7. **Position** Two students compared the position vectors they each had drawn on a motion diagram to show the position of a moving object at the same time. They found that their vectors did not point in the same direction. Explain.

A position vector goes from the origin to the object. When the origins are different, the position vectors are different. On the other hand, a displacement vector has nothing to do with the origin.

8. **Critical Thinking** A car travels straight along the street from the grocery store to the post office. To represent its motion you use a coordinate system with its origin at the grocery store and the direction the car is moving in as the positive direction. Your friend uses a coordinate system with its origin at the post office and the opposite direction as the positive direction. Would the two of you agree on the car's position? Displacement? Distance? The time interval the trip took? Explain.

The two students should agree on the displacement, distance, and time interval for the trip, because these three quantities are independent of where the origin of the coordinate system is placed. The two students would not agree on the car's position, because the position is measured from the origin of the coordinate system to the location of the car.

---

**Practice Problems**

2.3 **Position-Time Graphs**

*pages 38–42*

*page 39*

For problems 9–11, refer to Figure 2-13.

![Figure 2-13](image)

9. Describe the motion of the car shown by the graph.

The car begins at a position of 125.0 m and moves toward the origin, arriving at the origin 5.0 s after it begins moving. The car continues beyond the origin.

10. Draw a motion diagram that corresponds to the graph.

\[ t_0 = 0.0 \text{ s} \quad t_5 = 5.0 \text{ s} \]

11. Answer the following questions about the car's motion. Assume that the positive d-direction is east and the negative d-direction is west.

a. When was the car 25.0 m east of the origin?

at 4.0 s

b. Where was the car at 1.0 s?

100.0 m

12. Describe, in words, the motion of the two pedestrians shown by the lines in Figure 2-14. Assume that the positive direction is east on Broad Street and the origin is the intersection of Broad and High Streets.
Chapter 2 continued

b. Will Heather catch up to Juanita? How can you tell?
   No. The lines representing Juanita's and Heather's motions get farther apart as time increases. The lines will not intersect.

Section Review

2.3 Position-Time Graphs

Section Review 2.3 Position-Time Graphs pages 38—42

19. **Position-Time Graph** From the particle model in Figure 2-17 of a baby crawling across a kitchen floor, plot a position-time graph to represent his motion. The time interval between successive dots is 1 s.

   ![Position-Time Graph](image)

   - Figure 2-17

20. **Motion Diagram** Create a particle model from the position-time graph of a hockey puck gliding across a frozen pond in Figure 2-18.

   ![Motion Diagram](image)

   - Figure 2-18

21. **Time** Use the position-time graph of the hockey puck to determine when it was 10.0 m beyond the origin.

   • t₀ = 0.0 s
   • t₇ = 7.0 s
   • 0 m
   • 140 m

   ![Position-Time Graph](image)

   For problems 21–23, refer to Figure 2-18.

22. **Distance** Use the position-time graph of the hockey puck to determine how far it moved between 0.0 s and 5.0 s.

   • 100 m

23. **Time Interval** Use the position-time graph for the hockey puck to determine how much time it took for the puck to go from 40 m beyond the origin to 80 m beyond the origin.

   • 2.0 s

24. **Critical Thinking** Look at the particle model and position-time graph shown in Figure 2-19. Do they describe the same motion? How do you know? Do not confuse the position coordinate system in the particle model with the horizontal axis in the position-time graph. The time intervals in the particle model are 2 s.

   ![Position-Time Graph](image)

   - Figure 2-19
Chapter 2 continued

**Mixed Review**

pages 53–54

**Level 1**

54. **Cycling** A cyclist maintains a constant velocity of +5.0 m/s. At time \( t = 0.0 \) s, the cyclist is +250 m from point A.

a. Plot a position-time graph of the cyclist's location from point A at 10.0-s intervals for 60.0 s.

\[ d = vt \]

\[ 550 \text{ m} \]

b. What is the cyclist's position from point A at 60.0 s?

550 m

c. What is the displacement from the starting position at 60.0 s?

550 m - 250 m = 3.0 \times 10^2 \text{ m}

**55. Figure 2-29** is a particle model for a chicken casually walking across the road. Time intervals are every 0.1 s. Draw the corresponding position-time graph and write the equation to describe the chicken's motion.

\[ \text{This side} \]

\[ \text{The other side} \]

Time intervals are 0.1 s.

\[ \text{Figure 2-29} \]

56. **Figure 2-30** shows position-time graphs for Joszi and Heike paddling canoes in a local river.

\[ d = \frac{1}{2}at^2 \]

a. At what time(s) are Joszi and Heike in the same place?

1.0 h

b. How much time does Joszi spend on the river before he passes Heike?

45 min

c. Where on the river does it appear that there might be a swift current?

from 8.0 to 9.0 km from the origin

**Level 2**

57. **Driving** Both car A and car B leave school when a stopwatch reads zero. Car A travels at a constant 75 km/h, and car B travels at a constant 85 km/h.

a. Draw a position-time graph showing the motion of both cars. How far are the two cars from school when the stopwatch reads 2.0 h? Calculate the distances and show them on your graph.

\[ d_A = \frac{1}{2}at^2 \]

\[ = (75 \text{ km/h})(2.0 \text{ h}) \]

\[ = 150 \text{ km} \]

\[ d_B = \frac{1}{2}at^2 \]

\[ = (85 \text{ km/h})(2.0 \text{ h}) \]

\[ = 170 \text{ km} \]
Chapter 2 continued

60. Figure 2-31 shows the position-time graph depicting Jim’s movement up and down the aisle at a store. The origin is at one end of the aisle.

- Figure 2-31

a. Write a story describing Jim’s movements at the store that would correspond to the motion represented by the graph.

Answers will vary.

b. When does Jim have a position of 6.0 m? from 8.0 to 24.0 s, 53.0 to 56.0 s, and at 43.0 s

c. How much time passes between when Jim enters the aisle and when he gets to a position of 12.0 m? What is Jim’s average velocity between 37.0 s and 46.0 s?

\[ t = 33.0 \text{ s} - 24.0 \text{ s} = 9.0 \text{ s} \]

Using the points (37.0 s, 12.0 m) and (46.0 s, 3.00 m)

\[ \bar{v} = \frac{d_f - d_i}{t_f - t_i} = \frac{3.00 \text{ m} - 12.0 \text{ m}}{46.0 \text{ s} - 37.0 \text{ s}} \]

\[ = -1.00 \text{ m/s} \]

Thinking Critically

page 54

61. Apply Calculators Members of a physics class stood 25 m apart and used stopwatches to measure the time which a car traveling on the highway passed each person. Their data are shown in Table 2-3.

<table>
<thead>
<tr>
<th>Table 2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position v. Time</td>
</tr>
<tr>
<td>Time (s)</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>0.0</td>
</tr>
<tr>
<td>1.3</td>
</tr>
<tr>
<td>2.7</td>
</tr>
<tr>
<td>3.6</td>
</tr>
<tr>
<td>5.1</td>
</tr>
<tr>
<td>5.9</td>
</tr>
<tr>
<td>7.0</td>
</tr>
<tr>
<td>8.6</td>
</tr>
<tr>
<td>10.3</td>
</tr>
</tbody>
</table>

Use a graphing calculator to fit a line to a position-time graph of the data and to plot this line. Be sure to set the display range of the graph so that all the data fit on it. Find the slope of the line. What was the speed of the car?

The slope of the line and the speed of the car are 19.7 m/s.

62. Apply Concepts You plan a car trip for which you want to average 90 km/h. You cover the first half of the distance at an average speed of only 48 km/h. What must your average speed be in the second half of the trip to meet your goal? Is this reasonable? Note that the velocities are based on half the distance, not half the time.
Chapter 2 continued

720 km/h; No

Explanation:
Assume you want to travel 90 km in 1 h. If you cover the first half of the distance at 48 km/h, then you've gone 45 km in 0.9375 h (because \( t = \frac{d}{v} \)). This means you have used 93.75% of your time for the first half of the distance leaving 6.25% of the time to go the remaining 45 km.

\[ v = \frac{45 \text{ km}}{0.0625 \text{ h}} = 720 \text{ km/h} \]

63. **Design an Experiment** Every time a particular red motorcycle is driven past your friend's home, his father becomes angry because he thinks the motorcycle is going too fast for the posted 25 mph (40 km/h) speed limit. Describe a simple experiment you could do to determine whether or not the motorcycle is speeding the next time it is driven past your friend's house.

There are actually several good possibilities for answers on this one. Two that should be among the most popular are briefly described here. 1) Get several people together and give everyone a watch. Synchronize the watches and stand along the street separated by a consistent distance, maybe 10 m or so. When the motorcycle passes, have each person record the time (at least to an accuracy of seconds) that the motorcycle crossed in front of them. Plot a position time graph, and compute the slope of the best-fit line. If the slope is greater than 25 mph, the motorcycle is speeding. 2) Get someone with a driver's license to drive a car along the street at 25 mph in the same direction as you expect the motorcycle to go. If the motorcycle gets closer to the car (if the distance between them decreases), the motorcycle is speeding. If the distance between them stays the same, the motorcycle is driving at the speed limit. If the distance increases, the motorcycle is driving less than the speed limit.

64. **Interpret Graphs** Is it possible for an object's position-time graph to be a horizontal line? A vertical line? If you answer yes to either situation, describe the associated motion in words.

It is possible to have a horizontal line as a position-time graph; this would indicate that the object's position is not changing, or in other words, that it is not moving. It is not possible to have a position-time graph that is a vertical line, because this would mean the object is moving at an infinite speed.

**Writing in Physics**

page 54

65. Physicists have determined that the speed of light is \( 3.00 \times 10^8 \text{ m/s} \). How did they arrive at this number? Read about some of the series of experiments that were done to determine light's speed. Describe how the experimental techniques improved to make the results of the experiments more accurate.

*Answers will vary.* Galileo attempted to determine the speed of light but was unsuccessful. Danish astronomer Olaus Roemer successfully measured the speed of light in 1676 by observing the eclipses of the moons of Jupiter. His estimate was 140,000 miles/s (225,308 km/s). Many others since have tried to measure it more accurately using rotating toothed wheels, rotating mirrors and the Kerr cell shutter.

66. Some species of animals have good endurance, while others have the ability to move very quickly, but for only a short amount of time. Use reference sources to find two examples of each quality and describe how it is helpful to that animal.

*Answers will vary.* Examples of animals with high endurance to outlast predators or prey include mules, bears, and coyotes. Animals with the speed to quickly escape predators or capture prey include cheetahs, antelopes and deer.
Multiple Choice

1. Which of the following statements would be true about the particle model motion diagram for an airplane taking off from an airport?
   - The dots would form an evenly spaced pattern.
   - The dots would be far apart at the beginning, but get closer together as the plane accelerated.
   - The dots would be close together to start with, and get farther apart as the plane accelerated.
   - The dots would be close together to start, get farther apart, and become close together again as the airplane leveled off at cruising speed.

2. Which of the following statements about drawing vectors is false?
   - A vector diagram is needed to solve all physics problems properly.
   - The length of the vector should be proportional to the data.
   - Vectors can be added by measuring the length of each vector and then adding them together.
   - Vectors can be added in straight lines or in triangle formations.

Use this graph for problems 3–5.

3. The graph shows the motion of a person on a bicycle. When does the person have the greatest velocity?
   - section I
   - section III

4. When is the person on the bicycle farthest away from the starting point?
   - point A
   - point C
   - point B
   - point D

5. Over what interval does the person on the bicycle travel the greatest distance?
   - section I
   - section III
   - section II
   - point IV

6. A squirrel descends an 8-m tree at a constant speed in 1.5 min. It remains still at the base of the tree for 2.3 min, and then walks toward an acorn on the ground for 0.7 min. A loud noise causes the squirrel to scamper back up the tree in 0.1 min to the exact position on the branch from which it started. Which of the following graphs would accurately represent the squirrel's vertical displacement from the base of the tree?

   - [Graphs showing different positions over time]

Extended Answer

7. Find a rat’s total displacement at the exit if it takes the following path in a maze: start 1.0 m north, 0.3 m east, 0.8 m south, 0.4 m east, finish.

✓ Test-Taking TIP

Stock up on Supplies

Bring all your test-taking tools: number two pencils, black and blue pens, erasers, correction fluid, a sharpener, a ruler, a calculator, and a protractor.
Chapter 3 continued

5. Plot a $v$-$t$ graph representing the following motion. An elevator starts at rest from the ground floor of a three-story shopping mall. It accelerates upward for 2.0 s at a rate of 0.5 m/s$^2$, continues up at a constant velocity of 1.0 m/s for 12.0 s, and then experiences a constant downward acceleration of 0.25 m/s$^2$ for 4.0 s as it reaches the third floor.

![Graph](image)

6. A race car's velocity increases from 4.0 m/s to 36 m/s over a 4.0-s time interval. What is its average acceleration?

$$a = \frac{\Delta v}{\Delta t} = \frac{36 \text{ m/s} - 4.0 \text{ m/s}}{4.0 \text{ s}} = 8.0 \text{ m/s}^2$$

7. The race car in the previous problem slows from 36 m/s to 15 m/s over 3.0 s. What is its average acceleration?

$$a = \frac{\Delta v}{\Delta t} = \frac{15 \text{ m/s} - 36 \text{ m/s}}{3.0 \text{ s}} = -7.0 \text{ m/s}^2$$

8. A car is coasting backwards downhill at a speed of 3.0 m/s when the driver gets the engine started. After 2.5 s, the car is moving uphill at 4.5 m/s. If uphill is chosen as the positive direction, what is the car's average acceleration?

$$a = \frac{\Delta v}{\Delta t} = \frac{4.5 \text{ m/s} - (-3.0 \text{ m/s})}{2.5 \text{ s}} = 3.0 \text{ m/s}^2$$

9. A bus is moving at 25 m/s when the driver steps on the brakes and brings the bus to a stop in 3.0 s.

Section Review

3.1 Acceleration pages 57–64

10. Rohith has been jogging to the bus stop for 2.0 min at 3.5 m/s when he looks at his watch and sees that he has plenty of time before the bus arrives. Over the next 10.0 s, he slows his pace to a leisurely 0.75 m/s. What was his average acceleration during this 10.0 s?

$$a = \frac{\Delta v}{\Delta t} = \frac{0.75 \text{ m/s} - 3.5 \text{ m/s}}{10.0 \text{ s}} = -0.28 \text{ m/s}^2$$

11. If the rate of continental drift were to abruptly slow from 1.0 cm/yr to 0.5 cm/yr over the time interval of a year, what would be the average acceleration?

$$a = \frac{\Delta v}{\Delta t} = \frac{0.5 \text{ cm/yr} - 1.0 \text{ cm/yr}}{1.0 \text{ yr}} = -0.5 \text{ cm/yr}^2$$
Chapter 3 continued

is 15 m east of the origin and the other is 15 m west.

a. What would be the difference(s) in the position-time graphs of their motion?
   Both lines would have the same slope, but they would rise from the d-axis at different points, +15 m, and −15 m.

b. What would be the difference(s) in their velocity-time graphs?
   Their velocity-time graphs would be identical.

14. **Velocity**

   Explain how you would use a velocity-time graph to find the time at which an object had a specified velocity.
   Draw or imagine a horizontal line at the specified velocity. Find the point where the graph intersects this line. Drop a line straight down to the t-axis. This would be the required time.

15. **Velocity-Time Graph**

   Sketch a velocity-time graph for a car that goes east at 25 m/s for 100 s, then west at 25 m/s for another 100 s.

![Velocity-Time Graph](image)

16. **Average Velocity and Average Acceleration**

   A canoeist paddles upstream at 2 m/s and then turns around and floats downstream at 4 m/s. The turnaround time is 8 s.

   a. What is the average velocity of the canoe?
      Choose a coordinate system with the positive direction upstream.
      \[ \bar{v} = \frac{v_f + v_i}{2} \]
      \[ = \frac{2 \text{ m/s} + (-4 \text{ m/s})}{2} \]
      \[ = -1 \text{ m/s} \]

   b. What is the average acceleration of the canoe?
      \[ \bar{a} = \frac{\Delta v}{\Delta t} \]
      \[ = \frac{v_f - v_i}{\Delta t} \]
      \[ = \frac{(-4 \text{ m/s}) - (2 \text{ m/s})}{8 \text{ s}} \]
      \[ = 0.8 \text{ m/s}^2 \]

17. **Critical Thinking**

   A police officer clocked a driver going 32 km/h over the speed limit just as the driver passed a slower car. Both drivers were issued speeding tickets. The judge agreed with the officer that both were guilty. The judgement was issued based on the assumption that the cars must have been going the same speed because they were observed next to each other. Are the judge and the police officer correct? Explain with a sketch, a motion diagram, and a position-time graph.

   No, they had the same position, not velocity. To have the same velocity, they would have had to have the same relative position for a length of time.
Chapter 3 continued

Part 2: Constant velocity:
\[ d_2 = vt = (18.0 \text{ m/s})(60.0 \text{ s}) = 1.08 \times 10^3 \text{ m} \]
Thus \[ d = d_1 + d_2 \]
\[ = 81.0 \text{ m} + 1.08 \times 10^3 \text{ m} \]
\[ = 1.16 \times 10^3 \text{ m} \]

33. Sunee is training for an upcoming 5.0-km race. She starts out her training run by moving at a constant pace of 4.3 m/s for 19 min. Then she accelerates at a constant rate until she crosses the finish line, 19.4 s later. What is her acceleration during the last portion of the training run?

Part 1: Constant velocity:
\[ d = vt \]
\[ = (4.3 \text{ m/s})(19 \text{ min})(60 \text{ s/min}) \]
\[ = 4902 \text{ m} \]
Part 2: Constant acceleration:
\[ d_f = d_i + v_i t + \frac{1}{2} at^2 \]
\[ a = \frac{2(d_f - d_i - v_i t)}{t^2} = \frac{(2)(5.0 \times 10^3 \text{ m} - 4902 \text{ m} - (4.3 \text{ m/s})(19.4 \text{ s}))}{(19.4 \text{ s})^2} \]
\[ = 0.077 \text{ m/s}^2 \]

Section Review

3.2 Motion with Constant Acceleration

pages 65–71

34. Acceleration A woman driving at a speed of 23 m/s sees a deer on the road ahead and applies the brakes when she is 210 m from the deer. If the deer does not move and the car stops right before it hits the deer, what is the acceleration provided by the car’s brakes?
\[ v_f^2 = v_i^2 + 2a(d_f - d_i) \]
\[ a = \frac{v_f^2 - v_i^2}{2(d_f - d_i)} \]
\[ = \frac{0.0 \text{ m/s} - (23 \text{ m/s})^2}{(2)(210 \text{ m})} \]
\[ = -1.3 \text{ m/s}^2 \]

35. Displacement If you were given initial and final velocities and the constant acceleration of an object, and you were asked to find the displacement, what equation would you use?
\[ v_f^2 = v_i^2 + 2ad_f \]
Chapter 3 continued

36. **Distance** An in-line skater first accelerates from 0.0 m/s to 5.0 m/s in 4.5 s, then continues at this constant speed for another 4.5 s. What is the total distance traveled by the in-line skater?

   **Accelerating**
   \[ d_1 = \frac{v_1 + v_t}{2} t_f \]
   \[ = \left( \frac{0.0 \text{ m/s} + 5.0 \text{ m/s}}{2} \right)(4.5 \text{ s}) \]
   \[ = 11.25 \text{ m} \]

   **Constant speed**
   \[ d_2 = v_t t_f \]
   \[ = (5.0 \text{ m/s})(4.5 \text{ s}) \]
   \[ = 22.5 \text{ m} \]

   **Total distance**
   \[ = 11.25 \text{ m} + 22.5 \text{ m} \]
   \[ = 34 \text{ m} \]

37. **Final Velocity** A plane travels a distance of \(5.0 \times 10^2\) m while being accelerated uniformly from rest at the rate of 5.0 m/s\(^2\). What final velocity does it attain?

   \[ v_f^2 = v_i^2 + 2a(d - d_i) \]
   \[ v_i = \sqrt{(0.0 \text{ m/s})^2 + 2(5.0 \text{ m/s}^2)(5.0 \times 10^2 \text{ m})} \]
   \[ = 71 \text{ m/s} \]

38. **Final Velocity** An airplane accelerated uniformly from rest at the rate of 5.0 m/s\(^2\) for 14 s. What final velocity did it attain?

   \[ v_f = v_i + at \]
   \[ = 0 + (5.0 \text{ m/s}^2)(14 \text{ s}) = 7.0 \times 10^1 \text{ m/s} \]

39. **Distance** An airplane starts from rest and accelerates at a constant 3.00 m/s\(^2\) for 30.0 s before leaving the ground.

   **a.** How far did it move?
   \[ d_t = v_i t_f + \frac{1}{2} at_t^2 \]
   \[ = (0.0 \text{ m/s})(30.0 \text{ s})^2 + \left( \frac{1}{2} \right)(3.00 \text{ m/s}^2)(30.0 \text{ s})^2 \]
   \[ = 1.35 \times 10^3 \text{ m} \]

   **b.** How fast was the airplane going when it took off?
   \[ v_f = v_i + at \]
   \[ = 0.0 \text{ m/s} + (3.00 \text{ m/s}^2)(30.0 \text{ s}) \]
   \[ = 90.0 \text{ m/s} \]
Chapter 3 continued

\[ v_f^2 = v_i^2 + 2a\Delta d \]
\[ v_i = \sqrt{v_f^2 + 2g\Delta d} \text{ where } a = -g \]
and \( v_i = 0 \) at the height of the toss, so
\[ v_i = \sqrt{(0.0 \text{ m/s})^2 + (2)(9.80 \text{ m/s}^2)(0.25 \text{ m})} \]
\[ = 2.2 \text{ m/s} \]

b. If you catch it at the same height as you released it, how much time did it spend in the air?
\[ v_f = v_i + at \text{ where } a = -g \]
\[ v_i = 2.2 \text{ m/s and} \]
\[ v_f = -2.2 \text{ m/s} \]
\[ t = \frac{v_i - v_f}{-g} \]
\[ = \frac{-2.2 \text{ m/s} - 2.2 \text{ m/s}}{-9.80 \text{ m/s}^2} \]
\[ = 0.45 \text{ s} \]

Section Review

3.3 Free Fall

pages 72–75

47. Maximum Height and Flight Time Acceleration due to gravity on Mars is about one-third that on Earth. Suppose you throw a ball upward with the same velocity on Mars as on Earth.

a. How would the ball’s maximum height compare to that on Earth?

Acceleration of an object results from the influence of the planet’s gravity. Because the gravity on Mars is one-third that on Earth, the maximum height would be three times higher.

b. How would its flight time compare?

Because the gravity on Mars is one-third that on Earth, the flight time would be three times as long.

48. Velocity and Acceleration Suppose you throw a ball straight up into the air. Describe the changes in the velocity of the ball. Describe the changes in the acceleration of the ball.
Chapter 3 continued

Velocity is reduced at a constant rate as the ball travels upward. At its highest point, velocity is zero. As the ball begins to drop, the velocity begins to increase in the negative direction until it reaches the height from which it was initially released. At that point, the ball has the same speed it had upon release. The acceleration is constant throughout the ball’s flight.

49. Final Velocity Your sister drops your house keys down to you from the second floor window. If you catch them 4.3 m from where your sister dropped them, what is the velocity of the keys when you catch them?

Upward is positive

\[ v_f^2 = v_i^2 + 2a\Delta d \text{ where } a = -g \]

\[ v_i = \sqrt{v_f^2 - 2g\Delta d} \]

\[ = \sqrt{(0.0 \text{ m/s})^2 - (2)(9.80 \text{ m/s}^2)(-4.3 \text{ m})} \]

\[ = 9.2 \text{ m/s} \]

50. Initial Velocity A student trying out for the football team kicks the football straight up in the air. The ball hits him on the way back down. If it took 3.0 s from the time when the student punted the ball until he gets hit by the ball, what was the football’s initial velocity?

Choose a coordinate system with up as the positive direction and the origin at the punter. Choose the initial time at the punt and the final time at the top of the football’s flight.

\[ v_f = v_i + at \text{ where } a = -g \]

\[ v_i = v_f - gt \]

\[ = 0.0 \text{ m/s} + (9.80 \text{ m/s}^2)(1.5 \text{ s}) \]

\[ = 15 \text{ m/s} \]

51. Maximum Height When the student in the previous problem kicked the football, approximately how high did the football travel?

\[ v_f^2 = v_i^2 + 2a\Delta d \text{ where } a = -g \]

\[ \Delta d = \frac{v_f^2 - v_i^2}{-2g} \]

\[ = \frac{(0.0 \text{ m/s})^2 - (15 \text{ m/s})^2}{-2(9.80 \text{ m/s}^2)} \]

\[ = 11 \text{ m} \]

52. Critical Thinking When a ball is thrown vertically upward, it continues upward until it reaches a certain position, and then it falls downward. At that highest point, its velocity is instantaneously zero. Is the ball accelerating at the highest point? Devise an experiment to prove or disprove your answer.

The ball is accelerating; its velocity is changing. Take a strobe photo to measure its position. From photos, calculate the ball’s velocity.
A ball rolls down a hill with a constant acceleration of 2.0 m/s². The ball starts at rest and travels for 4.0 s before it stops.

1. How far did the ball travel before it stopped?
   - 8.0 m
   - 16 m
   - 12 m
   - 20 m

2. What was the ball’s velocity just before it stopped?
   - 2.0 m/s
   - 12 m/s
   - 8.0 m/s
   - 16 m/s

3. A driver of a car enters a new 110-km/h speed zone on the highway. The driver begins to accelerate immediately and reaches 110 km/h after driving 500 m. If the original speed was 80 km/h, what was the driver’s rate of acceleration?
   - 0.44 m/s²
   - 8.4 m/s²
   - 0.60 m/s²
   - 9.80 m/s²

4. A flowerpot falls off the balcony of a penthouse suite 85 m above the street. How long does it take to hit the ground?
   - 4.2 s
   - 8.7 s
   - 8.3 s
   - 17 s

5. A rock climber’s shoe loosens a rock, and her climbing buddy at the bottom of the cliff notices that the rock takes 3.20 s to fall to the ground. How high up the cliff is the rock climber?
   - 15.0 m
   - 35.0 m
   - 31.0 m
   - 13.0 kg m²

6. A car traveling at 91.0 km/h approaches the turnoff for a restaurant 30.0 m ahead. If the driver slams on the brakes with an acceleration of −6.40 m/s², what will be her stopping distance?
   - 14.0 m
   - 50.0 m
   - 29.0 m
   - 40.0 m

7. What is the correct formula manipulation to find acceleration when using the equation \( v_f^2 = v_i^2 + 2ad \)?
   - \( (v_f^2 - v_i^2)/d \)
   - \( (v_i + v_f)/2d \)
   - \( (v_i^2 + v_f^2)/2d \)
   - \( (v_f - v_i)/2d \)

8. The graph shows the motion of a farmer’s truck. What is the truck’s total displacement? Assume that north is the positive direction.
   - 150 m south
   - 300 m north
   - 125 m north
   - 600 m south

9. How can the instantaneous acceleration of an object with varying acceleration be calculated?
   - by calculating the slope of the tangent on a distance-time graph
   - by calculating the area under the graph on a distance-time graph
   - by calculating the area under the graph on a velocity-time graph
   - by calculating the slope of the tangent on a velocity-time graph

Extended Answer

10. Graph the following data, and then show calculations for acceleration and displacement after 12.0 s on the graph.

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>8.10</td>
</tr>
<tr>
<td>6.00</td>
<td>26.3</td>
</tr>
<tr>
<td>9.00</td>
<td>31.3</td>
</tr>
<tr>
<td>12.00</td>
<td>35.4</td>
</tr>
</tbody>
</table>

If a test question involves a table, then the table before reading the question. Read the title, column heads, and row heads. Then read the question and interpret the information in the table.

\[ \text{Slope} = \frac{0.00}{6.00 \text{ s}} = 4.80 \text{ m/s}^2 \]

acceleration = 4.80 m/s²

displacement = area under graph

area under graph = area of rectangle

area of triangle = \( \frac{1}{2} \times \text{base} \times \text{height} \)

area = \( \frac{1}{2} \times 12.00 \text{ m/s} \times 57.6 \text{ m/s} \)

\[ = 443 \text{ m} \]