**4.28**  The centripetal acceleration is \( a_c = \frac{v^2}{r} \), so the required speed is

\[
v = \sqrt{a_c} = \sqrt{1.40(9.80 \text{ m/s}^2)(10.0 \text{ m})} = 11.7 \text{ m/s}
\]

The period (time for one rotation) is given by \( T = \frac{2\pi}{v} \) and the rotation rate is the frequency:

\[
f = \frac{1}{T} = \frac{v}{2\pi} = \frac{11.7 \text{ m/s}}{2\pi(10.0 \text{ m})} = 0.186 \text{ s}^{-1}
\]

**4.34**  (a)  \( a_{\text{top}} = \frac{v^2}{r} = \frac{(4.30 \text{ m/s})^2}{0.600 \text{ m}} = 30.8 \text{ m/s}^2 \text{ down} \)

(b)  \( a_{\text{bottom}} = \frac{v^2}{r} = \frac{(6.50 \text{ m/s})^2}{0.600 \text{ m}} = 70.4 \text{ m/s}^2 \text{ upward} \)

**4.35**  (a)

(b)  The components of the 20.2 and the 22.5 m/s² along the rope together constitute the radial acceleration:

\[
a_r = (22.5 \text{ m/s}^2) \cos (90.0^\circ - 36.9^\circ) + (20.2 \text{ m/s}^2) \cos 36.9^\circ
\]

\[
a_r = \left| 29.7 \text{ m/s}^2 \right|
\]

(c)  \( a_r = \frac{v^2}{r} \)

\[
v = \sqrt{a_r} = \sqrt{29.7 \text{ m/s}^2(1.50 \text{ m})} = 6.67 \text{ m/s} \text{ tangent to circle}
\]

\[
v = \left| 6.67 \text{ m/s at } 36.9^\circ \text{ above the horizontal} \right|
\]
4.39 \( v = (150^2 + 30.0^2)^{1/2} = 153 \text{ km/h} \)

\[ \theta = \tan^{-1}\left( \frac{30.0}{150} \right) = 11.3^\circ \text{ north of west} \]

4.41 \( \alpha = \) Heading with respect to the shore

\( \beta = \) Angle of boat with respect to the shore

(a) The boat should always steer for the child at heading

\[ \alpha = \tan^{-1} \frac{0.600}{0.800} = 36.9^\circ \]

(b) \( v_x = 20.0 \cos \alpha - 2.50 = 13.5 \text{ km/h} \)

\( v_y = 20.0 \sin \alpha = 12.0 \text{ km/h} \)

\[ \beta = \tan^{-1} \left( \frac{12.0 \text{ km/h}}{13.5 \text{ km/h}} \right) = 41.6^\circ \]

(c) \( t = \frac{d_y}{v_y} = \frac{0.600 \text{ km}}{12.0 \text{ km/h}} = 5.00 \times 10^{-2} \text{ h} = 3.00 \text{ min} \)

4.46 After the string breaks the ball is a projectile, for time \( t \) in

\[ y = v_y t + \frac{1}{2} a_y t^2 \]

\[-1.20 \text{ m} = 0 + \frac{1}{2} (-9.80 \text{ m/s}^2)t^2 \]

\( t = 0.495 \text{ s} \)

Its constant horizontal speed is

\[ v_x = \frac{x}{t} = \frac{2.00 \text{ m}}{0.495 \text{ s}} = 4.04 \text{ m/s} \]

so before the string breaks

\[ a_c = \frac{v^2}{r} = \frac{(4.04 \text{ m/s})^2}{0.300 \text{ m}} = 54.4 \text{ m/s}^2 \]

5.44 \( m_{\text{suitcase}} = 20.0 \text{ kg}, \quad F = 35.0 \text{ N} \)

(a) \( F \cos \theta = 20.0 \text{ N} \)

\[ \cos \theta = \frac{20.0}{35.0} = 0.571, \quad \theta = 55.2^\circ \]

(b) \( n = F_g - F \sin \theta = [196 - 35.0(0.821)] \text{ N} \)

\[ n = 167 \text{ N} \]
4.57 Choose upward as the positive y-direction and leftward as the positive x-direction. The vertical height of the stone when released from A or B is

\[ y_i = (1.50 + 1.20 \sin 30.0^\circ) \text{ m} = 2.10 \text{ m} \]

(a) The equations of motion after release at A are

\[ v_y = v_i \sin 60.0^\circ - gt = (1.30 - 9.80t) \text{ m/s} \]

\[ v_x = v_i \cos 60.0^\circ = 0.750 \text{ m/s} \]

\[ y = (2.10 + 1.30t - 4.90t^2) \text{ m} \]

\[ \Delta x_A = (0.750t) \text{ m} \]

When \( y = 0 \), \( t = \frac{-1.30 \pm \sqrt{(1.30)^2 + 41.2}}{-9.80} = 0.800 \text{ s} \)

Then, \( \Delta x_A = (0.750)(0.800) \text{ m} = 0.600 \text{ m} \)

(b) The equations of motion after release at point B are

\[ v_y = v_i(-\sin 60.0^\circ) - gt = (-1.30 - 9.80t) \text{ m/s} \]

\[ v_x = v_i \cos 60.0^\circ = 0.750 \text{ m/s} \]

\[ y_i = (2.10 - 1.30t - 4.90t^2) \text{ m} \]

When \( y = 0 \), \( t = \frac{+1.30 \pm \sqrt{(-1.30)^2 + 41.2}}{-9.80} = 0.536 \text{ s} \)

Then, \( \Delta x_B = (0.750)(0.536) \text{ m} = 0.402 \text{ m} \)

(c) \[ a_r = \frac{v^2}{r} = \frac{(1.50 \text{ m/s})^2}{1.20 \text{ m}} = 1.87 \text{ m/s}^2 \text{ toward the center} \]

(d) After release, \( a = -8g = 9.80 \text{ m/s}^2 \text{ downward} \)

5.13 \[ F_g = mg = 900 \text{ N} \]

\[ m = \frac{900 \text{ N}}{9.80 \text{ m/s}^2} = 91.8 \text{ kg} \]

\[ (F_g)_{\text{on Jupiter}} = (91.8 \text{ kg})(25.9 \text{ m/s}^2) = 2.38 \text{ kN} \]
4.48 (a)(b) Since the shot leaves the gun horizontally, the time it takes to reach the target is \( t = \frac{x}{v_i} \).

The vertical distance traveled in this time is

\[
y = -\frac{1}{2} g t^2 = -\frac{g}{2} \left( \frac{x}{v_i} \right)^2 = Ax^2
\]

where \( A = -\frac{g}{2v_i^2} \)

(c) If \( x = 3.00 \text{ m} \), \( y = -0.210 \text{ m} \), then \( A = \frac{-0.210}{9.00} = -2.33 \times 10^{-2} \)

\[
v_i = \sqrt{\frac{-g}{2A}} = \sqrt{\frac{-9.80}{-4.66 \times 10^{-2}}} \text{ m/s} = 14.5 \text{ m/s}
\]

*5.1 For the same force \( F \), acting on different masses

\[
F = m_1 a_1 \quad \text{and} \quad F = m_2 a_2
\]

(a) \( \frac{m_1}{m_2} = \frac{a_2}{a_1} = \frac{1}{3} \)

(b) \( F = (m_1 + m_2) a = 4m_1 a = m_1 (3.00 \text{ m/s}^2) \)

\[
a = 0.750 \text{ m/s}^2
\]

*5.8 \( F_g = mg \)

1 pound = (0.453 592 37 kg)(32.1740 ft/s^2) \( \left( \frac{12.0 \text{ in}}{1 \text{ ft}} \right) \left( \frac{0.0254 \text{ m}}{1 \text{ in.}} \right) = 4.45 \text{ N} \)

5.9 \( m = 4.00 \text{ kg}, v_i = 3.00i \text{ m/s}, v_f = (8.00i + 10.0j) \text{ m/s}, t = 8.00 \text{ s} \)

\[
a = \frac{\Delta v}{t} = \frac{(5.00i + 10.0j)}{8.00} \text{ m/s}^2
\]

\[
F = ma = (2.50i + 5.00j) \text{ N}
\]

\[
F = \sqrt{(2.50)^2 + (5.00)^2} = 5.59 \text{ N}
\]

5.12 (a) \( F_g = mg = 120 \text{ lb} = \left( \frac{4.448 \text{ N}}{1 \text{ lb}} \right) (120 \text{ lb}) = 534 \text{ N} \)

(b) \( m = \frac{F_g}{g} = \frac{534 \text{ N}}{9.80 \text{ m/s}^2} = 54.5 \text{ kg} \)
5.19  Choose the x-axis forward. Then
\[ \Sigma F_x = ma_x \]

\[ (2000 \text{ Ni}) - (1800 \text{ Ni}) = (1000 \text{ kg}) a \]

\[ a = 0.200 \text{ m/s}^2 \]

(b) \[ x_f - x_i = v_i t + \frac{1}{2} a t^2 = 0 + \frac{1}{2} (0.200 \text{ m/s}^2)(10.0 \text{ s})^2 = 10.0 \text{ m} \]

(c) \[ v_f = v_i + at = 0 + (0.200 \text{ m/s}^2)(10.0 \text{ s}) = 2.00 \text{ m/s} \]

5.21 (a) 15.0 lb up  (b) 5.00 lb up  (c) 0

5.27 (a) Isolate either mass
\[ T + mg = ma = 0 \]

\[ |T| = |mg| \]

The scale reads the tension \( T \), so
\[ T = mg = 5.00 \text{ kg} \times 9.80 \text{ m/s}^2 \]

\[ = 49.0 \text{ N} \]

(b) Isolate each mass
\[ T_2 + 2T_1 = 0 \]

\[ T_2 = 2|T_1| = 2mg \]

\[ = 98.0 \text{ N} \]

(c) \[ \Sigma F = n + T + mg = 0 \]

Take the component along the incline
\[ n_x + T_x + mg_x = 0 \]

or \[ 0 + T - mg \sin 30.0^\circ = 0 \]

\[ T = mg \sin 30.0^\circ = \frac{mg}{2} = \frac{(5.00)(9.80)}{2} \]

\[ = 24.5 \text{ N} \]
mg \sin 5.00^\circ - f = ma_x \quad \text{and} \quad f = \mu mg \cos 5.00^\circ

\therefore \quad g \sin 5.00^\circ - \mu g \cos 5.00^\circ = a_x

a_x = g(\sin 5.00^\circ - \mu \cos 5.00^\circ) = -0.903 \text{ m/s}^2

From Equation 2.12,

\[ v_f^2 - v_i^2 = 2ax \]

\[ -(20.0)^2 = -2(0.903)x \]

\[ x = 221 \text{ m} \]

5.50 Let \( a \) represent the positive magnitude of the acceleration \(-a_j\) of \( m_1 \), of the acceleration \(-a_i\) of \( m_2 \), and of the acceleration \(+a_j\) of \( m_3 \). Call \( T_{12} \) the tension in the left rope and \( T_{23} \) the tension in the cord on the right.

For \( m_1 \), \( \Sigma F_y = m a_y \quad +T_{12} - m_1 g = -m_1 a \)

For \( m_2 \), \( \Sigma F_x = m a_x \quad -T_{12} + \mu_i n + T_{23} = -m_2 a \)

and \( \Sigma F_y = m a_y \quad n - m_2 g = 0 \)

for \( m_3 \), \( \Sigma F_y = m a_y \quad T_{23} - m_3 g = +m_3 a \)

we have three simultaneous equations

\[-T_{12} + 39.2 \text{ N} = (4.00 \text{ kg})a \]

\[+T_{12} - 0.350(9.80 \text{ N}) - T_{23} = (1.00 \text{ kg})a \]

\[+T_{23} - 19.6 \text{ N} = (2.00 \text{ kg})a \]

(a) Add them up:

\[+39.2 \text{ N} - 3.43 \text{ N} - 19.6 \text{ N} = (7.00 \text{ kg})a \]

\[a = 2.31 \text{ m/s}^2, \text{ down for } m_1, \text{ left for } m_2, \text{ and up for } m_3 \]

(b) Now \(-T_{12} + 39.2 \text{ N} = 4.00 \text{ kg}(2.31 \text{ m/s}^2)\)

\[T_{12} = 30.0 \text{ N} \]

and \( T_{23} - 19.6 \text{ N} = 2.00 \text{ kg}(2.31 \text{ m/s}^2) \)

\[T_{23} = 24.2 \text{ N} \]