# EXERCISES AND PROBLEMS

## Exercises

### Section 1.1 Motion Diagrams

1. A car skids to a halt to avoid hitting an object in the road. Draw a basic motion diagram, using the images from the movie, from the time the skid begins until the car is stopped.
2. You drop a soccer ball from your third-story balcony. Draw a basic motion diagram, using the images from the movie, from the time you release the ball until it touches the ground.

### Section 1.2 The Particle Model

3. a. Write a paragraph describing the *particle model.* What is it, and why is it important?
   b. Give two examples of situations, different from those described in the text, for which the particle model is appropriate.
   c. Give an example of a situation, different from those described in the text, for which it would be inappropriate.

### Section 1.3 Position and Time

4. Write a sentence or two describing the difference between position and displacement. Give one example of each.

### Section 1.4 Velocity

5. a. What is an *operational definition?*
   b. Give operational definitions of displacement and velocity. Your definition should be given mostly in words and pictures, with a minimum of symbols or mathematics.
6. A softball player hits the ball and starts running toward first base. Draw a motion diagram, using the particle model, showing her position and her average velocity vectors during the first few seconds of her run.
7. A softball player slides into second base. Draw a basic motion diagram, using the particle model, showing his position and his average velocity vectors from the time he begins to slide until he reaches the base.

### Section 1.5 Acceleration

8. Give an operational definition of acceleration. Your definition should be given mostly in words and pictures, with a minimum of symbols or mathematics.
9. a. Find the average acceleration vector point 1 of this three-point motion diagram.
   b. Is the object's average speed between points 1 and 2 greater than, less than, or equal to its average speed between points 0 and 1? Explain how you can tell.

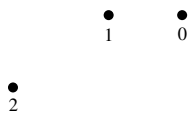


FIGURE EX1.9

10. a. Find the average acceleration vector point 1 of this three-point motion diagram.
    b. Is the object's average speed between points 1 and 2 greater than, less than, or equal to its average speed between points 0 and 1? Explain how you can tell.

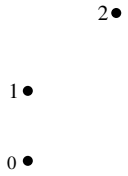


FIGURE EX1.10

11. Figure 1.21 showed the motion diagram for Anne as she rode a Ferris wheel that was turning at a constant speed. The inset to the figure showed how to find the acceleration vector at the lowest point in her motion. Use a similar analysis to find Anne's acceleration vector at the 12 o'clock, 4 o'clock, and 8 o'clock positions of the motion diagram. Use a ruler so that your analysis is accurate.
12. Figure 1.18 showed the motion diagram of a runner on a circular track. Find the acceleration vector when the runner is at the top of the diagram and when the runner is at the bottom of the diagram.

### Section 1.6 Examples of Motion Diagrams

13. A car travels to the left at a steady speed for a few seconds, then brakes for a stop sign. Draw a complete motion diagram of the car.
14. A child is sledding on a smooth, level patch of snow. She encounters a rocky patch and slows to a stop. Draw a complete motion diagram of the child and her sled.
15. A roof tile falls straight down from a two-story building. It lands in a swimming pool and settles gently to the bottom. Draw a complete motion diagram of the tile.
16. Your roommate drops a tennis ball from a third story balcony. It hits the sidewalk and bounces as high as the second story. Draw a complete motion diagram of the tennis ball from the time it is released until it reaches the maximum height on its bounce. Be sure to determine and show the acceleration at the lowest point.
17. A car is driving north at steady speed. It makes a gradual 90° left turn without losing speed, then continues driving to the west. Draw a complete motion diagram as seen from a helicopter hovering over the highway.
18. A toy car rolls down a ramp, then across a smooth, horizontal floor. Draw a complete motion diagram of the toy car.

### Section 1.7 From Words to Symbols

### Section 1.8 A Problem-Solving Strategy

19. Draw a pictorial representation for the following problem. Do *not* solve the problem. The light turns green, and a bicyclist starts forward with an acceleration of 1.5 m/s$^2$. How far must she travel to reach a speed of 7.5 m/s?
20. Draw a pictorial representation for the following problem. Do *not* solve the problem. What acceleration does a rocket need to reach a speed of 200 m/s at a height of 1.0 km?

**Section 1.9 Units and Significant Figures**

21. Convert the following to SI units:
    a. 9.12 $\mu$s  b. 3.42 km
    c. 44 cm/ms  d. 80 km/hour
22. Convert the following to SI units:
    a. 8 in  b. 66 ft/s
    c. 60 mph  d. 14 in$^2$
23. Convert the following to SI units:
    a. 1 hour  b. 1 day
    c. 1 year  d. 32 ft/s$^2$
24. Using the approximate conversion factors in Table 1.4, convert the following to SI units *without* using your calculator.
    a. 20 ft  b. 60 mi
    c. 60 mph  d. 8 in
25. A regulation soccer field for international play is a rectangle with a length between 100 m and 110 m and a width between 64 m and 75 m. What are the smallest and largest areas that the field could be?
26. The quantity called *mass density* is the mass per unit volume of a substance. Express the following mass densities in SI units.
    a. Aluminum, $2.7 \times 10^{-3}$ kg/cm$^3$
    b. Alcohol, 0.81 g/cm$^3$
27. How many significant figures does each of the following numbers have?
    a. 6.21  b. 62.1
    c. 0.620  d. 0.062
28. How many significant figures does each of the following numbers have?
    a. 6200  b. 0.006200
    c. 1.0621  d. $6.21 \times 10^3$
29. Compute the following numbers, applying the significant figure rule adopted in this textbook.
    a. $33.3 \times 25.4$  b. $33.3 - 25.4$
    c. $\sqrt{33.3}$  d. $333.3 \div 25.4$
30. Compute the following numbers, applying the significant figure rule adopted in this textbook.
    a. $33.3^2$  b. $33.3 \times 45.1$
    c. $\sqrt{22.2} - 1.2$  d. 1/44.4
31. Estimate (don't measure!) the length of a typical car. Give your answer in both feet and meters. Briefly describe how you arrived at this estimate.
32. Estimate the height of a telephone pole. Give your answer in both feet and meters. Briefly describe how you arrived at this estimate.
33. Estimate the average speed with which you go from home to campus via whatever mode of transportation you use most commonly. Give your answer in both mph and m/s. Briefly describe how you arrived at this estimate.
34. Estimate the average speed with which the hair on your head grows. Give your answer in both m/s and $\mu$m/hour. Briefly describe how you arrived at this estimate.

## Problems

For Problems 35 through 44, draw a complete motion diagram *and* a pictorial representation. Do *not* solve these problems or do any mathematics.

35. A Porsche accelerates from a stoplight at 5.0 m/s$^2$ for five seconds, then coasts for three more seconds. How far has it traveled?
36. Billy drops a watermelon from the top of a three-story building, 10 m above the sidewalk. How fast is the watermelon going when it hits?
37. Sam is recklessly driving 60 mph in a 30 mph speed zone when he suddenly sees the police. He steps on the brakes and slows to 30 mph in three seconds, looking nonchalant as he passes the officer. How far does he travel while braking?
38. A speed skater moving across frictionless ice at 8.0 m/s hits a 5.0-m-wide patch of rough ice. She slows steadily, then continues on at 6.0 m/s. What is her acceleration on the rough ice?
39. You would like to stick a wet spit wad on the ceiling, so you toss it straight up with a speed of 10 m/s. How long does it take to reach the ceiling, 3.0 m above?
40. A student standing on the ground throws a ball straight up. The ball leaves the student's hand with a speed of 15 m/s when the hand is 2.0 m above the ground. How long is the ball in the air before it hits the ground? (The student moves her hand out of the way.)
41. A ball rolls along a smooth horizontal floor at 10 m/s, then starts up a 20° ramp. How high does it go before rolling back down?
42. A motorist is traveling at 20 m/s. He is 60 m from a stop light when he sees it turn yellow. His reaction time, before stepping on the brake, is 0.50 s. What steady deceleration while braking will bring him to a stop right at the light?
43. Ice hockey star Bruce Blades is 5.0 m from the blue line and gliding toward it at a speed of 4.0 m/s. You are 20 m from the blue line, directly behind Bruce. You want to pass the puck to Bruce. With what speed should you shoot the puck down the ice so that it reaches Bruce exactly as he crosses the blue line?
44. You are standing still as Fred runs past you with the football at a speed of 6.0 yards per second. He has only 30 yards left to go before reaching the goal line to score the winning touchdown. If you begin running at the exact instant he passes you, what acceleration must you maintain to catch him 5.0 yards in front of the goal line?

Problems 45 through 50 show a motion diagram. For each of these problems, write a one or two sentence "story" about a *real object* that has this motion diagram. Your stories should talk about people or objects by name and say what they are doing. Problems 35–44 are examples of motion short stories.

45.

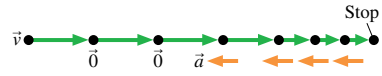


FIGURE P1.45

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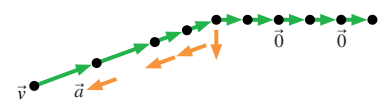


FIGURE P1.46

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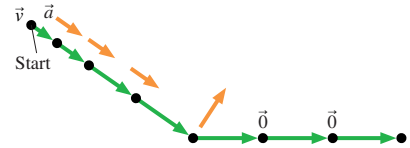


FIGURE P1.47

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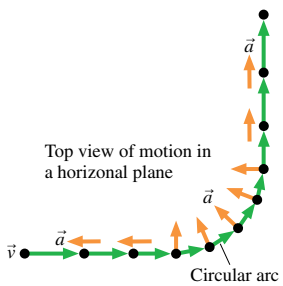


FIGURE P1.48

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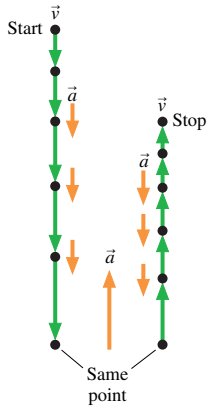


FIGURE P1.49

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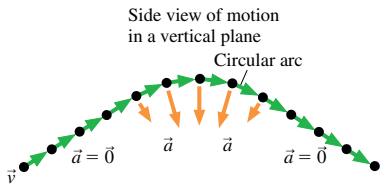


FIGURE P1.50

Problems 51 through 56 show a partial motion diagram. For each:

a. Complete the motion diagram by adding acceleration vectors.
b. Write a physics *problem* for which this is the correct motion diagram. Be imaginative! Don't forget to include enough information to make the problem complete and to state clearly what is to be found.
c. Draw a full pictorial representation for your problem.

51.

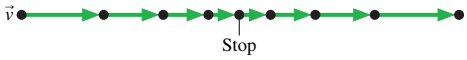


FIGURE P1.51

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FIGURE P1.52

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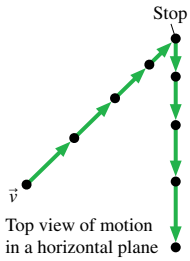


FIGURE P1.53

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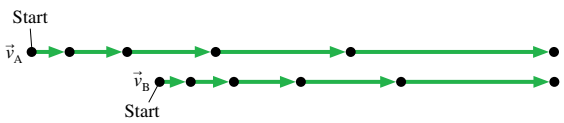


FIGURE P1.54

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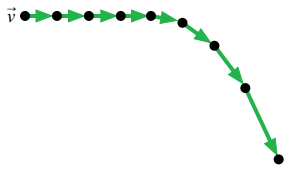


FIGURE P1.55

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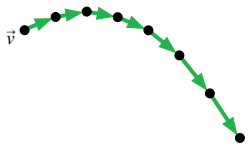



FIGURE P1.56

57. Consider a pendulum swinging back and forth on a string. Use a motion diagram analysis and a written explanation to answer the following questions.
   a. At the lowest point in the motion, is the velocity zero or nonzero? Is the acceleration zero or nonzero? If these vectors aren't zero, which way do they point?
   b. At the end of its arc, when the pendulum is at the highest point on the right or left side, is the velocity zero or nonzero? Is the acceleration zero or nonzero? If these vectors aren't zero, which way do they point?

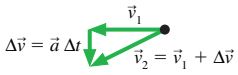
## STOP TO THINK ANSWERS

**Stop to Think 1.1: B.** The images of B are farther apart, so it travels a larger distance than does A during the same intervals of time.

**Stop to Think 1.2: a.** Dropped ball. **b.** Dust particle. **c.** Descending rocket.

**Stop to Think 1.3: e.** The average velocity vector is found by connecting one dot in the motion diagram to the next.

**Stop to Think 1.4: c.** The velocity leading away from this point is $\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$.




**Stop to Think 1.5: d > c > b = a.**