For homework assigned on MasteringPhysics, go to www.masteringphysics.com | BIO Biology and/or medical-related problems C Computer problems

For Thought and Discussion

1. Explain why measurement standards based on laboratory procedures are preferable to those based on specific objects such as the international prototype kilogram.
2. Which measurement standards are now defined operationally? Which aren't?
3. When a computer that carries seven significant figures adds 1.000000 and 2.5310215, what's its answer? Why?
4. Why doesn't Earth's rotation provide a suitable time standard?
5. To raise a power of 10 to another power, you multiply the exponent by the power. Explain why this works.
6. What facts might a scientist use in estimating Earth's age?
7. How would you determine the length of a curved line?
8. Write $1/x$ as x to some power.
9. Emissions of carbon dioxide from fossil-fuel combustion are often expressed in gigatonnes per year, where 1 tonne = 1000 kg. But sometimes CO_2 emissions are given in petagrams per year. How are the two units related?

Exercises and Problems

Exercises

Section 1.2 Measurements and Units

10. The power output of a typical large power plant is 1000 megawatts (MW). Express this result in (a) W, (b) kW, and (c) GW.
11. The diameter of a hydrogen atom is about 0.1 nm, and the diameter of a proton is about 1 fm. How many times bigger than a proton is a hydrogen atom?
12. Use the definition of the meter to determine how far light travels in 1 ns.
13. In nanoseconds, how long is the period of the cesium-133 radiation used to define the second?
14. Lake Baikal in Siberia holds the world's largest quantity of fresh water, about 14 Eg. How many kilograms is that?
15. A hydrogen atom is about 0.1 nm in diameter. How many hydrogen atoms lined up side by side would make a line 1 cm long?
16. How long a piece of wire would you need to form a circular arc subtending an angle of 1.4 rad, if the radius of the arc is 8.1 cm?
17. Making a turn, a jetliner flies 2.1 km on a circular path of radius 3.4 km. Through what angle does it turn?
18. A car is moving at 35.0 mi/h. Express its speed in (a) m/s and (b) ft/s.
19. You have postage for a 1-oz letter but only a metric scale. What's the maximum mass your letter can have, in grams?
20. A year is very nearly $\pi \times 10^7$ s. By what percentage is this figure in error?
21. How many cubic centimeters are in a cubic meter?
22. Since the start of the industrial era, humankind has emitted about half an exagram of carbon to the atmosphere. What's that in tonnes (t; 1 t = 1000 kg)?
23. A gallon of paint covers 350 ft². What's its coverage in m²/L?
24. Highways in Canada have speed limits of 100 km/h. How does this compare with the 65 mi/h speed limit common in the United States?
25. One m/s is how many km/h?
26. A 3.0-lb box of grass seed will seed 2100 ft² of lawn. Express this coverage in m²/kg.
27. A radian is how many degrees?

Section 1.3 Working with Numbers

28. Add 3.63105 m and 2.13103 km.
29. Divide 4.23103 m/s by 0.57 ms, and express your answer in m/s².
30. Add 5.131022 cm and 6.83103 mm, and multiply the result by 1.83104 N (N is the SI unit of force).
31. Find the cube root of 6.4×10^{19} without a calculator.
32. Add 1.46 m and 2.3 cm.
33. You're asked to specify the length of an updated aircraft model for a sales brochure. The original plane was 41 m long; the new model has a 3.6-cm-long radio antenna added to its nose. What length do you put in the brochure?
34. Repeat the preceding exercise, this time using 41.05 m as the airplane's original length.

Problems

35. To see why it's important to carry more digits in intermediate calculations, determine $(\sqrt{3})^3$ to three significant figures in two ways: (a) Find $\sqrt{3}$ and round to three significant figures, then cube and again round; and (b) find $\sqrt{3}$ to four significant figures, then cube and round to three significant figures.
36. You've been hired as an environmental watchdog for a big-city newspaper. You're asked to estimate the number of trees that go into one day's printing, given that half the newsprint comes from recycling, the rest from new wood pulp. What do you report?
37. The average dairy cow produces about 10^4 kg of milk per year. Estimate the number of dairy cows needed to keep the United States supplied with milk.
38. How many Earths would fit inside the Sun?
39. The average American uses electrical energy at the rate of about 1.5 kilowatts (kW). Solar energy reaches Earth's surface at an average rate of about 300 watts on every square meter. What fraction of the United States' land area would have to be covered with 20% efficient solar cells to provide all of our electrical energy?
40. You're writing a biography of the famous physicist Enrico Fermi, who was fond of estimation problems. Here's one problem Fermi posed: What's the number of piano tuners in Chicago? Give your estimate, and explain to your readers how you got it.
41. (a) Estimate the volume of water going over Niagara Falls each second. (b) The falls provides the outlet for Lake Erie; if the falls were shut off, estimate how long it would take Lake Erie to rise 1 m.
42. Estimate the number of air molecules in your dorm room.
43. A human hair is about 100 μm across. Estimate the number of hairs in a typical braid.
44. You're working in the fraud protection division of a credit-card company, and you're asked to estimate the chances that a 16-digit number chosen at random will be a valid credit-card number. What do you answer?
45. Bubble gum's density is about 1 g/cm³. You blow an 8-g wad of gum into a bubble 10 cm in diameter. What's the bubble's thickness? (*Hint*: Think about spreading the bubble into a flat sheet. The surface area of a sphere is $4\pi r^2$.)
46. The Moon barely covers the Sun during a solar eclipse. Given that Moon and Sun are, respectively, 4×10^5 km and 1.5×10^8 km from Earth, determine how much bigger the Sun's diameter is than the Moon's. If the Moon's radius is 1800 km, how big is the Sun?
47. The semiconductor chip at the heart of a personal computer is a square 4 mm on a side and contains 10^9 electronic components. (a) What's the size of each component, assuming they're square? (b) If a calculation requires that electrical impulses traverse 10^4 components on the chip, each a million times, how many such calculations can the computer perform each second? (*Hint*: The maximum speed of an electrical impulse is 3×10^8 m/s, close to the speed of light.)
48. Estimate the number of (a) atoms and (b) cells in your body.
49. When we write the number 3.6 as typical of a number with two significant figures, we're saying that the actual value is closer to 3.6 than to 3.5 or 3.7; that is, the actual value lies between 3.55 and 3.65. Show that the percent uncertainty implied by such two-significant-figure precision varies with the value of the number, being the lowest for numbers beginning with 9 and the highest for numbers beginning with 1. In particular, what is the percent uncertainty implied by the numbers (a) 1.1, (b) 5.0, and (c) 9.9?
50. Continental drift occurs at about the rate your fingernails grow. Estimate the age of the Atlantic Ocean, given that the eastern and western hemispheres have been drifting apart.
51. You're driving into Canada and trying to decide whether to fill your gas tank before or after crossing the border. Gas in the United States costs \$2.97/gallon, in Canada it's 94¢/L, and the Canadian dollar is worth 87¢ in U.S. currency. Where should you fill up?
52. In the 1908 London Olympics, the intended 26-mile marathon was extended 385 yards to put the end in front of the royal reviewing stand. This distance subsequently became standard. What's the marathon distance in kilometers, to the nearest meter?
53. Express the following with appropriate units and significant figures: (a) 1.0 m plus 1 mm, (b) 1.0 m times 1 mm, (c) 1.0 m minus 999 mm, (d) 1.0 m divided by 999 mm.
54. You're shopping for a new computer, and a salesperson claims the microprocessor chip in the model you're looking at contains 10 billion electronic components. The chip measures 5 mm on a side and uses 32-nm technology, meaning each component is 32 nm across. Is the salesperson right?
55. Café Milagro sells coffee online. A half-kilogram bag of coffee costs \$8.95, excluding shipping. If you order six bags, the shipping costs \$6.90. What's the cost per bag when you include shipping?
56. The world consumes energy at the rate of about 450 EJ per year, where the joule (J) is the SI energy unit. Convert this figure to watts (W), where 1 W = 1 J/s, and then estimate the average per capita energy consumption rate in watts.

Passage Problems

The human body contains about 10^{14} cells, and the diameter of a typical cell is about 10 μm. Like all ordinary matter, cells are made of atoms; a typical atomic diameter is 0.1 nm.

57. How does the number of atoms in a cell compare with the number of cells in the body?
    a. greater b. smaller c. about the same
58. The volume of a cell is about
    a. 10^{-10} m³. b. 10^{-15} m³. c. 10^{-20} m³. d. 10^{-30} m³.
59. The mass of a cell is about
    a. 10^{-10} kg. b. 10^{-12} kg. c. 10^{-14} kg. d. 10^{-16} kg.
60. The number of atoms in the body is closest to
    a. 10^{14}. b. 10^{20}. c. 10^{30}. d. 10^{40}.

Answers to Chapter Questions

Answer to Chapter Opening Question

All of them!

Answers to GOT IT? Question

1.1. (a) 2.998×10^{-9}, 0.0008, 3.14×10^7, 0.041×10^9, 55×10^6 (b) 0.0008, 0.041×10^9 and 55×10^6 (with two significant figures each), 3.14×10^7, 2.998×10^{-9}

For homework assigned on MasteringPhysics, go to www.masteringphysics.com | BIO Biology and/or medical-related problems C Computer problems

For Thought and Discussion

1. Under what conditions are average and instantaneous velocity equal?
2. Does a speedometer measure speed or velocity?
3. You check your odometer at the beginning of a day's driving and again at the end. Under what conditions would the difference between the two readings represent your displacement?
4. Consider two possible definitions of average speed: (a) the average of the values of the instantaneous speed over a time interval and (b) the magnitude of the average velocity. Are these definitions equivalent? Give two examples to demonstrate your conclusion.
5. Is it possible to be at position $x = 0$ and still be moving?
6. Is it possible to have zero velocity and still be accelerating?
7. If you know the initial velocity v_0 and the initial and final heights y_0 and y, you can use Equation 2.10 to solve for the time t when the object will be at height y. But the equation is quadratic in t, so you'll get two answers. Physically, why is this?
8. Starting from rest, an object undergoes acceleration given by $a = bt$, where t is time and b is a constant. Can you use bt for a in Equation 2.10 to predict the object's position as a function of time? Why or why not?
9. In which of the velocity-versus-time graphs shown in Fig. 2.14 would the average velocity over the interval shown equal the average of the velocities at the ends of the interval?

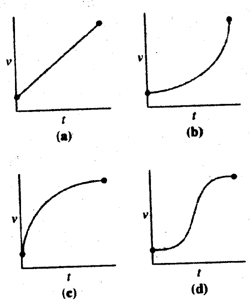

FIGURE 2.14 For Thought and Discussion 9

10. If you travel in a straight line at 50 km/h for 1 h and at 100 km/h for another hour, is your average velocity 75 km/h? If not, is it more or less?
11. If you travel in a straight line at 50 km/h for 50 km and then at 100 km/h for another 50 km, is your average velocity 75 km/h? If not, is it more or less?

Exercises and Problems

Exercises

Section 2.1 Average Motion

12. In 2009, Usain Bolt of Jamaica set a world record in the 100-m dash with a time of 9.58 s. What was his average speed?
13. The standard 26-mile, 385-yard marathon dates to 1908, when the Olympic marathon started at Windsor Castle and finished before the Royal Box at London's Olympic Stadium. Today's top marathoners achieve times around 2 hours, 4 minutes for the standard marathon. (a) What's the average speed of a marathon run in this time? (b) Marathons before 1908 were typically about 25 miles. How much longer does the race last today as a result of the extra mile and 385 yards, assuming it's run at the average speed?
14. Starting from home, you bicycle 24 km north in 2.5 h and then turn around and pedal straight home in 1.5 h. What are your (a) displacement at the end of the first 2.5 h, (b) average velocity over the first 2.5 h, (c) average velocity for the homeward leg of the trip, (d) displacement for the entire trip, and (e) average velocity for the entire trip?
15. The Voyager 1 spacecraft is expected to continue broadcasting data until at least 2020, when it will be some 14 billion miles from Earth. How long will it take Voyager's radio signals, traveling at the speed of light, to reach Earth from this distance?
16. In 2008, Australian Emma Snowsill set an unofficial record in the women's Olympic triathlon, completing the 1.5-km swim, 40-km bicycle ride, and 10-km run in 1 h, 58 min, 27.66 s. What was her average speed?
17. Taking Earth's orbit to be a circle of radius 1.5×10^8 km, determine Earth's orbital speed in (a) meters per second and (b) miles per second.
18. What's the conversion factor from meters per second to miles per hour?

Section 2.2 Instantaneous Velocity

19. On a single graph, plot distance versus time for the first two trips from Houston to Des Moines described on page 14. For each trip, identify graphically the average velocity and, for each segment of the trip, the instantaneous velocity.
20. For the motion plotted in Fig. 2.15, estimate (a) the greatest velocity in the positive x-direction, (b) the greatest velocity in the negative x-direction, (c) any times when the object is instantaneously at rest, and (d) the average velocity over the interval shown.

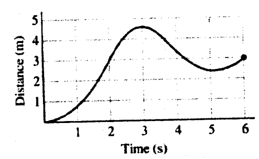

FIGURE 2.15 Exercise 20

21. A model rocket is launched straight upward. Its altitude y as a function of time is given by $y = bt - ct^2$, where $b = 82$ m/s, $c = 4.9$ m/s^2, t is the time in seconds, and y is in meters. (a) Use differentiation to find a general expression for the rocket's velocity as a function of time. (b) When is the velocity zero?

Section 2.3 Acceleration

22. A giant eruption on the Sun propels solar material from rest to 450 km/s over a period of 1 h. Find the average acceleration.
23. Starting from rest, a subway train first accelerates to 25 m/s, then brakes. Forty-eight seconds after starting, it's moving at 17 m/s. What's its average acceleration in this 48-s interval?
24. A space shuttle's main engines cut off 8.5 min after launch, at which time its speed is 7.6 km/s. What's the shuttle's average acceleration during this interval?

25. An egg drops from a second-story window, taking 1.12 s to fall and reaching 11.0 m/s just before hitting the ground. On contact, the egg stops completely in 0.131 s. Calculate the average magnitudes of its acceleration while falling and while stopping.
26. An airplane's takeoff speed is 320 km/h. If its average acceleration is 2.9 m/s^2, how much time is it accelerating down the runway before it lifts off?
27. ThrustSSC, the world's first supersonic car, accelerates from rest to 1000 km/h in 16 s. What's its acceleration?

Section 2.4 Constant Acceleration

28. You're driving at 70 km/h when you apply constant acceleration to pass another car. Six seconds later, you're doing 80 km/h. How far did you go in this time?
29. Differentiate both sides of Equation 2.10, and show that you get Equation 2.7.
30. An X-ray tube gives electrons constant acceleration over a distance of 15 cm. If their final speed is 1.2×10^7 m/s, what are (a) the electrons' acceleration and (b) the time they spend accelerating?
31. A rocket rises with constant acceleration to an altitude of 85 km, at which point its speed is 2.8 km/s. (a) What's its acceleration? (b) How long does the ascent take?
32. Starting from rest, a car accelerates at a constant rate, reaching 88 km/h in 12 s. Find (a) its acceleration and (b) how far it goes in this time.
33. A car moving initially at 50 mi/h begins slowing at a constant rate 100 ft short of a stoplight. If the car comes to a full stop just at the light, what is the magnitude of its acceleration?
34. BIO In a medical X-ray tube, electrons are accelerated to a velocity of 10^8 m/s and then slammed into a tungsten target. As they stop, the electrons' rapid acceleration produces X rays. If the time for an electron to stop is on the order of 10^{-9} s, approximately how far does it move while stopping?
35. The Barringer meteor crater in Arizona is 180 m deep and 1.2 km in diameter. Fragments of the meteor lie just below the bottom of the crater. If these fragments negatively accelerated at a constant rate of 4×10^5 m/s^2 as they plowed through Earth, what was the meteor's speed at impact?
36. You're driving at speed v_0 when you spot a stationary moose on the road, a distance d ahead. Find an expression for the magnitude of the acceleration you need if you're to stop before hitting the moose.

Section 2.5 The Acceleration of Gravity

37. You drop a rock into a deep well and 4.4 s later hear a splash. How far down is the water? Neglect the travel time of sound.
38. Your friend is sitting 6.5 m above you on a tree branch. How fast should you throw an apple so it just reaches her?
39. A model rocket leaves the ground, heading straight up at 49 m/s. (a) What's its maximum altitude? Find its speed and altitude at (b) 1 s, (c) 4 s, and (d) 7 s.
40. A foul ball leaves the bat going straight up at 23 m/s. (a) How high does it rise? (b) How long is it in the air? Neglect the distance between bat and ground.
41. A Frisbee is lodged in a tree 6.5 m above the ground. A rock thrown from below must be going at least 3 m/s to dislodge the Frisbee. How fast must such a rock be thrown upward if it leaves the thrower's hand 1.3 m above the ground?
42. Space pirates kidnap an earthling and hold him on one of the solar system's planets. With nothing else to do, the prisoner amuses himself by dropping his watch from eye level (170 cm) to the floor. He observes that the watch takes 0.95 s to fall. On what planet is he being held? (*Hint:* Consult Appendix E.)

Problems

43. You allow 40 min to drive 25 mi to the airport, but you're caught in heavy traffic and average only 20 mi/h for the first 15 min. What must your average speed be on the rest of the trip if you're to make your flight?
44. A base runner can get from first to second base in 3.4 s. If he leaves first as the pitcher throws a 90 mi/h fastball the 61-ft distance to the catcher, and if the catcher takes 0.45 s to catch and rethrow the ball, how fast does the catcher have to throw the ball to second base to make an out? Home plate to second base is the diagonal of a square 90 ft on a side.
45. You drive 4600 km from coast to coast of the United States at 65 mi/h (105 km/h), stopping an average of 30 min for rest after every 2 h of driving. (a) What's your average velocity for the entire trip? (b) How long does the trip take?
46. You can run 9.0 m/s, 20% faster than your brother. How much head start should you give him in order to have a tie race over 100 m?
47. A jetliner leaves San Francisco for New York, 4600 km away. With a strong tailwind, its speed is 1100 km/h. At the same time, a second jet leaves New York for San Francisco. Flying into the wind, it makes only 700 km/h. When and where do the two planes pass?
48. An object's position is given by $x = bt + ct^3$, where $b = 1.50$ m/s, $c = 0.640$ m/s^3, and t is time in seconds. To study the limiting process leading to the instantaneous velocity, calculate the object's average velocity over time intervals from (a) 1.00 s to 3.00 s, (b) 1.50 s to 2.50 s, and (c) 1.95 s to 2.05 s. (d) Find the instantaneous velocity as a function of time by differentiating, and compare its value at 2 s with your average velocities.
49. An object's position as a function of time t is given by $x = bt^4$, with b a constant. Find an expression for the instantaneous velocity, and show that the average velocity over the interval from $t = 0$ to any time t is one-fourth of the instantaneous velocity at t.
50. In a drag race, the position of a car as a function of time is given by $x = bt^2$, with $b = 2.000$ m/s^2. In an attempt to determine the car's velocity midway down a 400-m track, two observers stand at the 180-m and 220-m marks and note when the car passes. (a) What value do the two observers compute for the car's velocity over this 40-m stretch? Give your answer to four significant figures. (b) By what percentage does this observed value differ from the instantaneous value at $x = 200$ m?
51. An object's position is given by $x = bt^3$, with x in meters, t in seconds, and $b = 1.5$ m/s^3. Determine (a) the instantaneous velocity and (b) the instantaneous acceleration at the end of 2.5 s. Find (c) the average velocity and (d) the average acceleration during the first 2.5 s.
52. Squaring Equation 2.7 gives an expression for v^2. Equation 2.11 also gives an expression for v^2. Equate the two expressions, and show that the resulting equation reduces to Equation 2.10.
53. On packed snow, computerized antilock brakes can reduce a car's stopping distance by 55%. By what percentage is the stopping time reduced?
54. A particle leaves its initial position x_0 at time $t = 0$, moving in the positive x-direction with speed v_0 but undergoing acceleration of magnitude a in the negative x-direction. Find expressions for (a) the time when it returns to x_0 and (b) its speed when it passes that point.
55. A hockey puck moving at 32 m/s slams through a wall of snow 35 cm thick. It emerges moving at 18 m/s. Assuming constant acceleration, find (a) the time the puck spends in the snow and (b) the thickness of a snow wall that would stop the puck entirely.

56. Amtrak's 20th-Century Limited is en route from Chicago to New York at 110 km/h when the engineer spots a cow on the track. The train brakes to a halt in 1.2 min, stopping just in front of the cow. (a) What is the magnitude of the train's acceleration? (b) What's the direction of the acceleration? (c) How far was the train from the cow when the engineer applied the brakes?
57. A jetliner touches down at 220 km/h and comes to a halt 29 s later. What's the shortest runway on which this aircraft can land?
58. A motorist suddenly notices a stalled car and slams on the brakes, negatively accelerating at 6.3 m/s^2. Unfortunately, this isn't enough, and a collision ensues. From the damage sustained, police estimate that the car was going 18 km/h at the time of the collision. They also measure skid marks 34 m long. (a) How fast was the motorist going when the brakes were first applied? (b) How much time elapsed from the initial braking to the collision?
59. A racing car undergoing constant acceleration covers 140 m in 3.6 s. (a) If it's moving at 53 m/s at the end of this interval, what was its speed at the beginning of the interval? (b) How far did it travel from rest to the end of the 140-m distance?
60. The maximum braking acceleration of a car on a dry road is about 8 m/s^2. If two cars move head-on toward each other at 88 km/h (55 mi/h), and their drivers brake when they're 85 m apart, will they collide? If so, at what relative speed? If not, how far apart will they be when they stop? Plot distance versus time for both cars on a single graph.
61. After 35 min of running, at the 9-km point in a 10-km race, you find yourself 100 m behind the leader and moving at the same speed. What should your acceleration be if you're to catch up by the finish line? Assume that the leader maintains constant speed.
62. You're speeding at 85 km/h when you notice that you're only 10 m behind the car in front of you, which is moving at the legal speed limit of 60 km/h. You slam on your brakes, and your car negatively accelerates at 4.2 m/s^2. Assuming the other car continues at constant speed, will you collide? If so, at what relative speed? If not, what will be the distance between the cars at their closest approach?
63. Airbags cushioned the Mars rover Spirit's landing, and the rover bounced some 15 m vertically after its first impact. Assuming no loss of speed at contact with the Martian surface, what was Spirit's impact speed?
64. Calculate the speed with which cesium atoms must be "tossed" in the NIST-F1 atomic clock so that their up-and-down travel time is 1.0 s. (See the Application on page 24.)
65. A falling object travels one-fourth of its total distance in the last second of its fall. From what height was it dropped?
66. You're on a NASA team engineering a probe to land on Jupiter's moon Io, and your job is to specify the impact speed the probe can tolerate without damage. Rockets will bring the probe to a halt 100 m above the surface, after which it will fall freely. What speed do you specify? (Consult Appendix E.)
67. You're atop a building of height h, and a friend is poised to drop a ball from a window at $h/2$. Find an expression for the speed at which you should simultaneously throw a ball downward, so the two hit the ground at the same time.
68. A castle's defenders throw rocks down on their attackers from a 15-m-high wall, with initial speed 10 m/s. How much faster are the rocks moving when they hit the ground than if they were simply dropped?
69. Two divers jump from a 3.00-m platform. One jumps upward at 1.80 m/s, and the second steps off the platform as the first passes it on the way down. (a) What are their speeds as they hit the water? (b) Which hits the water first and by how much?
70. A balloon is rising at 10 m/s when its passenger throws a ball straight up at 12 m/s relative to the balloon. How much later does the passenger catch the ball?
71. Landing on the Moon, a spacecraft fires its rockets and comes to a complete stop just 12 m above the lunar surface. It then drops freely to the surface. How long does it take to fall, and what's its impact speed? (*Hint*: Consult Appendix E.)
72. You're at mission control for a rocket launch, deciding whether to let the launch proceed. A band of clouds 5.3 km thick extends upward from 1.9 km altitude. The rocket will accelerate at 4.6 m/s^2, and it isn't allowed to be out of sight for more than 30 s. Should you allow the launch?
73. You're an investigator for the National Transportation Safety Board, examining a subway accident in which a train going at 80 km/h collided with a slower train traveling in the same direction at 25 km/h. Your job is to determine the relative speed of the collision, to help establish new crash standards. The faster train's "black box" shows that it began negatively accelerating at 2.1 m/s^2 when it was 50 m from the slower train, while the slower train continued at constant speed. What do you report?
74. You toss a book into your dorm room, just clearing a windowsill 4.2 m above the ground. (a) If the book leaves your hand 1.5 m above the ground, how fast must it be going to clear the sill? (b) How long after it leaves your hand will it hit the floor, 0.87 m below the windowsill?
75. Consider an object traversing a distance L, part of the way at speed v_1 and the rest of the way at speed v_2. Find expressions for the average speeds when the object moves at each of the two speeds (a) for half the total *time* and (b) for half the *distance*.
76. A particle's position as a function of time is given by $x = x_0 \sin \omega t$, where x_0 and ω are constants. (a) Find expressions for the velocity and acceleration. (b) What are the maximum values of velocity and acceleration? (*Hint*: Consult the table of derivatives in Appendix A.)
77. Ice skaters, ballet dancers, and basketball players executing vertical leaps often give the illusion of "hanging" almost motionless near the top of the leap. To see why this is, consider a leap to maximum height h. Of the total time spent in the air, what fraction is spent in the upper half (i.e., at $y > \frac{1}{2}h$)?
78. You're staring idly out your dorm window when you see a water balloon fall past. If the balloon takes 0.22 s to cross the 1.3-m-high window, from what height above the window was it dropped?
79. A police radar's effective range is 1.0 km, and your radar detector's range is 1.9 km. You're going 110 km/h in a 70 km/h zone when the radar detector beeps. At what rate must you negatively accelerate to avoid a speeding ticket?
80. An object starts moving in a straight line from position x_0, at time $t = 0$, with velocity v_0. Its acceleration is given by $a = a_0 + bt$, where a_0 and b are constants. Find expressions for (a) the instantaneous velocity and (b) the position, as functions of time.
81. You're a consultant on a movie set, and the producer wants a car to drop so that it crosses the camera's field of view in time Δt. The field of view has height h. Derive an expression for the height above the top of the field of view from which the car should be released.
82. (a) For the ball in Example 2.6, find its velocity just before it hits the floor. (b) Suppose you had tossed a second ball straight down at 7.3 m/s (from the same place 1.5 m above the floor). What would its velocity be just before it hits the floor? (c) When would the second ball hit the floor? (Interpret any multiple answers.)
83. Your roommate is an aspiring novelist and asks your opinion on a matter of physics. The novel's central character is kept awake at night by a leaky faucet. The sink is 19.6 cm below the faucet. At the instant one drop leaves the faucet, another strikes the sink below and two more are in between on the way down. How many drops per second are keeping the protagonist awake?
84. You and your roommate plot to drop water balloons on students entering your dorm. Your window is 20 m above the sidewalk. You plan to place an X on the sidewalk to mark the spot a student must be when you drop the balloon. You note that most students approach the dorm at about 2 m/s. How far from the impact point do you place the X?
85. Derive Equation 2.10 by integrating Equation 2.7 over time. You'll have to interpret the constant of integration.

Passage Problems

A wildlife biologist is studying the hunting patterns of tigers. She anesthetizes a tiger and attaches a GPS collar to track its movements. The collar transmits data on the tiger's position and velocity. Figure 2.16 shows the tiger's velocity as a function of time as it moves on a one-dimensional path.

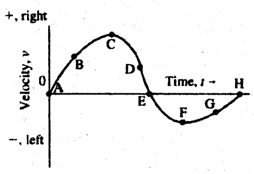

FIGURE 2.16 The tiger's velocity (Passage Problems 86–90)

86. At which marked point(s) is the tiger not moving?
    a. E only
    b. A, E, and H
    c. C and F
    d. none of the points (it's always moving)
87. At which marked point(s) is the tiger not accelerating?
    a. E only
    b. A, E, and H
    c. C and F
    d. all of the points (it's never accelerating)
88. At which point does the tiger have the greatest speed?
    a. B
    b. C
    c. D
    d. F
89. At which point does the tiger's acceleration have the greatest magnitude?
    a. B
    b. C
    c. D
    d. F
90. At which point is the tiger farthest from its starting position at $t = 0$?
    a. C
    b. E
    c. F
    d. H

Answers to Chapter Questions

Answer to Chapter Opening Question

Although the ball's velocity is zero at the top of its motion, its acceleration is -9.8 m/s^2, as it is throughout the toss.

Answers to GOT IT? Questions

2.1. (a) and (b); average speed is greater for (c).
2.2. (b) moves with constant speed; (a) reverses; (d) speeds up.
2.3. (a) halfway between the times. Because its acceleration is constant, the police car's speed increases by equal amounts in equal times. So it gets from 0 to half its final velocity—which is twice the car's velocity—in half the total time.
2.4. The dropped ball hits first; the thrown ball hits moving faster.