6. To emphasize the fact that the velocity is a function of time, we adopt the notation $v(t)$ for dx/dt.

(a) Eq. 4-10 leads to

$$v(t) = \frac{d}{dt}\,(3.00t\hat{\text{i}} - 4.00t^2\hat{\text{j}} + 2.00\hat{\text{k}}) = (3.00 \text{ m/s})\hat{\text{i}} - (8.00t \text{ m/s})\,\hat{\text{j}}$$

(b) Evaluating this result at $t = 2.00$ s produces $\vec{v} = (3.00\hat{\text{i}} - 16.0\hat{\text{j}})$ m/s.

(c) The speed at $t = 2.00$ s is $v = |\vec{v}| = \sqrt{(3.00)^2 + (-16.0)^2} = 16.3$ m/s.

(d) And the angle of $\vec{v}$ at that moment is one of the possibilities

$$\tan^{-1}\left(\frac{-16.0}{3.00}\right) = -79.4° \text{ or } 101°$$

where we choose the first possibility (79.4° measured clockwise from the $+x$ direction, or 281° counterclockwise from $+x$) since the signs of the components imply the vector is in the fourth quadrant.

38. In this projectile motion problem, we have $v_0 = v_x$ = constant, and what is plotted is $v = \sqrt{v_x^2 + v_y^2}$. We infer from the plot that at t = 2.5 s, the ball reaches its maximum height, where $v_y = 0$. Therefore, we infer from the graph that v_x = 19 m/s.

(a) During t = 5 s, the horizontal motion is $x - x_0 = v_x t$ = 95 m.

(b) Since $\sqrt{(19 \text{ m/s})^2 + v_{0y}^2} = 31 \text{ m/s}$ (the first point on the graph), we find $v_{0y} = 24.5$ m/s. Thus, with t = 2.5 s, we can use $y_{\max} - y_0 = v_{0y}t - \frac{1}{2}gt^2$ or $v_y^2 = 0 = v_{0y}^2 - 2g(y_{\max} - y_0)$, or $y_{\max} - y_0 = \frac{1}{2}(v_y + v_{0_y})t$ to solve. Here we will use the latter:

$$y_{\max} - y_0 = \frac{1}{2}(v_y + v_{0y})\ t \Rightarrow y_{\max} = \frac{1}{2}(0 + 24.5 \text{m/s})(2.5 \text{ s}) = 31 \text{ m}$$

where we have taken $y_0 = 0$ as the ground level.

57. The magnitude of centripetal acceleration ($a = v^2/r$) and its direction (toward the center of the circle) form the basis of this problem.

(a) If a passenger at this location experiences $\vec{a} = 1.83 \text{ m/s}^2$ east, then the center of the circle is *east* of this location. The distance is $r = v^2/a = (3.66 \text{ m/s})^2/(1.83 \text{ m/s}^2) = 7.32$ m.

(b) Thus, relative to the center, the passenger at that moment is located 7.32 m toward the west.

(c) If the direction of $\vec{a}$ experienced by the passenger is now *south*—indicating that the center of the merry-go-round is south of him, then relative to the center, the passenger at that moment is located 7.32 m toward the north.

76. The destination is $\vec{D}$ = 800 km $\hat{\text{j}}$ where we orient axes so that +y points north and +x points east. This takes two hours, so the (constant) velocity of the plane (relative to the ground) is $\vec{v}_{\text{pg}}$ = (400 km/h) $\hat{\text{j}}$. This must be the vector sum of the plane's velocity with respect to the air which has (x,y) components (500cos70º, 500sin70º), and the velocity of the air (*wind*) relative to the ground $\vec{v}_{\text{ag}}$. Thus,

$$(400 \text{ km/h})\,\hat{\text{j}} = (500 \text{ km/h}) \cos 70^\circ\,\hat{\text{i}} + (500 \text{ km/h}) \sin 70^\circ\,\hat{\text{j}} + \vec{v}_{\text{ag}}$$

which yields

$$\vec{v}_{\text{ag}} = (-171 \text{ km/h})\hat{\text{i}} - (70.0 \text{ km/h})\hat{\text{j}}\ .$$

(a) The magnitude of $\vec{v}_{\text{ag}}$ is $|\vec{v}_{\text{ag}}| = \sqrt{(-171 \text{ km/h})^2 + (-70.0 \text{ km/h})^2} = 185 \text{ km/h}.$

(b) The direction of $\vec{v}_{\text{ag}}$ is

$$\theta = \tan^{-1}\left(\frac{-70.0 \text{ km/h}}{-171 \text{ km/h}}\right) = 22.3^\circ \quad (\text{south of west}).$$

78. We make use of Eq. 4-44 and Eq. 4-45.

The velocity of Jeep *P* relative to *A* at the instant is

$$\vec{v}_{PA} = (40.0 \text{ m/s})(\cos 60°\hat{\text{i}} + \sin 60°\hat{\text{j}}) = (20.0 \text{ m/s})\hat{\text{i}} + (34.6 \text{ m/s})\hat{\text{j}}.$$

Similarly, the velocity of Jeep *B* relative to *A* at the instant is

$$\vec{v}_{BA} = (20.0 \text{ m/s})(\cos 30°\hat{\text{i}} + \sin 30°\hat{\text{j}}) = (17.3 \text{ m/s})\hat{\text{i}} + (10.0 \text{ m/s})\hat{\text{j}}.$$

Thus, the velocity of *P* relative to *B* is

$$\vec{v}_{PB} = \vec{v}_{PA} - \vec{v}_{BA} = (20.0\hat{\text{i}} + 34.6\hat{\text{j}}) \text{ m/s} - (17.3\hat{\text{i}} + 10.0\hat{\text{j}}) \text{ m/s} = (2.68 \text{ m/s})\hat{\text{i}} + (24.6 \text{ m/s})\hat{\text{j}}.$$

(a) The magnitude of $\vec{v}_{PB}$ is $|\vec{v}_{PB}| = \sqrt{(2.68 \text{ m/s})^2 + (24.6 \text{ m/s})^2} = 24.8 \text{ m/s}$.

(b) The direction of $\vec{v}_{PB}$ is $\theta = \tan^{-1}[(24.6 \text{ m/s})/(2.68 \text{ m/s})] = 83.8°$ north of east (or 6.2º east of north).

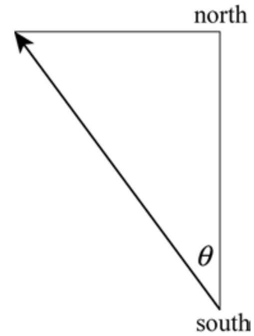
(c) The acceleration of *P* is

$$\vec{a}_{PA} = (0.400 \text{ m/s}^2)(\cos 60.0°\hat{\text{i}} + \sin 60.0°\hat{\text{j}}) = (0.200 \text{ m/s}^2)\hat{\text{i}} + (0.346 \text{ m/s}^2)\hat{\text{j}},$$

and $\vec{a}_{PA} = \vec{a}_{PB}$. Thus, we have $|\vec{a}_{PB}| = 0.400 \text{ m/s}^2$.

(d) The direction is 60.0° north of east (or 30.0° east of north).

82. We construct a right triangle starting from the clearing on the south bank, drawing a line (200 m long) due north (*upward* in our sketch) across the river, and then a line due west (upstream, leftward in our sketch) along the north bank for a distance $(82\text{ m}) + (1.1\text{ m/s})t$, where the t-dependent contribution is the distance that the river will carry the boat downstream during time t.



The hypotenuse of this right triangle (the arrow in our sketch) also depends on t and on the boat's speed (relative to the water), and we set it equal to the Pythagorean "sum" of the triangle's sides:

$$(4.0)t = \sqrt{200^2 + (82 + 1.1t)^2}$$

which leads to a quadratic equation for t

$$46724 + 180.4t - 14.8t^2 = 0.$$

(b) We solve for t first and find a positive value: t = 62.6 s.

(a) The angle between the northward (200 m) leg of the triangle and the hypotenuse (which is measured "west of north") is then given by

$$\theta = \tan^{-1}\left(\frac{82 + 1.1t}{200}\right) = \tan^{-1}\left(\frac{151}{200}\right) = 37°.$$