Padasalai's Telegram Groups!

(தலைப்பிற்கு கீழே உள்ள லிங்கை கிளிக் செய்து குழுவில் இணையவும்!)

- Padasalai's NEWS - Group
https://t.me/joinchat/NIfCqVRBNj9hhV4wu6_NqA

- Padasalai's Channel - Group
https://t.me/padasalaichannel

- Lesson Plan - Group
https://t.me/joinchat/NIfCqVWwo5iL-21gpzrXLw

- 12th Standard - Group
https://t.me/Padasalai_12th

- 11th Standard - Group
https://t.me/Padasalai_11th

- 10th Standard - Group
https://t.me/Padasalai_10th

- 9th Standard - Group
https://t.me/Padasalai_9th

- 6th to 8th Standard - Group
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- 1st to 5th Standard - Group
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- TET - Group
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- PGTRB - Group
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- TNPSC - Group
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1. Nature of Physical World and Measurement

1. **Given:** Time delay, $t = 80\,s$.
Speed of sound in water, $v = 1460\,ms^{-1}$
distance of enemy submarine = ?

Solution:
Echo distance, $2d = \text{speed} \times \text{time}$

$\therefore d = \frac{\text{speed} \times \text{time}}{2} = \frac{1460 \times \cancel{80}^{40}}{\cancel{2}}$

$d = 58{,}400\,m = 5.84 \times 10^3\,m$

$\boxed{d = 5.84\,km}$

$$\begin{array}{r} 1460 \times 40 \\ \hline 0000 \\ 5840 \\ \hline 58400 \end{array}$$

2. **Given:** Radius, $r = 3.12\,m$.
Solution: Area, $A = ?$
Area of a circle, $A = \pi r^2$

$A = 3.14 \times (3.12)^2$

$\boxed{A = 30.6\,m}$

log 3.14 ⇒ 0.4969
3.12 ⇒ 0.4942
3.12 ⇒ 0.4942 (+)
Antilog ⇐ 1.4853
30.57 ⇐ 3.057×10^1

3. **Solution:** Frequency, $\gamma \propto \frac{1}{l}\sqrt{\frac{F}{m}}$

$\therefore$ Frequency, $\gamma \propto F^a l^b m^c \longrightarrow ①$

Physical quantity	Dimensions
Frequency (γ)	$[T^{-1}]$
Force (F)	$[MLT^{-2}]$
Length (l)	$[L]$
mass per unit length (m)	$[ML^{-1}]$

$① \Rightarrow [T^{-1}] \propto [MLT^{-2}]^a [L]^b [ML^{-1}]^c$

$[T^{-1}] \propto [M]^{a+c} [L]^{a+b-c} [T]^{-2a}$

comparing the powers of M, L and T on both sides,

$a + c = 0$, $a + b - c = 0$, $-2a = -1$; $\boxed{a = 1/2}$

$\therefore \frac{1}{2} + c = 0$; $\boxed{c = -1/2}$

$\frac{1}{2} + b - (-1/2) = 0$; $\boxed{b = -1}$

$① \Rightarrow \gamma \propto F^{1/2}\, l^{-1}\, m^{-1/2}$

$\gamma \propto \frac{1}{l} \frac{(F)^{1/2}}{(m)^{1/2}}$; $\gamma \propto \frac{1}{l}\left(\frac{F}{m}\right)^{1/2}$

$\therefore \boxed{\gamma \propto \frac{1}{l}\sqrt{\frac{F}{m}}}$

4. Distance, $D = 824.7$ million km.
$D = 824.7 \times 10^6 \times 10^3\,m$.
Angular diameter, $\theta = 35.72''$
$(1'' = 4.85 \times 10^{-6}\,rad)$,
Diameter, $d = ?$

Solution:
Diameter of Jupiter $d = D \times \theta$
$= 824.7 \times 10^9 \times 35.72 \times 4.85 \times 10^{-6}$

$\therefore d = 824.7 \times 10^3 \times 35.72 \times 4.85$

$d = 1.429 \times 10^5\,km$

log 824.7 ⇒ 2.9163
35.72 ⇒ 1.5529
4.85 ⇒ 0.6857 (+)
Antilog ⇐ 5.1549
1.429×10^5

5. **Given:** $l = (l \pm \Delta l) = (20\,cm + 2\,mm)$
$\therefore l = 20\,cm$, $\Delta l = 2\,mm = 0.2\,cm$
$t = (t + \Delta t) = (40 \pm 1)\,s$, $t = 40\,s$, $\Delta t = 1\,s$
$\therefore$ % of accuracy in 'g' = ?

Solution:
$g = \frac{4\pi^2 l}{t^2}$

$T = 2\pi\sqrt{\frac{l}{g}}$
$T^2 = 4\pi^2 \left(\frac{l}{g}\right)$
$g = \frac{4\pi^2 l}{T^2}$

$\therefore$ The percentage of error in determination of acceleration due to gravity 'g' is

$\frac{\Delta g}{g} \times 100\% = \frac{\Delta l}{l} \times 100\% + 2\frac{\Delta t}{t} \times 100\%$

$= \frac{0.2\,cm}{20\,cm} \times 100\% + \cancel{2} \times \frac{1}{\cancel{40}_{20}} \times 100\%$

$= 1\% + 5\%$

$\therefore \boxed{\frac{\Delta g}{g} \times 100\% = 6\%}$

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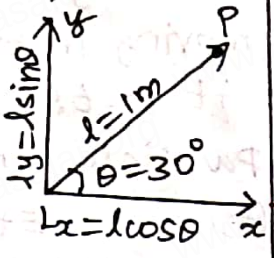
2. Kinematics

1. Given:- $l = 1m$, $\theta = 30°$, $l_x = ?$, $l_y = ?$



Solution:-

(i) components of 'l' along x-axis.

$l_x = l\cos\theta = 1 \times \cos 30° = 1 \times \frac{\sqrt{3}}{2}$

$\therefore l_x = \frac{\sqrt{3}}{2} m$

(ii) components of 'l' along 'y' axis

$l_y = l\sin\theta = 1 \times \sin 30° = 1 \times \frac{1}{2} = 0.5m$

$\therefore l_y = 0.5m$

2. Given:- $\vec{r_1} = 3\hat{i} + 4\hat{j}$, $\vec{r_2} = \hat{i} + 2\hat{j}$, $\Delta\vec{r} = ?$

Solution:-

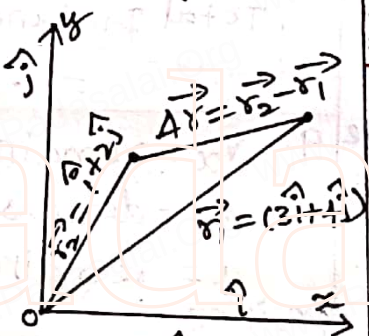
$\vec{r} = x\hat{i} + y\hat{j}$

$\vec{r_1} = 3\hat{i} + 4\hat{j}$

$x_1 = 3, y_1 = 4$

$\vec{r_2} = \hat{i} + 2\hat{j}$

$x_2 = 1, y_2 = 2.$



$\therefore \Delta\vec{r} = \vec{r_2} - \vec{r_1} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j}$

$\therefore \Delta\vec{r} = (1-3)\hat{i} + (2-4)\hat{j}$

$\boxed{\Delta\vec{r} = -2\hat{i} - 2\hat{j}}$

3. Given:- $\vec{r_1} = 5\hat{i} + 6\hat{j}$, $x_1 = 5, y_1 = 6$

$\vec{r_2} = 2\hat{i} + 3\hat{j} \Rightarrow x_2 = 2, y_2 = 3$

$V_{ave} = ?$ $t = 5s$.

Solution:-

$V_{av} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\vec{r_2} - \vec{r_1}}{t} = \frac{(x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j}}{t}$

$\therefore V_{av} = \frac{(2-5)\hat{i} + (3-6)\hat{j}}{5}$

$V_{ave} = \frac{-3\hat{i} - 3\hat{j}}{5}$. $\boxed{V_{av} = -\frac{3}{5}(\hat{i} + \hat{j})}$

4. Given:- $\vec{r} = 3\hat{i} + 2\hat{j}$, $\hat{r} = ?$

Solution:- unit vector, $\hat{r} = \frac{\vec{r}}{|\vec{r}|}$

$|\vec{r}| = \sqrt{3^2 + 2^2} = \sqrt{9+4} = \sqrt{13}$

$\therefore \hat{r} = \frac{3\hat{i} + 2\hat{j}}{\sqrt{13}}$

5. Given:- $\vec{A} = 4\hat{i} - 2\hat{j} + \hat{k}$, $\vec{B} = 5\hat{i} + 3\hat{j} - 4\hat{k}$

$\vec{A} \times \vec{B} = ?$

Solution:- vector product of two given vectors by determinant method,

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4 & -2 & 1 \\ 5 & 3 & -4 \end{vmatrix}$$

$\vec{A} \times \vec{B} = \hat{i}[(-2 \times -4) - (1 \times 3)] - \hat{j}[4(-4) - 1 \times 5] + \hat{k}(12 - (5 \times -2))$

$= \hat{i}[8-3] - \hat{j}[-16-5] + \hat{k}[12+10]$

$\vec{A} \times \vec{B} = 5\hat{i} + 21\hat{j} + 22\hat{k}$

6. Given:- Range, $R = 4 \times H_{max}$, $\theta = ?$

Solution:-

$R = \frac{u^2 \sin 2\theta}{g}$, $H_{max} = \frac{u^2 \sin^2\theta}{2g}$

$\therefore R = 4 \times H_{max}$

$\therefore \frac{\cancel{u^2}\sin 2\theta}{\cancel{g}} = \cancel{4}^{2} \times \frac{\cancel{u^2}\sin^2\theta}{\cancel{2}\cancel{g}}$

$[\sin 2\theta = 2\sin\theta\cos\theta]$

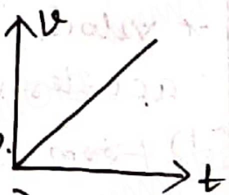
$\therefore \cancel{2}\cancel{\sin\theta}\cos\theta = \cancel{2}\sin^{\cancel{2}}\theta$

$\therefore \frac{\sin\theta}{\cos\theta} = 1 \Rightarrow \tan\theta = 1$

$\theta = \tan^{-1}(1)$

Angle of projection $\therefore \boxed{\theta = 45°}$

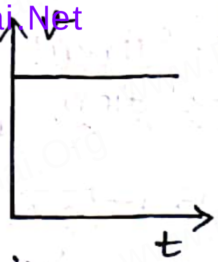
7. (i) Velocity varies uniformly w.r.t. time. This is known as acceleration.



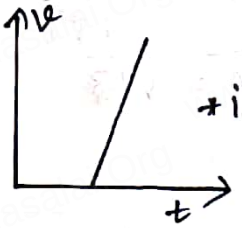
$\therefore$ constant acceleration, $\vec{a} = \frac{d\vec{v}}{dt}$.

(ii) velocity is constant.

$\therefore \vec{a} = 0.$



(iii)



* initial velocity $u \neq 0$ ($t=0$)

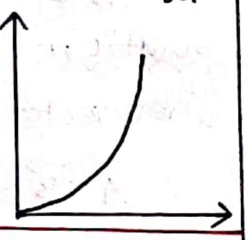
$\therefore \vec{a} = $ constant.

but greater than first graph. $\vec{a} = \frac{d\vec{v}}{dt}$.

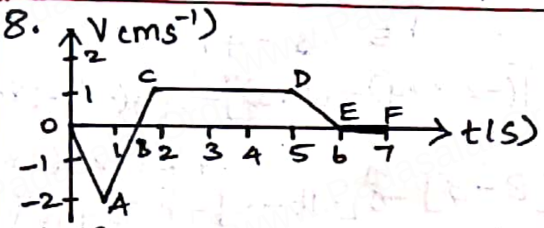
(iv)

velocity is variable

$\therefore$ acceleration ($\vec{a}$) is also variable.



8.



Solution:- (a) From O to A (0s to 1s)

* At $t=0s$, the particle has zero velocity. At $t>0$, particle has negative velocity and moving in $-ve$ x-direction

* 0s to 1s the slope is $\left(\frac{dv}{dt}\right)$ is $-ve$

* $\therefore$ velocity decreases during this time interval.

(b) From A to B :- (1s to 1.5s)

* the velocity is still $-ve$. but starts increasing from $-2ms^{-1}$. At $t=1.5s$, velocity is zero and particle comes to rest.

(c) From B to C :- (1.5s to 2s)

* velocity is zero at 1.5s.

* velocity increases (1.5s to 2s), particle is accelerating. slope $\frac{dv}{dt}$ is $+ve$

(d) From C to D :- (2s to 5s)

* velocity is constant ($1ms^{-1}$)

$\therefore a = 0$. particle continous to travel in the $+ve$ x-direction.

(e) From D to E (5s to 6s)

* From 5s to 6s (slope is $-ve$).

* velocity decreases, particle is moving in $+ve$ x-direction.

* At $t=6s$, velocity is zero. particle comes to rest momentarily

(f) From E to F (6s to 7s)

* particle is at rest ($V = 0ms^{-1}$)

Displacement of the particle

(0s to 1.5s) $= \frac{1}{2} \times b \times h = -\frac{1}{2} \times 1.5 \times 2$

$= -1.5\,m$

(1.5s to 2s) $= \frac{1}{2} \times b \times h = \frac{1}{2} \times 0.5 \times 1 = 0.25m$

$\therefore$ Total Displacement (0s to 2s) $= -1.5 + 0.25$

$= -1.25\,m$

$\therefore$ Total Distance (0s to 2s)

$= 1.5 + 0.25 = 1.75\,m$

9. V_x = remains constant.

V_y = decreases and increases.

a = remains downward

position vector, r = varies.

10. Given:- Speed of fountain is 'v'

$r \rightarrow$ radius of circle of wet region.

Total area around the fountain, $A = \pi r^2$

Solution:- $A = ?$

$\therefore$ centripetal acceleration, $a = \frac{V^2}{r}$

$\therefore g = \frac{V^2}{r}$; $r = \frac{V^2}{g}$. $(a = g)$

$\therefore$ Total area $A = \pi r^2 = \pi \left(\frac{V^2}{g}\right)^2$

Area, $\boxed{A = \frac{\pi V^4}{g^2}}$

11. Given :- $R_J = 50$, $R_E = 75$, $R_{Mars} = 90$, $R_{mercury} = 95$

gravity, $g = ?$

Solution :- Range, $R = \frac{u^2 \sin 2\theta}{g}$

$\therefore R \propto \frac{1}{g}$ (u, θ are constants)

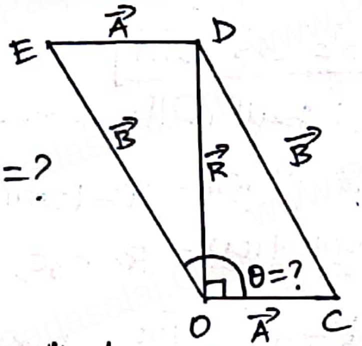
$\therefore R_{mercury}$ is maximum, hence $g_{mercury}$ is minimum.

$\therefore g_{mercury} < g_{mars} < g_{Earth} < g_{Jupiter}$

12. Given :-

$\vec{R} = \frac{\vec{B}}{2}$

Angle b/w $\vec{A}$ & $\vec{B}$, $\theta = ?$



Solution :-

ΔODC,

$CD^2 = OC^2 + OD^2$

$B^2 = A^2 + R^2$

$B^2 = A^2 + \frac{B^2}{4}$

$B^2 - \frac{B^2}{4} = A^2$

$A^2 = \frac{3B^2}{4}$

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

Magnitude of $\vec{R}$ is

$R^2 = A^2 + B^2 + 2AB\cos\theta$

$2AB\cos\theta = R^2 - A^2 - B^2$

$2AB\cos\theta = \frac{B^2}{4} - \frac{3B^2}{4} - B^2$

$2AB\cos\theta = \frac{B^2 - 3B^2 - 4B^2}{4}$

$2AB\cos\theta = -\frac{\cancel{6}^{3} B^2}{\cancel{4}_{2}}$

$\therefore \cancel{2} \times \frac{B\sqrt{3}}{\cancel{2}} \times \cancel{B} \times \cos\theta = -\frac{3B^{\cancel{2}}}{2}$

$\therefore \cos\theta = -\frac{\sqrt{3} \times \cancel{\sqrt{3}}}{2\cancel{\sqrt{3}}}$

$[\cos(180° - \theta) = -\cos\theta]$

$-\cos\theta = \frac{\sqrt{3}}{2}$

$\therefore \cos(180° - \theta) = \sqrt{3}/2$

$180° - \theta = 30°$

$\boxed{\theta = 150°}$

13. comparing the components for following vector eqns.

(a) $T\hat{j} - mg\hat{j} = ma\hat{j}$

$(T - mg)\hat{j} = ma\hat{j}$

$T - mg = ma$ //

(b) $\vec{T} + \vec{F} = \vec{A} + \vec{B}$ ⇒ For x-components.

(i) $T_x\hat{i} + F_x\hat{i} = A_x\hat{i} + B_x\hat{i}$

$(T_x + F_x)\hat{i} = (A_x + B_x)\hat{i}$

$T_x + F_x = A_x + B_x$ //

(ii) For y-components.

$T_y\hat{j} + F_y\hat{j} = A_y\hat{j} + B_y\hat{j}$

$(T_y + F_y)\hat{j} = (A_y + B_y)\hat{j}$

$T_y + F_y = A_y + B_y$ //

(c) $\vec{T} - \vec{F} = \vec{A} - \vec{B}$

(i) For x-components.

$T_x\hat{i} - F_x\hat{i} = A_x\hat{i} - B_x\hat{i}$

$(T_x - F_x)\hat{i} = (A_x - B_x)\hat{i}$

$T_x - F_x = A_x - B_x$ //

(ii) For y-components.

$T_y\hat{j} - F_y\hat{j} = A_y\hat{j} - B_y\hat{j}$

$(T_y - F_y)\hat{j} = (A_y - B_y)\hat{j}$

$T_y - F_y = A_y - B_y$ //

(d) $T\hat{j} + mg\hat{j} = ma\hat{j}$

$(T + mg)\hat{j} = ma\hat{j}$

$T + mg = ma$ //

14. $\vec{A} = 5\hat{i} - 3\hat{j}$, $\vec{B} = 4\hat{i} + 6\hat{j}$

$\therefore$ Area of a triangle, $A = \frac{1}{2}|\vec{A} \times \vec{B}|$

$= \frac{1}{2}\begin{vmatrix} 5 & -3 \\ 4 & 6 \end{vmatrix} \Rightarrow \frac{1}{2} \times (30 - (-12))$

$A = \frac{1}{\cancel{2}} \times \cancel{42}^{21}$; $\boxed{A = 21\ m^2}$

15. $T = 24\,hr$ (period of revolution)
Angular displacement made by earth in one hour, $\theta = ?$

Solution:-

$24\,hr = 360°$

∴ Angle made in 1 hour, $\theta = \frac{360°}{24} = 15°$

$\left(1° = \frac{\pi}{180}\,rad\right)$

$\boxed{\theta = 15°}$

∴ $\theta = 15° \times \frac{\pi}{180}\,rad$

∴ $\boxed{\theta = \frac{\pi}{12}\,rad}$

16. Given:- $u = 5\,ms^{-1}$, $\theta = 30°$
$H_{max} = ?$, Range, $R = ?$

Solution:- (i) $H_{max} = \frac{u^2 \sin^2\theta}{2g}$

$H_{max} = \frac{5^2 \times \sin 30° \times \sin 30°}{2 \times 9.8}$

$= \frac{25 \times 0.5 \times 0.5}{19.6}$

$= \frac{6.25}{19.6} = 3.18 \times 10^{-1}$

$6.25 \Rightarrow 0.7959$
$19.6 \Rightarrow 1.2923$
$\bar{1}.5036$
3.188×10^{-1}

∴ $\boxed{H_{max} = 0.318\,m}$

(ii) Range, $R = \frac{u^2 \sin 2\theta}{g}$; $2\theta = 2 \times 30°$, $2\theta = 60°$

$R = \frac{5^2 \times \sin 60°}{9.8}$

$= \frac{25 \times \sqrt{3}}{9.8 \times 2}$

$= \frac{25 \times 1.732}{19.6}$

$25 \Rightarrow 1.3979$
$1.732 \Rightarrow 0.2385$ (+)
1.6364
$19.6 \Rightarrow 1.2923$ (−)
0.3441
2.209×10^{0}
2.21

∴ $\boxed{R = 2.21\,m}$

17. Given:- $u = 20\,ms^{-1}$, $\theta = 30°$, $d = 40\,m$, $R = ?$

Solution:-

Range, $R = \frac{u^2 \sin 2\theta}{g}$ ∴ $2\theta = 60°$

∴ $R = \frac{(20)^2 \times \sin 60°}{g}$

($\sin 60° = 0.866$ (or) $\sqrt{3}/2$)

$= \frac{400 \times 0.866}{9.8}$

$= \frac{34.64 \times 10^{1}}{9.8} = 3.53 \times 10$

$\log 34.64 \Rightarrow 1.5396$
$9.8 \Rightarrow 0.9912$ (−)
0.5484
3.538×10^{0}

$\boxed{R = 35.3\,m}$

∴ Ball will not reach the goal post.

18. Given:- $u = 10\,ms^{-1}$, $h = 100\,m$, $R = ?$

Solution:- Range, $R = u\sqrt{\frac{2h}{g}}$

$R = 10\sqrt{\frac{2 \times 100}{9.8}} = \frac{10 \times 10\sqrt{2}}{\sqrt{9.8}}$

$\log 141.4 \Rightarrow 2.1504$

$R = \frac{100 \times 1.414}{\sqrt{9.8}}$

$\frac{1}{2}\log 9.8 \Rightarrow 0.9912 / 2$
0.4956

$= \frac{141.4}{\sqrt{9.8}} = 45.16\,m$

2.1504
0.4956 (−)
Antilog 1.6548
4.516×10^{1}
45.16.

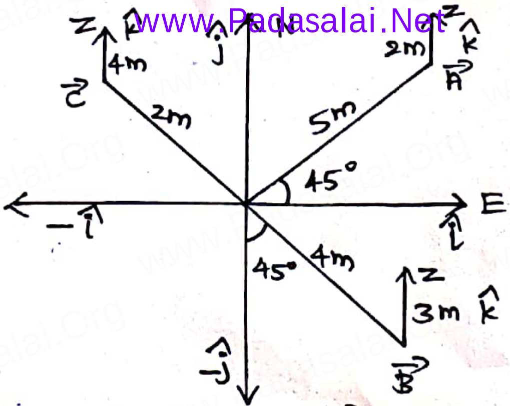
∴ $\boxed{R = 45\,m}$

19. Given:- Angular displacement $\theta = \frac{\pi}{12}$
θ after $4\,s = ?$

Solution:-
Angular displacement after $4\,s$, $\theta = 4 \times \frac{\pi}{12}$

$\boxed{\theta = \frac{\pi}{3} \text{ (or) } 60°}$

20. (a) 5m north east and 2m up.
(b) 4m South east and 3m up.
(c) 2m north west and 4m up



(i) The components of $\vec{A}$ along x, y, Z axes,

$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$

$= A\cos\theta\hat{i} + A\sin\theta\hat{j} + A_z\hat{k}$

$= 5\cos45°\hat{i} + 5\sin45°\hat{j} + 2\hat{k}$

$= 5\times\frac{1}{\sqrt{2}}\hat{i} + 5\times\frac{1}{\sqrt{2}}\hat{j} + 2\hat{k}$

$\therefore \vec{A} = \frac{5}{\sqrt{2}}(\hat{i}+\hat{j}) + 2\hat{k}$

(ii) The components of $\vec{B}$ along x, y, z axes

$\vec{B} = B_x\hat{i} + B_y(-\hat{j}) + B_z\hat{k}$

$= B\cos\theta\hat{i} + B\sin\theta(-\hat{j}) + B_z\hat{k}$

$= 4\cos45°\hat{i} - 4\sin45°\hat{j} + 3\hat{k}$

$= 4\times\frac{1}{\sqrt{2}}\hat{i} - 4\times\frac{1}{\sqrt{2}}\hat{j} + 3\hat{k}$

$\vec{B} = \frac{4}{\sqrt{2}}(\hat{i}-\hat{j}) + 3\hat{k}$

(iii) The components of $\vec{C}$ along x, y, z axes

$\vec{C} = -C_x\hat{i} + C_y\hat{j} + C_z\hat{k}$

$= -C\cos\theta\hat{i} + C\sin\theta\hat{j} + C_z\hat{k}$

$= -2\cos45°\hat{i} + 2\sin45°\hat{j} + 4\hat{k}$

$= -2\times\frac{1}{\sqrt{2}}\hat{i} + 2\times\frac{1}{\sqrt{2}}\hat{j} + 4\hat{k}$

$= \frac{2}{\sqrt{2}}(-\hat{i}+\hat{j}) + 4\hat{k}$

$= \frac{\sqrt{2}\times\cancel{\sqrt{2}}}{\cancel{\sqrt{2}}}(-\hat{i}+\hat{j}) + 4\hat{k}$

$\vec{C} = \sqrt{2}(-\hat{i}+\hat{j}) + 4\hat{k}$

21. Given:- Period of rotation $T = 27$ days.

θ per day $= ?$

Solution:- Moon completes 360° in 27 days

$\therefore$ 27 days = 360°

$\therefore$ Angle transversed in a day, $\theta = \frac{360°}{27}$

log 360 ⇒ 2.5563
27 ⇒ 1.4314 (−)
Antilog ↙ 1.1249
1.333 × 10¹
13.3

$\boxed{\theta = 13°3'}$

22. Given:- angular acceleration (α)

$\theta = ?$, $t = 3s$. $\alpha = 0.2\ rad\,s^{-1}$

Solution:- At $\theta = 0$, $\omega_0 = 0$.

Angular displacement (θ)

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$= (0)3 + \frac{1}{\cancel{2}}\times 0.\cancel{2}^{\,0.1}\times(3)^2$

$= 0.1\times 9$

$\boxed{\theta = 0.9\ rad}$

[rad to degree ↓ $\times\frac{180°}{\pi}$]

$\theta = 0.9\times\frac{180°}{\pi}$

$= \frac{162°}{3.14}$

$\boxed{\theta = 51°}$

log 162 ⇒ 2.2095
3.14 ⇒ 0.4969 (−)
1.7126
5.159 × 10¹
51.59

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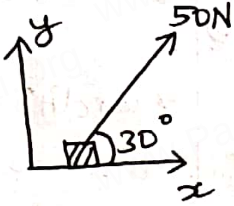
3. Laws of Motion

⑦

1. Given :-

$F = 50N, m = 20kg$

$a_x = ?, \ a_y = ?$



Solution :-

(i) components of force along x-direction.

$F_x = F\cos\theta$

$= 50 \times \cos 30^\circ$

$= 50 \times \frac{\sqrt{3}}{2}$

$= 50 \times \frac{1.732}{2}$

$= 50 \times 0.866$

$F_x = 43.3 \ N$

acceleration, $a_x = \frac{F_x}{m}$

$a_x = \frac{43.3}{20} = 2.165 \ ms^{-2}$

(ii) components of force along y-direction.

$F_y = F\sin\theta$

$= 50 \times \sin 30^\circ$

$= 50 \times \frac{1}{2}$

$F_y = 25 N$

$\therefore a_y = \frac{F_y}{m} = \frac{25}{20} = \frac{5}{4}$

$a_y = 1.25 \ ms^{-2}$

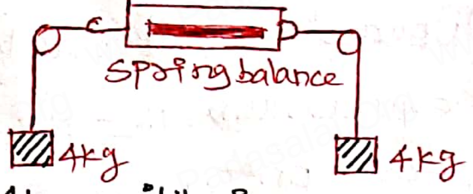
2. Given :- $m = 50g = 50 \times 10^{-3} kg$

$T = ?$

$\therefore$ Tension on the string, $T = mg$

$T = 50 \times 10^{-3} \times 9.8 = 0.49 N$

3.



a) At equilibrium, $T_1 = T_2$

spring reads value

$R = T_1 - T_2 = 0, \ R = 0.$

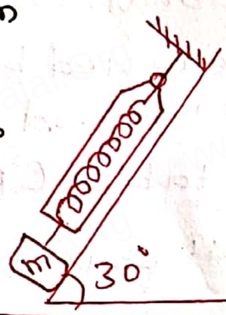
b) At equilibrium

$T = mg\sin\theta$

$= 2 \times 9.8 \times \sin 30^\circ$

$= \cancel{2} \times 9.8 \times \frac{1}{\cancel{2}}$

$T = 9.8 \ N$



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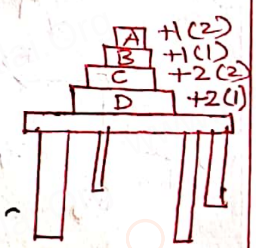


(i) Force on Book 'A'

* Downward gravitational force by earth ($m_A g$).

* Upward Normal force 'N_B' by B.

At equilibrium, $N_B = m_A \cdot g$.

(ii) Force on Book 'B'

* Downward gravitational force by earth ($m_B g$)

* Downward force exerted by 'A' (N_A)

* Upward normal force by C, (N_C)

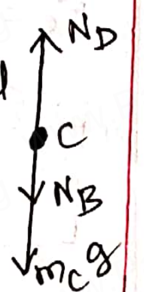
At equilibrium,

$N_C = N_A + m_B \cdot g.$

(iii) Force on Book 'c'

* Downward gravitational force by earth ($m_C g$)

* Downward force exerted by earth (N_B)



* Upward normal force by 'D' (N_D)

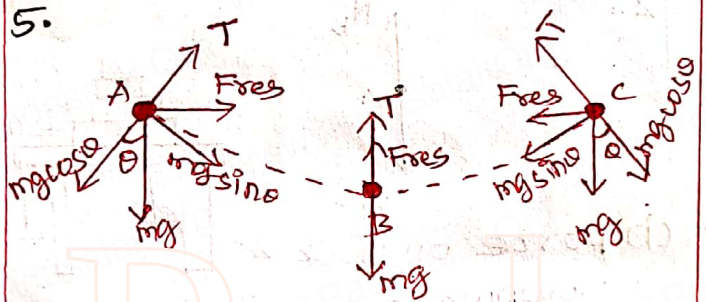
At equilibrium, $N_D = N_B + m_C g$

(iv) Force on Book 'D'

* Downward gravitational force by Earth ($m_D g$)
* Downward force exerted by 'C' (N_C)
* Upward normal force by table (N_{table}).

At equilibrium, $N_{table} = N_C + m_D g$

5.



* The gravitational force (mg) acting downward can be resolved into two components as $mg\cos\theta$ and $mg\sin\theta$
* Tangential acceleration :- brings the bob to equilibrium position and acts towards mean position.

Tangential force, $F_T = ma_T$

$ma_t = mg\sin\theta$

$$\boxed{a_t = g\sin\theta}$$

Centripetal Force (F_c) :-

$F_c = ma_c = T - mg\cos\theta$

∴ centripetal acceleration

$$\boxed{a_c = \frac{T - mg\cos\theta}{m}}$$

6. $m_1 = 15\,kg$, $m_2 = 10\,kg$, $m_3 = 25\,kg$

$\mu_s = 0.2$

* condition to prevent sliding due to friction.

Maximum static friction, f_s^{max} = Tension acting on string (T)

$f_s^{max} = \mu_s N$

$N = (m_1 + m_3)$

$T = m_2 g$

∴ Non-sliding condition

$\mu_s (m_1 + m_3) g = m_2 g$

$m_1 + m_3 = \frac{m_2}{\mu_s}$

$\therefore m_3 = \frac{m_2}{\mu_s} - m_1$

$= \frac{10}{0.2} - 15 = 50 - 15$

$m_3 = 35\,kg$

∴ The minimum mass $m_3 = 35\,kg$ has to be placed on m_1 to prevent it from sliding.

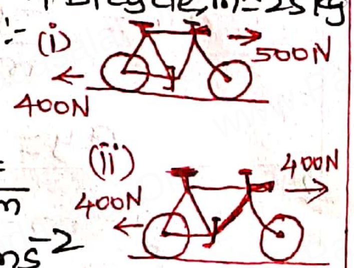
But here $m_3 = 25\,kg$ only.

∴ The combined mass ($m_1 + m_3$) will slide.

7. (i) Net Force (F) :- mass of bicycle, $m = 25\,kg$

$F = 500 - 400$

$F = 100\,N$



∴ acceleration, $a = \frac{F}{m}$

$a = \frac{100}{25} = 4\,ms^{-2}$

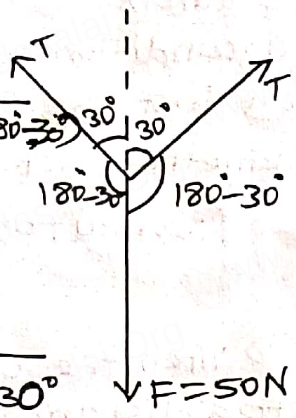
(ii) Net force, $F = 400 - 400 = 0\,N$

∴ acceleration, $a = \frac{F}{m} = \frac{0}{25} = 0$

8. Given :- $F = 50N$, $T = ?$

According to Lami's theorem

$$\frac{F}{\sin 2\theta} = \frac{T}{\sin(180^\circ - 30^\circ)} = \frac{T}{\sin(180^\circ - 30^\circ)}$$



$$\frac{F}{\sin 2\theta} = \frac{T}{\sin(180^\circ - 30^\circ)}$$

$$\frac{F}{2\sin\theta\cos\theta} = \frac{T}{\sin 30^\circ}$$

$[\sin(180^\circ - \theta) = \sin\theta]$

$[\sin 2\theta = 2\sin\theta\cos\theta]$

$$\frac{F}{2\cancel{\sin 30^\circ} \times \cos 30^\circ} = \frac{T}{\cancel{\sin 30^\circ}}$$

$$T = \frac{F}{2\cos 30^\circ}$$

$$T = \frac{50}{\cancel{2} \times \frac{\sqrt{3}}{\cancel{2}}} = \frac{50}{1.732}$$

$$\boxed{T = 28.87\,N}$$

$\log 50 \Rightarrow 1.6990$
$1.732 \Rightarrow 0.2385$ (−)
1.4605
Antilog ⇐
2.887×10^1
$28.87N$

9. $m = 0.8kg$, Final velocity $v = 12ms^{-1}$, Initial velocity, $u = 0$, $t = \frac{1}{60}s$

$F = ?$

Average kicking force

$$F = ma = \frac{m(v-u)}{t} = \frac{0.8(12-0)}{1/60}$$

$$= 0.8 \times 12 \times 60$$

$$= 9.6 \times 60$$

$$\boxed{F = 576\,N}$$

9.6×60
00
576
576.0

10. $m = 2kg$, $l = 1m$, $T = 200N$

When the object in whirling motion (tension provides centripetal force)

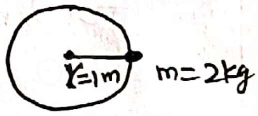
$$\therefore T = \frac{mv^2}{r}$$

$$v^2 = \frac{T \cdot r}{m}$$

$$v^2 = \frac{\cancel{200}^{100} \times 1}{\cancel{2}}$$

$$V = \sqrt{100}$$

$$\boxed{\therefore V_{max} = 10ms^{-1}}$$



11. Given :- $M_{moon} = 7.34 \times 10^{22} kg$.

$R = 3.84 \times 10^8 m$, Tension $T = ?$

Solution :-

At equilibrium, $F_g = F_{CPF}$

$$\frac{GM\cancel{m}}{R^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{R}}$$

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

$\therefore$ Tension on the string provides necessary centripetal force

$$T = \frac{mv^2}{R} = \frac{m}{R}\left(\frac{GM}{R}\right) = \frac{GMm}{R^2}$$

mass of Earth, $m_E = 5.98 \times 10^{24} kg$.

Gravitational constant, (G)

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

$$T = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times 7.34 \times 10^{22}}{(3.84 \times 10^8)^2}$$

$$= \frac{6.67 \times 5.98 \times 7.34 \times 10^{35}}{3.84 \times 3.84 \times 10^{16}}$$

$$= \frac{6.67 \times 5.98 \times 7.34 \times 10^{19}}{3.84 \times 3.84}$$

$$\boxed{T = 2.0 \times 10^{20}\,N}$$

$\therefore T = 1.986 \times 10^1 \times 10^{19} \approx 2.0 \times 10^{20}$

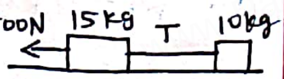
$\log 6.67 \Rightarrow 0.8241$
$5.98 \Rightarrow 0.7767$ (+)
$7.34 \Rightarrow 0.8657$
2.4665

$\log 3.84 \Rightarrow 0.5843$ (+)
$3.84 \Rightarrow 0.5843$
1.1686

2.4665
1.1686 (−)
1.2979

1.986×10^1 ⇐ Antilog

12. Given:-



$m_1 = 15\,kg$, $m_2 = 10\,kg$

$F = 500\,N$; $T = ?$

Solution:-

Total mass, $m = m_1 + m_2$

$m = 15 + 10 = 25\,kg$

$\therefore$ Total acceleration, $a = \frac{F}{m}$

$a = \frac{500}{25} = 20\,ms^{-2}$

$\therefore$ Tension, $T = m_2\, a$

$T = 10 \times 20$

$\boxed{T = 200\,N}$

13.
* Newton's third law is applicable to only human's actions which involves physical force.
* Third law is not applicable to human's psychological actions or thoughts.

14. mass of a person, $m = 60\,kg$

Velocity of the car, $v = 50\,ms^{-1}$

Radius of curvature, $r = 10\,m$

Centrifugal force, $F = ?$

Solution:-

Centrifugal force, $F = \frac{mv^2}{r}$

$F = \frac{\cancel{60}^{6} \times 50 \times 50}{\cancel{10}}$

$F = 15,000\,N$

15. Given:- $\mu_k = 0.7$, $m = 0.5\,kg$

$v = ?$ $h = 10\,m$.

Solution:-

(i) condition for the object to move against the frictional force,

kinetic friction, $f_k = \mu_k N$

Normal force, $N = mg$

$\therefore f_k = \mu_k\, mg$

(ii) When the object is thrown to a distance 'h', workdone is converted into K.E.

i.e E_K = workdone

$\frac{1}{2}mv^2$ = Force x distance

$\frac{1}{2}mv^2 = f_k \times h$

$\frac{1}{2}\cancel{m}v^2 = \mu_k \cancel{m} g \times h$

$v^2 = 2\mu_k\, gh$

$v = \sqrt{2\mu_k\, gh}$

$v = \sqrt{2 \times 0.7 \times 9.8 \times 10}$

$= \sqrt{1.4 \times 98}$

$v = \sqrt{137.2}$

$\therefore$ minimum speed (v)

$\boxed{v = 11.71\,ms^{-1}}$

98×1.4

392

98

137.2

$\frac{1}{2}\log 137.2 \Rightarrow \frac{2.1373}{2}$

Antilog 1.0686

1.171×10^1

11.71

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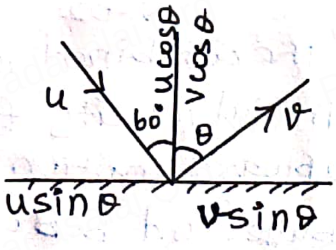
4. WORK, ENERGY AND POWER

1. **Given:-** $F = 30\,N$, height$(d) = 10\,m$.
$W = ?$ $m = 2\,kg$

Solution:-

Workdone, $W = F \cdot d$
$= 30 \times 10$
$W = 300\,J$ //

2.
$u = 5\,m/s$
$\theta = 60°$
$e = 0.5$



Solution:-

$v\cos\theta = eu\cos\phi \rightarrow (1)$
$v\sin\theta = u\sin\phi \rightarrow (2)$

* Co-efficient of restitution (e)

$e = \dfrac{\text{velocity of separation}}{\text{velocity of approach}}$

$e = \dfrac{v\cos\theta}{u\cos\phi}$; $v\cos\theta = eu\cos\phi$

* Horizontal component

$v\sin\theta = u\sin\phi$

$(1)^2 + (2)^2 \Rightarrow$

$v^2[\sin^2\theta + \cos^2\theta] = e^2u^2\cos^2\phi + u^2\sin^2\phi$

$v^2 = u^2(e^2\cos^2\phi + \sin^2\phi)$

$v = u\sqrt{e^2\cos^2\phi + \sin^2\phi}$

$v = 5\sqrt{\left(\frac{1}{2}\right)^2 \times \cos 60° \times \cos 60° + \sin 60° \times \sin 60°}$

$= 5\sqrt{\frac{1}{4} \times \frac{1}{2} \times \frac{1}{2} + \frac{\sqrt{3}}{2} \times \frac{\sqrt{3}}{2}}$

$= 5\sqrt{\frac{1}{16} + \frac{3}{4}}$

$= 5\sqrt{\frac{1}{4} \times \frac{1}{4} + \frac{3}{4}} = 5\sqrt{\frac{0.25 + 3}{4}}$

$v = \frac{5}{2}\sqrt{3.25} = 2.5\sqrt{3.25}$

$\therefore \boxed{v = 4.5\,ms^{-1}}$

(ii) Direction after impact

Substitute the value 'v' in eq (1)

$4.5\cos\theta = 0.5 \times 5 \times \cos 60°$

$\frac{9}{2}\cos\theta = 2.5 \times \frac{1}{2}$

$\cos\theta = \frac{5}{2} \times \frac{1}{9} = \frac{5}{18}$

$\cos\theta = 0.2777$

$\theta = \cos^{-1}(0.2777)$

$\boxed{\theta = 73.9°}$

$18 \overline{)50}$ = 0.277
36
140
126
140
126

3.

(i) At the bottom
K.E is maximum
$E_K = \frac{1}{2}mv^2$ & $E_P = 0$.

(ii) At the top P.E is maximum
$E_P = mgh = mg(2r) = 2mgr$
$E_K = 0$.

According to Law of conservation of energy.

E_K at bottom $= E_P$ at top

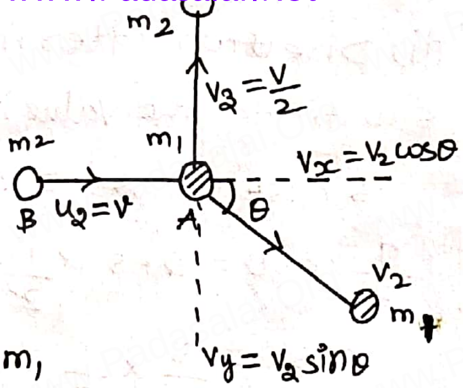
$\frac{1}{2}\cancel{m}v^2 = 2\cancel{m}gr$

$v^2 = 4gr$

$v = \sqrt{4gr}\ ms^{-1}$ //

$\log 2.5 \Rightarrow 0.3979 \Rightarrow 0.3979$ (+)
$\frac{1}{2}\log 3.25 \Rightarrow \frac{0.5119}{2}$ 0.2559
0.6538
4.506×10^0

4.



Given:-

mass of $A = m_1$

initial velocity of A, $u_1 = 0$.

mass of $B = m_2$, initial velocity $u_2 = V$

Final velocity of $A = V_2$

" $B \Rightarrow V_3$. $\theta = ?$

Solution:-

using Linear momentum,

(i) Along x-axis

$$m_2 V = m_1 V_x$$

$$m_2 V = m_1 V_2 \cos\theta \rightarrow (1)$$

(ii) Along y-axis

$$m_2 V_3 = m_1 V_y \quad \left(V_3 = \frac{V}{2}\right)$$

$$\frac{m_2 V}{2} = m_1 V_2 \sin\theta \rightarrow (2)$$

$$\frac{(2)}{(1)} \Rightarrow \frac{\cancel{m_1}\cancel{V_2} \sin\theta}{\cancel{m_1}\cancel{V_2} \cos\theta} = \frac{\cancel{m_2 V}}{2} \times \frac{1}{\cancel{m_2 V}}$$

$$\tan\theta = \frac{1}{2} = 0.5$$

$$\theta = \tan^{-1}(0.5)$$

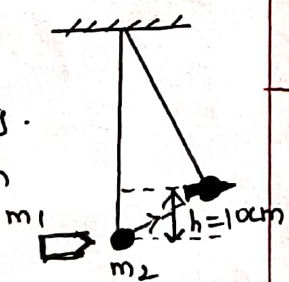
$$\theta = 26°33'$$

5. Given:-

mass of the bullet,

$m_1 = 20g = 0.02kg$.

mass of the pendulum bob, $m_2 = 5kg$.



The initial velocity $u_1 = ?$

Solution:-

The speed of the bullet is u_1.

The pendulum bob is at rest, $u_2 = 0$.

$\therefore$ The common velocity of the bullet and bob of the pendulum is

(12)

$$V = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$$

$$V = \frac{0.02 \times u_1 + 5(0)}{0.02 + 5}$$

$$V = \frac{0.02 u_1}{5.02} \rightarrow (1)$$

The combined velocity is the initial velocity for the vertical upward motion of the combined bullet and bob of the pendulum.

using Equation of motion,

$$v^2 = u^2 + 2gh$$

$$u = 0.$$

$$V^2 = 2gh$$

$$V^2 = 2 \times 9.8 \times 10 \times 10^{-2}$$

$$V^2 = 196 \times 10^{-2}$$

$$V = \sqrt{196 \times 10^{-2}}$$

$$V = 14 \times 10^{-1} ms^{-1}$$

$$(1) \Rightarrow \overset{7}{\cancel{14}} \times 10^{-1} = \frac{\cancel{2} \times 10^{-2} u_1}{5.02}$$

$$5.02 \times 7 \times 10 = u_1$$

$$u_1 = 50.2 \times 7$$

$$\boxed{u_1 = 351.4 \ ms^{-1}}$$

$\therefore$ initial velocity $u_1 = 351.4 ms^{-1}$

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5. Motion of System of Particles and Rigid bodies

1. **Given:-** $m = 100g = 0.1kg$

$V = 20cm\,s^{-1} = 0.2\,m\,s^{-1}$

diameter $d = 10cm$

$\therefore$ radius, $r = 5cm = 0.05m$.

$E_{Tot} = ?$

Solution:- For a pure rolling on a horizontal surface,

$E_{Tot} = KE_{TRANS} + KE_{rot}$

$E_{Tot} = \frac{1}{2}MV_{cm}^2 + \frac{1}{2}I_{cm}\omega^2$

For a disc, $I_{cm} = \frac{MR^2}{2}$

$\omega = \frac{V}{R},\ \omega^2 = \frac{V^2}{R^2}$

$E_{Tot} = \frac{1}{2}MV^2 + \frac{1}{2}\left(\frac{M\cancel{R^2}}{2} \times \frac{V^2}{\cancel{R^2}}\right)$

$= \frac{1}{2}mV^2 + \frac{1}{4}mV^2$

$E_{Tot} = \frac{3MV^2}{4}$

$= \frac{3}{4} \times 0.1 \times 0.2 \times 0.2$

$= \frac{3 \times 10^{-1} \times \cancel{2} \times 10^{-1} \times \cancel{2} \times 10^{-1}}{\cancel{4}}$

$= 3 \times 10^{-3} J$

$\boxed{E_{TOT} = 0.003 J}$

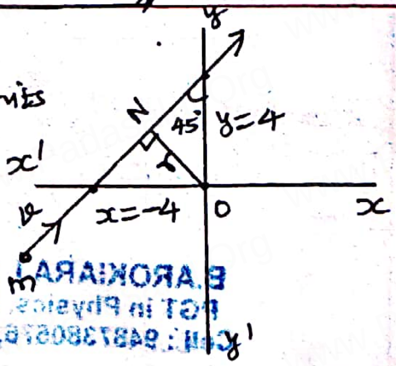
2. **Given:-**

Mass, $m = 5$ units

$V = 3\sqrt{2}$ units

$y = x + 4$

$L = ?$



Solution:-

The given eqn of the line is $y = x + 4$.

At $x = -4$, $y = 0$, and $x = 0$, $y = 4$

The line is drawn as shown in figure.

From diagram,

$\sin 45° = \frac{r}{4}$

$r = 4 \times \sin 45°$

$\therefore$ Angular momentum,

$L = mvr = 5 \times 3\sqrt{2} \times 4 \times \sin 45°$

$L = 5 \times 3\cancel{\sqrt{2}} \times 4 \times \frac{1}{\cancel{\sqrt{2}}}$

$\boxed{L = 60 \text{ units}}$

3. **Given:-**

initial angular velocity, $\omega_0 = 20\pi$ rad/s

Final " " $\omega = 40\pi$ rad/s

time, $t = 10s$, $n = ?$

Solution:-

Angular acceleration, $\alpha = \frac{\omega - \omega_0}{t}$

$\alpha = \frac{40\pi - 20\pi}{10} = \frac{2\cancel{0}\pi}{1\cancel{0}} = 2\pi$

$\alpha = 2\pi\ rad/s^2$

Angular displacement (θ)

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$\theta = 20\pi \times 10 + \frac{1}{\cancel{2}} \times \cancel{2}\pi \times (10)^2$

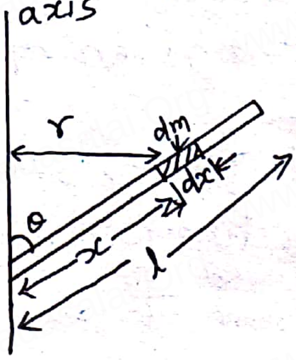
$= 200\pi + 100\pi$

$\theta = 300\pi$.

$\therefore$ Number of rotations (n)

$n = \frac{\theta}{2\pi} = \frac{300\cancel{\pi}}{2\cancel{\pi}} = 150$ rotations

4.



$\sin\theta = \frac{r}{x}$

$r = x\sin\theta$.

The M.I (dI) of mass (dm) about an axis is

$dI = (dm)\, r^2$

*As the mass is uniformly distributed, the mass per unit length (λ) of the rod is, $\lambda = \frac{M}{l}$

The mass (dm) of the infinitesimally small length (dx) is $dm = \lambda \cdot dx$

$dm = \frac{M}{l}\, dx$.

∴ The M.I about an axis of the rod is $I = \int dI = \int_0^l dm\, r^2$

$I = \int_0^l \frac{M}{l} dx \times (x\sin\theta)^2$

$= \int_0^l \frac{M}{l} dx \times x^2 \sin^2\theta$

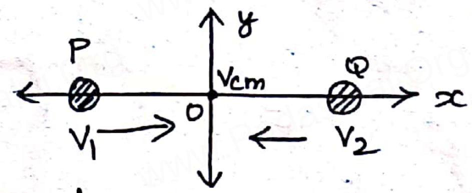
$= \frac{M}{l}\sin^2\theta \int_0^l x^2 dx$

$= \frac{M}{l}\sin^2\theta \left[\frac{x^3}{3}\right]_0^l$

$= \frac{M}{\cancel{l}}\sin^2\theta \times \frac{l^{\cancel{3}\,2}}{3}$

$$\boxed{I = \frac{Ml^2}{3}\sin^2\theta}$$

5. Given:- $m_1 = 1kg,\ m_2 = 3kg$



$V_1 = \frac{dr}{dt} \Rightarrow$ (towards right)

$V_2 = \frac{dr}{dt} \Rightarrow$ (towards left)

$\therefore V_{cm} = \frac{m_1V_1 + m_2V_2}{m_1+m_2}$

As two particles moves towards each other, momentum are equal but opposite.

$m_1V_1 = -m_2V_2$

$\therefore V_2 = -\frac{m_1V_1}{m_2}$

$\therefore V_{cm} = \frac{m_1V_1 - \cancel{m_2} \times \frac{m_1V_1}{\cancel{m_2}}}{m_1+m_2}$

$V_{cm} = \frac{0}{m_1+m_2} = 0$

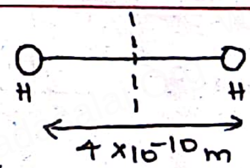
$$\boxed{V_{cm} = 0}$$

6.

Given:-

$r = 4\times10^{-10}m$

mass of $H_2 = 1.7\times10^{-27}kg$



Solution:- Total mass, $M = 2m$,

Radius, $R = \frac{r}{2}$

M.I of H_2 molecule, $I = MR^2$

$I = 2m\left(\frac{r}{2}\right)^2 = \cancel{2}m \times \frac{r^2}{\cancel{4}\,2}$

$I = \frac{1.7\times10^{-27} \times \cancel{4}^{2}\times10^{-10} \times 4\times10^{-10}}{\cancel{2}}$

$I = 1.7\times10^{-47} \times 8 = 13.6\times10^{-47}$

$$\boxed{I = 1.36\times10^{-46}\ kg\,m^2}$$

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