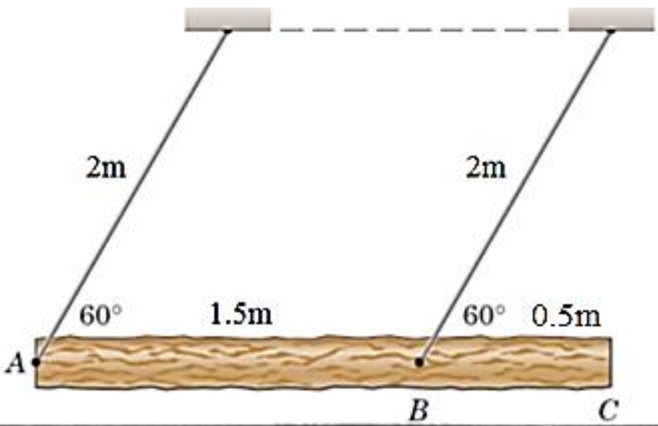
PROBLEM 6/19
(CURV. TRANS.)

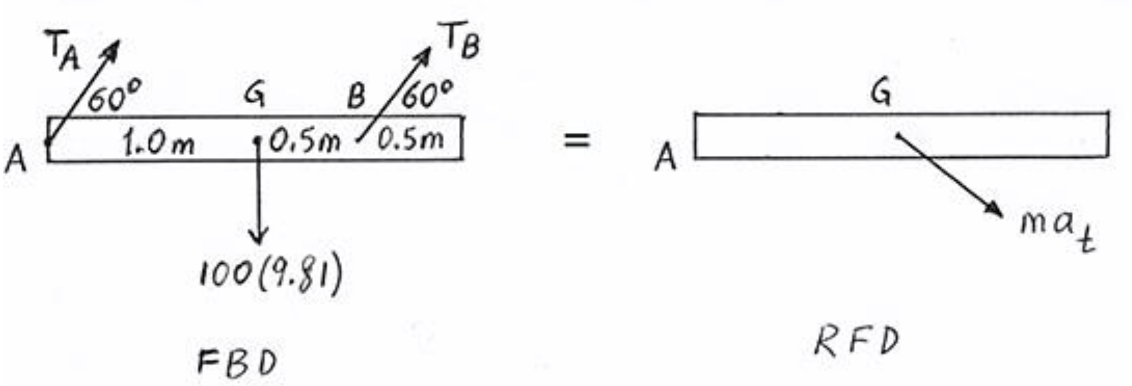
The uniform 100kg log is supported by the two cables and used as a battering ram. If the log is released from rest in the position shown, calculate the initial tension induced in each cable immediately after release and the corresponding angular acceleration α of the cables.



Curvilinear Translation : $\vec{a}_G = \vec{a}_A = \vec{a} = \vec{a}_t + \vec{a}_n$

$a_n = \omega^2 r = 0$ (ω is angular velocity of cable, r is cable length)

$a_t = \alpha\, r$, perpendicular to cable



$\Sigma F_t = ma_t : 100(9.81)\cos 60° = 100 a_t ,$

$a_t = 4.90 \text{ m/s}^2$

$\alpha = a_t / r = 4.90/2 = \underline{2.45 \text{ rad/s}^2}$

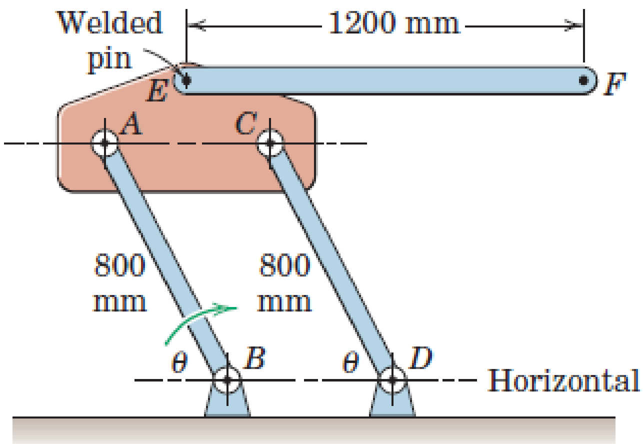
$\circlearrowleft + \Sigma M_G = 0 : T_B \sin 60° \times 0.5 - T_A \sin 60° \times 1.0 = 0 , \quad T_A = \frac{1}{2} T_B$

$\Sigma F_n = ma_n = 0 : \quad T_A + T_B - 100(9.81)\sin 60° = 0 , \quad T_A + T_B = 850 \text{ N}$

Combine & get $\underline{T_A = 283 \text{ N}}$, $\underline{T_B = 567 \text{ N}}$

PROBLEM 6/23
(CURV. TRANS.)

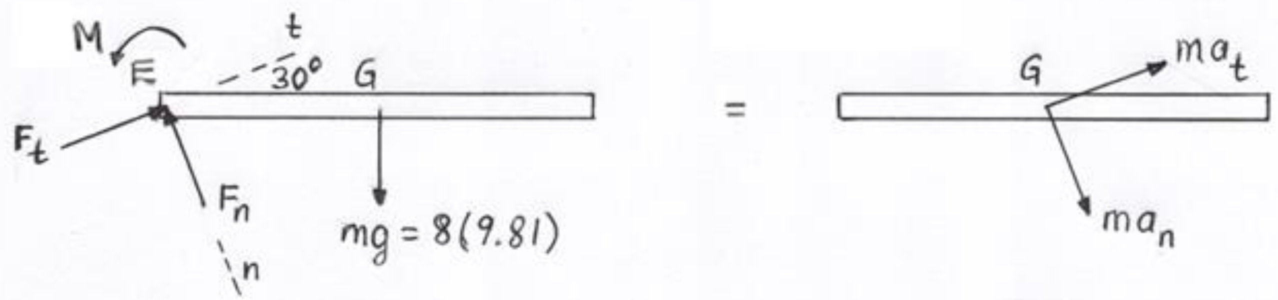
The parallelogram linkage shown moves in the vertical plane with the uniform 8-kg bar *EF* attached to the plate at *E* by a pin which is welded both to the plate and to the bar. A torque (not shown) is applied to link *AB* through its lower pin to drive the links in a clockwise direction. When θ reaches 60°, the links have an angular acceleration and an angular velocity of 6 rad/s^2 and 3 rad/s, respectively. For this instant calculate the magnitudes of the force *F* and torque *M* supported by the pin at *E*.



6/23 Curvilinear Translation : $a_E = a_A = a_C$

$(a_E)_n = r\omega^2 = 0.8(3)^2 = 7.2 \text{ m/s}^2$, $ma_n = 8(7.2) = 57.6 \text{ N}$

$(a_E)_t = r\alpha = 0.8(6) = 4.8 \text{ m/s}^2$, $ma_t = 8(4.8) = 38.4 \text{ N}$



FBD RFD

$\curvearrowleft \Sigma M_E = \Sigma mad$: $M - 8(9.81)(0.6) = 38.4(0.6\sin 30°) - 57.6\,(0.6\cos 30°)$, $\underline{M = 28.7 \text{ N·m CCW}}$

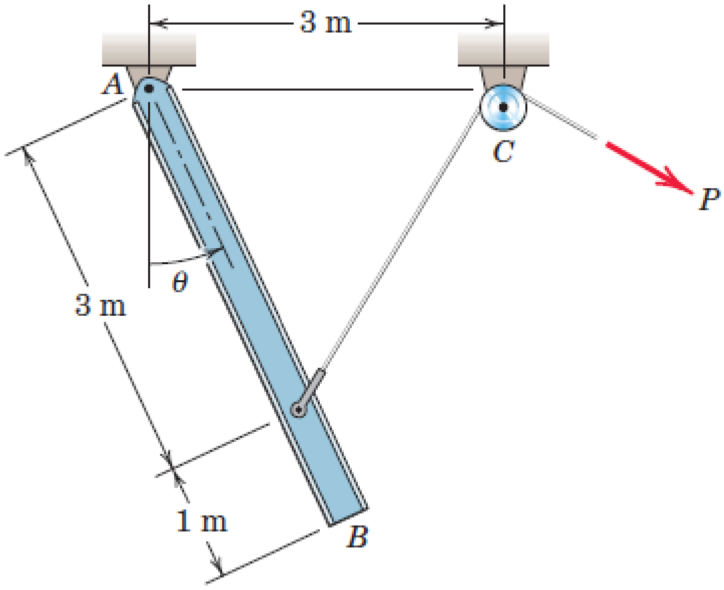
$\Sigma F_t = ma_t$: $F_t - 8(9.81)\sin 30° = 38.4$, $F_t = 77.6 \text{ N}$

$\Sigma F_n = ma_n$: $-F_n + 8(9.81)\cos 30° = 57.6$, $F_n = 10.37 \text{ N}$

$F = \sqrt{F_t^2 + F_n^2} = \underline{78.3 \text{ N}}$

PROBLEM 6/35
(FIXED AXIS ROT.)

The uniform 100-kg beam is freely hinged about its upper end A and is initially at rest in the vertical position with $\theta = 0$. Determine the initial angular acceleration α of the beam and the magnitude F_A of the force supported by the pin at A due to the application of a force $P = 300$ N on the attached cable.



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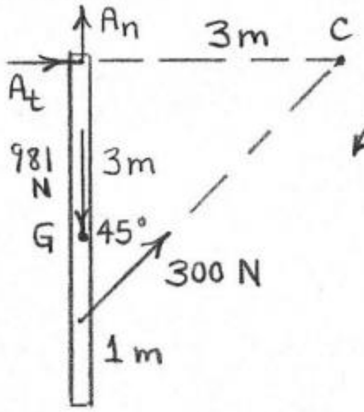


$$I_A = \frac{1}{3} m l^2 = \frac{1}{3}(100)(4)^2$$

$$= 533 \ \text{kg}\cdot\text{m}^2$$

$$\circlearrowleft + \ \Sigma M_A = I_A \alpha :$$

$$300(3 \sin 45^\circ) = 533\alpha$$

$$\underline{\alpha = 1.193 \ \text{rad/s}^2}$$

$$\Sigma F_n = m\bar{a}_n : \ A_n + 300 \cos 45^\circ - 981 = 0, \ A_n = 769 \ \text{N}$$

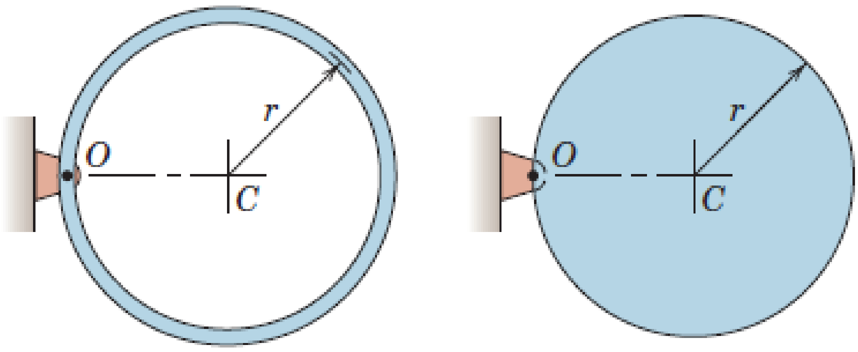
$$\Sigma F_t = m\bar{a}_t : \ A_t + 300 \sin 45^\circ = 100(2)(1.193)$$

$$A_t = 26.5 \ \text{N}$$

$$F_A = \sqrt{A_n^2 + A_t^2} = \underline{769 \ \text{N}}$$

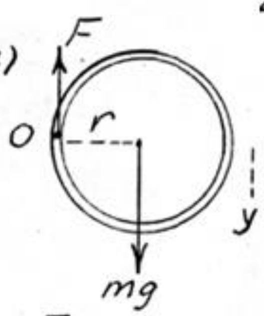
PROBLEM 6/38
(FIXED AXIS ROT.)

Determine the angular acceleration and the force on the bearing at O for (a) the narrow ring of mass m and (b) the flat circular disk of mass m immediately after each is released from rest in the vertical plane with OC horizontal.



(a) (b)

(a)



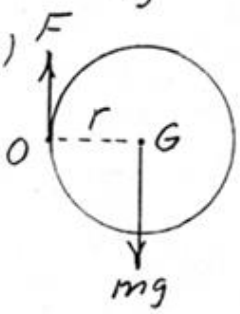
$$\Sigma M_O = I_O\alpha \; ; \; I_O = I_G + mr^2 \; ; \; I_G = mr^2$$

$$mgr = 2mr^2\alpha \qquad \underline{\alpha = g/2r}$$

$$\Sigma F_y = m\bar{a}_y ; \; mg - F = mr\left(\frac{g}{2r}\right)$$

$$\underline{F = mg/2}$$

(b)



$$\Sigma M_O = I_O\alpha ; \; mgr = \left(\frac{1}{2}mr^2 + mr^2\right)\alpha$$

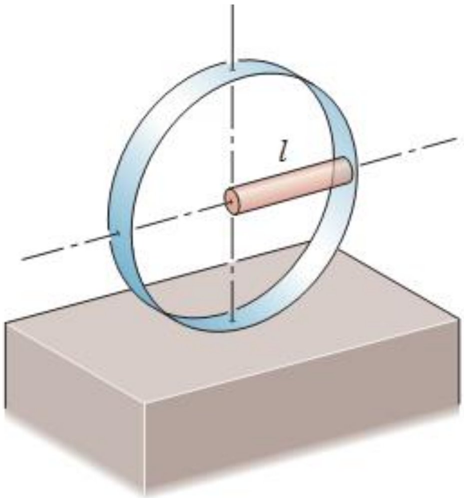
$$\underline{\alpha = 2g/3r}$$

$$\Sigma F_y = m\bar{a}_y ; \; mg - F = mr\left(\frac{2g}{3r}\right)$$

$$\underline{F = mg/3}$$

PROBLEM 6/83
(GEN. PLANE M.)

A uniform slender rod of length l and mass m is secured to a circular hoop of radius l as shown. The mass of the hoop is negligible. If the rod and hoop are released from rest on a horizontal surface in the position illustrated, determine the initial values of the friction force F and normal force N under the hoop if friction is sufficient to prevent slipping.

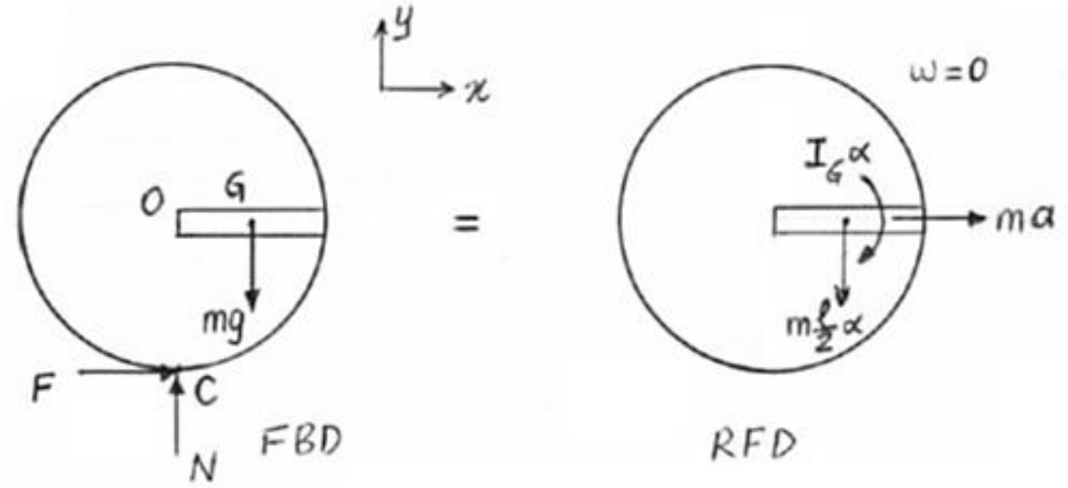


$\vec{a}_G = \vec{a}_O + \vec{\alpha} \times \overrightarrow{OG} + \vec{\omega} \times (\vec{\omega} \times \overrightarrow{OG})$

$\vec{a}_O$: magnitude is a, direction is along x

$\vec{\alpha} \times \overrightarrow{OG}$: magnitude is $\frac{\ell}{2}\alpha$, direction is perpendicular to OG

$\vec{\omega} \times (\vec{\omega} \times \overrightarrow{OG})$ is zero since $\omega = 0$.



No slip condition : $a = \ell\,\alpha$

$$\sum M_C = I_G\alpha + ma\ell + m\frac{\ell}{2}\alpha\frac{\ell}{2} \quad \Rightarrow \quad mg\frac{\ell}{2} = \frac{1}{12}m\ell^2\frac{a}{\ell} + ma\ell + m\frac{\ell}{2}\frac{a}{\ell}\frac{\ell}{2}$$

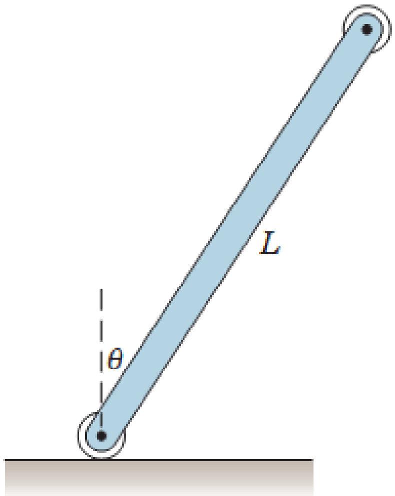
$$\Rightarrow \quad a = \frac{3}{8}g\ , \quad \alpha = \frac{3g}{8\ell}$$

$$\sum F_x = ma_{Gx} \quad \Rightarrow \quad F = ma = \frac{3}{8}mg$$

$$\sum F_y = ma_{Gy} \quad \Rightarrow \quad N - mg = -m\frac{\ell}{2}\alpha \quad \Rightarrow \quad N = \frac{13}{16}mg$$

PROBLEM 6/104
(GEN. PLANE M.)

The uniform slender bar of mass m and length L with small end rollers is released from rest in the position shown with the lower roller in contact with the horizontal plane. Determine the normal force N under the lower roller and the angular acceleration α of the bar immediately after release.

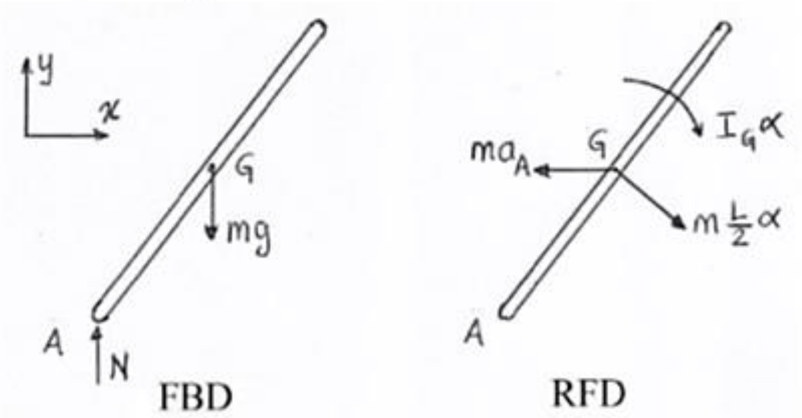


$\vec{a}_G = \vec{a}_A + \vec{\alpha} \times \overrightarrow{AG} + \vec{\omega} \times (\vec{\omega} \times \overrightarrow{AG})$

$\vec{a}_A$: magnitude is a_A, direction is along x (sense is arbitrarily taken towards left)

$\vec{\alpha} \times \overrightarrow{AG}$: magnitude is $\frac{L}{2}\alpha$, direction is perpendicular to AG (sense of α is arbitrarily taken as cw)

$\vec{\omega} \times (\vec{\omega} \times \overrightarrow{OG})$ is zero since $\omega = 0$.



$\sum M_A = I_G\alpha - ma_A\frac{L}{2}\cos\theta + m\frac{L}{2}\alpha\frac{L}{2} \quad \Rightarrow \quad mg\frac{L}{2}\sin\theta = \frac{1}{12}mL^2\alpha - ma_A\frac{L}{2}\cos\theta + m\frac{L^2}{4}\alpha \quad (1)$

$\sum F_x = ma_{Gx} \quad \Rightarrow \quad 0 = -ma_A + m\frac{L}{2}\alpha\cos\theta \quad (2)$

From equations (1) and (2) one can find a_A and α. $\Rightarrow \quad \alpha = \frac{2g}{L}\frac{\sin\theta}{\frac{1}{3}+\sin^2\theta}$

$\sum F_y = ma_{Gy} \quad \Rightarrow \quad N - mg = -m\frac{L}{2}\alpha\sin\theta \quad \Rightarrow \quad N = mg - m\frac{L}{2}\frac{2g}{L}\frac{\sin\theta}{\frac{1}{3}+\sin^2\theta}\sin\theta = \frac{mg}{1+3\sin^2\theta}$