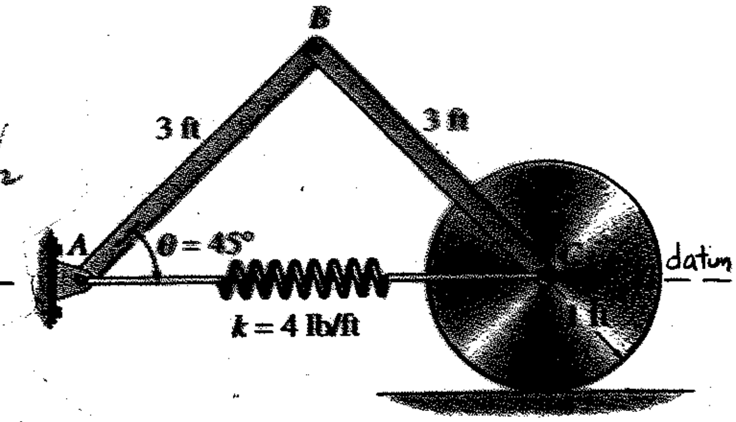
Problem 18.30 (Page 466)

The assembly shown below consists of two 15-lb slender rods and a 20-lb disk. If the spring is unstretched when $\theta = 45°$ and the assembly is released from rest at this position, determine the angular velocity of the rod AB, ω_{AB} when $\theta = 0°$. The disk rolls without slipping.

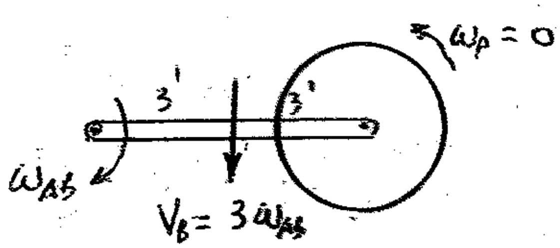


$$T_1 + V_1 + \sum U_{1-2} = T_2 + V_2$$

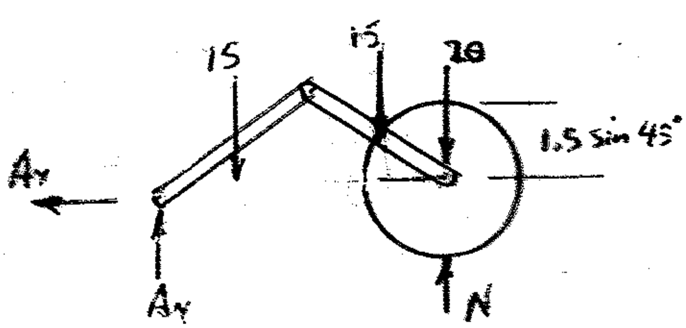
$$0 + 2(15)(1.5 \sin 45°)$$

$$= \frac{1}{2}(4)\left[6 - 2(3)\cos 45°\right]^2$$

$$+ 2\left[\frac{1}{2}\underbrace{\left(\frac{1}{3}\cdot\frac{15}{32.17}\right)3^2}_{I_{AB} = I_{BC}}\right]\omega_{AB}^2$$

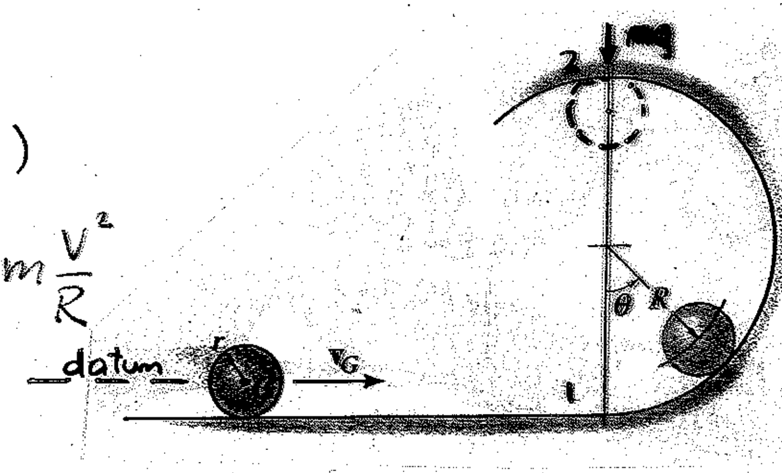


$$\omega_{AB} = 4.28 \text{ rad/sec}$$



Problem 18.33 (Page 467 11th Ed)

A ball of mass m and radius r is cast onto the horizontal surface as shown such that it rolls without slipping. Determine the minimum initial speed v_G of its mass center G so that it rolls completely around the loop of radius $R + r$ without leaving the track.



At the top (position 2)

$$\downarrow \Sigma F_y = mg = ma_{G_y} = m\frac{v^2}{R}$$

$$v_2^2 = gR$$

$$T_1 + V_1 + \Sigma U_{1-2} = T_2 + V_2$$

$$\frac{1}{2}\left[\frac{2}{5}mr^2\right]\left(\frac{v_G}{r}\right)^2 + \frac{1}{2}mv_G^2 + 0$$

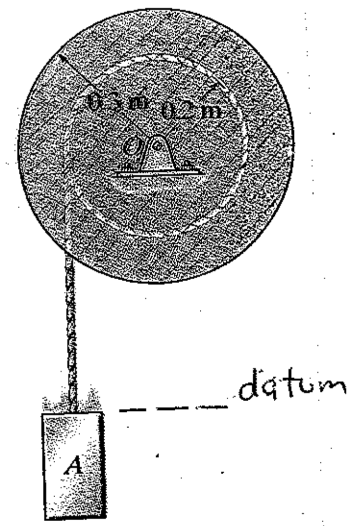
$$= \frac{1}{2}\left[\frac{2}{5}mr^2\right]\frac{gR}{r^2} + \frac{1}{2}m(gR)$$

$$+ mg(2R)$$

$$v_G = \sqrt{\frac{9gR}{7}}$$

Problem 18.41 (Page 474)

The spool shown has a mass of 50 kg and a radius of gyration $k_o = 0.28$ m If the 20-kg block A is released from rest, determine the distance the block must fall in order for the spool to have an angular velocity $\omega = 5$ rad/sec. Also, determine the tension in the cord while the block is in motion. Neglect the mass of the cord.



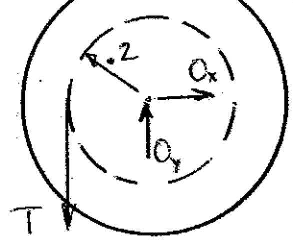
$I_o = K_o^2 m = (.28)^2(50) = 3.92 \text{ kg m}^2$

$T_1 + V_1 + U_{1-2} = T_2 + V_2$

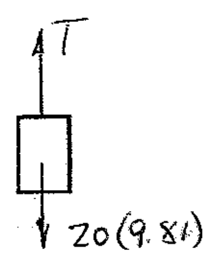
$0 + 0 + 0 = \underbrace{\tfrac{1}{2} I \omega^2} + \underbrace{\tfrac{1}{2} m v^2 - mgh}_{\text{block}}$

$V = .2\omega$
$= .2(5)$
$= 1 \text{ m/sec}$

$\tfrac{1}{2}(3.92)(5)^2 + \tfrac{1}{2}(20)(1)^2$
$- 20(9.81)h = 0$
$h = 0.3 \text{ m}$



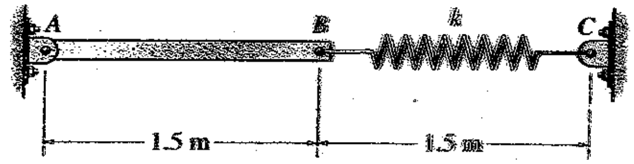
Spool $(+\sum M_o = .2T = I\alpha = 3.92\alpha$
$T = 19.6\alpha$



block $+\downarrow \sum F_y = 196.2 - T = 20(.2)\alpha$
$\alpha = 8.31 \text{ r/sec}^2$)
$T = 163 \text{ N}$

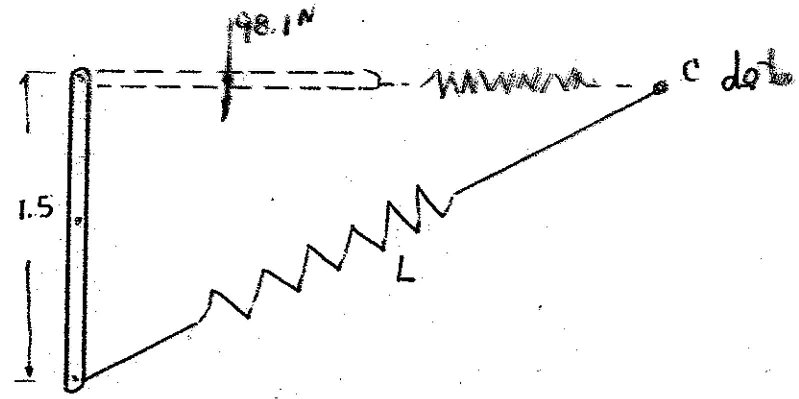
Problem 18.42 (Page 474)

The slender 10-kg bar AB shown is horizontal and at rest and is attached to a spring that is unstretched. Determine the spring stiffness k that would cause the motion of the bar to momentarily stop when it has rotated downward 90°.



$3^2 + 1.5^2 = L^2$

$L = 3.354$ m



$T_1 + V_1 + U_{1-2} = T_2 + V_2$

$0 + 0 + 0 = 0$

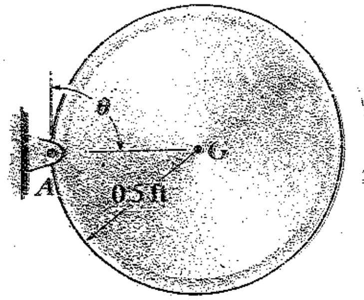
$+ \frac{1}{2} k (3.354 - 1.5)^2$

$- 98.1 \left(\frac{1.5}{2}\right)$

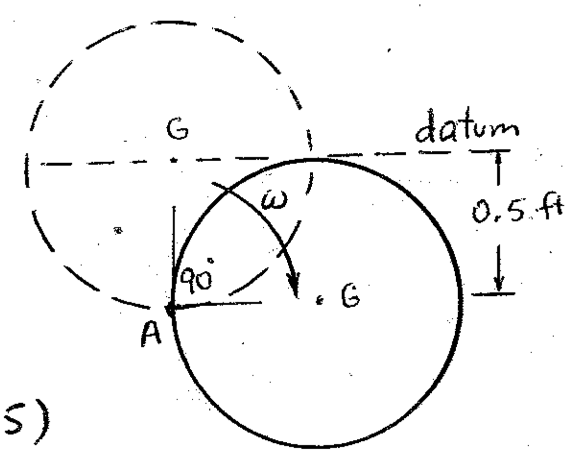
$k = 42.8$ N/m

Problem 18.43 (Page 474)

The 15 lb disk below is rotating about a pin A in the vertical plane with an angular velocity $\omega = 2$ rad/sec when $\theta = 0°$. Determine its angular velocity at the instant $\theta = 90°$. Also, determine the horizontal and vertical components at A at this instant (when $\theta = 90°$).

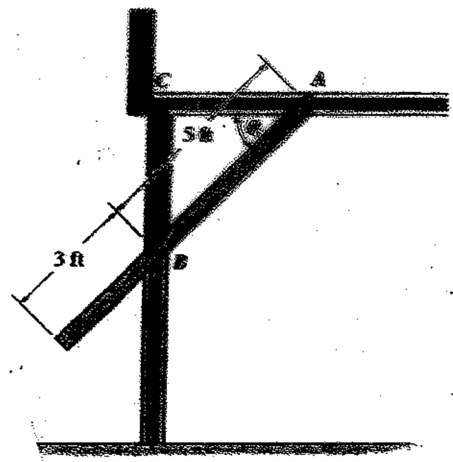


$$I_A = I_G + md^2$$
$$= \frac{1}{2}mr^2 + md^2$$
$$= \frac{1}{2}\left(\frac{15}{32.17}\right)(.5)^2 + \left(\frac{15}{32.17}\right)(.5)^2$$
$$= 0.175 \text{ slug ft}^2$$



$$T_1 + V_1 + U_{1-2} = T_2 + V_2$$
$$\frac{1}{2}I\omega_1^2 + 0 + 0 = \frac{1}{2}I\omega_2^2 - 15(.5)$$
$$\frac{1}{2}(.175)(2)^2 = \frac{1}{2}(.175)\omega_2^2 - 15(.5)$$
$$\omega_2 = 9.477 \text{ rad/sec}$$

Problem 18.44 (Page 475)
The door shown below is made from one piece, whose ends move along the horizontal and vertical tracks. If the door is in the open position, $\theta = 0°$. and then released, determine the speed at which its end A strikes the stop at C. Assume the door is a 180-lb thin plate having a width of 10 ft.



$$I_B = \frac{1}{12}\left(\frac{180}{32.17}\right)(8)^2 + \frac{180}{32.17}(1)^2$$

$$= 35.43 \text{ slug ft}^2$$

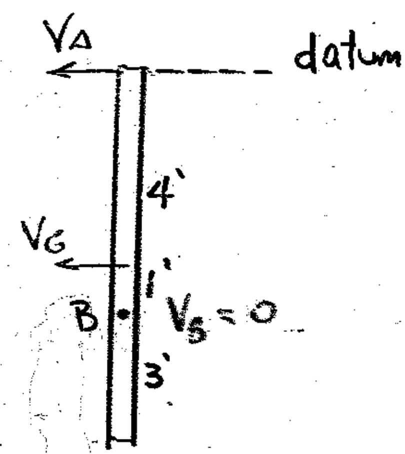
$$T_1 + V_1 + \sum U_{1-2} = T_2 + V_2$$

$$0 + 0 + 0 = \frac{1}{2} I_B \omega^2 - 4(180)$$

$$= \frac{1}{2}(35.43)\omega^2 - 720$$

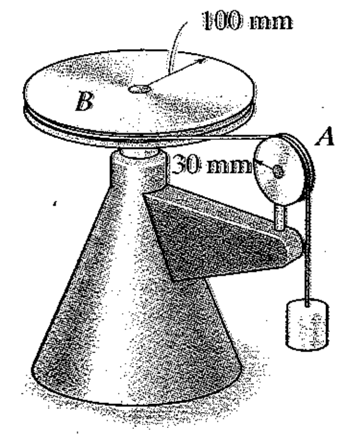
$$\omega = 6.375 \text{ r/sec}$$

$$V_A = 5\omega = 31.87 \text{ ft/sec}$$



Problem 18-50

The assembly shown consists of a 3-kg-pulley A and a 10-kg-pulley B. If a 2-kg-block is suspended from the cord, determine the block's speed after it descends 0.5 m starting from rest. Neglect any friction and the mass of the cord. Also, treat the pulleys as thin disks.



$T_1 = 0 \quad V_1 = 0 \quad U_{1-2} = 0$

$.03\omega_A = 0.1\omega_B \qquad V_b = .03\,\omega_A$

$\omega_A = 3.33\,\omega_B$

$T_2 = \frac{1}{2} I_A \omega_A^2 + \frac{1}{2} I_B \omega_B^2 + \frac{1}{2} m_b V_b^2$

$= \frac{1}{2}\left[\frac{1}{2}(3)(.03)^2\right]\omega_A^2 + \frac{1}{2}\left[\frac{1}{2}(10)(.1)^2\right]\left(\frac{\omega_A}{3.33}\right)^2$

$+ \frac{1}{2}(2)(.03\,\omega_A)^2 \qquad V_2 = -2(9.81)(.5) = -9.81$ ft lb

$T_1 + V_1 + U_{1-2} = T_2 + V_2$

$0 + 0 + 0 = .000675\,\omega_A^2 + .18\,\omega_A^2 + .0009\,\omega_A^2$

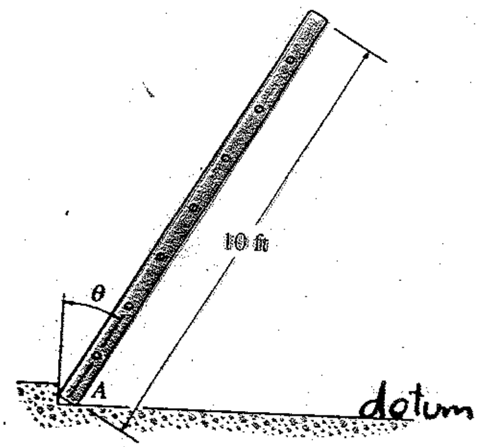
-9.81

$\omega_A = 50.64$

$V_A = .03(50.64) = 1.52$ m/sec

Problem 18.51 (Page 467)

A uniform ladder having a weight of 30 lbs is released from rest when it is in the vertical postion. If it is allowed to fall freely, determine the angle θ at which the bottom end A starts to lift off the ground. For the calculation, assume the ladder to be a slender rod and neglect friction at A.



$$V_1 = 30(5) = 150 \text{ ft lb}$$

$$V_2 = 150 \cos\theta$$

$$I_A = \frac{1}{3} mL^2 = \frac{1}{3}\left(\frac{30}{32.2}\right)(10)^2$$

$$= 31.06 \text{ slug ft}^2$$

$$T_1 = 0 \qquad T_2 = \frac{1}{2} I_A \omega^2 = 15.53\,\omega^2$$

$$T_1 + V_1 + \sum U_{1-2} = T_2 + V_2$$

$$0 + 150 + 0 = 15.53\omega^2 + 150\cos\theta$$

$$\omega^2 = 9.66(1 - \cos\theta)$$

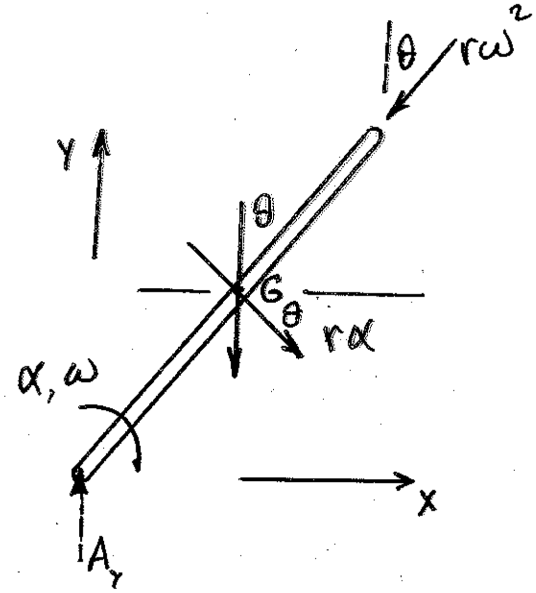
$$\circlearrowleft + \sum M_A = +30 \sin\theta\,(5) = I_A \alpha = 31.06\,\alpha$$

$$+\uparrow \sum F_y = A_y - 30 = m a_{G_y}$$

Problem 18.51 (Continued)

From:

$\sum M_A$, $\alpha = 4.83 \sin\theta$



$a_{G_Y} = -r\alpha\sin\theta - r\omega^2\cos\theta$

$\omega^2 = 9.66(1-\cos\theta)$

$a_{G_Y} = -24.15\sin^2\theta - 48.3\cos\theta$
$\quad + 48.3\cos^2\theta$

$\sum F_Y = A_Y - 30 = m\,a_{G_Y}$

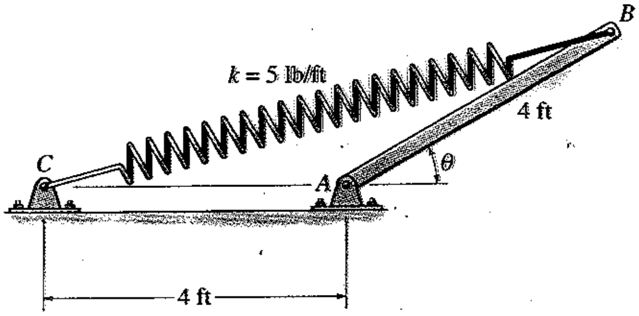
$A_Y = 30 - \frac{30}{32.17}\left[-24.15\sin^2\theta - 48.3\cos\theta + 48.3\cos^2\theta\right]$

Ladder lifts off when $A_Y = 0$

$\theta = 48.19^\circ$ $\quad \omega = 1.794$ r/sec $\quad \alpha = 3.6$ r/sec²

Problem 18.53 (Page 467)

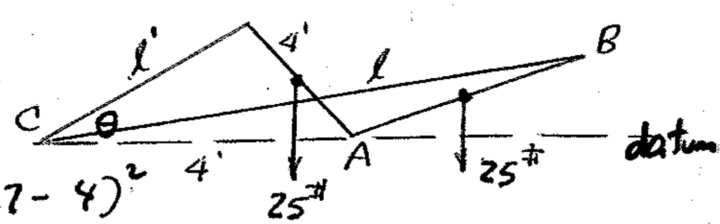
The 25-lb slender rod AB is attached to a spring BC which has an unstretched length of 4 ft. If the rod is released from rest when $\theta = 30^\circ$, determine the angular velocity of the rod the instant the spring becomes unstetched.



$$\ell^2 = 4^2 + 4^2 - 2(4)(4)\cos 150^\circ$$

$$\ell = 7.727 \text{ ft}$$

$$T_1 + V_1 + U_{1-2} = T_2 + V_2$$



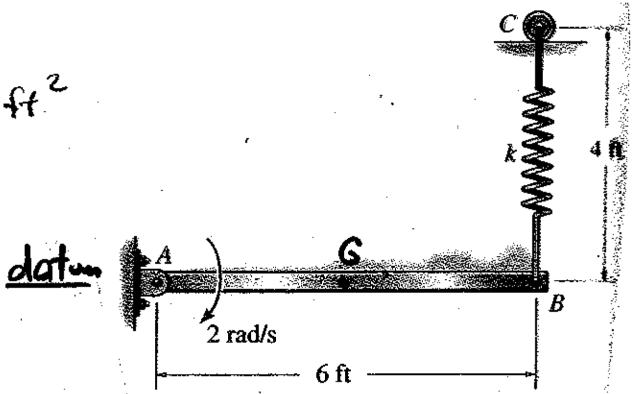
$$0 + 25(2)\sin 30^\circ + \frac{1}{2}(5)(7.727-4)^2$$

$$= \frac{1}{2}\left[\frac{1}{3}\left(\frac{25}{32.2}\right)4^2\right]\omega^2 + 25(2)\sin 60^\circ + 0$$

$$\omega = 2.82 \text{ r/s}$$

Problem 18.58 (Page 468)

At the instant shown, the 50-lb bar is rotating downwards at 2 rad/sec. The spring attached to its end always remains vertical due to the roller guide at C. If the spring has an unstretched length of 2 feet and a stiffness of k = 12 lb/ft, determine the angle θ, measured below the horizontal, to which the bar rotates before it stops.



$$I_A = \frac{1}{3}(6)^2\left(\frac{50}{32.17}\right) = 18.65 \text{ slug ft}^2$$

$$T_1 + V_1 + \sum U_{1-2} = T_2 + V_2$$

$$\frac{1}{2}(18.65)(2)^2 + \frac{1}{2}(12)2^2 + 0$$

$$= 0 + \frac{1}{2}(12)(4 + 6\sin\theta - 2)^2 - 50(3)\sin\theta$$

$$37.3 + 24 = 24 + 144\sin\theta + 216\sin^2\theta - 150\sin\theta$$

$$216\sin^2\theta - 6\sin\theta - 37.3 = 0$$

$$\sin\theta = .4297$$

$$\theta = 25.45^\circ$$