1.4) Speed: \( s = 34.0 \text{ m/s} \)
   a) \( 1 \text{ m}^2 = 1.609 \text{ km} \)
   \[ s = 34.0 \frac{\text{m}}{\text{s}} \times 1.609 \frac{\text{km}}{\text{m}} \]
   \[ s = 54.706 \frac{\text{km}}{\text{h}} \]
   b) \( 1 \text{ km} = 10^3 \text{ m} \)
   \[ s = 54.706 \frac{\text{km}}{\text{h}} \times 10^3 \frac{\text{m}}{\text{km}} \times \frac{1}{3600} \frac{\text{h}}{\text{s}} \]
   \[ s = 15.196 \frac{\text{m}}{\text{s}} \]

1.7) a) \( F = m a \)
   \[ [F] = [m] \times [a] \]
   \[ [F] = [m] \times [L] \]
   \[ [F] = [L][T] \]
   \[ \text{correct dimensions} \]

   b) \( x = \frac{1}{2} a t^2 \)
   \[ [x] = [L] \]
   \[ [L] = [L] \times [T]^2 \]
   \[ [L] \neq [L][T] \]
   \[ \text{incorrect dimensions} \]

   c) \( E = \frac{1}{2} m v^2 \)
   \[ [E] = [m] \times [v]^2 \]
   \[ [E] = [m] \times [L][T]^2 \]
   \[ [E] = [L][T]^2 \]
   \[ \text{incorrect dimensions} \]

   d) \( E = m a x \)
   \[ [E] = [m] \times [a] \times [x] \]
   \[ [E] = [L][T]^2 \]
   \[ \text{correct dimensions} \]

   e) \( v = \sqrt{\frac{F}{2m}} \)
   \[ [v] = [L]/[T] \]
   \[ [v] = [L][T]^{-1} \]
   \[ \text{correct dimensions} \]

1.10) \( T = \sqrt[3]{\frac{L}{g}} \)

What are the dimensions of \( g \)?

\[ [T] = \sqrt[3]{[L][T]^2} \]
\[ [T]^3 = [L][T]^2 \]
\[ [L][T]^2 = [m] \]
\[ [T]^3 = [T]^2 \]

The dimensions of \( g \) have to be \([L][T]^2\]
for the equation to be dimensionally correct.
1.4) What is the horizontal distance $x$ between the balloons?

$\mu = \text{difference in height of the balloons}$

$\mu = 61.0\text{ m} - 48.3\text{ m} = 12.8\text{ m}$

$\tan 13.3^\circ = \frac{\mu}{x}$

$x = \frac{\mu}{\tan 13.3^\circ}$

$x = \frac{12.8\text{ m}}{\tan 13.3^\circ} = 54.1\text{ m}$

2.2) $r = 1.5\text{ km}$

a) What is the distance the couple traveled after walking $\frac{3}{4}$ of the way around the lake?

Circumference $= \pi r$

$= 3.14 \times 9.42\text{ m} = 30.065\text{ m}$

Distance traveled $= \frac{3}{4} \times \text{Circumference} = 7.065\text{ m}$

b) What is the magnitude and direction of the displacement?

$R = \sqrt{r^2 + r^2}$

$R = 2.13\text{ m}$

$\theta = \tan^{-1}\left(\frac{x}{r}\right)$

$\theta = \tan^{-1}(1)$

$\theta = 45^\circ$ North of East

2.8) 6.44 km $= 6.44 \times 10^3\text{ m}$

We know that $t_E = \frac{x_E}{v_E}$ and $t_W = \frac{x_W}{v_W}$.

The average velocity $v$ is $v = \frac{x_E + x_W}{t_E + t_W}$.

We are only given velocities and distances,
so we need to substitute our equations for time.
\[ u = \frac{(x_e + x_w)}{u_e + u_w} \]

We need to solve for the distance traveled east.

\[ u(u_e + u_w) = x_e + x_w \]
\[ u_x + u_x u_w = x_e + x_w \]
\[ u_x = x_e + x_w - u_x u_w \]
\[ x_e \left( \frac{u_x}{u_x - 1} \right) = x_w \left( \frac{u_x}{u_x - 1} \right) \]
\[ x_e = \frac{x_w (u_x - 1)}{u_x - 1} \]

Now we can plug in our numbers

\[ x_e = \left( -\frac{1134 \text{ m/s}}{6441 \text{ m/s}} \right)(2.0) \]
\[ x_e = 1610 \text{ m} \]

2.18) Motorcycle A : \( a_A = 2.0 \text{ m/s}^2 \), \( u_{0A} \)
Motorcycle B : \( a_B = 4.0 \text{ m/s}^2 \), \( u_{0B} \)

Subtract the two velocity equations

\[ v - u = u_{0A} + a_A t - u_{0B} - a_B t \]
\[ 0 = u_{0A} + u_{0B} + a_A t - a_B t \]
\[ u_{0A} - u_{0B} = -(a_B - a_A) t \]
\[ u_{0A} - u_{0B} = -t(a_B - a_A) \]
\[ = -4.0 \text{ m/s} \left( 2.0 \text{ s}^2 - 4.0 \text{ s}^2 \right) \]
\[ = -4.0 \text{ m/s} \left( -2.0 \text{ s}^2 \right) \]
\[ = 8 \text{ m/s} \]

2.19) \( v_f = 0 \)
\( x_f = 6.0 \text{ m} \)
\( t_f = 0 \)
\( t_f = 1.5 \text{ s} = t \)

\[ \vec{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{6.0 \text{ m/s}}{1.5 \text{ s}} \]

\[ x = u_0 t + \frac{1}{2} \vec{a} t^2 \]
\[ x = \frac{1}{2} \vec{a} t^2 \quad (\text{since } u_0 = 0) \]
\[ x = \frac{1}{2} \left( \frac{6.0 \text{ m/s}}{1.5 \text{ s}} \right) t^2 \]
\[ x = \frac{1}{2} \left( 4.0 \text{ m/s} \right)^2 \left( 1.5 \text{ s} \right)^2 = 4.5 \text{ m} \]
2.33) \( v_1 = 0 \quad v_x = 36 \text{ cm/s} \quad x = 3.0 \text{ cm} \\

a) \quad v^2 = v_0^2 + 2ax \\
v^2 = 2ax \\
A = \frac{v^2}{2a} \\
A = \frac{(36 \text{ cm/s})^2}{2 \times 3 \text{ cm}} \\
A = 169 \text{ cm}^3 \\

b) \quad x = \frac{1}{2} (v_0 + v)t \\
x = \frac{1}{2} vt \\
t = \frac{2x}{v} \\
t = \frac{2(3.0 \text{ cm})}{(36 \text{ cm/s})} \\
t = 0.16 \text{ s} \\

2.40) \quad \begin{align*}
\text{Calculate the distances.} \\
\mu &= v_0t + \frac{1}{2}at^2 \\
\mu &= \frac{1}{2}at^2 \quad (\text{since } v_0 = 0)
\end{align*}
\\
A = \text{gravity} \quad \mu = 9.8 \text{ m/s}^2
\\
<table>
<thead>
<tr>
<th>t (ms)</th>
<th>t (s)</th>
<th>a (m/s^2)</th>
<th>\mu</th>
<th>d_1</th>
<th>d_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.06</td>
<td>9.8</td>
<td>0.018</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>0.12</td>
<td>9.8</td>
<td>0.07</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>0.18</td>
<td>9.8</td>
<td>0.16</td>
<td>0.16</td>
<td></td>
</tr>
</tbody>
</table>

2.55) \( \mu \): the position above the ground where the balls meet \\
\( t \): the time at which the balls meet \\
ball 1: dropped ball \\
ball 2: thrown ball
ball 1: \[ \mu = v_0t + \frac{1}{2}at^2 + h \]
\[ v = \frac{1}{2}at^2 + h \]

ball 2: \[ v = v_0t + \frac{1}{2}at^2 \]

We can now combine these two equations because \( v = \mu \).

\[ h + \frac{1}{2}at^2 = v_0t + \frac{1}{2}at^2 \]
\[ h = v_0t \]
\[ t = \frac{h}{v_0} \]

We are told that the initial velocity of the second ball is the same velocity as the first ball when it hits the ground. Remember that if we set "up" as the positive direction the velocity and distance traveled by ball 1 will be negative.

\[ v^2 = v_0^2 + 2ah \]
\[ v^2 = 2ah \]
\[ v = \sqrt{2ah} \]
\[ v = \sqrt{2 \times 9.8 \times (-24 \text{ m})} \]
\[ v = \sqrt{470.4 \text{ m}^2/\text{s}^2} \]
\[ v = 21.69 \text{ m/s} = v_0 \]

Now we can find \( t \).

\[ t = \frac{h}{v_0} \]
\[ t = \frac{21.69 \text{ m}}{21.69 \text{ m/s}} = 1.107 \text{ s} \]
Using the equation from ball 1 we can find $\mu$.

\[
\mu = \frac{1}{2} g t^2 + h \\
\mu = \frac{1}{2} (9.8 \text{ m/s}^2) (1.107 \text{ s})^2 + 24 \text{ m} \\
\mu = -6 \text{ m} + 24 \text{ m} \\
\mu = 18 \text{ m}
\]

The ball reach the same height 6m below the top of the cliff which is 18m above the ground.

2.58) \( \bar{V} = \frac{X_f - X_i}{T_f - T_i} \)

A = \frac{10.0 \text{ km} - 40.0 \text{ km}}{1.5 \text{ hr} - 0 \text{ hr}} = -20 \frac{\text{ km}}{\text{ hr}}

B = \frac{20 \text{ km} - 10 \text{ km}}{2.5 \text{ hr} - 1.5 \text{ hr}} = 10 \frac{\text{ km}}{\text{ hr}}

C = \frac{40 \text{ km} - 50 \text{ km}}{3.0 \text{ hr} - 2.5 \text{ hr}} = 40 \frac{\text{ km}}{\text{ hr}}

1) \( v_0 = 15 \frac{\text{ km}}{\text{ hr}} \)

A = -5 \frac{\text{ km}}{\text{ hr}^2}

X = 33.60 \text{ km} \quad (\text{www.mapcctow.friago})

We know how to find the final velocity of the hurricane.

\[
\begin{align*}
V^2 &= V_0^2 + 2ax \\
V &= \sqrt{V_0^2 + 2ax}
\end{align*}
\]

We can now use this velocity to find out the amount of time it takes for it to go over Tampa.
\[ t = \frac{(v_0 - v_f)}{a} \]

Plugging in \( v \)...

\[ t = \frac{\sqrt{v_0^2 + 2ax} - v_0}{a} \]

\[ t = \frac{(\sqrt{(15 \text{ km/hr})^2 + 2(-5 \text{ km/hr})(33.60 \text{ km})}) - 15 \text{ km/hr}}{-5 \text{ km/hr}} \]

\[ t = \frac{(\sqrt{-111 \text{ km/hr}^2} - 15 \text{ km/hr})}{-5 \text{ km/hr}} \]

This causes problems. Time is not supposed to be an irrational number. To find out what this means try plugging around with the equations to try and get some useful information. We know that the hurricane is slowing down so how long does it take for it to stop?

\[ v_0 = 15 \frac{\text{km}}{\text{hr}} \quad v_f = 0 \quad a = -5 \frac{\text{km}}{\text{hr}^2} \quad t = ? \]

\[ v_f = v_0 + at \]

\[ 0 = 15 \frac{\text{km}}{\text{hr}} + (-5 \frac{\text{km}}{\text{hr}^2})t \]

\[ (5 \frac{\text{km}}{\text{hr}^2})t = 15 \frac{\text{km}}{\text{hr}} \]

\[ t = 3 \text{ hr} \]

Now we can find out how far the hurricane traveled in 3 hr.

\[ x(t) = v_0t + \frac{1}{2}at^2 \]

\[ x(t) = (15 \frac{\text{km}}{\text{hr}})(3 \text{ hr}) + \frac{1}{2}(-5 \frac{\text{km}}{\text{hr}^2})(3 \text{ hr})^2 \]

\[ x(t) = 22.5 \text{ km} \]

If the distance between Clearwater and Tampa is 33.60 km the hurricane won't even make it to Tampa.
b) Since velocity is distance over time we can solve for the time before C+C got stopped and the time after they got stopped.

\[ T_{total} = t_1 + t_2 + t_{bummer} \]

\[ t_1: \quad \frac{c}{t_1} = \frac{D_1}{v} \]
\[ t_1 = \frac{D_1}{c} \]

\[ t_2: \quad \frac{c}{t_2} = \frac{D_2}{v} \]
\[ t_2 = \frac{D_2}{c} \]

\[ T_{total} = \frac{D_1}{c} + \frac{D_2}{c} + t_{bummer} \]

c) What is their average velocity?

\[ \bar{v} = \frac{\text{distance traveled}}{\text{elapsed time}} \]
\[ \bar{v} = \frac{D_1 + D_2}{(D_1/c) + (D_2/c) + t_{bummer}} \]

Keep in mind that C+C were stopped for the time of bummer but it still needs to be figured into the average velocity calculation because they still had a velocity, it was 0 m/s.
Notice that $\theta_1$ is greater than $\theta_2$. This is because they reduced their velocity by half after being pulled over. Also note that the tan of $\theta_1 + \theta_2$ gives $C$ and $\frac{g}{a}$.

3) \[ 3.14 \times 10^7 \text{ s} \div 60 \frac{\text{s}}{\text{min}} = 523333 \text{ min} \]
\[ 523333 \text{ min} \div 60 \frac{\text{min}}{\text{hr}} = 8722.29 \text{ hr} \]
\[ 8722.29 \text{ hr} \div 24 \frac{\text{hr}}{\text{day}} = 363.43 \text{ days} \approx 1 \text{ year} \]

4) 1 nanosecond = $10^{-9}$ seconds
To put this in perspective, how many feet would the object in question travel in 1 second?

\[ 1 \frac{\text{ft}}{\text{s}} = 1 \frac{\text{ft}}{10^{-9} \text{s}} = 1 \times 10^9 \frac{\text{ft}}{\text{s}} \]

If Dr. Rosencu's Honda Civic could do this, I would be highly impressed but my money is on d) light and a vacuum.

5) We know from the book...

\[ v = v_0 + at \]

If the final velocity is $\frac{1}{3}$ of the initial
velocity we have the following:

\[
\begin{align*}
\frac{\Delta v}{\Delta t} &= v_f - v_i \\
\Delta t &= \frac{v_f - v_i}{\Delta v} \\
\end{align*}
\]

Remember that gravity is accelerating the ball in the opposite direction of its motion.

<table>
<thead>
<tr>
<th>(v_f)</th>
<th>(\Delta v)</th>
<th>(\Delta t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 m/s</td>
<td>10 m/s^2</td>
<td>0.05 s</td>
</tr>
<tr>
<td>10 m/s</td>
<td>10 m/s^2</td>
<td>0.5 s</td>
</tr>
<tr>
<td>10 m/s</td>
<td>5 m/s^2</td>
<td>1.0 s</td>
</tr>
</tbody>
</table>

6) What we want to find is the initial velocity, \(v_i\). We can use the kinematic equations to give us an equation for the height of the ball as a function of time.

\[ x(t) = h + v_i t - \frac{1}{2} a t^2 \]

Where \(h\) is the height of the window, \(a\) is the acceleration due to gravity, and \(t\) is the time. We can find the time it takes for the sound to reach the window.

\[ v_f = \frac{h}{t} \]

If the total time is \(T\), we can find the time it took for the ball to hit the ground.
\[ t' = T - \frac{h}{u_0^2} \]

We can also say that \( x(t') = 0 \) because the ball is on the ground (0 height). Now we can solve for \( u_0 \).

\[
\begin{align*}
    x(t') &= 0 = h + u_0 t' - \frac{1}{2} a t'^2 \\
    u_0 t' &= \frac{1}{2} a t'^2 - h \\
    u_0 &= (\frac{1}{2} a t'^2 - h) / t'
\end{align*}
\]

It would be good practice to check this problem using dimensional analysis.