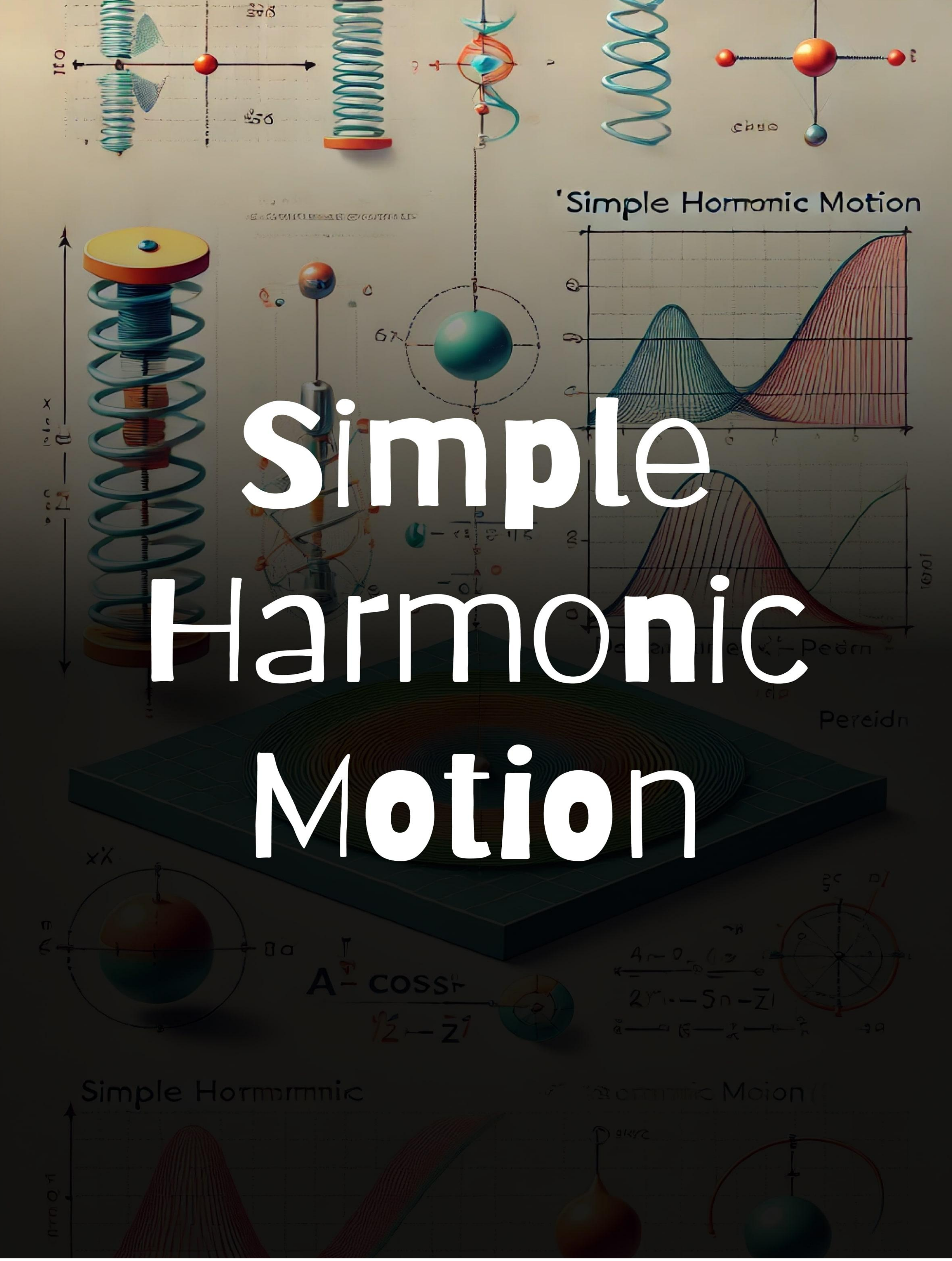
Simple Harmonic Motion



Simple harmonic motion

Periodic Motion → Motion which repeats itself after equal Interval of time.

T = time period of Periodic motion.

Some example of periodic motion

1. Motion of earth around sun.
2. Uniform Circular motion
3. Sattelite motion.
4. An Insect is climbing an wall & fall in equal Interval.
5. Ball is bouncing b/w two fixed point (ground and roof)
6. Simple pendulum (No damping
7. Spring mass System.

All Periodic are not Oscillatory.

Oscillation :-

Periodic motion which is to & fro

- All oscillatory are periodic
- Oscillation or Vibration motion is refined as a periodic and bounded motion of a body

→ Vibration - High frequency.

SHM (Simple harmonic motion)

Oscillation with small amplitude

Periodic

[Motion repeats its Path in Fixed Interval]

About mean position
To & fro
(Oscillation)

Amplitude large
(Variable)
- Non simple harmonic motion

Amplitude small
(Energy conserved
Amplitude - fixed
restoring force
S.H.M.

Not about any mean
Non - oscillatory
Ex: Circular motⁿ
Satellite motⁿ

Que Periodic motion must be oscillatory motion → False

2. Periodic motion may be oscillatory motion → True

3. Oscillatory motion must be Periodic → True

4. S.H.M must be Periodic & Oscillatory → True

5. Oscillation must be simple harmonic → false

6. Oscillation may be simple harmonic → True

Variable amplitude →

Not a periodic

Que Circular motion is an Example of:

(a) Periodic motion
(b) Non Periodic
(c) oscillatory
(d) may be periodic or non periodic

Que. The Circular motion of a Particle with const speed is

1. Periodic but not simple harmonic
2. Simple harmonic but not periodic
3. Period and simple harmonic
4. Neither periodic nor simple harmonic

Period and frequency

Period is the interval of time after which the motion is repeated. It is denoted by T

- frequency is defined as the num. of oscillations per unit time. It is the reciprocal of time period T. It is represented by the symbol

The relation b/w ν and T is

$$\boxed{f = \nu = \frac{1}{T}}$$

$$\boxed{\omega = 2\pi f} \qquad \omega = \frac{2\pi}{T} \ \frac{rad}{sec}$$

Angular freq. = Angular Speed.

Time Period. $\boxed{T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}}$

Qu If frequency of Object is π rad/sec then find time period.

$$\omega = \pi \text{ rad/sec} = \frac{2\pi}{T}$$

$$\boxed{T = 2 \text{ sec}}$$

Qu A nurse in a hospital noted for a patient the heart was beating 75 times a minute find its frequency and time period.

75 time in a minut (60 sec)

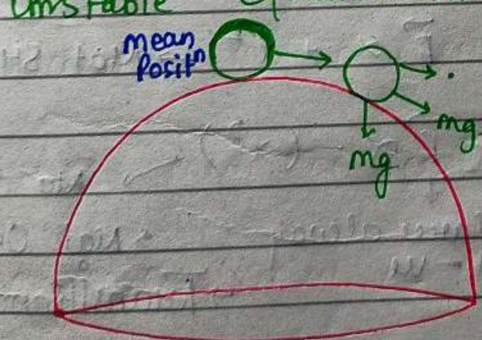
60 sec —— 75 time

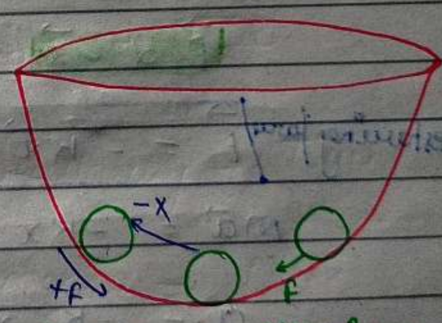
1 sec —— $\frac{75}{60}$

$$f = 1.25 \text{ Hz}$$

$$T = \frac{1}{1.25} \text{ sec} = 0.8 \text{ sec}$$

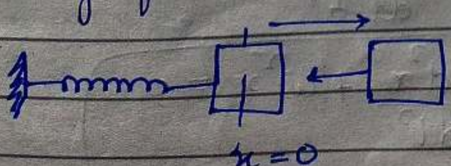
Unstable equilibrium.

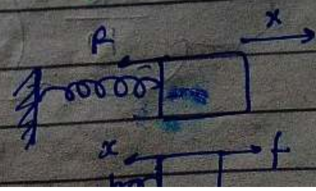


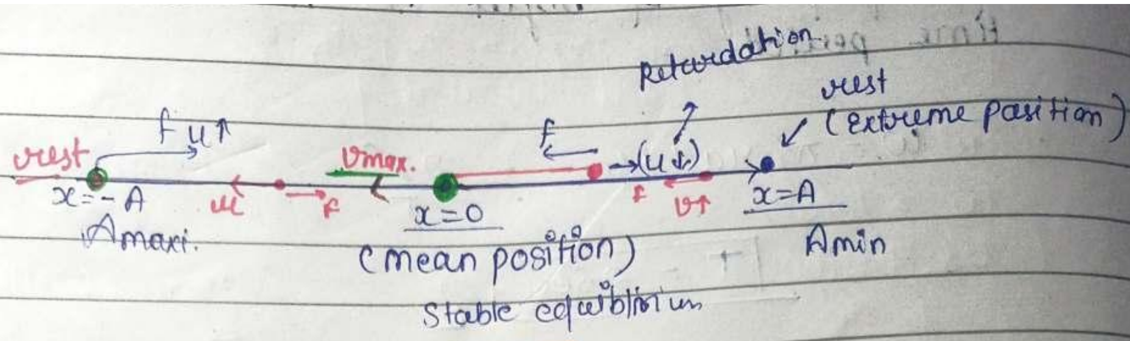


Stable equilibrium.
- Oscillation
- SHM (Small amplitude)

Restoring force oppose motion → F



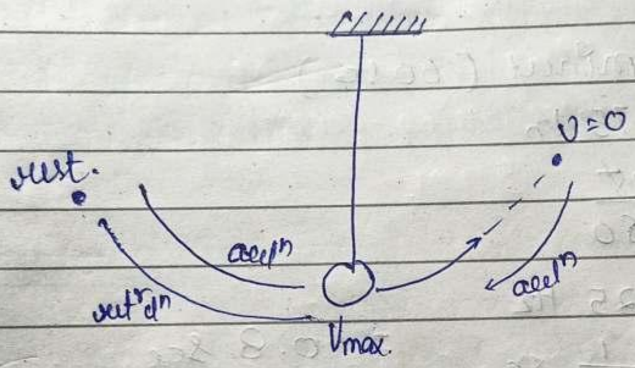




Restoring force always acts toward mean position

$\vec{F} \propto -\vec{x}$

maxi at Extreme.



Condition of SHM

$\vec{F} \propto -\vec{x}$

Restoring force $\boxed{\vec{F} = -K\vec{x}}$

$m\vec{a} = -Kx$

$\vec{a} = \frac{-K}{m}\vec{x}$

$$\boxed{\vec{a} = -\omega^2\vec{x}}$$

$$\omega^2 = \frac{K}{M} = \left(\frac{2\pi}{T}\right)^2$$

$\vec{F} \propto +x^2 \rightarrow$ Not SHM

$\vec{F} \propto -(x^2) \rightarrow$ No SHM

force alway $-ve$

→ Not Oscill^n

→ Translational motio

acel^n ka double diff.

$$\frac{d^2x}{dt^2} = -\omega^2 x$$

Imp

$$\boxed{\frac{d^2x}{dt^2} + \omega^2 x = 0}$$

✲ differential form of SHM.

$F = -x^3$ — Oscillation but not S.H.M

$F = -x^n \longrightarrow n = 0, 2, 4, 6, 8$ even no
- only transitional

Imp
$\rightarrow n = 1 \longrightarrow$ S.H.M
$\rightarrow n = 1, 3, 5, 7 \longrightarrow$ Oscillation not S.H.M.

JEE main
Que If force $F = -4x + 8$ then due to this force motion

(a) Oscillation but not Periodic
(b) SHM with equilibrium at 2m
(c) " " " " $\frac{1}{2}$ m
(d) Oscillation but not S.H.M

Soln $F \propto -x$
$F = 0 = -4x + 8$
$4x = 8 = x = \frac{8}{4} = \boxed{x = 2m}$

Que A particle move under force $F = -5(x-2)^3$ motion of the particle is.

$F = -5(x-2)^3$

① Translatary
② Oscillatary
③ S.H.M
④ All of these

$x = -4$
$F = +ve.$

Qu For a particle showing motion under the force $F = -5(x-2)^2$, the motion is.
① Translatory
② Oscillatory
③ SHM

$F = -5(x-2)^2$ even no.

Qu A particle moves under force $F = -5(x-2)^3$. motion of the particle is.

1. Translatory
2. Oscillatory
3. SHM
4. All of these

Qu If a particle is executing simple harmonic motion, then acceleration of particle

1. Is uniform
2. Varies linearly with time
3. Is no uniform
4. Both 2, 3

Qu A particle moves such that acceleration is given by $a = -4x$, the period of oscillation is

1. π
2. $2/\pi$
3. $1/\pi$
4. 2π

$$a = -4x$$
$$a = -\omega^2 x$$
$$\omega^2 = 4$$
$$\omega = \sqrt{4} = 2$$
$$\frac{2\pi}{T} = 2$$
$$\boxed{T = \pi}$$

Condition of SHM

$\vec{F} \propto -\vec{x}$

$\vec{F} = -K\vec{x}$

$\vec{a} = -\frac{K}{m}\vec{x}$

$\boxed{a = -\omega^2 \vec{x}}$

$\frac{d^2x}{dt^2} = -\omega^2 x$

$\boxed{\frac{d^2x}{dt^2} + \omega^2 x = 0}$ Relation B/W position & time

$x \propto t^2$

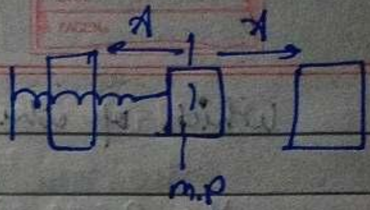
$x \propto t$

$x \propto -t$

$x \propto (t-2)^{-2x}$

$$\boxed{\frac{d^2x}{dt^2} + \omega^2 x = 0}$$

$$\boxed{x = A \sin(\omega t + \phi)}$$



Position of particle at time 't'

- A = Amplitude – Max^m Position from mean Position
- ϕ = Initial phase diff (at $t=0$)
  decide from where motion has started
- ω = Angular frequency

Q. Find value of ϕ if mot^n started

$t=0, \quad x=0.$

$0 = A \sin(0+\phi)$

$0 = \sin\phi \quad (\phi = 90^\circ)$

Q. If motion started from +ve Extreame then find θ

$\theta/2 = 90^\circ \qquad x = A\sin(\omega t + \theta)$

$x = A\sin\left(\omega t + \frac{\pi}{2}\right) = A\cos(\omega t)$

Q. If motion started from $x = +\frac{A}{2}$. Find ϕ

$\frac{\phi}{6} = 30^\circ \qquad x = A\sin\left(\omega t + \frac{\phi}{6}\right)$

Q. If motion started from $x = \frac{A}{\sqrt{2}}$ find θ

$\frac{\phi}{4} = 45^\circ \qquad x = A\sin\left(\omega t + \frac{\pi}{4}\right)$

Which of the following is are not SHM

$y = A\cos\omega t$ ✓

$y = A\sin\omega t$ ✓

$y = A\sin(3\omega t)$ ✓

$y = Ae^{KT}$ ✗

If motion started from mean position then find

Position / time

Velocity / time

acc^n / time

$\phi = 0$ (motion start from mean) $x = A\sin(\omega t + \phi)$

$$x = A\sin(\omega t)$$

$$\frac{dx}{dt} = V = A\cos(\omega t) \times \omega$$

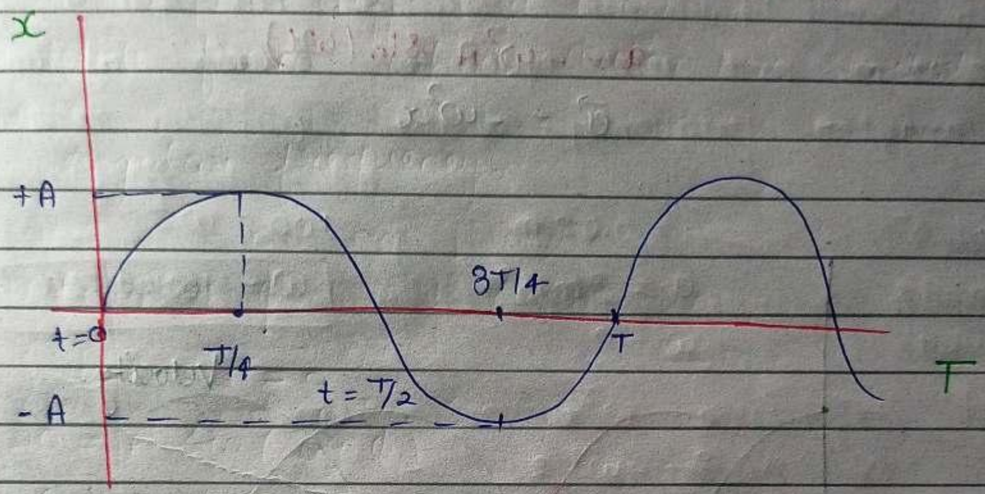
$$A = A\omega\cos(\omega t)$$

$$a = \frac{dV}{dt} = A\omega^2[-\sin(\omega t)$$

$$\boxed{a = -A\omega^2\sin(\omega t)}$$

Imp $\boxed{a = -\omega^2 x}$

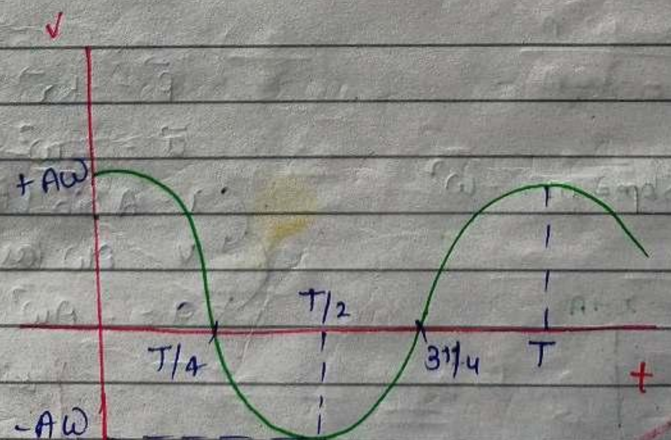
$x = A\sin(\omega t)$	$x = A\sin(\omega t + \phi)$
$V = \omega A\cos(\omega t)$	$V = A\omega\cos(\omega t + \phi)$
$a = -A\omega^2\sin(\omega t)$	$a = -A\omega^2\sin(\omega t + \phi)$
$a = -\omega^2 x$	
For mean	For general S.H.M
$V = \omega\sqrt{A^2 - x^2}$	



$x = A\sin(\omega t)$

$x = A\sin\left(\frac{2\pi}{T} \times \frac{T}{2}\right)$

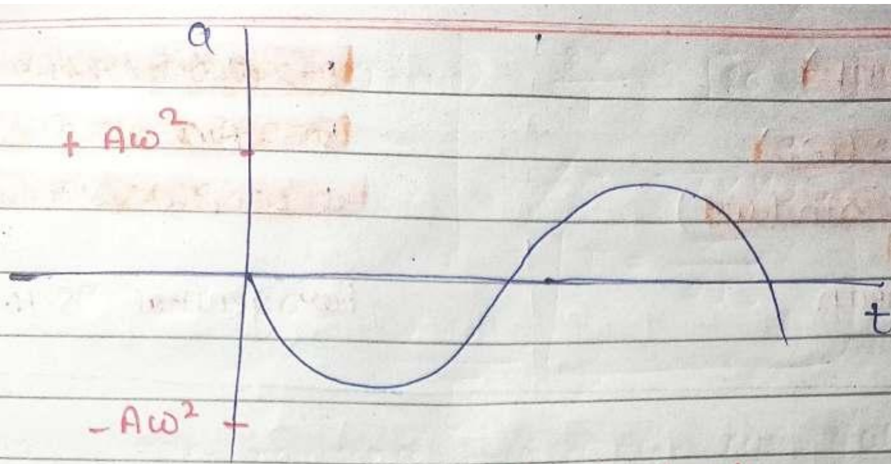
at $t = \frac{T}{2}$



$V = A\omega\cos(\omega t) \longrightarrow A\omega\cos\left(\frac{2\pi}{T} \times \frac{T}{2}\right)$

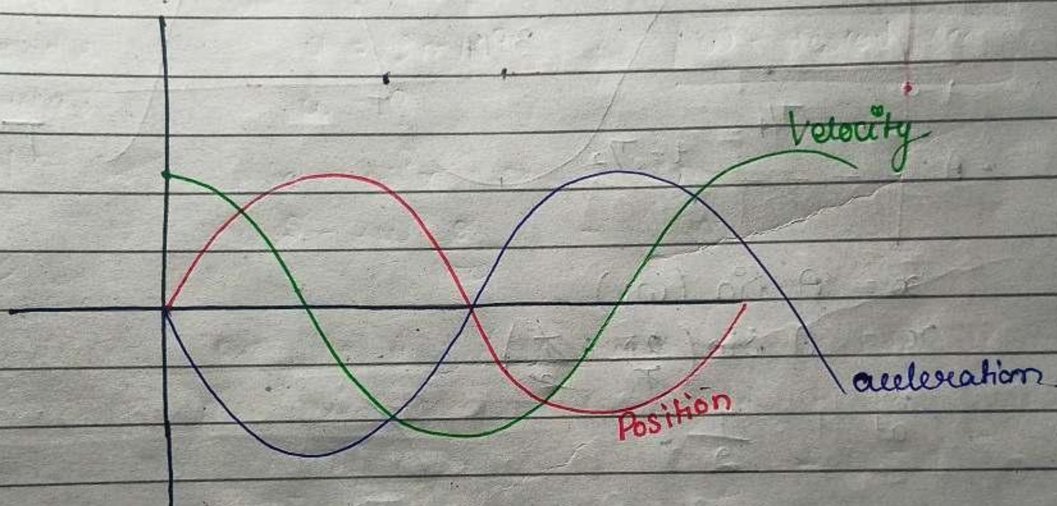
$t = 0$, mean, $V_{max} = A\omega$.

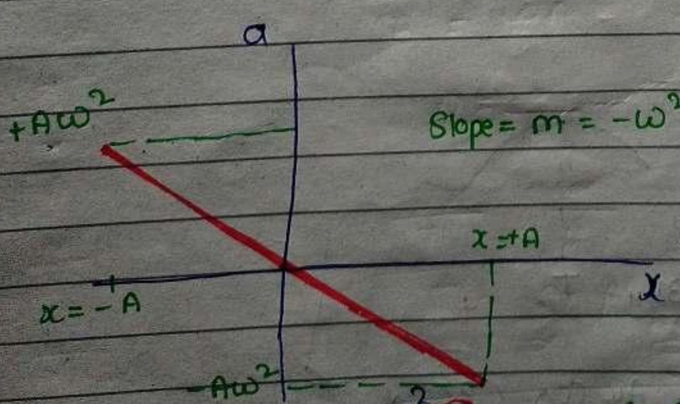
$t = \frac{T}{4}$, extreme, $V = 0$



$$a = -\omega^2 A \sin(\omega t)$$

$$\vec{a} = -\omega^2 x$$





$$\vec{F} = -k\vec{x}$$

$$\vec{a} = -\omega^2 \vec{x}$$

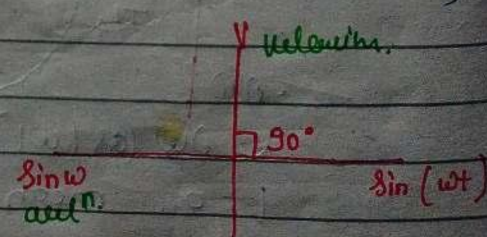
$$x = A \sin(\omega t)$$

$$v = A\omega \cos(\omega t)$$

$$a = -A\omega^2 \sin(\omega t)$$

$$a = -\omega^2 x \qquad c = 0$$

$$y = mx + c \qquad m = -ve$$



Position $\xrightarrow{\frac{\pi}{2}}$ Velocity $\xrightarrow{\frac{\pi}{2}}$ acceleration

Vo $\frac{\pi}{2}$ Mai $\frac{\pi}{2}$ uske

Qu 1 Phase diff b/w the Inst. Velo and accel^n of a particle executing S.H.M is

(1) zero (2) $\frac{\pi}{2}$ (3) π (4) 2π

Qu 2 A particle executing SHM along y-axis, which is described by $y = 10 \sin \frac{\pi t}{4}$, phase of particle at $t = 2$ sec is.

(1) $\frac{\pi}{4}$ $y = 10 \sin\left(\frac{\pi t}{4}\right)$

(2) $\frac{\pi}{2}$ Phase $= \frac{\pi t}{4} = \frac{\pi}{4} \times 2 = \frac{\pi}{2}$ A2

(3) $\frac{\pi}{8}$

Qu 3 Two simple Harmonic motion of angular frequency 100 and 1000 rad^{-1} have the same displacement amplitude the ratio of their maxim^m accl^n.

$\omega_1 = 100$ $\omega_2 = 1000$

$$\frac{a_{max} = \omega_1^2 A}{a_n = \omega_2^2 A} = \left(\frac{10^2}{10^3}\right)^2 = \left(\frac{1}{10}\right)^2 = \frac{1}{10^2} \text{ A}$$

Qu 4 A particle execute simple Harmonic motion according to equation $4\frac{d^2x}{dt^2} + 320x = 0$. Its time period of Oscillation is.

(1) $\frac{2\pi}{5\sqrt{3}}$ s (2) $\frac{\pi}{3\sqrt{2}}$ s (3) $\frac{\pi}{2\sqrt{5}}$ s (4) $\frac{2\pi}{\sqrt{3}}$ s

$$4a + 320x = 0$$
$$4a = -320x$$
$$a = 80x$$
$$\omega^2 = 80$$

$$\frac{2\pi}{T} = \sqrt{80} = \sqrt{16 \times 5}$$
$$2\pi = T \times 4\sqrt{5}$$
$$\boxed{T = \frac{\pi}{2\sqrt{5}}}$$

Ans 5 If a Simple harmonic Oscillator has got a displace of 0.02 m and accⁿ equal to $2.0\,ms^{-2}$ at any time the angular frequency of the Oscillator is equal to

ⓐ $10\ rad\ s^{-1}$
ⓑ $0.1\ rad\ s^{-1}$
ⓒ $100\ rad\ s^{-1}$
ⓓ $1\ rad\ s^{-1}$

$$x = 0.02\ m$$
$$a = 2\ m/s^2$$
$$\omega = ?$$
$$a = -\omega^2 x$$
$$\cancel{2} = +\omega^2 \cdot \frac{\cancel{2}}{100}$$

$$100 = \omega^2$$
$$\boxed{\omega = 10\ rad/sec}$$

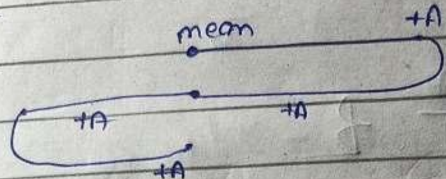
Ans 6 A particle is executing a simple harmonic motion Its maxim accⁿ is α maxim velocity is β. then its time period of vibration will be

① $2\pi\beta$
② $\frac{\beta^2}{\alpha^2}$
ⓒ $\frac{\alpha}{\beta}$
ⓓ $\frac{\alpha}{\beta}$
ⓔ $\frac{\beta^2}{\alpha}$

$$\frac{\alpha = \omega^{\cancel{2}} \cancel{A}}{\beta = \cancel{\omega} \cancel{A}}$$
$$\omega = \frac{\alpha}{\beta}$$
$$\frac{2\pi}{T} = \frac{\alpha}{\beta}$$
$$\boxed{T = \frac{2\pi\beta}{\alpha}}$$ Ans

Qu 7. The distance covered by a particle undergoing SHM in one time period is (amplitude = A)

(a) 4A ✓
(b) zero
(c) A
(d) 2A



disp^n is oscillation $= 0$
dist in one oscillation $= 4A$

Qu 8. A particle is executing SHM with amplitude A and has maximum velocity V_0. Its speed at displacement $\frac{3A}{4}$ will be

Amplitude = A
Velocity = V_0

(1) $\frac{\sqrt{7}}{4} V_0$ ✓
(2) $\frac{V_0}{\sqrt{2}}$
(3) V_0
(4) $\frac{\sqrt{3}}{2} V_0$

$x = \frac{3A}{4}$, $V_0 = A\omega$

$V = \omega\sqrt{A^2 - x^2}$

$V = \omega\sqrt{A^2 - \frac{9A^2}{16}}$

$\omega A\sqrt{\frac{16-9}{16}} = V_0\sqrt{\frac{7}{16}} = \boxed{\frac{\sqrt{7}V_0}{4}}$

Qu 9. Which one of the following statement is true for the velocity V and the accl^n a of a particle executing simple harmonic motion?

(1) When V is maximum, a is zero
(2) When V is zero, a is zero
(3) When V is maximum, a is maximum
(4) Value of a is zero, whatever may be the value of V.

Que 10. For a particle executing simple harmonic motion, the amplitude

(1) $4AT$

(2) $\frac{2A}{T}$

(3) 2π

(4) $2\pi A/T$

$V_{max} = \omega A$

$\frac{2\pi A}{T}$ B

Que 11. A body is executing S.H.M when its displacement from the mean position is 4 cm and 5 cm, the corresponding velocity of the body is 10 cm/sec

(1) 2π sec

(2) $\pi/2$

(3) π

(4) $3\pi/2$

$x_1 = 4$ cm $\qquad x_2 = 5$ cm

$V_1 = 10$ cm $\qquad V_2 = 8$ cm

$$\frac{10 = \cancel{\omega}\sqrt{A^2-16}}{8 = \cancel{\omega}\sqrt{A^2-25}}$$

$$\frac{5}{4} = \sqrt{\frac{A^2-16}{A^2-25}}$$

$$\left(\frac{10}{\omega}\right)^2 = A^2 - 16 \quad \text{— (1)}$$

$$\left(\frac{10}{\omega}\right)^2 + 16 = A^2$$

$$\left(\frac{8}{\omega}\right)^2 + 25 = A^2 \quad \text{— (II)}$$

$$\left(\frac{10}{\omega}\right)^2 + 16 = \left(\frac{8}{\omega}\right)^2 + 25$$

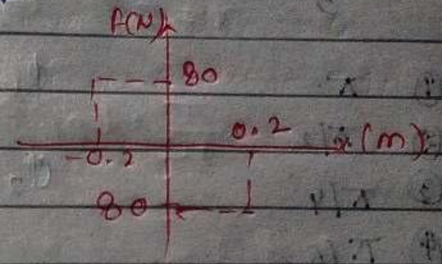
$$\frac{100}{\omega^2} - \frac{64}{\omega^2} = 25 - 16$$

$$\frac{\cancel{36}^{\,4}}{\omega^2} = \cancel{9} = \omega^2 = 4$$

$$\frac{2\pi}{T} = 2$$

$$\boxed{T = \pi}$$

Qu 12 A body of mass 0.01 kg Executes Simple Harmonic motion about $x=0$ under the influence of a force as shown in figure. The time period of SHM is:-



① 1.05 s
② 0.52 s
③ 0.25 s
④ 0.03 s

$\vec{F} = -K\vec{x}$

$+80 = +K\, 0.2$

$K = \frac{80}{2} \times 10$

$K = 400$

$m\omega^2 = 400$

$\frac{1}{100}\omega^2 = 400$

$\omega^2 = 400 \times 100$, $\frac{2\pi}{T} = 2 \times 10^2$

$T = \frac{\pi}{10^2} = \frac{3.14}{100} = 0.0314$

Qu 13 A particle is executing SHM about $y=0$ along y-axis its position at an instant is given by $y(m) = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$. The amplitude of oscillation is

① 10 m
② 5 m
③ $5(1+\sqrt{3})$ m
④ $5\sqrt{3}$ m

$y = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$

$y = 5\sin(3\pi t) + 5\sqrt{3}\cos(3\pi t)$

$5\sqrt{3}$

$\sqrt{25 + 25 \times 3}$

$\sqrt{100}$

$= 10$

Qu 14 Particle executing SHM along y-axis has its motion described by the equation $y = 2 + 10\sin 5\pi t$. Amplitude of SHM is.

① 2
② 12
③ 10
④ $\sqrt{104}$

$y = 2 + 10\sin(5\pi t)$ time=0

$y_{max} = 12$

10

$y = 2$

10

$y = -8$

$y = 2 + 10(-1)$

$2 - 10$

$= -8$

Qu 15 The displacement of two Particle executing SHM on the Same lines are given as $y_1 = a\sin\left(\frac{\pi}{2}t+\phi\right)$ and $y_2 = b\sin\left(\frac{2\pi}{3}t+\theta\right)$. The phase difference b/w them at t = 1s

1. π
2. $\pi/2$
3. $\pi/4$
4. $\pi/6$

$$\phi_1 = \frac{\pi}{2} + \theta$$

$$\phi_2 = \frac{2\pi}{3} + \theta$$

$$\theta_2 - \theta_1 = \frac{2\pi}{3} - \frac{\pi}{2} = \frac{4\pi - 3\pi}{6} = \frac{\pi}{6}$$

diff graph

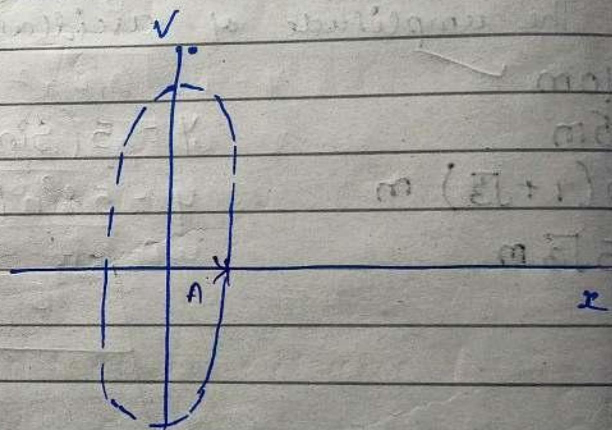
$$\frac{v^2}{(\omega A)^2} + \frac{x^2}{A^2} = 1$$

$$V = \omega\sqrt{A^2 - x^2}$$

$$\frac{V}{\omega} = \sqrt{A^2 - x^2}$$

$$\frac{V^2}{\omega^2} = A^2 - x^2$$

$$\frac{V^2}{\omega^2} + x^2 = A^2$$

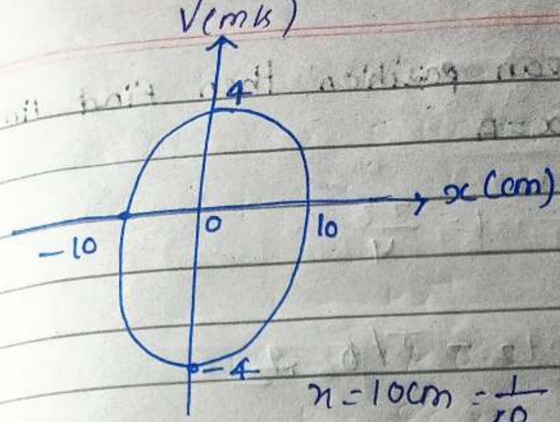


divided by A^2 both side

$$\frac{V^2}{\omega^2 A^2} + \frac{x^2}{A^2} = 1$$

Qu 16 The plot of velocity (v) versus displacement (x) of a particle executing simple harmonic motion is shown in figure. The time period of oscillation of particle is

1. $\frac{\pi}{2}$ s
2. $\frac{\pi}{20}$ s
3. 2π s
4. 3π s



$x = 10cm = \frac{1}{10} m$

$\omega A = 4$

$\frac{2\pi}{T} \cdot \frac{1}{10} = 4$

$T = \frac{\pi}{20}$.

Q. Graph Velocity and acceleration.

$a = -\omega^2 x \longrightarrow \left(\frac{a}{\omega^2}\right)^2 = (-x)^2 \Rightarrow \frac{a^2}{\omega^2} = x^2$ —— (i)

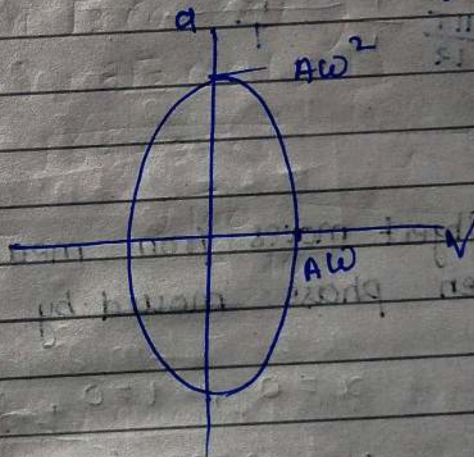
$V = \omega\sqrt{A^2 - x^2}$

$\frac{V^2}{\omega^2} = A^2 - x^2$ —— (ii)

$= \frac{a^2}{\omega^2} + \frac{V^2}{\omega^2} = \cancel{x^2} + A^2 - \cancel{x^2}$

$\frac{a^2}{a^2\omega^4} + \frac{V^2}{A^2\omega^2} = 1$

$\frac{a^2}{(A\omega^2)^2} + \frac{V^2}{(A\omega)^2} = 1$



Q. A motion start from mean position then find time taken from $x = 0$ to $x = A/2$

$x = A\sin(\omega t)$

$\frac{\cancel{A}}{2} = \cancel{A}\sin(\omega t)$

$\frac{1}{2} = \sin(\omega t)$

$\omega t = \frac{\pi}{6}$

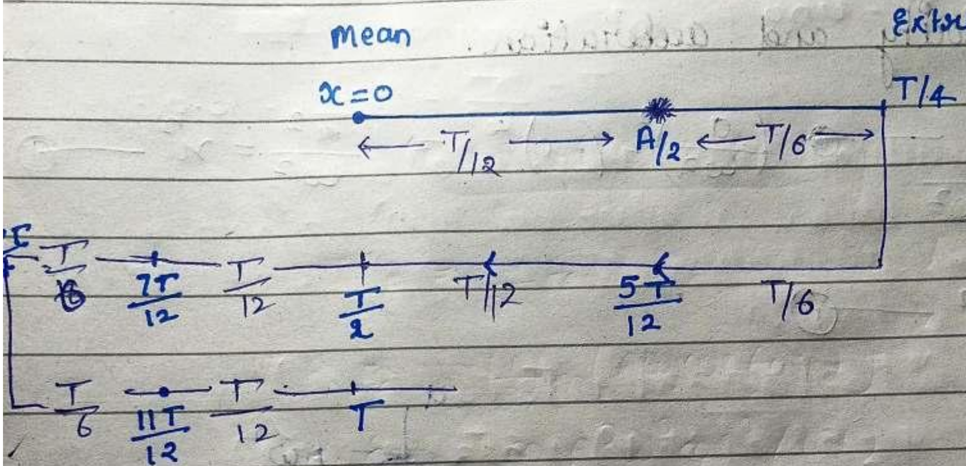
$\frac{2\cancel{\pi}}{T} t = \frac{\cancel{\pi}}{6}$

$\boxed{t = \frac{T}{12}}$

Que 18 Motion start from mean position then find time taken from $x = \frac{A}{2}$ to $x = A$

$x = 0$ to $x = A$ — $t = \frac{T}{4}$

$\frac{T}{12} + t_2 = T/4$, $t_2 = T/6$



Q19 Object moves from mean half of the extreme $\left(x = \frac{A}{2}\right)$ then phase moved by object. at that time 't'

$x = 0$, $t = 0$, $\phi = 0$

$x = A \sin(\omega t)$

$\frac{\cancel{A}}{2} = \cancel{A} \sin(\omega t)$

$\frac{1}{2} = \sin \omega t$

$$\boxed{\omega t = \frac{\pi}{6}}$$

Qu 20 Find time taken from mean to $x = \frac{A}{\sqrt{2}}$

$$\phi = \frac{\pi}{4}$$

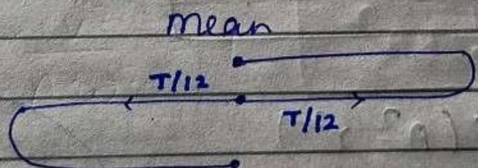
$$T = \frac{T}{8}$$

Qu 21 A particle is executing S.H.M b/w $x = \pm A$, the time tak to go from to $\frac{A}{2}$ is T_1 and to go from $\frac{A}{2}$ to A is T_2 then.

1. $T_1 < T_2$
2. $T_1 > T_2$
3. $T_1 = T_2$
4. $T_1 = 2T_2$

Qu 22 A particle is excuting SHM with time Period T. Starting from mean position, time taken by it to complete $\frac{5}{8}$ oscillation is.

1. $\frac{T}{12}$
2. $\frac{T}{6}$
3. $\frac{5T}{12}$
4. $\frac{7T}{12}$



$\frac{5}{8}$ Oscillation

$\frac{4+1}{8} = \frac{4}{8} + \frac{1}{8}$

$= \frac{1}{2} + \frac{1}{8}$

$= T/2$

$$T = \frac{T}{2} + \frac{T}{12}$$

$$\frac{6T + T}{12} = \frac{7T}{12}$$

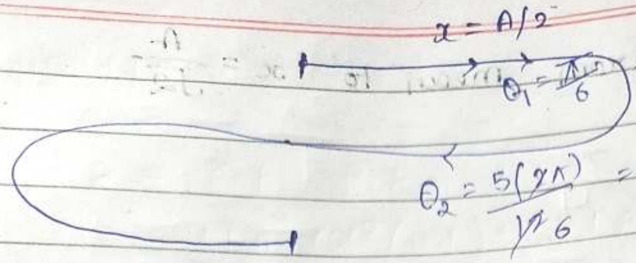
Qu 23 Two Particle executing SHM of same frequency meet at $x = +\frac{A}{2}$

$\frac{x}{6}$

$\frac{x}{3}$

$\frac{5\pi}{6}$

$\frac{2\pi}{3}$



$\theta_2 = \frac{5(\pi)}{6} = \frac{5\pi}{6}$

$\Delta\phi = \frac{5\pi}{6} - \frac{\pi}{6}$

Kinetic Energy

$V = A\omega \cos(\omega t)$

$V = \omega\sqrt{A^2 - x^2}$

$K.E = \frac{1}{2}mv^2$

$K.E = \frac{1}{2}m(A\omega\cos(\omega t))$

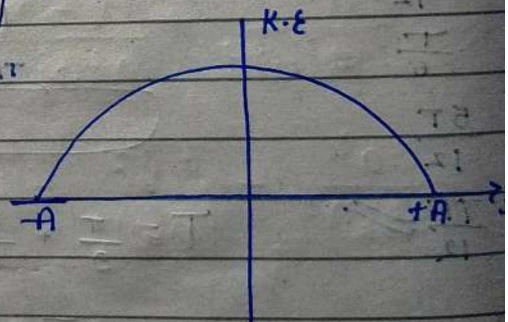
$K.E = \frac{1}{2}m A^2\omega^2\cos^2(\omega t)$

$$\boxed{K.E = \frac{1}{2}KA^2\cos^2(\omega t)}$$

if t is zero

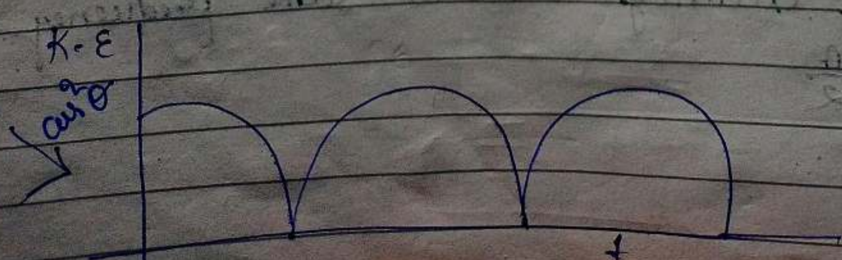
$K.E = \frac{1}{2}m\omega^2(A^2 - x^2)$

$$\boxed{K.E = \frac{1}{2}K(A^2 - x^2)} \Longrightarrow$$



If $(x = A)$ at Extreme $K.E = 0$

If $(x = 0)$ at mean $K.E = \frac{1}{2}KA^2$



Potential Energy

$$\vec{F} = -k\vec{x}$$

ref at mean $(U_0 = 0)$

$$-\frac{dU}{dx} = -kx$$

$$U = \frac{1}{2}kx^2$$

$$\int_{U_0}^{U} dU = \int_{x=0\,(\text{mean})}^{x} kx\,dx$$

$$\boxed{U = \frac{1}{2}kA^2\sin^2(\omega t)}$$

$$U - U_0 = k\left[\frac{x^2}{2}\right]$$

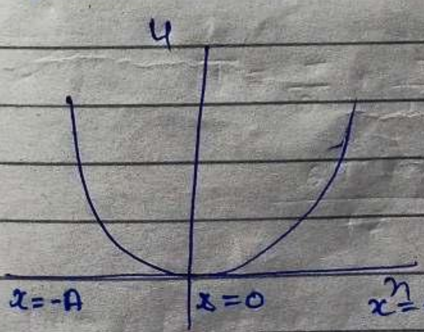
$$\boxed{U = U_0 + \frac{1}{2}kx^2}$$

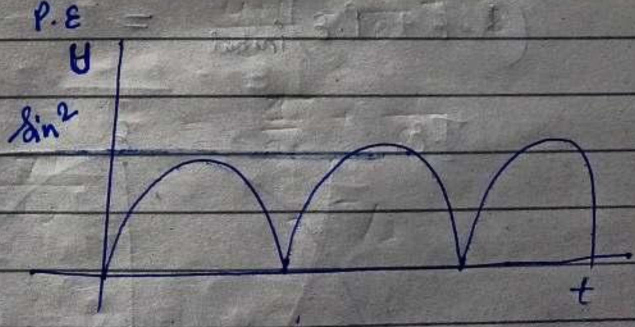
ref Potential at mean

Q. K.E must be zero at Extreme = T
P.E must be zero at mean = F

* If potential energy U_0 = 0 at mean

Potential Energy $\boxed{U = \frac{1}{2}kx^2} = \frac{1}{2}kA^2\sin^2\omega t$





Total Energy =

$$T.E = K.E + P.E$$

$$\frac{1}{2}KA^2\cos^2(\omega t) + \frac{1}{2}KA^2\sin^2(\omega t)$$

$$T.E = \frac{1}{2}KA^2\left[\cos^2\omega t + \sin^2\omega t\right]$$

$$\boxed{T.E = \frac{1}{2}KA^2}$$

At all the time

$$T.E\,(M.E) = \text{const}$$

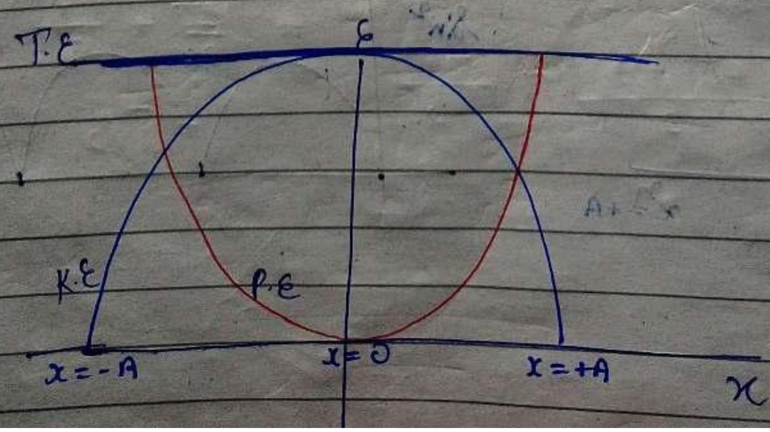
$$T.E = K.E + P.E$$

$$T.E = \frac{1}{2}K(A^2 - x^2) + \frac{1}{2}Kx^2$$

$$T.E = \frac{1}{2}KA^2 - \cancel{\frac{1}{2}Kx^2} + \cancel{\frac{1}{2}Kx^2}$$

$$\boxed{T.E = \frac{1}{2}KA^2}$$

$$(K.E + P.E)_{initial} =$$



Qu 24 The Kinetic energy and P.E of a particle executing S.H.M are equal, when dispm in term of amplitude 'A' is.

(1) $\frac{A}{2}$

(2) $\frac{A}{\sqrt{2}}$ ✓

(3) $\frac{A\sqrt{2}}{3}$

(4) $A\sqrt{2}$

$K.E = U$

$K.E + U = T.E$ $= U + U = T.E$

$2\left(\frac{1}{\cancel{2}}\cancel{k}x^2\right) = \frac{1}{\cancel{2}}\cancel{k}A^2$

$x^2 = \frac{A^2}{2}$ $= \boxed{x = \frac{A}{\sqrt{2}}}$

Qu 25 At what displacement the Kinetic Energy is half of the potential Energy ?

$K.E = \frac{U}{2}$

$K.E + U = T.E$

$\frac{U}{2} + U = \frac{1}{2}kx^2$

$\frac{3}{2}\left(\frac{1}{\cancel{2}}\cancel{k}x^2\right) = \frac{1}{\cancel{2}}kA^2$

$x^2 = \frac{2A^2}{3}$

$\boxed{x = \sqrt{\frac{2}{3}}k}$

$\frac{1}{\cancel{2}}\cancel{k}(A^2 - x^2) = \frac{\frac{1}{\cancel{2}}\cancel{k}x^2}{2}$

$A^2 - x^2 = \frac{x^2}{2}$

$A^2 = \frac{3x^2}{2}$

$x = \sqrt{\frac{2A^2}{3}}$

$x = \sqrt{\frac{2}{2}}k$

Que 26 A body is executing SHM with amplitude a and time Period T. the ratio of Kinetic and P.E when displ^m from the equilibrium Position is half the amplitude

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

$x = \frac{A}{2}$

$$\frac{K.E}{U} = \frac{\cancel{\frac{1}{2}}\cancel{K}(A^2 - x^2)}{\cancel{\frac{1}{2}}\cancel{K}x^2}$$

$$\frac{A^2 - A^2/4}{\frac{A^2}{4}} = \frac{3\cancel{A^2}/\cancel{4}}{\frac{\cancel{A^2}}{\cancel{4}}} = \frac{3}{1}$$

Qu 27 Find ratio of Kinetic & P.E at $x = \frac{x}{4}$

$$K.E = \frac{1}{2}K\left(A^2 - \frac{A^2}{16}\right) = 15\left(\frac{\frac{1}{2}KA^2}{16}\right)$$

$$U = \frac{1}{2}K(A/4)^2 = \frac{1}{2}K\frac{A^2}{16}$$

$= 15 : 1$

Qu 28 Find Position of Particle from mean position where P.E is half of the kinetic energy.

$$P.E = \frac{K.E}{2}$$

$$\cancel{\frac{1}{2}}Kx^2 = \frac{\cancel{\frac{1}{2}}K(A^2 - x^2)}{2}$$

$$2x^2 = A^2 - x^2$$

$$3x^2 = A^2$$

$$\boxed{x = \frac{A}{3}}$$

At the time $t = 0$, the particle is at its mean position. Then at what time, the particle will have potential energy 50 % of its total energy within $t = 0$ to $t = T$

$$U = 50\ \%\ T.E$$

$$\cancel{\frac{1}{2}} Kx^2 = \frac{50}{100_2} \cancel{\frac{1}{2}} KA^2$$

$$x = \sqrt{\frac{A^2}{2}} = \frac{A}{\sqrt{2}}$$

$t = \frac{T}{8}$ sec

A linear Harmonic Oscillator of force constant 6×10^5 N/m and amplitude 4 cm, has a total energy 600 J, select the correct statement

Maximum P.E is 600 J
" K.E is 480 J
Minimum PE is 120 J
All of these

$K = 6 \times 10^5$ N/m $\quad A = 4$ cm

$T.E = 600$ J

$$K.E_{max} = \frac{1}{2} KA^2$$

$$= \frac{1}{2} 6 \times 10^5 \times \left(\frac{4}{100}\right)^2$$

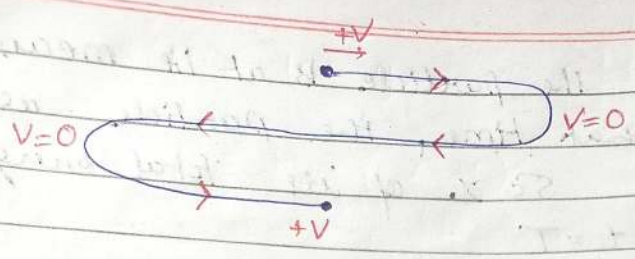
$$= \frac{1}{\cancel{2}} \cancel{6}^{3} \times 10^5 \times \frac{16}{10^4}$$

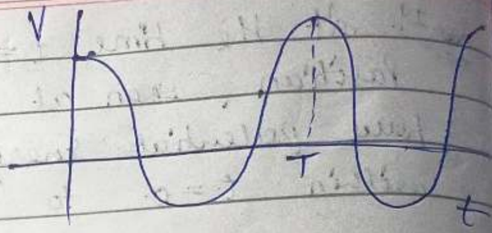
$$\boxed{K.E_{max} = 480}$$

$-U = T.E \qquad K.E + U = T.E$

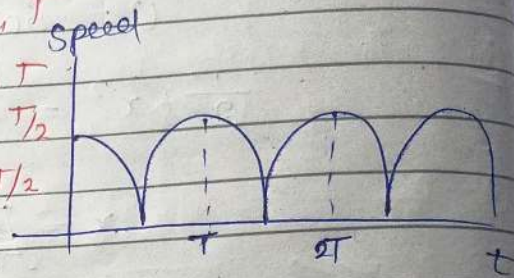
$U_{max} = 600$ J $\qquad 480 + U_{min} = 600$ J

$\boxed{U_{max} = 600 J}$ $\qquad \boxed{U_{min} = 120 J}$





Oscillate its position = f, T
" " Velocity = f, T
" " Speed = 2f, T/2
" " K.E = 2f, T/2



Physical Quantity	Time period	frequency
Position	T	f
Distance	T/2	2f
Velocity	T	f
Speed	T/2	2f
Acceleration	T	f
K.E	T/2	2f
P.E	T/2	2f
K.E − P.E	T/2	2f
||K.E| − |P.E||	T/4	4f
M.E	Infinity	Zero

Qu A loaded vertical spring executes S.H.M with a time period of 4S, the difference b/w the kinetic energy and P.E of this system varies with a period of.

1. 2s
2. 1s
3. 8s
4. 4s

$t = \frac{T}{2}$

Time period of S.H.M

Force method

$F = -Kx$

$\therefore a = -\frac{K}{m}x$

$$\boxed{a = -\omega^2 x}$$

$\omega = \frac{2\pi}{T}$

Energy method.

$F = -\frac{du}{dx}$

$a = \frac{F}{m} = -\frac{1}{m}\left(\frac{du}{dx}\right)$

Que The P.E of a Particle

$m = 100 \text{ gram} = 0.1 \text{ kg}$

$U = 5x(x-4)$

$U = 5x^2 - 20x$

$F = -\frac{dU}{dx} = -[10x - 20]$

$ma = -10x + 20$

$a = \frac{-10x}{0.1} + \frac{20}{0.1}$

$a = -100x + 200$

$\omega^2 = 100$

$\frac{2\pi}{T} = \sqrt{100} \quad = \frac{2\pi}{T} = 10 = T = \frac{\pi}{5}$

Que P.E of oscillating object is $U = U_0[1 - \alpha \cos(\alpha x)]$ then find time period of oscillation.

$U = U_0(1 - \alpha \cos(\alpha x)]$

$U = U_0 - \alpha U_0 \cos(\alpha x)$

$\frac{dU}{dx} = 0 + \alpha U_0 \sin(\alpha x)\alpha$

$\frac{dU}{dx} = \alpha^2 U_0 \sin(\alpha x)$

$F = -\frac{dU}{dx}$

$F = -\alpha^2 U_0 \sin(\alpha x)$

$ma = -\alpha^2 U_0 (\alpha x)$

cond S.H.M aplitud small

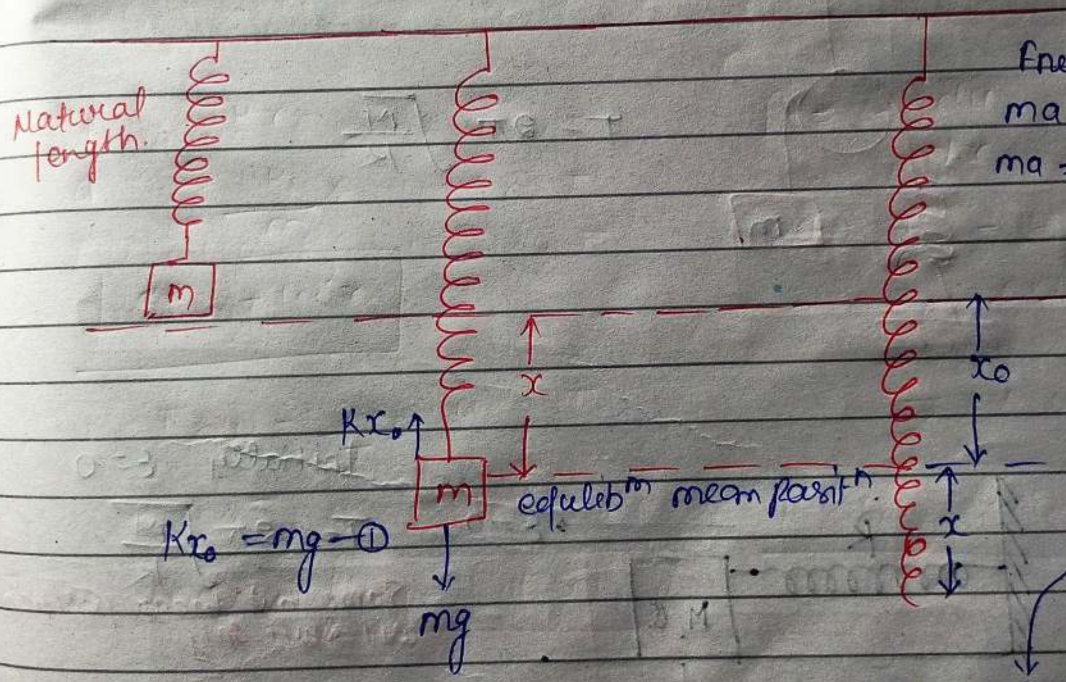
$$a = -\frac{\alpha^3 V_0}{m} x$$

$$\omega^2 = \frac{\alpha^3 V_0}{m}$$

$$\omega = \sqrt{\frac{\alpha^3 V_0}{m}}$$

$$\boxed{T = 2\pi\sqrt{\frac{m}{\alpha^3 V_0}}}$$

Spring mass Oscillation



$Kx_0 = mg$ —(1)

$F_{net} = f_s - mg$

$ma = k(x + x_0) - mg$

$ma = Kx + \cancel{Kx_0} - \cancel{mg}$

$$a = \frac{Kx}{m}$$

$$\vec{a} = \frac{-K}{m}\vec{x}$$

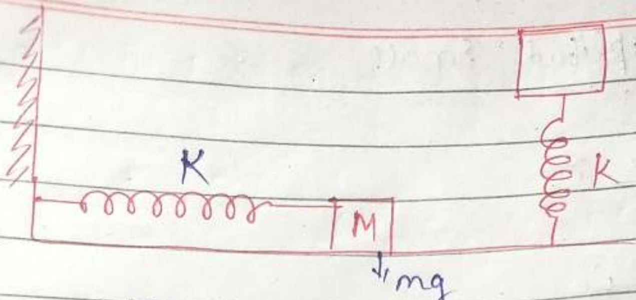
$$\omega = \sqrt{\frac{K}{m}}$$

$$\left[T = 2\pi\sqrt{\frac{m}{K}}\right]$$

= does not depend on aplitude

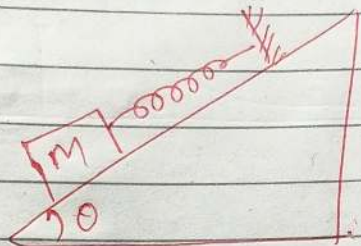
= does not depende on g

Variable force $F \propto -x$

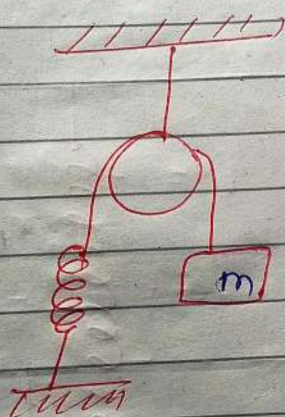


$T = 2\pi\sqrt{\frac{m}{K}}$

$T = 2\pi\sqrt{\frac{M}{K}}$

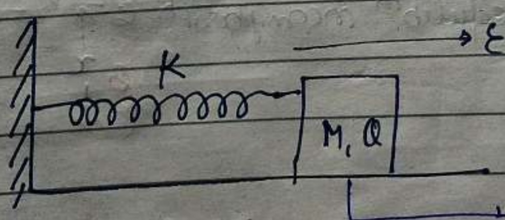


$T = 2\pi\sqrt{m/K}$



$T = 2\pi\sqrt{\frac{M}{K}}$

[Que]



Initially $E = 0$

$T = 2\pi\sqrt{\frac{M}{K}}$

Same but mean position will shift only.

mass $= M$

Charge $= Q$

Finally Electric field switch on

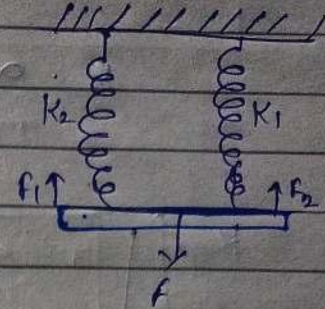
① $T = 2\pi\sqrt{\frac{m}{K}}$

② $T < 2\pi\sqrt{\frac{m}{K}}$

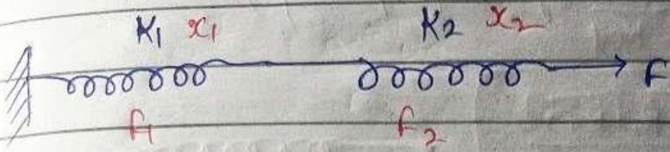
③ $T > 2\pi\sqrt{\frac{m}{K}}$

Combination of Spring

② Parallel Combination



① Series Combination



→ Force same $(F_1 = F_2 = F)$

→ elongation different

$$x = x_1 + x_2$$

$$\frac{\cancel{F}}{K_{eq}} = \frac{\cancel{F}}{K_1} + \frac{\cancel{F}}{K_2}$$

$$\boxed{\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}}$$

$$\boxed{K_{eq} = \frac{K_1 K_2}{K_1 + K_2}}$$

elongation same

Force different.

$$K_{eq}\, x = K_1 x + K_2 x$$

$$\boxed{K_{eq} = K_1 + K_2}$$

$$K_1 = K_2$$

$$\boxed{K_{eq} = 2K}$$

If n- Identical Spring connected in series

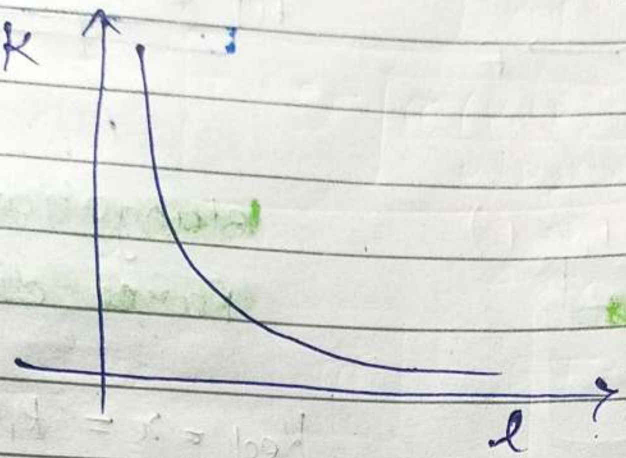
$$\boxed{K_{eq} = \frac{K}{n}}$$

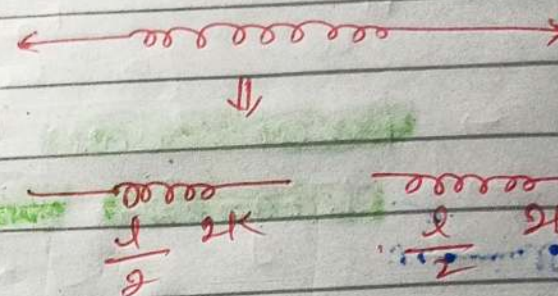
If n- Identical Spring Connected in Parallel

$$\boxed{K_{eq} = nK}$$

Relation b/w length & spring Const

$$K \propto \frac{1}{l} \text{ (length of spring)}$$





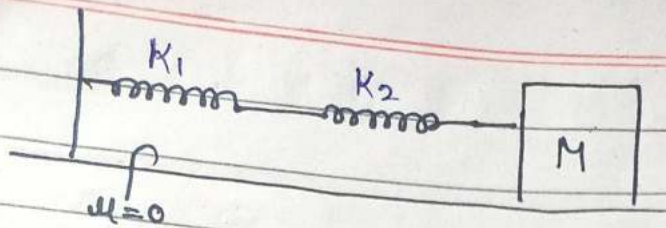
A block of mass m hangs from three springs having same spring constant K. If the mass is ...lly displaced downwards, the time period of oscillat... ...be

$\sqrt{\frac{m}{3K}}$

$\pi\sqrt{\frac{3m}{2K}}$

$\pi\sqrt{\frac{2m}{3K}}$

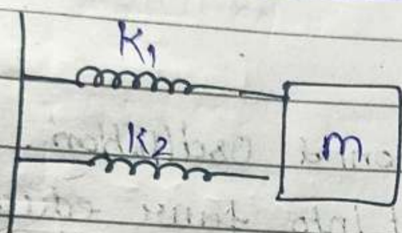
$\pi\sqrt{\frac{3K}{m}}$



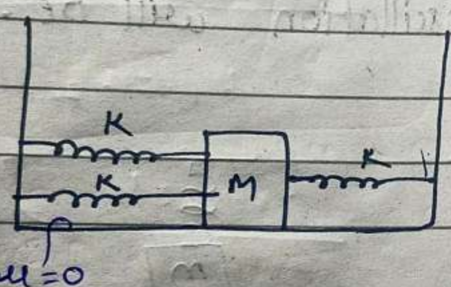
$$K_{eq} = \frac{K_1 K_2}{K_1 + K_2}$$

$$T = 2\pi\sqrt{\frac{m}{K_{eq}}}$$

$$\boxed{T = 2\pi\sqrt{\frac{m(K_1+K_2)}{K_1 K_2}}}$$

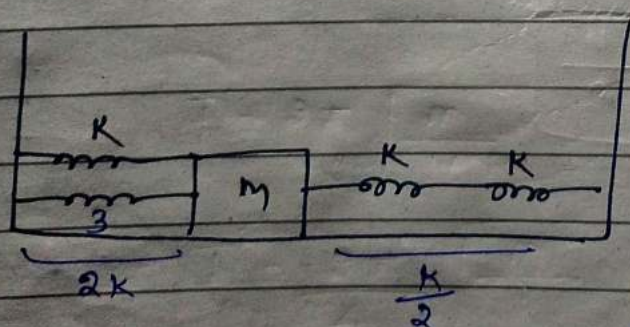


$$\boxed{T = 2\pi\sqrt{\frac{m}{(K_1+K_2)}}}$$



$$K_{eq} = 3K$$

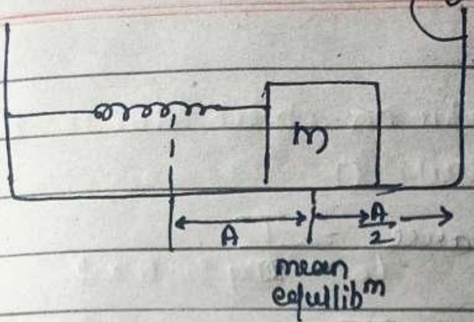
$$\boxed{T = 2\pi\sqrt{\frac{m}{3K}}}$$



$$K_{eq} = 2K + \frac{K}{2} = \frac{5K}{2}$$

$$\boxed{T = 2\pi\sqrt{\frac{2m}{5K}}}$$

elastic collision.

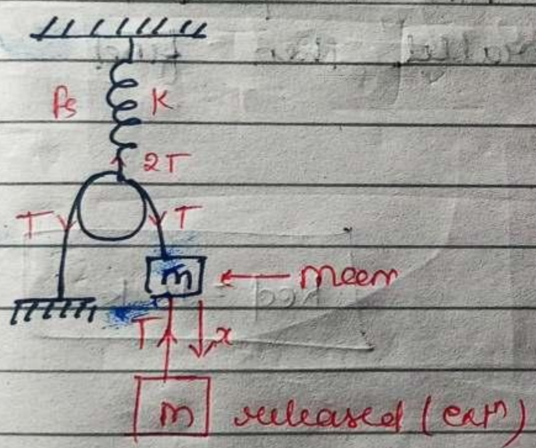


Qu Object is at mean Position now it is compressed to a distance A and released as shown in fig. then find time Period of Periodic motion

$$\frac{T}{2}+\frac{T}{12}+\frac{T}{12}=\frac{T}{2}+\frac{T}{6}=\frac{4T}{6}=\frac{2T}{3}=\frac{2}{3}2\pi\sqrt{\frac{m}{k}}$$

$$\boxed{=\frac{4\pi}{3}\sqrt{\frac{m}{k}}}\ \ B$$

Qu Object is in equili^m now displaced x distance downward then find time



$$2T = f_s = k\left(\frac{x}{2}\right)$$

$$2T=\frac{kx}{2}$$

$$T=\frac{kx}{4}$$

Block will accelerate by T

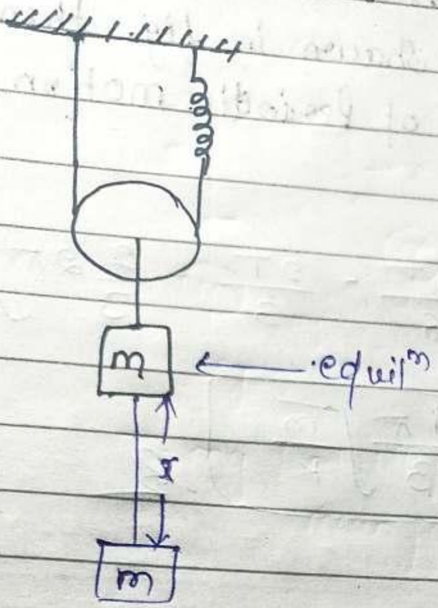
$$T = ma$$

$$ma=\frac{kx}{4}$$

$$\vec{a}=-\frac{k}{4m}\vec{x}$$

$$\omega=\sqrt{\frac{k}{4m}}\ =\ T=2\pi\sqrt{\frac{4m}{4}}$$

Que Object is in equilibrium.



Spring force $= \frac{T}{2}$

$k(2x) = \frac{T}{2}$

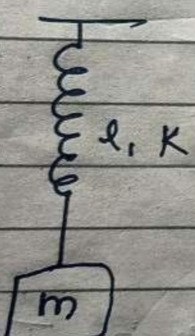
$k\,4x = T$

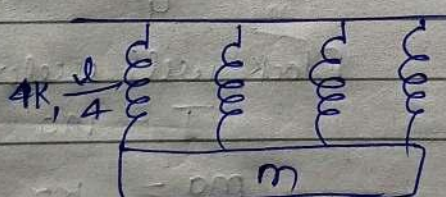
$4kx = m$

$a = \frac{4k}{m}$ k

$\frac{2\pi}{T} = \omega = \sqrt{\frac{4k}{m}} = \boxed{T = 2\pi\sqrt{\frac{m}{k}}}$

Que New spring is cut into 4 equal Part Connected in parallel then find New time period.





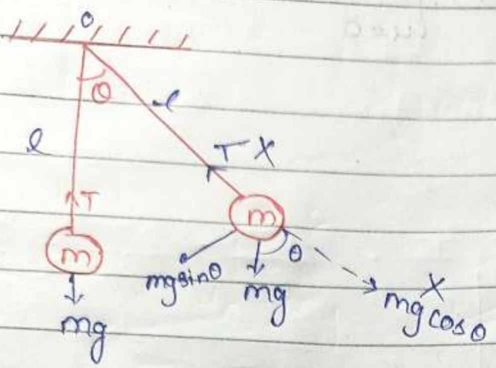
$\boxed{K_{eq} = 16K}$

$T' = 2\pi\sqrt{\frac{m}{16k}}$

$T' = \frac{2\pi}{4}\sqrt{\frac{m}{k}}$

$T' = \frac{T}{4}$

Simple pendulum



$T = mg$ (equli^m posit^n)
mean posit^n

$$\boxed{T = 2\pi\sqrt{\frac{l}{g}}}$$

Torque on object due to $mg\sin\theta$ about 'O'

$$\tau_0 = mg\sin\theta \times l$$

$$I\alpha = mg\sin\theta\, l$$

$$\cancel{m}l^{\cancel{2}}\alpha = \cancel{m}g\sin\theta\,\cancel{l}$$

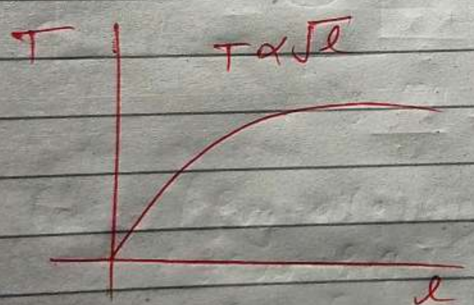
$$\alpha = \frac{g}{l}\sin\theta$$

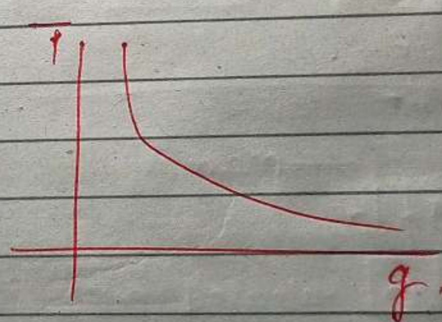
Cond^n of S.H.M (θ + small)

$$\alpha = \frac{g}{l}\theta$$

$$\vec{\alpha} = \frac{-g}{l}\vec{\theta} \qquad \because \omega^2 = \frac{g}{l}$$

$$\omega = \sqrt{\frac{g}{l}} = f = \frac{1}{2\pi}\sqrt{g/l}$$





Accelerated Pendulum :- IN LIFT

(i) $T = 2\pi\sqrt{\frac{l}{g+a}}$ (upward acceleration)

$g_{eff} = g + a$

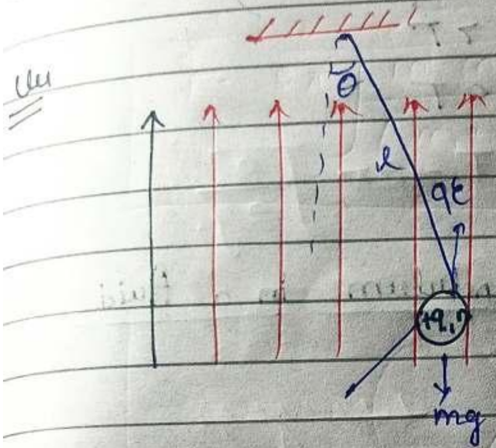
(ii) $T = 2\pi\sqrt{\frac{L}{g-a}}$ (downward acceleration)

$g_{eff} = g - a$

Simple Pendulum in horizontal accelerated lift

$$T = 2\pi\sqrt{\frac{L}{\sqrt{g^2+a^2}}}$$ $g_{eff} = \sqrt{g^2+a^2}$

Qu



When electric field is zero then Time period $T = 2\pi\sqrt{\frac{l}{g}}$, find time Period when electric field is switch on.

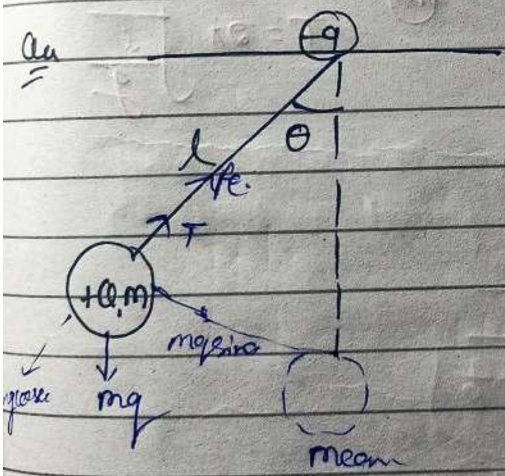
(a)

ⓐ $T' > T$

ⓑ $T' < T$

ⓒ $T' = T$

Qu

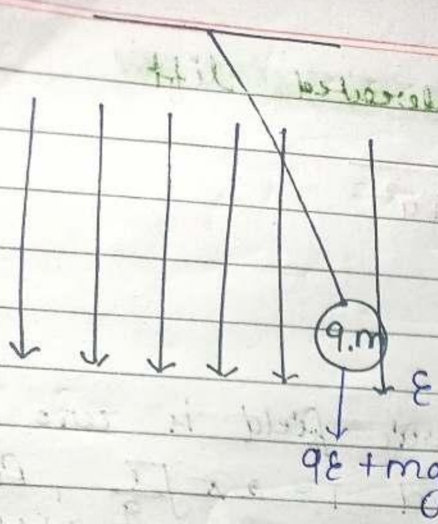


(a) $T = 2\pi\sqrt{a/g}$

(b) $T > 2\pi\sqrt{l/g}$

(c) $T < 2\pi\sqrt{l/g}$.

Que



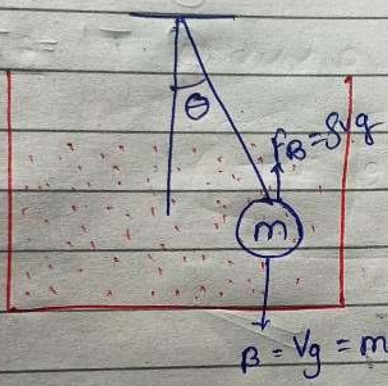
When electric field is zero then time period $T = 2\pi\sqrt{\frac{l}{g}}$, find time period when electric field is switch on

(a) $T' = T$ (Initial)

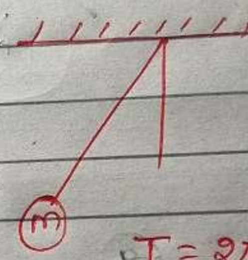
(b) $T' > T$

✓ (c) $T' < T$

Simple Oscillation of simple Pendulum in a fluid



$\boxed{\sigma > \rho}$



$T = 2\pi\sqrt{\frac{l}{g}}$

$$f_{net} = (\rho V g - \sigma (g) \sin\theta)$$

$$(\sigma \rho V g - \rho V g) \sin\theta$$

$$ma = \rho V g \left[1 - \frac{\rho}{\sigma}\right]$$

$$\cancel{m}a = \cancel{m}g\left(1 - \frac{\rho}{\sigma}\right)$$

$$a = g\left(1 - \frac{\rho}{\sigma}\right)$$

$$\boxed{T' = 2\pi\sqrt{\frac{l}{g\left(1 - \frac{\rho}{\sigma}\right)}}}$$

$\rho = \sigma$ $\qquad$ $\rho > \sigma$ $\qquad$ $\sigma > \rho$

$N = 0$

float with compt

$$\frac{V_{in}}{V_{Total}} = \frac{\sigma}{\rho}$$

$$N' = mg\left(1 - \frac{\rho}{\sigma}\right)$$

$$\cancel{m} g_{eff} = \cancel{m} g\left(1 - \frac{\rho}{\sigma}\right)$$

$$g = g\left(1 - \frac{\rho}{\sigma}\right)$$

Que A simple pendulum with a

(1) $T/\sqrt{3}$

(2) $\frac{2T}{\sqrt{3}}$ ✓

(3) $\frac{4}{3}T$

(4) $\frac{2}{3}T$

$\rho = \frac{\sigma}{4}$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T' = 2\pi\sqrt{\frac{l}{g\left(1 - \frac{\sigma}{4\sigma}\right)}}$$

$$T' = 2\pi\sqrt{\frac{l}{g\frac{3}{4}}}$$

$$T' = T\sqrt{\frac{4}{3}}$$

$$\boxed{T' = \frac{2T}{\sqrt{3}}}$$

If length of simple pendulum is very large

$$T = 2\pi\sqrt{\frac{1}{g\left(\frac{1}{R} + \frac{1}{l}\right)}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Very small Pendulum

R = Radius of earth

l = length of Pendulum

Case-1 $\quad l >>> R$

$$\boxed{T = 2\pi\sqrt{\frac{R}{g}}}$$

Case-2 $\quad l = R$

$$\boxed{T = 2\pi\sqrt{\frac{1}{g\frac{2}{R}}}} = T = 2\pi\sqrt{\frac{R}{2g}}$$

Case-3 $\quad l <<< R$

$$\boxed{T = 2\pi\sqrt{\frac{l}{g}}}$$

Que If effective length of a simple pendulum is equal to radius of earth (R), time period will be.

(1) $T = \pi\sqrt{\frac{R}{g}}$

(2) $T = 2\pi\sqrt{\frac{2R}{g}}$

(3) $T = 2\pi\sqrt{\frac{R}{g}}$

(4) $T = 2\pi\sqrt{\frac{R}{2g}}$ ✓

$$T = 2\pi\sqrt{\frac{1}{g\left(\frac{1}{R}+\frac{1}{R}\right)}}$$

$$\boxed{T = 2\pi\sqrt{\frac{R}{2g}}}$$

R

boy is swimming in a swing if he stands
he time period will

decrease, then increase

crease

rease

ain same

particle is executing simple harmonic motion
period T, then the time period of it
is.

ite

dentify the Correct definition.

Que. A particle is executing

Second pendulum :-

$$T = 2 sec \quad , \quad l = 1m$$

$$T = 2\pi \sqrt{\frac{l}{g}}$$

Que. If a second pendulum is moved to a planet where accel^n due to gravity is 4 times, the length of the second's pendulum on the planet should be made.

2 time

4 time

8 time

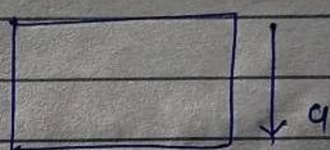
$$g' = 4g$$

$$T = 2\pi \sqrt{\frac{l}{g}}$$

(1) $1.57\ ms^{-1}$
(2) $3.12\ ms^{-1}$
(3) $2.0\ ms^{-1}$
(4) $6.42\ ms^{-1}$

Q. A Simple pendulum suspended from the ceilling of a Stationary lift has period T_0. When the lift descends at steady speed. the period is T_1, and when it descend with Const downward accln the period is T_2. Which one of the following is true?

(1) $T_0 = T_1 = T_2$
(2) $T_0 = T_1 < T_2$ ✓
(3) $T_0 = T_1 > T_2$
(4) $T_0 < T_1 < T_2$



Q. The time period of the oscillation of a simple pendulum is 1 minute. If its length is Increased by 44%. then its new time period of Oscillation will be

(1) 96 s
(2) 58 s
(3) 82 s
(4) 72 s

$T = 1$ mint.

$l_i = l$ (let)

$l_f = l + 44\%\ l$

$l + \frac{44}{100} l$

$l_f = \frac{144}{100} l$

$T' = 2\pi \sqrt{\frac{144}{100} \frac{l}{g}}$

$T' = \sqrt{\frac{144}{100}}\, T$

$T' = \frac{12}{10} T = 1.2\ T$

$\frac{1.2}{1\cancel{0}} \times 6\cancel{0}$ sec

72 sec

Que If the length of a clock pendulum increase by 0.2% due to atmospheric temp. rise then the loss in time of clock per day

(1) 86.4 s

(2) 43.2 s

(3) 72.5 sec

(4) 32.5 s

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Que

(1) $\tan^{-1}\left(\frac{g}{a}\right)$ with y axis in +x direction

$\tan^{-1}\left(\frac{a}{g}\right)$ " " " " -x direction.

$\tan^{-1}\left(\frac{a}{g}\right)$ " " " " +x direction

$\tan^{-1}\left(\frac{g}{a}\right)$ " " " " -x "

Que The time period of oscillation of a second pendulum on the surface of a planet having mass and radius double those of earth is

(1) 4 s

(2) 1 s

(3) $\sqrt{2}$ s

(4) $2\sqrt{2}$ s

$m_p = 2m_e$

$R_p = 2R_e$

$$T = 2\pi\sqrt{\frac{l}{g_e}} = 2\,sec$$

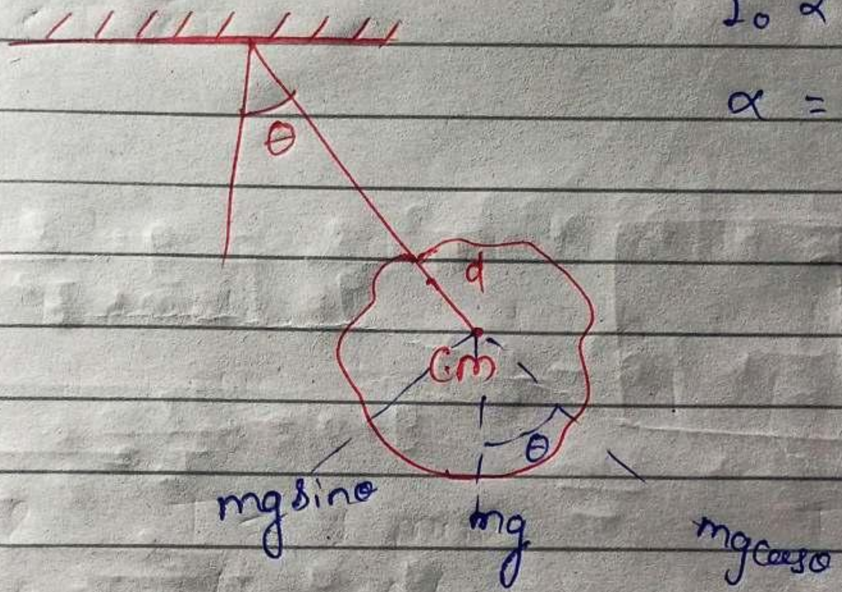
$$T' = 2\pi\sqrt{\frac{l}{g_e}} = 2\sqrt{2}$$

$2\sqrt{1.4}$

$$g_e = \frac{Gm}{R^2}$$

$$g_p = \frac{G\,2m}{4R^2} = \frac{g_e}{2}$$

Compound pendulum ⇒



$$\tau = mgd\sin\theta$$

$$I_0\alpha = mgd\sin\theta$$

$$\alpha = \frac{mgd}{I_0}\sin\theta$$

$$\omega^2$$

$$\because \omega = \sqrt{\frac{mgd}{I_0}}$$

$$\boxed{T = 2\pi\sqrt{\frac{I_0}{mgd}}}$$

d = dist. c.o.m & Point of Suspensor I_0 = m.o.I of Body form Point Suspension

Que A particle is executing SHM and its velocity v is related to its position (x) as $v^2 + ax^2 = b$ where an and b are positive constant. The frequency of oscillation of Particle is

(1) $\frac{1}{2\pi}\sqrt{\frac{b}{a}}$

(2) $\frac{\sqrt{a}}{2\pi}$

(3) $\frac{\sqrt{b}}{2\pi}$

(4) $\frac{1}{2\pi}\sqrt{\frac{a}{b}}$

$v^2 + ax^2 = b$

$v^2 = b - ax^2$

$v = \sqrt{b - ax^2}$

$v = \sqrt{a\left(\frac{b}{a} - x^2\right)}$

$v = \sqrt{a}\sqrt{\left(\frac{b}{a} - x^2\right)}$

$v = \omega\sqrt{(A^2 - x^2)}$

$\omega = \sqrt{a}$

$= \boxed{f = \frac{\sqrt{a}}{2\pi}}$ B

Que A simple pendulum

(1) $\sqrt{2mE}$

(2) $\sqrt{\frac{3mE}{2}}$

(3) $2\sqrt{mE}$

(4) $\sqrt{\frac{2mE}{3}}$

$K.E = \frac{1}{2}k(A^2 - x^2)$

$K.E = \frac{1}{2}k\left(A^2 - \frac{A^2}{4}\right)$

$K.E = \frac{1}{2}k\,\frac{3A^2}{4}$

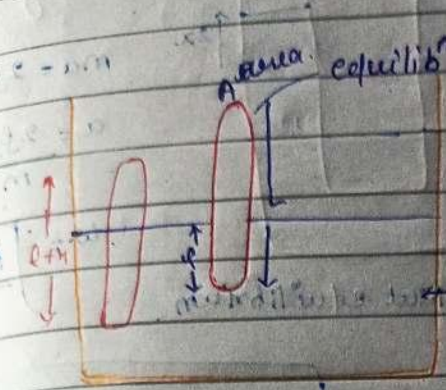
$K.E = \frac{3E}{4}$

$P = \sqrt{2mK.E}$

$\sqrt{\cancel{2}m \times \frac{3E}{\cancel{4}\,2}}$

$= \sqrt{\frac{3mE}{2}}$ B

Oscillation of Solid Cylinder Inside liquid



equilib^m $(F_B = mg)$

$$\rho l A g = \sigma l A g \longrightarrow (1)$$

ρ (density of liquid)

$$F_{net} = F_B - mg$$
$$= \rho A (l+x) g - \sigma A l g$$

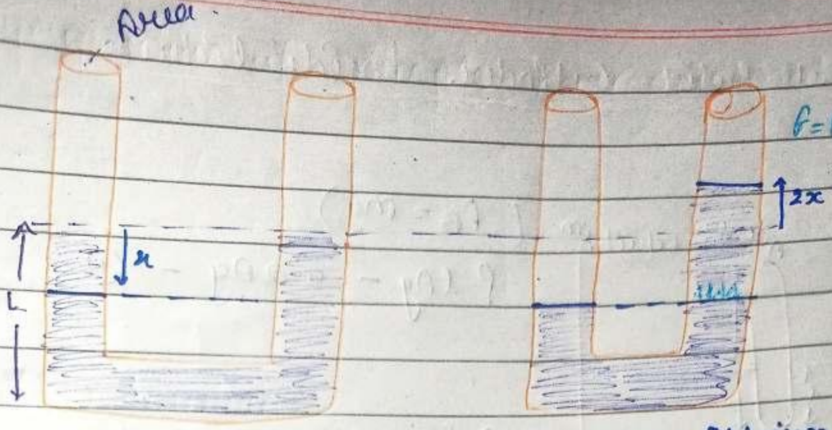
$$ma = \cancel{\rho A l g} + \rho A x g - \cancel{\sigma A l g}$$

$$\vec{a} = \frac{\rho A g x}{m} \qquad \omega = \sqrt{\frac{\rho A g}{m}}$$

$$\boxed{T = 2\pi\sqrt{\frac{m}{\rho A g}}}$$

$\therefore \quad T \propto \frac{1}{\sqrt{A}}$

$\therefore \quad T \propto \frac{1}{\sqrt{\rho}}$



At equilibrium. Not equilibrium.

$F = \Delta P = \rho g \, 2x A$

$ma = 2\rho g x A$

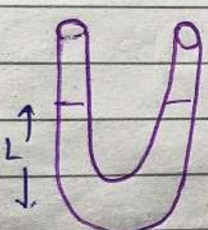
$a = \frac{2\rho g A}{m} x$

$\omega = \sqrt{\frac{2\rho g A}{m}}$

$$\boxed{T = 2\pi \sqrt{\frac{m}{2\rho g A}}}$$ mass of liquid.

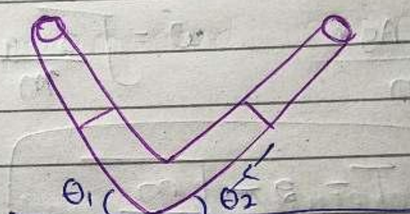
$T = 2\pi \sqrt{}$

Qu



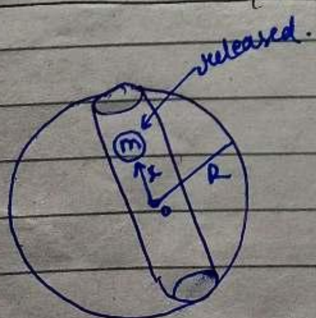
$T = 2\pi \sqrt{\frac{L}{g}}$

Qu



$T = 2\pi \sqrt{\frac{2L}{g(\sin\theta_1 + \sin\theta_2}}$

· Oscillation of Object in funnel of earth



$F = mg \Rightarrow \cancel{m}a = \cancel{m}g\frac{x}{R}$

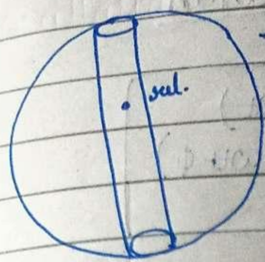
$$\boxed{g_x = \frac{gx}{R}}$$

$a = \frac{g}{R}x$

$\vec{a} = -g/R \, \vec{x}$

$\omega = \sqrt{g/R}$

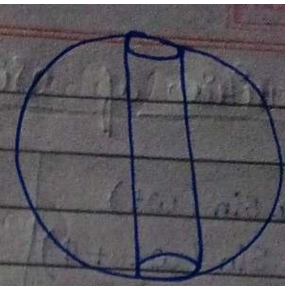
$$\boxed{T = 2\pi\sqrt{\frac{R}{g}}} = 84.6 \text{ sec.}$$



Time period of Oscill

$T = 2\pi\sqrt{\frac{R}{g}}$

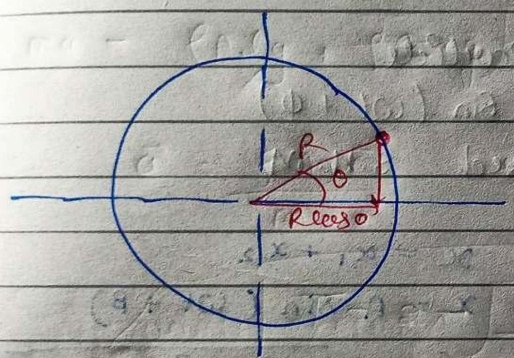
$\boxed{84.6 \text{ sec}}$

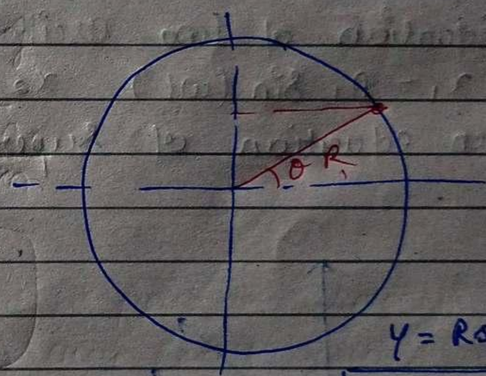


When two identical object released from $2x$ & x dist from centre then will object will cross the centre.

<u>Ans</u> — Same time

Simple Harmonic as a projection of Circular motion





$Y = R\sin\theta$

$\boxed{Y = R\sin(\omega t)}$

Superposition of Simple harmonic motion

$$\boxed{\begin{aligned} x_1 &= A_1 \sin(\omega t) \\ x_2 &= A_2 \sin(\omega t + \phi) \end{aligned}}$$

Both are Oscillatory in Same direction.

$$\boxed{\begin{aligned} x_1 &= A_1 \sin(\omega t) \\ y_1 &= A_2 \sin(\omega t + \phi) \end{aligned}}$$

Both are oscillatory in Perpendicular direction.

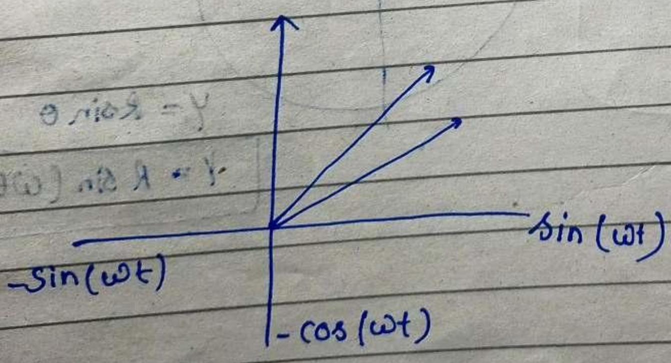
Superposition of S.H.M ⇒ Two Particles Oscillating in Same direction.

Que Equation of two oscillatory particle
$x_1 = A_1 \sin(\omega t)$ $x_2 = A_2 \sin(\omega t + \phi)$
then equation of superimposed S.H.M

$$x = x_1 + x_2$$

$$x = A \sin(\omega t + \beta)$$

$$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$$



If $A_1 = A_2 = A_0$

$$A = 2A_0 \cos\left(\frac{\phi}{2}\right)$$