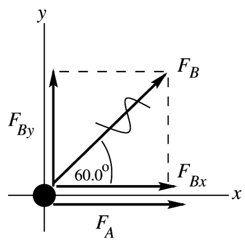
1. **IDENTIFY:** Vector addition.

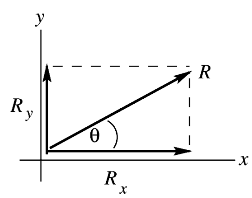
SET UP: Use a coordinate system where the $+x$-axis is in the direction of $\vec{F}_A$, the force applied by dog A. The forces are sketched in Figure.

EXECUTE:



$$F_{Ax} = +270\text{ N},\quad F_{Ay} = 0$$
$$F_{Bx} = F_B\cos 60.0° = (300\text{ N})\cos 60.0° = +150\text{ N}$$
$$F_{By} = F_B\sin 60.0° = (300\text{ N})\sin 60.0° = +260\text{ N}$$

$$\vec{R} = \vec{F}_A + \vec{F}_B$$
$$R_x = F_{Ax} + F_{Bx} = +270\text{ N} + 150\text{ N} = +420\text{ N}$$
$$R_y = F_{Ay} + F_{By} = 0 + 260\text{ N} = +260\text{ N}$$



$$R = \sqrt{R_x^2 + R_y^2}$$
$$R = \sqrt{(420\text{ N})^2 + (260\text{ N})^2} = 494\text{ N}$$
$$\tan\theta = \frac{R_y}{R_x} = 0.619$$
$$\theta = 31.8°$$

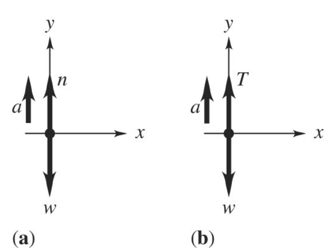
EVALUATE: The forces must be added as vectors. The magnitude of the resultant force is less than the sum of the magnitudes of the two forces and depends on the angle between the two forces.

2. **IDENTIFY:** The elevator and everything in it are accelerating upward, so we apply Newton's second law in the vertical direction.

SET UP: Your mass is $m = w/g = 63.8$ kg. Both you and the package have the same acceleration as the elevator. Take $+y$ to be upward, in the direction of the acceleration of the elevator, and apply $\sum F_y = ma_y$.

EXECUTE: (a) Your free-body diagram is shown in Figure 4.8a, where n is the scale reading. $\sum F_y = ma_y$ gives $n - w = ma$. Solving for n gives $n = w + ma = 625\text{ N} + (63.8\text{ kg})(2.50\text{ m/s}^2) = 784\text{ N}$.

(b) The free-body diagram for the package is given in Figure. $\sum F_y = ma_y$ gives $T - w = ma$, so $T = w + ma = (3.85\text{ kg})(9.80\text{ m/s}^2 + 2.50\text{ m/s}^2) = 47.4\text{ N}$.



EVALUATE: The objects accelerate upward so for each of them the upward force is greater than the downward force.

3. **IDENTIFY:** The system is accelerating so we use Newton's second law.

SET UP: The acceleration of the entire system is due to the 100-N force, but the acceleration of box B is due to the force that box A exerts on it. $\sum F = ma$ applies to the two-box system and to each box individually.

EXECUTE: For the two-box system: $a_x = \dfrac{100\text{ N}}{25\text{ kg}} = 4.0\text{ m/s}^2$. Then for box *B*, where F_A is the force exerted on *B* by *A*, $F_A = m_B a = (5.0\text{ kg})(4.0\text{ m/s}^2) = 20\text{ N}$.

EVALUATE: The force on B is less than the force on A.

4. **IDENTIFY:** Use a constant acceleration equation to find the stopping time and acceleration. Then use $\sum\vec{F} = m\vec{a}$ to calculate the force.

SET UP: Let $+x$ be in the direction the bullet is traveling. $\vec{F}$ is the force the wood exerts on the bullet.

EXECUTE: **(a)** $v_{0x} = 350\text{ m/s}$, $v_x = 0$ and $(x - x_0) = 0.130\text{ m}$. $(x - x_0) = \left(\dfrac{v_{0x} + v_x}{2}\right)t$ gives

$$t = \frac{2(x - x_0)}{v_{0x} + v_x} = \frac{2(0.130\text{ m})}{350\text{ m/s}} = 7.43\times10^{-4}\text{ s}.$$

(b) $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$ gives $a_x = \dfrac{v_x^2 - v_{0x}^2}{2(x - x_0)} = \dfrac{0 - (350\text{ m/s})^2}{2(0.130\text{ m})} = -4.71\times10^5\text{ m/s}^2$

$\sum F_x = ma_x$ gives $-F = ma_x$ and $F = -ma_x = -(1.80\times10^{-3}\text{ kg})(-4.71\times10^5\text{ m/s}^2) = 848\text{ N}$.

EVALUATE: The acceleration and net force are opposite to the direction of motion of the bullet.

5. **IDENTIFY:** Calculate $\vec{a}$ from $\vec{a} = d^2\vec{r}/dt^2$. Then $\vec{F}_{\text{net}} = m\vec{a}$.

SET UP: $w = mg$

EXECUTE: Differentiating twice, the acceleration of the helicopter as a function of time is $\vec{a} = (0.120\text{ m/s}^3)t\hat{i} - (0.12\text{ m/s}^2)\hat{k}$ and at $t = 5.0\text{s}$, the acceleration is $\vec{a} = (0.60\text{ m/s}^2)\hat{i} - (0.12\text{ m/s}^2)\hat{k}$. The force is then

$$\vec{F} = m\vec{a} = \frac{w}{g}\vec{a} = \frac{(2.75\times10^5\text{ N})}{(9.80\text{ m/s}^2)}\left[(0.60\text{ m/s}^2)\hat{i} - (0.12\text{ m/s}^2)\hat{k}\right] = (1.7\times10^4\text{ N})\hat{i} - (3.4\times10^3\text{ N})\hat{k}$$

EVALUATE: The force and acceleration are in the same direction. They are both time dependent.

6. **IDENTIFY:** $x = \int_0^t v_x dt$ and $v_x = \int_0^t a_x dt$, and similar equations apply to the *y*-component.

SET UP: In this situation, the *x*-component of force depends explicitly on the *y*-component of position. As the *y*-component of force is given as an explicit function of time, v_y and *y* can be found as functions of time and used in the expression for $a_x(t)$.

EXECUTE: $a_y = (k_3/m)t$, so $v_y = (k_3/2m)t^2$ and $y = (k_3/6m)t^3$, where the initial conditions $v_{0y} = 0, y_0 = 0$ have been used. Then, the expressions for a_x, v_x and *x* are obtained as functions of time:

$$a_x = \frac{k_1}{m} + \frac{k_2k_3}{6m^2}t^3,\quad v_x = \frac{k_1}{m}t + \frac{k_2k_3}{24m^2}t^4 \text{ and } x = \frac{k_1}{2m}t^2 + \frac{k_2k_3}{120m^2}t^5.$$

In vector form, $\vec{r} = \left(\dfrac{k_1}{2m}t^2 + \dfrac{k_2k_3}{120m^2}t^5\right)\hat{i} + \left(\dfrac{k_3}{6m}t^3\right)\hat{j}$ and $\vec{v} = \left(\dfrac{k_1}{m}t + \dfrac{k_2k_3}{24m^2}t^4\right)\hat{i} + \left(\dfrac{k_3}{2m}t^2\right)\hat{j}$.

EVALUATE: a_x depends on time because it depends on *y*, and *y* is a function of time.

7. **IDENTIFY:** Apply $\Sigma\vec{F} = m\vec{a}$ to each block. Each block has the same magnitude of acceleration a.

SET UP: Assume the pulley is to the right of the 4.00 kg block. There is no friction force on the 4.00 kg block; the only force on it is the tension in the rope. The 4.00 kg block therefore accelerates to the right and the suspended block accelerates downward. Let $+x$ be to the right for the 4.00 kg block, so for it $a_x = a$, and let $+y$ be downward for the suspended block, so for it $a_y = a$.

EXECUTE: **(a)** The free-body diagrams for each block are given in below Figures.

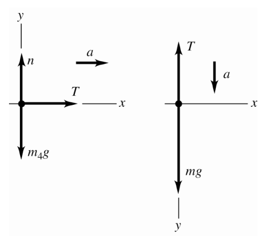
(b) $\Sigma F_x = ma_x$ applied to the 4.00 kg block gives $T = (4.00\text{ kg})a$ and $a = \dfrac{T}{4.00\text{ kg}} = \dfrac{10.0\text{ N}}{4.00\text{ kg}} = 2.50\text{ m/s}^2$.

(c) $\Sigma F_y = ma_y$ applied to the suspended block gives $mg - T = ma$ and

$$m = \frac{T}{g-a} = \frac{10.0\text{ N}}{9.80\text{ m/s}^2 - 2.50\text{ m/s}^2} = 1.37\text{ kg}.$$

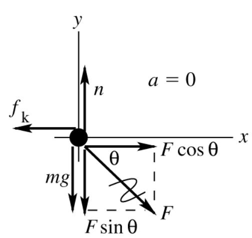
(d) The weight of the hanging block is $mg = (1.37\text{ kg})(9.80\text{ m/s}^2) = 13.4\text{ N}$. This is greater than the tension in the rope; $T = 0.75mg$.

EVALUATE: Since the hanging block accelerates downward, the net force on this block must be downward and the weight of the hanging block must be greater than the tension in the rope. Note that the blocks accelerate no matter how small m is. It is not necessary to have $m > 4.00\text{ kg}$, and in fact in this problem m is less than 4.00 kg.



8. (a) **IDENTIFY:** Apply $\Sigma\vec{F} = m\vec{a}$ to the crate. Constant v implies $a = 0$. Crate moving says that the friction is kinetic friction. The target variable is the magnitude of the force applied by the woman.

SET UP: The free-body diagram for the crate is sketched in Figure.



$$\Sigma F_y = ma_y$$
$$n - mg - F\sin\theta = 0$$
$$n = mg + F\sin\theta$$
$$f_k = \mu_k n = \mu_k mg + \mu_k F\sin\theta$$

$$\Sigma F_x = ma_x$$
$$F\cos\theta - f_k = 0$$
$$F\cos\theta - \mu_k mg - \mu_k F\sin\theta = 0$$
$$F(\cos\theta - \mu_k\sin\theta) = \mu_k mg$$
$$F = \frac{\mu_k mg}{\cos\theta - \mu_k\sin\theta}$$

(b) **IDENTIFY** and **SET UP:** "start the crate moving" means the same force diagram as in part (a), except that μ_k is replaced by μ_s. Thus $F = \dfrac{\mu_s mg}{\cos\theta - \mu_s\sin\theta}$.

EXECUTE: $F \to \infty$ if $\cos\theta - \mu_s\sin\theta = 0$. This gives $\mu_s = \dfrac{\cos\theta}{\sin\theta} = \dfrac{1}{\tan\theta}$. **EVALUATE:** $\vec{F}$ has a downward component so $n > mg$. If $\theta = 0$ (woman pushes horizontally), $n = mg$ and $F = f_k = \mu_k mg$.

9. **IDENTIFY:** $a_{rad} = v^2/R$, directed toward the center of the circular path. At the bottom of the dive, $\vec{a}_{rad}$ is upward. The apparent weight of the pilot is the normal force exerted on her by the seat on which she is sitting.

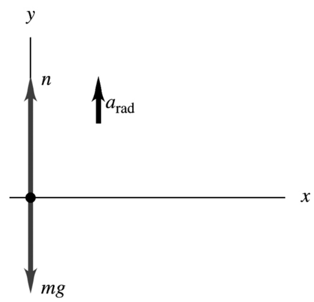
SET UP: The free-body diagram for the pilot is given in Figure 5.52.

EXECUTE: (a) $a_{rad} = \dfrac{v^2}{R}$ gives $R = \dfrac{v^2}{a_{rad}} = \dfrac{(95.0\ \text{m/s})^2}{4.00(9.80\ \text{m/s}^2)} = 230\ \text{m}$.

(b) $\Sigma F_y = ma_y$ gives $n - mg = ma_{rad}$.

$n = m(g + a_{rad}) = m(g + 4.00g) = 5.00mg = (5.00)(50.0\ \text{kg})(9.80\ \text{m/s}^2) = 2450\ \text{N}$

EVALUATE: Her apparent weight is five times her true weight, the force of gravity the earth exerts on her.



10. **IDENTIFY:** The ball has acceleration $a_{rad} = v^2/R$, directed toward the center of the circular path. When the ball is at the bottom of the swing, its acceleration is upward.

SET UP: Take $+y$ upward, in the direction of the acceleration. The bowling ball has mass $m = w/g = 7.27\ \text{kg}$.

EXECUTE: (a) $a_{rad} = \dfrac{v^2}{R} = \dfrac{(4.20\ \text{m/s})^2}{3.80\ \text{m}} = 4.64\ \text{m/s}$, upward.

(b) The free-body diagram is given in Figure 5.54. $\Sigma F_y = ma_y$ gives $T - mg = ma_{rad}$.

$T = m(g + a_{rad}) = (7.27\ \text{kg})(9.80\ \text{m/s}^2 + 4.64\ \text{m/s}^2) = 105\ \text{N}$

EVALUATE: The acceleration is upward, so the net force is upward and the tension is greater than the weight.