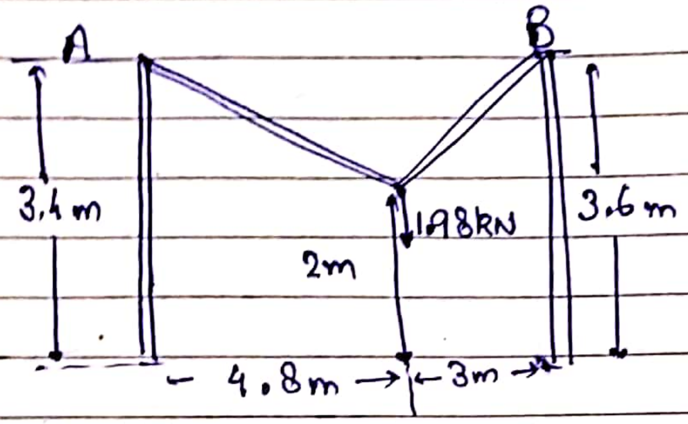
Name: Mohd. Zaid
19COB 103.
Roll. No. 03.

MECHANICS
ASSIGNMENT

Prob. 2.47:

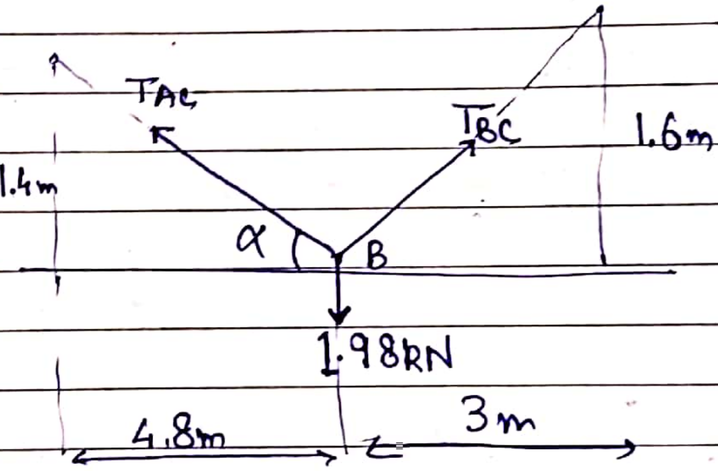


Two cables are tied together at C and loaded as shown, Determine,

a) Tension in cable AC
b) Tension in BC

Solution:

FBD:

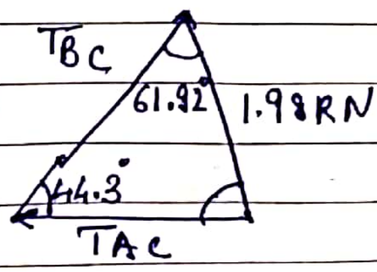


$$\tan\alpha = \frac{1.4}{4.8}$$

$$\alpha = 16.2602^\circ$$

$$\tan\beta = \frac{1.6}{3} \Rightarrow \beta = 28.073^\circ$$

Force triagle.



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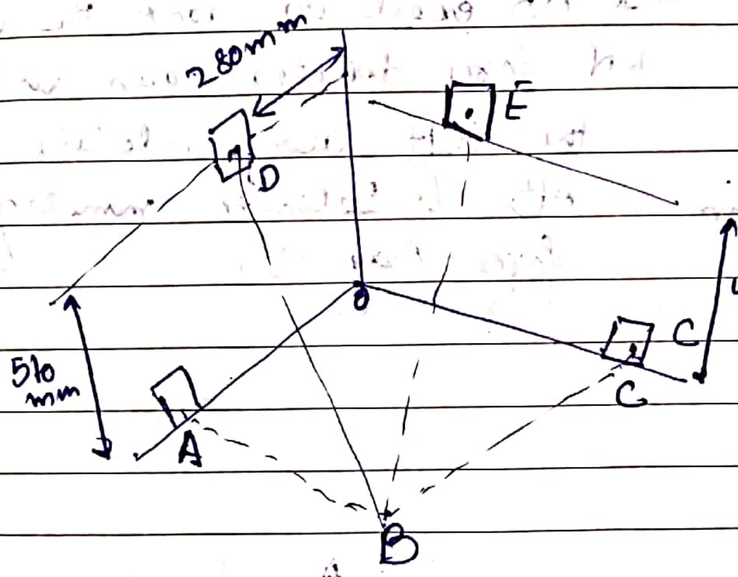
Law of sines

$$\frac{T_{AC}}{\sin 61.927} = \frac{T_{BC}}{\sin 73.74} = \frac{1.98\,kN}{\sin 44.33°}$$

$$\Rightarrow T_{AC} = \frac{1.98}{\sin 44.33} \times \sin 61.927 \Rightarrow \underline{T_{AC} = 2.50\,kN}$$

$$T_{BC} = \frac{1.98}{\sin 44.33} \times \sin 73.740 \Rightarrow T_{BC} = \underline{2.72\,kN}$$

Problem 2.89



A frame ABC is supported in parts by cable DBE that passes through a frictionless ring at B. Knowing tension in cable 385N, determine components of force exerted by cable on support at D.

Solution:

$$\vec{DB} = (480\,mm)i - (510\,mm\,j) + (320\,mm)k$$

$$|DB| = \sqrt{(480)^2 + (510)^2 + (320)^2}$$

$$= 770\,mm$$

$$\vec{F} = |F|\,\lambda_{DB}$$

$$= F \cdot \frac{\vec{DB}}{|DB|}$$

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$$\frac{385\,N}{770\,mm}\left[480\,mm\,\hat{i} - 510\,mm\,\hat{j} + (320\,mm)\,\hat{k}\right]$$

$$= 240N\,\hat{i} - 255N\,\hat{j} + 160N\,\hat{k}$$

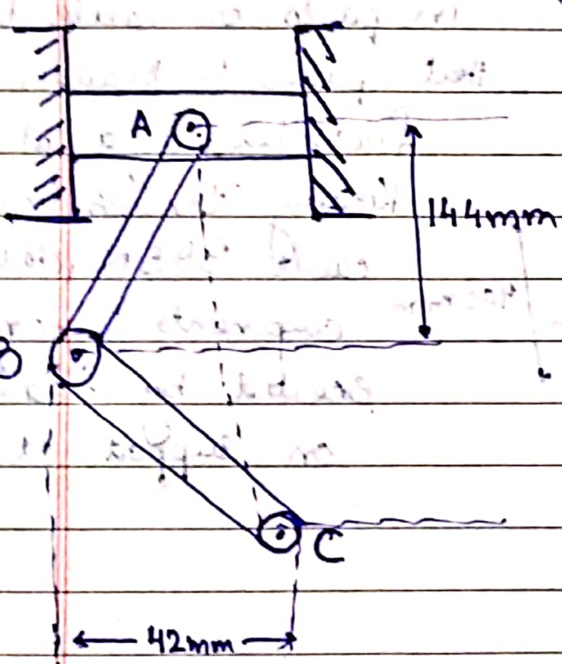
$F_x = +240N$

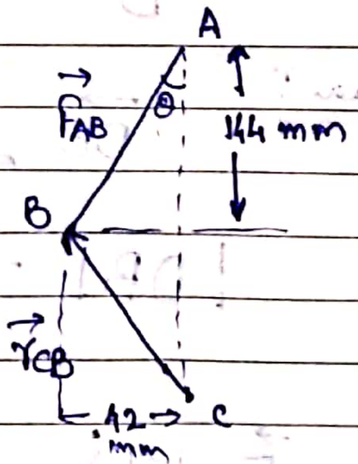
$F_y = -255N$

$F_z = +160N.$

Prob. 3.9.

It is known that the connecting rod AB exerts on crank BC a 2.5 kN force directed down and to the left along centerline of AB. Determine moment of force Along C.





Solution:

Taking C as origin,

$$\tan\theta = \frac{42}{144}$$

$$\theta = \tan^{-1}\left(\frac{42}{144}\right)$$

$$\vec{F}_{AB} = -2.5\cos\left(\tan^{-1}\left(\frac{42}{144}\right)\right)j - 2.5\sin\left(\tan^{-1}\frac{42}{144}\right)j$$

$$= (+2.4j - 0.7i)\ kN$$

$$\vec{r}_{CB} = (-42i + 56j)\ mm$$

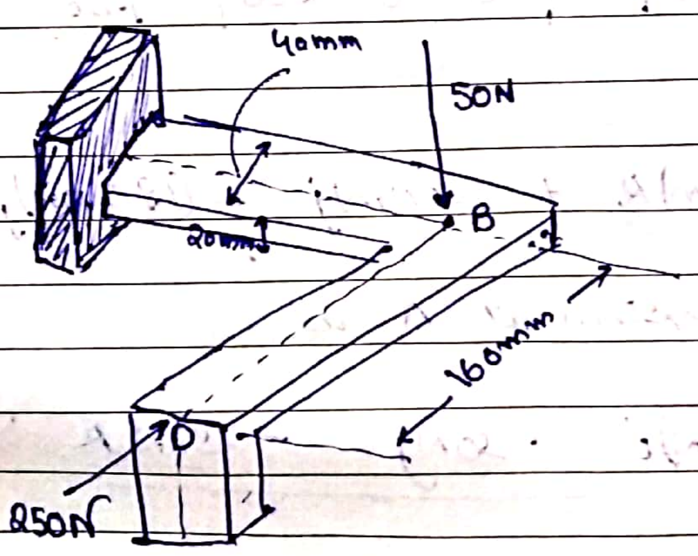
Moment about C $\rightarrow$ $\vec{r}_{CB} \times \vec{F}_{AB}$

$$= (42i + 56j) \times (+2.4j - 0.7i)$$

$$= 100.8k + 39.2k$$

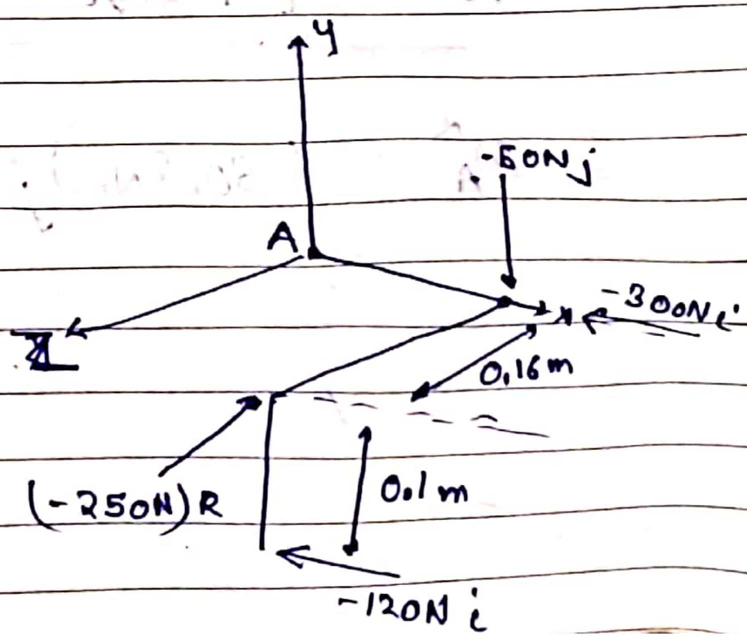
$$\boxed{M_c = (140k)\ Nm}$$

Prob. 3.121



Four forces are applied to the machine conpond ABDE as shawn, Replace these forces with an equivalent force couple system at A.

Solution:



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$R = (-50N)j - (300N)i - (120N)i - (250N)k$

$R = -(420N)i - (50N)j - (250N)k$

$r_B = (0.2m)i$

$r_D = 0.2mi + 0.16m\hat{k}$

$r_E = 0.2m\,i - 0.1j + 0.16m\hat{k}$

$M_A = r_B \times (-300Ni - 50Nj) + r_D \times (-250N) + r_E \times (-120N)i$

$$\Rightarrow \begin{vmatrix} i & j & k \\ 0.2 & 0 & 0 \\ -300 & -50 & 0 \end{vmatrix} + \begin{vmatrix} i & j & k \\ 0.2 & 0 & 0.16 \\ 0 & 0 & -250 \end{vmatrix} + \begin{vmatrix} i & j & k \\ 0.2 & -0.1 & 0.16 \\ -120 & 0 & 0 \end{vmatrix}$$

$= (-10Nm)k + (50Nm)j - (19.2Nm)j - (12Nm)k$

Force caple system at A is,

$R = (-420N)i - 50Nj - 250N\,k$ Ans

$M_A^R = (30.8Nm)j - (220N.m)k$ Ans

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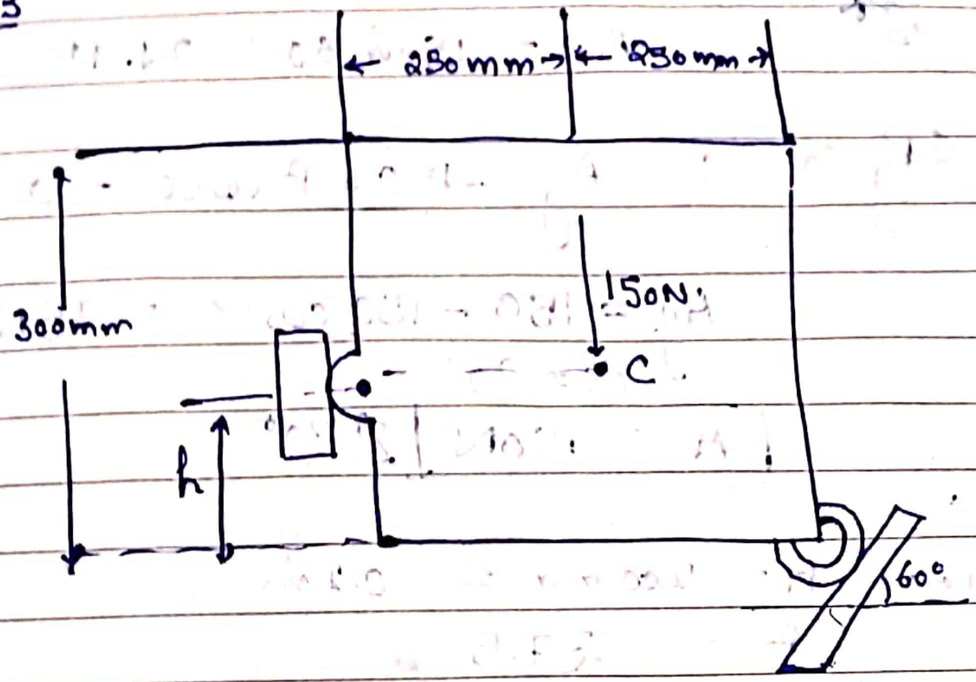
Prob. 4.23



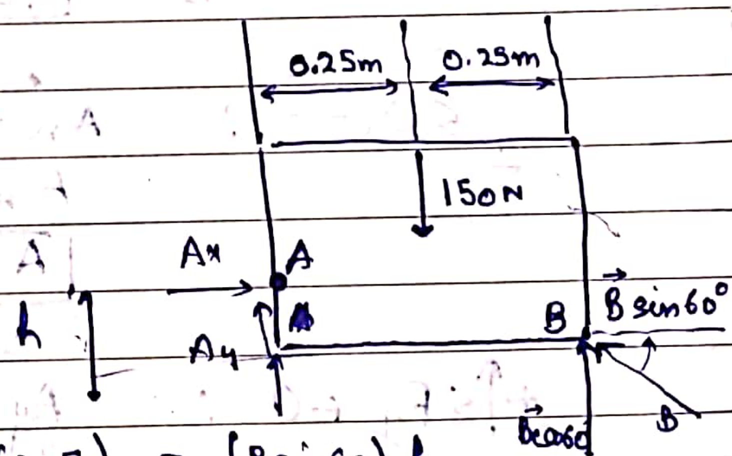
Determine the reaction at A and B. when

a) $h = 0$

b) $h = 200\,mm$.

Solution.

F.B.D:



$$+\circlearrowleft \Sigma M_A = 0. = B\cos 60 \times (0.5) - (B\sin 60)\,h - (150N)(0.25m) = 0$$

$$B = \frac{37.5}{0.25 - 0.866h}$$

a) when $h = 0$. $B = \dfrac{37.5}{0.25}$

$$= \boxed{150\,N \; 30^\circ}$$

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$\xrightarrow{+} \Sigma F_x = 0$: $A_x - B\sin 60 = 0$

$A_x = 15\sin 60 = 129.9\,N$

$+\uparrow \Sigma F_y = 0$: $A_y - 150 + B\cos 60 = 0$

$A_y = 150 - 150\cos 60 = 75\,N$

$\alpha = 30^\circ$

$\boxed{A = 150\,N}$ $\angle 30^\circ$

b) when $h = 200\,mm \Rightarrow 0.2\,m$

$$B = \frac{37.5}{0.25 - 0.866\,h}$$

$B = \boxed{488.3\,N}$ 30°

$\xrightarrow{+} \Sigma F_x = 0$: $A_x - B\sin 60 = 0$

$A_x = 488.3\sin 60$

$\boxed{A_x = 422.88\,N}$

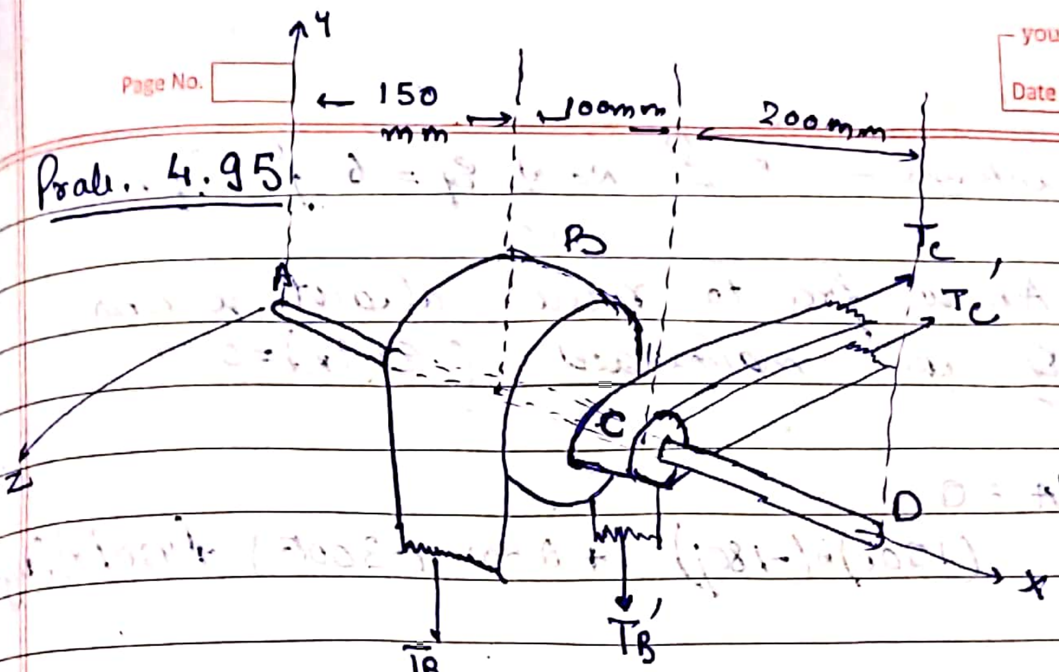
$+\uparrow \Sigma F_y = 0$: $A_y - 150 + B\cos 60 = 0$

$A_y = 150 - 488.3\cos 60$

$\therefore A_y = -94.15\,N$ $\alpha = 12.55^\circ$

$\boxed{A = 433.2\,N}$ 12.55°

Prob. 4.95



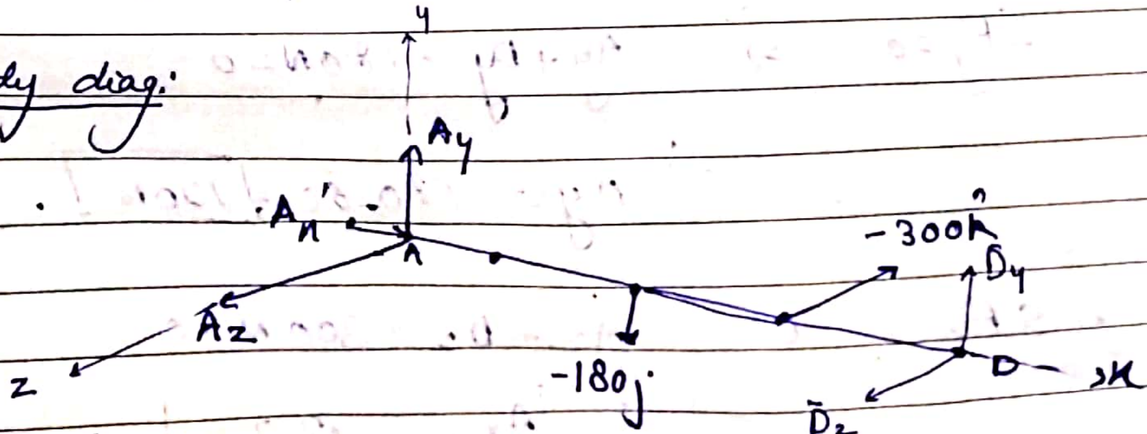
Two transmission belts pass over a double shaved pully that is attached to an axle supported by bearing at A and D. Radius of inner shape is 125mm and outer is 250mm. At rest tension is 90N in Both portion of B and 150N in both portions of Belt C. Determine Reaction At A and D.

Solution:

Replacing T_B and T_B' by resultant $= \underline{-180N\hat{j}}$

Replacing T_c and T_c' by resultant $= \underline{-300N\hat{k}}$

Free Body diag:



~~To find~~.

~~A_y~~

~~A_z~~

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No of unknowns = 5 & No of Eq = 6 for Eq.

Axle AD is free to rotate about x axis, but Eq is maintained $(\Sigma M_x) = 0$

$\therefore \Sigma M_A = 0$

$$(150i)\times(-180j) + 250i\times(-300k) + (450i\times)(D_y + D_z$$

$\Rightarrow$

$$-27\times10^3 k + 75\times10^3 j + 450 D_y k - 450 D_z j = 0$$

$$D_y k \times 450 = 27\times10^3 k$$

$$\therefore \boxed{D_y = 60\,N}$$

$$-450 D_z j = -75\times10^3$$

$$\therefore \boxed{D_z = 166.7\,N}$$

$\Sigma F_x = 0 \Rightarrow A_x = 0$

$\Sigma F_y = 0 \Rightarrow A_y + D_y - 180N = 0$

$$\therefore A_y = 180 - 60 = \boxed{120\,N}.$$

$\Sigma F_z = 0$, $A_z + D_z - 300\,N = 0$

$$\therefore \boxed{A_z = 133.3\,N}$$

$\therefore$

$$\boxed{A = (120N)j + (133.3N)\hat{k}}$$

& $\boxed{D = (60.0N)j + (166.7N)k}$ Ans.

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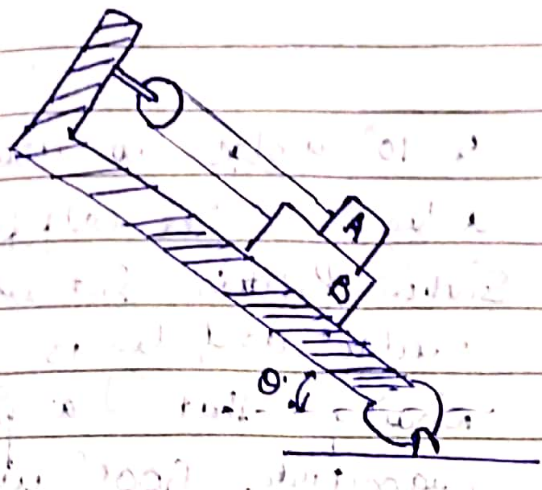
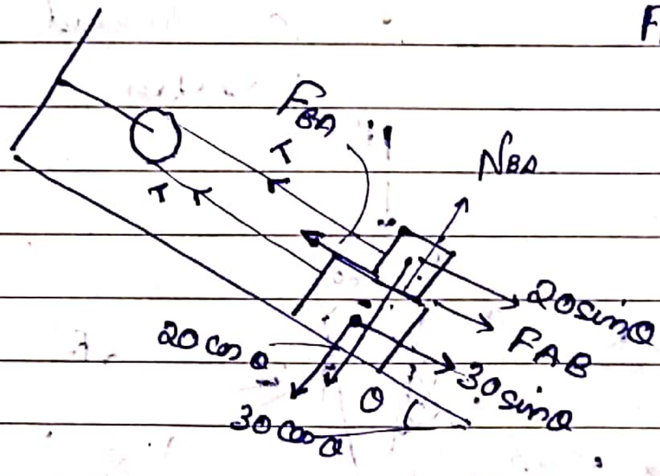
Problem 8.11

A 20N block A and 30N Block B are supported by an incline that is held as shown. Coefficient of static friction is 0.15 bw two block & zero btw block and incline. Find θ for which motion is impending.



Solution

$F_{BA} \rightarrow$ force on B due to A



$$F_{BA} = \mu N_{AB}$$

$$= 0.15 \times \underline{20\cos\theta}$$

For A.
$$T = 20\sin\theta + F_{AB}$$
$$T = 20\sin\theta + 0.15 \times 20\cos\theta \quad -(1)$$

For B,
$$T = 30\sin\theta - 0.15 \times 20\cos\theta \quad -(2)$$

Since T is same through we equating (1) & (2)

$$20\sin\theta + 0.15 \times 20\cos\theta = 30\sin\theta - 0.15 \times 20\cos\theta$$
$$10\sin\theta = 0.3 \times 20\cos\theta \Rightarrow \boxed{\tan\theta = 0.6}.$$

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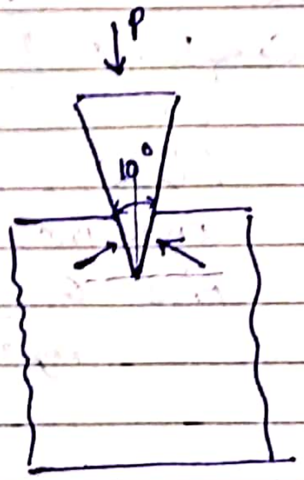
$\theta = \tan^{-1}(0.6)$

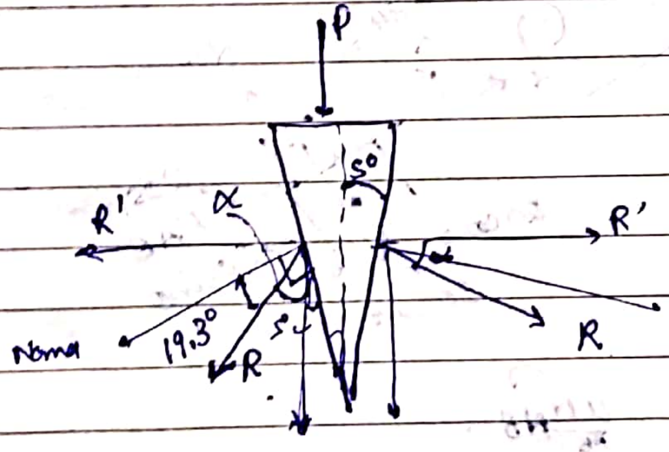
$\boxed{\theta = 30.96^\circ}$ Ans.

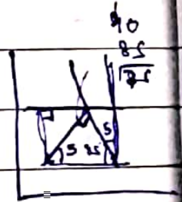
Prob. 8.58 :



A 10° wedge is used to split a log. The coefficient of static friction between the wedge and log is 0.35. Knowing that a force P of magnitude 600N was required to insert wedge, determine magnitude of force exerted on wood by wedge after insertion.

Solution:





Let force by wedge on wood be 'R' when P applied on wedge.

ϕ_s is the angle between normal to the wedge & R,

So,

$\phi_s = \tan^{-1}(\mu_s) = \tan^{-1}(0.35)$

$\phi_s = 19.30^\circ$.

Now, $\alpha = 90^\circ - (5^\circ + \phi_s)$

$\boxed{\alpha = 65.7^\circ}$,

$\Sigma F_y = 0 \Rightarrow 2R\cos 65.7^\circ - P = 0$

$2R = 1458.029N$

when P is removed the vertical components of R_1 and R_2 vanishes leaving horizontal compo

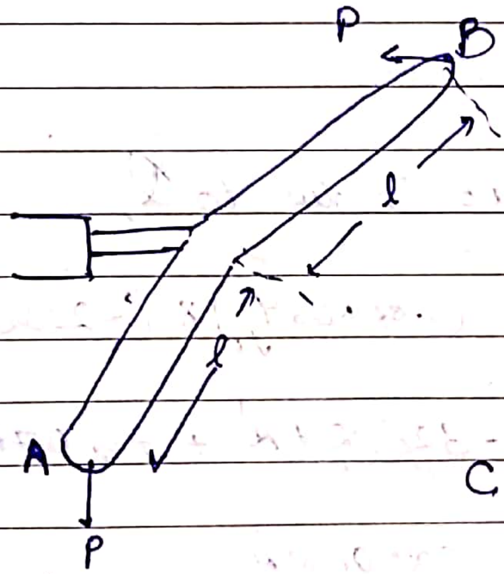
So,

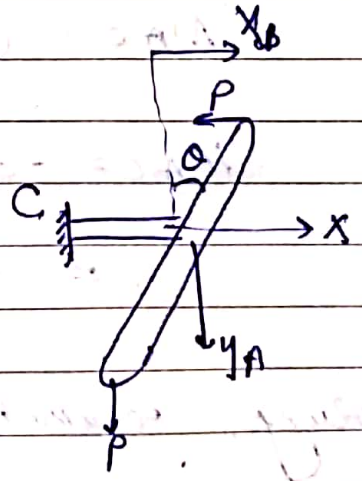
$2R' = 2R\cos(19.3+5)$

$2R' = 1328.85N$

$\boxed{R' = 664.43} N$ Ans.

Prob. 10.16





$X_B = L\sin\theta$

$\delta x_B = l\cos\delta\theta$

$y_A = l\cos\theta$

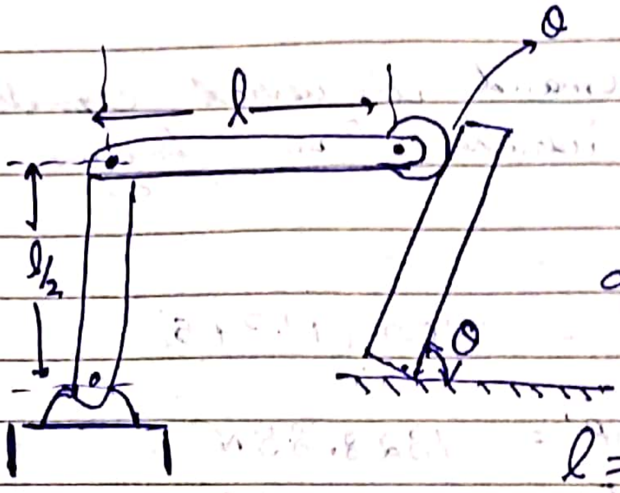
$\delta y_A = -l\sin\theta\ \delta\theta$

$\delta u = 0 \Rightarrow M\delta\theta - P\delta X_B + P\delta y_A = 0$

$\Rightarrow M\delta\theta - P(l\cos\theta\ \delta\theta) + P(l\sin\theta\ \delta\theta) = 0$

$$M = Pl(\sin\theta + \cos\theta)$$ Ans.

Prob. 10.19:



For the linkage shown determine the couple M required for equilibrium when, $l = 1.8$ m, $Q = 200$ N, and $\theta = 65°$.

Solution :

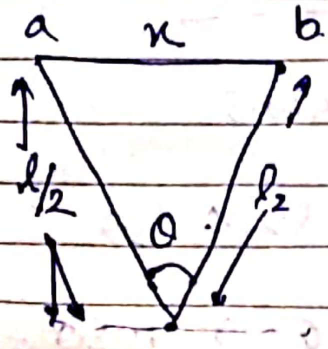
• Moment at C due to Q,

$$M_{AC} = (1.8i + 0.9j) \times (-200\cos 65\, i - 200\sin 65\, j)$$

$$M_{AC} = -326.27\hat{k} + 76.07\hat{k}$$

$$= -250.2\hat{k}$$

Obtaining relationship between θ and x.



$ab = cd = x$

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$$\frac{x}{\sin\theta} = \frac{l/2}{\sin(90-\theta/2)} \Rightarrow \boxed{x = l\sin\theta/2}$$

if θ is small, $\sin\theta/2 \approx \theta/2$

$$\Rightarrow \boxed{x = l/2\,\theta}$$

$$dx = \frac{l\,d\theta}{2}$$

$$d\theta = \frac{2\,dx}{l}$$

Virtual work $du = 0$

$$M d\theta - Q\,dl - M_{ac}d\theta = 0$$

$$M.\frac{2dx}{l} = Q.dx + M_{oc}.\frac{2dx}{l}$$

$$M = \frac{lQ}{2} + M_{OC}$$

$$M = 0.9 \times 200 + 250.2$$

$$\boxed{M = 430.2\,Nm}$$ Ans

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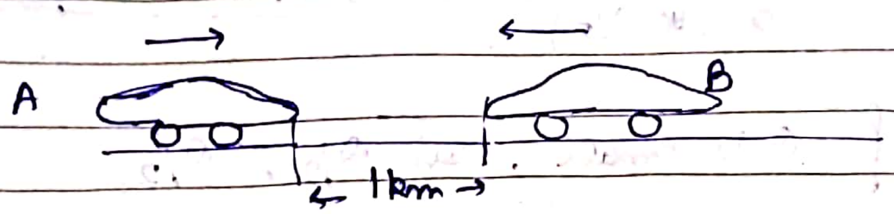
Prob. 11.43

t=0



Two automobiles A and B are appraching each other in adjacent highways. At t=0 A and B are 1km apart.

$V_A = 108 km/h$ and $V_B = 63 km/h$ and they are at Points P and Q.

Knowing that A passes Q 40seconds after B was there & B passes past P 42second after A was there find.

a) uniform acc^n of A and B.

b) when vehicles pass each other.

c) Speed of B at that time.

Solution:

a) use Law for con^t acc^n

$$\vec{x}_A(t) = u(t)\,t + \tfrac{1}{2}a(t).t^2$$

$V_A(t=0) = 30 ms^{-1}$,

at t= 40s

$$1000 = 30\times40 + \tfrac{1}{2}a(t).(40)^2$$

$$-200 = 800\,\vec{a}_A$$

$$\therefore \vec{a}_A = -\tfrac{1}{4}ms^{-2} = \boxed{-0.25\,ms^{-2}}.$$

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Also,

1) $x_B(t) = 0 + (V_B)(t=0)t + \frac{1}{2} a_B t^2$

$\therefore \quad V_B(t=0) = \underline{17.5\ ms^{-2}}$.

At $\underline{t = 42s}$

$\therefore$

$1000 = 17.5 \times 42 + \frac{1}{2} a_B (42)^2$

$$\boxed{a_b = 0.30045\ ms^{-2}}$$

2) Let at $t = t$ cars cross each other.

then

$x_A + x_B = 1000$

$$\left[30t + \tfrac{1}{2}(-0.25)t^2\right] + \left[17.5t + \tfrac{1}{2}(0.30)t^2\right] = 1000$$

$\therefore \quad t_{AB}$

$0.025225t^2 + 47.5t - 1000 = 0$

$t = 20.82s$

or $t = -1.9038s$,

$\therefore$

$$\boxed{t = 20.822\ sec}$$

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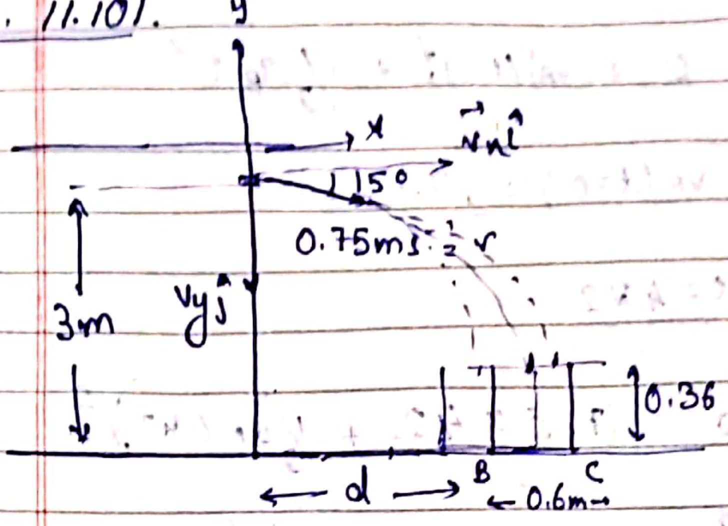
Prob. 11.101.



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

Water flows from a drain spout with an initial velocity of $0.75ms^{-1}$ at 15° to horizontal. Determine the range of 'd' for which water will enter the through BC.

Solution:

$\vec{V}_x(t=0) = 0.75\cos 15°\hat{i} = 0.7244\ ms^{-1}$

$V_y(t=0) = -0.75\sin 15°\hat{j} = -19.41\ ms^{-1}$

Vertical motion :- for constⁿ accⁿ ie g

$$y = u(t).t + \frac{1}{2}at^2$$

∴ total vertical distance before entering

$$3 - 0.36 = \underline{2.64m}$$

$$-2.64 = -(0.194)t - \frac{1}{2}(9.8)t^2$$

$$4.9t^2 + 0.194t - 2.64 = 0$$

$\boxed{t = 0.714s}$ other root being negative.

Horizontal Motion

$$\text{Range} = v_x t + \frac{1}{2} a_x t^2$$

$a_x = 0$

$$= 0.714 \times 0.7244$$

$$= \boxed{0.5173\,m}$$

So trough must be placed such

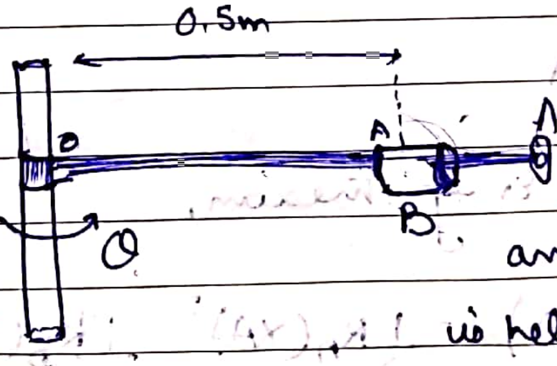
$x_b < 0.5173\,m$ or

$x_c > 0.5173\,m$

tray is 0.6m wide

$\boxed{0 < d < 0.5173\,m}$ Ans

Problem 12.69:



OA rotates about shaft such that $\theta = 10t$, θ and t are expressed in $rad\,s^{-1}$ and s. A 250 g collar B is held by a cord with a breaking strength of 18N. Neglecting friction determine

a) Relative acceleration of collar with respect to rod.

b). magnitude of horizontal force exerted on the collar by the rod.

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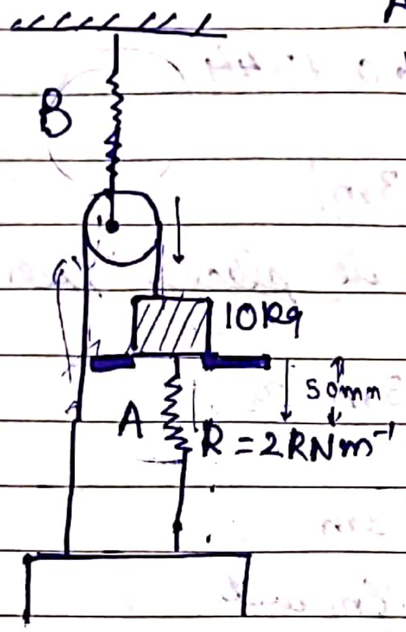


A 10kg Black is attached to a spring 'A' and connected to spring B by a cord and pully. The black is held in position shown with both springs unstrached. when the supports are remaved & black is released with no initial velocity..
$R_A = R_B = 2kNm^{-1}$.
determine,

a) velocity of black after it moves down 30mm.

b) Max velocity attained by black.

a) weight of black $= 10 \times 9.81 = \boxed{98.1N}$

$x_b = \frac{1}{2} x_A$

Apply work Energy Theoram,

$$U_{12} = W(x_A) - \frac{1}{2}R_A(x_A)^2 - \frac{1}{2}k_b(x_B)^2$$

$$U_{12} = (98.1)(0.05) - \frac{1}{2}(2000)(0.05)^2 - \frac{1}{2}(2000)(0.025)^2$$

$$U_2 = \frac{1}{2}mv^2 = \frac{1}{2}(10)v^2$$

$$4.905 - 2.5 - 0.625 = \frac{1}{2}(10)v^2$$

$$\boxed{v = 0.597\,ms^{-1}}$$ Ans.

Let x = distance moved down by 10kg block

$$U_{1,2} = W(x) - \frac{1}{2}k_A x^2 - \frac{1}{2}k_B\left(\frac{x}{2}\right)^2 = \frac{1}{2}mv^2$$

$$\frac{d}{dx}\left[\frac{1}{2}mv^2\right] = 0 = W - k_A(x) - \frac{k_B}{8} \cdot 2x$$

$$0 = 98.1 - 2000x - \frac{2000}{8}(2x) = 98.1 - 2250x$$

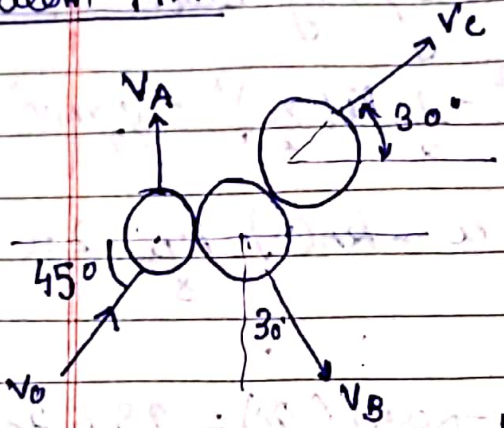
$$\underline{x = 0.0436\,m}$$

For $x = 0.0436\,m$, $U = 4.2772 - 1.9010 - 0.4752$
$= \frac{1}{2}(10)v^2$

$\boxed{V_{max} = 0.617\,ms^{-1}}$ Ans.

Problem 14.41: In a game of pool, ball A is moving with $v_0 = 5\,m\,s^{-1}$, when it strikes balls B and C, while all are at rest and aligned as shown: Knowing that after collision the three balls move in directions indicated. Assuming perfectly elastic collision.

Determine V_A, V_B, V_C



Velocity vector,

$$V_0 = V_0(\cos 45\,\hat{i} + \sin 45\,\hat{j})$$
$$V_A = V_A\hat{j}$$

$$V_B = V_B(\sin 30\,\hat{i} - \cos 30\,\hat{j})$$
$$V_C = V_C(\cos 30\,\hat{i} + \sin 30\,\hat{j})$$

Applying momentum conservation,

$$mV_0 = mV_A + mV_B + mV_C$$

Resolving into $\hat{i}$ & $\hat{j}$

$$V_0 \cos 45 = V_B \sin 30 + V_C \cos 30$$

$$V_0 \sin 45 = V_A - V_B \cos 30 + V_C \sin 30.$$

Solving for V_B & V_C

$$V_B = -0.25882 V_0 + 0.86603 V_A$$
$$V_C = 0.96593 V_0 - 0.5 V_A.$$

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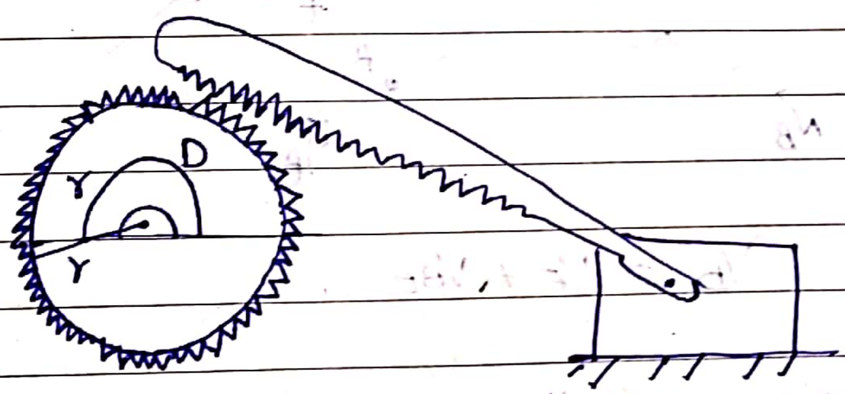
Conservation of energy,

$$\frac{1}{2} m v_0^2 = \frac{1}{2} m v_A^2 + \frac{1}{2} m v_B^2 + \frac{1}{2} m v_C^2$$

Substitute v_B and v_C,

$$V_A = 0.70711 V_0 \Rightarrow V_A = 3.5355 ms^{-1}$$
$$V_B = 0.35355 V_0 \Rightarrow V_B = 1.66775 ms^{-1}$$
$$V_C = 0.61237 V_0 \Rightarrow V_C = 3.06175 ms^{-1}$$

Prob. 15.57.

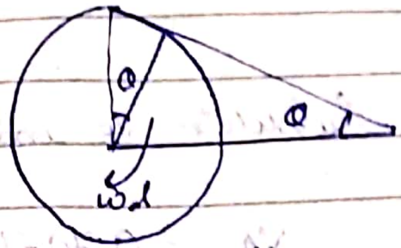


A straigh rack rests on a gear of radius r and is attached to a block B as shown. Donating by ω_D, the clockwise angular velocity of gear D and by θ the angle formed by the rack and horizontal derive expressions for the velocity of block B and angular velocity of rack in terms of r, θ and ω_D

Solution:

Gears: Rotation about D. Tooth E in in contact with rack AB.

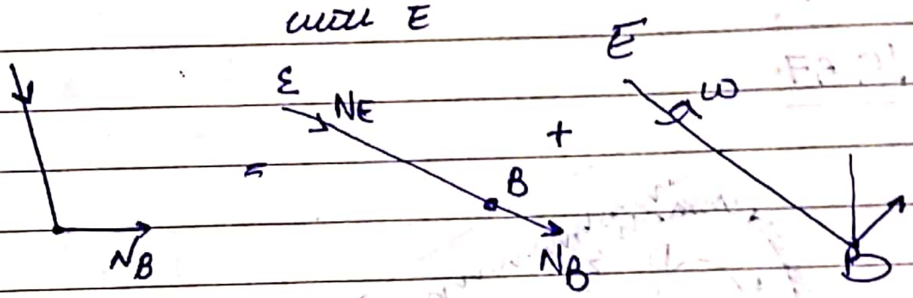
$V_E = r\omega_D \measuredangle \theta$



$I_{EB} = \frac{r}{\tan\theta}$

Rack AB

Plane motion = Translation with E + Rotation about E.



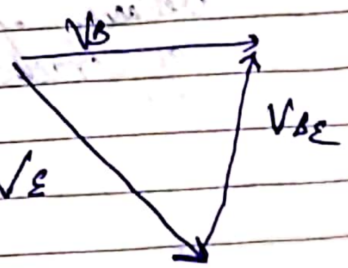
$V_B = V_E + V_{BE}$

Drawing velocity vector diag.

$V_B = \frac{V_E}{\cos\theta} \Rightarrow \boxed{V_B = \frac{r\omega_D}{\cos\theta}}$

$V_{B/E} = V_E \tan\theta$
$= r\omega_D \tan\theta$

$\omega_{AB} = \frac{V_{BE}}{I_{EB}}$



$\boxed{\omega_{AB} = \omega_D \tan^2\theta} = \frac{r\omega_D \tan\theta}{r/\tan\theta}$

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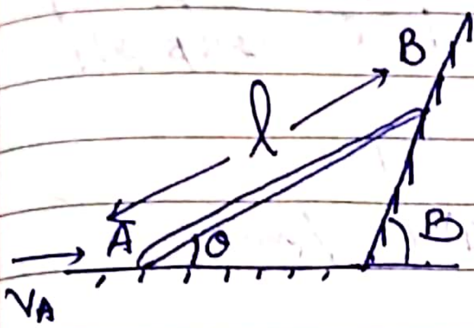
Problem 15.88



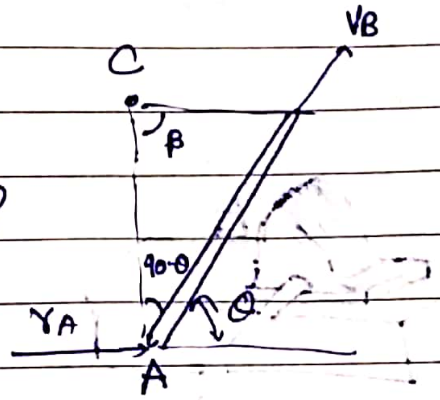
Rod AB can slide freely along the floor and the inclined plane. Denoting by V_A, the velocity at point A, derive expression for.

a) angular velocity of rod

b) velocity at end B.

Solution

Locating instantaneous centre by drawing ⊥'s to V_A & V_B.



Law of sines,

$$\frac{AC}{\sin(90-(\beta-\theta))} = \frac{BC}{\sin(90-\theta)} = \frac{l}{\sin\beta}.$$

$$AC = \frac{l\cos(\beta-\theta)}{\sin\beta}$$

$$BC = \frac{l\cos\theta}{\sin\beta}$$

a) angular velocity

$$V_A = (AC)\omega = \frac{l\cos(\beta-\theta)\,\omega}{\sin\beta}$$

$$\therefore \boxed{\omega = \frac{V_A \sin\beta}{l\cos(\beta-\theta)}} \quad \text{Ans.}$$

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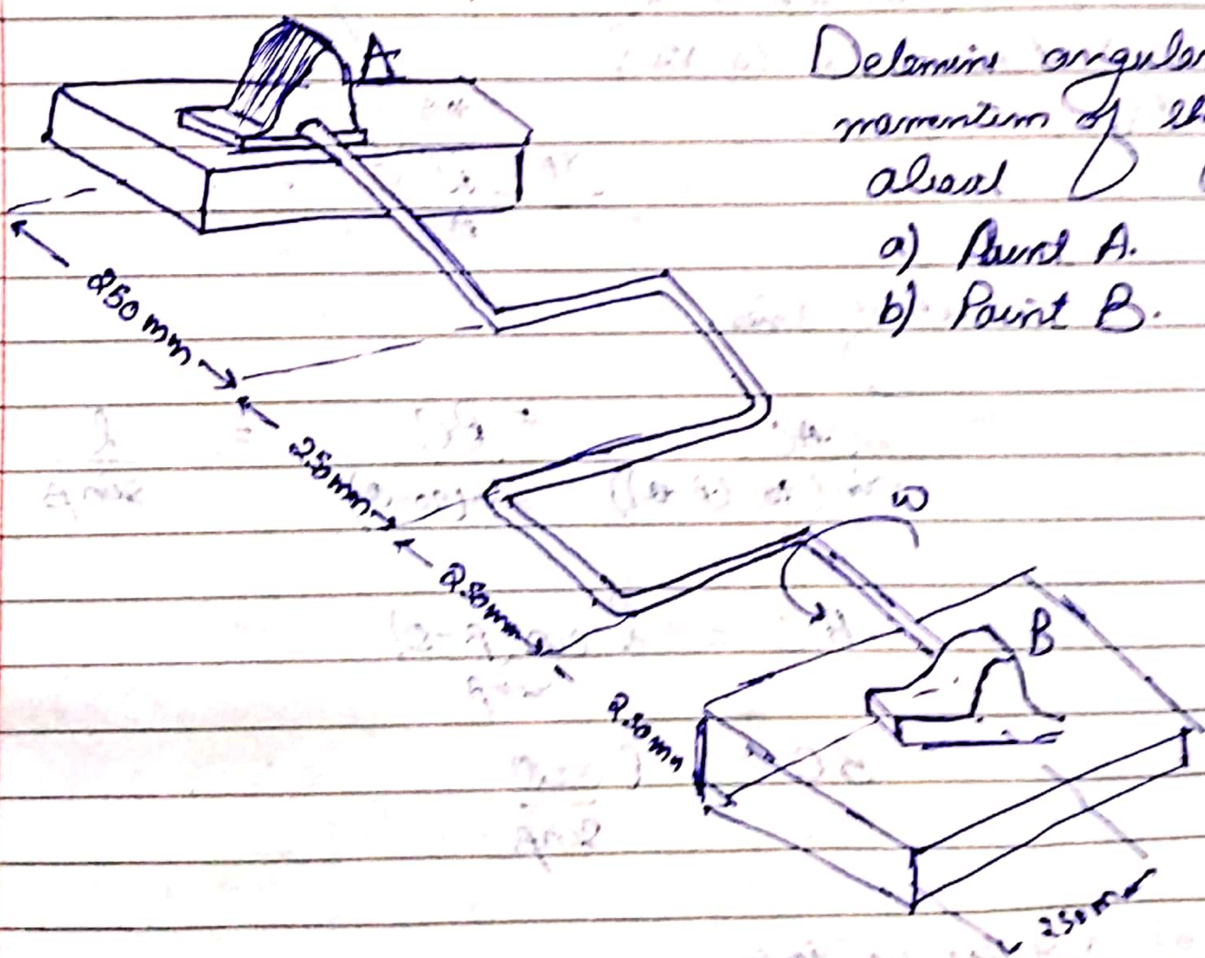
b) velocity of B

$$V_B = (BC)\,\omega = \frac{l\cos\theta}{\sin\beta}\left[\frac{V_A}{l}\,\frac{\sin\beta}{\cos(\beta-\theta)}\right]$$

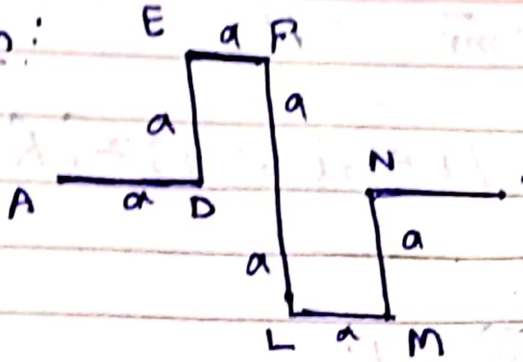
$$= \boxed{V_B = \frac{V_A\cos\theta}{\cos(\beta-\theta)}}\quad \text{Ans}$$

Prob. 18.16



Determine angular momentum of shaft about
a) Point A.
b) Point B.

Solution:



$\omega = (12 \text{ rad.s}^{-1})\,i$

$\omega_y = \omega_z = 0$

$m = 5\text{kg}$

$(H_G)_y = +\bar{I}_y \omega$

$(H_G)_x = (\bar{I}_x)\omega$

$(H_G)_z = -(\bar{I}_{xz})\omega$

The shaft is comprised of 8 sections each of length $a = 0.25\,m$ and mass $m' = m/8$
$= 0.625\text{ kg}$.

$$(\bar{I}_x) = 4\left(\tfrac{1}{3}m'a^2\right) + 2(m'a^2) = \frac{10}{3}m'a^2 =$$
$$0.130208\text{ kgm}^2$$

$$\bar{I}_{xy} = 0$$

$$\bar{I}_{xz} = 4\left(m'a.\frac{a}{2}\right) = 2m'a^2 = 0.078125\text{ kgm}^2$$

$$(H_G)_x = (0.130208)(12) = 1.5625\text{ kg m}^2 s^{-1}$$

$$(H_G)_y = 0$$

$$(H_G)_z = -(0.078125)(12) = -0.9375\text{ kg m}^2 s^{-1}$$

$$\therefore H_G = [1.5625i - 0.9375k]\text{ kg m}^2 s^{-1}$$

Since G lies on the axis of rotation, its velocity is 0.

$$\bar{v} = v_G = 0.$$

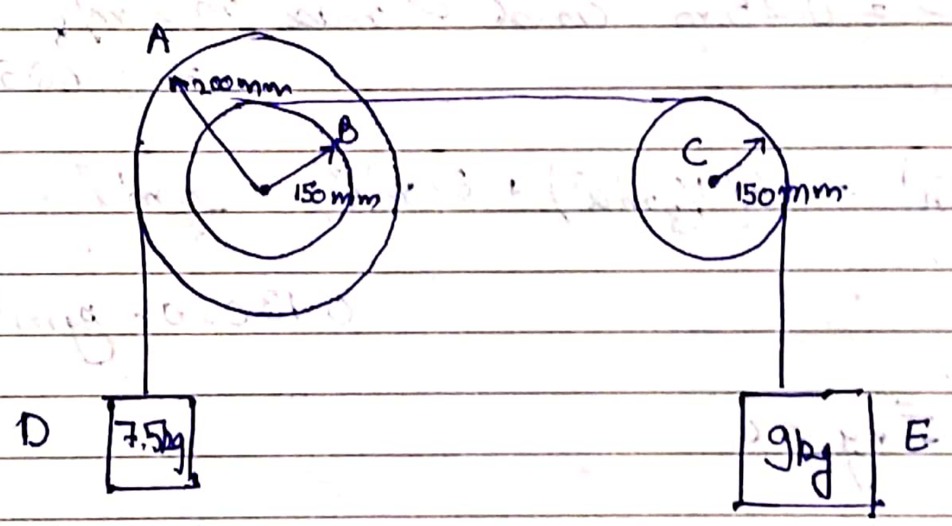
a) $H_A = H_G + r_{G/A} \times m\vec{v} = H_G$.

$\therefore \boxed{H_A = [1.563i - 0.9375]\hat{k} \ kg\,m^2 s^{-1}}$

b) $H_B = H_G + r_{G/B} \cdot m\vec{v} = H_G$

$\therefore \boxed{H_B = [1.563i - 0.9375\hat{k}] \ kg\,m^2 s^{-1}}$

Prob. 16.37:



Disc A and B are bolted together, and cylinder D and E are attached to seperate cords wrapped on the disc. A single cord passes over disc B and C, Disc A has a mass of 10 kg and disc B has mass of 6 kg each. Knowing that the system is released from rest, there is no-slipping occurs between the cords and the disc, determine acceleration a) of cylinder D b) of cylinder E.

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Selution

$I_A = 0.2\ kgm^2$

$I_B = I_C = 0.0675\ kgm^2$

$I_{AB} = 0.2675\ kgm^2$

$a_D = 0.2\alpha$ (-i)

$a_E = 0.15\ \alpha$ -(ii)

Let T be the tension lites ends B and C.

I). Pulley I: $0.2 \times 7.5g - 0.15T = 0.2675\ \alpha + 0.2 \times m_D a_D.$

$= 0.2 \times 7.5g - 0.2675\ \alpha - 0.2 \times 7.5 \alpha 0.2\alpha = 0.15T.$

$= 1.5g - 0.5675\alpha = 0.15T.$

$T = 10g - \frac{0.5675\alpha}{0.15}$ —(iii).

II. Pulley II:

$0.15T - 0.15 \times 9g = 0.0675\alpha + 0.15 m_3 a_E.$

$0.15T - 1.35g = 0.0675\ \alpha + 0.11 \times 9 \times 0.15\alpha$

$\boxed{T = 9g + \frac{0.27\ \alpha}{0.15}}$ —(iv).

from iii and (iv)

$\boxed{\alpha = 1.75\ rad\ s^{-1}}$

∴ from eqn ① $a_D = 0.35 ms^{-2}$ and $a_E = 0.2625 ms^{-2}$

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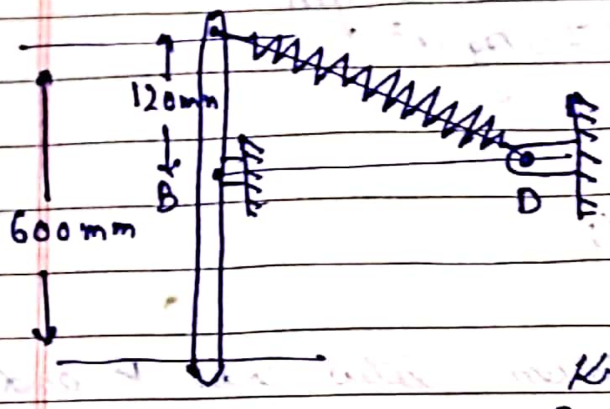
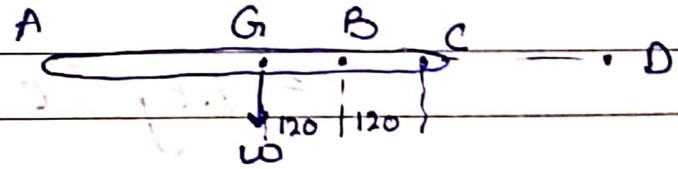
Problem 17.19



A slender 4 kg rod can rotate in a vertical plane about a pivot at B. A spring of constant K 400 N m⁻¹ and of unstretched length 150 mm is attached to the rod as shown. Knowing that the rod is released from rest position shown. Determine its angular velocity after rotation through 90°.

Solution:

After rotation.



$$CD = \sqrt{BD^2 + BC^2}$$
$$= \sqrt{(350)^2 + (120)^2}$$
$$= \underline{370mm}$$

Position I:

Spring $x_1 = CD - (150mm)$
$= 370 - 150 = 220\,mm$

$V_e = \frac{1}{2}kx_1^2 = \frac{1}{2} \times 400 \,(0.220)^2 = \boxed{9.68J}$

Gravity, $V_g = -mgh = -4 \times 9.8 \times 0.18$
$= \boxed{-7.056J}$

$V_1 = V_e - V_g = 9.68 - 7.056$
$= 2.624 J.$

$T_1 = 0$

Position 2:

Spring: $x_2 = 350 - 120 - 150$
$= 80 mm$

$V_e = \frac{1}{2} k x_2^2 = \frac{1}{2} \times 400 \times (0.08)^2$
$= \boxed{1.28 J}$

Gravity: $V_g = 0.$

Kinetic Energy: $\vec{v_2} = r\omega_2 = 0.18\omega_2$

$I = \frac{1}{12} ml^2 = \frac{1}{12} (0.6)^2 \times 4 = 0.12 kg m^2$

$T_2 = \frac{1}{2} m v_2^2 + \frac{1}{2} I \omega^2$

$T_2 = \frac{1}{2} \times 4 \times (0.18 \omega_2)^2 + \frac{1}{2} \times 0.12 \times \omega_2^2$

$\boxed{T_2 = 0.1248 \omega_2^2}$

Conservation of Energy: $T_1 + V_1 = T_2 + V_2$

$0 + 2.624 J = 0.1248 \omega_2^2 + 1.28 J$

$\omega_2^2 = 1.344 / 0.1248$

$\boxed{\omega_2 = 3.28 rad s^{-1}}$

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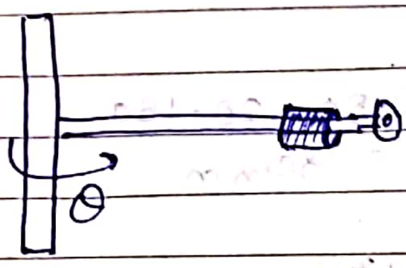
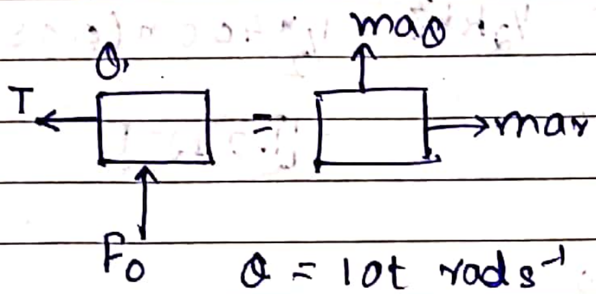
Problem 12.69

Solution:





$\dot{\theta} = 10t \text{ rad s}^{-1}$ $\quad$ $\ddot{\theta} = 10 \text{ rad s}^{-2}$

$m = 0.250 \text{ kg}$ $\quad$ Before cable Breaks.

$F_r = -T$ and $\ddot{r} = 0$

$F_r = ma_r = \quad -T = m(\ddot{r} - r\dot{\theta}^2)$

$mr\dot{\theta}^2 = m\ddot{r} + T$ or $\dot{\theta}^2 = \dfrac{m\ddot{r}+T}{mr}$ $\quad$ $\boxed{\dot{\theta} = 12 \text{ rad s}^{-1}}$

Immediately after cable breaks.

a) Acc^n of B relative to rod.

$m(\ddot{r} - r\dot{\theta}^2) = 0$ or $\ddot{r} = r\dot{\theta}^2 = 0.5 \times 144$

$= 72 \text{ ms}^{-2}$

$\boxed{a_{B/rod} = 72 \text{ ms}^{-2} \text{ radially outward}}$

Ans.

b) Transeverse component of face:

$F_\theta = m a_\theta$: $F_\theta = m(r\ddot{\theta} + 2\dot{r}\dot{\theta})$

$$F_\theta = (0.250)[(0.5)(10) + 2(0)(12)]$$

$$= 1.25$$

$$\boxed{F_\theta = 1.25\,N}$$ Ans.