8. Our coordinate system has $\hat{\text{i}}$ pointed east and $\hat{\text{j}}$ pointed north. The first displacement is $\vec{r}_{AB} = (483\text{ km})\hat{\text{i}}$ and the second is $\vec{r}_{BC} = (-966\text{ km})\hat{\text{j}}$.

(a) The net displacement is

$$\vec{r}_{AC} = \vec{r}_{AB} + \vec{r}_{BC} = (483\text{ km})\hat{\text{i}} - (966\text{ km})\hat{\text{j}}$$

which yields $|\vec{r}_{AC}| = \sqrt{(483\text{ km})^2 + (-966\text{ km})^2} = 1.08\times10^3\text{ km}$.

(b) The angle is given by

$$\theta = \tan^{-1}\left(\frac{-966\text{ km}}{483\text{ km}}\right) = -63.4°.$$

We observe that the angle can be alternatively expressed as 63.4° south of east, or 26.6° east of south.

(c) Dividing the magnitude of $\vec{r}_{AC}$ by the total time (2.25 h) gives

$$\vec{v}_{\text{avg}} = \frac{(483\text{ km})\hat{\text{i}} - (966\text{ km})\hat{\text{j}}}{2.25\text{ h}} = (215\text{ km/h})\hat{\text{i}} - (429\text{ km/h})\hat{\text{j}}$$

with a magnitude $|\vec{v}_{\text{avg}}| = \sqrt{(215\text{ km/h})^2 + (-429\text{ km/h})^2} = 480\text{ km/h}$.

(d) The direction of $\vec{v}_{\text{avg}}$ is 26.6° east of south, same as in part (b). In magnitude-angle notation, we would have $\vec{v}_{\text{avg}} = (480\text{ km/h} \angle -63.4°)$.

(e) Assuming the *AB* trip was a straight one, and similarly for the *BC* trip, then $|\vec{r}_{AB}|$ is the distance traveled during the *AB* trip, and $|\vec{r}_{BC}|$ is the distance traveled during the *BC* trip. Since the average speed is the total distance divided by the total time, it equals

$$\frac{483\text{ km} + 966\text{ km}}{2.25\text{ h}} = 644\text{ km/h}.$$

15. Since the acceleration, $\vec{a} = a_x\hat{\mathrm{i}} + a_y\hat{\mathrm{j}} = (-1.0\ \mathrm{m/s^2})\hat{\mathrm{i}} + (-0.50\ \mathrm{m/s^2})\hat{\mathrm{j}}$, is constant in both $x$ and $y$ directions, we may use Table 2-1 for the motion along each direction. This can be handled individually (for $x$ and $y$) or together with the unit-vector notation (for $\Delta\vec{r}$).

The particle started at the origin, so the coordinates of the particle at any time $t$ are given by $\vec{r} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$. The velocity of the particle at any time $t$ is given by $\vec{v} = \vec{v}_0 + \vec{a}t$, where $\vec{v}_0$ is the initial velocity and $\vec{a}$ is the (constant) acceleration. Along the $x$-direction, we have

$$x(t) = v_{0x}t + \frac{1}{2}a_x t^2, \quad v_x(t) = v_{0x} + a_x t$$

Similarly, along the $y$-direction, we get

$$y(t) = v_{0y}t + \frac{1}{2}a_y t^2, \quad v_y(t) = v_{0y} + a_y t$$

(a) Given that $v_{0x} = 3.0\ \mathrm{m/s}$, $v_{0y} = 0$, $a_x = -1.0\ \mathrm{m/s^2}$, $a_y = -0.5\ \mathrm{m/s^2}$, the components of the velocity are

$$v_x(t) = v_{0x} + a_x t = (3.0\ \mathrm{m/s}) - (1.0\ \mathrm{m/s^2})t$$
$$v_y(t) = v_{0y} + a_y t = -(0.50\ \mathrm{m/s^2})t$$

When the particle reaches its maximum $x$ coordinate at $t = t_m$, we must have $v_x = 0$. Therefore, $3.0 - 1.0t_m = 0$ or $t_m = 3.0$ s. The $y$ component of the velocity at this time is

$$v_y(t = 3.0\ \mathrm{s}) = -(0.50\ \mathrm{m/s^2})(3.0) = -1.5\ \mathrm{m/s}$$

Thus, $\vec{v}_m = (-1.5\ \mathrm{m/s})\hat{\mathrm{j}}$.

(b) At $t = 3.0$ s, the components of the position are

$$x(t = 3.0\ \mathrm{s}) = v_{0x}t + \frac{1}{2}a_x t^2 = (3.0\ \mathrm{m/s})(3.0\ \mathrm{s}) + \frac{1}{2}(-1.0\ \mathrm{m/s^2})(3.0\ \mathrm{s})^2 = 4.5\ \mathrm{m}$$
$$y(t = 3.0\ \mathrm{s}) = v_{0y}t + \frac{1}{2}a_y t^2 = 0 + \frac{1}{2}(-0.5\ \mathrm{m/s^2})(3.0\ \mathrm{s})^2 = -2.25\ \mathrm{m}$$

Using unit-vector notation, the results can be written as $\vec{r}_m = (4.50\ \mathrm{m})\hat{\mathrm{i}} - (2.25\ \mathrm{m})\hat{\mathrm{j}}$.

28. (a) Using the same coordinate system assumed in Eq. 4-22, we solve for $y = h$:

$$h = y_0 + v_0 \sin\theta_0 t - \frac{1}{2}gt^2$$

which yields $h = 51.8$ m for $y_0 = 0$, $v_0 = 42.0$ m/s, $\theta_0 = 60.0°$, and $t = 5.50$ s.

(b) The horizontal motion is steady, so $v_x = v_{0x} = v_0 \cos\theta_0$, but the vertical component of velocity varies according to Eq. 4-23. Thus, the speed at impact is

$$v = \sqrt{(v_0\cos\theta_0)^2 + (v_0\sin\theta_0 - gt)^2} = 27.4\ \mathrm{m/s}.$$

(c) We use Eq. 4-24 with $v_y = 0$ and $y = H$:

$$H = \frac{(v_0 \sin\theta_0)^2}{2g} = 67.5\ \mathrm{m}.$$

70. We use Eq. 4-44, noting that the upstream corresponds to the $+\hat{i}$ direction.

(a) The subscript b is for the boat, w is for the water, and g is for the ground.

$$\vec{v}_{bg} = \vec{v}_{bw} + \vec{v}_{wg} = (14\text{ km/h})\,\hat{i} + (-9\text{ km/h})\,\hat{i} = (5\text{ km/h})\,\hat{i}.$$

Thus, the magnitude is $|\vec{v}_{bg}| = 5$ km/h.

(b) The direction of $\vec{v}_{bg}$ is $+x$, or upstream.

(c) We use the subscript c for the child, and obtain

$$\vec{v}_{cg} = \vec{v}_{cb} + \vec{v}_{bg} = (-6\text{ km/h})\,\hat{i} + (5\text{ km/h})\,\hat{i} = (-1\text{ km/h})\,\hat{i}.$$

The magnitude is $|\vec{v}_{cg}| = 1$ km/h.

(d) The direction of $\vec{v}_{cg}$ is $-x$, or downstream.