Section 2.2: Newton's Laws of Motion
Tutorial 1 Practice, pages 72–73

1. (a) Given: $m = 1.2 \times 10^2$ kg; $\vec{F}_1 = 1.5 \times 10^2$ N [N]; $\vec{F}_2 = 2.2 \times 10^2$ N [W]

Required: $\vec{a}$

Analysis: $\left|\Sigma\vec{F}\right| = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$; $\theta = \tan^{-1}\left(\dfrac{\Sigma F_y}{\Sigma F_x}\right)$; $\Sigma\vec{F} = m\vec{a}$. Choose east and north as positive.

Solution: For the x-components of the force:

$$\begin{aligned}\Sigma\vec{F}_x &= \vec{F}_{1x} + \vec{F}_{2x}\\ &= (0\text{ N}) + (-220\text{ N})\\ \Sigma\vec{F}_x &= -220\text{ N}\end{aligned}$$

For the y-components of the force:

$$\begin{aligned}\Sigma\vec{F}_y &= \vec{F}_{1y} + \vec{F}_{2y}\\ &= (150\text{ N}) + (0\text{ N})\\ \Sigma\vec{F}_y &= 150\text{ N}\end{aligned}$$

Construct $\Sigma\vec{F}$:

$$\begin{aligned}\left|\Sigma\vec{F}\right| &= \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}\\ &= \sqrt{(220\text{ N})^2 + (150\text{ N})^2}\\ \left|\Sigma\vec{F}\right| &= 266.3\text{ N (two extra digits carried)}\end{aligned}$$

$$\begin{aligned}\theta &= \tan^{-1}\left(\frac{\Sigma\vec{F}_y}{\Sigma\vec{F}_x}\right)\\ &= \tan^{-1}\left(\frac{150\ \cancel{\text{N}}}{220\ \cancel{\text{N}}}\right)\\ \theta &= 34^\circ\end{aligned}$$

Calculate $\vec{a}$:

$$\begin{aligned}\Sigma\vec{F} &= m\vec{a}\\ \vec{a} &= \frac{\Sigma\vec{F}}{m}\\ &= \frac{266.3\text{ N [W } 34^\circ\text{ N]}}{120\text{ kg}}\\ \vec{a} &= 2.2\text{ m/s}^2\text{ [W } 34^\circ\text{ N]}\end{aligned}$$

Statement: The acceleration of the mass is 2.2 m/s^2 [W 34° N] or 2.2 m/s^2 [N 56° W].

(b) Given: $m = 26$ kg; $\vec{F}_1 = 38$ N [N 24° E]; $\vec{F}_2 = 52$ N [N 36° E]

Required: $\vec{a}$

Analysis: $\left|\Sigma\vec{F}\right| = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$; $\theta = \tan^{-1}\left(\dfrac{\Sigma F_y}{\Sigma F_x}\right)$; $\Sigma\vec{F} = m\vec{a}$. Choose east and north as positive.

Solution: For the x-components of the force:

$$\begin{aligned}
\Sigma\vec{F}_x &= \vec{F}_{1x} + \vec{F}_{2x} \\
&= (38\ N)\sin 24° + (52\ \text{N})\sin 36° \\
&= 15.46\ \text{N} + 30.57\ \text{N} \\
\Sigma\vec{F}_x &= 46.03\ \text{N (two extra digits carried)}
\end{aligned}$$

For the y-components of the force:

$$\begin{aligned}
\Sigma\vec{F}_y &= \vec{F}_{1y} + \vec{F}_{2y} \\
&= (38\ \text{N})\cos 24° + (52\ \text{N})\cos 36° \\
&= 34.72\ \text{N} + 42.07 \\
\Sigma\vec{F}_y &= 76.79\ \text{N (two extra digits carried)}
\end{aligned}$$

Construct $\Sigma\vec{F}$:

$$\begin{aligned}
\left|\Sigma\vec{F}\right| &= \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} \\
&= \sqrt{(46.03\ \text{N})^2 + (76.79\ \text{N})^2} \\
\left|\Sigma\vec{F}\right| &= 89.53\ \text{N (two extra digits carried)}
\end{aligned}$$

$$\begin{aligned}
\theta &= \tan^{-1}\left(\frac{\Sigma\vec{F}_y}{\Sigma\vec{F}_x}\right) \\
&= \tan^{-1}\left(\frac{76.79\ \cancel{\text{N}}}{46.03\ \cancel{\text{N}}}\right) \\
\theta &= 59°
\end{aligned}$$

Calculate $\vec{a}$:

$$\begin{aligned}
\Sigma\vec{F} &= m\vec{a} \\
\vec{a} &= \frac{\Sigma\vec{F}}{m} \\
&= \frac{89.53\ \text{N [E 59° N]}}{26\ \text{kg}} \\
\vec{a} &= 3.4\ \text{m/s}^2\ \text{[E 59° N]}
\end{aligned}$$

Statement: The acceleration of the mass is 3.4 m/s^2 [E 59° N] or 3.4 m/s^2 [N 31° E].

2. Given: $m = 65\ \text{kg}$; $\vec{F}_1 = 2.2\times10^2\ \text{N [E 42° N]}$; $\vec{F}_\text{f} = 1.9\times10^2\ \text{N [W]}$; $\vec{a} = 2.0\ \text{m/s}^2\ \text{[E]}$

Required: $\vec{F}_2$

Analysis: $\Sigma\vec{F} = m\vec{a}$; $\Sigma\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_\text{f}$. Choose east and north as positive.

Solution:

Calculate the net force $\Sigma\vec{F}$:

$$\begin{aligned}\Sigma\vec{F} &= m\vec{a}\\ &= (65\ \text{kg})(2.0\ \text{m/s}^2)\\ \Sigma\vec{F} &= 130\ \text{N [E]}\end{aligned}$$

Find $\vec{F}_2$ in terms of the other forces:

$$\begin{aligned}\Sigma\vec{F} &= \vec{F}_1 + \vec{F}_2 + \vec{F}_\text{f}\\ \vec{F}_2 &= \Sigma\vec{F} - \vec{F}_1 - \vec{F}_\text{f}\end{aligned}$$

Calculate the components of $\vec{F}_2$.

For the x-components of the force:

$$\begin{aligned}\vec{F}_{2x} &= \Sigma\vec{F}_x - \vec{F}_{1x} - \vec{F}_{\text{f}x}\\ &= (130\text{N}) - (220\ \text{N})\cos 42° - (-190\ \text{N})\\ &= 130\ \text{N} - 163.5\ \text{N} + 190\ \text{N}\\ \vec{F}_{2x} &= 156.5\ \text{N (two extra digits carried)}\end{aligned}$$

For the y-components of the force:

$$\begin{aligned}\vec{F}_{2y} &= \Sigma\vec{F}_y - \vec{F}_{1y} - \vec{F}_{\text{f}y}\\ &= (0\text{N})\ - (-220\ \text{N})\sin 42° - (0\ \text{N})\\ \vec{F}_{2y} &= 147.2\ \text{N (two extra digits carried)}\end{aligned}$$

Construct $\vec{F}_2$:

$$\begin{aligned}\left|\vec{F}_2\right| &= \sqrt{(F_{2x})^2 + (F_{2y})^2}\\ &= \sqrt{(156.5\ \text{N})^2 + (147.2\ \text{N})^2}\\ &= 214.9\ \text{N}\\ \left|\vec{F}_2\right| &= 2.1\times10^2\ \text{N}\end{aligned}$$

$$\begin{aligned}\theta &= \tan^{-1}\left(\frac{\vec{F}_{2y}}{\vec{F}_{2x}}\right)\\ &= \tan^{-1}\left(\frac{147.2\ \cancel{\text{N}}}{156.5\ \cancel{\text{N}}}\right)\\ \theta &= 43°\end{aligned}$$

Statement: The second student applies a force of 2.1 × 10^2 N [E 43° N] to the trunk.

3. Given: $m = 1.5 \times 10^2$ kg; $\vec{F}_g = 1.47 \times 10^3$ n [down]; $\vec{F}_1 = 1.8 \times 10^3$ N [up 30.0° left];

$\vec{F}_2 = 1.8 \times 10^3$ N [up 30.0° right]

Required: $\vec{a}$

Analysis: $\Sigma\vec{F} = m\vec{a}$. Choose right and up as positive.

Solution: For the x-components of the force:

$$\begin{aligned}\Sigma\vec{F}_x &= \vec{F}_{gx} + \vec{F}_{1x} + \vec{F}_{2x} \\ &= (0\text{ N}) + (-1800\text{ N})\sin 30.0° + (1800\text{ N})\sin 30.0° \\ \Sigma\vec{F}_x &= 0\text{ N}\end{aligned}$$

For the y-components of the force:

$$\begin{aligned}\Sigma\vec{F}_y &= \vec{F}_{gy} + \vec{F}_{1y} + \vec{F}_{2y} \\ &= (-1470\text{ N}) + (1800\text{ N})\cos 30.0° + (1800\text{ N})\cos 30.0° \\ \Sigma\vec{F}_y &= 1648\text{ N (two extra digits carried)}\end{aligned}$$

Since the x-component of $\Sigma\vec{F}$ is zero, $\Sigma\vec{F} = 1648$ N [up].

Calculate $\vec{a}$:

$$\begin{aligned}\Sigma\vec{F} &= m\vec{a} \\ \vec{a} &= \frac{\Sigma\vec{F}}{m} \\ &= \frac{1648\text{ N [up]}}{150\text{ kg}} \\ \vec{a} &= 11\text{ m/s}^2\text{ [up]}\end{aligned}$$

Statement: The acceleration of the beam is 11 m/s^2 [up].

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1. Answers may vary. Sample answers:

(a) The rocket engine pushes down on the burning fuel ($\vec{F}_{\text{R on F}}$) while the burning fuel pushes up on the rocket ($\vec{F}_{\text{F on R}}$).

(b) The plane pushes back on the air passing through the jets ($\vec{F}_{\text{P on A}}$) while the air passing through the jets pushes the plane forward ($\vec{F}_{\text{A on P}}$).

(c) The runner pushes down on the ground ($\vec{F}_{\text{R on G}}$) while the ground pushes up on the runner's foot ($\vec{F}_{\text{G on R}}$). This last force takes the form of the normal force of the ground on the runner.

2. Given: $m = 56$ kg; $\Delta t_1 = 0.75$ s; $v_i = 0$ m/s; $\vec{v}_f = 75$ cm/s [W] $= 0.75$ m/s [W]

Required: $\vec{a}$

Analysis: $\vec{a} = \dfrac{\Delta\vec{v}}{\Delta t}$. Choose east as positive.

Solution: $\vec{a} = \dfrac{\Delta v}{\Delta t}$

$$= \frac{(-0.75 \text{ m/s}) - (0 \text{ m/s})}{0.75 \text{ s}}$$

$$= -1.0 \text{ m/s}^2$$

$$\vec{a} = 1.0 \text{ m/s}^2 \text{ [W]}$$

Statement: The magnitude of the (constant) acceleration is 1.0 m/s^2 [W].

(b) Given: $m = 56$ kg**;** $\vec{a} = 1.0 \text{ m/s}^2$ [W]

Required: $\vec{F}_{\text{S on W}}$

Analysis: $\vec{F}_{\text{S on W}} = m\vec{a}$

Solution: Force of the swimmer on the wall:

$$\vec{F}_{\text{S on W}} = m\vec{a}$$

$$= (56 \text{ kg})(1.0 \text{ m/s}^2)$$

$$\vec{F}_{\text{S on W}} = 56 \text{ N [E]}$$

Statement: The force exerted by the swimmer on the wall is 56 N [E].

(c) Given: $\vec{F}_{\text{S on W}} = 56$ N [E]

Required: $\vec{F}_{\text{W on S}}$

Analysis: $\vec{F}_{\text{W on S}} = m\vec{a}$. The force of the swimmer on the wall, $\vec{F}_{\text{S on W}}$**,** is the action–reaction partner to the force of the wall on the swimmer, $\vec{F}_{\text{W on S}}$. It is the force of the wall on the swimmer that causes the swimmer's acceleration.

Solution: The force of the wall on the swimmer:

$$\vec{F}_{\text{W on S}} = -\vec{F}_{\text{S on W}}$$

$$= -56 \text{ N [E]}$$

$$\vec{F}_{\text{W on S}} = 56 \text{ N [W]}$$

Statement: The force exerted by the wall on the swimmer is 56 N [W].

(d) Given: $\vec{a} = 1.0 \text{ m/s}^2$ [W]; $\Delta t_2 = 1.50 \text{ s} - 0.75 \text{ s} = 0.75 \text{ s}$

Required: $\Delta\vec{d} = \Delta\vec{d}_1 + \Delta\vec{d}_2$

Analysis: $\Delta d_1 = v_{\text{i}}\Delta t + \dfrac{1}{2}a(\Delta t)^2$; $\Delta d_2 = v_{\text{f}}\Delta t_2$.

Solution: The first distance covered is Δd_1:

$$\Delta d_1 = v_{\text{i}}\Delta t + \frac{1}{2}\overset{\text{r}}{a}(\Delta t)^2$$

$$\Delta d_1 = (0 \text{ m/s})(0.75 \text{ s}) + \frac{1}{2}(1.0 \text{ m/s}^2)(0.75 \text{ s})^2$$

$$\Delta d_1 = 0.2813 \text{ m (two extra digits carried)}$$

The second distance covered is Δd_2:

$$\Delta d_2 = v_\text{f}\Delta t_2$$
$$= (0.75 \text{ m/s})(0.75 \text{ s})$$
$$\Delta d_2 = 0.5625 \text{ m (two extra digits carried)}$$

The total distance covered is:

$$\Delta\vec{d} = \Delta\vec{d}_1 + \Delta\vec{d}_2$$
$$= 0.2813 \text{ m} + 0.5625 \text{ m}$$
$$\Delta\vec{d} = 0.84 \text{ m}$$

Statement: Both parts of the swimmer's motion were away from the wall. The total displacement is 84 cm [W].

3. (a) Given: $m_\text{boy} = 32.5 \text{ kg}$; $m_\text{mattress} = 2.50 \text{ kg}$; $\Sigma\vec{F}_\text{boy} = 0 \text{ N}$; $\Sigma\vec{F}_\text{mattress} = 0 \text{ N}$

Required: $\vec{F}_\text{W on M}$

Analysis: $\vec{F}_\text{B on M} + \vec{F}_\text{W on M} + \vec{F}_g = 0 \text{ N}$

Solution: Equation for upward force of the water on the mattress:

$$\vec{F}_\text{B on M} + \vec{F}_\text{W on M} + \vec{F}_g = 0 \text{ N}$$
$$-\left|\vec{F}_\text{B on M}\right| + \left|\vec{F}_\text{W on M}\right| - \left|\vec{F}_g\right| = 0 \text{ N}$$
$$\left|\vec{F}_\text{W on M}\right| = \left|\vec{F}_\text{B on M}\right| + \left|\vec{F}_g\right|$$
$$= (32.5 \text{ kg})(9.8 \text{ m/s}^2) + (2.50 \text{ kg})(9.8 \text{ m/s}^2)$$
$$= 318.5 \text{ N} + 24.5 \text{ N}$$
$$\left|\vec{F}_\text{W on M}\right| = 3.4 \times 10^2 \text{ N}$$

Statement: The upward force of the water on the mattress is 3.4×10^2 N.

(b) Given: $m_\text{boy} = 32.5 \text{ kg}$; $m_\text{mattress} = 2.50 \text{ kg}$; $\Sigma\vec{F}_\text{boy} = 0 \text{ N}$; $\Sigma\vec{F}_\text{mattress} = 0 \text{ N}$

Required: $\vec{F}_\text{B on M}$

Analysis: $\vec{F}_\text{B on M} = -\vec{F}_\text{M on B}$. Choose up as positive.

Solution:

Since $\vec{F}_\text{B on M} = -\vec{F}_\text{M on B}$; solve by determining the upward force of the mattress on the boy, $\vec{F}_\text{M on B}$.

$$\vec{F}_\text{M on B} + \vec{F}_\text{g} = 0 \text{ N}$$
$$\left|\vec{F}_\text{M on B}\right| = \left|\vec{F}_\text{g}\right|$$
$$= (32.5 \text{ kg})(9.8 \text{ m/s}^2)$$
$$= 318.5 \text{ N (two extra digits carried)}$$
$$\left|\vec{F}_\text{M on B}\right| = 3.2 \times 10^2 \text{ N}$$

Statement: The force that the boy exerts on the mattress, $\vec{F}_\text{B on M}$, is 3.2×10^2 N.

(c) Since $\vec{F}_\text{B on M} = -\vec{F}_\text{M on B}$, the upward force of the mattress on the boy is 3.2×10^2 N.

4. Given: $m_\text{P} = 0.20\text{ kg}$; $\vec{a}_\text{P} = 25\text{ m/s}^2\text{ [forward]}$; $\vec{a}_\text{L} = 0.25\text{ m/s}^2\text{ [backward]}$

Required: m_L

Analysis: $\vec{F}_\text{P on L} = -\vec{F}_\text{L on P}$. Choose forward as positive.

Solution: $\vec{F}_\text{P on L} = -\vec{F}_\text{L on P}$

$$m_\text{L}\vec{a}_\text{L} = -m_\text{P}\vec{a}_\text{P}$$

$$m_\text{L} = \frac{-m_\text{P}\vec{a}_\text{P}}{\vec{a}_\text{L}}$$

$$m_\text{L} = \frac{-(0.20\text{ kg})(25\ \cancel{\text{m/s}^2})}{-0.25\ \cancel{\text{m/s}^2}}$$

$$m_\text{L} = 20\text{ kg}$$

Statement: The mass of the launcher is 20 kg.

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1. According to Newton's first law of motion, when the snowboarder suddenly encounters the rough patch on the hill, her body will continue in a forward motion, but her snowboard may stick instead of slide.

2. As you are sitting in the bus tossing the ball vertically, both you and the ball are acted upon by the forward motion of the bus. By Newton's first law of motion, both you and the ball continue in a forward direction. From your point of view, the ball remains directly in front of you and will not hit you in the face unless a horizontal force is exerted.

3. (a) Given: $v_\text{i} = 4.2\text{ m/s [E]}$; $v_\text{f} = 0\text{ m/s}$; $m = 41\text{ kg}$; $\vec{F}_\text{f} = 25\text{ N [W]}$

Required: $\vec{a}$

Analysis: $\Sigma\vec{F} = m\vec{a}$

Solution: $\Sigma\vec{F} = m\vec{a}$

$$\vec{a} = \frac{\Sigma\vec{F}}{m}$$

$$\vec{a} = \frac{25\text{ N [W]}}{41\text{ kg}}$$

$$= 0.6098\text{ m/s}^2\text{ [W] (two extra digits carried)}$$

$$\vec{a} = 0.61\text{ m/s}^2\text{ [W]}$$

Statement: The child's acceleration across the ice is 0.61 m/s^2 [W].

(b) Given: $v_\text{i} = 4.2\text{ m/s [E]}$; $\vec{a} = 0.61\text{ m/s}^2\text{ [W]}$

Required: Δt

Analysis: $\vec{a} = \dfrac{\Delta\vec{v}}{\Delta t}$. Choose east as positive.

Solution: $a = \frac{\Delta v}{\Delta t}$

$$\Delta t = \frac{\Delta v}{a}$$

$$= \frac{0 \text{ m/s} - 4.2 \ \cancel{\text{m}}\text{/s}}{-0.6098 \ \cancel{\text{m}}\text{/s}^{\cancel{2}}}$$

$$\Delta t = 6.9 \text{ s}$$

Statement: It will take the child 6.9 s to stop.

4. Given: $|\vec{a}| = a = 12 \text{ m/s}^2$; $|\vec{F}| = F = 2.2 \times 10^2 \text{ N}$

Required: m

Analysis: $\vec{F} = m\vec{a}$

Solution: $\vec{F} = m\vec{a}$

$$m = \frac{\vec{F}}{\vec{a}}$$

$$= \frac{2.2 \times 10^2 \text{ N}}{12 \text{ m/s}^2}$$

$$m = 18 \text{ kg}$$

Statement: The mass of the object is 18 kg.

5. (a) Given: $v_\text{i} = 0 \text{ m/s}$; $v_\text{f} = 2.5 \text{ m/s [forward]}$; $\Delta t_1 = 1.0 \text{ min} = 60 \text{ s}$; $m = 1.2 \times 10^3 \text{ kg}$

Required: $\vec{F}_\text{N}$

Analysis: $\vec{F} = m\vec{a}$. Choose forward as positive.

Solution: $\vec{a} = \frac{\Delta v}{\Delta t}$

$$= \frac{2.5 \text{ m/s} - 0 \text{ m/s}}{60 \text{ s}}$$

$$\vec{a} = 0.0417 \text{ m/s}^2 \text{ (two extra digits carried)}$$

$$\vec{F}_\text{N} = m\vec{a}$$

$$= (1.2 \times 10^3 \text{ kg})(0.0417 \text{ m/s})$$

$$\vec{F}_\text{N} = 50 \text{ N}$$

Statement: The normal force between the two bumpers is 50 N.

(b) Given: $v_2 = v_\text{f} = 2.5 \text{ m/s}$; $\Delta d = 2.0 \text{ km} = 2000 \text{ m}$

Required: $\Delta t = \Delta t_1 + \Delta t_2$

Analysis: $\Delta d = \Delta d_1 + \Delta d_2$

Solution: $\Delta d_1 = \left(\dfrac{v_\text{i} + v_\text{f}}{2}\right)\Delta t$

$$= \left(\frac{0\text{ m/s} + 2.5\text{ m/s}}{2}\right)(60\text{ s})$$

$$= \frac{(2.5\text{ m/}\cancel{\text{s}})}{2}(60\cancel{\text{s}})$$

$$\Delta d_1 = 75\text{ m}$$

$$\Delta d = \Delta d_1 + \Delta d_2$$
$$\Delta d_2 = \Delta d - \Delta d_1$$
$$= 2000\text{ m} - 75\text{ m}$$
$$\Delta d_2 = 1925\text{ m}$$

The second time interval is:

$$v_2 = \frac{\Delta d_2}{\Delta t_2}$$

$$\Delta t_2 = \frac{\Delta d_2}{v_2}$$

$$= \frac{1925\ \cancel{\text{m}}}{2.5\ \cancel{\text{m}}\text{/s}}$$

$$= 770\text{ s}$$

$$\Delta t_2 = 7.7 \times 10^2\text{ s}$$

Statement: It takes 7.7×10^2 s to reach the repair shop.

6. Given: $m = 250$ kg; $\vec{F}_1 = 150$ N [E]; $\vec{F}_2 = 350$ N [S 45° W]

Required: $\vec{a}$

Analysis: $\Sigma\vec{F} = m\vec{a}$. Choose east and north as positive.

Solution: For the x-components of the force:

$$\Sigma\vec{F}_x = \vec{F}_{1x} + \vec{F}_{2x}$$
$$= (150\text{ N}) + (-350\text{ N})\sin 45°$$
$$= 150\text{ N} - 247.49\text{ N}$$
$$\Sigma\vec{F}_x = -97.49\text{ N (one extra digit carried)}$$

For the y-components of the force:

$$\Sigma\vec{F}_y = \vec{F}_{1y} + \vec{F}_{2y}$$
$$= (0\text{ N}) + (-350\text{ N})\cos 45°$$
$$\Sigma\vec{F}_y = -247.49\text{ N (two extra digits carried)}$$

Construct $\Sigma\vec{F}$:

$$\left|\Sigma\vec{F}\right| = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$$
$$= \sqrt{(97.49\text{ N})^2 + (247.49\text{ N})^2}$$
$$\left|\Sigma\vec{F}\right| = 266\text{ N}$$

$$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$
$$= \tan^{-1}\left(\frac{247.49\ \cancel{\text{N}}}{97.49\ \cancel{\text{N}}}\right)$$
$$\theta = 68°$$

Calculate $\vec{a}$:

$$\Sigma\vec{F} = m\vec{a}$$
$$\vec{a} = \frac{\Sigma\vec{F}}{m}$$
$$= \frac{266\text{ N [W 68° S]}}{250\text{ kg}}$$
$$\vec{a} = 1.1\text{ m/s}^2\text{ [W 68° S]}$$

Statement: The acceleration of the mass is 1.1 m/s^2 [W 68° S] or 1.1 m/s^2 [S 22° W].

7. Answers may vary. Sample answers:

(a) When a tennis racquet hits a tennis ball, exerting a force on the ball, the tennis racquet pushes forward on the tennis ball and the tennis ball pushes back on the racquet.

(b) When a car is moving at high speed and runs into a tree, exerting a force on the tree, the car pushes forward on the tree and the tree pushes back on the car.

(c) When two cars are moving in opposite directions and collide head-on, the first car pushes the second car in the direction of the first car's initial velocity. The second car pushes the first car in the opposite direction.

(d) When a person leans on a wall, exerting a force on the wall, the person pushes forward on the wall and the wall pushes back on the person.

(e) When a mass hangs by a string attached to the ceiling, and the string exerts a force on the mass, the mass pulls down on the string and the string pulls up on the mass.

(f) When a bird sits on a telephone pole, exerting a force on the pole, the bird pushes down on the telephone pole and the telephone pole pushes up on the bird.

8. Given: $m_1 = m_2 = 5.2$ kg

Required: $\vec{F}_1$; $\vec{F}_2$

Analysis: $\Sigma\vec{F} = 0$ N. Choose right and up as positive.

Solution: $\Sigma\vec{F} = 0\text{ N}$

$$\vec{F}_1 - m_1 g = 0\text{ N}$$
$$\vec{F}_1 = (5.2\text{ kg})(9.8\text{ m/s}^2)$$
$$\vec{F}_1 = 51\text{ N}$$

Equation for second mass:

$$\Sigma\vec{F} = 0\text{ N}$$
$$\vec{F}_2 - m_2 g = 0\text{ N}$$
$$\vec{F}_2 = (5.2\text{ kg})(9.8\text{ m/s}^2)$$
$$\vec{F}_2 = 51\text{ N}$$

Statement: The tension is each string is 51 N.

(b) The spring scale reads 51 N, the string tension on the left side that is pulling the hook.

(c) The answers would remain the same if you removed one mass and held everything in place. A weight of 51 N would be exerted on the remaining mass, balanced by a string tension of 51 N. The spring scale is at rest so the other string also would also have a tension of 51 N. You have to pull down with a force of 51 N, effectively replacing the weight of the mass you removed.

9. Given: $m = 62\text{ kg}$; $\vec{F}_{\text{ground}} = 1.1\times10^3\text{ N}$ [backward 55° up]

Required: $\vec{a}$

Analysis: $\Sigma\vec{F} = m\vec{a}$. Choose forward and up as positive.

Solution:

For the x-components of the force:

$$\begin{aligned}\Sigma\vec{F}_x &= \vec{F}_{\text{earth}\,x} + \vec{F}_{gx}\\ &= (-1100\text{ N})\cos 55° + (0\text{ N})\\ &= 150\text{ N} - 247.49\text{ N}\\ \Sigma\vec{F}_x &= -630.9\text{ N (two extra digits carried)}\end{aligned}$$

For the y-components of the force:

$$\begin{aligned}\Sigma\vec{F}_y &= \vec{F}_{\text{ground}\,y} + \vec{F}_{gy}\\ &= (1100)\sin 55° - (62\text{ kg})(9.8\text{ m/s}^2)\\ &= 901.1\text{ N} - 607.6\text{ N}\\ \Sigma\vec{F}_y &= 293.5\text{ N (two extra digits carried)}\end{aligned}$$

$$\begin{aligned}\left|\Sigma\vec{F}\right| &= \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}\\ &= \sqrt{(630.9\text{ N})^2 + (293.5\text{ N})^2}\\ \left|\Sigma\vec{F}\right| &= 695.8\text{ N (two extra digits carried)}\end{aligned}$$

$$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$

$$= \tan^{-1}\left(\frac{293.5\ \cancel{\text{N}}}{630.9\ \cancel{\text{N}}}\right)$$

$$\theta = 25^\circ$$

$$\Sigma\vec{F} = m\vec{a}$$

$$\vec{a} = \frac{\Sigma\vec{F}}{m}$$

$$= \frac{695.8\text{ N [backward }25^\circ\text{ up]}}{62\text{ kg}}$$

$$\vec{a} = 11\text{ m/s}^2\text{ [backward }25^\circ\text{ up]}$$

Statement: The acceleration of the athlete is 11 m/s^2 [backward 25° up].