

PRAYAS

JEE 2025



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Lecture - 02

Physics

Oscillations

(SHM)

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Physics Wallah



Topics *to be covered*

1

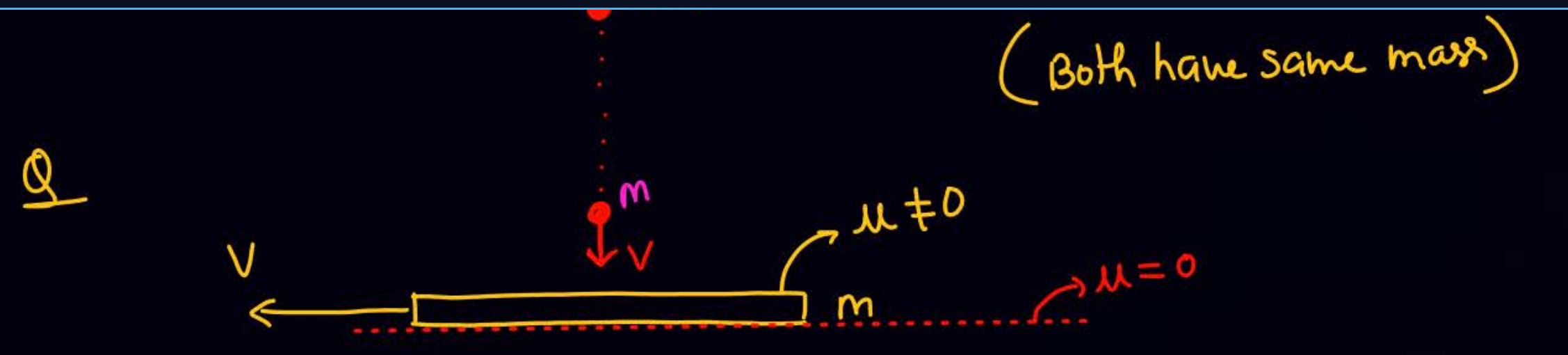
Equation of SHM

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2

3

4

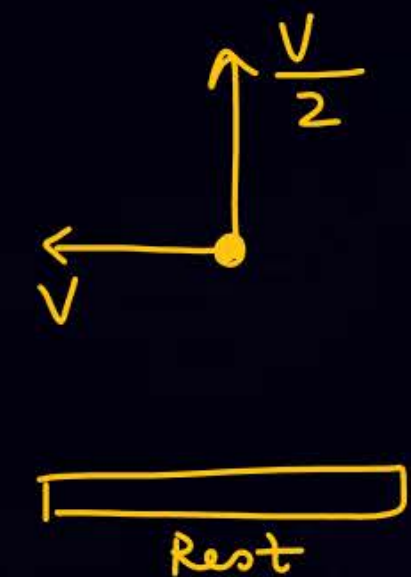
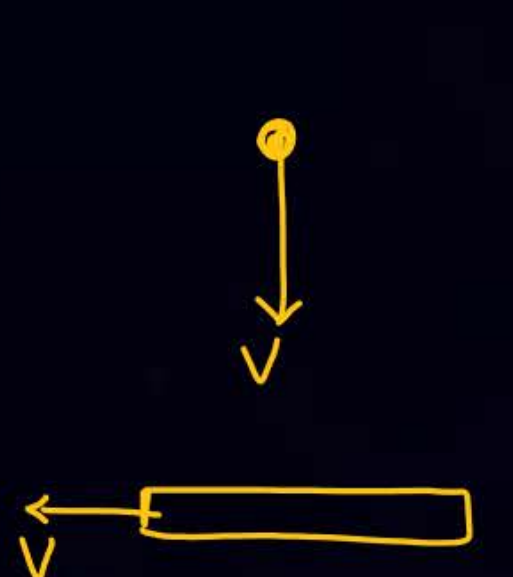
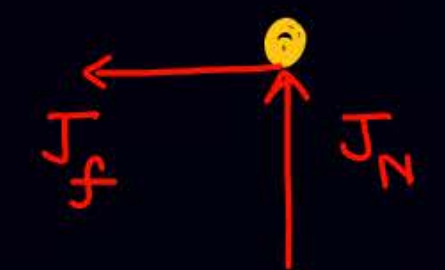
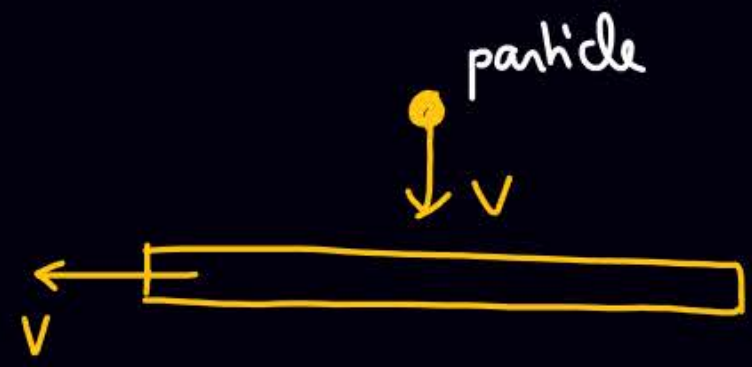


After collision platform (m) comes to at rest & velocity of ball become $\frac{v_0}{2}$
 find

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- ① $J_{\text{common normal}}$
- ② J_{friction}

- ③ (\vec{v}_f) ball just after collision
- * ④ coeff of friction b/w ball & platform



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$$-J_f = 0 - mv$$

$$J_f = mv$$

$$J_N = (\Delta P)_{ball} = m \frac{v}{2} - m(-v) = \frac{3mv}{2}$$

$$J_f = mv$$

④

$$J_N = \int N dt = \frac{3mv}{2}$$

$$J_f = \int f dt = \int \mu N dt = mv$$

$$\mu \int N dt = mv$$

$$\mu \frac{3mv}{2} = mv$$

$$\mu = \frac{2}{3}$$



SHM

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

Net ext. force

Displacement from M.P

SHM $\frac{d^2x}{dt^2}$ const

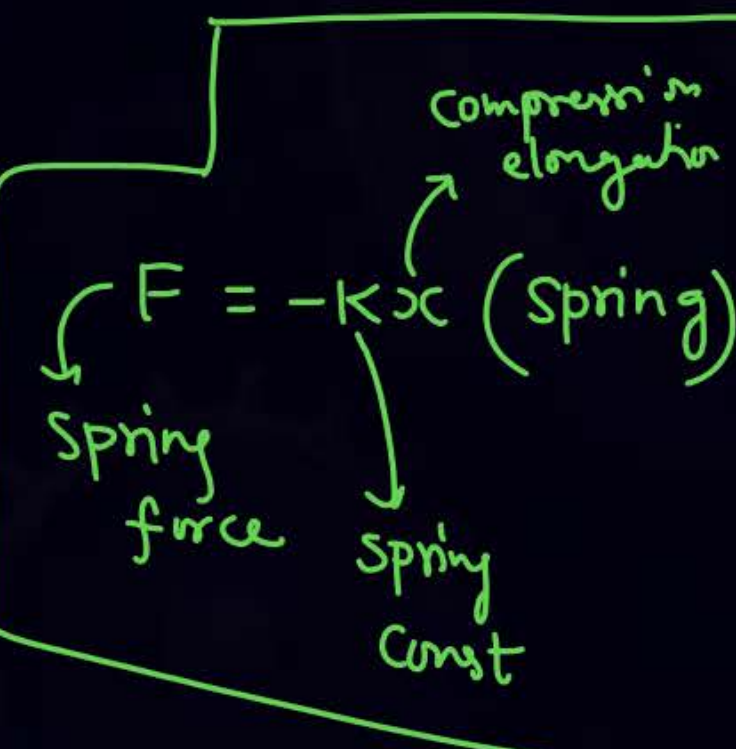


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$x \rightarrow$ Displacement from M.P.

- * acc is always towards the mp
- * \vec{a}, \vec{F}_{net} " " " " " "

Amplitude \rightarrow max Displacement from M.P.





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

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

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

$$\frac{d^2 \vec{x}}{dt^2} = -\frac{k}{m} \vec{x}$$

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

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

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

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

$$a = -\omega^2 [A \sin(\omega t + \phi)]$$

$$a = -\omega^2 x$$

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$$\omega^2 = \frac{k}{m}$$

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

$$F = -k x$$



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

$\omega t + \phi$ \longrightarrow phase

ϕ \longrightarrow initial phase

x \longrightarrow Displacement of particle from m.p.

A \longrightarrow Amplitude

ω \longrightarrow Angular frequency

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

T \longrightarrow time period

f \longrightarrow frequency = $\frac{1}{T}$

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

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

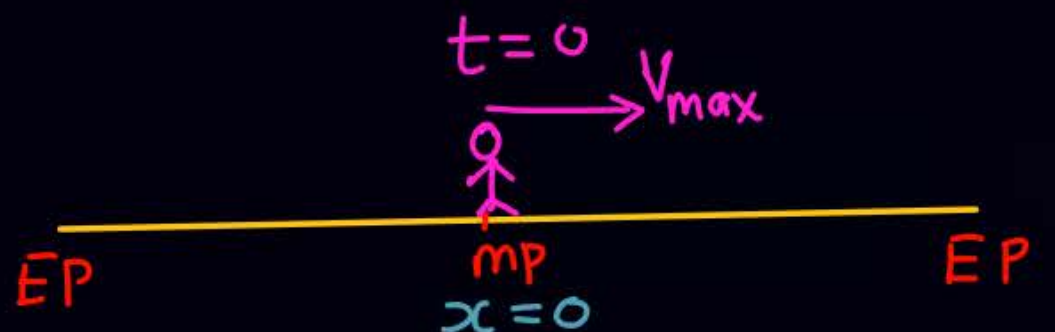
$$\vec{F} = -k\vec{x} \quad (\text{SHM})$$

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



Q $x = 10 \sin\left(\frac{\pi}{2}t\right)$

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



① $A = 10$, $\omega = \frac{\pi}{2}$, $T = ?$

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

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

$$T = 4 \text{ sec}$$

initial phase = 0

② $x = 10 \sin\left(\frac{\pi t}{2}\right)$

$$v = \frac{dx}{dt} = 10 \cdot \frac{\pi}{2} \cos(\pi t) \Rightarrow v_{\max} = 10\pi/2$$

$$a = \frac{dv}{dt} = -10 \frac{\pi}{2} \frac{\pi}{2} \sin \pi t$$

③ find x, v, a at $t=0$

$$t=0, \quad x=0, \quad v=10\pi/2 = v_{\max}$$

$$a=0$$



Q $x = 10 \sin\left(\frac{\pi}{2}t\right)$

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

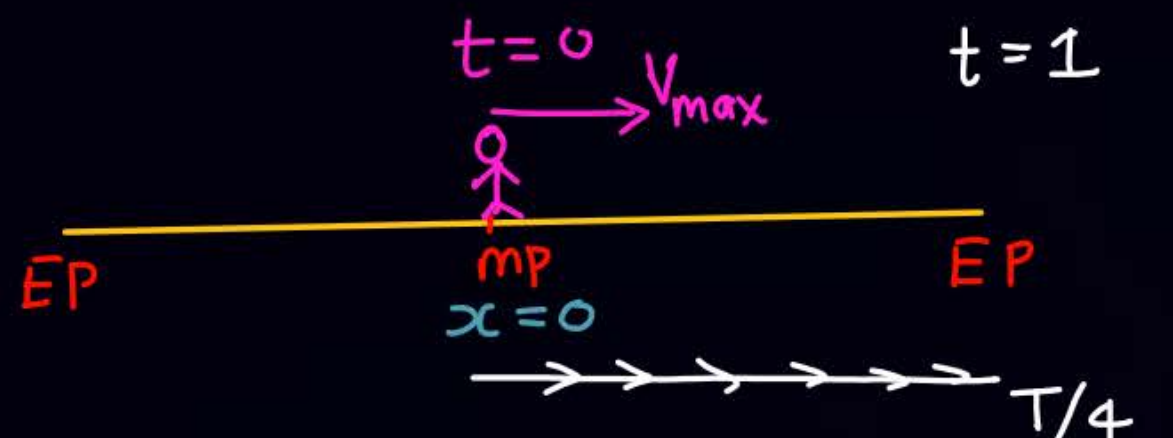
④ find x, v at $t = 1 \text{ sec}$

$$x = 10 \sin \frac{\pi}{2} t = 10 \sin \frac{\pi}{2} = 10$$

$$v = 10 \frac{\pi}{2} \cos\left(\frac{\pi}{2}t\right) = 0$$

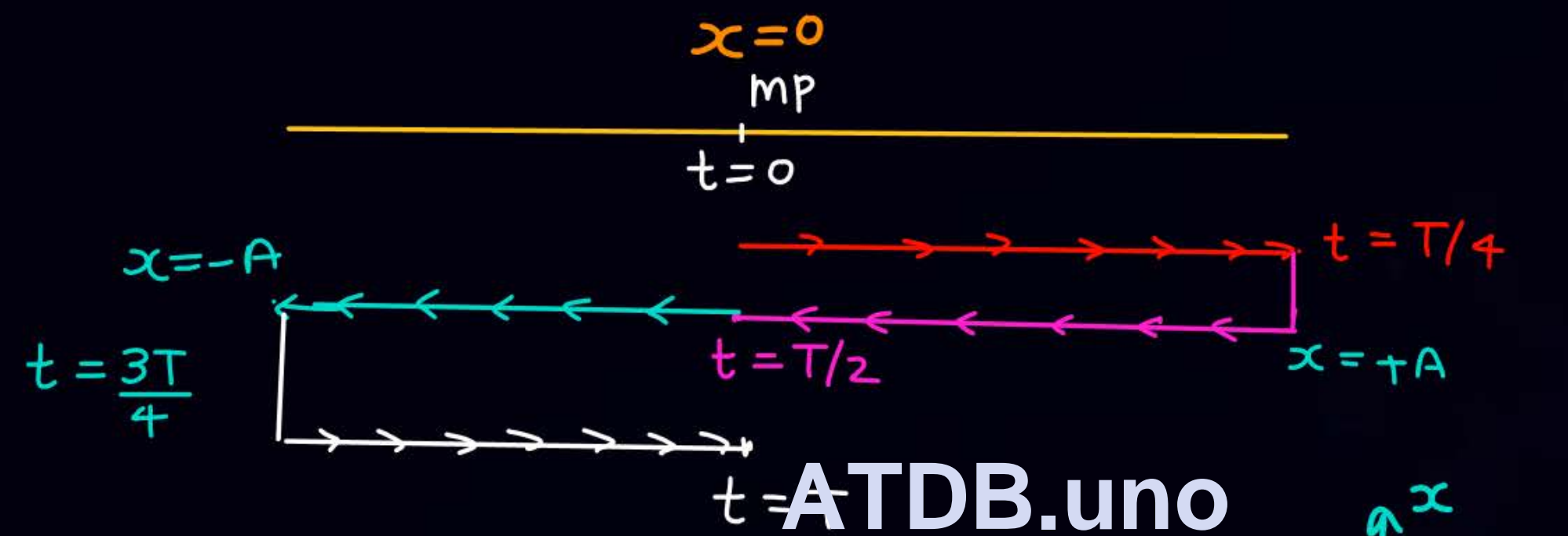
$$T = 4 \text{ sec}$$

$$\frac{T}{4} = 1 \text{ sec}$$



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$$x = A \sin(\omega t + 0)$$

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

$$KE = \frac{1}{2} m v^2 = \frac{1}{2} m A^2 \omega^2 \cos^2 \omega t$$

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





Q A particle is performing SHM on x-axis s.t.

$$x = 10 \sin\left(\frac{\pi t}{4} + \pi/6\right)$$

① $A = 10$
 $\omega = \pi/4 = 2\pi/T$
 $T = 8 \text{ sec}$

initial phase = $\pi/6 = 30^\circ$

$$v = f(t) = 10 \cdot \frac{\pi}{4} \cos\left(\frac{\pi t}{4} + 30^\circ\right)$$

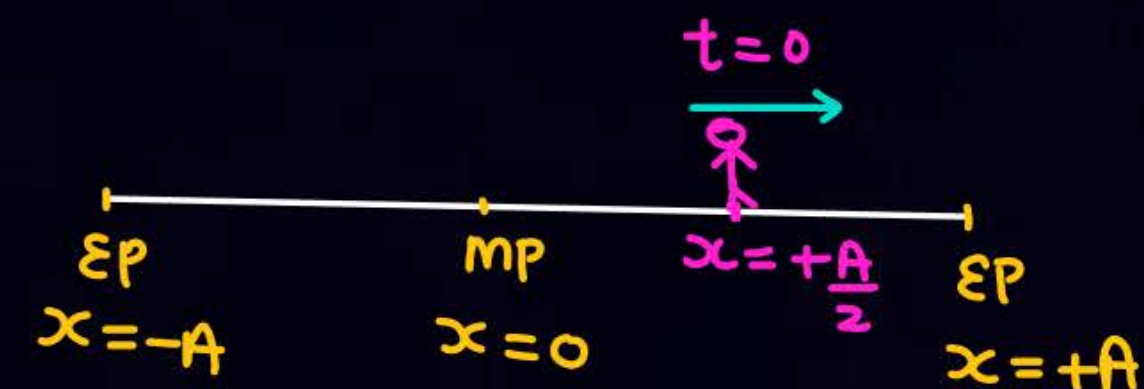
$$a = f(t) = -10 \left(\frac{\pi}{4}\right)^2 \sin\left(\frac{\pi t}{4} + 30^\circ\right)$$

$$v_{\max} = 10\pi/4$$

$$a_{\max} = 10 \left(\frac{\pi}{4}\right)^2$$

② Find location of particle, x, v at $t=0$

$$t=0, \quad x = 10 \sin(0 + 30^\circ) = \frac{10}{2} = \frac{A}{2} = 5$$



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$$v = 10 \frac{\pi}{4} \cos\left(\frac{\pi t}{4} + 30^\circ\right)$$

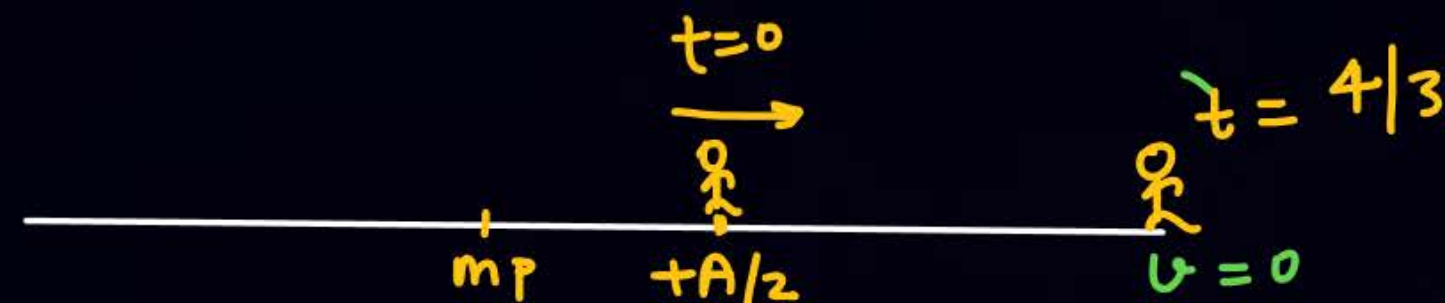
$$t=0, \quad v = 10 \frac{\pi}{4} \cos(0 + 30^\circ)$$

$$v = \frac{10\pi}{4} \frac{\sqrt{3}}{2}$$



$$\textcircled{3} \quad x = 10 \sin\left(\frac{\pi t}{4} + \frac{\pi}{6}\right)$$

find location & v at $t = \frac{4}{3}$



$$x = 10 \sin\left(\frac{\pi}{4} \cdot \frac{4}{3} + \frac{\pi}{6}\right) = +10$$

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$$v = 10 \frac{\pi}{4} \cos\left(\frac{\pi t}{4} + \frac{\pi}{6}\right)$$

$$t = \frac{4}{3}$$

$$v = 10 \frac{\pi}{4} \cos\left(\frac{\pi}{4} \cdot \frac{4}{3} + \frac{\pi}{6}\right) = 0$$



④ $x = 10 \sin\left(\frac{\pi t}{4} + \frac{\pi}{6}\right)$

$y = \frac{10\pi}{4} \cos\left(\frac{\pi t}{4} + \frac{\pi}{6}\right)$

find the time when y become 0 $\implies \frac{\pi t}{4} + \frac{\pi}{6} = (2n+1)\frac{\pi}{2}$ $n=0,1,2\dots$

" " " " " max \implies
 " " " a " 0
 " " " a " max
 " " " KE " max

$\frac{\pi t}{4} + \frac{\pi}{6} = n\pi$

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✓ Maths



अगर आपको eq^n given है
या eq^n मिल गयी } At any time
कुछ भी निकाल सकते हैं

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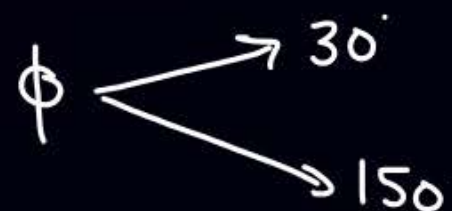
Q A particle is performing SHM on x-axis having amplitude A, time period T and angular freq. ω . Find eqⁿ of SHM if at $t=0$ particle is at $x = +\frac{A}{2}$ moving away from m.p.

Solⁿ

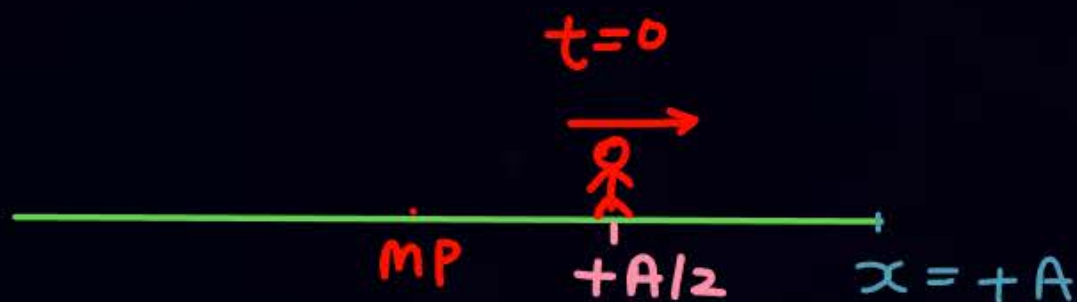
$$x = A \sin(\omega t + \phi)$$

$$t=0, x = \frac{A}{2} = A \sin(0 + \phi)$$

$$\sin \phi = A/2$$



(b)



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

At $t=0, v > 0$

$$v = A\omega \cos(0 + \phi) > 0$$

$$\cos \phi > 0$$

$$\phi = 30^\circ \checkmark$$

$$= 150^\circ \times$$

$$x = A \sin(\omega t + 30)$$



मजेदार shortcut तरीका
logical

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(b) Repeat the above prob. if at $t=0$, $x = +\frac{A}{2}$ moving towards m.p

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$$x = A \sin(\omega t + 150^\circ)$$



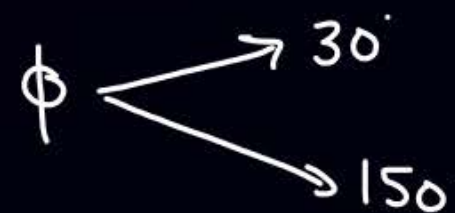
Q A particle is performing SHM on x-axis having amplitude A, time period T and angular freq. ω . Find eqⁿ of SHM if at $t=0$ particle is at $x = +\frac{A}{2}$ moving Towards m.p.

Solⁿ

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

$$t=0, x = \frac{A}{2} = A \sin(0 + \phi)$$

$$\sin \phi = \frac{1}{2}$$



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

At $t=0, v < 0$

$$v = A\omega \cos(0 + \phi) < 0$$

$$\cos \phi < 0$$

$$\phi = 30^\circ \times$$

$$= 150^\circ \checkmark$$

$$x = A \sin(\omega t + 150^\circ)$$



Home work

- DPP 01
- module \rightarrow Prarambh \Rightarrow 2, 8, 10, 11, 18, 22,
- Start Rotation KPP & JA PYQ

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THANK YOU

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