

# PRAYAS

## JEE 2025

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Lecture - 5

Physics

# Oscillations

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# Topics *to be covered*

1

spring block system (SHM)

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2

3

4



Q  $v^2 = 108 - 9x^2$  (particle performing SHM.)

find  $A, T, \omega, v_{\max}, a_{\max}$

Sol<sup>n</sup>

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

$$v^2 = \omega^2 A^2 - \omega^2 x^2$$

$$\omega^2 = 9, \quad \omega = 3$$

$$A^2 \omega^2 = 108$$

$$A^2 \times 9 = 108$$

$$A^2 = 12$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{3}$$

$$A = \sqrt{12}$$

$$v_{\max} = A\omega = \sqrt{12} \times 3$$

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$$v^2 = 108 - 9x^2$$

diff wrt  $x$

$$2v \frac{dv}{dx} = 0 - 18x$$

$$a = -9x$$

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

$$\boxed{\omega = 3}$$

$$v_{\max}^2 = 108 - 0$$

$$v_{\max} = \sqrt{108} = A\omega$$

$$\boxed{A = \sqrt{12}}$$



SHM equation possible

-  $\vec{F} = -k\vec{x}$  ✓

-  $\vec{F} = +k\vec{x}$  ✗

-  $F = -kx^2$  ✗

-  $F = 10x + 20$  ✗

-  $F = -10x + 20$  ✓ ⇒ MP at  $x=2$

$x = A \sin \omega t$  ✓

$x = A \cos \omega t$  ✓

$x = A \cos \omega t = A \sin(\omega t + 90)$



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Q  $x = \sin \omega t + \sqrt{3} \cos \omega t$  SHM ✓

$= 2 \left[ \frac{1}{2} \sin \omega t + \frac{\sqrt{3}}{2} \cos \omega t \right] = 2 \sin(\omega t + 60)$

Amplitude =  $2 = \sqrt{1 + (\sqrt{3})^2}$



$$\begin{aligned} Q \quad x &= \cos \omega t - \sin \omega t \\ &= \sqrt{2} \left( \frac{1}{\sqrt{2}} \cos \omega t - \frac{1}{\sqrt{2}} \sin \omega t \right) \end{aligned}$$

$$x = \sqrt{2} \cos(\omega t + 45^\circ)$$

$$x = \sqrt{2} \sin(\omega t + 45^\circ + 90^\circ)$$



$$Q \quad x = \sin^2 \omega t$$

$$x = \frac{1 - \cos 2\omega t}{2}$$

$$\begin{aligned} \cos 2\theta &= \cos^2 \theta - \sin^2 \theta \\ &= 2\cos^2 \theta - 1 \\ &= 1 - 2\sin^2 \theta \end{aligned}$$

$$x = \frac{1}{2} - \frac{1}{2} \sin(2\omega t + 90^\circ)$$

$$x = \sqrt{2} \sin(45^\circ - \omega t)$$

$$x = -\sqrt{2} \sin(\omega t - 45^\circ)$$

$$\begin{aligned} x &= \sqrt{2} \sin(\omega t - 45^\circ + 180^\circ) \\ &= \sqrt{2} \sin(\omega t + 135^\circ) \end{aligned}$$



①



$$\vec{F}_{net} = \vec{F}_N + \vec{F}_{mg} + \vec{F}_{sp}$$

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

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

②



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$$\vec{F}_{net} = \vec{F}_{mg} + \vec{F}_{sp}$$

$$\vec{F}_{net} = mg - k(x_0 + x)$$

$$\vec{F}_{net} = mg - kx_0 - kx$$

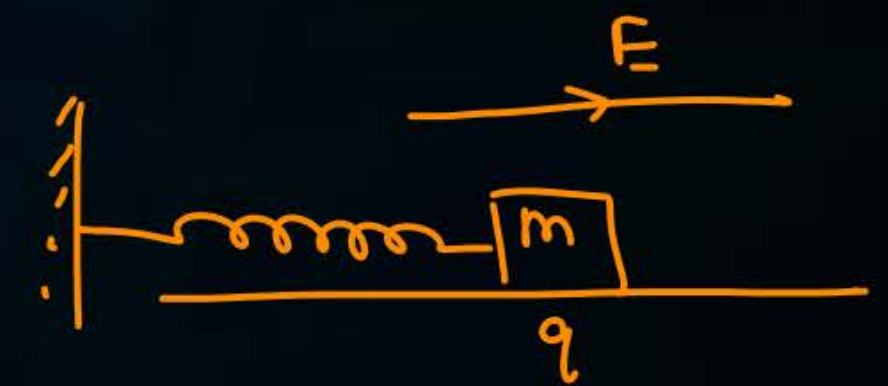
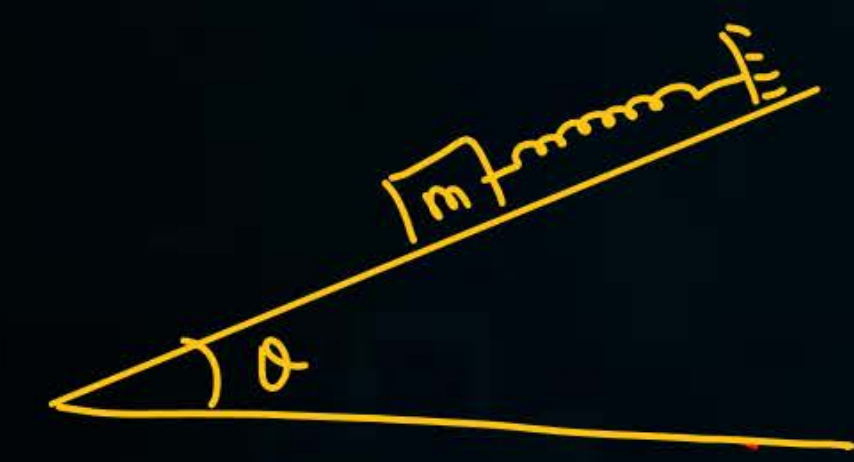
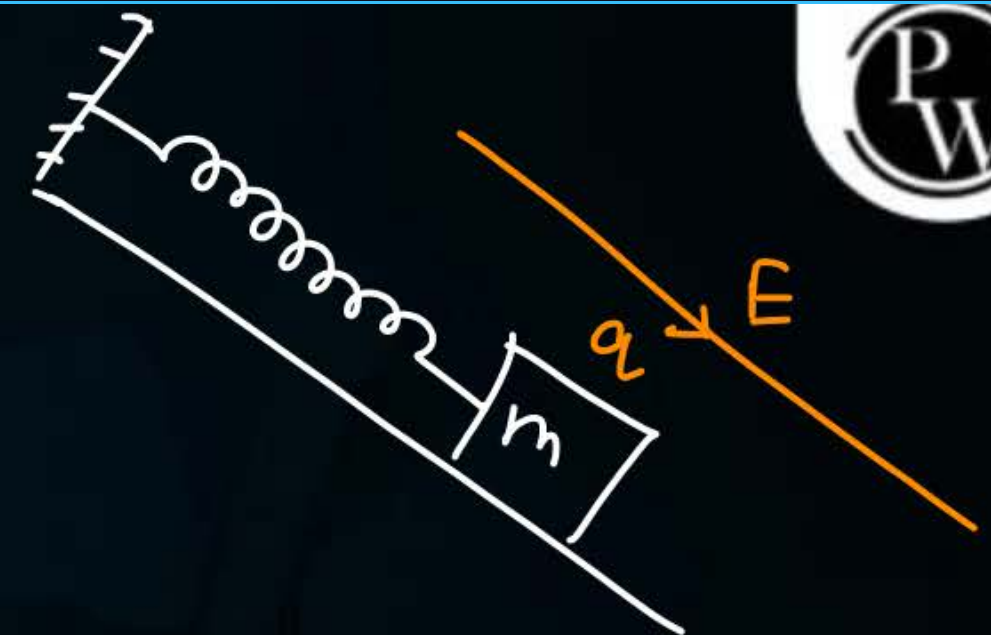
$$\vec{F}_{net} = -k\vec{x}$$

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



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

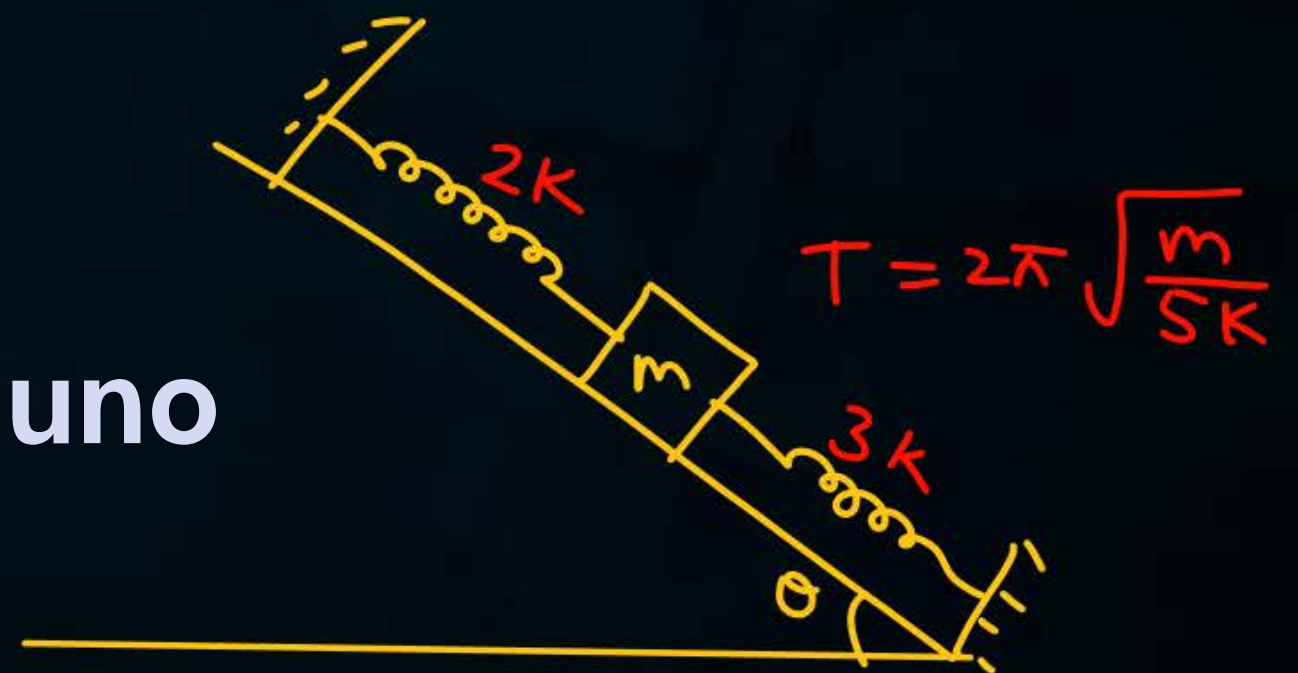
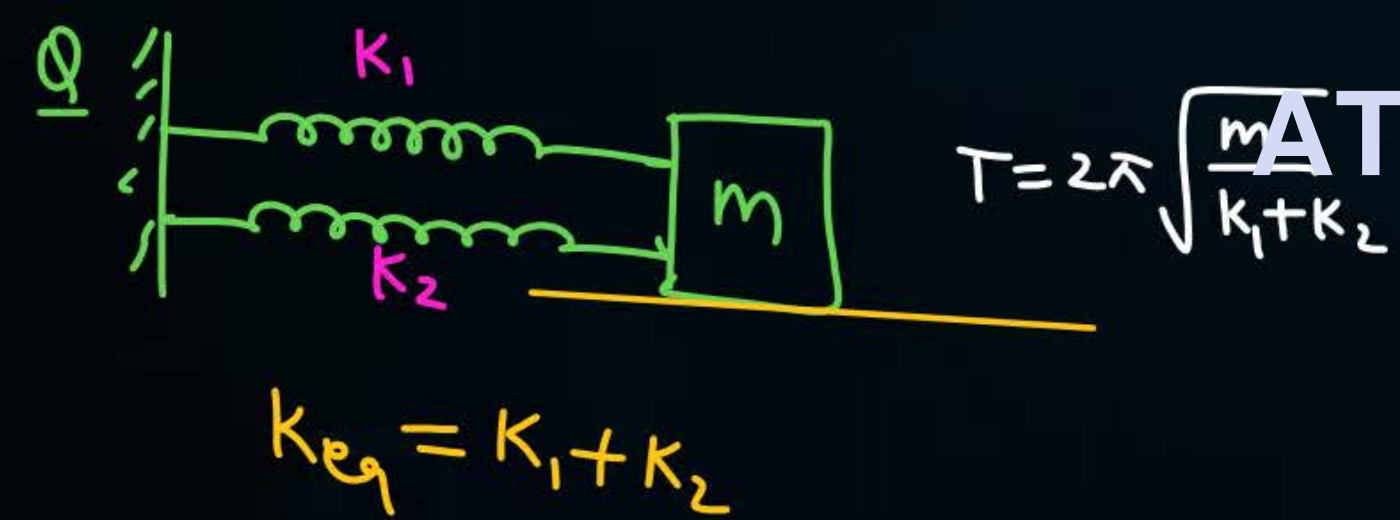
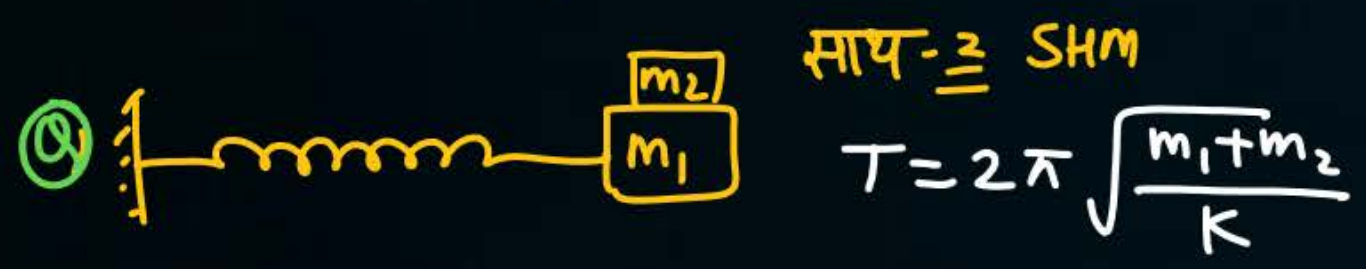
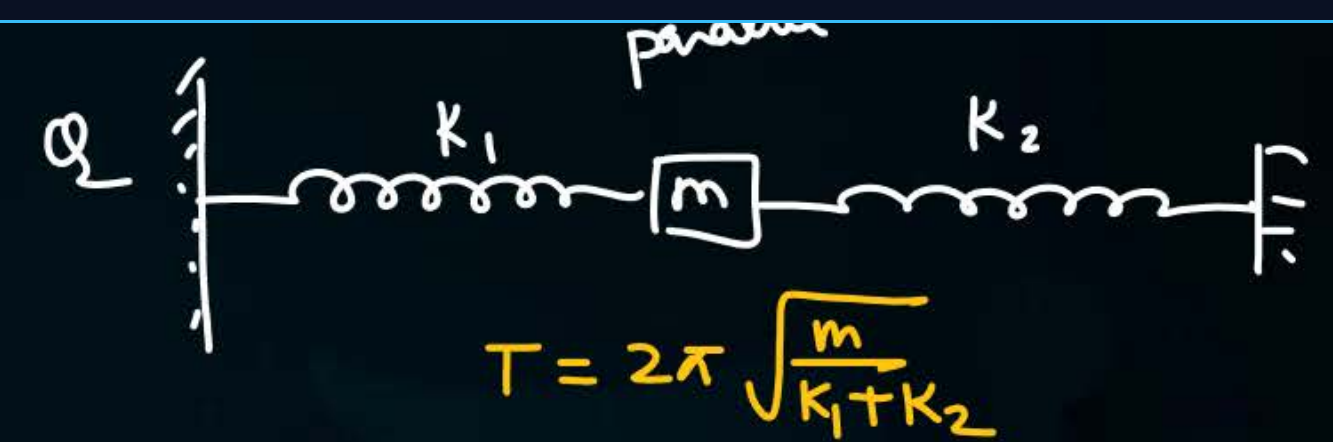
$\rightarrow$  mass  
 $\rightarrow$  Spring Const



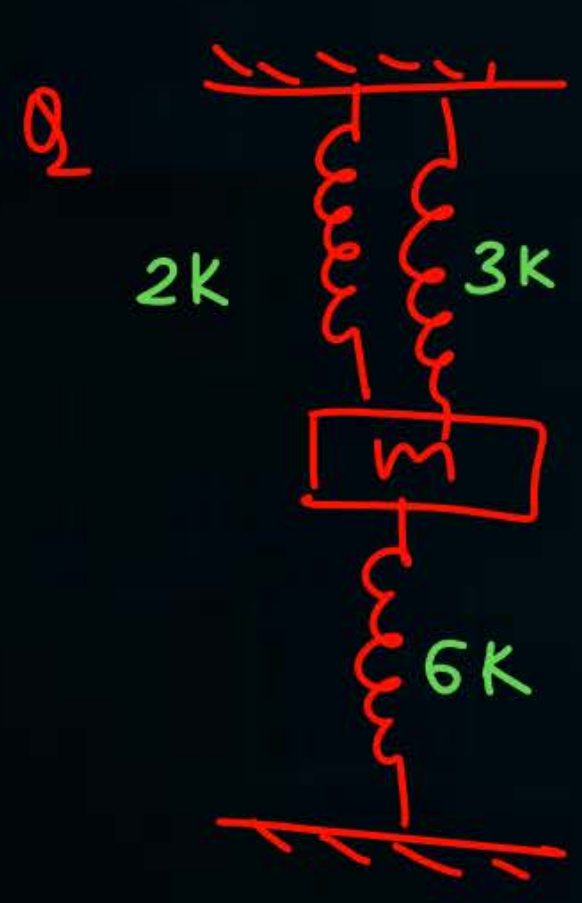
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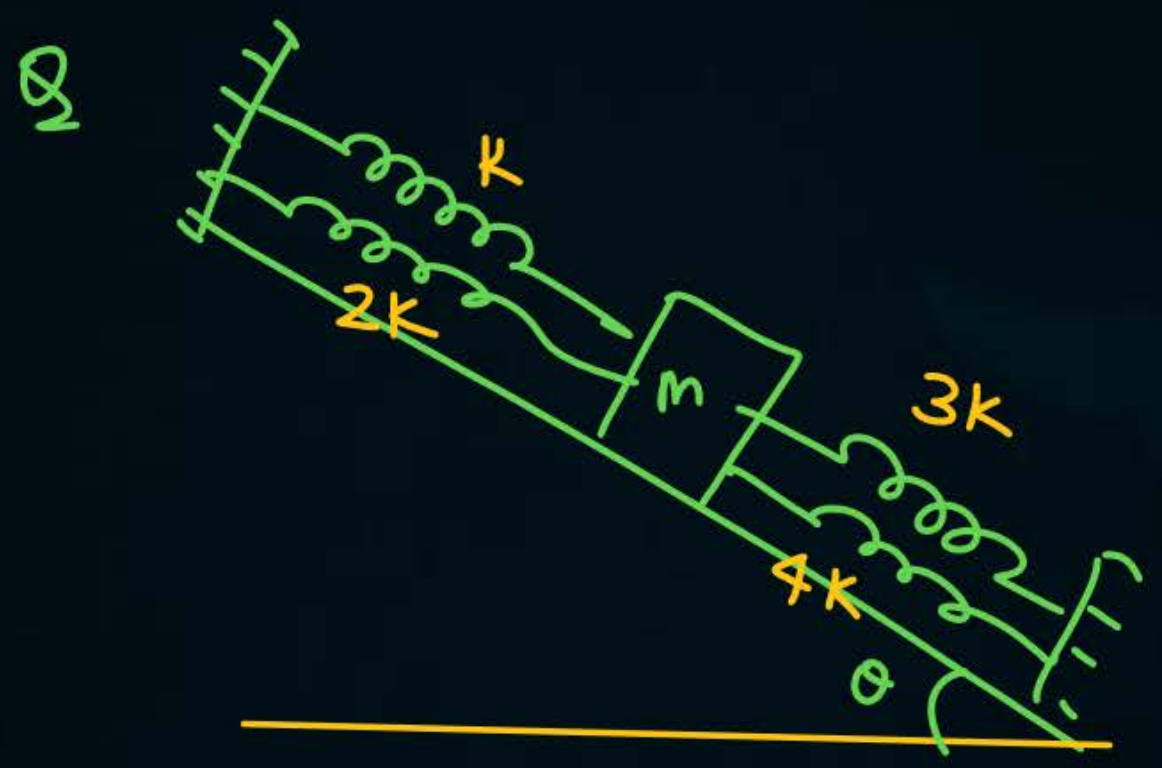
$$T = 2\pi \sqrt{\frac{m}{K_{eq}}}$$



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$$T = 2\pi \sqrt{\frac{m}{2K+3K+6K}}$$



$$T = 2\pi \sqrt{\frac{m}{10K}}$$



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

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

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



① Spring block system

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

②  $T = 2\pi \sqrt{\frac{\mu}{K}}$

$$\mu = \frac{m_1 m_2}{m_1 + m_2} = \text{Reduced mass}$$

③ Compound pendulum  $T = 2\pi \sqrt{\frac{I}{mgd_c}}$   $K \rightarrow K_{eq}$



$$T = 2\pi \sqrt{\frac{2}{7}}$$

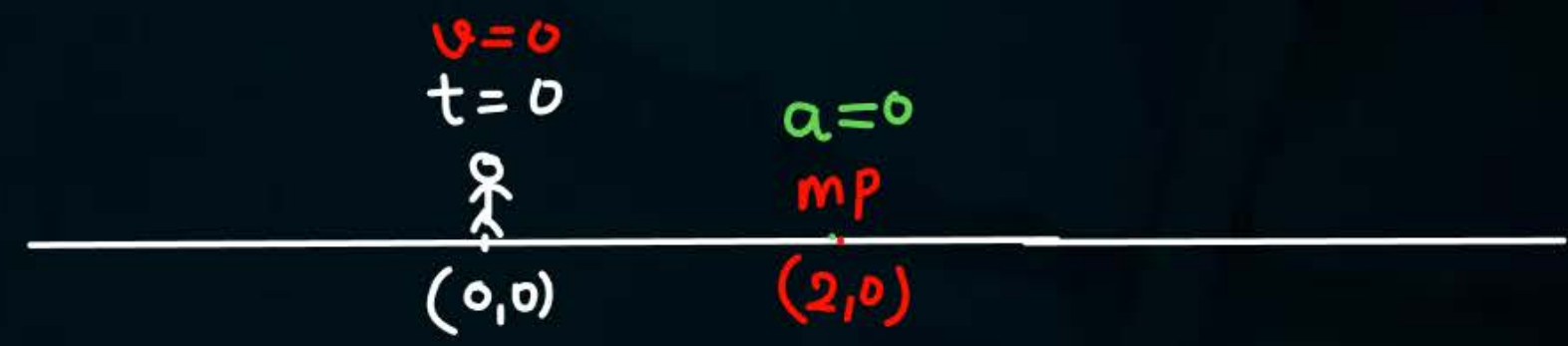
④ Simple pendulum  $T = 2\pi \sqrt{\frac{l}{g_{eff}}}$

⑤ Torsional pendulum  $T = 2\pi \sqrt{\frac{I}{C}}$   $\rightarrow$  torsional const



Q A particle is moving on axis such that net force on the particle is given by  $F = -10x + 20$ . If at  $t=0$ , particle is at rest at origin ( $m = 2.5 \text{ kg}$ ).

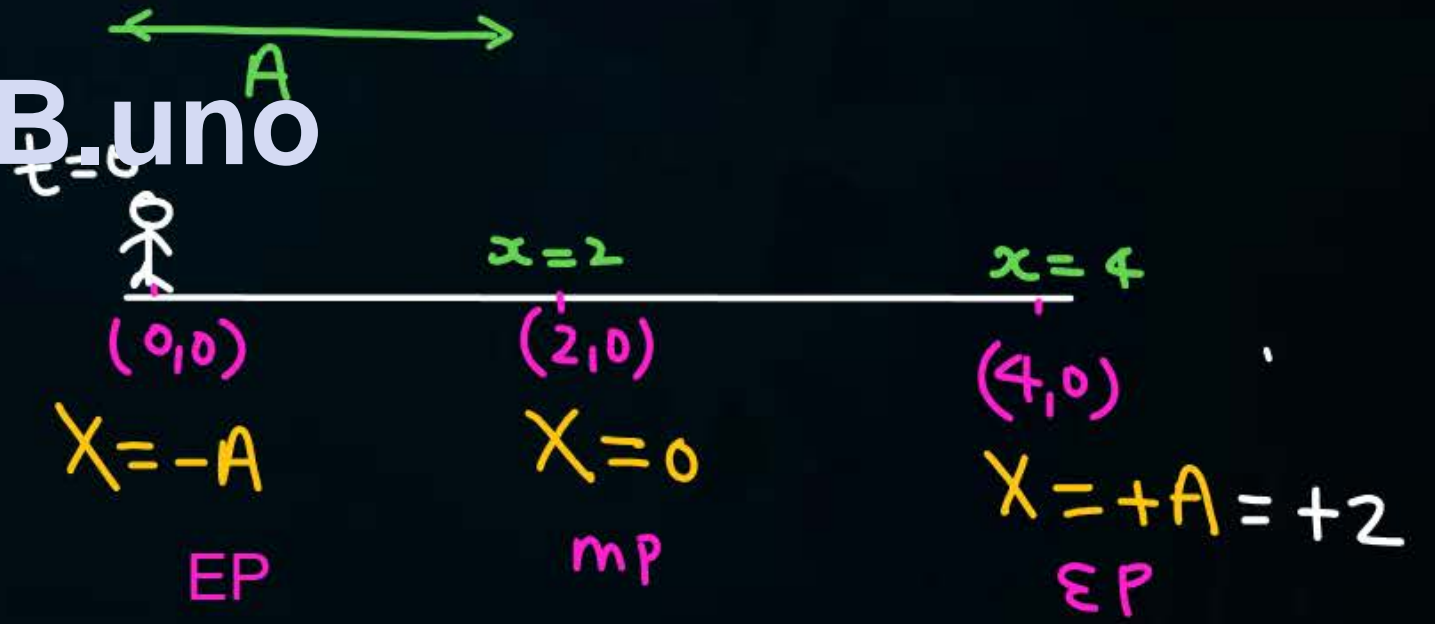
Sol<sup>n</sup>



$$F = -10(x-2) = -10X$$

↳ x-coordinate

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$A = 2$

$K = 10 = m\omega^2$

$10 = 2.5\omega^2$

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

↳ Displ. from mp

$$X = A \sin(\omega t + 3\pi/2)$$

$X = -A$   
EP

$X = 0$   
mp

$X = +A = +2$   
EP

$X = x - 2$



$$m = 5 \text{ kg}$$

Q A particle is performing SHM s.t.

$F = -20x + 60$ . At  $t=0$  particle is at rest at  $x = +7$

find eq<sup>n</sup> of SHM

Sol<sup>n</sup>

$$F = -20x + 60$$

$$K = 20 = m\omega^2$$

$$20 = 5\omega^2$$

$$\omega = 2$$

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$$A = 4$$

$$x = -A$$

EP

$$x = 3$$

$$a = 0$$

$$x = 0$$

MP

$$t = 0$$

Rest

0

$$x = 7$$

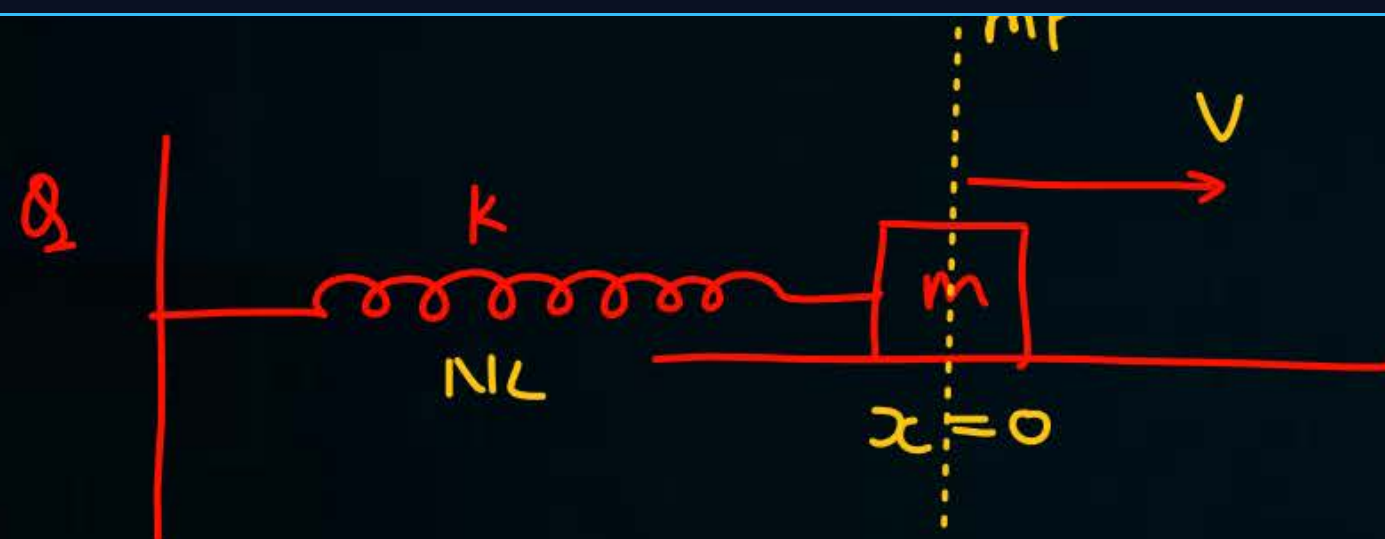
$$v = 0$$

$$x = +A$$

EP

$$X = 4 \sin\left(2t + \frac{\pi}{2}\right) = x - 3$$

$$X + 3 = x$$



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

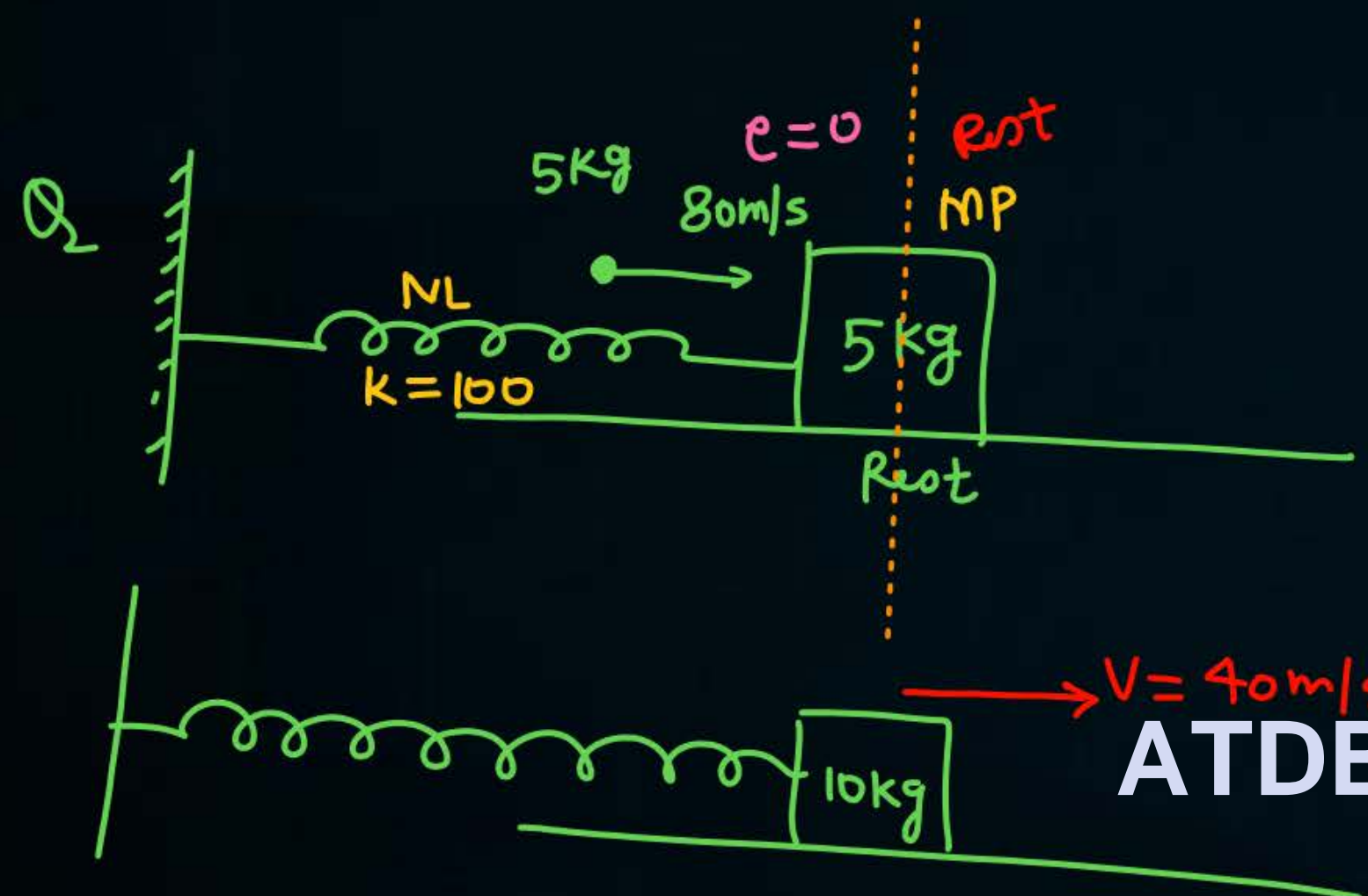
$$T = 2\pi \sqrt{\frac{m}{k}}$$

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

$$v = A\omega$$

$$A = \frac{v}{\omega}$$

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$$(P_i)_{\text{joint}} = (P_f)_{\text{joint}}$$

$$5 \times 80 + 0 = (5 + 5) v_f$$

$$v_f = 40\text{m/s}$$

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

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

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{100}{10}} = \sqrt{10}$$

$$v = A\omega$$

$$40 = A\sqrt{10}$$



SKC

SHM पता करना

①  $m_p \equiv F_{net} = 0$

②  $x$  displace. करो  $m_p$  से FBD बना लीं

③  $F_{net}$

④  $\vec{F}_{net} = -k\vec{x}$  SHM ✓

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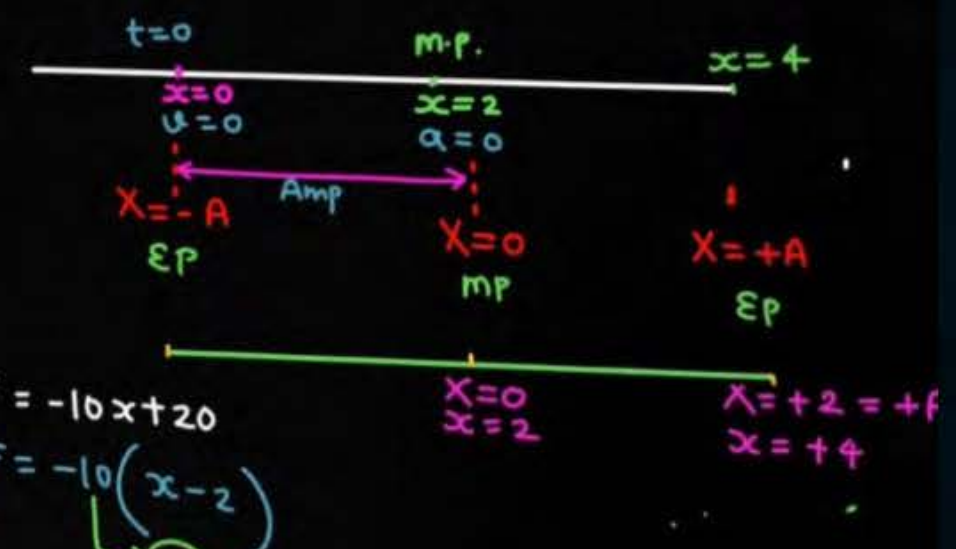
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Q

A particle moving on x-axis s.t. at  $t=0$  it is at rest at origin  $x=0$  and net force acting on the particle is  $F = -10x + 20$  find. ①  $A, \omega, T, f, \phi$ , find  $x_{max}$ ,  $x = f(t)$ ,  $v = f(t)$

② Eq<sup>n</sup> of SHM.  
 Sol<sup>n</sup>  $A = 2, \phi = 270^\circ$   
 $k = 10 = m\omega^2$   
 $\omega = \sqrt{10}$

Displ. from mp.  
 $X = A \sin(\omega t + \phi)$   
 $X = 2 \sin(\sqrt{10} t + 270^\circ)$   
 $x = X + 2$   
 $x = 2 \sin(\sqrt{10} t + 270^\circ) + 2$



$F = -20x + 10$   
 (JA)



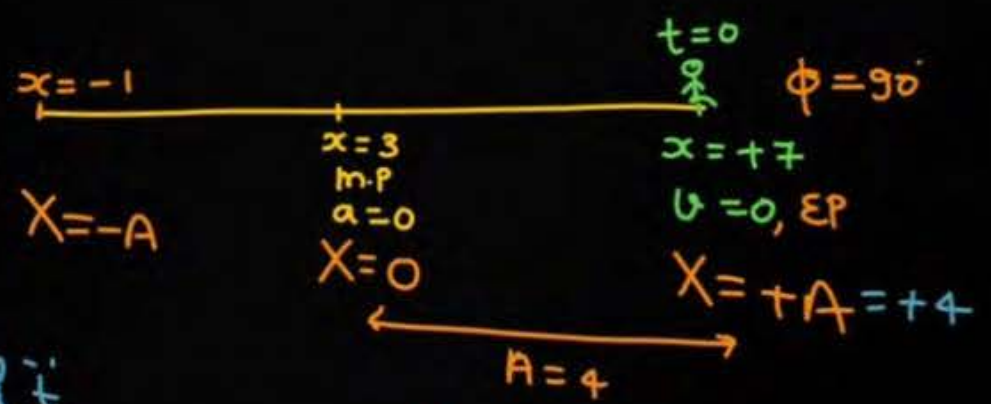
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Q

$m = 5 \text{ kg}$   
 A particle is moving on x-axis s.t.  $F = -20x + 60$  and at  $t=0$  particle is at  $x = +7$  at rest.

find  $A, \omega, x = f(t), v = f(t)$ , Eq<sup>n</sup> of SHM.

Sol<sup>n</sup>  $k = 20 = m\omega^2$   
 $20 = 5\omega^2$   
 $\omega = 2$   
 $\omega = \frac{2\pi}{T}$   
 $A = 4$   
 $T = \pi$



$X = 4 \sin(2t + 90^\circ)$

x-co-ordinate as fcn of t

$x = X + 3 = 4 \sin(2t + 90^\circ) + 3$

$v_{max} = A\omega = 4 \times 2 = 8$





## Home Work

- DPP -04

- HCV (5M)  $\rightarrow$  11, 12, 15, 16, 17, 18, 21, 22, 23, 25, 28,

- module Next '3' days H.W  $\Rightarrow$  Monday  $\Rightarrow$  Prarambh  $\Rightarrow$  (1-31)

Tuesday  $\rightarrow$  Prabhal  $\rightarrow$  (1-13), (18, 19, 20)

Wednesday  $\rightarrow$  Pankshat  $\Rightarrow$  (1-9), 23, 24,

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# THANK YOU

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