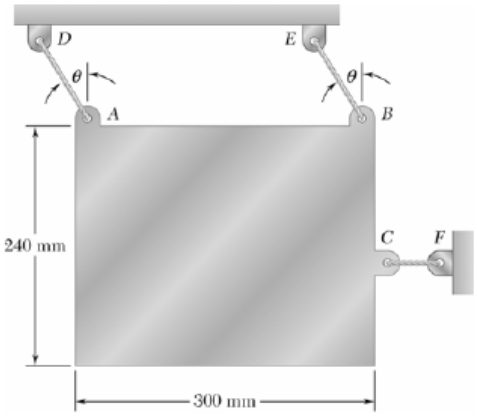
MCG 2108: DGD –Thursday 26 th Nov- Week 9

Problem : **16.124** : Board problem

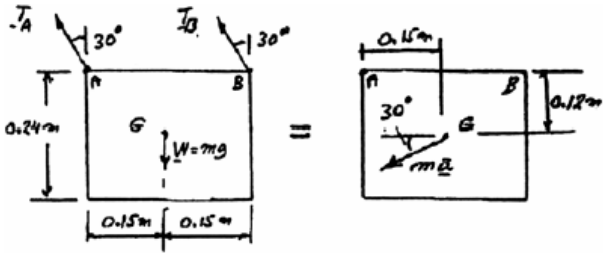
Problem(s) **16.14, 16.99** Assigned problems (for grading)



PROBLEM 16.14

A uniform rectangular plate has a mass of 5 kg and is held in position by three ropes as shown. Knowing that $\theta = 30°$, determine, immediately after rope CF has been cut, (a) the acceleration of the plate, (b) the tension in ropes AD and BE.

SOLUTION



(a) Acceleration $+\nearrow 30°\Sigma F = \Sigma F_{\text{eff}}: \quad mg\sin 30° = m\bar{a}$

$$\bar{a} = 0.5g = 4.905 \text{ m/s}^2 \qquad \bar{\mathbf{a}} = 4.91 \text{ m/s}^2 \nearrow 30° \blacktriangleleft$$

(b) Tension in ropes

$$+\circlearrowleft \Sigma M_A = \Sigma(M_A)_{\text{eff}}: \quad (T_B\cos 30°)(0.3 \text{ m}) - mg(0.15 \text{ m}) = -m\bar{a}(\cos 30°)(0.12 \text{ m}) - m\bar{a}(\sin 30°)(0.15 \text{ m})$$

$$0.2598T_B - (5 \text{ kg})(9.81 \text{ m/s}^2)(0.15 \text{ m}) = -(5 \text{ kg})(4.905 \text{ m/s}^2)(0.1039 + 0.075)$$

$$0.2598T_B - 7.3575 = -4.388$$

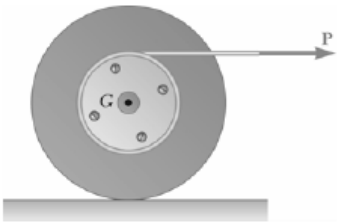
$$T_B = +11.43 \text{ N} \qquad T_{BE} = 11.43 \text{ N} \blacktriangleleft$$

$$+\nwarrow 10°\Sigma F = \Sigma F_{\text{eff}}: \quad T_A + 11.43 \text{ N} - mg\cos 30° = 0$$

$$T_A + 11.43 \text{ N} - (5 \text{ kg})(9.81)\cos 30° = 0$$

$$T_A + 11.43 \text{ N} - 42.48 \text{ N} = 0$$

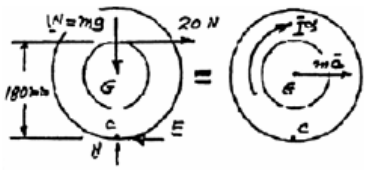
$$T_A = 31.04 \text{ N} \qquad T_{AD} = 31.0 \text{ N} \blacktriangleleft$$



PROBLEM 16.99

A drum of 60-mm radius is attached to a disk of 120-mm radius. The disk and drum have a total mass of 6 kg and a combined radius of gyration of 90 mm. A cord is attached as shown and pulled with a force P of magnitude 20 N. Knowing that the disk rolls without sliding, determine (*a*) the angular acceleration of the disk and the acceleration of *G*, (*b*) the minimum value of the coefficient of static friction compatible with this motion.

SOLUTION



$$\bar{a} = r\alpha = (0.12\text{ m})\alpha$$

$$\bar{I} = m\bar{k}^2$$

$$= (6\text{ kg})(0.09\text{ m})^2$$

$$\bar{I} = 48.6\times10^{-3}\text{ kg}\cdot\text{m}^2$$

$$+\circlearrowright \Sigma M_C = \Sigma(M_C)_{\text{eff}}: \quad (20\text{ N})(0.18\text{ m}) = (m\bar{a})r + \bar{I}\alpha$$

$$3.6\text{ N}\cdot\text{m} = (6\text{ kg})(0.12\text{ m})^2\alpha + 48.6\text{ kg}\cdot\text{m}^2$$

$$3.6 = 135\times10^{-3}\alpha$$

(*a*) $$\alpha = 26.667\text{ rad/s}^2 \qquad \alpha = 26.7\text{ rad/s}^2\ \circlearrowright \blacktriangleleft$$

$$\bar{a} = r\alpha = (0.12\text{ m})(26.667\text{ rad/s}^2)$$

$$= 3.2\text{ m/s}^2 \qquad \bar{\mathbf{a}} = 3.20\text{ m/s}^2 \rightarrow \blacktriangleleft$$

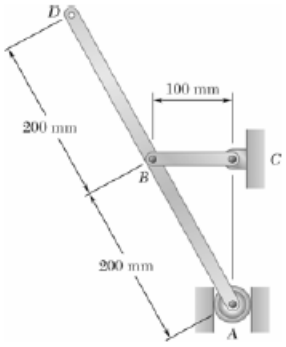
(*b*) $$+\uparrow \Sigma F_y = \Sigma(F_y)_{\text{eff}}: \quad N - mg = 0$$

$$N = (6\text{ kg})(9.81\text{ m/s}^2)\uparrow \qquad \mathbf{N} = 58.86\text{ N}\uparrow$$

$$\pm\rightarrow \Sigma F_x = \Sigma(F_x)_{\text{eff}}: \quad 20\text{ N} - F = m\bar{a}$$

$$20\text{ N} - F = (6\text{ kg})(3.2\text{ m/s}^2) \qquad \mathbf{F} = 0.8\text{ N}\leftarrow$$

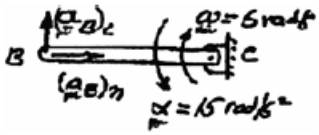
$$(\mu_s)_{\min} = \frac{F}{N} = \frac{0.8\text{ N}}{58.86\text{ N}} \qquad (\mu_s)_{\min} = 0.0136 \blacktriangleleft$$



PROBLEM 16.124

The 4-kg uniform rod ABD is attached to the crank BC and is fitted with a small wheel that can roll without friction along a vertical slot. Knowing that at the instant shown crank BC rotates with an angular velocity of 6 rad/s clockwise and an angular acceleration of 15 rad/s^2 counterclockwise, determine the reaction at A.

SOLUTION



Crank BC:

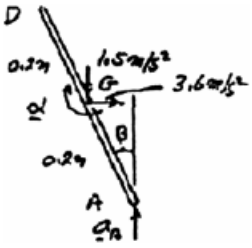
$$BC = 0.1 \text{ m}$$

$$(a_B)_t = (BC)\alpha = (0.1 \text{ m})(15 \text{ rad/s}^2) = 1.5 \text{ m/s}^2 \qquad (\mathbf{a}_B)_t = 1.5 \text{ rad/s}^2 \downarrow$$

$$(a_B)_n = (BC)\omega^2 = (0.1 \text{ m})(6 \text{ rad/s})^2 = 3.6 \text{ m/s}^2 \qquad (\mathbf{a}_B)_n = 3.6 \text{ m/s}^2 \rightarrow$$

Rod ABD:

$$\theta = \sin^{-1}\frac{BC}{AB} = \sin^{-1}\frac{0.1 \text{ m}}{0.2 \text{ m}} = 30°$$



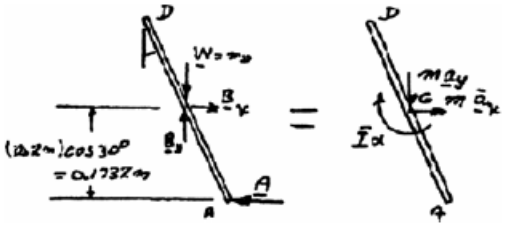
$$\mathbf{a}_A = \mathbf{a}_B + \mathbf{a}_{A/G}$$

$$[a_A \uparrow] = [1.5 \downarrow + 3.6 \rightarrow] + [0.2\alpha \measuredangle \beta]$$

$$+\rightarrow \quad 0 = 3.6 - (0.2\alpha)\cos\beta$$

$$\alpha = \frac{3.6}{0.2\cos\beta} = \frac{18}{\cos 30°} = 20.78 \text{ rad/s}^2 \qquad \alpha = 20.78 \text{ rad/s}^2 \curvearrowright$$

Kinetics:



$$+\circlearrowright \Sigma M_G = \Sigma(M_G)_{\text{eff}}: \quad A(0.1732 \text{ m}) = I\alpha = \frac{1}{12}mL^2\alpha$$

$$= \frac{1}{12}(4 \text{ kg})(0.4 \text{ m})^2(20.78 \text{ rad/s}^2)$$

$$A = 6.399 \text{ N} \qquad \mathbf{A} = 6.40 \text{ N} \leftarrow$$