CONCEPTUAL QUESTIONS

1. How many significant figures does each of the following numbers have?
   a. 53.2  
   b. 0.53  
   c. 5.320  
   d. 0.0532
2. How many significant figures does each of the following numbers have?
   a. 310  
   b. 0.00310  
   c. 1.031  
   d. 3.10 \times 10^3
3. Is the particle in FIGURE Q1.3 speeding up? Slowing down? Or can you tell? Explain.

   FIGURE Q1.3

4. Does the object represented in FIGURE Q1.4 have a positive or negative value of \(a_x\)? Explain.

   FIGURE Q1.4

5. Does the object represented in FIGURE Q1.5 have a positive or negative value of \(a_y\)? Explain.

   FIGURE Q1.5

6. Determine the signs (positive or negative) of the position, velocity, and acceleration for the particle in FIGURE Q1.6.

   FIGURE Q1.6

7. Determine the signs (positive or negative) of the position, velocity, and acceleration for the particle in FIGURE Q1.7.

   FIGURE Q1.7

8. Determine the signs (positive or negative) of the position, velocity, and acceleration for the particle in FIGURE Q1.8.

   FIGURE Q1.8

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. A rocket is launched straight up. Draw a basic motion diagram, using the images from the movie, from the moment of liftoff until the rocket is at an altitude of 500 m.
3. You're driving along the highway at 60 mph until you enter a town where the speed limit is 30 mph. You slow quickly, but not instantly, to 30 mph. Draw a basic motion diagram of your car, using images from the movie, from 30 s before reaching the city limit until 30 s afterward.

Section 1.2 The Particle Model

4. 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

Section 1.4 Velocity

5. You drop a soccer ball from your third-story balcony. Use the particle model to draw a motion diagram showing the ball's position and average velocity vectors from the time you release the ball until the instant it touches the ground.

6. A softball player hits the ball and starts running toward first base. Use the particle model to draw a motion diagram showing her position and her average velocity vectors during the first few seconds of her run.
7. A softball player slides into second base. Use the particle model to draw a motion diagram showing his position and his average velocity vectors from the time he begins to slide until he reaches the base.

Section 1.5 Linear Acceleration

8. a. FIGURE EX1.8 shows the first three points of a motion diagram. 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.
   b. Use Tactics Box 1.3 to find the average acceleration vector at point 1. Draw the completed motion diagram, showing the velocity vectors and acceleration vector.

   FIGURE EX1.8

9. a. FIGURE EX1.9 shows the first three points of a motion diagram. 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.
   b. Use Tactics Box 1.3 to find the average acceleration vector at point 1. Draw the completed motion diagram, showing the velocity vectors and acceleration vector.

   FIGURE EX1.9
10.  FIGURE EX1.10 shows two dots of a motion diagram and vector \( \vec{v}_1 \). Copy this figure and add vector \( \vec{v}_2 \) and dot 3 if the acceleration vector \( \vec{a} \) at dot 2 (a) points up and (b) points down.

![Figure EX1.10](image)

11.  FIGURE EX1.11 shows two dots of a motion diagram and vector \( \vec{v}_2 \). Copy this figure and add vector \( \vec{v}_1 \) and dot 1 if the acceleration vector \( \vec{a} \) at dot 2 (a) points to the right and (b) points to the left.

![Figure EX1.11](image)

12.  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.

13.  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.

14.  You use a long rubber band to launch a paper wad straight up. Draw a complete motion diagram of the paper wad from the moment you release the stretched rubber band until the paper wad reaches its highest point.

15.  A roof tile falls straight down from a two-story building. It lands in a swimming pool and bounces 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 toy car rolls down a ramp, then across a smooth, horizontal floor. Draw a complete motion diagram of the toy car.

Section 1.6 Motion in One Dimension

18.  FIGURE EX1.18 shows the motion diagram of a drag racer. The camera took one frame every 2 s.

![Figure EX1.18](image)

a. Measure the \( x \)-value of the racer at each dot. List your data in a table similar to Table 1.1, showing each position and the time at which it occurred.

b. Make a position-versus-time graph for the drag racer. Because you have data only at certain instants, your graph should consist of dots that are not connected together.

19.  Write a short description of the motion of a real object for which FIGURE EX1.19 would be a realistic position-versus-time graph.

![Figure EX1.19](image)

20.  Write a short description of the motion of a real object for which FIGURE EX1.20 would be a realistic position-versus-time graph.

![Figure EX1.20](image)

Section 1.7 Solving Problems in Physics

21.  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 \( \text{m/s}^2 \). How far must she travel to reach a speed of 7.5 \( \text{m/s} \)?

22.  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 \( \text{m/s} \) at a height of 1.0 \( \text{km} \)?

Section 1.8 Units and Significant Figures

23.  Convert the following to SI units:
   a.  6.15 \( \text{ms} \)
   b.  27.2 \( \text{km} \)
   c.  112 \( \text{km/h} \)
   d.  72 \( \mu\text{m/s} \)

24.  Convert the following to SI units:
   a.  8.0 \( \text{in} \)
   b.  66 \( \text{ft/s} \)
   c.  60 \( \text{mph} \)
   d.  14 \( \text{in}^2 \)

25.  Convert the following to SI units:
   a.  3 \( \text{hours} \)
   b.  2 \( \text{days} \)
   c.  1 \( \text{year} \)
   d.  215 \( \text{ft/h} \)

26.  Using the approximate conversion factors in Table 1.5, convert the following to SI units without using your calculator.
   a.  20 \( \text{ft} \)
   b.  60 \( \text{mi} \)
   c.  60 \( \text{mph} \)
   d.  8 \( \text{in} \)

27.  Using the approximate conversion factors in Table 1.5, convert the following SI units to English units without using your calculator.
   a.  30 \( \text{cm} \)
   b.  25 \( \text{m/s} \)
   c.  5 \( \text{km} \)
   d.  0.5 \( \text{cm} \)

28.  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.  \( 33.3 \div 25.4 \)

29.  Compute the following numbers, applying the significant figure rule adopted in this textbook.
   a.  \( 12.5^3 \)
   b.  \( 12.5 \times 5.21 \)
   c.  \( \sqrt{12.5 - 1.2} \)
   d.  \( 12.5^{-1} \)

30.  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.

31.  Estimate the height of a telephone pole. Give your answer in both feet and meters. Briefly describe how you arrived at this estimate.

32.  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 \( \text{mph} \) and \( \text{m/s} \). Briefly describe how you arrived at this estimate.
33. Estimate the average speed with which the hair on your head grows. Give your answer in both m/s and μm/hour. Briefly describe how you arrived at this estimate.

Problems

For Problems 34 through 43, draw a complete pictorial representation. Do not solve these problems or do any mathematics.

34. A Porsche accelerates from a stoplight at 5.0 m/s² for five seconds, then coasts for three more seconds. How far has it traveled?

35. A jet plane is cruising at 300 m/s when suddenly the pilot turns the engines up to full throttle. After traveling 4.0 km, the jet is moving with a speed of 400 m/s. What is the jet's acceleration as it speeds up?

36. 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?

37. You would like to stick a wet spilt 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?

38. A speed skater moving across frictionless ice at 8.0 m/s hits a 5.0-m-wide patch of rough ice. She skids steadily, then continues on at 6.0 m/s. What is her acceleration on the rough ice?

39. Santa loses his footing and slides down a frictionless, snowy roof that is tilted at an angle of 30°. If Santa slides 10 m before reaching the edge, what is his speed as he leaves the roof?

40. A motorist is traveling at 20 m/s. He is 60 m from a stoplight when he sees it turn yellow. His reaction time, before stepping on the brake, is 0.50 s. What steady acceleration while braking will bring him to a stop right at the light?

41. A car traveling at 30 m/s runs out of gas while traveling up a 10° slope. How far up the hill will the car coast before starting to roll back down?

42. 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?

43. David is driving a steady 30 m/s when he passes Tina, who is sitting in her car at rest. Tina begins to accelerate at a steady 2.0 m/s² at the instant when David passes. How far does Tina drive before passing David?

Problems 44 through 48 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 34 through 42 are examples of motion short stories.

44. 

45. 

Problems 49 through 52 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 pictorial representation for your problem.

49. 

50. 

51. 

Top view of motion in a horizontal plane

FIGURE P1.51

FIGURE P1.50

FIGURE P1.49

FIGURE P1.48

FIGURE P1.47

FIGURE P1.46

46. 

FIGURE P1.44

47. 

FIGURE P1.45
52. \[ v_x, \quad v_y, \quad \text{Start} \]

53. 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?

54. 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\(^3\)

55. FIGURE P1.55 shows a motion diagram of a car traveling down a street. The camera took one frame every 10 s. A distance scale is provided.

56. Write a short description of a real object for which FIGURE P1.56 would be a realistic position-versus-time graph.

57. Write a short description of a real object for which FIGURE P1.57 would be a realistic position-versus-time graph.

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 1.3: a. The average velocity vector is found by connecting one dot in the motion diagram to the next.

Stop to Think 1.4: b. \( \vec{v}_2 = \vec{v}_1 + \Delta \vec{v} \), and \( \Delta \vec{v} \) points in the direction of \( \vec{v}_2 \).

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