

38. **REASONING** It is the static friction force that accelerates the cup when the plane accelerates. The maximum magnitude that this force can have will determine the maximum acceleration, according to Newton's second law.

SOLUTION According to Newton's second law, we have

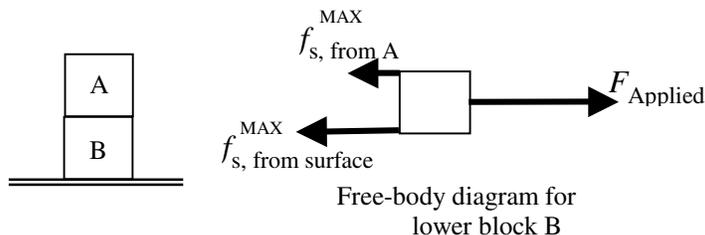
$$\Sigma F = f_s^{MAX} = \mu_s F_N = \mu_s mg = ma$$

In this result, we have used the fact that the magnitude of the normal force is $F_N = mg$, since the plane is flying horizontally and the normal force acting on the cup balances the cup's weight. Solving for the acceleration gives

$$a = \mu_s g = (0.30)(9.80 \text{ m/s}^2) = \boxed{2.9 \text{ m/s}^2}$$

42. **REASONING** Static friction determines the magnitude of the applied force at which either the upper or lower block begins to slide. For the upper block the static frictional force is applied only by the lower block. For the lower block, however, separate static frictional forces are applied by the upper block and by the horizontal surface. The maximum magnitude of any of the individual frictional forces is given by Equation 4.7 as the coefficient of static friction times the magnitude of the normal force.

SOLUTION We begin by drawing the free-body diagram for the lower block.



This diagram shows that three horizontal forces act on the lower block, the applied force, and the two maximum static frictional forces, one from the upper block and one from the horizontal surface. At the instant that the lower block just begins to slide, the blocks are in equilibrium and the applied force is balanced by the two frictional forces, with the result that

$$F_{\text{Applied}} = f_{s, \text{from A}}^{\text{MAX}} + f_{s, \text{from surface}}^{\text{MAX}} \quad (1)$$

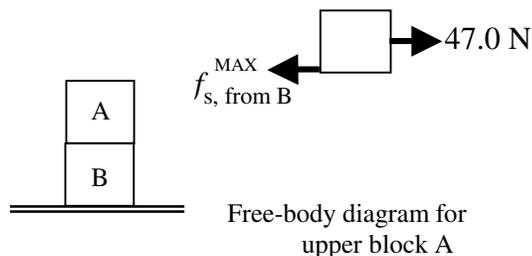
According to Equation 4.7, the magnitude of the maximum frictional force from the surface is

$$f_{s, \text{from surface}}^{\text{MAX}} = \mu_s F_N = \mu_s 2mg \quad (2)$$

Here, we have recognized that the normal force F_N from the horizontal surface must balance the weight $2mg$ of both blocks.

It remains now to determine the magnitude of the maximum frictional force $f_{s, \text{from A}}^{\text{MAX}}$ from the upper block.

To this end, we draw the free-body diagram for the upper block at the instant that it just begins to slip due to the 47.0-N applied force. At this instant the block is in equilibrium,



so that the frictional force from the lower block B balances the 47.0-N force. Thus, $f_{s, \text{from B}}^{\text{MAX}} = 47.0 \text{ N}$, and according to Equation 4.7, we have

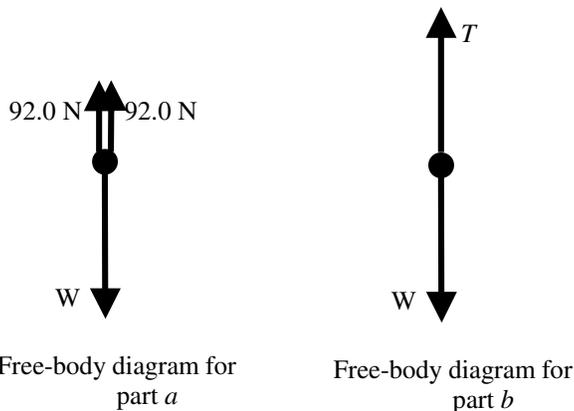
$$f_{s, \text{from B}}^{\text{MAX}} = \mu_s F_N = \mu_s mg = 47.0 \text{ N}$$

Here, we have recognized that the normal force F_N from the lower block must balance the weight mg of only the upper block. This result tells us that $\mu_s mg = 47.0 \text{ N}$. To determine $f_{s, \text{from A}}^{\text{MAX}}$ we invoke Newton's third law to conclude that the magnitudes of the frictional forces at the A-B interface are equal, since they are action-reaction forces. Thus, $f_{s, \text{from A}}^{\text{MAX}} = \mu_s mg$. Substituting this result and Equation (2) into Equation (1) gives

$$F_{\text{Applied}} = f_{s, \text{from A}}^{\text{MAX}} + f_{s, \text{from surface}}^{\text{MAX}} = \mu_s mg + \mu_s 2mg = 3(47.0 \text{ N}) = \boxed{141 \text{ N}}$$

46. **REASONING** At first glance there seems to be very little information given. However, it is enough. In part *a* of the drawing the bucket is hanging stationary and, therefore, is in equilibrium. The forces acting on it are its weight and the two tension forces from the rope. There are two tension forces from the rope, because the rope is attached to the bucket handle at two places. These three forces must balance, which will allow us to determine the weight of the bucket. In part *b* of the drawing, the bucket is again in equilibrium, since it is traveling at a constant velocity and, therefore, has no acceleration. The forces acting on the bucket now are its weight and a single tension force from the rope, and they again must balance. In part *b*, there is only a single tension force, because the rope is attached to the bucket handle only at one place. This will allow us to determine the tension in part *b*, since the weight is known.

SOLUTION Let W be the weight of the bucket, and let T be the tension in the rope as the bucket is being pulled up at a constant velocity. The free-body diagrams for the bucket in parts *a* and *b* of the drawing are as follows:



Since the bucket in part *a* is in equilibrium, the net force acting on it is zero. Taking upward to be the positive direction, we have

$$\Sigma F = 92.0 \text{ N} + 92.0 \text{ N} - W = 0 \quad \text{or} \quad W = 184 \text{ N}$$

Similarly, in part *b* we have

$$\Sigma F = T - W = 0 \quad \text{or} \quad T = W = \boxed{184 \text{ N}}$$

51. **REASONING AND SOLUTION** Consider a free body diagram for the stuntman with the x-axis parallel to the ground and the +y-axis vertically upward. The motion is along the +x-axis. Newton's second law written for no motion along the y-axis is $\Sigma F_y = 0$ or

$$F_N - mg = 0$$

This gives the normal force to be

$$F_N = mg = (109 \text{ kg})(9.80 \text{ m/s}^2)$$

Newton's second law for uniform motion in the x direction is $\Sigma F_x = 0$ or

$$T - f_k = 0$$

Then

$$T = f_k = \mu_k F_N = (0.870)(109 \text{ kg})(9.80 \text{ m/s}^2) = \boxed{929 \text{ N}}$$

55. **REASONING** Since the boxes are at rest, they are in equilibrium. According to Equation 4.9b, the net force in the vertical, or y , direction is zero, $\Sigma F_y = 0$. There are two unknowns in this problem, the normal force that the table exerts on box 1 and the tension in the rope that connects boxes 2 and 3. To determine these unknowns we will apply the relation $\Sigma F_y = 0$ twice, once to the boxes on the left of the pulley and once to the box on the right.

SOLUTION There are four forces acting on the two boxes on the left. The boxes are in equilibrium, so that the net force must be zero. Choosing the $+y$ direction as being the upward direction, we have that

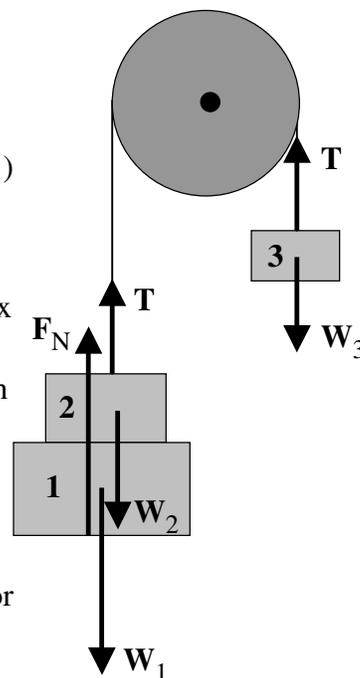
$$\underbrace{-W_1 - W_2 + F_N + T}_{\Sigma F_y} = 0 \quad (1)$$

where W_1 and W_2 are the magnitudes of the weights of the boxes, F_N is the magnitude of the normal force that the table exerts on box 1, and T is the magnitude of the tension in the rope. We know the weights. To find the unknown tension, note that the box 3 is also in equilibrium, so that the net force acting on it must be zero.

$$\underbrace{-W_3 + T}_{\Sigma F_y} = 0 \quad \text{so that} \quad T = W_3$$

Substituting this expression for T into Equation (1) and solving for the normal force gives

$$F_N = W_1 + W_2 - W_3 = 55 \text{ N} + 35 \text{ N} - 28 \text{ N} = \boxed{62 \text{ N}}$$



63. **REASONING** According to Newton's second law, the acceleration has the same direction as the net force and a magnitude given by $a = \Sigma F/m$.

SOLUTION Since the two forces are perpendicular, the magnitude of the net force is given by the Pythagorean theorem as $\Sigma F = \sqrt{(40.0 \text{ N})^2 + (60.0 \text{ N})^2}$. Thus, according to Newton's second law, the magnitude of the acceleration is

$$a = \frac{\Sigma F}{m} = \frac{\sqrt{(40.0 \text{ N})^2 + (60.0 \text{ N})^2}}{4.00 \text{ kg}} = \boxed{18.0 \text{ m/s}^2}$$

The direction of the acceleration vector is given by

$$\theta = \tan^{-1} \left(\frac{60.0 \text{ N}}{40.0 \text{ N}} \right) = \boxed{56.3^\circ \text{ above the } +x \text{ axis}}$$

65. **SSM REASONING** If we assume that the acceleration is constant, we can use Equation 2.4 ($v = v_0 + at$) to find the acceleration of the car. Once the acceleration is known, Newton's second law ($\Sigma \mathbf{F} = m\mathbf{a}$) can be used to find the magnitude and direction of the net force that produces the deceleration of the car.

SOLUTION The average acceleration of the car is, according to Equation 2.4,

$$a = \frac{v - v_0}{t} = \frac{17.0 \text{ m/s} - 27.0 \text{ m/s}}{8.00 \text{ s}} = -1.25 \text{ m/s}^2$$

where the minus sign indicates that the direction of the acceleration is opposite to the direction of motion; therefore, the acceleration points due west.

According to Newton's Second law, the net force on the car is

$$\Sigma F = ma = (1380 \text{ kg})(-1.25 \text{ m/s}^2) = -1730 \text{ N}$$

The magnitude of the net force is **1730 N**. From Newton's second law, we know that the direction of the force is the same as the direction of the acceleration, so the force also points **due west**.

66. **REASONING** The skydiver is falling along the $-y$ direction. There are two forces acting on him: the upward-acting force $+f_{\text{air}}$ of air resistance, and his weight, $-mg$. The net force is the sum of these forces. According to Newton's second law, Equation 4.2b, the net force is equal to the mass of the skydiver times his acceleration. We can use the second law to determine the acceleration.

SOLUTION

a. Newton's second law states that

$$\underbrace{+f_{\text{air}} - mg}_{\Sigma F_y} = ma_y \quad (4.2b)$$

Solving this equation for a_y and noting that $f_{\text{air}} = \frac{1}{3}mg$, we have

$$a_y = \frac{-mg + \frac{1}{3}mg}{m} = -\frac{2}{3}g = -6.5 \text{ m/s}^2$$

The magnitude of the skydiver's acceleration is $\boxed{6.5 \text{ m/s}^2}$.

b. When the skydiver falls at a constant velocity, his acceleration is zero, and he is in equilibrium. According to Equation 4.9b, $\Sigma F_y = 0$, and the net force acting on him must be zero.

$$\underbrace{f_{\text{air}} - mg}_{\Sigma F_y} = 0$$

The force of air resistance is

$$f_{\text{air}} = mg = (110 \text{ kg})(9.8 \text{ m/s}^2) = \boxed{1100 \text{ N, upward}}$$

67. **REASONING AND SOLUTION**

Newton's second law applied to object 1 (422 N) gives

$$T = m_1 a_1$$

Similarly, for object 2 (185 N)

$$T - m_2 g = m_2 a_2$$

If the string is not to break or go slack, both objects must have accelerations of the same magnitude.

Then $a_1 = a$ and $a_2 = -a$. The above equations become

$$T = m_1 a \quad (1)$$

$$T - m_2 g = -m_2 a \quad (2)$$

a. Substituting Equation (1) into Equation (2) and solving for a yields

$$a = \frac{m_2 g}{m_1 + m_2} = \boxed{2.99 \text{ m/s}^2}$$

b. Using this value in Equation (1) gives

$$T = m_1 a = \boxed{129 \text{ N}}$$

