Test 1

Name: [Handwritten name]

Place an X next to your Problems Lab section:

- Frank (TR 11:20 – 1:50)
- Weller (TR 2:40 – 5:10)
- Kavich (TR 6:00 – 8:30)
- Ford (MW 1:15 – 3:45)
- Youngkins (WF 8:00 – 10:30)
- Smith (WF 8:00 – 10:30)
- Youngkins (WF 11:30 – 2:00)
- Kavich (WF 6:00 – 8:30)

⇒ The following test consists of two parts. Part I contains 10 multiple choice questions worth 3 points each. Part II contains 3 problems worth a total of 70 points.
⇒ **Multiple Choice:** There is no partial credit for the multiple choice questions. Choose the **best** answer from the choices provided. Write the letter of the best answer in the boxes provided on page 3.
⇒ **The Problems:** To receive full credit on the problems, all reasoning must be shown and any numerical answer must have the appropriate units. Box in your final answer.
⇒ **Rounding:** Round final answers to two decimal places, if necessary.
⇒ Ask if you don’t understand the statement of a given problem.
⇒ Cell phones must be put in silent or vibrate mode and put away. Anybody caught using a cell phone during the test will receive a zero grade.
⇒ You may not leave the room during the exam unless you have permission from one of the proctors.
⇒ **CHEATING:** Cheating in any form will not be tolerated, and will result in a zero grade for this test. A formal complaint may also be submitted to the Office of Judicial Affairs. Refer to the course syllabus for further details.
⇒ You should have only a pencil, eraser, calculator, and the test papers out – all other material should be put away.

You have **1 hour and 25 minutes** to complete this exam.

GOOD LUCK!

---

Instructor use only:

<table>
<thead>
<tr>
<th>MC</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part I – Multiple Choice (3 points each)

Choose the best answer to each of the following questions. Write your answers in the spaces provided at the bottom of page 3.

1. What is a speed of 75 mi/h (miles per hour) in meters per second? (Note: 1 mi = 1.6 km.)
   A. 5.9 m/s
   B. 33.3 m/s
   C. 0.033 m/s
   D. 169 m/s
   E. 2000 m/s

   \[
   \frac{75 \text{ mi}}{\text{h}} \times \frac{1 \text{ h}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} \times \frac{1.6 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} = 33.3 \text{ m/s}
   \]

2. While the rock was moving upwards, its y-component of acceleration was
   A. positive  B. zero  C. negative

3. While the rock was moving upwards, its y-component of velocity was
   A. positive  B. zero  C. negative

4. Compared to when the rock was moving upwards, when the rock was falling back down its y-component of acceleration _______ and its y-component of velocity _______.
   A. kept the same sign; changed sign
   B. changed sign; kept the same sign
   C. remained zero; kept the same sign
   D. changed sign; changed sign
   E. kept the same sign; kept the same sign
   F. kept the same sign; remained zero

5. Dr. Klumpe, a professor in the Physics and Astronomy department, has a new Harley Davidson motorcycle which he loves to ride. Riding in the direction shown in the diagram, along a nice straight roadway, Dr. Klumpe’s x-component of acceleration is \(-3.7 \text{ m/s}^2\). Which of the following statements best describes what is happening to Dr. Klumpe?

   A. He is slowing down, because the x-component of acceleration is negative.
   B. He is speeding up, because the x-component of acceleration is in the same direction as Dr. Klumpe’s motion.
   C. He is speeding up, because the x-component of acceleration points in the positive x-direction.
   D. He is slowing down, because the x-component of acceleration points in the negative x-direction.
   E. He is moving with a constant speed.
6. Which of the following graphs represents an object moving with constant speed?

A. \[ \begin{array}{c}
\text{v (m/s)} \\
\text{0} \quad \text{t (s)}
\end{array} \]

B. \[ \begin{array}{c}
\text{v (m/s)} \\
\text{0} \quad \text{t (s)}
\end{array} \]

C. \[ \begin{array}{c}
\text{x (m)} \\
\text{0} \quad \text{t (s)}
\end{array} \]

D. \[ \begin{array}{c}
\text{x (m)} \\
\text{0} \quad \text{t (s)}
\end{array} \]

E. Both graphs B and C
F. Both graphs A and C
G. Both graphs A and B

7. An car starts from rest and speeds up at a constant rate of 5.5 m/s² as it drives on a long, straight road. How fast is the car moving after 10 s?

A. 9.8 m/s
B. 55 m/s
C. 108 m/s
D. 14 m/s
E. 0.68 m/s

\[ v_{\text{f}} = \frac{d}{dt} v_{\text{f}} = (5.5 \text{ m/s}) (10) = 55 \text{ m/s} \]

8. The length of a truck is 3.6 ± 0.1 m. What is the fractional uncertainty (FU) in the length of the truck?

A. 0.03 m
B. 0.028
C. 0.028 m
D. 0.03
E. 0.1

\[ \text{FU} = \frac{0.1}{3.6} = 0.03 \]

Questions 9 and 10 are on the next page.
Questions 9 and 10 refer to the following position vs. time graph for a toy car. This graph is similar to the position vs. time graphs you made for the toy cars in Activity 1.

9. What does the slope of the position vs. time graph represent?
   A. The speed of the toy car.
   B. The acceleration of the toy car.
   C. The position of the toy car.
   D. The force being applied to the toy car.
   E. None of the above. The slope is a meaningless number.

10. How should you write the equation for the best-fit line in your lab notebook?
    A. \( y = 0.4307x - 0.0272 \)
    B. \( x = 0.4307t - 0.0272 \)
    C. \( y = (0.4307 \text{ m/s})x - 0.0272 \text{ m} \)
    D. \( x = (0.4307 \text{ m/s})t - 0.0272 \text{ m} \)
    E. \( x = 0.4307 \text{ m/s} - 0.0272 \text{ m} \)

Write your multiple choice answers here. This is the ONLY place your answers will be graded!

1  2  3  4  5  6  7  8  9  10
B A C A B F B D A D
Part II – Long Answer Questions

1. (25 pts) A boat was driven (is that the right word for a boat?) back and forth along a long, straight canal. Starting at the jetty, it first traveled 100 m in 16 s in the positive x-direction. Then it immediately reversed direction and moved 355 m at a speed of 7.1 m/s. At this point it stopped for 20 s, before returning to its starting place at the jetty, in a time of 48 s.

(a) (8 pts) Draw a diagram to show the different stages of the boat’s journey. Make sure you label each stage, and be sure to indicate the positive x-direction and the initial and final positions.

(b) (6 pts) List the distance traveled, the time taken, and the speed of the boat for each stage of the boat’s journey. Show all calculations for quantities that are not given in the problem statement.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Distance (d)</th>
<th>Time (t)</th>
<th>Speed (v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100 m</td>
<td>16 s</td>
<td>6.25 m/s</td>
</tr>
<tr>
<td>2</td>
<td>355 m</td>
<td>16 s</td>
<td>7.1 m/s</td>
</tr>
<tr>
<td>3</td>
<td>0 m</td>
<td>20 s</td>
<td>0 m/s</td>
</tr>
<tr>
<td>4</td>
<td>255 m</td>
<td>48 s</td>
<td>5.81 m/s</td>
</tr>
</tbody>
</table>

(c) (5 pts) What was the average speed of the boat for the entire journey?

\[ \bar{v} = \frac{\text{Total Distance}}{\text{Total Time}} = \frac{100 + 355 + 0 + 255}{16 + 16 + 20 + 48} = 5.30 \text{ m/s} \]

(d) (3 pts) What was the average x-component of velocity of the boat for its entire journey?

\[ \bar{v}_{x} = \frac{x_f - x_i}{\Delta t_{total}} = \frac{0 - 0}{50} = 0 \text{ m/s} \]

(e) (3 pts) What was the boat’s x-component of velocity for the second stage of its journey?

\[ v_{x2} = \frac{x_f - x_i}{\Delta t} = \frac{-255 - 100}{50} = -7.1 \text{ m/s} \]
2. (25 pts) A certain physics lab instructor was driving down Middle Tennessee Blvd, doing a constant 15.6 m/s (that's about 35 mi/h). He/she (I don't want to get them in trouble) was approaching a green traffic light when it turned yellow. Faced with that difficult decision — slow down and stop, or floor it and try to beat the light — the instructor decided to floor it. They were 50.0 m from the traffic light when they started speeding up at a constant rate, and they reached the traffic light in 2.5 s.

(a) (23 pts) (i) How fast was the instructor driving when he/she reached the traffic light, and (ii) what was the x-component of acceleration of the car during the time it was speeding up? (I'm not going to break this up into small parts for you; you can solve this however you want. However, for full credit your solution must include a good diagram and a list of the six kinematic quantities.)

\[
x_i = 0 \text{ m} \\
x_f = 50 \text{ m} \\
v_{ix} = 15.6 \frac{\text{m}}{\text{s}} \\
v_{fx} = ? \\
a_x = ? \\
t = 2.5 \text{ s}
\]

\[
x_f = x_i + v_{ix} t + \frac{1}{2} a_x t^2 \\
x_f - v_{ix} t = \frac{1}{2} a_x t^2 \\
2(x_f - v_{ix} t) = a_x t^2 \\
a_x = \frac{2(x_f - v_{ix} t)}{t^2} \\
a_x = 3.52 \frac{\text{m}}{\text{s}^2}
\]

\[
v_{fx} = v_{ix} + a_x t \\
v_{fx} = 24.4 \frac{\text{m}}{\text{s}}
\]

(b) (2 pts) The speed limit along this particular stretch of Middle Tennessee Blvd is 45 mi/h. Was the instructor breaking the speed limit when he/she passed the traffic light? (Writing only "yes" or "no" is not sufficient and will earn you no credit - you must also give a reason for your answer. Hint: the conversion 1 mi = 1.6 km may be useful.)

\[
24.4 \frac{\text{m}}{\text{s}} \times \frac{1 \text{ mi}}{1600 \text{ m}} \times \frac{3600 \text{ s}}{1 \text{ h}} = 54 \text{ mi/h}.
\]

The instructor's speed was 54 mi/h, so they were breaking the speed limit.
3. (20 pts) A baseball is hit straight upwards, taking 3.6 s to reach its highest position before falling back to the ground. The baseball was 0.7 m above the ground when it was hit. Air resistance is negligible in this problem. In the questions that follow, we will be interested in the baseball at its highest position above the ground.

(a) (8 pts) Draw a good diagram for this problem, and list the six kinematic quantities, giving numerical values for any known quantities and placing a question mark for unknown quantities.

![Diagram of a baseball's motion](image)

\[ \begin{align*}
\gamma_i &= 0.7 \text{ m} \\
\gamma &= \gamma_i + v_{iy} \gamma + \frac{1}{2} a_{\gamma} \gamma^2 \\
\gamma &= 0.7 + (35.28)(3.6) + \frac{1}{2}(-9.8)(3.6^2) \\
\gamma &= 64.20 \text{ m}
\end{align*} \]

(b) (5 pts) What was the ball’s initial y-component of velocity?

\[ v_{iy} = v_{iy} + a_{\gamma} \gamma \]

\[ v_{iy} = -a_{\gamma} \gamma \]

\[ v_{iy} = -(9.8)(3.6) \]

\[ v_{iy} = 35.28 \text{ m/s} \]

(c) (5 pts) At its highest, how far above the ground was the ball?

\[ \gamma_i = \gamma_i + v_{iy} \gamma + \frac{1}{2} a_{\gamma} \gamma^2 \]

\[ \gamma_i = 0.7 + (35.28)(3.6) + \frac{1}{2}(-9.8)(3.6^2) \]

\[ \gamma_i = 64.20 \text{ m} \]

For my setup, \( \gamma_i \) is the distance above the ground, so \[ \text{distance} = 64.20 \text{ m} \]

(d) (2 pts) Explain why this is a freefall problem.

The only force acting on the ball is gravity, therefore by definition, this is a freefall problem.