2. The skier has zero initial velocity in the vertical direction \( v_{by} = 0 \) and undergoes a vertical displacement of \( \Delta y = -3.20 \text{ m} \). The constant acceleration in the vertical direction is \( a_y = -g \), so we use \( \Delta y = v_{by}t + \frac{1}{2}a_yt^2 \) to find the time of flight as

\[
-3.20 \text{ m} = 0 + \frac{1}{2}(-9.80 \text{ m/s}^2)t^2 \\
\text{or} \\
\frac{2(-3.20 \text{ m})}{-9.80 \text{ m/s}^2} = 0.808 \text{ s}
\]

During this time, the object moves with constant horizontal velocity \( v_x = v_{ox} = 22.0 \text{ m/s} \). The horizontal distance traveled during the flight is

\[
\Delta x = v_xt = (22.0 \text{ m/s})(0.808 \text{ s}) = 17.8 \text{ m}
\]

which is choice (d).

6. Consider any two very closely spaced points on a circular path and draw vectors of the same length (to represent a constant velocity magnitude or speed) tangent to the path at each of these points as shown in the leftmost diagram below. Now carefully move the velocity vector \( \vec{v}_f \) at the second point down so its tail is at the first point as shown in the rightmost diagram. Then, draw the vector difference \( \Delta \vec{v} = \vec{v}_f - \vec{v}_i \), and observe that if the start of this vector were located on the circular path midway between the two points, its direction would be inward toward the center of the circle.

Thus, for an object following the circular path at constant speed, its instantaneous acceleration, \( \vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} \), at the point midway between your initial and end points is directed toward the center of the circle, and the only correct choice for this question is (d).

10. While in the air, the baseball is a projectile whose velocity always has a constant horizontal component \( v_x = v_{ox} \) and a vertical component that changes at a constant rate \( \Delta v_y / \Delta t = a_y = -g \). At the highest point on the path, the vertical velocity of the ball is momentarily zero. Thus, at this point, the resultant velocity of the ball is horizontal and its acceleration continues to be directed downward \( (a_x = 0, \ a_y = -g) \). The only correct choice given for this question is (c).
12. When the apple first comes off the tree, it is moving forward with the same horizontal velocity as the truck. Since, while in free fall, the apple has zero horizontal acceleration, it will maintain this constant horizontal velocity as it falls. Also, while in free fall, the apple has constant downward acceleration \( a_y = -g \), so its downward speed increases uniformly in time.

(i) As the truck moves left to right past an observer stationary on the ground, this observer will see both the constant velocity horizontal motion and the uniformly accelerated downward motion of the apple. The curve that best describes the path of the apple as seen by this observer is (a).

(ii) An observer on the truck moves with the same horizontal motion as does the apple. This observer does not detect any horizontal motion of the apple relative to him. However, this observer does detect the uniformly accelerated vertical motion of the apple. The curve best describing the path of the apple as seen by the observer on the truck is (b).

13. Of the choices listed, the quantities that have magnitude or size, but no direction, associated with them (i.e., scalar quantities) are (b) temperature, (c) volume, and (e) height. The other quantities, (a) velocity of a sports car and (d) displacement of a tennis player who moves from the court's baseline to the net, have both magnitude and direction associated with them, and are both vector quantities.

4. The minimum sum for two vectors occurs when the two vectors are opposite in direction. If they are unequal, their sum cannot be zero.

10. The passenger sees the ball go into the air and come back in the same way he would if he were at rest on Earth. An observer by the tracks would see the ball follow the path of a projectile. If the train were accelerating, the ball would fall behind the position it would reach in the absence of the acceleration.
3.4 Sketches of the scale drawings needed for parts (a) through (d) are given below. Following the sketches is a brief comment on each part with its answer.

(a) Drawing the vectors to scale and maintaining their respective directions yields a resultant of $\mathbf{5.2 \text{ m at } 60^\circ}$.

(b) Maintain the direction of $\mathbf{A}$, but reverse the direction of $\mathbf{B}$ to produce $-\mathbf{B}$. The resultant is $\mathbf{3.0 \text{ m at } -30^\circ}$.

(c) Maintain the direction of $\mathbf{B}$, but reverse the direction of $\mathbf{A}$ to produce $-\mathbf{A}$. The resultant is $\mathbf{3.0 \text{ m at } +150^\circ}$.

(d) Maintain the direction of $\mathbf{A}$, reverse the direction of $\mathbf{B}$ and double its magnitude, to produce $-2\mathbf{B}$. The resultant is $\mathbf{5.2 \text{ m at } -60^\circ}$.

3.7 Using a vector diagram, drawn to scale, like that shown at the right, the final displacement of the plane can be found to be $\mathbf{\overrightarrow{R}_{\text{plane}} = 310 \text{ km at } \theta = 57^\circ \text{ N of E}}$. The requested displacement of the base from point B is $-\mathbf{\overrightarrow{R}_{\text{plane}}}$, which has the same magnitude but the opposite direction. Thus, the answer is $-\mathbf{\overrightarrow{R}_{\text{plane}}} = \mathbf{310 \text{ km at } \theta = 57^\circ \text{ S of W}}$. 

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3.13 (a) Her net $x$ (east–west) displacement is $-3.00 + 0 + 6.00 = +3.00$ blocks, while her net $y$ (north–south) displacement is $0 + 4.00 + 0 = +4.00$ blocks. The magnitude of the resultant displacement is

$$R = \sqrt{(\Sigma x)^2 + (\Sigma y)^2} = \sqrt{(3.00)^2 + (4.00)^2} = 5.00 \text{ blocks}$$

and the angle the resultant makes with the $x$-axis (eastward direction) is

$$\theta = \tan^{-1}\left(\frac{\Sigma y}{\Sigma x}\right) = \tan^{-1}\left(\frac{4.00}{3.00}\right) = \tan^{-1}(1.33) = 53.1^\circ$$

The resultant displacement is then $5.00 \text{ blocks at } 53.1^\circ \text{ N of E}$.

(b) The total distance traveled is $3.00 + 4.00 + 6.00 = 13.0 \text{ blocks}$.

3.15 $A_x = -25.0$ \hspace{1cm} $A_y = 40.0$

$$A = \sqrt{A_x^2 + A_y^2} = \sqrt{(-25.0)^2 + (40.0)^2} = 47.2 \text{ units}$$

From the triangle, we find that

$$\phi = \tan^{-1}\left(\frac{A_y}{A_x}\right) = \tan^{-1}\left(\frac{40.0}{25.0}\right) = 58.0^\circ, \text{ so } \theta = 180^\circ - \phi = 122^\circ$$

Thus, $\vec{A} = 47.2 \text{ units at } 122^\circ \text{ counterclockwise from } +x$-axis.

3.32 The components of the initial velocity are

$$v_{0x} = (40.0 \text{ m/s})\cos 30.0^\circ = 34.6 \text{ m/s}$$

and

$$v_{0y} = (40.0 \text{ m/s})\sin 30.0^\circ = 20.0 \text{ m/s}$$

The time for the water to reach the building is

$$t = \frac{\Delta x}{v_{0x}} = \frac{50.0 \text{ m}}{34.6 \text{ m/s}} = 1.44 \text{ s}$$

The height of the water at this time is

$$\Delta y = v_{0y} t + \frac{1}{2} a_y t^2 = (20.0 \text{ m/s})(1.44 \text{ s}) + \frac{1}{2}(-9.80 \text{ m/s}^2)(1.44 \text{ s})^2 = 18.7 \text{ m}$$
3.35 (a) The jet moves at $3.00 \times 10^2$ mi/h due east relative to the air. Choosing a coordinate system with the positive x-direction eastward and the positive y-direction northward, the components of this velocity are

$$
(\vec{v}_{JA})_x = 3.00 \times 10^2 \text{ mi/h} \quad \text{and} \quad (\vec{v}_{JA})_y = 0
$$

(b) The velocity of the air relative to Earth is $1.00 \times 10^2$ mi/h at $30.0^\circ$ north of east. Using the coordinate system adopted in (a) above, the components of this velocity are

$$
(\vec{v}_{AE})_x = |\vec{v}_{AE}| \cos \theta = (1.00 \times 10^2 \text{ mi/h}) \cos 30.0^\circ = 86.6 \text{ mi/h}
$$

and

$$
(\vec{v}_{AE})_y = |\vec{v}_{AE}| \sin \theta = (1.00 \times 10^2 \text{ mi/h}) \sin 30.0^\circ = 50.0 \text{ mi/h}
$$

(c) Carefully observe the pattern of the subscripts in Equation 3.16 of the textbook. There, two objects (cars A and B) both move relative to a third object (Earth, E). The velocity of object A relative to object B is given in terms of the velocities of these objects relative to E as $\vec{v}_{AB} = \vec{v}_{AE} - \vec{v}_{BE}$. In the present case, we have two objects, a jet (J) and the air (A), both moving relative to a third object, Earth (E). Using the same pattern of subscripts as that in Equation 3.16, the velocity of the jet relative to the air is given by

$$
\vec{v}_{JA} = \vec{v}_{JE} - \vec{v}_{AE}
$$

(d) From the expression for $\vec{v}_{JA}$ found in (c) above, the velocity of the jet relative to the ground is $\vec{v}_{JE} = \vec{v}_{JA} + \vec{v}_{AE}$. Its components are then

$$
(\vec{v}_{JE})_x = (\vec{v}_{JA})_x + (\vec{v}_{AE})_x = 3.00 \times 10^2 \text{ mi/h} + 86.6 \text{ mi/h} = 3.87 \times 10^2 \text{ mi/h}
$$

and

$$
(\vec{v}_{JE})_y = (\vec{v}_{JA})_y + (\vec{v}_{AE})_y = 0 + 50.0 \text{ mi/h} = 50.0 \text{ mi/h}
$$

This gives the magnitude and direction of the jet's motion relative to Earth as

$$
|\vec{v}_{JE}| = \sqrt{(3.87 \times 10^2 \text{ mi/h})^2 + (50.0 \text{ mi/h})^2} = 3.90 \times 10^2 \text{ mi/h}
$$

and

$$
\theta = \tan^{-1} \left( \frac{\vec{v}_{JE}}{\vec{v}_{JE}} \right) = \tan^{-1} \left( \frac{50.0 \text{ mi/h}}{3.87 \times 10^2 \text{ mi/h}} \right) = 7.37^\circ
$$

Therefore, $\vec{v}_{JE} = 3.90 \times 10^2 \text{ mi/h}$ at $7.37^\circ$ north of east.
3.36 We use the following notation:

\[ \tilde{v}_{bs} = \text{velocity of boat relative to the shore} \]

\[ \tilde{v}_{bw} = \text{velocity of boat relative to the water}, \]

and \[ \tilde{v}_{ws} = \text{velocity of water relative to the shore}. \]

If we take downstream as the positive direction, then \[ \tilde{v}_{ws} = +1.5 \text{ m/s for both parts of the trip.} \]

Also, \[ \tilde{v}_{bw} = +10 \text{ m/s while going downstream and } \tilde{v}_{bw} = -10 \text{ m/s for the upstream part of the trip.} \]

The velocity of the boat relative to the water is \[ \tilde{v}_{bw} = \tilde{v}_{bs} - \tilde{v}_{ws}, \]
so the velocity of the boat relative to the shore is \[ \tilde{v}_{bs} = \tilde{v}_{bw} + \tilde{v}_{ws}. \]

While going downstream, \[ \tilde{v}_{bs} = 10 \text{ m/s} + 1.5 \text{ m/s} \]
and the time to go 300 m downstream is

\[ t_{down} = \frac{d}{|\tilde{v}_{bs}|} = \frac{300 \text{ m}}{(10 + 1.5) \text{ m/s}} = 26 \text{ s} \]

When going upstream, \[ \tilde{v}_{bs} = -10 \text{ m/s} + 1.5 \text{ m/s} = -8.5 \text{ m/s} \]
and the time required to move 300 m upstream is

\[ t_{up} = \frac{d}{|\tilde{v}_{bs}|} = \frac{300 \text{ m}}{8.5 \text{ m/s}} = 35 \text{ s} \]

The time for the round trip is \[ t = t_{down} + t_{up} = (26 + 35) \text{ s} = 61 \text{ s}. \]
3.63 In order to cross the river in minimum time, the velocity of the boat relative to the water ($\vec{v}_{BW}$) must be perpendicular to the banks (and hence perpendicular to the velocity $\vec{v}_{WS}$ of the water relative to shore).

The velocity of the boat relative to the water is $\vec{v}_{BW} = \vec{v}_{BS} - \vec{v}_{WS}$, where $\vec{v}_{BS}$ is the velocity of the boat relative to shore. Note that this vector equation can be rewritten as $\vec{v}_{BS} = \vec{v}_{BW} + \vec{v}_{WS}$. Since $\vec{v}_{BW}$ and $\vec{v}_{WS}$ are to be perpendicular in this case, the vector diagram for this equation is a right triangle with $\vec{v}_{BS}$ as the hypotenuse.

Hence, velocity of the boat relative to shore must have magnitude

$$v_{BS} = \sqrt{v_{BW}^2 + v_{WS}^2} = \sqrt{(12 \text{ km/h})^2 + (5.0 \text{ km/h})^2} = 13 \text{ km/h}$$

and be directed at

$$\theta = \tan^{-1}\left(\frac{v_{BW}}{v_{WS}}\right) = \tan^{-1}\left(\frac{12 \text{ km/h}}{5.0 \text{ km/h}}\right) = 67^\circ$$

to the direction of the current in the river (which is the same as the line of the riverbank).

The minimum time to cross the river is

$$t = \frac{\text{width of river}}{v_{BW}} = \frac{1.5 \text{ km}}{12 \text{ km/h}} \left(\frac{60 \text{ min}}{1 \text{ h}}\right) = 7.5 \text{ min}$$

During this time, the boat drifts downstream a distance of

$$d = v_{WS} \cdot t = (5.0 \text{ km/h})(7.5 \text{ min})\left(\frac{1 \text{ h}}{60 \text{ min}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right) = 6.3 \times 10^2 \text{ m}$$