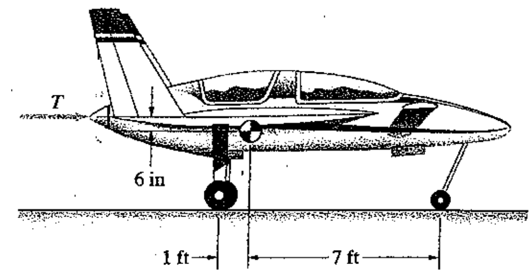
1. The airplane shown at the beginning of its take-off run weighs 1000 lbs, and has a total horizontal thrust of 300 lbs. Neglecting any horizontal forces by the tires, and assuming a constant acceleration, determine a) how long it will take the airplane to reach its take-off speed of 80 mi/hr, and b) the normal force exerted on the forward landing gear (front tire) at the beginning of the take-off run.



$$a = \frac{T}{m} = \frac{300\text{ lb }(32.17)\text{ ft}}{1000\text{ lb sec}^2}$$

$$= 9.65\text{ f/s}^2 = \frac{V}{t}$$

$R \uparrow \qquad \uparrow F$

$$V = 80\ \frac{\text{mi}}{\text{hr}}\ \frac{5280\text{ ft}}{\text{mi}}\ \frac{\text{hr}}{3600\text{ sec}} = 117.33\text{ f/sec}$$

$$t = \frac{V}{a} = \frac{117.33}{9.65} = 12.16\text{ sec}$$

$$\sum F_Y = R + F - W = 0 = R + F - 1000 = 0$$

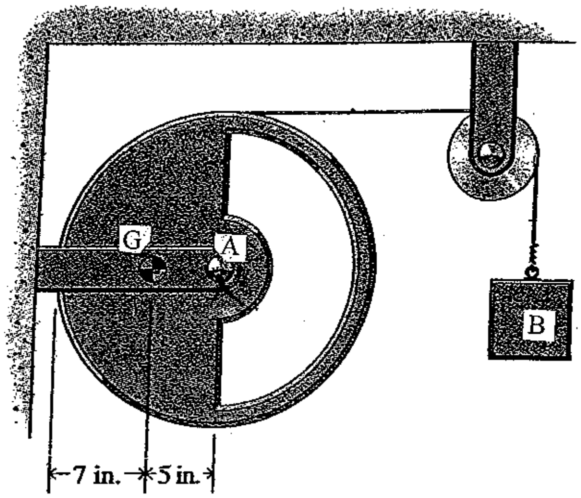
$$\sum M_G = 7F - 1R - .5T = 0$$

$$= 7(1000 - R) - R - .5(300) = 0$$

$R = 856.25$ lb (both wheels)

$F = 143.75$ lb

2. A 24-in diameter disk weighs 130 lbs and has a radius of gyration about point A of $k_A = 9$ inches. A cord wrapped around the periphery of the disk passes over a small pulley of negligible mass and is attached to a 70-lb block B. The system is released from rest. Determine a) the tension in the cord, and b) the acceleration of the block as the motion begins.



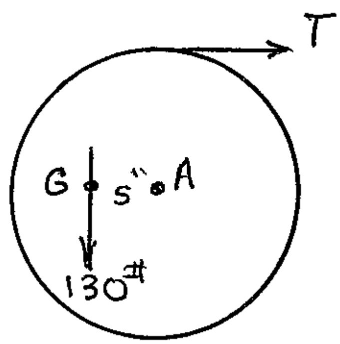
Disk rotates about A

$$I_A = k_A^2 m = \left(\frac{9}{12}\right)^2 \left(\frac{130}{32.17}\right)$$

$$= 2.273 \text{ slug ft}^2$$

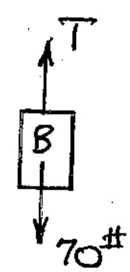
$$\circlearrowleft + \sum M_A = \frac{12}{12} T - \frac{5}{12}(130) = I_A \alpha$$

$$T = 54.17 + 2.273\,\alpha$$



$$a_B = r\alpha = \frac{12}{12}\alpha$$

$$+\downarrow \sum F_B = 70 - T = \frac{70}{32.17} a_B$$



$$T = 70 - 2.176\,\alpha$$

$$= 54.17 + 2.273\,\alpha$$

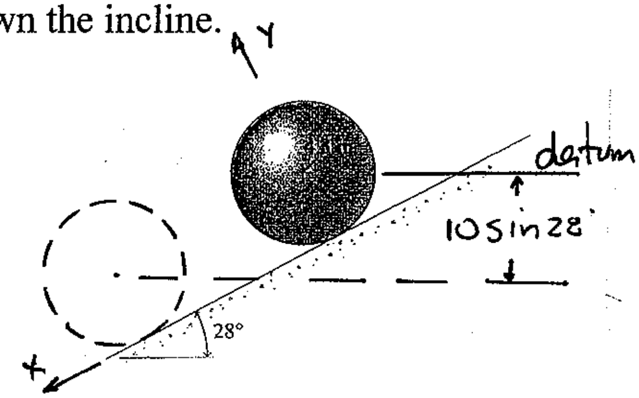
$$\alpha = 3.558 \text{ r/s}^2$$

$$a_B = r\alpha = \left(\frac{12}{12}\right)(3.558) = 3.558 \text{ ft/sec}^2 \downarrow$$

$$T = 62.25^{\#}$$

3. A bowling ball with a radius of 4.3 inches is released from rest on a 28° incline and rolls down the incline without slipping. After the ball has moved a distance of 10 ft, determine a) the angular velocity of the ball, b) the angular acceleration of the ball, and c) the time it takes the ball to move 10 feet.

Suggestion: Place your positive x-axis down the incline.



$$T = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\left(\frac{v}{r}\right)^2$$

$$= \frac{7}{10}mv^2$$

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

$$0 + 0 + 0 = \frac{7}{10}\cancel{m}v^2 - \cancel{m}g(10\sin 28°)$$

$$v = 14.689\ \text{ft/sec} = \left(\frac{4.3}{12}\right)\omega \qquad \underline{\omega = 41\ \text{rad/sec}}$$

$$S = 10\text{ ft} = r\theta = \frac{4.3}{12}\theta \qquad \theta = 27.91\ \text{rad}$$

$$\alpha = \omega\frac{d\omega}{d\theta} \qquad \int_0^\theta \alpha\, d\theta = \int_0^\omega \omega\, d\omega = \frac{\omega^2}{2} = 27.91\,\alpha$$

$$\alpha = \frac{(41)^2}{2(27.91)} = \underline{30.11\ \text{rad/sec}^2} \qquad a = r\alpha = \frac{4.3}{12}(30.11)$$

$$= 10.789\ \text{ft/sec}^2$$

$$v = at = 10.789\,t = r\omega = \left(\frac{4.3}{12}\right)(41)$$

$$\underline{t = 1.36\ \text{sec}}$$

3. A bowling ball with a radius of 4.3 inches is released from rest on a 28° incline and rolls down the incline without slipping. After the ball has moved a distance of 10 ft, determine a) the angular velocity of the ball, b) the angular acceleration of the ball, and c) the time it takes the ball to move 10 feet.

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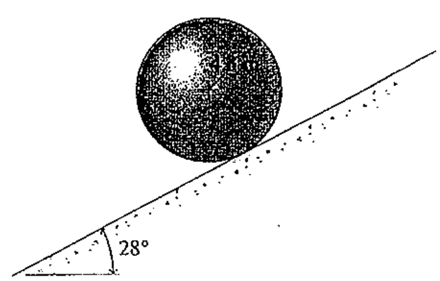
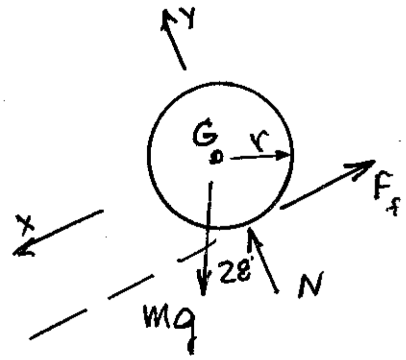


$$\overset{+}{\swarrow} \sum F_x = mg \sin 28^\circ - F_f = ma_x$$

$$+\nwarrow \sum F_y = N - mg\cos 28^\circ = 0$$

$$\circlearrowleft + \sum M_G = F_f r = I\alpha = \frac{2}{5} m r^2 \alpha$$

$$F_f = \frac{2}{5} m r \alpha = \frac{2}{5} m a_x$$



$$\cancel{m} g \sin 28^\circ - \frac{2}{5}\cancel{m} a = \cancel{m} a$$

$$a = \frac{5}{7} g \sin 28^\circ = 10.79 \text{ f/sec}^2$$

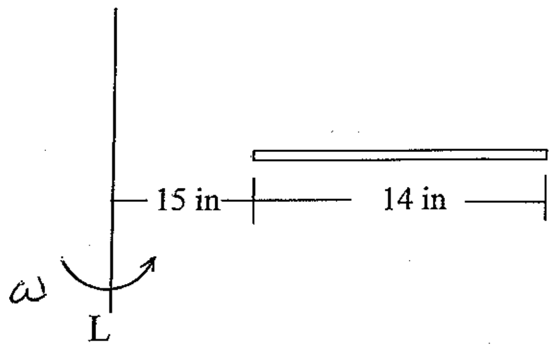
$$= r\alpha = \frac{4.3}{12}\alpha$$

$$\alpha = 30.105 \text{ r/sec}^2 = \omega \frac{d\omega}{d\theta} \qquad \theta = \frac{10}{r} = \underline{27.91 \text{ rad}}$$

$$\int_0^\theta \alpha \, d\theta = \int_0^\omega \omega \, d\omega \qquad \omega^2 = 2(27.91)\alpha \qquad \underline{\omega = 41 \text{ rad/sec}}$$

$$a = \frac{v}{t} = r\alpha \qquad t = \frac{v}{r\alpha} = \frac{r\omega}{r\alpha} = \frac{\omega}{\alpha} = \underline{1.36 \text{ sec}}$$

4. A 20 lb slender rod 14 inches long is rotating about the axis L as shown at 10 rev/min. The end of the rod is located a distance of 15 inches from the L axis. Determine a) the mass moment of inertia of the rod about the L axis, and b) the moment required to stop the rod from rotating in 20 seconds.



$10 \frac{rev}{min}\left(\frac{2\pi}{60}\right) = 1.0472 \ rad/sec$

$I_L = I_G + md^2$

$= \frac{1}{12}\left(\frac{20}{32.17}\right)\left(\frac{14}{12}\right)^2$

$+\left(\frac{20}{32.17}\right)\left(\frac{22}{12}\right)^2 = .0705 + 2.089$

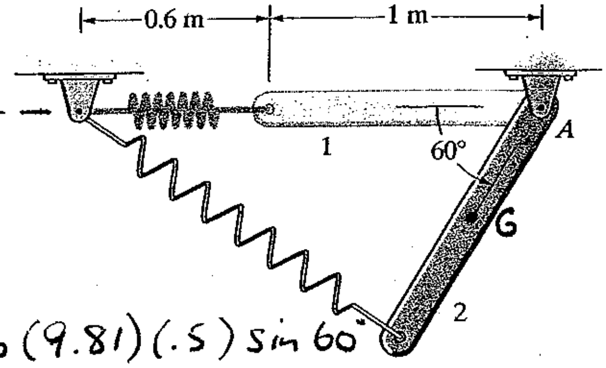
a) $I_L = 2.1595 \text{ slug ft}^2$

$\Sigma M = M = I_L \alpha = 2.1595 \frac{d\omega}{dt}$ $\qquad \int_0^t \alpha \, dt = \int_{1.0472}^{0} d\omega$

$\alpha = -\frac{1.0472}{20} = -.05236 \ r/sec^2$

$M = 2.1595(-.05236) = -0.113 \text{ ft lb}$

5. The 6-kg bar is released from rest in the horizontal position 1 and falls to position 2. The unstretched length of the spring is 0.6 m and the spring constant k = 18 N/m. Use the energy method to determine the angular velocity of the bar when it is at position 2.



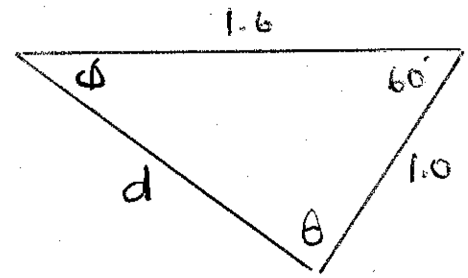
$$T_1 + V_1 + U_{1-2} = T_2 + V_2$$

$$0 + 0 + 0 = \frac{1}{2} I_A \omega_A^2 - 6(9.81)(.5)\sin 60^\circ + \frac{1}{2}(18)(1.4 - .6)^2$$

$$I_A = \frac{1}{3}(6)1^2 = 2 \text{ kg m}^2$$

$$0 = \frac{1}{2}(2)\omega^2 - 19.73$$

$$\omega = 4.44 \text{ rad/sec}$$



$$d^2 = 1.6^2 + 1^2 - 1.6(1)2\cos 60$$

$$d = 1.4 \text{ m}$$

$$\frac{\sin\theta}{1.6} = \frac{\sin 60}{1.4}$$

$$\theta = 81.8^\circ$$

$$\phi = 38.2^\circ$$