Chapter 2 – Describing Motion/ Key

Section Review 2.1

1. How is the position variable different from the distance variable in motion experiments?

The *position* of an object is given relative to an origin or starting point, whereas the distance an object travels does not take the origin into consideration.

Position is a vector quantity, which means it takes into account a measured (or calculated) magnitude AND direction. When reporting position, we speak of the direction an object travels (north, south, east, or west), but we take no such consideration when reporting the distance of an object.

2. A runner completes one lap around a 400-m oval track, returning to her starting position. What distance did she cover, and what was her displacement? Explain.

The runner covered a distance of 400m, but her displacement is 0, because she returned to the origin on the track.

3. Why can velocity be negative, but non-zero speed is always positive?

Velocity is a vector quantity, possessing both magnitude and direction. Negative velocity occurs when an object moves closer to its origin; positive velocity occurs when an object moves farther from its origin.

Speed does not take direction into account, only the distance covered by an object divided by a time interval, so it cannot have a negative value.

4. Compare and contrast: constant velocity, average velocity, and instantaneous velocity.

An object is experiencing a *constant velocity* when it travels at the same speed and the same direction per time interval.

Average velocity is calculated by dividing the total displacement of an object by the time taken for the object to undergo the displacement.

Instantaneous velocity describes the velocity of an object at a particular moment or instant of time.

5. Use the term *relative velocity* to explain why it is helpful to paddle a boat downstream.

The paddleboat scenario is similar in concept to the example in the text on page 34. If you paddle a boat downstream, your efforts to increase the velocity of the boat are *added* to the velocity of the moving waters. By contrast, if you paddle against the stream (moving upstream) then your efforts (in terms of velocity) are subtracted from the velocity of the moving waters.

6. What is the acceleration, in m/s^2, of a car that can go from 0 mph to 60 mph in 4 seconds? (*Hint*: Remember to convert all necessary units.)

Please look at the conversion tables on the back inside cover of the textbook; since you are interested in expressing the acceleration in units of m/s^2, convert the final velocity (v_f) of 60 mph, from units of mi/h to units of m/s:

$$\left(60\,\frac{\cancel{mi}}{\cancel{h}}\right)\left(\frac{1.609\,\cancel{km}}{\cancel{mi}}\right)\left(\frac{1000m}{\cancel{km}}\right)\left(\frac{1\,\cancel{h}}{3600\,s}\right) = 26.8167\,\frac{m}{s}$$

Then, use equation $a = \frac{v_f - v_i}{t}$; $a = \frac{26.8167\,m/s}{4\,s} = 6.7042\,\frac{m}{s^2}\ or\ 6.7\frac{m}{s^2}\ or\ technically\ 7\,\frac{m}{s^2}$

Section Review 2.2

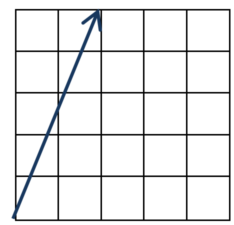
1. Explain how to calculate the slope of a graph.

Refer to page 38 in the text. The slope of a line (m) is calculated by dividing the rise by the run, or $m = rise/ run$. It can also be expressed by dividing the change in the y-axis (Δy) by the change in the x-axis (Δx), or $m = \Delta y/\Delta x$.

2. What does the slope of a position vs. time graph represent?

The slope of a position vs. time graph is represented mathematically as $m = \Delta x/t$, and is the velocity of a given object.

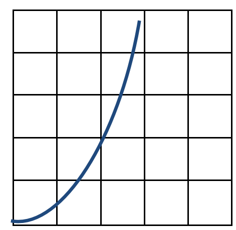
3. Draw the position vs. time graph for an object moving at a constant velocity of 2 m/s.



If the velocity is constant, that means the distance traveled per unit of time is constant, so the line is straight.

Make sure you label the x- and y-axes completely!

4. Sketch a position vs. time graph (no number scale needed) for a ball rolling down a ramp.



The curve on such a graph demonstrates that the velocity is increasing per unit of time.

Make sure you label the x- and y-axes completely!

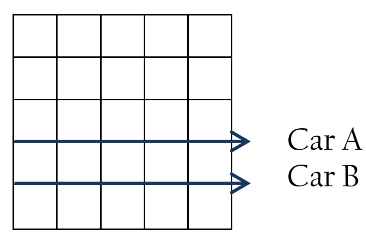
Section Review 2.3

1. Why does the velocity vs. time graph for constant velocity have a horizontal line, when the position vs. time graph for the same motion is a diagonal line?

The slope on a velocity vs. time graph represents the acceleration an object is experiencing. If an object is moving at a constant velocity, its acceleration is zero, as evidenced by a straight line (m=0). The slope on a position vs. time graph however, represents an objects velocity, and since its velocity is not zero, we would expect a diagonal line.

2. Figure 2.7 shows a position vs. time graph for two cars that have different constant velocities. Sketch a velocity vs. time graph for the same two cars.

Make sure you label the x- and y-axes completely!



3. What does the slope of a velocity vs. time graph represent?

The slope on a velocity vs. time graph represents the acceleration of an object.

4. How can you determine an object's displacement from its velocity vs. time graph? Is the method the same for both constant velocity and changing velocity?

The area under the curve (or slope) is the displacement. Recollect for a rectangle, A = l x h; with our curve, A (or x for displacement) = t(time interval) · v (velocity)

5. How do you indicate direction on a velocity vs. time graph?

Since velocity can have either a negative or positive value, you must use the appropriate negative value for y, which would fall below the x-axis (see figure 2.14 on page 44).

Chapter 2 Review

Understanding Vocabulary

Select the correct term in the term bank on page 48 to complete the sentences.

1. The rate at which speed changes is called _*acceleration*___.

2. ___*Position*__ is a variable that gives location relative to an origin.

3. ____*Relative velocity*__ describes the velocity of an object with respect to frame of reference.

4. A moving object has _*constant velocity*_ when both the speed and the direction of travel remain the same.

5. Dividing the total displacement by the total time taken determines the __*average velocity*__.

6. The __*slope*____ of a line is found by dividing the rise by the run.

Reviewing Concepts

Section 2.1

1. Compare and contrast the distance and displacement variables.

   The *displacement* of a body (Δx) is given relative to an origin, whereas the *distance* a body travels (d) is not. Both of these variables are reported in units of distance or length, such as feet, miles, km, inches or meters.

2. Olivia is doing a motion experiment with a car on a track. She records a negative displacement. Describe the motion of the car.

   When a negative displacement ($-x$) is recorded, the car is moving closer to the origin; a positive displacement would occur if the object were moving further from the origin.

3. What is the difference between speed and velocity?

   Speed measures simply the distance traveled by an object and divides that by the time interval it took for the object to travel that distance. The idea of speed does not take into consideration the objects position relative to its origin. *Velocity* does take direction in which an object travels into account relative to an origin and is not so concerned with the distance traveled by the object, but rather its displacement relative to an origin, divided by the time interval.

4. Can an object have negative speed? Can it have negative velocity? Explain.

   An object cannot have negative speed, but it can have negative velocity. Velocity is a measurement of the displacement of a body at a given time interval, relative to the body's origin. If the body moves towards its origin, we would describe it as having negative velocity; if it moves away from its origin, it possesses positive velocity.

5. What two values are needed to determine average velocity?

   a. the displacement of the body ($\Delta x = x_{final} - x_{initial}$)

   b. the time interval of the displacement (t)

6. If an object has an acceleration of 20 cm/ s^2, what do you know about how its velocity changes over time?

First of all, the value for acceleration is positive, so we know that velocity is increasing. By the value of 20 cm/s^2, we know that the velocity is increasing by 20 cm/s per second.

7. Provide two ways the unit "meters per second per second" can be abbreviated.

a. m/s/s

b. m/s^2

8. An object accelerates if its velocity changes. What is the other way an object can accelerate (without changing speed)?

Since velocity is a vector quantity that reveals not only the magnitude of an objects travel, but direction as well, if *either* the magnitude (speed) or direction is changed, the object undergoes an acceleration. If the object changes direction, but maintains constant speed (such as traveling in a curve), then the object is experiencing an acceleration.

9. What is the acceleration of a car moving at a constant velocity of 50 mph?

For a car traveling at a constant velocity, its acceleration is zero.

Section 2.2

10. Explain how to calculate the slope of a line.

The slope is a ratio of the rise divided by the run; $m = rise/run$, or $m = \Delta y/\Delta x$, or $m = y_2 - y_1/ x_2 - x_1$ There are many ways to think of this and they all state basically the same principle.

11. The slope of a position vs. time graph is equal to the object's _*velocity*_.

12. Sam rolls down his driveway on a skateboard while Beth keeps track of his position every second for 15 seconds. When they make a graph of the data, the position vs. time graph is a curve that gets steeper as time increases. What does this tell you about Sam's velocity?

Since Sam is rolling down a driveway, it is easy to imagine that his velocity is ever increasing. The line confirms this – his velocity is increasing per second.

Section 2.3

13. The slope of a velocity vs. time graph is equal to the object's __*acceleration*___.

14. A graph is made of the velocity vs. time of a plane as it flies from San Francisco to the Kahului Airport on Maui. How could the displacement of the plane be calculated from the graph?

The displacement of the place can be calculated by finding the area under the curve.

Solving Problems

Section 2.1

1. Ryan's family drives from San Diego to Phoenix. They continue from Phoenix to Flagstaff, and finally back to San Diego. Their travel is graphically represented on page 48.

a. What distance did this family travel?

480 km + 200 km + 585 km = 1265 km

b. What is their displacement?

0 km, since the family is back at their origin.

2. A car travels in one direction for 30 min at an average velocity of 20 km/ h. What is the distance the car travels?

$$(30\cancel{min})\left(\frac{20\ km}{\cancel{hr}}\right)\left(\frac{1\ \cancel{hr}}{60\ \cancel{min}}\right) = 10\ km$$

3. Emma is riding on a train. The train is moving at 50 m/s. Emma walks down the aisle at 1 m/s relative to the train in the same direction the train is moving. What is her relative velocity?

Since Emma is walking in the same direction the train is traveling, you would add her velocity vector (1 m/s) to that of the trains (50 m/s).
Relative to the train station or the earth, Emma is traveling 51 m/s.

4. A car accelerates from 0 to 20 m/s in 10 seconds. Calculate its acceleration.

Use $a = \frac{v_f - v_i}{t}$; $a = \frac{20\frac{m}{s} - 0\frac{m}{s}}{10\ s} = 2\,\frac{\mathrm{m}}{s^2}$

5. During a race, you speed up from 3 m/s to 5 m/s in 4 s.

a. What is your change in velocity?

Use $\Delta v = v_f - v_i$;
Δv = 5 m/s − 3 m/s;
Δv = 2 m/s

b. What is your acceleration?

Use $a = \frac{v_f - v_i}{t}$ or restated as $a = \frac{\Delta v}{t}$; $a = \frac{2\frac{m}{s}}{4\ s}$; the answer is $a = \frac{0.5\frac{m}{s}}{s}$ $or\ a = 0.5\,\frac{m}{s^2}$

6. Marcus is driving his car at 15 km/ h when he brakes suddenly. He comes to a complete stop in 2 s. What was his acceleration in km/h/s? Was his acceleration positive, negative, or zero?

Use $a = \frac{v_f - v_i}{t}$ or restated as $a = \frac{\Delta v}{t}$; $a = \frac{0\frac{km}{h} - 15\frac{km}{h}}{2\ s}$; the answer is $a = \frac{-15\frac{km}{h}}{2\ s}$ $or\ a = 7.5\,\frac{\frac{km}{h}}{s}$
His acceleration is negative, because he came to complete stop.

7. You start from rest and ski down a hill with an acceleration of 2 m/s^2. Find your velocity at the following times: HINT: since v_i is 0 m/s, we can remove it from the acceleration equation, because the value of v_f will be the same as Δv.

a. 1 s
Use $a = \frac{v_f - v_i}{t}$ or restated as $a = \frac{v_f}{t}$; rearrange to solve for v_f: $v_f = at$; $v_f = \left(\frac{2m}{s^2}\right) 1s$
V_f =2 m/s

b. 2 s
Use $a = \frac{v_f - v_i}{t}$ or restated as $a = \frac{v_f}{t}$; rearrange to solve for v_f: $v_f = at$; $v_f = \left(\frac{2m}{s^2}\right) 2s$
V_f =4 m/s

c. 3 s
Use $a = \frac{v_f - v_i}{t}$ or restated as $a = \frac{v_f}{t}$; rearrange to solve for v_f: $v_f = at$; $v_f = \left(\frac{2m}{s^2}\right) 3s$
V_f =6 m/s

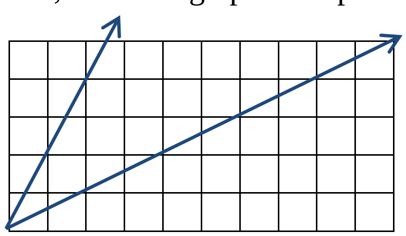
d. 10 s
Use $a = \frac{v_f - v_i}{t}$ or restated as $a = \frac{v_f}{t}$; rearrange to solve for v_f: $v_f = at$; $v_f = \left(\frac{2m}{s^2}\right) 10s$
V_f =20 m/s

Section 2.2

8. Referring to the graph on page 49, rank the four points on the position vs. time graph in order from slowest to fastest.

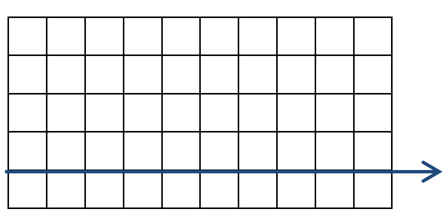
Points from slowest to fastest: 3, 4, 1, 2

9. Draw the position vs. time graph for a person walking at a constant speed of 1 m/s for 10 s. On the same axes, draw the graph for a person running at a constant speed of 4 m/s.



Make sure you label the x- and y-axes completely! On my y-axis, each gridline represents 2 meters; on the x-axis, each gridline represents 1 s.

10. Draw the position vs. time graph for an object that is not moving.



Make sure you label the x- and y-axes completely!

11. Why is the line in a position vs. time graph for an object in free fall a curve?

Refer to page 39 in text. Since the line (or slope) represents the velocity of the falling body, the curve suggests the velocity is increasing over time.

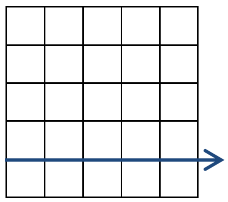
Section 2.3

12. View the graph on page 49 in your text, then answer the following:

a. Calculate the velocity from the position vs. time graph. Show your work.

Use $v = \frac{\Delta x}{t}; v = \frac{3m-1m}{4s}; v = 0.5\frac{m}{s}$

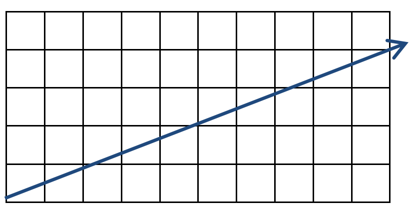
b. Draw the velocity vs. time graph showing the same motion.



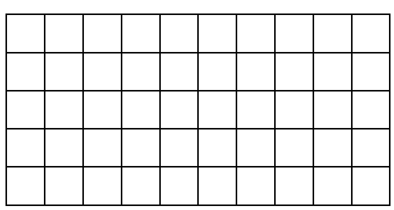
Make sure you label the x- and y-axes completely!

13. Draw a velocity vs. time graph for a car that starts at rest and steadily accelerates until it is moving at 40 m/s after 20 s. Then calculate the car's acceleration and displacement during the first 20 s.

Make sure you label the x- and y-axes completely! Each gridline running along my y-axis represents 10 m/s, and each along the x-axis represents 2 s.



14. Draw a velocity vs. time graph for an object accelerating from rest with a constant acceleration of 2 m/s^2.



Make sure you label the x- and y-axes completely!

Test Practice

Section 2.1

1. Jill drives from her house to school. After school, she drives to the library. What is her displacement?

a. 0 km　　b. 5 km　　c. 10 km　　d. 15 km

2. An object in motion has a displacement of 50 m. The average velocity is 25 m/s. The time taken is _____________ s. Use v = Δx/ t

a. 0.5　　b. 1　　c. 2　　d. 5

3. The table shows the speed of a person riding a bike uphill. What is the person's acceleration?

a. -2 m/s b. -1 m/s c. 1 m/s d. 2 m/s

4. A car starts at rest and accelerates at 2 m/s^2 for 10 s. What is the car's final velocity?

Use $v_f = at + v_i$

a. 2 m/s b. 5 m/s c. 10 m/s d. 20 m/s

Section 2.2

5. What is the velocity of the moving object represented by the position vs. time graph on page 50?

a. 0.5 m/s b. 1 m/s c. 2 m/s d. 5 m/s

6. A car on a track moves away from the origin with a constant velocity. Which position vs. time graph on page 50 could represent the car's motion?

a. A b. B c. C d. D

7. Which position vs. time graph represents the motion of an object with negative acceleration?

a. A. b. B c. C d. D

Section 2.3

8. The slope of a velocity vs. time graph represents the ____________ of the moving object.

a. velocity b. position c. acceleration d. displacement

9. Which velocity vs. time graph on page 51 represents a car moving at a constant velocity?

a. A b. B c. C d. D

10. The moving object represented by the velocity vs. time graph on page 51 has an acceleration of ________ m/s/s.

a. 0 b. 0.5 c. 1 d. 2

11. The velocity vs. time graph on page 51 represents the motion of a person riding a bike. The person's displacement after 4 s is

a. 1 m. b. 4 m. c. 8 m. d. 16 m.

Applying Your Knowledge – skip this section