CHAPTER 3 Review

REFLECTING ON CHAPTER 3

- The mathematical equations which are used to analyze the motion of an object undergoing constant acceleration relate various combinations of five variables: the object's initial velocity v_i, its final velocity v_f, its acceleration a, a time interval Δt, the object's displacement Δd during the time interval. The variables are written without vector notations because they represent components of vectors in one dimension.
  $a = \frac{(v_f - v_i)}{\Delta t}$
  $\Delta d = v_i \Delta t + \frac{1}{2} a \Delta t^2$
  $\Delta d = \frac{1}{2}(v_i + v_f)\Delta t$
  $v_f = v_i + a\Delta t$
- Vectors are represented by arrows that point in the direction of the quantity with respect to a frame of reference or coordinate system. The length of the arrow is proportional to the magnitude of the quantity.
- To add vectors graphically, place the first vector in a coordinate system. Place the tail of the second vector at the tip of the first. The vector formed along the third side of this triangle by connecting the tail of the first vector to the tip of the second represents the sum of both vectors, and is called the resultant vector.
- Two methods for subtracting vectors graphically are provided. In method 1, place the first vector in a coordinate system. Draw the negative of the second vector, and place its tail at the tip of the first. The vector along the third side of the triangle represents the difference between the two vectors. For method 2, place the two vectors on a coordinate system, *tail* to *tail*. The difference of the two vectors is represented by the vector drawn from the tip of the first vector to the tip of the second vector.
- The direction of a vector does not change when multiplied or divided by a scalar quantity. The magnitude and the units are affected.
- Relative velocity describes motion with respect to a specific coordinate system. A dog's velocity swimming directly across a fast-flowing river could be given relative to the moving water or to the ground.
- Turning a corner at constant speed involves a change in velocity (the direction is changing) and therefore is associated with an acceleration given by: $\vec{a}_{ave} = \frac{\Delta \vec{v}}{\Delta t}$

Knowledge/Understanding

1. Define or describe the following:
   (a) horizontal plane
   (b) scale vector diagram
   (c) coordinate system
   (d) frame of reference
   (e) resultant vector
   (f) vector components
2. Why are vectors so useful in solving physics problems?
3. When an airplane travels in a series of straight line segments, you can find the displacement for the whole trip by adding the various displacement vectors.
   (a) Why can't you add up the various velocity vectors for the different segments of the trip, to get the average velocity?
   (b) Describe how you would obtain the average velocity for the trip?
4. Suppose you swim across a river, heading toward a position on the far bank directly opposite from where you started from. If there is a strong current in the river, and you end up downstream from the position toward which you were headed, were you moving faster than you would be moving if there were no current? Explain.
5. A pilot wants to fly due north. However, a strong wind is blowing from the west. Therefore the pilot maintains a heading of a few degrees west of north so that her final

ground speed will be in a direction due north. Is the airplane accelerating in this situation? Why or why not?

Inquiry

6. In the Multi-Lab at the beginning of the chapter, a marble rolled along straight line A, then changed direction and rolled along straight line B. The lines made an angle of 30 degrees with each other. If the marble's speed, both before and after changing direction was 24 cm/s, calculate its *change in velocity.*

Communication

7. Summarize the ideas about vectors and motion presented in this chapter, by using one or both of the following organizers:

   Make a table listing the vector quantities introduced in this chapter (i.e. displacement, velocity, acceleration) and the various rules used to work with the quantities (i.e., sum, difference, product, components, etc.). In the first column, list the quantity or rule. In the second column, give a definition. In the third column, illustrate with a small diagram.

   Organize the vector quantities and rules you learned in this chapter into a *concept map*. This map should show the connection between the various concepts, quantities, and rules you learned.

8. Brainstorm as a class, or in a small group, the common mistakes students make when working with vectors. Make a list and give a concrete example for each item in the list (i.e., adding the speed of various flight segments to get the average speed).

Making Connections

9. Why do airplane pilots usually take off and land at airports so that they are facing the wind?

10. Imagine that you are a transportation consultant. You are hired by an intergovernmental agency, in the year 2015, to help plan a series of high-speed train lines across the Atlantic provinces and Quebec that connect the 20 most populous cities in the region. On the one hand, you want to minimize the time it takes for business people to travel between any two cities. On the other hand, you want to minimize the total amount of high speed track that will be constructed, as the construction, maintenance, and environmental impact of high speed lines is very high.

    Work in a group and brainstorm a list of the different things you would want to know in order to design the network of high speed railways.

    Critique the list of items that you came up with, and decide which items are the most important to know with certainty.

    Your options include setting up straight lines between two cities, or "crooked" lines that connect a series of cities more or less in the same direction. For which cities would it make sense to set up a single high-speed line?

Problems for Understanding

11. At the very end of the race, a runner accelerates at $0.3\ \text{m/s}^2$ for 12 s to attain a speed of 6.4 m/s. Determine the initial velocity of the runner.

12. The acceleration due to gravity on the moon is $1.6\ \text{m/s}^2$[down]. If a baseball was thrown with an initial velocity of 4.5 m/s[up], what would its velocity be after 4.0 s?

13. A car that starts from rest can travel a distance of 5.0×10^1 m in a time of 6.0 s.
    (a) What is the final velocity of the car at this time?
    (b) What is the acceleration of the car?

14. A cyclist is travelling at 5.6 m/s when she starts to accelerate at $0.60\ \text{m/s}^2$ for a time interval of 4.0 s.
    (a) How far did she travel during this time interval?
    (b) What velocity did she attain?

15. A truck is travelling at 22 m/s when the driver notices a speed limit sign for the town ahead. He slows down to a speed of 14 m/s. He travels a distance of 125 m while he is slowing down.
    (a) Calculate the acceleration of the truck.
    (b) How long did it take the truck driver to change his speed?

16. A skydiver falling toward the ground accelerates at 3.2 m/s^2. Calculate his displacement if after 8.0 s he attained a velocity of 28 m/s[down].

17. A car is travelling on the highway at a constant speed of 24 m/s. The driver misses the posted speed limit sign for a small town she is passing through. The police car accelerates from rest at 2.1 m/s^2. From the time that the speeder passes the police car:
   (a) How long will it take the police car to catch up to the speeder?
   (b) What distance will the cars travel in that time?

18. A car travelling at 50.0 km/h due north, turns a corner and continues due west at 50.0 km/h. If the turn takes 5.0 s to complete, calculate the car's (a) change in velocity and (b) acceleration during the turn.

19. A person walks 3.0 km[S] and then 2.0 km[W], to go to the movie theatre.
   (a) Draw a vector diagram to illustrate the displacement.
   (b) What is the total displacement?

20. A person in a canoe paddles 5.6 km[N] across a calm lake in a time of 1.0 h. He then turns west and paddles 3.4 km in 30.0 minutes.
   (a) Calculate the displacement of the canoeist from his starting point.
   (b) Determine the average velocity for the trip.

21. A cyclist is moving with a constant velocity of 5.6 m/s[E]. He turns a corner and continues cycling at 5.6 m/s[N].
   (a) Draw a vector diagram to represent the change in velocity.
   (b) Calculate the change in velocity.

22. A cyclist travels with a velocity of 6.0 m/s[W] for 45 minutes. She then heads south with a speed of 4.0 m/s for 30.0 minutes.
   (a) Calculate the displacement of the cyclist from her starting point.
   (b) Determine the average velocity for the trip.

23. Thao can swim with a speed of 2.5 m/s if there is no current in the water. The current in a river has a velocity of 1.2 m/s[S]. Calculate Thao's velocity relative to the shore if
   (a) she swims upstream
   (b) she swims downstream

24. A physics teacher is on the west side of a small lake and wants to swim across and end up at a point directly across from his starting point. He notices that there is a current in the lake and that a leaf floating by him travels 4.2 m[S] in 5.0 s. He is able to swim 1.9 m/s in calm water.
   (a) What direction will he have to swim in order to arrive at a point directly across from his position?
   (b) Calculate his velocity relative to the shore.
   (c) If the lake is 4.8 km wide, how long will it take him to cross?

25. A canoeist is paddling across a lake with a velocity of 3.2 m/s[N]. A wind with a velocity of 1.2 m/s[N20.0˚E] starts and alters the path of the canoeist. What will be the velocity of the canoeist relative to the shore?

26. A person is jogging with a velocity of 2.8 m/s[W] for 50.0 minutes, and then runs at 3.2 m/s[N30.0˚W] for 30.0 minutes. Calculate the displacement of the runner (answer in km).

27. A jogger runs 15 km[N35˚E], and then runs 7.5 km[N25˚W]. It takes a total of 2.0 hours to run.
   (a) Determine the displacement of the jogger.
   (b) Calculate the jogger's average velocity.

28. A sailboat is moving with velocity of 11.0 m/s[E] when it makes a turn to continue at a velocity of 12.0 m/s[S40.0˚E]. The turn takes 45.0 seconds to execute. Calculate the acceleration of the sailboat.

29. A canoeist wants to travel straight across a river that is 0.10 km wide. However, there is a strong current moving downstream with a velocity of 3.0 km/hr. The canoeist can maintain a velocity relative to the water of 4.0 km/hr.
   (a) In what direction should the canoeist head to arrive at a position on the other shore directly opposite to his starting position?
   (b) How long will the trip take him?