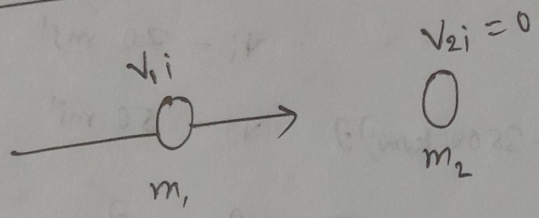
Collision

elastic collision

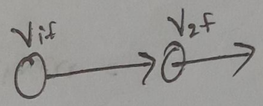
→ kinetic energy

$$K_i = K_f$$

Before collision



after,



$$m_1 v_{1i} = m_1 v_{1f} + m_2 v_{2f}$$

$$m_1 (v_{1i} - v_{1f}) = m_2 v_{2f} \quad \ldots (i)$$

Elastic collision:

$$\frac{1}{2} m_1 v_{1i}^2 = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2$$

$$m_1 (v_{1i}^2 - v_{1f}^2) = m_2 v_{2f}^2 \quad -- (ii)$$

(ii) ÷ (i),

(A) $v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i}$

(B) $v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i}$

Case-i :

$m_1 = m_2$

$v_{1f} = 0$

$v_{2f} = v_{1i}$

Case-ii :

$m_1 << m_2$

$v_{1f} \approx -v_{1i}$

$v_{2f} \approx 0$

Case-iii

$m_1 >> m_2$

$v_{1f} \approx v_{1i}$

$v_{2f} \approx 2v_{1i}$

Linear Motion

Position, x

Displacement, Δx

Shortage distance between two point

$\Delta x = x_2 - x_1$

Average velocity, v_{avg}

$v_{avg} = \frac{\Delta x}{\Delta t} = ms^{-1}$

$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$

Average Acceleration,

$a_{avg} =$

Rotational Motion

Angular position, $\theta \rightarrow rad$

Angular displacement, $\Delta\theta = \theta_2 - \theta_1$

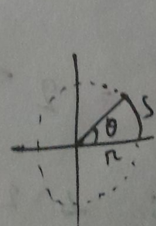
Average Angular velocity, ω_{avg}

$\omega_{avg} = \frac{\Delta\theta}{\Delta t}$

$\omega = \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t} = \frac{d\theta}{dt}$

Average angular acceleration,

α_{avg}



$s = r\theta$

$x(t) = t^2 + 2t + 1$

$t = 2$ sec

$V = \frac{dx}{dt} = 2t + 2$

$V = 2 \cdot 2 + 2$

$= 6$

$\theta(t) = t^2 + 2t + 1$

$\omega = \frac{d\theta}{dt} = 2t + 2$

$t = 2$ sec

$\omega = 6$ rad/sec

$a_{avg} = \frac{\Delta v}{\Delta t} = ms^{-2}$

$a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = \ddot{x}$ ms^{-2}

$\Delta\omega = \omega_2 - \omega_1$

$\alpha_{avg} = \frac{\Delta\omega}{\Delta t}$

$\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2} = \ddot{\theta}$ rad/sec^2

(*) $\theta(t) = t^2 + 2t + 1$

$t = 2$ sec

$\alpha = ?$

$\omega = \frac{d\theta}{dt} = 2t + 2$

$\alpha = \frac{d\omega}{dt} = 2$ → time independent.

$t = 2$ sec ; $\alpha = 2$ rad/sec^2

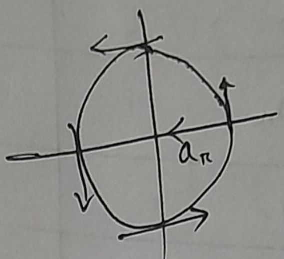
$s = \theta R$ $\rightarrow$ constant

$$\frac{ds}{dt} = R\frac{d\theta}{dt}$$

$$\boxed{v = R\omega}$$

$$\frac{dv}{dt} = R\frac{d\omega}{dt}$$

$$\boxed{a = R\alpha}$$



$$a_r = \frac{v^2}{R}$$

$$\boxed{a_r = \omega^2 R}$$

$$\boxed{\begin{gathered} s = R\theta \\ v = \omega R \\ a_t = \alpha R \end{gathered}}$$

if, ω = constant

$$a_r = \omega^2 R$$

$$a_t = \alpha R = R \cdot \frac{d\omega}{dt} = 0$$

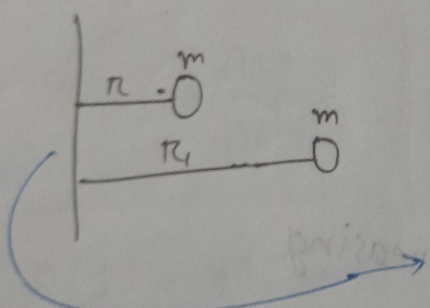
if, ω = increasing or decreasing

$$a_r = \omega^2 R$$

$$a_t = \alpha R$$

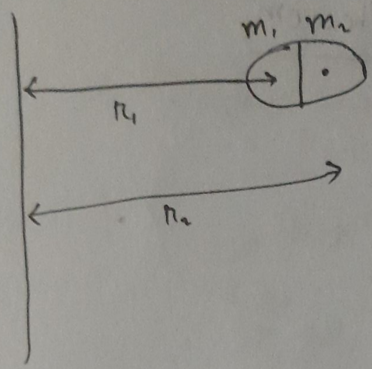
L-13/ 16.11.2022/

Linear	Rotational
x	θ
Δx	$\Delta\theta$
v	ω
a	α
F	τ
p	L
m	$I \rightarrow$ Rotational mass / moment of Inertia



$I = mr^2 \rightarrow kgm^2$

$I_1 > I$



$$K = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$$

$$= \sum_{i=1}^{n} \frac{1}{2} m_i v_i^2$$

$$= \sum \frac{1}{2} m_i \omega^2 r_i^2$$

$$= \sum \frac{1}{2} (m_i r_i^2) \omega$$

$$K = \sum \frac{1}{2} I \omega$$

$$\omega = \frac{d\theta}{dt}$$

$$v = \omega r$$

(*)

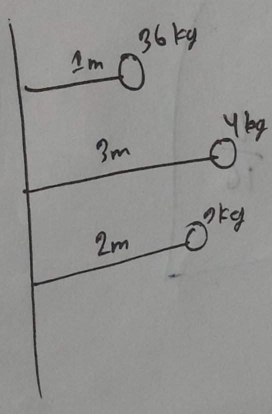
$\omega = 2$ rad/sec

$k = 10$ j

$I = ?$

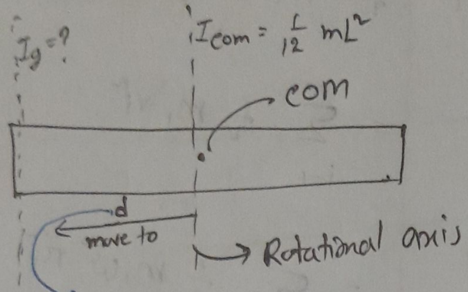
$$I = \frac{2k}{\omega}$$

$\cancel{k = \frac{1}{2} I\omega}$



$$\boxed{I_1 = I_2 = I_3 = 36}$$

Parallal axis theorem



assume that,

$d = \frac{L}{2}$

$$\therefore I_g = I_{com} + md^2$$

$$= \frac{1}{12} mL^2 + m\frac{L^2}{4}$$

$$= \frac{mL^2 + 3mL^2}{12}$$

$$= \frac{4mL^2}{12}$$

$$= \boxed{\frac{mL^2}{3}}$$

$m = 1$ kg
$L = 2$ m
$I_g = ?$

if, $d = \frac{L}{4}$

then,
$$I_g = \frac{1}{12} mL^2 + m\frac{L^2}{16}$$

Midterm

L-15/23.11.2022/

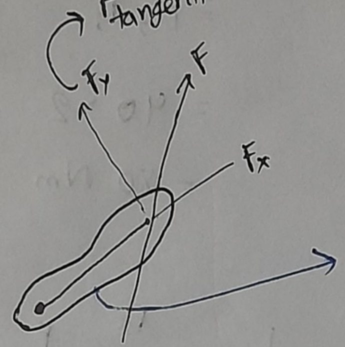
$K = \frac{1}{2}mv^2$

$\downarrow \quad \downarrow$

$I \quad \omega$

$\tau \rightarrow$ Torque $\rightarrow$ rotational force.

$F_{tangential} = F\sin\theta$



For this τ direction $\odot$

$$\vec{\tau} = r F_{tan} = |\bar{r}|\ |\bar{F}|\ \sin\theta$$

$$= \bar{r} \times \bar{F}$$

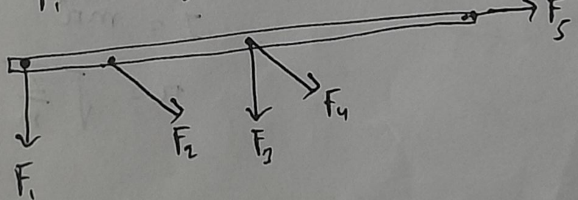
⊛ $F \neq 0$

(i) $\tau = 0,\ r = 0$

(ii) $\tau = 0,\ \theta = 0$

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$F_1 = F_2 = F_3 = F_4 = F_5$



$$\tau_3 > \tau_4 > \tau_2 > \tau_1 = \tau_5$$

if,

$F_1 = 3N \rightarrow \tau_1 = 0$

$F_2 = 3N$

$F_3 = F_4 = 2N$

$F_5 = 10N \rightarrow \tau_5 = 0$

$\tau_3 = \bar{r}_3 \times \bar{F}_3$

$= r_3 F_3 \sin 90$

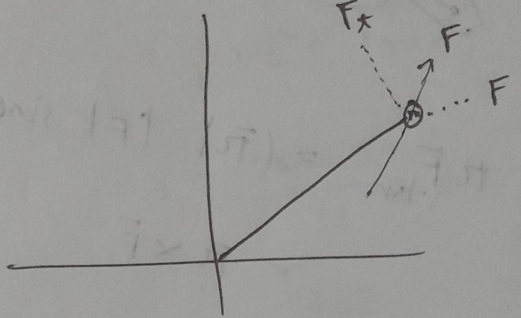
$= r_3 F_3$

$= 40 \times 2$

$= 80$ Nm

$F = ma$

$\tau = I\alpha$



$F_t = ma_t$

$\tau = rF_t$

$= r m \alpha r$

$= m r^2 \alpha$

$\tau = I\alpha$

$\tau = 20$ Nm

$\alpha = 2$ rad/sec

$\therefore I = \frac{\tau}{\alpha} = 10$ kgm^2

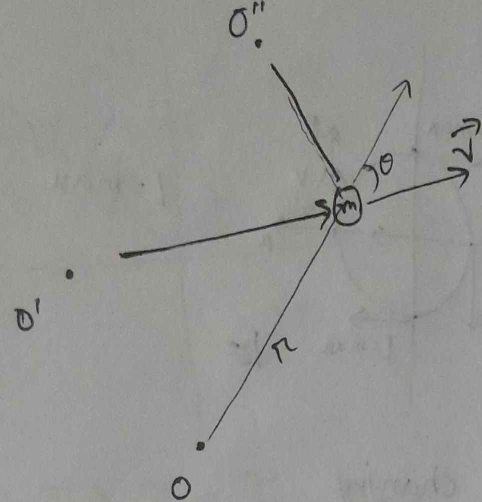
$m = 500$ gm

$r = ?$

$I = mr^2$

$r = \sqrt{\frac{I}{m}}$

L → Angular momentum



$\vec{p} = m\vec{v}$

$L = kg\, m^2\, sec^{-1}$

$\vec{\tau} = \vec{r} \times \vec{F}$

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

$\vec{L}'' = \vec{r} \times \vec{p} =$ man

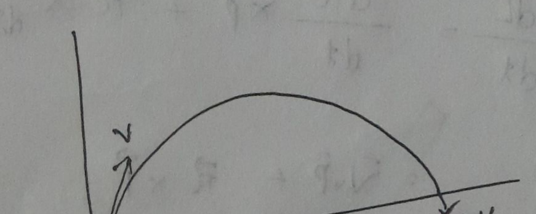
$\vec{L}' = \vec{r} \times \vec{p} = 0$

$\vec{p} \neq 0$

(i) $L = 0, r = 0$

(ii) $L = 0, \theta = 0$

case-1



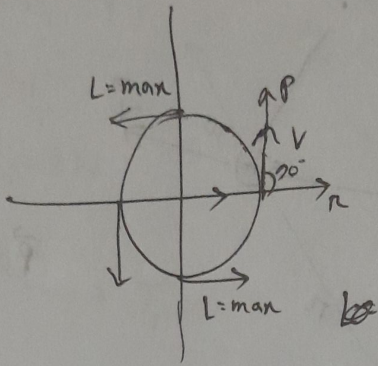
$L = 0$

$L' \neq 0$

v is changing

L is also changing

case-2/



L = max

v is changing

but, L is constant.

$$F = ma \qquad \vec{F} = \frac{d\bar{p}}{dt}$$

$$\tau = I\alpha \qquad \tau = \frac{d\bar{L}}{dt}$$

$$\bar{L} = \bar{r} \times \bar{p}$$

$$\frac{d\bar{L}}{dt} = \frac{d\bar{r}}{dt} \times p + \vec{r} \times \frac{d\bar{p}}{dt}$$

$$= \bar{v} \times \bar{p} + \vec{r} \times \vec{F}$$

$$= \underline{\bar{v} \times \bar{v}m} + \vec{r} \times \vec{F}$$

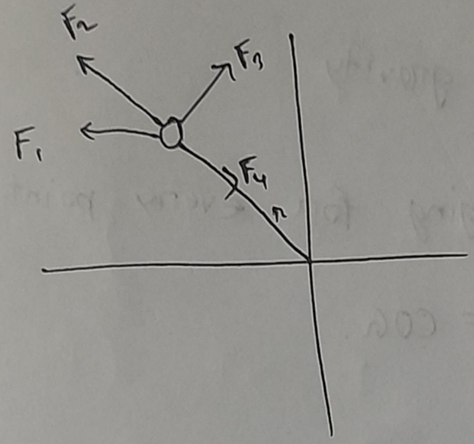
$\hat{i} \times \hat{i} = 0$

$$= \vec{r} \times \vec{F}$$

$$= \tau$$

$$\therefore \vec{\tau} = \frac{d\bar{L}}{dt}$$

⊛



$$\tau = \frac{dL}{dt}$$

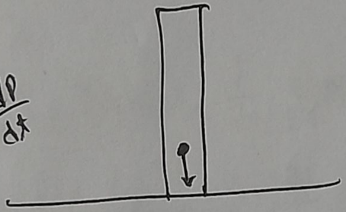
$$\tau_3 > \tau_1 > \tau_2 = \tau_4$$

$$L_3 > L_1 > L_2 = L_4$$

⊛

(i)

$$F = \frac{dp}{dt}$$



stable

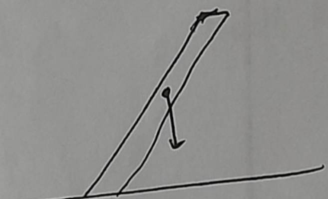
$F = 0$

$\tau = 0$

$p = \text{constant}$

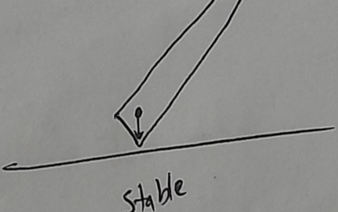
$L = \text{constant}$

(ii)



unstable

(iii)



stable

⊛ if the net torque is zero the angular momentum is constant.

↪ conservation of Angular momentum.

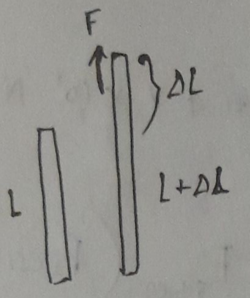
* COG → center of gravity

* If g is not changing for every point of an object then COM = COG.

L-16/ 28.11.2022/

Elasticity

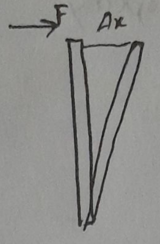
(i) → F & L Parallal



$\frac{F}{A} \propto \frac{\Delta L}{L}$

$\frac{F}{A} = E \frac{\Delta L}{L}$ → Elastic Modulus

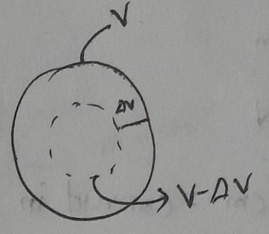
(ii) → F & L Perpendicular



$\frac{F}{A} \propto \frac{\Delta x}{L}$

$\frac{F}{A} = G \frac{\Delta x}{L}$ → Sear Modulus

(iii)



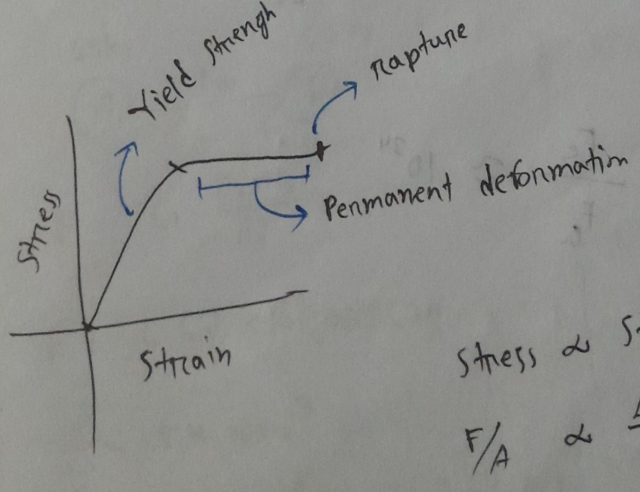
$\frac{F}{A} \propto \frac{\Delta V}{V}$

$\frac{F}{A} = \beta \frac{\Delta V}{V}$ → Bulk Modulus

Stress : $\frac{F}{A} = N m^{-2}$

Strain : $\frac{\Delta L}{L}$ (Unitless)

(*) Identify which formula will apply.



$$\left.\begin{array}{l} \text{Stress} \propto \text{Strain} \\ F/A \propto \frac{\Delta L}{L} \end{array}\right\}$$ within Elastic Limit only

$$E = \frac{F/A}{\Delta L/L}$$

Material Property

$E_{Steel} = 2.8 \times 10^8 \ Nm^{-2}$

$E_{silver} = 1.7 \times 10^8 \ Nm^{-2}$

$E_{steel} > E_{silver}$ (Pressure)

⊛

$L = 10 m$

$F = 2 N$

$r = 0.5 cm$ = convert in m

$E = 2.8 \times 10^8 \ Nm^{-2}$

Stress = ?

Strain = ?

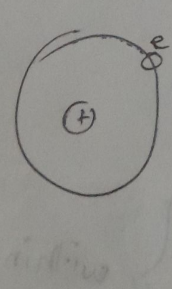
$\Delta L = ?$

$$\text{Stress} = \frac{F}{A} = \frac{2}{\pi r^2}$$

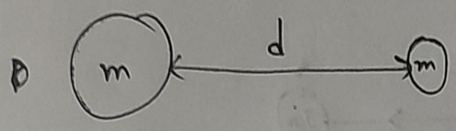
$$\text{strain} = \frac{F}{EA} \quad \left[E = \frac{F/A}{\Delta L/L} \right]$$

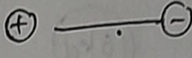
$$\Delta L = \frac{FL}{EA}$$

⊛



$$\frac{F_e}{F_G} \approx 10^{34}$$





$$F_e = k\frac{q_1 q_2}{d^2}$$

$$F \propto m_1 m_2$$

$$F \propto \frac{1}{d^2}$$

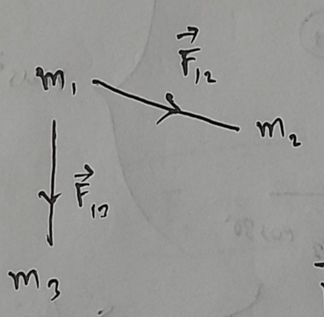
$$F \propto \frac{m_1 m_2}{d^2}$$

$$F = G\frac{m_1 m_2}{d^2}$$ [Limitation: only applieable with two object]

Vector Form:

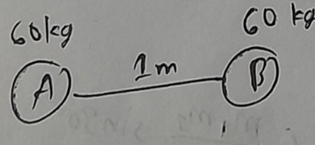
$$\vec{F}_{12} = G\frac{m_1 m_2}{d^2}\hat{r}_{12}$$ $\hat{r}_{12}$ → $m_1 \to m_2$

(*)



$$\vec{F}_{1net} = \vec{F}_{13} + \vec{F}_{12}$$

(*)



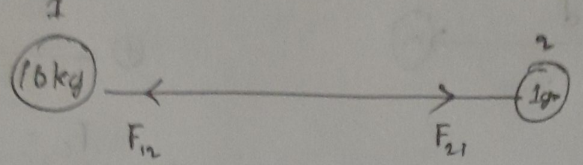
$$F = G\frac{m_1 m_2}{d^2}$$

$$G = 6.67 \times 10^{-11}\ Nm^2/kg^2$$

$$F = 6.67 \times 10^{-11} \times 3600$$

$$= 2.4 \times 10^{-7}\ N$$

$$= 0.24 \times 10^{-6}\ N = 0.24\ \mu N$$

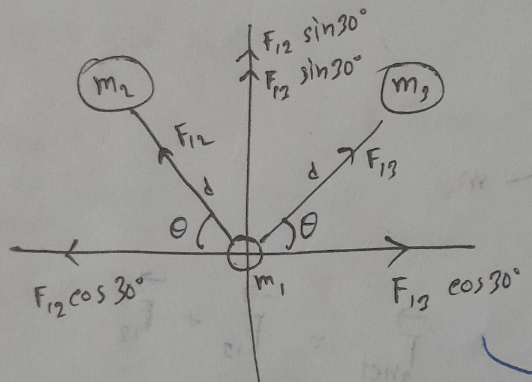


$$F_{12} = G\frac{m_1 m_2}{d^2} \qquad F_{21} = G\frac{m_1 m_2}{d^2}$$

$$\boxed{F_{12} = F_{21}}$$

* World moves towards me $\approx 10^{-24}\ ms^{-2}$

*



must 1 Question in Final

Assignment Question

$$F_{1net} = F_{12}\sin 30^\circ + F_{13}\sin 30^\circ$$

$$= G\frac{m_1 m_2}{d^2} \times \sin 30^\circ + G\frac{m_1 m_3}{d^2}\sin 30^\circ$$

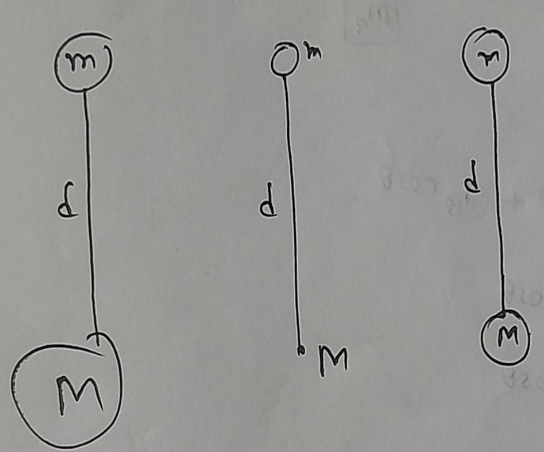
$$F_{1x} = F_{13}\cos 30^\circ - F_{12}\cos 30^\circ = 10\,N$$

$$F_{1y} = F_{13}\sin 30^\circ + F_{12}\sin 30^\circ = 12\,N$$

$$\vec{F} = F_{1x}\,\hat{i} + F_{1y}\,\hat{j}$$

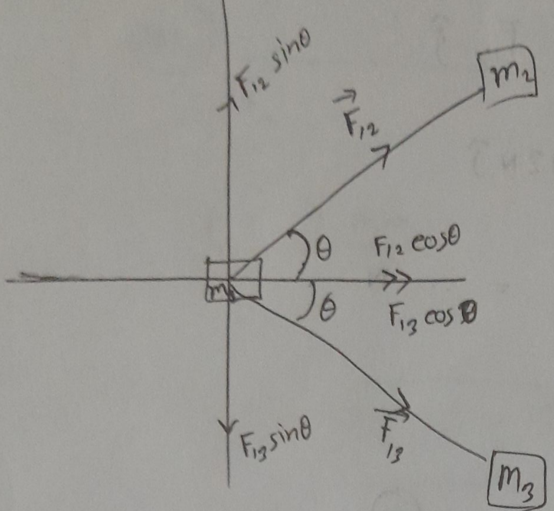
$$= 10N\,\hat{i} + 12N\,\hat{j}$$

$$|\vec{F}| = \sqrt{10^2+12^2} = \dots N$$



$\boxed{F_1 = F_2 = F_3}$ → Not depend on volume

L-17/ 30.11.2022/



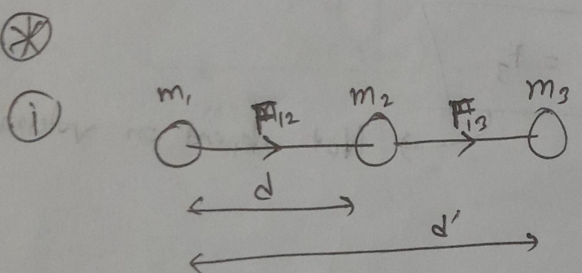
mass = same

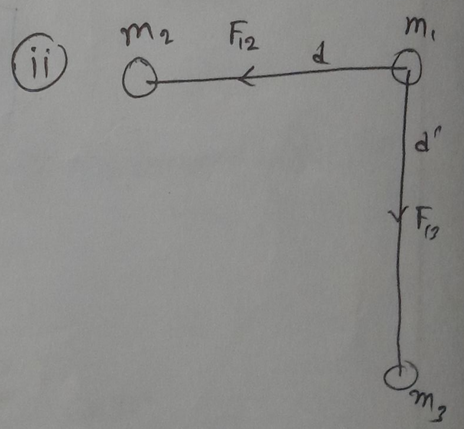
θ = same

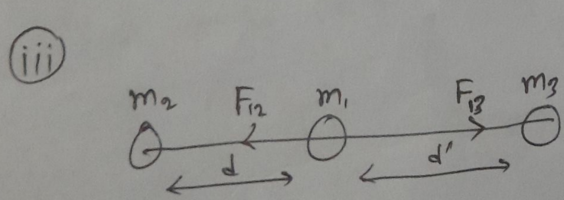
$$F_{1\,net} = F_{12}\cos\theta + F_{13}\cos\theta$$

$$= 2F_{12}\cos\theta$$

$$= 2F_{13}\cos\theta$$





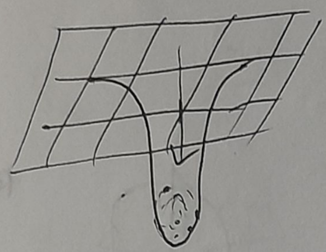


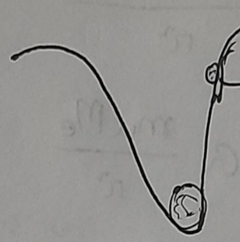
$F_{1\,net}$ 1 > 2 > 3

* in which arrangement m_1 will get maximum gravitional force?

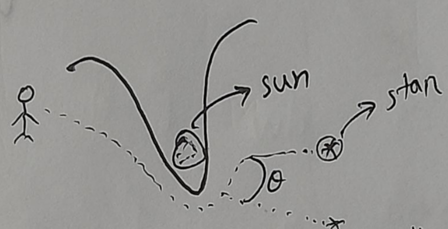
⊛ Space and time is co-related.

⊛ Heavy object in space distorted space more.





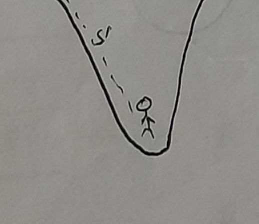
⊛



⊛ experiment only applicable in solar ecilipes

Heavy object makes time and space more distorted.

⊛



$s = vt$

$t = \frac{s}{v}$

$v = 3 \times 10^{8}\ ms^{-1}$

$s' = vt'$

$t' = \frac{s'}{v}$

$\therefore$ distortion $\propto$ time

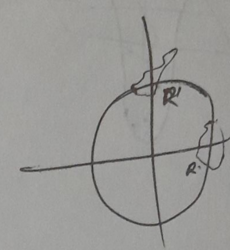
$$F = mg \qquad g = a_g$$

$$= m a_g$$

$$F_g = \frac{G m_u M_{earth}}{r^2}$$

$$m a_g = G \frac{m_u M_e}{r^2}$$

$$a_g = \frac{GM}{r^2}$$



R > R'

$\therefore a_g$ depends on M and r^2

$$g \approx M$$

$$g \approx r^2$$

when, R is bigger
g is smaller.

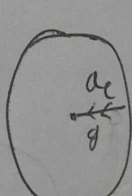
To calculate original weight.

$$mg = \cancel{mg}\ m a_g - \frac{mv^2}{r}$$

$$= \cancel{mg}$$

$$= m a_g - m\omega^2 r$$

$$g = a_g - \omega^2 r$$



$a_c = 0.3\ ms^{-2}$

$g = 9.8\ ms^{-2}$

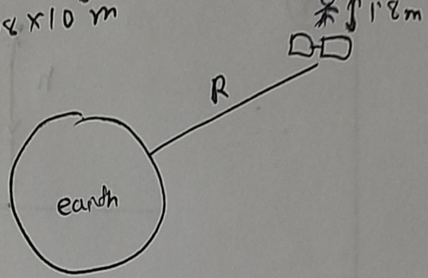
$$a_c = \frac{v^2}{R}$$

$$F = ma$$

$$v = \omega r$$

(X)

$r = 5.98 \times 10^6 m$



$$g = \frac{GM}{r^2}$$

$$g_{leg} = \frac{GM}{r^2}$$

$$g_{head} = \frac{GM}{(r+1.8)^2}$$ / we can't use 1.8m like that, so, we have use another method

~~$da_g = -14.5 ms^{-2}$~~

$$\frac{dg}{r} = -2\frac{GM}{r^3}$$

$$da_g = -2\frac{GM}{r^3}dr$$

$$da_g = -2\frac{GM}{r^3}dr$$

$$= -4.37 \times 10^{-6} ms^{-2}$$

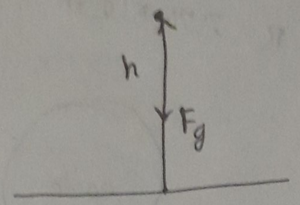
$$da_g = -14.5 ms^{-2}$$

$$\boxed{g = \frac{GMR'}{R^3}} \rightarrow R' = \text{diging height}$$

R = earth surface lengthth

m = mass

L-18 / 05.12.2022/



$$W_g = -mgh$$

$$\Delta u = -W$$
$$= -(-mgh)$$
$$= mgh$$

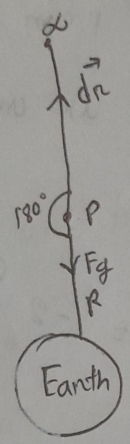
$$U_f - \overset{0}{U_i} = mgh$$

$$U_f = mgh$$

i. Reference Point

ii. Work done

iii. $W \to u$



$$\boxed{F_g = \frac{GM_m}{R^2}}$$

$$dw = \vec{F} \cdot \vec{dr}$$

$$\int dw = \int_R^{\alpha} \vec{F} \cdot \vec{dr}$$

$$= -\int_R^{\alpha} F\,dr$$

$$= -\int_R^{\alpha} \frac{GM_m}{r^2}\,dr$$

$$= -GM_m \int_R^{\alpha} r^{-2}\,dr$$

$$= -GM_m \left[-\frac{1}{r}\right]_R^{\alpha}$$

$$= -GM_m \left[0 + \frac{1}{R}\right]$$

$$W = -GMm\frac{1}{R}$$

$$= -\frac{GMm}{R}$$

$$\Delta u = -W$$

$$U_\infty - U_i = -\frac{GMm}{R}$$

0, in infinity

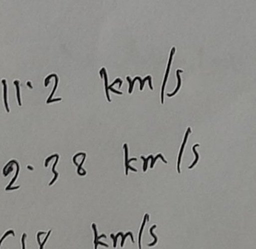
$$U_p = -\frac{GMm}{R}$$

work done positive. So, Potential energy will decrease and negative.

$$\therefore u = -\frac{GMm}{R}$$

Assignment Question

Escape Speed:



$$-\frac{GMm}{R} + \frac{1}{2}mv^2 = 0$$

$$\frac{1}{2}mv^2 = \frac{GMm}{R}$$

$$V_{es} = \sqrt{\frac{2GM}{R}}$$

Escape Speed

Earth = 11·2 km/s

Moon = 2·38 km/s

Sun = 618 km/s

Neuton Star = 2×10^5 km/s

Simple Harmonic Motion (SHM)

$$F \propto -x$$

$$F = -kx$$

↳ Spring Constant ⇒ Nm^{-1}

Hooks Law only works within Elastic Limit.

$$F = -kx$$

$$ma = -kx$$

$$ma + kx = 0$$

$$a + \frac{k}{m}x = 0$$

$$\boxed{a + \omega^2 x = 0}$$

$$\boxed{a_{(t)} = -\omega^2 x}$$

$$\boxed{a \propto -x}$$

↳ SHM: Simple Harmonic Motion

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

↳ Angular Frequency

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

Angular Frequency

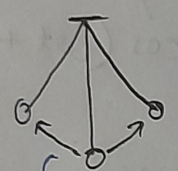
Phase angle

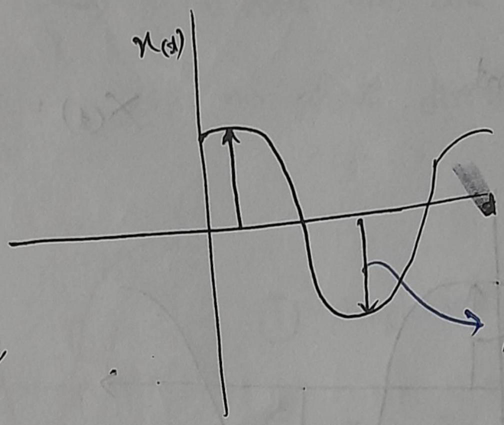
$$\Rightarrow \quad x_{(t)} = x_m \cos(\omega t + \theta)$$

Amplitude

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

$a = \frac{d^2x}{dt^2}$





T = time Period

T .. sec ... circle ... 1

1 .. " ... " .... $\boxed{\frac{1}{T}}$ → frequency

$f = \frac{1}{T}$ sec^{-1}/Hz

T 2π

1 ... $\frac{2\pi}{T} = \omega$ → Angular frequency

L-19 / 07.12.2022

SHM

$a_{(t)} = -\omega^2 x(t)$ → Angular frequency

$\omega = \sqrt{\frac{k}{m}}$ → Spring Constant, → mass

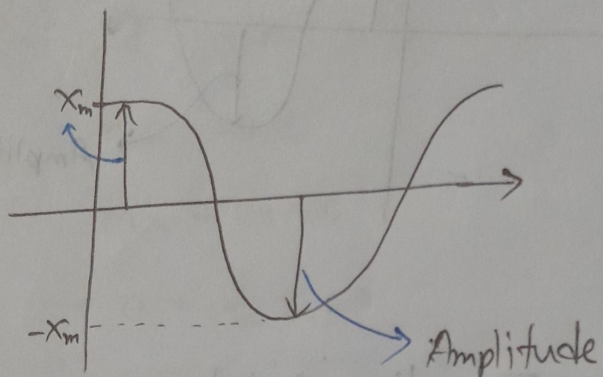
for a system
ω is constant

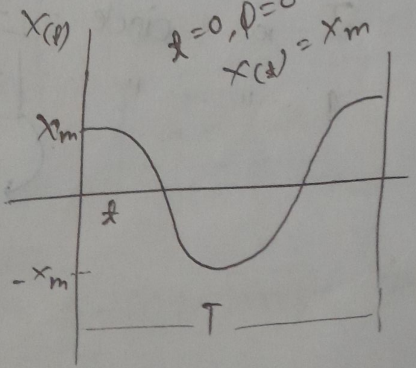
Angular Frequency
$\omega = \frac{2\pi}{T}$
= rad/sec

$x_{(t)} = x_m \cos(\omega t + \phi)$

Amplitude

Phase angle

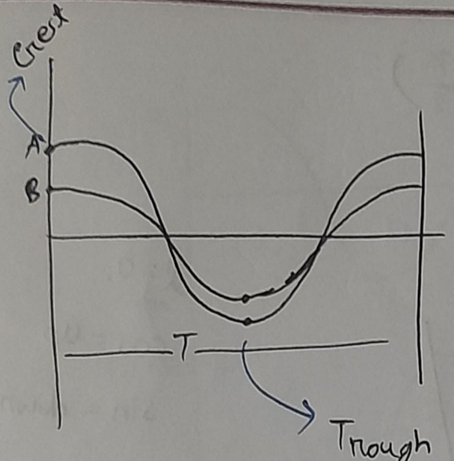




1 circle

Only frequency = $f = \frac{1}{T}$
$= Hz$

(*)



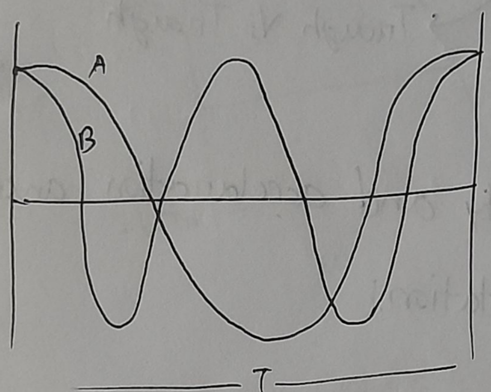
(i) Amplitude (Difference)

(ii) T, f, ω (same)

↪ in x-axis they are at the same point.

So, no phase difference.

(*)



(i) Amplitude same

(ii) T > T'

T = 2 T'

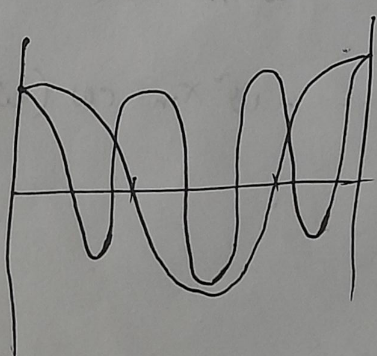
(iii) $f_B > f_A$

$f_B = 2 f_A$

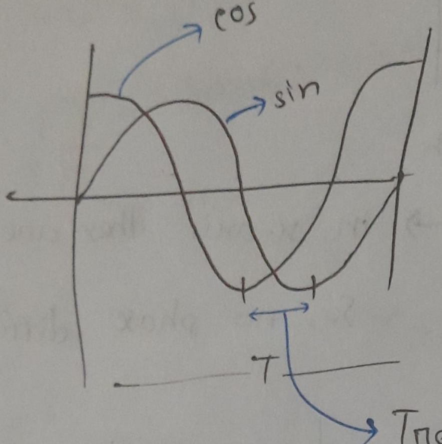
T = A

T' = B

(*) Can you draw, same amplitude, one has 3 times higher frequency.



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



$t = 0,$
cos = up
sin = down
then, cos leading the graph

Phase Difference
$-\frac{\pi}{2}$

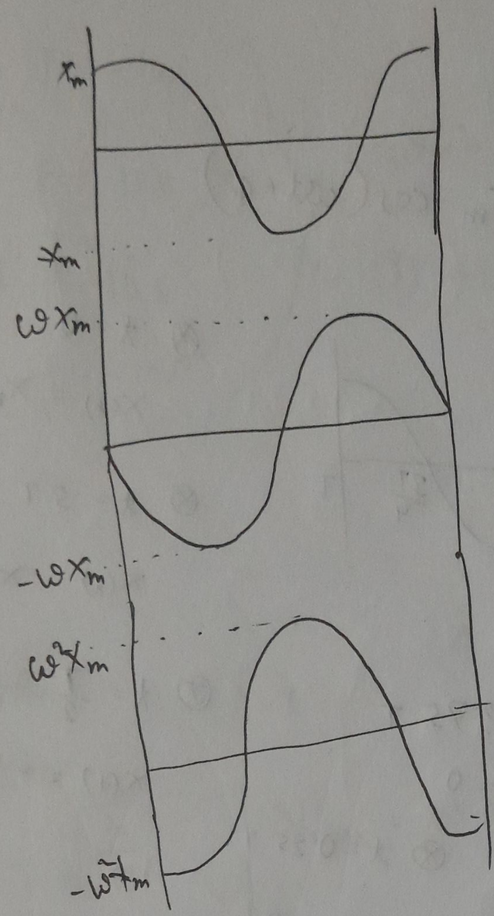
Can you find velocity and accelaration and show graphical representation.

$$x(t) = x_m \cos(\omega t + \phi)$$

derivative,

$$v(t) = -\omega x_m \sin(\omega t + \phi)$$

$$a(t) = -\omega^2 x_m \cos(\omega t + \phi)$$



$t=0,\ \phi=0$

$x(t) = x_m$

$t=0,\ \phi=0$

$v(t) = 0$

$t=0,\ \phi=0$

$a(t) = -\omega^2 x_m$

$$x(t) = 2\cos(2t+\phi)$$

$$v(t) = -4\sin(2t+\phi)$$

$$a(t) = -8\cos(2t+\phi)$$

maximum velocity

$$|v(t)| = |-\omega x_m|$$

$$= 2\times 2 = 4\ ms^{-1}$$

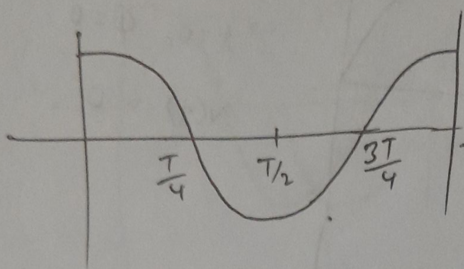
maximum accelaration

$$|a(t)| = |-\omega^2 x_m|$$

$$= 4\times 2 = 8\ ms^{-2}$$

Must in Final

$$x(t) = X_m \cos(\omega t + \phi)$$



- $t = 0$

  $x(t) = X_m$

- $t = 5T$

  $x(t) = X_m$

- $t = \frac{T}{2} = 5.5T$

  $x(t) = -X_m$

- $t = 99.75T$

  $x(t) = 0$

- $t = 0.25T$

  $x(t) = 0$

- Given

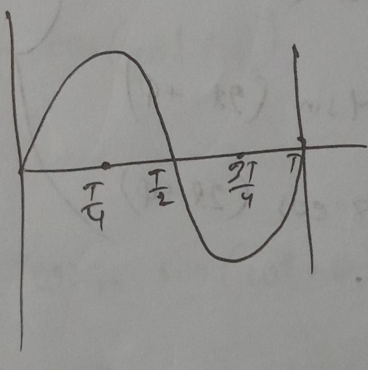
  $t = 0$

  $x(t) = 0$

  $\therefore t = 9.75T$

  $x(t) = ?$

  $= -X_m$



$\boxed{\text{marks} = 3 \text{ point}}$

must in final

(i) $F = -10x$
(ii) $F = 10x$
(iii) $F = 10x^2$
(iv) $F = -10x^2$

which is SHM?

(i) → Because similar to Hook's Law

$F = -kx$

m = defined

k = defined

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

$\omega = 2\pi f$

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

maximum amplitude x

$V_{max} = \omega x_m$

$a_{max} = \omega^2 x_m$

$K = \frac{1}{2} m v^2$

$U = \frac{1}{2} k x^2$

$E = K + U$

$= \frac{1}{2} m v^2 + \frac{1}{2} k x^2$

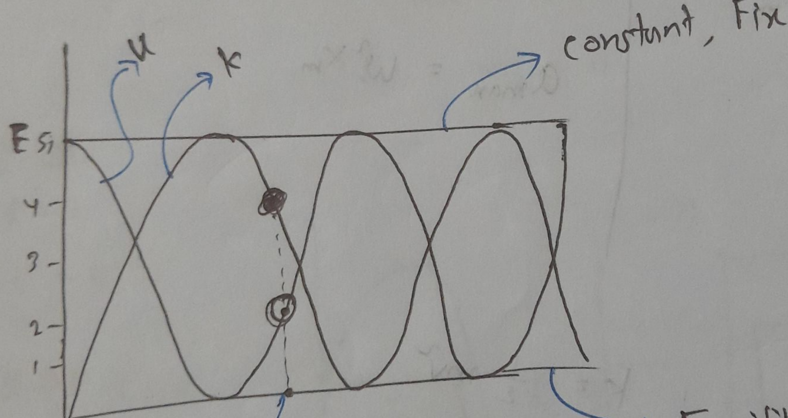
$= \frac{1}{2} m \omega^2 x_m^2 \sin^2(\omega t + \phi) + \frac{1}{2} k x_m^2 \cos^2(\omega t + \phi)$

$$= \frac{1}{2} m \frac{k}{m} X_m^2 \sin^2(\omega t + \phi) + \frac{1}{2} k X_m^2 \cos^2(\omega t + \phi)$$

$$= \frac{1}{2} k X_m^2 \left(\sin^2(\omega t + \phi) + \cos^2(\omega t + \phi) \right)$$

$E = \frac{1}{2} k X_m^2 \longrightarrow$ Total energy time independent.

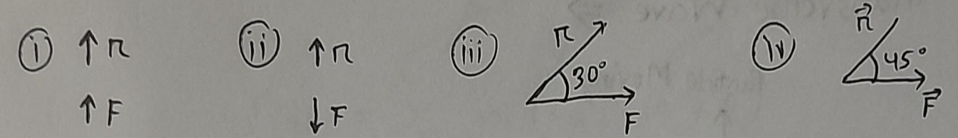
$$\left.\begin{array}{l} k = 2\ N/m \\ X_m = 10\ cm \\ \quad = 0.1\ m \end{array}\right\} E = ?$$



$$\left.\begin{array}{l} U = 2j \\ k = 3j \end{array}\right\} E = 5j$$

if intenceect point, then,

$$\left.\begin{array}{l} U = 2.5\ j \\ k = 2.5\ j \end{array}\right\} E = 5j$$



$$\tau_4 > \tau_3 > \tau_1 = \tau_2$$

Wave is a disturbance that's carries energy.

(i) Mechanical Wave

⇒ it requires medium

⇒ it follows Newton's Law

⇒ water wave, sound wave

(ii) Electro magnetic Wave

⇒ No medium required

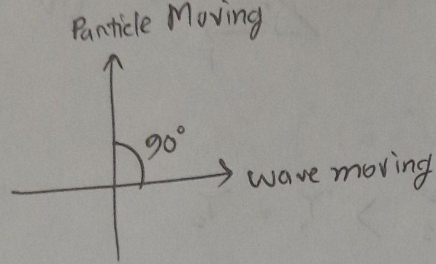
⇒ Doesn't follows Newton's Law

⇒ Light

(iii) Matter Wave

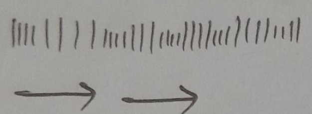
⇒ Electron & Proton

⊛ Transverse Wave ⇒



⇒ water wave

⊛ Longitudinal Wave :



Sound Wave

Amplitude
Angular frequency
Phase Difference

⊛ $x_{(t)} = x_m \cos(\omega t + \phi)$