Physics 12 - Unit Exam 1
Mechanics

For the questions that require calculations, use the space provided for the question to show how you arrived at your answer. Use 9.8 m/s² as the acceleration due to gravity at the surface of the earth.

1. A car is traveling at a constant 30 miles per hour. Does this represent a scalar quantity or a vector quantity? Explain.

   This is a scalar because no direction is indicated.

2. Complete the table of units shown below:

<table>
<thead>
<tr>
<th></th>
<th>Mass</th>
<th>Time</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Engineering</td>
<td>slug</td>
<td>second</td>
<td>foot</td>
</tr>
<tr>
<td>System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cgs</td>
<td>gram</td>
<td>second</td>
<td>centimeter</td>
</tr>
<tr>
<td>MKS (or International</td>
<td>kilogram</td>
<td>second</td>
<td>meter</td>
</tr>
<tr>
<td>System of Units)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. A freely falling ball has an acceleration of 9.8 m/s². Explain what this means in terms of the speed of the ball.

   The speed of the ball increases by \(\frac{9.8 m}{s}\) every second.

4. A car is traveling at a constant velocity of 10 m/s for 8 seconds. The car then speeds up at a constant rate of 2 m/s² for 4 seconds.

   a. How far did the car travel during the first 8 seconds?

      \[ \text{distance} = \text{const. vel} \times \text{time} = 10 \times 8 = 80 \text{ m} \]

   b. What is the average velocity of the car during the last 4 seconds?

      \[ \text{avg vel.} = \frac{\text{first} + 1}{2} = \frac{10 + (10+2+2+2)}{2} = \frac{10 + 16}{2} = \frac{26}{2} = 13 \frac{1}{2} \]  

   c. How far did the car travel during the last 4 seconds?

      \[ \text{dist.} = \text{avg vel} \times \text{time} = 13 \frac{1}{2} \times 4 = 56 \text{ m} \]
5. A physics student throws a ball straight upward from the surface of the earth. The ball leaves her hand with a speed of 29.4 m/s.

a. How much time does it take the ball to reach the top of its path?

\[
\begin{align*}
29.4 - 9.8 &= 19.6 \text{ first sec} \\
19.6 - 9.8 &= 9.8 \text{ second sec} \\
9.8 - 9.8 &= 0 \text{ third sec}
\end{align*}
\]

\[\text{3 sec}\]

b. What maximum height does it reach?

\[
\text{distance} = \text{avg vel} \times \text{time}
\]

\[
\text{avg vel} = \frac{29.4 + 0}{2} = 14.7
\]

\[
\text{distance} = 14.7 \times 3 = 44.1 \text{ m}
\]

6. The gravitational acceleration on the moon is roughly 1/6 of the acceleration due to gravity on the earth (about 1.6 m/s\(^2\)). An astronaut on the moon and throws a ball downward at 10 m/s.

a. What is the speed of the ball after 2 seconds?

\[
10 \rightarrow 11.6 \rightarrow 13.2 \frac{\text{m}}{\text{s}}
\]

\[\text{1 sec 2 sec}\]

b. What is the average speed of the ball between the time the ball was thrown (0 seconds) and 2 seconds later?

\[
\text{avg speed} = \frac{13.2 + 10}{2} = \frac{23.2}{2} = 11.6 \frac{\text{m}}{\text{s}}
\]

\[\text{23.2 m}\]

c. How far downward did the ball travel during the 2 seconds?

\[
\text{dist.} = \text{avg speed} \times \text{time} = 11.6 \times 2
\]

\[\text{23.2 m}\]
7. A 120 lb physics student stands on a bathroom scale in an elevator. She notices the reading on the scale to be 110 lb.

   a. What possible motion(s) is the elevator undergoing? Or is it moving at all?
      - speeding up going down
      - slowing going up

   b. If there is a net force on the student, then indicate the direction of the net force.
      down

   c. In what direction is the student accelerating (if there is an acceleration)?
      down

8. A car is traveling to the west at a constant speed of 30 miles/hour. In what direction is the net force acting on the car?
   
   no net force

9. A physics student pushes a 10 kg box from left to right across a smooth (no friction) floor. The horizontal force she exerts is 40 N.

   a. What is the value of the net force and the direction of the net force on the box?
      
      40 N to right

   b. What is the value of the acceleration and the direction of the acceleration of the box?
      
      \[ \text{accel} = \frac{\text{net force}}{\text{mass}} = \frac{40}{10} = 4 \text{ m/s}^2 \]

   c. After the box reaches a speed of 10 m/s, a second student exerts a 40 N horizontal force on the box, but in the opposite direction from the first. What happens to the box? Does it speed up, slow down and stop, or continue at a constant velocity? (Careful!)
      
      The net force = 0, so the box continues from left to right at a constant velocity.
10. A physics student is 60 kg in Santa Monica.
   
   a. How much does the student weigh?
      \[
      \text{weight} = \text{mass} \times g = 60 \times 9.8 = 588 \text{ N}
      \]
      \checkmark
   
   b. Is his mass more, less, or the same when he travels to the top of Mount Whitney, which is over
      14,000 ft above sea level? Explain.
      \text{mass is the same.} \checkmark
   
   b. He then travels to the moon where the acceleration due to gravity is about 1/6 the acceleration
      due to gravity on the earth. How much will he weigh on the moon?
      \[
      \text{weight} = \frac{1}{6} \times 588 = 98 \text{ N}
      \]
      \checkmark

11. A person weighs 140 lb at the surface of the earth.
   
   a. If the mass of the earth suddenly and mysterious doubled, how much will he now weigh.
      \[2 \times 140 = 280 \text{ lb} \checkmark\]
   
   b. A spaceship now lifts him to a height that is two earth radii above the surface of the earth. How
      much does he now weigh?
      \[
      \text{distance triples, so weight goes down by } \frac{1}{9} \\
      \frac{1}{9} \times 280 = 31 \text{ lb}. \checkmark
      \]

12. A physics student lifts her 3 kg physics book straight upward off the floor to a height of 1.5 meters.
    She then carries the book 4 meters across the room keeping the book 1.5 m above the floor.
    
    a. How much work did she do lifting the book from the floor?
      \[
      \text{Work} = \text{force} \times \text{dist.} = \text{weight} \times \text{dist.} = \left(3 \times 9.8 \right) \times 1.5 \\
      = 44.1 \text{ J}. \checkmark
      \]
    
    b. How much work did she do carrying the book across the room?
    \[\checkmark\]
13. When you climb stairs

a. do you do more work when you climb quickly or slowly?
   
   Same

b. do you use more power when you climb quickly or slowly?
   
   quickly, less time more power

14. A 2 kg ball is thrown straight downward at 5 m/s from the top of a cliff that is 40 meters above the ground. Find the gravitational potential energy, the kinetic energy, and the total energy of the ball at the times shown below.

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Gravitational Potential Energy (Joules)</th>
<th>Kinetic Energy (Joules)</th>
<th>Total Energy (Joules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$2 \times 9.8 \times 40 = 784$</td>
<td>$\frac{1}{2} \times 2 \times 5^2 = 25$</td>
<td>809</td>
</tr>
<tr>
<td>1</td>
<td>590</td>
<td>$\frac{1}{2} \times 2 \times 14.8^2 = 219$</td>
<td>809</td>
</tr>
<tr>
<td>2</td>
<td>204</td>
<td>$\frac{1}{2} \times 2 \times 24.6^2 = 605$</td>
<td>809</td>
</tr>
<tr>
<td>just before it hits the ground</td>
<td>zero, we are measuring potential energy from this height</td>
<td>809</td>
<td>809</td>
</tr>
</tbody>
</table>

$\frac{5}{4} + 9.8 = 14.8$
14.8 + 9.6 = 24.6

15. In the previous question, at time zero, the ball starts with some gravitational potential energy and some kinetic energy. After the ball hits the ground, the gravitational potential energy and the kinetic energy are zero. However, we know that the energy is supposed to be conserved. Was it truly conserved in this case? Explain;

energy is always conserved. The missing energy was converted into heat and sound energy.