Kinematics

Kinematics is a branch of physics concerned with the description of the motion of objects. A moving object can be described by more than just words. Graphs, diagrams, and equations are among the other means of describing an object's motion. For instance, consider a ball that is thrown upward from ground level. **Figure 1** depicts a motion diagram for the ball's motion. The position of the ball at 1 second intervals is represented by a dot. For the sake of our discussion, each dot has been labeled with a letter. The ball starts on the ground (**A**) rises upward to a peak position (**E**), turns around and falls back to the ground (**I**).

Figure 1

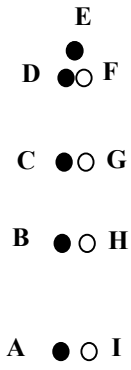


Figure 2 includes a graph that represents the position of the ball with respect to time. The position is measured relative to the ground. That is, ground level is considered to be a position of 0 meters. It thus follows that a height of 10 meters above the ground would be a position of 10 meters on the graph. The graph represents the complete up and down motion of the ball. For the sake of our discussion, several points on the graph are labeled with a letter.

Figure 2: Position vs. Time

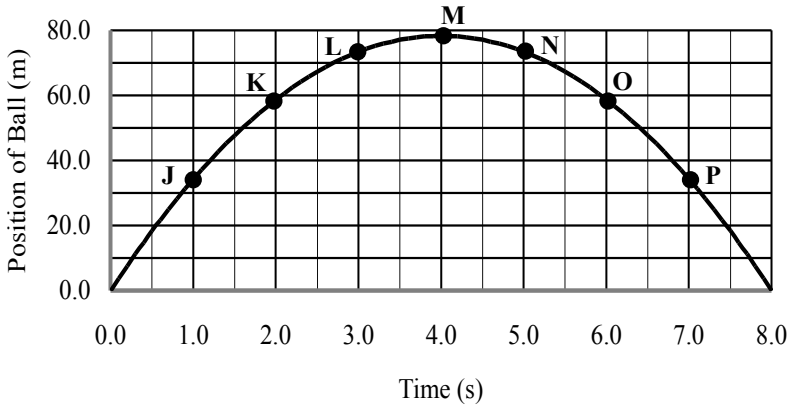
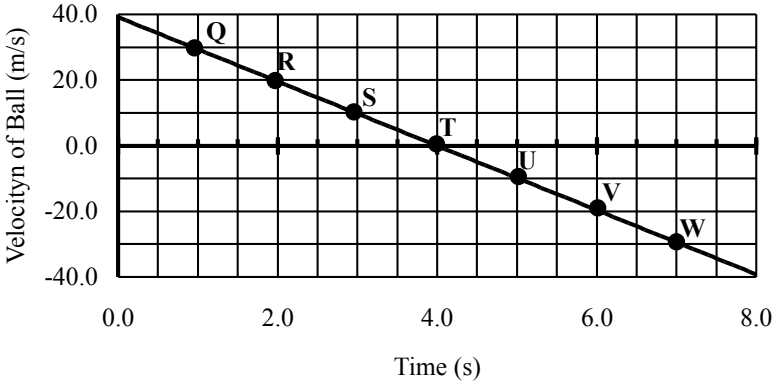


Figure 3 includes a graph that represents the velocity of the ball with respect to time. In kinematics, the **velocity** of an object describes how fast the object is moving and in what direction. When physicists represent the velocity of an object numerically, they often use a positive (+) or a negative (-) sign to describe the direction of the velocity. It is conventional to use a positive sign for an upward direction and a negative sign for a downward direction. For the sake of our discussion, several points on the graph are labeled with a letter.

Figure 3: Velocity vs. Time



Questions:

1. According to **Figure 1**, how much time does it take for the object to reach its peak position?
   a. 4.0 seconds
   b. 5.0 seconds
   c. 6.0 seconds
   d. 8.0 seconds

2. According to **Figure 1**, at which two times is the object the same height above the ground?
   a. At 2.0 seconds and 6.0 seconds.
   b. At 2.0 seconds and 7.0 seconds.
   c. At 4.0 seconds and 6.0 seconds.
   d. Impossible to tell.

3. According to **Figure 1**, the ball is at its highest point when it has been in the air for 4.0 seconds. How much additional time (past 4.0 seconds) must the object fall before it is at the same height as it was at position **C**?
   a. An additional 2.0 seconds.
   b. An additional 3.0 seconds.
   c. An additional 3.0 seconds.
   d. An additional 6.0 seconds.

4. What point on **Figure 1** corresponds to Point **L** in **Figure 2**?
   a. Point **C**
   b. Point **D**
   c. Point **G**
   e. Points **C** and **G**

5. According to **Figure 2**, how high is the object above the ground when it is 3.0 seconds into its flight?
   a. Approximately 10 m.
   b. Approximately 50 m.
   c. Approximately 66 m.
   d. Approximately 72 m.

6. Use **Figure 2** to determine the height of the object when it is at point **B** of **Figure 1**.
   a. About 10 meters high
   b. About 20 meters high
   c. About 34 meters high
   d. About 58 meters high

7. Use **Figure 2** to determine how much higher the object is when it is at point **D** (**Figure 1**) compared to point **G** (**Figure 1**).
   a. The object is 15 meters higher at point **D** than it is at point **G**.
   b. The object is 20 meters higher at point **D** than it is at point **G**.
   c. The object is 24 meters higher at point **D** than it is at point **G**.
   d. The object is 39 meters higher at point **D** than it is at point **G**.

8. According to **Figure 3**, how fast is the object moving at a time of 5.0 seconds?
   a. Approximately 5 m/s
   b. Approximately 10 m/s
   c. Approximately 40 m/s
   d. Approximately 72 m/s

9. According to **Figure 3**, at which of the following times is the object moving with a velocity of +24 m/s?
   a. At approximately 0.75 seconds.
   b. At approximately 1.1 seconds.
   c. At approximately 1.5 seconds.
   d. At approximately 7.5 seconds.

10. Which statement below accurately compares the speed of the object at point **D** (**Figure 1**) compared to point **H** (**Figure 1**).
    a. The object is moving 20 m/s faster at point **D** than it is at point **H**.
    b. The object is moving 40 m/s faster at point **D** than it is at point **H**.
    c. The object is moving 20 m/s faster at point **H** than it is at point **D**.
    d. The object is moving 40 m/s faster at point **H** than it is at point **D**.

11. Based on the data in **Figure 3**, how does the speed of the object at point **C** of **Figure 1** compare to the speed of the object at point **H** of **Figure 1**?
    a. The speed of the object is approximately 10 m/s greater at point **C**.
    a. The speed of the object is approximately 20 m/s greater at point **C**.
    a. The speed of the object is approximately 10 m/s greater at point **H**.
    a. The speed of the object is approximately 20 m/s greater at point **H**.

12. Use **Figure 2** and **Figure 3** to determine the position and the velocity of the object when it is at Point **D** in **Figure 1**.
    a. Position = 58 m; Velocity = 10 m/s
    b. Position = 58 m; Velocity = 20 m/s
    c. Position = 74 m; Velocity = 10 m/s
    d. Position = 78 m; Velocity = 0 m/s

13. Use **Figure 2** and **Figure 3** to determine the position of the object when its velocity is approximately -15 m/s.
    a. The position is 58 m.
    b. The position is 66 m.
    c. The position is 70 m.
    d. The position is 73 m.

14. Use **Figure 2** and **Figure 3** to determine the velocity of the object when its position is approximately 20 m above the ground and it is heading downward from its peak.
    a. The velocity is -33 m/s.
    b. The velocity is -18 m/s.
    c. The velocity is +18 m/s.
    d. The velocity is +58 m/s.

15 Which one of these statements is incorrect?
    a. The height of the object 2 seconds before and 2 seconds after its peak is the same.
    b. The time it takes the object to reach its peak equals the time to fall from its peak.
    c. The object's velocity is changing by the same amount during each second of motion.
    d. The object's position changes by the same amount during each second of motion.

16. A common means of describing an object's motion is through the use of a **velocity vector diagram**. A velocity vector diagram uses an arrow to represent the size and direction of the velocity at any given moment in time. The diagram at the right represents the velocity vector for the ball when it is at **position C** in **Figure 1**. What would the velocity vector diagram look like for **position F** in **Figure 1**?

Diagram A **Diagram B** **Diagram C** **Diagram D**