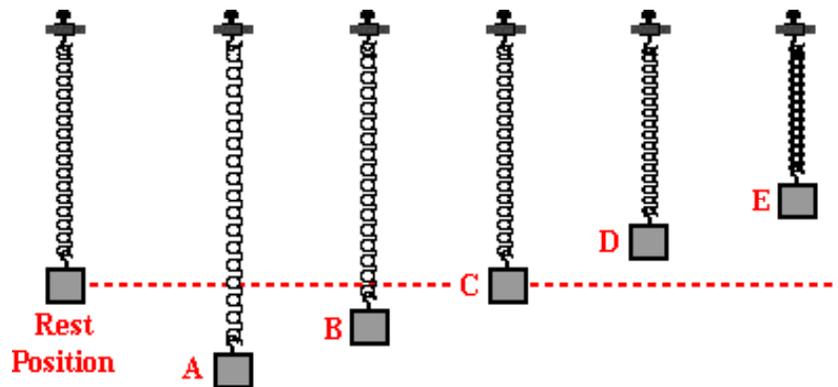


## Mass on a Spring

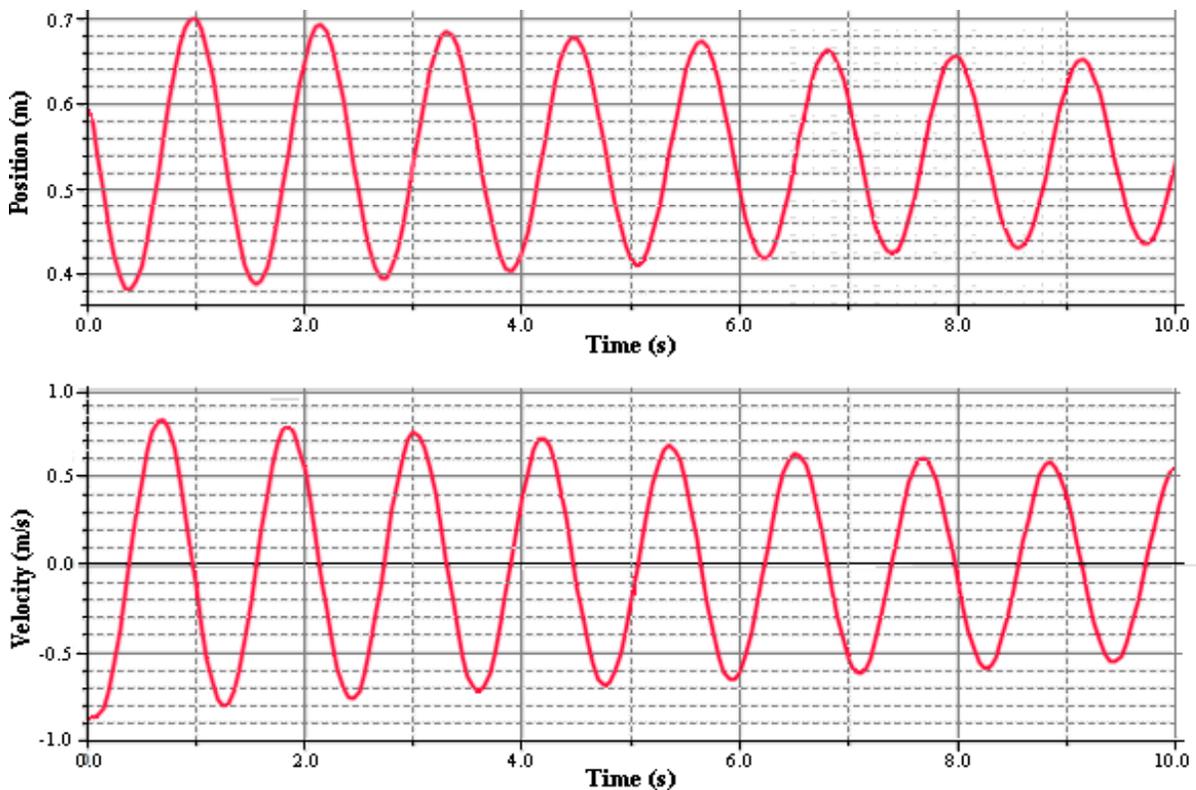
When a mass is suspended on a spring, the mass hangs at its **rest position**. If the mass is pulled below its rest position and released, it begins to vibrate up and down. It moves from position A to B to C (the original rest position) to D to E, and then back down to A. See **Figure 1**. The motion repeats itself in cyclic fashion over and over again.

**Figure 1: Up and Down Motion of a Mass on a Spring**



The vertical position is not the only property of the mass that changes over time. The velocity of the mass also changes. **Velocity** describes how fast an object moves and in what direction it moves. A + and - sign is used to indicate the directional aspect of velocity. A + sign indicates an upward direction of motion and a - sign indicates a downward direction of motion. If a motion detector is placed below the vibrating mass, it will detect the vertical position (height above the detector) and velocity as a function of time. The resulting graphical display is shown in **Figure 2**.

**Figure 2: Plots of Position and Velocity as a Function of Time**



## Questions

- At which one of the following times is the mass located at a highest vertical position?
  - 1.0 seconds
  - 3.0 seconds
  - 3.9 seconds
  - 5.9 seconds
- At which of the following times is the mass moving with a velocity of 0.40 m/s?
  - 0.5 seconds
  - 2.7 seconds
  - 8.1 seconds
  - 9.0 seconds
- At which one of the following times is the mass located at position E?
  - 1.0 seconds
  - 3.0 seconds
  - 3.9 seconds
  - 5.9 seconds
- According to **Figure 2**, at which of the following times is the mass located below its rest position and moving in the downward direction?
  - 2.0 seconds
  - 4.0 seconds
  - 6.0 seconds
  - 7.0 seconds
- A vibrating mass is often described as having a *period*. The period is the time that it takes the mass to complete one full up and down cycle of vibration. According to **Figure 2**, what is the period of this mass?
  - Approximately 0.6 seconds
  - Approximately 1.2 seconds
  - Approximately 1.8 seconds
  - Approximately 10.0 seconds

## Answers and Explanations

1. **Answer:** A

**Explanation:** The highest vertical position will be a time at which the plotted line on the position-time graph of **Figure 2** is at the highest point on the graph. Of the four listed times, the highest point is observed only at a time of 1.0 seconds.

2. **Answer:** D

**Explanation:** On the velocity-time graph (bottom graph) of **Figure 2**, the vertical coordinate is the velocity value. In this question, one must determine at which one of the times does the plotted line have a vertical coordinate of 0.40 m/s. For each listed time, find the time along the horizontal axis and then trace upward from that time to the plotted line. Then, trace horizontally across to the vertical axis to read the velocity. Of the listed times, the only time at which the velocity value is 0.40 m/s is at the time of 9.0 seconds.

3. **Answer:** A

**Explanation:** Based on **Figure 1**, position E is the highest position in the up and down motion of the mass. The mass is at this highest position at any time at which the plotted line on the position-time graph of **Figure 2** is at the highest point on the graph. Of the four listed times, the highest point is observed only at a time of 1.0 seconds.

4. **Answer:** C

**Explanation:** The rest position is position C; as discussed in question 3, it is 0.54 meters above the ground. In this question, we want to determine at which of the listed times is the mass below the rest position (less than 0.54 m above the ground) and moving in the downward direction (having a negative velocity). So for each listed time, both the position-time graph and the velocity-time graph must be used. The position-time graph can be used to insure that the mass is less than 0.54 m above the ground; the velocity-time graph can be used to insure that the velocity is a negative value. At 2.0 seconds and 7.0 seconds, the mass is above the rest position. At 4.0 seconds, the mass is below the rest position; however, the velocity value at this time is a positive value, indicating that the mass is moving upward. The only time that the mass meets the two criteria of being below the rest position and moving downward is at 6.0 seconds

5. **Answer:** B

**Explanation:** At 1.0 seconds, the mass is at its highest point above the ground. The next time it is at its highest point is at about 2.2 seconds. It takes approximately 1.2 seconds for the mass to complete one cycle. The period is approximately 1.2 seconds. Similarly, the mass is also at its highest point at the 8.0 second mark. This corresponds to six cycles of vibration later. It takes 7.0 seconds to complete these six cycles. Some simple division shows that this is an average time of approximately 1.2 seconds per cycle. This 1.2 second value is the period.