Multiple choice: Each question is worth 5 points.

1. A ball is thrown straight up into the air in one-dimensional motion. At the top of its path, which of the following is/are correct?

<table>
<thead>
<tr>
<th>A. The velocity is a maximum.</th>
<th>B. The velocity is zero.</th>
<th>C. The acceleration is zero.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. The acceleration changes.</td>
<td>E. Both B &amp; C.</td>
<td>F. Both B &amp; D.</td>
</tr>
</tbody>
</table>

2. A ball is launched across this room at an angle of 45.0° above the horizontal. Which of the following statements about the ball is/are correct?

<table>
<thead>
<tr>
<th>A. Its velocity in the horizontal (x) direction is always changing.</th>
<th>B. Its velocity in the horizontal (x) direction is always constant.</th>
<th>C. Its velocity in the vertical (y) direction is always changing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. Both A &amp; C.</td>
<td>E. Both B &amp; C.</td>
<td>F. None of these.</td>
</tr>
</tbody>
</table>

3. Force, \( F \), is measured in units of \((\text{kg m}^2)/\text{s}^2\). Position, \( x \), is measured in units of meters (m). Velocity, \( v \), is measured in units of m/s. Something known as a "spring constant", \( k \), is measured in units of \((\text{kg m})/\text{s}^2\). Which of the following is a possibly valid equation?

   | A. \( F = xv \) | B. \( F = kx \) | C. \( F = kv \) | D. None of these |

4. Acceleration is defined as

   | A. a change in position per time. | B. a change in velocity per time. | C. a change in force per time. |

5. Two divers run horizontally off the edge of a diving board. "Diver 2" has twice the velocity as "Diver 1". The time that Diver 2 will be in the air is:

   | A. exactly as much as the time of "Diver 1" | B. twice as much as the time of "Diver 1" | C. four times as much as the time of "Diver 1" | D. Additional information is needed to answer this question. |

6. The graph displayed below (of velocity versus time) demonstrates motion in which:

   | A. the velocity is constant | B. the acceleration is constant | C. both A & B | D. neither A nor B |
**Situation I: Fun on a gondola (40 points):**

A. [10 points] A gondola is a proposed method of moving students from downtown Ogden to campus. Its average speed might be about 13.0 miles per hour. How fast is this in units of meters per second?

\[
13.0 \text{ miles/hr} \left( \frac{1.609 \text{ km}}{1 \text{ mile}} \right) \left( \frac{1000 \text{ m}}{1 \text{ km}} \right) = 5.81 \text{ m/s}
\]

B. [15 points] While moving southbound in the gondola (at 13.0 miles per hour), you roll a bowling ball across the glass floor of the gondola directly to the east from your perspective at a speed of 10.0 miles per hour. From a ground-based observer's point of view, looking up through the glass floor of your gondola, what is the total velocity (including direction) of the bowling ball? (Your answer may be in either miles per hour or meters per second.)

\[
\begin{align*}
\sqrt{V^2} &= \sqrt{(10 \text{ mph})^2 + (13 - 10 \text{ mph})^2} \\
V &= 16.4 \text{ mph} \\
\theta &= \frac{7.33 \text{ mph}}{10 \text{ mph}} = 0.733 \\
\theta &= 37.6^\circ \text{ E of S}
\end{align*}
\]

C. [15 points] The bowling ball "accidentally" rolls out of the east side of the gondola while it is in the motion described in part B, above. (The "accident" is particularly curious, since the bowling ball is dropped at the same time you see your physics professor riding his bicycle below you.) If the gondola is 8.00 feet above the ground, how long is the ball in the air before it reaches the street below?

\[
\begin{align*}
\Delta t &= \frac{\Delta x}{a} + \frac{1}{2} \frac{a}{v^2} \\
\Delta t &= \frac{0 - 0}{-9.81 \text{ m/s}^2} + \frac{1}{2} \frac{-9.81 \text{ m/s}^2}{v^2} \\
\Delta t &= \frac{\sqrt{2(8.00 \text{ ft})}}{\sqrt{32 \text{ ft/s}}^2} = 1.28 \text{ s}
\end{align*}
\]
Situation II: Botanical revolution (30 points):
A botanist, as shown, is using her physics expertise to launch bags of potting soil (100 lbs. each!) onto the lawn below the Science Lab building. The launch speed is 10.0 m/s at an angle that is 30.0° away from the side of the 18.0-m building. (Note that this means that the launch is slightly downward, rather than upward or horizontal.)

A. [15 points] How far away from the building does the potting soil land?

\[ x = x_0 + v_{0x}t + \frac{1}{2}a_xt^2 \]

\[ x = (N_0 \cos \theta)t \]

\[ x = (10 \text{m/s} \cos 30°)(1.23 \text{ s}) \]

\[ x = 6.15 \text{ m} \]

B. [15 points] What is the total velocity (including the direction) of the potting soil as it reaches the ground?

\[ v_x = v_{0x} = v_0 \cos 30° = 5.00 \text{ m/s} \]

\[ v_y^2 = v_{0y}^2 + 2a_y(\Delta y) = (v_0 \sin 30°)^2 + 2(9.81 \text{ m/s}^2)(18 \text{ m}) \]

\[ v_y = \sqrt{(10 \text{ m/s} \sin 30°)^2 + 2(9.81 \text{ m/s}^2)(18 \text{ m})} = 20.7 \text{ m/s} \]

\[ v^2 = v_x^2 + v_y^2 \]

\[ v = \sqrt{21.3 \text{ m/s}^2} \]

\[ \Theta = 13.6° \text{ away from straight down} \]