18P. A loaded penguin sled weighing 80 N rests on a plane inclined at 20° to the horizontal (Fig. 6-28). Between the sled and the plane, the coefficient of static friction is 0.25, and the coefficient of kinetic friction is 0.15. (a) What is the minimum magnitude of the force $\vec{F}$, parallel to the plane, that will prevent the sled from slipping down the plane? (b) What is the minimum magnitude F that will start the sled moving up the plane? (c) What value of F is required to move the sled up the plane at constant velocity?

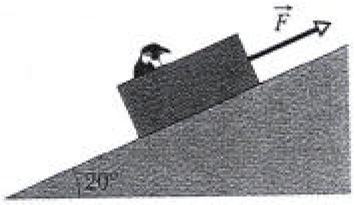
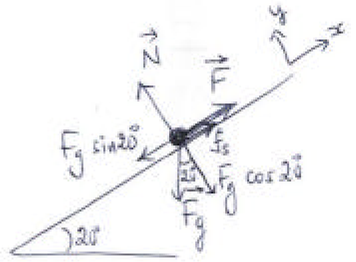


Fig. 6-28 Problem 18.

a)



$$\Sigma F_x = F_{min} + f_{s,max} - F_g \sin 20° = ma = 0$$

$$\Sigma F_y = N - F_g \cos 20° = 0$$

$$\Rightarrow N = F_g \cos 20° \quad \text{and} \quad f_{s,max} = \mu_s N$$

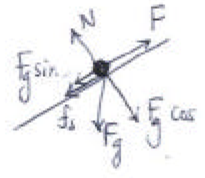
$$F_g = mg$$

$$f_{s,max} = \mu_s mg \cos 20°$$

and $F_{min} = F_g \sin 20° - f_{s,max} = mg \sin 20° - \mu_s mg \cos 20°$

$$= mg(\sin 20° - \mu_s \cos 20°) = \boxed{8.6\,N}$$

b)



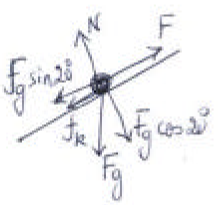
$$\Sigma F_x = F_{min} - F_g \sin 20° - f_{s,max} = ma = 0$$

$$\Sigma F_y = N - F_g \cos 20° = 0$$

$$\Rightarrow F_{min} = F_g \sin 20° + f_{s,max} = mg \sin 20° + \mu_s mg \cos 20°$$

$$= mg(\sin 20° + \mu_s \cos 20°) = \boxed{46\,N}$$

c) $v =$ Const and the object is moving $\Rightarrow$ μ_k



$$F - F_g \sin 20° - f_k = ma = 0$$

$$N - F_g \cos 20° = 0 \qquad f_k = \mu_k N = \mu_k mg \cos 20°$$

$$F = mg \sin 20° + \mu_k mg \cos 20° = \boxed{39\,N}$$

22P. In Fig. 6-31, two blocks are connected over a pulley. The mass of block A is 10 kg and the coefficient of kinetic friction between A and the incline is 0.20. Angle θ of the incline is 30°. Block A slides down the incline at constant speed. What is the mass of block B?

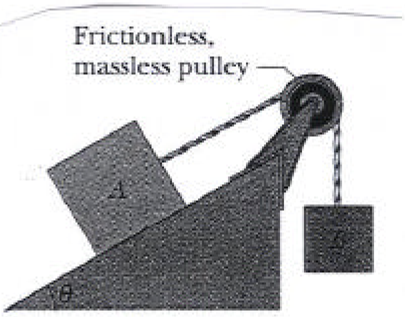
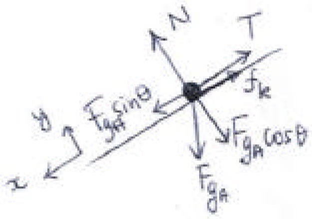
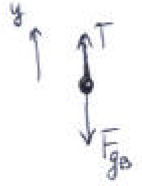


Fig. 6-31 Problems 21 and 22.





$v = \text{const}$
$\Rightarrow a = 0$

mass A

$\sum F_x = F_{g_A}\sin\theta - T - f_k = m_A a = 0$

$\sum F_y = N - F_{g_A}\cos\theta = 0 \Rightarrow N = F_{g_A}\cos\theta$

$f_k = \mu_k N = \mu_k F_{g_A}\cos\theta$

$F_{g_A}\sin\theta - T - \mu_k F_{g_A}\cos\theta = 0$

$\Rightarrow T = m_A g(\sin\theta - \mu_k\cos\theta) \quad -(1)$

mass B

$T - F_{g_B} = m_B a = 0$

$T = m_B g \quad -(2)$

$(1) = (2) \Rightarrow \quad m_A \cancel{g}(\sin\theta - \mu_k\cos\theta) = m_B \cancel{g}$

$\Rightarrow \boxed{m_B = 3.3\ \text{kg}}$

24P. In Fig. 6-32, a box of Cheerios and a box of Wheaties are accelerated across a horizontal surface by a horizontal force $\vec{F}$ applied to the Cheerios box. The magnitude of the frictional force on the Cheerios box is 2.0 N, and the magnitude of the frictional force on the Wheaties box is 4.0 N. If the magnitude of $\vec{F}$ is 12 N, what is the magnitude of the force on the Wheaties box from the Cheerios box?

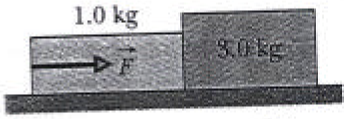
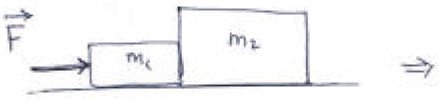


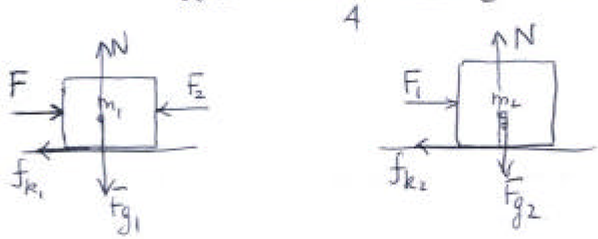
Fig. 6-32 Problem 24.



We apply Newton's 2^{nd} law to the total mass $(m_1 + m_2)$

$$F - f_k = (m_1 + m_2)\, a \Rightarrow a = \frac{F - f_k}{(m_1 + m_2)}$$

$$a = \frac{12 - 6}{4} = 1.5 \text{ m/s}^2$$



mass m_2 $\quad \sum F_x = F_1 - f_{k_2} = m_2 a \Rightarrow F_1 = m_2 a + f_{k_2}$

$$F_1 = 3 \times 1.5 + 4 = \boxed{8.5 \text{ N}}$$

37E. Suppose the coefficient of static friction between the road and the tires on a Formula One car is 0.6 during a Grand Prix auto race. What speed will put the car on the verge of sliding as it rounds a level curve of 30.5 m radius? **ssm**

$\mu_s = 0.6$

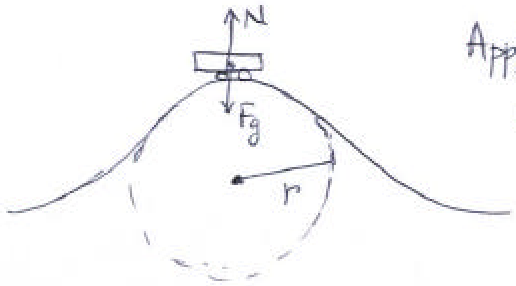
$v_{max} = ?$

The car is on the verge of sliding $\Rightarrow f_{s,max} = \mu_s N = \mu_s mg$

$$f_{s,max} = \frac{\cancel{m} v_{max}^2}{r} = \mu_s \cancel{m} g \Rightarrow v_{max} = \sqrt{\mu_s g r}$$

$$v_{max} = \sqrt{0.6 \times 9.8 \times 30.5} = \boxed{13.4 \text{ m/s}}$$

38E. A roller-coaster car has a mass of 1200 kg when fully loaded with passengers. As the car passes over the top of a circular hill of radius 18 m, its speed is not changing. What are the magnitude and direction of the force of the track on the car at the top of the hill if the car's speed is (a) 11 m/s and (b) 14 m/s?



Apply Newton's second law at the top of the hill.

$$\sum F = m\frac{v^2}{r} = \bar{F}_g - N = mg - N$$

$$\Rightarrow \quad N = mg - m\frac{v^2}{r} = m\left(g - \frac{v^2}{r}\right)$$

a) $v = 11$ m/s $\Rightarrow$ $N = 2733$ N

b) $v = 14$ m/s $\Rightarrow$ $N = -1307$ N unphysical

the car will leave the track.

41P. A puck of mass m slides on a frictionless table while attached to a hanging cylinder of mass M by a cord through a hole in the table (Fig. 6-37). What speed keeps the cylinder at rest? ssm

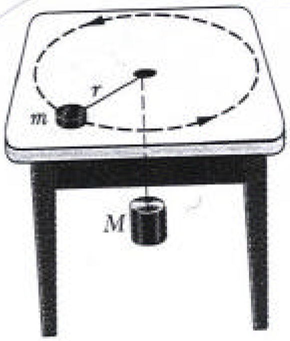
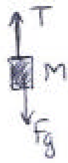


Fig. 6-37 Problem 41.

$$T = m\frac{v^2}{r} = Mg$$

$$\Rightarrow \boxed{v = \sqrt{\frac{Mgr}{m}}}$$



Newton's second law

$$T - Mg = Ma = 0$$

$$\Rightarrow T = Mg$$

45P. An airplane is flying in a horizontal circle at a speed of 480 km/h. If its wings are tilted 40° to the horizontal, what is the radius of the circle in which the plane is flying? (See Fig. 6-38.) Assume that the required force is provided entirely by an "aerodynamic lift" that is perpendicular to the wing surface. ssm

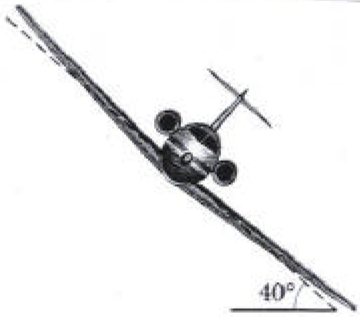
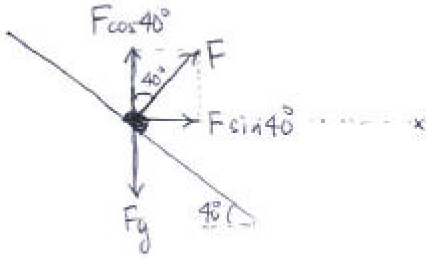


Fig. 6-38 Problem 45.

$v = 480 \text{ km/h} = 133 \text{ m/s}$



$$F \sin 40° = m\frac{v^2}{r}$$

$$F \cos 40° - mg = 0 \Rightarrow F = \frac{mg}{\cos 40°}$$

$$\Rightarrow \cancel{m} g \tan 40° = \cancel{m}\frac{v^2}{r} \Rightarrow r = \frac{v^2}{g \tan 40°} = 2151 \text{ m}$$

$$\simeq 2 \text{ km}$$