JEE MAIN

SIMPLE HARMONIC MOTION

REVISION

Now that's how you REVISE

EDUNITI YouTube Channel

Learn Like Never Before

List of Content on Eduniti YouTube Channel:

1. PYQs Video Solution Topic Wise:
   (a) JEE Main 2018/2020/2021 Feb & March
2. Rank Booster Problems for JEE Main
3. Part Test Series for JEE Main
4. JEE Advanced Problem Solving Series
5. Short Concept Videos
6. Tips and Tricks Videos
7. JEE Advanced PYQs
8. Formulae Revision Series

........and many more to come

TOPICS COVERED

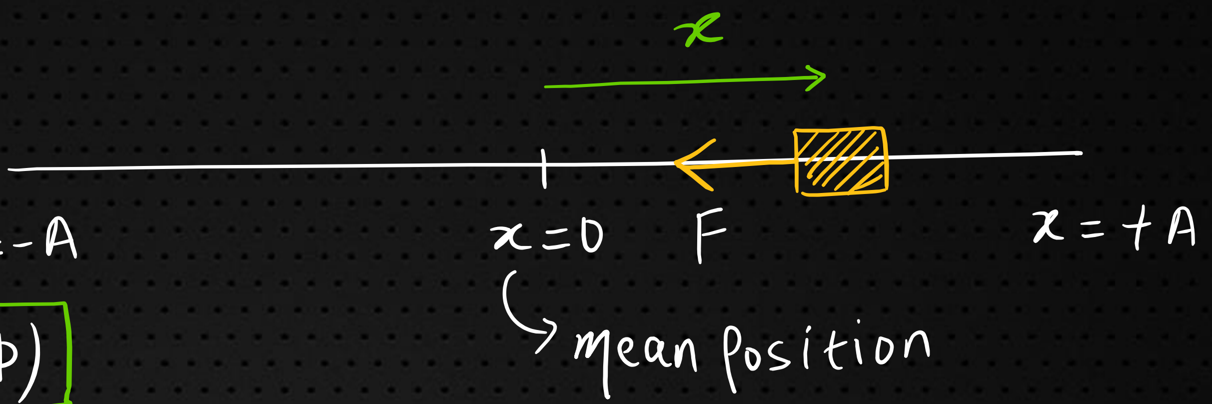
1. Kinematics and Energy of SHM
2. Steps to Find Time Period (Linear/Angular SHM)
3. Spring Block and Simple Pendulum
4. T of Spring Block (under constant force)
5. Combination of Spring
6. Spring Cut
7. Two Block System (Reduced Mass)
8. SHM of Block in a Liquid
9. SHM of Piston in Cylinder
10. SHM in Tunnel of Planet
11. SHM of Charge
12. Physical Pendulum
13. Torsional Pendulum
14. SHM of Dipole in Field (Electric/Magnetic Dipole)
15. Time Period of Simple Pendulum (Different Conditions)
16. Superposition of SHM

1. KINEMATICS/ENERGY OF SHM

$F \propto -x$

$\Rightarrow F = -kx$

$a = -\left(\frac{k}{m}\right)x$



$\frac{d^2x}{dt^2} + \frac{k}{m}x = 0 \Rightarrow \boxed{x = A\sin(\omega t + \phi)}$

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

(a) $V(x) = \omega\sqrt{A^2 - x^2}$
$V(t) = A\omega\cos\omega t$

$V_{max} = \pm\omega A, \quad x = 0$

$V_{min} = 0, \quad x = \pm A$

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

$a_{max} = \pm\omega^2 A, \quad x = \mp A$

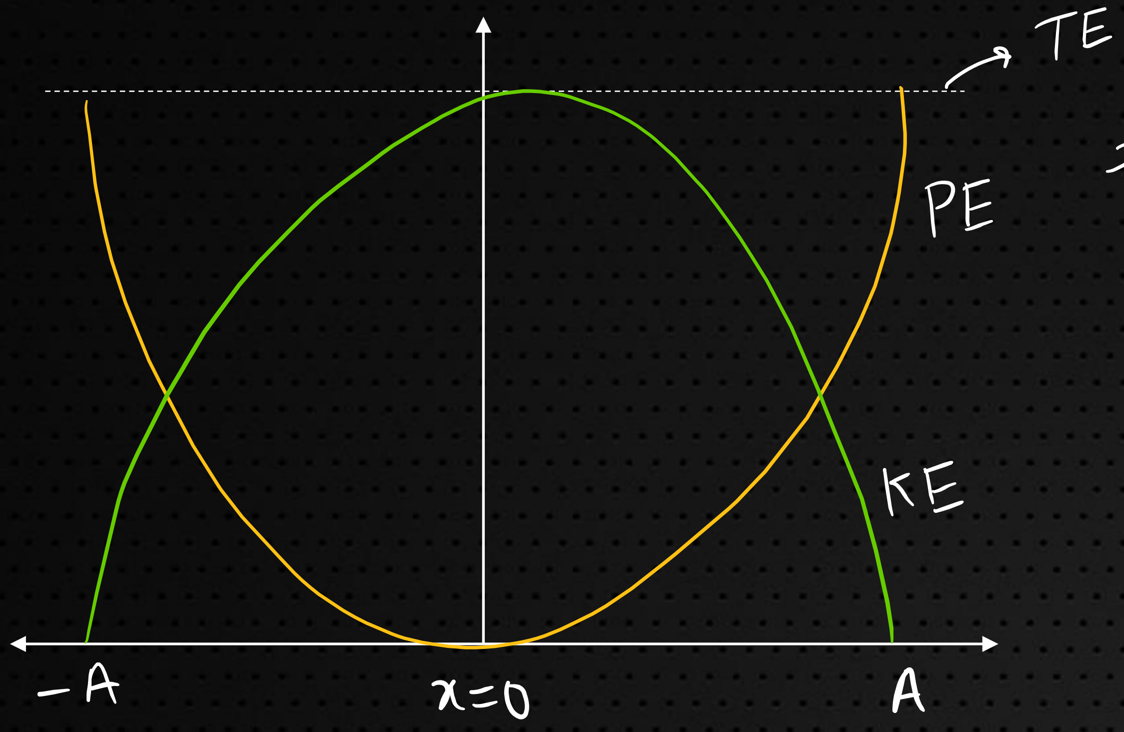
$a_{min} = 0, \quad x = 0$

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

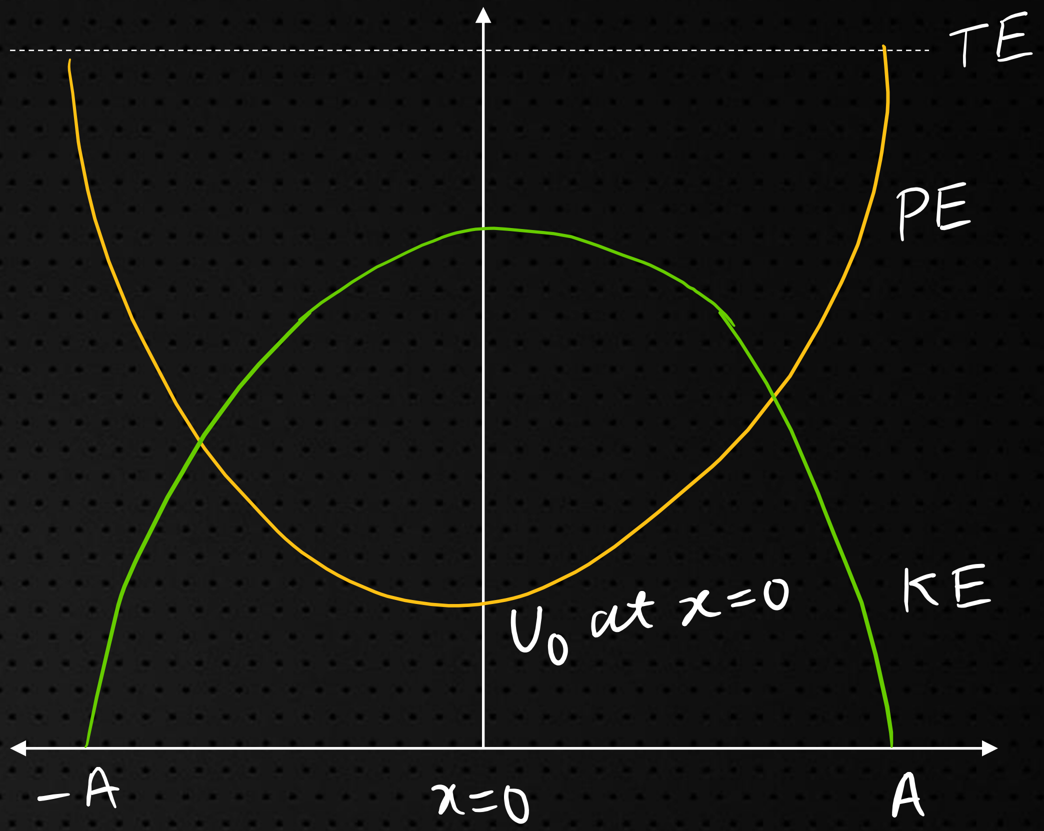
$TE = KE + PE = \frac{1}{2}m\omega^2 A^2$

constant.

#

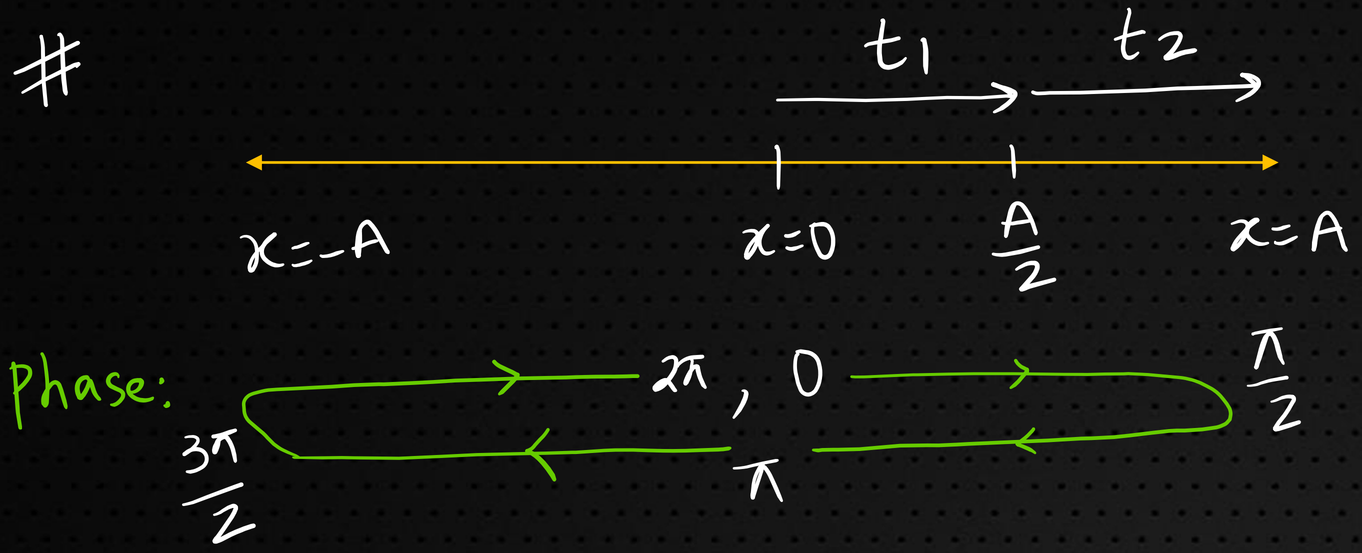


#



↳ At mean position system has PE.

#



(i) $t_{x=0 \to x=A} = T/4$

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

$\Rightarrow \frac{A}{2} = A\sin\omega t_1$

$\Rightarrow \frac{1}{2} = \sin\omega t_1 \Rightarrow \frac{\pi}{6} = \frac{2\pi}{T} t_1$

$\therefore \boxed{t_1 = \frac{T}{12}}$

(iii) $t_2 = \frac{T}{4} - t_1 = \boxed{\frac{T}{6}}$

2. STEPS TO FIND TIME PERIOD

LINEAR SHM

(1.) Give linear displacement of x from mean position

(2.) Find linear acceleration. $F = ma$

(3) you will get

$$a = -\underbrace{(\text{some constant})}_{\omega^2} \times x$$

$$\therefore T = 2\pi/\omega$$

ANGULAR SHM

(1.) Give angular displacement of θ (small) from mean position.

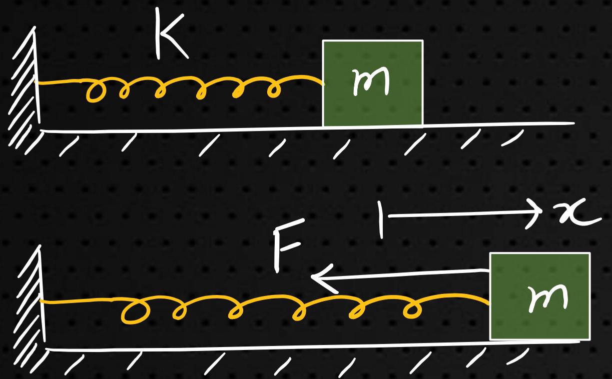
(2.) Find angular acceleration $\tau = I\alpha$

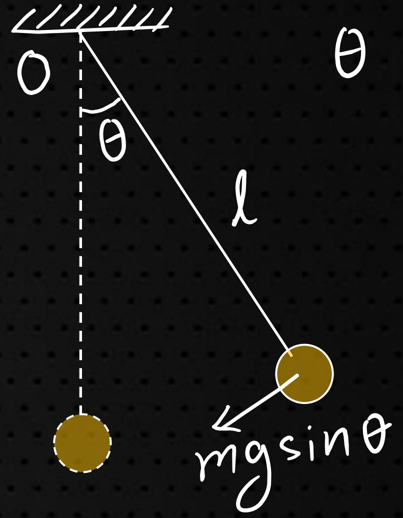
(3.) you will get

$$\alpha = -\underbrace{(\text{some const.})}_{\omega^2} \times \theta$$

$$\therefore T = 2\pi/\omega$$

3. SPRING BLOCK AND SIMPLE PENDULUM





θ is very small

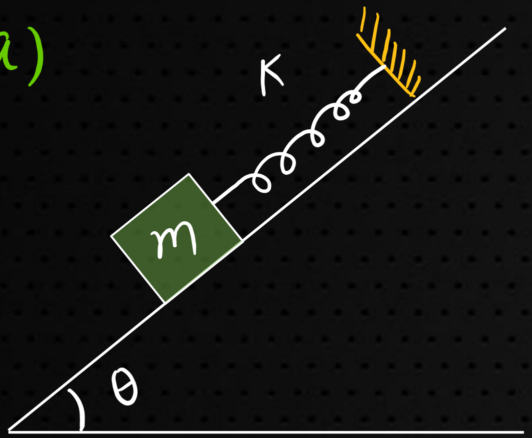
$$F = -Kx$$
$$\Rightarrow ma = -Kx$$
$$\Rightarrow a = -\left(\frac{K}{m}\right)x$$
$$\left(\frac{K}{m}\right) \rightarrow \omega^2$$
$$\therefore T = 2\pi\sqrt{\frac{m}{K}}$$

$$\tau = -mg\sin\theta \times l$$
$$\Rightarrow I\alpha = -mgl \times \theta$$
$$\Rightarrow ml^2\alpha = -mgl \times \theta$$
$$\Rightarrow \alpha = -\left(\frac{g}{l}\right)\theta$$
$$\left(\frac{g}{l}\right) \rightarrow \omega^2$$
$$\therefore T = 2\pi\sqrt{\frac{l}{g}}$$

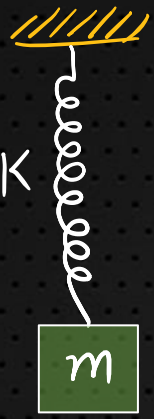
4. SPRING BLOCK (under presence of Constant force)

NOTE: Result remains same (only mean position changes)

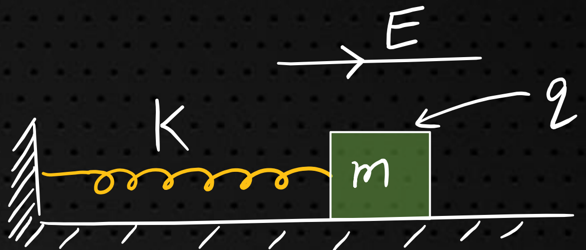
(a)



(b)



(c)

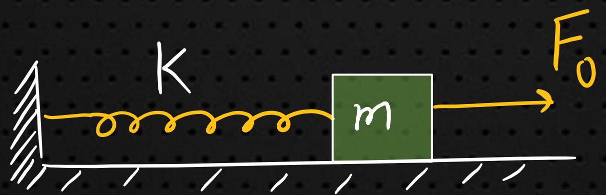


(i) In all cases

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

(ii) Mean position changes.

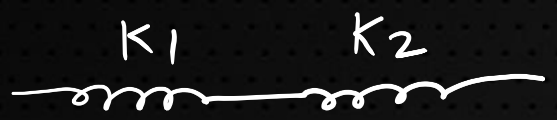
(d)



F_0 is external constant force

5. COMBINATION OF SPRING

(a)

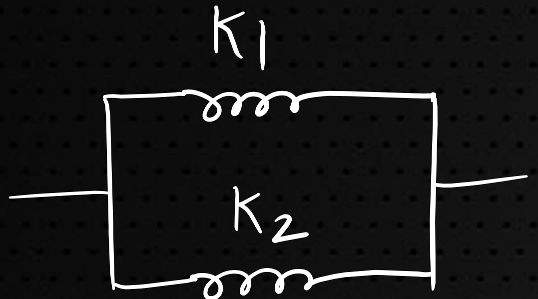


(SERIES)

≡

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

(b)



(PARALLEL)

≡

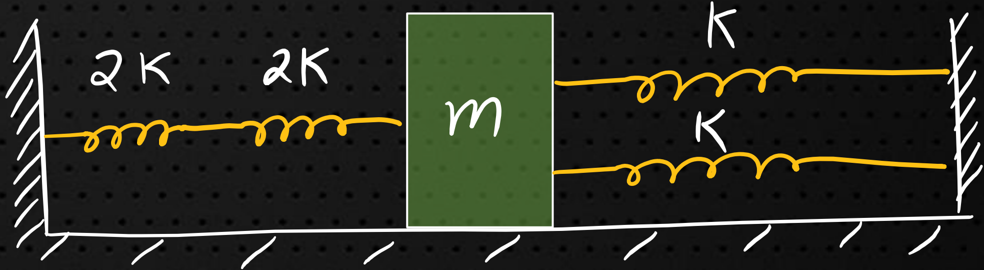
$$K_{eq} = K_1 + K_2$$

Ex: 1

Here still K_1 and K_2 are in Parallel.

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

Ex: 2



$$K_{eq} = \frac{2K}{2} + 2K = 3K$$

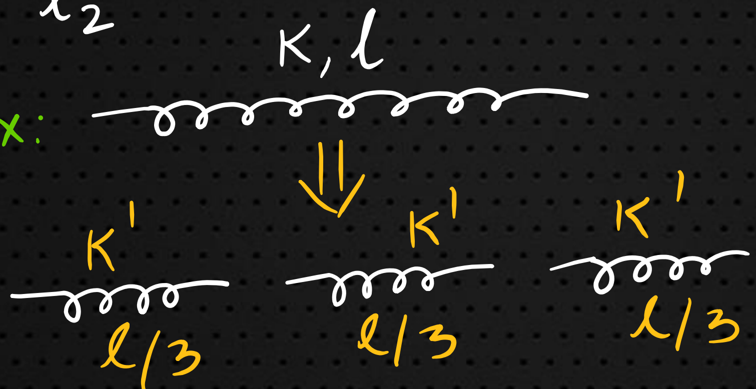
$$T = 2\pi\sqrt{\frac{m}{3K}}$$

6. SPRING CUT ($K \cdot l = \text{const.}$)

$$K l = K_1 l_1 = K_2 l_2$$

$$\therefore K_1 = \frac{K l}{l_1}, \quad K_2 = \frac{K l}{l_2}$$

Ex:

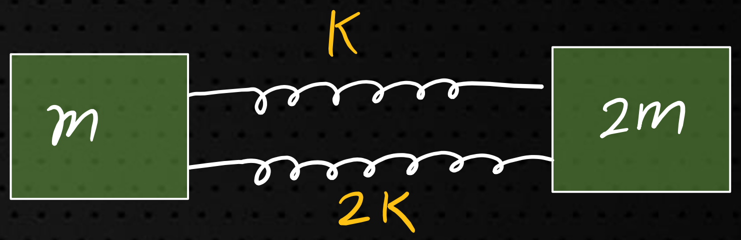


$\therefore$ Each $K' = 3K$

7. TWO BLOCK SYSTEM

$$\left(\text{Reduced mass, } \mu_{red} = \frac{m_1 m_2}{m_1 + m_2}\right)$$

Ex:



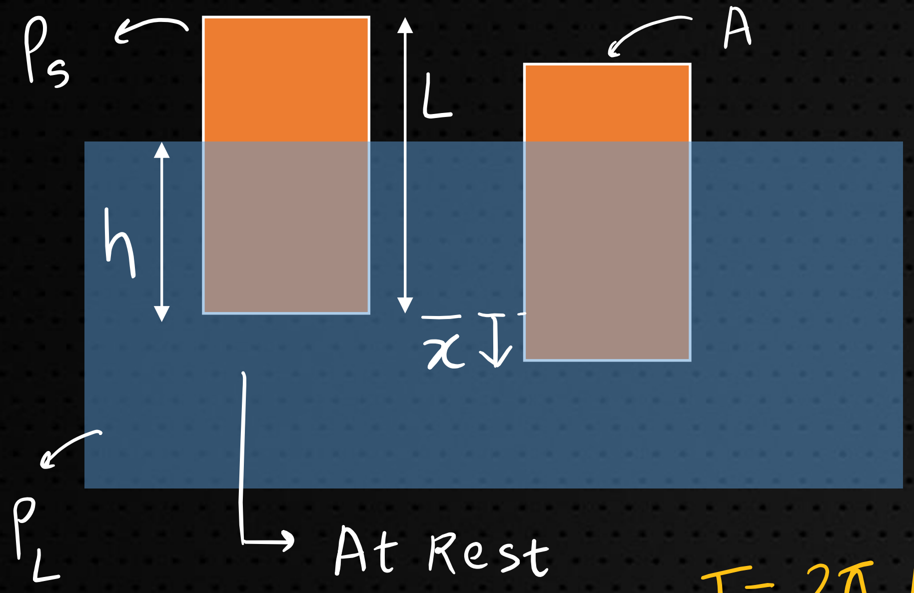
$$T = 2\pi \sqrt{\frac{\mu_{red}}{K_{eq}}}$$

$$\# \ \mu_{red} = \frac{m \times 2m}{m + 2m} = \frac{2m}{3}$$

$$K_{eq} = K + 2K = 3K$$

$$\therefore T = 2\pi \sqrt{\frac{2m}{9K}}$$

8. BLOCK IN LIQUID ($\rho_s < \rho_L$)



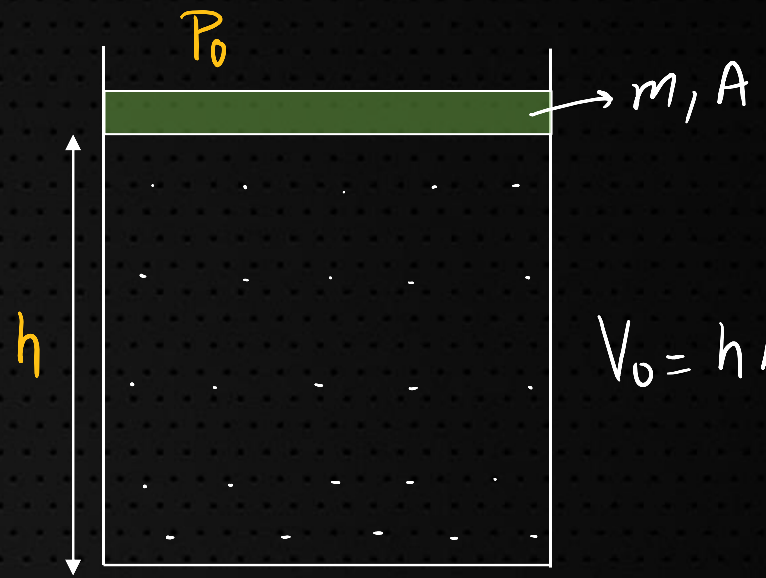
$$T = 2\pi\sqrt{\frac{h}{g}} \quad \text{or} \quad T = 2\pi\sqrt{\frac{m}{A\rho_L g}}$$

A: Cross-section area

At equillibrium:

$$\frac{\rho_s}{\rho_L} = \frac{h}{L}$$

9. SHM OF PISTON IN CYLINDER



$V_0 = hA$

Piston given small displacement

Isothermal

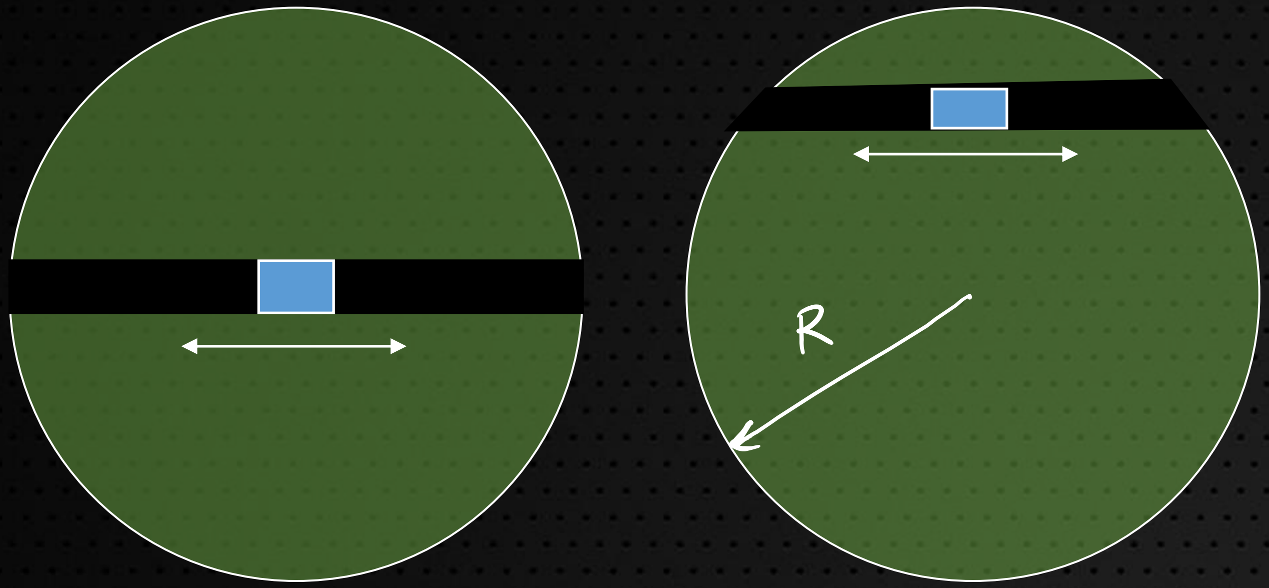
$$T = 2\pi\sqrt{\frac{mV_0}{P_0A^2}}$$

Adiabatic

$$T = 2\pi\sqrt{\frac{mV_0}{\gamma P_0 A^2}}$$

C_p/C_v

10. SHM IN TUNNEL IN A PLANET

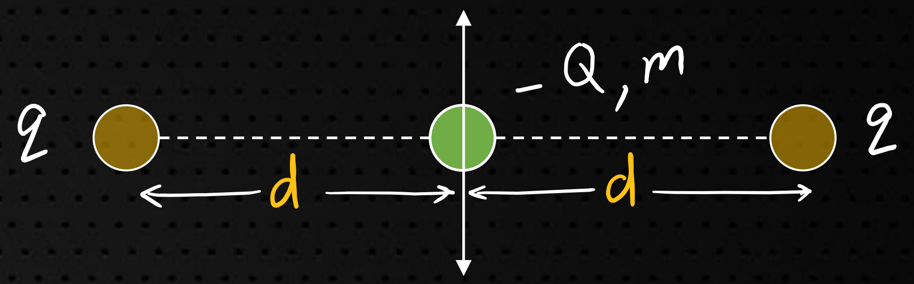


$$T = 2\pi\sqrt{\frac{R}{g}}$$

where $g = \frac{GM}{R^2}$

11. SHM OF CHARGE

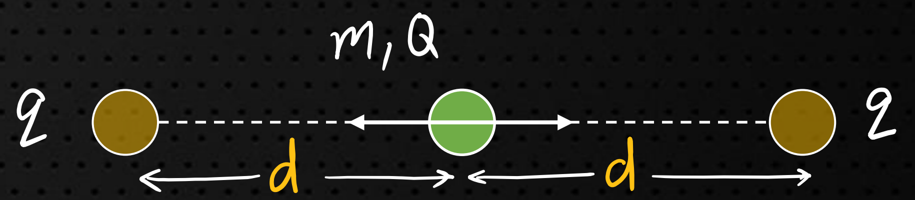
(a)



For small disturbance

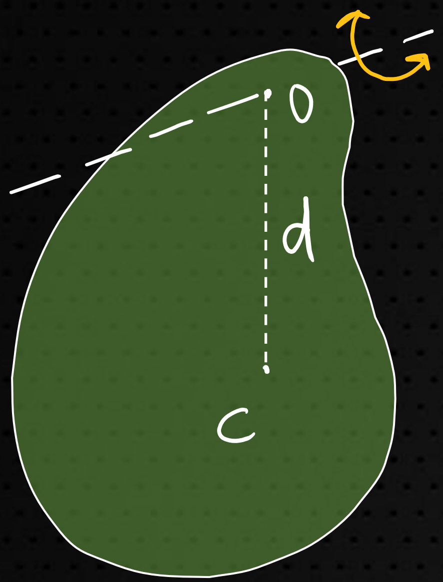
$$T = 2\pi\sqrt{\frac{md^3}{2KQq}}, \quad K = \frac{1}{4\pi\varepsilon_0}$$

(b)



$$T = 2\pi\sqrt{\frac{md^3}{4KQq}}, \quad K = \frac{1}{4\pi\varepsilon_0}$$

12. PHYSICAL PENDULUM



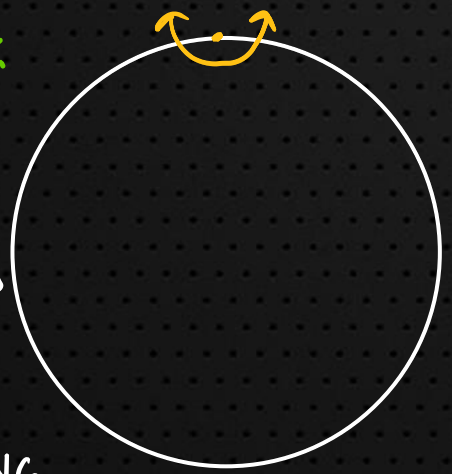
$$T = 2\pi\sqrt{\frac{I}{mgd}}$$

I : MOI of body about O (point of suspension)

d : Distance between O and C (centre of mass)

Ex:

M, R



RING

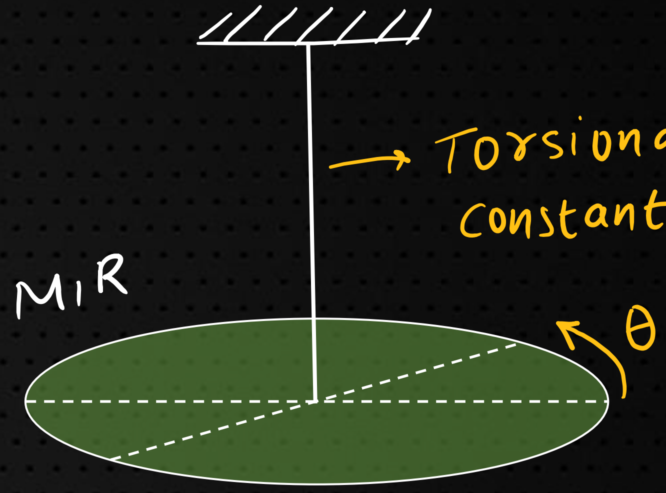
$I = MR^2 + MR^2$
$= 2MR^2$

$d = R$

$$\therefore T = 2\pi\sqrt{\frac{2MR^2}{MgR}}$$

$$\Rightarrow T = 2\pi\sqrt{2R/g}$$

13. TORSIONAL PENDULUM



$\tau = -C\theta$

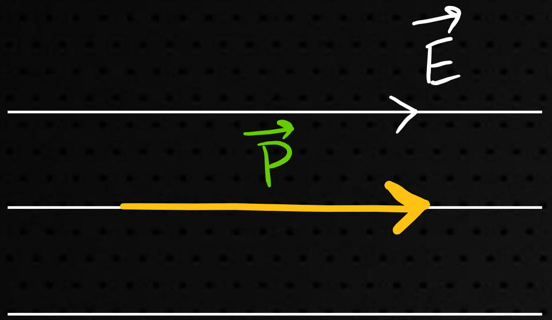
$\Rightarrow I\alpha = -C\theta$

$\therefore \alpha = -\left(\frac{C}{I}\right)\theta$

$\left(\frac{C}{I}\right) \rightarrow \omega^2$

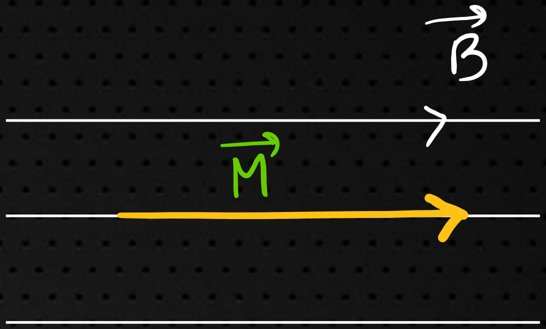
$$\therefore T = 2\pi\sqrt{\frac{I}{C}}$$

14. SHM OF DIPOLE IN FIELD (small angular displacement)



$$T = 2\pi\sqrt{\frac{I}{PE}}$$

I : Moment of Inertia

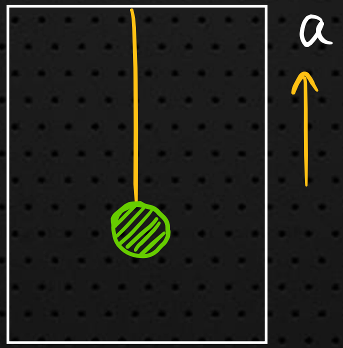


$$T = 2\pi\sqrt{\frac{I}{MB}}$$

I : Moment of Inertia

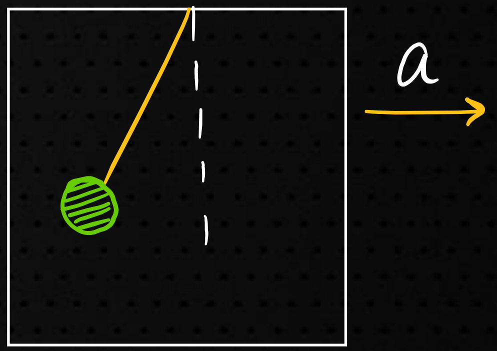
15. T OF SIMPLE PENDULUM (Different condition)

$$\boxed{T = 2\pi\sqrt{\frac{L}{g_{eff}}}}$$



$g_{eff} = a + g$

$g_{eff} = g - a$



$g_{eff} = \sqrt{a^2 + g^2}$

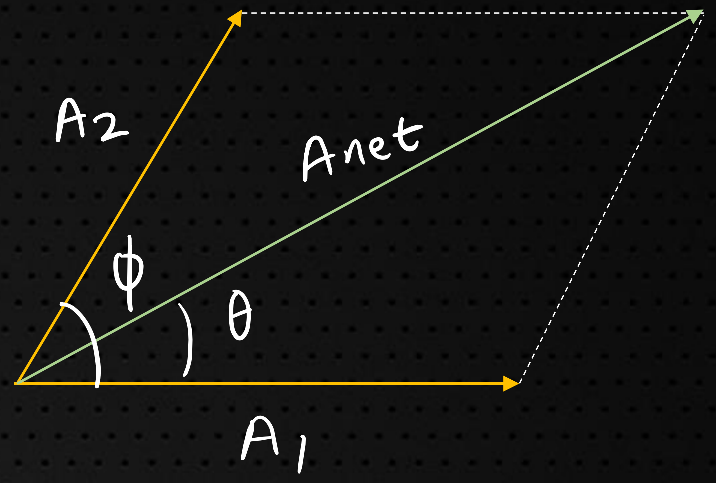
16. SUPERPOSITION OF SHM

$$Y = A_1 \sin \omega t + A_2 \sin(\omega t + \phi)$$

$$= A_{net} \sin(\omega t + \theta)$$

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

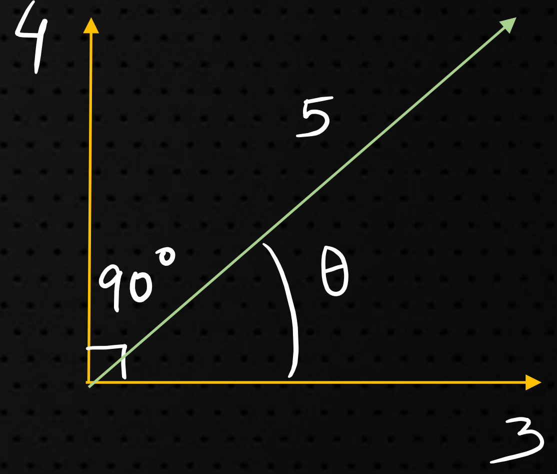
$$\theta = \tan^{-1}\left(\frac{A_2 \sin\phi}{A_1 + A_2\cos\phi}\right)$$



Ex: $Y = 3\sin(\omega t + 30^\circ) + 4\sin(\omega t + 120^\circ)$

$$\Rightarrow Y = 5\sin(\omega t + 30^\circ + \theta)$$

where $\theta = \tan^{-1}\frac{4}{3}$



LINK IN DESCRIPTION

in 55 sec

#8 - SHM

$$A(t) = A_0 e^{-bt/2m}$$

Amplitude Variation in Damped Oscillation