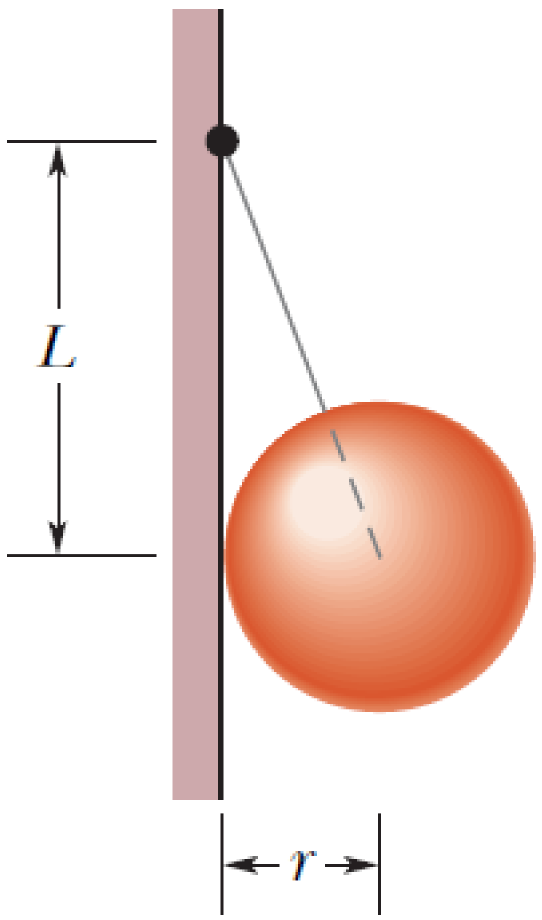
RECITATION 13

CH 12

•3 SSM WWW In Fig. 12-24, a uniform sphere of mass $m = 0.85$ kg and radius $r = 4.2$ cm is held in place by a massless rope attached to a frictionless wall a distance $L = 8.0$ cm above the center of the sphere. Find (a) the tension in the rope and (b) the force on the sphere from the wall.



a)

$$F_{y,\text{net}} = 0$$

$$T\cos\theta - mg = 0$$

$$T = \frac{mg}{\cos\theta} = \frac{mg}{\frac{L}{\sqrt{L^2 + r^2}}} = \frac{mg\sqrt{L^2 + r^2}}{L}$$

$$= \frac{(0.85\text{ kg})(9.8\text{ m/s}^2)\sqrt{8.0^2 + 4.2^2}}{8.0\text{ cm}} = 9.4\text{ N.}$$

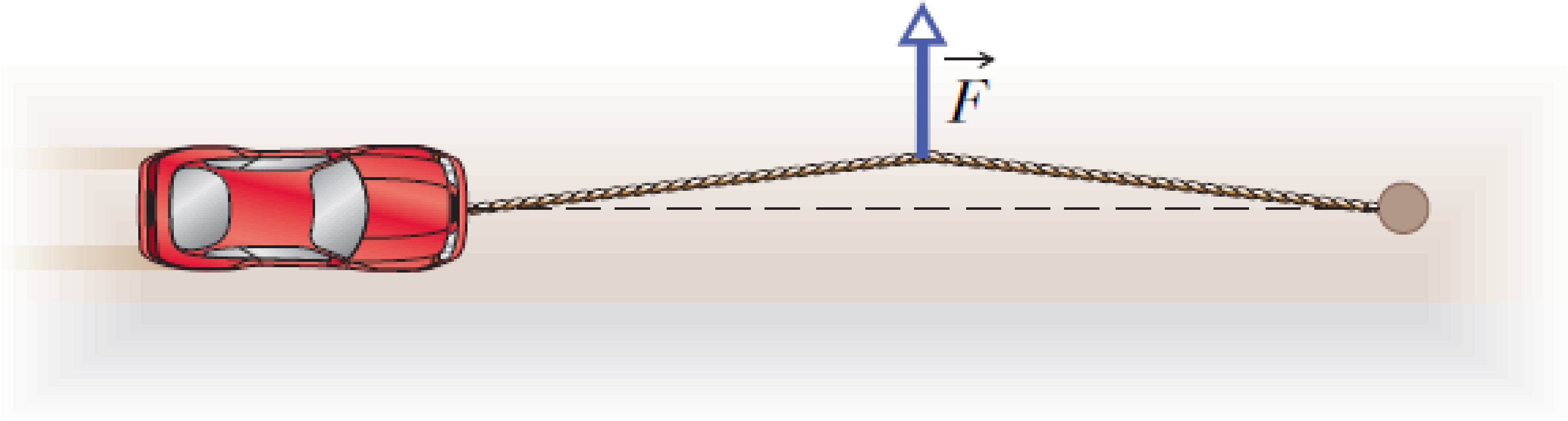
b)

$$F_{x,\text{net}} = 0$$

$$F_\text{w} - T\sin\theta = 0$$

$$F_\text{w} = T\sin\theta = T\frac{r}{\sqrt{L^2 + r^2}} = (9.41\text{ N})\frac{4.2}{\sqrt{8.0^2 + 4.2^2}} = 4.4\text{ N.}$$

•**12** In Fig. 12-28, trying to get his car out of mud, a man ties one end of a rope around the front bumper and the other end tightly around a utility pole 18 m away. He then pushes sideways on the rope at its midpoint with a force of 550 N, displacing the center of the rope 0.30 m, but the car barely moves. What is the magnitude of the force on the car from the rope? (The rope stretches somewhat.)



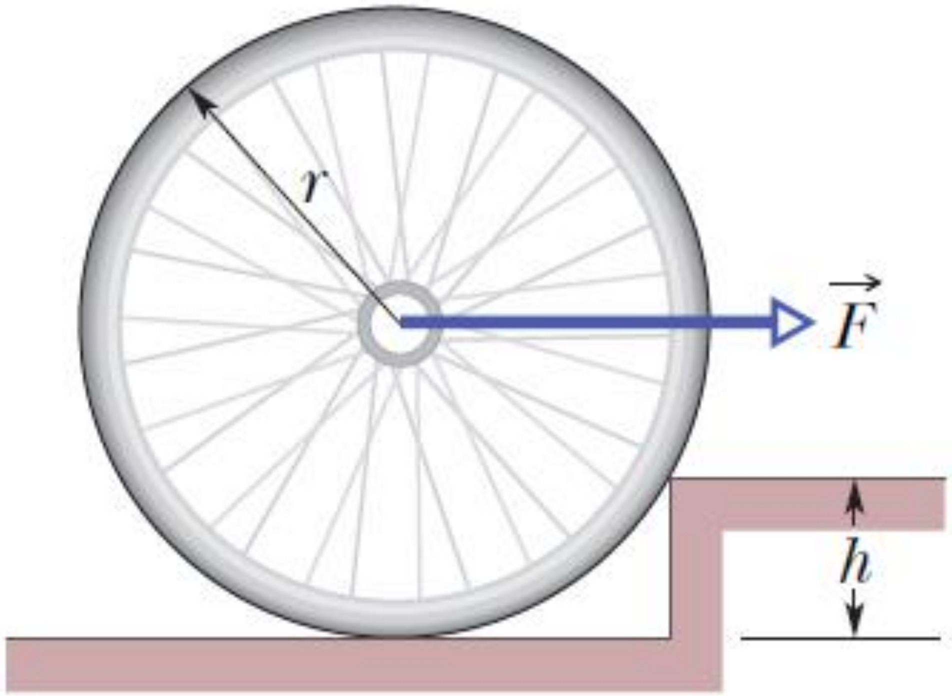
$$F_{y,\mathrm{net}} = 0$$

$$F - 2T\sin\theta = 0$$

$$\sin\theta = \frac{d}{\sqrt{(L/2)^2 + d^2}} = \frac{0.30}{\sqrt{9.0^2 + 0.30^2}} = 0.0333.$$

$$T = \frac{F}{2\sin\theta} = \frac{550\ \mathrm{N}}{2(0.0333)} = 8300\ \mathrm{N}.$$

••25 SSM WWW In Fig. 12-40, what magnitude of (constant) force $\vec{F}$ applied horizontally at the axle of the wheel is necessary to raise the wheel over an obstacle of height $h = 3.00$ cm? The wheel's radius is $r = 6.00$ cm, and its mass is $m = 0.800$ kg.



$$\tau_{z,\text{net}} = 0$$

$$\tau_{F_g} - \tau_F = 0$$

$$mg\, r_{\perp,F_g} - F r_{\perp,F} = 0$$

$$r_{\perp,F} = r - h$$

$$r_{\perp,F_g} = \sqrt{r^2 - (r-h)^2} = \sqrt{2rh - h^2}$$

Thus,

$$F = \frac{mg\sqrt{2rh - h^2}}{r - h}$$

$$= \frac{(0.800\ \text{kg})\left(9.81\,\frac{\text{m}}{\text{s}^2}\right)\sqrt{2(6.00\text{m})(3.00\text{m}) - (3.00\text{m})^2}}{6.00\text{m} - 3.00\text{m}}$$

$$= 13.6\ \text{N}.$$

•43 SSM ILW A horizontal aluminum rod 4.8 cm in diameter projects 5.3 cm from a wall. A 1200 kg object is suspended from the end of the rod. The shear modulus of aluminum is 3.0×10^{10} N/m². Neglecting the rod's mass, find (a) the shear stress on the rod and (b) the vertical deflection of the end of the rod.

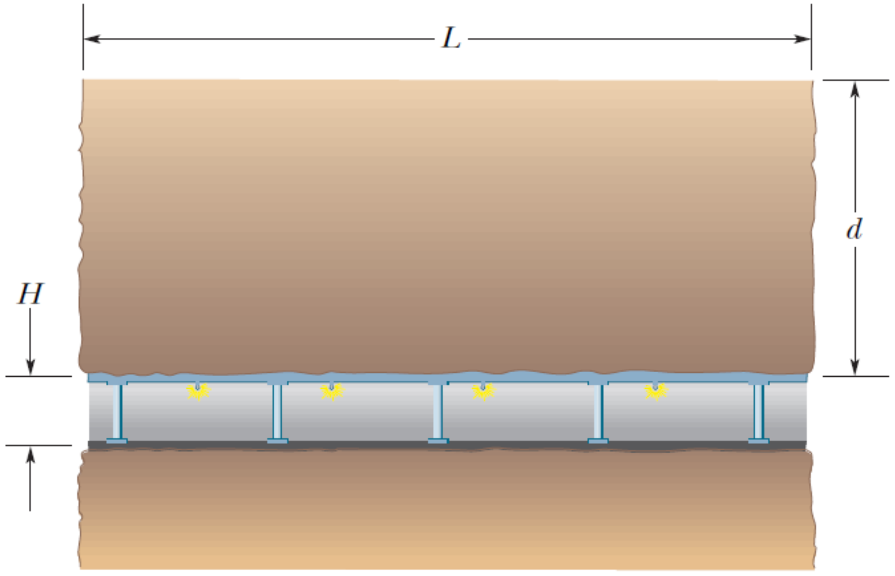
a)

$$\frac{F}{A} = \frac{mg}{\pi r^2} = \frac{(1200\ \mathrm{kg})\left(9.81\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)}{\pi(0.024)^2} = 5.5 \times 10^6\,\frac{\mathrm{N}}{\mathrm{m}^2}.$$

b)

$$\Delta x = \frac{F}{A}\frac{L}{G} = \left(1.63 \times 10^6\,\frac{\mathrm{N}}{\mathrm{m}^2}\right)\left(\frac{5.3\ \mathrm{cm}}{3.0 \times 10^{10}\,\frac{\mathrm{N}}{\mathrm{m}^2}}\right) = 1.1 \times 10^{-3}\ \mathrm{cm}.$$

••47 A tunnel of length $L = 150$ m, height $H = 7.2$ m, and width 5.8 m (with a flat roof) is to be constructed at distance $d = 60$ m beneath the ground. (See Fig. 12-56.) The tunnel roof is to be supported entirely by square steel columns, each with a cross-sectional area of 960 cm^2. The mass of 1.0 cm^3 of the ground material is 2.8 g. (a) What is the total weight of the ground material the columns must support? (b) How many columns are needed to keep the compressive stress on each column at one-half its ultimate strength?



a)

$$W = mg = \rho V g = \rho g L D d$$
$$= \left(2800\,\frac{\text{kg}}{\text{m}^3}\right)(150\text{ m})(5.8\text{ m})(60\text{ m})\left(9.81\,\frac{\text{m}}{\text{s}^2}\right)$$
$$= 1.4 \times 10^9\text{ N}.$$

b)

$$W = nAS_y$$
$$n = \frac{W}{AS_y}$$

At one-half of the ultimate strength

$$n = \frac{2W}{AS_y} = \frac{2(1.43 \times 10^9\text{N})}{(0.096\text{ m}^2)(4.00 \times 10^8\text{ N/m}^2)} = 75.$$