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PHYSICS NOTES

XI

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Multiple Choice Questions

Chapter 1

THE SCOPE OF PHYSICS

1. Physics can be defined as the study of:
   (a) Chemical Properties of matter
   (b) Physical properties of matter
   (c) Relation between matter and energy
   (d) Both (b) and (c)
2. Physics can be defined as a branch of science based on a:
   (a) Aberration and analysis of facts
   (b) Experimental observation and quantitative measurement.
   (c) Mathematical calculation and interpretation.
   (d) Replication and verification of known facts.
3. The branch of physics deals with the study if production propagation and properties:
   (a) Magnetics (b) Optics (c) Statics (d) Acoustics
4. High energy physics deal with the:
   (a) Study of electron behaviour (b) Study of electronic charges
   (c) Study of mechanics of energetic bodies.
   (d) Study of properties and behaviour of elementary particles.
5. The ancient Greeks originated the idea that:
   (a) Matter and energy are the same thing
   (b) Perpetual motion is not possible.
   (c) Matter is discontinues
   (d) Matter does not exist in different forms.
6. Archimedes the Greek physicist has made significant contributions in the field of.
   (a) High energy physics and electronics
   (b) Nuclear and atomic Physics
   (c) Mechanics hydrauties and hydrostatics
   (d) Special theory of relativity
7. Al – Beruni is famous for finding out the
   (a) Distance of moon from earth
   (b) Mass of the earth
   (c) Diameter of earth's orbit
   (d) Circumference of the earth
8. The book "Kitab-ul-Qanoon-ul-Masoodi" was written by
   (a) Iben-e-Sina (b) Al-Razi
   (c) Abu-Rehan Al-Beruni (d) Ibn-al-Haitham
9. Dr. Asalam was awarded noble Prize for has work on.
   (a) Electronics (b) Radiations
   (c) Optics (d) Grand unification theory
10. The first book on analytical "Hisab-ul-jabrwai-Moqab" was written by:
    (a) Al-Khawarzmi (b) Al-Beruni
    (c) Al-Razi (d) Ibn-e-sina
11. "Kitab-ul-Manazir" the famous book on optical is written by
    (a) Ibn-e-Sina (b) Al-Khawrzmi
    (c) Jabir-bin-Hayan (d) Ibn-ul-Hailham

12. In international system of units, the length mass time electric current temperature, intensity of light and quantity of light and quantity are called
(a) Derived (b) basic
(c) Fundamental (d) only (b) and (c)

13. Written of the flowing physical quantity will be different units as compared to that of others
(a) Weight (b) Tensioq
(c) Buoyant Force (d) Electromotive Force

14. Which one of the following is not the of same quantity?
(a) Horse (b) Calorie (c) Jou;es (d) BTU

15. The S.I unit of current is :
(a) one volt (b). One
(c). One ampere (d) One ohm-m

16. The famous mathematical and the founder of algebra was.
(a). Al kindi (b). AL Khwarizmi
(c). Al beruni (d). Naserudin tusi

17. Light year is a unit of
(a). Distance (b) Light (c) Time (d) Pressure

18. Some of the basic S. I units are
(a) Second Ampere mole (b) Kelvin Ampere watt
(c). Candela Mole volt (d). Meter Second watt

19. 10^{-9} second are equivalent to:
(a). Deci Second (b). Nano Second
(c). Milli second (d). Micro second

20. The S. I unit of temperature is
(a). Fahrenheit (b) Kelvin (c). Centigrade (d). Farad

21. One Angstron equal
(a) 10^{-8} cm (b) 10^{8} m (c) 10^{-6} (d) 10^{8} mm

22. In Physics the term "dimension" represent the
(a) mechanical nature of a quantity
(b) chemical nature of quantity
(c) Physical nature of quantity
(d) electric nature of quantity

23. Dimension of pressure is.
(a) $ML^{-1}T^{-2}$ (b) $ML^{-2}T^{-3}$ (c) $ML^{-2}T^{-4}$ (d) MLT^{-1}

24. Which one of the following represent the dimension of power:
(a) L^2T^2 (b) MLT^2 (c) ML^2T^{-3} (d) $ML^{-2}T$

25. Which one of the following represent dimension for the unit of torque.
(a) M^2LT^2 (b) ML^2T^2 (c) M^2LT^2 (d) MLT^2

26. 0.0084 has ________ significant figure.
(a) 2 (b) 4 (c) 5 (d) 1

27. The dimension of angular momentum similar to that of.
(a) energy (b) heat (c) Plank's constant (d) work

Chapter 2
SCALARS AND VECTORS

1. Which of the following is a vector quantity
   (a). Mass (b) Speed
   (c). Temperature (d). Acceleration
2. Which one of the following is scalar?
   (a) Acceleration (b) Velocity (c) Force (d) Work
3. In contrast to a scalar a vector must have a.
   (a) Direction (b) Weight
   (c) Quantity (d) None of the above
4. Which is the following group of quantities represent the vectors:
   (a) Acceleration, Force, .Mass (b) Mass .Displacement, velocity
   (c) Acceleration, Electric flux force
   (d) Velocity, Electric field momentum
5. The following physical are called vectors"
   (a) Time and mass (b) Temperature and density
   (c) Force and Displacement (d) Length and volume
6. Vectors are physical quantities which are completely specified by:
   (a) Magnitude only (b) Direction only
   (c) Magnitude and direction only (d) A & B
7. Scalar quantities have:
   (a) Only magnitudes (b) Only directions
   (c) Both magnitude and direction (d) None of these
8. A unit of a vector A is given by:
   (a) $a = \frac{\vec{A}}{|\vec{A}|}$ (b) $a = \vec{A} \times |\vec{A}|$ (c) $\hat{a} = \frac{\vec{A}}{|\vec{A}|}$ (d) $a = \vec{A}$
9. A vector in space has ________ components.
   (a) one (b) Two (c) Three (d) Four
10. When a vector is multiplied by a negative number its direction.
    (a) is reversed (b) remains unchanged
    (c) make and angle of 60° (d) may be changed or not
11. A vector which can be changed by display parallel to itself and applied at any point is known as:
    (a) Parallel vector (b) Null vector
    (c) Free vector (d) position
12. A vector in any given direction whose magnitude is unity is called:
    (a) Normal vector (b) parallel vector
    (c) Free vector (d) unit vector
13. The position vector of a point p is a vector that represent its position with respect to:
    (a) Another vector (b) Center of the earth
    (c) Any point in space (d) origin of the coordinate system
14. Negative of a vector has a direction ________ that of the original vector.
    (a) Same as (b). Perpendicular to
    (c) Opposite to (d) Inclined to

15. The sum and different of two vector are equal in magnitude. The angle between the vector is:
(a) 0° (b) 90° (c) 120° (d) 180°

16. Two forces act together on an object The magnitude of their resultant is least when the angle between the forces is:
(a) 0° (b) 45° (c) 60° (d) 180°

17. The dot product of I and J is.
(a) more (b) 1 (c) 0 (d) any value

18. Scalar product obtain when.
(a) A Scalar is multiplied by a scalar.
(b) A scalar is multiplied by a vector
(c) Two vectors are multiplied to give a scalar
(d) Sum of two scalars is taken

19. If dot product of two vectors which are not perpendicular to each other is zero then either of the vector is obtain by adding two or more vectors is called:
(a) A unit vector (b) Opposite to the other
(c) A null vector (d) Position vector

20. The vector obtain by adding two or more vectors is called:
(a) Product Vector (b) Sum vector
(c) Resultant vector (d) Final vector

21. Scalar product of two vectors obeys.
(a) Commutative Law (b) Associate Law
(c) Both "a" and "b" (d) None of the above

22. If the dot product of two non-zero vectors A and B is zero. Their cross product will be of magnitude.
(a) AB Sin θ (b) B cos θ (c) AB Sin 6 θ (d) AB

23. If the angle between the two vectors is zero degree then their
(a) Dot product is zero (b) Cross product is zero
(c) Either dot or cross product is zero
(d) Both dot & cross product is zero

24. k x i = ________.
(a) j (b) - j (c) k (d) - k

25. If $\bar{a} \times \bar{h} = 0$ and also $\bar{a} \times h = 0$ then
(a) $\bar{a}$ and $\bar{h}$ are parallel to each other
(b) $\bar{a}$ and $\bar{h}$ are perpendicular to each
(c) $\bar{a}$ and $\bar{h}$ is a null vector (d) Either $\bar{a}$ or $\bar{h}$ is a null vector

26. The magnitude of product vector i.e $\bar{A} \times \bar{B} = \bar{C}$
(a) Sum of the adjacent side (b) Area of the parallelogram
(c) Product of the parallelogram (d) Parameter of the parallelogram

27. If two vectors lie in xy-plan then their cross product lies.
(a) In the same plane (b) Adjacent plane
(c) Alone parallel to that plan (d) Parallel to the plane

28. Two focus of 8N and 6N are acting simultaneously at right angle the resultant force will be:
(a) 14N (b) 2N (c) 10N (d) 12N

29. Two forces each of magnitude F act perpendicular to each other. The-angle made by the resultant force with the horizontal will be.
(a) 30° (b) 2N (c) 60° (d) 90°

30. When two equal forces F and F makes an angle 180° with each other the magnitude of their resultant is.
(a) F (b) 0 (c) 2F (d) 0.5F

31. The resultant of a 3N and 4N force acting simultaneously on an at right angles to each other is in Newtons's.
(a) 0 (b) 1 (c) 3.5 (d) 5

32. (6i + 4j – k)(4i +2j – 2k) = >
(a) 24i +8j + 2k (b) 30 (c) 34 (d) 40

33. The diagram shows four acting on a block

What is the resultant force?
(a) Zero (b) 5 N to left
(c) 6 N to right (d) 11 N to right

Chapter 3
MOTION

1. If an object is moving towards, its acceleration pointed towards.
(a) North (b) East
(c) West (d) May be any direction

2. If the velocity of a body changes it may be termed as:
(a) Instantaneous velocity (b) speed of the body
(c) Magnitude of displacement (d) Deceleration

3. Acceleration is a physical quantity that can be specified completely by:
(a) Both magnitude and direction (b) Only magnitude
(c) Only direction (d) None of the above

4, The shortest distance between two .points in a specific direction is called:
(a) Distance (b) Acceleration
(c) Speed (d) Displacement

5. Change in velocity per unit time same is equal to:
(a) Distance / time (b) displacement / time
(c) Acceleration (d) Force / mass

6. Inertia of a body is measured in terms of
(a) its weight (b) its applied force
(c) its reaction (d) its mass

7. A body moving with constant velocity be:
(a) Changing its direction of motion
(b) in equilibrium
(c) Accelerating (d) Traveling in circle

8. A car is moving with uniform velocity then its acceleration is.
(a) Zero (b) constant (c) Increased (d) Decreased

9. The area between a velocity time graph and the time axis is equal to the
(a) Velocity (b) Distance
(c) Displacement (d) Acceleration

10. Terminal velocity is usually defined as the
(a) Velocity of shock waves (b) Velocity of light in water
(c) Velocity at which air resistance balance gravity
(d) All of the above

11. The laws of motion deal with:
(a) Force and acceleration (b) Width and length
(c) Vertical and horizontal (d) Viscosity and density

12. Swimming is possible on account of:
(a) First law of motion (b) Second law of motion
(c) Third law of motion (d) Newton's law of gravitation

13. The statement "to every action there is always equal and opposite reaction." is the statement of:
(a) Newton's first law (b) Newton's second law
(c) Newton's third law (d) Newton's gravitational fired

14. F = ma, is the mathematical expression of ________.
(a) Newton's 1st law of motion (b) Newton's 2nd law of motion
(c) Newton's 3rd law of motion (d) Newton's law of gravitation.

15. Newton's first law of motion gives definition of.
(a) Force (b) Inertia (c) Both(a) & (b) (d) None

16. During free fall, of air friction is negligible then acceleration of bodies of different masses is:
(a) The same for all the masses (b) Different for different masses
(c) Different for different vertical positions. (d) Both A & B

17. If the resultant force on an object is zero the object will move with:
(a) Constant speed . (b) Constant velocity
(c) Constant deceleration (d) Constant deceleration

18. The force of friction, generated to resist the motion, occurs between connecting media in,
(a) Liquids (b) Solids. (c) Gases (d) All of these

19. The concept of force might, best be described as:
(a) The push or pull
(b) A quantity, tending to change body state of rest or state of motion of a body
(c) Energy in motion
(d) Power transmitted from one place to another

20. Stoke's law holds for
(a) bodies of all shapes (b) Motion through free space
(c) horizontal motion of particles
(d) motion through a viscous medium

21. When the body is stationary
(a) There is no force acting on it
(b) The force acting on it are not in contact each other
(c) The forces acting on it are balanced with it
(d) The body is in vacuum

22. The coefficient of frictional force between two surfaces in contact does NOT depends upon.
    (a) The normal force passing one against the other
    (b) The area of surfaces
    (c) Whether the surfaces are stationary or in relative motion
    (d) whether a lubricant is used or not.
23. The frictional resistance between its various layers of fluids is called
    (a) Viscous drag (b) Viscosity
    (c) Friction (d) Up thrust
24. If there is no external force applied to a system then the total momentum of that system:
    (a) Turn to zero (b) remains constant
    (c) is maximum (d) is minimum
25. If two bodies of equal mass collide elastically then
    (a) their velocities are added to each other
    (b) their velocities are subtracted
    (c) their velocities do not changed
    (d) they exchange their velocities
26. If the rate of change momentum with respect to time is zero then
    (a) The momentum is a function of time
    (b) The momentum is not conserved
    (c) The momentum is constant
    (d) Some force acts
27. If linear momentum of a particle in doubled, its kinetic energy will
    (a) be double (b) be halved
    (c) be quadrupled (d) Remains unchanged
28. A collision in which momentum conserved but K.E is not conserved is called
    (a) Elastic collision (b) In elastic collision
    (c) Both A & B (d) either A or B
29. Momentum of a moving mass is the amount of:
    (a) Energy possessed by body (b) Inertia possessed by a body
    (c) work possessed by a body (d) Motion possessed by a body.
30. The time rate of change of linear momentum of a body is equal to
    (a) The applied torque (b) The applied force
    (c) Impulse (d) None of the above
31. ____________ is also called to quantity of motion:
    (a) Acceleration (b) Momentum (c) Force (d) Energy
32. The net force acting on the body of 10 kg moving with uniform velocity of S^{-1} is:
    (a) 40 N (b) 4 N (c) 4 N (d) zero.
33. The velocity of the body is increase to 100% then linear momentum of the body increase to:
    (a) 50 % (b) 100 % (c) 10 % (d) 35 %

Chapter 4
MOTION AND TWO DIMENSION

1. A. Maximum range attained by a projectile can be found by the formula
   (a) $\frac{V_o Sin\theta}{g}$ (b) $\frac{2V_o Sin\theta}{g}$ (c) $\frac{2V_o^2 Sin2\theta}{g}$ (d) $\frac{2V_o^2 Sin2\theta}{2g}$
2. In the absence of air friction projectile has maximum range when fired at an angle.
   (a) 30° with the horizontal (b) 45° with the vertical
   (c) 30° with the vertical (d) 60° with the horizontal
3. During the projectile motion, the horizontal component of velocity
   (a) Change with time (b) Becomes zero
   (c) Does not change but remains constant.
   (d) Increases with time
4. The maximum height of a projectile is directly proportional to.
   (a) The initial velocity (b) Launch angle
   (c) Square of the initial velocity
   (d) The friction between the tyres of cycle and road vanished.
5. A body is moving in a circle at a constant speed which of the following statements about the body is true?
   (a) There is no acceleration. (b) There is no force acting on it
   (c) There is force acting at a tangent to the circle,
   (d) There is force acting towards the centre of the circle
6. The rate at which a body rotates about an axis expressed
   (a) Velocity (b) Angular acceleration
   (c) Angular momentum (d) None of these
7. The rate of charge of angular displacement is.
   (a) Angular momentum (b) angular acceleration
   (c) Angular velocity. (d) velocity
8. The acceleration in uniform circular motion.
   (a) varies inversely with the velocity of the particle.
   (b) varies inversely with the radius of the orbit.
   (c) varies directly with the square of the velocity.
   (d) is both (b) and (c)
9. If a body is rotating in a circle with variable linear speed, it must have:
   (a) Only centripetal acceleration. (b) Only tangential acceleration
   (c) Both centripetal and tangent acceleration (d) None of these
10. The direction of angular velocity can be find out by ________.
    (a) Left hand rule (b) Angular displacement
    (c) Direction of movement (d) Right hand rule
11. If a particle moves in a circle describing equal angles in equal intervals, then
    (a) Angular velocity change and linear velocity constant.
    (b) Angular velocity constant and linear velocity constant
    (c) Angular velocity constant and linear velocity changes.
    (d) None of these
12. The rate of change of angular displacement with time is called
    (a) Angular acceleration. (b) Linear velocity
    (c) Angular velocity (d) None of these

13. The centripetal acceleration produced in a rotating body is commonly due to the change in ________ of the velocity.
(a) Magnitude. (b) Direction
(c) Value (d) None of these

14. An object is hunched in an arbitrary direction in space with a certain initial velocity and of moves freely under gravity. Its path will be a.
(a) Straight line (b) circle
(c) parabola (d) hyperbola

15. The velocity component with which a projectile covers certain vertical distance is minimum at the moment of
(a) Projection (b) Hitting the ground
(c) Highest point (d) None pf these

16. A projectile has its speed maximum at the moment of
(a) Projection (b) Hitting the ground
(c) Both of these (d) None of these

17. The horizontal range of a projectile depend upon.
(a) The angle of projection (b) The velocity of projection
(c) Both of these (d) None of these

18. If a projectile is projected at an angle of 35°, it hits certain target. It will have the same range if it is projected at an angle of
(a) 45° (b) 55° (c) 90° (d) 70°

19. The linear and angular velocity of a particle, moving about the centre of a circle of radius r, are related by
(a) $\overline{v} = \overline{\omega} \times \overline{r}$ (b) $\overline{v} = \overline{r} \times \overline{\omega}$ (c) $\overline{\omega} = \overline{v} \times \overline{r}$ (d) $\overline{\omega} = \overline{r} \times \overline{v}$

20. A ball is thrown at 40 m/s with the angle of projection of 30° with the horizontal, the vertical velocity, of the projectile after 1 sec.
(a) A. 20 m/s (b) 15 m/s (c) 10 m/s (d) Zero

21. A car moving at a constant speed of 20 ms^{-1} on a circular path of radius 100m what is the acceleration?
(a) 0.4 ms^2 (b) 6 sec (c) 4.0 ms^3 (d) 33 ms^2

22. The missile is fired at 20 m/s at 60° with respect to the horizontal, the horizontal and vertical component of the velocity at the maximum height is respectively :
(a) 10 m/s, 10 m/s (b) 10 m/s, 5 m/s
(c) 10 m/s, 0 (d) 0, 10 m/s

23. A 100 kg body is rotating in circular path of radius 200m, at 50 m/sec. find the centripetal force acting on the body.
(a) 225 N (b) 125 N (c) 525 N (d) 500 N

24. If a body covers 5 rotations in 2 seconds, around a path of radius 2m the linear velocity of body is
(a) π m/s (b) 10 π m/s (c) 5 πm/s (d) 20 π m/s

25. The angular speed of an hour's hand of a watch in radian / minute is
(a) $\pi/6$ (b) $\pi/30$ (c) $\pi/180$ (d) $\pi/360$

Chapter 5

TORQUE ANGULAR MOMENTUM AND EQUILIBRIUM

1. Torque is synonymous of:
   (a) A. Angular speed (b) Angular momentum
   (c) Moment of inertia (d) Moment of force
2. The rate of change of angular momentum is called.
   (a) Force (b) Torque (c) Momentum (d) Alt of these
3. The product of force and moment am is equal to the magnitude
   (a) Momentum (b) Torque
   (c) centripetal force (d) Angular momentum
4. Torque is zero, if angle θ between force and momentum arm is
   (a) 0° (b) 60° (c) C. 90° (d) 180°
5. The motion of the body can describe by the motion of it's
   (a) Center of gravity (b) Origin
   (c) Center of mass (d) None of these
6. If a body is rotating clock-wise direction, the torque:
   (a) Positive (b) Negative (c) Maximum (d) Minimum
7. The two forces constitute couple are.
   (a) Equal in magnitude (b) Opposite in direction
   (c) Not acting along the same line (d) All of these
8. The centre of gravity of a body of irregular shape lies:
   (a) At its centre (b) At its intersection of medians
   (c) At the intersection of diagonals
   (d) At the surface of the body
9. The point at which whole weight of the body is concentrated is called
   (a) Centre of mass (b) Centre of gravity
   (c) Origin (d) Centre of action
10. Torque equals to:
    (a) Mass xf acceleration (b) Force x momentum arm
    (c) Force x centre of gravity (d) Mass x mass arm
11. Physical quantity not directly involved in rotational motion is:
    (a) Moment of inertia (b) Mass
    (c) Angular velocity (d) Torque
12. The centre of mass coincides with centre of gravity of body, if it is placed
    (a) In a non-uniform gravitation field.
    (b) In a uniform gravitation field
    (c) At the centre of earth (d) At the poles
13. The magnitude of the angular momentum is given by:
    (a) A. 1 =m sin θ (b) i = rp/sin θ
    (c) L = rp sin θ (d) only A & B
14. The angular momentum of a particle is conserved it the net torque is
    (a) Infinity (b) Zero
    (c) Constant (d) None of these
15. If the not torque acting on a body is zero then the ___ of the body is conserved.
    (a) Force (b). Liner momentum
    (c) Torque (d) Angular momentum

16. According to law of conservation of angular momentum.
(a) $\overline{\Gamma} = dl$ (b) $\overline{\Gamma} = dt/dl$ (c) $\overline{\Gamma} = dt x dl$; (d) $\overline{\Gamma} = dl/dt$.

17. A body acted is said to be in equilibrium when it:
(a) Move with a variable velocity
(b) Moves with a uniform velocity
(c) Moves very fast in space (d) Moves very slow in space

18. A body is said to be in ______ if it is at rest or is moving with uniform velocity.
(a) Period motion (b) Rotator motion
(c) Arbitrary motion (d) Equilibrium

19. A body will be in translation equilibrium if the vector sum of external forces acting on a body is
(a) Maximum (b) Minimum (c) Square (d) Zero

20. If the axis of rotation passes through the body itself. the corresponding rotator motion is called the:
(a) Spin –motion (b) Orbital motion
(c) vibratory motion (d) To-and for motion

21. The object in equilibrium may not have any:
(a) force acting (b) Acceleration
(c) velocity (d) Torque acting upon it

Chapter 6
GRAVITATION

1. The force of attraction acts along the.
(a) axis of rotation.
(b) Line joining the interacting bodies.
(c) Line perpendicular to the interacting (d) None of these

2. The range through which the gravitation force acts is:
(a) Limited to 1×10^{-10} m (b) Limited to 1×10^{-2} m
(c) Extremely long (d) About 1×10^{6} m

3. According to the law of universal Gravitation.
(a) Every body in the universes attracts every body.
(b) The force of attraction is directly proportional to the product of their masses
(c) The force of attraction is inversely proportional to the squire of their distance.
(d) All of the above

4. Force of gravitational attraction of earth on other bodies is given by:
(a) $F = G\dfrac{M_E m}{R_E^2}$ (b) $F = G\dfrac{M_1 m}{G}$
(c) $F = R_1^2\dfrac{M_1 m}{G}$ (d) $F = R_1^2\dfrac{M_1 m}{m}$

5. The force of attraction or repulsion between two bodies is:
(a) Inversely proportional to the distance
(b) Directly proportional to the distance
(c) Inversely proportional to the square of the distance
(d) None of the above

7. The acceleration due to gravity on moon is $1/6^{th}$ of that on earth, what will be the mass of the body on moon, if its mass on earth is m:
   (a) m/6 (b) 6 m (c) m (d) m/3
8. The value of 'g' at the centre of earth is:
   (a) Maximum (b) Minimum (c) Zero (d) None of them
9. The value of g at a certain height above the earth is;
   (a) nearly the same as an the surface of earth.
   (b) Nearly the same as an the center of earth.
   (c) Estimated to decreases with altitude.
   (d) Estimated to depend on the variation of the earth radius.
10. The value of 'g' is maximum at.
   (a) Centre of the earth. (b) poles of the earth
   (c) Equator of the earth. (d) Surface of the earth
11. If the mass of the earth becomes four times large, the value of g will
   (a) remain unchanged (b) Becomes four times larger
   (c) Be double (d) sixteen times larger
12. The value of 'g' is maximum
   (a) At the surface of earth
   (b) An infinite distance from the earth (d) Below the surface of earth
   (c) At the centre of earth
13. When a lift is moving upward with a uniform velocity, the apparent weight of a body inside the lift will be,
   (a) Equal to its actual weight (b) Less than the actual weight
   (c) More than the actual weight (d) Zero
14. The source of electric energy in an artificial satellite is:
   (a) A mini nuclear reactor (b) A dynamo
   (c) A thermo pile (d) Solar cells
15. Artificial gravity can be created in the space craft by:
   (a) Revolving it around the earth
   (b) Spinning it around its own axis (d) decreasing its velocity
   (c) Increasing its velocity

Chapter 7
WORK, POWER AND ENERGY

1. The example of negative work is:
   (a) Work done under a conservative force
   (b) Work done perpendicular to a conservation force
   (c) Work done against friction,
   (d) Work done against gravity
2. The work done by centripetal force is:
   (a) Equal to that of centrifugal force.
   (b) Greater than that of centrifugal force
   (c) Variable in different cases. (d) Zero
3. Work is defined as
   (a) Scalar product of force and displacement.
   (b) Vector product of force and displacement
   (c) Scalar product of force and velocity
   (d) Vector product of force and velocity

4. The work done on a body under going a certain displacement is given by:
   (a) The area under a force vs. time curve
   (b) The area under a force vs. distance curve
   (c) The area under a velocity vs time curve
   (d) The area under an acceleration vs time curve
5. Work is always done in a body when
   (a) A force action on it
   (b) It covers some displacement.
   (c) Force moves it in its direction or in opposite directions
   (d) The resultant force on its is zero.
6. The work given to the machine is called:
   (a) Input (b) Output
   (c) Velocity ratio (d) Mechanical advantage
7. All of them are true accept:
   (a) Work is defined as the product of force and distance.
   (b) Joule is the unit of work.
   (c) Force moves in its direction or in opposite directions.
   (d) The resultant force on it is zero.
8. Work done will be zero when force and displacement are
   (a) In the same direction (b) In opposite direction
   (c) Perpendicular to each other (d) Not zero
9. The energy due the motion of a mass is known as.
   (a) A. Potential energy (b) Motion energy
   (c) Mobile energy (d) Kinetic energy
10. The amount of work required to stop a moving object is equal to the:
   (a) Velocity of the object (b) Kinetic energy of the object
   (c) Mass of the object times its acceleration
   (d) Mass of the object times its velocity
11. Power is the dot product of.
   (a) Mass & velocity (b) Force & velocity
   (c) Force & Energy (d) Force & mass
12. The sum of kinetic and potential energies of a falling body
   (a) Is constant at all points. (b) Is maximum in the beging
   (c) Is minimum in the beginning
   (d) Is maximum in the middle of the path
13. Potential energy is increased when the work is done,
   (a) Along the field (b) Against the field
   (c) By the field
   (d) All of the above in different cases
14. If the velocity of the moving particle is double the factor by, which the K. E is increased is.
   (a) 4 (b) ½ (c) 2 (d) 6
15. The heat energy is transferred to a body, it is converted into:
   (a) Internal energy of the body (b) work done by the body
   (c) Mass of the molecules
   (d) Potential energy of the body
16. The tidal energy is due to:
   (a) The rotation of earth about sun
   (b) The rotation of earth relative moon
   (c) The radio active decay inside earth
   (d) Attraction of sun and moon

17. Energy is:
(a) Work divided by time
(b) The ability to do work
(c) Measurable in Horse Power
(d) Force divided by distance

18. The work done in moving a object along a vector = 3i + 2j – 5k. If the applied force is F = 2i – j – k:
(a) 10j
(b) 6i – 2j – 5k
(c) 0j
(d) 9j

19. The power required to lift a 40 kg. weight up to the height of 5 m in 10 sec will be
(a) 80 watts
(b) 200 watts
(c) 28 watts
(d) 14000 watts

20. The K. E of a 1000 kg car moving at a speed of 80 km/hr will be.
(a) 2.47×10^8 J
(b) 2.47×10^5 J
(c) 24.7×10^7 J
(d) 24.7×10^8 J

Chapter 8 - A

WAVE MOTION AND SOUND

1. The oscillatory motion in which the instantaneous acceleration is proportional to the displacement of the displacement of the oscillating bodies is called
(a) Elastic motion
(b) Translating motion
(c) Transverse motion
(d) Harmonic motion

2. Total energy of a particle performing SHM is directly proportional to:
(a) The amplitude
(b) The square root of amplitude
(c) Square of amplitude
(d) The reciprocal of amplitude

3. When a particle is executing SHM it is found that
(a) The frequency depends upon the amplitude
(b) The periods depend on the amplitude.
(c) The period and frequency depend upon the amplitude
(d) The period and frequency are independent of the amplitude.

4. When a stone is thrown in water, any circle draw with its centre as the stone is a.
(a) Longitudinal wave
(b) Stationary wave
(c) Circular wave
(d) Wave front

5. Which one of the following undergoing a simple harmonic motion?
(a) Motion of a pendulum
(b) vibration of a violen string
(c) Motion of body in a rectilinear
(d) Oscillation of mass on a string

6. Mechanical wave are produced disturbance in
(a) Vacuum
(b) Space
(c) Materiel
(d). No of these

7. If a second pendulum is taken up on the moon, in order to have its time period same:
(a) The length of the pendulum must be increased
(b) The length of the pendulum must be decreases
(c) The length of the pendulum must be kept the same
(d) None of the above

8. An ordinary clock loses time in summer this is because
   (a) The length of the pendulum increases
   (b) The length of the pendulum decreases
   (c) The length of the pendulum decreases and time period increases.
   (d) The length the pendulum decreases and time period increases.
9. Which is the true for gamma - rays?
   (a) They move with half the speed of light.
   (b) They are stopped by a thick sheet of paper.
   (c) The have no mass
   (d) The can not pass through a sheet of Aluminum.
10. Which one of the following contains a pair of transverse and longitudinal wave?
   (a) Radio & X - rays (b) Infra - red & ultra- violet
   (c) Sound & radio wave (d) Wave in a ripple tank & light
11. The velocity of a particle moving with a frequency 'f' and wave length 'λ' is:
   (a) $f\lambda$ (b) f/λ (c) λ/f (d) $\lambda^2 f$
12. The one which has the longest wave length in the following is?
   (a) Red light (b) X - rays
   (c) Infra – red (d) radio waves
13. Which of the following has the shortest wavelength?
   (a) Gamma rays (b) Ultraviolet
   (c) Microwaves (d) Radio waves
14. All the points on a wave front, formed by throw a stone in water will:
   (a) Be in the same phase
   (b) Have the same phase & displacement
   (c) Have the same displacement only
   (d) None of these
15. It is common characteristics of all types of wave motion that without the transport of particles.
   (a) Particles (b) Down
   (c) Energy transferred (d) Mass decrease
16. The wave length of a radio wave when transmitted as a frequency of 150 MHz, will be :
   (a) 20 m (b) 2 m (c) 10 m (d) 0.75 m
17. A simple pendulum completes one vibration in one second. If g = 981 sm/s² its length will be:
   (a) 24.8 m (b) 24.8 (c) 2.48 cm (d) 2.48 cm
18. When two waves traveling through the same medium arrive at the same medium arrive at the same point 180° out of phase, they give rise to.
   (a) Polarization (b) Destructive
   (c) Diffraction (d) Constructive interferes
19. When a string which is tied at both the ends is plucked from the centre the wave produced is:
   (a) Transverse wave (b) Longitudinal wave
   (c) Standing wave (d) Electromagnetic wave
20. The wave phenomenon that definitely classifies light as a transverse wave is.
   (a) Polarization (b) Diffraction
   (c) Interference (d) Scattering of electrons

21. Which of the following is not a transverse waves?
(a) x-rays (b) sound (c) γ-rays (d) infrared

22. The distance between adjacent nodes or antinodes is.
(a) λ (b) λ/2 (c) λ/4 (d) 2λ

23. Transverse waves can propagate:
(a) Both in gas and a metal (b) In a gas but not in metal
(c) not in gas but in a metal (d) neither in any of these

24. The travelling wave in which particle of the disturbed medium move perpendicular to the direction of propagation of the wave is called.
(a) Longitudinal wave (b) transverse wave
(c) Standing wave (d) stationery wave

25. The direction travel by the transverse wave to the direction of the associated disturbance will be
(a) parallel (b) Angular
(c) Perpendicular (d) Opposite

26. In a stretched string, if the length and speed of the wave is double, the tension will be ____ times the original.
(a) 2 (b) 4 (c) 8 (d) 6

27. Frequency of a stretched string is proportional to the
(a) Tension (b) linear density
(c) reciprocal of the length (d) Square of the tension

28. For a stationary wave in a string the points at which the particle is at maximum displacement from the mean position are called.
(a) nodes (b) anti nodes
(c) compression (d) rare friction

29. A string fixed at two ends vibrates in two whole segment. The standing wave pattern set up is called.
(a) First overtone (b) Second overtone
(c) Fundamental (d) Second harmonics

30. When a wave is reflected from rigid support, the phase change will be equal to.
(a) λ/2 (b) λ (c) λ/4 (d) 2λ

Chapter 8 - B
WAVE MOTION AND SOUND

1. Sound waves are
(a) Transverse waves (b) Electro-magnetic waves
(c) Longitudinal wave (d) Standing waves

2. The difference between a noise and a musical note is that a noise is:
(a) Louder (b) Of higher pitch
(c) Louder and usually lower pitch
(d) Formed by irregular vib

3. Which of the following properties of sound is affected by change
(a) Frequency (b) Amplitude
(c) Wave length (d). Intensity

4. The bodies travel at velocities greater than velocity of sound in air are called.
(a) Ultrasonic (b) Infrasonic
(c) Supersonic (d) Revelberator

5. Two sounds of the same frequency in air must have the same
   (a) amplitude (b) intensity
   (c) loudness (d) Wavelength
6. In order to emit sound a body must.
   (a) Absorb sound waves (b) Vibrate
   (c) Reflect sound waves (d) Move towards the hearer
7. Which of the following phenomenon cannot take place with sound wave:
   (a) refection (b) Interference
   (c) diffraction (d) polarization
8. Velocity of sound in a gas is proportional to:
   (a) square root of proportional elasticity
   (b) adiabatic elasticity
   (c) square root of adiabatic elasticity
   (d) Isothermal elasticity
9. Which of the following factor(s) effect(s) the velocity of sound in air?
   1. Frequency of the source 2. Loudness of the sound
   3. The temperature of the air.
   (a) 1 only (b) 2 only
   (c) 3 only (d) 1 and 3 only
10. Presence of moisture in air.
    (a) increases the velocity of sound
    (b) decreases the velocity of sound
    (c) may increases or decreases the velocity
    (d) does not have any effect
11. Speed of sound at 0º in the air is:
    (a) 33.13 m/s (b) 3.313 m/s (c) 331.3 m/s (d) 3313 cm/s
12. The speed of sound in a compressible medium which has a bulk modulus B, and density p,
    (a) $p = \sqrt{B/P}$ (b) $V = \sqrt{B}/P$ (c) $P = \sqrt{P/B}$ (d) $V = \sqrt{P}/B$
13. Space of sound is _______ speed of light
    (a) greater then (b) les than (c) equal to
    (d) nothing can be said
14. In which of the following is the speed of sound greatest?
    (a) Air (b) Water (c) Vacuum (d) Steel
15. The velocity of sound in air is not affected by changes in the;
    (a) Moisture content of the air (b) Temperature of the air
    (c) Atmospheric pressure (d) Compression of the air
16. Which one of the following is correct?
    (a) The louder the sound, the greater is the amplitude.
    (b) The louder the-sound, the greater is the velocity
    (c) The louder the sound, the greater is the frequency
    (d) The louder the sound, greater is the wavelength
17. The intensity level of faintest audible sound is:
    (a) 0 db (b) 10 bd (c) 20 bd (d) 20 db
18. The term loudness of a sound is most intimately with the:
    (a) Wave amplitude (b) wave intensity
    (c) intensity level of the sound (d) sound pitch
19. Pitch is a sensation produced by sound that depends upon its:
    (a) velocity (b) intensity (c) amplitude (d) Frequency

20. The pitch of the sound depends on its
(a) Frequency (b) Speed (c) Amplitude (d) Period

21. The sweetness or harshness of a sound depends on its.
(a) Wavelength (b) Frequency (c) Wave amplitude (d) Irregularity

22. The human ear is most sensitive sound in the frequency range from.
(a) 2 to 4 hertz (b) 20 to 40 hertz
(c) 200 to 400 hertz (d) 2000 to 4000/hertz

23. The term which bears the same relationship to light as pitch bears to sound.
(a) Wave length (b) Frequency (c) Colour (d) Shade.

24. The study of generation production and propagation sound is called:
(a) Photometry (b) Acoustics (c) Mechanics (d) Series

25. Quality is the difference in sounds having.
(a) Same pitch (b) Same loudness
(c) Different natural frequencies (d) All of the above.

26. Number of beats produced is equal to:
(a) Difference of frequencies of superimposing waves.
(b) Sum of frequencies of superimposing waves.
(c) Product of frequencies of superimposing waves.
(d) Ratio of frequencies of superimposing waves.

27. If the two sound waves produced beats, it is necessary that the two have
(a) The same frequencies (b) Slightly different frequencies
(c) Slightly different amplitudes (d) The same time period

28. Beats are the result of:
(a) Diffraction (b) constructive interference
(c) Constructive and destructive interference (d) None of these

29. The sound waves give rise to the phenomenon of beats due to their,
(a) Reflection (b) Refraction
(c) Interference (d) Polarization

30. At the end of the open pipe
(a) Always a node is produced
(b) Always an antinode is produced
(c) Both can be produced (d) none of the above

31. If a body is set to be in resonance with another body its natural frequency must be:
(a) half of that of the other body
(b) vibrates in greatest amplitude
(c) Double of that of the other body
(d) equal to that of the other body

32. A regiment of soldiers is crossing a suspension bridge. They are ordered to:
(a) A. March in steps (b) Break the Steps
(c) Twist their bodies (d) Lie flat and craw!

33. Listener moves towards stationary source. Pitch of sound heard.
(a) Increases (b) Decreases (c) Remains constant (d) zero

34. Doppler's move measures the change in ________ of wave due to the relative motion of source & observer.
(a) Intensity (b) Frequency (c) Velocity (d) Energy

35. Mark the false statement
(a) Doppler effect is used in measuring the speed of automobile
(b) Doppler effect provides a method for tracking satellite
(c) Each proton has total energy E = hv (where h = plank's, v = frequency of the electromagnetic field's)
(d) X - rays are electromagnetic waves with long wavelength.

Chapter 9
NATURE OF LIGHT

1. The wave theory of light was proposed by.
(a) Galileo (b) Huygens (c) Kepler (d) Hewton
2. Electromagnetic theory of light was proposed by;
(a) Faraday (b) Maxwell (c) Ampere (d) De
3. Yellow light of a single wavelength can't be:
(a) Reflected (b) Refracted (c) Dispersed (d) Red
4. The characteristic property of light wave which does not vary with the medium is:
(a) Frequency (b) Amplitude (c) Velocity (d) Wave
5. When light is incident on a substance it can be:
(a) Absorbed (b) Reflected
(c) Transmitted (d) All of above
6. Color of light is determined by its.
(a) Frequency (b) Amplitude
(c) Speed (d) Wavelength
7. A monochromatic red light appears to be.
(a) Blue (b) Red (c) Black (d) White
8. The locus of all points in the same phase of vibration is:
(a) Wave front (b) interference
(c) diffraction (d) polarization
9. Huygens theory of light says that light consists of:
(a) Wave fronts (b) Discrete particle
(c) Photons (d) dual nature
10. A thin layer of oil on the surface of water looks coloured due to:
(a) Polansation of light.
(b) different elements presenting the oil
(c) Interference of light (d) The transmission of light
11. In Newton's rings experiment the piano convex lens used should be of.
(a) Small focal length (b) Large focal length
(c) Neither of the two (d) None of the above
12. In Newton's rings seen throughout reflected light:
(a) The central spot is dark (b) The central spot is dark
(c) Both of above (d) None of the above
13. The phenomenon of interference comeout because wave obey:
(a) The impulse moment theorem
(b) The 1^{st} law of thermodynamics
(c) The inverse square law
(d) The principle of superposition

14. The air between the lens and glass plak the in Newton's rings experiment is replaced by water. The ring pattern.
(a) Contracts (b) Expands
(c) Remains the same (d) None of the above

15. Newton's ring are produced by.
(a) A lighted cigarette falling non uniform acceleration.
(b) A lighted cigarette subject force of several g's interference of light
(c) Interference of light (d) Polarization of light

16. Which of the following phenomenon produce the colors in soap bubble?
(a) Interference (b) Polarization (c) Diffraction (d) Dispersion

17. The path difference in destructive interference must be:
(a) $d = 0, 2\lambda, 3\lambda$ (b) $d = \lambda/2, 3\lambda/2, 5\lambda/2$
(c) $d = 0, \lambda/6, 3\lambda/6, 5\lambda/6$ (d) $d = 0, 3\lambda/4, 5\lambda/4$

18. One condition for interference is that the two sources should be coherent and.
(a) Close together (b) at a far off distance
(c) Opposite to each other (d) Coinciding

19. Width of the interference fringes in young's double slit experiment increase
(a) Slit separation (b) Wave length
(c) order of the fringes (d) frequency of the source

20. The property which enables waves to bend around the edge of an opening or obstacle in its path is called:
(a) Dispersion (b) Diffraction
(c) Super position (d) interference

21. Which of the following are types of diffraction?
(a) Interfering and non interfering
(b) Transparent – semi transparent
(c) Fresnel - Fraun hoffer diffraction
(d) Gratingy- element attraction

22. Diffraction when source and screen are very near the slit then diffraction is said to be ________ diffraction.
(a) Fresnel (b) Fraunhoffer
(c) Maxwell (d) Huygens

23. Which of the following is used to plane polarize light?
(a) A sheet with small opening (b) A thick glass sheet
(c) A plano-convex lens (d) A paper sheet

Chapter 10
GEOMETRICL OPTICS

1. When light passes from air to glass it:
(a) Bends towards the normal without changing speed.
(b) Bends towards the normal and slows down
(c) Bends towards the normal and speed up
(d) Bends away from the normal and slows down

2. The refractive index is.
   (a) Directly proportional to the wave length of light.
   (b) Inversely proportional to the wave length of light
   (c) Directly proportional to the square of the wave length of light
   (d) Inversely proportional to the square of the wave length of light.
3. When light enters from a rarer to a denser medium its
   (a) Velocity increases (b) Wave length increases
   (c) Its velocity remains same (d) Its frequency remains same
4. Light from the sun reaches us in nearly
   (a) 8 min (b) 16 min (c) 8 sec (d) 16 sec
5. A lens that is thicker at the edge thin it is in the middle is:
   (a) Converging lens (b) Diverging lens
   (c) Angular lens (d) Plain lens
6. The sign convention for virtual images is:
   (a) Positive (b) Negative
   (c) Sometimes positive and sometimes – Negative
   (d) All of these
7. "Mirage" is based on the phenomenon of.
   (a) Reflection (b) Diffraction (c) Refraction
   (d) Total internal reflection
8. In a convex lens when the object lies at infinity, the image formed is:
   (a) Real (b) Inverted (c) Extremely small in size
   (d) All of the above
9. Image formed by a concave lens is:
   (a) Real, inverted magnified
   (b) Virtual , erect, magnified
   (c) Virtual, erect, diminished.
   (d) Real, erect, diminished
10. Two convex lens of same focal length 'F' are placed in contact: The focal length of this lens combination is
   (a) F (b) 2F (c) F/2 (d) F/4
11. Power of a lens is equal to
   (a) Focal length in meters (b) Reciprocal of focal length
   (c) Dobbin of focal length (d) Half of focal length
12. The poorer or converging lens is.
   (a) Positive (b) Negative
   (c) Natural (d) None of these
13. The focal length of a lens depends upon.
   (a) The radius of curvature of its surface
   (b) The material of the lens
   (c) The refractive index of the medium in which it placed.
   (d) All of these
14. A terrestrial telescope can be made by adding an erecting lens to a
   (a) Prism spectroscope (b) Reflecting telescope
   (c) Field telescope- (d) Astronautically telescope
15. In an astronomical telescope objective is a:
   (a) Concave lens of large focal length
   (b) Convex lens of large focal length
   (c) Concave lens of small focal length.
   (d) Convex lens of small focal length.

16. The length of a simple astronomical telescope is:
   (a) The difference of the focal length of two lenses.
   (b) The sum of the focal length of two lenses.
   (c) Half the sum of the focal length
   (d) Equal to the focal length of the objective lens

17. A Galilean telescope consists of.
   (a) A converging objective and a converging eye-piece
   (b) A converging objective and a diverging eye piece
   (c) A diverging objective and a diverging eye piece
   (d) A diverging objective and a converging eye-piece

18. The magnifying power of a compound microscope is given by (where f_1 = focal length of objective f_2= focal length of eyepiece)
   (a) $M = L/f_2(d/f_2 + 1)$ (b) $M = Lf_2(d/f_2 + 1)$
   (c) Both have the same meaning (d) None of the above

19. In compound microscope, normally the intermediate image is.
   (a) Virtual erect and magnified (b) Virtual erect enlarged
   (c) Real inverted enlarged (d) Virtual inverted and enlarged

20. How can the spherical aberration be, corrected.
   (a) By using a Plano-convex lens (b) By using a cylindrical lens
   (c) By using a thin les (d) All of the above

21. The final image of Astronomical telescope is:
   (a) Real erect enlarged (b) Virtual erect enlarged
   (c) Real inverted enlarged (d) Virtual inverted enlarged

22. The refraction of different wavelength of light at different angles through a convex lens produce a defected called.
   (a) Astigmatism (b) Chromatic aberration
   (c) Spherical aberration (d) Short sightedness

23. In a compound microscope the lenses used are.
   (a) Objective of Small focal length and eye-piece of large focal length
   (b) Objective of small focal length and eye-piece of small focal length
   (c) Objective of large focal length and eye-piece of small focal length
   (d) Objective of large focal length and eye-piece of large focal length

24. Chromatic aberration can be removed by combining.
   (a) A convex lens and concave lens of same type of glass.
   (b) Two convex lenses or different types of glass
   (c) Two concave lenses of different types of glass.
   (d) A concave lens of one type of glass and a convex lens of another types of glass

25. Long sightedness can be cured by.
   (a) Convex lens (b) Concave lens
   (c) Cylindrical lens (d) Bifocal lens

26. The fact that energy point on any advancing wave front may be considered as a source of secondary wave which move forward s spherical wavelets is a principle attributed to,
   (a) Faraday (b) Michelson (c) Huygen (d) Galileo

PHYSICS NO

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Chapte
1 d 11 d 21 a

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1 d 11 a 21 c 31 d

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1 b 11 b

ANSWER:

Chapter 1

1	2	3	4	5	6	7	8	9	10
d	b	d	d	a	c	d	c	D	a
11	12	13	14	15	16	17	18	19	20
d	d	d	A	c	b	a	a	B	b
21	22	23	24	25	26	27			
a	c	a	c	b	a	c			

Chapter 2

1	2	3	4	5	6	7	8	9	10
d	d	a	d	c	c	a	a	c	a
11	12	13	14	15	16	17	18	19	20
a	d	d	b	b	d	c	c	C	c
21	22	23	24	25	26	27	28	29	30
c	d	b	a	d	b	c	c	B	b
31	32	33							
d	c	c							

Chapter 3

1	2	3	4	5	6	7	8	9	10
d	d	a	d	c	d	b	a	c	c
11	12	13	14	15	16	17	18	19	20
a	c	c	b	c	a	b	d	B	d
21	22	23	24	25	26	27	28	29	30
c	b	b	b	d	c	c	b	Ds	b
31	32	33							
b	d	b							

Chapter 4

1	2	3	4	5	6	7	8	9	10
c	b	c	c	d	d	c	d	c	d
11	12	13	14	15	16	17	18	19	20
c	c	b	c	c	c	d	b	b	c
21	22	23	24	25					
c	C	b	b	d					

Chapter 5

1	2	3	4	5	6	7	8	9	10
d	B	b	a	c	b	d	b	b	b
11	12	13	14	15	16	17	18	19	20
b	B	d	b	d	d	b	d	d	a
21									
b									

Chapter 6

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

Chapter 7

1	2	3	4	5	6	7	8	9	10
c	D	a	b	c	a	d	c	d	b
11	12	13	14	15	16	17	18	19	20
b	A	b	a	a	d	b	d	b	B

Chapter 8 -A

1	2	3	4	5	6	7	8	9	10
d	C	d	d	c	c	b	a	c	c
11	12	13	14	15	16	17	18	19	20
a	D	a	a	c	b	b	b	c	a
21	22	23	24	25	26	27	28	29	30
b	B	c	b	c	c	b	d	b	b

Chapter 8 - B

1	2	3	4	5	6	7	8	9	10
c	D	b	c	c	d	b	d	c	a
11	12	13	14	15	16	17	18	19	20
c	A	b	d	c	a	a	c	d	a
21	22	23	24	25	26	27	28	29	30
b	d	b	b	d	a	b	c	c	b
31	32	33	34	35					
d	b	a	b	d					

Chapter 9

1	2	3	4	5	6	7	8	9	10
b	B	c	a	d	a	b	a	a	c
11	12	13	14	15	16	17	18	19	20
b	b	d	a	c	a	b	a	b	b
21	22	23							
c	a	a							

Chapter 10

1	2	3	4	5	6	7	8	9	10
b	B	d	d	b	b	d	d	c	c
11	12	13	14	15	16	17	18	19	20
b	a	d	d	b	b	b	a	d	d
21	22	23	24	25	26	27	28	29	30
d	b	a	d	a	c	b	d	b	c
31	32	33	34	35					
b	b	c	a	c					

CHAPTER # 1
THE SCOPE OF PHYSICS

IMPORTANT QUESTIONS & ANSWERS

Q1(a) What is science?
(b) Also write down the names of main branches of Science.

Ans. *(a)* ***Definition of Science:-***
"Science is the name of identification, description, experimental investigation and theoretical explanation of natural phenomena."

(b) ***Branches of Science:-***
The subject science is classified into two main branches.
i. The Physical Sciences and
ii. The Biology Science

Q2 Define
(i) Physical Sciences
(ii) Biological science

Ans. (i) The Physical Sciences:-
"It is concerned with the properties and behavior of non-living matter". It is divided into "Physics, Astronomy and Chemistry".

(ii) The Biological Sciences:-
"it deals with the living things. It is divided into Botany and Zoology".

Q3. Give an account of different branches of Physics.

Ans. Physics is divided into several branches such as:

(i) Atomic Physics (ii) Nuclear Physics (iii) Plasma Physics
(iv) Astro Physics (v) Bio Physics (vi) Solid Stale Physics

These are defined as follows:

i. ***Atomic Physics:***
It is concerned with the structure and properties of atoms.

ii. ***Nuclear Physics:***
It is concerned with the structure, properties and reaction between the nuclei of Atoms.

iii. ***Plasma Physics:***
It is concerned with the properties of highly ionized atoms forming in a mixture of bare nuclei and electron called ion plasma.

iv. ***Astro Physics:***
It is concerned with the application of modern physics, to the problems of astronomy.

v. ***Bio Physics:***
It is concerned with the application of physical methods and types of explanation to bio-physical systems and structures.

vi. ***Solid Stale Physics:***
It is concerned with the properties of crystalline materials.

Q4. Write down the names of some Muslim scientists.

Ans. The names of some Muslim scientists are given below:

(i) Abu Ali Hasan Ibn – al – Haitham (ii) Al-Beruni
(iii) Yaqub Kindi (iv) M. Bin Moosa Khawarzmi
(v) Dr. Abdul Salam (iv) Dr. Abdul Qadeer Khan

Q5. Briefly describe the contribution of Muslim Scientists.

Ans. The contribution of Muslim scientists described as follows:

(i) Al – Khawarzmi:-
He was the founder of Analytical Algebra. His important achievement was the Hisab – ul – Jabr – wal – Muqabla. He also invented the term logarithm.

(ii) Ibn – al – Haitham: -
He was a great Physicist. He wrote many books. His masterpiece work was the book named "K.itab – ul – Manazir" on optics. He developed the laws of reflection and refraction. He also constructed pinhole camera.

(iii) Al - Razi:-
He wrote about two hundred (200) original monographs, half of which pertained medicine.

(iv) Abu - Rehan Al - Beruni:-
He was the most famous scholar of golden age of Islam. He wrote more than one hundred and fifty books on such subjects as Mathematics, Physics, History, Geography etc. He discussed the measurement of earth the shape of earth, the movement of sun and moon. One of his famous books was Qanoon – ul –Masoodi. He also determined the density of metals.

(v) Yaqoob Kindi:-
He worked on metrology, specific gravity and on tides, but his most important work was done in the field of optics, especially on reflection of light.

(vi) Ibn – e – Sina:-
He worked a lot in medicine. He also wrote Al – Shifa an Encyclopedia of Philosophy.

(vii) Dr. Abdus Salam:-
He established International center for theoretical Physics at Trieste. He was awarded Noble prize in Physics in 1979 for his work on Grand Unification Theory (GUT).

(viii) Dr. Abdul Qadeer Khan:-
He established nuclear research Laboratory at Kahuta, where a large number of Pakistani scientists are engaged in research work, in the field of nuclear Physics.

Q6. What are different systems of units? Defined them.

Ans. Systems of Units:

There are different systems of units, which are defined as follows:

i. MKS system (meter, Kg, second sy stem)
ii. CGS system (cm, gm, second system)
iii. FPS system (ft, pound, second system)
iv. S.I. Units (international system of Units)

i. **M.K.S System:-**
In M.K.S system, the fundamental units of length, mass and time are meter, kilogram and second respectively.

ii. **C.G.S. System:-**
In CGS system, the fundamental units of length, mass and time are taken as
centimetre, gram and second respectively.

iii. **F.P.S. System:-**
In FPS system, the unit of force, length and time are chosen as the fundamental units. In it, the unit of mass is derived unit. The unit of force, length and time are pound, foot and second respectively.

iv. **S.I units:-**
The SI units are derived from the earlier M.K.S system. It was introduced in 1960 and is now in use all over the world. The S.I units unlike three basic units of the F.P.S, the C.G.S and the M.K.S system comprise seven basic units. These are

S.No.	Quantity	S.I Units
1.	Length	Metre (m)
2.	Mass	Kilogram (kg)
3.	Time	Second (s)
4.	Electric Current	Ampere (A)
5.	Temperature	Kelvin (k)
6.	Amount of Substance	Mole (mol)
7.	Luminous Intensity	Candela (cd)

Q7. What are Derived Unite?

Ans. Derived Unite:-
The units of other Physical quantities derived from the fundamental units are known as Derived units".

Example:-

i. The unit of speed or velocity is m/s.
ii. The unit of force is Newton.

Q8. What do you understand by dimension?

Ans. Dimensions:-
Dimensions of a quantity represent the physical nature of quantity. Dimensions of quantities can be expressed as some combination by dimension of fundamental quantities. Length, mass & time is taken as fundamental quantities. Dimensions of fundamental quantities are L, M & T respectively.

Example:-

S. No.	Quantity	Dimensions
1.	Area	L^2
2.	Acceleration	LT^2
3.	Force	MLT^{-2}
4.	Work	ML^2T^{-2}

CHAPTER # 2
SCALARS AND VECTORS
IMPORTANT QUESTIONS & ANSWERS

Q1. Define scalars and vectors with five examples of each?

Ans. Scalars:

"Those Physical quantities, which are specific only by magnitude having appropriate units are called scalar quantities or simply called SCALARS".

Representation:-

Scalars are represented by an ordinary number (positive, negative or zero). These numbers are known as magnitude of scalars. They are denoted by letters in ordinary type. They do not require any mention of direction for their specification and representation.

Required Methods:-

Scalars are added, subtracted, multiplied and divided by ordinary arithmetical rules.

Example:-

Temperature, length, speed, time, density, mass, etc are the examples of scalars.

Vectors:-

"Those Physical quantities which are specified by magnitude and as well as direction with appropriate units are called vector quantities or simply called vector".

Representation:-

A vector is represented by putting a line segment or an arrow head over the appropriate symbol. They are denoted by bold faced letters with an arrow, i.e. $\vec{A}$, $\vec{B}$ and their magnitudes are denoted by $|\vec{A}|$ or A and $|\vec{B}|$ or B respectively.

Required Methods:-

Vectors are added by two different rules i.e. head to tail rule and the second method is addition of vector by rectangular component method.

Example :-

Displacement, velocity, acceleration, force, moment of force are all vectors

Q2. Differentiate between scalars and vectors.

Ans.

S. No	Scalars	Vectors
1.	Definition:	Definition:
	Those Physical quantities, which are specified only by magnitude with out any direction are called	Those Physical quantities, which are specified by magnitude and direction are called vectors.

S. No	Scalars	Vectors
2.	Representation:	Representation:
	Scalars are represented by an ordinary no. & are denoted by letters in ordinary type.	Vectors are represented by putting a line segment or an arrow-head over the appropriate symbol.
3.	Example:	Example:
	Mass, time, length, temperature, volume etc.	Force, velocity, acceleration, displacement etc.
4.	Required Methods:	Required Methods:
	Scalars are added subtracted, multiplied & divided by ordinary arithmetical rules.	Vectors may not be added, subtracted, multiplied and divided by ordinary arithmetical rules.

Q3. Define unit vector and also write its formula:

Ans. **Definition:**

"A vector; whose magnitude is unity, i. e (A = 1) in any given direction is called unit vector"

Consider a vector 'A', whose unit vector is represented by 'a'.

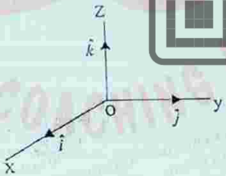
The unit vector '$\vec{a}$' can be obtained by dividing the vector b its magnitude, i.e

$$\hat{a} = \frac{\vec{A}}{A}$$

Q4. Define rectangular unit vectors;

Ans. Rectangular unit vectors is the set of vector, which have the directions of the positive x,y and z axes of a three; dimensional rectangular co-ordinate system.

These are denoted by $\hat{i}, \hat{j}$ and $\hat{k}$ respectively, it can be shown by the following figure.



Q5. How-do you find the magnitude of a resultant vector in a three of a resultant vector in a three dimensional rectangular co-ordinate system?

Ans. Consider a vector 'A' with its initial points placed at the origin of a rectangular co –ordinate system. The rectangular components of the vector '$\vec{A}$' along positive x, y, & z axes are 'Ax', 'Ay' & 'Az' respectively. By adding the rectangular components such as

Ax Ay and Az we get the original vector $\vec{A}$. i.e

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

and the magnitude of the resultant vector ' $\vec{A}$ ' is given by

$$A = \sqrt{(A.i)^2 + (A.j)^2 + (A.k)^2}$$

But $i^2 = j^2 = k^2 = 1$

Therefore:-

$$A = \sqrt{Ax^2 + Ay^2 + Az^2}$$

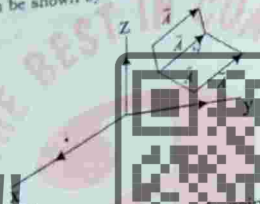
Q6. Define free vector and position vector.

Ans. Free Vector:-

A vector which can be displaced parallel to itself & applied at any point, is known as Free vector.

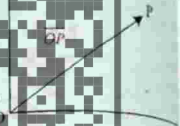
Example 1:

The velocity of a body undergoing uniform translational motion. Free vector can be shown by the following figure



Position Vector:

"A vector, which determines the position of a point relative to the fixed point is called position vector" Consider a fixed reference point 'O' and specify the position of a given point 'P' with respect to the point 'O' by means of vector having magnitude and direction represented by a directed line segment OP. This can be shown by the following figure.



Q7. What do you know about Null vector?

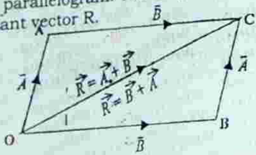
Ans. Null Vector:

"If two vectors are identical in magnitude and opposite in direction, then the difference vector is called Null or ZERO vectors". The null vector has zero magnitude and has no direction or it may have any direction.

Q8. Proof the commutative and associative laws of vector addition.

Ans. Commutative Law of Vector Addition:

Consider a parallelogram. OACB. Let the two vectors $\vec{A}$ and $\vec{B}$ represent the adjacent sides of the parallelogram. The diagonal OC of the parallelogram represents the resultant vector R.



From fig,

$$\vec{A} + \vec{B} = \vec{R} \quad \text{and}$$
$$\vec{B} + \vec{A} = \vec{R}$$

Therefore

$$\vec{A} + \vec{B} = \vec{B} + \vec{A}$$

This is known as commutative law

Associative Law of Vector Addition:-

Consider the following figure in which $\overline{OP}$ represents the vector $\vec{A}$, $\overline{PQ}$ represents vector $\vec{B}$, $\overline{QS}$ represents the vector $\vec{C}$ and $\overline{OS}$ represents the vector $\vec{R}$.

From the ΔOQS, in which $\overline{OQ}$ represents the resultant $\vec{A} + \vec{B}$, which is obtained by using "head to tail" rule.

Thus,

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

Similarly in ΔOPS, the line PS, represents the resultant $\vec{B} + \vec{C}$.

Thus

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

Therefore,

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

This is known as associative law of vector addition.

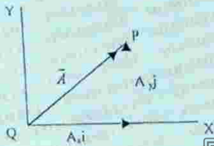
Q9. Define and explain resolution of vector.

Ans. Definition:

"The process of splitting a vector into its components is called resolution of vector".

Explanation:-

A vector can be resolved into a number of components, but generally a vector is resolved into two components at right angle to each other, i.e. the components along x-axis is called x-components or horizontal components & the components along y-axis is called y-component or vertical components. Such components are called rectangular components. Consider a vector ' $\vec{A}$ ', whose initial point is placed at the origin of two dimensional co-ordinate system, is making an angle 'Q' which the x-axis.



From the terminal points 'P' of the vector draw two perpendiculars on X-axis and y-axis From figure the resultant vector ' $\vec{A}$ ' can be obtained by using Head-To-Tail rule, i.e.

$$\vec{A} = \vec{A}x + \vec{A}y$$

The vector A may also be written in terms of its components and rectangular unit vector, such as $\vec{A} = A_x\, i + A_y\, j$

Magnitudes of Rectangular Components:

By using the trigonometric ratios, the magnitudes of horizontal & vertical components can be obtained, i.e

$$A_x = A \cos\theta$$

And

$$A_y = A \sin\theta$$

Magnitude of The Resultant Vector:

From the Pythagorous theorem, we can easily get the magnitude of resultant vector '$\vec{A}$'.

i.e.

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

Direction:

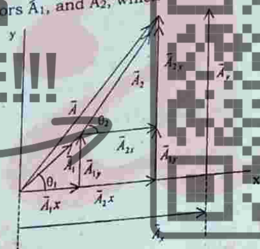
Direction can be find out by the following formula

$$\theta = \tan^{-1}\frac{A_y}{A_x}$$

Where 'θ' gives the direction of the vector w.r.t. the positive x-axis measured counter clock wise.

Q10. Explain addition of vector by rectangular components method:

Ans. Consider two vectors $\vec{A}_1$, and $\vec{A}_2$, which are making angles 'θ_1' and 'θ_2' with the positive x-axis.



When $\vec{A}_1$ and $\vec{A}_2$ are added by head-to-tail rule, then we obtain the resultant vector $\vec{A}$.

Now resolve the vector $\vec{A}$ into its components $\vec{A}_{1x}$ and $\vec{A}_{1y}$. The magnitudes of these components are as follows.

$$A_{1x} = A_1 \cos\theta_1$$

And

$$A_{1y} = A_1 \sin\theta_1$$

Similarly the vector, $\vec{A}_2$ is also resolved into its components $\vec{A}_{2x}$ & $\vec{A}_{2y}$, and their magnitudes areas follows:

$$A_{2x} = A_2 \cos\theta_2$$

And

$$A_{2y} = A_2 \sin\theta_2$$

The sum of the component vectors along x-axis is equal to the x-components of resultant vector.

$$\vec{A}_x = \vec{A}_{1x} + \vec{A}_{2x}$$

or

$$\vec{A}_x = (A_{1x} + A_{2x})i$$

Similarly the sum of the component vectors along y-axis is

$$\vec{A}_y = \vec{A}_{1y} + \vec{A}_{2y}$$

or

$$\vec{A}_y = (A_{1y} + A_{2y})\hat{j}$$

Now the sum of the magnitudes of x-components is equal to the magnitude of the x-components of resultant vector, i.e.

$$A_x = A_{1x} + A_{2x}$$
$$A_x = A_1 \cos\theta_1 + A_1 \cos\theta_1$$

Similarly the sum of the magnitudes of y-components is

$$A_y = A_{1y} + A_{2y}$$
$$A_y = A_1 \cos\theta_1 + A_2 \cos\theta_2$$

The magnitudes of the resultant vector is obtained as

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

$$A = \sqrt{(A_1\cos\theta_1 + A_2\cos\theta_2)^2 + (A_1\sin\theta_1 + A_2\sin\theta_2)^2}$$

The direction of the resultant vector is

$$\theta = \tan^{-1}\frac{A_y}{A_x}$$

Q11. Define scalar product or dot product:

Ans. "If two vector are multiplied and their product is a scalar, then the product is called scalar product or Dot Product".

Or

In other words, the scalar product of two vectors A and B is defined as:
"The product of magnitudes of two vectors and the cosine of the angle between them is called scalar product or Dot product".

<u>Mathematical Expression:-</u>

Consider two vectors $\vec{A}$ and $\vec{B}$ having angle θ between them, then their product is mathematically expressed as

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

Where the quantity 'AB cos θ' is a scalar, therefore this product is called scalar product and is also called dot product of two vectors A and $\vec{B}$.

Q12. Write down the characteristics of dot product?

Ans. <u>Characteristics of dot product:</u>

If the vectors $\vec{A}$ and $\vec{B}$ are parallel i.e. θ = 0, then

$$\because \cos\theta = 1$$
$$\vec{A}.\vec{B} = A\,B\cos\theta$$
$$= AB\cos(0)$$
$$= AB(1)$$
$$\vec{A}.\vec{B} = A\,B\cos\theta$$

If $\vec{A} = \vec{B}$, i.e. $\vec{A}$ is parallel and equal to $\vec{B}$ ($\theta = 0^o$), then

$$\vec{A}.\vec{B} = A\,B\cos\theta$$
$$\vec{A}.\vec{A} = A\,A\cos(0)$$
$$\vec{A}.\vec{B} = A^2\,(1)$$
$$\vec{A}.\vec{B} = A^2$$

If $\vec{A}$ & $\vec{B}$ are perpendicular to each other i.e. $\theta = 90°$ or any one of the two vectors is a null vector then.

$$\vec{A}.\vec{B} = A\,B\cos\theta \qquad \because \cos 90 = 0$$
$$= AB\cos 90$$
$$\vec{A}.\vec{B} = A\,B\,(0)$$
$$\vec{A}.\vec{B} = 0$$

If the unit vectors $\hat{i}, \hat{j}$ and $\hat{k}$ are perpendicular to each other, then.

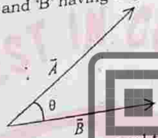
$$i.i = j.j = k.k = 1$$
$$i.j = j.k = k.i = 0$$

Q13. Explain the commutative and distributive law for dot product:

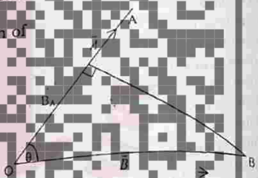
Ans. Commutative law for dot product:

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

Consider two vectors $\vec{A}$ and $\vec{B}$ having angle 'θ' between them.

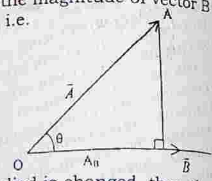


The dot product of vectors A and B is equal to the magnitude of vector A times projection of vector B onto the direction of vector A , i.e



$$\vec{A}.\vec{B} = AB_A$$
$$\vec{A}.\vec{B} = AB\cos\theta \qquad \text{(I)}$$

Also the dot product of vectors $\vec{B}$ and $\vec{A}$ is equal to the magnitude of vector B times projection of $\vec{A}$ onto the direction of vector B, i.e.



$$\vec{B}.\vec{A} = BA_B$$
$$\vec{B}.\vec{A} = BA\cos\theta$$
$$\vec{B}.\vec{A} = AB\cos\theta \qquad \text{(2)}$$

On comparing equation (I) and (2), we get

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

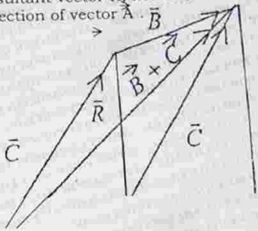
This means that, if the order of vectors to be multiplied is changed, then there is no effect on the scalar product of two vectors. Hence scalar product obeys commutative law for dot product.

Distributive law for dot product:-

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

To prove the distributive law for dot product, we consider three vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$. First obtain the resultant vector R by applying head to tail rule on vector $\vec{B}$ and $\vec{C}$.

Then draw the projection of vector $\vec{C}$, i.e. OC_A from the terminal point of vector $\vec{C}$ and the projection of the resultant vector $\vec{R}$, i.e. OR_A from the terminal point of vector $(\vec{B} + \vec{C})$ onto the direction of vector $\vec{A}$.



Now taking L. H. S of the distributive law. The dot product $\vec{A} \cdot (\vec{B} + \vec{C})$ is equal to the product of magnitude $\vec{A}$ of the vector $\vec{A}$ and the projection of the vector $(\vec{B} + \vec{C})$ on to the direction of vector $\vec{A}$.

$$\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{R}$$
$$\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A}\,(ORA)$$

But from figure,

$$\vec{A} \cdot (\vec{B} + \vec{C}) = A[C_AR_A + OC_A]$$
$$\vec{A} \cdot (\vec{B} + \vec{C}) = A\,[C_AR_A] + A[OC_A]$$

Where C_AR_A = projection of vector $\vec{B}$ onto the direction of vector $\vec{A}$

$$C_AR_A = B_A$$

And

OCA = projection of vector $\vec{C}$ onto the direction of vector $\vec{A}$.

$$OC_A = C_A$$

Therefore, from the above explanation the equation (I) becomes,

$$\vec{A} \cdot (\vec{B} + \vec{C}) = AB_A + AC_A$$

Or

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

Hence we have proved the distributive law for dot product.

Q14. Define cross or vector product and also show that:

$$\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$$

Ans. Definition:-

"If two vectors are multiplied mid their resultant product is vector then the product is called vector product or cross product."

Mathematical Expression:-

Consider two vectors $\vec{A}$ and $\vec{B}$ and the product of these two vectors is denoted by $\vec{A} \times \vec{B}$, that's why it is read as $\vec{A}$ cross $\vec{B}$ and the product of these two vectors gives a new vector C. Mathematically it can be expressed as:

$$\vec{A} \times \vec{B} = \vec{C}$$

Magnitude of vector C:

The magnitude of vector C is given by

$$|\vec{A} \times \vec{B}| = A\,B \sin\theta = |\vec{C}|$$

Or

$$C = AB \sin\theta$$

Were 'θ 'is the smaller angle between positive direction of $\vec{A}$ and $\vec{B}$.

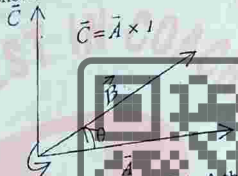
Proof:

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

The vector $\vec{C}$ represents the cross or vector product of A and B it is perpendicular to the plane containing A and B and the point in the direction in such a way as to make A , B and C a right handed system. We generalize the definition.

$$C = A \times B = [AB \sin\theta]\ \hat{u} \quad \text{———} \quad (i)$$

Where $\hat{u}$ is the unit vector, perpendicular to the plane containing A and B and the point in the direction in which right handed screw advances when it is rotated from A to B, as shown in the following figure.

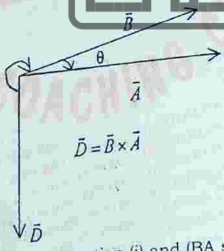


Similarly a right handed screw is rotated from B to A then the unit vector will be $(-\hat{u})$

$$\vec{D} = \vec{B} \times \vec{A} = [BA \sin\theta]\ (\hat{u})$$

or $\vec{D} = \vec{B} \times A = -[BA \sin\theta](\hat{u})$

or $\vec{D} = -\vec{B} \times A = [BA \sin\theta](-\hat{u})$ ——— (ii)



Since the quantities (AB sin θ) in equation (i) and (BA sin θ) in equation (ii), being the magnitudes are equal, therefore on comparing equation (i) and (ii) we get,

$$\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$$

The above expression shows that the vector product is not commutative.

Characteristics of Cross Product:

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

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

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

(iv) If $\vec{A} \neq 0$, $\vec{B} \neq 0$ and $\vec{A} \times \vec{B} = 0$
then $\vec{A}$ and $\vec{B}$ are parallel

(v) $\hat{i} \times \hat{i} = 0$

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

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

(vi) $\hat{i} \times \hat{j} = \hat{k}$ or $\hat{j} \times \hat{i} = \hat{k}$

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

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

(vii) If $\vec{A} = A_1 i + A_2 j + A_3 k$
$\vec{B} = B_1 i + B_2 j + B_3 k$

Then the cross product of A and $\vec{B}$ is

$$A \times B = \begin{vmatrix} i & j & k \\ A_1 & A_2 & A_3 \\ B_1 & B_2 & B_3 \end{vmatrix}$$

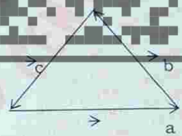
$$= i \begin{vmatrix} A_2 & A_3 \\ B_2 & B_3 \end{vmatrix} - j \begin{vmatrix} A_1 & A_3 \\ B_1 & B_3 \end{vmatrix} + k \begin{vmatrix} A_1 & A_2 \\ B_1 & B_2 \end{vmatrix}$$

$$= (A_2 B_3 - A_3 B_2)\, i - (A_1 B_3 - A_3 B_1)\, j + (A_1 B_2 - A_2 B_1)\, k$$

Q15. Using the definition of vector product, prove the law of sines for plane triangles of Sides a, b and c. $\frac{SinA}{a} = \frac{SinB}{b} = \frac{SinC}{c}$

Ans. **Proof:-**

Consider a triangle ABC



Area of the triangle:

$$\Delta = \frac{1}{2}\left(\vec{a} \times \vec{b}\right)$$

$$\Delta = \frac{1}{2} ab SinC \quad \text{\_\_\_\_\_\_\_\_\_\_ (1)}$$

$$\Delta = \frac{1}{2}\left(\vec{b} \times \vec{c}\right)$$

$$\Delta = \frac{1}{2} bc SinA \quad \text{\_\_\_\_\_\_\_\_\_\_ (2)}$$

$$\Delta = \frac{1}{2}\left(\vec{c} \times \vec{a}\right)$$

$$\Delta = \frac{1}{2} caSinB \quad \text{———— (3)}$$

Now comparing equation (1) and (2)

$$\frac{1}{2} abSinC = \frac{1}{2} bcSinA$$

c Sin A = a Sin C

$$\frac{SinA}{a} = \frac{SinC}{c} \quad \text{———— (4)}$$

Comparing equation (2) and (3)

$$\frac{1}{2} bcSinA = \frac{1}{2} caSinB$$

b Sin A = a Sin B

$$\frac{SinA}{a} = \frac{SinB}{b} \quad \text{———— (5)}$$

Comparing equation (1) and (3)

$$\frac{1}{2} abSinC = \frac{1}{2} caSinB$$

b Sin C = c Sin B

$$\frac{SinC}{c} = \frac{SinB}{b} \quad \text{———— (6)}$$

From eq (4), (5) and (6), we get

$$\frac{SinA}{a} = \frac{SinB}{b} = \frac{SinC}{c}$$

This is known as law of sines.

CHAPTER # 3
MOTION
IMPORTANT QUESTIONS & ANSWERS

Q1. Define displacement?

Ans. Definition:

"The change of position of a body in a particular direction is Displacement". Displacement is a vector, because if a body moves from a position A to position B, its motion from A to B determines the direction of motion. In other words displacement defined as

"The distance covered by a body in specific direction is called Displacement". Displacement is usually represented by 'S'.

Units:

1. In M. K. S system, it is measured in metre (m).
2. In C.G.S system, it is measured in centimetre (cm).

Q2. Define velocity and explain the types of velocity,
(a) Uniform Velocity (b) Variable Velocity (c) Instantaneous Velocity

Ans. Velocity:

Definition:

"The rate of change of displacement is called velocity".

Or

"The distance covered by a body with respect to time in a specified direction is called velocity.

Or

"The speed of a body in a particular direction is called velocity".

Velocity is a vector, because it has direction. It is denoted by $\vec{V}$.

Mathematical expression:

Mathematically, velocity can be expressed as

$$\text{Velocity} = \frac{\textit{Displacement}}{\textit{time}}$$

$$V = \frac{\Delta\vec{r}}{\Delta t}$$

Where, $\Delta\vec{r}$ = change of displacement

$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$

Δt = change in time

This velocity is called average velocity. Hence it may also be written as

$$V_{av} = \frac{\Delta\vec{r}}{\Delta t}$$

Units:

1. In M.K.S system, its unit is metre per second and written as m/s or $m.s^{-1}$.
2. In C.G.S system, its unit is centimetre per second and written as cm/s or $cm\ s^{-1}$.

Types of Velocity:

The types of velocity are defined as follows:

(a) Uniform Velocity:

Definition:

"The velocity of a body is said to be uniform, if it covers equal distances in equal intervals of time in a specified direction".

(b) Variable Velocity:

Definition:-

"A body is said to possess a variable velocity, if its speed or its direction changes continuously".

Or in words it can be defined as:

"The body does not cover equal distances in equal intervals of time, in a specified direction, then it is said to move with variable velocity".

(c) Instantaneous Velocity:

Definition:-

"The velocity of a body measured for a very small interval of time is called instantaneous velocity".

Mathematical Expression:-

If the time is very small such that

$\Delta t \to 0$

$$\vec{V}_{ins} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t}$$

When the average and instantaneous velocities are equal, then the body is said to move with uniform velocity.

(d) Graphical determination of uniform and Variable (non-uniform) velocities:

When we plot the displacement (s) of a moving body from some fixed point against the time (t), a displacement time graph of the motion of the body is obtained.

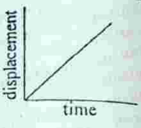
One must note the following points about the displacement time graph.

i. If the slope of the graph is constant for different points on the curve, it means that the velocity is constant. That is the body is moving with uniform velocity.

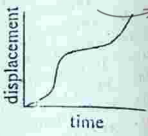
ii. If the slope of the curve is different for different points on the curve it means that the body is moving with variable velocity.

iii. If the slope of the curve is zero, then it means that the body is at rest.

iv. If a body is moving with uniform velocity, then its displacement time graph is a straight line as shown in figure.



v. If a body is, not moving with uniform velocity then its displacement-time graph is not a straight line, it is curved as shown in figure. Note that it may take any shape depending upon the situation.



Q3. Define acceleration and explain different types of acceleration.
(a) Uniform Acceleration, (b) Variable Acceleration
(c) Instantaneous Acceleration.

Ans. Acceleration:

Definition;

"The rate of change of velocity is called acceleration".

When the velocity of a body changes, then the body possess acceleration. The change in velocity may be due to the change in its magnitude or direction. Acceleration is a vector. It is denoted by $\vec{a}$ because it has direction. If the velocity of a body is increased, then the acceleration is positive and if the velocity is decreased, that the acceleration is negative acceleration is called Retardation or Deceleration.

Mathematical Expression:

Mathematically it can be expressed as: change in velocity

$$acceleration = \frac{change \ \ in \ \ velocity}{time}$$

$$\vec{a} = \frac{\Delta \vec{V}}{\Delta t}$$

$$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{t_2 - t_1}$$

Units:-

i. In M.K.S system, its units is meter per second square and it is written as m/sec^2 or ms^{-2}.

ii. In C.G.S system, its unit is centimeter per second square and it is written as cm/sec^2 or $cm.s^{-2}$.

Types of Acceleration:

They types are defined as follows:

(a) Uniform Acceleration:

Definition:-

"If the velocity of a body moving along a straight line changes uniformly in equal intervals of time, however short the interval may be, the acceleration so produced is called Uniform Acceleration".

(b) Variable Acceleration:

Definition:-

"If the velocity of a body does not change equally in equal interval of time, then the acceleration produced is called Variable Acceleration".

(c) Instantaneous Acceleration:

Definition-

"The acceleration of a body measured for a very short interval of time, and then this acceleration is called Instantaneous Acceleration".

In the limits of a very small Δr the average acceleration will approach the value of instantaneous acceleration. It is denoted by $\vec{a}_{ins}$.

Mathematical Expression:-

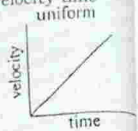
Mathematically it can be expressed as

$$\vec{a}_{av} = \lim_{\Delta t \to 0} \frac{\Delta \vec{V}}{t}$$

Where $\overrightarrow{\Delta V}$ is the change in velocity.

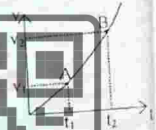
(d) Graphical determination of uniform and variable (non-uniform) acceleration:

If a body is moving with uniform acceleration, then its velocity-time graph is as shown in figure.



The figure shows that the slope of the velocity-time graph is positive and constant. It means that the velocity is increasing at a uniform rate. That is, rate of change of velocity is constant. In other words, the body is moving with uniform acceleration then the value of this acceleration is equal to the slope of the curve.

If a body is not moving with uniform acceleration, then its velocity-time graph is as shown in figure.



This figure shows that the slope of its velocity-time graph will be different at different points. It may take any shape depending upon the situation.

Q4. State and explain Newton's law o f motion?

Ans. Issac Newton studied motion of bodies and formulated the following three important laws of motion.

1. Newton's first law of motion.
2. Newton's second law of motion.
3. Newton's third law of motion.

1. Newton's first law Motion:

Introduction:

In this law Newton explain the two important definitions first is the force & the second one is inertia.

Statement:

"A body remains at rest or continues to move with uniform velocity unless it is acted upon by an unbalanced force".

Explanation:

From the statement of Newton's first law of motion, we draw the following conclusion that. That law consists of two parts; the first part states that a body cannot change its state of rest or of uniform motion in a straight line unless it is acted upon by some unbalanced force to change its state.

Example:

This law can also be explained with the help of following examples:

i. A book lying on a table will remain there forever in the same position unless someone comes and removes it.

ii. A bullet is fired from a gun. Its motion is opposed both by air resistance and the pull of earth. If the pull of the earth and the air resistance could be eliminated, the bullet could go on moving in a straight line for ever.

The second part of this law gives us the qualitative definition of the net force, which is stated as follows:
"Force is an agent, which produces or tends to produce a change in the state of rest or of uniform motion of an object, i.e. produces the acceleration in the body".

First Law of Motion is also called Law of Inertia:
First law of motion is also called law of inertia, because it points towards a very important property of matter. This is called INERTIA.

Definition of Inertia:
"Inertia is that properly of matter by virtue of which if it is in state of rest or motion it tries to remain in that state".
Or simply it is defined as:
"Inertia is the tendency of an object resists a change in its state".
Experiments show that the inertia of an object is directly proportional to the mass of the object, i.e. the greater the mass of an object, greater will be the inertia.

2. **Newton's second law of motion.**

Introduction:-
In this law of motion Newton provide a means for the quantitative measurement of force as well as mass.

Statement:
"When a force acts on an object, it produces an acceleration in its own direction, which is directly proportional to the magnitude of the force and inversely proportional to the mass of the object".

Explanation:
If we push a body harder, it moves faster. Its velocity changes in the direction of the force exerted. From such experiences it is established that when a force acts upon a body, the acceleration produced is directly proportional to the force symbolically it can be expressed as:

$$F \propto a$$

Or $$F = ma$$

Where "F" is a (vector) sum of all the forces acting on the body, and "m" is the mass of the mathematical expression of Newton's second law of motion. It can be written as:

$$\vec{a} = \frac{\vec{F}}{m}$$

The above equation explains that the acceleration is directly proportional to the resultant force acting on a body and the direction of acceleration is same as that of the force and the acceleration is inversely proportional to the mass of the body.

3. Newton's second law of motion.

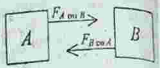
Introduction:

In this law Newton explain the action and reaction of the force. It is stated as follows.

Statement:

"To every action, there is an equal and opposite reaction".

Explanation:



When a body "A" exerts a force on another body "B", it is called the action of force "A" on "B". The body "B" will also exerts a force on body "A", which will be equal in magnitude, but opposite in direction. This force is called the reaction of "B" on "A".

The force of body "A" on body "B" is written as $\vec{F}_{AB}$ and the force of body "B" on the body "A" is written as $\vec{F}_{BA}$, which be equal in magnitude, but opposite in direction and these force lie on the line joining the two bodies. Symbolically, it can be expressed as

$$\vec{F}_{action} = -\vec{F}_{reaction}$$

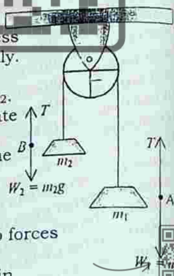
$$\vec{F}_{A\,on\,B} = \vec{F}_{B\,on\,A}$$

Where negative sign shows that the two forces are acting in opposite direction.

Q5. Two bodies of unequal masses are attached to the two ends of a string which passes over a friction less pulley. If the bodies are moving vertically, find the expression for the tension in the string and the acceleration of the system.

Ans. when both the bodies move vertically:

Consider two bodies of unequal masses "m_1" and "m_2" which are connected by a string, passes over a frictionless pulley as shown in figure. Both the bodies move vertically.



Let m_1 be the greater mass as compound to the mass m_2. Hence body A have greater mass i.e. "m_1" it will accelerate in downward direction with an acceleration "a" and the body B due to less mass "m_2" will move up with the same acceleration.

Let "T" be the tension in the string.

Let us first consider the motion of body A. There are two forces acting on the body A,

i. The weight of the body $W_1 = m_1g$, which is acting in downward direction.

ii. The tension "T" in the string, which is acting in upward direction.

Since the body A moves downward, therefore the weight of body A is greater than the tension. Thus the net force F, which moving downward with an acceleration "a" is given by

$$F = W_1 - T$$

Or

$$F = m_1g - T$$

But according to Newton's second law of motion, the net force is m_1a. Thus the equation of motion for body A is

$$m_1a = m_1g - T \quad \text{\_\_\_\_\_\_ (i)}$$

Now consider the motion of body B. There are also two forces acting on the body B.

1. Weight of the body W_2 and
2. The tension T in the string.

Since the body B is moving upward therefore the net force F which is moving the body upward is

$$F = T - W_2$$

Or

$$F = T - m_2g$$

Similarly the force on body B by the application of Newton's second law of motion is m_2g,

Thus the equation of motion for body B is

$$m_2a = T - m_2g \quad \text{\_\_\_\_\_\_ (ii)}$$

Calculation of Acceleration:

To calculate the acceleration "a" adding equation (i) & (ii), we get

$$m_1a = m_1g - T$$

$$m_2a = T - m_2g$$

$$m_1a + m_2a = m_1g - m_2g$$

$$a(m_1 + m_2) = g(m_1 + m_2)$$

$$\boxed{a = \frac{(m_1 + m_2)g}{(m_1 + m_2)}}$$

Calculation of Tension:

Tension in the string can be calculated by dividing equation (i) & (ii).

$$\frac{m_1a}{m_2a} = \frac{m_1g - T}{T - m_2g}$$

$$\frac{m_1}{m_2} = \frac{m_1g - T}{T - m_2g}$$

By cross multiplication we get

$$m_1(T - m_2g) = m_2(m_1g - T)$$

$$m_1T - m_1m_2g = m_1m_2g - m_2T$$

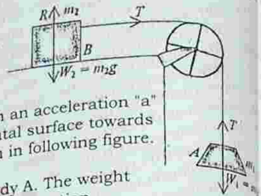
$$m_1T + m_2T = m_1m_2g + m_1m_2g$$

$$T(m_1 + m_2) = 2\,m_1m_2g$$

$$T = \left[\frac{2m_1m_2}{m_1 + m_2}\right]g$$

Q6. Two bodies of unequal masses are attached to the ends of a string passing over a pulley; in such away that the body A moves vertically and the body B moves on a horizontal surface. Find the expression for the tension in the string and the acceleration.

Ans. **<u>When one body moves vertically and other moves on a smooth horizontal surface:</u>**



Consider two bodies A and B of masses m_1 and m_2 respectively, which are attached to the ends of a string passes over a frictionless pulley.

The body A moves vertically downward with an acceleration "a" and the body B moves on a smooth horizontal surface towards the pulley with same acceleration as shown in following figure.

Let us first consider the motion of body A. The weight

i. There are two forces acting on the body A. The weight $W_1 = m_1g$, which is acting in downward direction.

ii. The tension T is the string, which is acting in upward direction.

Since the body A moves downward, therefore the weight of body A is greater than the tension. Thus the net force "F" which is moving the body A downward with an acceleration "a" is given by

$$F = W_1 - T$$

Or

$$F = m_1g - T$$

But according to Newton's second law of motion, the net force is m_1a.

Thus the equation of motion for body A is $m_1a = m_1g - T$ ——— 1

Now consider the motion of body B. There are three forces acting on it.

i. The tension 'T' in the string which acts horizontally towards the pulley.

ii. The weight $W_2 = m_2g$, which acts vertically downward.

iii. The reaction "R" of the smooth horizontal surface on the body B, acts vertically upward.

Since there is no motion of body "B" in vertical direction, hence the two forces i.e. the weight of the body and the reaction of the surface are equal and opposite. Therefore they cancel each other.

Now consider the horizontal motion of body 'B'. If we neglect the force of friction, then the horizontal force, which pulls the block towards pulley, is the tension Tin the string. Thus the equation of motion for body B, by applying Newton's second law of motion is

$$F = T$$

$$m_2a = T \quad \text{——— 2}$$

<u>Calculation of Acceleration:</u>

To obtain the value of acceleration, add equation (1) and (2)

$$m_1a = m_2g - T$$

$$m_2a = T$$

$$m_1a + m_2a = m_1g$$

$$a(m_1 + m_1) = m_1g$$

$$a = \left[\frac{m_1}{m_1 + m_2}\right]g$$

Calculation of Tension:-

To obtain the expression for tension, put the value of 'a' in equation (2)

$$T = m_2 a$$

$$T = m_2\left[\frac{m_1}{m_1 + m_2}\right]g$$

$$\mathbf{T} = \left[\frac{m_1 m_2}{m_1 + m_2}\right]g$$

Q7. Write down the equations of a uniformly accelerated rectilinear motion. Which is the most common example of a uniformly accelerated motion? "What is the free fall method?

Ans. Equation of a Uniformly Accelerated Rectilinear Motion:

If a body is moving with constant acceleration 'a', its initial velocity is "V_i" after time "t" it covers the distance "S" and its final velocity will be "V_f". Then the motion of the body is governed by the following equations.

1. $V_f = V_i + at$
2. $S = V_i t + \frac{1}{2} at^2$
3. $2aS = V_f^2 - V_i^2$

Example of a Uniformly Accelerated Motion:

The most common example of motion with nearly constant acceleration is that of a body falling towards the earth. This acceleration is due to pull of the earth (gravity), which is known as acceleration due to gravity and is denoted by "g". Its unit is meter per second square (m/s^2). Its value 9.8 m/s^2 in S. I. units.

Free Fall Method:

If the body moves towards earth, neglecting resistance and small changes in the acceleration with altitude. This body is referred to as free falling body and the motion is called Free Fall.

Equations for Free Fail Motion:-

Replacing acceleration "a" by acceleration due to gravity "g", the equations of motion become

1. $V_f = V_i + gt$
2. $S = V_i t + \frac{1}{2} gt^2$
3. $2gS = V_f^2 - V_i^2$

Q8. (a) Define momentum. Also write down its unit.
(b) Derive the unit of momentum.

Ans. (a) Define momentum:

"The quantity of motion, which increases with the increase of mass and as well as of velocity and decreases with the decreases of mass as well as of velocity is called momentum".

Or

in other words, It can be defined as:

"A moving body having greater velocity has a greater quantity of motion than the body having lesser velocity. This quantity of motion is called momentum".

Mathematical Expression:-

Mathematically it can be expressed as

Momentum = mass x velocity

Unit:

In S. I. system, its unit is N - s.

(b) Derivation of the Unit of Momentum:

As momentum is the product of mass and velocity, so its unit is derived as follows. Momentum = mass x velocity

$= kg \times m/s$

Divide and multiply the above expression by second (s).

$$= kg \times \frac{m}{s} \times \frac{s}{s}$$

$$= kg \times \frac{m}{s^2} \times s$$

since $kg \times \frac{m}{s^2} = N$

Therefore the unit of momentum is N—s.

Q9. State and explain law of conservation of momentum.

Ans. Law of Conservation of Momentum:

Statement:

"The momentum of an isolated system always remains constant".

Or in other words.

"If there is no external force applied to a system, then the total momentum of that system remains constant".

Explanation:

Consider a system consisting of two bodies A and B of masses m_1 and m_2 respectively. These are moving in a straight line, with velocities u_1 and u_2 before collision. On colliding with each other, their final velocities will be v_1 and v_2 respectively. Thus the total momentum of system before collision.

$= m_1u_1 + m_2u_2$

And the total momentum of the system after collision.

$= m_1v_1 + m_2v_2$

When the two bodies collide with other, they come in contact for a time interval 't'. According to Newton's third law of motion, if body A exerts a force on body B, then the body B also exerts a force on body A but in opposite direction. The average force acting on body B is also equal to the rate of change of its momentum during the time interval 't' i.e. it is equal to.

$$\frac{m_2v_2 - m_2u_2}{t}$$

Similarly the average force acting upon the body, A is.

$$\frac{m_1v_1 - m_1u_1}{t}$$

As these forces fire oppositely directed therefore

$$\frac{m_2v_2 - m_2u_2}{t} = -\frac{m_1v_1 - m_1u_1}{t}$$

$$m_2v_2 - m_2u_2 = -m_1v_1 + m_1u_1$$

$$m_2v_2 + m_1v_1 = m_1u_1 + m_2u_2$$

OR $$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

The above expression can be explained in words as:
Total momentum of the system before collision = Total momentum of the system after collision

This is known as law of conservation of momentum-. Thus the above equation shows that the total momentum of the system before and after collision is the same. The mutual action and reaction of the bodies of an isolated system are unable to change the momentum of the system, i.e. the momentum of the system is conserved.

Q10. Define Elastic and Inelastic collision.

Ans. **Elastic Collision:**

"An elastic collision is that in which, the momentum of the system as well as the kinetic, energy of the system before and after collision is conserved, i.e. remains same".

Inelastic collision:

"In inelastic collision, the momentum of the system before and after collision is conserved, but the kinetic energy before and after collision changes, i.e. the total kinetic energy does not remain constant".

Q11. Two bodies having different masses and moving with different velocities have an elastic collision in one dimension. Calculate their final velocities after collision. What will happen if

i. The masses of the two bodies are equal.
ii. When the second body is initially at rest.
iii. When a light body collides with massive body at rest.
iv. When the massive body collides with the light stationary body.

Ans. **Elastic Collision in one Dimension:**

Consider two smooth non-rotating spheres A and B of masses m_1 and m_2 respectively, moving initially along the line joining their centers with velocities u_1 and u_2. If u_1 is greater than u_2, so they collide with one another and after having an elastic collision start moving with velocities v_1 and v_2 respectively in the same line and direction.

Now the momentum of the system before collision = $m_1u_1 + m_2u_2$

And the momentum of the system after collision = $m_1v_1 + m_2v_2$

Before Collision After collision

According to law of conservation of momentum, we have

Total momentum before collision = Total momentum after collision

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$m_1u_1 - m_1v_1 = m_2v_2 - m_2u_2$$

$$m_1(u_1 - v_1) = m_2(v_2 - u_2) \quad \text{\_\_\_\_\_\_\_\_(1)}$$

K. E of the system before collision

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$$

K.E of the system after collision

$$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

As the collision is elastic, so the kinetic energy of the system is also conserved

Thus

K.E of the system before collision = K.E of the system after collision

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$\frac{1}{2}(m_1u_1^2 + m_2u_2^2) = \frac{1}{2}(m_1v_1^2 + m_2v_2^2)$$

$$(m_1u_1^2 + m_2u_2^2) = (m_1v_1^2 + m_2v_2^2)$$

$$m_1u_1^2 - m_2v_2^2 = m_1v_1^2 - m_2u_2^2$$

$$m_1(u_1^2 - v_2^2) = m_1(v_1^2 - u_2^2) \quad \text{———— (2)}$$

Divide equation (2) by (1)

$$\frac{m_1(u_1^2 - v_1^2)}{m_1(u_1 - v_1)} = \frac{m_2(v_2^2 - u_2^2)}{m_2(v_2 - u_2)}$$

$$\frac{u_1^2 - v_2^2}{u_1 - v_1} = \frac{v_2^2 - u_2^2}{v_2 - u_2}$$

$$(u_1 + v_1) = (v_2 + u_2)$$

$$u_1 + v_1 = v_2 + u_2 \quad \text{———— (3)}$$

The above equation shows that the sum of the initial and final velocities of the body A is equal to the sum of the initial and final velocities of the body B.

Now take the value of v_2 from eq (i), we get

$$m_1(u_1 - v_1) = m_2(v_2 - u_2)$$

$$m_1(u_1 - v_1) = m_2(u_1 + v_1 - u_2 - u_2)$$

$$m_1(u_1 - v_1) = m_2(u_1 + v_1 - 2u_2)$$

$$m_1u_1 - m_1v_1 = m_2u_1 + m_2v_1 - 2m_2u_2$$

$$m_1u_1 - m_2u_1 + 2m_2u_2 = m_1v_1 + m_2v_1$$

or it can be written as

$$m_1v_1 + m_2v_1 = m_1u_1 - m_2u_1 + 2m_2u_2$$

$$v_1(m_1 + m_2) = u_1(m_1 - m_2) + 2m_2u_2$$

$$v_1 = \frac{u_1(m_1 - m_2) + 2m_2u_2}{(m_1 + m_2)}$$

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2 \quad \text{———— (4)}$$

Similarly we take the value of v_1 from eq (iii), we get

$$v_1 = v_2 + u_2 - u_1$$

Put this value of v_1, in eq (i)

$$m_1(u_1 - v_1) = m_2(v_2 - u_2)$$
$$m_1[u_1 - (v_2 + u_2 - u_1)] = m_2(v_2 - u_2)$$
$$m_1[u_1 - v_2 - u_2 + u_1] = m_2(v_2 - u_2)$$
$$m_1[2u_1 - v_2 - u_2] = m_2 v_2 - m_2 u_2$$
$$2m_1u_1 - m_1u_2 + m_2u_2 = m_2 v_2 + m_1 v_2$$

Or it can be written as

$$m_2 v_2 + m_1 v_2 = 2m_1u_1 + m_2u_2 - m_1u_2$$
$$v_2(m_1 + m_2) = 2m_1u_1 + u_2(m_2 - m_1)$$
$$v_2 = \frac{2m_1u_1 + u_2(m_2 - m_1)}{(m_1 + m_2)}$$

Or it can be written as

$$v_2 = \frac{2m_1u_1}{(m_1 + m_2)} + \frac{u_2(m_2 - m_1)}{(m_1 + m_2)}$$
$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2 \quad \text{———— (5)}$$

Thus from the equations (iv) and (v), we can calculate the values of unknown velocities, i.e. v_1, and v_2.

i. **<u>If the masses of two bodies are equal:</u>**

i.e. $m_1 = m_2 = m$, then after collision their final velocities can be obtained by putting $m_1 = m_2 = m$ in eq, (iv) and (v).

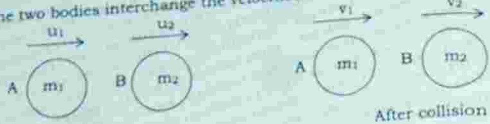
The velocity of first body is

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$
$$v_1 = \left(\frac{m - m}{m + m}\right)u_1 + \left(\frac{2m}{m + m}\right)u_2$$
$$= 0 + \left(\frac{2m}{2m}\right)u_2$$
$$v_1 = u_2$$

And the velocity of second body is:

$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2$$
$$v_2 = \left(\frac{2m}{(m + m)}\right)u_1 + \left(\frac{m - m}{m + m}\right)u_2$$
$$v_2 = \left(\frac{2m}{2m}\right)u_1 + 0$$
$$v_2 = u_1$$

Thus the two bodies interchange the velocities after collision.



Before Collision After collision

ii. When the body B is initially at rest:

i.e. $u_2 = 0$, then the final velocities of both bodies can be calculated as follows; From eq. (iv)

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)(0)$$

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + 0$$

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1$$

and from eq (v)

$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2$$

$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)(0)$$

$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + 0$$

$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1$$

Further if $m_1 = m_2 = m$. i.e. both the bodies are equal, then first body after collision will stop and body B will start moving with the velocity u_1 i.e. $v_1 = 0$ and $v_2 = v_1$.

Before Collision After collision

iii. When the light body collides with a massive body, which is at rest:

i.e. $m_1 << m_2$ and $u_2 = 0$, under these conditions m_1 is so small as compared to m_2, that it can be neglected in eq (iv) and (v). Thus we have from eq (iv)

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

$$v_1 = \left(\frac{0 - m_2}{0 + m_2}\right)u_1 + \left(\frac{2m_2}{0 + m_2}\right)(0)$$

$$v_1 = \left(\frac{0 - m_2}{0 + m_2}\right)u_1 + 0$$

$$v_1 = \left(\frac{-m_2}{m_2}\right)u_1$$

$$v_1 = -u_1$$

and from eq (v)

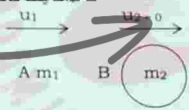
$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2$$

$$v_2 = \left(\frac{2(0)}{(0 + m_2)}\right)u_1 + \left(\frac{m_2 - 0}{0 + m_2}\right)(0)$$

$$v_2 = (0)u_1 + 0$$

$$v_2 = 0$$

It means that the body B will remain stationary wile body A will bounce back with the velocity u_1



Before Collision

After collision

iv. When the massive body collides with the light body, which is at rest:

i.e. $m_1 >> m_2$ and $u_2 = 0$. Now m_2 can be neglected as compared to m_1 in eq (iv) and (v).

Thus from eq (iv)

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

$$v_1 = \left(\frac{m_1 - 0}{m_1 + 0}\right)u_1 + \left(\frac{2(0)}{0 + m_2}\right)(0)$$

$$v_1 = \left(\frac{m_1}{m_1}\right)u_1 + 0$$

$$v_1 = u_1$$

and from eq (v)

$$v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2$$

$$v_2 = \left(\frac{2(0)}{(0 + m_2)}\right)u_1 + \left(\frac{m_2 - 0}{0 + m_2}\right)(0)$$

$$v_2 = (0)u_1 + 0$$

$$v_2 = 0$$

CHAPTER # 4
MOTION AND TWO DIMENSION

IMPORTANT QUESTIONS & ANSWERS

Q1. Define
- **i. Projectile**
- **ii. Projectile motion**

Ans. **i. Projectile**

"Any object that is given any initial velocity and which subsequently follows a path determined by the gravitational force acting on it and by the fictional resistance of the atmosphere is called a Projectile".

Or

"An object projected into space without the driving power of its own and moves under the action of gravity is called Projectile".

ii. Projectile Motion:

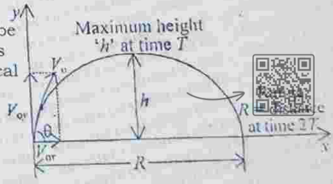
"When a body is thrown with an angle 'θ' and it covers a (distance) parabolic path under the action of gravity, this type of motion is called Projectile Motion".

Example:
- i. Kicked or thrown balls.
- ii. Jumping annuals.
- iii. Object thrown from a window.
- iv. Object released from an aeroplane.

Q2. A particle is projected at an angle 'θ' to the horizontal with the velocity 'v_0' and is allowed to fall freely so that it covers a certain distance in a parabolic path. Derive the expression for the following
- **(1) Horizontal component of velocity.**
- **(2) Vertical component of velocity.**
- **(3) Maximum height of the projectile**
- **(4) Range of the projectile**
- **(5) The maximum range**
- **(6) Projectile trajectory**

Ans. Suppose a particle is projected at an angle 'θ' with the horizontal, as shown in figure.

The initial, velocity $\vec{V}$, of the particle can be resolved into two rectangular components V_{ox} & V_{oy}, along horizontal axis and vertical axis respectively. The magnitudes of the horizontal and vertical components of velocity are as follows.



1. **Horizontal Velocity Component:**

The horizontal component of initial velocity is given by

$$V_{ox} = V_o \cos\theta \quad \text{———— (i)}$$

But during the projectile motion, there is no net force acts in the horizontal direction, therefore the final velocity V_x in the horizontal direction is equal to its initial velocity V_{ox}.

i.e. $$V_x = V_{ox} = V_o \cos\theta \quad \text{———— (ii)}$$

2. **Vertical Velocity Component:**

The vertical component of the initial velocity is

$$V_{oy} = V_o \sin\theta \quad \text{———— (iii)}$$

But as the net force acts in vertical direction, which produces acceleration in the y-direction, therefore the final velocity in vertical direction can be calculated with the help of the following data.

Initial Velocity = $V_{oy} = V_o \sin\theta$
Acceleration $a_y = -g$
time = 1
final velocity = V_y = ?

Using the first equation of motion, i.e.

$$V_f = V_i + at$$
$$V_y = V_{oy} + a_y t$$
$$= V_o \sin\theta + (-g)t$$
$$V_y = V_o \sin\theta - gt \quad \text{———— (iv)}$$

And the magnitude of the resultant velocity can be calculated by the following formula.

$$V = \sqrt{V_x^2 + V_y^2}$$

iii. **Maximum Height of the Projectile:**

To derive the maximum height of the projectile first we have to calculat the time for upward motion.

The maximum height occurs when the vertical component of the final velocity reduces to zero and the particle is projected with the acceleratio due to gravity (-g). Therefore

Initial velocity = $V_{oy} = V_o \sin\theta$
Final velocity = $V_y = 0$
Acceleration = $a_y = -g$
Time for upward motion = $t = T_1$ = ?
Maximum height = S = h = ?

Calculation of time:

For the calculation of time 'T_1' we use first equation of motion

$$V_y = V_i + at$$
$$V_y = V_i + (-g)T_1$$
$$0 = V_o \sin\theta - gT_1$$
$$gT_1 = V_o \sin\theta$$
$$T_1 = \frac{V_o \sin\theta}{g} \quad \text{———— (v)}$$

Where 'T' is half of the total time elapsed between launching and landin of the projectile.

Calculation of Maximum height:

To calculate the maximum height we use the third equation of motion, i.e.

$$S = V_i t + \frac{1}{2} at^2$$

$$h = V_{oy} T_1 + \frac{1}{2} a_y T^2$$

$$h = V_o \sin\theta . \frac{V_o \sin\theta}{g} + \frac{1}{2}(-g)\left(\frac{V_o \sin\theta}{g}\right)^2$$

$$h = \frac{V_o \sin^2\theta}{g} - \frac{1}{2} g . \frac{V_o^2 \sin^2\theta}{g^2}$$

$$h = \frac{V_o \sin^2\theta}{g} - \frac{V_o^2 \sin^2\theta}{2g}$$

$$h = \frac{2V_o^2 \sin^2\theta - V_o^2 \sin^2\theta}{g}$$

$$h = \frac{V_o^2 \sin^2\theta}{g}$$

Or it can be written as

$$h = \frac{1}{2g} V_o^2 \sin^2\theta \qquad \text{(vi)}$$

iv. Range of the Projectile:

"The horizontal distance from the origin to the point where the projectile returns is called range of the projectile".

It is denoted by 'R'

In order to find the range of the projectile, we make use of the fact that the total flight takes the time, that is twice the time to reach the highest point. Therefore

Distance = S = X = R = ?

Time = t = $2T_1$

Velocity = V = V_{ox}

Using $S = V \times t$

$$X = V_{ox} \times 2T_1$$

$$R = V_o \cos\theta \times 2\frac{V.\sin\theta}{g}$$

$$R = \frac{2V_o^2}{g} \sin\theta \cos\theta$$

$$R = \frac{V_o^2}{g} 2\sin\theta \cos\theta$$

But from trigonometry, we know that

$$2 \sin\theta \cos\theta = \sin 2\theta$$

Therefore the above equation becomes

$$R = \frac{V_o^2}{g} 2\sin\theta \qquad \text{(vii)}$$

Thus the range of the projectile depends on the square of the initial velocity and sine of twice the projection angle θ.

v. The Maximum Range:

The range is said to be maximum,, i.e. R_{max} , when the factor Sin 2θ in equation (vii) is maximum, i.e.

$$\sin 2\theta = 1$$
$$2\theta = \sin^{-1}(1)$$
$$2\theta = 90$$
$$\theta = \frac{90}{2}$$
$$\theta = 45^\circ$$
$$R_{max} = \frac{V_o^2}{g} 2\sin\theta$$
$$R_{max} = \frac{V_o^2}{g} \sin 2(45)$$
$$R_{max} = \frac{V_o^2}{g} \sin 90^\circ$$
$$R_{max} = \frac{V_o^2}{g}(1)$$
$$R_{max} = \frac{V_o^2}{g} \quad \text{—— (viii)}$$

Hence the projectile must be launched at an angle of 45°, with the horizontal to attain the maximum range. For all other angle greater or smaller than 45°, the range will be less than R_{max}.

vi. Projectile Trajectory:

"The path followed by a projectile is referred as its trajectory".

To derive the expression for trajectory, we use the third equation of motion, i.e.

$$S = V_i t + \tfrac{1}{2} g t^2$$
$$Y = V_{oy} t + \tfrac{1}{2}(-g)t^2$$
$$Y = V_o \sin\theta t - \tfrac{1}{2} g t^2 \quad \text{—— (ix)}$$

As

$$X = V_{ox} t$$
$$t = \frac{X}{V_{ox}}$$
$$t = \frac{X}{V_o \cos\theta}$$

On substituting the value of 't' in eq (ix), we get

$$Y = V_o \sin\theta t - \tfrac{1}{2} g t^2$$
$$Y = V_o \sin\theta \frac{X}{V_o \cos\theta} - \frac{1}{2} g \left(\frac{X}{V_o \cos\theta}\right)^2$$
$$Y = X \frac{\sin\theta}{\cos\theta} - \frac{1}{2} g \frac{X^2}{V_o^2 \cos^2\theta}$$
$$Y = X \tan\theta - \frac{1}{2} X^2 \frac{g}{V_o^2 \cos^2\theta} \quad \text{—— (x)}$$

In the above equation, the quantities V_{ox} tan θ, cosθ, g are constant and therefore we can lump them into another constant such that a = tanθ

and $b = \frac{g}{V_o^2 Cos^2\theta}$

Hence eq (x) reduces to

$$Y = ax - \frac{1}{2}bx^2 \qquad \text{(xi)}$$

Q3. Define radian and explain the relation between radians and degree.

Ans. *"One radian is defined to be the angle subtended, where the arc length 'S' is exactly equal to the radius of the circle".*

For one complete revolution θ = 360° then 'S' becomes the circumference of circle

i.e. $S = 2\pi r$

Now eq (i) becomes $r\theta = 2\pi r$

$\theta = 2\pi$ radians

Or $\theta = 360° = 2\pi$ radians

Therefore $1\ \text{radian} = \frac{360}{2\pi} = 57.3°$

Or $1\ \text{degree} = \frac{2\pi}{360}$

Q4. Define Centripetal Acceleration and derive the formula $a_c = \frac{v^2}{r}$.

Ans. **Definition:**

"When an object moves in a circle, the magnitude of the velocity remains same, but the direction of velocity changes of every point during the circular motion. Due to changing the direction of velocity an acceleration is produced, which is always directed towards the centre of the circle, it is called centripetal acceleration".

It is denoted by $\vec{a}_c$ and some times it is denoted by $\vec{a}_\perp$, indicating that the acceleration acts perpendicular to the path.

Derivation:

In order to calculate the magnitude of centripetal acceleration a_c, we must first find the velocity difference ΔV for two successive positions of an object moving along a circular path. Suppose the object takes a time $\Delta t = t_2 - t_1$ to go from position 1 to position 2.

vThe vector difference $\overline{\Delta V}$ is due to the different directions of the velocity vectors at the two positions.

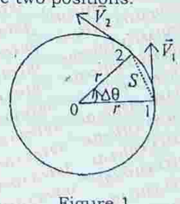
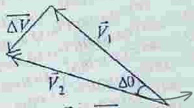


Figure 1



$\vec{V}_2 = \vec{V}_1 + \overline{\Delta V}$

$\overline{\Delta V} = \vec{V}_2 - \vec{V}_1$

Figure 2

The angle $\Delta\theta$ between the velocity vector $\vec{V}_1$ and $\vec{V}_2$ is the same as $\Delta\theta$ in fig (i). Since $\vec{V}_1$ and $\vec{V}_2$ each perpendicular to the radius lines at position 1 & 2 respectively. Since both are isosceles triangles and $\Delta\theta$ are the same.

Hence
$$\frac{\Delta V}{V} = \frac{\Delta S}{r}$$
$$\Delta V = V\frac{\Delta S}{r}$$

Dividing both sides by Δt of the above equation.
$$\frac{\Delta F}{\Delta t} = \frac{V}{r}\frac{\Delta S}{\Delta t}$$

As $\Delta t \rightarrow 0$
$$\lim_{\Delta t \to 0} \frac{\Delta F}{\Delta t} = \frac{V}{r} \lim_{\Delta t \to 0} \frac{\Delta S}{\Delta t}$$
$$a_c = \frac{V}{r}V$$
$$a_c = \frac{V^2}{r}$$

Q5. Write short note on centripetal force.

Ans. Centripetal Force:

That force which keeps the body in the circular path and acts towards the centre is known as Centripetal Force.

OR

The force which forces a body to move along a circular path is termed as Centripetal Force.

Examples of Centripetal Forces:

i. The Centripetal force is required by natural planets to move constantly round a circle is provided by gravitational force.

ii. The electronic attraction between an electron and the nucleus is the centripetal force for the circular motion of the electron around the nucleus.

iii. If a stone tied to a string is whirled in a circle the required centripetal force is supplied to it by our hand. As reaction the stone exerts an equa[l] force which is felt by our hand.

Factors on which the centripetal force depends:

i. Centripetal force is directly proportional to mass of the body.

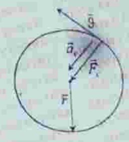
ii. Centripetal force is directly proportional to the square of the velocity.

iii. Centripetal force is inversely proportional to the radius of the orbit.

Magnitude of Centripetal Force:

Consider a ball of mass 'm' tied to a string of length 'r' is being whirled with a constant speed in a circular orbit as shown in the given figure. As the vector changes its direction continuously during the circular motion, so the ball experiences a centripetal acceleration which is directed toward, the centre of the orbit.

According to "First Law of Motion", the inertia of the ball tends to maintain in a straight line path but the string does not let it happen by applying a force on the ball such that the ball may follow its circular path. This force (the force of tension) is always directed along the length of the string toward the centre of the circle which is quite clear from the figure. This force is known as Centripetal Force and represented by F_c.



According to Newton's second law of motion we know that

$$F_c = ma_c \qquad \text{———— (i)}$$

But we know that Centripetal Acceleration $a_c = v^2/r$. Putting value of a_c in eq. (i) we have

$$F_c = \frac{mV^2}{r}$$

$$F_c = \frac{m(r\varpi)^2}{r} \qquad \because [V = r\varpi]$$

Or

$$F_c = \frac{mr^2\varpi^2}{r}$$

$$F_c = mr\omega^2$$

Q6. In the game of Cricket a ball of high trajectory is easy to catch, explain it.

Ans. As we know that, trajectory is the path followed by the projectile. It is parabolic in shape. If a projectile is projected at a small angle its trajectory will be flat and it's time of flight will be short. For a larger angle of projection, trajectory is high and it's time of flight Will be long.

Therefore, in the game of Cricket a ball of high trajectory is easy to catch, because the total time of flight would be long and the player has sufficient time to get into position, where as in of low trajectory it is much harder to shot/catch the ball since the time of flight is not so long.

Q7. Why a bomber does not drop the bombs, when it is vertically above the target?

Ans. When a bomber drops a bomb, it will undergo accelerated motion downward and the bomber also give it some initial velocity in the horizontal direction equal to the velocity of the plane, obviously the motion will no longer be straight downward, but will be at some angle to the vertical and the motion of the bomb becomes a projectile motion. Hence it is clear that the bomb should be dropped before the bomber is vertically above the target.

Q8. Does the horizontal velocity component of velocity of projectile motion remains constant" if yes, then why?

Ans. The horizontal component of velocity during the projectile motion remains constant, because there is no net force acts in the horizontal direction and there is no horizontal component of acceleration.

Thus, if an object is projected with some initial horizontal velocity V_{ox}, then its final velocity V_x in the horizontal direction is equal to its initial velocity V_{ox} i.e.

$$V_x = V_{ox}$$

CHAPTER # 5

TORQUE ANGULAR MOMENTUM AND EQUILIBRIUM

IMPORTANT QUESTIONS & ANSWERS

QI (a) Define torque.
(b) Write down the magnitude of torque.

Ans. **Torque:**

"The turning effect of force is called torque".

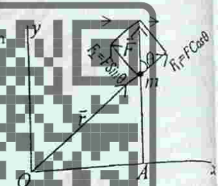
Or

It can be defined as

"Torque is the vector product of position vector $\vec{r}$ and the force $\vec{F}$.

It is denoted by 'τ' (tau). It is a vector.

Magnitude of Torque:



Consider a particle of mass 'm' which is acted upon by a force 'F'. Let r be the position vector of the particle. We can resolve this force into two rectangular components, i.e.

i. $F_\parallel$, the force which acts in the direction of $\vec{r}$ and can pull the mass.

ii. $F_\perp$, the force which acts in the direction perpendicular to $\vec{r}$ and produces rotation.

Let 'r' and '$F_\perp$' be the magnitudes of $\vec{r}$ and $F_\perp$ respectively. The magnitude of torque vector $\vec{\tau}$ produced by the force $\vec{F}$ about the centre 'O' is expressed as

$$\tau = r\, Sin\theta$$

Or

according to the second definition, it can be expressed as

$$\vec{\tau} = \vec{r} \times \vec{F}$$

Direction of Torque:-

The direction of torque can also be given by the 'right hand rule'.

Sing Convention:-

The torque may be clock wise or counter-clock-wise. Hence a torque which produces a counter-clockwise rotation is considered to be positive, while that producing clockwise rotation is taken as negative.

Vector representation of Torques:

We can represent the torque vector $\vec{\tau}$ in the determinant form, as given below:

$$\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} i & j & k \\ x & y & z \\ F_x & F_y & F_z \end{vmatrix}$$

Q2. Define types of equilibrium.

Ans. **Types of Equilibrium:**

The types of equilibrium are:

1. Static equilibrium and
2. Dynamic equilibrium,

1. Static Equilibrium:

"If a body is at rest then it is said to be in static equilibrium".

Example:-

A book lying on a table, building & bridges are in static equilibrium.

2. Dynamic Equilibrium:

"If a body is in uniform motion along a straight line is said to be in dynamic equilibrium".

Example:-

Vertically downward motion of a small steel ball through a viscous liquid & the jumping of a paratrooper from an helicopter.

Q3. State and explain the first condition of equilibrium.

Ans. **First condition of Equilibrium:**

Statement:

"If the sum of all the forces or resultant of all the forces acting on a body is zero, then the body is said to be in state of equilibrium or it satisfies the first condition of equilibrium".

Explanation:

Let $\vec{F}_1, \vec{F}_2, \ldots, \vec{F}_n$ be the 'n' external forces acting on a body. Then according to first condition of equilibrium

$$\vec{F}_1 + \vec{F}_2 + \ldots\ldots + \vec{F}_n = 0 \qquad \text{(i)}$$

To simplify, it we use the summation sign

$$\sum_{i=1}^{n} \vec{F}_i = 0 \qquad \text{(ii)}$$

If the forces are acting only in x-y plane then, the above equation will be

$$\vec{F}_i = F_{ix}\, i + F_{iy}\, j$$

Where F_{ix} is the x-component of the force F_{ix} and F_{iy} is the y-component of the force F_{iy} and i, j are the unit vectors in the direction of x and y respectively.

Thus the equation (ii) can be written as

$$(F_{1x}\, i + F_{1y}\, J) + (F_{2x}\, i + F_{2y}\, J) + \ldots\ldots + (F_{nx}\, i + F_{ny}\, j) = 0$$

Or $$(F_{1x} + F_{2x} + \ldots\ldots + F_{nx})\, i + (F_{1y} + F_{2y} + \ldots\ldots + F_{ny})\, j = 0$$

Let $\vec{F}$ be the resultant of forces $\vec{F}_1, \vec{F}_2, \ldots, \vec{F}_n$

$$\therefore \quad \vec{F} = \vec{F}_1 + \vec{F}_2 + \ldots\ldots + \vec{F}_n$$

Or $$F_{xi} + F_{yj} = (F_{1x} + F_{2x} + \ldots + F_{nx})i + (F_{1y} + F_{2y} + \ldots + F_{ny})j$$

On equating the x and y components of the forces on both sides of the above equation

$$F_x = F_{1x} + F_{2x} + \ldots\ldots + F_{nx}$$

And $$F_y = F_{1y} + F_{2y} + \ldots\ldots + F_{ny}$$

Since $$\vec{F}_1 + \vec{F}_2 + \ldots\ldots + \vec{F}_n = 0$$

Therefore $$\vec{F} = 0$$

$$F_x = 0\ ,\ F_y = 0$$

$$F_{1x} + F_{2x} + \ldots\ldots + F_{nx} = 0$$

$$F_{1y} + F_{2y} + \ldots\ldots + F_{ny} = 0$$

Or it can be written as

$$\sum_{i=1}^{n} F_{ix} = 0$$

and

$$\sum_{i=1}^{n} F_{iy} = 0$$

For simplification, we omit i from the summation sign in the above equation,

$$\sum F_x = 0$$

$$\sum F_y = 0$$

Let $\theta_1, \theta_2, \ldots \theta_n$ be the angles which the forces $F_1, F_2, \ldots F_n$ make with x-axis respectively, then

$$F_{1x} = F_1 \cos\theta_1,\ F_{2x} = F_2 \cos\theta_2, \ldots F_{nx} = F_n \cos\theta_2$$

$$F_{1y} = F_1 \sin\theta_1,\ F_{2y} = F_2 \sin\theta_2, \ldots F_{ny} = F_n \sin\theta_2$$

The first condition of equilibrium is written as

$$\sum F_x = \sum_{i=1}^{n} F_{ix} = \sum_{j=1}^{n} F_j Cos\theta_j = 0$$

$$\sum F_y = \sum_{i=1}^{n} F_{iy} = \sum_{j=1}^{n} F_j Cos\theta_j = 0$$

Q4. State and explain the second condition of equilibrium:

Ans. Second Condition of Equilibrium:

Statement:

If the vector sum of all the torques acting on a body is zero, then the body is said to be in rotational equilibrium".

Explanation:

If $\vec{\tau}_1, \vec{\tau}_2, \ldots\ldots\ldots \vec{\tau}_n$ are the torques on the body, then according to second condition of equilibrium.

$$\vec{\tau}_1 + \vec{\tau}_2 + \vec{\tau}_3 \ldots\ldots\ldots \vec{\tau}_n = 0$$

$$\sum_{i=1}^{n} \vec{\tau}_i = 0$$

Where τ_i is the moment of the ith force? For simplification we omit the subscript from the summation sign. Thus $\sum \vec{\tau}_i = 0$

Q5(a) What do you understand by Angular momentum?

(b) How will you represent Angular Momentum in Determinant Form?

(c) What are its components?

(d) What are its dimensions?

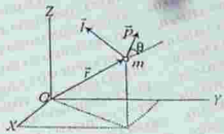
(e) Write down the unit of Angular Momentum.

Ans. (a). Angular Momentum:

We know that a body having rotatory motion possesses angular velocity & angular momentum.

Angular Momentum like linear momentum obeys the law of conservation also. For studying the angular momentum of an object, let us first study the angular momentum of a particle the angular momentum.

Let $\vec{r}$ be the position of a particle of mass 'm' with respect to the origin 'O' shown in the given figure. Moreover let $\vec{p}$ be the linear momentum of the particle measured in an inertial frame of reference with origin O as already shown in the figure.



The angular momentum of the particle about the origin O is defined as the vector product of $\vec{r}$ and $\vec{P}$. Hence if 'l' stands for angular momentum then

$$\vec{l} = \vec{r} \times \vec{P}$$
$$\vec{l} = \vec{r} \times m\vec{v}$$

Where $\vec{P} = m\vec{v}$ & $\vec{v}$ represents the velocity of the particle.

We know that vector product of two vectors is itself a vector so angular momentum is also a vector. Its direction lies along the normal to the plane formed by vectors $\vec{r}$ & $\vec{P}$ according to right hand rule. The magnitude of angular momentum is given by

$$|\vec{l}| = l = rPSin\theta$$

Where r and P represent magnitude of $\vec{r}$ and $\vec{P}$ respectively,

$$l = mvr \text{ Sin } \theta \qquad \text{(i)}$$

θ represents the angle between $\vec{r}$ and $\vec{P}$

In circular motion $\vec{r}$ and $\vec{P}$ are perpendicular to each other.

$\therefore \quad \theta = 90^\circ$, Sin θ = Sin 90° = 1

Hence for circular motion we have:

$$|\vec{l}| = l = rPSin\theta$$

$$|\vec{l}| = l = (r)(P)(Sin 90^\circ)$$

$$= rP$$

x, y, z represent the components of $\vec{r}$ and p_x , p_y , p_z are the components of $\vec{p}$

$$\vec{l} = \vec{r} \times \vec{P}$$
$$= (xi + yj + zk) \times (p_x i + p_y j + p_z k)$$

(b). Angular Momentum in Determinant Form:

Angular momentum $\vec{l}$ can be written in determinant form as:

$$\vec{l} = \begin{vmatrix} i & j & k \\ x & y & z \\ P_x & P_y & P_z \end{vmatrix}$$

(c). Components of Angular Momentum:

The scalar components of angular momentum $\vec{l}$ are:

$$l_x = yP_z - zP_y$$
$$l_y = zP_x - xP_z$$
$$l_z = xP_y - yP_x$$

(d). Dimensions of Angular Momentum:

The dimensions of angular momentum are given below.

$$l = rP$$
$$= rmv$$
$$= L.M.L/T$$
$$= L^2MT^{-1}$$

(e) Units of Angular Momentum:

Unit of angular momentum can also be obtained from equation:

$$l = rmv$$
$$= [m]\,[Kg]\,[m/s]$$
$$= kgm^2/s$$

or

$$l = kgm^2/s \times s/s$$
$$= kgm^2/s^2 \times s$$
$$= [kgm/s^2] \times m \times s \qquad [kgm/s^2] = N$$
$$= N \times m \times s$$
$$= (N \times m) \times s \qquad [N \times m = J]$$
$$= J \times s$$

Q6. Derive the conservation law for angular momentum of a particle:

Ans. Conservation of Angular Momentum of a Particle:

According to Newton's second law of motion, the net force acting on a particle of mass 'm' moving with an instantaneous velocity $\vec{V}$ is the rate of change of its linear momentum. Thus F is the force and P is the linear momentum, then

$$\vec{F} = \frac{d}{dt}\vec{P}$$

Taking vector product of both the sides of the above equation with $\vec{r}$ from left, we get

$$\vec{r} \times \vec{F} = \vec{r} \times \frac{d\vec{P}}{dt}$$

But $\vec{r} \times \vec{F} = \vec{\tau}$, which is acting on the panicle

$$\vec{\tau} = \frac{d}{dt}\vec{P}$$

But the angular momentum is

$$\vec{l} = \vec{r} \times \vec{P}$$

Differentiating the above equation with respect to time. We get

$$\frac{d\vec{l}}{dt} = \frac{d}{dt}\left(\vec{r} \times \vec{P}\right)$$

$$\frac{d\vec{l}}{dt} = \frac{d\vec{r}}{dt} \times \vec{P} + \vec{r} \times \frac{d\vec{P}}{dt} +$$

where $\vec{v} = \frac{d\vec{r}}{dt}$, and $\vec{P} = m\vec{v}$

$$\therefore \quad \frac{d\vec{l}}{dt} = \vec{v} \times m\vec{v} + \vec{r} \times \vec{F}$$

$$\frac{d\vec{l}}{dt} = m\vec{v} \times \vec{v} + \vec{\tau}$$

Since the vector product of a vector with itself is zero i.e.

$$m\vec{v} \times \vec{v} = 0$$

$$\frac{d\vec{l}}{dt} = m\vec{v} \times \vec{v} + \vec{\tau}$$

$$\frac{d\vec{l}}{dt} = (0) + \vec{\tau}$$

$$\frac{d\vec{l}}{dt} = \vec{\tau}$$

This is the required relation. This equation states that,
"The torque acting on a particle is the time rate of change of its angular momentum".
It the net external torque acting on the particle is zero, then

$$\frac{d\vec{l}}{dt} = 0$$

$$\vec{l} = 0 \quad \text{constant}$$

Thus the angular momentum of a particle is conserved, if the net torque acting on it is zero.

Q7. Derive the conservation law for angular momentum of a system of particles.

Ans. <u>Conservation Law for The Angular Momentum of a System of Particles:</u>

Consider a system of 'n' particles which is acted upon by external as well as internal forces. We assume that the internal forces obey the law of action and reaction. Hence they cancel out and the system is purely under the action of external (applied) forces. Thus the total angular momentum is

$$\vec{L} = \vec{l_1} + \vec{l_2} + \dots\dots + \vec{l_n}$$

$$\vec{L} = \vec{r_1} \times \vec{P_1} + \vec{r_2} \times \vec{P_2} + \dots\dots + \vec{r_n} \times \vec{P_n}$$

Taking the time derivatives of both the sides of the above equation

$$\frac{D\vec{L}}{dt} = \frac{d}{dt}\left(\vec{r_1} \times \vec{P_1}\right) + \frac{d}{dt}\left(\vec{r_2} \times \vec{P_2}\right) + \frac{d}{dt}\left(\vec{r_n} \times \vec{P_n}\right)$$

$$\frac{D\vec{L}}{dt} = \frac{\vec{r_1} \times d\vec{P_1}}{dt} + \frac{\vec{r_2} \times d\vec{P_2}}{dt} + \dots\dots + \frac{\vec{r_n} \times d\vec{P_n}}{dt}$$

$$\frac{D\vec{L}}{dt} = \vec{r_1} \times \vec{F_1} + \vec{r_2} \times \vec{F} + \dots\dots + \vec{r_n} \times \vec{F_n}$$

$$\frac{D\vec{L}}{dt} = \vec{\tau_1} + \vec{\tau} + \dots\dots + \vec{\tau_n}$$

$$\frac{D\vec{L}}{dt} = \sum_{i=1}^{n} \vec{\tau_1} = \tau$$

Where $\vec{F}_i$ and $\vec{\tau}_i$ are the external forces and external torque respectively acting on the ith particle.

If the net external torque $\vec{\tau}$ acting on the system is zero, then the total angular momentum is

$$\frac{D\vec{L}}{dt} = 0$$

$$\therefore \quad \vec{L} = 0$$

Thus the total angular momentum of a system of particles is conserved (constant) if the net external torque acting on the system is zero.

Q8(a) What do you understand by Centre of Mass? Give one example also.
(b) What is the difference between centre of gravity and centre of mass?
(c) How will you represent coordinates of centre of mass?

Ans. (a) <u>Centre of Mass:</u>

When a body rotates or vibrates as it moves, then centre of mass moves in the same way that a single panicle would move under the influence of the same external forces.

Centre of mass of a body or a system of particles is defined to be a point which moves as if total mass of the body or the system of panicles were concentrated there and all applied forces were acting at that point.

Hence the motion of the whole system or the body can be described by the motion of their centres of mass.

Example:

Let us consider a rectangular block of wood lying on a smooth horizontal surface. The block is acted upon by a number of forces. For describing the motion of the block as a whole we suppose that these forces were acting at the centre of mass which is the geometrical centre of the block and where the total mass is supposed to be concentrated.

Following steps are taken for describing complete motion of the body.

i. We find the resultant of all the forces acting at the centre of the body.
ii. Acceleration is calculated by applying Newton's Second Law of Motion.
iii. By using initial conditions the velocity of centre of mass is determined.

(b) <u>Difference between Centre of Gravity and Centre of Mass</u>

Actually centre of gravity and Centre of Mass are so similar in many ways that the two terms can he used in place of each other.

If the object is lying completely in uniform gravitational field then the centre of gravity coincides with centre of mass. In other cases the centre of gravity does not coincide with the centre of mass.

(c) Coordinates of Centre of Mass:

If X_o, Y_o and Z_o are the coordinates of centre of mass.

$$X_o = \frac{m_1x_1 + m_2x_2 + m_3x_3 + \dots\dots}{m_1 + m_2 + m_3 + \dots\dots}$$

$$Y_o = \frac{m_1y_1 + m_2y_2 + m_3y_3 + \dots\dots}{m_1 + m_2 + m_3 + \dots\dots}$$

$$Z_o = \frac{m_1z_1 + m_2z_2 + m_3z_3 + \dots\dots}{m_1 + m_2 + m_3 + \dots\dots}$$

i.e. $$X_o = \frac{\sum m_i x_i}{\sum m_i}$$

$$Y_o = \frac{\sum m_i y_i}{\sum m_i}$$

$$Z_o = \frac{\sum m_i z_i}{\sum m_i}$$

CHAPTER # 6
GRAVITATION
IMPORTANT QUESTIONS & ANSWERS

Q1(a) State and explain Newton's law of gravitation.
(b) Write down the value and unit of gravitational constant in M.K.S system

Ans. Newton's law of gravitation:

Introduction:

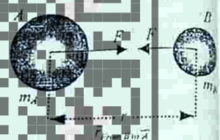
In order to explain the gravitational force, Newton formulated the law of universal gravitation, which is stated as under:

Statement:

"Every body in the 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 their centres and directed along the line joining their centres".

Explanation:

Let us consider two spheres A & B of masses m_A and m_B with their centres at a distance 'r' from each other as shown in the figure.



According to observation obtained by Newton in case of moon and the earth, it can be said that magnitude of force which B exerts on A is given by

$$F_{AB} \propto \frac{1}{(r_{BA})^2}$$

Besides this F_{AB} must also be proportional to m_A (mass of A), m_B (mass of B) i

$$F_{AB} \propto m_B$$
$$F_{AB} \propto m_A$$

Combining the above three relations we have:

$$F_{AB} \propto \frac{m_A m_B}{(r_{BA})^2}$$

$$F_{AB} = \frac{G m_A m_B}{(r_{BA})^2} \qquad \text{——— (i)}$$

Where G is called the gravitational constant i.e.

$$G = 6.67 \times 10^{-11} \frac{Nm^2}{Kg^2}$$

Expression of equation (i) {law of gravitation} in vector form:

The equation (i) expressing the law of gravitation in vector form which gives the direction as well as the magnitude.

$$\vec{F}_{AB} = \frac{Gm_A m_B}{(r_{BA})^2}\hat{r}_{BA} \quad \text{———— (ii)}$$

Where $\hat{r}$ is a unit vector having direction from B to A. The negative sign shows that the force is attractive just similar to eq (ii(. The force exerted by sphere A on sphere B $\left(\vec{F}_{BA}\right)$ is given by the equation.

$$\vec{F}_{BA} = -\frac{Gm_A m_B}{(r_{AB})^2}\hat{r}_{AB} \quad \text{———— (iii)}$$

Where $\hat{r}_{AB}$ is a unit vector from A to B.

(b) Value and Unit of G:

In M.K.S system the value of 'G' (gravitational constant) is 6.67×10^{-11} Nm^2/kg^2

Q2. Derive the equations for mass and average density of earth.

Ans. Mass of Earth:

By using Newton's law of gravitation mass of earth can be calculated as under. Consider an object of mass 'm' placed near the surface of the earth. If M_E is the mass of the earth and R_E is the radius of earth. Then according to Newton's universal law of gravitation, the gravitational force with which the earth attracts the object towards its centre is

$$F = \frac{GmM_E}{R_E^2} \quad \text{———— (i)}$$

But the force exerted on the object is also given by the mass 'm' of the object multiplied by the acceleration due to gravity, i.e.

$$F = W = mg$$

Thus equation (i) becomes

$$W = \frac{GmM_E}{R_E^2}$$

$$mg = \frac{GmM_E}{R_E^2}$$

By cross multiplication, we get

$$GmM_E = mgR_E^2$$

$$M_E = \frac{mgR_E^2}{Gm}$$

$$\boxed{M_E = \frac{gR_E^2}{G}}$$

From the above formula we can easily calculate the mass of earth.

If

$$g = 9.8\ m/s^2$$
$$R_E = 6.38 \times 10^6\ m$$
$$G = 6.67 \times 10^{-11}\ \frac{Nm^2}{Kg^2}$$

Then

$$M_E = \frac{9.8 \times (6.38 \times 10^6)^2}{6.67 \times 10^{-11}}$$
$$= \frac{9.8 \times 4.07 \times 10^{13}}{6.67 \times 10^{-11}}$$
$$\boxed{M_E = 5.98 \times 10^{24}\ kg}$$

Now we calculate the average density of the earth.

Density of Earth:

The average density 'ρ' of the earth can be calculated by the following formula

$$\rho = \frac{M_E}{V} \quad \text{——— (i)}$$

Where 'V' is the volume of the earth and it is given by

$$V = \frac{4}{3}\pi R_E^3$$

By substituting the value of 'v' in equation (i), we get

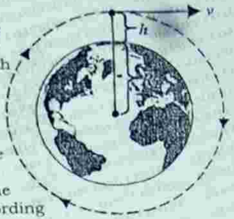
$$\rho = \frac{M_E}{\frac{4}{3}\pi R_E^3}$$
$$\boxed{\rho = \frac{3M_E}{4\pi R_E^3}} \quad \text{——— (ii)}$$

If we put $M_E = 5.98 \times 10^{24}$ kg and $R_E = 6.38 \times 10^6$m in the above equation, th
we can get the density of earth as

$$\rho = \frac{3 \times 5.98 \times 10^{24}}{4 \times \pi (6.38 \times 10^6)^3}$$
$$= \frac{17.94 \times 10^{24}}{4 \times \pi \times 2.596 \times 10^{20}}$$
$$\boxed{\rho = 5.49 \times 10^3\ kg/m^3}$$

Q3. Derive the egression for the variation of 'g' with altitude and depth.

Ans. **Variation of 'g' with Altitude:**



The earth is not a perfect sphere, but bulges at the equator. Therefore if a body is taken from a pole to the equator its distance from the centre of the earth will change. Consequently, according to Newton's law of gravitation, the gravitational pull (force) on it will also vary.

Consider an object, which is placed on the surface of earth. If mass of the object is m and mass of earth is M_E. The distance between the centre of the earth and the centre of the object is R_E, then according to Newton's law of gravitation.

$$F = \frac{GmM_E}{R_E^2} \quad \text{———— (i)}$$

But the force on the object by the earth is F = W = mg. Therefore equation (i) becomes

$$mg = \frac{GmM_E}{R_E^2}$$

$$g = \frac{GmM_E}{R_E^2 m}$$

$$g = \frac{GM_E}{R_E^2} \quad \text{———— (ii)}$$

From the above equation we can conclude that, if the earth be considered as a sphere, then 'g' at any point above its surface will vary inversely as the square of the distance from the centre of the earth i.e. R_E.

Now if the object is placed at a distance 'h' from the surface of the earth then the equation (ii) becomes for the value of g' at a distance $(R_E + h)$.

$$g' = \frac{GM_E}{(R_E + h)^2} \quad \text{———— (iii)}$$

Now divide equation (ii) by (iii), we get the following equation.

$$\frac{g}{g'} = \frac{\frac{GM_E}{R_E^2}}{\frac{GM_E}{(R_E+h)^2}}$$

$$\frac{g}{g'} = \frac{GM_E}{R_E^2} \div \frac{GM_E}{(R_E + h)^2}$$

$$\frac{g}{g'} = \frac{GM_E}{R_E^2} \times \frac{(R_E + h)^2}{GM_E}$$

$$\frac{g}{g'} = \frac{(R_E + h)^2}{R_E^2}$$

$$\frac{g}{g'} = \left(\frac{R_E + h}{R_E}\right)^2$$

$$\frac{g}{g'}=\left(\frac{R_E}{R_E}+\frac{h}{R_E}\right)^2$$

$$\frac{g}{g'}=\left(1+\frac{h}{R_E}\right)^2$$

$$\frac{g}{g'}=1+2\frac{h}{R_E}+\frac{h^2}{R_E^2}$$

If 'h' is small as compared to the radius of the earth 'R_E', then the quantity $\frac{h^2}{R_E^2}$ in the above equation will be negligibly small. Therefore we have

$$\frac{g}{g'}=\left(1+\frac{2h}{R_E}\right)$$

or

$$\frac{g'}{g}=\frac{1}{\left(1+\frac{2h}{R_E}\right)}$$

$$\frac{g'}{g}=\left(1+\frac{2h}{R_E}\right)^{-1}$$

Then term on right hand side of the above equation can be expand by using binomial theorem, i.e.

$$(a+b)^n = a^n + na^{n-1}b + \ldots$$

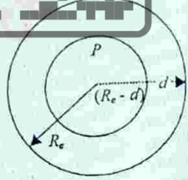
Thus we obtain

$$\frac{g'}{g}=\left(1-\frac{2h}{R_E}\right)$$

$$\boxed{g'=g\left(1-\frac{2h}{R_E}\right)}$$

The above equation explains that the greater the value of 'h', the smaller is the value of g' or simply we can say that value of 'g' decreases with altitude

Variation of 'g' with Depth:



Let g' be the acceleration due to gravity at a depth 'd' below the surface of the earth, i.e. at a distance (R_E – d) from the centre of the earth.

From the equation (ii) of average density of earth, we have

$$\rho=\frac{3M_E}{4\pi R_E^2}$$

By cross multiplication, we have

$$3M_E = 4\pi R_E^3\rho$$

$$M_E=\frac{4\pi}{3}R_E^3\rho$$

Where 'ρ' is the density of earth, supposed to be uniform every where. Now the mass of earth 'M_E' at a depth 'd' from its surface is

$$M'_E=\frac{4\pi}{3}(R_E-d)^3\rho \quad \text{———— (ii)}$$

But we know that the value of 'g' at the surface of earth is

$$g = \frac{GM_E}{R_E^2} \qquad \text{——— (iii)}$$

Put the value of 'M_E' from equation (i) in equation (iii), we get

$$g = \frac{G\frac{4\pi}{3}R_E^3\rho}{R_E^2}$$

$$g = \frac{4\pi}{3}R_E\rho G \qquad \text{——— (iv)}$$

Similarly the value of 'g' at a depth 'd' from the earth's surface is g' which is given by

$$g' = \frac{GM'_E}{(R_E - d)^2} \qquad \text{——— (v)}$$

Put the value of 'M_E' from equation (ii) in equation (v), we get,

$$g' = \frac{G\frac{4\pi}{3}(R_E - d)^3\rho}{(R_E - d)^2}$$

$$g' = \frac{4\pi}{3}(R_E - d)\rho G \qquad \text{——— (vi)}$$

By dividing equation (vi) by equation (iv), we get

$$\frac{g'}{g} = \frac{\frac{4\pi}{3}(R_E - d)\rho G}{\frac{4\pi}{3}R_E\rho G}$$

$$\frac{g'}{g} = \frac{R_E - d}{R_E}$$

$$\frac{g'}{g} = \frac{R_E}{R_E} - \frac{d}{R_E}$$

$$\frac{g'}{g} = 1 - \frac{d}{R_E}$$

$$\boxed{g' = g\left(1 - \frac{d}{R_E}\right)}$$

The above equation explains that the value of 'g' decreases with depth from the surface of earth. It also explains that, when $d = R_E$, the value of 'g' will be zero.

Q4. Describe weightlessness in satellites.

Ans. **Weightlessness in Satellite:**

In order to understand the weightlessness in satellites, let us consider a simple case of the weight of a body in an elevator. If a body of mass 'm' tied to a spring balance that is attached to the ceiling of a lift as shown in figure. The reading of the spring balance indicates the tension in the string and is called the apparent weight 'W' of the body.

$$F = T - W$$

$$ma = T - W$$

$$0 = T - W$$
$$T = W$$

or

Since tension in the string is equal to the apparent weight of the body, thus

$$W' = T$$
$$W' = W$$
$$W' = mg$$

Thus the apparent weight is equal to the gravitational force on the body according to an observer inside the lift.

Elevator is moving upward with uniform acceleration:

In this case T > W and net force acting on the body is T – W. Now according to Newton's second law of motion.

$$F = T - W$$
$$ma = T - W$$
$$T = ma + W$$
$$T = ma + mg$$

Thus the apparent weight of the body is

$$W' = ma + mg$$

This shows that in this case the string not only supports the gravitational pu[ll] but an additional amount of force 'ma' in the upward direction, the tension in the string increases from mg to (mg + ma). This is the situation experienced b[y] astronauts during the take off process in rockets.

Elevator is moving downward with constant acceleration:

In this case T< W and net force acting on the body is W – T and its direction i[s] downward. Now according to Newton's second law of motion.

$$F = W - T$$
$$ma = mg - T$$
$$T = mg - ma$$

Thus the apparent weight of the body is

$$W' = mg - ma$$
$$W' = m(g - a)$$

Thus shows that in this case the apparent weight W' is less than the gravitational force on the body.

If the cable supporting the elevator breaks:

Suppose, if the cable supporting the elevator breaks, then the elevator will fa[ll] down w an acceleration which is equal to the acceleration due to gravity 'g'. T[he] net force in this case will be:

$$F = W - T$$
$$ma = mg - T$$
$$T = mg - ma$$

But $a = g$

Thus $T = mg - mg$

$$T = 0$$

Or $W' = 0$

Consequently, the spring balance will read zero, and the man in the elevator will find that the block has no weight besides the fact that the force of gravity still acts upon the block and its weight W is given by mg. This is referred as t[he] state of "Weightlessness".

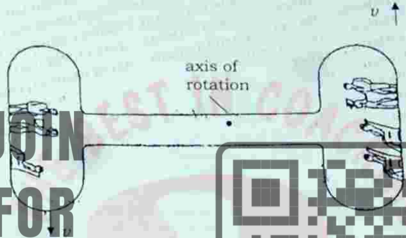
Q5. Write short note on artificial gravity.

Ans. Artificial Gravity:

We know that weightlessness a great handicap to the astronaut in space. For overcoming this problem an artificial gravity can be created in the spacecraft by spinning it around its own axis. In this way normal force of gravity can be supplied to the occupants in the spacecraft.

Let us consider a space craft consisting of two chambers connected by a tunnel of length 20 meters. We have to calculate how many revolutions per second must the spacecraft make for supplying artificial gravity for the astronauts.

Suppose T is the time for one revolution and v is the frequency of rotation



Magnitude of centripetal acceleration in this case is given by:

$$a_c = \frac{V^2}{R} \quad [V = linear\ speed]$$

But V = Rω

$$a_c = \frac{(R\omega)^2}{R}$$

$$= \frac{R^2\omega^2}{R}$$

$$= R\omega^2$$

As

$$\omega = \frac{2\pi}{T}$$

$$a_c = R\left(\frac{2\pi}{T}\right)^2$$

$$a_c = \frac{4\pi^2 R}{T^2}$$

$$a_c T^2 = 4\pi^2 R$$

$$T^2 = \frac{4\pi^2 R}{a_c}$$

$$\frac{1}{T^2} = \frac{a_c}{4\pi^2 R}$$

$$\upsilon^2 = \frac{a_c}{4\pi^2 R} \quad \left[\upsilon = \frac{1}{T} \text{ is the frequency}\right]$$

Or

$$\upsilon = \frac{1}{2\pi}\sqrt{a_c/R}$$

If we want to produce acceleration (a_c) equal to 'g' then

$$\upsilon = \frac{1}{2\pi}\sqrt{g/R}$$

Hence when the space craft or satellite rotates with this frequency, the artific gravity like earth will be provided to the astronaut

If R = half of the tunnel length i.e

$$R = \frac{20m}{2} = 10m$$

i.e.

$$\upsilon = \frac{1}{2\pi}\sqrt{a_c/R}$$

when a body falls freely $a_c = g$

$$\upsilon = \frac{1}{2\pi}\sqrt{g/R}$$

$$\upsilon = \frac{1}{2\pi}\sqrt{9.8/10}$$

$$= 0.158\ Rev/S$$

$$= \frac{0.158}{1/60}\ Rev/min$$

$$= 0.158 \times 60$$

υ = 9.5 Revolutions per minute

Hence an astronaut will feel comfortable at a distance of 10m from axis of rotation if the space craft is revolving about its axis at 9.6 Revolutions per minute.

Q6. Find low deep from the surface of earth a point is where the acceleratio due to gravity is half the value on the earth's radius.

Ans. Suppose at depth'd' from the surface of the earth, the acceleration due to gravity 'g' is half the value on the earth's radius.

$$g' = \tfrac{1}{2} g \quad \text{(i)}$$

But we know that

$$g' = g\left(1 - \frac{d}{Re}\right) \quad g\left(1 - \frac{d}{Re}\right) = \frac{1}{2} g$$

$$1 - \frac{d}{Re} = \frac{1}{2} \cdot \frac{g}{g}$$

Thus equation Tj) becomes

$$1-\frac{d}{Re}=\frac{1}{2}$$

$$-\frac{d}{Re}=\frac{1}{2}-1$$

$$-\frac{d}{Re}=\frac{1-2}{2}$$

$$-\frac{d}{Re}=-\frac{1}{2}$$

$$\frac{d}{Re}=\frac{1}{2}$$

Or

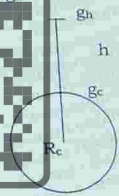
$$\boxed{d=\frac{1}{2}Re}$$

This shows that at a depth equal to half the radius of the earth, the value of 'g' reduces to half its value on the surface of the earth.

Q7. At what distance from the centre of the earth does the gravitational acceleration has one half the value that it has on the earth's surface.

Ans. Solution:

Suppose at a height 'h' the value of acceleration due to gravity 'g_h' is half of the acceleration due to gravity on the surface of earth.



$$g_h=\frac{g_e}{2}$$

As we know that the gravitational acceleration on the surface of earth is

$$g_e=\frac{GM_e}{R_e^2} \quad \text{———(i)}$$

But at a height 'h', the gravitational acceleration will be

$$g_h=\frac{GM_e}{(R_e+h)^2} \quad \text{———(ii)}$$

Substituting $g_h=\frac{g_e}{2}$ in equation (ii)

$$\frac{g_e}{2}=\frac{GM_e}{(R_e+h)} \quad \text{———(iii)}$$

Dividing equation (i) by equation (iii)

$$\frac{g_e}{\frac{g_e}{2}} = \frac{\frac{GM_e}{R_e^2}}{\frac{GM_e}{(R_e+h)^2}}$$

$$g_e + \frac{g_e}{2} = \frac{GM_e}{R_e^2} + \frac{GM_e}{(R_e+h)^2}$$

$$g_e \times \frac{2}{g_e} = \frac{GM_e}{R_e^2} \times \frac{(R_e+h)^2}{GM_e}$$

$$2 = \frac{(R_e+h)^2}{R_e^2}$$

Taking square root on both sides.

$$\sqrt{2} = \frac{R_e+h}{R_e}$$

Or

$$\frac{R_e+h}{R_e} = \sqrt{2}$$

$$\frac{\text{Distance from centre of earth}}{\text{Earth's radius}} = \sqrt{2}$$

$$\frac{\text{Distance from centre of earth}}{\text{Earth's radius}} = 1.41$$

Distance from centre of earth = 1.41 x Earth's radius,

It means that,

At a distance of 1.41 times of radius of earth, the gravitational acceleration have half the value that it has on earth's surface.

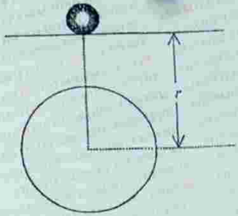
Q8. Distinguish between 'g' and 'G'.

Ans. Differences between 'g' and 'G':

g	G
Name	
• It is known as gravitational acceleration.	• It is known as gravitational constant
Definition	
• All the bodies fall downward with some acceleration as this acceleration is due to the gravitational force, so it is called gravitational acceleration.	• If two bodies each of masses 1 kg are placed at a distance of 1m, then the force of attraction exists between them is equal to the gravitational constant.
Value	
• It's value is $9.8\ m/s^2$.	• Its value is $6.67 \times 10^{-11}\ Nm^2/kg^2$.
Direction	
• It is directed towards the centre of the earth.	• It has no direction.
Variation in Value	
• Its value does not remain constant every where.	• Its value remains constant every where.

Q9. With the help of the law of gravitation prove that the value of acceleration due to gravity at a point above the surface of the earth is inversely proportional to the square of the distance of the point from the centre of the earth.

Ans. **Derivation of $g \alpha \frac{1}{r^2}$:**



To derive the expression, let us suppose that the ball is falling freely towards the centre of the earth and the ball is placed at a distance 'r' from the centre of the earth. As shown in figure. If the mass of the ball is 'm' and mass of the earth is 'Me'. Then according to Newton's law of gravitation.

$$F = \frac{GmMe}{r^2} \quad \text{———— (i)}$$

As we know that the force exerted on the body by the earth is equal to the weight of the body, thus

$$F = W = mg$$

Put the value of F in equation (i), we get

$$mg = \frac{GmMe}{r^2}$$

$$g = \frac{GmMe}{mr^2}$$

$$g = \frac{GMe}{r^2}$$

$$g = GMe \cdot \frac{1}{r^2}$$

$$g = constant \cdot \frac{1}{r^2}$$

$$g \alpha \frac{1}{r^2} \quad \text{———— (ii)}$$

The above expression shows that the value of 'g' does not depend upon the mass of the body. This means that light and heavy bodies should fall towards the centre of the earth with the same acceleration.

Q10. Why do two books lying separately on a table not move towards each other due to gravitational attraction?

Ans. The value of gravitational constant is very small, i.e., 6.67×10^{-11} Nm^2/kg^2. So we cannot feel the force of attraction between the bodies around us. That's why the two books lying separately on a table do not move towards each other due to gravitational attraction.

CHAPTER # 7

WORK, POWER AND ENERGY

IMPORTANT QUESTIONS & ANSWERS

Ql. Define work. What is the magnitude of work? And also write its unit.

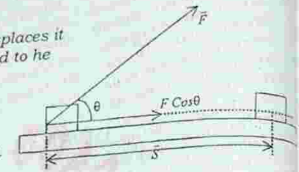
Ans. Work:

Definition:

"When a force acts upon a body and displaces it through a distance, then the work is said to he done by the force on the body".

Or it is defined as:

"The product of the component of force '$\vec{F}$' in the direction of displacement '$\vec{S}$' and the magnitude of the displacement".



Magnitude of Work:

Work is a scalar quantity by definition and is given by the dot product of force $\vec{F}$ and displacement $\vec{d}$. i.e.

$$W = \vec{F}\cdot\vec{d}$$

Since the force vector $\vec{F}$ and the displacement vector $\vec{d}$ are in same direction, therefore

$$W = Fd\cos\theta$$

Work is an algebraic quantity. It can be positive or negative depending on the value of angle between force $\vec{F}$ and the

1. When the component of force is in the same direction of displacement,
   i.e. $\theta = 0°$, then work is positive.

$$W = Fd\cos\theta$$
$$= Fd\cos(0) \qquad \because \cos(0) = 1$$
$$= Fd(1)$$
$$W = Fd$$

Example:

When a spring is stretched the work done by the stretching force is positive.

2. When the direction of force is opposite to the direction of displacement
   i.e. $\theta = 180°$, then work is negative.

$$W = Fd\cos\theta$$
$$= Fd\cos 180° \qquad \because \cos 180 = -1$$
$$= Fd(-1)$$
$$W = -Fd$$

Example:

The work done by the gravitational force on the body being lifted is negative. Since the upward displacement is opposite to the gravitational force.

3. When the force acts at right angles to the displacement,
   i.e. $\theta = 90°$, then the work is zero.

$$W = Fd\cos\theta$$
$$= Fd\cos 90° \qquad \because \cos 90 = 0$$
$$= Fd(0)$$
$$W = 0$$

Example:

It is considered 'hard work' to hold a heavy stone stationary at stretched hand but no work is done in the technical sense.

Units of work:

1. In S.I units, unit of work is joule (J) which is equal to N x m.

   1J = 1 N – m

   1055 J= 1 British Thermal Unit

   Or 1055 J=1BTU

2. In the physics of atoms, molecules and elementary particles, a much smaller unit is used.

   This unit is called the electron-volt. (eV).

   $1ev = 1.60 \times 10^{-19}$ J

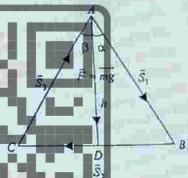
   The multiples of electron-volt are

   1 Million electron-volt = 1 MeV = 10^6 eV

   1 Billion electron-volt = 1 BeV = 10^{12} eV.

Q2. Show that the gravitational field is a conservative field.

Ans. To prove this statement, we consider a closed path of any shape in the gravitational field and show that the work done in carrying a body along this path is zero. For the sake of simplicity we take a triangular path ABCA in which the base BC is perpendicular to the gravitational field as shown in figure. The amount of work done in carrying the body from A to B, B to C and from C to A are represented by $W_{A\to B}$, $W_{B\to C}$ and $W_{C\to A}$ respectively. Thus



$$W_{A\to B} = \vec{F}.\vec{S}_1 = (F)(S_1 Cos\alpha) = (mg)(h) = mgh$$

$$W_{B\to C} = \vec{F}.\vec{S}_2 = (F)(S_2 Cos 90) = (mg)(S_2 \times O) = 0$$

$$W_{C\to A} = \vec{F}.\vec{S}_3 = (F)[S_3 Cos(180^\circ - \beta)] = (mg)(-S_3 Cos\beta) = -mgh$$

Where h = m $\overline{AD}$

Total work done along the closed path ABCA

h = mgh + o-mgh = 0

We now divide the whole path into two parts, one from A to B, B to C and the other from C to A.

$$\therefore \quad W_{A\to B\to C\to A} = W_{A\to B\to C} + W_{C\to A} = 0$$

Also $$W_{C\to A} + W_{A\to C} = 0$$

Comparing these equations

$$W_{A\to B\to C} = W_{A\to C}$$

Thus whether we carry the body from A to C (along AC directly) or along the path ABC, the work done is the same. There may be an infinite number of paths going from A to C, but the work done along any path is the same. Such a type of field of force in which the work is independent of the path is called a conservative field. Thus gravitational field is a conservative field.

Q3. Define Power. What is its unit in S.I system? Define it.

Ans. Power:

Definition:

"The rate of doing work is called power".

When an amount of work ΔW is done in time Δt, the average power, P_{av} is defined as

$$P_{av} = \frac{\Delta W}{\Delta t}$$

We can obtain an alternative expression for power, as

$$P_{av} = \frac{\vec{F}.\vec{S}}{t}$$

If W is the work done when a constant force, $\vec{F}$ of magnitude F points in the direction of the displacement '$\vec{S}$'

i.e. $\theta = 0$

then

$$P_{av} = \frac{FS\,Cos\theta}{t}$$

$$P_{av} = \frac{FS\,Cos(0)}{t}$$

$$P_{av} = \frac{FS}{t}$$

$$P_{av} = F\frac{S}{t}$$

$$P_{av} = F\,V_{av}$$

Where P_{av} = Average Power

And V_{av} = Average Velocity.

Units of Power:

i. In S.I units, the unit of power is watt (W), which is equal to J/sec.

$$1W = \frac{1J}{1S}$$

The multiples of watt are

1 mega watt = IMW = 10^6 W

1 giga watt = 1GW = 10^9 W

ii. In British engineering system, the unit of power is ft.lb/sec. (Foot. Pound / Second).

iii. A bigger unit of power is called horse power.

1 horsepower = 1 hp = 746 watt

Q4. Define Joule and Watt.

Ans. Joule:

In the SI system the unit of work is called a joule. A joule (J) is defined as "the amount of work done, when a force of one Newton acting on a body displaces it through a distance of 1 meter along the direction of force".

1 joule = 1 newton x 1 meter

Watt:

In S.I units, the unit of power is watt (W), which is equal to J/Sec.

$$1W = \frac{1J}{1S}$$

The multiples of watt are

1 mega watt = 1MW = 10^6 W

1 giga watt = 1GW = 10^9 W

Q5. Convert 1KWh into joule.

Ans. Conversion of Kilo watt – hour into joule:

One kwh is the energy delivered by the current in one hour when it supplies energy at the rate of 1000 joules per second, i.e.

$$1 \text{ KWh} = 1 \text{ Kilo watt} \times \text{hour}$$
$$= 1000 \text{ watt} \times 3600 \text{ sec.}$$
$$= 1000 \frac{joules}{second} \times 360 \text{ second}$$
$$1 \text{ KWh} = 36 \times 10^5 \text{ joule}$$

Q6(a) Define Energy.

(b) State and explain the law of conservation of energy. Give its two examples.

Ans. (a) Energy:

Definition:

"The ability of doing work is called energy".

Energy is associated with the performance of work; because more work that is done the greater the quantity of energy is needed.

Unit of Energy:-

In S.I units, energy is measured in joules.

(b) Law of Conservation of Energy:

Statement:-

"Energy can neither be created nor it can be destroyed, but it can only be transformed from one form to another, the total energy remains constant".

Explanation:-

Energy cannot be created means one cannot produce energy by expanding nothing. Similarly we cannot destroy energy. We get some thing equivalent in return if we annihilate it. Pair production is a good example of annihilation of energy. On the other hand in nuclear fission or fusion energy is created at the cost of mass. If 'm' is the mass annihilated, then according to Einstein's mass-energy relation the energy produced is

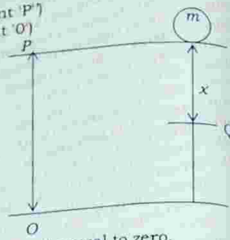
$$E = mc^2$$

Where 'c' is the velocity of light in vacuum.

With reference to the problem of a freely falling body, such as a body of mass 'm' placed at a point 'P', which is at a height 'h' from the surface of earth. The body possesses the P.E equal to 'mgh' with respect to point 'O' lying at the surface of the earth. But the K.E of the body at point 'P' is zero. i.e.

$$T.E = K.E + P.E$$
$$= 0 + mgh$$
$$T.E = mgh$$

Now we calculate the kinetic energy at point 'O', for this we make the following data.



Initial velocity = $V_i = 0$ (at point 'P')
Final velocity = $V_f = V$ (at point 'O')
Acceleration = g
Distance = S = h

Now by using third equation of motion

$$2aS = V_f^2 - V_i^2$$
$$2gh = V^2 - (0)^2$$
$$V^2 = 2gh$$

Hence the kinetic energy of the body is

$$KE = \frac{1}{2} mv^2$$

Put the value of v^2 in above equation

$$KE = \frac{1}{2} m \cdot 2gh$$
$$KE = mgh$$

And at point 'O' the potential energy is taken arbitrarily equal to zero.

$$T.E = K.E + P.E$$
$$= mgh + O$$
$$T.E = mgh$$

We now calculate the potential energy and kinetic energy at any point 'Q' at a distance 'x' below the point 'P'.

$$P.E = mg(h - x)$$

And $K.E = \frac{1}{2} mv^2$

But at a distance 'x' below the point 'P' the K.E will be

$$K.E = \frac{1}{2} mv^2$$
$$= \frac{1}{2} m \cdot 2gx$$
$$K.E = mgx$$

Thus the total energy is

$$T.E = K.E + P.E$$
$$= mgx + mg(h - x)$$
$$= mgx + mgh - mgx$$
$$T.E = mgx$$

This shows that the sum of kinetic energy and the potential energy i.e. total energy is always constant provided there is no force of friction involved during the motion of the body.

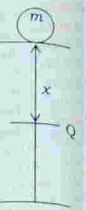
Examples:

Some most common examples of law of conservation of energy are:

i. When we switch on our electric bulbs, their filaments are heated up and begins to emit light. In switching on the bulb we supply electrical energy to it. It is converted into heat and light energies. Here one form of energy (electrical) is converted in other forms (light and heat) of energies and the electrical energy supplied is equal to the sum of the heat energy and light energy and the energy is neither created nor destroyed.

ii. In rubbing our hands we do mechanical work which produces an equal amount of heat energy, i.e.

Mechanical energy = Heal energy + Losses



Q7. Define K.E. Derive the expression for K.E of mass 'm' moving with velocity 'V'.

Ans. **Kinetic Energy:**

Definition:

"The energy possessed by a body by virtue of its motion is called kinetic energy".

Mathematical Expression:

If a body of mass 'm' which is moving with velocity of 'v', then the kinetic energy of the body can be calculated by the formula

$$K.E = \frac{1}{2} mv^2$$

Examples:

i. Moving ball can break glass window.

ii. A striking hammer can drive a nail

Derivation of the formula of Kinetic Energy:

To find the expression for K.E of an object in motion, we have to determine the work done by the moving object. This work is obviously equal to the change in K.E of the object.

Consider a body of mass 'm', which is projected up in the gravitational, field with the velocity 'v'. After attiring the maximum height 'h', the body comes to rest. The initial kinetic energy of the body is capable of doing work and is used up in doing work against the force of gravity.

At the maximum height the kinetic energy of the body is zero, because it is no more capable of doing work against the gravity. This means that the total work done by the body is a measure of its initial kinetic energy.

Work done by the body = $\vec{F} \cdot \vec{S}$

$$W = FSCos\theta$$

Since $\theta = 0$

Therefore $W = FSCos(0)$

$$W = FS$$

But the distance covered in vertical direction i.e. equal to height 'h' and the force F is equal to 'g'

$\therefore$ $W = mgh$ ——— (i)

Now we calculate 'h' by using the following data

Initial velocity of the body = $v_i = v$

Final velocity of the body = $v_f = 0$

Acceleration of the body = a = -g

Distance = S = h = ?

$$2aS = V_f^2 - V_i^2$$

$$2(-g)h = (0)^2 - v^2$$

$$-2gh = -v$$

Put the value of 'h' in equation (i)

$$W = mg.\frac{v^2}{2g}$$

$$W = \frac{mv^2}{2}$$

or

$$W = \frac{1}{2} mv^2$$

Hence the kinetic energy of the body of mass 'm' and moving with velocity 'v' is

$$K.E = \frac{1}{2} mv^2$$

Q8. Define Potential Energy. Derive the equation of P.E of a body of mass 'm' lying on the surface of the earth.

Ans. Potential Energy:

Definition:

"The energy possessed by the body by virtue of its position is called potential energy".

Mathematical Expression:

When a body of mass 'm' is lifted to a height 'h' against the gravitational field, then the P.E of the body is.

$$P.E = mgh$$

Example:

If we compress a spring, an elastic potential energy is developed in it; this energy is stored in it because a work is done in compressing the spring against the elastic force.

Derivation of the expression for potential energy:

In order to derive an expression for the gravitational potential energy at a height 'h' (very near to the surface of the earth). Consider a ball of mass 'm' which is taken very slowly to the height 'h'. The very slow motion is possible only when the applied force on the body by an external agency is equal in magnitude to that of the force of gravity, i.e.

$$F = mg$$

The work done by the applied force is

$$W = \vec{F}.\vec{S} = FSCos\theta$$

$\because$ $S = h$ and $\theta = 0$

$\therefore$ $W = FhCos(0)$

$= mgh$ (1)

$W = mgh$

Thus the work done on a body by applying an external force against the gravitational force is stored in it in the form of potential energy.

$$P.E = mgh$$

Q9(a) Define Absolute Potential Energy.

(b) Derive an expression for absolute P.E of a body having mass 'm' in the gravitational field of the earth having radius 'Re'.

Ans. (a) Absolute Potential Energy:

Definition:

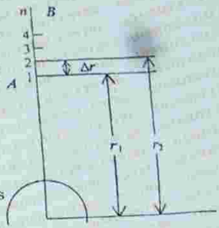
"The potential energy of a body at a height 'h' from the centre which is very far away from the centre of the earth at which the gravitational field is zero, is called absolute P.E".

(b) Derivation of Absolute P.E:

In order to calculate the absolute potential energy of the body, we assumed that the force of gravity through out the displacement of the body from the initial position to the final position remains constant.

On the other hand, when we consider problems involving large displacements 'h' as measured from the surface of the earth, e.g. in space flights we cannot take the gravitational force as constant. Infect, it decreases with the increase in height. Hence we cannot apply the simple formula of work i.e. $\vec{F}.\vec{S}$ to calculate the work done against the force of gravity.

To over come this difficulty, we divide the entire displacement into a large number of small displacement intervals and applying Newton's law of gravitation.



Suppose a point B is situated at a very large distance from the surface of the earth in the gravitational field as shown in figure.

Now consider a body of mass 'm' from an initial position A (or 1) to the final position B(or n).

We divide the distance between A and B into a large number of intervals of equal small width Δr each.

Since Δr is small, the force of gravity throughout this interval may be assumed to be constant.

The magnitude F_1 of the force $\vec{F_1}$ acting at the point I is given by:

$$F_1 = \frac{Gm\,Me}{r_1^2}$$

Where Me is the mass of earth, G is the gravitational constant and r_1 is the distance of point I from the centre of earth.

Similarly the magnitude F_2 of the force $\vec{F_2}$, acting at point 2 is given by

$$F_2 = \frac{Gm\,Me}{r_2^2}$$

The average force acting throughout the first interval

$$F = \frac{F_1 + F_2}{2}$$

Where F represents the magnitude of the average force $\vec{F}$, therefore

$$F = \tfrac{1}{2}(F_1 + F_2)$$

$$= \frac{1}{2}\left[\frac{GmMe}{r_1^2} + \frac{GmMe}{r_2^2}\right]$$

$$= \frac{GmMe}{2}\left[\frac{1}{r_1^2} + \frac{1}{r_2^2}\right]$$

$$F = \frac{GmMe}{2}\left[\frac{r_2^2 + r_1^2}{r_1^2\, r_2^2}\right] \quad \text{——— (i)}$$

Since

$$r_2 - r_1 = \Delta r \quad \text{——— (ii) from figure.}$$
$$r_2 = \Delta r + r_1$$

Put the value of 'r_2' in equation (i), then we get

$$F = \frac{GmMe}{2}\left[\frac{(\Delta r + r_1)^2 + r_1^2}{r_1^2\, r_2^2}\right]$$

$$F = \frac{GmMe}{2}\left[\frac{(\Delta r)^2 + 2\Delta r r_1 + r_1^2 + r_1^2}{r_1^2\, r_2^2}\right]$$

As Δr is very small, so $(\Delta r)^2$ is negligibly small.

$$F = \frac{GmMe}{2}\left[\frac{2\Delta r r_1}{r_1^2 r_2^2} + \frac{2r_1^2}{r_1^2 r_2^2}\right]$$

$$F = \frac{GmMe}{2}\left[\frac{2r_1(\Delta r + r_1)}{r_1^2 r_2^2}\right]$$

$$F = \frac{GmMe}{2}\left[\frac{2r_1 r_2}{r_1^2 r_2^2}\right]$$

$$F = \frac{GmMe}{r_1 r_2} \qquad \text{——— (iii)}$$

The work done in lifting the body from point 1 (position A) to point 2, by an applied force is equal hand opposite to the gravitational force is given by.

$$W_{12} = \vec{F}.\Delta r$$

Since the applied force and the displacement in same direction, therefore

$$W_{12} = F.\Delta r \cos\theta$$

i.e. $\theta = 0$ and $\cos(0) = 1$

$$W_{12} = F.\Delta r(1)$$

$$W_{12} = F.\Delta r \qquad \text{——— (iv)}$$

Substitute the value of 'F' from equation (iii) and of Δr from equation (ii) in equation (iv)

$$W_{12} = \frac{GmMe}{r_1 r_2}.(r_2 - r_1)$$

$$W_{12} = GmMe\left[\frac{r_2 - r_1}{r_1 r_2}\right]$$

$$= GmMe\left[\frac{r_2}{r_1 r_2} - \frac{r_1}{r_1 r_2}\right]$$

$$W_{12} = GmMe\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

The above equation shows that W_{12} is the work done in lifting the body from point 1 to point 2.

Similarly the work done in lifting the body from point 2 to point 3 is

$$W_{23} = GmMe\left[\frac{1}{r_2} - \frac{1}{r_3}\right]$$

And the work done from the point (n - 1) to n is

$$W_{(n-1)n} = GmMe\left[\frac{1}{r_{n-1}} - \frac{1}{r_n}\right]$$

Hence the total work done by the applied force in lifting the body from initial position A to final position B, we get

$$W = W_{12} + W_{23} + \ldots\ldots\ldots\ldots + W_{(n-1)n}$$

$$W = GmMe\left(\frac{1}{r_1} - \frac{1}{r_2}\right) + GmMe\left(\frac{1}{r_2} - \frac{1}{r_3}\right) + \ldots\ldots\ldots\ldots + GmMe\left(\frac{1}{r_{n-1}} - \frac{1}{r_n}\right)$$

$$W = GmMe\left[\frac{1}{r_1} - \frac{1}{r_2} + \frac{1}{r_2} - \frac{1}{r_3} + \frac{1}{r_3} - \frac{1}{r_4} + \ldots\ldots + \frac{1}{r_{n-1}} - \frac{1}{r_n}\right]$$

$$W = GmMe\left(\frac{1}{r_1} - \frac{1}{r_n}\right)$$

This is the potential energy which is represented by U of the body at the point B with respect to point A.

Hence the potential energy of the body at the point A with respect to that to the point B is ΔU = - W

$$\therefore \quad \Delta U = -GmMe\left(\frac{1}{r_1} - \frac{1}{r_n}\right)$$

or

$$\Delta U = GmMe\left(-\frac{1}{r_1} + \frac{1}{r_n}\right)$$

$$\Delta U = GMem\left(\frac{1}{r_n} - \frac{1}{r_1}\right)$$

Where the point B lies at an infinite distance, i.e. $r_n = \infty$ the potential energy at that point is zero, then

$$\Delta U = U$$

$$U = (P.E_{abs}) = GMem\left(\frac{1}{\infty} - \frac{1}{r_1}\right)$$

$$U = P.E_{abs} = GMem\left(0 - \frac{1}{r_1}\right)$$

$$U = P.E_{abs} = GMem\left(-\frac{1}{r_1}\right)$$

$$U = P.E_{abs} = -\frac{GMem}{r_1} \quad \text{———— (v)}$$

Assigning an arbitrary value of r i.e. $(r_1 = r)$ in equation (v)

$$U = P.E_{abs} = -\frac{GMem}{r}$$

Therefore the absolute P. E of a body of mass m lying at the surface of the earth is given by

$$P.E_{abs} = -\frac{GMem}{Re} \quad \text{——— (vi)}$$

Where 'Re' is the radius of the earth;
And the negative sign indicates that the potential energy is negative at any finite distance i.e. the potential energy is zero at infinity and decreases as the separation distance decreases.
Thus
"The fact that the gravitational force acting on the particle by the earth is attractive".

Value of the absolute potential energy at a height 'h':

An approximate value of the absolute potential energy at a height 'h' i.e. $(h << R_e)$ above the surface of the earth can be obtained from the equation (vi)

$$P.E_{abs} = -\frac{GMem}{Re}$$

$$P.E_{abs} = -\frac{GMem}{Re + h}$$

$$P.E_{abs} = -\frac{GMem}{Re\left(1 + \frac{h}{Re}\right)}$$

$$P.E_{abs} = -\frac{GMem}{Re}\left(1 + \frac{h}{Re}\right)^{-1}$$

The expression $\left(1 + \frac{h}{Re}\right)^{-1}$ can be expended by using the binomial theorem i e

$$(a + b)^n = a^n + n\,a^{n-1}b^1 + \dots\dots$$

$$\left(1 + \frac{h}{Re}\right)^{-1} = (1)^{-1} + (-1)(1)^{-1-1}\left(\frac{h}{Re}\right)^1$$

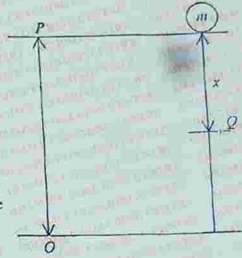
$$\left(1 + \frac{h}{Re}\right)^{-1} = 1 - \frac{h}{Re}$$

Where we have neglected the higher order terms and therefore

$$P.E_{abs} = -\frac{GMem}{Re}\left(1 - \frac{h}{Re}\right)$$

Q10. Derive work energy equation.

Ans. Consider a body of mass 'm' placed at a point 'P' which is at a height 'h' measured from the surface of earth. The body possesses a gravitational potential energy 'P.E' equal to 'mgh' with respect to point 'O' lying on the surface of the earth as shown in figure.



We assume that, the surface of the earth is a level of zero P.E. Suppose the body is fall freely under the action of gravity. Consider its position 'Q' at a distance 'x' below the point 'P' during the downward motion.

Obviously the P.E of the body at this point is
P.E = mg (h – x).

This means that the value of P.E is less than 'mgh' i.e.

$$mg\,(h - x) < mgh.$$

Thus the body has lost P.E by an amount mgx.

At point 'P' the body is at rest so its K.E is zero. During its downward motion, its velocity increases and so its K.E increases. We also assume that there is no force of friction involved during the motion of the body thus the loss of P.E must be equal to the gain in K.E i.e. P.E is being convened into K.E.

When the body reaches just above the point 'O', its P.E is nearly zero, i.e. whole of its P.E is converted into K.E. Therefore,

Loss of P.E = Gain in K.E

In practice there is always a force of friction 'f', say opposing the down ward motion of the body. Here a fraction of the P.E is used up in doing work against the force of friction. Thus a modified form of the above equation is

Loss of P.E = Gain in K.E + Work done against friction

Or Gain in K.E = Loss of P.E – Work done against friction

$$= mgx - fx$$

Where 'f' is the frictional force.

If 'x' is replace by 'h' then

Gain in K.E = mgh – fh

The above equation is called the WORK ENERGY EQUATION.

CHAPTER # 8

WAVE MOTION AND SOUND

IMPORTANT QUESTIONS & ANSWERS

Q1. State and explain Hooke's law.

Ans. Hooke's law:

Statement:

"If the deformation of a material is proportional to the force applied, then the material is said to obey Hooke's law".

Or

In other words it can be explained as:

"Within the elastic limit, the force acting on a body is directly proportional to the displacement of the body (extension) from it's equilibrium position is called Hooke's law".

Explanation:

Consider body of mass 'm' attached to a horizontal helical spring. The whole system is placed on a horizontal, smooth surface. If the spring is stretched or compressed, a small distance from its equilibrium position, and then released, the spring will exert a force on the body which is given by

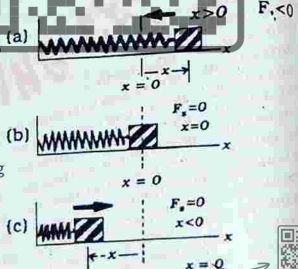
$$F \propto -x$$

$$F = -kx$$

Where 'x' is the displacement of the body from its equilibrium position and 'k' is a constant, which is known as the force constant of the spring.

The above equation is the mathematical expression of Hooke's law.

The negative sign in the above equation, shows that the force exerted by the spring on the body is always directed opposite to the displacement.



For example, when 'x' is greater than zero as shown in figure (a) the spring force is to the left i.e. negative.

When 'x' is less than zero as shown in figure (c), the spring force is to the right that is positive. No doubt, when 'x' is equal zero as shown in figure (b) the spring is neither stretched nor compressed and E = 0

As the spring force always tends to restore the original condition of the spring, it is some times called a restoring force or more correctly elastic restoring force.

Q2 (i) **Define S.H.M.**
(ii) **Show that the motion of a mass attached to the end of an elastic spring is SHM.**
(iii) **Derive the expression for its time-period and frequency.**

Ans. i. **Simple Harmonic Motion:**

Definition:

"The back and forth (oscillatory) motion in which the instantaneous acceleration is directly proportional to the displacement of the oscillating body and the acceleration is always directed towards the equilibrium position, is called simple harmonic motion".

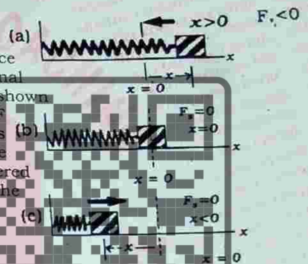
i.e. acceleration α (–) displacement.

Simple harmonic motion is abbreviated as SHM.

ii. **Motion of mass attached to the end of an elastic spring is S.H.M:**

Explanation:

Consider a block is at rest in its equilibrium position on a frictionless surface as shown in figure (b). If we apply an external force to displace the block to the right, as shown in figure (a) there will be a restoring force F exerted on the block by the spring and this is directed the block to the left. We assume that 'x' is the maximum displacement covered by the block, which is opposite to that of the restoring force 'F'. From Hooke's law, we have



$$F = -kx \qquad \text{(i)}$$

We know that, when a force 'F' is applied on a mass 'm', then the acceleration 'a' is produced. Thus from Newton's second law of motion.

$$F = ma \qquad \text{(ii)}$$

On comparing equation (i) and (ii), we have

$$ma = -kx$$

$$a = \frac{-kx}{m}$$

$$a = \frac{k}{m}(-x)$$

Since 'm' and 'k' are constants, therefore

$$a = \text{constant } (-x)$$

$$a \propto -x$$

Acceleration α (-) displacement

Where minus shows that the acceleration is always directed towards the equilibrium position.

iii. Derivation for the expression of:

a. Time Period:

To calculate the time period of oscillation, compare the following equations.

$$a = \frac{k}{m}(-x)$$

and $$a = -\omega^2 x$$

Therefore we get

$$-\omega^2 x = \frac{k}{m}(-x)$$

$$\omega = \sqrt{\frac{k}{m}}$$

or $$\frac{1}{\varpi} = \sqrt{\frac{m}{k}} \quad \text{——— (iii)}$$

But we know that the time period 'T' and the angular speed 'w' are inversely related, i.e.

$$T = \frac{2\pi}{\varpi}$$

Or $$T = 2\pi.\frac{1}{\varpi}$$

Put the value of $\frac{1}{\varpi}$ in the above equation,

$$T = 2\pi.\frac{1}{\varpi}$$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Where 'T' is the time period required for one complete trip.

b. *Frequency:*

The frequency is the reciprocal of the time period, which is given by

$$f = \frac{1}{T}$$

or $$f = \frac{\varpi}{2\pi}$$

Thus from equation (iv) we have

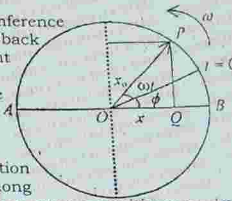
$$f = \frac{1}{2\pi\sqrt{\frac{m}{k}}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad \text{——— (v)}$$

From the above expression, we can calculate the frequency in hertz (Hz).

Q3. Show that the motion of projection of a uniform circular motion of a particle on the diameter of the reference circle is S.H.M. Derive the expression for: (i) Displacement (ii) Acceleration (iii) Time period (iv) Frequency (v) Velocity

Ans. Consider a point mass 'm' at a point 'P' moving in a circle of radius 'x_o' with constant angular velocity 'ω' we call this circle as our reference circle for the motion.



As the particle at point 'p' rotates along the circumference of a circle the projection 'Q' of the particle, moves back and forth along the diameter AQB. At some instant of time 't' the angle between OP and the x-axis at time (t = 0). This angle φ is known as initial phase angle. We take this as our reference point for measuring angular displacement. As the particle 'p' rotates on the circle, the angle that OP makes with the x-axis changes with time and the projection of particle on the x-axis, moves back and forth along the diameter of the reference circle between the two extreme positions x = ±x_o.

(i) Displacement of Projection 'Q':

In order to derive the expression for the displacement of the projection 'Q', we consider the right angle triangle OPQ, in figure (a). By using the trigonometric ratio, we have, the following:

$$Co\sec\theta = \frac{Base}{Hypotnuse}$$

$$Cos(\varpi t + \phi) = \frac{x}{x_o}$$

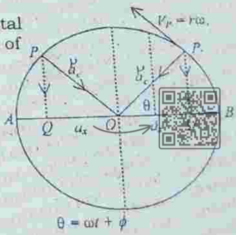
By cross multiplication we get

$$x = x_o Cos(\varpi t + \phi) \quad \text{(i)}$$

Where 'x" is the displacement of the projection 'Q'.

It may be positive when displacement is to the right, while it is negative, when the displacement is to the left and Cos(ωt +φ) < 0. The constant angle 'φ' is called the phase constant or phase angle.
The quantity (ωt +φ) is called the phase of the motion.
And 'x_o' is the amplitude of motion is simply the maximum displacement of the particle, in either positive or negative direction of the axis of 'x'.

(ii) Acceleration of the projection:



θ = ωt + φ

As the particle 'p' moves doing the circle, its centripetal acceleration 'a_c' which is directed towards the centre of the circle along the line PO as shown in figure (b).

The magnitude of the centripetal acceleration is

$$a_c = \frac{v^2}{r}$$

From figure (b), the above expression, will become

$$a_c = \frac{v_p^2}{x_o} \quad \text{——— (ii)}$$

but $\quad v = r\omega$

or $\quad v_p = x_o\omega$

Put the value of 'p,' in equation (ii):

$$a_c = \frac{(x_o\varpi)^2}{x_o}$$

$$a_c = \frac{x_o^2\varpi^2}{x_o}$$

$$a_c = x_o\varpi^2 \quad \text{——— (iii)}$$

Where $v_p = x_o\omega$ represents the linear speed of the particle at point 'P'. Now the acceleration of projection Q is equal to the component of the acceleration along the x-axis and by considering figure (b), it is given by

$$Cos\theta = \frac{Base}{Hypotenuse}$$

$$Cos\theta = \frac{a_x}{a_c}$$

$$a_x = a_c\,Cos\theta$$

From equation (iii), put the value of 'a_c' in the above equation

$$a_x = x_o\,\omega^2\,Cos\theta$$

But a minus sign is needed because the acceleration, a_x of the projection 'Q' is towards the left (along negative x-axis). Therefore,

$$a_x = -x_o\varpi^2 Cos\theta \quad \text{——— (iv)}$$

When the projection 'Q' is left of the centre, the acceleration of the point mass 'p' is towards the right, bat since Cosθ is negative at such point, and the minus sign is still needed.

$$x = -x_o\,Cos\theta$$

Hence equation (iv) because

$$a_x = -\omega^2 x \quad \text{——— (v)}$$

The above equation shows that the acceleration of the projection 'Q" is directly proportional to its displacement and is directed towards the centre of the circle. Hence the motion of the projection 'Q' is simple harmonic motion. Equation no (v) shows that the acceleration is maximum at the extreme positions.

iii. Time Period:

To calculate the time period of oscillation compares the following equation with equation (v)

$$a = -\frac{k}{m}x$$

Therefore, we get

$$-\omega^2 x = -\frac{k}{m}x$$

$$\omega^2 = \frac{k}{m}$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$\frac{1}{\omega} = \sqrt{\frac{m}{k}}$$

But we know that the time period T and the angular speed 'ω' are inversely related i.e.

$$T = \frac{2\pi}{\varpi}$$

therefore

$$T = 2\pi\sqrt{\frac{m}{k}} \qquad \text{———— (vi)}$$

Where T is the time required for one complete trip.

(iv) Frequency:

The frequency is the reciprocal of the time period, which is given by

$$f = \frac{1}{T} = \frac{w}{2\pi}$$

Thus from equation (vi) we have,

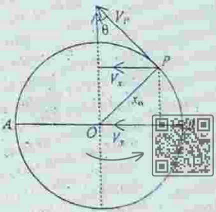
$$f = \frac{1}{2\pi\sqrt{\frac{m}{k}}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad \text{———— (vii)}$$

From the above expression, we can calculate the frequency in hertz (Hz).

(v) Velocity of the Projection:

The speed of the projection 'Q' is the component of the speed of the point mass 'p' along the diameter AOB as shown in figure.



$$Sin\theta = \frac{Perpendicular}{Hypotenuse}$$

But from figure

$$Sine\,\theta = \frac{v_x}{v_p}$$

$$v_x = v_p\, Sin\theta \qquad \text{———— (viii)}$$

but $\quad v_p = x_o\omega$

Put the value of 'v_p' in equation (viii)

$$v_x = x_o\omega\ Sin\theta \qquad \text{———— (ix)}$$

As we know that

$$Sin^2\theta = 1 - Cos^2\theta$$

$$Sin\ \theta = \sqrt{1 - Cos^2\theta}$$

Substitute the value of Sin θ in equation (ix)

$$v_x = x_o\omega\ Sin\theta$$

$$v_x = x_o\omega\ \sqrt{1 - Cos^2\theta}$$

But $Cos\theta = \frac{x}{x_o}$

Therefore the above equation becomes

$$v_x = x_o\omega\sqrt{1 - \left(\frac{x}{x_o}\right)^2}$$

$$= x_o\omega\sqrt{1 - \frac{x^2}{x_o^2}}$$

$$= x_o\omega\sqrt{\frac{x_o^2 - x^2}{x_o^2}}$$

$$= x_o\omega\frac{\sqrt{x_o^2 - x^2}}{x_o}$$

$$v_x = \omega\sqrt{x_o^2 - x^2} \quad \text{---- (x)}$$

$$v_x = \sqrt{\frac{k}{m}} \times \sqrt{x_o^2 - x^2} \quad \text{---- (xi)}$$

The equation (x) shows that the velocity is maximum at the mean position '0' where x = 0 and is equal to

$$v_x = \omega\sqrt{x_o^2 - 0}$$

$$v_x = \omega\sqrt{x_o^2}$$

$$v_{max} = \omega x_o$$

And the velocity is minimum ($v_{min} = 0$) at tins extreme positions A end.

Q4(a) What is simple pendulum?
(b) Show that the motion of a simple pendulum is S.H.M.
(c) Derive the expression for its time period and frequency.

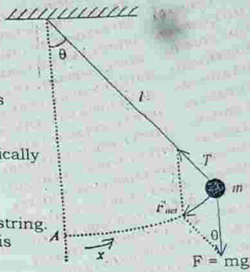
Ans. (a) <u>Simple Pendulum:</u>

<u>Definition:</u>

"The pendulum consists of a spherical bob suspended from a light, flexible and inextensible string tied to a fixed rigid and friction less support, is called simple pendulum".

(b) To show that motion of simple pendulum is SHM:

When the bob is displaced from its, equilibrium position, it begins to perform oscillatory motion. We will prove that the bob executes S.H.M, providing that the amplitude is sufficiently small.



The figure clearly shows that, there are two forces acting on the pendulum, i.e.

1. The gravitational force which is acting vertically downward.

$$\vec{F}_G = m\vec{g}$$

2. The tension 'T' acts along the suspension string. Therefore, the net force acting on the bob is given by

$$\vec{F}_{net} = \vec{F}_G + \vec{T}$$

Now resolve the gravitational force $\vec{F}_G$ into two components.

The parallel component of force, which acts along the length of the string of pendulum, which is given by

$$(F_G)_{//} = mg \, Cos\,\theta$$

The perpendicular component of force. Which acts perpendicular to the string which is given by

$$(F_G)_{\perp} = mg \, Sin\theta$$

Where 'm' is the mass of the bob.

Since there is no motion along the string, the net force acting in the direction of the string is zero. i.e.

$$(F_G)_{//} = 0$$

Hence the magnitude of the net force acting on the bob is

$$F_{net} = mg \, Sin\theta \qquad \text{(i)}$$

Because the component mgCosθ balances the tension 'T'. This force is the restoring force which is responsible for the oscillatory motion.

In figure 3, is the distance through which the bob moves along the are starting from 'A'.

Thus we know that the are length is

$$S = r\theta \qquad \text{(ii)a}$$

From figure (iii) S = x, r = l

Therefore equation (ii) becomes

$$S = l\theta \qquad \text{(iii)b}$$

According to Newton's second law of motion, the net force is

$$F_{net} = F = ma \qquad \text{(iii)}$$

On comparing equation (i) and (iii), we get

$$ma = -mgSin\theta$$

$$a = -gSin\theta \qquad \text{(iv)}$$

The negative sign shows that the force and hence the acceleration are always directed towards the mean position.

If 'θ' is sufficiently small, then

$$\sin\theta = 0$$

But from equation (iii)b, 'θ' is equal to

$$\theta = \frac{x}{l}$$

Thus $$\sin\theta = \frac{x}{l}$$

Put the value of $\sin\theta$ in equation (iv)

$$a = -g\,\frac{x}{l}$$

$$a = -\left(\frac{g}{l}\right)x \qquad \text{(v)}$$

Where 'l' is the length of the pendulum and 'g' is the acceleration due to gravity. (g/l) is a constant, then the above equation can be written as

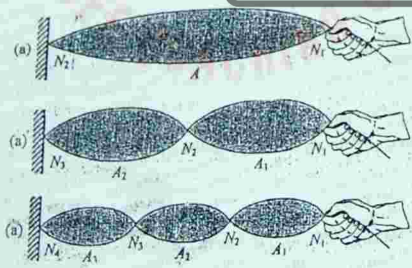
$$a = \text{constant}\,(-x)$$

$$a \propto -x$$

Thus the acceleration of the pendulum is directly proportional to its displacement and is directed towards its mean position. Hence it proves that the motion of the simple pendulum is S.H.M or in other words, the simple pendulum executes S.H.M.

Formation of stationary waves in a stretched string:-

Consider a rubber cord whose and end is fixed while the other is in our hand, if we wiggle it from the end in our hand a wave is set up which moves towards the other end. If we stop the motion of our hand we will see that the wave which was set up in the cord subsides. If we go on increasing the wiggling we will see that at a particular frequency say f_1 even if the motion of the hand is stopped the cord will continue to oscillate in one loop (Figure).



This wave is known as standing or stationary wave because no wave, moving on the cord, is visible.

If we increase the wiggling frequency beyond f_1, the stationary waves will not be set up, unless frequency of the motion of the hand is $2f_1$. This time the cord will oscillate in two loops as shown in figure.

Similarly if the wiggling frequency is $3f_1$, stationary waves are set up and the cord oscillate in three loops (figure). In general if wiggling frequency is nf_1 the cord will oscillate in loops.

Nodes:

Points where the displacement of the particle is zero but the tension is maximum are called nodes.

Antinodes:

Points where the displacement is maximum but the tension is minimum are called antinodes.

Transverse stationary waves in a stretched string:

Consider a string of length 'l' which is kept stretched by clamping it at two ends. It has tension T, now we study what happens when the string is plucked at different places and then released.

i. **When Plucked at its Middle Point:**

If the string is plucked at its middle point and then released, two transverse waves are set up in the string moving in opposite directions. At the ends reflection takes place and stationary waves are produced. The string vibrates in one loop (Figure). If f_1 and λ_1 be the frequency and wavelength of either of the wave respectively, then from figure we see that:

Stationary waves set up in a stretched string with its two clamped ends as nodes and the centre as an antinodes, are shown.

$$l = \frac{\lambda_1}{2}$$

$$\lambda_1 = 2l$$

If v is the speed of either of the component waves, then

$$v = f_1\lambda_1$$

$$v = f_1 2l$$

or
$$f_1 = \frac{v}{2l} \qquad \text{—————— (i)}$$

If m is the total mass of the string, then it can be shown that the velocity v of the wave along the string is given by:

$$v = \sqrt{\frac{T \times l}{m}} \qquad \text{—————— (ii)}$$

Putting the value of v in equation (i)

$$f_1 = \frac{1}{2l}\sqrt{\frac{T \times l}{m}} \qquad \text{—————— (iii)}$$

ii. If the String is Plucked from one Quarter of its Length:

If f_2 and λ_2 be the frequency and wavelength of one of the component Waves, then from figure, we can see that

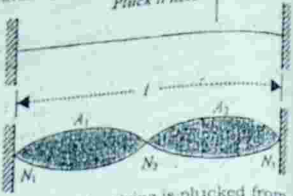
$\lambda_2 = l$

The speed will be same since it does not depend on the number of loops. Therefore

$v = f_2 \times \lambda_2$

or $v = 2f_2$

or $f_2 = \frac{v}{l}$ ______ (iv)



When the string is plucked from one quarter of its length, stationary waves are set up with the string vibrating in two loops.

Comparing equations (i) and (iv):

$f_1 = \frac{v}{2l}$ or $f_2 = 2f_1$

iii. If the string is plucked from one sixth of its length:

In this case string will vibrate in three loops. From figure, we can see that:

$\frac{3\lambda_3}{2} = l$

or $\lambda_3 = \frac{2l}{3}$

also $v = f_3\lambda_3$

Position of nodes and antonodes in the Stationary waves when the string vibrates in 3 loops

Putting the value of λ_3

$$v = f_3 \times \frac{2l}{3}$$

or $$f_3 = \frac{3v}{2l}$$ ______ (v)

Comparing equation (i) and (v) we have:

$$f_3 = 3f_1$$ ______ (vi)

since $$\frac{v}{2l} = f_1$$

Thus we can generalize that if the string is made to vibrate in n loops then the frequency at which the stationary waves will be set up in the string will be:

$$f_n = nf_1$$

The lowest of these frequencies i.e. f_1 is known as the fundamental and the others which are the integral multiples of the fundamental are known as overtones or harmonics.

c. Sononmeter is used in the laboratory to study such vibrations, because sonometer is the instrument which is generally used to determine the frequency of a tuning fork and to verify the laws of transverse vibration of strings.

Q6. Describe Newton's formula for the speed of sound in a medium. What correction did Laplace make and on what assumption?

Ans. **Newton's formula for the speed of sound waves:**

As we know that, the sound waves are compression waves, which propagate through a compressible medium, such as air. The speed of such compressional waves depends upon the compressibility and the inertia of the medium. The compressibility means the elastic property (elasticity) and inertia of the medium means inertial property (density) of the medium. The exact relation for the speed 'v' is given by:

$$v = \sqrt{\frac{\text{elastic property}}{\text{inertial property}}} = \sqrt{\frac{E}{\rho}}$$

Where 'E' is the elastic property and 'ρ' is the inertial property.

For solids:- (thin rods and wires)

The elastic property is equals to Young's modulus, 'Y'.

$$E = Y = \frac{\text{stress}}{\text{longitudinal Strain}}$$

$$E = Y = \frac{\text{Force per unit Area}}{\text{Change in length per unit length}}$$

For liquids & gases:

The elastic property is equal to Bulk Modulus 'B'.

$$E = B = \frac{\text{stress}}{\text{Volumetric strain}}$$

$$E = B = \frac{\text{Force per unit Area}}{\text{Change in volume per unit volume}}$$

Thus the speed of sound in air can be calculated by the following formula

$$\upsilon = \sqrt{\frac{B}{\rho}} \qquad \text{(i)}$$

The above expression is known as Newton's formula for the speed of sound waves. In air, the sound waves move in the form of compressions and rarefactions.

Since, it is explained that, the Bulk Modulus B, is the ratio of the change in pressure ΔP, (force per unit area), to the resulting fractional change in volume, $\frac{-\Delta V}{V}$

$$\therefore \quad B = \frac{-\Delta P}{\Delta V / V}$$

Here 'Δv' is the change in original volume v. The ratio (ΔP/Δv) always, negative because Δv decreases as ΔP increases and vice versa. This shows that 'B' is always positive.

Laplace's Correction:

The Newton's formula in equation (i) was obtained on the assumption that the compressions and rarefactions take place at constant temperature. This kind of process is called isothermal process or simply we can say that, according to Newton, sound waves travel through air pressure and volume to the final pressure and volume under this condition the Bulk modules 'B' is equals to the pressure of the gas.

Therefore

$$\upsilon = \sqrt{\frac{P}{\rho}}$$

Equation (i) was later on corrected by Laplace. According to Laplace When a layer of air is compressed, the temperature rises and when it is rarefied, the temperature falls. The motion of sound waves is so rapid and the compressions and rarefactions are formed so rapidly, that the temperature does not remain constant and Boyle's law is not applicable. This means the process is no more isothermal. Thus according to Laplace compressions and rarefactions occur adiabatically (A process in which heat does not flow into or out of the system). For adiabatic, the Bulk Modulus of the gas is not equal to pressure 'P' but it is equal to γ (Gamma) times the pressure 'P' of the gas

$$B = \gamma P$$

Now equation (i) becomes

$$\upsilon = \sqrt{\frac{\gamma P}{\rho}} \quad \text{(ii)}$$

Where 'r' is the ratio of molar specific heat of gas at constant pressure 'C_P' to the molar specific heat at constant volume 'C_V'.

The equation (ii) is called the Laplace's correction.

If we use the ideal gas law, i.e.

$$PV = nRT$$

$$P = \frac{nRT}{V}$$

Put the value of 'P' in equation (ii)

$$\nu = \sqrt{\frac{\gamma}{\rho}\frac{nRT}{V}}$$

But we know that

$$\rho = \frac{m}{V}$$

Therefore the above equation becomes

$$v = \sqrt{\frac{\gamma nRT}{\frac{m}{V} \times V}}$$

$$v = \sqrt{\frac{\gamma nRT}{m}}$$

$$v = \sqrt{\frac{\gamma RT}{\frac{m}{n}}}$$

Where m/n = M = mass per mole.

$$v = \sqrt{\frac{\gamma RT}{M}}$$

Where 'M' is the molecular mass of the gas in units kg/mole, 'n' is the number of moles 'R' is the universal gas constant and has value 8.314 J/mole-k and 'T' is the temperature expressed on Kelvin scale.

Calculation of speed of sound at 0°C:

We can calculate the velocity of sound at in air at 0°C. We know that air Consists of approximately 80% of Nitrogen and 20% of Oxygen. Hence for calculation we make the following data

Mass of nitrogen = m = 28 a.m.u

Mass of oxygen = m = 32 a.m.u

$\gamma = 1.40$

R = 8.314 J/mole - k

T = 0°C + 273 = 273 k

Solution:

Mean molecular mass of air is

$$M = 28 \times \frac{80}{100} + 32 \times \frac{20}{100}$$

$$M = 22.40 + 6.4$$

$$M = 28.8 \text{ gm / mole}$$

To convert 'gm' into kg divide 28.8 by 1000

$$M = 0.0288 \text{ kg/mole}$$

Now the velocity of sound is:

$$v = \sqrt{\frac{\gamma RT}{M}}$$

$$v = \sqrt{\frac{1.4 \times 8.314 \times 273}{0.0288}}$$

$$v = \sqrt{\frac{3177.6108}{0.0288}}$$

$$v = \sqrt{110333.7083}$$

$$v = 332 \ m/s \text{ at } 0^{\circ}C$$

Speed of Sound At Any Temperature 'T':

At any other temperature 't', the speed of sound in air can be obtained by multiplying this result by $\sqrt{T/273}$. For example at an altitude of 10,000 ft (3.05 km), the temperature, is about 50°C or 223K, therefore

$$v = 332\times\sqrt{\frac{T}{273}}$$

$$v = 332\times\sqrt{\frac{223}{273}}$$

$$v = 332\times\sqrt{0.8168}$$

$$v = 332 \times 0.9037$$

$$v = 300 \text{ m/s}$$

Q7. What are the characteristics of musical sound?

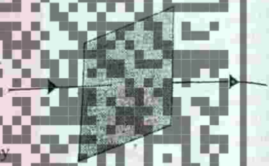
Ans. **Characteristics of musical sound:**

Musical sound or tones can be distinguished from one another by the following characteristics.

i. Intensity (loudness)
ii. Pitch or frequency
iii. Quality

Intensity of sound:

The amount of sound energy falling on unit area of a surface held normal to direction of propagation of sound in unit time is called the intensity of sound. It is denoted by I.



Formula:

Mathematically intensity of sound is given by

$$I = \frac{E}{A\times t}$$

Where
E = sound energy
A = Area of the surface
T = Time

Unit:

In MKS system the unit of intensity is $\frac{J}{m^2 - \text{sec}}$ or watt/m^2.

Loudness of Sound:

The magnitude of auditory sensation produced in ear by sound is called loudness of sound. It is denoted 'L'.

Weber Fechner Law:

This law sates that loudness of sound is directly proportional to the logarithm of intensity, i.e.

$$L \propto \log_{10} I$$

$$L = K \log_{10} I$$

Where K is a constant of proportionality and its value depend upon system of units.

Intensity Level:

The difference in loudness of two sounds where one sound is faintest audible sound, is called intensity level.

Formula:

If the intensities of the two sounds are I and I_o and loudness L and L_o respectively, then

$$L = K \log_{10} I$$
$$\text{and} \quad L_o = K \log_{10} I_o$$

Where I_o is intensity of faintest audible sound.

According to the definition of intensity level, we can write

$$\text{Intensity level} = L - L_o$$
$$= K \log_{10} I - K \log_{10} I_o$$
$$\text{Intensity level} = K \log_{10} \frac{I}{I_o} \qquad \text{(i)}$$

Where I is intensity of any given sound and I_o is intensity of faintest audible sound which is considered as 10^{-12}. watt/m².

Unit:

The unit of intensity level is 'bel' after the name of famous scientist Alexander Grahm Bel.

Bel:

If the intensity of sound is $10I_o$ (ten times of I_o), then the intensity level of the given sound is called "one bel".

i.e; Put $I = 10I_o$ in equation (i)

$$\text{Intensity level} = K \log_{10} \frac{10 I_o}{I_o}$$
$$= K \log_{10} 10 = K \times 1$$

If we measure intensity level in bel, then K = 1. Thus

$$\text{Intensity level} = 1 \text{ bel}$$

Deci – Bel:

It is a smaller unit of intensity level and is defined as.

$$1db = \frac{1}{10} bel$$

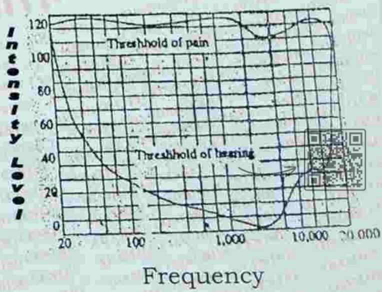
Note: 'db' stands for deci-bel.

Audible frequency range or frequency response of ear:

An average human ear can hear those sound frequencies which lie between 20 hertz and 20,000 hertz.

If the frequency of sound is higher than 20,000 Hz. It cannot be heard, Sounds of frequency higher than 20,000 Hz, are called ultrasonics.

The sensitiveness offs with age. Children can generally hear of 20,000 Hz while elderly people cannot hear anything above 15,000 Hz;



The sensitivity of an average human ear is different in different frequency ranges. Normal ear is most sensitive in the frequency range 2000 to 4000 Hz.

There is a threshold value of intensity level below which we cannot hear. There is also an upper limit of intensity above which we feel pain rather than of hearing.

Pitch and Quality of sound:

Pitch of sound:

The property or characteristic of sound by which a shrill sound can be distinguished from a grave one is called pitch of sound.
It depends upon the frequency i.e. the greater the frequency, the higher the pitch and the smaller the frequency the smaller the pitch.
The sounds produced by cats, rats, children and birds etc. are of high pitch.
The sounds produced by man, dogs, frogs are of low pitch.

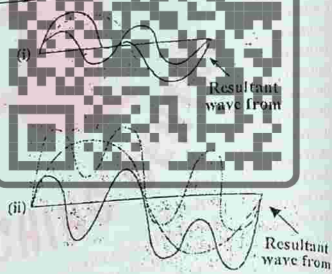
Quality of Sound:

The property or characteristic of sound by which it can be assigned to its source is called quality of sound.
The property of sound by which a note produced by a certain source is well distinguished from the note of the same pitch and loudness produced by another source of sound is called quality of sound.

Quality of sound depends upon the following factors:

The quality of sound depends upon the wave-form of the resultant and is controlled by the number and relative intensities and phase of harmonics that are present, the resultant wave forms as shown in figure have different effects on the ear though they have the same pitch and loudness. They will, however give rise to notes of different qualities.

Due to quality, of sound, the sound Produced in piano ear easily be distinguish From sound produced on violin even of both sounds are same pitch and loudness.



Resultant waveform when two Waves are combined

Q8. What is the principle of superposition of waves?

Ans. **Principle of Superposition of Waves:**

"When two or more waves in the same (linear) medium travel the net displacement of the medium caused by the resultant waves at any point is equal to the sum of the displacements of all the waves".

We apply the principle of superposition of sound waves to two harmonic waves travelling in the same direction in a medium. These two waves are travelling in the same direction in a medium. The two waves are travelling to the right and have the same frequency, same amplitude and same wavelength, but the differ in phase; we can express their individual wave function displacements as

$$y_1 = A_o Sin(kx - \omega t)$$
$$y_2 = A_o Sin(kx - \omega t - \phi)$$

Hence the resultant wave function displacement is given by

$$y = y_1 + y_2$$
$$y = A_o\,[Sin\,(kx - \omega t)] + A_o\,[Sin\,(kx - \omega t - \phi)]$$
$$y = A_o\,[Sin\,(kx - \omega t) + Sin\,(kx - \omega t - \phi)] \quad \text{———— (i)}$$

Since we know that, according to trigonometry,

$$Sin\alpha + Sin\beta = 2Cos\left(\frac{\alpha - \beta}{2}\right) Sin\left(\frac{\alpha + \beta}{2}\right)$$

Let $\alpha = kx - \omega t$

And $\beta = kx - \omega t - \phi$

Therefore equation (i) becomes

$$Y = A_o\left[2Cos\left\{\frac{(kx - \omega t) - (kx - \omega t - \phi)}{2}\right\} Sin\left\{\frac{(kx - \omega t) + (kx - \omega t - \phi)}{2}\right\}\right]$$
$$Y = A_o\left[2Cos\left(\frac{kx - \omega t - kx + \omega t + \phi}{2}\right) Sin\left(\frac{kx - \omega t + kx - \omega t - \phi}{2}\right)\right]$$
$$Y = A_o\left[2Cos\frac{\phi}{2} Sin\left(\frac{2kx - 2\omega t - \phi}{2}\right)\right]$$
$$Y = A_o\left[2Cos\frac{\phi}{2} Sin\left(\frac{2kx}{2} - \frac{2\omega t}{2} - \frac{\phi}{2}\right)\right]$$
$$Y = 2A_o Cos\frac{\phi}{2} Sin\left(kx - \omega t - \frac{\phi}{2}\right)$$

From the above equation, it can be easily seen that the resultant wave function 'Y' is also harmonic and has the same frequency and wavelength as the individual waves. The amplitude of the resultant wave is $2A_o\ Cos\ \phi/2$ and its phase is equal to $\phi/2$. If the phase constant ϕ is zero.

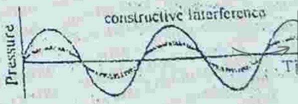
Then $Cos\ \phi/2 = 1$

And the amplitude of the resultant wave is

$$Y = 2A_o$$

This means that the amplitude of the resultant wave is twice as large as that of either of individual wave having the same wavelength.

In this case, the waves are said to interfere constructively that i.e. the crests of one fall on the crests of the other and troughs of one fall on the troughs of other. When two sound waves interfere constructively, then loud sound is heard.



In general constructive interference take place, when

$$\cos\frac{\phi}{2} = \pm 1$$

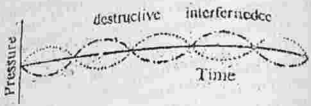
Or when $\phi = 0, 2\pi, 4\pi, \ldots\ldots 2n\pi$

When n is an integer

On the other hand, if $\phi = \pi$ radians (or any odd multiple of π)

Then $\cos\frac{\pi}{2} = 0$

And the resultant wave has zero amplitude everywhere. In this case, the two waves are said to interfere destructively, that is the crests of one wave coincide with the troughs of the second wave and vice versa, and their displacement cancel at every point. When two sound waves interfere destructively, then no sound is heard.



Q9. Write short note on the following:
1. **Sonometer and laws of vibrations of a stretched string.**
2. **Beats**
3. **Acoustics**

Ans. 1. Sonometer and laws of vibration of a stretched string:

Definition:

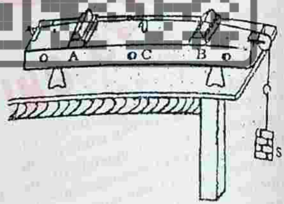
It is an instrument which is generally used to determine the frequency of a tuning fork to verify the laws of transverse vibration of strings.

Principle of working:

If a stretched string as excited by small periodic force having frequency equal to any of the quantised frequencies of the string, the phenomenon of resonance will take place and stationary waves will be set up on the string.

Construction:

It consists of wooden box over which a steel wire is stretched. One end of which is fixed to a peg and the other end pusses over a pulley. This end carries a hunger on which slotted weights can be slipped to vary tension in the siring (wire).



Two sharp wedges are placed below the wire.
A horizontal graduated scale is fixed below the wire on the box in order to measure the length of the wire.

Laws of vibration of a stretched string:

All the laws of vibration i.e. transverse vibration of the siring can be verified by using sonometer. If 'L' is the length of the vibrating segment of the string, 'T' is the tension and 'μ' is the mass per unit length of the wire, then the frequency produced in the string is

$$f_1 = \frac{n\nu}{\lambda} \qquad \text{(i)}$$

$$\nu = \sqrt{\frac{T}{\mu}}$$

Therefore equation (i) becomes

$$f_1 = \frac{n}{2L}\sqrt{\frac{T}{\mu}} \qquad \text{(ii)}$$

Where 'n' = 1, 2, 3, ... , i.e. frequencies are the integral multiple of the fundamental frequency, and

$v = \sqrt{\frac{T}{\mu}}$ is the speed of the wave.

The equation (ii) shows that

i. The frequency produced in the string for a given tension is inversely proportional to its length, i.e. $f \alpha \frac{1}{L}$.

ii. The frequency varies directly as a square root of the tension, i.e. $f \alpha \sqrt{T}$.

iii. The frequency of vibration varies inversely as the square root of the mass per unit length of the string, i.e. $f \alpha \frac{1}{\sqrt{\mu}}$.

2. Beats:

Definition:

When two bodies (e.g. tuning fork) having slightly different frequencies are sounded simultaneously, the periodic alterations of sound between maximum and minimum loudness are produced, which are known as beats.

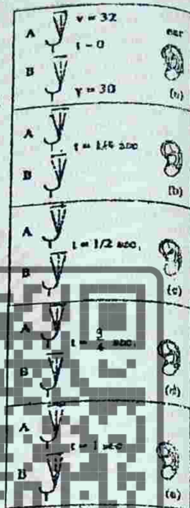
Principle of Production of Beats:

The two sound waves from two sources of slightly different frequencies interface constructively as well as destructively. When they interfere constructively max. loudness is produced and when they interfere destructively minimum loudness is produced.

Hence we can say that the production of beats is special type of interference.

Production of Beats:

Let us consider two vibration tuning forks A and B of frequencies 32 Hertz and 30 Hz respectively placed at equal distances from the ear.



i. Let us suppose that a certain, time t = 0, the two forks are in phase i.e. right hand prongs, of both the forks are moving towards right and are thus sending compressions. These two compressions will reach at the ear together and thus a loud sound (max: loudness) is heard.

ii. When t = ¼ sec, the fork A completes 8 vibrations and B completes 7½ vibrations. The fork A is compression while B is sending rarefaction. They will cancel each other and no sound (min. loudness) is heard.

iii. When t = ½ sec, the fork A and B completes 16 vibrations and15 vibrations respectively. Both the fork are sending compressions which reinforce each other and thus a loud sound (max. loudness) is heard.

iv. After t = ¾ sec fork A will complete 24 vibration and fork B will 22½ vibrations. At this instant fork A will be sending a compression while fork B will be sending a rarefaction. Thus no sound (min. loudness) will be heard.

v. After t = 1 sec. fork A will complete 32 vibration and fork B will complete 30 vibrations. Both these forks will be sending compressions and a loud sound (max. loudness) will be heard.

Conclusion:

From above illustration we can conclude that the number of beats per second is equal to the difference between the frequencies of the two forks (sounding bodies).

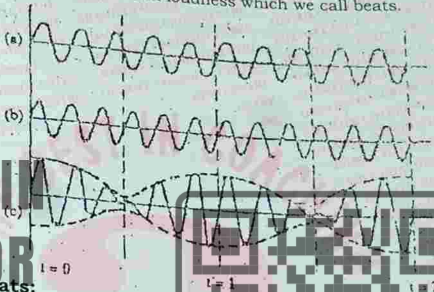
Formula:

$f_1 - f_2 = n$ = *No of beats*

In general $f_1 = f_2 \pm 1$

Graphical Representation of Beats or Displacement Curve for Beats:

The phenomenon of beats can be understood by considering the displacement curves of sound waves. In the figure as given below, the displacements of two sound waves are plotted against time. The total extent of time axis is 2 seconds. If both sounds propagate along the same line, then the resultant displacement of the particles of the medium will give rise to beats, i.e. From graph it can be seen that amplitude varies with time, this variation in amplitude give rise to variations in loudness which we call beats.



Uses of Beats:

1. The phenomenon of beats is used in finding the unknown frequencies.
2. Beats are also used in tuning the musical instruments.

3. Acoustics:

A sound wave will continue to recede from its source until it is converted into some other form of energy. When a sound wave passes through a given material, some of the sound-wave energy is absorbed and converted into heat energy. That is, as the sound-wave energy strikes the absorbing material, it increases the motion of its molecules. This increase in molecular motion appears as added heat energy. Porous materials are effective sound absorbs because they contain many packets of air whose molecules can readily be set into increased motion.

The greater the conversion to heat, the greater the absorption coefficient. The absorption coefficient of a given material is the fraction of the sound energy that it will absorb at each reflection or transmission. Some materials have low absorption coefficients, and sound waves pass through them are reflected from then with little loss of energy. Other materials, such as sponge rubber, rugs, draperies, pressed plant fibers and porous felt, are good absorbing materials and are used commercially for such purposes.

Materials with a high coefficient of absorption are of importance for the acoustical treatment of rooms and auditoriums. An auditorium is said to have good acoustics when speech can be heard almost equally well throughout the space, without troublesome echoes and reverberations. The podium and stage should be so designed that speech sounds are projected out into the audience and not "lots" backstage. Multiple echoes from the ceiling and walls of the room should not be entirely absent or the room will be acoustically "dea", as if the speaker were addressing a crowed in the open air. On the other hand, if multiple echoes (reverberations) persist for too long a time, the echoes from previous syllables uttered by the speaker will arrive at the listener's ear just in time to interfere with the hearing of the next syllable. Music, too, can be adversely being excessive reverberation.

Interference is another factor that must be considered in designing auditoriums. Interference will cause variations may be minimized by a proper choice of the dimensions and shape of the auditorium and by having "clean" lines, free from pillars, overhangs, and unnecessary architectural embellishments.

Q10. (a) What is Doppler's effect?
(b) Discuss the Doppler's effect for following possibilities:
i. When the listener is moving and the source is at rest.
ii. When the source is moving and the listener is at rest.
iii. When both the source and listener are moving.

Ans. (a) <u>Doppler's effect:</u>
<u>Definition:</u>
When a source of sound or a listener, or both are in motion relative to the medium (air), the frequency and hence the pitch of the sound as heard by the listner, is in general not the some as when listener and source are at rest. This phenomenon is referred to as the Doppler's Effect.

(b) <u>Doppler's Effect for different possibilities:</u>
Obviously, there are three general possibilities to discuss the Doppler's effect, which are explained a follows.

i. ***<u>When the listener is moving and the source is at rest:-</u>***
In this case, there are two different possibilities that, either the listener is moving towards the stationary source or the listener is moving away from the stationary source.

(a) Suppose the listener is moving towards a stationary source as shown in figure.
Suppose its velocity is 'v_o' and the source emits a wave with frequency 'v' and wavelength $\lambda = V/v$. The figure shows several wave crests separated by equal distances i,e. 1λ (1 wavelength). The waves approaching the moving listener have a speed of propagation relative to the listener $(v + V_o)$.

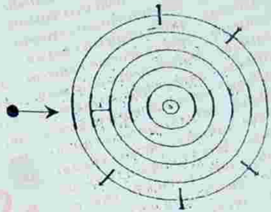
The frequency 'υ'' heard by the listener is

$$Frequency = \frac{Velocity}{Wavelength}$$

$$\upsilon' = \frac{v + v_o}{\lambda} \qquad \text{(i)}$$

But we know that

$$\lambda = \frac{v}{\upsilon}$$



Thus equation (i) becomes

$$\upsilon' = \frac{v + v_o}{v/\upsilon}$$

$$\upsilon' = \left(\frac{v + v_o}{v}\right)\upsilon$$

$$\upsilon' = \left(\frac{v}{v} + \frac{v_o}{v}\right)\upsilon$$

$$\upsilon' = \left(1 + \frac{v_o}{v}\right)\upsilon$$

$$\upsilon' = \upsilon + \left(\frac{v_o}{v}\right)\upsilon$$

Therefore, the listener is moving towards a source at rest, detects the larger frequency and hence higher pitch. Consequently, the change in pitch in this case is

$$\upsilon' - \upsilon = \left(\frac{v_o}{v}\right)\upsilon$$

(b) Similarly, a listener moving away from the stationary source hears a lower pitch and frequency detected by the listener is

$$\upsilon' = \left(1 - \frac{v_o}{v}\right)\upsilon$$

$$\upsilon' = \upsilon - \left(\frac{v_o}{v}\right)\upsilon$$

Consequently the change in pitch in this case is

$$\upsilon' - \upsilon = -\left(\frac{v_o}{v}\right)\upsilon$$

Hence the general relation holding when the source is at rest with respect to the medium and observer is moving through it, is given by

$$\upsilon' = \upsilon \pm \left(\frac{v_o}{v}\right)\upsilon$$

$$\upsilon' = \left(\frac{v \pm v_o}{v}\right)\upsilon$$

Where positive sign refers to the motion toward the source and negative sign refers to the motion away from the source.

ii. When the source is moving and listener is at rest.

(a) Now consider the case, when the source is in motion and moving with a speed, 'v_s' towards a stationary listener as in figure.

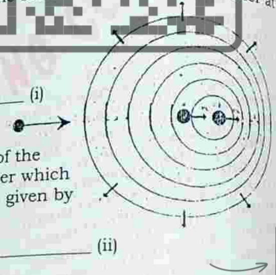
The wave, crests detected by the stationary listener are closer together because the source is moving, in the direction of the outgoing wave resulting in a shortening of wavelength.

i.e. the wavelength 'λ'' measured by the listener is shorter than the true wavelength 'λ' of the source ($\lambda' < \lambda$). If the speed of the source is 'v_s' and its frequency 'υ', then during each vibration it travels a distance v_s/υ.

Thus the wavelength of the sound arriving at the listener at rest is

$$\lambda' = \frac{v}{\upsilon} - \frac{v_S}{\upsilon}$$

$$\lambda' = \frac{1}{\upsilon}(v - v_S) \quad \text{——— (i)}$$



Therefore, the frequency of the sound heard by the listener which is at rest increased and is given by

$$\lambda' = \frac{v}{\upsilon'} \quad \text{——— (ii)}$$

Put the value of λ' from equation (i) in equation (ii)

$$\upsilon' = \frac{\nu}{\left(\frac{\nu - \nu_S}{\upsilon}\right)}$$

$$\upsilon' = \frac{\nu\upsilon}{\nu - \nu_S}$$

$$\upsilon' = \frac{\upsilon}{\frac{\nu - \nu_S}{\nu}}$$

$$\upsilon' = \frac{\upsilon}{\frac{\nu}{\nu} - \frac{\nu_S}{\nu}}$$

$$\upsilon' = \frac{\upsilon}{1 - \frac{\nu_S}{\nu}}$$

The above equation indicates that an increase in the frequency of the sound heard by the stationary listener.

(b) On the other hand, if the source is moving away from the stationary listener, the wavelength of the sound arriving at listener is greater than the true wavelength λ i.e. ($\lambda' > \lambda$) and the listener detects a decreased frequency which is given by

$$\upsilon' = \frac{\upsilon\nu}{\nu \pm \nu_S}$$

$$\upsilon' = \frac{\upsilon}{\left(1 \pm \frac{\nu_S}{\nu}\right)}$$

Where the minus sign refers to the motion of the source towards the stationary observer and positive sign indicates the motion of the source away from the stationary observer.

When the source is at rest i.e. $V_s = 0$ then no change in the frequency of sound is observed i.e. $\upsilon' = \upsilon$

iii. **When both the source and the listener are moving:**

(a) If the source and the listener are approaching along the line joining the two in the direction towards each other, then the frequency heard by the moving listener is given by

$$\nu' = \left(\frac{\nu + \nu_o}{\nu - \nu_s}\right)\upsilon$$

Where 'V' is the velocity of sound waves, 'V_o' is the velocity of listener and 'V_s' is the velocity of source.

(b) On the other hand, if the source and the listener are moving away from each other along the line joining the two, then the frequency heard by moving listener is

$$\nu' = \left(\frac{v - v_o}{v + v_s}\right)\upsilon$$

In general, the above two equations are expressed as

$$\nu' = \left(\frac{v \pm v_o}{v \pm v_s}\right)\upsilon$$

Q11. Why explosion taking place in the sun are not heard on earth?

Ans. We know that there is a vacuum between the sun and the earth. As the sound waves can not travel through the vacuum, so we cannot hear the sound produced by the explosions going on the sun.

Q12. Difference between Longitudinal and transverse waves.

Ans.

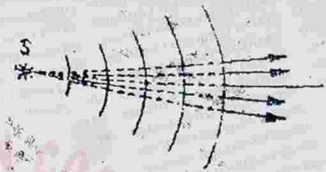
Longitudinal waves	*Transverse waves*
• The waves in which the particles of the medium vibrate parallel to the direction of propagation of waves are called longitudinal waves.	• The waves in which the particles of the medium vibrate perpendicular to the direction of propagation of waves are called transverse waves.
• These waves consists of compressions and rarefactions.	• These waves consists of crests and troughs.
• Sound waves are the example of longitudinal waves.	• Light waves are the example of transverse waves.

CHAPTER # 9
NATURE OF LIGHT
IMPORTANT QUESTIONS & ANSWERS

Q1(a) What are wave fronts?
(b) Explain Huygen's principle.

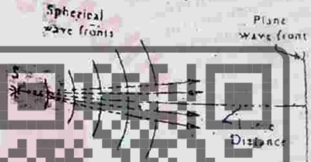
Ans. (a) Wave fronts:

Whenever waves pass through, a medium, its particles execute SHM. The path (locus) of all the particles of the medium having the same phase is known as wave front.



Spherical Wave front:

In case of a point sources of light the wave front will be concentric spheres with centre at the source S. Such a wave front is known as spherical wave front.



Plane Wave front:

At a very large distance from the source a small portion of a spherical wave front will become plane wave front.

The direction in which wave moves is always normal to the wave front. Thus a ray of light means the direction in which a light wave propagates and it is always along the normal to the wave front.

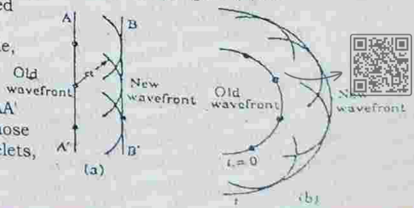
(b) Huygen's Principle:

It has two parts:

i. Every point on a wave front can be considered as a source of secondary spherical wave front.

ii. The new position of the wave front after a time t can be found by drawing a plane tangential to the secondary wave-lets.

Figure illustrates two simple examples of Huygen's construction. First, consider the plane wave front moving through medium as in Figure (a) At $t = 0$, the wave front is indicated by the plane labelled AA'. According to Huygen's principle, each point on this wave front is considered as a point source. Only a few points on AA' are shown for clarity. Using those points as sources for the wavelets, we draw circles of radius 'ct',



where 'c' is the speed of light and 't' is the time of propagation from one wave front to the next. The plane tangent to these wavelets is BB', which is parallel to AA'. In a similar manner Figure (b) shows Huygen's construction for spherical wave fronts.

Q2(a) What is interference of light?
(b) Give the conditions of interference of light waves.

Ans. (a) Interference of Light:

Definition:

The phenomenon of two or more waves of the same frequency combining to form a wave in which the disturbance at any point is the algebraic or vector sum of the disturbances sue to the interfering waves at that points.

The interference phenomenon of waves is general feature of all types of waves such as sound waves mechanical waves, light waves etc.

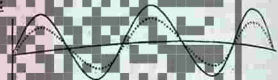
But the interference effects in the light waves are not easy to observe because of short wave lengths, (about 4×10^{-7}m to 7×10^{-7}m)

Types of interference:

There are two types of interference, named as

i. Constructive Interference
ii. Destructive Interference.

i. CONSTRUCTJVE INTERFERENCE:

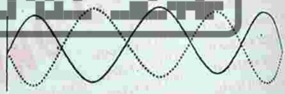


"If the crests of one wave fall on the crests of the other then these waves are said to interfere constructively".

Constructive interference can also be defined as:

"If the resultant intensity of the interfering waves is greater than the intensity of an individual wave, then this type of interference is known as constructive interference".

ii. DESTRUCTIVE INTERFEREENCE:



If the crests of one wave coincide with the troughs of the second wave and vice versa and their displacement cancel at every point, then the two waves are said to interfere destructively.

Destructive interference can also be defined as:

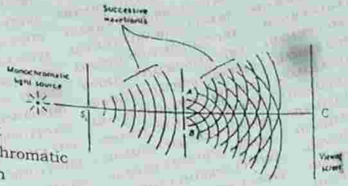
"If the resultant intensity of the interfering waves is zero or less than the intensity of the individual wave, then this type of interference is called destructive interference".

(b) Conditions For Interference:

The conditions for interference are:

i. The sources must be phase coherent.
ii. The sources must be monochromatic.
iii. The superposition principle must apply.

In order to observe stable interference of light waves, the following condition must be applied .



A common method for producing two coherent light sources is to use one monochromatic source to illuminate a screen with two small slits as shown in figure;

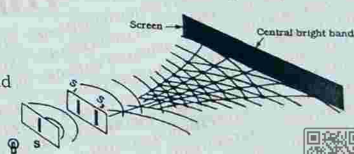
The light emerging from both slits is coherent because a single source produces the original light beam and the two slits serve only to separate the original beam into the parts. Consequently, a random change, in the light emitted by the source will in the two separate beams at the same time, and interference effects can be observed.

Q3(a) Describe Young's double-slit experiment for demonstrating the phenomena of interference of light.
(b) derive the expression for the fringe spacing.

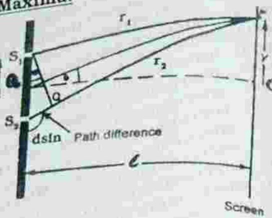
Ans. (a) <u>Young's double – slit experiment:</u>

The phenomenon of interference in light waves from two sources was first demonstrated by Thomas Young in 1801. a schematic diagram of the apparatus used by him during demonstration.
To obtain two coherent light sources light is incident on a screen, which has a narrow slit 'S_o'. The waves emerging from this slit are then allowed to incident on a second screen, which has two narrow parallel-slits 'S_1', and 'S_2'. These two slits serve as a pair of coherent light sources. Because waves coming out from these slits originate from the same wave front and therefore always in phase.

A screen is placed at some distance away from the second screen young found a series of alternately dark and bright parallel bands corresponding to the position of destructive and constructive interference on this screen. These alternate dark and bright parallel bands are called fringes. That is, when two light waves add constructively at any location on the screen, a bright fringe is produced and when two light waves add destructively at any location on the screen, a dark fringe is produced.



Derivation of the Expression for Maxima:



In order to derive the expression of maxima consider figure.
Light waves with a definite wave length λ, are incident on the pair of narrow slits S_1 and S_2, which are separated by a distance 'd'. The fringes are obtained on the screen which is placed at a perpendicular distance 'l' from the screen containing slits S_1 and S_2 as shown in figure. Consider a point 'P' on the viewing screen, suppose

$$PS_1 = r_1$$

And $$PS_2 = r_2$$

The light intensity on the screen at point 'P' is the resultant of the light coming from both slits. Note that a wave coming from the lower slit S_2 travels a greater distance than a wave from the upper slit S_1 which is equal to the difference between the two paths. The difference between PS_2 and PS_1 is known as path difference, which is obtained by the geometry.

$$PS_2 - P'S_1 = r_2 - r_1 = d\sin\theta \qquad \text{(i)}$$

If the path difference is either zero or integral multiple of wavelength of the light used, the two waves are in phase and constructive interference results, i.e. a bright fringe is produced.

Therefore, for constructive interference

$$d\sin\theta = m\lambda \qquad \text{(ii)}$$

Where 'λ' is the wavelength of light and 'm' is the order of fringes, i.e.

$$m = 0, \pm1, \pm2, \pm3, \ldots$$

The equation (ii) is the expression for maxima.
The central bright fringe at θ = 0 (m = 0) is called zeroth order maximum, and when m = ±1 is called first order maximum and so on.

Derivation of the Expression for Minima:

Similarly, if the distance $(r_2 - r_1)$ contains an odd number of half wavelengths, then the waves will arrive at the point 'P' with their maxima displaced from one another by half wavelength (½ λ). Therefore at point 'P' the waves will be out of the phase and destructive interference will occur.

$$d\sin\theta = (m + \tfrac{1}{2})\lambda \qquad \text{(iii)}$$

where $m = 0, \pm1, \pm2, \pm3, \ldots$

The equation (iii) shows the expression for minima.

(b) Derivation for the Expression of fringe Spacing:

To derive the expression for fringe spacing, first we have to obtain the expressions of the bright and dark fringes, which are measured vertically from O to P. We shall assume that the distance between the slit and the screen is much larger than the distance between the two slits (d<<L). In practice 'L' is of the order of 1m, while 'd' is a fraction of a millimeter, under these conditions 'θ' is small, therefore

$$\sin\theta = \tan\theta$$

In fig (2) Consider the triangle OPQ we see

$$Sin\theta = \tan\theta = \frac{Y}{L}$$

Multiplying both sides by 'd' we get

$$dSin\theta = \frac{Y}{L}d \qquad \text{(iv)}$$

Position of bright fringe:-

For computing the position of a m^th bright fringe, we substitute $Y = Y_m$ and comparing equation (iv) and equation (ii).

$$\frac{Y_m}{d}d = m\lambda$$

Where Y_m, be the distance of the centre of the m^th bright band from the centre of the central band at $\theta = 0$.

$$Y_m = \frac{\lambda L}{d}m \qquad \text{(v)}$$

Position of dark fringe:

Similarly by comparing equation (iii) and equation (v), the positions of dark fringes measured and substitute $Y = Y_d$ in equation (v), we get

$$\frac{Y_d^d}{L} = (m+\frac{1}{2})\lambda$$

$$Y_d = \frac{\lambda L}{d}(m+\frac{1}{2}) \qquad \text{(vi)}$$

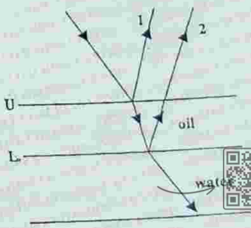
Where Y_d is the distance of the dark fringe from the centre.
From equation (v), we can calculate the distance between the two adjacent bright and dark fringes. This distance is known as "FRINGE SPACING" 'Δx'.
As 'm' increases by unit then we get.

$$\text{Fringe spacing} = \Delta x = \frac{\lambda L}{d} \qquad \text{(vii)}$$

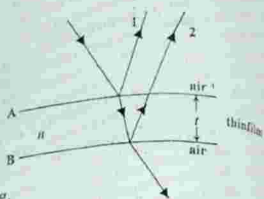
Q4. Explain the interference in thin film.

Ans. Interference in thin film:

Light waves interference causes the colours that appear when oil or petrol is spilled on water or a wet surface. The very thin films formed reflect light from both upper and lower surfaces (U and L, figure), resulting in path differences that provide the conditions for destructive and constructive interference for an observer 'O' the different coulours of light. Similar effects are observed in soap bubbles or in thin films of air enclosed between glass plates. Now we discuss the interference of waves reflected from the opposite surfaces of the films.



Consider a thin film of uniform thickness t and index of refraction n, as shown in figure. Let us assume that the light rays travelling in air are nearly normal to the surface of the film. In order to determine whether the reflected rays interfere constructively or destructively, we must first note the following facts:



1. There is a phase change of 180° upon reflection if the reflecting medium has a higher index of refraction than the medium in which the wave is travelling.

2. The wavelength of light $\frac{\lambda}{n}$ in a medium whose index of refraction is n is,

$$\lambda_n = \frac{\lambda}{n} \quad \text{———— (i)}$$

Where λ is the wavelength of light in free space.
Let us apply these facts to the thin film shown in figure, we find that ray 1, which is reflected from the upper surface (A), undergoes a phase change of 180° with respect to the incident wave. Ray 2, which is reflected from the lower surface (B), undergoes no phase change with respect to the incident wave. Therefore rays 1 and 2 are 180° out of phase following reflection. However, we must also consider that ray 2 travels an extra distance equal to 2t before the waves recombine. For example if $2t = \lambda_n/2$, rays 1 and 2 will recombine in phase and constructive interference will result. In general, the condition for constructive interference can be expressed as

$$2t = (m + \frac{1}{2})\lambda_n \quad \text{———— (ii)}$$

Where m = 0, 1, 2, ...
Making use of Eq. (2), we get

$$2nt = (m + \frac{1}{2})\lambda \quad \text{———— (iii)}$$

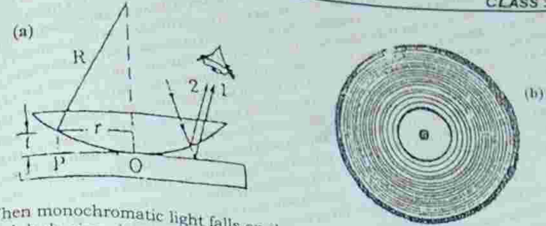
If the extra distance '2t' travelled by ray 2 corresponds to a multiple of λ_n, the two waves will come back together out of phase and destructive interference will result. The general equation for destructive interference is

$$2nt = m\lambda \quad \text{———— (iv)}$$

Where m = 0, 1, 2, ...

Q5(a) What are Newton's rings? Give experimental arrangement for producing Newton's rings.
(b) Derive an expression for the radius of curvature of the lens used in the arrangement.

Ans. (a) <u>Newton's rings:</u>
When a plano-convex lens is placed on a plane glass plate, a thin film of air is enclosed between the lower surface of the lens and the upper surface of the plate. The thickness of the air film is very small at the point of contact and gradually increases from the centre outwards, as shown in figure.



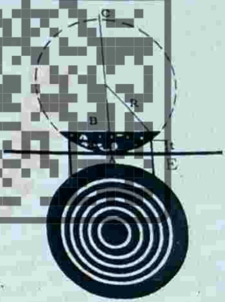
When monochromatic light falls on the surface from above, a pattern of bright and dark, rings is seen, as shown in figure (b) these circular fringes, discovered by Newton, are referred to as Newton's rings. These rings are also due to interference of light as explained below.

The interference effect is due to the combination of ray 1, reflected from the glass plate, with ray 2 reflected from the lower part of the lens. Ray 1 undergoes a phase change of 180° upon reflection, since it is reflected form a medium of higher index of refraction, whereas ray 2 undergoes no phase change. These two rays will interfere constructively or depending upon conditions.

(b) Derivation of the expression for radius of curvature of the lens:

To obtain the radius of curvature of the lens, consider the figure.

The arrangement in this diagram shows that, the thickness of the air film between the glass surface varies from zero at the point of contact to some value 't' at some point 'E'.



The radius of curvature 'R' is very large as compared to the radius 'r' of a ring. The point of contact gives a dark circle due to zero path difference at this point and 180° change in phase in the light externally reflected at the lower surface.

Using the geometrical theorem that the product of intercepts of intersecting chords are equal, we have.

$$r^2 = (BC) \times (AB) \quad \text{——— (i)}$$

The figure show that

$$BC = 2R - t$$

And $\quad AB = t$

Therefore equation (i) becomes

$$r^2 = (2R - t) \times t$$

$$r^2 = 2Rt \times t^2$$

As 't^2' being small, so it is neglected

$$r^2 = 2tR$$

$$r = \sqrt{2tR} \quad \text{——— (ii)}$$

For constructive interference:-

As we know that, the path difference for constructive interference in this film is

$$2t = (m + \frac{1}{2})\lambda_n \qquad \text{(iii)}$$

But $\lambda_n = \frac{\lambda}{n}$

Put the value of λ_n a in eq (iii)

$$2t = (m + \frac{1}{2})\frac{\lambda}{n}$$

$$2nt = (m + \frac{1}{2})\lambda$$

assuming n = 1, for air

$$2t = (m + \frac{1}{2})\lambda$$

for first bright ring(m = 0), we write

$$2t_1 = (0 + \frac{1}{2})\lambda$$

$$2t_1 = \frac{1}{2}\lambda$$

For second bright ring m = 1

$$2t_2 = (1 + \frac{1}{2})\lambda$$

$$2t_2 = \frac{3}{2}\lambda$$

For third bright ring m = 2

$$2t_3 = (2 + \frac{1}{2})\lambda$$

$$2t_3 = \frac{5}{2}\lambda$$

Similarly, for N^{th} bright ring, m-N-1

$$2t_N = \{(N - 1) + \frac{1}{2}\}\lambda$$

$$= (N - 1 + \frac{1}{2})\lambda$$

$$2t_N = (N - \frac{1}{2})\lambda$$

Substitute the value of $2t_n$ in equation (ii)

$$r_n = \sqrt{(N - \frac{1}{2})\lambda R}$$

$$r_n = \sqrt{R(N - \frac{1}{2})\lambda}$$

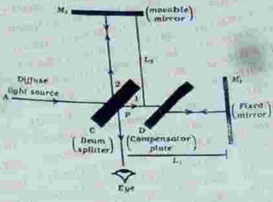
From the above, equation, the radius of curvature of the lens can also be calculated.

Q6. Write Short note on Michelson interferometer.

Ans.

The Michelson Interferometer:

The interferometer, invented by American physicist A.A. Michelson (1852-1931), is an ingenious device which splits a light beam into two parts and then recombines them to form an interference pattern alter they have travelled over different paths. The device can be used for obtaining accurate measurements of wavelength and for precise length measurements.



A schematic diagram of the interferometer is shown in Figure. A beam of light provided by a monochromatic source is split into two rays by a partially silvered mirror M inclined at 45° relative to the incident light split beam. One ray is reflected vertically upward towards mirror M_1 while the second ray is transmitted horizontally through M towards mirror M_2. hence, the two rays travel separate path l_1 and l_2. After reflecting from mirrors M_1 and M_2, the two rays eventually recombine to produce an interference pattern which can be viewed through a telescope. The glass plate P, equal in thickness to M, is Placed in the path of the horizontal ray in order to equalize the path length of the two rays. With this arrangement each ray will then pass through the same thickness of glass.

The interference condition for the two rays is determined by the difference in the optical path lengths. When the two rays are viewed as shown, the image of M_2 is at M_2' parallel to M_1. Hence M_1 and M_2 form the equivalent of a parallel air film.

The effective thickness of the film is varied by moving mirror M_1, parallel to itself with a finely threaded screw. Under these conditions, the interference pattern is series of bright and dark circular rings which resemble Newton's rings. If a dark circle appears at the centre of the pattern, the two rays interfere destructively. If the mirror M_1 is moved a distance of $\lambda/4$, the path difference changes by $\lambda/2$ (twice the separation between M_1 and M_2). The two rays will now interfere constructively, giving a bright circle in the middle. As M_1 is moved an additional distance of $\lambda/4$ (total distance of $\lambda/2$), a dark circle will appear once again. Thus we see that successive dark and bright circles are formed each time M_1 is moved a distance $\lambda/4$. The wave length of light is then measured by counting the number of fringes shifts for a given displacement of M_1. Conversely, if the wavelength is accurately known, mirror displacements can be measured to within a fraction of the wavelength.

Suppose 'n' fringes move through a certain reference point when the minor M_1 is moved slowly a distance do the right, then

$$d = \frac{n\lambda}{2}$$

or

$$\lambda = \frac{2d}{n}$$

This equation shows that just by counting the number of fringes 'n' and by measuring the distance 'd' through which the mirror is moved, the wavelength λ of light can be determined.

Q7(a) What is diffraction of light? How does it differ from interference?
(b) What is the difference between Fresnel's and Fraunhofer's diffraction of light?

Ans. (a) Diffraction:

"The bending of light around an obstacle is called diffraction".

The bending of light, i.e. the diffraction effect depends upon the size of the obstacle. Diffraction effects are larger only when we deal with the obstacles or apertures comparable in size to the wavelength. Usually diffraction effects are small and must be looked carefully.

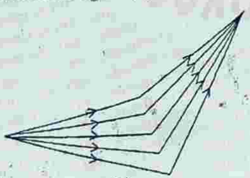
Difference between Interference and Diffraction:-

	Interference	*Diffraction*
1.	Interference is the result of interaction of light coming from two different wave fronts originating from the same source.	Diffraction is interaction of light coming from different parts of the same wave front.
2.	The fringe spacing may or may not be of the same width.	Diffraction fringes are not of same width.
3.	Points of minimum intensity are perfectly dark.	Points of minimum intensity are not perfectly dark.
4.	All bright bands are of same intensity.	All bright bands are not of the same

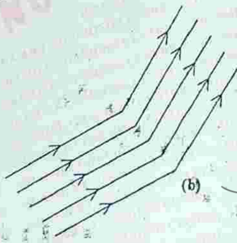
(b) Difference between Fresnel's and Fraunhofer's diffraction of light:

1. Frensnel Diffraction:

When both the point source and screen at which the diffraction pattern is formed are kept at finite distance from the diffracting obstacle, the wave fronts leaving the aperture or obstacle to illuminate the screen are not plane. This situation is decribed as Fresnel diffraction, which is shown in figure (a).



(a)



(b)

2. Fraunhofer Diffraction:

If the source and screen on which diffraction pattern is formed are removed at a large distance, so that the corresponding rays are parallel

to each other and the wave fronts are plane. This situation is described as Fraunhofer diffraction, and shown in figure (b).
Fraunhofer diffraction can be produced in laboratories by using two converging lenses. A lens between the distant source of light and obstacle, renders the rays parallel to each other and hence produces plane wave fronts. Where as second lens collects the parallel set of diffracted rays and focus then at a point on the screen.

Q8. What is diffraction grating? How is it used to determine the wave length of light?

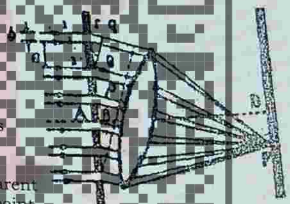
Ans. Diffraction Grating:

"Instead of a single slit or two slits side by side, a German physicist, Joseph von Fraunhofer used as many close parallel slits, all with the same width and spaced equal distance apart, such a device is called a diffraction grating'.

A diffraction grating is a very useful device for analysing light sources. A diffraction grating consists of a piece of glass with number of parallel lines marked on it. The thin clear strips between the lines transmit light and act as slits. A fine grating with 6000 lines per cm has a slit spacing 'd' equal to = 1.66 x 10^{-4} cm.

Construction:-

An arrangement consisting of large number of parallel slits of the same width and separated by equal opaque spaces is known as diffraction grating.



Fraunhofer used the first grating which consisted of a larger number of parallel wires placed very closely side by side at regular intervals. Now gratings are constructed by ruling equidistant parallel lines on a transparent material such a glass, with a fine diamond point. The ruled lines are opaque to light while the space between any two lines is transparent to light and acts as slit. This is known as plane transmission grating. On the other hand, if the lines are drawn on a silvered surface (plane or concave) then the light is reflected from the positions of mirrors in between any two lines and it forms a plane or concave reflection grating. When the spacing between the lines is of the order of the wavelength of light, then an appreciable deviation of the light is produced.

Theory:

Consider the parallel rays which after diffraction through the grating make an angle θ with AB, the normal to the grating. These diffracted rays are focused at P with the help of a convex lens. Now consider rays 1 and 2. The ray 1 covers a distance rq more than ray 2. if the path difference i.e. rq is λ, they will reinforce each other at P. similarly waves from any two consecutive slits will differ in λ when they come at P.

Thus for constructive interference

$$rq = \lambda$$

From trigonometry ______ (i)

$$\frac{rq}{a+b} = \text{Sin}\,\theta \quad \text{______ (ii)}$$

Or

$$rq = (a + b)\,\text{Sin}\,\theta$$

Where b = width of slit, and
a = separation between two consecutive slits.
a + b = d and it is called as grating element and it is determined by dividing the length of grating by the number of lines i.e.

$$d = \frac{\text{length of grating}}{\text{No.of lines}} = \frac{L}{N}$$

So

$$rq = d\text{Sin}\,\theta \quad \text{______ (iii)}$$

Thus

$$d\text{Sin}\,\theta = \lambda$$

In general there will be other directions on each side of AB for which waves from adjacent slits, will differ in path by 2λ ; 3λ . . . . . for which corresponding bright images are obtained.

Thus the grating equation can be written as

$$d\text{Sin}\theta = n\lambda \quad \text{______ (iv)}$$

Where n =1, 2, 3, ... called as order.

Note that the effect of grating is to produce a series of bright images, known as principal maxima, for different values of θ which are given by equation (iv). Putting n = 0, 1, 2, 3, ... in equation (iv), we get the zeroth order, first order, second order, third order, etc, principal maxima. For constants values of d and λ there is a unique value of θ corresponding to each order.

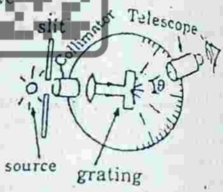
Measurement of Wavelength of Grating:

According to equation of diffraction grating, we have

$$d\text{Sin}\,\theta = n\lambda$$

or

$$\lambda = \frac{d\text{Sin}\theta}{n}$$



This equation tells that knowing the values of θ and n one can find the value of unknown wavelength with which the grating is illuminated. As the value of d is provided by the manufacturer of the grating.

We can find the value of θ for a particular value of n using the experimental arrangement shown below:

This is a form of diffraction grating spectrometer. The light to be analyzed is allowed to pass through a slit and is made parallel with the help of a collimator. Then the parallel light is allowed to fall on the diffraction grating perpendicularly. The diffracted light leaves the grating al angles that satisfy the grating equation. A telescope is used to view the image of the slit. By measuring the precise angles at which the images of slit appear for the various orders, the wavelength can be determined.

Q9. What do you mean by plane polarized light? How does the phenomena decide that light waves are transverse?

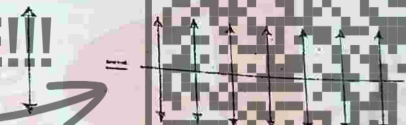
Ans. **Polarization of Light:**

The experiments on interference and diffraction have shown light is a form of wave motion. These effects do not tell us about the type of wave motion i.e. whether the light waves are longitudinal or transverse waves.

Unpolarized Light:

A beam of ordinary light consists of a large number of waves, each in its own plane of vibration. In this case all directions of vibration are equally probable and are always perpendicular to the direction of propagation. Such a beam of light is called an unpolarized light beam figure (a).


(a)


(b)

Polarized Light:

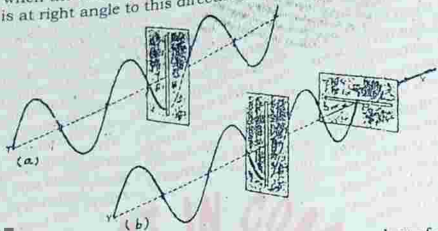
If unpolarized beam is made to pass through a polarizing device called a polarizer, the transmitted beam will have electric and magnetic field vectors only in certain directions. The resulting light beam, as shown in figure (b), is said to be polarized and the phenomenon is called polarization.

Transverse Nature of Light:

There is a periodic fluctuation in electric and magnetic fields along the propagation of light waves. These fields vary at right angles to the direction of propagation of the light wave, so light wave is transverse wave.

Transverse nature of light makes it possible to produce and detect polarized light.

Consider a stretched string along which a transverse wave is passing. The particles of the string are vibrating perpendicular to the length of the string. If a block of wood with a slot in it is placed over the string, the vibrations are not effected when the slot is parallel to the direction of vibrations. However when the slot is at right angle to this direction, the vibrations do not pass.



A beam of light from the normal source contains large number of waves. The beam of light is said to be polarized, if unpolarized beam passes through a polarizing sheet known as Polaroid.

The plane polarized light can be obtained by passing light through a tourmaline crystal. When two tourmaline crystals are placed parallel to each other the light transmitted by the first crystal is also transmitted by the second crystal. When the second crystal is rotated through 90º, no light gets through. The observed effect is due to selective absorption by tourmaline of all light waves vibrating in one particular plane, the second crystal is known as analyzer and the first crystal is known as polarizer.

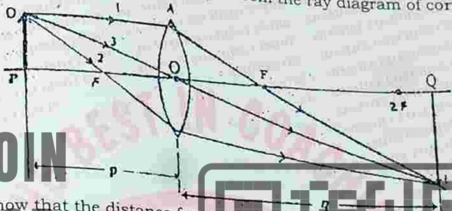
The method of polarizing the light discussed above is called polarization by selective absorption.

CHAPTER # 10
GEOMETRICL OPTICS
IMPORTANT QUESTIONS & ANSWERS

Q1. Derive the thin lens formula with the help of two contrast lenses.

Ans. Thin Lens formula:

The thin lens formula can be developed from the ray diagram of convex lens as shown below.



As we know that the distance from the optical centre of the lens to the object is denoted by 'P', and the distance from the optical centre to the image is denoted by 'q', and the distance between the optical centre and the principal focus is called focal length and is denoted by 'f'. All the distances are measured in 'cm'.

Consider an object whose real and inverted image is formed by a thin convex lens as show by the ray diagram.

As shown in the figure considers the right angled triangles OPX & IQX. These triangles are similar, therefore we can write.

$$\frac{OP}{IQ}=\frac{PX}{QX}=\frac{p}{q}$$

A gain Δ AXF and ΔIQF are also similar

$$\therefore \quad \frac{AX}{IQ}=\frac{XF}{QF}=\frac{f}{q-f}$$

since AX = OP

$$\therefore \quad \frac{OP}{IQ}=\frac{XF}{QF}$$

$$\frac{h_o}{h_i}=\frac{f}{q-f} \quad \text{———— (i)}$$

But we .know that

$$\frac{h_o}{h_i}=\frac{p}{q}$$

Thus equation (i) becomes

$$\frac{p}{q}=\frac{f}{q-f}$$

$$\frac{q}{p}=\frac{q-f}{f}$$

Or
Dividing both sides by 'q' we get

$$\frac{q}{pq} = \frac{q-f}{fq}$$

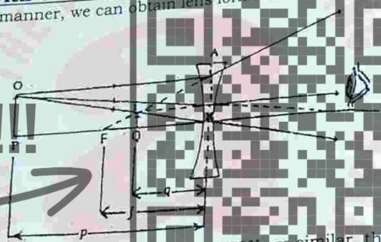
$$\frac{1}{p} = \frac{q}{fq} - \frac{f}{fq}$$

$$\frac{1}{p} = \frac{1}{f} - \frac{1}{q}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

This is known as the lens equation or lens formula.

Starting with Concave Lens:
In the same manner, we can obtain lens formula with the help of concave lens.



Consider the figure, the triangles OPX and IQX are similar, therefore

$$\frac{OP}{IQ} = \frac{PX}{QX} = \frac{p}{q}$$

Similarly the ΔAXF and ΔIQX are also similar
Therefore,

$$\frac{AX}{IQ} = \frac{FX}{QF} = \frac{f}{f-q}$$

Since $AX = OP$

$$\therefore \quad \frac{OP}{IQ} = \frac{FX}{QF}$$

$$\frac{p}{q} = \frac{f}{f-q}$$

$$\frac{q}{p} = \frac{f-q}{f}$$

Or

Dividing both sides by q, we get

$$\frac{q}{pq} = \frac{f-q}{fq}$$

$$\frac{1}{p} = \frac{f}{fq} - \frac{q}{fq}$$

$$\frac{1}{p} = \frac{1}{q} - \frac{1}{f}$$

Applying sign convention, the above equation becomes

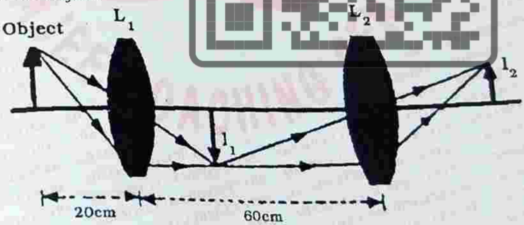
$$\boxed{\frac{1}{p} + \frac{1}{q} = \frac{1}{f}}$$

Q2. Two thin lenses of focal length 'f_2' and 'f_1' are placed in contact. Derive a formula for the focal length of the combination.

Ans. **Combination of Thin Lenses:**

In most of the optical instruments two or more lenses are used in combination. We locate first the image formed by the first lens and then using that image as the object for the second lens, the final image formed by the second lens can be located. If there are more than two lenses, this process is continued, the object for each lens is the image for the preeding lens.

The figure shows that the lens L_1 forms an image I_1. This image acts as a real object for the lens L_2, which forms a real image I_2. Notice that I_2 is inverted with respect to the object.



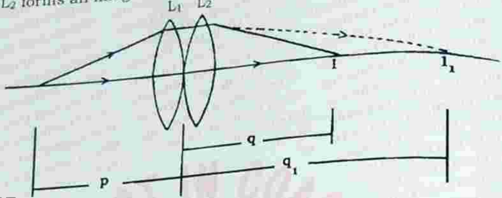
If the two lenses are in contact, that is their separation is very small as compared to their focal lengths, then it is illustrated in figure.

Let a point object 'O' be placed at a distance 'P' from the lens L_1 whose real image I_1, is formed by it at a distance q_1. From the lens formula we have

$$\frac{1}{P} + \frac{1}{q_1} = \frac{1}{f_1} \qquad \text{(i)}$$

Where f_1 is the focal length of the lens L_1.

This image now serves as a virtual object, for the second lens L_2 of focal length f_2. If we neglect the small separation between the lenses, the distance of this virtual object from lens L_2 will be the same as its distance from the lens L_1. If the lens L_2 forms an image I of this virtual object at a distance 'q'.



$$-\frac{1}{q_1}+\frac{1}{q}=\frac{1}{f_2} \quad \text{(ii)}$$

As the object is virtual for lens L_2, i.e. $P_2 = -q_1$

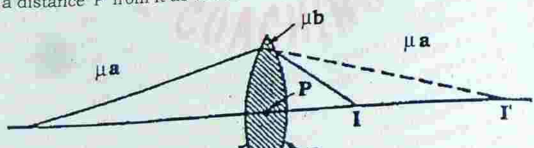
Adding equation (i) and (ii), we get

$$\left(\frac{1}{P}+\frac{1}{q_1}\right)+\left(-\frac{1}{q_1}+\frac{1}{q}\right)=\frac{1}{f_1}+\frac{1}{f_2}$$

$$\frac{1}{P}+\frac{1}{q_1}-\frac{1}{q_1}+\frac{1}{q}=\frac{1}{f_1}+\frac{1}{f_2}$$

$$\frac{1}{P}+\frac{1}{q}=\frac{1}{f_1}+\frac{1}{f_2} \quad \text{(iii)}$$

Now if we replace the two lenses of focal lengths f_1 and f_2 by a single lens of focal length 'f', such that it forms an image at a distance 'q' of an object placed at a distance 'P' from it as shown in figure.



Such a lens is called equivalent lens, and its focal length is known as equivalent focal length. For equivalent lens L, we have

$$\boxed{\frac{1}{p}+\frac{1}{q}=\frac{1}{f}} \quad \text{(iv)}$$

Comparing equation (iii) and (iv) we get

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

This equation shows that the sum of the reciprocal of their individual focal lengths is equal to the reciprocal of the focal length of the combination.

Q3. What is visual angle? Explain the principle of magnifying glass. Calculate its magnifying power with the help of a ray diagram.

Ans. The greater the visual angle, the greater is the apparent size of object, if the object distance from the eye is smaller, then greater will be the visual angle. Consequently, if we bring the object as close to the eye as possible thus the visual angle will be increased and getting a large and real image on the retina of eye.

Magnifying Glass:

"We know that a normal person cannot see clearly an object if it is closer than the least distance of distinct vision, i.e. d = 25cm. A convex lens helps us to see the details of an object by brining it closer than 25 cm. Such a convex lens is known as magnifying glass"

Principle of Magnifying Glass:

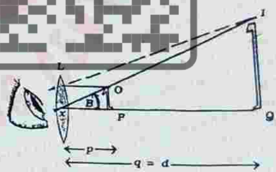
If the object is placed within the focal length, i.e. between the optical centre and the principal focus, then an enlarged, virtual and erect image is formed.

Magnifying Power:

"The ratio of the visual angle subtended by the image seen through a magnifying glass to the visual angle subtended by the object when placed at the least distance of distinct vision, when see through naked eye, is called magnifying power or angular magnification of the magnifying glass".

Calculation of Magnifying Power:-

Consider a small object OP which is placed at a distance 'P' within the focal length of the magnifying glass 'L', such that it's virtual erect and magnified image IQ is produced at the least distance of distinct vision 'd' as shown in figure.



The magnifying power of the magnifying glass is given by

$$M = \frac{\beta}{\alpha} \qquad \text{(i)}$$

Where α is the visual angle subtended by the object when placed at least distance of distinct vision, when seen through unaided eye.
And 'β' is the visual angle subtended by the image seen through magnifying glass. Therefore,

$$\tan \alpha = \frac{Perpendicular}{Base}$$

$$\tan \alpha = \frac{OP}{d} \qquad \text{(ii)}$$

Since α is small

$\therefore \quad \tan\alpha = \alpha$

$\therefore \quad \alpha = \frac{OP}{d}$

In ΔOPX in figure we have

$$\tan \beta = \beta$$

$$\beta = \frac{IQ}{d} \qquad \text{(iii)}$$

$$\beta = \frac{OP}{p}$$

by substituting the value of 'α' and 'β' from eq. (ii) and (iii) respectively, in eq. (i), we get

$$M = \frac{\beta}{\alpha}$$

$$M = \frac{\frac{IQ}{d}}{\frac{OP}{d}}$$

$$M = \frac{IQ}{OP}$$

$$M = \frac{\text{Size of Image}}{\text{Size of Object}} \qquad \text{(iv)}$$

From lens formula, we have

$$\boxed{\frac{1}{p} + \frac{1}{q} = \frac{1}{f}} \qquad \text{(v)}$$

For magnifying glass

p = +p, q = -d, f = +f

Thus equation (v) becomes

$$\frac{1}{p} + \left(\frac{1}{-d}\right) = \frac{1}{f}$$

$$\frac{1}{p} - \frac{1}{d} = \frac{1}{f}$$

Multiplying throughout by 'd',

$$d\left(\frac{1}{p} - \frac{1}{d}\right) = \frac{d}{f}$$

$$\frac{d}{p} - \frac{d}{d} = \frac{d}{f}$$

$$\frac{d}{p} - 1 = \frac{d}{f}$$

But $M = \frac{d}{p}$ and d = 25 cm

$$M - 1 = \frac{25}{f}$$

$$M = \frac{25}{f} + 1$$

Or $$M = \frac{d}{f} + 1$$

Q4. Describe with the help of a ray diagram, the construction and working of a compound microscope and hence derive the expression for its magnifying power.

Ans. **Description:**

A compound microscope is an optical instrument which is used to see small object with very high magnification.

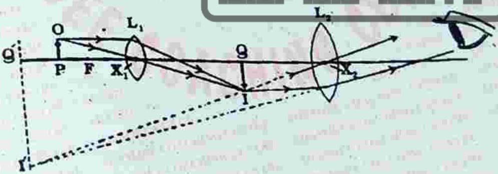
Construction:

A compound microscope consists of two convex lenses named as objective, which is near to the object and the other is eye – piece, near the eye. The objective has very short focal length f_1 and eye-piece has relatively long focal length f_2.

Working:

The objective lens forms a real, inverted and magnified image of the object, which is placed beyond its focus on the stage of the microscope. The mirror at the base reflects light on the object. This objective lens produced an inverted, enlarged and real image *IQ*, which acts as the object for the second lens, i.e. the eye-piece. This image is focused with in the focal length of the eye-piece resulting an erect, highly magnified and virtual image I'Q'. This image can finally be seen by the eye. The focusing of the final image is achieved by mounting the eye-piece in a tube that can be adjusted up and down with the help of geared wheel.

The following ray diagram shows the path of rays through the microscope.



Derivation For The Expression of Magnifying Power:-

In order to derive the expression for the magnifying power of microscope consider a small object OP, which is placed at a distance 'p' just beyond the focus of the objective lens L_1 whose real, inverted and magnified image *IQ* is formed at a distance 'q' from the objective lens L_1.

The magnifying power of the microscope is given by

$$M = \frac{\beta}{\alpha} \qquad \text{(i)}$$

Where 'β' is the visual angle subtended by the image and 'α' is the visual angle subtended by the object, when the image formed at the least distance of distinct vision.

$$\therefore \quad \alpha = \frac{OP}{d}$$

$$\therefore \quad \beta = \frac{I'Q'}{d}$$

Put the values of 'α' and 'β' in equation (i)

$$M = \frac{\frac{I'Q'}{d}}{\frac{OP}{d}}$$

$$M = \frac{I'Q'}{OP}$$

Multiplying and divided by IQ

$$M = \frac{I'Q'}{OP} \times \frac{IQ}{IQ} \quad \text{———— (ii)}$$

The magnifying power of the objective lens L_1 is given by

$$M = \frac{IQ}{OP} = \frac{q}{p}$$

ΔOPX and ΔIQX are similar.

The magnifying power of the eye-piece lens L_2 is given by

$$M_2 = \frac{I'Q'}{IQ}$$

Thus equation (ii) can also be written as

$$M_1 = M_1 \times M_2 \quad \text{———— (iii)}$$

As the eye-piece acts here as a magnifying glass, hence its magnifying power can also be written as

$$M_2 = \frac{d}{f_2} + 1$$

By substituting the values of M_1 and M_2 in equation (iii), we get

$$M_2 = \frac{q}{p}\left(\frac{d}{f_2} + 1\right) \quad \text{———— (iv)}$$

Since the object OP lies just beyond the focus of the objective lens L_1.

$$\therefore \quad p \cong f_1$$

Also the image IQ is formed very close to the eye-piece lens L_2. Therefore

$$X_1I \cong X_1X_2$$

Or $\quad q \cong L$

Where 'L' is the distance between objective and the eye-piece, which is also called the "LENGTH OF THE MICROSCOPE".

Hence the magnifying power of the compound microscope is found by writing the equation (iv) in the following form.

$$M_2 = \frac{L}{f_1}\left(\frac{d}{f_2}+1\right)$$

Where 'd' is the least distance of distinct vision, which is equal to 25 cm.

Q5. Define telescope with the help of ray diagram derive the expression for magnifying power of Astronomical telescope.

Ans. **Definition:**

Telescopes are used to see the distant objects. The image of a distant object formed by a telescope is smaller than the actual object, because it is much nearer to the eye and has greater visual angle.

Construction:

An astronomical telescope is used to see the heavenly bodies i.e. planets and stars.

It consists of two convex lenses. The lens towards the object is called the objective lens L_1, it has long focal length f_1. And the lens near the eye is called the eye-piece L_2 and it has short focal length f_2. The distance between the two lenses is made slightly greater than the sum of their focal lengths, the eye-piece no longer produces a virtual image and a real image can be obtained on a screen and we can get photo graphs of distant objects. For this purpose a camera is attached to the telescope to take the photographs of distant objects.

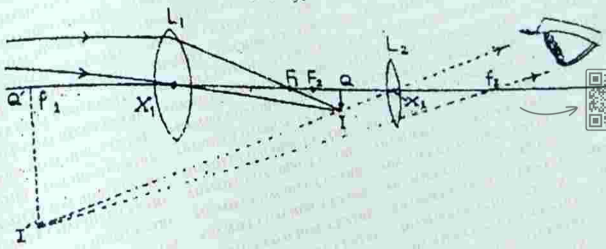
Working:

Since the stars are so distant, the rays of light coming from them will be almost parallel and are focused to a point by the objective lens at its principal focus and form the image I_1 of the star. This image is real, inverted and diminished. The eye-piece is adjusted so that the image obtained from the objective acts as the object for the second lens i.e. the eye-piece. This image is focused within the focal length of the eye-piece, resulting in an erect and virtual image I_2, and a real image can be obtained on a screen by adjusting the distance between the two lenses i.e. it is made slightly greater than the sum of their focal lengths.

Derivation For The Magnifying Power:

In order to derive an expression for the magnifying power of the astronomical telescope, consider a distant object, whose real, inverted image IQ is formed by the objective lens L_1 at is focus.

$$QX_1 = f_1$$



The eye-piece lens L_1 is so adjusted that IQ lies just inside its focal length hence a virtual and magnified I'Q' is formed by it at infinity.

$$QX_2 = f_2$$

The distance between the objective lens and eye-piece lens is called the length of the telescope, which is given as follows

$$L = X_1X_2 \qquad \text{(i)}$$

$$L = QX_1 + QX_2$$

Since $QX_1 = f_1$ and $QX_2 = f_2$

∴ Equation (i) becomes

$$L = f_1 + f_2$$

The magnifying power of the telescope is given by

$$M = \frac{\beta}{\alpha} \qquad \text{(ii)}$$

Where α is the visual angle subtended by the object and β is the visual angle subtended by the image.

In right angled triangle IQX_1 we have

$$\alpha = \tan \alpha$$

Since 'α' is very small

$$\therefore \quad \alpha = \frac{IQ}{QX_1} = \frac{IQ}{f_1}$$

Again in the right angled IQX_2, we have

$$\beta = \tan \beta$$

$$\beta = \frac{IQ}{QX_2} = \frac{IQ}{f_2}$$

Substituting the values of α and β in equation (ii), we get

$$M = \frac{\frac{IQ}{f_2}}{\frac{IQ}{f_1}}$$

Or

$$M = \frac{IQ}{f_2} \div \frac{IQ}{f_1}$$

$$M = \frac{IQ}{f_2} \times \frac{f_1}{IQ}$$

$$M = \frac{f_1}{f_2}$$

$$M = \frac{\text{Focal length of the objective}}{\text{Focal length of the eye piece}}$$

From the above equation, it is clear that for high magnification, the focal length of the objective should be very large as compared to that of the eye-piece. The Yerkes refracting telescope is the largest of its kind in the world. The diameter of its objective lens is about one metre. The telescope is about 18 m long and is located at William Bay, Lake Geneva, and Wisconsin.

Q6(a) Define dioptre.
(b) A lens has a power of +2D (dioptre). What do you know about the lens?

Ans. (a) Definition of Dioptre:

It is the unit of power of lens. Which is equal to the reciprocal of the focal length in meters.

Example:

A 5D (dioptre) lens has a focal length of 0.2m.
The dioptre is often now called the radian per meter (rad. m^{-1}).

(b) Definition of Lens:

If a lens has +2D, then its focal length is +0.5m or +50 cm. Its positive sign shows that the lens is converging or convex lens. This lens is used by the person, who is suffering from long - sightedness, which is also known as Hypermetropia.
When a person can see distant objects clearly, but cannot see the near objects clearly, because in this case the focal length of the eye lens is too long. This means the light rays from near objects are focused behind the retina. This defect can be corrected by wearing spectacles or contact lenses with convex lenses as these lenses converge rays so that the eye lens can focus the image on the retina.

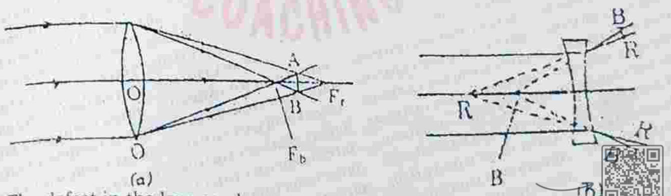
Q7. Write short note on the following:
i. Defects of lenses.
ii. Terrestrial telescope.

Ans. i. Defects of Lenses:

Lenses suffer from two important defects which are known as chromatic aberration and spherical aberration. We shall discuss the defects one by one.

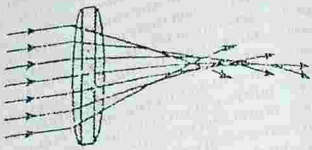
Chromatic Aberration:

A lens may be regarded as made up of two prisms placed one above the other, it is evident that when a ray of white light passes through it, it will be dispersed into its component colours. All the red rays are brought to focus at F_b. A complete image will consist of a small linear spectrum lying along the axis, which can be projected on a white screen. A screen will be coloured and image will not be well defined. This defect in the image is called chromatic aberration.



The defect in the lens can be removed by using a combination of a convex lens and a concave lens made of two different materials having unequal dispersive powers. The lenses are given such suitable shapes that the dispersion produced by one lens is exactly equal and opposite to the produced by other. The focal lengths of the lenses are, of course, unequal in numerical values, so that the focal length of the combination has a finite value. Such a combination is called an chromatic combination of lenses.

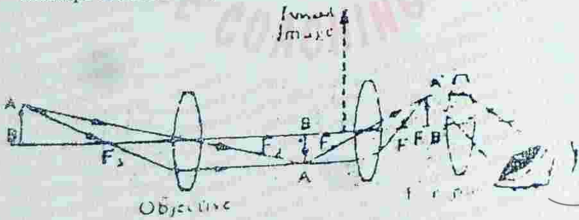
Spherical Aberration:



A beam of parallel rays is focused at a point by a lens only if the aperture of the lens is small, otherwise the lens will refract outer rays slightly more than the inner rays. The image produced will not be well defined and sharp. This defect in a lens is called spherical aberration to reduce this defect, optical instruments using lenses are provided with a stop which allows only the central rays to pass through the lens. In this way, the effective aperture of the lens remains small and so the spherical aberration is almost removed. The spherical aberration can also be reduced by taking suitable values of the radii of curvature of the surfaces of a lens or by using two lenses dept at a suitable distance apart. Now we shall discuss how the lenses are used in optical instruments.

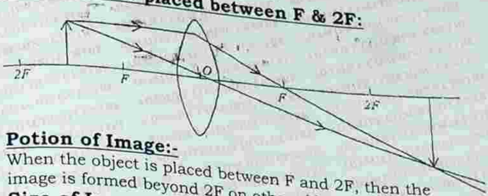
(b) Terrestrial Telescope:

The final image formed by an astronomical telescope is inverted with respect to the object. It makes no difference when we observe heavenly bodies such as stars and planets etc. But when we use a telescope to observe terrestrial objects (distant objects on earth) it is desirable lo seeing erect image of the object. For this purpose astronomical telescope is modified into terrestrial telescope. The construction of terrestrial telescope is same as that of astronomical telescope except that it has an additional convex lens between objective and eye-piece. This lens is called field lens. The function of this lens is to invert the image A'B' formed by objective into A"B" which is erecting w.r.t object so the position of this lens is adjusted beyond image A'B'. The image A"B" serves as object for eye-piece and final image is observed as A'"B'" which is also erect w.r.t. object. Due to addition of field lens, the length of terrestrial telescope is considerably increased.



Q8. **Where will he the image formed, if an object is placed between F and 2F of a convex lens. Sketch the ray diagram.**

Ans. **When the object is placed between F & 2F:**



1. **Potion of Image:-**
When the object is placed between F and 2F, then the image is formed beyond 2F on other side of lens.

2. **Size of Image:**
The size of image is magnified (large) as compared to the size of object.

3. **Nature of Image:**
The image is real and inverted.

SCIENTIFIC REASONS / SHORT QUESTIONS:

CHAPTER # 01 "SCOPE OF PHYSICS"

Q1. What is physics? What are its main branches?

Ans. Physics: The branch of the physical sciences which deals with interaction of matter and energy and their relationship. It explains the natural phenomena with help of fundamental laws and principles. Main branches of physics are: Electronics, Bio-physics, Nuclear physics, electrical physics, Plasma physics, e.t.c,

Q2. Name some of the household applications in your home which are based on the principle of physics.

Ans. Radio, Television, Telephone, Electric fans, Washing Machine, Electric Iron, Bulb, Fluorescent Tube, Heater, Toaster, Grinder, Refrigerator, Sewing Machine, Electric Bell.

Q3. What type of natural phenomena could serve as alternative time standard?

Ans. Any phenomenon that repeats itself can be used as a measure of time: the measurement consists of counting the repetitions.

Q4. Are the radians and steradian the basic units of SI?

Ans. Are radians and steradians are two supplementary basic units of SI. Radian is used for the plane angles and steradian for solid angles.

Q5. Express the following quantities using the prefixes.

(a) 3×10^{-4} m.

(b) 5×10^{-5} s.

(c) 72×10^{2} g.

Ans.

(a) $3 \times 10^{-1}\text{m} = 0.3 \times 10^{-3} = 0.3$ mm

(b) $5 \times 10^{-5}\text{s} = 50 \times 10^{-6}\text{s} = 50\ \mu s$

(c) $72 \times 10^{2}\text{g} = 7.2 \times 10^{3}\text{g} = 7.2$ Kg

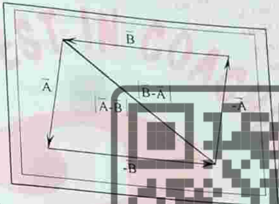
CHAPTER # 02 "Scalar & Vector"

Q1. Can the magnitude of the resultant of two vectors is greater then the magnitude of sum of the individual vectors?

Ans. No, the magnitude of the resultant of two vectors can be equal to or less than the sum of the magnitude of the individual vector.

Q2. Can the magnitude of $\vec{A}-\vec{B}$ be the

Ans. Yes, If two vectors $\vec{A}$ and $\vec{B}$ represent two adjacent sides of a parallelogram as shown in figure then from figure we can write:



$|\vec{A}-\vec{B}| = OP$ ....Eq. (i)

$|\vec{B}-\vec{A}| = OP$ ....Eq. (ii)

By comparing Eq. (i) and (ii) we get

$|\vec{A}-\vec{B}| = |\vec{B}-\vec{A}|$ ....**Proved**

Q3. If $\vec{C}$ is the vector sum of $\vec{A}$ and $\vec{B}$ does $\vec{C}$ have to lie the same plane of $\vec{A}$ and $\vec{B}$?

Ans. Yes, if $\vec{C}=\vec{A}+\vec{B}$ then $\vec{C}$ lies in the same plane of $\vec{A}$ and $\vec{B}$.

Q4. Can a scalar product of two vectors be negative?

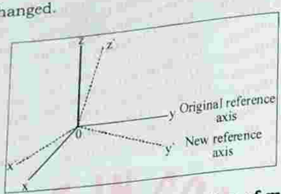
Ans. Yes, If the angle between two vectors is 180°.

Q5. Is it possible that the magnitude of the resultant of two equal vector be equal to the magnitude of either vector.

Ans. Yes, it is possible if the angle between two given vector is 120°.

Q6. Will the value of a vector quantity change if it's reference axis are changed. Explain?

Ans. **No**, since the vector depends upon only magnitude and direction and independent to the reference axis, so the vector remains unchanged if it's reference axis are changed.



Q7. Show that scalar product holds commutative law of multiplication.

Proof:

Consider two vector A and B having angle 'θ' between them. (as shown in Fig1)

Scalar product means the product of the magnitudes of those vectors that have same directions.

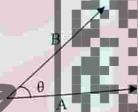


Fig1

From Fig 2.

$A \bullet B = |A| B_A = |A| B_x$

But $B_x = |B| \cos\theta$

$A \bullet B = |A||B| \cos\theta$ (1)

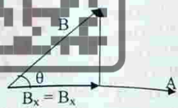


Fig 2

From Fig 3

$B \bullet A = |B| A_B = |B| A_x$

But $A_x = |A| \cos\theta$

$B \bullet A = = |B| |A| \cos\theta$

$B \bullet A = |A| |B| \cos\theta$ (2)

Combining (1) & (2)

$$\mathbf{A \bullet B = B \bullet A}$$

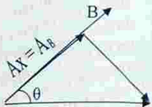


Fig 3.

This is the required expression and it shows that "If the order of the addition of two vectors is changed then resultant remains unchanged."

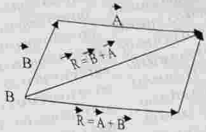
Q8. State and verify the law of parallelogram.

Consider two vectors A and B which represent the two adjacent sides of a parallelogram. If these vectors are added graphically by head and tail rules, the resultant vector is obtained as,

$$\vec{R} = \vec{A} + \vec{B}$$

or

$$\vec{R} = \vec{B} + \vec{A}$$



This property is called law of parallelogram and it states that 'If the two adjacent sides of the parallelogram are represented by two vectors then the diagonal of the parallelogram gives the resultant vector.'

Q9. State 'right hand rule' for the direction of the vector product.

The direction of the product can be determined by using right hand rule which is given as "If the curl of the figures of right hand gives the direction of the plane of the multiplied vectors then the direction of thumb which is perpendicular on the finger gives the direction of the product vectors."

Q10. Define unit vector.

A vector having magnitude on e and used to indicate only the direction of the vector is called unit vector.

OR

The ratio of a vector with its magnitude is called unit vector.

Mathematical Form:

A unit vector can be determined just by dividing a vector with its magnitude.

i.e, $$a = \frac{A}{|A|}$$

Q11. Define rectangular components. Give its different types.

The components of a vector that are perpendicular on each other and can be form the side of the rectangular are called rectangular components of a vector. There are two types of rectangular components.

i. Horizontal component or x-component.

ii. Vertical component or y-component

Q12. Define product of two vectors. Give its types.

The multiplication of two vectors with each other is called product of the vector.

There are two types of the product of the vectors.

I. Scalar product or dot product.

II. Vector product or cross product.SS

Q13. Give the mathematical form of scalar product.

consider two vectors A and B having angle 'θ' between them. (as shown in Fig 1)

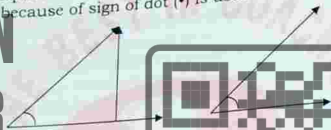
Scalar product means the product of the magnitudes of those vectors that are acting in the same direction. From Fig 2.

$A \cdot B = |A|\ B_A = B_{xs}$

But $B_x = B_A = |B| \cos\theta$

$A \cdot B = |A||B| \cos\theta$

This is the required mathematical form for the scalar product. It is also called dot product because of sign of dot (•) is used between the multiplied vectors.



Q14. Show that the scalar product of two perpendicular vectors always be zero.

Scalar product of two vectors that are equal in magnitude and are perpendiculars to each other is equal to zero.

$A \cdot B = |A|\ |B| \cos\theta$

$|A| = |B|$; Equal in magnitudes

$\theta = 90$; Perpendicular vector

$A \cdot B = |A|\ |A| \cos 90$ cos90=0

$A \cdot B = |A|^2 (0)$

$A \cdot B = (0)$

$A \cdot B = |B|\ |B| \cos 90$ cos90=0

$A \cdot B = |B|^2 (0)$

$A \cdot B = (0)$

Scalar product of two vectors that are not equal in magnitude and are perpendicular to each other is equal to zero.

$A \cdot B = |A|\ |B| \cos\theta$

$|A| \neq |B|$; not equal in magnitudes

$\theta = 90$; Perpendicular vectors

$A \cdot B = |A|\ |B| \cos 90$ cos90=0

$A \cdot B = |A|\ |B| (0)$

$A \cdot B = (0)$

Q15. Show the scalar product of two equal and parallel vectors is equal to square of magnitude of any of them.

Scalar product of two vectors that are equal in magnitude and are parallel to each other is equal to the square of magnitude of any of them.

A • B = IAI IBI cosθ

IAI = IBI ; Equal in magnitude

θ = 0 ; Parallel vectors

A • B = IAI IAI cosθ

= IAI² (1) = IAI²

A • B = IAI IBI cosθ

= = IBI² (1) = IBI²

cosθ=1.

Q16. Show the scalar product of two unequal and parallel vectors is equal to product of their magnitudes.

Scalar product of two vectors that are not equal in magnitude and are acting n the same direction is equal to the product of their magnitudes.

A • B = IAI IBI cosθ

IAI ≠ IBI ; not equal in magnitudes

θ = 0 ; acting in the same directions

A • B = IAI IBI cosθ

A • B = IAI IBI (1)

A • B = IAI IBI

cosθ=1

Q17. Show that i . i = j . j = k . k = 1

î•î = j•j = k•k = 1

A • B = IAI IBI cosθ

î • î = 1 x 1 x cosθ

= 1 x 1x 1

= 1

Similarly j•j = k•k = 1

Q18. Show that i . j = j . k = k . i = 0

î•j = j•k = k•î = 0

A • B = IAIIBI cos90

î • j = 1x1x cos90

î • j = 1x1x0

î • j = 0

Similarly j•k = k•î = 0

Q19. Show that j . i = k . i = i . k = 0

î•j = k•j = î•k = 0

A • B = IAI IBI cosθ

j • î = 1x1x cos90

j • î = 1x1x0

j • î = 0

Similarly j•k = k•î = 0

Q20. Give the mathematical form of vector product.

Mathematical From:

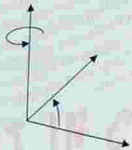
Consider two vectors A and B having angle 'θ' between them.

Mathematically, vector product of A and B is given as

$$A \times B = C$$

$$A \times B = |A|\,|B| \cos\theta\ \hat{n}$$

Where $|A|$ & $|B|$ are the magnitudes of the multiplied vector and $\hat{n}$ is the normal unit vector.



Q21. Show that the vector product of two parallel vectors always be zero.

The magnitude of the vector product of two vector products of two vectors that are equal in magnitude and are parallel to each other is equal to zero.

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

$$|A \times B| = |A||B| \sin\theta$$

$|A| = |B|$; Equal in magnitudes.

$\theta = 0$; parallel vectors.

$$|A \times B| = |B||B| \sin 90$$

$$= |B|^2 (0) = 0$$

$$\sin 0 = 0$$

$$|A \times B| = |A||B| \sin 0^0$$

$$|A \times B| = |A||B| (0) = 0$$

Q22. Show the vector product of two equal and perpendicular vectors is equal to square of magnitude of any of them.

The magnitude product of two vectors that are equal in magnitude and are perpendicular to each other is equal to the square of magnitude of any of them.

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

$$|A \times B| = |B||B| \sin\theta$$

$|A| = |B|$; Equal in magnitudes.

$\theta = 90$; Perpendicular vectors.

$$|A \times B| = |A||A| \sin 90$$

$$= |A|^2 (1) = |A|^2$$

OR $|A \times B| = |B||B| \sin 90^0$ $\qquad \sin 90 = 1$

$$= |B|^2 (1) = |B|^2$$

Q23. Show the scalar product of two unequal and perpendicular vectors is equal to product of their magnitudes.

The magnitude of the vector product of two vectors that not equal in magnitude and are perpendicular to each other is equal to the product of their magnitudes.

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

$$|A \times B| = |A||B| \sin\theta$$

$|A| \neq |B|$; not Equal in magnitudes.

$\theta = 90$; Perpendicular vectors.

$$|A \times B| = |A||B| \sin 90$$

$= |A||B| (1)$ $\sin 90 = 1$

$$|A \times B| = |A||B|$$

Q24. Show that $\mathbf{i \times i = j \times j = k \times k = 0}$

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

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

$$i \times i = 1 x 1 x \sin 0 \times \hat{n}$$

$$i \times i = 1 x 1 x\ 0 = 0$$

similarly $j \cdot j = k \cdot k = 0$

CHAPTER # 03 "MOTION"

Q1. Under what condition instantaneous velocity becomes equal to average velocity.

Ans. When object is in a state of uniform motion i.e., moving with the uniform velocity.

Q2. How the velocity can be determined from displacement-time graph.

Ans. When body moves with uniform velocity, it travels equal displacement in equal interval of time. The graph between the displacement and the time will be straight line as shown in Fig (1)

If we take any point A on the graph and draw a perpendicular AB on the time axis, It is clear that AB represents the displacement and OB represents the time taken.

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

$$V = \frac{AB}{OB}$$

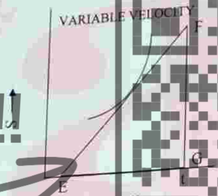


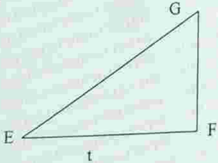
Fig (2)

When body moves with variable velocity, then graph between displacement and time will not be curve as shown in Fig (2)

The velocity of a body at any point A can be found by drawing a tangent EG on the curve at point A. Now draw a perpendicular GF on the time axis. The velocity of a body at A is given as

$$\text{Velocity at A} = \frac{\text{Displacement}}{\text{time}}$$

$$V_A = \frac{GF}{E}$$



Q3. How the acceleration can be determined from velocity-time graph.

Ans. When a body moves with uniform acceleration the graph between its velocity and time will be straight line, as shown in Fig (1)

From Fig, acceleration of a body is given as,

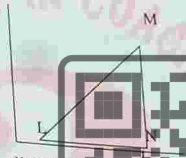
$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{Time}}$$

$$\vec{a} = \frac{\vec{PQ}}{OQ}$$

If the acceleration of a body is variable then graph will not be straight line. It will be curve as shown in Fig (2)

The acceleration at any point 'P' is given as acceleration at

Fig (2)



VARAIBLE ACCELERATION

$$P = \frac{\text{Change in velocity}}{\text{time}}$$

$$\vec{a} = \frac{\vec{MN}}{LN}$$

Q4. Show that force is equal to the rate of change of momentum.

Ans. Let mass of a body = m

Initial velocity of a body = v_i

Initial momentum of a body = mv_i

Final velocity of a body = v_f

Final momentum of a body = mv_f

Change in momentum of a body = $mv_f - mv_i$

Rate of change of a body = $\frac{mv_f - mv_i}{t}$

Rate of change of a body = $\frac{m(v_f - v_i)}{t}$

But a $\frac{(v_f - v_i)}{t}$

Rate of change of a b0dy= ma

According to Newton's second law of motion.

$$F = ma$$

Rate of change of a body = F

It shows that " Rate of change of momentum is equal to force"

Q5. Show that 1 Kg ms^{-1} = 1 Ns.

Ans.

$p = mv$

$p = kg\ m/s$

In MKS system

Multiply and divide by s

$P = kg \frac{m}{s} \times \frac{s}{s}$

$P = kg \frac{m}{S^2} \times s$ ———— (i)

$F = ma$

$N = kg \frac{m}{S^2}$ ———— (ii)

Using (ii) in (i)

$P = NS$ ———— (iii)

Equating (i) and (iii)

$Kg\ ms^{-1} = Ns.$

$1\ Kg\ ms^{-1} = 1\ Ns.$

Q6. Define tension in the string.

Ans. A reaction form acts along the string upward due to the suspended weight of the body is called tension in the string. It is denoted by T.

Q7. What is the main cause of force of friction?

Ans. It is due the roughness of the surface. When body surface slides over any surface then projection and depression between body and the surface interlock into one another. This interlocking causes the force of friction.

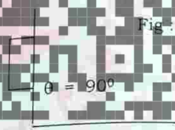
Q8. Under acceleration will be maximum and minimum on the inclined plane.

Ans. Minimum Acceleration :

Fig : I

Maximum Acceleration :

Fig : II



a = g sin θ

a = g sin θ

From Fig (i)

From Fig (ii)

a = g sin (0)

a = g sin (90)

Sin (0) = 1

Sin (90) = 1

a = 0

a = g

Result: When angle of Inclination is '0' then block does not move.	Result: When angle of Inclination is '90' then block falls freely under the action of gravity.

Q9. State the condition for block remains at rest on the inclined plane.

Ans. Form vector diagram for Block to be rest

$R - W_x = 0$

$R = W_x$

$R = w\cos\theta$ $\quad Ax = A\cos\theta$

$R = w\,mg\cos\theta$ $\quad$ (I) $\quad W = mg$

Also $f - W_y = 0$

$f = W_y$

$f = W\sin\theta$ $\quad Ay = A\sin\theta$

$f = mg\sin\theta$ $\quad$ (II) $\quad w = mg$

If conditions (I) & (II) are satisfied the block remains at rest on an inclined plane.

Q10. State the condition for block slides downward on the inclined plane.

Ans. The block to be slides downwards:

$W_y > f$

$W\sin\theta > f$

$Mg\sin\theta > f$

If above condition is satisfied then block slides down ward on the inclined plane.

Q11. Describe the final velocities when two bodies of same velocities collide with each other.

Ans.

$V_1 = \frac{(m_1 - m_2)U_1}{(m_1 + m_2)} + \frac{2m_2U_2}{(m_1 + m_2)}$

Let $m_1 = m_2 = m$

$V_1 = \frac{(m - m)U_1}{(m + m)} + \frac{2mU_2}{(m + m)}$

$V_1 = \frac{(0)U_1}{2m} + \frac{2mU_2}{2m}$

$\boxed{V_1 = U_2}$

$V_2 = \frac{2m_1U_1}{(m_1 + m_2)} + \frac{(m_2 - m_1)U_2}{(m_1 + m_2)}$

Let $m_2 = m_1 = m$

$V_2 = \frac{2mU_1}{(m + m)} + \frac{(m - m)U_2}{(m + m)}$

$V_2 = \frac{2mU_1}{2m} + \frac{(0)U_2}{2m}$

$\boxed{V_2 = U_1}$

Result:

When two bodies of same masses collide with each other elastically, then after collision they interchange their velocities

Q12. Describe the final velocities when two bodies of same velocities colli with each other such that target is at rest.

Ans.

$V_1 = \frac{(m_1 - m_2)U_1}{(m_1 + m_2)} + \frac{2m_2U_2}{(m_1 + m_2)}$

Let $m_1 = m_2 = m$

$V_1 = \frac{(m - m)U_1}{(m + m)} + \frac{2m(0)}{(m + m)}$

$V_1 = \frac{(0)U_1}{2m} + 0$

$\boxed{V_1 = 0}$

$V_2 = \frac{2m_1U_1}{(m_1 + m_2)} + \frac{(m_2 - m_1)U_2}{(m_1 + m_2)}$

Let $m_2 = m_1 = m$

$V_2 = \frac{2mU_1}{(m + m)} + \frac{(m - m)U_2}{(m + m)}$

$V_2 = \frac{2mU_1}{2m} + 0$

$\boxed{V_2 = U_1}$

Result::
When two bodies of same masses collide with each other in such a way that body 2 in initially at rest then after collision body 1 comes to rest while body 2 starts its motion with the initial velocity of body 1.

Q13. Describe the final velocities when heavy body collides with the light body, which is initially at rest.

Ans.

$$V_1 = \frac{(m_1 - m_2)U_1}{(m_1 + m_2)} + \frac{2m_2U_2}{(m_1 + m_2)}$$

Let $m_1 >> m_2$

$m_2 = 0$

$$V_1 = \frac{(m_1 - 0)U_1}{(m_1 + 0)} + \frac{2(0)(0)}{(m_1 + 0)}$$

$$V_1 = \frac{m_1U_1}{m_1} + 0$$

$$\boxed{V_1 = U_1}$$

$$V_1 = \frac{2m_1U_1}{(m_1 + m_2)} + \frac{(m_2 - m_1)U_2}{(m_1 + m_2)}$$

Let $m_1 >> m_2$

$m_2 = 0$

$$V_1 = \frac{2m_1U_1}{(m_1 + 0)} + \frac{(0 - m_1)(0)}{(m_1 + 0)}$$

$$V_1 = \frac{2m_1U_1}{2m_1} + 0$$

$$\boxed{V_1 = 2U_1}$$

Result:
When heavy body collide with light body which is initially at rest then after collision comes body 1 continue its motion with same speed while body 2 starts its motion with the twice of the initial velocity of the body 1.

Q14. Describe the final velocities when light body collides with the heavy body, which is initially at rest.

Ans.

$$V_1 = \frac{(m_1 - m_2)U_1}{(m_1 + m_2)} + \frac{2m_2U_2}{(m_1 + m_2)}$$

Let $m_1 << m_2$

$m_1 = 0$

$$V_1 = \frac{(0 - m_2)U_1}{(0 + m_2)} + \frac{2(0)U_1}{(0 + m_2)}$$

$$V_1 = \frac{m_2U_1}{m_2} + 0$$

$$\boxed{V_1 = U_1}$$

$$V_1 = \frac{2m_1U_1}{(m_1 + m_2)} + \frac{(m_2 - m_1)U_2}{(m_1 + m_2)}$$

Let $m_1 << m_2$

$m_1 = 0$

$$V_1 = \frac{2(0)U_1}{(0 + m_2)} + \frac{(0 - m_1)(0)}{(0 + m_2)}$$

$$V_1 = 0 + 0$$

$$\boxed{V_1 = 0}$$

Result:
When light body collide with heavy body which is initially at rest then after collision comes body 1 reflect back with same speed while body remains at rest.

CHAPTER # 04 "MOTION IN TWO DIMENSIONS"

PROJECTILE MOTION:

Q1. Define projectile motion.

Ans. The motion of an object in the curved path with constant horizontal velocity and variable vertical velocity is called projectile motion."

OR

When an object is projected with certain angle θ ($0 < \theta < 90^0$) called angle of projection, with certain velocity called velocity of projection then its moves in the curved path called parabolic path with constant horizontal velocity, variable vertical velocity and under the action of gravity. Such object is called projectile and its motion is called projectile motion.

Q2. Under what condition horizontal range will maximum.

Ans. When the projectile is projected with 45^0

Q3. Show that when a projectile is projected is 45^0, its range will maximum.

Ans. Horizontal Range is given as,

$$R = \frac{V_o^2 \sin 2\theta}{g}$$

Above expression shows that, for constant velocity of projection (V_0) and gravitational acceleration (g), horizontal range depends on the factor sin2θ and it will be maximum at the maximum value of sin2θ. The maximum value of sin is 1.

$$\sin 2\theta = 1$$
$$2\theta = \sin^{-1}(1)$$
$$2\theta = 90^0$$
$$\theta = 90/2$$
$$\theta = 45^0$$

It shows that, "when a projectile is projected with 45^0, its horizontal range will be maximum."

Q4. Under what condition horizontal range will be equal to the maximum height.

Ans. When the projectile is projected with 76^0

Q5. Show that when a projectile is projected with 76°, its horizontal range will be equal to the maximum height.

Ans. Proof: when horizontal range becomes equal to maximum height.

$$h_{max} = R$$

$$\frac{v_0^2 \sin^2\theta}{2g} = \frac{v_0^2 \sin 2\theta}{g}$$

$$\frac{\sin^2\theta}{2} = \sin 2\theta$$

$$\sin^2\theta = 2\sin\theta\cos\theta$$

$$\frac{\sin^2\theta}{\sin\theta\cos\theta} = 2 \times 2$$

$$\frac{\sin\theta}{\cos\theta} = 4$$

$$\tan\theta = 4$$

$$= \tan^{-1}(4)$$

$$\theta = 76^0$$

When projectile is projected with 76°, horizontal range becomes equal to maximum height.

Q6. At what position, projectile has maximum velocities during its motion.

Ans. Projectile has maximum velocities at the point of projection and just before striking the ground.

Q7. At what position, projectile has minimum velocity during its motion.

Ans. Projectile has minimum velocity at its maximum height and it is equal to the horizontal component of the velocity.

Q8. What is the value of the horizontal acceleration during projectile motion?

Ans. During projectile motion horizontal velocity always be zero because through out the projectile motion horizontal velocity always remains constant.

Q9. What are the values of the vertical acceleration during projectile motion?

Ans. As projectile motion occurs under the influence of gravity therefore vertical acceleration is equal to the gravitational acceleration. For upward motion it is equal to "+ g" and for downward motion it is equal to "- g"

Q10. Define the trajectory of projectile motion. Give its mathematical form.

Ans. The curved path followed by the projectile during its motion is called trajectory of projectile motion.

For upward motion

$$Y = \tan\theta\, x - \frac{1}{2}\frac{g}{V_o^2}\sec^2\theta\, x^2$$

For downward motion

$$Y = \tan\theta\, x - \frac{1}{2}\frac{g}{V_o^2}\sec^2\theta\, x^2$$

Q11. Show that projectile performs its motion in the parabolic path.

Ans. Considering

$$Y = \tan\theta x - \frac{1}{2}\frac{g\sec^2\theta}{V_o^2}x^2$$

Let $\tan\theta x = a$

$$\frac{g\sec 2\theta}{V_o^2} = b$$

$$\boxed{Y = ax - \frac{1}{2}bx^2}$$

This is the general form for parabola hence if is proved that projectile performs its motion in the parabolic path.

CIRCULAR MOTION:

Q1. Differentiate circular motion and uniform circular motion.

Ans. During circular motion object moves in the circular orbit with any speed where as in uniform circular motion object moves in the circular orbit with uniform speed.

Q2. Why during circular motion velocity can never be uniform.

Ans. During circular motion velocity can never be uniform because the direction of velocity which is tangent on the circle changes at every point.

Q3. Derive the relation between linear and angular velocities.

Ans. Supposed ΔS is the linear distance and $\Delta\theta$ is the angular distance in a circle of radius r.

Then $\Delta S = r\Delta\theta$

But ΔS and $\Delta\theta$ are covered in the same time Δt. Dividing both sides of above equation by Δt we get,

$$\frac{\Delta S}{\Delta t} = \frac{r\Delta\theta}{\Delta t}$$

Ration $\frac{\Delta S}{\Delta t}$ gives the average linear speed whereas the ration $\frac{\Delta\theta}{\Delta t}$ gives the average angular speed. If

The time Δt is so small that it approaches zero. Then these ratios will give the instantaneous values of linear and angular speed i.e.

$$\lim_{\Delta t \to 0} \frac{\Delta S}{\Delta t} = \frac{r\Delta\theta}{\Delta t}$$

$$v = r\omega$$

In the form of cross product, the above equation is written as

$$v = \omega \; r$$

Q4. Derive the relation between linear and angular accelerations.

Ans. Suppose a body is revolving in a circle of radius r. Its linear and angular speeds change by Δv and Δw in time Δt. Then

$$\Delta v = r\,\Delta w$$

Dividing both sides by Δt we get

$$\frac{\Delta v}{\Delta t} = r\,\frac{\Delta w}{\Delta t}$$

$\frac{\Delta v}{\Delta t}$ is the average linear acceleration a and $\frac{\Delta v}{\Delta t}$ is the average angular acceleration α.

If time Δt → 0 then we get the instantaneous values of these accelerations i.e.

$$\lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = r \lim \frac{\Delta w}{\Delta t}$$

$$\boxed{a = r\alpha}$$

Q5. Express centripetal acceleration in terms of time period.

Ans. Considering

$$a_c = \frac{v^2}{r} \quad \text{(i)}$$

Suppose T is the time taken to complete one rotation. Distance covered in one rotation is given by 2πr where r is the radius of the circle. Then speed v is given by,

$$V = \frac{S}{T}$$

$$V = \frac{2\pi r}{T}$$

Put this value in equation (i)

$$a_c = \left(\frac{2\pi r}{T}\right)^2 \times \frac{1}{r}$$

$$a_c = \frac{4\pi^2 r^2}{T^2} \times \frac{1}{r}$$

$$\boxed{a_c = \frac{4\pi^2 r}{T^2}}$$

Q6. Express centripetal acceleration in terms of frequency.

Ans. Considering

$$a_c = \frac{4\pi^2 r}{T^2}$$

It can also be written as

$$a_c = 4\pi^2 r \times \frac{1}{T^2}$$

But f = 1/ T

$$a_c = 4\pi^2 r f^2$$

$$\boxed{a_c = 4\pi^2 f^2 r}$$

CHAPTER # 05 "TORQUE, EQUILBRIUM & ANGULAR MOMENTUM"

Q1. Define moment arm.

Ans. The perpendicular distance from the point of application and the axis of rotation is called moment arm. It is denoted by $\vec{r}$.

Q2. Express torque in terms of vector product.

Ans. Vector Form of Torque is given a.

$$\tau = r F \sin\theta \, \hat{n}$$

Where n is the normal unit vector vector used to indicate the direction.

$A \times B = AB \sin\theta \, \hat{n}$ Torque can also be written as

$$\vec{\tau} = \vec{r} \times \vec{F}$$

It show that," the vector product of moment arm and force is called Torque."

Q3. Which component of force is responsible to produce torque?

Ans. The perpendicular component of force is responsible to produce torque.

Q4. How the direction of torque be determined.

Ans. The direction of Torque is always perpendicular on both moment arm and force and can be determined by using right hand rule which is stated as, *"If the figures of the right hand represent the direction of moment arm and applied force, then the direction of thumb which is perpendicular to the figures gives the direction of torque."*

Q5. Define equilibrium and its types.

Ans. ***DEFINITION:*** 'If an object is in a state of rest or in a state of uniform motion, then it is said to be in a state of equilibrium.

TYPES OF EQUILIBRIUM: There are two type of equilibrium.

1. Static equilibrium.
2. Dynamic equilibrium

1. **Static equilibrium**: If an object is in a state of rest than it is said to be in a state of static equilibrium.
2. **Dynamic equilibrium**: If an object in a state of uniform motion, them if is said to be in a state of dynamic.

There are two types of dynamic equilibrium

i) Translational equilibrium

ii) Rotational equilibrium

i) ***Translational dynamic equilibrium***: If an object is moving straight line with uniform velocity, them it is said to be in a state of translational equilibrium.

ii) ***Rotational dynamic equilibrium:*** If an object is moving in a circular orbit with uniform speed, then it is said to be in a state of rotational equilibrium.

Q6. Define angular momentum.

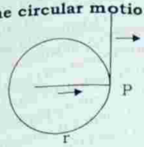
Ans. "The momentum of an object τ revolving gin a circular orbit is called angular momentum

OR

"The vector product of moment arm and linear momentum is called momentum."

Q7. Derive the expression of angular momentum for the circular motion.

Ans. *Angular momentum during Circular motion.*



Angular momentum is given as

$L = mvr \sin\theta$

During circular motion: $\theta = 90^0$

$L = mvr \sin 90^0$ $\qquad \sin 90^0 = 1$

$L = mvr \quad (1)$

$\boxed{L = mvr}$

Q8. Show that torque is equal to rate of change of angular momentum.

Ans. Angular momentum is given as

$\vec{L} = \vec{r} \times \vec{p}$

Diff w.r.t 't'

$\frac{d\vec{L}}{dt} = \frac{d}{dt}(\vec{r} \times \vec{P})$

$\frac{d\vec{L}}{dt} = \vec{r} \times \frac{d\vec{P}}{dt} + \vec{P} \times \frac{d\vec{r}}{dt}$

But

$\vec{F} = \frac{d\vec{P}}{dt}$ Rate of change of momentum

$\vec{v} = \frac{d\vec{r}}{dt}$ Rate of change of moment arm(Displacement)

$\frac{d\vec{L}}{dt} = \vec{r} \times \vec{F} + \vec{P} \times \vec{v}$

But $\vec{\tau} = \vec{r} \times \vec{F}$: Torque

$\vec{P} = m\vec{v}$: Momentum

$\frac{d\vec{L}}{dt} = \vec{\tau} + m\vec{v} \times \vec{v}$

$\frac{d\vec{L}}{dt} = \vec{\tau} + m(0)$

$\frac{d\vec{L}}{dt} = \vec{\tau}$

It show that, *" The rate of change of angular momentum is equals to torque."*

Q9. Show that 1 Kg m s^{-1} = 1 J s.

Ans. Angular momentum is given as L = m v r

In MKS system L = kg m/s x m

$L = kg\ m^2/s$ ______ (i)

Multiply and divide by s

$L = \frac{kg\ m^2}{s} \times \frac{s}{s}$

$L = kg\ \frac{m^2}{s^2} \times s$

$L = kg\ \frac{m}{s^2} \times m \times s$ ______ (ii)

$F = ma$

$N = kg\ \frac{m}{S^2}$ ______ (iii)

Using (iii) in (ii)

$L = N \times m \times s$

But $J = N \times m$

$L = J \times s$ ______ (iv)

Equating (i) and (iv)

$Kg\ m^2\ s^{-1} = J\ s.$

$$1\ Kg\ m^2\ s^{-1} = 1\ J\ s.$$

Q10. Derive the angular mathematical form for the angular momentum.

Ans. Angular momentum is given as

$L = mvr\ Sin\ \theta$

But $v = r\omega$

$L = m\ (r\omega)\ r\ sin\ \theta$

$$L = m\ r^2\ \omega\ sin\ \theta$$

Which is the required angular form of angular momentum.

Q11. What is required condition for the law of conservation of angular momentum?

Ans. The object must be in rotational equilibrium i.e., the sum of all torques acting on the object equals to zero.

Q12. State the law of conservation of angular momentum.

Ans. ***Statement:***

"When ever an object is in rotational equilibrium, its total angular momentum always remains constant."

OR

"During uniform circular motion total angular momentum always remains constant."

Mathematical Form:

Mathematically it is given as

$$\vec{L} = \text{Constant}$$

CHAPTER # 06 "GRAVITATION"

Q1. Define gravitation.

Ans. Gravitation means attraction. It is the property due bodies attracts each other. It depends on the mass and the density of the body.

Q2. Show that gravitational force is a mutual force.

Ans. Gravitational force is mutual force. It exists between two bodies and in the absence of any body gravitational force will be zero.

Q3. Show that two bodies exert equal and opposite forces on each other.

Ans. Vector form of gravitational force can be expressed as,

$$\vec{F} = G\frac{m_1 m_2}{r^2}\hat{r}$$

Where $\hat{r}$ is a unit vector used to indicate the direction of unit vector.

Force on Body 1 due to Body 2 is given as,

$$\vec{F}_{21} = G\frac{m_1 m_2}{r^2}\hat{r}_{12}$$

Force on body 2 due to Body 1 is given as

$$\vec{F}_{12} = G\frac{m_1 m_2}{r^2}\hat{r}_{21}$$

Both bodies exert same force on each other but in opposite direction.

$$\vec{F}_{12} = -\vec{F}_{21}$$

It shows that " two bodies exert and opposite forces on each other."

Q4. What happen with gravitational force if the masses are doubled?

Ans. Gravitational force becomes 4 times i.e. it becomes 4F.

Q5. What happen with the gravitational force if the distance between the bodies is doubled?

Ans. Gravitational force is decreased by 4 time i.e., it becomes ¼ F.

Q6. What happen with the gravitational force if the masses as well as the distance between the bodies are doubled?

Ans. Gravitational force remains same.

Q7. Calculate the value of the mass of earth.

Ans. Considering an object of mass 'm' radius 'r' placed at the surface of Earth having mass 'M_E' and radius 'R_E.

Let Mass of Earth = M_E

mass of body = m

Radius of body = r'

Radius of Earth = R_E

Body is at the surface of earth

Mean Distance between Centers of Earth and body = $r = r' + R_E$

A/c to Newton's Law of Gravitational

$$F = G\frac{m_1 m_2}{r^2}$$

On substitution of values

$$F = G\frac{M_E m}{(r' + R_E)^2}$$

$r' <<< R_E$ therefore r' is so small as compared $r' \approx 0$ to R_E that it can be neglected.

$$F = G\frac{M_E m}{R_E^2}$$

It is the force with which Earth attracts the body towards its centre and by definition it is equal to the weight of the body

$$F = w$$

Substituting values,

$$\frac{G M_E m}{R_E^2} = mg$$

$$\boxed{M_E = \frac{g R_E^2}{G}}$$

This is the required expression for the mass of Earth.

We have $g = 9.8\ m/s^2$

R_E = Radius of Earth; $6.4 \times 10^6 m$

G = Grav. Const. $6.67 \times 10^{-11}\ N.m^2/kg^2$

On the substitution of values, mass of Earth is found to be 5.98×10^{24} kg.

Q8. Calculate the value of the density of earth.

Ans. "The ration of mass of the object with its volume is called Density of the object."

By definition, density is given as

$$P = \frac{m}{V}$$

For Earth: $\rho_E = \frac{M_E}{V_E}$ (1)

Using relation for the mass of Earth.

$$M_E = \frac{g R_E^2}{G} \quad (2)$$

Earth is considered as a spherical body.

Volume of earth cab be given as

$$V_E = \frac{4}{3}\pi R_E^3 \quad (3)$$

Substituting (2) & (3) in (1)

$$\rho_E = \frac{\frac{g R_E^2}{G}}{\frac{4}{3}\pi R_E^3}$$

$$\rho_E = \frac{g R_E^2}{G} \times \frac{3}{4\pi R_E^3}$$

$$\rho_E = \frac{3g}{4\pi G R_E}$$

This is the required expression for the density of Earth.

We have

$g = 9.8\ m/s^2$

$\pi = 3.142$

$G = 6.67 \times 10^{-11}\ N\text{-}m^2/kg^2$

$R_E = 6.4 \times 10^6\ m$

On the substitution of values, Density of Earth is found to be $5.5 \times 10^3\ kg/m^3$.

Q9. What is effect of altitude on "g"?

Ans. The value of g decreases because it is inversely proportional to the square of the distance away from the centre of the earth.

Q10. What is effect of depth on "g"?

Ans. The value of g decreases because it has inverse effect with the depth.

Q11. What is artificial gravity and how it is produced?

Ans. The gravity which is developed due to rotation of the object in order of balance the gravitation of the earth is called artificial gravity.

Q12. What is meant by weightlessness in satellite?

Ans. *See notes*

Q13. Differentiate between real and apparent weight.

Ans. *As discuss in the class*

Q14. Calculate the apparent weight of a body lift is at rest.

Ans. When lift is at rest the acceleration is zero. The apparent weight W indicated by the spring is the tension T.

Therefore $W/ = T = mg$

Result:- The apparent weight is equal to the actual weight.

Q15. Calculate the apparent weight of a body lift moves upward or downward with uniform velocity.

Ans. When lift is moving upward or downward with uniform velocity.

The acceleration is zero

$$T - W = 0$$

$$T = W$$

$$\text{But } T = F_w$$

$$F_w = W$$

Result:- The apparent weight is equal to the actual weight.

Q16. Calculate the apparent weight of a body lift moves upward with uniform acceleration.

Ans. When elevator move upward with uniform acceleration than tension in string is greater than its weight

$$T > W$$

Net force/weight with which it moves up

$$F = T - W$$

A/c to Newton's 2nd Law

$$F = ma$$

$ma = T - W$

But $T = F_w$

$ma = F_w - w$

$ma = F_w - mg$

$F_w = ma + mg$

$F_w = m(a + g)$

Result;-

When elevator moves upward uniform velocity it apparent weight is greater than actual weight.

Q17. Calculate the apparent weight of a body lift moves downward with uniform acceleration.

Ans. When elevator moving downward with uniform acceleration than tension in string is lesser than its weight.

$W > T$

Net force with which it moves down

$F = W - T$

A/c to Newton's 2nd Law

$F = ma$

$W - T = ma$

$W - ma = T$

$T = W - ma$

$T = mg - ma$

$T = m(a - g)$

Result:- The apparent weight is lesser than the actual weight

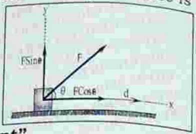
Q18. Show during free fall motion apparent weight of a body becomes zero.

Ans. When body falls freely under the action of gravity it is in a state of downward accelerated motion.

CHAPTER # 07 "WORK, ENERGY & POWER"

Q1. Show that work is the scalar product of force and displacement.

Ans. If a force **F** acts on the body by making an angle θ with horizontal then force of a body can be resolved in to two rectangular components **FCosθ** and **FSinθ**. Where **FSinθ** can not perform any work therefore work done by the force is given by:



$$\text{Work} = (F\cos\theta)(d)$$

$$\text{Work} = Fd\cos\theta$$

$$\text{Work} = \vec{F} \cdot \vec{d}$$

So work can also be defined as:

"Work is the dotproduct of force and displacement"

Q2. State the condition for which work will be maximum.

Ans. Work is said to be maximum or positive if force and displacement are in the same direction.

Q3. State the condition for which work will be minimum.

Ans. Work is said to be minimum or zero if force and displacement are perpendicular to each other.

Q4. Under what condition work will be negative.

Ans. Work is said to be negative if force and displacement are opposite to each other.

Q5. Show that power is the scalar product of force and velocity.

Ans. Power is the amount of work done by a body in unit time. Mathematically it can be expressed as:

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

$$P = \frac{\vec{F} \cdot \vec{d}}{t}$$

$$P = \vec{F} \cdot \frac{\vec{d}}{t}$$

$$P = \vec{F} \cdot \vec{V}$$

With the help of above equation power can also be defined as:

"Power is the dot product of force and velocity."

Q6. State the conditions of conservative field.

Ans. Such a field in which work done is independent of the path followed by the body.

OR

Such a field in which the total work done in a moving body along a closed path is equal to zero.

Q7. Why gravitational field is said to be conservative field.

Ans. Gravitational field is said to be conservative field because it satisfy the following required condition of conservative field.

i) Work done is independent of the path followed and only depends on the displacement between initial and final positions.

ii) The total work done in a moving body along a closed path is equal to zero.

Q8. What is absolute gravitational potential energy?

Ans. The amount of work required to displace an object against the gravitational field to an infinite point stored in the object in the form of absolute gravitational energy.

Q9. State the law of conservation of energy.

Ans. "Energy can neither be created nor can it be destroyed. It can only be transformed from one form to another."

Q10. When an object is dropped from certain height, why its potential energy is not completely converted into kinetic energy.

Ans. Its potential energy is not completely converted into kinetic energy because certain amount of energy is utilized to overcome the air friction.

CHAPTER # 08 "WAVE MOTION AND SOUND"

Q1. State the basic conditions of simple harmonic motion.

Ans. Basic conditions for AHM. The basic condition for a system to execute simple harmonic motion is:-

(i) There must be an elastic restoring forc acting on the system

(ii) The system must have inertia.

(iii) The acceleration of the system should be proportional to its displacement (from the main position) but opposite in direction.

Q2. Give some examples of simple harmonic motion.

Ans. Examples of SHM.

I) The motion of the bob of a simple pendulum.

II) The motion of a stretched string when it is plucked to disturb it from the mean position.

III) The motion of a body (i.e. heavy mass particle) attached to the end of an a elastic spring hanging vertically.

IV) The motion of the projection of a particle moving round a circle with uniform speed.

V) The motion of an elastic metallic strip, held vertically in a rigid support with a heavy mass attached to its free end.

Q3. A certain simple pendulum has an iron bob. Would its behavior change if we replace the iron bob with a lead bob of the same size?

Ans. Change in behaviour of a simple pendulum with bobs of different materials. There time period of a simple pendulum is given but the relations.

$$T = 2\Pi\sqrt{\frac{l}{g}}$$

Where l = length of the pendulum, and

g = acceleration due to gravity.

The above relation shows that the time period of a simple pendulum only depends upon its length and value of 'g' at a certain place and its is independent of the mass of the bob. Therefore, if we replace the iron bob with a lead bob, only the mass of the bob will change but h behavior of he pendulum will not be affected. It means that the time period and the frequency of the pendulum, having a certain length, will remain unchanged with the change of bobs.

Q4. Will the period of a vibrating spring increase, decrease or remain constant by addition of more weight?

Ans. Period of vibrating spring is given by

$$T = 2\Pi\sqrt{\frac{m}{k}}$$

where m = mass attached to the free end of the spring, and K = spring constant.

Above relation shows that the period of a vibrating spring is directly proportional to the mass attached to its free end i.e. $T \alpha \sqrt{m}$ period increases with the addition of mass. Thus with the addition of more weight (mg), mass m will increase and the period of the vibrating spring will also increase.

Q5. What happen to the time period if the length of the pendulum is changed?

Ans.

Q6. What happen to the time period of the pendulum if the mass its bob is changed?

Ans.

Q7. Would you keep the amplitude of a simple pendulum small or large? Why?

Ans. Amplitude of a simple pendulum. We should keep the amplitude of simple pendulum small because in deriving the relation for its time period.

$$(T = 2\Pi\sqrt{\frac{l}{g}})$$

the distance through a which pendulum is displaced, son small that sinθ =θ, 'θ' carr only be small, if amplitude is small.

Q8. What is the frequency of the second pendulum.

Ans. Frequency of a second's pendulum. A second's pendulum is that pendulum whose time period is 2 seconds i.e.

T = 2 seconds

But relation between the frequency and time period is given by

$$F = \frac{1}{T}$$

Therefore the frequency of a second's pendulum is given by

f = ½ = 0.5 vibration/second

Q9. Differentiate transverse wave and longitudinal wave.

Ans. DIFFERENCE BETWEEN TRANSVERSE & LONGITUDINAL WAVE:

Transverse Waves	Longitudinal Waves
1. Wave in which particles of the medium vibrates perpendicular to the direction of propagation is called transverse wave.	1. Wave is which particle of the medium vibrates along the direction of propagation is called longitudinal waves.
2. Transference of energy through perpendicular vibration of the particle of eh medium.	2. Transference of energy through parallel vibration of the particles of the medium.
3. Crest and trough form due to perpendicular vibration.	3. Compression and rarefaction form due to parallel vibration.
4. Light waves, electromagnetic waves are some examples of transverse waves	4. Wave in stretched string, spring waves are some examples of longitudinal waves.

Q10. Is it possible for two identical waves traveling in the same direction along a string to give rise to a standing wave?

Ans. It is not possible for two identical waves traveling in the same direction along a string to given rise to a standing wave. Two identical waves moving along the same string can only reduce standing waves when they are moving in the opposite directions.

Q11. Define the terms: crest, trough, compression, rarefaction node and antinode.

Ans. **Crest**:-The highest portion of the wave above the mean position is called crest.
Trough:-The lowest portion of the wave below the mean position is called trough.
Compression:-The portion of the wave in which particles of the medium close to each other is called compression.
Refractions:-The portion of the wave in which particle of the medium are away from each other is called rarefaction.
Node:-The point of standing wave which lies on the mean position having minimum displacement is called node.
Anti Node:- The point of standing wave where displacement is maximum is called antinodes.

Q12. How the speed of a transverse in the string will change if its tension is made four times.

Ans. The speed of a transverse wave in a string is given by

$$v = \sqrt{\frac{TxL}{m}}$$

if the tension is made four times, then the speed of the wave will become

$$v' = \sqrt{\frac{4TxL}{m}}$$

or $$v' = 2\sqrt{\frac{TxL}{m}} = 2v$$

Thus the speed of the transverse wave will be doubled if the tension is made four times.

Q13. Why does sounds travel faster in solids than in gases.

Ans. Sound travels faster in solids than in gases
The speed of sound is given by the formula

$$v = \sqrt{\frac{E}{\rho}}$$

Where E = elasticity of the medium, and
ρ = density of the medium through which sound travels.
It is true that the density of solids is larger than that for gases but the elasticity of the solids is much larger than gases, so the ratio E/ Speed of transverse becomes four times. Is much larger for solids is much larger than gases. That is why the sound travels faster in solids than is gases.

Q14. Why does the speed of a sound wave in gas change with temperature?

Ans. Speed of sound changes with the change in the temperature of a gas.
The speed of sound in a gas is given by

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

here P=pressure of the gas.
When the temperature of a gas rises its pressure increases and its density decreases, therefore the speed of sound increases. On the other hand with the

decrease of temperature, the pressure of a gas decreases and factor P/ρ become less thus decreasing the speed of sound.

Q15. How are beats useful in tuning musical instrument?

Ans. We know that the number of beats produced per second is equal to the differences between the frequencies of two sounding bodies. If we know that frequency of standard instruments, we can tune the other instruments to the desired frequency by counting the number of beats as compared to the standard instrument. In this way beats are useful for tuning a musical instrument.

Q16. What is meant by the quality of the sound?

Ans. It is the characteristics by which two sound waves of same pitch and possibly of the same intensity, given out by two different sources may be distinguished from each other .It is the internal characteristics of eh vibrating body depending on the nature of body. the quality of sound waves also depends on the shape of wave form produced b it, in turn it depends upon the number and type of Harmonics occurring in the sound.

Q17. How the intensity of sound related with loudness.

Ans. *Relation between intensity and loudness:-* (Weber-Fechner law)

Statement: "loudness of a sound wave is directly proportional to the logarithm of intensity."

Mathematical form:- Mathematically, it is given as \

$L \propto \log I$

$L = k \log I$

Q18. Differentiate between musical sound and noise.

Ans. <u>**Musical sound**</u>: Sound which produces pleasant effect in our ear in called musical sound.

Or

Sound in which there is uniform change in frequency is called sound waves.

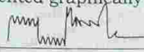
<u>**Noise:**</u>

Sound which produce unpleasant effect tin our ear is called Noise

Or

Sound in which there is a rapid change in the frequency is called Noise.

Following are the point of distinguish between a musical sound and a Noise.

	MUSICAL SOUND		NOISE
1	It produce pleasant situation upon the ear.	1	It do not produce pleasant situation upon the ear.
	It is smooth and agreeable		It is jarring and disagreeable.
	If has periodicity i.e, waves follow each other at regular interval.		Wave do not follow each other with regular interval
	All the waves are similar & there is no sudden change of loudness or frequency		All the wave are not similar and there is sudden change in Loudness
	Change in frequency can be represented by the curve. 		Change on frequency can be represented graphically as 

CHAPTER # 09 "NATURE OF LIGHT"

Q1. What is the necessary condition on the path difference between two waves interfere (a) constructively (b) destructively.

Ans. Condition for constructive interference:- For constructive Interference path difference between the two waves coming from different source should be integral multiple of the wave length.

i.e., path diff. = $0, \lambda, 2\lambda, 3\lambda, 4\lambda, 5\lambda \ldots\ldots n\lambda$.

Where $m = 0, 1, 2, 3 \ldots\ldots$

Condition for destructive interference:- For destructive interference path difference between two waves coming from different source should be odd integral multiple of the wave length.

I.e., Path difference = $\frac{o\lambda}{2}, \frac{2\lambda}{2}, \frac{3\lambda}{2}, \frac{4\lambda}{2} \ldots\ldots (m+1)\frac{\lambda}{2}$

Where $m = 0, 1, 2, 3, \ldots\ldots$

Q2. Why we do not find interference in ordinary light?

Ans. Interference of light needs coherent waves from monochromatic sources. Ordinary light beams are not coherent.

Q3. Why the distant flash lights will not produce an interference pattern.

Ans. Two light beams which are coherent when they are closer to the source, at large distance they do not remain coherent thus distant flash lights are unable to produce an interference pattern.

Q4. Although we can hear but can not see around corners. How can you explain this in view of the fact that sound and light are both waves?

Ans. The wavelength of sound waves in very large, of the order of several feet, or meters therefore they can diffract about corners and we can hear them. But the wavelength of light wave is much smaller, of the order of 10^{3} m, therefore they can not diffract about large corners and we can not see light.

Q5. Explain, why it is said that the light wave fronts from sun are plane wave fronts.

Ans. The sun is at a large distance, wave fronts from sun when reach to earth, are spheres of large radii. Only a small portion is found plane, thus these wave fronts are called plane wave front.

Q6. Why central ring in the Newton's ring always be dark.

Ans. The interference pattern formed at center of the rings is due to path difference equal to zero, but in thin film an additional phase inversion occurs, it givers destructive interference. Hence central point in Newton's ring is always dark.

Q7. What are the Newton's rings?

Ans. When a monochromatic ray of light incident on a Plano convex lens, which placed on a glass surface, then circular dark and bright consecutive circles, will be obtained, these rings are called Newton's rings

Q8. What is the main cause of Newton's rings.

Ans. Air in between Plano convex lens and a flat glass surface behave like air wedge film. The thickness of air wedge film is zero at the contact if such a film is illuminated by a monochromatic light then dark bands is obtained at its centre. As we go away from the centre then the thickness changes gradually due to which alternative bright and dark rings are obtained.

Q9. Give the condition for the bright Newton's ring.

Ans. For nth Bright Ring: m = N-1

$$m=\sqrt{(N-1+\frac{1}{2})R\lambda}$$

$$m=\sqrt{(N-\frac{1}{2})R\lambda}$$

this is the required expression for the radius of bright rings.

Q10. Give the condition for the dark Newton's ring.

Ans. For First dark ring: m=1 $\gamma_1=\sqrt{1.R\lambda}$

For Second dark ring; 2 $\gamma_{21}=\sqrt{2.R\lambda}$

For nth dark ring: m = N $\gamma_{N1}=\sqrt{N.R\lambda}$

This is the required expression for the radius of the Nth dark ring.

Q11. Why the central point on the screen in Young's double slit arrangement is always bright?

Ans. The path difference for interference pattern at centre is zero then interference is constructive and image is bright.

Q12. Give the condition for the formation of bright fringes in the Michelson's interferometer.

Ans. For constructive interference i.e., for the bright fringes the distance moved by moveable mirror is:

$$P = m\lambda / 2$$

Q13. Give the condition for the formation of dark fringes in the Michelson's interferometer.

Ans. For destructive interference i.e., for the dark fringes the distance moved by moveable mirror is:

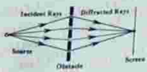
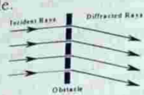
$$P = m\lambda / 4$$

Q14. What is the use of compensator in the Michelson's interferometer?

Ans. Compensator is used to avoid difference of the time interval produced in the two light waves coming from the two mirrors.

Q15. Differentiate Fresnel diffraction and Frunhoffer diffraction.

Ans.

FRESNEL DIFFRACTION	FRAUNHOFER DIFFRACTION
In Fresnel Diffraction the source of light and the screen where diffraction is formed are kept at finite distance from the diffracting obstacle 	In Fraunhofer Diffraction the source of light and the screen where diffraction is formed are kept at infinite distance from the diffracting obstacle. 
In Fresnel Diffraction the wave fronts falling and leaving the obstacle are not plane.	In Fraunhofer Diffraction the wave fronts falling and leaving the obstacle are plane.
In Fresnel Diffraction the corresponding rays are not parallel	In Fraunhofer Diffraction the corresponding rays are parallel to each other.

Q16. State Bragg's Law.

Ans. "To determine the structure of crystal those light can be used having wave length comparable to the distance between atomic planes."

Q17. What aspect of light is produced by the phenomena of polarization?

Ans. The process of polarization proves that light is a transverse wave.

Q18. Why diffraction is called special type of interference?

Ans. Diffraction of light is due to the formation of source (spherical wave front) on the edge of the obstacle. Now the secondary waves interfere them selves in obstructed portion in a special way that is only on one side.

CHAPTER # 09 "GEOMETRICAL OPTICS"

Q1. What is the effect on the image if half of converging lens is covered?

Ans. The image will remain unchanged, only the intensity of light passing thought the lens will be halved causing less brightness.

Q2. Define power of the lens. Give its units.

Ans. *Definition:* the reciprocal of the focal length is called power of the lens.

Mathematical Form:

$$\text{Power} = \frac{1}{\text{Focal length}}$$

$$P = \frac{1}{f}$$

<u>Unit:</u> It unit is diopter. The unit of power of the lens is diopter if focal length is taken in meter.

Q3. Define linear magnification.

Ans. *Definition # 01:* The ratio between the height of image and the height of object is called linear magnification.

i.e,. $\text{Magnification} = \dfrac{\text{Image height}}{\text{Object height}} = \dfrac{h_i}{h_o}$

Definition # 02: The ratio between the image distance and the object distance is called linear magnification.

i.e,. $\text{Magnification} = \dfrac{\text{Image distance}}{\text{Object distance}} = \dfrac{q}{p}$

Q4. Define angular magnification.

Ans. Definition: "The ratio between the angles formed by the image at the eye when it is viewed through instrument to the angle formed by the object when it is viewed without instrument is called angular magnification."

$$\text{Magnification} = \frac{\text{Angle formed at the eye when it is viewed with instrument}}{\text{Angle formed at the eye when it is viewed without instrument}}$$

Or $M = \dfrac{\beta}{\alpha}$

When β: Angle formed at the eye with instrument.

α: Angle formed at the eye without instrument.

Q5. Give the sign convention used in the lens formula.

Ans. The image seen in lens have coloured by edges. Why?

1. **What is best position to see any object?**
   The best position to observe any object is the least distance of distinct vision.
2. **What is meant by least distance of distinct vision?**
   It is the minimum distance from to observe any object clearly. For normal human eye it is 25 cm or 250 mm.
3. **How a convex lens is used as a magnifier?**
4. **State the principle used for the construction of magnifying glass.**
   It is based on the principal that" if object is placed within the focal length of the lens then virtual and magnified image is formed on the same side of the lens."

5. State the principle used for the construction of compound microscope.
It is based on the principal that" if object is placed within the focal length of the lens then virtual and magnified image is formed on the same side of the lens."

6. Why would be advantageous to use blue light with a compound microscope?

7. Why Objective of short focal length is preferred in microscope?

8. State the principle used for the construction of astronomical telescope.
It is based on the principal that" if object is at infinite distance then parallel rays enter into lens and form image will be formed at the principal focus of the lens."

9. What is length of astronomical telescope?
The sum of the focal lengths of objective and image distances. i.e.,

$$L = f_o + f_e$$