of self inductance
b) Rate of change of magnetic flux	f) Electrical inertia
c) Total magnetic flux linked with a coil	g) Induced emf
d) Inductance	h) Law of conservation of energy

The correct match is

1) a→h; b→g; c→f; d→e 2) a→e; b→f; c→g; d→h

3) a→h; b→g; c→e; d→f 4) a→h; b→e; c→f; d→g

15) Match List-I and List-II

List –I	List –II
a) Step down transformer	e) $N_S < N_P$
b) Ideal transformer	f) turns ratio in one
c) Capacitive constant	g) CR
d) Inductive time constant	h) $\frac{L}{R}$

The correct match is

1) a→e; b→f; c→g; d→h 2) a→h; b→g; c→f; d→e

3) a→f; b→e; c→g; d→h 4) a→g; b→h; c→f; d→e

Assertion & Reason Type Questions:

16) Assertion: Only a change in magnetic flux will maintain an induced current in the coil
Reason: The presence of large magnetic flux through a coil maintains a current in the coil if the circuit is continuous

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4)A is false but R is true

17) Assertion: If current is flowing through a machine of iron eddy currents are produced
Reason: Change in magnetic flux through an area causes eddy currents

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4)A is false but R is true

18) Assertion: When magnetic field is in a direction perpendicular to the given area, magnetic flux linked with it is zero

Reason: This follows from $\phi = 2A\cos\theta$, where the symbols have their standard meanings

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4)A is false but R is true

19) Assertion: When a bar magnet is rapidly moves towards or away from a closed coil of wire, a large emf is induced

Reason: The rate of change of magnetic flux cutting the coil is proportional to the induced emf is the underlying principle

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4)A is false but R is true

20) Assertion: Faraday's laws are consequences of conservation of energy

Reason: In a purely resistive A.C., circuit, the current lags behind the emf in phase

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false 4)A is false but R is true

Magnetic flux, Faraday's Laws & Lenz's law:

21) A magnetic field of induction 10T acts at an angle of 30^0 to the plane of the circular coil of area $0.1m^2$ having 100 turns. If the coil is removed from the field in 0.1sec, the induced emf in the coil is

1) 866 V 2) 400V 3) 500V 4) 1000V

22) The magnetic flux (ϕ in weber) in a closed circuit of resistance 10 ohm varies with time t (in seconds) according to the equation $\phi = 6t^2 - 5t + 1$. The magnitude of the induced current at $t = 0.25$s is

1) 0.5A 2) 0.2A 3) 0.1A 4) 0.4A

23) A rectangular coil of wire 10 cm x 5 cm has 500 turns. It is kept such that the plane of the coil is perpendicular to varying magnetic field. If the field changes from 0.5T to 1.5T in 1 milli second. The induced emf is

1) 2500V 2) 3500V 3) 4500V 4) 1500V

24) A square coil of $10^{-2}m^2$ area is placed perpendicular to a uniform magnetic filed of induction 10^{-3} wbm^{-2}. The magnetic flux through the coil is

1) 10 *wb* 2) 20 *wb* 3) 30 *wb* 4) 40 *wb*

25) A field of induction $2x10^{-2}$ tesla acts at right angle to a coil of area $100cm^2$ and the coil is removed from the field in $\frac{1}{10}$ sec. Find the average emf induced in it if the number of turns is 50

1) 0.4V 2) 0.3V 3) 0.1V 4) 0.2V

26) A coil of dimensions 10 cm x 20 cm having 60 turns is making 1800 revolutions per minute in a magnetic field of induction 0.5T. The peak value of induction is
1) 103V 2) 203V 3) 223V 4) 113V
27) A flux of 8.66 milliweber passes through a strip having an area $0.02m^2$. The plane of the strip is at an angle of 60^0 to the direction of the magnetic field B. The value of B is
1) 0.5T 2) 0.866T 3) 0.25T 4) 0.433T
28) A square coil of each side 0.5m has movable sides. It is placed such that its plane is perpendicular to uniform magnetic field of induction 0.2T. If all the sides are allowed to move with a speed of $0.1ms^{-1}$ for 4 sec outwards, average induced emf is
1) zero 2) 0.01V 3) 0.028V 4) 0.072V
29) A horizontal straight wire 10m long extending east and west is falling at right angles to the horizontal component of earths magnetic field $0.30x10^{-4}Wbm^{-2}$.
If the induced emf is $1.5x10^{-3}$V, the velocity of wire is
1) $5.4x10^4ms^{-1}$ 2) $5x10^2ms^{-1}$ 3) $50ms^{-1}$ 4) $5ms^{-1}$

Self induction:

30) A coil of self inductance 0.5H is connected to a 12 V battery. The rate of growth of current in the circuit is
1) 12 As^{-1} 2) 48 As^{-1} 3) 24 As^{-1} 4) 36 As^{-1}
31) An emf of 5V is produced by a self inductance when the current changes at a steady rate from 3A to 2A in 1 millisecond. The value of self inductance is
1) 5 MH 2) 8 MH 3) 9 MH 4) 2 MH
32) An air cored solenoid 40 cm long has 500 turns. Its diameter is 3 cm. The self inductance of the coil is
1) 0.554 mH 2) 0.545 mH 3) 0.455 mH 4) 0.555 mH
33) The self inductance of a coil of 100 turns will be, if a current a 6 A produces a magnetic flux of $6x10^3$ maxwell in it. [1 maxwell = 10^{-8} weber]
1) $2x10^{-3}$H 2) $0.5x10^{-3}$H 3) 10^{-3}H 4) $4x10^{-3}$H
34) The self inductance of a coil is 2 H and its resistance is 20Ω. The value of current in it changes from 10 A to 9A is 0.01s. The time constant of the coil will be
1) 2s 2) 0.1s 3) 10 ms 4) 1 ms
35) A closely wound coil of 100 turns and area of cross-section $1cm^2$ has a coefficient of self induction 1 mH. Find the magnetic induction at the center of the core of the coil when a current of 2 A flows through it
1) 3.2T 2) 2.2T 3) 0.2T 4) 1.2T
36) In an inductance coil the current increases from zero to 6 ampere in 0.3 second by which an induced emf of 60 volt is produced in it. The value of coefficient of self induction of coil is
1) 1 H 2) 1.5 H 3) 2 H 4) 3 H

37) The coefficient of self induction of the coils are $L_1 = 8$ mH and $L_2 = 2$ mH respectively. The current in the two coils at the same rate. The power given to the tow coils any instant is same. The ratio of currents flowing in the coils will be

1) $\frac{i_1}{i_3} = \frac{1}{4}$ 2) $\frac{i_1}{i_3} = \frac{4}{1}$ 3) $\frac{i_1}{i_3} = \frac{3}{4}$ 4) $\frac{i_1}{i_3} = \frac{4}{3}$

38) If the flux linked up with a coil changes by 10% then change in energy stored in the coil is

1) 11%5 2) 21% 3) 90% 4) 5%

Mutual Induction:

39) If the current in the primary coil is reduced from 3A to zero is 0.001s, the induced emf in the secondary coil is 1500V. The mutual inductance between the coils is

1) 1.5H 2) 2.5H 3) 3.5H 4) 0.5H

40) The current decays from 4A to 2A in 0.01s in a coil. The emf induced in a coil near by it is 20V. The mutual inductance of the coil is

1) 1.5H 2) 1.1H 3) 0.5H 4) 0.1H

41) An emf of 40 mV is induced in a coil when the current in the neighboring coil changes from 15 to 5 amp in 0.1s. The mutual inductance of the two coils is

1) 0.4 mH 2) 0.3 mH 3) 0.2 mH 4) 0.1 mH

42) The emf induced in a secondary coil 20 kV when the current breaks in the primary. IF the mutual inductance is 5 H and the current reaches to zero in 10^{-4}s in the primary. Calculate the maximum current in the primary before the break

1) 1.4A 2) 0.4A 3) 2.4A 4) 3.4A

43) The number of turns of the primary and secondary coils of a transformer is 5 and 10 respectively and the mutual inductance of the transformer is 25 H. Now the number of turns in the primary and secondary of the transformer is made 10 and 5 respectively, the mutual inductance of the transformer in henry will be

1) 6.25 2) 12.5 3) 25 4) 50

44) The coefficient of mutual inductance of two coils is 0.5H. If the current is increased from 2A to 3A in 0.01s in the primary coil, find the inductance emf in the secondary coil

1) 50V 2) 20V 3) 40V 4) 55V

45) If the coefficient of mutual induction of primary and secondary of an induction coil is 6H and a current of 5A is cut off in $2x10^{-4}$s, find the induced emf in the secondary coil

1) 150KV 2) 250KV 3) 50KV 4) 350KV

1)	**3**	2)	**3**	3)	**1**	4)	**2**	5)	**2**	6)	**4**	7)	**3**	8)	**3**	9)	**4**	10)	**1**
11)	**1**	12)	**2**	13)	**1**	14)	**3**	15)	**1**	16)	**3**	17)	**4**	18)	**4**	19)	**2**	20)	**3**
21)	**3**	22)	**2**	23)	**1**	24)	**1**	25)	**3**	26)	**4**	27)	**1**	28)	**4**	29)	**4**	30)	**3**
31)	**1**	32)	**1**	33)	**3**	34)	**2**	35)	**3**	36)	**4**	37)	**1**	38)	**2**	39)	**4**	40)	**4**
41)	**1**	42)	**2**	43)	**3**	44)	**1**	45)	**1**										

Chapter 24
ALTERNATING CURRENT

- The instantaneous value (value at any time t) of alternating current is given by,

$I = I_0 \sin \omega t$ or $I = I_0 \cos\omega t$

Where I_0 is called current amplitude or peak (maximum) value of alternating current

- If T is time period of alternating current and f its frequency, then $\omega = \frac{2\pi}{T} = 2\pi f$
- The instantaneous value of alternating voltage may be represented by,

$V = V_0 \sin\omega t$ or $V = V0 \cos \omega t$

Similarly, the instantaneous value of alternating emf

RMS value of A.C current:

- Root mean square of A.C is defined as the steady current, which when passes through a resistance for a given time will produce the same amount of heat as the alternating current does in the same resistance and in the same time

Growth and Decay of Current in L-R Circuit:

Consider a battery of emf E connected to a series combination of an inductance L and resistance R through a two-way key as shown in the figure

Growth of Current:

- Induced emf produced in the inductance = $-L \frac{dl}{dt}$
- Effective emf in the circuit = E = $-L \frac{dl}{dt}$
- According to Ohm's law potential difference across resistance, IR = E = $-L \frac{dl}{dt}$
- Current in the circuit at any time 't' is $I = I_0[1-e^{\frac{-R}{L}t}]$. Here I_0 is the maximum value of current
- When $t = \frac{L}{R}$, then $I = 0.63I_0$ The value of $\frac{L}{R}$ is known as inductive time constant

Decay of Current:

- Induced emf in the circuit = $-L \frac{dl}{dt}$ Potential difference across resistance,

$IR = -L \frac{dl}{dt}$, When $t = \frac{L}{R}$ then $I = 0.37I_0$

Growth and Decay of Charge in C-R circuit:

- Potential difference across the resistance = IR

Where I is the current in the circuit at any time 't'

- According to Ohm's law potential difference across resistance, IR = E = $-\frac{q}{C}$
- Charge on the capacitor at any time t during charging in q = q_0 [1 –$e^{\frac{-t}{CR}}$], where q_0 is the maximum charge
- The instantaneous p.d. across the plates, V = V_0 [1–$e^{\frac{-t}{CR}}$]
- When t = CR, then q = 0.63% The value of CR is known as capacitance time constant

Decay of Charge:

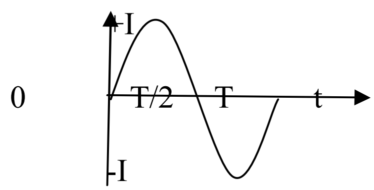
- Charge on capacitor at any time t during discharging is, q = q_0 $e^{\frac{-t}{CR}}$
- Rate of decay of charge, $\frac{dq}{dt} = \frac{-q}{CR}$ i.e., smaller the value of product CR, the quicker is the discharge of the conductor
- When t = CR, then q = $0.37q_0$.

A.C Through L-C Circuit:

- Potential difference across inductor, V_L = ILω and potential difference across condenser, $V_C = \frac{I}{C\omega}$
- Impedance of the circuit, Z = $\left(L\omega - \frac{1}{C\omega}\right)$
- Instantaneous current in circuit, $I = \frac{V_0}{\left(L\omega - \frac{1}{C\omega}\right)} \sin\left(\omega t - \frac{\pi}{2}\right)$
- I will be maximum, if Lω = $\frac{1}{C\omega}$ or $\omega^2 = \frac{1}{LC}$ or $\omega = \frac{1}{\sqrt{LC}}$

<u>**ALTERNATING CURRENT (A.C):**</u>

1. If the direction of current in a resistor or in any other element likes a coil or a capacitor charges alternately, the current is called alternating current.
2. Electro motive force (e.m.f) induced in a coil, rotated in a magnetic field with constant angular velocity, is alternating e.m.f. the current , because of it is called alternating current, its magnitude varies continuously and its direction reversers perdically.
3. An alternating current, in the simplest form, is sinusoidal.
4. $I_t = I_0 \sin \omega t$
5. Here It is the instantaneous current, I_0 is the maximum or peak current.



ω is the angular frequency

6. Alternating voltage $v_t = v_0 \sin \omega t$
7. Time period (T) is the time interval between two successive maximum or minimum currents in the same direction.
   $T = \frac{2\pi}{\omega}$
8. Frequency (F) is the reciprocal of time period (T).
   $F = 1/t = \omega/2\pi$
9. The term ωt is called a phase angle.

RMS value or Virtual value or effective value of A.C. current:

10. The r.m.s. value of alternating current is that steady current which when passed through a given resistance for a certain time will develop the same amount of heat as the actual alternating current will develop passed for the same time.
    r.m.s value = 0.707 x peak value $= \frac{\text{peak value.}}{\sqrt{2}}$
    $I_{rms} = 0.707\ I_0$
11. The rms value of A.C. current and voltages are also called virtual current and voltage respectively.

Mean value or Average value:
this is a arithmetic average of all values in a sine wave half cycle. Here half cycle is used because the full cycle averages to zero.
Average or mean value = 2/Π x peak value

a) Mean value of A.C. over one complete cycle
   $I_{mean} = 0.$
b) Mean value of A.C. voltage over one complete cycle.
   $V_{mean} = 0.$
c) Mean value of A.C. over a one half cycle.
   $I_{mean} = 0.637\ I_{0.}$
d) Mean value of A.C. over a one half voltage cycle.
   $V_{mean} = 0.637V_0.$

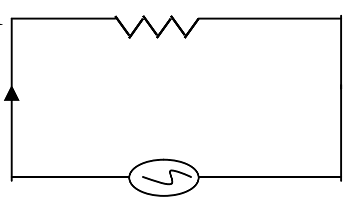
12. **Alternating voltage applied to a pure Resistor, pure Inductor, and pure Capacitor:**

When an alternating emf is applied to a resistor, an inductor or a capacitor the current through them is alternating current.

13. **A.C. through pure Resistor:**

a) When an alternating voltage $V = V_0 \sin \omega t$ is applied to a non- inductive resistance R, the instantaneous current.
$I = V_0/R \sin \omega t$.

b) The current and voltage increase and decrease simultaneously. They are in phase with each other.

c) 

fig(i) ac through resistor

$e= E_0 \sin \omega t$

d) $i = E_0/R \sin \omega t$. The peak or maximum current is denoted by I_0 and is given by E_0/R.

e) There no phase different between current and emf in pure resistor.

f) The current or voltage varies sinusoidally in pure resistor.

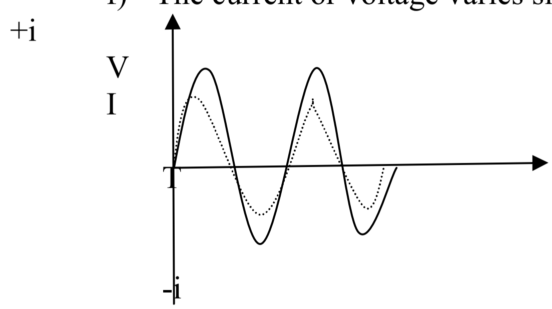
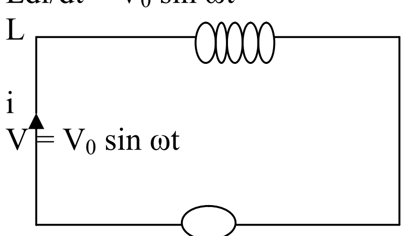


Fig (ii) Wave form diagram of current or voltage through a resistor.

14. Ac through pure inductor:

a) When an alternating voltage $V = V_0 \sin \omega t$ is applied to inductor L and of negligible resistance, the inclined e.m.f. (or back emf) is Ldl/dt.

b) $Ldl/dt = V_0 \sin \omega t$



c) The applied emf must be at least equal to this back emf in order that a current may just flow through the circuit.

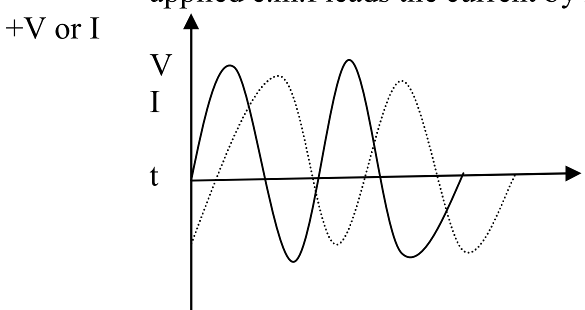
d) The instantaneous current through the inductor is

$$i = \frac{V_0}{L\omega} \sin\left(\omega t - \pi/2\right)$$

$$i = I_0 \sin \omega t - \pi/2$$

The quantity $V_0/ L\omega$ is the maximum current or peak current, and it is denoted by I_0 .

e) The current (I) in the inductor lags behind the applied e.m.f. by $\pi/2$ or the applied e.m.f leads the current by $\Pi/2$.



(I lags behind V)

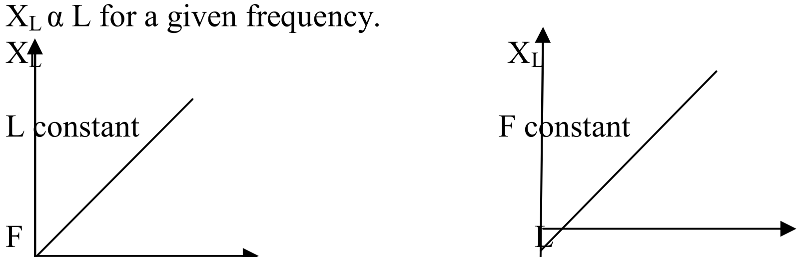
f) The term ωL plays the role of effective resistance of the circuit. It is called the **reactance** of the inductor or inductive reactance.

$$\mathbf{X_L = \omega L = 2\pi f.L}$$

Where f is the frequency of A.C,

g) $X_L \alpha f$ for a given inductance.

h) $X_L \alpha L$ for a given frequency.



Graphs between X_L and f or L are straight lines.

i) An inductor allows Direct current (D.C) and controls A.C. For direct current f = 0. And so $X_L = 0$.

j) $X_L = V_0/I_0, = V_{rms}/I_{rms}$.

k) If f is in hertz and L is in Henry. Then the reactance X_L will be in ohms.

l) A choke coil has high inductance and very low resistance. When it is connected in series in an A.C. circuit. It controls the current without appreciable loss of energy. So it is preferred to a resistance which dissipates energy.

16. **A.C Through a capacitor:**

a) When an alternating voltage $V = V_0 \sin \omega t$ is applied to a capacitor C, the instantaneous current.

i. $I = I_0 \cos \omega t$; here $I_0 = V_0 C\omega$;

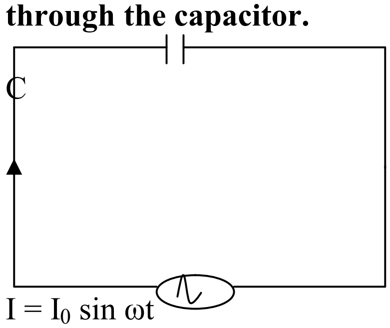
b) $= I_0 \sin(\omega t + \Pi/2)$;

c) The quantity $V_0 C\omega$ is the maximum current or peak current.

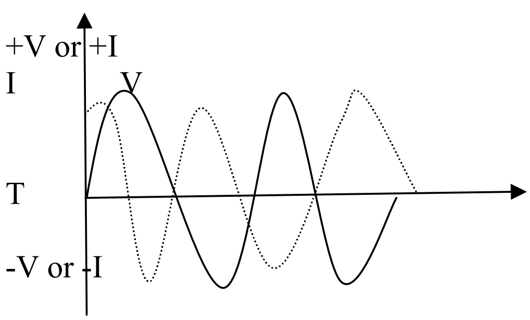
d) the current through the capacitor leads the applied voltage by $\Pi/2$ or the applied voltage lags behind the current by $\Pi/2$.

e) **Capacitive reactance(X_C) = 1/ωc** $= \frac{1}{2\pi f c}$,

f) Capacitive reactance (X_C) is defined as the opposite offered by a capacitor when current flows through it. For constant dc, $\omega = 2\Pi f = 0$. **Making $X_C = \alpha$. Hence constant dc does not flow through a capacitor. But a.c. passes through the capacitor.**



$I = I_0 \sin \omega t$

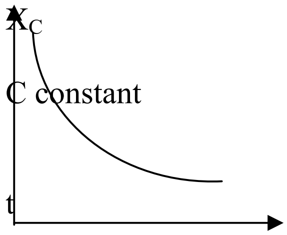


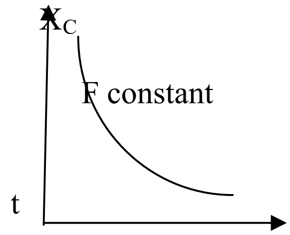
g) X_C depends upon the frequency and capacity.

m) $X_c \,\alpha\, 1/f$ for a given capacitor.

n) $X_c \,\alpha\, 1/C$ for a given frequency.

o) The capacitor offers low resistance for high frequency and high resistance for low frequency.





15. **A.C. Circuit containing L and R in series:**

a) When an alternating voltage $V = V_0 \sin \omega t$ is applied to a circuit containing Land R in series, alternating current flows through the circuit.

b) Voltage across the coil $V_L = \omega L$, this leads current I by 90^0.

c) Voltage across the resistor is $V_R = I_0R$. This is in phase with the current I.

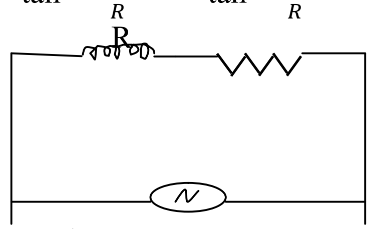
d) According to the parallelogram law of vectors

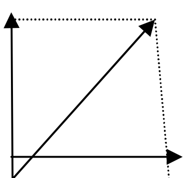
$$I_0 = \frac{V_0}{\sqrt{R^2 + (L\omega)^2}}$$

e) Its impendence $Z = \frac{V_0}{I_0} = \sqrt{\{R^2 + (L\omega)^2\}}$

f) The current in the circuit is behind emf by an angle θ and it is by

$$\theta = \tan^{-1} \frac{L\omega}{R} = \tan^{-1} \frac{XL}{R}$$





$V_L = IX_L$ .... WHERE VL LEADS I BY 90^0

$V_R = IR$ .... where V_R is in phase with I

g) For very small frequencies Z = R.

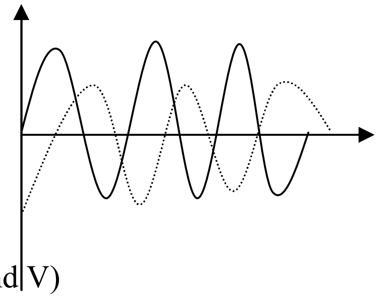
h) For large frequencies $Z = \omega L$.

+V or +I

V

I

t



-v (I lags behind V)

16. **<u>A.C. Circuit containing C and R in series:</u>**

i) When an alternating voltage $V = V_0 \sin \omega t$ is applied to a circuit containing C and R in series, alternating current flows through the circuit.

j) Voltage across the coil $V_c = 1/\omega c$, this lags current I by 90^0.

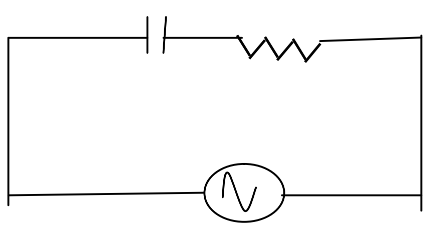
k) Voltage across the resistor is $V_R = I_0 R$. This is in phase with the current I.

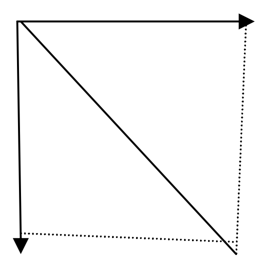
l) According to the parallelogram law of vectors

$$I_0 = \frac{V_0}{\sqrt{R^2 + 1/(C\omega)^2}}$$

O V_R

C R





V_C

m) Its impendence $Z = \frac{V_0}{I_0} = \sqrt{\left\{R^2 + 1/(C\omega)^2\right\}}$

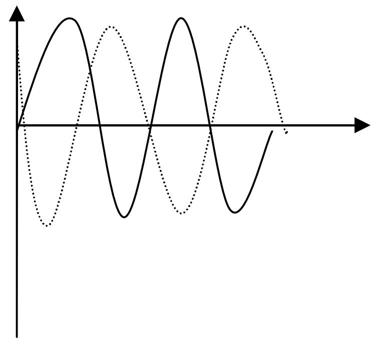
n) The current in the circuit is leads emf by an angle θ and it is by

$$\theta = \tan^{-1}\left(\frac{1}{-\omega C}\right) = \tan^{-1}\left[\frac{Xc}{R}\right]$$

o) For very small frequencies $Z = \frac{1}{\omega CR}$.

p) For large frequencies Z = R.

+V or +I
V
I
t



-Vor –I
(I leads V)

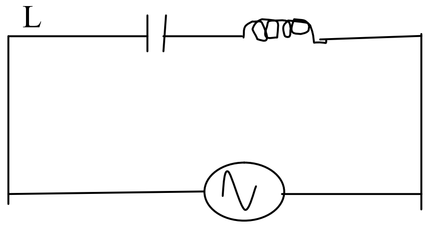
17. **A.C. circuit containing L and C in series :**

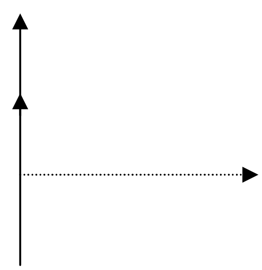
a) When an alternating voltage $V = V_0 \sin \omega t$ is applied to a circuit containing C and R in series, alternating current flows through the circuit.
b) Voltage across the coil $V_L = \omega L. I_o$, this leads current I by 90^0.
c) Voltage across the capacitor is $V_c = 1/\omega c * I_0$.
d) This lags behind the current I by 90^0.

C
V_L - V_C

T

L





$V = V_0 \sin\omega t$

e) The phase difference between V_L and V_c is 180^0.
f) When $X_C > X_L$, the LC circuit is equivalent to a single element, capacitor.
g) When $X_C < X_L$, the LC circuit is equivalent to a single element, inductor.
h) When $X_C = X_L$, the current I becomes infinite. This is called resonance.

18. **A.C. circuit containing L, C and R in series:**

q) When an alternating voltage $V = V_0 \sin \omega t$ is applied to a circuit containing L, C and R in series, alternating current flows through the circuit.
r) Voltage across the coil $V_L = \omega L . I_0 = X_C. I_0$,
s) This leads current I by 90^0.
t) Voltage across the capacitor is $V_c = \frac{Io}{\omega C} = X_C.I_0$.
u) This lags behind the current I by 90^0.

v) Voltage across the resistor is $V_R = I_0R$. This is in phase with the current I.

w) According to the parallelogram law of vectors

$$I_0 = \frac{V_0}{\sqrt{R^2 + (L\omega - 1/\omega C)^2}}$$

x) Its impendence $Z = \frac{VO}{IO} = \sqrt{R^2 + \left(L\omega - \frac{1}{\omega C}\right)^2}$

y) The phase difference(θ) between I and V is given by

$$\theta = \tan^{-1}\left(\frac{L\omega - 1/\omega C}{R}\right) = \tan^{-1}\left(\frac{X_L - X_c}{R}\right)$$

It should be remembered that θ will lead or lag depending up on the values of ωL and $\frac{1}{\omega C}$.

If $\omega L > \frac{1}{\omega C}$. Current lags. If $\omega L < \frac{1}{\omega C}$.current leads.

The LCR series circuit has very large capacitive reactance Xc = $\frac{1}{\omega C}$.at low frequency.

The LCR series circuit has very large inductive reactance $X_L = \omega L$ at high frequency.

At resonance:

$$\omega L - \frac{1}{\omega C} = 0.$$

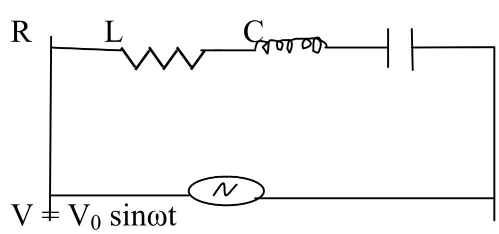
$$\omega = \frac{1}{\sqrt{LC}}$$

$$f_O = \frac{1}{2\Pi\sqrt{LC}}$$

At some particular frequency, the total reactance of the circuit is zero i.e, ωL – 1/ωC = 0. Under this condition impedance **Z=R,**

$$Z = \sqrt{R^2 + \left(\omega L - 1/\omega c\right)}$$

Z = R.



$V = V_0 \sin\omega t$

z) If $X_C > X_L$, then tan θ is negative and θ is negative.

Then applied voltage lags behind the current.

$I = V_0/Z \sin(\omega t + \theta)$

If $X_C < X_L$, then tan θ is positive and θ is negative.

Transformer:

- It is a device used for converting low alternating voltage at high current into high voltage at low current
- It works on the principle of mutual induction

Step up transformer:

- In a step up transformer the number of turns in secondary coil (N_S) is greater than the number of turns in primary coil (N_P).

Step down transformer:

- In a step down transformer the number of turns in secondary coil (N_S) is less than the number of turns in primary coil (N_P).
- IF E_P and E_S are the primary and secondary emf's in a transformer and N_P and N_S are the number of turns in the primary and secondary coils, then $\frac{E_S}{E_P} = \frac{N_S}{N_P}$

The ratio $\frac{N_S}{N_P}$ = K is called transformation ratio

- If I_P and I_S are the primary and secondary currents respectively, then $\frac{I_P}{I_S} = \frac{N_S}{N_P}$
- The efficiency of a transformer is the ratio of the output power to input power.

$$\therefore \text{Efficiency, } \eta = \frac{\text{input power}}{\text{output power}} = \frac{E_S I_S}{E_P I_P} \text{k}$$

$$\text{Percentage of efficiency, } \eta = \frac{\text{input power}}{\text{output power}} \text{x } 100$$

- For an ideal transformer, η = 100% and for most of the transforms η varies in between 90% to 99%

Problems based on AC circuits:

1. When the emf is maximum how is the current in a pure inductor.
   a) Minimum
   b) Maximum
   c) Zero
   d) None of the above
2. When the emf is maximum how is the current in a pure resistor.
   a) Minimum
   b) Maximum
   c) Zero
   d) None of the above
3. When the emf is maximum how is the current in a pure capacitor.
   a) Minimum
   b) Maximum

c) Zero
d) None of the above
4. In a series LCR circuit, at resonance what is the nature of the circuit.
a) Pure resistor
b) Pure inductor
c) Pure capacitor
d) All the above
5. In a series LCR circuit, what is the relation between the potential differences across the inductor and capacitor.
a) Not equal and opposite
b) Equal and opposite
c) Zero
d) Equal and not opposite
6. The phase difference between emf and current in pure resistor.
a) No
b) Zero
c) 90^0
d) 180^0
7. The phase difference between emf and current in pure inductor.
a) Zero
b) 90^0
c) 180^0
d) 360^0
8. The phase difference between emf and current in pure capacitor.
a) Zero
b) 180^0
c) 90^0
d) 360^0
9. In an pure inductor relationship between current and inductor.
a) Lags
b) Leads
c) Zero
d) π
10. In an pure capacitor the relationship between current and emf is
a) Lags
b) Leads
c) Zero
d) π
11. At resonance current in LCR circuit is
a) Maximum
b) Minimum
c) Zero
d) π
12. Equation for time constant in RL circuit is
a) $\lambda = L/R$
b) $\lambda = LR$
c) $\lambda = 2LR$
d) $\lambda = 4RL$
13. Equation for time constant in RCL circuit is
a) $\lambda = 2RC$
b) $\lambda = 3R/C$
c) $\lambda = RC$
d) $\lambda = 5RC$
14. An inductor of inductance 2mH is connected to an alternating emf of 50Hz. Find the inductive reactance.
a) 0.342Ω
b) 0.638 Ω
c) 2.456Ω
d) 4.322Ω
15. When an inductor, a capacitor and a resistor are connected in series across a source of alternating emf, the p.d.'s across the inductor, capacitor and resistor are 70V, 30V, and 30V respectively. Find the emf of the soure.
a) 40V
b) 35V
c) 50V

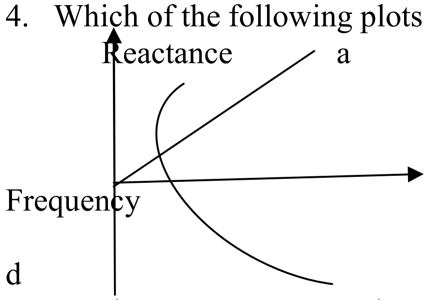
d) 20V

Key

1. a	2.b	3.b	4.a	5.b
6.a	7.b	8.c	9.a	10.b
11.a	12.a	13.c	14.b	15.c

Additional questions:

1. The average power dissipation in a pure inductor L of inductance when A.C. current is passing through it is :
   a) ½ Lt^2 c) zero
   b) ¼ Lt^2 d) Lt^2
2. A transformer is used to
   a) Charge the alternating potential
   b) Charge the alternating current
   c) To prevent the present the power loss in alternating current flow
   d) To increases the poser of current sorce
3. In alternating R-L Circuits expressions of quality- factor is:
   a) $\left(\frac{\omega L}{R}\right)^2$ c) $\frac{\omega L}{R}$
   b) $\left(\frac{R}{\omega L}\right)^2$ d) $\frac{R}{\omega L}$
4. Which of the following plots may represent the reactance of a series LC combination?



   a) a c) c
   b) b d) d
5. A coil of inductance L and an inductive reactance X_L in an a.c. circuits in which the effective current is l. the coil is made from a super conducing materials and has no resistance . the ratio at which power is dissipated in the coils is
   a) 0 c) I^2X_L
   b) I X_L d) IX^2_L

6. The park voltage of 220V AC mains is
   a) 155.6v   c) 220v
   b) 311v   d)440v
7. In an a.c. circuits V and l are given by V = 100 sin (100t) volts, l = 100 sin (100t + Π/3) mA. The power dissipated in an circuit is
   a) 104 watt   c) 10 watt
   b) 2.5 watt   d) 5.0 watt
8. In an a.c. circuit, the current lags behind the voltage by Π/3. The component in the circuits are
   a) R and L   c) L and C
   b) R and C   d) only R
9. The voltage of an A.C. source varies with time according to the equation V = 100 sin 100Πt cos Πt, where t is in seconds and V is in volts. Then
   a) The peak voltage of the source is 100 volts
   b) The peak voltage of the source is 50volts
   c) The peak voltage of the source is 100Γ2 volts
   d) The frequency of the source is 50 hertz.
10. The reactance of a coil when used in the domestic A.C. power supply (220 volts, 50 cycles per second) is 50 ohms. The inductance of the coil is nearly:
    a) 2.2 Henry   c) 0.22 Henry
    b) 1.6 Henry   d) 0.16 Henry
11. Power loss in an A.C. circuits will be minimum when
    a) High resistance, high inductance
    b) High resistance, low inductance
    c) Low resistance, high inductance
    d) Low resistance, high inductance
12. For the advantage of power factor in a circuit it must have
    a) Condenser
    b) Low resistance with inductance
    c) Choke coil
    d) All the above
13. The phase difference between V and I in pure inductance is
    a) 360^0 c) 90^0
    b) 0^0 d) 180^0
14. An a.c of 50 Hz and 1A peak value flows in a transformer whose mutual inductance is 1.5 H. the induced emf in the secondary is:
    a) 75   c) 225
    b) 150   d) 300
15. In an A.C. circuits AC voltages V = 200 sin 300t and if R = 1Ω; and L = 800mH, peak value of current will be
    a) 1.82A   c) 2.0A

b) 1.5A d) 0.83A

16. In an A.C. circuit R = 0Ω, X_L = 8Ω, and X_C = 6Ω phase difference between voltage and current is:
    a) 90^0 c) 37^0
    b) 45^0 d) 12^0
17. Peak value of AC current in AC circuits is $4\sqrt{2}$ A. Rms current is
    a) $2\sqrt{2}$ A c) $4\sqrt{2}$ A
    b) 8A d) 4A
18. Power factor of LCR circuit is maximum when
    a) $X_L = X_C$ c) $X_L = 0$
    b) R = 0 d) $X_C = 0$
19. The peak value of A.C. voltage on a 220V mains is
    a) $200\sqrt{2}$ V c) $220\sqrt{2}$ V
    b) $230\sqrt{2}$ V d) $240\sqrt{2}$ V
20. If resistance R = 1.2Ω, inductance(L) = 2H, and capacitance (C) = 5μF are connected in series to an A.C. generator of frequency 50Hz, then at resonance the circuit impendence is
    a) Zero c) 18Ω
    b) 12Ω d) 24Ω

21. For high frequency, capacitor offers
    a) More reactance c) less reactance
    b) Zero reactance d) none of the these
22. Power factor in a series LCR resonant circuit is
    a) 0.5 c) 0.707
    b) 1 d) 0
23. A choke coil has
    a) High resistance, low inductance
    b) Low resistance, high inductance
    c) Low resistance, high inductance
    d) High resistance, high inductance
24. In an A.C. circuits the potential difference across an inductance and resistance joined in series are respectively 16V and 20V. the total potential difference across the circuits is
    a) 20V c) 31.9V
    b) 25.5V d) 53.3V
25. Quality factor LCR circuit having resistance(R) and inductance(L) at resonance frequency (ω) is given by :
    a) $\frac{\omega L}{R}$ c) $\frac{R}{\omega L}$
    b) L/R d) R/L

26. The value of the current though a coil of inductance 1H and negligible resistance when connected through an A.C. source of 200V and 50Hz is :
   a) 0.637 A   c) 1.637 A
   b) 1A   d) 2A
27. In a series LCR circuit R = 10Ω, and Z = 20Ω, then the phase different between the current and the voltage is
   a) 45^0 c) 60^0
   b) 90^0 d) 0
28. A capacitor C and an inductance L have a certain resonant frequency. The capacitor is increased to 4C. For what value of L. the resonant frequency remains the same?
   a) L   c) 3L
   b) 4L   d) 4/3 L
29. In LCR series A.C. circuit, the phase angle between current and voltage is
   a) Any angle between 0 and Π/2
   b) π/2
   c) π
   d) 0
30. The power factor in an A.C. series L-R circuit is:
   a) $\sqrt{R^2 + L^2\omega^2}$ c) L/R
   b) R/L   d) $\sqrt{R / R^2 + L^2\omega^2}$
31. In an A.C. circuits a resistance of R ohm is connected in series with an inductive L. if the phase angle between voltage and current be 45^0, the value inductive reactance will be
   a) R/4
   b) R/2
   c) R
   d) Cannot be found with the given data
32. In an A.C. containing only capacitance the current
   a) Leads voltage by 180^0
   b) Remains in phase with voltage
   c) Leads voltage by 90^0
   d) Lags voltages by 90^0
33. A capacitor C has reactance X. if the capacitances and frequency becomes double then reactance will be
   a) 4X
   b) X/2
   c) X/4
   d) 2X
34. Choke used to limit high frequency A.C. has :
   a) Air core
   b) Iron core

c) A paramagnetic core
d) A diamagnetic core

35. Power factor of a good coil is:
a) Exactly one
b) Nearly one
c) Exactly one
d) Nearly one

Key

1.c	2.a	3.b	4.d	5.a
6.b	7.b	8.a	9.b	10.d
11.d	12.d	13.c	14.d	15.d
16.a	17.d	18.a	19.c	20.b
21.c	22.b	23.b	24.b	25.a
26.a	27.c	28.b	29.a	30.d
31.c	32.c	33.c	34.b	35.d

Transformers:

36) The transformer is a device based on the phenomenon of
1) self inductance 2) electric discharge 3) mutual inductance 4) production of electromagnetic waves

37) Which quantity is increased in step down transformer?
1) current 2) voltage 3) power 4) frequency

38) The core of transformer is laminated so that
1) ratio of voltage in the primary and secondary may be increased
2) energy losses due to eddy currents may be minimised
3) weight of transformer may be reduced
4) rusting may be prevented

A.C circuits:

39) In an AC circuit containing only capacitance the current
1) leads voltage by 180^0 2) lags the voltage by 90^0
3) leads the voltage by 90^0 4) remains in phase with the voltage

40) The value of induced emf in an LR circuit at break, as compared to its value at make will be
1) less 2) zero 3) some time less and some times more 4) nothing can be said

41) Assertion: A transformer can't work on d.c supply
Reason: d.c changes neither in magnitude nor in direction
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false 4)A is false but R is true

42) Assertion: Impedance of primary and secondary in a transformer is directly proportional to number of turns in these coils

Reason: More the turns, more is the resistance

a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false 4)A is false but R is true

43) Assertion: We use a thick wire in the secondary of a step down transformer to reduce the production heat

Reason: When the plane of the armature is parallel to the line of force of magnetic field, the magnitude of induced emf is maximum

a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false 4)A is false but R is true

44) Assertion: The rate of growth of current in an LR circuit decreases with increases of time till the current becomes steady

Reason: The rate of growth of current in an LR circuit is directly proportional to the excess of steady current over the instantaneous current

a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false 4)A is false but R is true

45) Assertion: The quantity L/R possesses dimension of time

Reason: To reduce the rate of increase of current through a solenoid, we should increase the time constant (L/R)

a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false 4) A is false but R is true

46) Assertion: In series LCR circuit, the resonance is equal and opposite to the capacitive reactance

Reason: At resonance the inductive reactance is equal and opposite to the capacitive reactance

a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A true but R is false 4) A is false but R is true

47) Assertion: In series LCR circuit, the resonance occurs at one frequency only

Reason: At resonance the inductive reactance is equal and opposite to the capacitive reactance

a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false 4) A is false but R is true

Transformer:

48) A step up transformer operates on a 230 V line and supplies a load 2A. The ratio of primary and secondary windings is 1:25. The primary current is

1) 50A 2) 100A 3) 12.5A 4) 8.8A

49) A transformer has an efficiency of 80% and works at 100V and 4KW. If the secondary voltage is 240V then primary and secondary currents are

1) 40A; 73.3A 2) 40A; 13.3A

3) 20A; 13.3A 4) 20A; 73.3A

50) An ideal transformer is used to step up an alternating emf of 220 V to 4.4KV to transmit 6.6KW of power. The current rating of the secondary is

1) 30A 2) 3A 3) 1.5A 4) 1A

51) In a transformer, the number of turns in the primary and secondary coils are 1000 and 3000 respectively. If the primary is connected across 80 V A.C, the potential difference across each turn of the secondary will be

1) 240 V 2) 0.24 V 3) 0.8 V 4) 0.08 V

52) A step up transformer operating on a 220 V line draws a current of 3A in the secondary. If the transformation ratio is 20, the output power is

1) 4400 W 2) 8800 W 3) 13200 W 4) 22000 W

53) A transformer having input voltage 110 V draws a primary current of 0.4A. If its output power is 33W, its efficiency is

1) 25% 2) 75%I 3) 80% 4) 85%5

54) Alternating voltage V = 400 sin (500πt) is applied the resistance 0.2KΩ. The rms value of current in ampere is

1) 1.414 A 2) 14.14 A 3) 0.1414 A 4) 2A

55) The instantaneous values of current and voltage in an A.C circuit are respectively

I = 4sinωt and E = 100 (ωt + $\frac{\pi}{3}$). The phase difference between voltage and current is

1) $\frac{7\pi}{6}$ 2) $\frac{5\pi}{6}$ 3) $\frac{\pi}{6}$ 4) $\frac{6\pi}{6}$

56) A capacitor of 10μF and an inductor of 1H are joined in series. An A.C of 50 Hz is applied to the combination. The impedance of combination is

1) 8.47Ω 2) 6.47Ω 3) 4.47Ω 4) 2.47Ω

57) The resonant frequency of a circuit of negligible resistance one inductance of 50 mH and a capacitance of 500*p* F is

1) $\frac{10^5}{\pi}$ Hz 2) $\frac{1}{\pi}$ Hz 3) $\frac{100}{\pi}$ Hz 4) $\frac{1000}{\pi}$ Hz

58) What is the resistance to be connected in series with a condenser of a capacity 5μF so that the phase difference between the current and the applied voltage is 45^0 when the angular frequency of the applied voltage is 400 $rads^{-1}$

1) 250Ω 2) 400Ω 3) 500Ω 4) 600Ω

59) The coils A and B are connected in series across a 240 V – 50 Hz supply. The resistance of A is 5Ω and the inductance of B is 0.02 H. The power consumed is 3 KW and power factor is 0.75. The impedance of the circuit is

1) 0.144Ω 2) 1.44Ω 3) 14.4Ω 4) 144Ω

60) A 100V alternating current of frequency 500 Hz is connected to L –C –R series circuit with L = 8.1 mH; C = 12.5μF and R = 10Ω. The potential difference across resistance is

1) 100V 2) 10V 3) 20V 4) 200V

61) A series L –C –R series circuit with 100Ω resistance is connected to an A.C source of 200V and angular frequency 300 rads^{-1}. When only the capacitor is removed, the current lags behind the voltage by 60^0. When only the inductor is removed, the current leads the voltage by 60^0. If all elements are connected, the current in the circuit is

1) 0.5A 2) 1.5A 3) 2A 4) 2.5A

62) In an L –C –R circuit having L = 8H, C = 0.5μF and R =100Ω in series, the resonance frequency in rads^{-1} is

1) $\frac{600}{\pi}$ 2) $\frac{250}{\pi}$ 3) 500π 4) 250π

Key

36) 3	37) 1	38) 2	39) 3	40) 2	41) 1	42) 4	43) 2	44) 1
45) 3	46) 4	47) 1	48) 1	49) 2	50) 3	51) 4	52) 3	53) 2
54) 1	55) 2	56) 3	57) 1	58) 3	59) 3	60) 1	61) 2	62) 2

<u>Previous Eamcet Questions</u>

1) A coil has 1000 turns and 500cm^2 as its area. The plane of the coil is placed at right angles to a magnetic induction field of 2x10^{-5}web/m^2. The coil is rotated through 180^0 in 0.2 seconds. The average e.m.f induced in the coil, in millivolts is [2003E]

1) 5 2) 10 3) 15 4) 20

2) Two coils have self inductance L_1 = 4mH and L_2 = 1mH respectively. The currents in the two coils are increased at the same rate. At a certain instant of time both the coils are given the same power. If i_1 and i_2 are the currents in the two coils, as that instant of time respectively, then the value of i_1/i_2 is [2003M]

1) 1/8 2) 1/4 3) 1/2 4) 1

3) The magnetic flux of 500 micro-webers passing through a 200 turn coil is reversed in 20x10^{-3} seconds. The average e.m.f induced in the coil in volts is [2004M]

1) 2.5 2) 5.0 3) 7.5 4) 10.0

4) An inductance 1H is connected in series with an A.C source of 220V and 50Hz. The inductive reactance (in ohms) is: [2005E]

1) 2π 2) 50π 3) 100π 4) 1000π

5) The inductance L (in mH) of the coil which is to be connected in series with a capacitor of 0.3pF to get an oscillatory frequency of 1MHz is:

1) 8.44 2) 84.4 3) 844 4) 8440 [2005M]

6) A small square loop of wire of side 'l' is placed inside a large square loop of side 'L' (L>>l). If the loops are coplanar and their centres coincide, the mutual induction of the system is directly proportional to [2006E]

1) $\frac{L}{l}$ 2) $\frac{l}{L}$ 3) $\frac{L^2}{l}$ 4) $\frac{l^2}{L}$

7) Assertion (A): When a conducting wire loop which is inside a uniform magnetic field directed perpendicular to its plane, is moving with uniform velocity, an emf is induced in it.

Reason (R): When the magnetic flux linked with a conducting wire loop changes with time an emf is induced in the cable. [2006M]

1) Both A and R are true and R is the correct explanation of A.
2) Both A and R are true but R is not the correct explanation of A.
3) A is true but R is false.
4) A is false but R is true.

8) A coil of 1200 turns and mean area of $500cm^2$ is held perpendicular to a uniform magnetic field of induction 4×10^{-4}T. The resistance of the coil is 20 ohms. When the coil is rotated through 180^0 in the magnetic field in 0.1 seconds the average electric current (in mA) induced is: [2006M]

1) 12 2) 24 3) 36 4) 48

9) The natural frequency of an L.C circuit is 1,25,000 cycles per second. Then the capacitor C is replaced by another capacitor with a dielectric medium of dielectric constant K. In this case, the frequency decreases by 25KHz. The value of K is

1) 3.0 2) 2.1 3) 1.56 4) 1.7 [2007E]

10) The emf induced in a secondary coil is 20000V when the current breaks in the primary coil. The mutual inductance is 5H and the current reaches to zero in 10^{-4}sec in the primary. The maximum current in the primary before it breaks is [2007M]

1) 0.1A 2) 0.4A 3) 0.6A 4) 0.8A

11) Two coils are wound on the same iron rod so that the flux generated by one passes through the other. The primary coil has N_p turns in it and when a current 2A flows through it the flux in it is 2.5×10^{-4}Wb. If the secondary coil has 12 turns the mutual inductance of the coil is (assume the secondary coil is in open circuit). [2007M]

1) 10×10^{-4}H 2) 15×10^{-4}H 3) 20×10^{-4}H 4) 25×10^{-4}H

12) A coil of 40H inductance is connected in series with a resistance of 8 Ω and this combination is connected to the terminals of a 2V battery. The inductive time constant of the circuit is (in seconds) [2007M]

1) 40 2) 20 3) 5 4) 0.2

KEY:

1) 2 2) 2 3) 4 4) 3 5)2 6) 4 7) 4 8) 2 9) 3 10) 2 11) 2 12) 3

Chapter 25
ELECTROMAGNETIC WAVES

- Maxwell theoretically predicted the existence of electromagnetic waves, involving fluctuating electric and magnetic fields that propagate through space. Maxwell calculated the speed of these waves to be identical with the measured value of the speed of light, $c = 3 \times 10^8$ m/s.
- Hertz first experimentally produced and detected electromagnetic waves in the laboratory. He demonstrated that these waves are transverse waves. Hertz also found the velocity of the electromagnetic waves to be close to 3×10^8 m/s, the value theoretically predicted by Maxwell.

- The basic mechanism for the production of electromagnetic waves is the acceleration of a charged particle. Any circuit carrying an alternating current radiates electromagnetic waves.
- Electromagnetic waves are transverse waves since the electric and magnetic fields are perpendicular to the direction of travel of the wave.
- Electromagnetic waves travel with the speed of light.

  For free space

$$c = \frac{1}{\sqrt{\mu_o \varepsilon_o}} = 2.99792 \times 10^8 \text{ m/s}$$

where $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N.m^2$ is the permittivity of free space, and

$\mu_o = 4\pi \times 10^{-7}\ N.s^2/C^2$ is the permeability of free space.

- The ratio of the electric to the magnetic field in an electromagnetic field equals the speed of light. That is

$$\frac{E}{B} = c$$

- Electromagnetic waves carry energy as they travel through space.

The average intensity of an electromagnetic wave,

$$S = \frac{1}{2}c\varepsilon_o E_{rms}^2 + \frac{c}{2\mu_o} B_{rms}^2$$

$$\text{or } S = c\varepsilon_o E_{rms}^2$$

$$\text{or } \bar{S} = \frac{c}{\mu_o} B_{rms}^2$$

- Electromagnetic waves transport momentum.

- Electromagnetic spectrum is the ordered series of the frequencies or wavelengths of the various types of electromagnetic waves. The different regions of the series are known by different names: radio waves, microwaves, infrared waves, visible light, ultraviolet light, X-rays and gamma rays.
- Radio waves are low-frequency electromagnetic waves, generally produced by charges accelerating through conducting wires, using electric oscillator circuits.

  Short wave band: higher frequencies up to 54 MHz.

  FM (frequency modulation) band: frequencies from 88 to 108 MHz.

  Radio waves find applications in Cochlear implants and radar gun.

- Microwaves have wavelengths between about 1 mm and 30 cm, and are usually generated using electron tubes called klystrons. Microwaves are used in microwave ovens, communications and radar.
- Infrared waves have wavelengths ranging from about 1 mm to the longest wavelength of visible light, 7×10^{-7}m, and are produced by hot objects. Infrared waves are used in ear thermometer, greenhouse effect, land navigation and infrared scan.

- Visible light forms the part of the electromagnetic spectrum that the human eye can detect, and is emitted by the rearrangement of excited electrons in atoms and molecules. The wavelengths range from about 3.8×10^{-7}m (violet) to 7.5×10^{-7}m (red). The eye's sensitivity is a maximum at a wavelength of about 5.6×10^{-7}m (yellow-green).
- Ultraviolet light falls in the region of wavelengths ranging from about 3.8×10^{-7}m down to 6×10^{-8}m, and can be produced from the discharge of an electric arc. The Sun also produces ultraviolet light. Ultraviolet radiation is used to kill germs and in tanning.

- *X-rays* are electromagnetic waves having wavelengths ranging from about 10^{-8}m to 10^{-13}m, and are produced when high-speed electrons suddenly decelerate after striking a metal target. X-rays are used in medical diagnosis, destroying cancerous cells, curing skin disease and detecting contraband in baggage.

- Gamma rays are electromagnetic waves of extremely short wavelengths, ranging from about 10^{-10}m to less than 10^{-14}m, and are emitted by radioactive nuclei and during certain nuclear reactions. Gamma rays, under controlled conditions, can be used to destroy cancerous cells.

- The Earth's atmosphere consists of various gaseous layers in which electromagnetic waves of different frequencies propagate in a variety of ways. The lowermost layer extending up to about 12 km from the surface of the Earth is called the troposphere. The next region from about 12 km to 50 km is called the stratosphere. The ozone layer is formed in this region extending from about 15 km to 30 km. The region from 50 km to about 80 km is the mesosphere. Above 80 km to the edge of the atmosphere is the thermosphere. The region from about 100 km to 400 km is called the ionosphere. Electrons and ions are present throughout the ionosphere.

- The atmosphere is transparent to visible light, but it absorbs most of the infrared waves from the solar radiation. The infrared radiation from the Earth is trapped in the lower atmosphere by the gases such as carbon dioxide and water vapour. This process leads to the phenomenon called the greenhouse effect, which keeps the Earth warm.
- The effect of the atmosphere on the propagation of radio waves having wavelength 10^{-3}m and higher is of great importance because of their direct relevance in all modern forms of communication: radio, television, microwaves etc.

- Early worldwide communications were developed in the low frequency region (frequencies less than 300 kHz). The principal mode of propagation of a signal in this low frequency region is via the direct wave (or space wave).
- Another mode of propagation, called the surface wave (or ground wave), allows the signal to go beyond the horizon, following the curvature of the Earth. Due to attenuation, the transmission via the ground wave is in practice possible for frequencies up to about 1500 kHz.
- The long-distance over-the-horizon communication is carried out by high frequency radio waves (frequencies from 3MHz to 30MHz) via the sky wave, which

results from reflection off the ionosphere. The lower atmosphere is more or less transparent to waves in this range.

- The sky wave mechanism has an upper limit of about 30 MHz, beyond which the ionosphere does not reflect back the wave. For the transmission of *TV* signals (100-200MHz), the only mechanism is the space wave propagation.
- The radio waves with frequencies higher than television signals are the microwaves. Nowadays, the artificial satellites are used for transmitting microwave signals from one point on the Earth to practically any other point on the Earth.

Problems

(1) The sunlight reaching the surface of the earth has an electric field whose rms value is 700N/c.the average total energy density of the electromagnetic wave is $\in_0 = 8.85\times10^{-12} c^2 / N-m^2$

( )

a) $8.6\times10^{-6} J/m^3$ b) $4.3\times10^{-6} J/m^3$

c) $2.2\times10^{-6} J/m^3$ d) $1.2\times10^{-6} J/m^3$

(2) An electromagnetic wave propagates in a ferrite material having dielectric constant 10 and relative permeability 1000. The speed of propagation is( )

a) $9\times10^{6} m/sec$ b) $6\times10^{6} m/sec$

c) $3\times10^{6} m/sec$ d) $12\times10^{6} m/sec$

(3) In a travelling electromagnetic wave, the electric field is represented a $E = E_0 \sin[(1.2\times10^{-10}/s)t.(2\times10^{-2}/m)x]$ the frequency of the wave is ( )

a) $1.9\times10^{9} Hz$ b) $3.8\times10^{18} Hz$

c) $5.4\times10^{18} Hz$ d) None

(4) A 60W bulb emits height unformally in all direction. For a point located 10m away from the bulb, the maximum values of the electric and magnetic fields in the light waves are

( )

a) $6V/m, 4.6\times10^{-7} T$ b) $9V/m, 8\times10^{-7} T$

c) $17V/m, 16\times10^{-7} T$ d) $24V/m, 50\times10^{-7} T$

(5) Frequency of an electromagnetic wave is 10MHz then its wavelength is( )

a) 3M b) 30M c) 300M d) 3000

(6) Velocity of E.M.Waves in paraffin is $2.07 \times 10^8 m/s$ the dielectric constant of paraffin is ( )

a) 2.10 b) 1.87 c) 1.45 d) 1.22

(7) Relation between peak electric field E_0 and the root square value of electric field is

a) $E_0 = \sqrt{3}E_{rms}$ b) $E_0 = \sqrt{2}E_{rms}$ c) $E_0 = \frac{E_{rms}}{\sqrt{2}}$ d) $E_0 = \frac{E_{rms}}{\sqrt{3}}$

KEY

1) b 2) c 3) a 4) a 5) b 6) a 7) b

1. A plane electromagnetic wave is incident on a material surface. The wave delivers momentum *p* and Energy *E*.
   (a) $p = 0$, E $\neq$ 0. (b) $p \neq 0$, E = 0
   (b) $p \neq 0$, E $\neq$ 0. (c) $p = 0$, E = 0.

2. Which of the following have zero average value in plane electromagnetic wave?
   (a) electric field (b) magnetic field
   (c) electric energy (d) magnetic energy

3. The energy contained in a small volume through which an electromagnetic wave is passing oscillates with
   (a) zero frequency (b) the frequency of the wave
   (c) half of the frequency of the wave
   (d) double the frequency of the wave

4. The sunlight reaching the earth has maximum electric field of 810 V/m. What is the maximum magnetic field in this light?

5. The magnetic field in a plane electromagnetic wave is given by

$B = (200\mu T) \sin [(4.0 \times 10^{15} s^{-1}0(t - x/c)]$

The maximum electric field and the average energy density corresponding to the electric field is

6. A laser beam has intensity 2.5×10^{14} W/m^2. Find the amplitude of electric and magnetic fields in the beam.
7. The intensity of the sunlight reaching the earth is 1380W/m2, Assume this light to be a plane, monochromatic wave. The amplitudes of electric and magnetic fields in this wave is

K E Y

1. (c) 2. (a) 3. (d) 4. 2.7 μT

5. 6×10^4N/C, 0.016J/m^3 6. 4.3×108 N/C, 1.44T
7. 1.02×10^3 N/C, 3.40×10^{-6}T

Chapter 26

DUAL NATURE OF RADIATION AND MATTER

- Work function of a metal is the minimum energy required to remove an electron from a metal surface. It depends on the properties of the metal and nature of the surface. It is generally expressed in eV (electron volt).
- One electron volt (1eV) is the energy acquired or lost by an electron in moving through an electrical potential difference of 1 volt. $1eV = 1.602 \times 10^{-19}$ J
- In thermionic emission, heat provides the energy required by an electron to escape from the metal.
- In field emission or cold emission, a strong electric field of the order of 10^8 volts per metre is applied at the surface to remove the electrons from the metal.
- In photoelectric emission, light of appropriate frequency is incident on the metal to eject the electrons from its surface.
- The photoelectric effect is a phenomenon in which electrons are liberated from the surface of a material when radiation of suitable frequency is incident upon it.
- The stopping potential is the minimum negative potential applied to the anode with respect to the cathode for which the photocurrent becomes just zero.

  For a particular frequency of incident light, the maximum kinetic energy (K_{max}) of the photoelectrons is related to the stopping potential V_o through the relation

  $$K_{max} = eV_o$$

- Photoelectric effect:
  (i) There exists a threshold frequency ν_o of the incident light, which depends on the material being illuminated, below which no electrons are emitted, no matter what the intensity of the incident light is, or for how long it falls on the surface.
  (ii) If the light frequency exceeds the threshold frequency, a photoelectric effect is observed and the number of photoelectrons emitted is proportional to the light intensity. However, the maximum kinetic energy of the photoelectrons is independent of light intensity.

(iii) The maximum kinetic energy of the photoelectrons increases linearly with increasing light frequency.

(iv) Photoelectric emission takes place from the surface almost instantaneously, with no detectable time delay (less than $10^{-9}s$ after the surface is illuminated), even at low light intensities.

- Classical wave theory cannot explain the photoelectric effect.
- Einstein explained that photoelectric emission results from the complete absorption of a photon of energy $h\nu$ by an electron in a metal. Einstein's photoelectric equation:

$$K_{max} = h\nu - \Phi_o$$

where K_{max} is the maximum kinetic energy of the electron, and Φ_o is the work function of the metal.

In terms of the threshold frequency ν_o and stopping potential V_o:

$$eV_o = h\nu - h\nu_o$$

- Einstein's theory of photoelectric emission was confirmed by Millikan's experiment.
- Photo-cells work on the principle of photoelectric effect. They are used for detection, recording and measurement of light intensities.
- Waves associated with material particles are called matter waves or de Broglie waves. The wavelength associated with a particle of mass m and velocity v is given by the de Broglie relation:

$$\lambda = h/mv$$

- The de Broglie wavelength for an electron accelerated from rest through a potential difference V is

$$\lambda = 1.227/\sqrt{V}\,\text{nm}$$

where V is in volts.

- C.J. Davisson and L. Germer verified the de Broglie relation and succeeded in measuring the wavelength of electrons by experiments involving the diffraction of electrons by crystals.
- Just like the electric field and magnetic field vary in light waves, the quantity whose variations make up in matter waves is called the **wave function**, denoted by ψ. The probability of experimentally finding a particle described by the wave function ψ at certain point is proportional to the value of ψ^2, called the **probability density**.

- Heisenberg uncertainty principle states that it is physically impossible to measure the exact position and exact momentum of a particle simultaneously. If Δx and Δp represent the uncertainties in the particle's position and momentum respectively, then

$$\Delta x \Delta p = h/4\pi$$

- An **electron microscope** uses a beam of electrons instead of light rays as in the optical microscope. These electrons are focused by electric or magnetic fields, much like the light rays are focused by glass lenses. The electron microscope, with its high order of magnification, great resolving power and increased depth of focus, is a powerful tool for many areas of modern research.

- Fundamental particles in nature are electron, neutron & proton
- Unit of energy of all fundamental particles is g*enerally expressed in electron volt (ev)*
  1ev = $1.6x10^{-19}$J or $1.6x10^{-12}$erg

Particle	Representation	Charge Value	Mass	Specific Charges
Proton (Hydrogen)	$_1H^1$	+1 unit	Unity	Unity
Electron	$_{-1}e^0$	-1 unit	$\frac{1}{1837}$ that of proton	1837
Neutron	$_0n^1$	zero	Unity	
Duetron	$_1H^2$	unit	2 units	$\frac{1}{2}$
α -particle (He – Nucleus)	$_2He^4$	+2 unit	4 units	$\frac{1}{2}$
Positron	$_{+1}e^0$	+1 unit	same as that of e^-	1837

- Cathode rays are produced when a p.d of about 10KV volt is applied between the two electrodes of a discharge tube in which the gas pressure has been reduced to below 0.1mm of Hg
- Cathode rays consist of a stream of fast moving negatively charged particles called the electrons

Properties:

- The value of specific charge (e/m) of cathode rays is constant ($1.7592x10^{11}$C/kg) and is independent of nature of gas and nature of material of cathode

Effect of Electric Field (Uniform on Charged Particle):

• Motion of charged particle in a longitudinal electric field

Acceleration $a = \frac{qE}{m} = \frac{qV}{md}$, under constant p.d $a \alpha \frac{q}{md}$

• KE acquired by particle $\frac{1}{2} mv^2 = qV$

• Motion of charged particle in a transverse electric field

• Velocity (v) of particle remains constant in perpendicular direction to the field

• Time taken by the charged particle to cross the electric field of length 'l' is $t = \frac{l}{v}$

• The displacement of the charged particle parallel to field E

$$y = \frac{1}{2} at^2 = \frac{1}{2} \frac{qE}{m} t^2 = \frac{qE\,l^2}{2\,m\,v^2} = \frac{q\,V\,l^2}{2\,m\,dv^2}$$

Effect of uniform Magnetic field on charged particle:

• When a charged particle having charge q, of mass m moving with velocity $\bar{v}$ is subjected to a force experienced by the particle $\bar{F} = q(\bar{v} \times \bar{B})$ (vector form)

• The speed, magnitude of momentum, angular momentum and kinetic energy of the particle remains constant.

• Trajectory is a circle, Radius of circle $r = \frac{mv}{qB} \left[\because \frac{mv^2}{r} = Bqv\right]$

• The direction of velocity and momentum of the charged particle continuously change and whose directions are always perpendicular to the direction of magnetic field

• Angular frequency $\omega = \frac{qB}{m}$, magnitude of momentum p = Bqr

Kinetic energy $K.E = \frac{p^2}{2m} = \frac{B^2q^2r^2}{2m}$

• Maximum centripetal force or magnetic force $F = Bqv = Bqr(2\pi r) = Bqr\omega$

Determination of e/m electron – Thomson's method:

• If the electric and magnetic fields are choosen so that the cathode ray beam remains undeflected, then Force due to magnetic field = force due to electric field

• $Bev = eE \Rightarrow v = \frac{E}{B}$

• If "V" is the potential difference between the cathode and anode, through which the cathode ray particles each of mass "m" are accelerated, then by work energy theorem

$$V \times e = \frac{1}{2} mv^2, \quad \frac{e}{m} = \frac{E^2}{2VB^2}$$

Millikan's Oil Drop Experiment:

- Millikan determined the charge of an electron by using the oil drop method
- When the oil drop falls under gravity, it experiences three forces
- The resultant downward force $F = F_g - F_B - F_V$
- As the oil drop accelerates downwards, its velocity increases and hence viscous force increases. When the velocity increases to a particular value V_g, the viscous force increases to such a value that F becomes zero. V_g is called terminal velocity

$\Rightarrow F_g - F_B = F_V$

When an uniform electric field E is applied the oil drop experiences

1) Weight F_g downwards 2) Buoyant force F_B upwards
3) Electrostatic force $F_E = Eq$ upwards 4) Viscous force F_V

- If the oil drop moves upwards, then $F = F_E + F_B - F_g - F_V$
- IF V_e is the terminal velocity, then $F_E = (F_g - F_B) + F_V$

$q E = 6\pi\eta r v_g + 6\pi\eta r v_e = 6\pi\eta r (V_g + V_e)$

- An oil drop of charge q_0 falls freely under gravity with a terminal velocity v. It is held stationary in an electric field. Then $mg = Eq_0 = 6\pi\eta r v$
- After picking up an additional charge the total charge is q and it moves up with a terminal velocity v, $Eq = mg + 6\pi\eta r v V = 2mg \Rightarrow q = 2q_0$

Excess charge acquired $= q - q_0 = q_0$

- After picking up additional charge if the drop moves with a terminal velocity nV, then

$q = (n + 1) q_0$

Photo Electric Effect:

- Discovered by Hertz and explained by Einstein
- When light of suitable frequency or wavelengths falls on certain alkali metals, electrons are released from the metal. This phenomenon is called photoelectric effect
- Intensity effect: For a given metal, rate of emission of photoelectrons, i.e., photo current is directly proportional to the intensity of incident radiation for a given light
- Frequency effect: For a given metal, maximum kinetic energy of photoelectrons varies linearly with the frequency of incident radiation and is independent of its intensity
- Effect of nature of metal: If light of different frequencies in turn is incident on a given metal, photoelectric effect takes place only if the frequency of incident radiation is more than a specific value ϑ_0. This specific value of frequency (ϑ_0) is called threshold frequency.
- Stopping Potential: The minimum negative potential to be applied to the collector to just stop the electrons reaching it is called stopping potential (V_S)
- Maximum K.E of the electron emitted: It is equal to the product of stopping potential (V_S) and electron charge (e). That is, $K_{max} = eV_S$
- K.E of electron increases with the frequency of the incident radiation, but independent of the intensity of incident radiation

- Einstein's photoelectric equation: $h\nu = W + \frac{1}{2} mv^2_{max} = W + K_{max} = W + eV_S$The K.E of the emitted electron $\frac{1}{2} mv^2 = h(\vartheta - \vartheta_0) = hc\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$
- Energy of Photon in eV : E = $\frac{12400}{\lambda(\text{in Angstom Units})}$ in eV
- Work function in eV: W = $\frac{12400}{\lambda_0(\text{in Angstom Units})}$ in eV
- The stopping potential depends on frequency of incident light, work function of the metal and independent of the intensity of the incident radiation
- The graph between stopping potential (V_S) and incident frequency (ν) is a straight line with slope $\frac{h}{e}$ the intercept on x –axis gives v_0 the intercept on the negative side of Y axis gives $\frac{W}{e}$

Dual Nature of Matter De Broglie's Hypothesis:

- According to deBroglie matter should be exhibit dual nature just like the radiation. This means matter behaves both as particles and waves
- A moving particle behaves sometimes as a wave and sometimes as a particle. The waves are called deBroglie waves or matter waves. The wavelength associated with matter wave is called deBroglie wavelength
- Energy of a photon of frequency υ is $E_2 = h\vartheta = \frac{hC}{\lambda}$
- Energy of a photon of mass m moving with velocity C is $E_2 = mc^2$
- $\lambda = \frac{h}{mv} = \frac{h}{p}$ is the deBroglie wavelength
- When a particle of charge q and mass m is accelerated through a potential difference V then $\lambda = \frac{h}{\sqrt{2mqV}}$
- For an electron $\lambda \approx \frac{12.27}{\sqrt{V}} A^0 \approx \sqrt{\frac{150}{\nu} A^0}$ for a photon $\lambda = \frac{0.286}{\sqrt{V}} A^0$

Question Bank:

Conceptual Question:

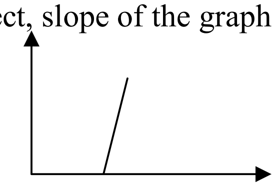
Change in electric and magnetic fields:

1) Cathode rays enter a magnetic field at an angle of 30^0 to the lines of force. Then their path in the magnetic field will be
   1) Helix 2) Parabola 3) Ellipse 4) Circle
2) The specific charge is least for
   1) α -particle 2) Proton 3) Positron 4) Positive meson
3) Millikan oil drop experiment is based on
   1) Coloumb's law 2) Stoke's law 3) Wien's law 4) Newton's law

Photoelectric effect:

4) The least energy required to eject an electron from an atom is called
   1) K.E 2) Electrical energy 3) Work function energy 4) Chemical energy
5) Work function is the energy required
   1) to produce X –rays 2) to excite an atom
   3) to explore an atom 4) to eject an electron just out of the surface
6) The maximum number of photoelectrons released in a photocell is independent of:
   1) nature of the cathode surface 2) frequency of incident ray
   3) intensity of radiations incident on cathode surface 4) none of the above
7) If the frequency of light in a photoelectric experiment is doubled, the stopping potential will
   1) be doubled 2) be halved 3) become more than double 4) become less than double
8) The K.E of photoelectrons depends on
   1)Intensity of incident light
   2) The difference between the frequency of the incident light and the threshold frequency
   3) The sum of frequency of incident light and threshold frequency
   4) The ratio of frequency of light used and threshold frequency
9) In photoelectric effect, slope of the graph given below gives

Stopping Potential



Frequency of incident light

   1) charge on the electron 2) plank's constant 3) work function of emitter 4) h/e
10) Photoelectric cell is a device to
   1) Measure light intensity 2) Store photons

3) Convert photon energy into mechanical energy

   4) Store electrical energy for replacing storage batteries
11) A photoelectric cell converts light energy into electrical energy by:
   1) developing an emf 2) decreasing resistance

3) ejecting photoelectrons   4) ejecting thermionic electrons

True or False Type Questions:

12) Consider the following statements A and B and identify the correct choice given in the answer:
   A) In photovoltaic cells the photo electric current produced is not proportional to the intensity of incident light
   B) In gas filled photo emissive cells, the velocity of photoelectrons depends on the wavelength of the incident radiation
   1) Both A & B are true   2) Both A & B are false
   3) A is true but B is false   4) A is false but B is true
13) Consider the following two statements A & B and identify the correct answer
   A) X –rays are produced when energetic electrons are suddenly stopped by a metal
   B) If the frequency of light incident on a metallic plate be doubled, the kinetic energy of the emitted electrons is also doubled
   1) Both A & B are true   2) A is true but B is false
   3) A is false but B is true   4) Both A & B are false
14) Consider the following two statements A & B and identify the correct choice in the given answer:
   A) The characteristic X –ray spectrum depends on the nature of the material of the target
   B) The short wavelength limit of continuous X –ray spectrum varies inversely on the potential difference applied to the X –ray tube
   1) A is true but B is false   2) A is false but B is true
   3) Both A & B are true   4) Both A & B are false
15) Consider the following statements A & B and identify the correct choice in the given answers.
   A) Tightly bound electrons of target material scatterer X –ray photon, resulting in the Compton effect
   B) Photo electric effect takes place with free electrons
   1) Both A & B are true   2) A is true but B is false
   3) A is false but B is true   4) Both A & B are false

Assertion & Reason Type Questions:

Directions: These questions consists of two statements as Assertion and Reason. While answering these questions you are required to choose any of the following four responses.

A) If both A & R are true and R is the correct explanation of A
B) If both A & R are true and R is not the correct explanation of A
C) A is true but R is false
D) A is false but R is true

16) Assertion: Work function of copper is greater than that of sodium. But both will have same value of threshold frequency and threshold wavelength

Reason: The frequency is inversely proportional to wavelength
1) A 2) B 3) C 4) D

17) Assertion: The Kinetic energy of the emitted photo-electrons changes only with a change in the frequency of the incident radiations
Reason: The Kinetic energy of photo –electrons emitted by a photo-sensitive surface depends upon the intensity of the incident radiation
1) A 2) B 3) C 4) D

18) Assertion: On increasing the frequency of light larger number of photoelectrons are emitted
Reason: The number of electrons emitted depends on the intensity of incident light
1) A 2) B 3) C 4) D

19) Assertion: Characteristic X –ray spectrum depends on the nature of the material of the target
Reason: Characteristic X –rays are emitted when the electrons in the target shift from lower to higher orbits of the atom
1) A 2) B 3) C 4) D

20) Assertion: In the Compton effect, the wavelength shift of the incident radiation is independent of the nature of the scattering material
Reason: The Compton wavelength shift depends only upon the scattering angle
1) A 2) B 3) C 4) D

Key

1)1	2)1	3)2	4)3	5)4	6)2	7)3	8)2	9)4	10)1
11)1									
12)4	13)2	14)3	15)4	16)4	17)3	18)4	19)3	20)1	

Numerical Question:

1) A proton, duetron and α -particle with the same kinetic energy enter a region of uniform magnetic field at right angles to the field. Compare the radii of their circular paths
1) $1:\sqrt{2}:1$ 2) $\sqrt{2}:1:\sqrt{2}$ 3) $1:\sqrt{2}:\sqrt{2}$ 4) $1:1:\sqrt{2}$

2) Two metal plates having a P.D of 800V are 0.02m apart horizontally. A particle of mass $1.96x10^{-15}$Kg suspended in equilibrium between the plates. If 'e' is the elementary charge, then on the particle is
1) e 2) 3e 3) 6e 4) 8e

3) An electron and a proton enter at right angles into a uniform electric field E then the radius of the circular path of the particle is approximately
1) 1:1 2) $1:\sqrt{1837}$ 3) $\sqrt{1837}:1$ 4) $1:\sqrt{2}$

4) In Thomson's experiment, electrons accelerated through 2500V enter the region of crossed electric and magnetic fields of strengths $36x10^{4}$V/m and $1.2x10^{3}$T and pass through undeflected. Then the specific charge of electron will be
1) 10 2) 12 3) 16 4) 18

5) r is the radius of the circular path of a charged particle in uniform magnetic field. If the energy of the particle is doubled, then radius of the circular path will be

1) $\sqrt{2}$ r 2) $\frac{r}{\sqrt{2}}$ 3) r 4) $\frac{r}{2}$

6) An oil drop of radius r and charge q is held in equilibrium between the plates of a charged parallel plate capacitor when the p.d is V. To keep a drop of radius 2r and with a charge 2q in between the plates, the p.d will be

1) V 2) 2V 3) 3V 4) 4V

7) Cathode rays moving with 10^6m/s describe an approximate circular path of radius 1m in an electric field of 400 V/cm. If the velocity of cathode rays is doubled, find the field needed so that the rays describe the same circular path

1) 800V/cm 2) 1600V/cm 3) 1200V/cm 4) 2400V/cm

8) A beam of electrons enter at right angles to a uniform electric field with $3x10^7$m/s. E = 1800V/m while travelling through a distance of 10cm. The beam deflected by 2mm, then specific charge of electrons is

1) $2x10^{10}$C/kg 2) $2x10^9$C/kg 3) $2x10^{11}$C/kg 4) None

9) An α -particle of mass $6.65x10^{-27}$kg travels at right angles to a field of 0.2T with a speed of $6x10^5$m/s, then its acceleration is

1) $5.77x10^{10}m/s^2$ 2) $5.77x101^{-10}m/s^2$ 3) $6.7x10^{12}m/s^2$ 4) $5.77x10^{12}m/s^2$

10) A stream of electrons moving with a velocity of $8x10^7$m/s passes between the condenser plates between which an electric field of $2x10^3$V/m. Find the strength of the magnetic field required to keep the electrons undeflected

1) 0.025mT 2) 2.5mT 3) 0.025mT 4) 0.0025mT

11) Proton and α -particle are accelerated by the same potential difference (V). The ratio of velocities acquired by them is

1) 1: $\sqrt{2}$ 2) $\sqrt{2}$:1 3) 1: $\sqrt{3}$ 4) $\sqrt{3}$:1

12) An α -particle accelerated through V volt is projected towards a nucleus. Its distance of closest approach is r. If a proton accelerated through the same potential is fired towards the same nucleus, the distance of closest approach of proton will be

1) r 2) 2r 3) 3r 4) 4r

13) An electron moving with velocity $2x10^7$m/s describes a circle in a magnetic field of strength $2x10^{-2}$Tesla. If e/m of electron is $1.76x10^{11}$C/kg, then the diameter of the circle in nearly

1) 1.1mm 2) 1.1cm 3) 1.1m 4) 11cm

14) An α particle and a proton are accelerated from rest through potential differences in ratio 2:1. Find the ratio of the velocities acquired

1) 1:2 2) 1: $\sqrt{2}$ 3) 1:1 4) $\sqrt{2}$:1

Millikan's oil drop experiment:

15) In the absence of electric field, an oil drop falls freely under gravity through 2mm in 40sec. The coefficient of viscosity of air is $1.8x10^{-5}$pa.sec. Density of oil is $880kg/m^3$. Then find the radius of the drop [Ignore buoyancy] {$g = 10m/s^2$}

1) $0.68x10^{-6}\mu m^2$ 2) $6.8\mu m^2$ 3) $0.68\mu m^2$ 4) $68\mu m^2$

16) In Millikan's experiment, oil drop falls freely under gravity with a terminal velocity 'v'. If it is held floating in air in an electric field, it has two electronic charge. It is observed that the same drop suddenly moves up with a terminal velocity 'v' after picking up some charge. Find the excess charge gained by it

1) e 2) 2e 3) 3e 4) 4e

17) A drop of radius 10^{-6}m carries a charge of 4 times the electric charge, density of the drop is $2000kg/m^3$. Find the p.d which must be applied across the plates in millikan's experiment inorder to make the drop floating if the plates are separated by 5mm

1) 650V 2) 654V 3) 651V 4) 652V

18) An oil drop of radius 10^{-6}m carrying certain charge in balanced in an electric field applied between the plates separated by 5mm. Density of the oil is $2400kg/m^3$. If the p.d applied between the plates is 200π volt, find the charge on the drop

1) $8x10^{-10}$C 2) $8x10^{-19}$C 3) $9x10^{-19}$C 4) $9x10^{-10}$C

19) In a Millikan oil drop apparatus an oil drop of radius $6x10^{-7}$M and density $0.85x10^3kg/m^3$ is seen to fall freely without any field. Then find the viscosity of air if the velocity of the drop is $36.45x10^{-6}$m/s. (Neglect the effect of upthrust force due to air)

1) $1.8x10^{-5}N-sec/m^2$ 2) $1.9x10^{-5}N-sec/m^2$ 3) $1.8x10^{-4}N-sec/m^2$ 4) None

20) A charged oil drop is falling freely under gravity in the absence of electric field with a velocity 'v'. It is held stationary in an electric field. As it acquires a charge it moves

1) q 2) 2q 3) 3q 4) 4q

21) A charged oil drop falls with a terminal velocity V in the absence of electric field. An electric field E keeps the oil drop stationary in it. When the drop acquires a charge 'q' it moves up with same velocity. Find the initial charge on the drop

1) $\frac{q}{2}$ 2) $\frac{q}{4}$ 3) 3q 4) q

Photo electric effect:

22) Light of wavelength $2200A^0$ falls on a metal surface. If 4.1eV energy is required to remove the electron, find the stopping potential

1) 5.63eV 2) 1.53eV 3) 6.04eV 4) 5.63eV

23) A radiation of wavelength $5400A^0$ falls on a metal with work function 1.9eV. Find the energy of photo electrons emitted

1) 0.4eV 2) 2.3eV 3) 0.4V 4) 2.3V

24) What p.d should be applied to stop the fastest photo electrons emitted by the surface if work function 5eV under the action of U.V rays of wavelength $1500A^0$

1) 8.267V 2) 13.267V 3) 3.26V 4) None

25) Wavelength of light incident on a photo cell is $3000A^0$. If stopping potential is 2.5V, then work function of the cathode of photo cell is

1) 1.41eV 2) 1.52eV 3) 1.56eV 4) 1.64eV

26) When a metal surface is illuminated with a light of wavelength λ, the stopping potential for photo current is $3V_0$. When the same surface is illuminated with a light of wavelength 2λ, stopping potential is V_0. Then find the threshold wavelength

1) λ 2) 2λ 3) 3λ 4) 4λ

27) The threshold frequency of metal is V_0. When a light of frequency $4V_0$ is incident on metal then find $K.E_{max}$ of emitted electrons

1) $2v_0 h$ 2) $3v_0 h$ 3) $4v_0 h$ 4) $v_0 h$

28) Light of frequency of 1.5 times threshold frequency is incident on a photo metal. If the frequency is halved and intensity is doubled, the photocurrent becomes

1) 1A 2) zero 3) 2A 4) 3A

29) For a certain metal, for incident radiation of frequency $2v_0$, electrons come out with a maximum. Velocity $4x10^8$m/s. If the value of incident radiation is $5v_0$, the maximum velocity of photo electrons will be ----- if v_0 is threshold frequency

1) $8x10^8$m/s 2) $2x10^8$m/s 3) $4x10^8$m/s 4) $6x10^8$m/s

30) A reverse voltage of 2.5V is required to reduce the photo current to zero when light of wavelength $4000A^0$ strikes a metal plate. Find the maximum. Kinetic energy of electrons emitted if $hC = 2x10^{-25}$ Jm

1) $2.5x10^{-19}$J 2) $4x10^{-19}$J 3) $4x10^{19}$J 4) 2.5eV

31) Find the maximum K.E of photo electrons form the surface of a metal when it is irradiated with light of wavelength $1800A^0$, threshold wavelength is $2300A^0$

1) 1eV 2) 1.25eV 3) 1.75eV 4) 1.5eV

32) The work functions of metals A& B are in the ratio 1:2. If light of frequencies f & 2f are incident on A & B respectively, the ratio of maximum K.E of electrons is

1) 1:1 2) 1:2 3) 2:1 4) 2:3

33) The minimum intensity of light to be detected by the human eye is $10^{-10}W/m^2$. The number of protons of wavelength $5.6x10^{-7}$m entering the eye pupil area $10^{-6}m^2$ per second for vision is nearly

1) 28 2) 280 3) 2800 4) 28000

34) U.V radiation of wavelength 250nm and intensity $5W/m^2$ is incident on a metal of work function 3.2eV. The maximum energy of the emitted photo electrons will be

1) 3.2eV 2) 5.0eV 3) 1.8eV 4) 2.5eV

35) In the above problem, if only 1% of the incident photon emit the electrons find the number of electrons emitted per second per unit area will be

1) $6.25x10^{16}$ 2) $6.25x10^{18}$ 3) $6.25x10^{20}$ 4) $6.25x10^{14}$

36) Photo electric emission is observed from a metallic surface for frequencies v_1 and v_2 of the incident light ($v_2>v_1$). If the maximum value of K.E of the photo electrons emitted in these two cases are in the ratio 1:K. Then find the threshold frequency of the metal surface

1) $\frac{K v_1 + v_2}{K+1}$ 2) $\frac{K v_1 - v_2}{K+1}$ 3) $\frac{K v_2 - v_1}{K-1}$ 4) $\frac{K v_1 - v_2}{K-1}$

37) The threshold frequency of a metal is $4.8x10^{16}$Hz. Find the stopping potential if it is irradiated by a light of frequency $5.6x10^{16}$Hz (h = $6.6x10^{-34}$Js)
1) $5.28x10^{-18}$V 2) 33V 3) 330V 4) 3.3V

38) Work function of a metal is 2.1eV which of the waves of the following wavelength will be able to emit photoelectrons from its surface?
1) $4000A^0$, $7500A^0$ 2) $4000A^0$, $6000A^0$
3) $5500A^0$, $6000A^0$ 4) $5500A^0$, $7500A^0$

39) Threshold wavelength for a metal having work function W_0 is λ. What is the threshold wavelength for the metal having work function $2W_0$?
1) 4λ 2) $\frac{\lambda}{2}$ 3) 2λ 4) $\frac{\lambda}{4}$

40) A source of light is placed at a distance of 1m from a photo cell and cut off potential is found to be v_0. If the distance is doubled, the cut off potential will be
1) $2v_0$ 2) v_0 3) $\frac{v_0}{2}$ 4) $\frac{v_0}{4}$

41) Light from a hydrogen discharge tube is incident on the cathode of a photoelectric cell. The work function of the cathode surface is 3.8eV. Inorder to reduce the photoelectric current to zero the voltage of anode relative to cathode must be made
1) 3.8V 2) –9.8V 3) –17.4eV 4) 9.8V

42) A body of mass 100gm is moving with 10m/s. Find the de –Broglie wavelength associated with it (h = plank's constant)
1) h 2) $\frac{h}{2}$ 3) 2h 4) 3h

43) Find the de –Broglie wavelength of an electrons with a kinetic energy of 10eV
1) 3.8m 2) $3.8A^0$ 3) 3.8cm 4) 3.8mm

44) Find the velocity and kinetic energy of neutron having de –Broglie wavelength $1A^0$
1) $1.31x10^{-21}$J 2) $13.1x10^{-21}$J 3) $131x10^{-21}$J 4) None

45) Find the de –Broglie wavelength of helium atom at 27^0C and 1 atmospheric pressure (h = $6.6x10^{-34}$ j –sec) {Boltzmann constant K = $1.38x10^{-23}$*j/mol/K*}
1) $0.826x10^{-10}$m 2) $0.526x10^{-9}$m 3) $0.726x10^{-10}$m 4) None

46) The de –Broglie wavelength of a neutron at 27^0C is λ. What will be its wavelength at 927^0C?
1) $\frac{\lambda}{2}$ 2) $\frac{\lambda}{3}$ 3) $\frac{\lambda}{4}$ 4) 4λ

47) A photon when accelerated through a p.d of V volts has a wavelength λ associated with it. An α -particle inorder to have same λ must be accelerated through a p.d of
1) V volt 2) 4V volt 3) 2V volt 4) $\frac{V}{8}$ volt

Key

1)1	2)2	3)2	4)4	5)1	6)4	7)2	8)3	9)4	10)1
11)2	12)1	13)2	14)3	15)1	16)2	17)2	18)2	19)1	20)4
21)1	22)2	23)1	24)3	25)4	26)4	27)2	28)2	29)1	30)2
31)4	32)2	33)2	34)3	35)1	36)4	37)2	38)2	39)2	40)2
41)2	42)1	43)2	44)2	45)3	46)1	47)4			

Previous Eamcet Question:

1) Two ions having masses in the ratio 1:1 and charges 1:2 are projected into uniform magnetic field perpendicular to the field with speeds in the ratio 2:3. The ratio of the radii of circular paths along which the two particles move is (2003 M&E)
   1) 4:3 2) 2:3 3) 3:1 4) 1:4
2) When radiation of wavelength λ is incident on a metallic surface, the stopping potential is 4.8 volts. If the same surface is illuminated with radiation of double the wavelength, then the stopping potential becomes 1.6 volts. Then the threshold wavelength for the surface is (2003E)
   1) 2λ 2) 4λ 3) 6λ 4) 8λ
3) The de –Broglie wavelength of a particle moving with a velocity $2.25 x 10^3 ms^{-1}$ is equal to the wavelength of a photon. The ratio of kinetic energy of the particle to the energy of the photon is [velocity of light = $3x10^8 ms^{-1}$] (2003M)
   1) $\frac{1}{8}$ 2) $\frac{3}{8}$ 3) $\frac{5}{8}$ 4) $\frac{7}{8}$
4) $\Delta\lambda$ is the difference between the wavelength of K_α line and the minimum wavelength of the continuous X –ray spectrum when the X –ray tube is operated at a voltage V. If the operating voltage is changed to $\frac{V}{3}$, then the above difference is $\Delta\lambda^1$. Then
   1) $\Delta\lambda^1 = 5\Delta\lambda$ 2) $\Delta\lambda^1 = 4\Delta\lambda$ 3) $\Delta\lambda^1 = 3\Delta\lambda$ 4) $\Delta\lambda^1 < 3\Delta\lambda$ (2004E)
5) Electrons ejected from the surface of a metal, when light of certain frequency is incident on it, are stopped fully by a retarding potential of 3 volts. Photoelectric effect in this metallic surface begins at a frequency $6x10^{14} s^{-1}$. The frequency of the incident light in s^{-1} is [Plank's constant = $6.4x10^{-34}$J –sec; charge on the electron = $1.6x10^{-19}$C]
   1) $7.5x10^{13}$2) $13.5x10^{13}$ 3) $13.5x10^{14}$ 4) $7.5x10^{15}$ (2004E)
6) K_1 and K_2 are the maximum kinetic energies of the photoelectrons emitted when light of wavelengths λ_1 and λ_2 respectively are incident on a metallic surface.
   If $\lambda_1 = 3\lambda_2$, then (2004M)
   1) $K_1 > \frac{K_2}{3}$ 2) $K_1 < \frac{K_2}{3}$ 3) $K_1 = 3K_2$ 4) $K_2 = 3K_1$
7) A particle of mass 10^{-26}kg and charge $1.6x10^{-18}$C travelling with a velocity $1.28x10^6 ms^{-1}$ along positive X –axis enter a region of electric field and magnetic field. (2005E)

If $E = -102.4x10^2$ k N/C and $B = 8x10^{-2}$j Wbm^{-2} the direction of motion of particle is
1) along positive X –axis 2) along negative X –axis
3) at 45^0 to the positive X –axis 4) at 135^0 to the positive X –axis

8) The de-Broglie wavelength of an electron and the wavelength of a photon are same. The ratio between energy of photon and momentum of electron (2006M)
1) h 2) C 3) 1/h 4) 1/C

9) A oil drop having mass $4.8x10^{-10}$gm and charge $2.4x10^{-18}$C stands still between two charged horizontal plates separate by a distance of 1cm. If polarity of plates is changed acceleration of a drop is $g = 10m/s^2$ (2006E)
1) 5 m/s^2 2) 10 m/s^2 3) 20 m/s^2 4) 40 m/s^2

10) A proton and deuteron and an α particle with same kinetic energy enter a region of uniform magnetic field moving at right angles the ratio of radii of circular paths is
1) 1:2:4 2) 1: $\sqrt{2}$:1 3) 2: $\sqrt{2}$:1 4) 1:1:2

11) An electron beam travels with a velocity of $1.6x10^7$m/s perpendicularly to magnetic field of intensity 0.1T. The radius of path of electron beam is ($m = 9x10^{-31}$kg)
1) $9x10^{-3}$m2) $9x10^{-2}$m 3) $9x10^{-4}$m 4) $9x10^{-5}$m (2007E)

12) The work function of nickel is 5 eV. When a light of wavelength $2000A^0$ falls on it, it emits photoelectrons in the circuit. Then the potential difference necessary to stop emitted electrons is (2007E)
1) 1V 2) 1.75V 3) 1.25V 4) 0.75V

KEY

1)1	2)2	3)2	4)4
5)3	6)2	7)1	8)2
9)3	10)2	11)3	12)3

Chapter 27

ATOMS

1. J.J. Thomson proposed a structure for the atom.
2. Rutherford and then Niel Bohr modified the structure of atom proposed by Thomson.
3. Rutherford $\propto$ −particlescattering experiment established the existence of nucleus.
4. The distance of closest approach, gives an estimate of the size of the nucleus.
5. Rutherford's atom model could not explain the stability of the atom and the line spectrum of atoms.
6. Bohr suggested a new model of atoms to account for the stability of the atom and emission of line spectra by the atoms.
7. Bohr postulated that the electrons can revolve only in certain non-radiating orbits for which $mvr = \frac{nh}{2\pi}$.
8. Non-radiating orbits are called stationary orbits.
9. Stationary orbits of electrons are not equally spaced.
10. The radius of first orbit of hydrogen atom is called Bohr's radius.
11. The total energy of an electron in an orbit is equal to the negative of the K.E in that orbit.
12. Ionisatom potential for a given element is fixed but for different elements, Ionisation potentials are different.
13. Ionisation potential of H-atom = 13.6V.
14. Impact parameter of the $\propto -$ particle is defined as the $\perp^r$ distance of the velocity vector of the $\propto -$ particle from the centre of the nucleus, when it is far away from the atom.
15. Wave number is the number of complete waves in unit length.
16. Ground states is defined as the energy state of electron corresponding to n = 1.
17. The energy slates of electrons corresponding to n = 2, 3 .... Are called excited states.
18. Excitation energy required, so as to raise an electron from its ground state to an excited.

19. Ionisation is the process of knocking an electron out of the atom.

20. Ionisation energy is defined as the energy required to knock an electron completely out of the atom.

IMPORTANT FORMULAE

1. Distance of closest approach $r_0 = \frac{1}{4\pi\varepsilon_0} \times . \frac{2Ze^2}{\frac{1}{2}mv^2}$

2. Impact parameter $b = \frac{1}{4\pi\varepsilon_0} \times . \frac{Ze^2 \cot\theta/2}{\frac{1}{2}mv^2}$

3. Bohr's quantization condition $mvr = \frac{nh}{2\pi}$

4. Bohr's frequency condition $hv = E_i - E_f$

5. Radius of Bohr's n^{th} orbit is $r_n = 4\pi\varepsilon_0 \frac{n^2h^2}{4\pi^2 me^2}$

6. Speed of an electron revolving in n^{th} orbit is given by $v_n = \frac{1}{4\pi\varepsilon_0} \frac{2h\pi e^2}{nh}$

7. Rydberg constant $v_n = \left(\frac{1}{4\pi\varepsilon_0}\right)^2 \frac{2\pi^2 me^4}{ch^3}$

8. Energy of electron in n^{th} orbit, $E_n = -\left(\frac{1}{4\pi\varepsilon_0}\right)^2 \frac{2\pi^2 me^4}{n^2 h^2}$

9. Energy of radiation emitted $E = \left(\frac{1}{4\pi\varepsilon_0}\right)^2 \frac{2\pi^2 me^4}{h^2} \frac{1}{n_f^2} - \frac{1}{n_i^2}$

10. Ionisaton potential $= \frac{\text{Ionisation energy}}{e}$

11. Excitation potential potential $= \frac{\text{Excitation energy}}{e}$

12. The impact parameter related to angle of scatting is given by

$$b = \frac{1}{4\pi\varepsilon_0} \times \frac{Ze^2}{\left(\frac{1}{2}mv^2\right)} \cot\theta_2$$

13. Wavelength limits of some spectral series of hydrogen.

Sl.No.	Spectral series	Longest wavelength λ max Å	Shortest wavelength λ min Å
1.	Lyman	1216	912
2.	Balmer	6563	3646
3.	Paschen	18751	8220
4.	Brackett	40514	14585
5.	Pfund	74583	22789

(1) The wavelength of the first time in the balmer series of hydrogen spectrum is( )

a) $6561A^o$ b) $5561A^o$ c) $4561A^o$ d) $3561A^o$

(2) The Shortest wavelength of the bracket series of the hydrogen spectrum is)

a) 13377^oA b) $14577A^o$ c) 16515A d) 17577A

(3) A hydrogen atom is exited from n=1 to n=3 state the amount of energy absorbed by the atom will be ( )

a) 12.7ev b) 25ev c) 13.6ev d) -13.6pv

(4) According to Bohr hypothsis, which of the following is discrete? ( )

a) Momentum b) angular velocity

c) potential energy d) Angular momentum

(5) The ratio of minimum wavelength of Lyman and Balmer series will be( )

a) 1.25 b) 0.25 c) 5 d) 10

(6) The Energy of an electron in excited hydrogen atom is -3.4eV. then according to Bohr's Theory the angular momentum of the electrons is( )

a) $2.11 \times 10^{-34} JS$ b) $3 \times 10^{-34} JS$

c) $2 \times 10^{-34} JS$ d) $0.5 \times 10^{-34} JS$

(7) In the following transitions , which one has higher frequency ( )

a) $4 \rightarrow 2$ b) $3 \rightarrow 1$ c) $4 \rightarrow 3$ d) $3 \rightarrow 2$

(8) If in an atom electron are filled up to quantum number n=4, the total number of electrons in the atom will be ( )

a) 30 b) 60 c) 32 d) 70

(9) Minimum energy required to take out the only one electron from ground state of He+ is ( )

a) 13.6eV b) 54.4eV c) 27.2eV d) 6.8eV

(10) In Bohr's model of Hydrogen , the ratio of K.E to total energy is ( )

a) 1 b) -1 c) 3 d) ½

KEY

1) a 2) b 3) a 4) d 5) b 6) a 7) a 8) a 9) b 10) b

Additional Problems

1. **Which of the following is not a fundamental particle?**

   1) Proton 2) Neutron

   3) Alpha particle 4) Electron

2. **A neutral atom (At.no. >1) has (AFMC)**

   1) electron and proton

   2) neutron and electron

   3) neutron, electron and proton

   4) neutron and proton

3. **The study of discharge of electricity through gases led to the discovery of**

   1) Structure of the atom 2) Nucleus

   3) Spectral lines 4) Electron

4. **Electron is a particle having a (CPMT)**

   1) negative charge of one unit and zero mass

   2) positive charge of one unit and zero mass

   3) negative charge of one unit and a mass of about 9.1×10^{-31} kg

   4) negative charge of one unit and a mass of about 1.67×10^{-27} kg .

5. **The value of e/m for an electron is**

   1) 1.78×10^{8} c/g 2) 1.6724×10^{-24} c/g

   3) 0.005486 c/g 4) 1.00866 c/g

6. **Charge of electron is**

   1) 1.602×10^{-10} Coulomb

   2) 4.8×10^{-10} coulomb

   3) 1.602×10^{-19} e.s.u

   4) 4.8×10^{-10} e.s.u

7. **The e/m of proton is**

   1) 1.78×10^{8} c/g 2) 9.57×10^{4} c/g

   3) 19.14×10^{4} c/g 4) 0.478×10^{4} c/g

Atomic number and mass number

8. **Atomic number is equal to the (AFMC)**

   1) number of neutrons in the nucleus

2) number of protons in the nucleus
3) sum of protons and neutrons
4) atomic mass of the element.

9. A & Z can be

1) negative 2) fractional
3) zero 4) Whole number

10. The number of protons electrons and neutrons in $^{80}_{35}Br$ are respectively

1) 35, 35, 80 2) 35, 35, 45
3) 80, 80, 35 4) 45, 45, 35

11. Which one of the following is an isobar of $_6C^{14}$? (EAMCET 2001M)

1) $_6C^{13}$ 2) $_6C^{12}$ 3) $_7N^{14}$ 4) $_7N^{15}$

12. Number of protons in the nucleus of carbon atom is

1) 7 2) 8 3) 4 4) 6

13. The number of nucleons in chlorine–37 is

1) 17 2) 20 3) 54 4) 37

14. The nucleus of an atom contains

1) Electrons and protons
2) Protons and neutrons
3) Electrons and beta particles
4) Protons and alpha particles

1 5. The isotopes of neutral atoms of an element differ in

1) Atomic number 2) Mass number
3) Number of electrons
4) Chemical properties

16. The nucleus of tritium consists of

1) 1 proton + 1 neutron
2) 1 proton + 3 neutrons
3) 1 proton + zero neutrons
4) 1 proton + 2 neutrons

17. Sodium ion is isoelectronic with -- atom

1) Mg^{2+} 2) Al^{3+} 3) Ne 4) N^{3-}

18. An atom differs from its ion in

1) Nuclear charge 2) Mass number
3) Number of electrons 4) Number of neutrons

19. In C^{14} isotope the number of neutrons would be

1) 6 2) 14 3) 8 4) 10

20. The number of neutrons in the dipositve zinc ion (Mass no. of Zn = 65)

1) 35 2) 33 3) 65 4) 67

Atomic models

21. Rutherford's alpha ray scattering experiment showed for the first time that the atom has

1) Nucleus 2) Proton

3) Electron 4) Neutron

22. The radius of the atom is of the order of

1) 10^{-10} cm 2) 10^{-13} cm (PMT)

3) 10^{-15} cm 4) 10^{-8} cm

23. When alpha particles are sent through a thin metal foil, most of them go straight through the foil because

1) Alpha particles are much heavier than electrons

2) Alpha particles are positively charged

3) Most part of the atom is empty

4) Alpha particles move with high velocity

Nature of light

24. Identify the incorrectly matched set from the following

SET - A	SET - B
1) Wavelength()	Nanometre
2) Frequency ()	Hertz
3) Wave number ()	$metre^{-1}$
4) Velocity (C)	ergs

25. Einstein was awarded Noble Prize for

1) General theory of relativity

2) The equation, $E = mc^2$

3) Enunciation of quantum theory

4) Explanation of photoelectric effect

26. In electromagnetic radiation, which of the following has greater wavelength than visible light?

1) U.V-rays 2) I.R-rays

3) Gamma rays 4) X-rays

27. Which of the following is not an electromagnetic radiation?

1) Gamma rays   2) Alpha rays
3) Radio waves   4) X-rays

28. The energy of a photon is inversely proportional to its
1) Wavelength   2) Frequency
3) Wave number   4) Velocity

29. The value of Planck's constant is
1) 6.626×10^{-27}Js   2) 6.626×10^{-34}Js
3) 6.023×10^{23}Js   4) 1.602×10^{-19}Js

30. Which of the following properties of a wave is independent of the other?
1) Wave number   2) Wave length
3) Frequency   4) Amplitude

31. The radiation with highest wave number
1) Microwaves   2) X - rays
3) I.R. - rays   4) Radiowaves

32. Which of the following relates to photon both as wave motion and as a stream of particles?
1) $E = mc^2$ 2) Photoelectric effect
3) Diffraction   4) E = h

33. The metal best used in photoelectric cells is
1) Na   2) Mg   3) Al   4) Cs

34. The energy required to emit an electron from the surface of a metal is called
1) Activation energy   2) Threshold energy
3) Critical energy   4) Kinetic energy

35. Kinetic energy of photoelectrons is independent on --------- of incident radiation.
1) Wavelength   2) Wave number

1) 3	2) 3	3) 4	4) 3	5) 1	6) 4	7) 2	8) 2	9) 4	10) 2
11) 3	12) 4	13) 4	14) 2	15) 2	16) 4	17) 3	18) 3	19) 3	20) 1
21) 1	22) 4	23) 3	24) 4	25) 4	26) 2	27) 2	28) 1	29) 2	30) 4
31) 2	32) 4	33) 4	34) 2	35) 4					

Chapter 28
NUCLEAR PHYSICS

Synopsis

1. *Nucleus* :-

The atomic nucleus was first discovered by Rutherford in the year 1911 from α-rays scattering experiment.

→ The nucleus of the atom consists of protons and neutrons collectively known as nucleons.

→ Protons and neutrons are the building blocks of nucleus.

→ Atomic number (z) is the number of protons present inside the nucleus.

→ The total number of protons and neutrons present inside the nucleus is called atomic mass number (A).

→ Number of neutron inside the nucleus N= A-Z.

2. ***Classification of nuclei*** :-

→ **Isotopes**: - Nuclei having same atomic number (Z) but different mass number (A) are called isotopes. Ex:- H^1,H^2

→ **Isobars** : Nuclei having same mass number (A) but different atomic number (z) are called isobars. Ex: $_6C^{14}$ $_7N^{14}$

→ **Isotones** : nuclei having same number of neutrons but different atomic number(z) and different mass number (A) are called isotones .

Ex: $_7N^{15}$ $_80^{16}$

→ **Isomers**: - Nuclei having same atomic number (Z) . same mass number(A) but with different nuclear properties such as radio active decay are called isomers. Ex: Br80 g $_{35}Br^{80}m$

35

→ **Isodiapheres**: Nuclei having same excess number of neutrons over protons . i.e. nuclei having (A-2z) values. Ex: $_{17}Cl^{37}$, $_{18}Ar^{39}$

3. ***Nucleus size*** :

→ Size of atom is 10^{-10}m =$1A^0$

→ Size of nucleus is 10^{-15} m = 1 Fermi

→ Size of nucleus is 10^5 times smaller than size of atom

→ Radius of nucleus is R= $R_0a^{1/3}$ where R_o is contant and R0 = 1.1 x10^{-15}m .

4. ***Nucleus Mass*** : the mass of nucleus is equal to the sum of masses of protons and neutrons present in it . mass of nucleus = ZM_P +m (A-z) M_n

→ Nuclear mass are expressed in amu. (atomic mass unit)

5. ***Atomic mass unit (amu)*** : it is $1/12^{th}$ of the mass of carbon atom.

1 amu= 1.67 x10-27 kg.

1 amu = 931.5 Mev

6. ***Nuclear charge*** :- it is due to the presence of positively charged protons inside the nucleus.

Nuclear charge = no.of protons x charge of proton = $zx1.6x10^{-19}$ c

7. ***Nuclear density*** :-

Nuclear density ∫ = Mass of nucleus / volume of nucleus

∫ = A amu / 4/3 ΠR^3 = $Ax1.67x10^{-27}$ / 4/3x3.14 $x(1.1x10\text{-}15)^3xA = 2.97x10^{17}$ kg/m^3

→ The density of nucleus is independent of mass number.

→ The density of maximum at the centre and gradually falls to zero to the edge.

→ Nuclear density is about 10^{14} times the density of water

8. Einsteins mass – energy equivalence :-

→ According to einsteins theory $E= mc^2$

→ The amount of energy released when one gram of mass is completely annihilated = $9x10^{13}$J

→ Amount of energy released for annibilation of electron = 0.56 Mev.

9. ***Properties of nuclear forces*** :

→ They are non-gravitational

→ They are extremely strong

→ They are short range forces

→ They are charge independent

→ They are spin dependent.

→ They are non- central forces

→ The ratio between $F_G:F_e:F_n=1:10^{36}:10^{38}$

10. ***Mass defect (ΔM)*** : The mass difference between the sum of the masses of all the nucleus constituting a nucleus and actual mass of nucleus is known as mass defect.

$\Delta M= [\{Zm_p + (A\text{-}Z) m_n \} –M_n]$

11. ***Packing fraction*** :- it is defined as the mass defect per nucleon of the nucleus.
Packing fraction = Δ M/A

→ Smaller the value of packing fraction, greater will be the stability of nucleus vice-versa.

12. ***Binding energy***: energy required to keep the nucleons in the nucleus is called binding energy (or) the energy required to break the nucleus into constituent nucleons is called binding energy.

B.E. = Δ M x 931.5 Mev (ΔM → mass defect)

13. ***Binding fraction*** :- binding energy per nucleon inthenucleus is called biding fraction
B= Δ M x 931.5 /A Mev/nucleon.

→ Higher the value of binding fraction, greater the stability of nucleus.

→ The maximum average binding energy per nucleon is 8.5 Mev.

→ Binding energy per nucleon is least and is 7.6 Mev

14. ***Discovery of Neutron*** :- Existence of neutron predicted by Rutherford in 1920.

→ In 1930 bothe and becker conducted experiment on bombardment of α – particles with beryllium emitting high energetic radiations (γ-rays).

${}_4Be^9 + {}_2He^4 \rightarrow {}_6C^{13}$ + (γ-photons)

The total energy emitted in above process is 14 mev. Hence the energy of γ-rays should be less than 14 mev. But from other experiments it was observed energy of γ-rays is 64 Mev. Which is contradiction .

→ In 1932 James chadwick proved that this radiation consists of neutral particles of definite mass which is about the same as that of proton. These particles are known as neutrons.

$_4Be^9 + _2He^4 \rightarrow _6C^{13} + _0n^1$

→ Ss

15. ***properties of neutron***:- it is uncharged particle (neutral)

→ It possesses very high penetrating power.

→ Neutrons cannot ionize a gas.

→ Stable inside the nucleus and unstable outside the nucleus.

→ Neutrons having less velocity are called thermal neutrons.

→ The velocity of neutron is reduced by passing them through heavy water or paraffin or graphite.

→ The half life period is nearly 12 minutes.

16. ***Nuclear Fission*** :- The process of splitting heavy nucleus into two nuclei of nearly comparable masses with liberation of energy is called nuclear fission.

→ Nuclear fission was discovered by otto Hahn in and strassman.

→ The fission reaction of $_{92}U^{235}$ is

$_{92}U^{235} + _0n^1 \rightarrow _{56}Ba^{141} + _{36}Kr^{92} + 3_0n^1$ + (200 Mev) energy

→ The energy released per each fission is 200 Mev. Of $_{92}U^{235}$

→ Slow neutrons can cause fission in $_{92}U^{235}$

→ About 97% of U^{235} undergoing fission give fragments which are of two groups.

i) Light group with mass numbers from 85 to 104 and

ii) Heavy group with mass numbers from 130 to 149

→No. of fission fragments are maximum at mass numbers 95 and 139.

→ No.of fission fragments are minimum at mass number 117.

→ Neutrons released spontaneously with fission reaction are called prompt neutrons. % of prompt neutrons is 99.36%

→ Fission fragments also emit neutrons. these are called delayed neutrons. % of delayed neutrons is 0.64%

→ On an average 2.5 neutrons are emitted during each fission.

→ Bohr and wheeler could successfully explain the nuclear fission on the basis of liquid drop model. U^{235} , U^{233} and Pu^{239} undergo fission by neutrons of energy from almost zero upwards. Such nuclei are called fissile nuclides.

17. ***Chain reaction*** :- A fission reaction of $_{92}U^{235}$ which continues once started and left to itself is called chain reaction .

→ In chain reaction neutrons increase in geometric progression.

→ A single thermal neutron is enough to start chain reaction.

→ Velocity of fast neutrons released during chain reaction can be reduced with the help of moderator.

→ State of chain reaction depends on neutron reproduction factors (k) .

K = Rate of neutrons produced / Rate of neutrons lost

→ An atom bomb is an example of uncontrolled fission reaction.

→ Nuclear reactor is an example of controlled chain reaction.

18. ***Nuclear reactor***: - Nuclear reactor or atomic pile is a device which works on the principle of nuclear fission by controlled chain reaction.

→ The first nuclear reactor was constructed by Fermi in 1942 . the basic components of nuclear reactor are

→ Nuclear fuel:- The fissionable material used in the reactor is called nuclear fuel. U^{238} is used as fuel. The commonly used fuels are natural uranium containing 99.3% of ${}_{92}U^{238}$, 0.7% of U^{235} and isotopes of uranium ${}_{92}U^{235}$, ${}_{92}U^{238}$, plutonium ${}_{94}Pu^{236}$ and thorium ${}_{96}Th^{236}$.

→ Moderator :- Moderator is used to slow down the fast neutrons to thermal neutrons.

Eg: Heavy water, graphite, Hydrocarbon plastics, beryllium, carbon.

→ Control rods :- these rods absorb the excess neutrons to control the rate of nuclear fission reaction.

Eg:- cadmium, Boron rods.

→ Coolants :- The material used to absorb the thermal energy generated in reactor is called coolant .

Eg:- water, molten sodium, Co_2

→ Protective shielding :- the surroundings of a reactor are to be protected from neutrons , and spreading of radio active effect to the space around the nuclear reactor.

→ Power of nuclear reactor

P= ne/t n→ number of fission in the time 't'

E= Energy released in Joules per fission.

19. ***Nuclear Fusion***: The formation of heavier nuclei by the combination of two lighter nuclei with the release of energy is called nuclear fusion.

→ In nuclear fusion there is a decrease in mass which is converted into energy.

→ High temperature and high pressure are required for nuclear fusion.

→ The energy released for fusion of 4 hydrogen nuclei into a helium nucleus is about 27 to 28 mev.

→ Hydrogen bomb works on the principle of fusion.

→ 4,H1 → ${}_2He^4$ + 2_1 e0 +Q

→ As fusion reactions occur at very high temperature (of 10^7 k). they are called thermo – nuclear reaction and the energy released is called thermo-nuclear energy.

→ Carbon –nitrogen cycle was discovered by both and weizsacker. Energy released per each nucleon is 6Mev. It is 7 times more than that of fission reaction.

→ Proton – proton cycle also produce same amount of energy as inthecase of carbon – nitrogen cycle .
→ Proteon – proteon cycle starts at less temperature than C.N. cycle.
→ The stars at comparatively low temperature emit energy with proton – proton cycle.
→ The source of stellar energy is the fusion, when the temperature is about $2x10^7$ k.
→ The sun radiates energy at the rate of $3.8x10^{26}$ J/s.
→ **Photon** :- it was proposed by max planck. It is a quantum of EM
→ radiation. No charge, no rest mass. Spin (h/2Π) . it travels with velocity of light. It is stable.
→ **Electron** :- It was discovered by Thomson. Its charge is $1.6x10^{-19}$ c. mass = $9.1x10^{-31}$kg. it is stable.
→ Positron :- it is antiparticle of electron
→ **Proton** :- it was discovered by Rutherford. Its mass is $1.67x10^{-27}$ kg . charge = 1.6x10-19c. it has +ve charge. It is stable in free state.
→ **Antiproton**:- it was discovered by chamberlene. It is antiparticle of proton.
→ **Neutron** :- it was discovered by Chadwick . it is electrically neutral . it is unstable in free state.
→ **Antineutron** :- it was discovered bycork, lambertonand wenzel. It has no charge. It is antiparticle of neutron.
→ **Neutrine** :- it was discovered by pauli. It has no charge and zero or nearly zero mass.
→ **Antineutrino** :- it is antiparticle of neutrino.
→ **Mu meson (μ-)** :- it has a –ve charge and mass equal to 207 times the mass of electron. Its mean life is $1.5x10^{-6}$s. it decays into electron and two neutrinos.
→ **Anti-Mu meson(μ+)** :- it was first discovered by yukawa. It has a mass 27.3 times the mass of electron. Its mean life is 2.55x10-8 s. its decays into meson and neutrino.
→ **Negative pi meson (π-)** :- it is an anti particle of +ve pimeson.
→ **Neutral pi meson (π^0)** :- It has no charge and its mass is 264 times the mass of electron. It has mean life of $2x10^{-16}$ S. it decays into 2 protons
→ **K- meson (kaons)** :- K+ it has mass 966 times the mass of electron. It has +ve charge.
→ **Neutral k-meson** :- K :- It has a mass 956 times that of electron mass. It has no charge.
→ Eta-meson (n) :- its mass is nearly 1075 me- it decays into two gamma rays.
→ **Baryons** :- baryons are heavy particles . they are nucleons and hyperons
→ Hyperons (strange particles): Its decay times is very high 10^{-3} sec. strange particles are always produced in pairs. $\pi + N \rightarrow \Lambda + K$
→ N → nucleon, Λ → lambda, k →kaon
They are unstable with mean lives 10^{-8} to 10^{-16} s.
20. ***Pair production*: -** The phenomenon in which pair particles are produced when γ - ray photon interacts with matter.

$\gamma \rightarrow {}_{+1}e^0 + {}_{-1}e^0$

it was discovered by Anderson

21. ***Annihilation*: -** the converse of pair production is called annihilation.

$_{+1}e^0 + {}_{-1}e^0 \rightarrow \gamma$ (photon) + γ (Photon).

Radioactivity:

- Natural radioactivity is a process by which unstable nuclei spontaneously emit α, β, and γ- rays in an order to acquire stability.
- α – rays consists of positively charged particles, each particle being nucleus of helium. β – Rays consists of negatively charged particles, the electrons. γ – rays are high energy photons.
- The half life T of a radioactive isotope is the time required for one-half of the original nuclei present to disintegrate. $T = 0.693/\lambda$ where λ is the disintegration constant.
- The activity of the radioactive substance is the number of disintegration per second.
- The average life time τ of a radioactive substance is equal to the total life time of all the nuclei present initially divided by the total number of nuclei that were present initially. $\tau = 1/\lambda$.

  The force that holds the nucleons together in the nucleus is an attractive force and is called nuclear forces.
- Properties of the nuclear forces:

1. Nuclear force is attractive in nature and is the strongest of all the basic forces.
2. Nuclear force is a short – range force.
3. The nuclear force is independent of electric charge of the nucleons.
4. Nuclear force is Spin dependent.
5. Nuclear force is completely central.
6. Nuclear force has the property of saturation
7. Nuclear force is an exchange force.

Problems:

1) A radioactive sample has $2.0 * 10^{20}$ active nuclei at a certain instant of time. How many them will still be in the same active state after three half-lives?
   a) 2.3×10^{19} b) 2.0×10^{20} c) 2.5×10^{19} d) 3.5×10^{19}
2) The half-life of ^{238}U for α – decay is $4.5 * 10^{19}$ years. How many disintegrations per second occurs in 1 g of ^{238}U?
   a) $1.235 \times 10^4\ s^{-1}$ (b) $2.234 \times 10^4\ s^{-1}$ (c) $3.45 \times 10^4\ s^{-1}$ (d) $5.67 \times 10^4\ s^{-1}$
3) A radioactive substance has $6.0 * 10^{18}$ active nuclei initially. What time is required for the active nuclei of the same substance to become $1.0 * 10^{18}$ if its half life is 40s.
   a) 108.3s b) 103.4s c) 107.3s d) 102.1s
4) Two radioactive substances X and Y initially contain an equal number of atoms. Their half-lives are 1 hours and 2 hours respectively. Calculate the ratio of their rates of disintegration after four hours.
   a) ½ b) ¼ c) 1/3 d) 1/5

5) A radioactivity sample can decay by two different processes. The half-life for the first process is T_1 and for second process is T_2. Find the effective half-life T of the radioactivity sample.
a) T_1T_2/T_1+T_2 (b) T_1T_2/T_1-T_2 (c) T_1T_2/T_1T_2 (d) None of above

6) How many α-rays and β-particles are emitted when uranium nucleus ($^{238}U_{92}$) decay to $^{214}Pb_{82}$?
a) 8 and 3 (b) 9and 5 (c) 6 and 1 (d) 6 and 2

7) How much ^{238}U is consumed in a day in an atomic power house operating at 400MW provided the whole of mass ^{235} U is converted into energy?
a) 0.256g b) 0.456g c) 0.384g d) 0.113g

8) Plutonium decays with a half-life of 24,000 years, if plutonium is stored for 72,000 years, what is fraction o f it remains?
a) 1/3 b) 1/5 c) 1/8 d) ½

9) A certain substance decays to 1/32 of its initial activity in 25 days. Calculate its half-life.
a) 3 days b) 4 days c) 5 days d) 8 days

10) The half-life period o f a radioactivity substance is 20 days. What is the time taken for 7/8 th of its original mass to disintegrate?
a) 55 days b) 45 days c) 40 days d) 60 days

11) A radioactivity nucleus undergoes a series of decays according to the sequence
$A \xrightarrow{\beta} A_1 \xrightarrow{\alpha} A_2 \xrightarrow{\alpha} A_3$. If the mass number and atomic number of A_3 are 172 and 69 respectively. What is the mass number and atomic number of A?
a) 180 and 86 (b) 180 and 75 (c) 180 and 72 (d) 169 and 72

12) One gram of radium is reduced by 2 milligram in 5 years by α- decay. Calculate the half-life of radium.
a) 1309 years b) 1703.3 years c) 1603.3 years d) 1203.4 years

13) Match the pairs in the two lists given below.

List –I	List – II
A) Gravitons	E) Hyperons
B) Baryons	F) Positrons
C) Pions	G) Paricles with zero mass and with a spin ao unity
D) Leptons	H) Decays to μ-mesons
	I) Mass less particles with a probable spin

a) A-E; B-H; C-G; D-I
b) A-I; B-E; C-I; D-F
c) A-H; B-F; C-I; D-E
d) A-F; B-G; C-E; D-H

14) The particles that possess half integral spin is
a) Photon b) Pian c) Proton d) K-meson

15) It is possible to understand nuclear fission on the basis of the
a) Meson theory of the nuclear forces
b) Proton- proton cycle
c) Independent particle model of the nucleus
d) Liquid drop model of the nucleus

ANSWERS:

1) C	2) a	3) b	4) a	5) a
6) d	7) c	8) c	9) c	10) d
11) c	12) b	13) b	14) c	15) d

NEW TYPES OF QUESTIONS

1) Assertion: Neutrons penetrate matter more readily as compared to protons
Reason: Neutrons are slightly more massive than protons
1) Both A and R are true and R is the correct explanation of A
2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is the not correct explanation of A Key:1

2) Assertion: On increasing the frequency of light number of photoelectrons are emitted.
Reason: The number of electrons emitted depends on the intensity of incident light.
1) Both A and R are true and R is the correct explanation of A
2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is not the correct explanation of A Key:2

3) Assertion: Density of all the nuclei is same
Reason: Radius of nucleus is directly proportional to the cube root of mass number
1) Both A and R are true and R is the correct explanation of A
2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is not the correct explanation of A Key:1

4) Assertion: The K.E of the emitted photo-electrons changes only with a change in the frequency of the incident radiations
Reason: The K.E of Photo-electrons emitted by a photo-sensitive surface depends upon the intensity of the incident radiation
1) Both A and R are true and R is the correct explanation of A
2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is not the correct explanation of A Key: 3

5) Assertion: The relative velocity of two photons travelling in opposite direction is the velocity of light.
Reason: the rest mass of a proton is zero.
1) Both A and R are true and R is the correct explanation of A

2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is not the correct explanation of A Key:4

6) Assertion: In the process of nuclear fission, the fragments emit two or three neutrons as soon as they are formed subsequently emit particles.
Reason: As the fragments contain an excess of neutrons over protons, emission of neutrons and particles bring their neutron/proton ratio to stable values
1) Both A and R are true and R is the correct explanation of A
2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is not the correct explnation of A Key: 1

7) Assertion: If a heavy nucleus is split into two medium sized parts, each of the new will have more binding energy per nucleon than the original nucleus
Reason: Joining two light nuclei together to give a single nucleons of medium size means more binding energy per nucleon in the new nucleus
1) Both A and R are true and R is the correct explanation of A
2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is not the correct explanation of A Key:4

8) Assertion: The phenomenon of pair production is not possible unless the energy of gamma ray photon is equal to greater then 1.02MeV.
Reason: The rest mass of an electron is 0.51MeV.
1) Both And R are true and R is the correct explanation of A
2) A is false R is true 3) A is true R is false
4) Both A and R are true and R is not the correct explanation of A Key: 1

Question Bank:

1) $_{17}Cl^{37}$, $_{19}K^{39}$ are
1) Isotopes 2) Isobars 3) Isomers 4) Isotones

2) The mass number "A" of a nucleus is related to surface area "X" of nucleus as
1) $X \alpha A^2$ 2) $X \alpha A^{2/3}$ 3) $X \alpha A^{1/3}$ 4) $X \alpha A^3$

3) The relative strengths of gravitational coulomb's and nuclear forces of protons are in the ratio (nearly)
1) 1:1:1 2) $1:10^{36}:10^{38}$ 3) $10^{38}:10^{36}:1$ 4) $1:10^{30}:10^{34}$

4) Nuclear forces between two protons, a proton and a neutron and between two neutrons are respectively F_{PP}, $F_{n\,m}$ and $F_{n\,n}$ thern
1) $F_{PP}>F_{n\,P}>F_{n\,n}$ 2) $F_{PP}<F_{n\,P}<F_{n\,n}$
3) $F_{PP}= F_{n\,P} = F_{n\,n}$ 4) $F_{PP}<F_{nP}= F_{nn}$

5) Nuclear forces are
1) Non –central forces 2) Saturated 3) Spin dependent 4) All the above

6) If the packing fraction is +ve this indicates
1) Stability of nucleus 2) Unstability of nucleus
3) High binding energy 4) 1 or 3

7) If the packing fraction is –ve this indicates
1) stability of nucleus 2) unstability of nucleus

3) high binding energy per nucleon 4) 1 and 3

8) The stability of a nucleus can be measured by
1) Average binding energy 2) Packing fraction
3) Ratio of number of neutrons and protons 4) 1, 2 and 3

9) If multiplication factor (K) is less than one the chain reaction is
1) Critical 2) Supercritical 3) Under- crictical 4) Explosive

10) The working principle in atom bomb is
1) under –critical chain reaction 2) critical chain reaction
3) super critical chain reaction 4) 1 or 2 or 3

11) The time interval between the fission and emission of prompt neutron is
1) 10^{-10}sec 2) 10^{-12}sec 3) 10^{-13}sec 4) 10^{-14}sec

12) Bosons have
1) integral spins 2) Half integral spins 3) Zero spin 4) 2 or 3

13) Gravitons have a probable spin of
1) 1 Unit 2) 2 Units 3) 3 Units 4) 4 Units

14) Which of the following is Boson
1) Graviton 2) Photon 3) π^0 4) 1, 2 and 3 are Boson

15) The particle that is much heavier than π - mesons is
1) electron 2) μ -meson 3) anti – neutrino 4) Kaon

16) The radius of the nucleus of the atom with A = 216 of R_0 = 1.2 fm is
1) 1.2 fm 2) 2.4 fm 3) 3.6 fm 4) 7.2 fm

17) The ratio of radii of the nucleus ${}_{13}Al^{27}$ and ${}_{52}Te^{125}$ is
1) $\sqrt{3} : \sqrt{52}$ 2) $3\sqrt{13} : 3\sqrt{52}$ 3) $3\sqrt{3} : 5\sqrt{5}$ 4) 3:5

18) The mass defect for the nucleus of helium is 0.0303 amu. The binding energy per nucleon is MeV is nearly
1) 28 2) 7 3) 4 4) 1

19) 1g of hydrogen is converted into 0.993g of helium in a thermo –nuclear reactions. The energy released is
1) $63x10^7$J 2) $63x10^{10}$J 3) $63x10^{13}$J 4) $63x10^{20}$J

20) Energy released when 1mg of mass is converted in joules is
1) $3x10^2$J 2) $3x10^{10}$J 3) $9x10^{10}$J 4) $9x10^2$J

21) The binding energy per nucleon for deutron ${}_1H^2$ and ${}_2He^4$ are 1.1 MeV and 7MeV respectively. The energy released when two deutrons fuse to form a helium nucleus is
1) 1.1 MeV 2) 7 MeV 3) 23.6 MeV 4) 6 MeV

Key

1)4	2)2	3)2	4)3	5)4	6)2	7)4	8)4
9)3	10)3	11)4	12)1	13)2	14)4	15)4	16)4
17)4	18)2	19)2	20)3	21)3			

NUCLEAR PHYSICS Previous Eamcet Questions

1) The mass defect in a particular nuclear reaction is 0.3 grams. The amount of energy liberated in kilowatt hours is (velocity of light = $3 \times 10^8 ms^{-1}$).
   1) 1.5×10^6 2) 2.5×10^6 3) 3×10^6 4) 7.5×10^6 [2003E]
2) A nucleus splits into two nuclear parts having radii in the ratio 1: 2. Their velocities are in the ratio [2003M]
   1) 8: 1 2) 6 : 1 3) 4 : 1 4) 2 : 1

3) Consider the following two statements A and B identify the correct answer given below:
   A: Nuclear density is same for all nuclei.
   B: Radius of the nucleus 'R' and its mass number 'A' are related as $\sqrt{A} \; \alpha \; R^{\frac{1}{6}}$.
   1) Both A and B are true. 2) Both A and B are false. [2004E]
   3) A is true but B is false. 4) A is false but B is true.

4) Matching pairs in the two lists given below are:

LIST I	LIST II
A) Gravitons	E) Hyperons
B) Baryons	F) Positrons
C) Pions	G) Particles with zero mass and with a spin of unity.
D) Leptons	H) Decay to μ - measons.
I) Massless particles with a probable spin of two units.	

   1) A-E, B-H, C-G, D-I 2) A-I, B-E, C-H, D-F [2004M]
   3) A-H, B-F, C-I, D-E 4) A-F,B-G,C-E, D-H.

5) Consider the following statements (A) and (B) and identify the correct answer given below:
   A: positive value of packing fraction implies a large value of binding energy.
   B: The difference between the mass of the nucleus and the mass number of the nucleus is called packing fraction. [2004M]
   1) A and B are correct 2) A and B are false.
   3) A is true, B is false. 4) A is false, B is true.

6) Particles and their anti-particles have: [2005E]
   1) the same masses but opposite spins.
   2) the same masses but opposite magnetic moments.
   3) the same masses and same magnetic moments.
   4) opposite spins and same magnetic moments.

7) The particle that posses half integral spin is: [2005M]
   1) Photon 2) Pion 3) Proton 4) K-Meson.

8) A free neutron decays spontaneously into: [2006E]
   1) a proton, an electron and anti-neutrino.

2) a proton, an electron and a neutrino.
3) a proton and electron.
4) a proton, an electron, a neutrino and an anti-neutrino.

9) Assertion (A): Nuclear forces arise from strong coulombic interactions between proton and neutrons. [2006M]
Reason(R): Nuclear forces are independent of the charge of the nucleons.
1) Both (A) and (R) are true and (R) is the correct explanation of (A).
2) Both (A) and (R) are true and (R) is not the correct explanation of (A).
3) (A) is true, but (R) is false. 4) (A) is false, but (R) is true.

10) In sun, the important source of energy is [2007E]
1) proton-proton cycle 2) carbon-Nitrogen cycle.
3) carbon-carbon cycle 4) Nitrogen-Nitrogen cycle.

11) Electron belongs to the following class of elementary particles:
1) Hardon 2) Lepton 3) Boson 4) Baryon [2007M]

KEY

1) 4 2 1 3) 3 4) 2 5) 2 6) 2 7) 3 8) 1 9) 4 10) 1 11) 2

Chapter -29

SEMICONDUCTOR ELECTRONICS:MATERIALS, DEVICES AND SIMPLE CIRCUITS

- In crystalline solids, the atoms or molecules are arranged in regular periodic geometrical pattern over a long range
- Sugar, Quartz, mica, calcite, sodium chloride, diamond etc are the examples of crystalline solids
- Crystalline solids are antisotropie, i.e. their physically properties like thermal conductivity, clasticity, electrical conductivity, refractive index, mechanical strength are different in different directions
- They have sharp melting points

Amorphous Solids:

- In amorphous solids, the atoms or molecules are arranged in irregular pattern
- Rubber, glass, plastics, sulphur etc are the examples of amorphous solids
- Amorphous solids are isotropic i.e. their physical properties are same in all directions
- They do not have well defined melting and freezing points

Energy Bands:

Valence Band:

- The range of energies possessed by the valence electrons is called as valence band
- This band may be partially filled or completely filled with electrons depending on the nature of crystal

Conduction Band:

- The range of energies possessed by the conduction electrons is called as conduction band
- This band may be empty or may partially filled with electrons

Forbidden Energy Gap:

- The energy gap between the valence band and the conduction band is called forbidden energy gap
- No electron will exist with an energy level in forbidden gap

Classification of Substances:

Conductors:

- If the conduction band and valency band overlap one over the other then such substances are called as conductors. Ex: metals (Na crystal)

Insulators:

- If the conduction band and valence band are well separated (about 5eV) by forbidden gap then such substances are called as insulators

Ex: Diamond

Semi –Conductors:

- If the forbidden energy gap between the conduction band and valence band is very small (about 1eV) then such substances are called semi-conductors.

Ex: Silicon & Germanium

- For silicon forbidden energy gap is 1.1 eV and for germanium 0.72 eV
- At absolute zero semiconductors behaves as perfect insulators
- Semi conductors are of two types 1) Intrinsic 2) Extrinsic

Intrinsic Semiconductors:

- Pure form of **Si** or **Ge** crystals are called Intrinsic Semiconductors (tetravalent)
- The responsible charge carries for conduction are both the free electrons and holes. [Note: From now onwards we refer these 'free electrons' as 'simply electrons']
- The number of holes and the number of free electrons are equal. ($n_e = {}^n h$) increases with increase of temperature
- Even though the responsible charge carries are both the free electrons and holes the current contributed by the electrons is more than that of holes because of their higher mobility
- Fermi-energy level lies exactly at the end point of the forbidden gap

Hole:

- A hole is an unfilled covalent bond
- Hole is a positive charge carrier

Extrinsic Semiconductors:

- The conductivity of intrinsic semi-conductor is relatively less. To increase their conductivity pure semi-conductors are doped with trivalent or pentavalent substances. Doping:-adding of impurities

P-type Semi-conductor:

- When a trivalent substance (III group elements) like Boron, Aluminium, Gallium, Indium,(BAGI) etc are added in sufficient quantities [1 in 106 or less] to the pure form of Si or Ge Crystal then it is said to be P-type
- In P-type semi-conductor holes are majority carries and electrons are minority carries (${}^n h > n_e$)
- The fermi-energy level lies nearer to the valence band
- The energy level formed slightly above (about 0.01 eV) the valence band due to acceptor impurities is called acceptor energy level

n-type Semi-conductor:

- When a pentavalent substance (V group elements) like Phosphorous, Arsenic, Antimony,(PAAI) etc, are added in sufficient quantities to the pure form of Si or Ge crystal then it is said to be n-type
- In n-type semiconductor, electrons are majority carriers and holes are minority carriers ($n_e > {}^n h$)
- The fermi-energy level nearer to the conduction band

- The energy level formed slightly below (above 0.01 eV) the conduction band due to donor impurities is called donor energy level

P-n Junction diode:

- A P-n junction diode cannot be obtained by simple contact of p-type and n-type semiconductor
- During crystal growth in an intrinsic semi-conductor in the same crystal if one side of it is doped with a third group and another side with a fifth group impurity, a p-n junction can be formed
- Due to diffusion, positive ions are left over n-region and negative ions are left over p-region, near the junction. These ions are immobile
- Due to immobile ions on either side of the junction an internal electric field is formed at the junction which is directed from n to p
- The no charge carrier region formed at P-n junction due to the combination of electrons and holes is called depletion layer
- The thickness of the depletion layer is of the order of 10^{-6} m
- The potential difference across the barrier which is set up to prevent diffusion of charge carriers through the junction is called potential barrier or contact potential
- The potential barrier value lies in between 0.1 to 0.7 volts, which depends on the nature of semi conductor, doping concentration and temperature of the junction
- It can be presumed to be equivalent to a condenser in which the depletion layer act as a dielectric
- P-n junction diode can be used as rectifier, detectors
- As they are solid state devices, no evacuation is needed as for vacuum tubes
- They are also quite strong and sturdy
- Usually they have long life
- There is no filament heating and consequent power loss
- These can be prepared to function over wide voltage range and to give very large rectified currents

Forward Bias:

- In a P-n junction diode, if P-region is connected to +ve terminal (relatively higher potential) of the battery and n-region is connected to –ve terminal (relatively lower potential) of the battery then it is said to be forward biased
- In forward biased condition, the width of depletion layer, decreases barrier potential decreases
- It is a low resistance connection
- The resistance of an ideal diode in forward biased condition is zero
- The direction of current is from P to n

Reverse Bias:

- In a P-n junction diode, if P-region is connected to –ve terminal (relatively low potential) of the battery and n-region is connected to the +ve terminal (relatively high potential) of the battery then it is said to be reverse biased
- In reverse biased condition, the width of the depletion layer increases, barrier potential increases
- It is a high resistance connection
- The resistance of an ideal diode in reverse bias condition is infinity
- The direction of current in it is from n to P

Rectifiers (Half wave Rectifier):

- It is a device which converts A.C to D.C
- In half-wave rectifier one diode is used
- It converts half cycle of applied A.C into D.C
- When a half wave rectifier is used to convert 'n' Hz A.C into D.C then the number of pulses per second present in the rectified voltage is n
- Efficiency $(\eta) = \frac{0.406 \, x R_L}{(r_f + R_L)} X 100\%$

Full wave Rectifier:

- For full wave rectifier Two diodes are required
- It converts the whole cycle of applied input A.C signal into D.C signal
- When a full wave rectifier is used to convert 'n' Hz A.C into D.C then the number of pulses per second present in the rectified voltage is 2n
- Efficiency $(\eta) = \frac{0.812 \, x R_L}{(r_f + R_L)} X \ 100\%$

Zener Diode:

- It is a heavily doped P-n junction diode which is operated in the breakdown region in reverse bias mode
- Zener diode has a sharp breakdown voltage in the reverse bias because of heavy doping
- In forward bias, zener diode act like an ordinary P-n junction diode
- Zener diode is used as a voltage regulator
- Output voltage (V_0) = Zener Voltage (V_Z)
- Current through load resistance $(I_L) = \frac{V_Z}{R_L}$
- Voltage across series resistance (V) = input voltage – zener voltage $V = V_i - V_Z$
- Current through series resistance (R) is $I = \frac{V}{R} = \frac{V_i - V_Z}{R}$
- Current through zener diode $(I_Z) = I - I_L$

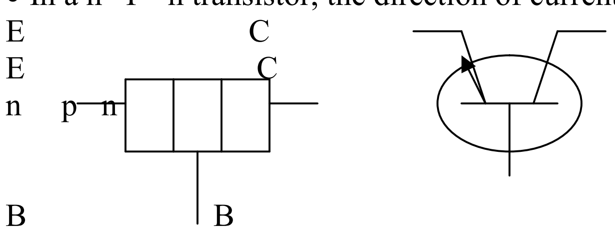
Transistors:
- Transistors means transfer of resistance i.e. transfer of current from low resistance circuit to high resistance circuit
- Transistors are of two types 1) P –n –P 2) n –P –n
- Transistor will mainly consists of 3 sections

1) Emitter 2) Base 3) Collector

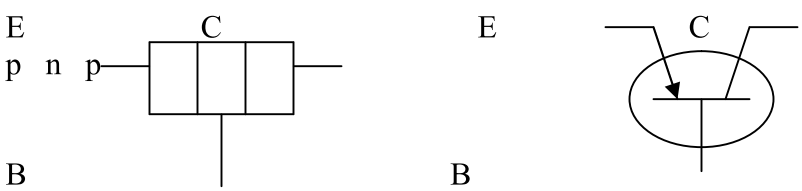
Emitter:
- It is heavily doped to get more number of majority charge carriers
- Width of this region is slightly less than that of collector region
- Its function is to supply majority carriers to the base

Base:
- It is the middle section of the transistor
- It is slightly doped
- Width of this region is very thin (of the order of 10^{-6}m)

Collector:
- It is moderately doped
- Width of this region is moderant of all regions to get large number of charge carriers
- Its function is to collect majority carriers from the base
- In a transistor, the arrow head should always be at the emitter base junction which represents the direction of flow of conventional current
- In a transistor emitter –base junction should be forward biased and collector –base junction should be reverse biased
- In a n –P –n transistor, the direction of current is from base to emitter



- In a P –n –P transistor, the direction of current is from emitter to base



- Transistors are used as oscillators, amplifiers, electronic switches etc
- Transistors can be connected in three different configurations

1) common base configuration
2) common emitter configuration

3) common collector configuration

- In any transistor circuit $I_E = I_B + I_C$
- In common base configuration transistor, the current gain is $\alpha_{a.c} = \frac{\Delta I_C}{\Delta I_E}$
- In common base configuration transistor α value is less than 1 ($\alpha<1$)
- In common –emitter configuration transistor, the current gain is $\beta_{a.c} = \frac{\Delta I_C}{\Delta I_B}$
- The value of β is greater than one ($\beta>1$)
- Relation between α, β:

$$\beta = \frac{\alpha}{1-\alpha}\ ;\ \alpha = \frac{\beta}{1+\beta}$$

- Input resistance in CE configuration transistor is $\gamma_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right) V_{CE}$
- The output resistance in C-E configuration transistor is $r_0 = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right) I_B$
- C –E configuration transistors are widely used as amplifiers because of its higher efficiency over the other configuration
- The device which is used to strengthen a weak signal into a strong signal is called amplifier
- Voltage gain

$$A_V = \beta \text{ X } \frac{R_L}{R_i} = \frac{\Delta V_{CE}}{\Delta V_{BE}} = \frac{\Delta I_C}{\Delta I_B} \text{ X } \frac{R_L}{R_i}$$

- Power gain

$$(A_P) = \beta^2 \text{ X } \frac{R_L}{R_i} = \beta A_V = \beta \text{ X } \frac{\Delta V_{CE}}{\Delta V_{BE}}$$

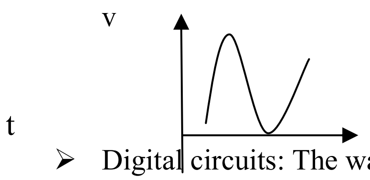
Different Operation region of junction in Transistor:

Operation of region	**Emitter junction(J_E)**	**Collector junction(J_C)**
Active region	**Forward biased**	**Reverse biased**
Saturation region	**Forward biased**	**Forward biased**
Cutoff region	**Reverse biased**	**Reverse biased**

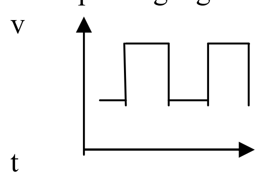
- $I_E = I_B + I_C$.
- The voltage gain is very less (>1) in case of CC configuration.
- The current gain is very less (=1) in case of CB configuration.
- Whereas CE is moderate or high in voltage or current gain

LOGIC GATES

1) The electronic circuits are of two types they are analog and digital circuits.
   - Analog circuits: The waveforms are continuous and a range of values of voltages are possible.
     Example: amplifier, oscillator circuits etc.



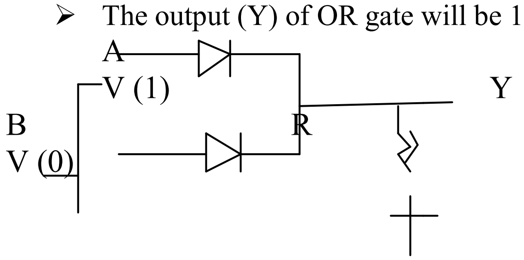
   - Digital circuits: The waveforms are pulsated and only descrete values of voltages are possible.
     Example: logic gates.

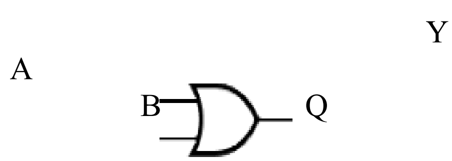


2) In the decimal system, there are ten digits. They are 0,1,2,3,4,5,6,7,8,9.
3) In the binary system, there are only two digits 0 1nd 1.
4) Digital electronics is developed by representing the low and high levels of voltages in pulsated waveform with binary digits 0 and 1(called bits).
5) The basic building blocks of digitals circuits are called as logic gates, since They perform logic operations.
6) Generally the level is at 4$\pm$1v and level 0 or low level is at 0.2$\pm$ 0.2v

OR GATE (A+B)

- An OR gate has two or more inputs with one output.
- The Boolean expression is Y=A+B
- The output (Y) of OR gate will be 1 when the inputs A or B or both 1.





a) Two input OR gate

b) circuit symbol **OR**gate

Truth table		
input		**output**
A	**B**	**Q**
0	**0**	**0**
1	**0**	**1**
0	**1**	**1**
1	**1**	**1**

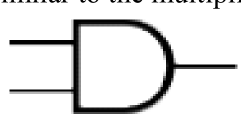
b) Two input OR gate

Truth table		
input		output
A	B	Q
Low	Low	Low
High	Low	High
Low	High	High
High	High	High

AND Gate (A.B):

- It has two terminals and one output terminal.
- An AND gate has two or more inputs with one output.
- The Boolean expression is Y = A.B
  (Y equals A and B)
- The output (Y) of AND gate is 1 only when all the inputs are simutanatanly A and B or both are 0.
- The output of the gate is high when both the inputs are high.
- The logical function AND is similar to the multiplication
  A

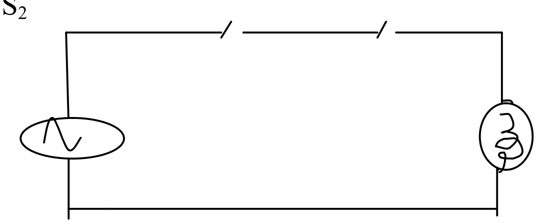
Y
B



a) Circuit symbol **AND** gate

- Implementation of AND gate using switches:
  S_1 S_2

Electric bulb



- Let S_1 and S_2be two switches connected in series with a power source and an electric bulb as shown in fig. here open represents zero (0) and closed represents one(0). Bulb glows represents (1) and does not glow represents zero (0). The output is same as that of an AND gate.

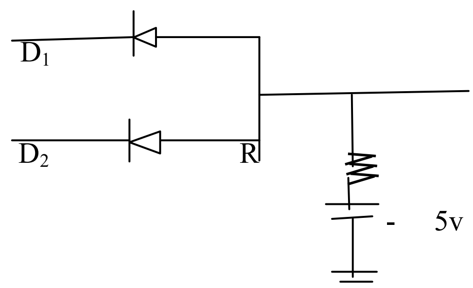
Truth table		
Input		output
A	B	Q
Low	Low	Low
Low	High	Low
High	Low	Low
High	High	High

➢ Implementation of AND gate using diodes:

A
Q = A.B

B
+

0v



AND gate

Truth table		
Input		**Output**
A	**B**	**Q**
0	**0**	**0**
0	**1**	**0**
1	**0**	**0**
1	**1**	**1**

➢ Let D_1 and D_2 are the diodes. A potential of 5V represent the logical value (1) and a potential of 0v represents the logical value zero (0).
When A=0 or B=0, D_1 and D_2 is forward- biased and they behaves like a closed switches and Q is zero.
When A=1 or B=1, D_1 and $D_2$is reverse- biased and they behaves like a open switches and Q is one.
The output is same that of AND gate.

<u>NOT Gate</u>

➢ It has one input and one output terminal.
➢ When input is low, the output is high.
➢ When input is high, the output is low.
➢ It as denoted by symbol by $\overline{Q} = A$

Not Gate

Truth table	
Input A	Output Q
Low High	High Low

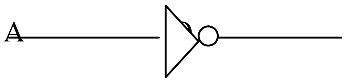
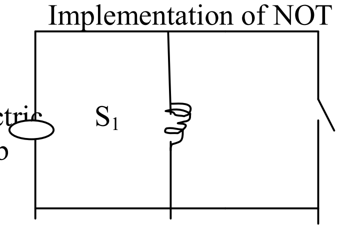
A 

Figure (i) symbol for NOT symbol

- The circuit on the vertex of the triangle represents inversion.
- NOT gate is a logic gate whose output is an inversion of its input..
- Truth table for NOT Gate:

Truth table	
Input A	**Output Q**
0 **1**	**1** **0**

- Implementation of NOT Gate using a switch:

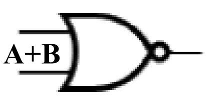


- The bulb glow not glows. Here, switch open represents zero (0) and closed represents one. Bulb glows represents (1) and does not glow represents zero (0). The output is same as that of a NOT gate.

NOR GATE :

- It has two inputs and one output terminal.
- The output of the NOR gate is an inversion of the output of an OR gate.
- It is denoted by the symbol **$Q = \overline{A+B}$.**

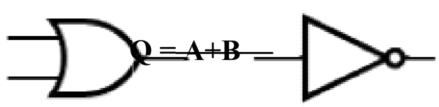
A
B

$Q = \overline{A+B}$ 

Fig(i) symbol of **NOR** Gate

- The Boolean expression is $Y = \overline{A+B}$
- NOR gate in term of OR gate as shows in below figure.

A
A+B
B



- **NOR gate = OR gate + NOT gate.**
- Truth table for NOR gate:

Truth table		
Input		Output
A	B	Q
Low Low High High	Low High Low High	High Low Low Low

➢ Truth table for **NOR Gate** for digital input and output:

Truth table		
Input		**Output**
A	**B**	**Q**
0 **0** **1** **1**	**0** **1** **0** **1**	**1** **0** **0** **0**

NAND GATE:

➢ It has two inputs and one output terminal.

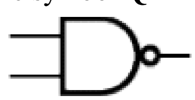
➢ The output of the NOR gate is an inversion of the output of an AND gate. i.e., if A and B are the inputs of the NAND gate its output is NOT (A AND B).

➢ It is denoted by the symbol **$Q = \overline{A.B}$.**

A

Q = A.B

B



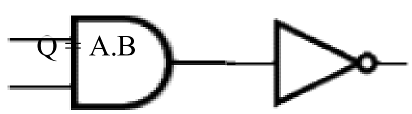
Fig(ii) symbol of NAND gate

➢ NAND gate in term of AND gate as shows in below figure.

A

A.B

B



➢ Truth table for **NAND Gate:**

Truth table		
Input		**Output**
A	**B**	**Q**

0	**0**	**1**
0	**1**	**1**
1	**0**	**1**
1	**1**	**0**

- **NAND Gate = AND Gate + NOT Gate.**
- **NAND Gate and NOR Gate are known as universal gates.**

The basic relation between for OR gate.

i) A+0 = A   iii) A+1 = 1
ii) A+A = A   iv) $\bar{A}$+A = 0

The basic relation between for AND gate.

i) A.0 = 0   iii) A.1 = 1
ii) A.A = A   iv) $\bar{A}$.A = 0

Exclusive-OR Gate:

- It has two inputs and one output terminal.
- It is called XOR gate.
- XOR gate is obtained by using OR, AND and NOT gates.
- The output of the two input XOR gate is 1. Only when the two inputs are different.
- The Boolean equation is

Q = A.B + A.B.
= $A \oplus B$

A
Q = $A \oplus B$
B

Symbol of XOR gate

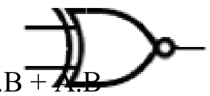
- The truth table for XOR gate

Truth table		
Input		Output
A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

Exclusive-NOR Gate:

- It has two inputs and one output terminal.
- It is called EX-NOR gate.
- X-NOR gate is obtained by using OR, AND and NOT gates.
- The output of the two input XOR gate is 1. Only when the two inputs are different.
- The Boolean equation is

A



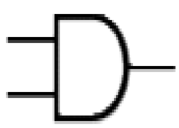
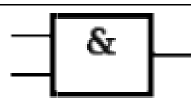
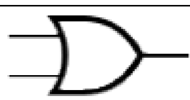
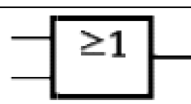
B

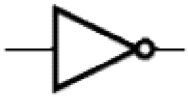
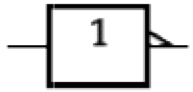
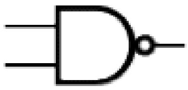
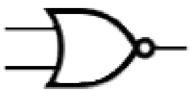
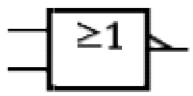
Q = A.B + A.B

= $\overline{A \oplus B}$

- The truth table for XOR gate

Truth table		
Input		Output
A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1

Type	Distinctive shape	Rectangular shape	Boolean algebra between A & B	Truth table
AND			$A \cdot B$	**INPUT** **OUTPUT** A B A AND B 0 0 0 0 1 0 1 0 0 1 1 1
OR			$A + B$	**INPUT** **OUTPUT** A B A OR B 0 0 0 0 1 1 1 0 1 1 1 1

<table>
<tr><td>NOT</td><td></td><td>
</td><td>$\overline{A}$</td><td>
<table>
<tr><th>INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>NOT A</td></tr>
<tr><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td colspan="5">In electronics a NOT gate is more commonly called an inverter. The circle on the symbol is called a bubble, and is generally used in circuit diagrams to indicate an inverted (active-low) input or output.[1]</td></tr>
<tr><td>NAND</td><td></td><td>
</td><td>$\overline{A \cdot B}$</td><td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A NAND B</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>NOR</td><td></td><td>
</td><td>$\overline{A + B}$</td><td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A NOR B</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
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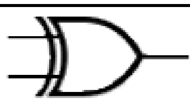
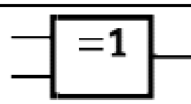
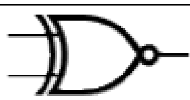
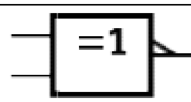
</td></tr>
<tr><td>XOR</td><td></td><td>
</td><td>$A \oplus B$</td><td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A XOR B</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>XNOR</td><td></td><td>
</td><td>$\overline{A \oplus B}$</td><td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A XNOR B</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
</table>

DeMorgan’s theorem:

- $\overline{AB} = \overline{A} + \overline{B}$
- $\overline{A+B} = \overline{A}\,\overline{B}$

EXERCISE-I

1. Which of the following gates the given truth table represents:

   a) NOT gate
   b) NOR gate
   c) OR gate
   d) AND gate

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

2. Which of the following gates the given truth table represents:

   a) NOT gate
   b) NOR gate
   c) OR gate
   d) AND gate

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

3. Which of the following gates the given truth table represents:

   a) NAND gate
   b) NOR gate
   c) OR gate
   d) AND gate

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

4. Which of the following gates the given truth table represents:

   a) NAND gate
   b) NOR gate
   c) OR gate
   d) AND gate

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

5. Which of the following gates the given truth table represents:

   a) NAND gate
   b) NOR gate
   c) OR gate
   d) XOR gate

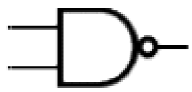
A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

6. Which of the following gates the given truth table represents:

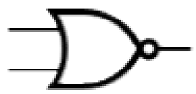
A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1

a) NAND gate
b) NOR gate
c) EX-OR gate
d) XOR gate

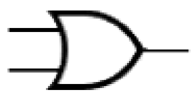
7. The logic symbol shown in figure represents
   a) NAND gate
   b) NOR gate
   c) OR gate
   d) AND gate



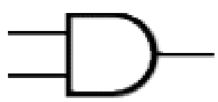
8. The logic symbol shown in fig represents
   a) NAND gate
   b) NOR gate
   c) OR gate
   d) AND gate



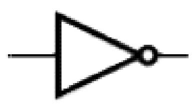
9. The logic symbol shown in fig represents
   a) NAND gate
   b) NOR gate
   c) OR gate
   d) AND gate



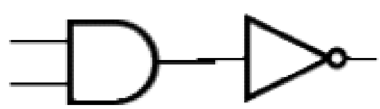
10. The logic symbol shown in fig represents
    a) NAND gate
    b) NOR gate
    c) OR gate
    d) AND gate



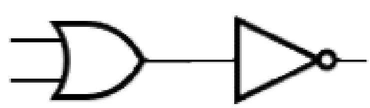
11. The logic symbol shown in fig represents
    a) NAND gate
    b) NOT gate
    c) OR gate
    d) AND gate



12. The name gate obtained by the combination as shown in fig
    a) NAND gate
    b) NOR gate
    c) OR gate
    d) AND gate



13. The name gate obtained by the combination as shown in fig
    a) NAND gate
    b) NOR gate
    c) OR gate
    d) AND gate



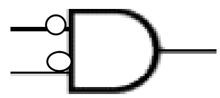
14. Which of the following gates are **universal gates?**
    a) NAND and NOR gate

b) NAND and OR gate
c) NOR and AND gate
d) AND and OR gate

15. If the two inputs of NOR gate are shorted as shown if fig then what does it represent?

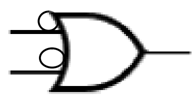
a) NAND gate
b) NOR gate
c) OR gate
d) AND gate

16. Find the logic gate given below:



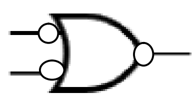
a) NAND gate
b) NOR gate
c) OR gate
d) AND gate

17. Find the logic gate given below:



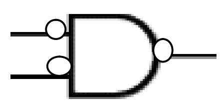
a) NAND gate
b) NOR gate
c) OR gate
d) AND gate

18. Find the logic gate given below:



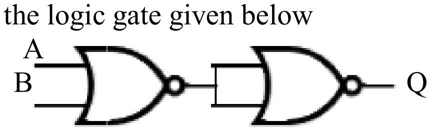
a) NAND gate
b) NOR gate
c) OR gate
d) AND gate

19. Find the logic gate given below:



a) NAND gate
b) NOR gate
c) OR gate
d) AND gate

20. Find the output of the logic gate given below



a) A+B
b) A.B
c) $\overline{A.B}$
d) $\overline{A+B}$

Key:

1.d	2.c	3.a	4.b
5.d	6.c	7.a	8.b
9.c	10.d	11.b	12.a
13.b	14.a	15.b	16.b
17.a	18.d	19.c	20.a

Question Bank:

Theory Questions:

Semiconductors:

1) Semi conductors have
   1) zero coefficient of resistivity 2) negative coefficient of resistivity
   3) positive coefficient of resistivity 4) infinite coefficient of resistivity
2) At zero degree kelvin a piece of germanium
   1) becomes semiconductor 2) becomes good semiconductor
   3) becomes bad conductor 4) has maximum conductivity
3) In a semi conductor the majority charge carrier concentration varies as a function of
   1) temperature 2) pressure 3) doping concentration 4) all the above
4) Which of the statement below is true
   1)the forbidden gap in a metal is greater than the forbidden gap in a semiconductor
   2)the forbidden gap in a semi conductor is greater than the forbidden gap in a metal and less than the forbidden gap in the insulator
   3)the metal, semiconductor and insulator have same forbidden gap
   4)the forbidden gap in a metal is less than the forbidden gap in a semi conductor, but greater than the energy gap in an insulator
5) Pure or intrinsic semi conductor at absolute zero is a
   1) super conductor 2) good conductor
   3) perfect insulator 4) none
6) In intrinsic semi-conductor at room temperature, number of electrons and holes are
   1) equal 2) zero 3) unequal 4) infinite
7) The ratio of free electrons to holes in intrinsic semiconductor is
   1) 1 2) <1 3) >1 4) $=2$
8) N-type semiconductor is
   1) Ge doped with *As* 2) Ge doped with *In*
   3) Ge doped with *Al* 4) SI doped with *In*
9) In n –type semi conductor fermi energy level lies
   1) nearer to valence band 2) nearer to conduction band
   3) at midpoint of forbidden gap 4) nearer to donor level
10) A p –type semi conductor can be obtained by doping Si with
   1) Germanium 2) Gallium 3) Nitrogen 4) Phosphorous
11) A p –type semi conductor is electrically
   1) positive 2) negative 3) neutral 4) none

Junction Diodes:

12) The potential barrier at a p –n junction is due to the charges on either side of the junction. These charges are
   1) fixed ions 2) majority carriers
   3) both majority and minority carriers 4) minority carriers
13) The electrical resistance of depletion layer is large because
   1)it contains electrons as charge carriers 2)it contains holes as charge carriers

3)it has large number of charge carriers 4)it has no charge carriers

14) In a semi conductor diode, the barrier potential opposes diffusion of
1) free electrons from n –region 2) holes from p –region
3) majority carriers from both the region 4) minority carriers from both region

15) A p –n junction diode is said to be forward biased, when
1) no potential difference is applied across p and n regions
2) a potential difference is applied across p and n regions making p region positive and n region negative
3) a potential difference is applied across p and n region making p region negative and n region positive
4) a magnetic field is applied in the region of junction

16) In forward biased condition, the width of depletion layer will
1) increases 2) decreases 3) remains same 4) first increases and then decreases

17) The resistance of an ideal diode in forward biased condition is
1) zero 2) infinity 3) finite 4) negative

18) A p –n junction diode is said to be reverse biased, when
1) no potential difference is applied across p and n regions
2) a potential difference is applied across p and n regions making p region positive and n region negative
3) a potential difference is applied across p and n regions making p region negative and n region positive
4) a magnetic field is applied in the region of junction

19) When a p –n junction diode is reverse biased, the flow of current across the junction is mainly due to
1) diffusion of charges 2) drift of charges
3) both drift & diffusion of charges 4) neither diffusion nor drift of charges

20) In a half-wave rectifier, the load current flows for
1) the complete cycle of the input signal
2) more than half-cycle but less than the complete cycle of the input signal
3) less than half cycle of the input signal
4) only for every half cycle of the input signal

21) A half-wave rectifier circuit is operating at n Hz mains frequency. The fundamental frequency in the ripple would be
1) n Hz 2) $\frac{n}{2}$ Hz 3) 2n Hz 4) 4n Hz

22) In half-wave rectifiers maximum percentage of a.c power that can be converted into d.c power is
1) 25% 2) 40.6% 3) 81.2% 4) 10%

23) A half-wave rectifier is used to convert n Hz a.c., into d.c., then the number of pulses per second present in rectified voltage is

1) n 2) $\frac{n}{2}$ 3) 2n 4) 3n

24) In a full wave rectifier the maximum a.c power that can be converted into d.c power is
1) 81.2% 2) 40.6% 3) 50% 4) 25%

25) A diode as a rectifier converts
1) a.c., into d.c., 2) d.c., into a.c., 3) varying d.c., current into constant d.c., current
4) high voltage into low voltage & vice –versa

26) Zener diode will function in
1) forward bias 2) reverse bias 3) both 1&2 4) none

27) Zener breakdown will occur if
1) impurity current source2) impurity level is high
3) impurity is less in n-side 4) impurity is less in p-side

28) At breakdown region of a Zener diode which of the following does not change much
1) current 2) voltage 3) dynamic impedence 4) capacitance

Junction Transistors:

29) Transistors are made up of
1) Copper 2) Aluminium 3) Silicon 4) Constantan

30) The emitter of a transistor is doped the heaviest because it
1) is supplier of charge carriers 2) receives the input
3) dissipates maximum power 4) should have low resistance

31) A n –p –n transistor conducts when
1) both collector and emitter are positive with respect to base
2) collector is positive and emitter is negative with respect to base
3) collector is positive and emitter is at same potential as the base
4) both collector and emitter are negative with respect to base

32) Which of the following is correct?
1) In a transistor power disspated in emitter region is greater than that in collector region
2) In a transistor power disspated in emitter and collector regions is same
3) In a transistor power dissipated in collector region is greater than that in emitter region
4) None of the above

33) Transistor input characteristic curves are the graphs drawn with
1) collector current I_c on Y- axis and the collector emitter voltage V_{ce} on X-axis for a constant base current
2) base current I_b an Y-axis and the base collector voltage V_{be} on X-axis for a constant collector emitter voltage
3) base current I_b on Y-axis and the collector emitter voltage V_{ce} on X-axis for a constant collector current 4)none

34) Transistor output characteristic curves are the graphs drawn with

1) collector current I_c on Y- axis and the collector emitter voltage V_{ce} on X-axis for a constant base current
2) base current I_b an Y-axis and the base collector voltage V_{be} on X-axis for a constant collector emitter voltage
3) base current I_b on Y-axis and the collector emitter voltage V_{ce} on X-axis for a constant collector current 4)none

35) The value of current gain α of a transistor should be
1) =1 2) >1 3) <1 4) any value

36) The current amplification factor β can never be
1) = 100 2) >1 3) <1 4) none

Match the Following Questions:

37) Match Column I with column II

Column –I	Column –II
a) Conductors	e) energy gap is 5eV
b) Insulators	f) energy gap is zero
c) Semiconducotrs	g) energy gap is 1eV

The correct match is
1) a→e; b→d; c→f 2) a→f; b→e; c→d
3) a→d; b→e; c→f 4) a→d; b→f; c→e

38) Match the following lists:

List –I	List –II
a) current gain	e) $\frac{\Delta I_C}{\Delta I_b}$
b) voltage gain	f) $\frac{\Delta I_C}{\Delta I_b}\frac{R_L}{R_I}$
c) power gain	g) $\left(\frac{\Delta I_C}{\Delta I_b}\right)^2\frac{R_L}{R_I}$
d) resistance gain	h) $\frac{R_L}{R_I}$

The correct match is
1) a→e; b→d; c→g; d→h2) a→f; b→g; c→h; d→e
3) a→g; b→h; c→e; d→f 4) a→h; b→e; c→f; d→g

Assertion & Reason Type Questions:

39) Assertion: When the temperature of a semiconductor is increased, then its resistance decreases

Reason: The energy gap between conduction band and valence band is very small
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

40) Assertion: The conductivity of a semiconductor increases with rise of temperature
Reason: On rising temperature covalent bonds of semiconductor breaks
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

41) Assertion: All the intrinsic semiconductors are insulators at absolute zero
Reason: All electrons are tightly bound at absolute zero
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

42) Assertion: The temperature coefficient of resistance is positive for metals and negative for p –type semiconductors
Reason: The effective charge carriers in metals are negatively charged whereas in p –type semiconductors they are positively charged
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

Key

1) 2	2) 3	3) 3	4) 2	5) 3	6) 1
7) 1	8) 1	9) 2	10) 2	11) 3	12) 3
13) 4	14) 3	15) 2	16) 2	17) 1	18) 3
19) 2	20) 4	21) 1	22) 2	23) 3	24) 1
25) 1	26) 3	27) 2	28) 2	29) 3	30) 1
31) 2	32) 3	33) 2	34) 1	35) 3	36) 3
37) 1	38) 1	39) 1	40) 3	41) 1	42) 2

Numerical Questions:
Semiconductors & Diodes:

1) The depletion layer in a silicon diode is 1μ m with and its knee potential is 0.6 V, then the electric field in the depletion layer will be
1) 0.6 V/m 2) $6x10^4$V/m 3) $6x10^5$V/m 4) zero

2) In a p –n junction diode made with Ge the thickness of depletion layer is 2x10-6m and barrier potential is 0.3volts. The strength of electric field at the junction is
1) $0.6x10^{-6}Vm^{-1}$ from n to p side 2) $0.6x10^{-6}Vm^{-1}$ from p to n side
3) $1.5x10^5Vm^{-1}$ from n to p side 4) $1.5x10^5Vm^{-1}$ from p to n side

3) The barrier potential in a p –n junction diode is 0.3 volts. The current required is 6 mA. If a resistance of 200Ω is connected in series with the junction diode then the emf of the cell required for use in the circuit is
1) 0.3V 2) 1.2V 3) 0.9V 4) 1.5V
4) In a half wave rectifier a load resistance of 1KΩ and a diode of internal resistance 10Ω are used. What is the efficiency of this rectifier?
1) 10.2% 2) 20.2% 3) 30.2% 4) 40.2%
5) In a half wave rectifier circuit operating from 50Hz mains frequency, the fundamental frequency in the ripple would be
1) 25Hz 2) 50Hz 3) 70.7Hz 4) 100Hz
6) In the half wave rectifier circuit the applied A.C voltage is V = 5 sin 100πt. Assuming the diode to be ideal, find the D.C output voltage when the load resistor is of 200Ω and D.C current in the load resistor
1) 1.6V, 7.95mA 2) 1.4V, 2.95mA
3) 2.2V, 3.95mA 4) 3.2V, 4.95mA
7) If the internal resistance of the diodes used in a fullwave rectifier is 12Ω and the load resistance is 1200Ω, what is the efficiency?
1) 20.4% 2) 80.4% 3) 40.4% 4) 60.4%
8) In a full wave rectifier circuit operating from 50Hz mains frequency, the fundamental frequency in the ripple would be
1) 25Hz 2) 50Hz 3) 70.7Hz 4) 100Hz
9) A full wave p –n diode rectifier uses a load resistance of 1300Ω, No filter is used. The internal resistance of each diode is 9Ω, what is the efficiency of the rectifier
1) 80.64% 2) 60.64% 3) 40.64% 4) 20.64%
10) In a filterless rectifier 60W d.c output power is obtained from 130W a.c input power. What is the efficiency of the rectifier?
1) 46.15% 2) 56.15% 3) 66.15% 4) 76.15%

Transistors:

11) In an NPN transistor circuit the collector current is 10mA. If only 90% of emitted electrons reach the collector, then
1) $I_B = -1$mA 2) $I_C = 1$mA 3) $I_E = 11$mA 4) $I_E = 9$mA
12) In an NPN transistor the values of base current and collector current are 100μA and 9mA respectively, the emitter current will be
1) 9.1mA 2) 18.2mA 3) 9.1μA 4) 18.2μA
13) If a change of 100μA in the base current of an n –p –n transistor causes a change of 10mA in the collector current, the gain of the transistor is
1) 10 2) 100 3) 200 4) 1000
14) In a p –n –p transistor circuit, the collector current is 10mA. If 95% of the electrons emitted reach the collector, what is base current
1) 0.35mA 2) 0.25mA 3) 0.4mA 4) 0.53mA

15) A transistor is connected in common emitter configuration. The collector supply is 8V and the voltage drop across a resistor of 800Ω in the collector circuit is 0.5 V. If α = 0.96 calculate the base current
1) 12μA 2) 32μA 3) 26μA 4) 20μA
16) A current gain α of a transistor is 0.95. Find the change in collector current corresponding to a change of 0.4mA in base current in CE arrangement
1) 7.6mA 2) 0.76mA 3) 760mA 4) 0.076mA
17) In common emitter circuit find collector to emitter voltage when applied voltage is 24V and p.d in series collector load resistance is 7V
1) 31V 2) 17V 3) 7V 4) 24V
18) In a transistor (CE) when the base current is changed from 50μA to 150μA, the collector current changes from 0.2mA to 4.2mA. Find the current gain
1) 4 2) 0.4 3) 40 4) 400
19) In CE configuration of a transistor, input resistance is 2KΩ, load resistance is 5KΩ, current gain is 60. An input signal of 12mV is applied to the transistor, calculate the voltage gain
1) 15 2) 150 3) 1500 4) 1.5
20) If α for a transistor is 0.95, then value of β is
1) 18 2) 19 3) 20 4) 95
21) For a transistor, the value of β = 99. The value of "α" is
1) 99 2) 9.9 3) 0.99 4) 100
22) In a common base transistor amplifier if the input resistance R_i is 200Ω and load resistance R_L is 20KΩ, find voltage gain (α = 0.95)
1) 86 2) 98 3) 94 4) 95

Key

1)3	2)3	3)4	4)4	5)2	6)1	7)2	8)4
9)1	10)1	11)3	12)1	13)2	14)4	15)3	16)1
17)2	18)3	19)2	20)2	21)3	22)4		

SEMICONDUCTOR DEVICES Previous Eamcet Questions

1) When n-p-n transistor is used as an amplifier [2003E]
1) electrons move from base to collector 2) holes move from emitter to base
3) holes move from collector to base 4) holes move from base to emitter. Key:1

2) Consider the following statements A and B and identify the correct answer: [2003M]
A) A zener diode is always connected in reverse bias.
B) The potential barrier of a p-n junction lies between 0.1 to 0.3V approximately.
1) A and B are correct 2) A and B are wrong
3) A is correct, but B is wrong 4) A is wrong, but B is correct. Key:1

3) In n-p-n transistor, in CE configuration:
a) The emitter is heavily doped than the collector.
b) Emitter and collector can be interchanged,
c) The base region is very thin but is heavily doped.
d) The conventional current flows from base to emitter. [2004E]
1) (a) and (b) are correct. 2) (a) and (c) are correct.
3) (a) and (d) are correct 4) (b) and (c) are correct. Key:3

4) A zener diode when used as a voltage regulator is connected: [2004M]
a) in forward bias b) in reverse bias c) in parallel to the load d) in series with the load.
1) (a) and (b) are correct. 2) (b) and (c) are correct.
3) (a) only is correct. 4) (d) only is correct. Key:2

5) An n-p-n transistor power amplifier in CE configuration gives: [2005E]
1) voltage amplification only 2) current amplification only
3) Both current and voltage amplification 4) only power gain of unity. Key:3

6) Consider the following statements A and B and identify the correct answer:
(A): Germanium is preferred over silicon in construction of zener diode.
(B): Germanium has high thermal stability. [2005M]
1) Both (A) and (B) are true. 2) Both (A) and (B) are false.
3) (A) is true, but (B) is false. 4) (A) is false, but (B) is true. Key:2

7) Consider a p-n junction as a capacitor, formed with p and n – materials acting as thin metal electrodes and depletion layer width acting as separation between them. Basing on this, assume that a n-p-n transistor is working as an amplifier in CE configuration. If C_1 and C_2 are the base-emitter and collector emitter junction capacitances, then: [2006E]
1) $C_1 > C_2$ 2) $C_1 < C_2$ 3) $C_1 = C_2$ 4) $C_1 = C_2 = 0$ Key:1

8) A p-n-p transistor is said to be in active region of operation, when:
1) Both emitter junction and collector junction are forward biased.
2) Both emitter junction and collector junction are reversed biased.
3) Emitter junction is forward biased and collector junction is reversed biased.
4) Emitter junction is reversed biased and collector junction is forward biased.
Key:3

9) In an n-type semiconductor, the Fermi energy level lies [2007E]
1) In the forbidden energy gap nearer to the conduction band.
2) In the forbidden energy gap nearer to the valance band. Key:1
3) In the middle of forbidden energy gap. 4) outside the forbidden energy gap.

10) In a transistor circuit the base current changes from 30 μA to 90 μA. If the current gain of the transistor is 30, the change in the collector current is
1) 4mA 2) 2mA 3) 3.6mA 4) 1.8mA [2007M] Key:4

Chapter 30
COMMUNICATION SYSTEMS

SYNOPSIS:

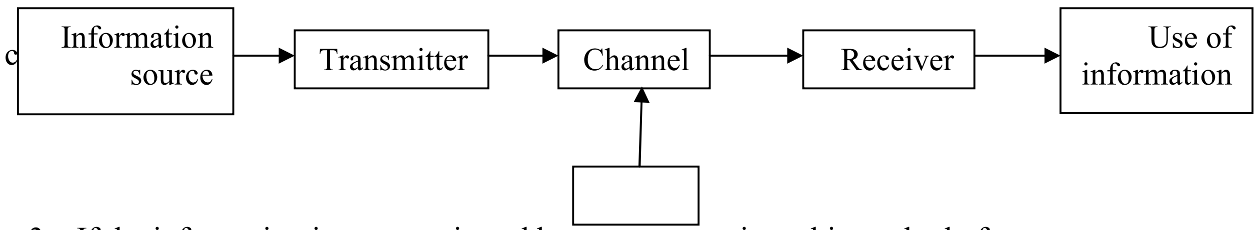
INTRODUCTION

1. The exchange of information between a Sender and receiver is called communication.
2. The arrangement of devices to transfer the information is called the communication system.

COMMUNICATION SYSTEM:

A communication system consists of three essential parts

a) Transmitter b) medium or channel c) receiver



3. If the information is communicated between two points, this method of communication is point to point mode.
4. If the information is communicated form one point to several points, this method is called Broad casting mode.

MESSAGE SIGNAL:

The information converted into electrical form by a transducer suitable for transmission is called message signal.

Signals are of two types **analog** and **digital**.

- **Analog signal:** any physical variable is converted into continuous variations of current or voltage. These changes are analogous to the changes of the information. These changes are single valued functions of time.
- **Digital signal:** the physical variables are converted into stepwise variations of current or voltages. Generally two types of signals level corresponds to zero and high level corresponds to1.
- **Transducers:** any device that converts one energy form of energy into another form. An electrical Transducer converts some physical variable into electrical variables or vice versa. Example: Microphone-converts sound into electrical variables.
  Speaker- converts electrical variable into sound.
- **Transmitter:** the transmitter processes the message and makes suitable for transmission through a channel.
- **Noise:** the unwanted signals which tend to disturb the transmission or processing of message signals are called Noise. These may generate inside or outside the system.

- **Receiver:** the receiver extracts the message from the received signals at channel output.
- **Attenuation:** the loss of strength of a signal while propagating through a medium is known as attenuation.
- **Amplification:** it is process of increasing the amplitude (and consequently the strength) of a signal using an electronic circuit called the amplifier. Amplification is necessary to compensate the attenuation of the signal in communication systems.
- **Range:** it is the largest distance between a source and destination up to which the signal is received with sufficient strength.
- **Bandwidth:** bandwidth refers to the frequency range over which equipment operates or the portion of the spectrum occupied by the signal.
- **Modulation:** the original low frequency range message / information signal cannot be transmitted to long distances. Therefore, at the transmitter, information contained in the low frequency message signal is superimposed on a high frequency wave, which acts as a carrier of the information. This process is known as modulation.
- **Demodulation:** the process of retrieval of information from the carrier wave at the receiver is termed as demodulation. This is the reverse process of modulation.

5) **Broadcasting mode of communication-propagation of em waves:**

a) This type of communication is also called as the wireless communication.
b) The em wave (radio waves) is used for the transmission.
c) The radio waves form transmitting antenna reach the receiving antenna through ground or through atmosphere.
d) The earth atmosphere plays an importance role in the propagation. Depending on the frequency of the radio waves and the ranges, three modes of propagation exist.
i) Ground wave propagation.
ii) Sky wave propagation.
iii) Space wave propagation.

6) **Layers of atmosphere.**

i) Sky wave propagation takes place with the help of the layer in the atmosphere.
ii) The gaseous envelope of the earth is called the earth atmosphere.
iii) There is no sharp boundary for the atmosphere
vi) The earth's atmosphere is divided into several layers; depending on the temperature variations.

7) **Troposphere:**

a) The region extends from the surface to approximately 10km above the surface.
b) This has large concentration of water vapour.
c) The temperature decreases up to 55^{o} c.

d) All the climatic changes occur in this region.

8) **Stratosphere:**

a) The region extends from 12km to 50km above the surface. The temperature constant up to 30km.

b) The upper part of thickness 20km and 30km to 50km from the surface is called Ozone layer. Temperature increases from 55^o c to 65^o c.

c) This layer absorbs a larger portion of UV radiations from the sun.

9) **Mesosphere:**

a) The layer between 50km to 80km from the surface of earth is called Mesosphere temperature again decreases to -73^o c.

10) **Ionosphere:**

a) The region from a height of nearly 65km to 400km above the earth is called the ionosphere.

b) Ionosphere is mainly composed of free electrons and ions.

c) Ions are produced due to UV radiations and rays or x-ray. And the temperature is increases.

11) **Different layers useful for sky wave propagation.**

a) During day time ionosphere separates into three layers. D-layer, E-layers, and F-layers(F1&F2).

b) D layer attenuates radio waves during day time.

c) The attenuation is maximum for lower frequencies.

d) Hence, HF waves are used for SKY waves propagation.

e) E layer of ionosphere reflects the radio waves of frequencies from 3MHz to 30MHz.

f) This reflection is similar to the total internal reflection of light.

g) This is used for range up to 500km.

h) The central part of E layer has maximum electron density. But it is less than the F layer.

i) Reflection takes place by E layer during day time.

j) This layer is highly variable in space and time.

k) F layer is the highest significant layer in the ionosphere.

l) During day time F layer splits into F1 to F2 layer.

m) F2 layer has more electron density.

n) F2 is stronger than F1 layer in reflection.

o) The range is maximum for the F2 layer. For reflection over 500km range this layer is used.

p) During night F1 and F2 layers combines and called F layer.

q) During night D and E layers disappear and the effective layer is only F layer.

r) **Kennely Heaviside layer:** at 110km above the surface of the earth the concretion of electrons is very large. This layer is called Kennely Heaviside layer .

s) This thickness of this layer is about a few km.

t) Beyond this layer the electrons concentration decrease up to 250km.

u) From 250km to 400km a layer of large concentration of electrons called Apple ton layer exist.

Name of the layer	Approximate height over earth's surface	Exists during	Frequencies most affected
Troposphere	10km	Day and night	VHF (up to several GHZ)
Parts of ionosphere			
D (part of stratosphere)	65- 75 km	Day only	Reflects LF, absorbs MF and HF to some degree
E(part of the stratosphere)	100km	Day only	Helps surface waves, reflects HF
F_1(part of the mesosphere)	170km-190km	Day time, merges with F_2 at the night	Partially absorbs HF waves yet allowing them to reach F_2
F_2(part of the thermosphere)	300km at night 250-400km during day time	Day and night	Efficiently reflects HF waves, particularly at night

12) **Frequencies Selection:**

FM Broad Cast - 88MHz to 108MHz.

AM Broad Cast- 535 KHz to 1605 KHz.

TV Broad Cast - VHF 54-72MHz. VHF (very high frequencies)

76-88MHz. TV

UHF 174-216MHz. UHF (ultra high frequencies)

420-890MHz. TV

Cellular Mobile 896MHZ to 901MHz. Mobile to Base station.

840MHz to 935MHz. Base station to mobile.

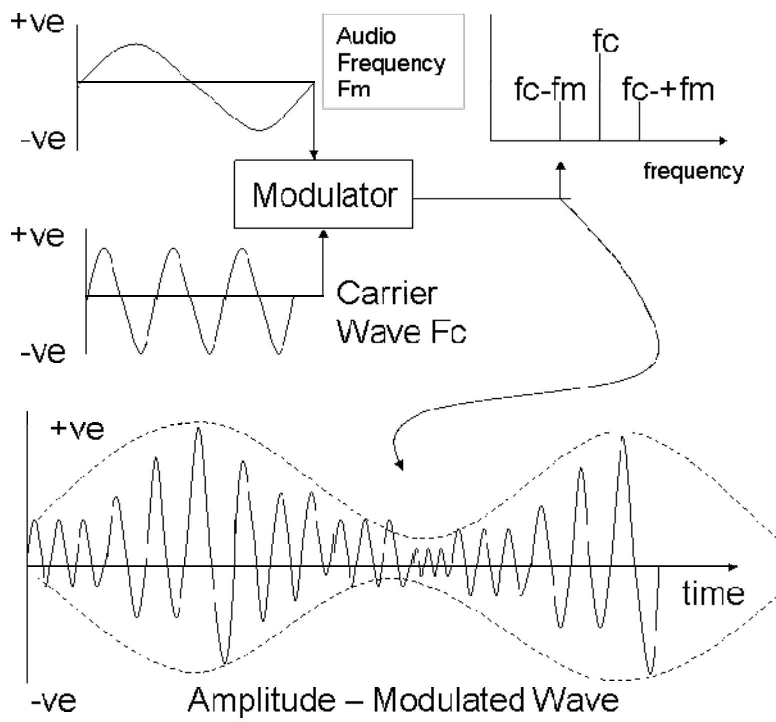
Satellite 5.923-6.453GHz UP LINK

3.424-4.234GHz DOWN LINK

Modulation:

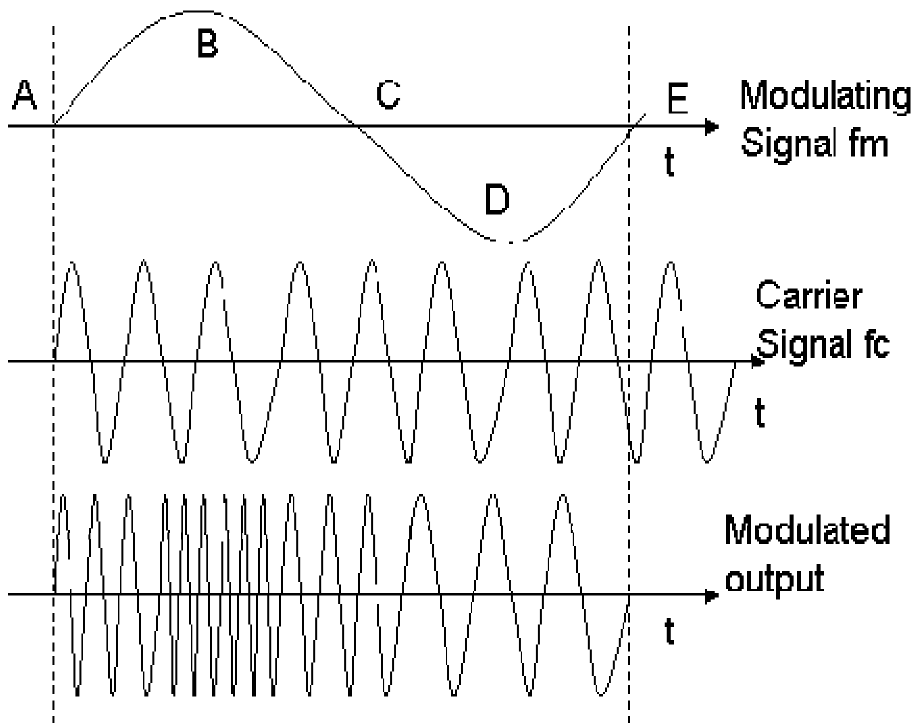
a) The message signals are also called base band signals which are in AF range (less than 20KHz).
b) These AF signals cannot be transmitted to a long distance because of attenuation (loss of energy).
c) For the transmission of AF range signals, the linear size (l)of the antenna should be large.

d) The effective power radiated by the transmitter is proportional to (l/λ^2). Hence the size of the antenna about 75km which is not feasible.
e) When many transmitters are radiating base band signals simultaneously, they mix up and it is difficult to distinguish the required signal.
f) The solution for the long distance transmission is the selection of the HF transmission.
g) As HF radio waves are preferred for transmission, the message contained by the baseband is to be translated on to a HF em wave.
h) Messages are converted into electrical variations by a transducers.
i) These electrical variations are called signal.
j) The sound waves are converted into electrical variations (either voltage or current) by the Microphone (transducer).
k) The signal wave is called modulation wave.
l) The electrical variations are super imposed on the RF em wave called carrier wave(CW).
m) The resultant wave is called modulation wave.
n) This process is called modulation.
o) During modulation one of the characteristics of the RF wave (CW) is to be changed in accordance with signal.
p) Modulation is of three types: i) Amplitude modulation: the amplitude of carrier wave is varies in accordance with the amplitude of the message signal or modulating signal. However the frequency and phase of remain same. ii) the amplitude of carrier wave increases in accordance with the increases of the amplitude of the signal in the positive half cycle and decreases with the amplitude of the signal in the negative



half cycle.

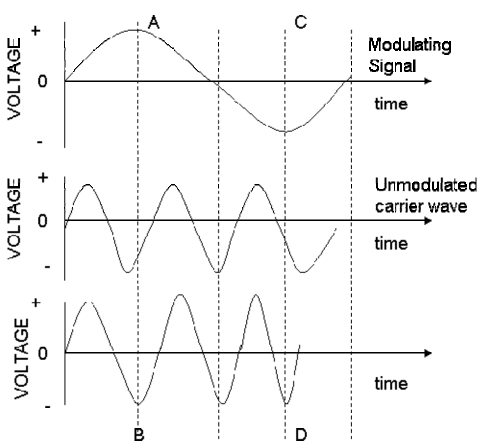
<u>Frequency Modulation:</u>1) the process of which the frequency of the carrier wave is changes in accordance with the instantaneous value of the message signals.
2) The amplitude of the modulated wave does not change.



FREQUENCY MODULATION WAVE

PHASE MODULATION: 1) The phase of the Carrier wave is changes in accordance with the phase of the message signal or the modulated signal.

2) The AMPLITUDE AND FREQUENCY does not change.



Phase Modulated carrier wave

Demodulation:

1) The process of extracting the message signal from the modulated wave is called Demodulation.
2) This consists of detection and amplification of signal.
3) This also called as original signal.

Need for modulation:

- To reduce the antenna height.
- To mixing up of signals from different transmitters.
- To reduce the bandwidth
- To reduce noise and interference
- For multiplexing of signals

EXERCISE:

Antenna:

1. An antenna
   a) Converts AF wave to RF wave.
   b) RF signal into electromagnetic energy.
   c) Converts the guided em wave into free space em wave and vice versa.
   d) Super imposes AF wave on RF wave.
2. An antenna behaves as a resonant circuits only when the circuit only when the length is
   a) Equal to λ/4.
   b) Equal to λ/2.
   c) Equal to the integral multiple of λ/2.
   d) Equal to 3λ/4.
3. The length of the antenna
   i) Limits the frequency of EM waves to be radiated.
   ii) Makes the users to opt for higher frequency transmission.
   iii) Is insignificant during transmission.
   a) i& ii are true b) ii & iii are c) iii &i are true d)i , ii &iii are true
4. The height of the antenna
   i) Limits the populated covered by the transmission.
   ii) Limits the ground wave propagation
   iii) Effectively used in line of slight communication.
   Then which of the following is correct
   a) i& ii are true
   b) ii & iii are true
   c) iii &i are true
   d)i , ii &iii are true

5.The length of the antenna required for the transmission of frequencies of em wave of bandwidth having AF range is
   a) 15km b) 1500km c) 300km d) 3km

6.The maximum distance up to which TV transmission form a TV tower of height ‘h’ can be received is proportional to

a) $h^{1/2}$ b) h c) $h^{3/2}$ d) h^2

ANSWERS:

1.c	2.a	3.a	4.d	5.a	6.a

Modulation space and line communication:

1. the process of translating the information contained by the low base band signal to high frequencies is called
a) Detection b) Modulation c) Demodulation d) amplification

2. Digital signals
a) Do not provide continuous set of values
b) Represent values as discrete steps
c) Utilize binary code system
d) All the above

3. High frequency waves are
a) Absorbed by F layer
b) Reflected by the E layer
c) Capable of use for the long distance transmission
d) Affected by the solar cycle

4. As EM waves travel in free space
a) Adsorption takes place
b) Attenuation takes place
c) Refraction takes place
d) Reflection takes place

5. The ground wave eventually disappears, as one move away from the transmitter, because of
a) Interface from the sky wave
b) Loss the line of signal condition
c) Maximum single- hop distance limitation
d) Diffraction effect causing tilting of the wave

6. Frequencies of UHF ranges normally propagated by means of
a) Ground waves (b) Sky waves (c) Surface waves (d) Space waves

7. For TV transmission the frequency range employed
a) 30-300MHz c) 30-300KHz 30-300GHz d) 30-300HZ

8. Band width of an optical fiber
a) More than 100GHz (b) Few KHz (c) Less than 1MHz (d) Less than 1GHz

9. The most commonly employed analog modulation technique in satellite communication is
a) AM b) FM c) PM d) all of the above

10. The frequency band of medium wave Radio broad casting transmission is
    a) 540KHz to 1600KHz (b) 30KHz to 300KHz
    (c) 3KHz to 300KHz d) 3Ghz to30GHz
11. The short wave Radio broadcasting band is
    a) 7MHz to 22MHz b) 88MHz to 108MHz
    c) 30Khz to 300KHz d) 3GHZ to 30GHz
12. The FM radio broad casting is
    a) 5MHz to 30MHz b) 88MHz to 108MHz
    c) 30KHZ to 300KHz d) 3Ghz to 30GHz
13. The TV broadcasting bands are
    a) MF and HF bands b) VHF and UHF bands
    c) UHF and SHF bands d) SHF and UHF bands
14. The number of bands in TV broad casting is
    a) 1 b) 2 c)3 d)4
15. The lower frequency of TV broad casting are
    a) 0.54KHz to 1.6KHz, 80MHz to 108MHz
    b) 896 to 901MHz, 0.84 to 0.96Hz
    c) 54MHz to 72 MHZ, 76MHz to 88MHz
    d) All of the above
16. Cellular mobile radio works on the frequency range of the
    a) 840 to 935 MHz b) 3.7 to 4.2 GHz
    c) 420 to 890MHz d) 30 to 300FHz
17. In satellite communication, the frequency for down linking range is
    a) 0.896 to 0.901GHz b) 0.420 to 0.890GHz
    c) 5.925 to 6.423GHz d) 3.723 to 4.200GHz
18. The sky wave propagation is suitable for
    a) Up to 2MHz b) From 2MHz to 20MHz
    b) Form 2MHz to 30MHz d) None of the above
19. Micro wave link repeaters are typically 50 km apart
    a) Because of atmosphere attenuation
    b) Because of the earth curvature.
    c) To ensure that signal voltages may be not harm the repeater.
    d) To reduce the interface of the microwaves.
20. Space wave propagation is used in
    a) Micro wave communication
    b) Satellite communication
    c) TV transmission.
    d) All the above.
21. The attenuation of ground waves due to
    a) Diffraction effect
    b) Radio waves induce current in the ground because of the polarization.

c) Then which of the following is correct
  a) a & b are true
  b) only a is true
  c) only b is true
  d) both a & b are false

22. the attenuation of the signal is compensated by
  a) rectifier b) oscillator c) modulator d) amplifier
23. What should be the bandwidth of frequencies required for the transmission of the pictures using video signals?
  a) 4.2MHz b) 15.2MHz c) 25.3MHz d) 35.3MHz
24. Which of the following is the example for point to point communication?
  a) Telephony b) voice c) Radio d) television
25. Which of the following is the example for broadcast communication?
  a) Radio and television b) Voice and picture c) Telephony d) None of the above
26. What should be the bandwidth of frequencies required for the transmission of the speech signals?
  a) 2800Hz b) 54kHz c) 34KHz d) 7823Hz
27. Ground waves propagation is also known as
  a) Surface wave propagation b) Sky wave propagation
  c) Space wave propagation d) None of the above
28. The maximum line of slight distance d_m between two antennas having heights h_T and h_R above the earth is given by
  a) $\Gamma(2Rh_T)$ and $\Gamma(2Rh_R)$ b) $\Gamma(2Rh_M)$ and $\Gamma(2Rh_R)$
  c) $\Gamma(2Rh_T)$ and $\Gamma(2Rh_m)$ d) None of the above
29. Which of the following is a example for space wave propagation
  a) Satellite communication b) Radio broadcast
  c) Voice broadcast d) All of the above
30. The standard AM broadcast frequency bands are
  a) 88 – 108MHz b) 540 – 1600KHz c) 540 – 1600MHz d) 467- 1366MHz

Key

1)b	2)d	3)b	4)b	5)d	6)d
7)a	8)a	9)b	10)a	11)a	12)b
13)b	14)d	15)c	16)a	17)c	18)c
19)b	20)d	21)a	22)d	23)a	24)a
25)a	26)a	27)a	28)a	29)a	30)b