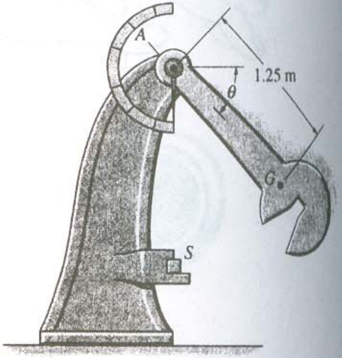
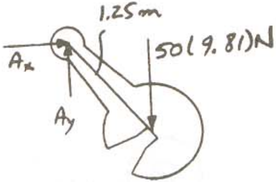
**18-13.** The pendulum of the Charpy impact machine has a mass of 50 kg and a radius of gyration of $k_A = 1.75$ m. If it is released from rest when $\theta = 0°$, determine its angular velocity just before it strikes the specimen $S$, $\theta = 90°$.



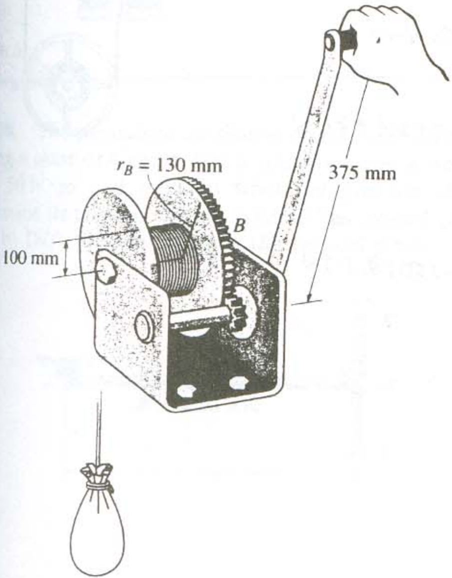




$$T_1 + \Sigma U_{1-2} = T_2$$

$$0 + (50)(9.81)(1.25) = \frac{1}{2}\left[(50)(1.75)^2\right]\omega_2^2$$

$\omega_2 = 2.83$ rad/s **Ans**

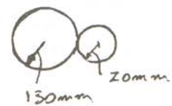
**18-15.** The hand winch is used to lift the 50-kg load. Determine the work required to rotate the handle five revolutions. The gear at $A$ has a radius of 20 mm.




$20(\theta_A) = \theta_B(130)$

When $\theta_A = 5$ rev. $= 10\pi$

$\theta_B = 4.8332$ rad

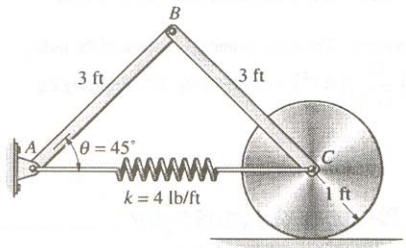



Thus load moves up

$s = 4.8332(0.1\text{ m}) = 0.48332\text{ m}$

$U = 50(9.81)(0.48332) = 237\text{ J}$ **Ans**

**18-30.** The assembly 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 rod $AB$ at the instant $\theta = 0°$. The disk rolls without slipping.

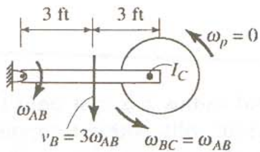


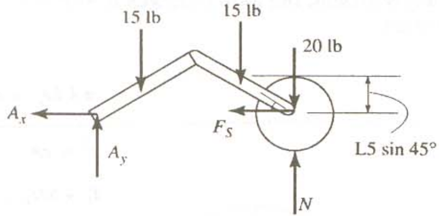

$$T_1 + \sum U_{1-2} = T_2$$

$$[0+0] + 2(15)(1.5)\sin 45° - \frac{1}{2}(4)[6 - 2(3)\cos 45°]^2$$

$$= 2\left[\frac{1}{2}\left(\frac{1}{3}\left(\frac{15}{32.2}\right)(3)^2\right)\omega_{AB}^2\right]$$

$\omega_{AB} = 4.28$ rad/s **Ans**



**18-38.** Solve Prob. 18–11 using the conservation of energy equation.

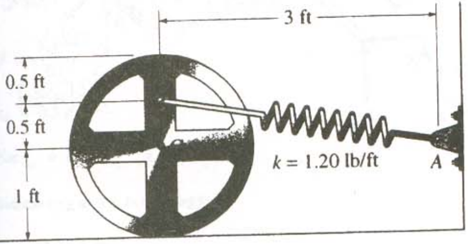
$$v_G = (0.02)\omega = 0.02(70) = 1.4 \text{ ft/s}$$

$$T_1 + V_1 = T_2 + V_2$$

$$0 + 0 = \frac{1}{2}\left(\frac{0.3}{32.2}\right)(1.4)^2 + \frac{1}{2}(0.06)^2\left(\frac{0.3}{32.2}\right)](70)^2 - (0.3)s$$

$$s = 0.304 \text{ ft} \qquad \textbf{Ans}$$

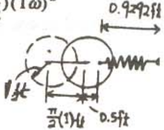
. The 50-lb wheel has a radius of gyration about nter of gravity $G$ of $k_G = 0.7$ ft. If it rolls without ing, determine its angular velocity when it has ed clockwise 90° from the position shown. The spring has a stiffness $k = 1.20$ lb/ft and an unstretched h of 0.5 ft. The wheel is released from rest.





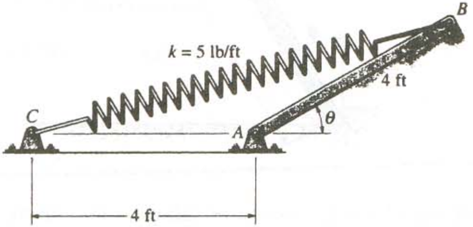
$$T_1 + V_1 = T_2 + V_2$$

$$0 + \frac{1}{2}(1.20)[\sqrt{(3)^2 + (0.5)^2} - 0.5]^2 = \frac{1}{2}[\frac{50}{32.2}(0.7)^2]\omega^2 + \frac{1}{2}(\frac{50}{32.2})(1\omega)^2 + \frac{1}{2}(1.20)(0.9292 - 0.5)^2$$

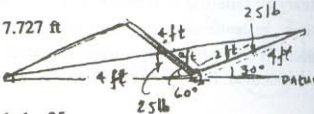



$\omega = 1.80$ rad/s **Ans**

**18-53.** 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 $\theta = 30°$, determine the angular velocity of the rod the instant the spring becomes unstretched.




$$l = \sqrt{(4)^2 + (4)^2 - 2(4)(4)\cos 150°} = 7.727 \text{ ft}$$



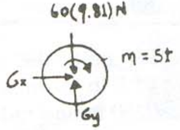

$$T_1 + V_1 = T_2 + V_2$$

$$0 + 25(2)\sin 30° + \frac{1}{2}(5)(7.727 - 4)^2 = \frac{1}{2}[\frac{1}{3}(\frac{25}{32.2})(4)^2]\omega^2 + 25(2)(\sin 60°) + 0$$

$\omega = 2.82$ rad/s **Ans**

10. A flywheel has a mass of 60 kg and a radius of
ation of $k_G = 150$ mm about an axis of rotation passing
ough its mass center. If a motor supplies a clockwise
que having a magnitude of $M = (5t)$ N·m, where $t$ is in
onds, determine the flywheel's angular velocity in $t =$
Initially the flywheel is rotating clockwise at $\omega_1 = 2$ rad/s.

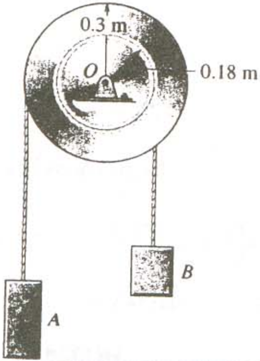
(↻+) $$(H_G)_1 + \Sigma\int M\,dt = (H_G)_2$$




$$60(0.15)^2(2) + \int_0^3 5t\,dt = 60(0.15)^2\,\omega$$

$$\omega = 18.7 \text{ rad/s}$$ **Ans**

***19-12.** The spool has a mass of 30 kg and a radius of gyration $k_O = 0.25$ m. Block $A$ has a mass of 25 kg, and block $B$ has a mass of 10 kg. If they are released from rest, determine the time required for block $A$ to attain a speed of 2 m/s. Neglect the mass of the ropes.




$$v_A = 2 \text{ m/s}$$

$$\omega = \frac{2}{0.3} = 6.667 \text{ rad/s}$$

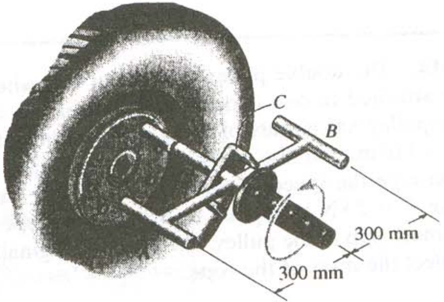
$$v_B = 6.667(0.18) = 1.20 \text{ m/s}$$

$$\circlearrowleft + \quad (H_O)_1 + \Sigma\int M\,dt = (H_O)_2$$

$$0 + 25(9.81)(0.3)\,t - 10(9.81)(0.18)(t) = 25(2)(0.3) + 30(0.25)^2(6.667) + 10(1.20)(0.18)$$

$$t = 0.530 \text{ s}$$ **Ans**

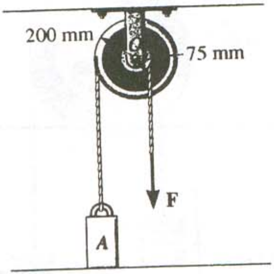
**19-15.** The impact wrench consists of a slender 1-kg rod $AB$ which is 580 mm long, and cylindrical end weights at $A$ and $B$ that each have a diameter of 20 mm and a mass of 1 kg. This assembly is free to turn about the handle and socket, which are attached to the lug nut on the wheel of a car. If the rod $AB$ is given an angular velocity of 4 rad/s and it strikes the bracket $C$ on the handle without rebounding, determine the angular impulse imparted to the lug nut.




$$I_{axle} = \frac{1}{12}(1)(0.6 - 0.02)^2 + 2\left[\frac{1}{2}(1)(0.01)^2 + 1(0.3)^2\right] = 0.2081 \text{ kg} \cdot \text{m}^2$$

$$\int M dt = I_{axle}\,\omega = 0.2081(4) = 0.833 \text{ kg} \cdot \text{m}^2/\text{s} \qquad \textbf{Ans}$$

**19-18.** The double pulley consists of two wheels which are attached to one another and turn at the same rate. The pulley has a mass of 15 kg and a radius of gyration $k_O = 110$ mm. If the block at $A$ has a mass of 40 kg, determine the speed of the block in 3 s after a constant force $F = 2$ kN is applied to the rope wrapped around the inner hub of the pulley. The block is originally at rest. Neglect the mass of the rope.

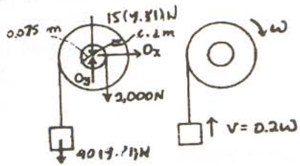



$(\circlearrowright +) \quad (H_O)_1 + \Sigma \int M_O dt = (H_O)_2$

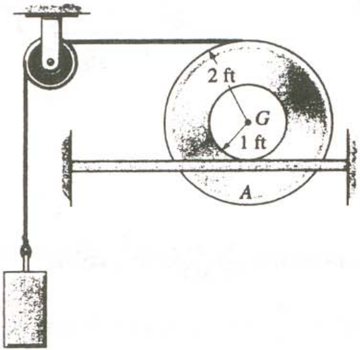
$$0 + 2000(0.075)(3) - 40(9.81)(0.2)(3) = 15(0.110)^2\omega + 40(0.2\omega)(0.2)$$

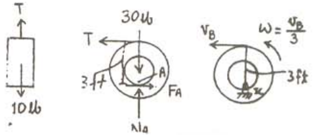
$\omega = 120.4$ rad/s

$v_A = 0.2(120.4) = 24.1$ m/s **Ans**



**19-23.** The inner hub of the wheel rests on the horizontal track. If it does not slip at $A$, determine the speed of the 10-lb block in 2 s after the block is released from rest. The wheel has a weight of 30 lb and a radius of gyration $k_G = 1.30$ ft. Neglect the mass of the pulley and cord.




Spool,

$$(\circlearrowleft +) \qquad (H_A)_1 + \Sigma \int M_A \, dt = (H_A)_2$$

$$0 + T(3)(2) = \left[\frac{30}{32.2}(1.3)^2 + \frac{30}{32.2}(1)^2\right]\left(\frac{v_B}{3}\right)$$

Block,

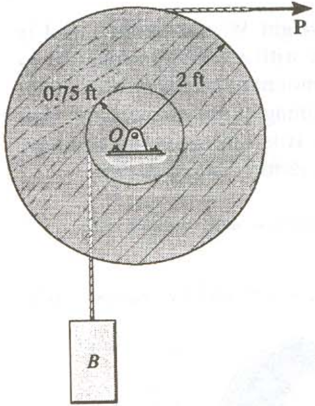
$$(+\downarrow) \qquad m(v_y)_1 + \Sigma \int F_y \, dt = m(v_y)_2$$

$$0 + 10(2) - T(2) = \frac{10}{32.2} v_B$$

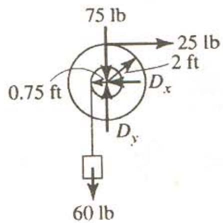
$v_B = 34.0$ ft/s **Ans**

$T = 4.73$ lb

**19-27.** The spool has a weight of 75 lb and a radius of gyration $k_O = 1.20$ ft. If the block $B$ weighs 60 lb, and a force $P = 25$ lb is applied to the cord, determine the speed of the block in 5 s starting from rest. Neglect the mass of the cord.




$$(\circlearrowleft +) \quad (H_O)_1 + \sum \int M_O dt = (H_O)_2$$




$$0 - 60(0.75)(5) + 25(2)(5) = \frac{75}{32.2}(1.20)^2\omega$$

$$+ \left[\frac{60}{32.2}(0.75\omega)\right](0.75)$$

$$\omega = 5.679 \text{ rad/s}$$

$$v_B = \omega r = (5.679)(0.75) = 4.26 \text{ ft/s}$$ **Ans**