10. The vectors are $\mathbf{V}_1 = -6.0\mathbf{i} + 8.0\mathbf{j}$, $\mathbf{V}_2 = 4.5\mathbf{i} - 5.0\mathbf{j}$.

(a) For the magnitude of $\mathbf{V}_1$ we have
$$||\mathbf{V}_1|| = (V_{1x}^2 + V_{1y}^2)^{1/2} = [(-6.0)^2 + (8.0)^2]^{1/2} = 10.0.$$ We find the direction from
tan $\theta_1 = V_{1y}/V_{1x} = (8.0)/(-6.0) = -1.33$.
From the signs of the components, we have $\theta_1 = 53^\circ$ above $-x$-axis.

(b) For the magnitude of $\mathbf{V}_2$ we have
$$||\mathbf{V}_2|| = (V_{2x}^2 + V_{2y}^2)^{1/2} = [(4.5)^2 + (-5.0)^2]^{1/2} = 6.7.$$ We find the direction from
tan $\theta_2 = V_{2y}/V_{2x} = (-5.0)/(4.5) = -1.11$.
From the signs of the components, we have $\theta_2 = 48^\circ$ below $+x$-axis.

(c) For the sum $\mathbf{V}_1 + \mathbf{V}_2$ we have
$$\mathbf{V}_1 + \mathbf{V}_2 = -1.5\mathbf{i} + 3.0\mathbf{j}.$$ For the magnitude of $\mathbf{V}_1 + \mathbf{V}_2$ we have
$$||\mathbf{V}_1 + \mathbf{V}_2|| = [(-1.5)^2 + (3.0)^2]^{1/2} = 3.4.$$ We find the direction from
tan $\theta_{1+2} = (3.0)/(-1.5) = -2.0$.
From the signs of the components, we have $\theta_{1+2} = 63^\circ$ above $-x$-axis.

(d) For the difference $\mathbf{V}_2 - \mathbf{V}_1$ we have
$$\mathbf{V}_2 - \mathbf{V}_1 = 10.5\mathbf{i} - 13.0\mathbf{j}.$$ For the magnitude of $\mathbf{V}_1 + \mathbf{V}_2$ we have
$$||\mathbf{V}_2 - \mathbf{V}_1|| = [(10.5)^2 + (-13.0)^2]^{1/2} = 16.7.$$ We find the direction from
tan $\theta_{2-1} = (-13.0)/(10.5) = -1.24$.
From the signs of the components, we have $\theta_{2-1} = 51^\circ$ below $+x$-axis.
11. The vectors are $\mathbf{V}_1 = 4\mathbf{i} - 8\mathbf{j}$, $\mathbf{V}_2 = \mathbf{i} + \mathbf{j}$, $\mathbf{V}_3 = -2\mathbf{i} + 4\mathbf{j}$.

(a) For the sum $\mathbf{V}_1 + \mathbf{V}_2 + \mathbf{V}_3$ we have
   $\mathbf{V}_1 + \mathbf{V}_2 + \mathbf{V}_3 = 3\mathbf{i} - 3\mathbf{j}$.

   For the magnitude of $\mathbf{V}_1 + \mathbf{V}_2 + \mathbf{V}_3$ we have
   $$|\mathbf{V}_1 + \mathbf{V}_2 + \mathbf{V}_3| = [(3)^2 + (-3)^2]^{1/2} = 4.2.$$  

   We find the direction from
   $$\tan \theta_a = (-3)/(3) = -1.0.$$  

   From the signs of the components, we have $\theta_a = 45^\circ$ below $+x$-axis.

(b) For $\mathbf{V}_1 - \mathbf{V}_2 + \mathbf{V}_3$ we have
   $\mathbf{V}_1 - \mathbf{V}_2 + \mathbf{V}_3 = \mathbf{i} - 5\mathbf{j}$.

   For the magnitude of $\mathbf{V}_1 - \mathbf{V}_2 + \mathbf{V}_3$ we have
   $$|\mathbf{V}_1 - \mathbf{V}_2 + \mathbf{V}_3| = [(1)^2 + (-5)^2]^{1/2} = 5.1.$$  

   We find the direction from
   $$\tan \theta_b = (-5)/(1) = -5.0.$$  

   From the signs of the components, we have $\theta_b = 79^\circ$ below $+x$-axis.
12. (a) For the components we have
\[ R_x = A_x + B_x + C_x = 44.0 \cos 28.0^\circ - 26.5 \cos 56.0^\circ + 0 = 24.0; \]
\[ R_y = A_y + B_y + C_y = 44.0 \sin 28.0^\circ + 26.5 \sin 56.0^\circ - 31.0 = 11.6. \]

(b) We find the resultant from
\[ R = (R_x^2 + R_y^2)^{1/2} = [(24.0)^2 + (11.6)^2]^{1/2} = 26.7; \]
\[ \tan \theta = R_y/R_x = (11.6)/(24.0) = 0.483, \] which gives \[ \theta = 25.8^\circ \] above +x-axis.
18. We find the velocity and acceleration by differentiating:

\[ \mathbf{r} = (7.60 \text{ m/s})\mathbf{i} + (8.85 \text{ m})\mathbf{j} - (1.00 \text{ m/s}^2)\mathbf{i}^2\mathbf{k}; \]

\[ \mathbf{v} = \frac{d\mathbf{r}}{dt} = (7.60 \text{ m/s})\mathbf{i} - (2.00 \text{ m/s}^2)\mathbf{k}; \]

\[ \mathbf{a} = \frac{d\mathbf{v}}{dt} = - (2.00 \text{ m/s}^2)\mathbf{k}. \]
21. (a) Because we do not know the displacement over the given time interval, the average velocity is unknown.

(b) The average acceleration is

\[ \mathbf{a}_{av} = \frac{\Delta \mathbf{v}}{\Delta t} = \frac{[(27.5 \text{ m/s})\mathbf{i} - (-18.0 \text{ m/s})\mathbf{j}] / (8.00 \text{ s})}{8.00 \text{ s}} = (3.44 \text{ m/s}^2)\mathbf{i} + (2.25 \text{ m/s}^2)\mathbf{k}. \]

The magnitude is

\[ |\mathbf{a}_{av}| = \sqrt{(3.44 \text{ m/s}^2)^2 + (2.25 \text{ m/s}^2)^2} = 4.11 \text{ m/s}^2. \]

We find the direction from

\[ \tan \theta = \frac{2.25 \text{ m/s}^2}{3.44 \text{ m/s}^2} = 0.654, \]

which gives \( \theta = 33.2^\circ \) north of east.

(c) Because we do not know the distance traveled, the average speed is unknown.
22. (a) For the vertical component we have
\[ a_y = (3.80 \text{ m/s}^2) \sin 30.0^\circ = 1.90 \text{ m/s}^2 \text{ down}. \]

(b) Because the elevation change is the vertical displacement, we find the time from the vertical motion, taking down as the positive direction:
\[ y = v_{0y}t + \frac{1}{2}a_yt^2; \]
\[ 250 \text{ m} = 0 + \frac{1}{2}(1.90 \text{ m/s}^2)t^2, \]
which gives \( t = 16.2 \text{ s}. \)
31. We find the time of flight from the vertical displacement:

\[ y = y_0 + v_0 t + \frac{1}{2} a_f t^2; \]

\[ 0 = 0 + (18.0 \text{ m/s})(\sin 32.0^\circ) t + \frac{1}{2} (-9.80 \text{ m/s}^2) t^2, \]

which gives \( t = 0, 1.95 \text{ s} \).

The ball is kicked at \( t = 0 \), so the football hits the ground \( 1.95 \text{ s} \) later.
32. We choose a coordinate system with the origin at the release point, with $x$ horizontal and $y$ vertical, with the positive direction down. The horizontal motion will have constant velocity. We find the time required for the fall from
\[ x = x_0 + v_0x t; \]
36.0 m = 0 + (22.2 m/s)$t$, which gives $t = 1.62$ s.
We find the height from the vertical motion:
\[ y = y_0 + v_0y t + \frac{1}{2}a_y t^2; \]
\[ h = 0 + 0 + \frac{1}{2}(9.80 \text{ m/s}^2)(1.62 \text{ s})^2 = 12.9 \text{ m}. \]
33. We choose a coordinate system with the origin at the release point, with \( x \) horizontal and \( y \) vertical, with the positive direction up. We find the time required for the fall from the vertical motion:
\[
y = y_0 + v_0 y + \frac{1}{2} a_y t^2;
\]
\[
-2.2 \ m = 0 + (14 \ \text{m/s})(\sin 40^\circ)t + \frac{1}{2}(-9.80 \ \text{m/s}^2)t^2.
\]
The solutions of this quadratic equation are \( t = -0.22 \ \text{s}, \ 2.06 \ \text{s} \). Because the shot is released at \( t = 0 \), the physical answer is \( 2.06 \ \text{s} \). We find the horizontal distance from
\[
x = x_0 + v_0 x t;
\]
\[
x = 0 + (14 \ \text{m/s})(\cos 40^\circ)(2.06 \ \text{s}) = 22 \ \text{m}.
\]
38. (a) Because the athlete lands at the same level, we can use the expression for the horizontal range:

\[ R = \frac{v_0^2 \sin(2\theta_0)}{g}; \]

\[ 7.80 \text{ m} = \frac{v_0^2 \sin(2(33.0^\circ))}{(9.80 \text{ m/s}^2)}, \]

which gives \( v_0 = 9.15 \text{ m/s}. \)

(b) For an increase of 5%, the initial speed becomes \( v'_0 = (1 + 0.05)v_0 = (1.05)v_0 \), and the new range is

\[ R' = \frac{v'_0^2 \sin(2\theta_0)}{g} = (1.05)^2 \frac{v_0^2 \sin(2\theta_0)}{g} = 1.10R. \]

Thus the increase in the length of the jump is

\[ R' - R = (1.10 - 1)R = 0.10(7.80 \text{ m}) = 0.78 \text{ m}. \]
40. (a) We choose a coordinate system with the origin at the base of the cliff, with $x$ horizontal and $y$ vertical, with the positive direction up. We find the time required for the fall from the vertical motion:

$$y = y_0 + v_{0y}t + \frac{1}{2}gt^2;$$

$$0 = 125 \text{ m} + (65.0 \text{ m/s})(\sin 37.0^\circ)t + \frac{1}{2}(-9.80 \text{ m/s}^2)t^2,$$

which gives $t = -2.45, 10.4 \text{ s}$. Because the projectile starts at $t = 0$, we have $t = 10.4 \text{ s}$.

(b) We find the range from the horizontal motion:

$$X = v_{0x}t = (65.0 \text{ m/s})(\cos 37.0^\circ)(10.4 \text{ s})$$

$$= 540 \text{ m}.$$

(c) For the velocity components, we have

$$v_x = v_{0x} = (65.0 \text{ m/s}) \cos 37.0^\circ = 51.9 \text{ m/s}.$$  

$$v_y = v_{0y} + gt = (65.0 \text{ m/s}) \sin 37.0^\circ + (-9.80 \text{ m/s}^2)(10.4 \text{ s}) = -62.8 \text{ m/s}.$$

(d) When we combine these components, we get

$$v = (v_x^2 + v_y^2)^{1/2} = [(51.9 \text{ m/s})^2 + (-62.8 \text{ m/s})^2]^{1/2} = 81.5 \text{ m/s}.$$

(e) We find the angle from

$$\tan \theta = v_y/v_x = (62.8 \text{ m/s})/(51.9 \text{ m/s}) = 1.21,$$

which gives $\theta = 50.4^\circ$ below the horizontal.
46. (a) We choose a coordinate system with the origin at the jump point, with $x$ horizontal and $y$ vertical, with the positive direction up. The horizontal motion will have constant velocity.

We find the time required for the fall from

$$x = x_0 + v_0 t,$$

$$L = 0 + v_0 t,$$ which gives $t = L/v_0$.

For the vertical motion we have

$$y = y_0 + v_0 y t + \frac{1}{2}a_y t^2;$$

$$-h = 0 + 0 + \frac{1}{2}(-g) t^2;$$ so

$$h = \frac{1}{2}g\left(L/v_0\right)^2;$$

$$1.5 \text{ m} = \frac{1}{2}(9.80 \text{ m/s}^2)(20 \text{ m})^2/v_0^2,$$ which gives $v_0 = 36 \text{ m/s (130 km/h)}$.

(b) If the ramp makes an angle $\theta_0$ with the horizontal, we have

$$x = x_0 + v_0 x t;$$

$$L = 0 + (v_0 \cos \theta_0) t,$$ which gives $t = L/v_0 \cos \theta_0$.

For the vertical motion we have

$$y = y_0 + v_0 y t + \frac{1}{2}a_y t^2;$$

$$-h = 0 + (v_0 \sin \theta_0) t + \frac{1}{2}(-g) t^2;$$ so

$$h = -(v_0 \sin \theta_0)(L/v_0 \cos \theta_0) + \frac{1}{2}g\left(L/v_0 \cos \theta_0\right)^2;$$

$$1.5 \text{ m} = -(20 \text{ m}) \tan 10^\circ + \frac{1}{2}(9.80 \text{ m/s}^2)(20 \text{ m})^2/v_0^2 \cos^2 10^\circ;$$ which gives $v_0 = 20 \text{ m/s (72 km/h)}$. 
53. The centripetal acceleration of the Earth is

\[ a_r = \frac{v^2}{r} = \frac{(2\pi r/T)^2}{r} = 4\pi^2 \frac{r}{T^2} \]

\[ = 4\pi^2 (1.5 \times 10^{11} \text{ m})/(3.16 \times 10^7 \text{ s})^2 = 5.9 \times 10^{-3} \text{ m/s}^2 \text{ toward the Sun.} \]
To complete an orbit in time $T$, the speed of the shuttle must be $v = \frac{2\pi r}{T}$.

Thus the centripetal acceleration in terms of $g$ is

$$a_R/g = \frac{v^2}{rg} = \frac{(2\pi r/T)^2}{rg} = \frac{4\pi^2 r^2}{gT^2}$$

$$= 4\pi^2(6.38 \times 10^6 \text{ m} + 0.40 \times 10^6 \text{ m})/(9.80 \text{ m/s}^2)[(90 \text{ min})(60 \text{ s/min})]^2,$$

which gives $a_R = 0.94g$. 

82. We choose a coordinate system with the origin at home plate, 
$x$ horizontal and $y$ up, as shown in the diagram.
The minimum speed of the ball is that which will have the 
ball just clear the fence. The horizontal motion is 
\[ x = v_0t; \]
\[ 92 \text{ m} = v_0 \cos 40^\circ t, \] which gives \( v_0t = 120 \text{ m}. \)
The vertical motion is 
\[ y = y_0 + v_0y t + \frac{1}{2}a_y t^2; \]
\[ 12 \text{ m} = 1.0 \text{ m} + v_0 \sin 40^\circ t + \frac{1}{2}(-9.80 \text{ m/s}^2)t^2. \]
We can use the first equation to eliminate \( v_0t \) from the second and 
solve for \( t \), which gives \( t = 3.67 \text{ s}. \)
When this value is used in the first equation, we get \( v_0 = 33 \text{ m/s}. \)
84. We use the coordinate system shown in the diagram.

We find the time for the ball to reach the net from the vertical motion:
\[ y = y_0 + v_0y t + \frac{1}{2}a_y t^2; \]
\[ 0.90 \, \text{m} = 2.50 \, \text{m} + 0 + \frac{1}{2}(-9.80 \, \text{m/s}^2)t^2, \]
which gives \( t = 0.571 \, \text{s}. \)

We find the initial velocity from the horizontal motion:
\[ x = v_0x t; \]
\[ 15.0 \, \text{m} = v_0(0.571 \, \text{s}), \]
which gives \( v_0 = 26.3 \, \text{m/s}. \)

We find the time for the ball to reach the ground from the vertical motion:
\[ y = y_0 + v_0y t_2 + \frac{1}{2}a_y t_2^2; \]
\[ 0 = 2.50 \, \text{m} + 0 + \frac{1}{2}(-9.80 \, \text{m/s}^2)t_2^2, \]
which gives \( t_2 = 0.714 \, \text{s}. \)

We find where it lands from the horizontal motion:
\[ x_2 = v_0x t_2 = (26.3 \, \text{m/s})(0.714 \, \text{s}) = 18.8 \, \text{m}. \]

Because this is \( 18.8 \, \text{m} - 15.0 \, \text{m} = 3.8 \, \text{m beyond the net} , \)
which is less than 7.0 m, the serve is good.
90. We use the coordinate system shown in the diagram, with up positive. For the horizontal motion, we have
\[ x = v_0 t; \]
\[ L = (v_0 \cos \theta)t; \]
195 m = \((v_0 \cos \theta)(7.6 \text{ s})\), which gives \(v_0 \cos \theta = 25.7 \text{ m/s}\).
For the vertical motion, we have
\[ y = y_0 + v_0 y t + \frac{1}{2} a_y t^2; \]
\[ H = 0 + (v_0 \sin \theta) t + \frac{1}{2} (-g) t^2; \]
155 m = \((v_0 \sin \theta)(7.6 \text{ s}) + \frac{1}{2} (- 9.80 \text{ m/s}^2)(7.6 \text{ s})^2\), which gives \(v_0 \sin \theta = 57.6 \text{ m/s}\).
We can find the initial angle \(\theta\) by dividing the two results:
\[ \tan \theta = \frac{(v_0 \sin \theta)}{(v_0 \cos \theta)} = \frac{(57.6 \text{ m/s})}{(25.7 \text{ m/s})} = 2.24, \text{ which gives } \theta = 66.0^\circ. \]
Now we can use one of the previous results to find the initial velocity:
\[ v_0 = \frac{(25.7 \text{ m/s})}{\cos \theta} = \frac{(25.7 \text{ m/s})}{\cos 66.0^\circ} = 63 \text{ m/s}. \]
Thus the initial velocity is \(63 \text{ m/s}, 66^\circ \text{ above the horizontal}\).
94. The centripetal acceleration is
\[ a_R = \frac{v^2}{r}, \quad \text{or} \quad r = \frac{v^2}{a_R}. \]
Thus \( r \) is minimal when \( a_R \) is maximal:
\[
r_{min} = \left[\frac{(700 \text{ km/h})/(3.6 \text{ ks/h})^2}{(6.0)(9.80 \text{ m/s}^2)}\right] = 6.4 \times 10^2 \text{ m} = 0.64 \text{ km}.
\]