Important snaps by Team PIS Class- X

SUBJECT: PHYSICS

BOOKS : SCIENCE NCERT

TEACHER: MR. BHUPENDER

CHAPTER -2: UNITS AND MEASUREMENT

- **Q1. How errors are propagated or combined ?**

Answer: While applying mathematical operations (e.g. addition, subtraction, multiplication and division) on physical quantities, errors are combined.

If A and B are two physical quantities represented as **$A \pm \Delta A$** and **$B \pm \Delta B$,** then
(a) In addition, i.e. $Z = A + B$, absolute error $\Delta Z = \Delta A + \Delta B$.

(b) In difference, $Z = A - B$, absolute error $\Delta Z = \Delta A + \Delta B$.

(c) In product, $Z = AB$, then absolute error $\Delta Z/Z = \Delta A/A + \Delta B/B$.

(d) In division, $Z = A/B$, $\Delta Z/Z = \Delta A/A + \Delta B/B$.

(e) In power, $Z = A^x.B^y/C^z$, then $\Delta Z/Z = x\Delta A/A + y\Delta B/B \pm z\Delta C/C$

CHAPTER -2: UNITS AND MEASUREMENT CONT.

- **Q2. The centripetal force (F) acting on a particle (moving uniformly in a circle) depends on the mass (m) of the particle, its velocity (v) and radius (r) of the circle. Derive dimensionally formula for force (F).**

Answer: Given, $F \propto m^a.v^b.r^c$

$\therefore F = km^a.v^b.r^c$ (where k is constant)

Putting dimensions of each quantity in the equation,

$$[M^1L^1T^{-2}] = [M^1L^0T^0]^a.\ [M^0L^1T^{-1}]^b.\ [M^0L^1T^0]^c = [M^aL^{b+c}T^{-b}]$$

$\Rightarrow$ a =1, b +c = 1, -b = -2

$\Rightarrow$ a= 1, b = 2, c = -1

$\therefore F = km^1.v^2.r^{-1} = kmv^2/r$

CHAPTER -2: UNITS AND MEASUREMENT CONT.

- **Q3 Hooke's law states that the force, F, in a spring extended by a length x is given by F = −kx. According to Newton's second law F = ma, where m is the mass and a is the acceleration. Calculate dimension of spring constant**

Answer: Given, F = -kx
⇒ k = - F/x

F = ma, the dimensions of force is:
$[F] = ma = [M^1L^0T^0].[M^0L^1T^{-2}] = [M^1L^1T^{-2}]$
Therefore, dimension of spring constant (k) is:
$[k] = [F]/[x] = [M^1L^1T^{-2}].[M^0L^{-1}T^0] = [M^1L^0T^{-2}]$ or $[MT^{-2}]$ .....

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Chapter 3 MOTION IN STRAIGHT LINE

- **Q1 Obtain Kinematics equations using Calculus Method.**
- **Ans**

1. By definition,

$$a = \frac{dv}{dt}$$

dv=adt

Integrating Both sides

$$\int dv = \int adt$$

$$\int dv = a\int dt$$ (as a is constant)

$v\text{-}v_0$ = at

$v = v_0$ + at

2. Now,

$$v = \frac{dx}{dt}$$

dx= vdt

Integrating Both the sides

$$\int dx = \int vdt$$

or

$$\int dx = \int (v_0 + at)dt$$

$x - x_0 = v_0t + ½(at^2)$

Chapter 3 MOTION IN STRAIGHT LINE CONT.

3.

Now, $a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = v\frac{dv}{dx}$

or vdv=adx

Integrating Both sides

$\int vdv = \int adx$

$\frac{v^2 - v_0^2}{2} = a(x - x_0)$

$v^2 = (v_0)^2 + 2a\,(x - x_0)$

Chapter 3 MOTION IN STRAIGHT LINE CONT.

- **Q2 A ball is dropped from a height of 90 m on a floor. At each collision with the floor, the ball loses one tenth of its speed. Plot the speed-time graph of its motion between t =0 to 12 s.**
- **Ans**

$u = 0$, $a = 10\ ms^{-2}$, $S = 90$ m, $t = ?$, $v = ?$

Using $v^2 - u^2 = 2as$, $v^2 - (0)^2 = 2 \times 10 \times 90$

$\Rightarrow \quad v = 30\sqrt{2}$ m/s

Again, using $\quad S = ut + \frac{1}{2}at^2$, $90 = 0 \times t + \frac{1}{2} \times 10t^2$

$\Rightarrow \quad t = \sqrt{18}\ s = 3\sqrt{2}\ s$

Rebound velocity $= \frac{9}{10} \times 30\sqrt{2}\ ms^{-1} = \sqrt{2}\ ms^{-1}$

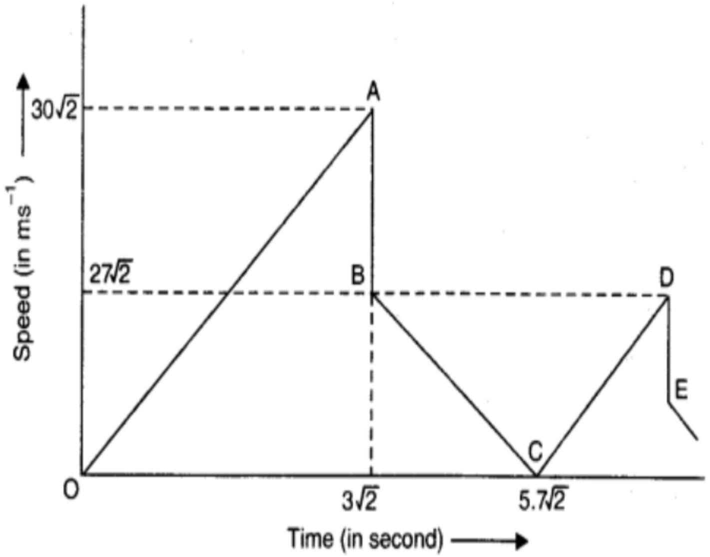
Time taken to reach highest point $= \frac{27\sqrt{2}}{10} s = 2.7\sqrt{2}\ s$

Total time $= (3\sqrt{2} + 2.7\sqrt{2})\ s = 5.7\sqrt{2}\ s$

Chapter 3 MOTION IN STRAIGHT LINE CONT.

OA represents the vertically downward motion after the ball has been dropped from a height of 90 m. The ball reaches the floor with a velocity of $30\sqrt{2}$ ms^{-1} after having been

in motion for $3\sqrt{2}$ s. The vertical straight portion AB represents the loss of $\frac{1}{10}$ th of speed. *BC* represents the vertically upward motion after first rebound. The ball reaches? the highest point in $2.7\sqrt{2}$ s. The total time from the beginning is $3\sqrt{2} + 2.7\sqrt{2}$ *i.e.,* $5.7\sqrt{2}$ s. *C* represents the highest point reached after first rebound. *CD* represents the vertically downward motion. *D* represents the situation when the ball again reaches the floor. *DE* represents the loss of speed.



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Chapter 4 MOTION IN PLANE

- **Q1 Derive expression following for Projectile thrown at an angle with horizontal**

1.Equation of Path of projectile(Trajectory

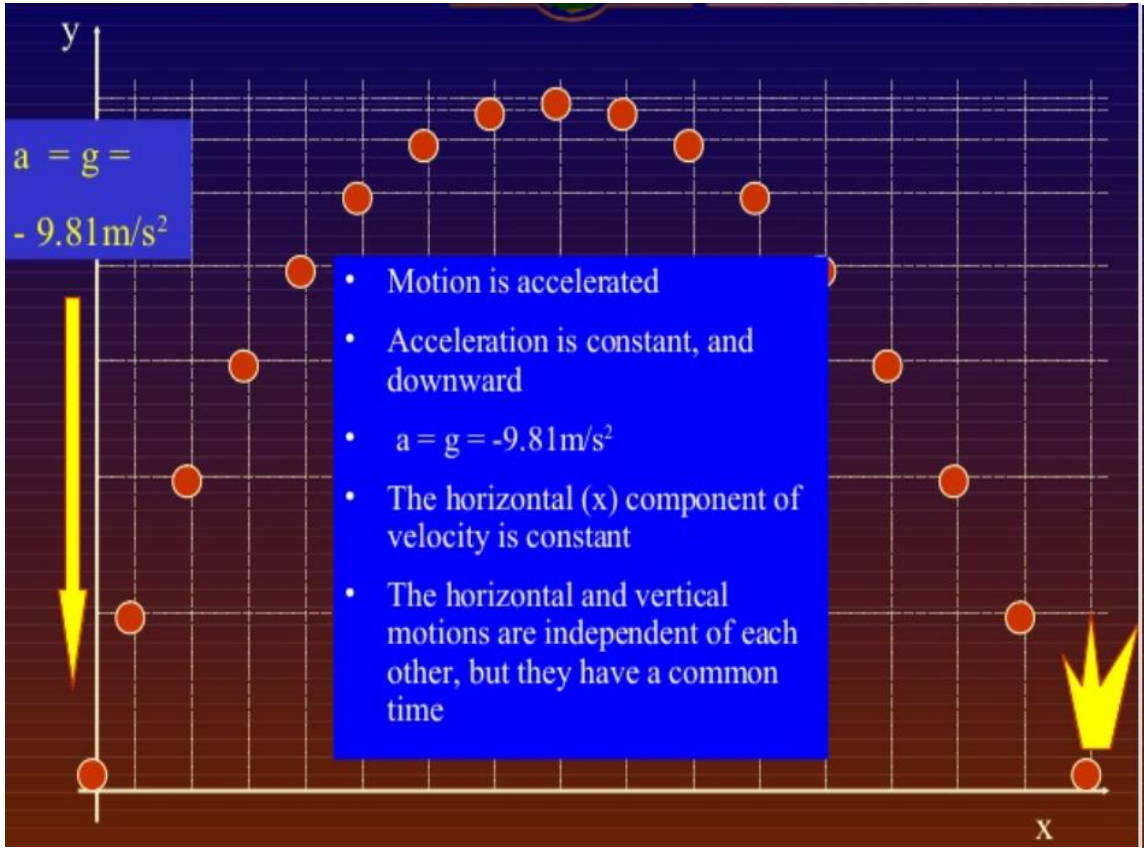
2. Time of Maximum height and total time

3.Maximum height of projectile

4.Horizontal Range of Projectile

- **ANS:**

Chapter 4 MOTION IN PLANE CONT.



Equations of motion:

	X Uniform motion	Y Accelerated motion
ACCELERATION	$a_x = 0$	$a_y = g = -9.81\ m/s^2$
VELOCITY	$v_x = v_{ix} = v_i \cos \Theta$	$v_y = v_{iy} + g\,t$
	$v_x = v_i \cos \Theta$	$v_y = v_i \sin \Theta + g\,t$
DISPLACEMENT	$x = v_{ix}\,t = v_i\,t \cos \Theta$	$y = h + v_{iy}\,t + \frac{1}{2} g\,t^2$
	$x = v_i\,t \cos \Theta$	$y = v_i\,t \sin \Theta + \frac{1}{2} g\,t^2$

Chapter 4 MOTION IN PLANE CONT.

Trajectory

$x = v_i\, t \cos\Theta$

$y = v_i\, t \sin\Theta + \frac{1}{2} g t^2$

Eliminate time, t

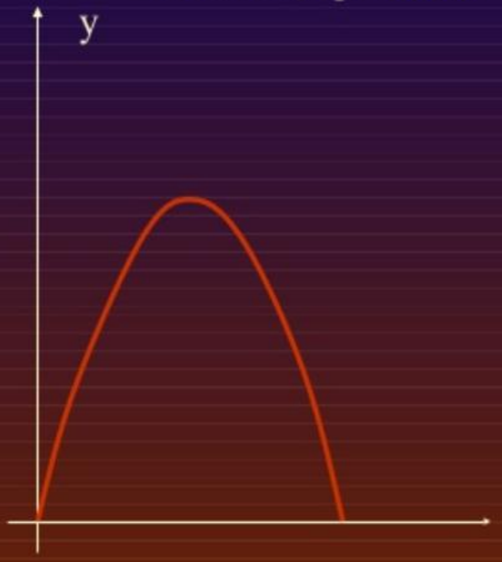
$t = x/(v_i \cos\Theta)$

$$y = \frac{v_i x \sin\Theta}{v_i \cos\Theta} + \frac{g x^2}{2 v_i^2 \cos^2\Theta}$$

$$y = x \tan\Theta + \frac{g}{2 v_i^2 \cos^2\Theta} x^2$$

$$\boxed{y = bx + ax^2}$$

Parabola, open *down*



Total Time, Δt

$y = v_i\, t \sin\Theta + \frac{1}{2} g t^2$

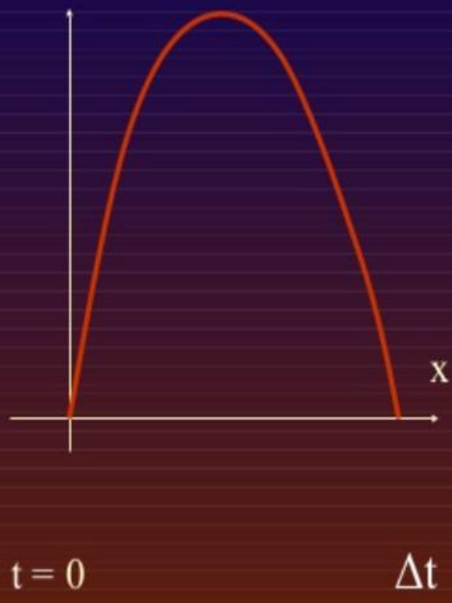
final height $y = 0$, after time interval Δt

$0 = v_i\, \Delta t \sin\Theta + \frac{1}{2} g (\Delta t)^2$

Solve for Δt:

$0 = v_i \sin\Theta + \frac{1}{2} g\, \Delta t$

$$\boxed{\Delta t = \frac{2\, v_i \sin\Theta}{(-g)}}$$



Chapter 4 MOTION IN PLANE CONT.

Horizontal Range, Δx

$x = v_i\, t \cos\Theta$

final y = 0, time is the total time Δt

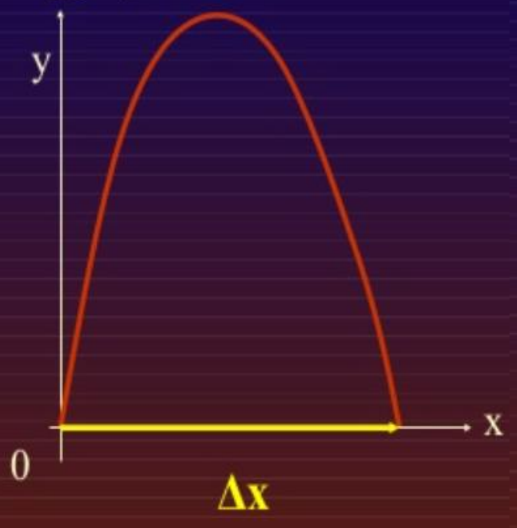
$\Delta x = v_i\, \Delta t \cos\Theta$

$$\Delta t = \frac{2\, v_i \sin\Theta}{(-g)}$$

$\sin(2\Theta) = 2\sin\Theta\cos\Theta$

$$\Delta x = \frac{2 v_i^{\,2} \sin\Theta\cos\Theta}{(-g)}$$

$$\boxed{\Delta x = \frac{v_i^{\,2}\sin(2\Theta)}{(-g)}}$$



Maximum Height

$v_y = v_i \sin\Theta + g\, t$

$y = v_i\, t \sin\Theta + \frac{1}{2} g\, t^2$

At maximum height $v_y = 0$

$0 = v_i \sin\Theta + g\, t_{up}$

$$t_{up} = \frac{v_i \sin\Theta}{(-g)}$$

$t_{up} = \Delta t/2$

$h_{max} = v_i\, t_{up} \sin\Theta + \frac{1}{2} g\, t_{up}^{\,2}$

$h_{max} = v_i^2 \sin^2\Theta/(-g) + \frac{1}{2} g(v_i^2 \sin^2\Theta)/g^2$

$$\boxed{h_{max} = \frac{v_i^2 \sin^2\Theta}{2(-g)}}$$

Chapter 4 MOTION IN PLANE CONT.

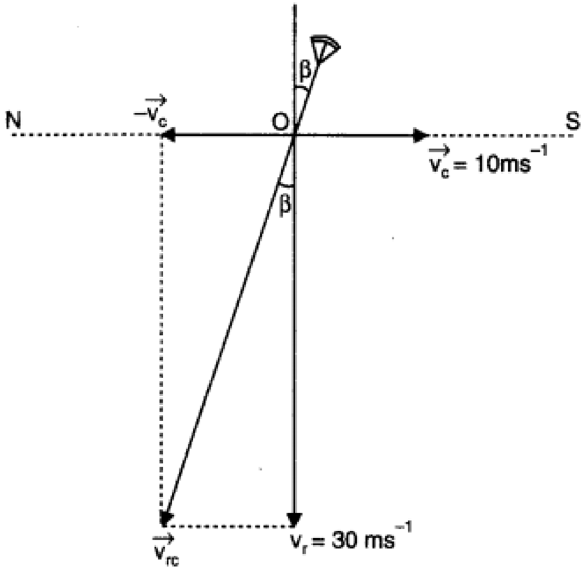
- **Q2 Rain is falling vertically with a speed of 30 m s^{-1}. A woman rides a bicycle with a speed of 10 m s^{-1} in the north to south direction. What is the direction in which she should hold her umbrella ?**
- **Ans** The situation has been demonstrated in the figure below. Here $\vec{v}_r = 30 \text{ ms}^{-1}$ is the rain velocity in vertically downward direction and $\vec{v}_c = 10 \text{ ms}^{-1}$ is the velocity of cyclist woman in horizontal plane from north N to south S.

  $\therefore$ Relative velocity of rain w.r.t. cyclist $\vec{v}_{rc}$ subtends an angle β with vertical such that

  $$\tan\beta = \frac{|\vec{v}_c|}{|\vec{v}_r|} = \frac{10}{30} = \frac{1}{3}$$

  $$\therefore \qquad \beta = \tan^{-1}\left(\frac{1}{3}\right) = 18^\circ 26'$$

  Hence, the woman should hold her umbrella at 18° 26′ south of vertical.



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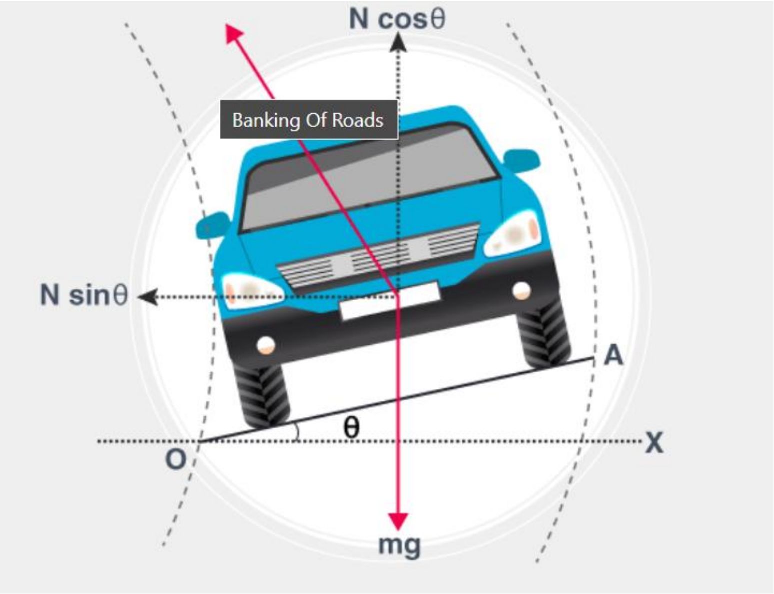
CHAPTER -5 LAWS OF MOTION

- **Q1 Derive the expression for max. speed on a banked road and hence angle of banking.**
- **Ans** Consider a vehicle of mass ‘m’ with moving speed ‘v’ on the banked road with radius ‘r’. Let ϴ be the angle of banking, with frictional force f acting between the road and the tyres of the vehicle.



Total upwards force = Total downward force

$$N cos\Theta = mg + f sin\Theta$$

Where,

$N cos\Theta$: one of the components of normal reaction along the verticle axis

mg: weight of the vehicle acting vertically downward

$f sin\Theta$: one of the components of frictional force along the verticle axis

therefore, $mg = N cos\Theta - f sin\Theta$ (eq.1)

$\frac{mv^2}{r} = N sin\Theta + f cos\Theta$ (eq.2)

Where,

CHAPTER -5 LAWS OF MOTION CONT.

$Nsin\Theta$: one of the components of normal reaction along the horizontal axis

$fcos\Theta$: one of the components of frictional force along the horizontal axis

$\frac{\frac{mv^2}{r}}{mg} = \frac{Nsin\Theta+fcos\Theta}{Ncos\Theta-fsin\Theta}$ (after diving eq.1 and eq.2)

therefore, $\frac{v^2}{rg} = \frac{Nsin\Theta+fcos\Theta}{Ncos\Theta-fsin\Theta}$

Frictional force $f = \mu_s N$ $\frac{v^2}{rg} = \frac{Nsin\Theta+\mu_s Ncos\Theta}{Ncos\Theta-\mu_s Nsin\Theta}$ $\frac{v^2}{rg} = \frac{N(sin\Theta+\mu_s cos\Theta)}{N(cos\Theta-\mu_s sin\Theta)}$ $\frac{v^2}{rg} = \frac{(sin\Theta+\mu_s cos\Theta)}{(cos\Theta-\mu_s sin\Theta)}$

$\frac{v^2}{rg} = \frac{(tan\Theta+\mu_s)}{(1-\mu_s tan\Theta)}$

therefore, $v = \sqrt{\frac{rg(tan\Theta+\mu_s)}{(1-\mu_s tan\Theta)}}$ $v_{max} = \sqrt{rgtan\Theta}$ $tan\Theta = \frac{v^2}{rg}$ $\Theta = tan^{-1}\frac{v^2}{rg}$

CHAPTER -5 LAWS OF MOTION CONT.

- **Q2 Two masses 8 kg and 12 kg are connected at the two ends of a light in extensible string that goes over a friction less pulley. Find the acceleration of the masses, and the tension in the string when the masses are released.**

- **Ans**

For block $m_2 \rightarrow m_2 g - T = m_2 a$ ...(*i*)

and for block $m_1 \rightarrow T - m_1 g = m_1 a$ ...(*ii*)

Adding (*i*) and (*ii*), we obtain

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

or

$$a = \left(\frac{m_2 - m_1}{m_2 + m_1}\right) g$$

$$= \frac{12 - 8}{12 + 8} \times 10$$

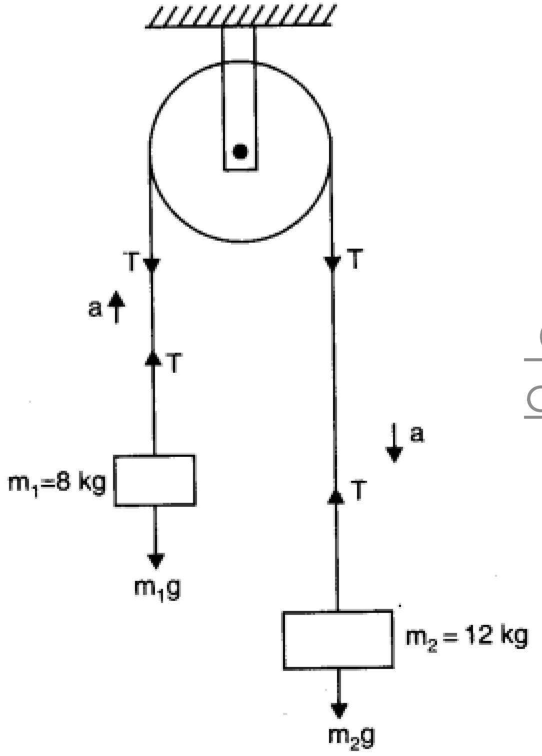
$$= \frac{4 \times 10}{20} = 2 \text{ ms}^{-2}$$

Substituting value of *a* in equation (*ii*), we obtain

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

$$= 8 \times (10 + 2)$$

$$= 8 \times 12 = 96 \text{ N.}$$



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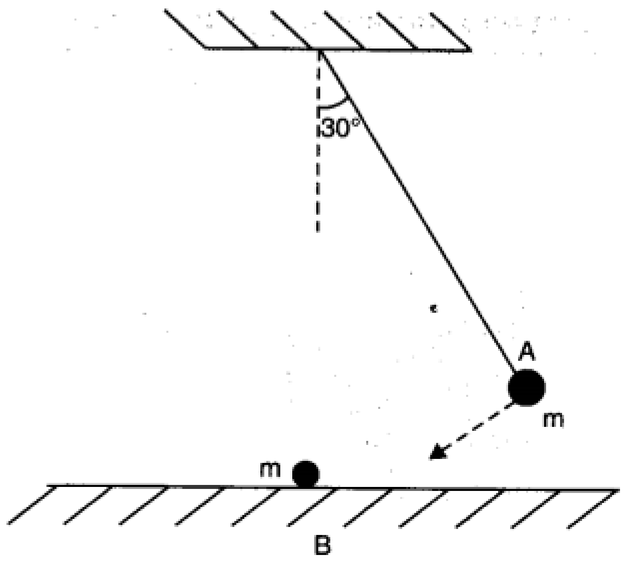
CHAPTER -6 WORK ENERGY AND POWER

- **Q1 The bob A of a pendulum released from 30° to the vertical hits another bob B of the same mass at rest on a table as shown in Fig. How high does the bob A rise after the collision? Neglect the size of the bobs and assume the collision to be elastic.**
- **Ans** Since collision is elastic therefore A would come to rest and B would begin to move with the velocity of A.

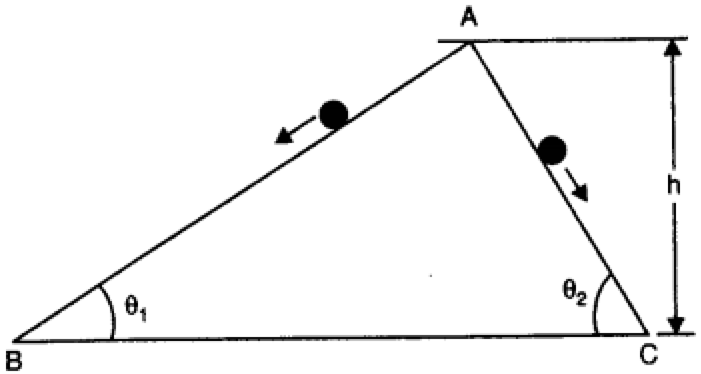


The bob transfers its entire momentum to the ball on the table.

The bob does not rise at all.

CHAPTER -6 WORK ENERGY AND POWER CONT.

- **Q2 Two inclined frictionless tracks, one gradual and the other steep meet at A from where two stones are allowed to slide down from rest, one on each track (Fig). Will the stones reach the bottom at the same time? Will they reach there at the same speed? Explain. Given θ_1 = 30°, θ_2 = 60°, and h = 10 m, what are the speeds and times taken by the two stones?**



- **Ans**

$$\frac{1}{2}mv^2 = mgh, \quad v = \sqrt{2gh}$$

$$= \sqrt{2 \times 10 \times 10}\ \text{ms}^{-1} = 14.14\ \text{ms}^{-1}$$

$$v_B = v_C = 14.14\ \text{ms}^{-1}, \quad l = \frac{1}{2}(g \sin\theta)\, t^2$$

$$\sin\theta = \frac{h}{l}, \quad l = \frac{h}{\sin\theta}$$

$$\frac{h}{\sin\theta} = \frac{1}{2} g \sin\theta\, t^2 \quad \text{or} \quad t = \sqrt{\frac{2h}{g} \cdot \frac{1}{\sin\theta}}$$

$$t_B = \sqrt{\frac{2\times 10}{10} \cdot \frac{1}{\sin 30^\circ}} = 2\sqrt{2}\text{s.}$$

$$t_C = \sqrt{\frac{2\times 10}{10} \cdot \frac{1}{\sin 60^\circ}} = \frac{2\sqrt{2}}{\sqrt{3}}\text{s.}$$

[Click here for Full REVISION Of chapter –WORK, ENERGY AND POWER]

CHAPTER 7 System of Particles and Rotational Motion

- **Q1 Find the components along the x, y, z-axes of the angular momentum l of a particle, whose position vector is r with components x, y, z and momentum is p with components p_x, p_y and p_z. Show that if the particle moves only in the x-y plane the angular momentum has only a z- component.**
- **Ans**

We know that angular momentum $\vec{l}$ of a particle having position vector $\vec{r}$ and momentum $\vec{p}$ is given by

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

But $\vec{r} = [x\hat{i} + y\hat{j} + z\hat{k}]$, where x, y, z are the components of

$\vec{r}$ and $\vec{p} = [p_x\hat{i} + p_y\hat{j} + p_z\hat{k}]$

$$\therefore \quad \vec{l} = \vec{r} \times \vec{p} = [x\hat{i} + y\hat{j} + z\hat{k}] \times [p_x\hat{i} + p_y\hat{j} + p_z\hat{k}]$$

or

$$(l_x\hat{i} + l_y\hat{j} + l_z\hat{k}) = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ x & y & z \\ p_x & p_y & p_z \end{vmatrix}$$

$$= (yp_z - zp_y)\hat{i} + (zp_x - xp_z)\hat{j} + (xp_y - yp_x)\hat{k}$$

From this relation, we conclude that

$$l_x = yp_z - zp_y \quad l_y = zp_x - xp_z \quad \text{and} \quad l_z = xp_y - yp_x$$

If the given particle moves only in the $x - y$ plane, then $z = 0$ and $p_z = 0$ and hence,

$\vec{l} = (xp_y - yp_x)\hat{k}$, which is only the z-comonent of $\vec{l}$.

It means that for a particle moving only in the $x - y$ plane, the angular momentum has only the z-component.

CHAPTER 7 System of Particles and Rotational Motion

- **Q2. A car weighs 1800 kg. The distance between its front and back axles is 1.8 m. Its centre of gravity is 1.05 m behind the front axle. Determine the force exerted by the level ground on each front wheel and each back wheel.**
- **Answer:** Let F_1 and F_2 be the forces exerted by the level ground on front wheels and back wheels respectively. Considering rotational equilibrium about the front wheels,F_2 x 1.8 = mg x 1.05 or F_2 = 1.05/1.8 x 1800 x 9.8 N =10290 N Force on each back wheel is =10290/2 N or 5145 N.
Considering rotational equilibrium about the back wheels.
F_1 x 1.8 = mg (1.8 – 1.05) = 0.75 x 1800 x 9.8
or F_1=0.75 x 1800 x 9.8/1.8 = 7350 N
Force on each front wheel is 7350/2 N or 3675 N.

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CHAPTER 8- GRAVITATION

- **Q1. A body weighs 63 N on the surface of the Earth. What is the gravitational force on it due to the Earth at a height equal to half the radius of the Earth?**
- **ANS** We know that

$$\frac{g_h}{g} = \left(\frac{R}{R+h}\right)^2 \quad \text{or} \quad \frac{g_h}{g} = \left(\frac{R}{R+\frac{R}{2}}\right)^2 = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$$

Let W be the weight of body on the surface of Earth and W_h the weight of the body at height h.

Then, $$\frac{W_h}{W} = \frac{mg_h}{mg} = \frac{g_h}{g} = \frac{4}{9}$$

or $$W_h = \frac{4}{9}W = \frac{4}{9} \times 63\text{ N} = \mathbf{28\ N}.$$

CHAPTER 8- GRAVITATION CONT.

- **Q2. A rocket is fired 'vertically' from the surface of Mars with a speed of 2 km s-1. If 20% of its initial energy is lost due to Martian atmospheric resistance, how far will the rocket go from the surface of mars before returning to it? Mass of Mars = 6.4 x 10^{23} kg; radius of Mars = 3395 km; G = 6.67 x 10^{-11} N m^2 kg^{-2}**

Initial K.E. = $\frac{1}{2}mv^2$; Initial P.E. = $-\frac{GMm}{R}$

where m = Mass of rocket, M = Mass of Mars, R = Radius of Mars

$\therefore$ Total initial energy = $\frac{1}{2}mv^2 - \frac{GMm}{R}$

Since 20% of K.E. is lost, only 80% remains to reach the height.

$\therefore$ Total initial energy available

$$= \frac{4}{5}\times\frac{1}{2}mv^2 - \frac{GMm}{R}$$

$$= 0.4\,mv^2 - \frac{GMm}{R}$$

When the rocket reaches the highest point, at a height h above the surface, its K.E. is zero and P.E. = $-\frac{GMm}{R+h}$.

Using principle of conservation of energy.

$$0.4\text{ mv}^2 - \frac{GMm}{R} = -\frac{GMm}{R+h}$$

CHAPTER 8- GRAVITATION CONT.

or $$\frac{GMm}{R+h} = \frac{GMm}{R} - 0.4\,mv^2 \Rightarrow \frac{GM}{R+h} = \frac{GM}{R} - 0.4\,v^2$$

or $$\frac{GM}{R+h} = \frac{1}{R}\,[GM - 0.4\,Rv^2] \Rightarrow \frac{R+h}{R} = \frac{GM}{GM - 0.4\,Rv^2}$$

or $$\frac{h}{R} = \frac{GM}{GM - 0.4\,Rv^2} - 1$$

or $$\frac{h}{R} = \frac{0.4\,Rv^2}{GM - 0.4\,Rv^2} \Rightarrow h = \frac{0.4\,R^2v^2}{GM - 0.4\,Rv^2}$$

or $$h = \frac{0.4 \times \left(2 \times 10^3\right)^2 \times \left(3.395 \times 10^6\right)^2}{6.67 \times 10^{-11} \times 6.4 \times 10^{23} - 0.4 \times \left(2 \times 10^3\right)^2 \times 3.395 \times 10^6}\ \text{m}$$

$$= 495\ \text{km.}$$

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CHAPTER 9- MECHANICAL PROPERTIES OF SOLIDS

- **Q1 The edge of an aluminum cube is 10 cm long. One face of the cube is firmly fixed to a vertical wall. A mass of 100 kg is then attached to the opposite face of the cube. The shear modulus of aluminum is 25 GPa. What is the vertical deflection of this face?**

Answer: Here, side of cube, L = 10 cm =10/100= 0.1 m

∴ Area of each face, $A = (0.1)^2 = 0.01\ m^2$

Tangential force acting on the face,

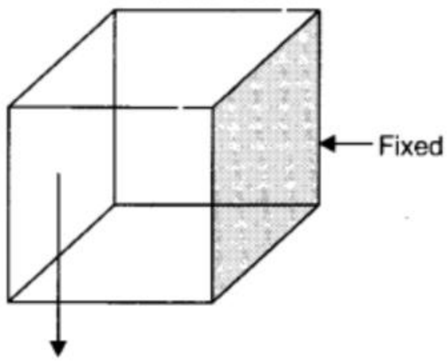
$$F = 100\ kg = 100 \times 9.8 = 980\ N$$

$$\text{Shear modulus, } \eta = 25\ GPa = 25 \times 10^9\ Nm^{-2}$$

Since shear modulus is given as:

$$\eta = \frac{\text{Tangential stress}}{\text{Shearing strain}}$$

$$\therefore \text{Shearing strain} = \frac{\text{Tangential stress}}{\text{Shear modulus}}$$



$$= \frac{F}{A\eta} = \frac{980}{0.01 \times 25 \times 10^9} = 3.92 \times 10^{-6}$$

$$\text{Now, } \frac{\text{Lateral Strain}}{\text{Side of cube}} = \text{Shearing strain}$$

$$\therefore \text{Lateral Strain} = \text{Shearing strain} \times \text{Side of the cube}$$

$$= 3.92 \times 10^{-6} \times 0.1$$

$$= 3.92 \times 10^{-7}\ m \approx 4 \times 10^{-7}\ m.$$

CHAPTER 9- MECHANICAL PROPERTIES OF SOLIDS CONT.

- **Q2. What is the density of water at a depth where pressure is 80.0 atm, given that its density at the surface is 1.03 x 10³ kg m⁻³?**
- **Ans** Compressibility of water,

$$k = \frac{1}{B} = 45.8 \times 10^{-11}\ \text{Pa}^{-1}$$

Change in pressure,

$$\Delta p = 80\ \text{atm} - 1\ \text{atm}$$
$$= 79\ \text{atm} = 79 \times 1.013 \times 10^5\ \text{Pa}$$

Density of water at the surface,

$$\rho = 1.03 \times 10^3\ \text{kg m}^{-3}$$

As $B = \frac{\Delta p . V}{\Delta V}$ or $\frac{\Delta V}{V} = \frac{\Delta p}{B} = \Delta p \times \frac{1}{B}$

or $\frac{\Delta V}{V} = 79 \times 1.013 \times 10^5 \times 45.8 \times 10^{-11} = 3.665 \times 10^{-5}$

Now $\frac{\Delta V}{V} = \frac{(M/\rho)-(M/\rho')}{(M/\rho)} = 1 - \frac{\rho}{\rho'}$

or $\frac{\rho}{\rho'} = 1 - \frac{\Delta V}{V}$

or $\rho' = \frac{\rho}{1-(\Delta V/V)}$

or $\rho' = \frac{1.03\times10^3}{1-3.665\times10^{-3}} = \frac{1.03\times10^3}{0.996}$

$= 1.034\times10^3\ \text{kg/m}^3.$

Click here for Full REVISION Of chapter – MECHANICAL PROP. OF SOLIDS

CHAPTER 10-MECHANICAL PROP. OF FLUIDS

- **Q1 A U-shaped wire is dipped in a soap solution, and removed. A thin soap film formed between the wire and a light slider supports a weight of 1.5×10^{-2} N (which includes the small weight of the slider). The length of the slider is 30 cm. What is the surface tension of the film?**
- **Answer:** In present case force of surface tension is balancing the weight of 1.5×10^{-2} N, hence force of surface tension, $F = 1.5 \times 10^{-2}$ N.

  Total length of liquid film, $l = 2 \times 30$ cm $= 60$ cm $= 0.6$ m because the liquid film has two surfaces.

  Surface tension, $T = F/l = 1.5 \times 10^{-2}$ N/0.6m $= 2.5 \times 10^{-2}$ Nm^{-1}

CHAPTER 10-MECHANICAL PROP. OF FLUIDS CONT.

- **Q2 During blood transfusion, the needle is inserted in a vein where the gauge pressure is 2000 Pa. At what height must the blood container be placed so that blood may just enter the vein? Given: density of whole blood = 1.06 x 10^3 kg m^{-3}**
- **Answer:** $h=P/\rho g = 200/(1.06 \times 10^3 \times 9.8) = 0.1925$ m
  The blood may just enter the vein if the height at which the blood container be kept must be slightly greater than 0.1925 m i.e„ 0.2 m.

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CHAPTER 11-THERMAL PROPERTIES OF MATTER

- Q1 **A large steel wheel is to befitted on to a shaft of the same material. At 27 °C, the outer diameter of the shaft is 8.70 cm and the diameter of the central hole in the wheel is, 8.69 cm. The shaft is cooled using 'dry ice'. At what temperature of the shaft does the wheel slip on the shaft ? Assume coefficient of linear expansion of the steel to be constant over the required temperature range α_{steel}= 1-20 x $10^{-5}K^{-1}$.**
- **Ans**

Here at temperature $T_1 = 27\ °C$, diameter of shaft $D_1 = 8.70$ cm

Let at temperature T_2, the diameter of shaft changes to $D_2 = 8.69$ cm and for steel

$$\alpha = 1.20 \times 10^{-5}\ K^{-1} = 1.20 \times 10^{-5}\ °C^{-1}$$

$\because$ Change in diameter $\Delta D = D_2 - D_1 = D_1 \times \alpha \times (T_2 - T_1)$

$$\therefore \quad 8.69 - 8.70 = 8.70 \times 1.20 \times 10^{-5} \times (T_2 - 27)$$

$$\Rightarrow \quad T_2 = 27 - \frac{0.01}{8.70 \times 1.20 \times 10^{-5}} = 27 - 95.8 = -68.8\ °C \quad \text{or} \quad -69\ °C.$$

CHAPTER 11-THERMAL PROPERTIES OF MATTER CONT.

- **Q2 A brass rod of length 50 cm and diameter 3.0 mm is joined to a steel rod of the same length and diameter. What is the change in length of the combined rod at 250 °C, if the original lengths are at 40.0 °C ? Is there a 'thermal stress' developed at the junction ? The ends of the rod are free to expand (Co-efficient of linear expansion of brass = 2.0 x 10^{-5} °C^{-1}, steel = 1.2 x 10^{-5} °C^{-3}.**

- **Ans**

Here, $l_{brass} = l_{steel} = 50$ cm, $d_{brass} = d_{steel} = 3$ mm $= 0.3$ cm, $\Delta l_{brass} = ?$, $\Delta l_{steel} = ?$

$$\Delta T = 250 - 40 = 210 \text{ °C.}$$

$$\alpha_{brass} = 2 \times 10^{-5} \text{ °C}^{-1} \quad \text{and} \quad \alpha_{steel} = 1.2 \times 10^{-5} \text{ °C}^{-1}$$

Now $$\Delta l_{brass} = \alpha_{brass} \times l_{brass} \times \Delta T$$
$$= 2 \times 10^{-5} \times 50 \times 210 = 0.21 \text{ cm}$$

Now $$\Delta l_{steel} = \alpha_{steel} \times l_{steel} \times \Delta T$$
$$= 1.2 \times 10^{-5} \times 50 \times 210$$
$$= 0.126 \text{ cm} \approx 0.13 \text{ cm}$$

$\therefore$ Total change in length, $\Delta l = \Delta l_{brass} + \Delta l_{steel} = 0.21 + 0.13 = 0.34$ cm

Since the rod is not clamped at its ends, no thermal stress is developed at the junction.

Click here for Full REVISION Of chapter – THERMAL PROP. OF MATTER

CHAPTER 12- THERMODYNAMICS

- Q1 **An electric heater supplies heat to a system at a rate of 100 W. If system performs work at a rate of 75 Joules per second. At what rate is the internal energy increasing?**
- **ANSWER**

Here $\Delta Q = 100 \text{ W} = 100 \text{ J/s}$

$\Delta W = 75 \text{ J/s}$

Since $\Delta Q = \Delta U + \Delta W$

$\therefore$ Change in internal energy, $\Delta U = \Delta Q - \Delta W$

$= 100 - 75 = 25 \text{ J/s}.$

CHAPTER 12- THERMODYNAMICS CONT.

- **Q2 A steam engine delivers 5.4 x 10^8 J of work per minute and services 3.6 x 10^9 J of heat per minute from its boiler. What is the efficiency of the engine? How much heat is wasted per minute?**
- **ANSWER** Work done per minute, output = 5.4×10^8 J

  Heat absorbed per minute, input = 3.6×10^9 J

  Efficiency, $\eta = \dfrac{\text{output}}{\text{input}} = \dfrac{5.4 \times 10^8}{3.6 \times 10^9} = 0.15$

  $\%\eta = 0.15 \times 100 = 15$

  Heat energy wasted/minute

  = Heat energy absorbed/minute – Useful work done/minute

  $= 3.6 \times 10^9 - 5.4 \times 10^8$

  $= (3.6 - 0.54) \times 10^9 = 3.06 \times 10^9$ J.

Click here for Full REVISION Of chapter – THERMODYANAMICS

CHAPTER 13-KINETIC THEORY OF GASES

- Q1 Molar volume is the volume occupied by 1 mol of any (ideal) gas at standard temperature and pressure (STP : 1 atmospheric pressure, 0 °C). Show that it is 22.4 litres.
- ANSWER

For one mole of an ideal gas, we have

$$PV = RT \Rightarrow V = \frac{RT}{P}$$

Putting $R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$, $T = 273K$ and $P = 1$ atmosphere $= 1.013 \times 10^5\ \text{Nm}^{-2}$

$$\therefore \quad V = \frac{8.31 \times 273}{1.013 \times 10^5} = 0.0224\ \text{m}^3$$

$$= 0.0224 \times 10^6\ \text{cm}^3 = 22400\ \text{ml} \qquad [1\ \text{cm}^3 = 1\text{ml}]$$

CHAPTER 13-KINETIC THEORY OF GASES CONT.

- **Q2 Estimate the average thermal energy of a helium atom at (i) room temperature (27 °C), (ii) the temperature on the surface of the Sun (6000 K), (iii) the temperature of 10 million kelvin (the typical core temperature in the case of a star).**
- **ANSWER**

(*i*) Here, $T = 27\ ^\circ\text{C} = 27 + 273 = 300\ \text{K}$

$$\text{Average thermal energy} = \frac{3}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 300 = 6.2 \times 10^{-21}\ \text{J}.$$

(*ii*) At $T = 6000\ \text{K}$,

$$\text{Average thermal energy} = \frac{3}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 6000 = 1.24 \times 10^{-19}\ \text{J}.$$

(*iii*) At $T = 10$ million $K = 10^7\ \text{K}$

$$\text{Average thermal energy} = \frac{3}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 10^7 = 2.1 \times 10^{-16}\ \text{J}$$

Click here for Full REVISION Of chapter – KINETIC THEORY OF GASES

CHAPTER 14- OSCILLATIONS

- **Q1. Which of the following function of time represent (a) simple harmonic, (b) periodic but not simple harmonic, and (c) non-periodic motion? Give period for each case of periodic motion (to is any positive constant). (a) sin wt – cos wt (b) sin² wt (c) 3 cos -2 cos (π/4-2 wt) (d) cos wt + cos 3 wt + cos 5 wt (e) exp (- w²t²) (f) 1 + wt + w²t².**
- The function will represent a periodic motion, if it is identically repeated after a fixed interval of time and will represent S.H.M if it can be written uniquely in the form of a cos OR sine function

(a) $\sin \omega t - \cos \omega t$

$$= \sqrt{2}\left[\frac{1}{\sqrt{2}}\sin \omega t - \frac{1}{\sqrt{2}}\cos \omega t\right]$$

$$= \sqrt{2}\left[\sin \omega t \cos \frac{\pi}{4} - \cos \omega t \sin \frac{\pi}{4}\right]$$

$$= \sqrt{2}\sin\left(\omega t - \frac{\pi}{4}\right)$$

It is a S.H.M. and its period is $2\pi/\omega$

(b) $\sin^3 \omega t$

$$= \frac{1}{3}[3\sin \omega t - \sin 3\omega t]$$

Here each term $\sin \omega t$ and $\sin 3\,\omega t$ individually represents S.H.M. But (*ii*) which is the outcome of the superposition of two SHMs will only be periodic but not **SHMs.** Its time period is $2\pi/\omega$.

CHAPTER 14- OSCILLATIONS CONT.

(*c*) $3\cos\left(\frac{\pi}{4}-2\omega t\right) = 3\cos\left(2\omega t-\frac{\pi}{4}\right)$. [$\because \cos(-\theta) = \cos\theta$]

Clearly it represents SHM and its time period is $2\pi/2\omega$.

(*d*) $\cos\omega t + \cos 3\omega t + \cos 5\omega t$. It represents the periodic but not S.H.M. Its time period is $2\pi/\omega$

(e) e^{-w2t2} . It is an exponential function which never repeats itself. Therefore it represents non-periodic motion.

(f) $1 + wt + w^2t^2$ also represents non periodic motion.

CHAPTER 14- OSCILLATIONS CONT.

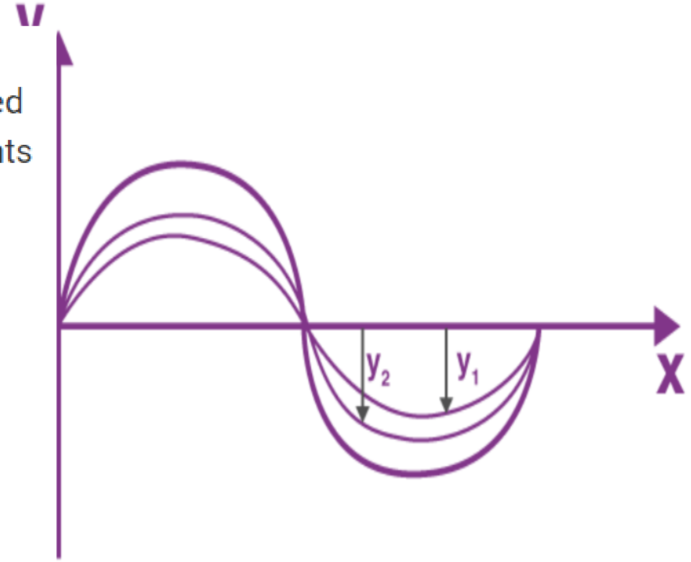
- **Q2 Which of the following relationships between the acceleration a and the displacement x of a particle involve simple harmonic motion?**
  (a) $a = 0.7x$ (b) $a = -200\ x^2$
  (c) $a = -10x$ (d) $a = 100\ x^3$
- **Answer:** Only (c) i.e., $a = -10x$ represents SHM. This is because acceleration is proportional and opposite to displacement (x)

Click here for Full REVISION Of chapter – OSCILLATIONS

CHAPTER 15- WAVES

- **Q1.What is Superposition of Waves? Derive an expression for the displacement of resultant wave.**
- **Ans -**Mixing of two waves to produce a resultant wave of changed amplitude is called superposition of waves

Considering two waves, travelling simultaneously along the same stretched string in opposite directions as shown in the figure above. We can see images of waveforms in the string at each instant of time. It is observed that the net displacement of any element of the string at a given time is the algebraic sum of the displacements due to each wave.



Let us say two waves are travelling alone and the displacements of any element of these two waves can be represented by $y_1(x, t)$ and $y_2(x, t)$. When these two waves overlap, the resultant displacement can be given as $y(x,t)$.

Mathematically, $y(x, t) = y_1(x, t) + y_2(x, t)$

As per the principle of superposition, we can add the overlapped waves algebraically to produce a resultant wave. Let us say the wave functions of the moving waves are

CHAPTER 15- WAVES CONT.

$y_1 = f1(x-vt)$,

$y_2 = f2(x-vt)$

……….

$y_n = f_n\,(x-vt)$

then the wave function describing the disturbance in the medium can be described as

$y = f_1(x - vt) + f_2(x - vt) + \ldots + f_n(x - vt)$

or, y=∑ i=1 to n = fi (x−vt)

Let us consider a wave travelling along a stretched string given by, $y_1(x, t) = A \sin(kx - \omega t)$ and another wave, shifted from the first by a phase φ, given as $y_2(x, t) = A \sin(kx - \omega t + \varphi)$

CHAPTER 15- WAVES CONT.

From the equations we can see that both the waves have the same angular frequency, same angular wave number k, hence the same wavelength and the same amplitude A.

Now, applying the superposition principle, the resultant wave is the algebraic sum of the two constituent waves and has displacement $y(x, t) = A \sin (kx - \omega t) + A \sin (kx - \omega t + \varphi)$

As, $\sin A = \sin B = 2\sin (A+B)/2 \cdot \cos (A-B)/2$

The above equation can be written as,

$y(x, t) = [2A \cos 1/2\ \phi] \sin (kx - wt + 1/2\phi)$

The resultant wave is a sinusoidal wave, travelling in the positive X direction, where the phase angle is half of the phase difference of the individual waves and the amplitude as $[2\cos 1/2\phi]$ times the amplitudes of the original waves.