

11TH PHYSICS MINIMUM STUDY MATERIAL VOL - 1

(For slow learners)

1. Explain basic forces of nature.

Gravitational Force:

- It is the force between any two objects in the universe.
- It is directly proportional to the product of masses and inversely proportional to the distance between them.
- It is the weakest force among the fundamental force of nature.
- It has the greatest large - scale impact on the universe.

Electromagnetic Force:

- It is the force between any two charged particles.
- It is attractive for unlike charges and repulsive for like charges.
- It obeys inverse square law.
- It is very strong compared to the gravitational force.
- It is the combination of electrostatic and magnetic forces.

Strong Nuclear Force:

- It is the strongest of all the basic forces of nature.
- It has the shortest range of the order of 10^{-15} m
- It holds the protons and neutrons together in the nucleus of an atom.

Weak Nuclear Force:

- It is important in certain types of nuclear process such as β - decay.
- It is not as weak as the gravitational force.

2. What are the rules and conventions to be followed for writing SI units and their symbols?

- 1) The units named after scientists should be written in small letter only.
- 2) Symbols of the units named after scientists should be written by a capital letter.
- 3) Small letters are used as symbols for units not derived from a proper name.
- 4) No full stop or any other marks should be used within or at the end of the symbols.
- 5) Symbols of the units do not take plural form.
- 6) When temperature is expressed in kelvin, the degree sign is omitted.
- 7) Not more than one solidus is used.
- 8) Some space is always to be left between the number and the symbol of the unit.
- 9) Some space is always to be left between the symbols for compound units such as force, momentum.,
- 10) Only accepted symbols should be used.
- 11) Numerical value of any physical quantity should be expressed in scientific notation.

3. How will you convert a physical quantity from one system of units to another by using dimensional analysis?

cgs system	SI system
$G_{cgs} = 6.67 \times 10^{-8} \text{ dyne cm}^2 \text{ g}^{-2}$	$G = ?$
$M_1 = 1 \text{ g}$	$M_2 = 1 \text{ kg}$
$L_1 = 1 \text{ cm}$	$L_2 = 1 \text{ m}$
$T_1 = 1 \text{ s}$	$T_2 = 1 \text{ s}$
Dimensional formula for $G = [M_1^x L_1^y T_1^z]$	Dimensional formula for $G = [M_2^x L_2^y T_2^z]$

here, $x = -1$, $y = 3$, $z = -2$

$$G[M_2^x L_2^y T_2^z] = G_{cgs}[M_1^x L_1^y T_1^z]$$

$$G = G_{cgs} \left[\frac{M_1}{M_2} \right]^x \left[\frac{L_1}{L_2} \right]^y \left[\frac{T_1}{T_2} \right]^z$$

$$G = 6.67 \times 10^{-8} \left[\frac{1 \text{ g}}{1 \text{ kg}} \right]^{-1} \left[\frac{1 \text{ cm}}{1 \text{ m}} \right]^3 \left[\frac{1 \text{ s}}{1 \text{ s}} \right]^{-2}$$

$$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$

4. Obtain the relation between the physical quantities in an equation using dimensional analysis method.

- $T \propto m^x l^y g^z$
- $T = k m^x l^y g^z$
- $[T^1] = [M^x L^y T^{-2z}]$
- $x = 0$, $y = \frac{1}{2}$, $z = -\frac{1}{2}$
- $T = k m^0 l^{\frac{1}{2}} g^{-\frac{1}{2}}$
- $T = k \left[\frac{l}{g} \right]^{1/2}$
- $k = 2\pi$
- $T = 2\pi \sqrt{\frac{l}{g}}$

5. Derive equations of motion.

(i) The acceleration of a body is given by the first derivative of the velocity with respect to time.

- $a = \frac{dv}{dt}$ (or) $dv = a dt$
- $\int_u^v dv = a \int_0^t dt$
- $v = u + at$

(ii) The velocity of the body is given by the first derivative of the displacement with respect to time.

- $v = \frac{ds}{dt}$ (or) $ds = v dt$
- $ds = (u + at) dt$
- $s = ut + \frac{1}{2}at^2$

(iii) The acceleration of a body is given by the first derivative of the velocity with respect to time.

- $a = \frac{dv}{dt}$ (or) $ds = \frac{1}{a} v dv$
- $s = \frac{1}{2a}(v^2 - u^2)$
- $2as = (v^2 - u^2)$
- $v^2 = u^2 + 2as$

6. Explain different types of vectors.

Equal vectors:

- Two vectors having same magnitude and same direction, whatever be their initial positions.

Like vectors: The vectors of same direction but different in magnitude.

Opposite vectors: The vectors of same magnitude but opposite in direction.

Unlike vectors: The vectors of different magnitude acting in opposite directions.

Unit vector: A vector having unit magnitude.

Zero vector: A vector whose magnitude is zero.

Proper vector: All the non zero vectors are proper vectors.

Co-initial vector: Vectors having the same starting point.

Coplanar vectors: Vectors lying on the same plane.

7. State triangle law of vectors and parallelogram law of vectors.

Triangle law of vectors:

- If two vectors are represented in magnitude and direction by the two adjacent sides of a triangle taken in order, then their resultant is the closing side of the triangle taken in reverse order.

$$\bullet \frac{P}{\sin \beta} = \frac{Q}{\sin \alpha} = \frac{R}{\sin(180^\circ - \theta)}$$

Parallelogram law of vectors:

- If two vectors acting at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant is represented in magnitude and direction by the diagonal passing through the common tail of the two vectors.

$$\bullet R = \sqrt{P^2 + Q^2 + 2PQ \cos \theta}$$

8. State and prove law of conservation of linear momentum.

- When the impulse due to external forces is zero, the momentum of the system remains constant.

$$\bullet J = mv - mu$$

$$\bullet \text{If } J = 0, \text{ then, } mv - mu = 0$$

$$\bullet mv = mu$$

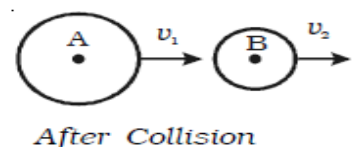
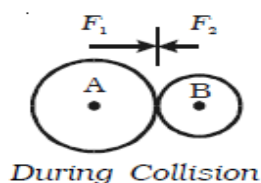
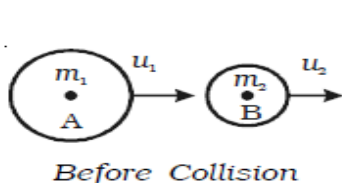
$$\bullet F_1 = m_2 \times \frac{(v_2 - u_2)}{t}$$

$$\bullet F_2 = m_1 \times \frac{(v_1 - u_1)}{t}$$

$$\bullet F_1 = -F_2$$

$$\bullet m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

- Initial momentum = Final momentum



9. Obtain an expression for centripetal acceleration.

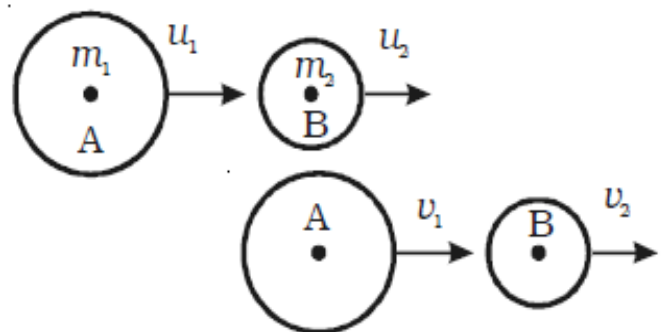
- The acceleration is directed towards the centre of the circle along the radius and perpendicular to the velocity of the particle.
- Change in velocity along the horizontal direction = 0
- Change in velocity in the vertical direction $dv = v \sin \theta d\theta$
- If $d\theta$ is very small, $\sin \theta = d\theta$
- $dv = v \cdot d\theta$
- $\frac{dv}{dt} = v \cdot \frac{d\theta}{dt}$
- $a = v\omega$
- $v = r\omega$
- $a = \frac{v^2}{r}$

10. Obtain an expression for the critical velocity of a particle revolving in a vertical circle.

- Net force on the body, $T = mg \cos \theta$
- $T = mg \cos \theta + \frac{mv^2}{r}$
- $T_A = m \left[\frac{v_A^2}{r} + g \right]$
- $T_B = m \left[\frac{v_B^2}{r} - g \right]$
- $v_2 = v_C$ v dpy; $T_B = 0$
- $v_C = \sqrt{rg}$
- (Potential energy at A + Kinetic energy at A) = (Potential energy at B + Kinetic energy at B)
- $v_A = \sqrt{5rg}$
- $T_A = 6mg$

11. Explain one dimensional elastic collision.

- Initial momentum = Final momentum
- $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$
- $\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$
- $m_1(u_1 - v_1) = m_2(v_2 - u_2)$
- $(u_1 - u_2) = (v_2 - v_1)$
- $v_1 = u_1 \left[\frac{m_1 - m_2}{m_1 + m_2} \right] + \frac{2m_2 u_2}{m_1 + m_2}$
- $v_2 = u_2 \left[\frac{m_2 - m_1}{m_1 + m_2} \right] + \frac{2m_1 u_1}{m_1 + m_2}$

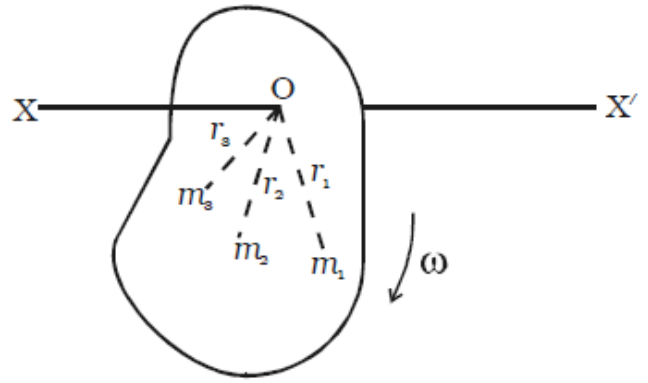


12. Derive rotational equations of motion.

- $\alpha = \frac{\omega - \omega_0}{t}$
- $\omega = \omega_0 + \alpha t$
- $\theta = \left[\frac{\omega + \omega_0}{2} \right] t$
- $\theta = \omega_0 t + \frac{1}{2} \alpha t^2$
- $t = \left(\frac{\omega - \omega_0}{\alpha} \right)$
- $\omega^2 = \omega_0^2 + 2\alpha\theta$

13. Prove that the moment of inertia of a body is equal to twice the kinetic energy of a rotating rigid body.

- Kinetic energy of the first particle = $\frac{1}{2}m_1r_1^2\omega^2$
- Kinetic energy of the second particle = $\frac{1}{2}m_2r_2^2\omega^2$
- $E_R = \frac{1}{2}\omega^2(m_1r_1^2 + m_2r_2^2 + \dots + m_nr_n^2)$
- $E_R = \frac{1}{2}\omega^2 \left[\sum_{i=1}^n m_i r_i^2 \right]$
- $I = \text{mass} \times (\text{distance})^2$
- $E_R = \frac{1}{2}\omega^2 I$
- $\omega = 1 \text{ rad s}^{-1}$, then
- $I = 2 E_R$



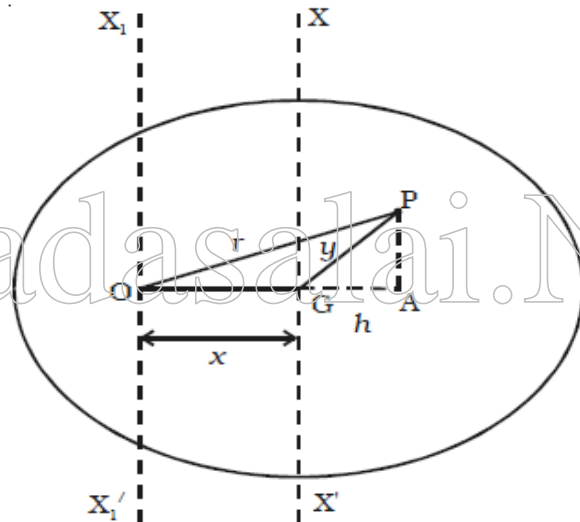
14. State and prove parallel axes theorem.

Parallel axes theorem:

The moment of inertia of a body about any axis is equal to the sum of its moment of inertia about a parallel axis through its centre of gravity and the product of the mass of the body and the square of the distance between the two axes.

nka;g;gpj;jy;:

- $I_o = \sum mr^2$
- $r^2 = x^2 + 2xh + h^2 + AP^2$
- $y^2 = h^2 + AP^2$
- $r^2 = x^2 + 2xh + y^2$
- $I_o = Mx^2 + My^2 + 2x \sum mh$
- $My^2 = I_G$
- $\sum mh = 0$
- $I_o = Mx^2 + I_G$

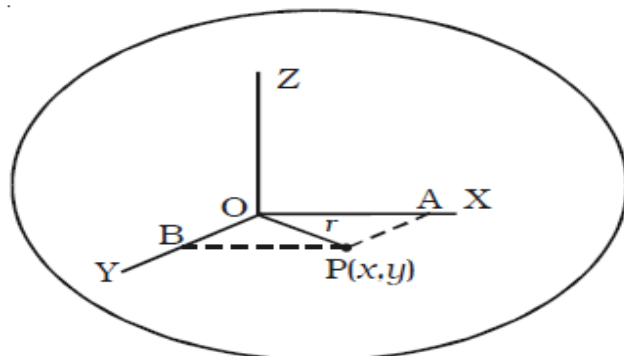


15. State perpendicular axes theorem.

Perpendicular Axes Theorem:

The moment of inertia of a plane lamina body about an axis perpendicular to the plane is equal to the sum of the moments of inertia about two mutually perpendicular axes in the plane of the lamina such that the three mutually perpendicular axes have a common point of intersection.

- $r^2 = x^2 + y^2$
- $I_z = \sum mr^2$
- $I_x = \sum my^2$
- $I_y = \sum mx^2$
- $I_z = I_x + I_y$

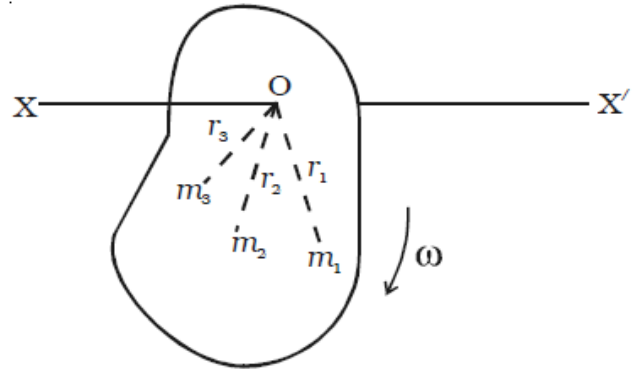


16. Obtain an expression for the angular momentum of a rotating rigid body.

- Linear momentum of the first particle = $m_1(r_1\omega)$
- Angular momentum of the first particle = $m_1r_1^2\omega$
- Angular momentum of the second particle = $m_2r_2^2\omega$
- Angular momentum of the third particle = $m_3r_3^2\omega$
- Angular momentum of the rotating rigid body = Sum of the angular momenta of all the particles.
- $L = \omega[m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + \dots + m_nr_n^2]$

- $L = \omega \left[\sum_{i=1}^n m_i r_i^2 \right]$

- $L = \omega I$



17. Obtain an expression for escape speed.

Escape speed:

It is the minimum speed with which a body must be projected in order that it may escape from the gravitational pull of the planet.

- $E_P = -\frac{GMm}{R}$
- $E_K = \frac{1}{2}mv_e^2$
- $E_i = \frac{1}{2}mv_e^2 - \frac{GMm}{R}$
- $E_P = -\frac{GMm}{(R+h)}$
- $E_K = \frac{1}{2}mv^2$
- $E_f = \frac{1}{2}mv^2 - \frac{GMm}{(R+h)}$
- $E_i = E_f$
- If $h = \infty, v = 0$
- $\frac{1}{2}mv_e^2 - \frac{GMm}{R} = 0$
- $v_e^2 = \frac{2GM}{R}$
- $v_e = \sqrt{2gR}$

18. Derive an expression for orbital velocity.

- The horizontal velocity that has to be imparted to the satellite at the determined height so that it makes a circular orbit around the planet is called orbital velocity.

- $r = R + h$

- Centripetal force, $F = \frac{mv_0^2}{R+h}$

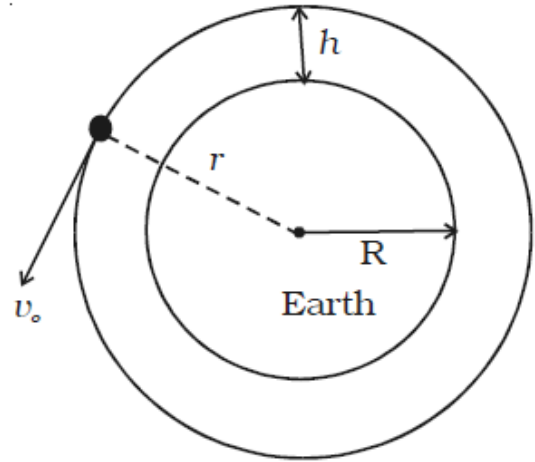
- Gravitational force, $F = \frac{GMm}{(R+h)^2}$

- For the stable orbital motion, $\frac{mv_0^2}{R+h} = \frac{GMm}{(R+h)^2}$

- $v_0 = \sqrt{\frac{GM}{R+h}}$

- $v_0 = \sqrt{\frac{gR^2}{R+h}}$ [(R + h) = R] v.d.f

- $v_0 = \sqrt{gR}$



19. Derive an expression for the orbital radius of the geo - stationary satellite.

- $v = \frac{2\pi r}{T}$

- Centripetal force, $F = \frac{4m\pi^2 r}{T^2}$

- Gravitational force, $F = \frac{GMm}{r^2}$

- For the stable orbital motion, $\frac{4m\pi^2 r}{T^2} = \frac{GMm}{r^2}$

- $r^3 = \frac{gR^2 T^2}{4\pi^2}$

- $r = \left(\sqrt{\frac{gR^2 T^2}{4\pi^2}} \right)^{1/3}$

- $r = 42400 \text{ km}$

- $h = r - R = 36000 \text{ km}$

20. Write the Kepler's laws of planetary motion.

Law of orbits:

Each planet moves in an elliptical orbit with the Sun at one focus.

Law of areas:

The line joining the Sun and the planet sweeps out equal areas in equal intervals of time.

Law of periods:

The square of the period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance between the planet and the Sun.

21. Write a note on Milky Way galaxy.

Shape and size:

- Milky Way is thick at the centre and thin at the edges.
- The diameter of the disc is 10^5 light years.
- Thickness at the centre is 5000 light years.
- Thickness at the position of the Sun is 1000 light years.
- Thickness at the edges is 500 light year.
- The Sun is at a distance of 27000 light years from the galactic centre.

Interstellar mater:

- The interstellar space in the Milky Way is filled with dust and gases called interstellar matter.
- It consists 90% of hydrogen.

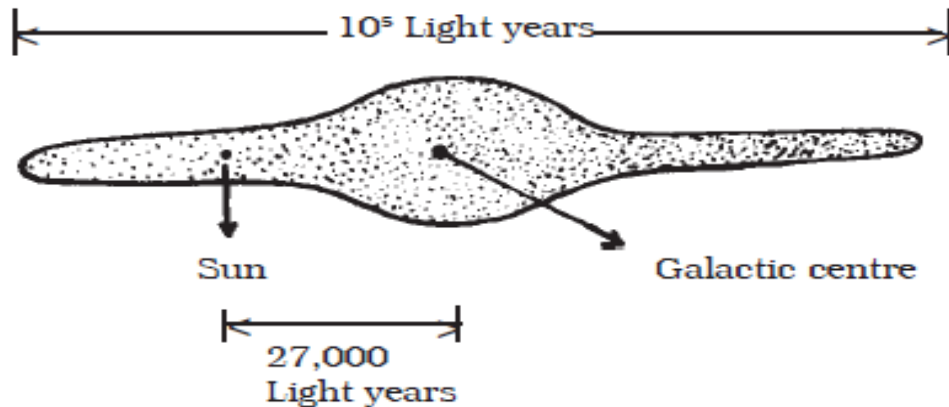
Clusters:

- Groups of stars held by mutual gravitation force in the galaxy are called star clusters.
- Galactic cluster: – A group of 100 to 1000 stars.
- Globular cluster: – A group of about 10000 stars.

Rotaion:

- The galaxy is rotating about an axis passing through its centre.
- The velocity of the Sun revolves around the centre is 250 km/s.
- The period of revolution of the Sun is about 220 millian years.

Mass: The mass of the Milky Way is estimated to be 3×10^{41} kg



22. Obtain an expression for the total energy of per unit mass of flowing liquid.

Pressure Energy:

- It is the energy possessed by a liquid due to its pressure.
- $P = h\rho g$
- $m = ax \rho$
- $W = P ax$
- Pressure energy per unit mass of the liquid = $\frac{P}{\rho}$

Kinetic Energy:

- It is the energy possessed by the liquid due to its motion.
- Kinetic energy of the liquid = $\frac{1}{2}mv^2$
- Kinetic energy per unit mass of the liquid = $\frac{v^2}{2}$

Potential Energy:

- It is the energy possessed by the liquid due to its height above the ground level.
- Potential energy per unit mass = gh
- Total energy per unit mass of the flowing liquid = $\frac{P}{\rho} + \frac{v^2}{2} + gh$

23. State and prove Bernoulli's theorem.

- **Bernoulli theorem:** For the streamline flow of a non-viscous and incompressible liquid, the sum of the pressure energy, kinetic energy and the potential energy per unit mass is a constant.

$$\frac{P}{\rho} + \frac{v^2}{2} + gh = \text{constant.}$$

$$a_1v_1 = a_2v_2 = \frac{m}{\rho} = V$$

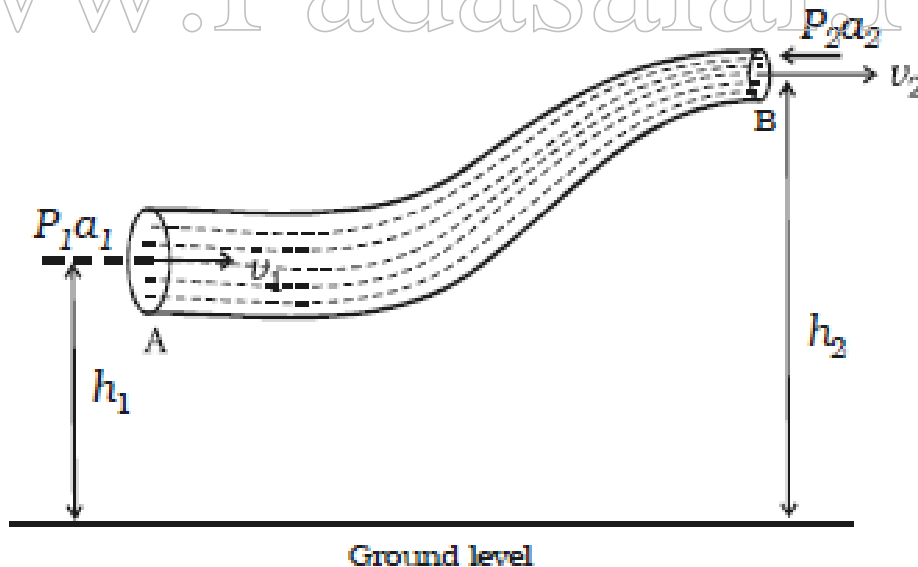
$$\text{Net work done per second on the liquid by the pressure energy} = P_1V - P_2V$$

$$\text{Increase in potential energy per second of the liquid} = mgh_2 - mgh_1$$

$$\text{Increase in kinetic energy per second of the liquid} = \frac{mv_2^2}{2} - \frac{mv_1^2}{2}$$

$$P_1V - P_2V = (mgh_2 - mgh_1) + \left(\frac{mv_2^2}{2} - \frac{mv_1^2}{2}\right)$$

$$\frac{P}{\rho} + \frac{v^2}{2} + gh = \text{constant.}$$



11TH PHYSICS MINIMUM STUDY MATERIAL VOL - 2

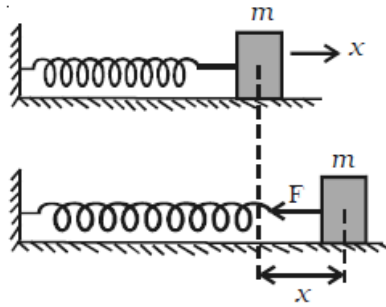
(For slow learners)

1. Obtain the expressions for displacement, velocity and acceleration in simple harmonic motion.

- Displacement in SHM : $y = a \sin \omega t$
- Velocity in SHM : $v = \omega \sqrt{a^2 - y^2}$
- Acceleration in SHM : $a = -\omega^2 a \sin \omega t = -\omega^2 y$

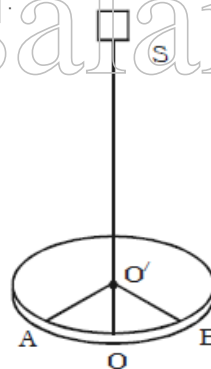
2. Deduce an expression for the time period of oscillations of a mass attached to a horizontal spring.

- $F = -kx$
- $F = ma$
- $a = \frac{-k}{m} x$
- $a = -\omega^2 x$
- $\omega = \sqrt{\frac{k}{m}}$
- $T = 2\pi \sqrt{\frac{m}{k}}$



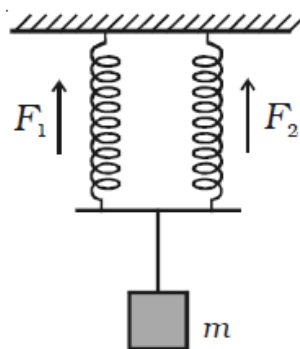
3. Deduce an expression for the time period of oscillation of a torsional pendulum or angular harmonic oscillator.

- $\tau = I\alpha$
- $\alpha = -\frac{c}{I}\theta$
- $a = -\omega^2 y$
- $\alpha = -\omega^2 \theta$ (if $y = \theta, a = \alpha$)
- $\omega = \sqrt{\frac{c}{I}}$
- $T = 2\pi \sqrt{\frac{I}{c}}$



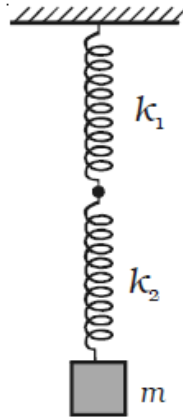
4. Obtain an expression for the time period of oscillations if two springs are connected in parallel.

- $F_1 = -k_1 y$
- $F_2 = -k_2 y$
- $F_1 + F_2 = -(k_1 + k_2) y$
- $T = 2\pi \sqrt{\frac{m}{k_1 + k_2}}$
- $(k_1 = k_2 = k)$
- $T = 2\pi \sqrt{\frac{m}{k}}$



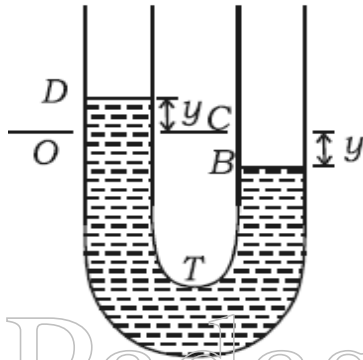
5. Obtain an expression for the time period of oscillations if two springs are connected in series.

- $F = -k_1 y_1$
- $F = -k_2 y_2$
- $y_1 + y_2 = -F \left[\frac{1}{k_1} + \frac{1}{k_2} \right]$
- $F = -k y$
- $y = -\frac{F}{k}$
- $k = \frac{k_1 k_2}{k_1 + k_2}$
- $T = 2\pi \sqrt{\frac{m(k_1 + k_2)}{k_1 k_2}}$



6. Obtain an expression for the time period of oscillations of liquid column in U - tube.

- $F = -2 y \rho g A$
- $F = l A \rho a$
- $a = -\frac{2g}{l} y$
- $a = -\omega^2 y$
- $\omega = \sqrt{\frac{2g}{l}}$
- $T = 2\pi \sqrt{\frac{l}{2g}}$



7. Obtain an expression for the time period of oscillations of a simple pendulum.

- $F = -mg \sin \theta$
- $\sin \theta \approx \theta$
- $F = -mg \theta$
- $F = -mg \frac{x}{l}$
- $a = -\frac{gx}{l}$
- $a = -\omega^2 x$
- $\omega = \sqrt{\frac{g}{l}}$
- $T = 2\pi \sqrt{\frac{l}{g}}$

8. Deduce an expression for the total energy of a vibrating particle in SHM.

- $v = \omega \sqrt{a^2 - y^2}$
- Kinetic energy : $K = \frac{1}{2} m \omega^2 (a^2 - y^2)$
- Potential energy : $U = \frac{1}{2} m \omega^2 y^2$
- Total energy : $E = K + U = \frac{1}{2} m \omega^2 a^2$

9. Derive the equation of plane progressive wave.

- $y = a \sin \omega t$
- $y = a \sin(\omega t - \phi)$
- $y = a \sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$
- $y = a \sin \frac{2\pi}{\lambda} (vt - x)$
- $y = a \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$
- $y = a \sin 2\pi\left(\frac{t}{T} + \frac{x}{\lambda}\right)$

10. Write the characteristics of progressive wave.

- Each particle of the medium executes vibration about its mean position.
- The particle of the medium vibrates with same amplitude about their mean positions.
- Each successive particle of the medium performs a motion similar to that of its predecessor along the propagation of the wave, later in time.
- The phase of every particle changes from 0 to 2π .
- No particle remains permanently at rest.
- Transverse progressive waves are characterized by crests and trough and Longitudinal waves are characterized by compressions and rarefactions.
- There is a transfer of energy across the medium in the direction of propagation of progressive wave.
- All the particles have the same maximum velocity when they pass through the mean position.
- The displacement, velocity and acceleration of the particle separated by $m\lambda$ are the same, where m is an integer.

11. Obtain the expressions for fundamental frequency and frequencies of harmonics of closed and open organ pipes.

CLOSED ORGAN PIPE	OPEN ORGAN PIPE
There is a node at the closed end and an antinode at the open end.	Antinodes are formed at the ends and a node is formed in the middle of the pipe.
$\lambda_1 = 4l$	$\lambda_1 = 2l$
$n_1 = \frac{v}{4l}$	$n_1 = \frac{v}{2l}$
$\lambda_3 = \frac{4l}{3}$	$\lambda_2 = l$
$n_3 = 3n_1$	$n_2 = 2n_1$
The frequency of P^{th} overtone is $(2P + 1)n_1$	The frequency of P^{th} overtone is $(P + 1)n_1$
The frequencies of harmonics are in the ratio of 1 : 3 : 5...	The frequencies of harmonics are in the ratio of 1 : 2 : 3...

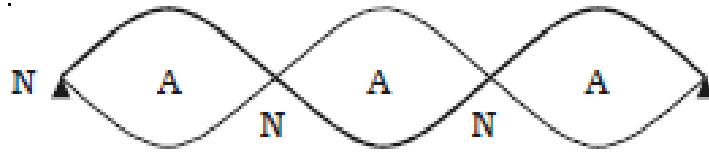
12. Deduce an expression for a stationary wave.

- When two progressive waves of same amplitude and wavelength travelling along a straight line in opposite directions superimpose on each other, stationary waves are formed.

$$y_1 = a \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda} \right)$$

$$y_2 = a \sin 2\pi \left(\frac{t}{T} + \frac{x}{\lambda} \right)$$

$$y = 2a \cos \frac{2\pi x}{\lambda} \sin \frac{2\pi t}{T}$$



13. Write the characteristics of stationary waves.

- The wave form remains stationary.
- Nodes and Antinodes are formed alternately.
- The points where the displacement is zero are called nodes and the points where the displacement is maximum is called antinodes.
- Pressure changes are maximum at nodes and minimum at the antinodes.
- All the particles except those at the nodes, execute simple harmonic motions of same period.
- Amplitude of each particle is not the same.
- The velocity of the particles at the nodes is zero.
- Distance between any consecutive nodes or antinodes is equal to $\frac{\lambda}{2}$
- There is no transfer of energy.
- Particles in the same segment vibrate in the same phase and between the neighbouring segments, the particles vibrate in opposite phase.

14. Derive Mayer's relation (or) prove that $C_p - C_v = R$.

- $dQ = dU = 1 \times C_v \times dT$
- $dQ' = dU + dW$
- $dQ' = C_p dT$
- $C_p dT = C_v dT + dW$
- $dW = PdV$
- $C_p dT = C_v dT + PdV$
- $PdV = RdT$
- $C_p dT = C_v dT + RdT$
- $C_p - C_v = R$

15. Explain the working of Carnot's engine.

- Carnot engine is a device which converts heat energy into mechanical energy.
- **Parts of Carnot engine:**

1. Source:

- It is a hot body which is kept at a constant higher temperature.
- It has infinite thermal capacity.
- Its temperature will remain even after drawing any amount of heat drawn from it.

2. Sink:

- It is a cold body which is kept at a constant lower temperature.
- It has also infinite thermal capacity.
- Any amount of heat added to it will not increase its temperature.

3. Cylinder:

- It is made up of non conducting walls and conducting bottom.
- A perfect gas is used as a working substance.
- It is fitted with a perfectly non conducting and frictionless piston.

4. Insulating stand:

- It is made up of non conducting material so as to perform adiabatic operations.

Working stages:

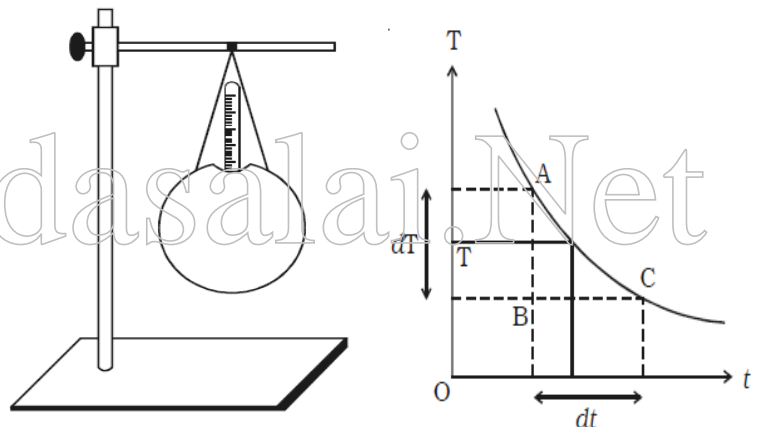
- 1. Isothermal expansion 2. Adiabatic expansion
- 3. Isothermal compression 4. Adiabatic compression.

15. State and prove Newton's law of cooling.

- The law states that the rate of cooling of a body is directly proportional to the temperature difference between the body and the surroundings.

$$\text{Rate of cooling} = \frac{\text{Heat energy lost}}{\text{Time taken}}$$

$$\frac{Q}{t} \propto \left(\frac{T_1 + T_2}{2} - T_0 \right)$$

**16. Prove that $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ or Obtain mirror equation.**

$$\frac{II'}{OO'} = \frac{PI}{PO}$$

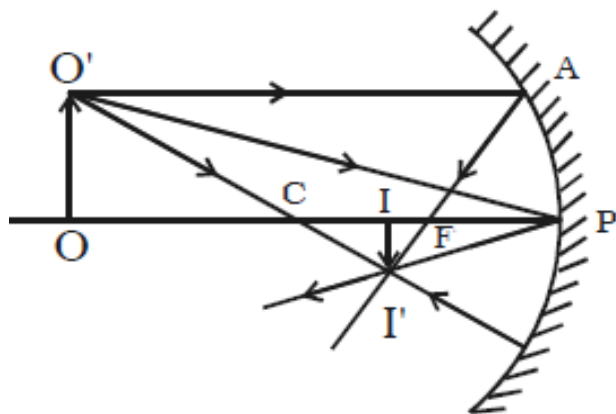
$$\frac{II'}{OO'} = \frac{IF}{PF}$$

$$IF = PI - PF$$

$$\frac{PI}{PO} = \frac{PI - PF}{PF}$$

$$PO = -u, PI = -v, PF = -f$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}, \text{ This is called mirror equation.}$$



17. Explain total internal reflection.

- The angle of incidence in the denser at which the refracted ray just grazes the surface of separation is called critical angle c of the denser medium.
- If i is increased further, refraction is not possible and the incident ray is totally reflected into the same medium itself. This is called total internal reflection.
- Conditions to take place total internal reflection
 - light must travel from a denser medium to a rarer medium.
 - $i > c$
- $\frac{\mu_a}{\mu_d} = \frac{\sin i}{\sin r}$
- $\frac{1}{\mu_d} = \frac{\sin i}{\sin r}$
- $r = 90^\circ, i = c$
- $c = \sin^{-1} \left(\frac{1}{\mu_d} \right)$

18. Deduce an expression for the refractive index of the prism or prove that $\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$.

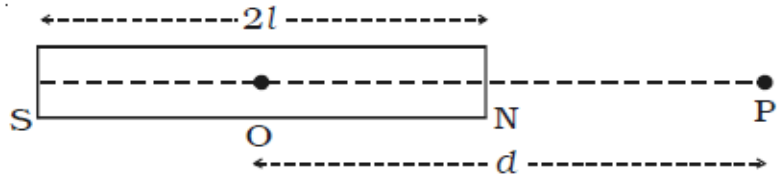
- $d = (i_1 + i_2) - (r_1 + r_2)$
- $A + \angle QOR = 180^\circ$
- $r_1 + r_2 + \angle QOR = 180^\circ$
- $r_1 + r_2 = A$
- $A + d = i_1 + i_2$
- $r = \frac{A}{2}$
- $i = \frac{A+D}{2}$
- $\mu = \frac{\sin i}{\sin r}$
- $\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

19. Write the formation of rainbow.

- One of the spectacular atmospheric phenomena is the formation of rainbow during rainy days.
- When the Sun light falls on small water drops suspended in air during or after rain, it suffers refraction, total internal reflection and dispersion.
- **Primary rainbow:**
It is formed by the light from the Sun undergoing one total internal reflection and two refractions and emerging at minimum deviation.
- **Secondary rainbow:**
It is formed by the light from the Sun undergoing two total internal reflections and two refractions and emerging at a minimum deviation.

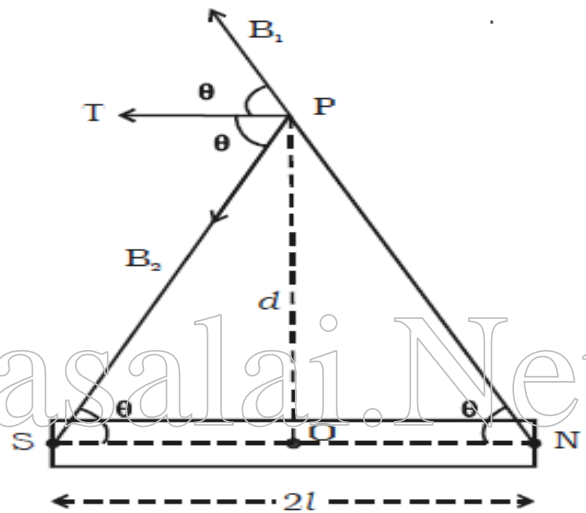
20. Obtain an expression for the **magnetic induction at a point** due a bar magnet on its **axial line**.

- $B_1 = \frac{\mu_0}{4\pi} \frac{m}{(d-l)^2}$
- $B_2 = \frac{\mu_0}{4\pi} \frac{m}{(d+l)^2}$
- $B = B_1 - B_2$
- $B = \frac{\mu_0 m}{4\pi} \left[\frac{1}{(d-l)^2} - \frac{1}{(d+l)^2} \right]$
- $B = \frac{\mu_0 m}{4\pi} \left[\frac{4ld}{(d^2-l^2)^2} \right]$
- $B = \frac{\mu_0}{4\pi} \frac{2Md}{(d^2-l^2)^2} \quad (\because M = m \times 2l)$
- $l \ll d$
- $B = \frac{\mu_0}{4\pi} \frac{2M}{d^3}$



21. Obtain an expression for the **magnetic induction at a point** due to a bar magnet along the **equatorial line**

- $B_1 = \frac{\mu_0}{4\pi} \frac{m}{(d^2+l^2)}$
- $B_2 = \frac{\mu_0}{4\pi} \frac{m}{(d^2+l^2)}$
- $B = B_1 \cos \theta + B_2 \cos \theta$
- $B = 2B_1 \cos \theta \quad (\because B_1 = B_2)$
- $B = \frac{\mu_0}{4\pi} \frac{2ml}{(d^2+l^2)^{3/2}}$
- $B = \frac{\mu_0}{4\pi} \frac{M}{(d^2+l^2)^{3/2}} \quad (\because M = m \times 2l)$
- $l \ll d$
- $B = \frac{\mu_0}{4\pi} \frac{M}{d^3}$



22. Compare the properties of dia, para and ferro magnetic materials.

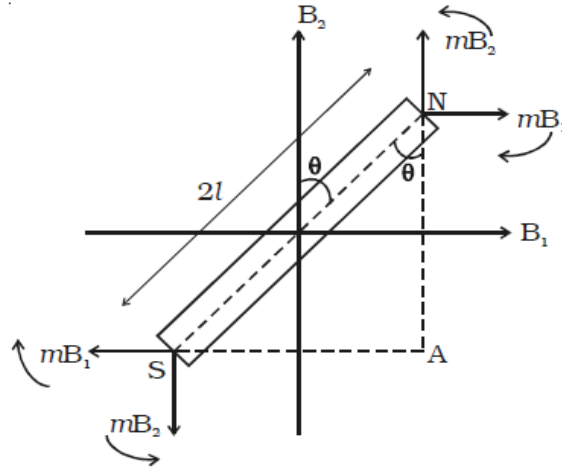
Magnetic properties	Dia magnetic substances	Para magnetic substances	Ferro magnetic substances
1. Susceptibility	low negative value	low positive value	very large positive value
2. χ_m with respect to T	independent of temperature T	$\chi_m \propto \frac{1}{T}$	$\chi_m \propto \frac{1}{T}$
3. Relative permeability	less than 1	greater than 1	very greater than 1 (for iron it is 200,000)
4. In non – uniform magnetic field	they get magnetized in the opposite direction of the field	they get magnetized in the direction of the field	they strongly magnetized in the direction of the field
5. In uniform magnetic field.	they set themselves perpendicular to the direction of the field.	they set themselves parallel to the direction of the field.	they set themselves parallel to the direction of the field.

23. State and prove tangent's law.

Tangent's law:

A magnetic needle suspended, at a point where there are two crossed magnetic fields acting at right angles to each other, will come to rest in the direction of the resultant of the two fields.

- $\tau_1 = MB_1 \cos \theta$
- $\tau_2 = MB_2 \sin \theta$
- $\tau_1 = \tau_2$
- $B_1 = B_2 \tan \theta$



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