SMART SKILLS

SYLLABUS 2016-2017

PHYSICS

Index

COURSE STRUCTURE
Class XI (Theory)
Three Hours

One Paper - **Max Marks: 70**

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Unit VII Properties of Bulk Matter Unit VIII Thermodynamics Unit XI Behaviour of Perfect Gas & Kinetic Theory of gases	20
Unit X Oscillations & Waves	10
	Total 70

APRIL-MAY

Unit I: Physical World and Measurement

Physics - scope and excitement; nature of physical laws; Physics, technology and society.
Need for measurement: Units of measurement; systems of units; SI units, fundamental and derived units. Length, mass and time measurements; accuracy and precision of measuring instruments; errors in measurement; significant figures. Dimensions of physical quantities, dimensional analysis and its applications.

Unit II: Kinematics

Frame of reference. Motion in a straight line: Position-time graph, speed and velocity. Uniform and non-uniform motion, average speed and instantaneous velocity.

Uniformly accelerated motion, velocity-time, position-time graphs. Relations for uniformly accelerated motion (graphical treatment). Elementary concepts of differentiation and integration for describing motion.

Scalar and vector quantities: Position and displacement vectors, general vectors and notation, equality of vectors, multiplication of vectors by a real number; addition and subtraction of vectors. Relative velocity.

Unit vector; Resolution of a vector in a plane - rectangular components. Scalar and vector product of vectors Motion in a plane. Cases of uniform velocity and uniform acceleration-projectile motion. Uniform circular motion.

JULY

Unit III: Laws of Motion

Intuitive concept of force. Inertia, Newton's first law of motion; momentum and Newton's second law of motion; impulse; Newton's third law of motion. Law of conservation of linear momentum and its applications. Equilibrium of concurrent forces. Static and kinetic friction, laws of friction, rolling friction, lubrication.

Dynamics of uniform circular motion: Centripetal force, examples of circular motion (vehicle on level circular road, vehicle on banked road)

AUGUST-

Unit IV: Work, Energy and Power

Work done by a constant force and a variable force; kinetic energy, work-energy theorem, power. Notion of potential energy, potential energy of a spring, conservative forces: conservation of mechanical energy (kinetic and potential energies); non-conservative forces: motion in a vertical circle; elastic and inelastic collisions in one and two dimensions.

SEPTEMBER – OCTOBER

Unit V: Motion of System of Particles and Rigid Body

Centre of mass of a two-particle system, momentum conservation and motion of centre of mass. Centre of mass of a rigid body; centre of mass of uniform rod. Moment of a force, torque, angular momentum, conservation of angular momentum with some examples.

Equilibrium of rigid bodies, rigid body rotation and equations of rotational motion, comparison of linear and rotational motions; moment of inertia, radius of gyration. Values of moments of inertia for simple geometrical objects (no derivation). Statement of parallel and perpendicular axes theorems and their applications.

Unit VI: Gravitation

Kepler's laws of planetary motion. The universal law of gravitation. Acceleration due to gravity and its variation with altitude and depth. Gravitational potential energy; gravitational potential. Escape velocity. Orbital velocity of a satellite. Geo-stationary satellites.

NOVEMBER

Unit VII: Properties of Bulk Matter

Elastic behavior, Stress-strain relationship, Hooke's law, Young's modulus, bulk modulus,shear, modulus of rigidity, Poisson's ratio, elastic energy. Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes). Effect of gravity on fluid pressure.Viscosity, Stokes' law, terminal velocity, Reynold's number, streamline and turbulent flow. Critical velocity .Bernoulli's theorem and its applications.
Surface energy and surface tension, angle of contact ,excess pressure, application of surface tension ideas to drops, bubbles and capillary rise.

Heat, temperature, thermal expansion; thermal expansion of solids, liquids and gases, anomalous expansion of water, specific heat capacity; C_p, Cv - calorimetry; change of state – latent heat capacity. Heat transfer-conduction, convection and radiation, Qualitative ideas of blackbody radiation, greenhouse effect, thermal conductivity, Wein's displacement Law, Stefan's Law.

DECEMBER

Unit X: Oscillations and Waves

Periodic motion – time period, frequency, displacement as a function of time. Periodic functions. Simple harmonic motion (S.H.M) and its equation; phase; oscillations of a spring-restoring force and force constant; energy in S.H.M.- kinetic and potential energies; simple pendulum-derivation of expression for its time period; free, forced and damped oscillations (qualitative ideas only), resonance.

Wave motion. Longitudinal and transverse waves, speed of wave motion. Displacement relation for a progressive wave. Principle of superposition of waves, reflection of waves, standing waves in strings and organ pipes, fundamental mode and harmonics, Beats, Doppler effect.

JANUARY

Unit VIII: Thermodynamics

Thermal equilibrium and definition of temperature (zeroth law of thermodynamics). Heat,work and internal energy. First law of thermodynamics. Isothermal and adiabatic processes. Second law of thermodynamics: reversible and irreversible processes. Heat engines and refrigerators.

Unit IX: Behavior of Perfect Gas and Kinetic Theory

Equation of state of a perfect gas, work done on compressing a gas. Kinetic theory of gases - assumptions, concept of pressure. Kinetic interpretation temperature; rms speed of gas molecules; degrees of freedom, law of equipartition of energy (statement only) and application to specific heats of gases; concept of mean free path, Avogadro’s number.

Practicals

The record, to be submitted by the students, at the time of their annual examination, has to include:

- Record of at least 15 Experiments [with a minimum of 8 from section A and 7 from section B], to be performed by the students.
- Record of at least 5 Activities [with a minimum of 2 each from section A and section B], to be performed by the students.
- Report of the project to be carried out by the students.

Evaluation scheme for Practical Examination :

Two experiments (one from each section)	(8 + 8) marks
Practical Record (experiments and activities)	6 marks
Project	3 marks
Viva on experiments of activities	5 marks
Total	30 marks

Experiments

SECTION A

1. To measure diameter of a small spherical/cylindrical body using Vernier Callipers and measure internal diameter and depth of a given beaker / calorimeter and hence find its volume using Vernier Callipers.
2. To measure diameter of a given wire and thickness of a given sheet using a screw gauge.
3. To measure volume of an irregular lamina using a screw gauge
4. To determine radius of curvature of a given spherical surface by a spherometer.
5. To find the weight of a given body using parallelogram law of vectors.
6. Using a simple pendulum, plot L- T and L- T^2 graphs. Hence find the effective length of second's pendulum using appropriate graph.
7. To study the relationship between force of limiting friction and normal reaction and to find the coefficient of friction between a block and a horizontal surface.
8. To study the variation of time period of a simple pendulum by changing its length and taking bobs of different masses independently and interpret the result.

Activities

SECTION A

1. To make a paper scale of given least count, e.g. 0.2cm, 0.5cm.
2. To determine mass of a given body using a metre scale by principle of moments.
3. To measure the force of limiting friction for rolling of a roller on a horizontal plane.

SECTION B

Experiments

1. To find the force constant of a helical spring by plotting graph between load and extension.
2. To determine the coefficient of viscosity of a given viscous liquid by measuring terminal velocity of a given spherical body.
3. To study the relationship between the temperature of a hot body and time by plotting a cooling curve.
4. To find the speed of sound in air at room temperature using a resonance tube by two-resonance positions.
5. To determine the surface tension of water by capillary rise method.
6. To determine Young's modulus of elasticity of the material of a given wire.

7. (i)To study the relation between frequency and length of a given wire under constant tension using sonometer.

   (ii)To study the relation between the length of a given wire and tension for constant frequency using sonometer. .

Activities

1 To observe and explain the effect of heating on a bi-metallic strip.

2 To study the factors affecting the rate of loss of heat of a liquid.

Chapter -2

UNITS AND MEASURMENT

GLIMPSES

1 Physical quantities All those quantities which can be measured directly or indirectly and in terms of which the laws of physics can be expressed are called physical quantities

2 a. Physical unit. The standard amount of a physical quantity chosen to measure the physical quantity of the same kind is called a physical unit.

Measure of a physical quantity= Numerical value of the quantity*size of the unit=nu

b. Relationship between the numerical value and the size of the unit. The numerical value (n) of a physical quantity is inversely proportional to the size of the unit.

$$n \propto 1/u \text{ or } nu = \text{constant or } n_1u_1 = n_2u_2$$

3 Fundamental quantities: The physical quantities which can be treated as independent of other physical quantities and are not usually defined in terms of other physical quantities are called fundamental quantities. The seven fundamental quantities are mass, length, time, electric current, temperature, luminous intensity and amount of substance

4 Derived quantities: The physical quantities whose defining operations are based on other physical quantities are called derived quantities

5 Fundamental units: The physical units which can neither be derived from one another, nor they can be further resolved into some simpler units are called fundamental units. The units of length, mass, time, etc. are fundamental units.

6 Derived units: All other units which can be expressed in terms of fundamental units are called derived units.

7 Systems of units: A complete set of units which is used for measuring all kinds of fundamental and derived quantities is called a system of units.

(i) The CGS or the metric system: In this system the fundamental units of length, mass and time are centimeter, gram and second respectively.

(ii) The FPS or the British system: In this system the fundamental units of length, mass and time are foot, pound and second respectively.

(iii) The MKS system: In this system the fundamental units of length, mass and time are metre, kilogram and second respectively.

(iv) The SI: SI is the system of abbreviation for Systeme Internationaled' Unites, which is the French equivalent for international system of units. In this system the fundamental units of length, mass, time, electric current temperature, luminous intensity and amount of substance are metre, kilogram, second, ampere, Kelvin, candela and mole respectively.

8 The seven basic SI units:

(i) Metre (m): One metre is defined as the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second(1983).
(ii) Kilogram(kg): It is the mass of a platinum-iridium cylinder (90% Pt and 10%Ir) whose height is equal to its diameter (each=3.9 cm) preserved at International Bureau of Weigths and Measures at Sevres (1889).
(iii) Second (s.): One second is defined as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the the two hyperfine levels of the ground state of the cesium-133 atom (1967).
(iv) Amper (A): One ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2*10 -7 newton per metre of length (1948).
(v) Kelvin (K0: One Kelvin is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water (1967).
(vi) Candela(cd): Cndela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540*1022 hertz and that has a radiant intensity in that direction of 1/683 watt per steradian (1979).
(vii) Mole (mol): One mole is rthe amount of substance of a system, which contains as many elementary antities as there are atoms in 0.012 kilogram of carbon-12(1971).

9 The two supplementary SI units

(i) Radian (rad.): It is defined as the plane angle subtended at the centre of a circle by an arc equal in length to the radius of the circle.

θ (in radians)= Arc / Radius = l/r

(ii) Steradian(sr.) It is the solid angle subtended at the centre of a sphere by a surface of the sphere equal in area to that of a square, having each side equal to the radius of the sphere.

$$\theta \text{ (in steradian)} = \frac{\text{Surface area}}{\text{Radius}^2}$$

10 Coherent system: A coherent sytem of units is a system based on a certain set of fundamental units from which all derived units are obtained by multiplication or division without introducing any numerical factor.

11 Advantages of SI: It is a metric, rational coherent and internationally acceptable system of units which covers all branches of physics.

12 Order of magnitude: The order of magnitude of a physical quantity is that power of ten which is closest to its magnitude. To determine the order of magnitude of a number N, we express it as $N=n*10^x$. If $0.5<ns5$, then x will be the order of magnitude of N.

13 Mass: The mass of a body is the quantity of matter contained in it. Its SI unit is kg

14 Weight: The weight of a body is the force with which a body is attracted towards the center of the earth. W=mg.

15 Inertial mass: The mass of a body which determines its inertia in translatory motion is called its inertial mass. It is measured from Newton's second law of gravitation.

$$M_i = F/a$$

16 Gravitational mass: The mass of a body which determines the gravitational pull upon it due to the earth is called its gravitational mass. It is measured by using Newton's law of gravitation.

$$M_g = FR^2/GM$$

17 Dimensions of the derived quantity: These are the powers to which the fundamental units of mass, length and time must be raised in order to represent a derived quantity completely.

18 Dimensional formula: It is an expression which shows how and which of the fundamental units of mass, length and time occur in the derived unit of a physical quantity

19 Dimensional equation: The equation which expresses a physical quantity in terms of the fundamental units of mass, length and time, is called dimensional equation.

20 Principle of homogeneity of dimensions: This principle states that a physical equation will dimensionally correct if the dimensions of all the terms occurring on both sides of the equation are the same

21 Uses of dimensional equations:

(i). To convert a physical quantity from one system of units to another.

Suppose a physical quantity has dimensional formula M $^{a}L^{b}bT^{c}$and n_2 be its numerical values when the units are u_1 and u_2. Then

$n_1 u_1 = n_2 u_2$

(ii) To check the corrections of a given physical relation.

(iii) To derive a relationship between different physical quantities.

22 Significant figures: The significant figures are normally those digits in a measured quantity which are known reliably plus one additional digit that is uncertain.

23 Rules for counting the number of significant figures in a measured quantity:

(i) All non-zero digits are significant.
(ii) All zeros between two-non zero digits are significant.
(iii) All zeros to the right of a non-zero digit but to left of an understood decimal point are not significant. But such zeros are significant if they come from a measurement.
(iv) All zeros to the right of a non-zero digit but to left of a decimal point are significant. For example, 648700 has a significant figures.
(v) All zeros to the right of a decimal point are significant.
(vi) All zeros to the right of a decimal point but to the left of a non-zero digit are not significant. Single zero conventionally placed to the left of the decimal point is not significant.
(vii) The number of significant figures does not depend on the system of units.

24 Significant figures in the sum or difference of two numbers. In addition or subtraction the result should be reported to the same number of decimal places as that of the number with minimum number of decimal places.

25 Significant figures in the product or quotient of two numbers. In multiplication or division, the result should be reported to the same number of significant figures as that of the number with minimum of significant figures.

26 Rules for rounding off a measurement :

(i) If the digit to be dropped is less than 5, then the preceding digit is left unchanged.
(ii) If the digit to be dropped is greater than 5, then the preceding digit is increased by 1.
(iii) If the digit to be dropped is 5, then the preceding digit is increased by 1.
(iv) If the digit to be dropped is 5, then the preceding digit is left unchanged if it is even.
(v) If the digit to be dropped is 5, then the preceding digit is increased by 1 if it is odd.

27 Accuracy and precision of a measurement: Accuracy refers to the closeness of a measurement to the true value of the physical quantity. Precision refers to the resolution or the limit to which the quantity is measured.

28 Error in a measurement: It is the difference between the measured value and the true value of a physical quantity. It gives an indication of the limits within which the true value may lie.

Chapter -2

UNITS AND MEASUREMENTS

Assignment :

1 The vernier scale is divided into 30 divisions, which coincide with 29 main scale divisions. Each main scale division is $(1/2)^\circ$. What is the least count of the instrument?

2 What are the values of one degree, one minute and one second in radians?

3 The radius of curvature of a convex mirror is given by
$R = \frac{l^2}{6h} + \frac{h}{2}$, if l = (4.4 + 0.1) cm and h =(0.85+0.001) cm .
Compute the maximum possible percentage error in the measurement of R.

4 When the planet Jupiter is at a distance of 824.7 million kilometers from the earth, its angular diameter is measured to be 35.72" of arc. Calculate the diameter of Jupiter.

5 A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the sun and the Earth in terms of the new unit if light takes 8 min and 20s to cover the distance?

6 The length and breadth of a rectangular sheet have been measured by a measuring scale to an accuracy of 0.2 cm. If the measured values are 35.2 cm and 21.7 cm respectively, then find the relative error in area of the sheet.

7 What do you mean by order of magnitude of a length? Write the order of magnitude of following lengths: (a) size of a hydrogen atom (b) diameter of Earth (c) light year (d) size of Milky way.

8 The frequency of vibration, n may depend on length of string L, mass per unit length, m, and force F with which it is stretched. Using dimensional analysis, derive expression of frequency.

9 Briefly explain how will you estimate the molecular diameter of oleic acid?

10 A student performed an experiment and found following values of the refractive index of a liquid:
1.29, 1.33, 1.34, 1.35, 1.32, 1.36, 1.30, 1.33
Find the mean value of refractive index, the mean absolute error, the relative error and the percentage error.

11 A physical quantity Q is given by $Q = \frac{A^2 B^{3/2}}{C^4 D^{1/2}}$

The percentage errors in A.B.C and D are 1%, 2%, 4% and 2% respectively. Find the percentage error in Q.

12 Two resistors of resistances R_1 = 100± 3 ohm and R_2 = 200 + 4 ohm are connected (a) in series, (b) in parallel. Find the equivalent resistance of the (a) series combination. (b) parallel combination. Use for (a) the relation R= R1 + R2 and for (b)$1/R = 1/R_1 + 1/R_2$

13 If the velocity be 20 cm s^{-1}, the unit of the acceleration be 40 cm s^{-2} and the unit of force be 30 dyne, what are the units of mass, length and time?

14 If the units of velocity v, density d and frequency f are fundamental units. What would be the dimensions of linear momentum?

15 Ultrasonic sent by a SONAR return back to it after reflection from a rock under water after a time lapse of 2.2 second. If the velocity of ultrasonic in water is 1450 ms^{-1}, find the depth below the water surface.

PRACTICE QUESTIONS

Short Answer Questions :

1 Write the dimensions of a) Work done, b) latent heat, c) Planck's constant, d) specific heat, e) Gravitational constant, f) velocity gradient, g) moment of force, h) refractive index

2 What is the value of one light year in SI unit. How many light years make one parsec?

3 How many mm make 1 nm?

4 What is the advantage of defining meter in terms of velocity of light?

5 Name two pairs of quantities which have the same dimensional formulae.

6 What is the number of electrons that would weigh I μg ? (mass of 1 electron = 9.11 x 10 -31 kg)

Long Answer Questions

1 The number of particles crossing a unit area perpendicular to x-axis in unit time is given by n = -D $(n_2 - n_1)/(x_2-x_1)$, where n_1 and n_2 are number of particles per unit volume at distance x_1 and x_2. What is the dimensional formula of diffusion constant D?

2 N divisions on the main scale of vernier coincides with N+ 1 division on the vernier scale. If each division on main scale is of x units, determine the least count of the instrument

3 Give two examples of each, (i) Dimensional constant ii) Dimensionless Variables

4 Give two examples of each
(i)Dimensionless constant (ii) Dimensional variable

Write the dimension of a/b in the relation, $F = a x + bt^2$, where F is force, x is distance and t is time.

5 Explain the triangulation method to find the height of an inaccessible object.

6 Using dimensional analysis determine an expression for the velocity of sound 'v'in gaseous medium if it is found to depend on pressure 'P' of the gas, density 'd 'of the medium and time 't' .

7 Differentiate between systematic and random errors , giving an example of each. How can they be minimized?

8 Describe the parallax method to measure the distance of a planet from the earth.

9 Discuss the propagation of errors when the result involves 1) a product of quantities 2) power of a physical quantity.

10 Check the accuracy of the following relations: a) $v=\sqrt{\frac{2GM}{R}}$ b) F=6πηρrv
(F=force η=coefficient of viscosity, r=radius , v=velocity)

11 What are the advantages of the S.I. system of units over the others? Explain

12 If $F=at^2 + bt$, where F denotes force and t denotes time, find the dimensions of a and b.

13 What does Radar stand for? A radar signal is projected towards a planet from the earth and its echo is received 7 minutes later. Calculate the distance between the planet and the earth.

14 A physical quantity x is calculated from $x= ab^2c^{-1/2}$. Find the percentage error in x if the corresponding error in measuring a, b and c is 4%, 2% and 3% respectively.

15 Define the terms mean absolute error and relative error. How are they calculated?

16 Time period T of a simple pendulum may depend upon its mass m, length l, and acceleration due to gravity g. Find an expression for time period T by method of dimensions.

17 Explain the method used to determine the size of a molecule of oleic acid.

18 Which of the following is the most precise device for measuring length :-
(a) avernier calipers with 20 divisions on sliding scale. (b) a screw gauge of pitch 1 mm & 100 divisions on circular scale. (c) an optical instrument that can measure length to within a wavelength of light ?

19 When white light travels through the glass the reflective index
μ = (Velocity of light in air/velocity of light in glass) is found to vary with wavelength as μ=A+B/λ2 where A and B are constants. Using the principle of homogeneity of dimensions, determine the SI unit in which A and B must be expressed.

Numericals

1 Convert a) 540km/h into m/s and cm/s. b) $20 m/s^2$ into km/h^2 and m/min^2.

2 If the units of force were kilo Newton, that of time millisecond and that of Power kilowatt, what would be the units of mass and length?

3 To determine the acceleration due to gravity , the time of 20 oscillations of a simple pendulum of length 100cm known to 1mm accuracy was observed to be 40s using a watch of 1s resolution. Calculate the value of g and maximum percentage error in the measured value of g.

4 The distance of a planet from the earth is 3.66×10^8 m. If the diameter of the planet is 9.6×10^5 m, what will be its angular diameter?

5 If 2 resistances of values x= (2.0 ±0.1) Ω, y=(12.3 ±0.2) Ω are put in parallel, find the error in the equivalent resistance.

6 A potential difference V = (100±5) volts, when applied across a resistor gives a current I = (10±0.2)A . Find percentage errors in V, I and R?

7 The shadow of a pole standing on a level ground is found to be 45 m longer
when the sun's altitude is 30° than when it was 60°. Determine the height of the pole.

8 Find the value of force 100 dyne on a system based on a meter, kilogram and minute as fundamental units.

Competition Kit

H.O.T

1 If the velocity of light c, the constant of gravitation G and Planck's constant h, be chosen as fundamental units find the value of mass, length and time in terms of dimensions of these quantities.

2 Reynold number N_R(a dimensionless quantity) determines the condition of laminar flow of a viscous liquid through a pipe. N_R is a function of the density (p) of the liquid, its speed (v) and coefficient of viscosity (ή) of the liquid. N_R is proportional to the diameter (D) of the pipe. Show that N_R ά pvD/ή using dimensional analysis

M.C.Q

1 Identify the pairs whose dimensions are equal.

a) torque and work (b) stress and energy (c) force and stress
(d)force and Work

2 Out of following pairs, which one does not have identical dimensions are
(a) Moments of inertia and moments of a force (b) Work and torque
(c) Angular momentum and Planck's constant (d) Impulse and momentum

3 ML^2T^2 are dimensions of

(a) force (b) moment of force (c) momentum (d) Power

4 Dimensions of bulk modulus are
(a) $M^{-1}LT^{-2}$ (b) $ML^{-1}T^{-2}$ (c) $ML^{-2}T^{-2}$ (d)$M^2L^2 T^{-1}$

5 If error in radius is 3%, what is the error in the volume of sphere?
(a) 3% (b) 27% (c) 9% (d) 6%

6 Dimensions of resistance in an electrical circuit, in terms of dimension of Mass M, of length L, of time T and of current I, would be

(a)ML^2T^{-2} (b) $ML^2T^{-2}I^{-1}$ (c) $ML^2T^{-3}I^{-2}$ (d) $ML^2T^{-3}I^{-1}$

7 Which of the following is a dimensional constant?

(a) relative density (b)gravitational constant (c)refractive Index
(d) poisson ratio

8 The time dependence of a physical quantity 'p' is given by $p=p_0\exp(-ἀt^2)$ where ἀ is a constant and 't' is the time. The constant ἀ

(a) Is dimensionless (b)has dimensions (T^2) (c) has dimensions (T^{-2})
(d) has dimensions of p

9 Dimensions of coefficient of viscosity are

(a) $ML^{-1}T^{-1}$ (b) $ML^{-3}T^{-4}$ (c) $ML^{-1}T^{-2}$ (d) MT^2

10 The unit of Planck's constant are

(a) J/s (b) Js^2 (c) Js (d) Js^{-2}

CHAPTER -3
MOTION IN A STRAIGHT LINE

GLIMPSES:

1. Mechanics: It is the branch of physics that deals with the conditions of rest or motion of material objects around us.

2. Statics: It is the branch of mechanics that deals with the study of objects at rest or in equilibrium.

3. Kinematics: It is the branch of mechanics that deals with the study of motion of objects without considering the cause of motion.

4. Dynamics: It is the branch of mechanics that deals with the study of motion of objects taking into consideration the cause of their motion.

5. Rest: An object is at rest if it does not change its position w.r.t. its surroundings with the passage of time.

6. Motion: An object is in motion if it changes its position w.r.t. its surroundings with the passage of time.

7. Rest and motion are relative terms: Nobody can exist in a state of absolute rest or of absolute motion.

8. Point object: If the position of an object changes by distances much greater than its own size in a reasonable duration of duration of time, then the object may be regarded as a point object.

9. One dimensional motion:The motion of an object is said to be one dimensional motion if only one out of the three coordinates specifying the position of the object changes with time. In such a motion, an object moves along a straight line path.

10. Two dimensional motion: The motion of an object is said to be two dimensional motion if two out of the three coordinates specifying the position of the object change with time. In such motion, the object moves in a plane.

11. Three dimensional motion: The motion of an object is said to be three dimensional motion if all the three coordinates specifying the position of the object change with time. In such a motion, the object moves in space.

12. Distance or path length: It is the length of the actual path traversed by a body between its initial and final positions. It is scalar quantity. Its SI unit is metre. It is always positive or zero.

13. Displacement: It is defined as the change in the position of an object in a fixed direction. It is given by the vector drawn from the initial position to the final position of the object. It is a vector quantity. It can be positive, negative or zero. Its SI unit is metre.

    The magnitude of displacement is less than or equal to the actual distance travelled by the object in the given time interval.

14. Speed: It is rate of change of position of a body in in any direction.

$$\text{Speed} = \frac{\text{Distance Travelled}}{\text{Time Taken}}$$

    Speed is a scalar quantity. Its SI unit is ms^{-1} and its dimensional formula is $[M^0L^1T^{-1}]$.

15. Uniform speed: An object is said to be moving with uniform speed if it covers equal distances in equal interval of time, however small these intervals may be.

16. Variable speed: An object is said to be moving with variable speed if it covers unequal distances in equal interval of time.

17. Average speed: It is equal to the total distance traveled by the object divided by the total time taken to cover that distance.

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

18. Instantaneous speed: The speed of an object at any particular instant of time or at a particular point of its path is called the instantaneous speed of the object.

    Instantaneous speed , $v = dx/dt$

19. Velocity: It is the rate of change of position of an object in a particular direction. It is equal to the displacement covered by a body per unit time.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

20. Uniform velocity: A body is said to be moving with uniform velocity if it covers equal displacements in equal intervals of time, however small these time intervals may be.

21. Variable velocity: A body is said to be moving with variable velocity if Either its speed changes or direction of motion changes or both change with time.

22. Average velocity: It is equal to the net displacement covered divided by the total time taken.

23. Instantaneous velocity: The velocity of an object at a particular instant of time or at a particular point of its path is called its instantaneous velocity.

24. Uniform motion: An object is said to be in uniform motion if it covers equal distances in equal intervals of time, however small these intervals may be, in the same fixed direction.

25. Displacement in uniform motion: If at time t=o, the displacement is x_0 then $x = x_0 + vt$

26. Non uniform motion: A body is said to be in non-uniform motion if its Velocity changes with time.

27. Acceleration: The rate of change of velocity of an object is called its acceleration.

    $$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

    Acceleration is a vector quantity.

28. Uniform acceleration : If the velocity of an object changes by an equal amount in equal intervals of time, however small these intervals may be, then the object is said to move with uniform or constant acceleration.

29. Variable acceleration: If the velocity of an object changes by an unequal amounts in equal intervals of time, then the object is said to be in variable acceleration.

30. Average Acceleration: The average acceleration of an object between two points on the path of its motion is defined as ratio of the change in velocity to the total time interval in which that change has taken place.

31. Instantaneous acceleration: The acceleration of an object at a given instant of time or at a given point of a motion is called its instantaneous acceleration.

32. Positive acceleration: If the velocity of an object increases with time, its acceleration is positive.

33. Negative acceleration: If the velocity of an object decreases with time, its acceleration is negative. Negative acceleration is called retardation deceleration.

34. Equations of motion for constant acceleration:
    In conventional form: Let u be the initial velocity of a particle, a the uniform acceleration, v its velocity after time t and s is the distance traveled in time t, then the following equations hold good:

    $$V = u + at$$

    $$S = ut + \tfrac{1}{2} at^2$$

    $$V^2 - u^2 = 2 a S$$

35. Free fall: In the absence of air resistance, all bodies fall with the same acceleration near the surface of the earth. This motion of a body falling towards the earth from a small height is called free fall. The acceleration with which a body falls is called acceleration due to gravity and is denoted by g. Near the surface of the earth, $g=9.8ms^{-2.}$

36. Motion under gravity: When a body falls freely under the action of gravity, its velocity increases and the value of g is taken positive.
When a body thrown vertically upward, its velocity decreases and the value of g is taken negative.

37. Position-time graph: It is the graph between the time t and position x of a particle relative to a fixed origin. Its slope at any point gives the instantaneous velocity at the point.
(i) For a stationary object, the position –time graph is a straight line parallel to the time-axis
(ii) For a body in a uniform motion, the position-time graph is a straight line inclined to the time-axis.
(iii) For uniformly accelerated motion, the position time graph is a parabola.

38. Velocity-time graph: It is a graph of time versus velocity. Its slope t any point gives the acceleration at the corresponding instant. Distance covered in time t equals area under the velocity –time graph bounded by the time-axis.

(i) For uniform motion, the velocity-time graph is a straight line parallel to the time-axis.

(ii) For uniform acceleration, the velocity-time graph is a straight line inclined to the time-axis.

(iii) For variable acceleration, the velocity time graph is a curve.

39. Relative velocity: The relative velocity of an object B with respect to object A when both are in motion is the rate of change of position of object B with respect to object A.

Relative velocity of object B w.r.t. object A, $v_{BA} = v_B - v_A$

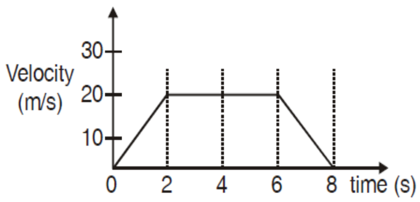
Relative velocity of object A w.r.t. object B, $v_{AB} = v_A - v_B$

ASSIGNMENT :

1 What will be the ratio of the distances traveled by a freely falling body from rest in the fourth and fifth second of its journey? (7:9)

2 The velocity-time relation of an electron starting from rest is given by v=kt, where k= 2 m/s^2. Calculate the distance traversed in 3 s. (9m)

3 Graphically derive the three equations of motion.
The velocity time graph for a particle is shown in figure. Draw acceleration time graph from it. Calculate the displacement in the time intervals i) 0-2 s ii) 2-8 s iii) 0-8 s.



4 A stone is thrown with a speed v from the top of a tower. It reaches the ground with a speed of 3v. What is the height of the tower?

5 A balloon is ascending at the rate of 9.8m/s at a height of 39.2m above the ground when a packet is dropped from the balloon. After how much time and with what velocity does it reach the ground? (4s,-29.4 m/s)

6 A particle is moving with uniform velocity v along a straight line. What will be the position –time graph of the motion of the particle in the following cases?
(a) x_0 = +ve , v = + ve (b) x_0 = - ve , v = +ve

7 The displacement x of a particle moving in one dimension , under the action of a constant force is related to time t by the equation $t = x^{1/2} + 3$, where x is in metres and t in seconds. Find the displacement of the particle when its velocity is zero. (0)

8 A particle moves along the x-axis in such a way that its x coordinate varies with time according to the equation $x = 3 - 4t + 6t^2$. Draw its position–time, velocity-time and acceleration-time graphs. Determine its i) initial velocity ii) average velocity in the time interval 2s to 4 s iii) acceleration.

9 For an object projected upward with a velocity Vo, which comes back to the same point after some time, draw
(i) Acceleration-time graph (ii) Position-time graph
(iii) Velocity-time graph

10 A ball is thrown vertically upwards with a velocity of 20 m/s from the top of a multistorey building. The height of the point from where the ball is thrown is 25 m from the ground. How high will it rise? How long does it take the ball to

hit the ground? (20m, 5s)

11 A bullet fired into a fixed target loses half of its velocity after penetrating 3 cm. How much further will it penetrate before coming to rest assuming that it faces constant resistance to motion?

12 Having seen a big stone falling from the top of a tower Ravi pulled his friend Kiran away. The stone hit Ravi slightly and he got hurt. But he was saved from a major accident

(a) What made Ravi act in such a way? (Mention 2 values)

(b) From the top of a tower 100 m in height, a ball is dropped and at the same time another ball is projected vertically upwards from the ground with a velocity of 25 m/s. Find when and where the two balls meet. Take g = 9.8 m/sec^2. (4 s, 78.4m)

13 The head and tail of train moving with a constant acceleration, crosses an electric pole on the track side with velocities u and v respectively. Find the velocity with which the middle point the train crosses the pole.

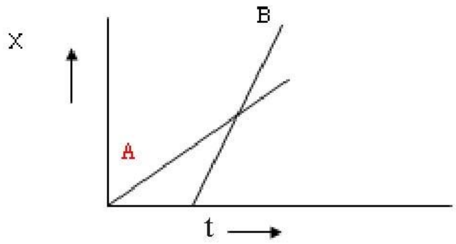
14 The velocity of a train increases at constant rate of ‘ a’ from 0 to v and then moves with uniform speed for some time interval and then finally velocity decreases to 0 at a constant rate of ‘b’. The total distance traveled by train is x. Show that total time taken by train is T= x/v + v/2(1/a+1/b)

15 A stone falls freely such that the distance covered by it in the last second of the motion is equal to the distance covered by it in the first five seconds. For what time did it remain in air?

PRACTICE QUESTIONS:

Short Answer Questions:

1. Can a body have varying speed but constant velocity? Can a body have varying velocity but constant speed?
2. What is the numerical ratio of velocity to speed of an object?
3. A stone is thrown vertically upwards from the surface of earth. What is the direction of the velocity and acceleration of the stone i) on its way up ii) on its way down.
4. The position –time graph for two children A and B returning from their school to their homes are shown in fig. Who lives closer to school?



5. Derive an expression for stopping distance 'd' of a vehicle in terms of initial Velocity v_o and deceleration 'a'.
6. A ball is thrown vertically upwards. Draw its velocity-time and speed-time graphs.
7. A stone released from a certain height 'h' reaches the ground in time 'T'. When will it be at (5/6) h below the point of release?
8. Can a particle have an acceleration at an instant if its velocity is zero at that instant? Give an example.

Long Answer Questions:

1. Draw the V-t graph for uniformly accelerated motion. Hence show that the area under V-t graph gives the distance traveled by the object.
2. A particle starts from rest and moves a distance S_1 with constant acceleration in time t. If this particle travels distance S_2 in the next t time. Show that $S_2 = 3S_1$.
3. Define the term relative velocity. Derive an expression for the relative velocity of one body with respect to each other when, i) both of them move in the same direction ii) they are moving in mutually opposite directions.
4. A car accelerates from rest at a constant rate a for some time , after which it decelerates at a constant rate b to come to rest. If t is the total time elapsed, then calculate 1) maximum velocity attained by the car 2) the total distance traveled by the car.

Numericals:

1 A tennis ball is dropped on to the floor from a height of 4m. It rebounds to a height of 3m. If the ball was in contact with the floor for 0.010 sec, what was its average acceleration during contact?

2 The motion of a car along y axis is given by the relation $y= t^3 - 6t^2+9t+5$, where y is in meter and t is in second. Calculate the velocity and acceleration at t=5 second.

3 Two cars A and B are at a positions 100 m and 200 m from the origin at time t=0. They start simultaneously with velocities 10m/s & 5m/s respectively. Determine the position of time at which they will overtake one another. Assume that they are moving in the same direction.

4 A river one kilometer wide is flowing at 3km/h. A swimmer, whose velocity in still water is 4km/h, can swim only for 15 minutes. In what direction should he strike out so as to reach the opposite bank in 15 minutes? What total distance will he swim?

5 A man walks on a straight road from his home to a market 2.5km away with a speed of 5km/h. Finding the market closed, he instantly turns and walks back home with a speed of 7.5km/h. What is average velocity of man over time interval 0 to 40minute?

6 A ball is thrown vertically upwards with a velocity of 29.4 m/s. After 3 s, another ball is thrown upwards from the same point with a velocity of 19.6 m/s When and at what height will the two balls collide? (19.3 m).

7 The displacement of a particle at any instant is given by $x= 8t^2 - 3t^3$. Calculate the average velocity in the interval from t=0 to t=2s and in the time interval from t=0 to. t=3s if x is measured in m.

8 A boy runs along a straight path for the first half distance with a velocity v_1 and the second half distance with velocity v_2. Find the average velocity of the boy.

9 Two trains 120m and 80m in length are running in opposite directions with velocities 42Km/h and 30 Km/h. In what time will they completely cross each other? (10 s)

10 A train 150 m in length is going northwards at a speed of 10 m/s. A parrot flies at a speed of 5 m/s southwards, parallel to the railway track. What is the time taken by the parrot to cross the train? (10s)

Competition Kit

H.O.T

1. A metal ball is allowed to fall freely on a perfectly elastic plate from a height of 3m. At t=0, the speed of the ball is zero. Represent graphically the variation of velocity with time.
2. A particle is subjected to an acceleration a= ἀt +βt², where = ἀ and β are constants. The position and velocity of the particle at t=0 are x_0 and v_0 respectively. What are the expression for position x and velocity v of the particle at time t.
3. A bus starting from rest moves with a constant acceleration of 2 ms^{-2} for some time. After this time, the bus moves with a uniform velocity for some more time and after which it moves with a constant retardation of 2ms^{-2} to finally come to rest in a total time of 20 s. Find the time for which the bus moves with a uniform velocity, if the average speed of the bus is 5 ms^{-1}.

M.C.Q

1. The motion of a particle is described by the equation u= at. The distance traveled by particle in first 4s is
   (a) 4a (b) 12a (c) 6a (d) 8a

2. The displacement of a body is given to be proportional to the cube of time elapsed. The magnitude of the acceleration of the body is
   (a) increasing with time (b) decreasing with time (c) constant but not zero
   (d) zero

3. Velocity of a body on reaching the point, from which it was projected upwards, is
   (a) v=0 (b) v=2u (c) v=0.5u (d) v=u

4. Three different objects of masses m_1, m_2, and m_3 are allowed to fall from the same point O along three different frictionless paths. The speed of the three objects, on reaching the ground, will be in the ratio of
   (a) $m_1 : m_2 : m_3$ (b) $m_1 : 2m_2 : 3m_3$ (c) $1/m_1 : 1/m_2 : 1/m_3$ (d) 1:1:1

5. The position x of a particle varies with time t as $x=at^2-bt^3$. The acceleration will be zero at time t equal to
   (a) a/3b (b) zero (c) 2a/3b (d) a/b

6. A particle is constrained to move on a straight line path. It returns to the starting point after 10 s. The total distance covered by the particle during this time is 30 s. Which of the following statements about the motion of the particle is false?

   (a) displacement of the particle is zero
   (b) displacement of the particle is 30 m
   (c) average speed of the particle is 3m/s
   (d) both(a) and (c)

7. A stone is thrown vertically up from the ground. It reaches a maximum height of 50 m in 10 sec. After what time it will reach the ground from maximum height position?
   (a) 1.2sec (b) 10sec (c) 5sec (d) 25sec

8 A body falling from rest describes distances s_1, s_2 and s_3 in the first, second and third seconds of its fall, then the ratio $s_1 : s_2 : s_3$ is
   (a) 1 : 1 : 1 (b) 1 : 3 : 5 (c) 1 : 2 : 3 (d)1 : 4 : 9

9 When a ball is thrown vertically upwards at the maximum height
   (a)the velocity is zero and therefore there is no acceleration acting on the particle
   (b)the acceleration is present and therefore the velocity is not zero
   (c) the acceleration depends on the velocity as a = dv/dt
   (d) the acceleration is independent of the velocity

10 Velocity-time curve for a body projected vertically upwards is
   (a) eclipse (b) hyperbola (c) parabola (d) straight line

CHAPTER -4
MOTION IN PLANE

GLIMPSES :

1. Scalars: The physical quantities which have only magnitude and no direction are called scalars e.g. mass, length, time, speed, work, power, etc.

2. Vectors: The physical quantities which have both magnitude and direction are called vectors e.g. displacement, velocity, acceleration, force, momentum, etc.

3. Representation of a vector: A vector is represented by a straight line with an arrowhead over it. The length of the line gives the magnitude and the arrowhead gives the direction of the vector.

4. Position vector: A vector which gives position of an object with reference to the origin of coordinate system is called position vector.

5. Displacement vector: It is that vector which tells how much and in which direction an object has changed its position in a given time interval.

6. Polar vectors: These are the vectors which have a starting point or a point of application e.g. displacement, force, velocity, etc.

7. Axial vectors: The vectors which represent rotation effect and act along the axis of rotation in accordance with right hand screw rile are called axial vectors e.g. torque, angular momentum, etc.

8. Equal vectors: Two vectors are said to be equal if they have the same magnitude and direction.

9. Negative vector: The negative of a vector is defined as another vector having the same magnitude but having an an opposite direction.

10. Zero vector: A vector having zero magnitude and an arbitrary direction is called zero or null vector.

11. Collinear vector: The vectors which either act along the same line or along parallel lines are called collinear vectors.

12. Coplanar vectors: The vectors which act in the same plane are called coplanar vector.

13. Modulus of a vector: The magnitude or length of a vector is called its modulus.

14. Fixed vector: The vector whose initial vector is fixed is called a fixed vector or localized vector.

15. Unit vector: A unit vector is a vector of unit magnitude drawn in the direction of a given vector.

16. Free vector: A vector whose initial point is not fixed is called a free vector or non-localised vector.

17. Co-initial vector: The vectors which have the same initial point are called co-initial vectors.

18. Co-terminus vectors: The vectors which have the common terminal point are called co-terminus vectors.

19. Multiplication of vector by a real number: When a vector A is multiplied by a real number λ, we get another vector λ A. The magnitude of λ A is λ times the magnitude of A. If λ is positive, then the direction of λ A is same as that of A. If λ is negative, then the direction of λ A is opposite to that of A.

20. Multiplication of vector by a scalar: When a vector A is multiplied by a scalar λ, which has certain units, the units of λ A are obtained by multiplying the units of A by the units of λ.

21. Triangle law of vector addition If two vectors can be represented both in magnitude and direction by the two sides of the triangle taken in the same order, then their resultant is represented completely both in magnitude and direction by the third side of the triangle taken in the opposite order.

22. Parallelogram law of vector addition: If two vectors acting simultaneously at a point can be represented both in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant is represented completely both in magnitude and direction by the diagonal of the parallelogram passing through that point.

23. Polygon law of vector addition: If a number of vectors are represented both in magnitude and direction by the sides of an open polygon taken in the same order, then their resultant is represented both in magnitude and direction by the closing side of the polygon taken in the opposite order.

24. Properties of vector addition:
    (i) Vectors representing physical quantities of same nature can only be added.
    (ii) Vector addition in commutative.
    (iii) Vector addition in associative.

25. Subtraction of vectors: The subtraction of a vector B from vector A is defined as the addition of vector –B to A.

26. Resolution of a vector: The process of splitting a vector into two or more vectors is known as resolution of the vector. The vectors into which the given vector is split are called component vectors. A vector A can be resolved into components along two given vectors a and b lying in the same plane in one and only one way.

27. Orthogonal triad of unit vectors: Base vectors. The unit vectors i, j, k are vectors of unit magnitude and point in the direction of the x-y-and z- axes respectively in a right handed coordinate system. These are collectively known as the orthogonal triad of unit vectors or base vectors.

28. Rectangular components of a vector: When a vector is resolved along two mutually perpendicular directions components so obtained are called rectangular components of the given vector.

29. Scalar or dot product: The scalar or dot product of two vectors A and B is defined as the product of the magnitudes of A and B and cosine of the angle θ between them. It can be positive, negative or zero depending upon the value of θ.
Geometrical interpretation of scalar product: The scalar product of two vectors can be interpreted as the product of magnitude of one vector and component of the other vector along the first vector.

30. Vector or cross product: for two vectors A and B inclined at an angle θ, the vector or cross product is defined as A x B = A B sinθ $\hat{n}$, where $\hat{n}$, is a unit vector perpendicular to the plane of A and B.
Geometrical interpretation of vector product: The magnitude of the vector product of two vectors is equal to (i) the area of the parallelogram formed by the two vectors as its adjacent sides and (ii) twice the area of the triangle formed by the two vectors as its adjacent sides.

ASSIGNMENT

1. What is the angle made by vector A= 2i + 2j with the x-axis?

2. Show that there are two angles of projection for which the horizontal range is the same. Also show that the sum of the maximum heights for these two angles is independent of the angle of projection.

3. An object is thrown with kinetic energy E at an angle θ with horizontal. Find its energy when it is at the maximum height?

4. A car traveling at a speed of 20m/s due north makes a right turn in 50sec. At the end of 50 sec. car has a speed of 15m/s. Determine magnitude and direction of acceleration.

5. State parallelogram law of vector addition and find the magnitude and direction of the resultant of two vectors P and Q inclined at an angle θ with each other.

6. A stone is projected horizontally from the top of a tower of height 50m with a velocity of 10 m/s. Calculate the time taken to reach the ground and the velocity with which it hits the ground.

7. i) If unit vector a and b are inclined at angle θ then prove that
   | a – b | = 2 sinθ/2.
   ii) What is the angle that $\hat{\imath} + \hat{\jmath}$ makes with $\hat{\jmath}$?
   iii) The equations of motion of a body projected at an angle are given by
   $x = 5t \quad and \quad y = 12t - 4.9t^2$. What is the velocity of projection of the body?
   iv) A projectile is given an initial velocity of i + 2j. Find the equation of its path.
   ($g=10m/s^2$).

8. Find i) the path of a projectile ii) time of flight iii) maximum height iv) horizontal range, when the projectile is projected with a velocity 'u' , making an angle θ with the vertical direction from the ground. Prove that the trajectory is parabolic.

9. A body is projected with a velocity of 40 m/s. After 2 s , it crosses a vertical pole of length 20.4 m. Calculate the angle of projection and horizontal range.

10. A boat is sent across a river with a velocity of 8km/h. if the resultant velocity of boat is 10 km/h , then calculate the velocity of the river. (6 km/h)

11. A ball of mass m is thrown vertically up. Another ball of mass 2m is thrown at an angle θ with the vertical. Both of them remain in the air for the same time. .What is the ratio of the heights attained by the two balls? (hint : their initial velocities are not the same) (1:1)

12. If P= 2i –j and Q = 3i + 4j , find a vector which has the magnitude of P and is parallel to Q.

13. On a rainy day, a woman with an umbrella saw a school girl struggling to return back to her home because of rain. The woman was very gentle and helped her by providing an umbrella to the girl as she had one extra umbrella.
i) At what angle should the girl hold the umbrella if she was walking with a speed of 10 km/hr and the velocity of the rain was 20 km/hr.
ii) What values do we get from the above incident? (name any two)

14. What is centripetal acceleration? Derive an expression for the centripetal acceleration of a body of mass m moving with a uniform speed v in a circular path of radius r. If two bodies have circular paths of radii r_1 and r_2 such that the time taken to complete one revolution is the same, find the ratio of their angular speeds.

15. A cyclist is riding with a speed of 27 km/h. As he approaches a circular turn on the road of radius 30 m, he applies brakes and reduces his speed at the constant rate 0.5 ms^{-2}. What is the magnitude and direction of the net acceleration of the cyclist on the circular turn?

PRACTICE QUESTIONS

Short Answer Questions:

1. Calculate the angular speed of minute hand and hour hand of the clock?
2. The resultant of 2 vectors P and Q is perpendicular to P and its magnitude is half of that of Q. What is the angle between P and Q?
3. Write down the vector whose head is at (4,3,2) and tail is at (3,2,1) .
4. What is the angle made by the vector A = 4î+ 4j with the x-axis?
5. Using the concept of resolution of vectors explain why pulling is easier than pushing.
6. The component of a vector A along the direction of B is zero. What can you conclude about the two vectors?
7. A projectile of mass m is projected with velocity u at angle θ with vertical. Find the expression of kinetic energy of projectile at the highest point?
8. A stone X is dropped from a height and another identical stone Y is projected in horizontal direction with a velocity u from the same height. Which one will reach the ground earlier?
9. At what angle to the horizontal should an object be projected so that the maximum height reached is equal to the horizontal range?
10. State the Polygon Law of vector addition.

Long Answer Questions:

1. What is meant by resolution of a vector and components of a vector? What is rectangular resolution?
2. A projectile is projected with initial velocity u making an angle of θ with vertical.
3. What is uniform circular motion? Establish the relation between linear velocity and angular velocity.
4. What is centripetal acceleration? Find its magnitude and direction in case of uniform circular motion of an object.
5. State the triangle law of vector addition. Find analytically, the magnitude and direction of the resultant vector.

NUMERICALS :

1 A person moves 30m north, then 20m east and finally 30√2m south-west. What is his displacement from the original position?

2 An object is projected from the top of tower of height 40m with velocity 20m/s at an angle of 30^0 with the horizontal in upward direction. Find the ratio of time taken by projectile to reach the earth to the time of flight?

3 Define unit vector. Given that vector A = 7î+ 24j and vector B = 3î+ 4j. Find a vector whose magnitude is same as that of vector A and direction is same as that of vector B.

4 A projectile is given an initial velocity of 2î+ j . Find the equation of its path ($g=10m/s^2$).

5 A train is moving with a velocity of 30 km/h due East and a car is moving with a velocity of 40 km/h due North. What is the velocity of the car as appears to a passenger in the train?

6 A man is going due East with a velocity of 3km/h. Rain falls vertically downwards at a speed of 10 km/h. Calculate the angle at which he should hold his umbrella so as to save himself from the rain.

7 Two billiard balls are rolling on a flat table. One has component velocities as v_x=1 m/ s,v_y= 3 m/s and the other has v_x' = 2 m/s , v_y' = 2 m/s. If both the balls start moving from the same point, what is the angle between their paths?

8 If a shower of rain appears to be falling vertically downwards with a speed of 12 Km/h to a person walking due East with a speed of 5 Km/h . What is the actual direction of the rain?

9 A bus with wheels of diameter 1 m is moving at a speed of 36 km/h. Calculate the angular velocity of the wheels and how many turns a wheel makes in 1 sec.

10 A person can throw a ball vertically upwards upto a height of 50 m. Find the max, distance in the horizontal direction upto which he can throw the ball.

11 A bird is sitting on top of a tree 35 m high. A shot is fired from a distance of 70 m from the foot of the tree such that it just hits the bird. Calculate the magnitude and direction in which the shot is fired.

12 A player kicks a football at an angle of 30° with the horizontal and with initial velocity of 19.6 m/s. A second player standing at a distance of 20m from the first player and in the direction of the kick, starts running to meet the ball at the instant it is kicked. How far and how fast must he run in order to catch the ball before it hits the ground?

Competition Kit

H.O.T.

1. A bird is at a point P whose coordinates are (4m,-1m,5m). The bird observes two points P_1 and P_2 having coordinates (-1m, 2m,0m) and (1m,1m ,4m) respectively. At time t=0 it starts flying in a plane of three positions, with a constant speed of $5ms^{-1}$ in a direction perpendicular to the straight line P_1 and P_2 till it sees P_1 and P_2 collinear at time t. Calculate t.
2. A ball rolls off the top of a stairway with a constant horizontal velocity u. if the steps are h meter high and w meter wide, show that the ball will just hit the edge f nth step if $n= 2hu^2/gw^2$
3. Two identical balls are simultaneously thrown towards each other from points P and Q horizontally separately by 8m and situated at height 4 m and 8m above the ground. One ball is thrown from P horizontally with a speed of $8ms^{-1}$, while the other is thrown downwards with an initial speed of 'v' at an angle of 45° to the horizontal. The two balls collide in space, calculate (a) the initial speed of ball thrown from the point Q, (b) coordinates of the point of collision $g= 10\ ms^{-2}$.

M.C.Q

1. The coordinates of a moving particle at any time are given by $x=\dot{\alpha} t^3$ and $y= \beta t^3$. The speed of the particle at time 't' is given by

(a) $3t\sqrt{\dot{\alpha}^2 + \beta^2}$ (b) $3t^2 \sqrt{\dot{\alpha}^2 + \beta^2}$ (c) $3t^2 \sqrt{\dot{\alpha}^2 + \beta^2}$ (d) $\sqrt{\dot{\alpha}^2 + \beta^2}$

2 Which of the following statements is false for a particle moving in a circle with constant angular speed?

(a) The velocity vector is tangent to the circle
(b) The acceleration vector is tangent to the circle.
(c) The acceleration vector points to the centre of the circle.
(d) The velocity and acceleration vectors are perpendicular to each other.

3. A particle is acted upon by a force of constant magnitude, which is always perpendicular to the velocity of the particle. The motion of the particle takes place in a plane. It follows that

(a) Its velocity is constant (b) Its acceleration is constant
(c) Its kinetic energy is constant (d) It moves in a circular path

4. A particle has an initial velocity of $3\ \hat{i} +4\ \hat{j}$ and acceleration of $0.4\ \hat{i} +0.3\ \hat{j}$. Its speed after 10s is

(a) $7\sqrt{2}$ units (b) 7 units (c) 8.4 units (d) 10 units

5. When vectoe A.B. = A & B then

(a) A and B are perpendicular to each other (c) A and B act in the same direction
(c) A and B act in the opposite directon (d) A and B act in any direction

6 If the angle between vector A and B is Ø, the value of the product (B X A) . Vector A is equal to

(a) $BA^2 \cos Ø$ (b) $BA^2 \sin Ø$ (c) $BA^2 \sin Ø \cos Ø$ (d) Zero

7. Two bullets are fired simultaneously, horizontally and with different speeds from the same place. Which bullet will hit the ground first.
   (a) The faster one
   (b) Depends on their masses
   (c) The slower one
   (d) Both will reach simultaneously

8. A stone tied to the end of a string 1m long is whirled in a horizontal circle with a constant speed. If the stone makes 22 revolution is 44s. What is the magnitude and direction of acceleration of the stone?
   (a) $\Pi^2/4$ ms^{-2} and direction along the radius towards the centre
   (b) Π^2 ms^{-2} and direction along the radius away from the centre
   (c) Π^2 ms^{-2} and direction along the radius towards the centre.
   (d) Π^2 ms^{-2} and direction along tangent to the centre.

9. Which of the following is constant in a projectile motion?
   (a) Horizontal component of the velocity
   (b) Vertical component of the velocity
   (c) Velocity of the projection
   (d) All of these
   (e) Two vectors are perpendicular if
      (a) A. B =1 (b) AX B = 0 (c)A.B =0 (d)A.B = AB

Chapter No: 5

Laws of Motion

Glimpse

1. Force: It may be defined as an agency (a push or pull) which changes or tends to change the state of rest or of uniform motion or the direction of a body. Force is a vector quantity.
2. Inertia: It is the inherent property of a material body by virtue of which it cannot change by itself, its state of rest or of uniform motion in a straight line. Inertia is of three types (i) inertia of rest (ii) inertia of motion (iii) inertia of direction.
3. Mass as the measure of inertia: If the body has more inertia i.e., it is more difficult to change its state of rest or of uniform motion.
4. Momentum: It is the quantity of motion in a body. It is equal the product of mass m and velocity v of the body.
5. Newton's first law of motion: It states that everybody continues in the state of rest or of uniform motion along a straight line, unless an external force is applied to change that state. This law defines forces.
6. Newton's second law of motion: It states that the rate of change of momentum of a body is directly proportional to the applied force and the change in momentum takes place in the direction of the applied force. This law gives a measure of the force.
7. Newton's third law of motion: It states that to every action, there is an equal and opposite reaction,
8. Absolute units of force: The SI unit of force is Newton(N) and CGS unit is dyne (dyn).
9. Gravitational unit of force: The SI unit of force is kilogram weight (kg wt) or kilogram force (kg f) and the CGS unit is gram weight (g wt) or gram force (g f)
10. Impulse of a force: Impulse is the total effect of a large force which acts for a short time to produce a finite change in momentum. It is defined as the product of the force and the time for which it acts and equal to the total change in momentum.

    Impulse=Force X time duration

    = Total change in momentum.

11. Law of conservation of linear momentum:

    In the absence of any external force, vector sum of the linear moment of a

System of particles remains constant.

12. Rocket propulsion: It is an example of momentum conservation in which the large backward momentum of the ejected gases imparts an equal forward momentum to the rocket. Due to the decrease in mass of the rocket-fuel system, the acceleration of the rocket keeps on increasing

13. Concurrent forces: The forces acting at the same point of a body are called concurrent forces..

14. Equilibrium of concurrent forces: A number of concurrent forces acting on a body are said to be in equilibrium if their vector sum is zero or if these forces can be completely represented by the sides of a closed polygon taken in the same order.

15. Friction: Whenever a body moves or tends to move over the surface of another body, a force comes into play which acts parallel to the surface of contact and opposes the relative motion. This opposing force is called friction.

16. Static friction: The force of friction which comes into play between two bodies before one body actually starts moving over the other is called static friction (fs). Static friction is a self-adjusting force.

17. Limiting friction: The maximum force of static friction which comes into pay when a body just starts moving over the surface of another body is called limiting friction.

18. Kinetic friction: The force of friction which comes into play when a body is in steady motion over the surface of another body is called kinetic or dynamic friction (fk) kinetic friction is less than limiting friction.

19. Laws of limiting factor:

(i) The force of limiting friction depends upon the nature of the two surfaces in Contact and their state of roughness.

(ii) The force of limiting friction acts tangential to the two surfaces in a contact and in a direction opposite to that of the applied force.

(iii) The force of limiting friction between any two surfaces is independent of the Shape or area of the surfaces in contact so long as the normal reaction remains the same.

(iv) The force of limiting friction between two given surfaces is directly proportional to the normal reaction between the two surfaces.

Where the constant of proportionality is called the coefficient of limiting Friction.

20. Angle of friction: It is the angle which the resultant of the limiting friction and the normal reaction makes with the normal reaction.

21. Angle of repose: It is the minimum angle that an inclined plane makes with the horizontal when a body placed on it just begin to slide down.

22. Centripetal force: It is the force required to make a body move along a circular path with a uniform speed. It always act along the radius and towards the centre of the circular path. The centripetal force required to move a body of mass m along a circular r with speed v is given by mv^2/r.

Assignments

1. A cricket player lowers his hands, while catching a ball. Why.

2. A force of 20N is applied on an object of mass m. the object moves in a straight line with its velocity increasing by 20m/s in every 2s. Find the mass (m) of the object?

3. A bullet of mass of 0.04kg moving with a speed of 90m/s enters a heavy wooden block and is stopped after a distance of 60cm. What is the average force exerted by the block on the bullet?

4. A boy is carrying a wire cage in which a bird is sitting on the floor of the cage. The bird starts flying in the cage. Will the boy experience any change in the weight of the cage?

5. Explain how friction helps in walking.
   A object takes n times as much time to slide down a 450 rough incline as it takes to slide down a perfectly smooth 450 incline. Find the coefficient of kinetic friction between object and incline.

6. The force on a particle of mass 10g is (10i + 5j) N. If it starts from rest find its position at time t = 5s

7. Why does a cyclist bend inwards while negotiating a curve? Explain with diagram.

8. A block slides down an incline plane having inclination of 30^0 with the horizontal. Starting from rest, it covers 13.5m in the first three seconds. Find the coefficient of kinetic friction between the block and the incline plane.

9. A horse pulls a cart with a horizontal force, causing it to accelerate. Newton's third law says that the cart exerts an equal and opposite force on the horse. In view of this, how can the cart accelerate? Explain with the help of diagram.

10. A block slides with a constant speed on a rough horizontal floor acted upon by a force F which is 1.5times the weight of the block. The line of action of force F makes 300 with the ground. Find the coefficient of friction between the block and the ground.

11. A girl riding a bicycle along a straight road with a speed of 5m/s throws a stone of mass 0.5kg with a speed of 15m/s with respect to ground along her direction of motion. The mass of the girl and bicycle is 50kg. Does the speed of the bicycle change after the stone is thrown? If yes, what is the change in speed?

12. State and prove the principle of conservation of linear momentum. Apply this law, to explain why (i) a gun recoils, when fired; (ii) a rocket goes up,

when fired and (iii) the boat moves away, when a man jumps from it to the shore.

13. A pendulum is hanging from the ceiling of a car having an acceleration ao with respect to the road. Find the angle made by the string with vertical at equilibrium.

14. A block of mass 2kg is lying on an incline plane, inclined to the horizontal at 30^0. If the coefficient of friction between the block and the plane is 0.7, then find the magnitude of frictional force acting on the block?

15. Same force acts on two different bodies of masses 3kg and 5kg initially at rest. Find the ratio of times required to acquire same final velocity?

16. The two forces, which when acting at right angles to each other, produce a resultant force of $\sqrt{10}$N and when at 600, produce a resultant of $\sqrt{13}$N. Find the magnitude of these forces?

PRACTICE QUESTIONS

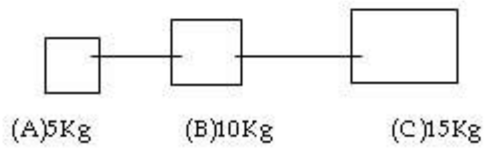
SHORT ANSWER QUESTIONS

1. The distance traveled by a body is directly proportional to time. Is any external force acting on it?

2. State the principle of conservation of linear momentum. Explain, why the gun recoils when a bullet is fired from it?

3 What are concurrent forces? What is the condition for the equilibrium of three concurrent forces?

4 Three blocks are connected as shown in fig on a horizontal frictionless table and pulled to the right with a force of 50N. Find the tensions in the strings between A & B, between B & C.



5 A man stands on a spring balance on an elevator. In which case will the scale record the minimum reading and the maximum reading: i) elevator stationary ii) elevator rope breaks, free fall iii) elevator speeds upward iv) elevator accelerates downward.

6 A block rests on a rough inclined plane making an angle of 30^0 with the horizontal. The coefficient of static friction between the block and the plane is 0.8. if the force of friction on the block is 10N. Find the mass of the block?

7 A balloon with mass M is descending down with an acceleration a where $a < g$. What mass m of its contents must be removed so that it starts moving up with acceleration a?

8 Define the angle of friction and angle of repose. Show that both are numerically equal.

9 What are factors on which force of friction depends? How does lubrication helps in reducing the lubrications?

10 Tyres are provided with irregular projections or grooves over their surfaces? Why?

11 A body is moving along a circular path such that its speed is always remains constant. Should there be force acting on the body?

12 Why are shockers used in scooter and cars? Explain

13 In which case will a rope have the greater tension:

(a) Two men pull the ends of the rope with forces F equal in magnitude but opposite in direction.

(b) One end of the rope is fastened to a fixed support and the other is pulled by a man with a force 2F

14 Why does a heavy rifle not kick as strongly as a light rifle using the same cartridges?

15 Polishing beyond a certain limit may increase the friction between the surfaces. Explain why?

16. A force of 49N is just able to move a block of wood of mass 10kg on a rough horizontal surface. Find the coefficient of friction?

17. Find angle of banking for a vehicle moving with velocity v to negotiate a safe turn of radius r, neglecting the force of friction

LONG ANSWER QUESTIONS

1. State and prove the principle of conservation of linear momentum. Apply this law to explain why (i) a gun recoils when fired; (ii) a rocket goes up, when fired and (iii) the boat moves away, when a man jumps from it on the shore.

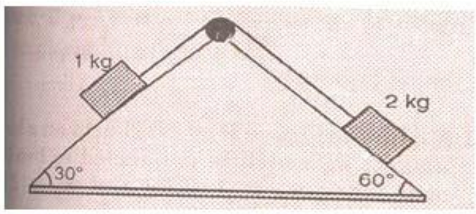
2 What is friction? State and explain the law of limiting friction. Give some advantages and disadvantages of friction.

3. Why does a cyclist bend inwards while negotiating a curve? Explain with diagram.
4. Describe the motion of a car on a leveled circular road.
5. Derive an expression for centripetal acceleration of an object in uniform circular motion in a plane. What will be its direction at any instant?
6. Explain the term impulse. Show that the impulse is equal to the change in momentum.
7. What are concurrent forces? Obtain a condition for the equilibrium of three concurrent forces.
8. Derive an expression for work done in moving a body up an incline plane.
9. What is a angular velocity? Derive a relation between the angular velocity and linear velocity of a particle in uniform circular motion.
10. What is the need for banking a road? Obtain an expression for the maximum speed with a vehicle can safely negotiate a curved road banked at an angle θ.

11 Derive law of conservation of linear momentum from Newton's third law of motion?

NUMERICALS

1 Two blocks of mass 1Kg and 2Kg are connected by an inextensible string which passes over a frictionless pulley as shown in the fig. . Calculate the acceleration of these blocks.



2 A block of 1Kg lies on horizontal surface in a truck. The coefficient of static friction between the block and the surface is 0.6. If the acceleration of the truck is $5 m/s^2$, calculate the frictional force acting on the block. 5N

3 A batsman deflects a ball by an angle of 45^0 without changing its initial speed which is 54km/h. what is the impulse imparted to the ball if its mass is 150g? 4.16kg m/s

4 A particle moves in a circle of radius 20cm at 120rpm. Calculate the acceleration of the particle? $32\pi^2 cm\ s^{-2}$

5 A car is moving with 72km/h on a flat circular road of radius 10m. Can the car negotiate the curve with this speed? Take $\mu = 0.3$

6 Calculate the angular speed of the second's hand of a clock. If the length of the seconds hand is 4cm, calculate the speed of the tip of the second's hand.

7. A particle of mass 14g attached to a string of 70cm length is whirled round a horizontal circle. If the period of revolution is 2s, calculate the tension in the string. 0.097N

8. A scooter is moving with a speed of 15m/s on a circular track of radius 50m. Its speed is increasing at the rate of $1 m/s^2$. Calculate its acceleration? $4.61 m/s^2$

9. A 0.5kg ball moving with a speed of 12m/s strikes a hard wall at an angle of 30^0 with the wall. it is reflected with the same speed at the same angle. If the ball remains in contact with wall for 0.25s, calculate the average force acting on the wall. 24N

10. A block released from rest from the top of a smooth incline plane of inclination 45^0 takes time t to reach the bottom. The same block released

from rest from the top of a rough incline plane of same inclination takes time 2t to reach the bottom. Find the coefficient of friction?

0.75

COMPETITION KITS

1. A man is pulling a rope attached to a block on a smooth horizontal table. The tension in the rope will be the same at all points:
   (a) If and only if the rope is not accelerated

   (b) If and only if the rope massless

   (c) If either the rope is not accelerated or is massless

   (d) Always

2. The action and reaction forces referred to Newton's third law of motion:
   (a) Must act upon the same body (b) must act upon different bodies

   (c)need not be equal in magnitude but must have the same line of action
   (d) must be equal in magnitude but need not have the same line of action

3. Mark correct option
   (a) Friction always opposes the motion of a body

   (b) Friction only opposes the relative motion between surfaces

   (c) Kinetic friction depends on the speed of body when the speed of body is less than 10m/s

   (d) The coefficient of friction is always less than or equal to one.

4. A bicycle is in motion. when it is not pedaled, the force of friction exerted by the ground on the two wheels is such that it acts:
   (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 and in the backward direction on rear wheel

   (c) In the backward direction on both the front and the rear wheels

   (d) In the forward direction on both the front and the rear wheels.

5. A monkey climbs up and another monkey climbs down a rope hanging from a tree with same uniform acceleration separately. If the respective masses of monkeys are in the ratio 2:3, the common acceleration must be
   (a) g/5 (b) g/3 (c) g/2 (d) g

6 . A player caught a cricket ball of mass 150g moving at the rate of 20m/s. If the catching process is completed in 0.1s, the force of blow exerted by the ball on the hand of the player is equal to
   (a) 3N (b) 30 N (c) 150N (d) 300N

7. An object at rest suddenly explodes into three parts with the mass ratio 2:1:1. The parts of equal masses move at right angles to each other with equal speeds v. The speed of the third part after the explosion will be
   (a) 2 v (b) $v/\sqrt{2}$ (c) v/2 (d) $\sqrt{2}v$

8. A body is moving with a velocity v on a horizontal surface of coefficient of friction μ. It will come to rest after moving a distance S given by
   (a) $2g/\mu v^2$ (b) $v^2/2\mu g$ (c) $v^2/\mu g$ (d) $2v^2/\mu g$

9. A block moving on a surface with velocity 20m/s comes to rest because of friction over a distance of 40m. the co efficient of dynamic friction is
   (a) 0.1 (b) 0.2 (c) 0.3 (d) 0.5

10. A machine gun fires a bullet of mass 25g with a velocity of 1000m/s. a person holding it can apply maximum force of 100N on the gun. What is maximum number of bullets that can be fired per second?
   (a) 1 (b) 2 (c) 3 (d) 4

11. A 100kg ball moving with a speed of 20m/s returns in opposite direction with a speed of 30m/s after striking with a bat. The impulse is
   (a) 15 Ns (b) 10 Ns (c) 5 Ns (d) 20Ns

12. Diwali rocket ejects 50g of gases per second at a velocity of 400m/s. the accelerating force on the rocket will be
   (a) 22dyne (b) 20N (c) 20dyne (d) 100N

13. When a horse pulls a cart, force that helps horse to move forward is the force exerted by
   (a) the cart on the horse (b) the ground on the horse
   (c) the ground on the cart (d)the horse on the ground.
14. A block of mass m is placed on a smooth inclined plane of inclination θ with the horizontal. The force exerted by the plane on the block has a magnitude
   (a) mg (b) mg/cosθ (c) mgcosθ (d) mgsinθ
15. While walking on ice, one should take small steps to avoid slipping. This is because smaller steps ensure
   (a) larger friction (b) smaller friction
   (c) larger normal force (d) smaller normal force.
16. A body at rest breaks into two pieces of equal masses. The parts will move
   (a) in same direction (b) along different lines
   (c) in opposite direction with equal speeds
   (d) in opposite directions with unequal speeds.

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

Chapter 6
Work Energy and Power

Glimpses

1 **Work**: Work is said to be done wherever a force acts on a body and the body moves through some distance in the direction of the force. If the force F makes angle θ with the direction of displacement S, then the work done is

$W = F.S = FS \cos\theta$

Work done is a scalar quantity. It can be positive or negative depending on θ is acute or obtuse. The work done by friction or viscous force on a moving body is negative.
Work done is scalar quantity.

2 **Work done against a variable Force.** The work done by a variable force F in changing the displacement from s_1 to s_2 is
W = Area under the force – displacement curve
$W = \int F.ds$

3 **Units of work**. (i) The SI unit of work is joule. One joule of work is said to be done when a force of one Newton displaces a body through a distance of one metre in its own direction.
1 joule = 1 newton x 1 metre or 1 J = 1Nm

ii) The CGS unit is erg. One erg of work is said to be done if a force of one dyne displaces a body through a distance of one centimeter in its own direction..
1 erg= 1 dyne x 1 cm

4 **Energy:** It is defined as the ability of a body to do work. It is measured by the amount of work that a body can do. It is a scalar quantity. Like work, SI unit of energy is joule

And the CGS unit is erg.

The unit of energy used at the atomic level is electron volt(eV).

5 **Kinetic energy**: It is the energy possessed by a body of virtue of its motion. The K.E. of a body of mass m moving with speed v is $K = (½)mv^2$

6 **Work-energy theorem**: The work done by the net force acting on a body is equal to the change in kinetic energy of the body.
$W = \text{Change in K.E.} = (1/2)\, mv^2 - (1/2)mu^2$
The WE theorem may be regarded as the scalar form of Newton's second law of motion.

7 **Potential energy**: It is the energy possessed by a body by virtue of its position (in a field) or configuration (shape or size).

8 **Gravitational potential energy**: It is the energy possessed by a body by virtue of its position above the surface of the earth. The gravitational P.E. of a body of a mass m at the height h above the earth's surface is $U = mgh$.

9 **Potential energy of a spring**: According to Hooke's law, when a spring is stretched through distance x, the restoring force set up in the spring due to its elasticity is such that

$$F \propto x \quad \text{or} \quad F = -kx$$

Where k is the force constant or spring constant of the spring. It is the restoring force set up in the spring per unit extension. It's unit is Nm^{-1}

10 **Conservative force**: A force is conservative (i) if the work done by the force in displacing a particle from one point to another is independent of the path followed by the particle and (ii) if the work done by the force in moving a particle around any closed path is zero. Gravitational force, electrostatic force and elastic force of a spring are all conservative forces.

11 **Non-conservative force**: If the amount of work done in moving an object against a force from one point to another depends on the path along which the body moves, then such a force is called a non-conservative force. Forces of friction and viscosity are non-conservative forces.

12 **Mass energy equivalence**: According to Einstein, mass can be converted into energy and energy into mass. A mass m is equivalent to energy E given by $E = mc^2$

13 **Power:** It is the rate of doing work. It is a scalar quantity.

$$\text{Power} = \frac{\text{work}}{\text{Time}} \quad \text{or} \quad p = \frac{w}{t}$$

14 Units of power: The SI unit of power is (W)

$$1 \text{ watt} = \frac{1 \text{ joule}}{1 \text{ second}} \text{ or I w} = 1 \text{ J s}^{-1}$$

The larger units of power are kilowatt (kw) and horse power (hp)

15 **Kilowatt hour**: It is the commercial unit of electrical energy. One kilowatt hour is the electrical energy consumed by an appliance of 1000 watt in 1 hour.

$1kWh = 3 \times 10^6 J$

16 **Law of conservation of energy**: It states that energy can neither be created nor destroyed but can only be transformed from one form to another.

17 **Collision:** A collision between two bodies is said to occur if either they physically collide against each other or the path of one body is influenced by the other.

18 **Elastic collision**: If there is no loss of kinetic energy during a collision, it is called elastic collision

19 **Inelastic collision**: If there is a loss of kinetic energy during a collision, it is called an inelastic collision.

Linear momentum is conserved both in elastic and inelastic collision.

20 **Perfectly inelastic collision**: It is the collision in which two bodies stick together, after the collision.

21 **Head- on collision or one-dimensional collision**: It is a collision in which the colliding bodies move along the same straight line path before and after the collision

22 **Oblique collision**: If the two bodies do not move along the same straight line path before and after the collision, the collision is said to be oblique collision.

Work Energy and Power

Assignments

1 Define average power and instantaneous power. Give its unit and dimensional formula.

2 Draw a plot of spring force versus displacement x . Hence find an expression for the Potential Energy of an elastic stretched spring. And also draw the variation of P.E. stored in a spring as a function of extension.

3 Two bodies of masses m and 4m are moving with equal kinetic energies. What is the ratio of their linear momenta?

4 A ball is dropped on the ground from a height of 1 m. The coefficient of restitution is 0.6. Find the height to which the ball will rebound.

5 Two inclined frictionless tracks, one gradual and the other steep, meet at A from where two stones are allowed to slide down from the rest, one on each track. Will the stones reach the bottom at the same time? Will they reach there with the same speed? Explain. Given $\theta_1 = 30°$, $\theta_2 = 60°$ and h=10m, what are the speeds and times taken by the two stones?

6 Springs A and B have same dimensions and mass but force constant $k_A < k_B$. In which spring is more work spent, if
(a) they are stretched by equal amount
(b) they are stretched by the same force?

7 A mass 'm' displaces in a straight line, guided by a machine delivering constant power. Prove that the displacement (x) is proportional to $t^{3/2}$.

8 Define coefficient of restitution. What is its value for different types of collisions? Distinguish between a head on and an oblique collision?

9 A body of mass M at rest is struck by a moving body of mass m. Show that the fraction of the initial kinetic energy of moving mass m transferred to the strucked body is $\frac{4Mm}{(m+M)^2}$

10 A body of mass 0.3 kg is taken up an inclined plane to length 10 m and height 5 m, and then allowed to slide down to the bottom again. The coefficient of friction between the body and the plane is 0.15. What is the
(i) work done by the gravitational force over the round trip,
(ii) work done by the applied force over upward journey,
(iii) work done by frictional force over the round trip,
(iv) kinetic energy of the body at the end of the trip?
How is the answer to (iv) related to the first three answers?

11 A massless platform is kept on a light elastic spring. When a sand particle of mass 0.1 kg is dropped on the pan from a height of 0.24 m, the particle strikes the pan, and the spring compresses by 0.01 m. From what height should the particle be dropped to cause a compression of 0.04 m?

12 A bullet of mass 0.012 kg and horizontal speed 70 m/s strikes a block of wood of mass 0.4 kg and instantly comes to rest with respect to the block. The block is suspended from the ceiling by means of thin wires. Calculate the height to which the block rises. Also, estimate the amount of heat produced to the block.

13 A particle moves along x-axis from x = 0 to x = 5m under influence of force $F = 7 - 2x + 3x^2$. Find work done in process

14 10 Kg ball and a 20 kg ball approach each other with velocities20ms^{1} & 10 ms^{-1} respectively. What are their velocities after collision if the collision is perfectly elastic?

15 Suraj went to Big Bazaar to purchase certain goods .There he has noticed an old lady struggling with her shopping. Immediately he showed her the lift and explained to her how it carries the load from one floor to the next. Even then the Old lady was not convinced.. Then suraj took her in the lift and showed her how to operate it. That old lady was very happy.

(a)What values does Suraj possess?

(b)An elevator can carry a maximum load of 1800 kg is moving up with a constant speed of 2 m/s , The frictional force opposing the motion is 4000 N. Determine the minimum power delivered by the motor to the elevator in watts as well as in horse power. .

PRACTICE QUESTIONS

Short Answer Questions :

1 A light body and heavy body have the same K.E., which will have the greater momentum?

2 Two bodies A and B weighing 5kg and 6kg respectively have equal momenta. Which one has more K.E?

3 State the law of conservation of mechanical energy. Show that it is conserved for a freely falling body.

4 A car of mass 2000kg is lifted up a distance of 30m by a crane in 1min. A second train does the same job in 2 min. Do the cranes consume the same or different amount of fuel? What is the power supplied by each crane? Neglect the power dissipation against friction

5 Two inclined frictionless tracks, one gradual and the other steep meet at A from where two stones are allowed to slide down from the rest, one on each track. Will the stones reach the bottom at the same time? Will they reach there with the same speed? Explain

6 What are central forces?

7 What is the work done by the force of tension in the string of a simple pendulum?

8 Define energy. What are its units? Name the different forms of energy. State if each of the following statement is true or false. Give reasons to your answer.

a) In an inelastic collision of two bodies, the momentum & energy of each body is conserved.
b) Total energy of a system is always conserved no matter what internal external forces on the body are present. c) Work done in the motion of a body over a closed loop is zero for every force in nature. d) In an inelastic collision, the final K.E. is always less than the initial K.E. of the system.

9 A truck and a car with same kinetic energy are brought to rest by the application of brakes, which provide equal retarding forces. Which of them will come to rest in a shorter distance?

10 Give one example each of positive, negative and zero work. State and prove the work-energy theorem.

11 The bob A of a pendulum released from 30^0 to the vertical hits another bob B of the same mass at rest on a table. How high does the bob A rise after the collision? Neglect the size of the bobs and assume the collision is elastic.

12 What are conservative and non-conservative forces? Give examples of each.

LONG ANSWER QUESTION

1 Calculate the velocities of two bodies moving in the same direction (1-D) after undergoing an elastic collision . Also define the coefficient of restitution.

2 Discuss elastic collision in 2-dimensions.

3 State and prove the work-energy theorem.

4 Show graphically how you can determine the work done by i) a constant force ii) variable force

5 Find the expression of maximum speed of the stretched spring when it is released. Show that the total energy of the stretched spring remains conserved when it is released.

6 Differentiate between conservative and non-conservative forces giving an example of each.

7 What is meant by positive work, negative work and zero work? Give one example of each.

8 Two ball bearings of mass m each moving in opposite directions with equal speeds v collide head on with each other. Predict the outcome of the collision, assuming it to be perfectly elastic.

NUMERICAL

1 A bullet of mass 0.012kg and horizontal speed 70m/s strikes a block of wood of mass 0.4kg and instantly comes to rest w.r.t. the block. The block is suspended from the ceiling by means of thin wires. Calculate the height to which the block rises. Also estimate the amount of heat produced in the block

2 A body of mass 2 kg makes an elastic collision with another body at rest & continues to move in the original direction with a speed equal to one-third of it's original speed. Find the mass of the second body.

3 A block of mass 5 kg slides down an incline of inclination 30^0 and length 10 m. Find the work done by the force of gravity.

4 A 40kg skater traveling at 4m/s over takes a 60kg skater traveling at 2m/s in the same direction and collides with him. If the two skaters remain in contact, how much K.E. is lost? Name this collision

5 A ball is moving on a horizontal frictionless plane with 0.5m/s hits an Identical ball at rest and moves with 30cm/s after collision. If collision is elastic, show that the two balls will move at right angles to each other after the collision.

6 A body of mass 10kg is moved along a straight line and its displacement (x) varies with time(t) according to relation $t = \sqrt{x}+1$ Find the work done in moving the body for first 10s

7 A body of mass 2 kg makes an elastic collision with another body at rest & Continues to move in the original direction with a speed equal to one-third of it's original speed. Find the mass of the second body.

8 A railway carriage of mass 10,000 kg moving with a speed of 54 km/hr strikes a stationary carriage of the same mass. After the collision the carriages get coupled & move together. What is their common speed after the collision? Is the collision elastic?

9 A spring requires 4J of work to stretch it through 10 cm beyond it's stretch length. Calculate a) the value of k, b) the extra work required to stretch it through an additional 10 cm.

10 A ball moving with a speed of 9m/s strikes an identical particle moves from point r_1= (2m)î + (3m)j to another point r_2= (3m)î + (2m)jduring which a certain force F =(5N)î + (5N)j acts on it. Find the work done by the force on the particle during the displacement.

11 A shot traveling at the rate of 100m/s is just able to pierce a plank 4 cm thick. What velocity is required to just pierce a plank 9 cm thick?

12 Define spring constant. A block of mass 5.7kg slides on a horizontal frictionless table with a constant speed of 1.2m/s. It is brought momentarily to rest by compressing a spring in its path. By what maximum distance is the spring compressed? The spring constant K is 1500N/m.

13 The blades of windmill sweep out a circle of area A (a) if wind flows at velocity v perpendicular to circle, what is mass of air passing through it in time t? (b) What is kinetic energy of air? (c) Assume that windmill converts 25% of wind's energy into electrical energy. Given A = 30m2, V = 36 km/hr and density of air =1.2 kg m^{-3}. What is electrical power produced?

COMPETITION KIT

H.O.T

1 A bullet of mass 0.01 kg traveling at a speed of 500 ms^{-1} strikes a block of mass 2kg. which is suspended by a string of length 5m. The centre of gravity of the block is found to rise a vertical distance of 0.1 m. What is the speed of the bullet after it emerges from the block? Take g=9.8 ms^{-2}.

2 A ball moves along a curved path of radius 5m. It starts from point A and reaches point B. If there is no force of friction between the ball and surface of the path, then find the normal force that acts on the ball at the bottom (B) of the curved path

3 Show that coefficient of restitution for one dimensional elastic collision is equal to one.

M.C.Q.

1 Two masses of 1g and 4g are moving with equal kinetic energy. The ratio of magnitudes of their momentum is
(a) 4 :1 (b)$\sqrt{2}$:1 (c) 1 :2 (d) 1 : 16

2 If a machine is lubricated with oil
(a) the mechanical advantage of the machine increases
(b) the mechanical efficiency of the machine increases
(c) both its mechanical advantage and efficiency increase
(d) its efficiency increases, but its mechanical advantage decreases

3 A particle of mass m is moving in a circular path of constant radius 'r' such that its centripetal acceleration a_c is varying with time t as $a_c = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is
(a) $2\Pi mk^2r^2t^2$ (b) $mk^2r^2t^2$ (c) $(mk^4r^2t^5)/3$ (d) zero

4 The work done in stretching a spring of force constant k from length l_1 to l_2 is
(a)$k(l_2^2 - l_1^2)$ (b) $1/2k(l_2^2 - l_1^2)$ (c) $k(l_2 - l_1)$ (d)$k/2(l_2 + l_1)$

5 A body of mass M_1 collides elastically with another mass M_2 at rest. There is maximum transfer of energy when
(a) $M_1 > M_2$ (b) $M_1 < M_2$ (c) $M_1 = M_2$
(d)same of all values for M_1 and M_2

6 A boy carrying a box on his head is walking on a level load from one place to another on a straight road is doing no work This statement is
(a) correct (b) incorrect (c) partly correct (d) insufficient data

7 If a spring extends by 'x' on loading, then the energy stored by the spring

is (if T is tension in the spring and k is spring constant)
(a) $T^2/2x$ (b) $T^2/2k$ (c) $2k/T^2$ (d) $2T^2/k$

8 A ball of mass 2kg and another of mass 4kg are dropped together from a 60 feet tall building. After a fall of 30 feet each together earth, their respective kinetic energies tall be in the ratio of
(a) √2 :1 (b) 1 : 4 (c) 1 : 2 (d) 1 : √2

9 In a body moves with constant speed in a circular path ,then
(a) work done will be zero (b)acceleration will be zero
(c) no force acts on the body (d) its velocity remains constant

10 A ball moves in a frictionless inclined table without slipping. The work done by the table surface on the ball is
(a) Postive (b) negative (c)Zero (d) none of these

Chapter 7

Motion of System of Particles and Rigid Body

Glimpses

1. Particle: A particle is an object whose mass is finite but whose size and internal structure can be neglected.

2. System: A system is a collection of a very large number of particles which mutually interact with one another.

3. Centre of mass: It is the point at which entire mass of a system may be supposed to be concentrated. The nature of motion of the system remains unaffected when all the forces acting on the system are applied directly on the centre of mass of the system.

4. Properties of centre of mass:

(1) The location of the centre of mass is the weighted average of the locations of the particles of the system

(ii) Centre of mass moves as if the external force acts on the entire mass concentrated at the point.

(iii) In the absence of any external force, the centre of mass moves with a constant velocity.

(iv) For bodies of normal dimensions, centre of mass and centre of gravity coincide.

5. Rigid body: A rigid body is one whose constituent particles retain their relative positions even when they move under the action of an external force.

6. Rotational motion of a rigid body: A body is said to posses' rotational motion if all its particles move along circles in parallel planes. The centers of these circles lie on a fixed line perpendicular to the parallel planes and is called the axis of rotation

8. Torque (t): The turning effect of a force about the axis of rotation is called moment of force or torque due to the force.

SI unit of torque is Nm .

9. Principle of moments of rotational equilibrium: When a body is in rotational equilibrium, the sum of the clockwise moments about any point is equal to the sum of the anticlockwise moments about that point. Or, the algebraic sum of moments about any point is zero. Clockwise moment = Anticlockwise moment

Or Load* load arm =Effort*effort arm

This is sometimes called the lever principle.

10. Couple: A pair of equal and opposite forces acting on a body along two different lines of action constitute a couple. In a couple, total external force is zero but torque is non zero. So a couple has a turning effect but cannot produce translation motion.

11. Moment of a couple: The moment of a couple is equal to the product of either of the forces and the perpendicular distance, called the arm of the couple, between their lines of action. It is independent of the choice of the fulcrum or the point of rotation.

Moment of couple = Force x arm of the couple

A couple can only be balanced by an equal and opposite couple.

12. Work done by a torque and power of a torque: If a torque applied on a body rotates it through an angle ω, the work done by the torque is

Or Work done = Torque x Angular displacement

Power of a torque is given by

$P = \tau\ \omega$

13. Angular momentum: It is the moment of linear momentum of a particle about the axis of rotation.

If a particle of mass m moves with uniform speed v along a circle of radius r, then its angular moment is L= mvr

SI unit of angular momentum is kgm^2

The linear momentum and velocity vector are always parallel to each other. But the angular momentum and the angular velocity are not necessarily parallel vectors.

14. Geometrical meaning of angular momentum: Geometrically, the angular momentum of a particle is equal to twice the product of its mass and areal velocity. Equivalently, the areal velocity of a particle is just half its angular momentum per unit mass.

15. Relation between torque and angular momentum: The rate of change of angular momentum of a system of particles about a fixed point is equal to the total external torque acting on the system about that point.

16. Equilibrium of rigid bodies: A rigid body is said to be in equilibrium if both the linear momentum and angular momentum of the rigid body remain constant with time. It must posses the following two equilibria simultaneously:

(i) Translation equilibrium: The resultant of all the external forces acting on the body must be zero.

(ii) Rotational equilibrium: The resultant of all the torques due to all the forces acting on the body about any point must be zero.

17. Moment of inertia: The moment of inertia of a rigid body about an axis of rotation is the sum of the products of masses of the various particles and squares of their perpendicular distances from the axis of rotation.SI unit of moment of inertia = kg m^2

The moment of inertia of a body can be regarded as the rotational inertia of a body. It is the rotational analogue of mass in linear motion.

18. Factors on which the moment of inertia depends: The moment of inertia of a body depends on the following factors:

(i) Mass of the body

(ii) Size and shape of the body

(iii) Distribution of mass about the axis of rotation

(iv) Position and orientation of the axis of rotation with respect to the body

19. Radius of gyration: It may be defined as the distance from the axis of rotation at which if whole mass of the body were supposed to be concentrated, the moment of inertia, would be same as with the actual distribution of mass.

20. Theorem of perpendicular axis: It states that the moment of inertia of a plane lamina about an axis perpendicular to its plane is equal to the sum of the moment of inertia of the lamina about any two mutually perpendicular axes in its plane and intersecting each other at the point, where the perpendicular axes pass through the lamina. Mathematically,

Where X-and Y- axes lie in the plane of the lamina and Z- axis is perpendicular to its plane and passes through the point of intersection of X- and Y- axes.

21. Theorem of parallel axes: It states that the moment of inertia of a rigid body about any axis is equal to the moment of inertia of the body about a parallel axis through its centre of mass plus the product of mass of the body and the square of the perpendicular distance between the parallel axes.

Assignment

1. Why does a child in merry –go – round press the side of his seat radially outward?

2. The wheel of a motor, accelerated uniformly from rest, rotates through 2.5radian during the first second. Find the angle rotated during the next second.

3. A thin wire of mass M and length L is bent into a circular ring. Find the moment of inertia of the ring about its axis?
   Find x and y if the force 2i-3j+k acting at(2,y,-1) produces no torque about (x,0,2)

4. Two rings have their moment of inertia in the ratio 2:1 and their diameter in the ratio 2:1. Find the ratio of their masses?

5. Three forces 2i +7j , 2i+5j+7k and i-2j+k act at (4, -1,2). Find the moment of these forces about (6,1,-3)?

6. A meter rod of uniform density is pivoted at 40cm mark. A block of mass 10g is suspended at 10cm mark. Find the mass of the meter rod if it is in equilibrium?

7. A flywheel of mass 25kg has a radius of 0.2m. it is making 240rpm. Find the force applied tangentially on the rim of the wheel to bring it to rest in 20s.

8. A child is standing with folded hands at the centre of a platform rotating about its central axis. The kinetic energy of system is K. the child now stretches his arm so that the moment of inertia of the system doubles. What will be new kinetic energy of system?

9. Derive an expression for position vector of the center of mass of two particle system.

10. A disc of mass 100g is rolling without slipping on a horizontal surface with a velocity of 10cm/s. Calculate its total energy.

11. A wheel rotates with a constant acceleration of 2.0rad/s^2. If the wheel starts from rest, how many revolutions will it make in the first 10seconds?

12. A grinding stone in the of solid cylinder has a radius of 0.5m and a mass 50kg. find

(a) What torque will bring it from to an angular velocity of 300rev/min in 10s?

(b) What is the kinetic energy when it is rotating at 300rev/min?

13. A wheel rotating at an angular speed of 20rad/s is brought to rest by a constant torque in 4.0seconds. If the moment of inertia of the wheel about the axis of rotation is $0.20 kgm^2$, find the work done by the torque in the first two seconds.

14. A uniform circular disc of mass 200g and radius 4.0cm is rotated about one of its diameter at an angular speed of 10rad/s. Find the kinetic energy of the disc and its angular momentum about the axis of rotation.

15. Calculate the radius of gyration of a uniform thin rod of mass M and length L about an axis of rotation perpendicular to its length and passing through its centre.

16. A man of mass m is standing on a platform of mass M kept on smooth ice. If the man starts moving on the platform with a speed v relative to the platform, with what velocity relative to the ice does the platform recoil?

Practice Questions

Short answer questions

1. A constant torque acting on a uniform circular wheel changes its angular momentum from L_0 to $4L_0$ in 4 seconds. Find the magnitude of torque.
2. If 2 discs of the same mass and thickness are made from metals of different densities, which disc will have the larger moment of inertia about its central axis? Explain.
3. Define Centre of mass of a system. Four particles of masses 2m, m,4m and 3m are placed at each corner A,B,C and D respectively, of a square of side 2 cm . Calculate the position of the centre of mass of the system.
4. If a body is rotating, is it being necessarily being acted upon by an external torque?

5. State the parallel and perpendicular axis theorems
6. What is the conservation of angular momentum?
7. What do you mean by principle of moment? How this principle is used to find the unknown weight of a given object
8. Derive the expression for tor torque in Cartesian coordinate system.
9. Define the term angular momentum. Establish relationship between angular momentum and moment of inertia.
10. Distinguish between partial equilibrium and complete equilibrium.
11. How does angular velocity of planet changes with distance of planet from sun? Explain
12. A flywheel is rotating about its axis with angular speed ω. What will be the ratio of the linear velocities of two points on the wheels at a distance R/3 and R respectively? Where R is the radius of the flywheel.
13 If the earth contracts to half its radius, what would be the duration of day?
14. Explain the geometrical meaning of angular momentum and prove that the areal velocity of a particle acted upon by a radial force is constant.
15. A bucket containing water is rotated in a vertical circle. Explain why the water does not fall?
16. Explain if the ice on the polar caps of the earth melts how it will affect the duration of the day.
17. How a diver jumping from a height is able to make a number of loops in mid air?
18. Explain why the speed of whirl wind in a tornado is alarmingly high?
19. Define radius of gyration. Explain if the ice on the polar caps of the earth melts how it will affect the duration of the day?
20. A circular ring and a disc have same mass and radius. Which has larger moment of inertia?
21. Two identical particles move towards each other with velocity v and 2v respectively. What is the velocity of the centre of mass?
22. State and explain law of conservation of linear momentum.

Long answer questions

1. Derive an expression for the rotational kinetic energy and hence define moment of inertia. How does angular velocity of planet changes with distance of planet from sun
2. Discuss rolling without slipping of a solid cylinder down a rough inclined plane and find an expression for the acceleration of the cylinder. What is the condition so that slipping does not take place?
3. If the three point masses m,2m,3m are situated at the vertices of an equilateral triangle of side a. Calculate the coordinates of the centre of mass of the system
4. What is the physical significance of moment of inertia? On what factors the moment of inertia depends?
5, Find an expression for the force of friction required by a body to roll down an incline plane without slipping?
6. Define moment of inertia. What is the moment of inertia and radius of gyration of a disc about a tangent parallel to its diameter?
7. Using the concept of conservation of angular momentum, show that the areal velocity of planet is constant.
8. Read and state:
   (a) During rolling, what is the direction of force of friction with respect to the direction of motion of center of mass of the body?
   (b) What is the instantaneous speed of the point of contact during rolling?
   (c) For perfect rolling motion, what is the work done against friction?
   (d) A wheel moving down a perfectly frictionless incline plane will undergo slipping or rolling motion?

9. Explain the concept of torque. Show that the torque is given by the product of the force and its lever arm.
10. Two identical spheres, one hollow and other solid are allowed to roll down an incline plane making an angle of θ with horizontal. Which one of them reaches the bottom of the incline plane?

Numerical

1. Two children weighing 20kg and 25kg wanted to balance a sea saw of length 4m pivoted at its mid point. A child of 20kg is sitting at one edge of the seesaw. Where should the other child sit so that the sea saw is exactly balanced? 0.8m
2. A meter rod of mass 200g is suspended by two strings at each end. A body of mass 300g is suspended by a weightless string at 30cm mark. Calculate the tensions in the strings by which the meter rod is suspended? 1.9N and 3.1N
3. A solid cylinder rolls down an inclined plane. If the height of the plane is 3m, what is the rotational kinetic energy of the cylinder when it reaches the foot of the inclined plane? Mass of the cylinder is 2 kg and its radius is 10 cm. Assume that friction is negligible. 19.6 J

4. Calculate the kinetic energy of the earth due to rotation about its own axis.
2.6×10^{29}J

5 A rigid circular ring of mass 50kg and radius 4m rolls along a horizontal surface such that the speed of its centre of mass is 40cm/s. Calculate the work done to stop the ring? 8J

6. An automobile engine develops 100kW when rotating at a speed of 1800 r.p.m. Find the torque produced? 531Nm

7. The center of mass of three particles of masses 1kg, 2kg and 3kg is at (3,3,3) with reference to a fixed coordinate system, where should be fourth particle of mass 4kg be placed so that the center of mass of the system of all particles shift to a point (1,1,1).

8. A flywheel of mass 1000kg and radius 1m is rotating at the rate of 420rpm. Find the constant retarding torque required to stop the wheel in 14 rotations, assuming mass to be concentrated at the rim of the, wheel.
11000Nm

9. A car of mass 900kg is travelling around a circular path of radius 300m with a steady speed of 72km/h. Calculate its angular momentum?
5.4×10^{6}kg m^2s^{-1}

10. What will be the duration of the day, if the earth suddenly shrinks to 1/64 of its original volume, mass remains unchanged? 1.5h

11. Energy of 484J is spent in increasing the speed of a flywheel from 60rpm to 360rpm. Find the moment of inertia of the flywheel. 0.7kgm^2.

12. A solid cylinder of radius 4cm and mass 250g rolls down an inclined plane (1 in 10). Calculate the acceleration and the total energy of the cylinder after5sec. 2.0J

13. A disc of moment of inertia 5×10^{-4} is rotating freely about axis through its centre at 40rpm. Calculate the new rpm if some wax of mass 0.02kg is dropped gently on to the disc 0.08m from the axis of rotation.
32rpm

14. A circular metal disc of mass 4kg and diameter 0.4m makes 10 revolutions per second about an axis passing through its centre and perpendicular to its plane. Calculate the magnitude of torque which will increase the angular momentum by 20% in 10sec.

15. Two identical spheres each of mass 1.20kg and radius 10.0cm are fixed at the ends of a light rod so that the separation between the centres is 50.0cm. Find the moment of inertia of the system about an axis perpendicular to the rod passing through its middle point.
0.160kgm^2

16. A wheel of perimeter 220cm rolls on a level road at a speed of 9km/h. How many revolutions does the wheel make per seconds?
25/22rev/s

17. A cylinder is released from rest from the top of an incline of inclination θ and length ℓ. If the cylinder rolls without slipping, what will be its speed when it reaches the bottom?

Completion kit

1. An earth satellite is moving around earth in circular orbit. In such case, which of the following is conserved?
(a) Velocity (b) linear momentum (c) angular momentum
(d) none of these.
2. A solid cylinder rolls down an inclined plane of height 3m and reached the bottom of plane with angular velocity $2\sqrt{2}$rad/s. the radius of the must be(g=10m/s^2)
(a)0.5m (b) $\sqrt{5}$m (c) $\sqrt{10}$m (d) 5m
3. A solid sphere rolls down two different inclined planes of same height, but of different inclinations. In both cases
(a) Speed and time of descent will be same
(b) Speed and time of descent both are different
(c) Speed will be different, but the time of descent will be same
(d) Speed will be same, but the time of descent will be different
4 Two bodies have moment of inertia I and 2I respectively about their axis of rotation. if their kinetic energies of rotation are equal, their angular momenta will be in the ratio
(a) 2:1 (b) 1:2 (c) $\sqrt{2}$:1 (d) 1:$\sqrt{2}$
5. If the earth shrinks to half of its radius without change in mass, the duration of the day will be:
(a) 24hr (b) 48hr (c) 13hr (d) 6hr
6. The moment of inertia of a body about a given axis is 1.2kgm^2. initially the body is at rest. In order to produce a rotational kinetic energy of 1500J, an angular acceleration of 25rad/s^2 must be applied about that axis for the duration of:
(a) 4s (b) 2s (c) 8s (d) 10s
7. A disc of mass m and radius r is rotating with angular velocity ω. Another disc of mass 2m and radius r/2 is placed coaxially on the first disc gently. The angular velocity of the system will be
(a) 5ω/2 (b) 3ω/2 (c) 2ω/5 (d) 2ω/3
8. A particle under uniform circular motion is having angular momentum L. if kinetic energy of the particle is halved and frequency is doubled , its new angular momentum is
(a) L/4 (b) L/2 (c) 2L (d) 4L
9. Consider a uniform square plate of side 'a' and mass 'm'. The moment of inertia of this plate about an axis perpendicular to its plane and passing one of its corners is
(a)$2ma^2/3$ (b) $5ma^2/6$ (c) $1ma^2/12$ (d) $7ma^2/12$

10. A solid sphere of mass 1kg and radius 10cm rolls down an inclined plane of height 7m. the kinetic energy of rotation of the sphere when it reaches the bottom of the plane is
    (a) 5J (b) 10J (c) 70J (d) 20J

11. A disc of mass m and radius r is rotating with angular velocity ω. Another disc of mass 2m and radius r/2 is placed coaxially on the first disc gently. The angular velocity of the system will be
    (a) 5ω/2 (b) 3ω/2 (c) 2ω/5 (d) 2ω/3

12. A particle under uniform circular motion is having angular momentum L. If kinetic energy of particle is halved and frequency is doubled, its new angular momentum is
    (a) L/4 (b) L/2 (c) 2L (d) 4L

13. The angular momentum of a system is not conserved
    (a) When net external force acts upon the system.

    (b) When a net external impulse acts upon the system

    (c) When a net external torque acts upon the system

    (d) None of these

14 A cylinder rolls up an incline plane, reaches some height and then rolls down (without slipping throughout these motions). The directions of the frictional force acting on the cylinder are
   (a) Up the incline while ascending and down the incline while descending

   (b) Up the incline while ascending as well as descending.

   (c) Down the incline while ascending and up the incline while descending

   (d) Down the incline while ascending as well as descending.

15. Assertion: If polar ice melts, days will be shortened.
    Reason: Moment of Inertia decreases and then angular velocity increases.
    (a) Both assertion and reason are true and reason is the correct explanation of assertion.

    (b) Both assertion and reason are true and reason is not the correct explanation of assertion.

    (c) Assertion is true and reason is false

    (d) Assertion is false and reason is true.

16. A person sitting firmly over a rotating stool has his arms stretched. If he folds his angular momentum about the axis of rotation

(a) increases (b) decreases
(c) remains unchanged (d) doubles

1. (c) 2. (d) 3. (d) 4. (d) 5. (d) 6. (b) 7. (d) 8. (a) 9. (a) 10. (d) 11. (d)

12. (a) 13. (c) 14. (b) 15. (a) 16. (c)

Chapter No. 8

Gravitation

GLIMPSES :

1. Gravitation and gravity: Gravitation is the force of attraction between any two bodies while gravity refers to the force of attraction between any body and the earth.

2. Newton's law of gravitation: It states that every body n this universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

   Where G is the universal gravitational constant. It was derived by Newton on the basis of Kepler's laws of planetary motion.

3. Universal gravitational constant: (G) : It is equal to the force of attraction between two bodies of unit mass each and separated by unit distance.

4. Properties of gravitational forces: The gravitational force between two point masses (i) is independent of intervening medium (ii) obey's Newton's third law of motion (iii) has spherical symmetry (iv) is independent of the presence of other bodies (v) obeys principle of superposition (vi) is conservative and central.

5. Principle of superposition of gravitational forces: The gravitational force between two masses acts independently and uninfluenced by the presence of other bodies. Hence the resultant force on a particle due to a number of masses is the vector sum of the gravitational forces exerted by the individual masses on the given particle.

6. Shell theorem: The gravitational force on a particle placed anywhere inside a spherical shell, the shell attracts the particle as though the mass of the shell were concentrated at the centre of the shell.

7. Free fall: The motion of a body under the influence of gravity alone is called a free fall.

8. Acceleration due to gravity (g): The acceleration produced in the motion of a body under the effect of gravity is called acceleration due to gravity.

   It is a vector quantity. Its SI unit is ms^{-2} .

9. Weight of a body: It is the gravitational force with which a body is attracted towards the centre of the earth. W = mg

10. Weight of a body is a vector quantity. It is measured in Newton, kg wt, etc. The weight of a body varies from place to place because of the variation in the value of g.

11. Variation of acceleration due to gravity:

    (i) Effect of altitude: At a height h,: The value of g decreases with the increase in h.
    (ii) Effect of depth: At a depth d, : The value of g decreases with the increase in depth d and becomes zero at the centre of the earth.
    (iii) Effect of non-sphericity of the earth: The earth has an equatorial bulge and is flattened at the poles. So the value of g is minimum at the equator and maximum at the poles.

12. Gravitational field: It is the space around a material body in which its gravitational pull can be experienced by other bodies.

13. Intensity of gravitational field: The intensity or strength of gravitational field at any point in a gravitational field is equal to the force experienced by a unit mass placed at that point. It is a vector quantity directed towards the body producing the gravitational field.

    The intensity of gravitational field at a point is equal to the acceleration due to gravity at that point.

14. Gravitational potential: The gravitational potential at a point in the gravitational field of a body is the amount of work done in bringing a body of unit mass from infinity to that point. It is a scalar quantity.

    $$\text{Gravitational potential, } v = \frac{\text{work done}}{\text{Mass}} = -\frac{GM}{r}$$

15. Gravitational potential energy: The gravitational potential energy of a body may be defined as the energy associated with it due to its position in the gravitational field of another body and is measured by the amount of work done in bringing a body from infinity to a given point in the gravitational field of the other body.

    Gravitational P.E. = Gravitational potential * mass of a body

    $$U = -\frac{GM}{r} * m$$

    Gravitational intensity (E) and gravitational potential (V) at a point are related as

    $$E = \frac{dV}{dr}$$

16. Escape velocity : It is the minimum velocity with which a body must be projected vertically upwards in order that it may just escape the gravitational field of the earth.
    For earth, the value of escape velocity is 11.2 kms^{-1}. It is independent of the mass of body projected.

17. Satellite: It is a heavenly or an artificial body which is evolving continuously in an orbit around a planet.

19. Orbital velocity of a satellite : It is the velocity required to put a satellite in its orbit around a planet.

20. Time period of a satellite (T): It is the time taken by a satellite to go once around the planet

$$T = \frac{\text{Circumference of the orbit}}{\text{Orbital velocity}}$$

21. Total energy of a satellite For a satellite of mass m moving with velocity v in an orbit of radius r

Potential energy, $U = -\frac{GMm}{r}$

Kinetic energy, $K = \frac{1}{2} m v^2$

Total energy, $E = K+U$

Clearly, $E = -K = U/2$

22. Geostationary or synchronous satellite: It is satellite which revolves around the earth, with the same angular speed and in the same direction as the earth rotates about its own axis. Such a satellite should revolve around the earth from west to east in an orbit concentric and coplanar with the equatorial plane of the earth at a height of 36,000 km.

Three geostationary satellites with a mutual angular separation of 60° can be used to communicate between any two points of the entire earth.

23. Polar satellite: A satellite that revolves in a polar orbit is called a polar satellite. Such a satellite passes once over geographical north and south poles during each round trip. A polar orbit has a smaller radius of 500-800 km.

24. Conservation of quantities in motion under gravitational influence: During the motion of an object under the gravitational influence of another object the following quantities are conserved : (a) Angular momentum (b) Total mechanical energy.
Linear momentum is not conserved. Conservation of angular momentum leads to Kepler's second law of planetary motion.

25. Kepler's law of planetary motion
    - (i) Law of orbits: Every planet moves in an elliptical orbit around the sun, with the sun being at one of the foci.
    - (ii) Law of areas: The radius vector drawn from the sun to the planet sweeps out equal areas in equal intervals of time i.e., the areal velocity of a planet is constant.
    - (iii) Law of periods or Harmonic law: The square of the period of revolution (T) of a planet around the sun is proportional to the cube of the semi-major axis r of the ellipse.

26. Weightlessness: A body is said to be in a state of weightlessness when the reaction of the supporting surface is zero or its apparent weight is zero. An astronaut experiences weightlessness in a space satellite. This is not because the gravitational force is small at that location in space. It is because both the astronaut and the satellite are in the state of free fall towards the earth.

27. Inertial mass: The mass of a body which measures its inertia and which is given by the ratio of the external force applied on it to the acceleration produced in it along a smooth horizontal surface is called inertial mass.

$$\text{Inertial mass} = \frac{\text{Applied force}}{\text{Acceleration produced}} \quad \text{or} \quad m = \frac{F}{a}$$

28. Gravitational mass: The mass of a body which determines the gravitational pull due to earth acting upon it is called gravitational mass. On the surface of the earth.

Inertial mass of a body is equivalent to its gravitational mass.

ASSIGNMENT

1 Three equal masses of m kg each are fixed at the vertices of an equilateral triangle. What is the force acting on a mass 2m placed at the centroid G of the triangle?

2 At what height from the surface of the earth will the value of 'g' be reduced by 36% of its value at the surface of earth. (1600 km)

3 At what depth is the value of 'g' same as at a height of 40 km from the surface of earth? (80 km)

4 The mass and diameter of a planet are twice those of the earth. What will be the time-period of a second's pendulum on this planet. ($2\sqrt{2}$ s)

5 i) Define the term gravitational field. Show that acceleration due to gravity is equal to the intensity of gravitational field at any point.
II) Define Gravitational potential energy. Plot it as a function of distance.

6 Two bodies of mass 100 kg and 1000 kg are at a distance of 1 m apart. Calculate the gravitational field intensity and the potential at the mid-point of the line joining them. (2.4×10^{-7} N/kg , -1.47×10^{-7} J/kg)

7 A particle is fired vertically upwards with a speed of 15 km/s. Find the speed of the particle when it goes out of the Earth's gravitational pull.

8 A particle is projected upwards from the surface of the earth of radius R with a K.E. equal to half the minimum value needed for it to escape. To what height does it rise above the earth's surface? (h=R)

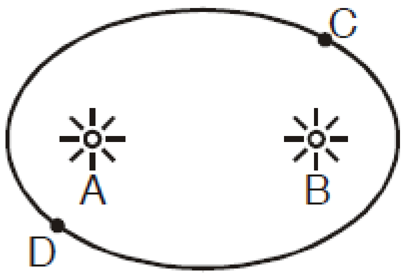
9 How much energy must be imparted to a 400Kg mass so that it escapes from the earth? (2.5×10^{10} J)

10 If the earth slows down while rotating on its axis, how will the weight of the bodies on it be affected?

11 Find the height at which the value of acceleration due to gravity reduces to half its value on the surface of the earth. (2649.6 km)

12 Find the potential energy of a system of four particles, each of mass m , placed at the vertices of a square of side 'a '. Also obtain the potential at the centre of the square.

13 Identify the position of sun in the following diagram if the linear speed of the planet is greater at C than at D.



14 The time period of the satellite of the earth is 5 hr. If the separation between earth and satellite is increased to 4 times the previous value, then what will be the new time period of satellite? (40 h)

15 A satellite is moving round the earth close to its surface, with velocity V_0 what should be the minimum percentage increase in its velocity so that the satellite escapes. (41.4%)

PRACTICE QUESTIONS

Short answer questions :

1. What will be the kinetic energy needed to project a body of mass m from the earth's surface (radius R) to infinity?

2. Describe the path of a bomb released from a satellite.

3. Why do different planets have different escape velocities.

4. The mass and diameter of a planet are twice those of the earth. What will be the time-period of that pendulum on this planet, which is a second's pendulum on the earth?

5. A satellite is orbiting the earth a speed v_o. To make the satellite escape, what should be the minimum percentage increase in its velocity?

6. Why is the weight of a body at the poles more than the weight at the equator? Explain.
   What is the trajectory followed by a body projected with a velocity greater than the orbital velocity but less than escape velocity.

7. If spheres of same material and same radius R are touching each other, then show that the gravitational force between them is directly proportional to R^4.

8. (i) What is a parking orbit? (ii) What is the use of stationery orbit?
   (iv) What is (a) period of revolution and
   (v) (b) sense of rotation of a geostationary satellite?

9. An earth satellite is moved from one stable circular orbit to a farther stable circular orbit. Which of the following increases(a) G (b)G.P.E .(c) linear orbital velocity

10. Imagine a space craft going from the earth to the moon. How does its weight vary as it goes from the earth to the moon?

11. Draw a graph showing the variation of acceleration due to gravity with distance from the centre of the earth to a height h above the surface of the earth.

12. What is the ratio of kinetic energy to potential energy for a satellite moving in a circular orbit around earth? (-1/2)

13. Name the two factors which determine whether a planet has an atmosphere or not.

Long answer questions:

1) What is the difference between gravitational potential and gravitational potential energy? Derive an expression for the gravitational potential energy of a body?
2) (i) What is meant by gravitational field strength?
(ii) Which of the planets of the solar-system has the greatest gravitational field strength?
(iii) What is greatest gravitational field strength of a planet where the weight of a 60 kg astronaut is 300N?
3) Escape velocity of a body of mass I kg from earth's field is 11.0 km/se approximately. What is the escape velocity of a 10 kg weight in the same field?
4) State Kepler's law of planetary motion and deduce Newton's law of gravitation from Kepler's law.
5) Prove that the distance we have to cover into earth below its surface is two times the distance we have to cover above the surface to get the same change in the value of g.
6) Define escape velocity. Prove that the velocity of escape of a body from the earth's surface is "2 times the velocity for a circular orbit just above the earth's surface.
7) What is weightlessness? How does the weight of the man vary, when the cabin of the lift (i) moves upwards (ii) moves downwards with an acceleration a
8) Show that the gravitational field and potential at any point of the surface f the earth are g and g R respectively. The earth may be assumed to be a sphere of uniform density.
9) Name the force that keeps the planets in their regular orbit. Express Newton's law of gravitation in vector form and show that it is consistent with the third law of motion.
10) Define acceleration due to gravity. Discuss the variation of g with (i) the altitude (ii) the depth and (iii) the shape of the earth.
11) Derive an expression from the increase in potential energy of a body, when moved from a point at distance r_1 to a point at a distance of r_2 ($r_1 < r_2$). Hence, prove that increase in potential energy of a body of mass m, when raised through a small distance h (h <<R) above the surface of the earth is m g h.
12) What is a satellite? Obtain expression for (a) orbital velocity,(ii) period of revolution and (iii) height of the orbit above the surface of the earth. How do the expressions for orbital velocity and time period modify, when the orbit of satellite is just above the surface of the earth.

Numericals

1 A mass of 0.5kg is weighted on a balance at the top of a tower 20m high. The mass is then suspended from the pan of the balance by a fine wire 20m long and is reweighed. Find the change in weight. Assume that the radius if the earth is 6400 km?

2 Two bodies of masses 10kg and 1000 kg are at a distance 1m apart. At which point on the line joining them will the gravitational field intensity be zero?

3 Three masses points each of mass m are placed at the vertices of an equilateral triangle of side 1. What is the gravitational field and potential due to three masses at the centroid of the triangle?

4 A geostationary satellite is orbiting the earth a height 6R above the surface of earth, where R is the radius of the earth. Find the time period of another a satellite at a height of 2.5m R from the surface of the earth in hours?

5 The time period of the satellite of the earth is 5 hours. If the separation between the earth and the satellite is increased to 4 times the previous value, then what will be the new time period of the satellite?

6 A man can jump 1.5m high on the earth. Calculate the approximate height he might be able to jump on a planet whose density is one-quarter that of the earth and whose radius is one-third of the earth's radius?

7 The escape velocity of a projectile on the Earth's surface is 11.2 km/s . A body is projected with thrice this speed. What is the speed of the body far away from the earth? (31.68 km/s)

Competition Kit

H.O.T.S.:

1. What will be the acceleration due to gravity on the surface of the moon if its radius were 1/4th the radius of the earth and its mass 1/80th the mass of the earth? What will be the escape velocity on the surface of the moon if it is 11.12 km s^{-1} on the surface of the earth?
2. Two satellites S_1 and S_2 revolves round a planet in co-planar circular orbitals in the same sense. Their periods of revolutions are 1 hours and 8 hours respectively. The radius of the orbit of S_1 is 10^4 km when S_2 is closest to S_1, find (1) the speed of S_2 relative to S_1 (2) the angular speed of S_2 actually observed by an astronaut in S_1.

M.C.Q

1. If the radius of earth were to shrink by one percent (its mass remaining the same), then the acceleration due to gravity on the earth's surface
   (a) Would decrease (b) Would remain unchanged
   (c) Would increase (d) cannot be predicated

2. An artificial satellite moving in a circular orbit around the earth has total (Kinetic+ potential) energy E_0. Its potential energy is
   (a) - E_0 (b) 1.5 E_0 (c) 2 E_0 (d) E_0
3. If Suddenly the gravitational force of attraction between the earth and a satellite revolving around I becomes zero, then the satellite will

   (a) continue to move in its orbit with same velocity'
   (b) move tangentially to the original orbit with the same velocity
   (c) become stationary in its orbits.
   (d) Move towards the earth

4. Average Density of the earth

   (a) does not depend on 'g' (b) is a complex function of 'g'
   (c) is directly proportional to 'g' (d) is inversely proportional to 'g'

5. The escape velocity of a body depends upon mass as
   (a) m^0 (b) m (c) m^2 (d) m^3

6. Two balls each of radius R, equal mass and density are placed in contact, then the force of gravitation between them is proportional to
   (a) $F \propto 1/R^2$ (b) $F \propto R$ (c) $F \propto 1/R$ (d) $F \propto R^4$

7 If M is the mass of the earth and R its radius, the ratio of the gravitational acceleration and the gravitional constant is
   (a) R^2/M (b) M/R^2 (c) $M R^2$ (d) M/R

8. A satellite revolves very near to the earth surface. Its speed should be around
   (a) 5Km/s (b) 8km/s (c) 2km/s (d) 11km/s

9. The acceleration due to gravity on the planet A is 9 times the acceleration due to gravity on planet B. A man jumps to a height of 2m on the surface of A. What is the height of jump by the same person on the planet of B?
   (a) (2/9) m (b) 18m (c) 6m (d) (2/3) m.

10. For a satellite moving in an orbit around the earth, the ratio of kinetic energy to potential energy is
   (a) 1/2 (b) $1/\sqrt{2}$ (c) 2 (d) $\sqrt{2}$

CHAPTER -9

MECHANICAL PROPERTIES OF SOLIDS

GLIMPSES

1. Interatomic force: It is the force between the atoms of a molecule. It arises due to the electrostatic interaction between the nuclei of two atoms, their electron clouds and between the nucleus of one atom and the electron cloud of the other atom.

2. Intermolecular forces: It is the force acting between the two molecules of a substance due to electrostatic interaction between their oppositely charged ends. Such forces operate over distances of 10-9 m and are weaker than interatomic forces.

3. Solids: A solid is a large accumulation of atoms or molecules. It has definite shape and size. The solids we come across in daily life can be classified in three groups:
 (i) Crystalline solids
 (ii) Amorphous solids
 (iii) Semi-crystalline solids

4. Crystalline solids: Those solids in which the atoms or molecules are arranged in a regular and repeated geometrical pattern are called crystalline solids. Such solids are bounded by flat surfaces, are anisotropic, have sharp melting points and have long range order in their structure.

Examples: Rock salt, quartz, mica, calcite, diamond etc.

5. Amorphous solids: These are the solids in which the atoms or molecules are nor arranged according to certain definite geometrical order, i.e., the atoms or molecules are arranged in a random order. Such solids are isotropic, do not have flat surfaces and their melting points are not sharp. They are super cooled liquids.
Examples: Glass, rubber, cellulose, bitumen, bone and many plastics

6. Semi-crystalline solids: These are the solids in which the crystalline phase is inter-dispersed in the amorphous phase, i.e. in which crystalline and amorphous phases co-exist. Polyethylene and protein are such solids.

7. Deforming force: A force which changes the size and shape of body is called deforming force.

8. Elasticity The property by virtue of which a body regains its original size and shape after the removal of deforming force is called elasticity.

9. Perfectly elastic body: If a body regains its original size and shape completely and immediately after the removal of deforming force, it is said to be perfectly elastic body. The nearest approach to a perfectly elastic body is quartz fibre.

10. Plasticity: The property by virtue of which a body does not regain its original size and shape even after the removal of the deforming force is called plasticity.

11. Perfectly plastic body: If a body not show any tendency to regain its original size and shape even after the removal of deforming force, it is said to be perfectly plastic body. Putty and paraffin wax are nearly perfectly elastic bodies.

12. Stress: The restoring force set up per unit area of a deformed body is called stress.

$$\text{Stress} = \frac{\text{Restoring force}}{\text{Area}} = \frac{\text{Applied force}}{\text{Area}} = \frac{F}{A}$$

The SI unit of stress is Nm^{-2} and the CGS unit is dyne cm^{-2}.
Stress is of two types:
(i) Normal stress
(ii) Tangential stress.

13. Strain: The ratio of the change in any dimension produced in the body to the original dimension is called strain.

$$\text{Strain} = \frac{\text{Change in dimension}}{\text{Original dimension}}$$

As strain is the ratio of two like quantities, it has no units and dimensions. Strain is of three types:
(i) Longitudinal strain: It is defined as the ratio of tangential stress to shear strain within the elastic limit.

20. Units of moduli of elasticity: As strain is a pure ratio, the unit of elasticity is same as that of stress. So SI unit of Y, K, or n is Nm^{-2} and the CGS unit is dyne cm^{-2}

21. Compressibility: The reciprocal of the bulk modulus of a material is called compressibility.
Compressibility = 1/k
22. Yield point: The stress beyond which a solid flows is called yield point. For example, a paste of flour and water flows under its own weight.

23. Breaking stress: The stress corresponding to which a wire breaks is called breaking stress.

Breaking force = Breaking stress * area of cross-section of the wire

24. Plastic region: The region of stress- strain curve between the elastic limit and the breaking point is called plastic region.

25. Ductile material: The materials which have large plastic range of extension are called ductile materials. Such materials can be drawn into thin wires.
Examples: Copper, silver, iron, aluminum, etc.

26. Brittle materials: The materials which have very small range of plastic extension are called brittle materials. Such materials break as soon as the stress is increased beyond the elastic limit.
Examples: Cast iron, glass, ceramics, etc.
27. Malleable metals: The metals which can be hammered or rolled into thin sheets are called malleable metals.
Examples: Gold, silver, lead, etc.

28. Elastomers: The materials which can be elastically stretched to large values of strain are called elastomers.They have large elastic region but do not obey Hooke's law.
Example: Rubber and elastic tissue of aorta.

ASSIGNMENT

1 Define Bulk Modulus.

2 What is the effect of increase in temperature on Young's modulus?

3 Which is more elastic-water or air, why?

4 What is the modulus of rigidity of a liquid?

5 Show that work done by a stretching force to produce certain extension in the wire is given by W= ½ (stretching force x extension).

6 Why are bridges declared unsafe after a long use?

7 The breaking force for a wire is F. What will be the breaking force for (a) two parallel wires of the same size (b) for a single wire of double the thickness?

8 Explain what happens when the load on a metal wire suspended from a rigid support is gradually increased. Illustrate your answer with a suitable stress-strain graph Use the graph to distinguish between ductile and brittle materials.

9 A wire is cut to half its original length. (a) How would it affect the elongation under a given load?
b) How does it affect the maximum load it can support without exceeding the elastic limit?

10 A wire stretches by a certain amount under a certain load. If the load and the radius are both increased to four times, find the stretch caused in the wire. (4 times)

Practice Questions

MECHANICS OF SOLIDS

Short answer questions

1 Two identical springs of steel and copper are equally stretched? On which more work will have to be done. Why?

2. States hooks law and define Young's modulus of elasticity.

3. Two wires made of the same material are subjected to forces in the ratio of 1:4. Their lengths are in the ration 8:1 and diameter in the ration 2:1. Find the ratio of their extensions.

4. The length of a metal wire is l_1 when the tension in it is T_1 and l_2 when tension in it is T_2, find the original length of wire.

5. Why do spring balances show wrong readings after they have been used for a long time?

6. Give one use of barometer other than measuring atmospheric pressure.

7. Explain why girders are I shaped.

8. A cable is cut to half its original length. Why does this have no effect on the maximum load it can support?

Long answer questions

1 Two wires of same length and material but of different radii are suspended from a rigid support. Both carry the same load. Will the stress, strain and extension in them be same or different?

2. What is elastic potential energy? Prove that the work done by a stretching force to produce certain tension in a wire is W= ½ stretching force X extension

3. Why do we prefer steel to copper in making springs?

4. What are ductile and brittle materials? Differentiate between them on the basis of their stress-strain curves.

5. A steel wire of length 2m and diameter 0.8mm is fastened between two points horizontally. When a weight W is suspended from its middle point, it is depressed by 1.0 cm. Calculate the value of W. $Y=2.0 \times 10_{11} Nm_{-2}$

0.01 Kgwt

Competition Kit

H.O.T.S

1. A wire of cross-sectional area A is stretched horizontally between two clamps located at a distance 21 metres from each other. A weight W kg is suspended from the midpoint of the wire. If the vertical distance through which the mid-point of the wire moves down be $x_{<}$ 1, then find (i) the strain produced in the wire. (ii) the stress in the area.(iii) if Y is the Young's modulus of wire, then find the value of x.
2. A stone of 0.5kg mass is attached to one end of a 0.8 m long aluminium wire 0.7 mm diameter and suspended vertically. The stone is now rotated in a horizontal plane at a rate such that the wire makes an angle of 85° with the vertical. Find the increase in the length of the wire. The Young's modulus of aluminium=$7x10^{10}$ Nm^{-2} sin 85°=0.9962, cos 85°=0.0872.
3. A light rod of length 2 m is suspended horizontally by means of two vertical wires of equal lengths tied to its ends. One of the wires is made of steel and is of cross-section A_1 =0.1cm^2 and the other is of brass and is of cross-section A_2= 0.2cm^2. Find out the position along the rod at which a weight must be suspended to produce (i) equal stresses in both wires, (ii) equal strains in both wires. For steel, Y=$20x10^{10}$ Nm^{-2} and for brass Y=$10x10^{10}$ Nm^{-2}.

M.C.Q

1. In solids interatomic forces are
   (a) totally repulsive (b)totally attractive (c) both (a) & (b) (d)None of these.

2. Which of the following is not a unit of Young's modulus
   (a) Nm^{-1} (b) Nm^{-2} (c) dyne Cm^{-2} (d) mega pascal.
3. These are two wires of same material and same length while the diameter of second wire is two times the diameter of first wire, then the ratio extension produced in the wire by applying same load will be
   (a) 1:1 (b) 2:1 (c) 1:2 (d) 4:1

4. A wire of diameter 1 mm breaks under a tension of 1000 N. Another wire of same material as that of the first one, but of diameter 2 mm breaks under a tension of
   (a) 500 N (b) 100 N (c) 1000N (d) 4000N

5. A body of weight 'mg' is hanging on a string which extends in length by 'l'. The work done in extending the string is
   (a) mgl (b) mgl/2 (c) 2mgl (d) none of these

6. If a wire of Young's modulus Y, longitudinal strain X is produced, then the value of potential energy stored in its units volume will be
   (a) YX^2 (b) $2YX^2$ (c) $0.5Y^2X$ (d) $0.5\ YX^2$

7. For a constant hydraulic stress on an object, the fractional change in the object's volume (ΔV/V) and its bulk modulus (B) are related as
   (a) ΔV/V ἀ B (b) ΔV/V ἀ 1/B (c) ΔV/V ἀ B^2 (d) ΔV/V ἀ $1/B^2$

8. The breaking stress of a wire depends upon
(a) length of wire (b) radius of the wire (c) material of the wire
(d) shape of the cross –section.

9. When a body of mass M is hung from a spring, the spring extends by 1 cm. If a body of mass 2M be hung from the same spring, the extension of spring will be
(a) 1 cm (b) 2 cm (c) 0.5 cm (d) 4 cm

10. With what minimum acceleration can a fireman slide down a rope whose breaking strength is two third of his weight

(a) g/3 (b) 2/3g (c) 3/2g (d) g/2

Chapter -10

MECHANICAL PROPERTIES OF FLUIDS

GLIMPSES

1. The basic property of a fluid is that it can flow. The fluid does not have any resistance to change it shape. Thus, the shape of a fluid is governed by the shape of its container.
2. Liquids and gases can flow and are therefore called fluids. Liquids possess finite volume but no definite shape. However, gases have neither definite shape nor a characteristic volume.
3. Whenever an object is submerged in a fluid at rest, the fluid exerts a force on its surface normally. It is called thrust of the fluid. Its unit is Newton (N).
4. The thrust exerted by a fluid , in equilibrium of rest, per unit area of the surface in contact with the fluid is called average pressure. $P = F/A$.
5. S.I. unit of pressure is Nm^2 or Pascal(Pa). It is a scalar quantity.
6. In equilibrium of rest , a fluid exerts a pressure normally at a surface.
7. According to Pascal's Law, pressure in a fluid at rest is same at all points which are at the same height. A chane in pressure applied to an enclosed fluis is transmitted equally to every point of the fluid as well as the walls of the containing vessel. The action of hydraulic lifts and brakes is based on Pascal's Law.
8. A column of height h of a fluid of density ρ exerts a pressure P given by $P = h\rho g$.
9. The pressure exerted by a fluid at a point depends on the vertical depth of the point and the density of the fluid but is independent of the shape or size of the containing vessel.
10. The Gauge Pressure P_g is the difference of the actual pressure (P) and the atmospheric pressure P_a . Thus , $P_g = P - P_a$
11. The flow of a fluid is said to be steady or streamline lined if each particle of the fluid passing through a given point travels along the same path and with the same speed as the preceding particle passing through that very point.
12. A streamline may be defined as the path, straight or curved, the tangent to which at any point gives the direction of fluid flow at that point. A tube of flow is a bundle of stream lines , having the same velocity, of fluid elements over any cross section perpendicular to the direction of flow.
13. A laminar flow is that streamline flow in which the velocities at different points in the fluid may have different magnitudes but their directions are parallel.
14. Flow remains streamlined till a limiting value of velocity called critical velocity, above which , the flow becomes turbulent.
15. According to the equation of continuity , if there is no fluid source or sink along the length of a pipe, then mass of the fluid crossing any section of the pipe per unit time remains constant.
16. Bernoulli's principle states that the total energy i. e. the sum of pressure energy per unit volume, kinetic energy per unit volume and potential energy per unit volume of an incompressible, non-viscous fluid remains constant throughout the fluid flow.

17. Bernoulli's principle is a restatement of the conservation law of energy for the flow of fluids. Some applications are Magnus effect, Torricelli's law , dynamic lift on aerofoil, Venturi-meter etc.
18. Viscosity is the property of fluids due to which a backward dragging force (viscous force) acts tangentially on the adjacent layers of the fluid, which are in relative motion, and tries to stop this relative motion.
19. The coefficient of viscosity η of a fluid may be defined as the viscous force acting tangentially per unit surface area of a fluid layer having unit velocity gradient in a direction perpendicular to the direction of fluid flow.
20. S.I. unit of coefficient of viscosity is $N\ s\ m^{-1}$ or Pa s.
21. According to Stoke's law , the backward dragging force acting on a small spherical body of radius r moving with a velocity v through a viscous medium of coefficient of viscosity η is given by $F = 6\pi r v \eta$.
22. Terminal velocity of a particle is defined as the constant maximum velocity acquired by it while falling through a viscous fluid.
23. Reynold number is a dimensionless number whose value gives an approximate idea whether the flow of a fluid will be streamlined or turbulent.
24. The coefficient of viscosity of liquids decreases with increase in temperature. However in gases, the viscosity increases with increase in temperature.
25. Surface tension (S) of a liquid is measured as the force(F) per unit length(l) on an imaginary line drawn on the liquid surface. $S = F/l$
26. Surface tension of a liquid may also be defined as its surface energy per unit area acting in the plane of interface between the liquid and the boundary surface. It is the extra energy that the molecules at the interface have as compared to those in the interior of the liquid.
27. Intermolecular force amongst molecules of the same material is called the force of cohesion Force amongst molecules of the different materials is called the force of adhesion.
28. For a curved liquid surface, pressure is always more on the concave side than on the convex side.
29. Angle of contact of a given solid-liquid pair is the angle which the tangent to the free surface of a liquid at the point of contact subtends with thw wall of the container solid.

    Angle of contact is acute for liquids having a concave meniscus (eg. Water with glass).

    Angle of contact is obtuse for liquids having a convex meniscus (eg. mercury with glass) .
30. A tube of extremely fine bore is called a capillary tube. Capillarity is the phenomenon of rise or fall of a liquid in a capillary tube as compared to the surroundings.
31. Surface tension of a liquid decreases with increase in its temperature.
32. Surface tension of a liquid is affected on adding impurities. When a detergent powder is added to water, its surface tension decreases.

Mechanical Properties of fluids

Assignment

1 State Pascal's Law. Explain the working of a hydraulic lift.

2 A swimmer is swimming at a depth of 10m inside water. Calculate the absolute and gauge pressure that he will experience.

3 A U- tube contains water and spirit separated by mercury. The mercury column in the two arms are in level with 10.0cm of water in one arm and 11.5cm of spirit in the other arm. What is the relative density of spirit?
(0.869)

4 What amount of energy is liberated if 1000 drops of water each 10^{-8} m in diameter coalesce to form one large spherical drop? Surface tension of water is 72×10^{-3}N/m.

5 Derive the expression for the excess pressure inside a soap bubble.

6 The surface tension of soap solution is 0.03N/m. What amount of work is required to produce a bubble of radius 0.05m?

7 Water rises in a capillary tube to a height of 2.0 cm. In another capillary whose radius is one third of it, how much the water will rise? If the first capillary is inclined at an angle of 60 degree with the vertical, then what will be the length of water in the capillary?

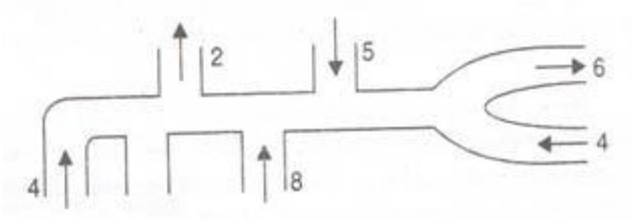
8 a) Discuss the effect of temperature on the viscosity of (i) Liquids (ii) Gases?

b) What is the effect of increase of pressure on the fusion point and boiling pt. of water?

9 A metal plate of area $5m^2$ rests on a liquid film of thickness 5mm. A force of 100N pulls the plate and it moves with a constant velocity of 2m/s. Find the coefficient of viscosity of the liquid.

10 A cylinder is filled with a non-viscous liquid of density of the height h_0 and a hole is made at a height h_1 from the bottom of the cylinder. Find the velocity of the liquid coming out of the hole?

11. The figure shows a pipe and gives the volume flow rate (in cm^3/s) and the direction of flow for all but one section. What are the volume flow rate and the direction of flow for the section?



12 Give reasons why

i) The wings of an aeroplane are rounded outwards while flattened inwards?

ii) A spinning cricket ball in the air does not follow a parabolic path.

iii) a raindrop falling freely does not acquire a high velocity ?

13 State and prove Bernoulli's theorem?

14 A film of water is formed between two straight parallel wires each of 10 cm long and at a separation 0.5 cm. Calculate the work required to increase 1mm distance between the wires. Surface tension of water = 72 x 10^{-3} N/m.

(1.44 x 10^{-5} J)

15 a) Discuss the effect of temperature on the viscosity of (i) Liquids (ii) Gases?

b) What is the effect of increase of pressure on the fusion and boiling pt. of water?

16. When school closed for summer break, Ammu's family was leaving for the native by train. In the railway station, Ammu saw two small children playing on the platform while their parents were sitting nearby. After sometime, Ammu saw that the children while playing have moved very close to the edge of the platform and a train was coming in the nearby track.

Immediately Ammu ran to the children and pulled them away from the edge of the platform.

(a) What values are displayed by Ammu, in this incident?

(b) What would happen if a person remains very close to the edge of the platform when a train passes in the nearby track? Explain.

17. Define angle of contact. A capillary is dipped in a vessel containing i) water ii) mercury. Draw the angle of contact for each.

18. Dimensionally derive an expression for the viscous force F acting on a spherical body of radius r falling through a liquid of coefficient of viscosity η with a velocity v.

Practice Questions

MECHANICS OF FLUIDS

Short answer questions

1 Why are the bags and suitcases provided with broad handles?
2 Why air bubbles in water are rises from bottom to top and grows in size?
3 Which fall faster- big raindrops or small rain drops?
4 Which practical unit of pressure is used in meteorological science?
5 What is the value of surface tension at the critical temperature?
6 How does the angle of contact of a liquid depend on temperature?
7 A liquid stands at the same level in the U-tube when at rest. If A is the area of cross-section and g the acceleration due to gravity, what will be the difference in height h of the liquid in the two limbs of U-tube. When the system is given an acceleration 'a' towards right, as shown in figure.
8. Why is it easier to swim in sea water than in river water?
9. A bucket of water is suspended from a spring balance. Does the reading of balance change (a)when a piece of stone suspended from a string is immersed in water without touching the bucket? (b) When a piece of iron or cork is put in water in the bucket?
10 Why it is dangerous to stand near the edge of the platform when a fast train is crossing it?
11. The clothes are better cleaned with hot water than with cold water. Why?
12 What is a Pilot tube? State the principle on which it is based?
13. If a ball is thrown and given a spin, then the path of the ball is more curved than in a usual spin free path. Explain .
14. How does ploughing of fields help in preservation of moisture in the soil?

Long answer questions

1 A sphere is dropped under gravity through a fluid of viscosity n. Taking the average acceleration as half of the initial acceleration, show that the time taken to attain the terminal velocity is independent of the fluid density.
2 What is capillary rise? Derive an expression for the height to which a liquid rises in the capillary tube of radius r?
3 Define surface tension. Derive a relation between surface tension and surface energy. What is the unit of surface tension?
4 Obtain expression for pressure exerted by a liquid column.
5 Explain the terms: streamline flow, streamline tube of flow and turbulent flow. Derive the equation of continuity for a steady flow of an incompressible liquid
6 Show that the excess of pressure inside a drop is inversely proportional to its radius
7 Show that when a large number of drops of a liquid (same size) coalesce to form a big drop, there is always liberation of energy.

8. State Bernoulli's theorem for a liquid having possessed by a flowing ideal liquid is conserved stating assumptions used.
9. Derive an expression for the elastic potential energy stored in a stretched wire under stress. Define the terms elastic after effect and elastic fatigue.
10 Show that a liquid, having density p, angle of contact θ and surface tension T rises in a capillary tube of radius r to height h given by $h = 2T\cos\theta/r\rho g$

Numerical

1 An automobile back is lifted by a hydraulic jack that consists of two pistons. The large piston is 1m in diameter and the small piston is 10 cm in diameter. If W be the weight of the car, how much smaller force is needed on the small piston to lift the car?

2 Water rises to a height of 20mm in a capillary. If the radius of the capillary is made 1/3rd of its previous value, to what Height will the water rises in the tube?

3 A non viscous liquid of constant density 1000 kg/m^3 flows in a streamline motion along a tube of variable cross section. The tube is kept inclined in the vertical plane with end P closer to ground as compared to end Q of the tube. The area of cross section of the tube at two points P and Q at heights of 2^m , 5 m are respect. 4×10^3 m^2 and 8×10^3 m^2. The velocity of liquid at P is 1m/s. Find the work done per unit volume by the pressure and gravity forces as the liquid flows from P to Q?

4 What will be the length of Mercury column in a barometer tube, when the atmospheric is 75 cm of mercury and the tube is inclined at an angle of 30° to the vertical? (86.6 cm)

5 Eight drops of radius 1 mm each falling down with terminal velocity of 5 cm/s coalesce to form a bigger drop. Find the terminal velocity of the bigger drop. (20 cm/s)

6 What should be the maximum average velocity of water in a tube of diameter 0.5 cm so that the flow is laminar? The viscosity of water is 0.00125 Ns/m^2 . (0.5m/s)

Competition Kit

H.O.T.S

1. A boat floating in a water tank is carrying a number of large stones. If the stones are unloaded into water, what will happen to the water level?
2. A beaker containing water is placed on a spring balance. A stone of weight W is hung and lowered into the water without touching the sides and bottom of the beaker. Explain how the reading will change.
3. A hemispherical portion of radius R is removed from the bottom of a cylinder of radius R. The volume of the remaining cylinder is V and its mass is M. It is suspended by a string in a liquid of density p where it stays vertical. The upper surface of the cylinder is at a depth h below the liquid surface. How much is the force on the bottom of the cylinder by the liquid?

M.C.Q.

1) A closed compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity. Then the pressure in the compartment is
   (a) Same every where (b) lower in the front side
   (c) lower in the rare side (d) lower in the upper side

2) A man is sitting in a boat, which is floating on a pond. If the man drinks some water from the pond, the level of water in the pond
   (a) decreases (b) increases (c) remains unchanged
   (d) may increase or decrease depending upon the weight of the man
3) A body floats in a liquid contained in a beaker. The whole system fails freely under gravity. The upthrust on the body is
   (a) zero (b) equal to the weight of the liquid displaced
   (c) equal to the weight of body in the air
   (d) equal to the weight of the immersed portion of the body.

4) A jar is filled with two non-mixing liquids 1 and 2 having densities p_1 and p_2 respectively. A solid ball, made of a material of density p_3 , is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of following is true for p_1 , p_2 and p_3.
   (a) $p_1 ,< p_3 < p_2$ (b) $p_3 ,< p_1 < p_2$ (c) $p_1 ,> p_3 > p_2$ (d) $p_1 ,< p_2 < p_3$

5) Spherical balls of radius R are falling in a viscous fluid of viscousity ή with a velocity 'v'. The retarding viscous force acting on the spherical ball is
   (a) directly proportional to R but inversely proportional to 'v'
   (b) directly proportional to both radius R and velocity 'v'
   (c) inversely proportional to both radius R and velocity 'v'
   (d) inversely proportional to R but directly proportional to 'v'

6) If two soap bubbles of different radii are connected by a tube,
   (a) air flows from the bigger bubble to the smaller bubble till the sizes become equal
   (b) air flows from bigger bubble to the smaller bubble till the sizes are interchanged.

(c) Air flows from the smaller bubble to the bigger.
(d) There is no flow of air.

7) An object is moving through the liquid. The viscous damping force acting on its proportional to the velocity. Then diamensions of constant of proportionality are
(a) $ML^{-1}T^{-1}$ (b) MLT^{-1} (c) M^0LT^{-1} (d) ML^0T^{-1}

8) The rate of flow of liquids in a tube of radius 'r' length 'l', whose ends are maintained at a pressure difference P is V= ΠQpr⁴/ ήl, where ή is coefficient of viscosity and Q is
(a) 8 (b) 1/8 (c) 16 (d) 1/16

9) The ratio of the terminal velocities of two drops of Radii R and R/2 is
(a) 2 (b) 1 (c) ½ (d) 4

10) The velocity of efflux of a liquid through an orifice in the bottom of the tank does not depend upon
(a) size of orifice (b) height of liquid (c) acceleration due to gravity
(d) none of the above.

11) A body is just floating in a liquid (their densities are equal). If the body is slightly pressed down ad released, it will
(a) Start oscillating (b) sink to the bottom
(c) come back to the same position immediately
(d) come back to the same position slowly.

12) In incompressible fluid flows streadily through a cylindrical pipe which has radius 2R at point A and R at a point B further along the flow direction. If the velocity at A is 'v' then that at B is
(a) v/2 (b) v (c) 2v (d) 4v

13) When the temperature is increased, the angle of contact of the liquid

(a) increase (b) decreases (c) remains the same
(d) first increases and then decreases.

Chapter -11

THERMAL PROPERTIES OF MATTER
GLIMPSES

1. Heat: Heat is a form of energy which produces in us the sensation of hotness or coldness. According to dynamic theory, heat may be regarded as the energy of molecular motion which is equal to the sum total of the kinetic energy possessed by the molecules by virtue of their translation, vibrational and rotational motions.

2. Units of heat: Calorie (cal) is the CGS unit of heat. One calorie is defined as the heat energy required the raise the temperature of one gram of water from . Like all other forms of energy, the S. I. unit of heat is joule
   1 calorie = 4.186 joule

3. Joule' s mechanical equivalent of heat: Whenever a given amount of work (W) is converted into heat, always the same amount of heat Q is produced.
   $J = W/Q$
   $W = JQ$

   The proportionally constant J is called Joule's mechanical equivalent of heat. It may be defined as the amount of work that must be done to produce a unit quantity of heat.

4. Temperature: It is the degree of hotness of a body. The temperature of a body gives a measure of the average kinetic energy of its molecules.

5. Thermometer: It is a device used to measure the temperature of a body. It makes use of some measurable property (called thermometric property) of a substance which changes linearly with temperature.

6. Absolute scale of temperature: The lowest possible temperature of 0 K (-273.15˚C) at which a gas is supposed to have zero volume (and zero pressure) and at which entire molecular motion stops is called absolute zero of temperature. The temperature scale which starts with -273.15˚C as its zero is called Kelvin scale or absolute scale. The size of degree on Kelvin scale is same as that on celsius scale.

7. Triple point of water: The triple point of water is the state at which the three phase of water namely ice, liquid water and water vapour are equally stable and co-exist in equilibrium. It is unique because it occurs at a specific temperature of 273.16 K and a specific pressure of 0.46 cm of Hg column.

8. Linear expansion:

   The coefficient of linear expansion of the material of a solid rod is defined as the increase in length per unit length per degree rise in temperature.

9. Superficial expansion:

Coefficient of superficial expansion is defined as the increase in surface area per unit surface area per degree rise in temperature.

10. Cubical expansion:
    Coefficient of cubical expansion:
    It is defined as the increase in volume per unit volume per degree in temperature.
    The coefficient expansion of an ideal gas is equal to the reciprocal of its absolute temperature.

11. Relation between the three coefficients of thermal expansion are related as
    $\alpha:\beta:\gamma = 1:2:3$

12. Coefficient of apparent expansion of a liquid: It is defined as the apparent increase in volume per unit original volume per degree rise in temperature.

    $$Ya = \frac{\text{Apparent increase in volume}}{\text{Original volume* Rise in temperature}}$$

13. Variation of density with temperature: The density of a solid or liquid decreases with the increase of temperature.

14. Specific heat: It may be defined as the amount of heat required to raise the temperature of unit mass of a substance through one degree.
    The cgs unit of specific heat is cal/ g /˚C and the SI unit is J/kg/K.

15. Molar specific heat: It is defined as the amount of heat required to raise the temperature of 1 mole of the substance through one degree.
    The cgs unit of specific heat is cal /mol/˚C and the SI unit is J/mol/K

16. Heat capacity or thermal capacity: It is defined as the amount of heat required raise the temperature of a body through one degree
    Heat capacity = Mass * Specific heat = mc

17. Water equivalent: The water equivalent of a body is defined as the mass of water which requires the same amount of heat as is required by the given body for the same rise of temperature.
    W = Mass * specific heat = mc
    The cgs unit of water equivalent is g and the SI unit is kg.

18. Latent heat: The amount of heat required to change the state of unit mass of a substance at a constant temperature is called its latent heat. It is denoted by L

19. Latent heat of fusion: The amount of heat required to change the state of unit mass of a substance from solid to liquid as its melting point is called latent heat of fusion.

20. Latent heat of vaporization: The amount of heat required to change the state of unit mass of a substance from liquid to vapour at its boiling point is called latent heat of vaporisation.

21 . Principle of calorimetry: When two bodies at different temperatures are placed in contact with each other, the heat lost by the hot body is equal to the heat gained by the cold body. This is the principle of calorimetry or the principle of mixtures.
    Heat gained = Heat lost

22. Transfer of heat: The three modes of transfer of heat are conduction, convection and radiation.

23. Conduction: It is a process in which heat is transmitted from one part of a body to another at a lower temperature through molecular collisions, without any actual of matter.

24. Steady state: The state of the rod when temperature of every cross-section of the rod becomes constant and there is no further absorption of heat in any part is called steady state.

25. Coefficient of thermal conductivity: It may be defined as the quantity of heat energy that flows in unit time between the opposite faces of a cube of unit side, the faces being kept at one degree difference of temperature.

    Thermal conductivities of metals are much greater than those for metals. Gases are poor thermal conductors.

26. Heat current and resistance: The flow of heat per unit time in conduction is called heat current. The ratio of the temperature difference between the ends of a conductor through it is called thermal resistance.

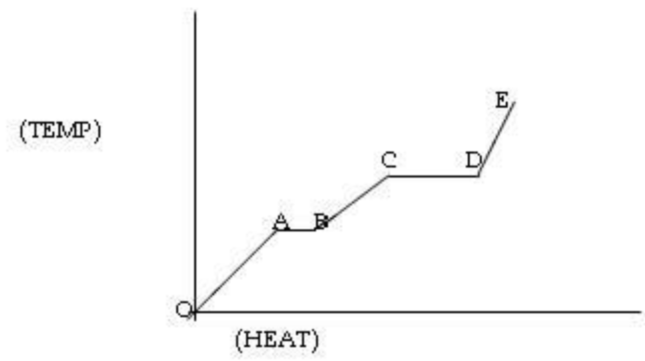
27. Convection: It is the process by which heat is transmitted through a substance from one point to another due to the bodily motion of the heated particles of the substance. Fluids are mainly heated through convection. Natural convection arises due to unequal heating and gravity, when more heated and less dense parts rise and are replaced by the fluid. In forced convection, a material is forced to move by an agency like a pump or blower.

Thermal properties of matter

ASSIGNMENT

1 A faulty thermometer has its fixed pts marked as 5^0 and 95^0. The temperature of the body as measured by it is 59^0. Find the correct temperature of the body on celsius scale? (60^0)

2. A solid is heated at constant rate. The variation of temperature with heat input is shown in figure below.
(i) What is represented by AB and CD ?
(ii) What conclusion would you draw if CD = 2 AB ?
(iii) What is represented by the slope of DE ?



iv) What conclusion would you draw from the fact that the slope of OA > Slope of BC?

3 A circular hole of radius 1 cm is drilled in brass sheet at 293 K. What will be the diametric of this hole when sheet is heated to 393 K ($\propto$ for brass = 18 x 10^{-6} K^{-1}). (2.0036 Cm)

4 (i) Why two layers of cloth of equal thickness provide warmer covering than a single layer of cloth of double the thickness?
(ii) Animals curl into a ball when it is very cold.
iii) What kind of thermal conductivity and specific heat requirement would you specify for a) Cooking utensils b) Thermometric substances
iv) Imagine a fire ball suspended in air, would you experience more heat above the ball or below the ball?

5 The opposite faces of a cubical block of iron of cross sectional area 4 cm^2 are kept in contact with steam and melting ice. Calculate quantity of ice melted at the end of 10 min. K for iron = 0.2 cgs unit, latent heat of fusion of ice = 80

cal/g

6 How does the anomalous expansion of water at 4 degree Celsius help marine life to survive in cold places?

7 Define regelation. Mention any one application of it.

8 Two rods one semicircular and the other straight , of the same material and same area of cross section are joined to form a D shape . The joints are maintained at a constant temp. difference. Calculate the ratio of the heat conducted through a cross section of the semicircular rod to the heat conducted through a cross section of the straight rod in a given time.

9. Derive the relation between ἀ, β and y.

10. Define coefficient of linear expansion. Write an expression for it. Give its units.

PRACTICE QUESTIONS :

1. A body cools from 80 ^{0}C to 50 ^{0}C in 5minutes. Calculate the time it take to cool from 60 ^{0}C to 30 ^{0}C. The temperature of surrounding is 20 ^{0}C. 9min.
2. Why do overhead telephone wires sag during summer?
3. Why is hot water bottle use7d for hot fomentation?
4. How is melting point affected by change in pressure?
5. Why is cooking difficult on hills?
6. What is the value of latent heat of steam?
7. On what factors does the heat given to a substance depend in order to raise its temperature? Hence define specific capacity of a substance?
8. What do you mean by molar specific heat of a substance? Write its SI unit?
9. Water is a very efficient coolant. Why?
10. Define relegation phenomenon. Mention any one application of it.
11. Two rods equal length and equal cross sectional area are soldered end to end. The free ends of the rods are maintained at temp t1 and t2 respectively. Obtain an expression for i) heat current ii) the equivalent thermal conductivity of the compound bar. $\underline{2K_1K_2}/(K_1+K_2)$
12. On heating a glass block of 10,000 cm^3 from 25° C to 40 ° C, its volume increases by 4 cm^3. Calculate coefficient of linear expansion of glass.
13. When 10g of coal is burnt, it rises the temperature of 2 litres of water from 20° C to 55 ° C. Calculate the heat of combustion of fuel.

14 Why are loops provided in long metal pipes used for carrying oil and any other liquid over long distances?

15 Woolen clothes are worn in winters. Why?

16 What are CGS and SI units of heat? How are they related to one another.

17 What is meant by thermal expansion of a body? What are the different types of thermal expansions?

Competition Kit

M.C.Q

1 According to kinetic theory of gases, at absolute zero of temperature
(a) water freezes (b) liquid helium freezes (c) molecular motion stops
(d) liquid hydrogen freezes

2 Mercury thermometer can be used to measure temperature up to
(a) 260°C (b) 100°C (c) 360°C (d) 500°C

3 Which of the statement is true about the radiation emitted by human body
(a) The radiation emitted lies in the ultraviolet region and hence is not visible
(b) The radiation is emitted during the summers and absorbed during winters
(c) The radiation is emitted only during the day.
(d) The radiation emitted is in the infrared region.

4. Two containers A and B are partly filled with water and closed. The volume of A is twice that of B and it contains half the amount of water in B. If both are at the same temperature, the water vapour in the containers will have pressure in the ratio of
(a) 1 :2 (b) 1: 1 (c) 2 : 1 (d) 4 : 1

5. At which temperature, the centigrade and Fahrenheit scales are equal?
(a) 40°C (b) - 40°C (c) -i37°C (d) -80°C

6. When a body is heated, then maximum rise will be in its
(a) length (b) surface area (c) Volume (d) density

7 Amount of heat required to raise the temperature of a body through 1K is called its
(a) specific heat (b) Thermal capacity (c) water equivalent (d) entropy

8 Mud houses are cooler in summer and warmer in winter
(a) Mud is good conductor of heat (b) Mud is supper conductor of heat
(c) mud is bad conductor of heat (d) none of these

9 A perfectly black body is one whose
(a) absorptive power is 1 (b) absorptive power is 0
(c) emissive power is 1 (d) absorptive power is 0.5

10 The emissive power of black body is proportional (T= absolute temperature)
(a) E ἀ T^{0} (b) E ἀ T^{2} (c) E ἀ T^{4} (d) E ἀ T^{-2}

CHAPTER NO. 12

THERMODYNAMICS

GLIMPSES

1 **Thermodynamics:** It is the branch of science that deals with the concepts of heat and temperature and the inter-conversion of heat and other forms of energy.

2 **Thermodynamic system:** An assembly of a very large number of particles having a certain value of pressure, volume and temperature is called a thermodynamic system.

3 **Surroundings:** Everything outside the system which can have a direct effect on the system is called its surroundings.

4 **Thermodynamic variables**: The quantities like pressure (P) , volume (V) and temperature (T) which help us to study the behaviour of a thermodynamic system are called thermodynamic variables.

5 **Equation of state**: The mathematical relation between the pressure, volume and temperature of a thermodynamic system is called its equation of state. For example, the equation of state of n moles of an ideal gas can be written as

$$PV = nRT$$

6 **Thermal equilibrium:** Two systems are in thermal equilibrium with each other if they have the same temperature.

7 **Thermodynamic equilibrium:** A system is said to be in the state of thermodynamic equilibrium, if the microscopic variables of the describing the thermodynamic state of the system do not change with time. A system in a state of thermodynamic equilibrium possess mechanical, thermal and chemical equilibria simultaneously.

8 **State variables**: The macroscopic quantities which are used to describe the equilibrium states of a thermodynamic system are called state variables. The value of a state variable depends only on the particular state, not on the path used to attain that state. Pressure (P) volume (V) and temperature (T) and mass (m) are the state variables. Heat (Q) and work (w) are not state variables.
each other. According to this law, temperature is a physical quantity which has the same value for all systems which are in thermal equilibrium with each other.

10 **Internal energy**: The internal energy of a system is the sum of the molecular kinetic and potential energies in the frame of reference relative to which the centre of mass of the system is at rest. It does not include the over-all kinetic energy of the system. It is a state variable denoted by U.

11 **Quasi-static process**: A quasi –static process is an infinitely slow process such that system remains in thermal and mechanical equilibrium with the surroundings throughout. In such a process the pressure and temperature of the surroundings can differ from those of the system only infinitesimally.

12 **Isothermal process**: A process in which temperature remains constant is called an isothermal process. For such a process

$$PV = \text{constant}$$

13 **Adiabatic process:** A process in which thermally insulated system neither loses nor gains heat from the surroundings is called adiabatic process.

$$PV^{\gamma} = \text{constant}$$

Thermodynamics

Thermodynamics : Thermodynamics is the branch of science that deals with the concepts of heat and temperature and the inter-conversion of heat and other forms of energy. It mainly deals with transformation of heat into mechanical work and vice versa.

Thermal Equilibrium : Two systems are said to be in the thermal equilibrium with each other if they have the same temperature.

Zeroth law of thermodynamics: It states that if two systems A and B are separately in thermal equilibrium with a third system C, the A and B are also in thermal equilibrium with each other.

Difference between heat and work :

(i) Heat is a mode of energy transfer due to temperature difference between the system and the surroundings. Work is the mode of energy transfer brought about by means that do not involve temperature difference such as moving the piston of a cylinder containing the gas, by raising or lowering the weight connected to it.

(ii) When heat is supplied to a gas, its molecules move faster in all directions at random. So heat is a mode of energy transfer that produces random motion, when a piston compresses a gas to do work on it, it forces the molecules to move in the direction of piston's motion. So work may be regarded as the mode of energy transfer that produces organised motion.

Sign conventions used:

(i) Heat absorbed by a system is **positive**. Heat given out by system is **negative**.

(ii) Work done by a system is **positive**. Work done on a system is **negative**.

(iii)The increase in internal energy of a system is **positive**. The decrease in internal energy of a system is **negative**.

First law of thermodynamics:

According to first law of thermodynamics, if some heat is supplied to a system which is capable of doing work, then the quantity of heat absorbed by a system will be equal to the sum of the increase in its internal energy and the external work done by the system on the surroundings.

Let

ΔQ= Heat supplied to the system by the surroundings.

ΔW= Work done by the system on the surroundings.

$\Delta\mu$= Change in internal energy of the system.

Then according to the first law of thermodynamics,

$\Delta Q = \Delta W + \Delta \mu$

Specific heat of a gas : When a gas is heated, its volume and pressure change with the increase in temperature. So the amount of heat required to raise the temperature of 1 gram of gas through 1^0 C is not fixed. That is a gas does not possess a unique or single specific heat. A gas can have any value of specific heat depending on the conditions under which it is heated.

Two principal specific heats of a gas. Out of the many specific heats of a gas, two are of a special significance: one when the gas is heated at constant volume and another when the gas is heated a constant pressure. These are known as the two principal specific heats of a gas and may be defined as follows :

(i) **Molar specific heat at a constant volume** : It is defined as the amount of heat required to raise the temperature of 1 mode of gas through 1^0 C at constant volume. It is denoted as C_v
(ii) **Molar specific heat at a constant pressure**: It is defined as the amount of heat required to raise the temperature of 1 mode of gas through 1^0 C at constant pressure. It is denoted as C_P

Thermodynamic Process: A thermodynamic process is said to occur if the thermodynamic variables of a system undergo a change with time.

Different types of Thermodynamic process are as follows :

(i) **Isothermal process** : It is a thermodynamic process which occurs at a constant temperature.
(ii) **Isobaric process** : It is a thermodynamic process which occurs at a constant pressure.
(iii) **Isochoric process** : It is a thermodynamic process which occurs at a constant volume.
(iv) **Adiabatic process** : It is a thermodynamic process in which there is no exchange of heat between the system and surroundings.

Heat engine : It is a device which converts continuously heat energy into mechanical energy in a cylic process.

As shown in the fig, a heat energy has the following essential parts :

(i) **Source**: It is heat reservoir at higher temperature T_1 It is supposed to have infinite thermal capacity so that any amount of heat can be drawn from it without changing the temperature.

Hot reservoir
I
I Q_1= Heat absorbed from the source
I
Heat Engine
I Work done $W=Q_1-Q_2$
I Two wheels of Vehicle
I Q_2= Heat rejected to sink
I
Cold reservoir or Sink

(ii) **Sink** : It is heat reservoir at a lower temperature T_2. It has also infinite thermal capacity so that any amount of heat can be added to it without changing its temperature.

(iii)**Working substance**: Working substance is any material (solid, liquid or gas) which performs mechanical work when heat is supplied to it.

For example, a mixture of fuel vapour and air is used in a gasoline or a diesel engine or steam in a steam engine.

Working: In every cycle of operation, the working substance absorbs a definite amount of heat Q_1 from the source of higher temperature T_1, converts a part of this heat energy into mechanical work W and rejects the remaining heat Q_2 to sink at lower temperature T_2. The work done W in a cycle is transferred to the environment by some arrangement e.g, the working substance maybe in a cylinder with a moving piston that transfers mechanical energy to the wheels of a vehicle via a shaft.

Efficiency of heat engine: The efficiency of a heat engine is defined as the ratio of the net work done by the engine in one cycle to the amount of heat absorbed by the working substance from the source.

As the working substance returns to its initial state after completing one cycle, there is no change in its internal energy. Hence by first law of thermodynamics, net heat absorbed in a cycle = work done

i.e $Q_1-Q_2= W$

The efficiency of heat engine is given by

$$\eta= \frac{\text{Work done by engine (Output)}}{\text{Heat absorbed from the source (input)}}$$

$$= \frac{W}{Q_1} = \frac{Q_1- Q_2}{Q_1}$$ Hence $\eta= 1-Q_2/Q_1$

Efficiency of a heat engine is always less than unity. Clearly, when $Q_2= 0$, $\eta= 1$ or 100%.

Second law of thermodynamics: It can be stated in a number of ways as follows :

(i) **Kelvin-Planck statement**: It is impossible to construct an engine, which can produce effect other than extracting heat from a reservoir and performing an equivalent amount of work.

This is applicable to a heat engine. It indicates that a working substance, operating in a cycle, cannot convert all the heat extracted from the source into mechanical work. It must reject some heat to the sink at a lower temperature.

(ii) **Clausius Statement**: It is impossible for a self-acting machine, unaided by any external agency, to transfer heat from a body to another at higher temperature.

This is applicable to a refrigerator. The working substance can absorb heat from a cold body only if work is done on it. The work is done by an electric compressor. If no external work is done, the refrigerator will not work.

Significance of second law: The second law of thermodynamics puts a fundamental limit to the efficiency of a heat engine and the coefficient of performance of a refrigerator.

(i) According to second law, the efficiency of a heat engine can never be unity. This in turns, implies that the heat released to the cold reservoir can never be made zero.

(ii) According to second law, the coefficient of performance of refrigerator can never be infinite. This implies that the external work (W) can never be zero.

Limitations of the second law of thermodynamics:

(i) The second law of thermodynamics cannot be proved directly. But its validity has not been contradicted by any machine designed so far.

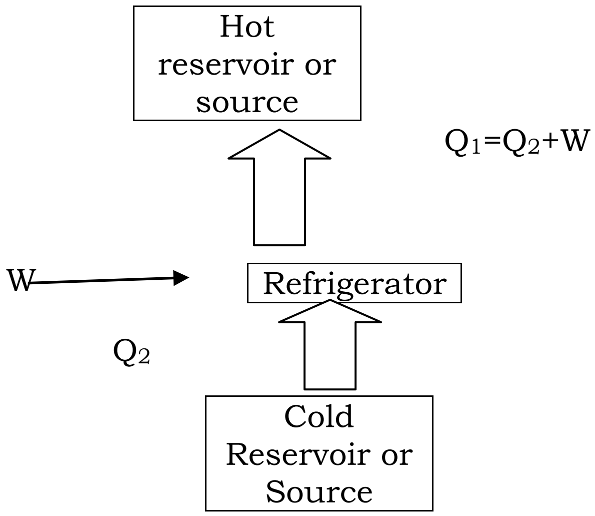
(ii) It is applicable to a cyclic process in which the system returns to its original state after a complete cycle of changes.

(iii) It makes no predictions as to what will happen under certain conditions but simply states what will happen under a given set of conditions.

Refrigerator:

A refrigerator is a carnot's heat engine working in the reverse direction.

In a refrigerator, the working substance absorbs an amount of heat Q_2 from the cold reservoir at temperature T_2. An amount of work W is done on it by some external agency (a compressor pump driven by an electric motor) and rejects a larger quantity of heat Q_1 to the source at temperature T_1 as shown in the fig.



In domestic refrigerators, food and ice constitute the cold reservoir and the surroundings act as hot reservoir. Work is done by an electric motor and Freon (CCI_2F_2) is used as working substance.

The working substance is carried through a cycle of the following steps:

(i) The gas is allowed to expand suddenly (adiabatically) from high to low pressure. This cools it and converts it into a vapour-liquid mixture.

(ii) The cold fluid is allowed to absorb heat Q_2 isothermally from cold reservoir. This converts the mixture into vapour.

(iii) Then the vapour is adiabatically compressed till it heat up to the temperature of the surroundings.

(iv) Finally the vapour is compressed isothermally in contact with the surroundings. The vapour releases heat Q_1 ($=Q_1+W$) to the surroundings and returns to the initial state. Here W is the work done on the gas per cycle.

ASSIGNMENT

1 Can the specific heat of gas be zero or negative?

2 What is the total work done in cyclic process .

3 An electric heater supplies heat to a system at a rate of 100 W. If system performs work at a rate of 75 joules per second. At what rate is the internal energy increasing?

4 State First Law of Thermodynamics mathematically

5 On which basic principle of physics is First Law of Thermodynamics based?

6 Define two principal specific heats of a gas. How are they related to?

7 What happens to the internal energy of an ideal gas during (i) isothermal expansion, and (ii) adiabatic expansion?

8 A monatomic ideal gas (γ = 5/3) initially at 17 °C is suddenly compressed to one -eight of its original volume. Find the final temperature after compression.

9 A Carnot's engine has the same efficiency (a) between 500 K and 100 K, and (b) between 900 K and T K. Final the value of T.

10 At 27 °C two moles of an ideal monatomic gas (γ = 5/3) Occupy a volume V. The gas expands adiabatically to a volume 2V. Calculate

(a) final temperature of the gas
(b) the work done by the gas during the expansion process, and
(c) Change in internal energy of gas. Take R = 8.31 J mol^{--1} K^{-1}

11 (i) Why a gas has two principal specific heat capacities?
(ii) Which one is greater and why?
(iii) Of what significance is the difference between these two specific heat capacities and their ratio?

12 What is an isothermal process? Derive a relation for work done during an isothermal process.

13 Draw a neat P-V diagram showing cycle of operations for an ideal heat engine. Also list the four stages of operations in proper order.

14 Explain briefly the working principle of a refrigerator and obtain an expression for its coefficient of performance.

15 One mole of an ideal gas requires 207 J heat to raise the temperature by 10 K when heated at constant pressure. Find the amount of heat required to heat the same gas to raise the temperature by same 10 K under constant volume conditions. Given R = 8.3 J mol^{-1} K^{-1}

Practice Question

1 Distinguish clearly between heat and internal energy of a system

2 Is the coefficient of performance of a refrigerator a constant quantity?

3 Mention two essential characteristics of an ideal heat engine.

4 Name the process in which no heat is transferred to or from a system but the temperature of the system changes

5 Heat is being supplied to a system but the system does not perform any external work. Is it possible? If yes, how?

6 An ideal gas is compressed at a constant pressure of 5000Pa from a volume of $10m^3$ to a volume of $4m^3$. Energy of 12000J is then added to the gas by heating. Find the change in internal energy of the gas.

7 What do you mean by a reversible process? State basic conditions required for a process to be reversible.

8 State whether the following processes are reversible or irreversible :

I. Rusting of iron during rainy season
   a. Melting of ice
   b. Infinitesimally slow
   c. expansion of an ideal gas contained in a cylinder with a frictionless piston.
   d. Flow of electric current through a resistance wire.
   e. Diffusion of gas.

9 Briefly explain what do you mean by thermal efficiency of a heat engine.

10 Applying the first law of thermodynamics, obtain the relation between the two specific heats of a gas.

11 What do you understand by reversible and irreversible processes? Give examples. What are the necessary conditions for a process to be reversible?

12 Heat equivalent to 50J is supplied to a thermodynamics system and 10J work is done on the system. What is the change in the internal energy of the system in the process?

13 Explain why the internal energy of a compressed gas is less than that of a rarefied gas at the same temperature?

14 Refrigerator A works between -10^0c and $27\ ^0c$, while refrigerator B works between $-27\ ^0C$ and $17\ ^0C$, both removing heat equal to 2000J from the freezer. Which of the two the better refrigerator?

15 Assuming that a domestic refrigerator can be regarded as a reversible engine working between the temperature of melting ice and that of the atmosphere of ($17\ ^0C$), calculate the energy which must be supplied to freeze one kilogram of already at 0^0C.

16 Explain the working principle of heat engine. Define its efficiency. Describe an analytical method for determining the work done during the expansion of gas.

17 Derive an expression for the work done during the adiabatic expansion of an ideal gas.

18 State the limitation of the first law of thermodynamics?

19 A carnot engine takes $3x10^6$cal of heat from a reservoir at 627°C and gives it to a sink at 27°C. Find the work done by the engine.

COMPETITION KIT

M.C.Q

1 In a given process of an ideal gas, dW=0 and dQ< 0. Then for the gas
(a) the temperature ill decrease (b) the volume will increase
(c) the pressure will remain constant
(d) the temperature will increase

2 First law of thermodynamics corresponds to
(a) conservation of energy
(b) heat flow from hotter to cooler body
(c) law of conservation of angular momentum
Newton's law of cooling

3 Which one of the following is not a state function?
(a) Temperature (b) entropy
(c) pressure (d) work

4 Which one is correct?
(a) In an isobaric process $\Delta P=0$
(b) In an isochoric process $\Delta W=0$
(c) In an isothermal process $\Delta T=0$
(d) In an isothermal process $\Delta Q=0$

5 Which is an intensive property?
(a) volume (b) mass (c) refrective index (d) weight

6 In an adiabatic system which is true?
(a) $P^y T^y -1$ = constant (b) $P^y T^{1-y}$ = constant
(c) PT^y = constant (d) $P^{1-y} T^y$ = constant

7 The volume of gas expands by 0.25 m^3 at a constant pressure of 10^3 $Nm^{-`1}$. The work done is equal to
(a) 2.5 erg (b) 250J (c) 250W (d) 250N

8 A perfect gas is contained in a cylinder kept in vacuum. If the cylinder suddenly bursts, then the temperature of the gas
(a) becomes Zero K (b) is decreased
(d) is increased (d) remains unchanged

9 An ideal heat engine operates in carnot cycle between 227°C and 127°C. It absorbs 6KJ of heat at the higher temperature.The amount of heat converted into work is
(a) 1.2 kJ (b) 1.6 kJ
(c) 3.5 kJ (d) 4.8 kJ

10 During adiabatic compression of a gas, its temperature
(a) falls (b) remains constant
(c)rises (d) becomes zero

Chapter -13

Kinetic Theory of Gases

Glimpses

1 **Boyle's law**: It states that at constant temperature, the volume of a given mass of a gas is inversely proportional to its pressure.
PV = constant
Or $P_1V_1 = P_2V_2$

2 **Charle's law**: It states that if the pressure remains constant, then the volume of a given mass of a gas increases or decreases by 1/273.15 of its volume at 0°C for each 1°C rise or fall of temperature.

Mathematically, V/T = constant

So Charle's law can also be stated as follows:
At constant pressure, the volume of a given mass of a gas is directly proportional to its absolute temperature.

3 **GayLussac' law**: It states that if the volume remains constant, then the pressure of the given mass of a gas increases or decreases by 1/273.15 of its pressure at 0°C for each 1°C rise or fall of temperature.

Mathematically, P/T = constant

So, Gay Lussac's can also be stated as follows:
At constant volume, the pressure of a given mass of a gas is directly proportional to its absolute temperature.

4 **Ideal gas equation**¨ For n moles of a gas
PV =nRT
For 1 mole of a gas, PV = RT

5 **Universal gas constant**: It signifies the work done by the gas per mole per kelvin
R = 8.31 J/mol/K

6 **Boltzman's constant**: It is the gas constant per molecule of a gas. If N is Avogadro's number, then
$k_B = R/N = 1.38 \times 10^{-23}$ J/molecule/K

7 Ideal or perfect gas: A gas which obeys gas laws strictly is an ideal or perfect gas. The molecules of such a gas are of point size and there is no force of attraction between them.The actual real gases

obey the ideal gas equation only approximately at low pressures and high temperatures.

8 **Assumptions of kinetic theory of gases:**

(i) All gases consist of molecules. The molecules are rigid, elastic spheres identical in all respects for a given gas and different for different gases.
(ii) The size of a molecule is negligible compared with the average distance between two molecules.
(iii) The molecules are in a state of continuous random motion, moving in all directions with all possible possibilities.
(iv) During the random motion, the molecules collide with one another and with the walls of the vessel.
(v) The collisions are perfectly elastic and there are no forces of attraction r repulsion between them
(vi) Between two collisions, a molecule moves in a straight path with a uniform velocity
(vii) The collisions are almost instantaneous.
(viii) The molecular density remains uniform through out the gas.

9 **Pressure exerted by gas**: According to kinetic theory of gases, the pressure exerted by a gas of mass M and volume V or density p is given by

$$P = (1/3)\ M\ v^2 /V$$

Here n is the number of molecules per unit volume, m the mass of each molecule and v^2 is the mean of square speed.

10 **Average K.E. of a gas:** Let Mbe the molecular mass and V the molar volume of a gas. Let m be the mass of each molecule. Then

(i) Mean K.E. per mole of a gas,
$E = (3/2)PV = (3/2)RT = (3/2)k_B N_A T$
(ii) Mean K.E. per molecule of a gas:
$E = (3/2)k_B\ T$

11 **Avogadro's law:** It states that equal volume of all gases under similar conditions of temperature and pressure contains equal number of molecules.

12 **Avogadro's number**: It is the number of particles present in one mole f a substance. Its most accepted value is

$$N_A = 6.0225 \text{ X } 10^{23} \text{ mole}^{-1}$$

13 **Grahom's law of diffusion:** It states that the rate of diffusion of a gas is inversely proportional to the square root of its density.

$r\ \alpha\ \rho^{-1/2}$

14 **Average speed**: It is defined as the arithmetic mean of the speeds of the molecules of a gas at a given temperature:

$\sqrt{\frac{8kT}{m}}$

15 **Root men square speed**: It is defined as the root of the mean of the squares of the speeds of the individual molecules of a gas

$\sqrt{\frac{8kT}{m}}$

16 **Degrees of freedom**: The degrees of a freedom of a dynamical system are defined as the total number of coordinates or independent quantities required to describe completely the position and configuration of the system

If N = number of particle in the system

K = number of independent relations between the particles.

Then the number of degrees of freedom of the system is

$$f = 2N-k$$

A monoatomic gas has 3 degrees of freedom, a diatomic gas molecule has 5 degrees of freedom. At high temperature, a diatomic molecule has 7 degrees of freedom.

17 **Law of equipartition of energy**: It states that in any dynamical system in thermal equilibrium, the energy of the system is equally divided amongst its various degrees of freedom and the energy associated with each degree of freedom is $(1/2)k_B$ T, where k_B is Boltzmann's constant and T is the absolute temperature of the system.

Kinetic Theory

ASSIGNMENT

1 State Boyle's law. Plot P-V, and P vs. 1/V graphs for a gas obeying Boyle's law.

2 Keeping temperature constant, pressure of a gas is doubled. What is the effect on volume of gas? What is the effect on the density of gas?

3 Two different gases have exactly the same temperature. Does it imply that their molecules have the same rms speed?

4 On the basis of kinetic theory, explain why the pressure of a gas is increased when its volume is compressed?

5 On the basis of kinetic theory, obtain a definition of absolute zero temperature?

6 Molecules of which gas will possess higher rms speed, hydrogen or helium? Give reason too.

7 If the number of molecules in a gas container is doubled, what will be the new (1) pressure of gas, (ii) rms speed of the gas molecules, and (iii) value of total energy of the gas? Assume the gas to be an ideal gas.

8 What is the kinetic interpretation of temperature? Briefly explain the kinetic interpretation of temperature.

9 An electric bulb of volume 250 cm^3 was sealed off during manufacture at a pressure of 10^{-3} mm of mercury at 27 °C. Compute the number of air molecules contained in the bulb. Given that R = 8.31 J mol^{-1} $K^{-1}$and Na = 6.02 x 10^{23}mol -1 (Take g = 10m s^{-2})

10 State the main postulates of kinetic theory of gases.

11 Obtain an expression for the pressure exerted by a gas on the basis of kinetic theory.

12 Calculate the temperature at which the rms speed of CO_2 gas molecule will be equal to 1 km s-1. Given that molecular mass of CO_2 = 44 u.

13 State and derive the perfect or ideal gas equation.

14 Define universal gas constant. Determine its values in SI unit and CGS unit

15 What is Bolzman constant? What is its value?

PRACTICE QUESTIONS

1 State the assumptions on which kinetic theory of gas is based.

2 On the basis of kinetic theory, derive an expression for the pressure exerted by an ideal gas.

3 Show that the pressure exerted by a gas is two-thirds of the average kinetic energy per unit volume of the gas molecules.

4 Calculate the kinetic energy of one mole of argon at 127°C.Given Boltzmann's constant k=1.38 x 10^{-23}Jmol^{-1}k^{-1}

5 Define average, root mean square and most probable speeds. Express these in terms of temperature of the gas.

6 Calculate the temperature at which r.m.s. velocity of the gas molecule is double its value at 27^0 C, pressure of the gas remaining the same

7 Calculate the kinetic energy per molecule and also r.m.s. velocity of a gas at 127°C. Given K_B= 1.38 x 10^{-23}J molecule^{-1} K^{-1} and mass per molecule of the gas =6.4 x 10^{-27} .

8 Derive Boyle's law, Charles law and perfect gas equation on the basis of kinetic theory of gases.

9 When a gas is heated, its temperature increases. Explain it on the basis of kinetic theory of gases.

10 A sample of an ideal gas occupies a volume V at a pressure P and absolute temperature. The mass of each molecule is m. If k_B is the Boltzmann's constant, then writes the expression for the density of the gas.

11 Two gases, each at temperature T volume V and pressure P are mixes such that The temperature and volume of the mixture are T and V respectively. What would be the pressure of the mixture? Justify your answer on the basis of kinetic theory.

COMPETION KIT

M.C.Q.

1 An absolute zero is the temperature at which
(a) Water solidifies (b) all gases become liquid
(c) rms velocity become zero (d) none of the above

2 The degree of freedom in case of an monoatomic gas is
(a) 1 (b) 3 (c) 5 (d) none of these.

3 Two gases are at absolute temperature 300 K and 350 K respectively. Ratio of average Kinetic energy of their molecules is
(a) 7: 6 (b) 6: 7 (c) 36 : 49 (d) 49 : 36

4 The mean kinetic energy of one mole of gas per degree of freedom on the basis of kinetic theory of gases) is
(a) ½ kT (b) 3/2 kT (c) 3/2RT (d) ½ RT

5 A gas behaves as an ideal gas at
(a) low pressure and high temperature
(b) low pressure and low temperature
(c) high pressure and low temperature
(d) high pressure and high temperature

6 The temperature of a gas is held constant, while the volume is decreased.
The pressure exerted by the gas on the walls of the container increases, because its molecules
(a) strike the walls with higher velocities
(b) strike the walls with large force
(c) Strike the wall more frequently
(d) Are in contact with the walls for a shorter time.

7 v_{rms} ,v_{av} and v_{mp} are root mean square, average and most probable speed of molecules of a gas obeying Maxwellian velocity distribution. Which of the following statements is correct.
(a) $v_{rms} < v_{av} < v_{mp}$ (b) v_{rms} , $> v_{av} > v_{mp}$ (c) v_{mp} , $< v_{rms} < v_{av}$ (d) v_{mp} ,$> v_{rms} > v_{av}$.

8 The root mean square velocity of a gas molecule of mass 'm' at a given temperature is proportional to
(a) m^0 (b) m (c) $\sqrt{m}$ (d) $m^{-1/2}$

9 Gas exerts pressure on the walls of the container because
(a) gas has weight (b) gas molecules have momentum
(c) gas molecules collide with each other (d) gas molecules collides with the walls of the container

10 At 0 K what happens
(a) efficiency of engines becomes infinite

(b) all liquid freezes
(c) molecular motion ceases
(d) none of these

11 Two gases of equal masses are in thermal equilibrium. If P_a, P_b, and $V_a$and V_b are their respective pressure and volumes, then which relation is true.
(a) $2 P_aV_a = P_b V_b$ (b) $P_a \neq P_b$, $V_a = V_b$ (c) $P_a/V_a = P_b/V_b$
(d) $P_aV_a = P_bV_b$

12 The r.m.s. velocity at a temperature is 2 times the r.m.s. velocity at 300K. What is the temperature.
(a) 900K (b) 2400 K (c) 600K (d) 1200 K

Chapter No: 14

Chapter Name: OSCILLATION

Glimpses

1. Periodic motion**:** A motion which repeats itself over and over **again** after a regular interval of time is called a periodic motion.

2. Oscillatory motion: A motion in which a body moves back and forth repeatedly about a fixed point (called mean position) is called oscillatory or vibratory motion.

3. Periodic motion: Any function that repeats its value at regular intervals of its argument is called a periodic function.

   The periodic functions which can be represented by a sine or cosine curve are called harmonic functions. All harmonic functions are necessarily periodic but all periodic functions are not harmonic.

   The periodic functions which cannot be represented by single sine or cosine function are called non-harmonic functions.

5. Simple harmonics motion: A particle is said to be execute simple harmonic motion if it moves to and fro about a mean position under the action of a restoring force which is directly proportional to its displacements from the mean position and is always directed towards the mean position

6. Oscillation or cycle: One complete back and forth motion of a particle is called cycle or vibration or oscillation.

7. Displacement: It is the distance of the oscillating particle from the mean position at any instant. It is denoted by x.

8. Amplitude (A): The maximum displacement of the oscillating particle on either side of its man position is called its amplitude.

9. Time period: It is the time taken by a particle to complete one oscillation about its mean position. It is denoted by T.

10. Frequency: It is the number of oscillations completed per second by a particle about its mean position. It is denoted by v and is equal to the reciprocal of tome period.

    Frequency is measured by in hertz(Hz).

12. Phase: The phase of vibrating particle ay any instant gives the state of the particle as regards its position and the direction of the motion at that instant.

13. Initial phase or epoch: The phase of a vibrating particle corresponding to time t = O is called initial phase or epoch.

14. Phase difference: The phase difference between two vibrating particles tells the lack of harmony in the vibrating states of the two particles at any instant.

15. Relation between SHM and uniform circular motion: Simple harmonic motion is the projection of uniform circular motion upon a diameter of a circle. This circle is called the reference circle and the particles which revolves along it is called reference particle or generating particle.

25. Simple pendulum: A simple pendulum is a heavy point mass suspended by a

    Weightless, inextensible and a perfectly flexible string from a rigid support about which it can vibrate freely. The distance between the point of suspension and the point of oscillation is called length of the pendulum

26. Second's pendulum: A second's pendulum is a pendulum whose time period is two seconds. Its length is 99.3 cm.

28. Motion of a body dropped in a tunnel dug along the diameter of earth: When a body is dropped in a tunnel dug along the diameter of the earth, it executes SHM.

29. Motion of a body floating in a liquid: When a body made of material of density p and total vertical length L floats in a liquid of density p, such that its length h is submerged in the liquid, its execute SHM on being pushed into the liquid

30. Free oscillations: If a body, capable of oscillation, is slightly displaced from its position of equilibrium and then released, its starts oscillating with a frequency of its own. Such oscillations are called free oscillations. The frequency with which a body oscillates is called natural frequency

31. Damped oscillations: The oscillations in which amplitude decreases gradually with the passage of time are called damped oscillations.

32. Forced oscillations: When a body oscillates under the influence of an external periodic force, not with its own natural frequency but the frequency of the external periodic force, its oscillations are said to be forced oscillations.

33. Resonant oscillations: It is a particular case of forced oscillations in which the frequency of the driving force is equal to the natural frequency of the oscillator itself and the amplitude of oscillations is greatest. Such oscillations are called resonant oscillations and phenomenon is called resonance.

34. Coupled oscillations: A system of two or more oscillators linked together in such a way that there is mutual exchange of energy between them is coupled oscillator. The oscillators of such a system are called coupled oscillations.

Assignment

1. A spring having a force constant K is divided into three equal parts. What would be the force constant for each individual part?

2. The equation of a transverse travelling wave is given by

   $y = 0 \cdot 05 sin2\pi(0 \cdot 4x - 5t)$. Where, x and y are in meters and t in seconds.

   Calculate (i) amplitude (ii) wavelength, (iii) angular wave number, (iv) frequency and (v) time period of the wave. Also find the displacement of the wave at x=50m and at t= 0.2s

3. A simple pendulum is suspended with the roof of a lift. What happens to its time period if (i) lift accelerates upward with an acceleration 'a' (ii) lift accelerates downward with 'a' (iii) lift moves downward or upward with constant velocity (iv) if the cables of the lift are cut and it begins to fall freely

4. In a laboratory experiment with simple pendulum it was found that it took 36s to complete 20 oscillations when the effective length was kept at 80cm. calculate the acceleration due gravity from these data.

5. A particle of mass 0.50kg executes a simple harmonic motion under a force $F = -(50N/m)\, x$. If it crosses the centre of oscillation with a speed of 10m/s^2, find the amplitude of the motion.

6. Show that the motion of simple pendulum is SHM. And hence find its time period.
   The length of a simple pendulum is increased by 21%. Find the percentage increase in the time period of the pendulum.

7. What is the ratio between potential energy and the total energy of a particle executing S.H.M, when its displacement is half of its amplitude?

8. A particle of mass 40g executes a simple harmonic motion of amplitude 2.0cm. If the time period is 0.20s, find the total mechanical energy of the system.

9. Show that for an object executing S.H.M, total energy remains conserved.

10 A girl swinging suddenly stands upon the swing. What is the influence on the time period and frequency?

11. Show graphically, the variation of kinetic energy, potential energy and the total energy with displacement of a particle executing simple harmonic motion. Also draw x-t, v-t and a-t graphs for a body executing SHM

12. At what positions, the tension in the string of a simple pendulum is (i) maximum and (ii) minimum?
13. Marching troops are asked to break their steps while crossing the bridge. Why?
14. The bob of a simple pendulum is a hollow sphere filled with water. How will the period of oscillation change if the water begins to drain out of the hollow sphere?
15. A body executing SHM has a maximum acceleration equal to 32m/s2 and maximum velocity equal to 16m/s. Find the amplitude of SHM.

Practice questions

Short answer questions

1. Show that the liquid in the limb of U tube moves in S.H.M.
2. Will a pendulum Clock gain or loose time when taken to the top of a mountain?
3. Can we use a simple pendulum watch in an artificial satellite?
4. A particle at the end of a spring executes simple harmonic with a period t_1, while the corresponding period for another spring is t_2 . What is the period of oscillation when the two springs are connected in series?
5. Derive an expression for the instantaneous velocity and acceleration of a particle executing SHM.
6. Two springs of force constants k_1 and k_2 are joined in series. What is the force constant of the combination?

7 In which position during a SHM is the particle acceleration (i) maximum, (ii) minimum?

8. A girl is swinging a swing in sitting position. What will be the effect on the frequency of oscillation if she stands up?

9. Draw the showing the variation of PE and KE of a simple harmonic oscillator with distance.

10 Draw the showing the variation of PE and KE of a simple harmonic oscillator with time.

11. A spring of force constant K has a mass M suspended from it. If the spring is cut into two halves, and the same mass is attached to one of pieces. What will be the new frequency of oscillation of mass?

12. The length of a second's pendulum on the surface of earth is 1m. What will be the length of a second's pendulum on the moon?

13. What are two basic characteristics of a simple pendulum?

14. Show that the liquid in the limbs of U tube moves in S.H.M. if the frictional forces are neglected.
15. What is the distance travelled by a body executing SHM in a time equal to its time period, if its amplitude 4cm.

16. Distinguish between forced and resonant oscillations. Give example of each.

17. Find the frequency and length of second's pendulum?

18. A particle executes simple harmonic motion with a frequency ν. What is the frequency which with the kinetic energy oscillate?

Long Answer questions

1. Define simple harmonic motion? Derive an expression for displacement, velocity and acceleration of a particle executing SHM.
2. Derive an expression for time period and frequency of a body executing SHM
3. Derive an expression for total energy of a particle executing SHM
4. Show that total energy of a particle execution SHM remain constant
5. Discuss the phase relation between the displacement, velocity and acceleration
6. If the earth were a homogeneous sphere, and a straight tunnel were dug along the diameter, show that a body dropped into tunnel will execute SHM and hence calculate its time period?

Numerical

1 A particle executing S.H.M. along a straight line has a velocity of $4cms^{-1}$, when at a distance of 3cm from its mean position and $3cms^{-1}$, when at a distance of 4cm from it. Find the time it takes to travel 2.5 cm from its mean position.

2. Calculate the percentage change in the time period of a simple pendulum, if the length of the pendulum be increased by 4%. 2%

3. A particle executes SHM of amplitude 30cm and time period 4s. What is the minimum time required for the particle to move from mean position to a point 15cm? (1/3)s

4. Two masses m_1 = 1.0 kg and m_2 = 0.5 kg are suspended together by a mass less spring of spring constant k as shown in figure. When masses are in equilibrium, m_1 is removed without disturbing the system. Calculate the amplitude of oscillation and angular frequency of m_2. (g=10 ms^{-2} and k= 12.5 Nm^{-1}) 0.8m,5rad/s

5. A mass M is attached to a spring oscillates with a period of 2s. If the mass is increased by 2kg, the period increases by 1s. Find the value of M? 1.6kg

6. A block is kept on a horizontal table. The table is undergoing simple harmonic motion of frequency 3Hz in a horizontal plane. The coefficient of static friction between the block and the table surface is 0.72. Find the maximum amplitude of the table at which the block does not slip on the surface. 0.02cm

7. A particle executing SHM has a maximum displacement of 4cm and its acceleration at a distance of 1cm from its mean position is $3cm/m^2$. What will be its velocity when it is at a distance of 2cm from its mean position? 6cm/s

8. A particle executes SHM of period 8seconds. After what time of its passing through the mean position will the energy be half kinetic and half potential? 1s

9. A body is executing SHM of amplitude 1m. Its velocity while passing through the mean position is 10m/s. Find its frequency? 1.59Hz

10. A long spring is stretched by 2cm. its potential energy is U. if the spring is stretched by 10cm, what will be new potential energy.

25U

11. The time period of a body executing S.H.M. is 2s. After how much interval from time t=0, will its displacement be half of its amplitude?

(1/6)s

12. A body executes 40 oscillations per minute. Its maximum speed is 36cm/s. Calculate the amplitude of oscillation.

3.82cm

13. A simple pendulum 2m length oscillates at a location where g = 9.8 m/s^{2}. How many completes oscillation will it make in 5 minutes.

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14. Find the amplitude of the simple harmonic motion obtained by combining the motions

$x1 = 2sin\omega t$

$x2 = 2\sin(\omega t + \frac{\pi}{3})$ 3.5cm

15. A block of mass 5kg executes simple harmonic motion under the restoring force of a spring. The amplitude and the time period of the motion are 0.1m and 3.14s respectively. Find the maximum force exerted by the spring on the block.

2N

Competition kit

M.C.Q

1. The instantaneous displacement of a simple harmonic oscillator is given by $y = A\cos(\omega t + \frac{\pi}{4})$, its speed will be maximum at the time
   (a) 2π/ω (b) ω/2π (c) ω/π (d) π/4ω

2. A particle of mass 5g is executing SHM with an amplitude 0.3m and time period (π/5)s. the maximum value of force acting on the particle is
   (a) 0.3 N (b) 0.5 (c) 0.15N (d) 4N

3. In a second's pendulum, mass of the bob is 30g. If it is replaced by 90g mass, its time period will be
   (a) 3s (b) 9s (c) 2s (d) 27s

4. A spring of spring constant K is cut into 4 equal parts and the parts are connected in parallel. What is the effective spring constant?
   (a) 4K ((b) 6K (c) 8K (d) 16K

5. The pendulum bob has a speed of 3m/s at its lowest position. The pendulum is 0.5m long. The speed of the bob, when the length makes an angle of 60^0 to the vertical will be
   (a) 1/3m/s (b) 1/2m/s (c) 2m/s (d) 3m/s

6. What is the ratio between the kinetic energy and the potential energy of a harmonically oscillating point for the moment t=T/12, where T is the period?
   (a) 1 :2 (b) 2:1 (c) 3:1 (d) 1: 4

7. A particle executes SHM with a frequency ν. The frequency with which its kinetic energy oscillates is
   (a) ν/2 (b) 2ν (c) ν (d) 4ν

8. A simple pendulum has a time period T_1 on the surface of earth and T_2 when taken to a height 2R above the earth's surface, where R is the radius of earth. The vale of T_1 / T_2 is
   (a) (1/3) (b)√2 (c)1/9 (d) 9

9. A particle of mass 0.1kg executes SHM under a force F= -10x. Speed of particle at mean position is 6m/s. Then amplitude of oscillation is
   (a) 0.6m (b) 0.2m (c) 0.4m (d) 0.1m

10. A simple pendulum 4m long swings with amplitude of 0.2m. What is its acceleration at the ends of its path($g=10m/s^2$):
    (a) Zero (b) $10m/s^2$ (c) $0.5m/s^2$ (d) $2.5m/s^2$

11. If the amplitude of a particle executing SHM is doubled, which of the quantities will not be changed
    (a) Total energy (b) time period (c) maximum velocity (d) maximum

acceleration

12. A tunnel has dug through the diameter of the earth and a ball is released in it. It executes a motion of time period:
    (a) 42minute (b) 1day
    (c) 1hour (d) 84.6minute

13. The velocity and acceleration of a particle executing SHM have a steady phase relationship. The acceleration leads velocity in phase by:
    (a) + π (b) +π/2 (c) -π/2 (d) -π

14. Which of the following properties makes difference between progressive and stationary waves?
    (a) Amplitude (b) frequency (c) propagation of energy
    (d) phase of wave

15. When a tuning fork vibrates, waves produced in the stem are:
    (a) Longitudinal (b) transverse
    (c) sometimes longitudinal and sometimes transverse
    (d) none of these

16. A particle executes simple harmonic motion under the restoring force provided by a spring. The time period is T. If the spring is divided in two equal parts and one part is used to continue the simple harmonic motion, the time period will
    (a)remain T (b) become 2T (c) become T/2 (d) become $T/\sqrt{2}$

17. A spring –mass system oscillates in a car. If the car accelerates on a horizontal road, the frequency of oscillation will
    (a)increase (b) decrease (c) remain same (d) becomes zero

18. A pendulum clock keeping correct time is taken to high altitudes
    (a) It will keep correct time
    (b) Its length should be increased to keep correct time
    (c) Its length should be decreased to keep correct time
    (d) It cannot keep correct time even if the length is changed.

19. A particle moves in a circular path with a uniform speed. Its motion is
    (a)periodic (b) oscillatory (c) simple harmonic (d) angular simple harmonic

1.(d) 2.(c) 3.(c)4.(c) 5. (c) 6. (c) 7. (b) 8. (a) 9. (a) 10. (c) 11. (b) 12. (d) 13. (b) 14. (c) 15. (a) 16. (d) 17. (c) 18. (d) 19. (a)

Chapter No: 15
Chapter Name: WAVES

Glimpses

1. Wave motion: It is a kind of disturbance which travels through a medium due to the repeated vibrations of the particles of the medium about their mean positions, the disturbance being handed over from one particle to the next. In a wave both information and energy propagate from one point to another but there is no motion of matter as a whole through medium.

2. Three types of waves:

   (i) Mechanical waves: The waves which requires a mechanical medium for their propagation are called mechanical waves or elastic waves. For their propagation, the medium must possess the properties of inertia and elasticity. For example, water waves, sound waves, etc.

   (ii) Electromagnetic waves: The waves which travel n in the form of oscillating electric and magnetic fields are called electromagnetic waves. Such waves do not require any material medium for their propagation. For example, visible light, radio waves, etc.

   (iii) Matter waves: The waves associated with microscopic particles, such as electrons, protons, neutrons, atoms, molecules, etc.

3. Spring-model for the propagation of a wave through an elastic medium Energy transfer takes place because of the coupling through elastic forces between neighboring oscillating parts of the medium.

4. Transverse waves: These are the waves in which particles of the medium vibrate about their mean positions in a direction perpendicular to the direction of propagation of the disturbance. These waves can propagate in those media which have a shear modulus of elasticity e.g., solids.

5. Longitudinal waves: These are the waves in which particles of the medium vibrate about their mean positions along the direction of propagation of the disturbance. These waves can propagate in those media having a bulk modulus of elasticity and are therefore possible in all media : solids, liquids and gasses.

6. Progressive wave: A wave that moves from one point of medium to another is called a progressive wave.

7. Amplitude (A): It is the maximum displacement suffered by the particles of the medium from the mean position during the propagation of a wave.

8. Time period (T): It is the time in which a particle of the medium completes one vibration about its mean position.

9. Frequency (v): It is the number of waves produced per second in a given medium.

10. Wave length : It is the distance covered by a wave during the time a particle of the medium completes one vibration about its mean position. It is the distance between two nearest particles of the medium which are vibrating in the same phase.

12. Wave velocity (v): It is the distance travelled by a wave in one second.

13. Relation between wave velocity, frequency and wave length:

    Velocity = wavelength x frequency

14. According to Newton, when sound travels through gas, the changes taking place in the medium are isothermal in nature.

15. According to the Laplace, when sound travels in a gas the changes taking place in the medium are adiabatic.

16. Factors affecting velocity of sound through gases:

    (i) Effect of pressure: Pressure has no effect on the speed of sound in a gas ..

    (ii) density:

    (iii) temperature:

    (iv) humidity:

    (v) Effect of wind:

17. Principle of superposition of waves: When a number of waves travel through a medium simultaneously, the resultant displacement at any point of the medium is equal to the vector sum of the displacements of the individual waves.

18. Reflection of a wave: When a wave is reflected from a rigid boundary or a closed end, it is reflected back with a phase reversal or phase difference of radians but reflection at an open boundary takes place without any phase change.

19. Stationary waves: When two progressive waves of equal amplitude and frequency, traveling in opposite directions along a straight line superpose each other, the resultant wave does not travel in either direction and is called a stationary or standing wave. At some points, the particles of the medium always remains at rest. These are called nodes. At some other points, the amplitude of oscillation is maximum. These are called antinodes..

20. Modes of vibrations of strings: On a stretched string, transverse stationary waves are formed due to superposition of direct and the reflected transverse waves.

21. Laws of transverse vibrations of a stretched string: The fundamental frequency of a vibrating is

    (i) inversely proportional to its length

    (Law of length)

    (ii) directly proportional to the square root of its tension

    (Law of tension)

    (iii) inversely proportional to its mass per unit length

    (Law of mass)

22. Organ pipe: It is the simplest musical instrument in which sound is produced by setting an air column into vibrations. Longitudinal stationary waves are formed on account of superposition of incident and reflected longitudinal waves.

23. Beats: The periodic variations in the intensity of sound due to the superposition of two sound waves of slightly different frequencies are called beats. One rise and one fall of intensity constitute one beat. The number of beats produced per second is called beat frequency.

Beats may be used to determine the frequency of a turning fork. It must be noted here that

(i) When the prong of a turning fork is slightly loaded with wax, its frequency of vibration decreases.

(ii) When the prong of a turning fork is filed slightly, its frequency of vibration increases.

24. Doppler effect in sound: The phenomenon of the change in apparent pitch of sound due to relative motion between the source of sound and the observer is called Doppler effect.

25. Musical sound: A musical sound consists of quick, regular and periodic succession of compressions and rarefactions without a sudden change in amplitude. It produces pleasing effect on the ears.

26. Noise: A noise consists of slow, irregular and non periodic succession of compressions and rarefactions, that may have a sudden change in amplitude. It produces non pleasing effect on the ears.

27. Intensity of sound: (i) The intensity of sound at any point may be defined as the amount of sound energy passing per unit time per unit area around that point in a perpendicular direction.

28. Zero level or threshold of hearing : The lowest intensity of sound that can be perceived by the human ear is called threshold of hearing.

29. Characteristic of a musical sound: These are

(i) Pitch: It is the characteristic of musical sound that helps the listener in distinguishing a shrill note from a grave (flat or dull) one. It depends on frequency.

(ii) Quality: It is the characteristic of the musical sound that distinguishes between two sound of same pitch and loudness from one another. It depends on the number or intensity of overtones.

(iii) Loudness: The sensation of hearing which enables us to distinguish between a loud and a faint sound is called loudness. It depends on intensity.

30. Units f loudness: The unit of loudness of a sound is bel. The loudness of a sound is said to be 1 bel, if its intensity is 10times that of the threshold of hearing.

31. Reverberation of sound: It is the phenomenon of persistence of sound after the source as stopped producing sound. The time for which sound persists after the source has stopped producing sound is called reverberation time (T).

32. Musical scale: A series of notes arranged such that their fundamental frequencies have definite ratios is called a musical scale.

Assignment

1. The radio and TV programmes, telecast at the studio, reach our antenna by wave motion. Is it a mechanical wave or non mechanical?

2. Explain the effect of temperature on speed of sound. Hence define temperature coefficient if velocity of sound
   At what temperature the speed of sound will be three times of its speed at 0^0 C.

3. A guitar string is 90cm long and has a fundamental frequency of 124Hz. Where should it be pressed to produce a fundamental frequency of 186Hz?
4. Discuss Newton's formula for the velocity of sound in air. What is Lap lace's correction?

5. Explain why solid can support both longitudinal and transverse waves, but only longitudinal waves can propagates in gases?

6. What is a progressive wave? Establish the displacement relation for harmonic wave traveling along the positive direction of X -axis

7. What is ratio of the fundamental frequency of an open pipe to that of closed pipe of same length?

8. If the frequency of the sound of a source appears to drop by 10% to a moving person. Determine the velocity of motion of person. Velocity of sound is 330m/s.

9. A transverse harmonic wave on string is given by

   $Y (x, t) = 5 \sin (0.09x + 10t + \pi/3)$

   Calculate
   (a) direction of propagation of wave.
   (b) Speed of wave
   (c) Amplitude and frequency
   (d) Initial phase
   (e) Distance between two successive crests in the wave?

10. Define the terms node and antinodes.
    The tunning fork and sonometer wire were sounded together and produce 4beats/second when the length of sonometer wire is 95cm or 100cm. Find the frequency of tunning fork.

11. Explain why solid can support both longitudinal and transverse waves, but only longitudinal waves can propagates in gases?

12. Why longitudinal waves are called pressure waves?
A cylindrical tube closed at one end contains air. It produces the fundamental note of frequency 512Hz. If the tube is opened at both ends, find the fundamental frequency that can be excited.

13. Explain why note produced by a open organ pipe is sweeter than that produced by the closed organ pipe?

14. Explain why the velocity of sound is greater in solids than in gases?
A source of sound of frequency 90Hz is approaching a stationary observer with a speed equal to 1/10 the speed of sound. What will be frequency heard by the observer.

15. The apparent frequency of the whistle of an engine changes in the ratio of 9:8 as the engine passes a stationary observer. If the velocity of sound is 340m/s. Find velocity of the engine.

16. A man is watching two trains, one leaving and the other coming in with speed of 4m/s. the frequency of their whistle is 240Hz each. Find the number of beats heard by the man. Velocity of sound in air is 320m/s.

Practice Questions:

Short answer questions

1. Can two persons hear each other on moon? Explain
2. Velocity of sound is greater in solids than in gases. Explain
3. Sound can be heard over a long distance on a rainy day. Explain
4. Why do stages of a large auditorium have curved backs?
5. Can transverse wave be produced in air?
6 Why is interference not possible in the sound produced by two violins?
7. Note produced by a open organ pipe is sweeter than that produced in a closed organ pipe. Explain.
8. On what factors does the speed of transverse waves setup in a string depends?
9. What is the nature of thermal changes taking place in air when a sound wave is propagated through it
10. What should be the minimum distance between the source of sound and the reflector for hearing a distinct echo?
11. Distinguish between progressive waves and stationary waves.
12. The speed of sound waves depends on temperature but speed of light waves does not, why?
13. The sound produced by an open organ pipe is shriller than that produced by closed organ pipe of same length. Explain
14. Distinguish between transverse and longitudinal waves.
15. What is meant by superposition of waves? Is it valid in case of light?
16. What are stationary waves? How are they produced?
17. Differentiate between compression and rarefaction.
18. We always see lightning before we hear thundering. Why?

Long answer questions:

1. Distinguish between transverse and longitudinal waves. Give examples of each.
2. Derive Newton's formula for velocity of sound in air. What is Laplace correction?

3. What is Doppler's effect? Derive expressions for the apparent frequency of notes when there is relative motion between the source and observer.
4. What is the effect of pressure, temperature, density, humidity on the velocity of sound?
5. What is progressive wave? Derive an equation for progressive wave.
6. Discuss the formation of standing waves in a string fixed at both the ends of the different modes of vibration.
7. What are organ pipes? Show that the ratio of the frequencies of first three harmonics in open pipe is 1:2:3.
8. Show that in the case of a closed organ pipe, the ratio of the frequencies of the harmonics is 1:3:5:7
9. What are beats? Explain the formation of beats analytically and hence calculate beat frequency.

Numerical

1. The fundamental frequency of a closed organ pipe is 250Hz. What will be the fundamental frequency of an organ pipe of the same length but open at both the ends? 500Hz
2. The velocity of sound in oxygen at STP is 332m/s. what will be the velocity of the sound in hydrogen at S.T.P.? 1328m/s
3. The bulk modulus of water is $2X10^9 N/m^2$. Find the speed of sound in water? 1414m/s
4. A steel wire 3mm in diameter is kept under the tension of 2kN. Find the speed of the transverse wave in the wire. Given density of steel is $7.9 X 10^3 kg/m^3$? 189.3m/s
5. A radio station broadcast at 700kHz. If the radio waves travel with a speed of $3 X 10^8 m/s$, calculate the wavelength of the radio waves. 428.6m
6. The equation of a transverse wave travelling along a string is given by $y = 2\cdot 0 sin\pi(0\cdot 2x - 2\cdot 0t)$ where y and x are in meter and t in second. Find amplitude, wavelength, initial phase at the origin speed and frequency of wave.
7. An open pipe is suddenly closed at one end with the result that the frequency

of the third harmonic of the closed pipe is found to be higher by 100Hz than the fundamental frequency of the open pipe. What is the fundamental frequency of the open pipe? 200Hz

8. A SONAR system fixed in a submarine operates at a frequency of 40kHz. An enemy submarine moves toward the SONAR with a speed of 360km/h. what is the frequency of sound reflected by the submarine? Take speed of sound in water = 1450m/s. 45.92Hz

9. A uniform rope of length 12m and mass 6kg hangs vertically from a rigid support. A block of mass 2kg is attached to the free end of the rope. A transverse pulse of wavelength 0.06m is produced at the lower end of the rope. What is the wavelength of the pulse when it reaches the top of the rope? 0.12m

10 A wire having a linear mass density $5.0x10^{-3}$kg/m is stretched between two rigid supports with a tension of 450N. The wire resonates at a frequency of 420Hz. The next higher frequency at which the same wire resonates is 490Hz. Find the length of the wire

2.1m

Competition kit

1. Two sound waves with wavelengths 5.0m and 5.5m respectively each propagate in a gas with velocity 300m/s. We expect the following number of beats per second
   (a) 0 (b) 1 (c) 6 (d) 12

2. The velocity of sound is V at 273K. The temperature at which it is 2V is
   (a) √2X273K (b) 2X273K (c) 8 X273K (d) 4 X 273k

3. The phenomenon of sound propagation in air is
   (a) isothermal (b) adiabatic (c) isobaric (d) isochoric process

4. Two stretched strings of same material are vibrating under the same tension in fundamental mode. The ratio of their frequencies is 1:2 and the ratio of the vibrating segment 1:4. Then the ratio of the radii of the string is
   (a) 8:1 (b) 4:1 (c) 4: 5 (d) 3:2

5. Let$x = x_m \cos(\omega t + \varphi)$. At t= 0, $x = x_m$. If time period is T , what is the time to reach $x = x_m/2$?
   (a) 3/2T (b) T/3 (c) 2T/3 (d) T/6

6. The distance between two consecutive antinodes is
   (a) 3λ/4 (b) λ/2 (c) λ/4 (d) λ

7. A sound wave generates fundamental note of vibration in an organ pipe of length L, open at one end. The same sound wave will generate fundamental note of vibration in an organ pipe, open at both ends, with length equal to
   (a) L (b) L/2 (c) 2L (d) 3L/2

8. Standing waves are produced in 10m long stretched string. If the vibrates in 5 segments and wave velocity is 20m/s, the frequency is
   (a) 2Hz (b) 4Hz (c) 5Hz (d) 10Hz

9. An observer moves toward a stationary source of sound, with a velocity one fifth of the velocity of sound. What is the percentage increase in the apparent frequency?
   (a) 20% (b) 5% (c) 0.5% (d) Zero

10. The fundamental frequency of a closed end pipe is 480Hz. What is the fundamental note when its $1/4^{th}$ length is filled with water?
    a) 120Hz (b) 240Hz (c) 640Hz (d) 960Hz

11. The extension in a string obeying Hooke's law is x. The speed of sound in a stretched string is v. If the extension in the string is increases to 1.5x, the speed of sound will be
    (a) 0.61v (b) 0.75v (c) 1.22v (d) 1.50v

12. A spring of force constant K is cut into two pieces such that one piece is double the length of the other. Then the longer piece will have a force

constant of
(a) 3K (b) 3K/2 (c) 2K/3 (d) 6K

13. A particle executes SHM with a frequency ν. The frequency with which its kinetic energy becomes four times is
(a) ν/2 (b) ν (c) 2 ν (d) 4ν

14. The temperature at which speed of sound in air becomes double of its value at 27^0C is
(a) 54^0C (b) 327^0C (c) 927^0C (d) 1000^0C

15. When the wavelength of sound changes from 1m to 1.01m, the number of beats heard are 4. The velocity of the sound is
(a) 400m/s (b) 404m/s (c) 300m/s (d) 100m/s

16. A sine wave is travelling in a medium. The minimum distance between the two particles, always having same speed, is
(a)λ/4 (b) λ/3 (c) λ/2 (d) λ

17. Which of the following is a mechanical wave?
(a) Radio waves (b) X-rays (c) Light waves (d) Sound waves.

18. A tuning fork of frequency 480Hz is used to vibrate a sonometer wire having natural frequency 240Hz. The wire will vibrate with a frequency of
(a) 240Hz (b) 480Hz (c) 720Hz (d) 960Hz

19. A wave moving in a gas
(a) must be longitudinal (b) may be longitudinal
(c) must be transverse (d) may be transverse

1. (c) 2. (d) 3. (b) 4. (a) 5. (d) 6. (b) 7. (c) 8. (c) 9. (a) 10. (c) 11. (c) 12. (b)
13. (c) 14. (c) 15. (b) 16. (c) 17. (d) 18. (b) 19. (a)

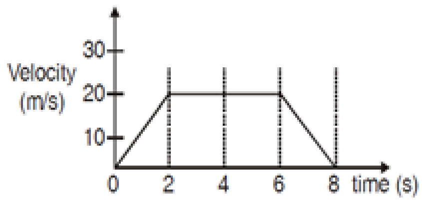
Sample Papers

Unit Test –I

Time: 1hour:30min ***M.M.: 35***

1. An object has uniformly accelerated motion. What will be velocity – time graph for the motion of the object if u = - ve, a = + ve — 1

2. Draw the x-t graph for an object where v-t graph is as follows : — 1



3. The radius of gold nucleus is 41.3 fermi. Express it in gigameter — 1

4. Give 2 example of each — 2
   (a) Dimensionless constant
   (b) Dimensional variable

5. Find the dimensions of (a X b) in the relation — 2

$$E = \frac{b - x^2}{at}$$

where E is energy, x is distance and t is time.

6. Rate of change of pressure is defined as momentum per unit area per unit time. Is it true? Verify the answer by dimensional analysis. — 2

7. A stone is dropped from a balloon rising upwards with a velocity of 16m/s . The stone reaches the ground in 4s Calculate the height of the balloon when the stone was dropped and with what velocity does stone reach the ground? — 3

8. Young's modulus of a steel is 19 x10^{10} N/m^2 . Express it in new system of units where L = 10cm ,t = 1 min and m = 20g. — 3

9. From the velocity-time graph of uniform accelerated motion establish the equation $v^2 - u^2 = 2as$, where symbols have their usual meaning. — 3

10. The displacement of the particle along Z direction is given by $Z = 8t^3 - 3t^2 + 4t$, calculate the average velocity in the interval from t=0 to t=4s and — 3

instantaneous velocity at t=2s.

11. Define the terms (1) absolute error (2) percentage error (3) random error How they are expressed mathematically? 3

12. A body covers 12m in 2nd second and 20m in 4th second. Find what distance the body will cover in 3 seconds after the 6th second. 3

13. If velocity of light c, planck's constant h and gravitational constant G are taken as fundamental quantities, then express time in terms of these quantities. 3

14. Show that the maximum relative error in the product of 2 quantities is equal to the sum of the relative errors in the individual quantities. 5
The radius of curvature of a convex mirror is given by
$R = \frac{l^2}{6h} + \frac{h}{2}$, if l = (4.4 $\pm$ 0.1) cm and h =(0.85$\pm$0.001) cm .
Compute the maximum possible percentage error in the measurement of R.

First Term Examination

TIME : 3 Hrs. **M.M. 70**

SECTION A

1 Give an example of each (i) dimensionless variable (ii) dimensional constant. 1

2 Why is it that when a man jumps down from a height of several storeys into a stretched tarpaulin, he receives no injury? 1

3 A mass is moving in a circular path with a constant speed. What is the work done in 3/4th of a rotation? 1

4 Two balls of masses m_1 and m_2 are thrown upwards with the same speed from a window. While coming down which ball will pass the window with a greater speed and why? 1

5 Two equal masses, one at rest and another moving undergo elastic oblique collision. If one mass goes at an angle $\pi/3$ with its original direction of motion, what is the direction of motion of another mass? 1

SECTION B

6 State the Newton's second law of motion and deduce the Newton's first law of motion from it. 2

7 Rain is falling vertically with a speed of 30 ms^{-1}. A woman rides a bicycle with a speed of 10 ms^{-1} in the north direction to south direction. What is the direction in which she should hold her umbrella to protect herself from the rain? 2

8 A light body and a heavy body have the same kinetic energy. Which one will have the greater momentum and why? 2

OR

A light body and a heavy body have the same momentum. Which one will have the greater kinetic energy and why?

9 The equations of motion of a body projected at an angle are given by $x=3t$ and $y=12t - 9.8t^2$. What is the velocity of the projection of the body? 2

10 Prove that horizontal range is same when angle of projection is (i) greater than 45° by certain value and (ii) less than 45° by the same value. 2

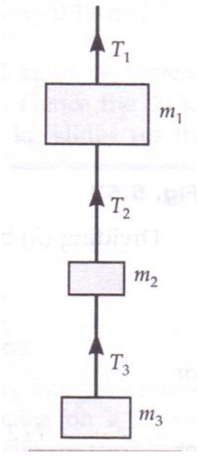
SECTION C

11 What do you mean by mean absolute error and relative error of a measurement? Give their respective expressions also. 3

12 Define impulse and derive impulse-momentum theorem? 3

13 The masses m_1, m_2 and m_3 of the three bodies shown in fig. are 5, 2 and 3kg 3

respectively. Calculate the values of the tensions T_1, T_2 and T_3 when (i) the whole system is going upward with an acceleration of $2ms^{-2}$. Given g= $9.8ms^{-2}$.



14 Draw and discuss the position-time graphs of two objects moving along a straight line, when their respective velocity is (i) zero (ii) positive and (iii) negative. 3

15 Assuming that the volume of a liquid of a liquid flowing per second (V) through a cylindrical tube depends on (i) pressure gradient (p/l) (ii) radius of the tube (r) and (iii) the coefficient of viscosity of liquid (η) .Find by the method of dimensions how it depends on these quantities.(Dimensions of η is $[M L^{-1} T^{-1}]$) 3

16 When do we say two vectors are orthogonal? The angle between vector A and B is 30°. What is the ratio of A . B and |A x B|. 3

OR

Find the unit vector perpendicular to the vectors A= 2î -3ĵ +6k and B= =î +ĵ - k.

17 Draw the following graphs for an object under free fall : 3

(a) Variation of acceleration with respect to time.
(b) Variation of velocity with respect to time.
(c) Variation of distance with respect to time.

18 A projectile is fired at an angle ø with the vertical. Show that its trajectory is a parabola. 3

19 A massless platform is kept on a light vertical elastic spring. When a sand particle of mas 0.1kg is dropped on the pan from a height of 0.24m, the particle strikes the pan and the spring compresses by 0.01m. From what height should the particle be dropped to cause a compression of 0.04m? 3

20 The radius of curvature of a concave mirror measured by speedometer is given by $R=l^2/6h+h/2$. The values of l and h are 4 and 0.65 respectively. Compute the error in measurement of radius of curvature. 3

21 A man of mass 80kg stands on a weighing scale in a lift which is moving 3

(a) Upwards with a uniform speed of 5 m/s.

(b) Upwards with a uniform acceleration of 10 m/s^2.

What would be the reading of the scale in each case?

(c) What would be the reading if the lift mechanism failed and it hurtled down freely under gravity?

22 Define coefficient of restitution. A ball at rest is dropped from a height of 12m. It loses 20% of its kinetic energy in striking the ground. Find the height to which it bounces. 3

SECTION D

23 Manu went to railway station to see off his uncle. At platform, he saw that an old coolie was carrying heavy load on his head. Suddenly coolie tripped and a baggage fell off his head. The owner of the bag started shouting at the old man. Manu couldn't tolerate this. He went to the old man, helped him in picking up the baggage and offered to carry some load of him. 4

(i) What does this tell you about the nature of Manu?

(ii) A man weighing 55 kg supports an object of 20 kg on his head. Calculate work done by him if he moves a distance of 20m (a) on horizontal road (b) upon a smooth inclined plane of 1/5 ($g=10m/s^2$).

(iii) When is the work done negative?

SECTION E

24 a) Define an expression for potential energy stored in an elastic spring, when it is pulled from its equilibrium position. Hence show that the elastic force of a spring is a conservative force. 5

b) A long spring is stretched by 2cm. Its P.E. is V. What will be its P.E. if the spring is stretched by 10cm?

OR

a) Show that a head on collision between two balls of equal masses moving along a straight line, the balls simply exchange their velocities.

b) A body of masses 3kg makes an elastic collision with another body at rest and continues to move in the original direction with a speed equal to one third of its original speed. Find the mass of the second body.

25 a) Define angle of friction and angle of repose. Hence show that angle of friction is equal to the angle of repose. 5

b) A body of mass 0.3kg is taken up an inclined plane to length 10m and height 5m and then allowed to slide down to the bottom again. The coefficient of friction between the body and the plane is 0.15. What is the Work done by the applied force over the upward journey?

OR

a) Why does a cyclist lean inwards while moving along a curved path? Determine the angle from the vertical, through which he bends while

negotiating the curve.
b) A cyclist speeding at 18km/h on a level road takes a sharp turn of radius 3m without reducing the speed and without bending towards the centre of the circular path. The coefficient of static friction between the tyres and the road is 0.1. Will the cyclist slip while taking the turn?

26 a) Derived Position – time relation for uniform accelerated motion from velocity time graph. 5
b) A body travels half its total path in the last second of its fall from rest; calculate the time of its fall.

OR

a) Derived Position – Velocity relation for uniform accelerated motion from velocity time graph.
b) Water drops fall at regular intervals from a tap which is 5m above the ground, the fourth drop is leaving the tap at the instant the first drop touches the ground. How far above the ground is the second drop at that instant. (g= $10m/s^2$).

Unit Test: 2

Time: 1hour 30min. M.M. 35

1.What is the work done on the planet revolving around earth by gravitational force? 1

2. The angular velocity of revolution of the earth around the sun increases, when it comes closer to the sun. Why? 1

3. What provides the centripetal force to a satellite revolving around the earth? 1

4. A body falling from a height of 15m rebounds to 10m height from a hard floor. Find the percentage loss of energy in impact? 2

5. When the diver leaves the diving board, why he brings his hands and feet close together in order to make a somersault? Explain 2

6. Define gravitational potential energy of an object at a point in gravitational field. Draw the graph showing the variation of gravitational potential energy with distance from the earth. 2

7. Which of the following are positive and which are negative works done? Justify your answer.

(i) Work done by a man in pulling a bucket out of a well by means of a rope.
(ii) Work done by gravitational force in the above case.
(iii) Work done by friction on a body sliding down an incline plane. 3

8. What is law of conservation of angular momentum? What will be the duration of the day, if the earth suddenly shrinks to 1/64 of its original volume, mass remaining unchanged? 3

9. Derive an expression for rotational kinetic energy and hence define moment of inertia. 3

10. Show that in a head on collision between two balls of equal masses moving along a straight line, the balls simply exchange their velocities. 3

11. What do you mean by elastic potential energy? An elastic spring of constant k is stretched by an amount x. show that its potential energy is $\frac{1}{2} kx^2$. 3

12. Define of radius of gyration. What is the moment of inertia of a disc about an axis passing through its centre perpendicular to it plane. Find the radius of gyration of disc about a tangent parallel to its diameter. 3

13. What should be the minimum speed with which an object of mass m be thrown from the surface of earth so that it can reach a height of R/4 above the surface of earth. Here R is the radius of earth and g is the acceleration due to gravity on the surface of earth. 3

14. Discuss the variation of acceleration of gravity with the depth. Find the weight of object of mass 60kg when taken to (a) a depth R/4 and (b) centre of earth? Given R= radius of earth. 5

Annual Examination

TIME : 3 Hrs. **M.M. 70**

1	Why is it dangerous to stand near the edge of the platform when a fast moving train crossing it.	1
2	A lift is going up with acceleration 2g. A man is inside the lift and his mass is m. What will be the reaction of the floor on the man?	1
3	Give the magnitude and direction of the net force acting on a stone of mass 0.1kg lying on the floor of a train which is accelerating with $1 m/s^2$, the stone being at rest relative to the train.	1
4	The body A starts from rest with an acceleration a_1 After 2s, another body B starts from the rest with an acceleration a_2. They travel equal distances in the 5^{th} second after the start of A. Find the ratio of their acceleration.	1
5	Two equal and opposite forces act on a rigid body. Under what condition will the body (i) rotate (ii) not rotate.	1
6	For a satellite orbiting in an orbit, close to the surface of the earth, to escape, what is the percentage increase in the kinetic energy required?	2
7	A light string passing over a smooth pulley connects two blocks of masses m1 and m2 (vertically) if the acceleration of the system is g/8, find the ratio of the two masses. **OR** A body is moving with a uniform speed in a circular path of radius 'R'. If 'n' is the frequency of circulation, then what will be the centripetal acceleration in terms of 'n' and 'R'	2
8	If $\vec{A} = 3\hat{i}+4\hat{j}$ and $\vec{B} = 7\hat{i} + 24\hat{j}$, find a vector having the same magnitude as $\vec{B}$and parallel to $\vec{A}$	2
9	A simple harmonic motion is described by a =-16x, where 'a' is the acceleration is m/s^2 and x is the displacement in 'm'. What is the time period?	2
10	Calculate the heat required to convert 3 kg of ice at -12^0C kept in a calorimeter to water at 100^oC at atmospheric pressure.	2
11	A projectile is projected with velocity u from ground making an angle of ø with vertical. Find the expression of time of flight and the maximum height attained.	3
12	The relation between position X and time t for an object is given by $X \alpha t^n$ where n is the power on which X is dependent. Draw the x-t graphs and predict the motion for 1) n=0, 2) n=1, 3) n=2.	3

13 The mass of a pendulum is 0.2kg, and it is suspended by a string 1m long. It is pulled aside until the thread is at 30° to the vertical. How much work is done? 3

14 The transverse displacement of a string is given by 3

$$y = 0.06 \sin\left(\frac{2\pi}{3}\right) x \; cos(120\pi)t$$

Where x and y are in m and t is the second, the length of the string is 1.5m and its mass is 3.0 x 10 $^{-2}$ kg.

Answer the following

(a) Does the function represent a travelling or stationary wave.

(b) Calculate wavelength, frequency and tension in the string.

15 Show that the total energy of a particle executing simple harmonic motion is directly proportional to the square of the amplitude and frequency. Draw graph showing the variation of K.E. and P.E. with Displacement. 3

16 Plot stress strain curve for a metallic wire with proper labelling. How can this curve be used to distinguish between ductile and brittle materials. 3

17 The Vander Wall's equation for a gas is { P+ a/V^2}(V-b) = RT. Where P is pressure and V is volume. Determine the dimensions of a and b. Hence write the SI unit of a and b. 3

18 A ball is dropped to the ground from a height of 2m. The coefficient of restitution is 0.6. To what height will the ball rebound? 3

19 Find an expression for the viscous force F acting on tiny steel ball of radius 'r' moving in a viscous liquid of coefficient of viscosity 'η' with a speed 'v' by the method of dimensional analysis 3

20 Show that the pressure exerted by a gas to two-third of the average kinetic energy per unit of volume of gas molecules. 3

21 Obtain expression for (a) orbital velocity and (b) period of revolution of the satellite above the surface of the earth. 3

22 Derive an expression for the work done by one mole of an ideal gas during isothermal expansion. 3

OR

Derive the relations between the coefficient of linear expansion (α) and cubical (γ).

23 One day Ashok was travelling with his car and his uncle was driving the car. Ashok observed that his uncle did not tie the seat belt. He requested his uncle to tie the seat belt but he ignored it. All of sudden Ashok's uncle had to apply powerful brakes to stop the car within a very short distance. Ashok's uncle 4

experienced a forward jerk and his head collided with the steering. Fortunately he did not receive serious injuries. Ashok immediately took his uncle to a nearby doctor for first-aid and immediate care. Later on he explained the use of seat belt to his uncle in details. His uncle promised to put on seat belt in future while driving.

(a) What values were shown by Ashok.

(b) When a car suddenly stops, in which direction a passenger would experience a jerk and why?

(c) What is the function of the seat belt.

24 Derive an expression for torque in Cartesian co-ordinates from rotation of a particle in a plane. 5
A rod of weight 30 kg is supported by two parallel edges A and B and is in equilibrium in horizontal position. The knives are at the distance 1m from each other. The centre of mass of the rod is at a distance 'x' from A. Find the normal reactions at the knife edges A and B.

OR

Define angular momentum. Prove that angular momentum of a particle is equal to twice the product of its mass and areal velocity.
A 40 kg flywheel in the form of a uniform circular disc of 1m radius is making 120rpm. Calculate the angular momentum.

25 Define terminal velocity and find an expression for the terminal velocity attained by a sphere falling through a viscous liquid. 5
Two drops of equal radius coalesce to form a bigger drop, what is the ratio of terminal velocity of bigger drop to the smaller one.

OR

Establish a relation for the excess pressure on a drop of liquid of Surface Tension T, giving reason for its presence.
Explain why a drop of liquid under no external forces is always spherical in shape.

26 Discuss the formation of standing waves in a pipe closed at one end and explain with the help of diagrams, the different modes of vibration. 5

OR

Discuss the formation of standing waves in a stretched string fixed at both ends and explain with the help of diagrams, the different modes of vibration.

VALUE BASED QUESTION

Q1. Suneel's uncle and aunt, living in a village had come to Delhi for visiting the AIIMS, New Delhi for a check-up for some medical problem, his uncle was suffering from. Suneel went to the station to receive them and took great care to make them feel comfortable and at ease. Suneel listened patiently to the problem of his uncle and assured them that he would go along with them for a complete and through medical check-up of his uncle.
While going with his uncle and aunt to the hospital next day Suneel explained to them the precautions they need to take while travelling the DTC bus. He told them about the possibility of their falling forward or back ward in the event of the driver suddenly applying brakes or starting the bus all of a sudden. He emphasised the need for their being alert all the time so that they can minimise the chance of such a fall. His explanation was of great help to his uncle and aunt who used to live in a small urbanised village. As a result of this understanding they had a trouble free bus journey. Suneel's helpful and considerate nature also helped them to get a proper check-up and prescription for his uncle's medical problem. They were highly thankful to Suneel and blessed him from the core of their heart.

(a) State the values displayed by Suneel.
(b) What values were shown by the uncle and aunt of Suneel?
(c) Name and state the law on which Suneel's explanation regarding safe journey in a bus was based.
(d) Give another example based on this law.

Q2. One day Ashok was travelling with his uncle in his car and his uncle was driving the car. Ashok observed that his uncle did not tie the seat belt. He requested his uncle to tie seat belt but he ignored it. All of sudden Ashok's uncle had to apply powerful brakes to stop the car within a very short distance. Ashok's uncle experienced a forward jerk and his head collided with the steering. Fortunately he did not receive serious injuries. Ashok immediately took his uncle to a nearby doctor for first-aid and immediate care. Later he explained the use of seat belt to his uncle in details. His uncle promised to put on seat belt in future while driving.

(a) What values were shown by Ashok?
(b) When a car suddenly stops, in which direction a passenger would experience a jerk and why?
(c) What is the function of seat belt?

Q3. An old man living in a village, once came to Gurgaon to visit his son, who worked in a software company there and living on the top apartment of a 35 storey building complex. One day the old man and his grandson Rakesh, who was doing a basic degree course in physical science, visited a market and purchased a weighing machine. When they came back to their building complex and entered in the lift, Rakesh put the weighing machine on the floor of the lift and asked his grandfather to stand on it. The weight shown by the machine was 48kg. The then lift started moving upward. Then old man observed that weight shown by machine increased to 72kg and after few seconds become 48 kg again. Then as the lift approached 35th floor, the reading shown by weighing machine was only 16 kg. When Rakesh and his grandfather come out of lift and entered their apartment, the Oldman again checked his weight by using the weighing machine is faulty and we must return it to shopkeeper.
When Rakesh came to know about this incident, he explained to his grandfather that there is no fault in the weighing machine and weight shown varied on account of the fact that motion of lift was sometimes accelerated one, some time with constant velocity and some time with a retardation. His grandfather was convinced.

(a) How did Rakesh convinced his grandfather that there was no fault in the machine? How you explain it?
(b) What is the acceleration of lift when reading shown by weighing machine is (i) 72kg (ii) 16kg?
(c) What values are shown by Rakesh?

Q4. Suresh read in his book that a vector quantity is that which has a definite magnitude as well as a sense of direction. He further read that electric current is a scalar. He was perturbed because in his opinion electric current has both magnitude and direction and should have been a vector. He narrated his problem to his elder brother Satish. Satish listened to him patiently and then explained to him that beside magnitude and direction a vector quantity must also obey the vector law of addition. As electric current does not obey the vector law of addition, it is a scalar. Satish also gave other examples to convince Suresh. Now he was happy.
(a) What values were exhibited by Satish? What values were shown by Suresh?
(b) Can you name one or two other physical quantities which are scalar in spite of having both magnitude and direction?

Q5. Mohinder Singh lived on the first floor flat of a four storey building at Tilak Nagar, New Delhi. One day only Mohinder Singh and his grandmother were at home and other family members had gone out of station due to some family reason. Suddenly Mohinder observed that there is dense smoke all around his flat. Soon he observed that flames of fire coming from the neighbouring flat in the same building. There was a lot of hue and cry in the building and people were panicked. Each one wanted to leave the building. There was a huge rush in the staircase. Mohinder could escape easily but he thought about how to save her aged and weak grandmother.
Mohinder got an idea. He used a turban cloth and suspended it downward from the balcony of his flat and asked a person standing on the ground floor to hold the other end of turban cloth. Now he asked his grandmother to gently sit on the turban cloth. She hesitated but after pursuation sat on the suspended piece of turban cloth. She comfortably reached the ground and the turban cloth remain intact.
(a) What values and quantities were exhibited by Mohinder Singh?
(b) What is the principal in your opinion which was employed by Mohinder Singh?
(c) What will be the tension in a cord/piece of cloth inclined at an angle 30° from horizontal when a person of mass 4okg falls through it with an acceleration of 2.0 ms^{-2} ?

Q6. Narender is a student of class XI. One day in his physics laboratory he was measuring the diameter of a wire by using a micrometre screw-gauge. He measured the diameter and showed the result to his teacher. His teacher told him to take at least 10 sets of observation and then find the mean value of the diameter of given wire. Narender did not argue with his teacher but he thought it is shear wastage of time when one repeat the same observation again and again. In the evening he asked about it from his elder sister who was student of B.Sc. Physics Hons. She told the real cause and logic of the advice given by Narender's teacher to him. Now Narender was satisfied.
(a) In your opinion what is the advantage of taking a large number of observations while performing an experiment?
(b) What values were shown by Narender and his sister?
(c) The length of a small cylinder is measured using a Vernier callipers of Vernier constant 0.01cm. A student measuring the length of given cylinder five times and recorded them as 2.34cm,2.35cm, 2.33cm and 2.34cm. What should be correct (mean) value of length of cylinder? Give reasons too?

Q. 7 A middle aged person was suffering from high blood pressure but did not undergo any regular treatment for it. His nephew Sohan, who was a first year student in a medical college, came to know of this. He visited his uncle's residence and requested him to take regular treatment otherwise serious complications including severe heart attack may take place in future. He explained the cause of high blood pressure too. He told his uncle that sometimes an artery may get constricted due to the accumulation of plaque on its inner walls. In order to drive blood through the constriction a greater demand is placed on the activity of the heart and hence blood pressure increases. The common medicine prescribed by doctors for treatment of high blood pressure helps in reducing the coefficient of viscosity of blood suitably so that blood may flow easily even through constriction. Moreover, one should be careful enough so that there is no further accumulation of plaque on the inner walls of arteries.

Sohan's uncle was convinced and started taking regular medicine. He also started doing regular exercises. Within a few weeks his blood pressure became normal and he was happy.

(a) What value/qualities were exhibited by Sohan?

(b) How is flow of fluid through a capillary tube related to the viscosity of that fluid?

(c) On what other factors does the volume flow rate of a fluid through a capillary tube depend? Write an expression for volume flow rate of a fluid.

Q. 8. Ram is a renowned swimming coach. Mohan is fond of diving. During his diving exercise Mohan observed that after jumping from the diving spring board he could neither exhibit somersaults in mid-air nor touch the water surface gently. He tried his best and could not succeed. He approached Ram. Ram carefully listened to him and then advised him to first curl his body by folding his arms and legs towards the centre of his body in mid-air so that he may easily take a somersault. The while entering the water in the swimming pool he should straighten his body by pulling apart his arms as well legs. In this way he touch the water surface gently. Mohan followed Ram's advice, practiced a lot and became an expert show diver. He thanked the diving coach Ram for his expert advice.

(a) What according to you are the values displayed by Ram and Mohan?

(b) Which principle is involved here? State the principle and explain it briefly.

© Give yet another application/illustration of the principle.

Q.9. Sunita's aunty had a history of high blood pressure but she did not care. One day she felt severe pain in her heart region. Doctor, on examination suggested her to undergo an angiography test so as to ascertain the extent of blockage in her arteries. However, Sunita's aunty was neither mentally prepared nor had enough money to have the test in a super specialty hospital.

.When Sunita came to know of this, she explained to her aunty the cause and effects of high blood pressure. Sunita told her aunty that an artery may get constricted due to the accumulation of plaque on its inner walls. In order to drive blood through the constriction a greater demand is placed on the activity of the heart. The flow speed of blood in this region is raised which lowers the pressure inside and the artery may collapse due to the external pressure. The heart exerts further pressure to open this artery and forces the blood through. As the blood rushes through the opening, the internal pressure once again drops due to same reasons leading to a repeat collapse.

This may result in severe heart attack.

After listening to Sunita, her aunty mentally prepared herself for the medical examination. Then Sunita, her friend and relatives contributed towards the cost of medical examination and treatment of Sunita's aunty. As a result Sunita's aunty got proper medical help and proper treatment in time save her life.

(a) What qualities and values were shown by Sunita?

(b) In an artery of radius 'a' blood flows with a uniform speed of v. If radius of artery becomes 3/4a' due to accumulation of plaque on its inner walls, what will be the flow speed of blood through the constriction?

Q. 10. We daily observed that motion of any object failing freely is continuously accelerated and the value of acceleration is found to be about 9.8 ms-1 near the Earth's surface. However, rain drops falling due to condensation of water vapour in a cloud do not fall on the ground with an excessively high speed although on an average, a cloud is moving at a height of more than a kilometre from Earth's surface. Rama's father did not know the cause of this. He thought that since size and mass of raindrops is extremely small, negligible force of gravity acts on a raindrop and so the falling speed of raindrop is quite small.

One day he asked Rama whether his thinking is correct or not. Rama knew the real cause. She told her father that acceleration due to force of gravity is same for all freely falling bodies irrespective of their size and mass. However, in case of raindrops there is a retarding force too which is due to viscosity of air medium. As a result after falling through certain distance raindrops acquire a constant terminal speed whose value is (i) proportional to square of drop, and (ii) inversely proportional to the coefficient of viscosity of the viscous medium (atmospheric air).

(a) Is explanation given by Rama correct? What qualities were exhibited by Rama in your opinion?

(b) Let a raindrop of radius 0.10 falls downward with a constant terminal speed v. If 8 such drops coalesce to form a single bigger drop then what will be the new terminal speed of the single bigger drop formed due to coalescence?

Q. 11. Samir read in his science book that work is being done when a force is applied on a body and under its effect the body moves through a certain distance in the direction of force applied. Samir could not understand this because he thought that he was doing work while reading a book or doing his school homework etc. He became impatient and immediately went to his elder brother Vijay. On listening the story of Samir, Vijay explained to him the difference between mechanical work and mental work. While reading a book or doing our school homework etc. we may be doing mental work but for mechanical work presence of a force acting on a body and its displacement is essential. Moreover, mechanical work can be positive as well as negative.

Now Samir was satisfied.

(a) Under what condition is the work done positive and under what condition negative. Give examples.

(b) Can mechanical work be zero in spite of applying a force on a body?

(c) What values were displaced by Vijay? What by Samir?

Q. 12. Ram went to a circus show along with his parents. There he saw an item, named "globe of death". A big size hollow sphere of steel rods with gaps in between was placed at the centre part of arena. The spherical shell had a door. Then suddenly a person riding a motor cycle rushed up towards the globe, entered into it through the door, completed vertical circles inside the globe and then escaped from the door. Ram was amazed because the motorcyclist did not fall even when he was upside down at the upper part of his vertical loop inside the globe of death. After viewing the circus show, when he returned to his home, he asked his father about this item. His father explained him the basic principle of successful looping the vertical loop by the motorcyclist.

(a) In your opinion how does motorcyclist maintain his equilibrium in the globe of a death?

(b) If a globe of death has a radius of 5 m, what should be the minimum speed of a motorcyclist at the top point of vertical circle executed by him so that he can maintain his equilibrium?

© What value were displayed by Ram and his father?

Q. 13. The water available in the pond as well as of village Kartarpur was satish one. People living in that village faced severe problems due to this. Village women complained that used clothes cannot be

properly cleaned in the water of village pond. They used to go to pond of neighbouring village which was about 10 km away from their village. It was a difficult, hectic and time consuming chore for them.
Satish once came to Kartarpur to pay a visit to his uncle's house in kartarpur village. He came to know that his aunty has gone to neighbouring village for washing of their clothes. When his aunty came back in the afternoon, Satish came to know about the whole situation. Being a science student, Satish immediately understood the problem. He advised the aunty to use some good quality detergent powder for washing purpose. He explained that clothing could not be cleaned easily in satish water because its surface tension is high and water does not penetrate in to the pores of clothes. A good quality detergent will reduce the surface tension of water and thus helps in cleaning action of water. Moreover, a good quality detergent is also useful to remove dirt present in clothe easily.
Satish's Aunty accepted his suggestion and told the same to other village women too. They all found suggestion of Satish wonderful and practicable. As a result, they were relieved a lot.

(a) What was the suggestion of Satish?
(b) Define surface tension of a liquid. What is its SI unit?
(c) Which liquid has higher surface tension satish water or a detergent solution?
(d) How does surface tension of a liquid change on heating the liquid?

Q. 14. Sudha's grandmother had read in Mahabharata' that during the famous was of Kurukshetra Bheem used to throw away elephants in sky so that they never returned back on the Earth. However, she could not understand how it is possible. She narrated the story to Sudha.
Sudha remarked that it is possible. Then she explained in detail to her grandmother that if any object is thrown from the surface of Earth with a speed equal or greater than escape speed, it will go on moving to cross the gravitational field of Earth and will never return on the Earth. Space crafts launched by scientists and aimed to land on moon or other planets are based on this very principle. Sudha's grandmother thanked her for the explanation given by her.

(a) In your opinion what is escape speed? Give a formula for it what is its value on surface of Earth?
(b) Planet Mars has a radius of 3400 km and value of acceleration due to gravity "g' at the surface of Mars is 4.5 m s-2 what is the value of escape speed at mars?
(c) What values were displayed by Sudha?

Q15 Anand and his classmates went to a hilly forest area for a plants collection tour. As students were moving in different directions collecting various plants, Mukul got separated from other students. He searched the other students but somehow passed in dense forest. He shouted loudly naming his classmates. He observed that somebody was copying him and shouting the same words. He got more perplexed and thought that some ghost is present here. He started crying. Somehow, Anand heard the sound of Mukul and guessed that Mukul is having some problem. He then asked his classmates to search Mukul. With some efforts they could locate Mukul. Mukul was highly depressed and terrified. Anand comforted him. When Mukul said some ghost is present in the forest, Anand told him that it is nothing. He listened the same sound again and again due to formation of echo. To demonstrate this Anand whistled sharply. After few seconds all students heard the same sound due to reflection from the nearby hills. Now Anand is satisfied and become normal.

(a) What value/qualities were shown by Anand?
(b) What is echo? How it is formed?
(c) If a reflection is situated at a distance of 860m from a sound source, what is the time of echo? Speed of sound in air at room temperature can be taken as 344 ms-1.