42. The vertical component (positive upward) of Newton's second law (with just the given forces acting) gives $a_y = F_{net,y}/m = (1.50\ mg - mg)/m = 0.5g = 4.9\ m/s^2$.

45. **INTERPRET** This problem deals with interaction between different pairs of objects. The key concepts involved here are Newton's second and third laws.

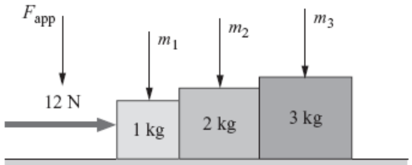
DEVELOP Let the three masses be denoted, from left to right, as m_1, m_2, and m_3, respectively. We take the right direction to be $+x$. Assume that the table surface is horizontal and frictionless so that the only horizontal forces are the applied force and the contact forces between the blocks. For example, $\vec{F}_{12}$ denotes the force exerted by block 1 on block 2. Since the blocks are in contact, they all have the same acceleration a, to the right. Newton's second law can be applied to each block separately:

$$\vec{F}_{app} + \vec{F}_{21} = m_1\vec{a}$$
$$\vec{F}_{12} + \vec{F}_{32} = m_2\vec{a}$$
$$\vec{F}_{23} = m_3\vec{a}$$

EVALUATE Adding all three equations and using Newton's third law ($\vec{F}_{12} + \vec{F}_{21} = 0$, etc.), one finds

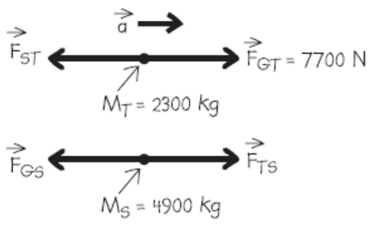
$$\vec{a} = \frac{\vec{F}_{app}}{m_1 + m_2 + m_3} = \frac{12\ \text{N}}{1\,\text{kg} + 2\,\text{kg} + 3\,\text{kg}} = 2\ \text{m/s}^2 \quad \text{(to the right)}$$

Thus, the force block 2 exerts on block 3 is $F_{23} = m_3a = (3\ \text{kg})(2.0\ \text{m/s}^2) = 6.0\ \text{N}$ (to the right).



ASSESS If we draw a free-body diagram for m_3, we will see that F_{23} is the only force acting on it (ignoring friction). Thus, the force that accelerates m_3 comes entirely from F_{23}.

48. **(b)** The horizontal forces acting on the tractor and the sledge are shown in separate diagrams. ($\vec{F}_{ST}$ is the force of the sledge on the tractor, $\vec{F}_{GT}$ is the force of the ground on the tractor, etc.) We assume that the tractor and sledge have the same acceleration, $a = 0.61\ \text{m/s}^2$, collinear to the forces. The horizontal component of Newton's second law (the equation of motion) for the tractor is $F_{GT} - F_{ST} = m_T a$ (positive component in direction of motion). Thus, $F_{ST} = 7700\ \text{N} - (2300\ \text{kg})\ (0.61\ \text{m/s}^2) = 6.30\ \text{kN}$. The direction of $\vec{F}_{ST}$ is opposite to $\vec{a}$. **(a)** From Newton's third law, $\vec{F}_{TS} = -\vec{F}_{ST}$, so $\vec{F}_{TS}$ is 6.30 kN in the direction of $\vec{a}$. **(c)** The horizontal component of the equation of motion of the sledge is $F_{TS} - F_{GS} = m_s a$, so that $F_{GS} = 6.30\ \text{kN} - (4900\ \text{kg})(0.61\ \text{m/s}^2) = 3.31\ \text{kN}$. $\vec{F}_{GS}$, which is a frictional force, is directed opposite to $\vec{a}$.



52. The equations of motion (Newton's second law) for the two crates are the same as those of the masses in the previous problem, namely $F_{app} - F_s = Ma$ (for the larger) and $F_s = ma$ (for the smaller). The magnitude of the compression in the spring is still given by Hooke's law, $F_s = k\,|x|$. Thus, $F_{app} = F_s(1 + M/m) = k\,|x|\,(1 + M/m) = (8.1\ \text{kN/m})(0.051\ \text{m}) \times (1 + 640/490) = 953\ \text{N}$.

62. **INTERPRET** We are asked to find the acceleration of your reference plane (the airplane) if objects falling with gravitational acceleration appear to be accelerating *upward.*

DEVELOP The pretzels are no longer supported by your tray, or anything else, so we must conclude that they are accelerating downward at g. They *appear* to be accelerating upward at $2\ \text{m/s}^2$, so our plane must be accelerating downward even faster than g.

EVALUATE $a = a_{\text{plane}} + a_{\text{apparent}} \to -g = a_{\text{plane}} + a_{\text{apparent}} \to a_{\text{plane}} = -(g + a_{\text{apparent}}) = -11.8\ \text{m/s}^2$

ASSESS This is downward acceleration, and it has a larger magnitude than g. That's what we expected.

Chapter 5

36. The sum of the forces acting on the pack (gravity and the tension along each rope) is zero, since it is at rest, $\vec{F}_g + \vec{T}_1 + \vec{T}_2 = 0$. In a coordinate system with x axis horizontal to the right and y axis vertical upward, the x and y components of the net force are $-T_1 \cos 71° + T_2 \cos 28° = 0$, and $-26 \times 9.8\ \text{N} + T_1 \sin 71° + T_2 \sin 28° = 0$ (see Example 5.2). Solving for T_1 and T_2, one finds $T_1 = (26 \times 9.8\ \text{N})(\sin 71° + \tan 28° \cos 71°) = 228\ \text{N}$ and $T_2 = (26 \times 9.8\ \text{N})/(\sin 28° + \tan 71° \cos 28°) = 84.0\ \text{N}$.

40. **INTERPRET** We find the turning radius for a plane, given a bank angle and a speed. We use centripetal acceleration, which is provided by the horizontal component of the force from the wings.

DEVELOP From Figure 5.32, we see that if the plane is to fly level, the vertical component of F_w must equal the gravitational force. We use this to find F_w. The horizontal component of F_w provides the centripetal force $F_c = m\frac{v^2}{R}$, and we use this to find R. The speed of the plane is $v = 950\frac{\text{km}}{\text{h}} \times \frac{1\ \text{h}}{3600\ \text{s}} \times \frac{1000\ \text{m}}{1\ \text{km}} = 264\ \text{m/s}$.

EVALUATE

$$F_w \cos\theta = mg \to F_w = \frac{mg}{\cos\theta}$$

$$F_w \sin\theta = m\frac{v^2}{R} \to R = \frac{mv^2}{\left(\frac{mg}{\cos\theta}\right)\sin\theta} = \frac{v^2}{g\tan\theta} = 8470\ \text{m}$$

ASSESS This may seem like a rather wide turn—but the speed of the plane is very high and the bank angle is low. These are actually reasonable values for a passenger jet.

70. **INTERPRET** We are shown a pulley system, and are asked to find the mass that can be supported by a maximum tension in the rope. We use Newton's first law.

DEVELOP We start by drawing a free-body diagram showing all the forces on the load of materials, or by looking closely at Figure 5.36. The tension in the rope is the same throughout the rope, so that tension pulls up on the materials *twice*, once on each side of the pulley.

EVALUATE The load can be at most $2 \times (500\ \text{N}) = 1000\ \text{N}$, so the maximum mass is

$$1000\ \text{N} = mg \to m = \frac{1000\ \text{N}}{9.8\ \text{m/s}^2} = 102\ \text{kg}$$

ASSESS The key to this problem—and any pulley problem—is to realize that the tension pulls on both sides of the pulley. In this case, that means that the construction worker lifts 1000 N while pulling up with a force of only 500 N. The trade-off is that he has to pull the rope twice the distance.