PROBLEMS

Section 2.1   Displacement,
Section 2.2   Speed and Velocity

1. ssm   The space shuttle travels at a speed of about 7.6×10^3 m/s. The blink of an astronaut's eye lasts about 110 ms. How many football fields (length = 91.4 m) does the shuttle cover in the blink of an eye?

2. GO For each of the three pairs of positions listed in the following table, determine the magnitude and direction (positive or negative) of the displacement.

Initial position x_0 Final position x
(a)   +2.0 m +6.0 m
(b)   +6.0 m +2.0 m
(c)   –3.0 m +7.0 m

3. ssm   Due to continental drift, the North American and European continents are drifting apart at an average speed of about 3 cm per year. At this speed, how long (in years) will it take for them to drift apart by another 1500 m (a little less than a mile)?

4.   You step onto a hot beach with your bare feet. A nerve impulse, generated in your foot, travels through your nervous system at an average speed of 110 m/s. How much time does it take for the impulse, which travels a distance of 1.8 m, to reach your brain?

5. GO The data in the following table describe the initial and final positions of a moving car. The elapsed time for each of the three pairs of positions listed in the table is 0.50 s. Review the concept of average velocity in Section 2.2 and then determine the average velocity (magnitude and direction) for each of the three pairs. Note that the algebraic sign of your answers will convey the direction.

Initial position x_0 Final position x
(a)   +2.0 m +6.0 m
(b)   +6.0 m +2.0 m
(c)   –3.0 m +7.0 m

6.   One afternoon, a couple walks three-fourths of the way around a circular lake, the radius of which is 1.50 km. They start at the west side of the lake and head due south to begin with. **(a)** What is the distance they travel? **(b)** What are the magnitude and direction (relative to due east) of the couple's displacement?

7. The three-toed sloth is the slowest-moving land mammal. On the ground, the sloth moves at an average speed of 0.037 m/s, considerably slower than the giant tortoise, which walks at 0.076 m/s. After 12 minutes of walking, how much further would the tortoise have gone relative to the sloth?

8. GO An 18-year-old runner can complete a 10.0-km course with an average speed of 4.39 m/s. A 50-year-old runner can cover the same distance with an average speed of 4.27 m/s. How much later (in seconds) should the younger runner start in order to finish the course *at the same time* as the older runner?

9. A tourist being chased by an angry bear is running in a straight line toward his car at a speed of 4.0 m/s. The car is a distance d away. The bear is 26 m behind the tourist and running at 6.0 m/s. The tourist reaches the car safely. What is the maximum possible value for d?

*****10.**   In reaching her destination, a backpacker walks with an average velocity of 1.34 m/s, due west. This average velocity results because she hikes for 6.44 km with an average velocity of 2.68 m/s, due west, turns around, and hikes with an average velocity of 0.447 m/s, due east. How far east did she walk?

*11. ssm   A bicyclist makes a trip that consists of three parts, each in the same direction (due north) along a straight road. During the first part, she rides for 22 minutes at an average speed of 7.2 m/s. During the second part, she rides for 36 minutes at an average speed of 5.1 m/s. Finally, during the third part, she rides for 8.0 minutes at an average speed of 13 m/s. **(a)** How far has the bicyclist traveled during the entire trip? **(b)** What is her average velocity for the trip?

*12. ▶️ .A car makes a trip due north for three-fourths of the time and due south one-fourth of the time. The average northward velocity has a magnitude of 27 m/s, and the average southward velocity has a magnitude of 17 m/s. What is the average velocity (magnitude and direction) for the entire trip?

**13. You are on a train that is traveling at 3.0 m/s along a level straight track. Very near and parallel to the track is a wall that slopes upward at a 12° angle with the horizontal. As you face the window (0.90 m high, 2.0 m wide) in your compartment, the train is moving to the left, as the drawing indicates. The top edge of the wall first appears at window corner A and eventually disappears at window corner B. How much time passes between appearance and disappearance of the upper edge of the wall?
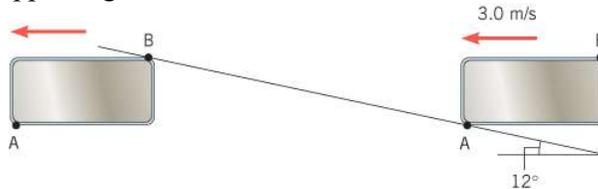
Problem 13

Section 2.3   Acceleration

14. Review Conceptual Example 6 as background for this problem. A car is traveling to the left, which is the negative direction. The direction of travel remains the same throughout this problem. The car's initial speed is 27.0 m/s, and during a 5.0-s interval, it changes to a final speed of **(a)** 29.0 m/s and **(b)** 23.0 m/s. In each case, find the acceleration (magnitude and algebraic sign) and state whether or not the car is decelerating.

15. GO **(a)** Suppose that a NASCAR race car is moving to the right with a constant velocity of +82 m/s. What is the average acceleration of the car? **(b)** Twelve seconds later, the car is halfway around the track and traveling in the opposite direction with the same speed. What is the average acceleration of the car?

16. Over a time interval of 2.16 years, the velocity of a planet orbiting a distant star reverses direction, changing from +20.9 km/s to –18.5 km/s. Find **(a)** the total change in the planet's velocity (in m/s) and **(b)** its average acceleration (in m/s²) during this interval. Include the correct algebraic sign with your answers to convey the directions of the velocity and the acceleration.

17. ssm   A motorcycle has a constant acceleration of 2.5 m/s². Both the velocity and acceleration of the motorcycle point in the same direction. How much time is required for the motorcycle to change its speed from **(a)** 21 to 31 m/s, and **(b)** 51 to 61 m/s?

18. A sprinter explodes out of the starting block with an acceleration of +2.3 m/s², which she sustains for 1.2 s. Then, her acceleration drops to zero for the rest of the race. What is her velocity **(a)** at $t = 1.2$ s and **(b)** at the end of the race?

19. GO The initial velocity and acceleration of four moving objects at a given instant in time are given in the following table. Determine the final *speed* of each of the objects, assuming that the time elapsed since $t = 0$ s is 2.0 s.

	Initial velocity v_0	Acceleration a
(a)	+12 m/s	+3.0 m/s²

(b)   +12 m/s   −3.0 m/s^2
(c)   −12 m/s   +3.0 m/s^2
(d)   –12 m/s   –3.0 m/s^2

20. GO   An Australian emu is running due north in a straight line at a speed of 13.0 m/s and slows down to a speed of 10.6 m/s in 4.0 s. **(a)** What is the direction of the bird's acceleration? **(b)** Assuming that the acceleration remains the same, what is the bird's velocity after an additional 2.0 s has elapsed?

21. ssm   For a standard production car, the highest road-tested acceleration ever reported occurred in 1993, when a Ford RS200 Evolution went from zero to 26.8 m/s (60 mi/h) in 3.275 s. Find the magnitude of the car's acceleration.

***22. mmh**   A car is traveling along a straight road at a velocity of +36.0 m/s when its engine cuts out. For the next twelve seconds the car slows down, and its average acceleration is $\bar{a}_1$. For the next six seconds the car slows down further, and its average acceleration is $\bar{a}_2$. The velocity of the car at the end of the eighteen-second period is +28.0 m/s. The ratio of the average acceleration values is $\bar{a}_1 / \bar{a}_2 = 1.50$. Find the velocity of the car at the end of the initial twelve-second interval.

****23.** Two motorcycles are traveling due east with different velocities. However, four seconds later, they have the same velocity. During this four-second interval, cycle A has an average acceleration of 2.0 m/s^2 due east, while cycle B has an average acceleration of 4.0 m/s^2 due east. By how much did the speeds *differ* at the beginning of the four-second interval, and which motorcycle was moving faster?

Section 2.4   Equations of Kinematics for Constant Acceleration,
Section 2.5   Applications of the Equations of Kinematics

24. In getting ready to slam-dunk the ball, a basketball player starts from rest and sprints to a speed of 6.0 m/s in 1.5 s. Assuming that the player accelerates uniformly, determine the distance he runs.

25. ssm   A jogger accelerates from rest to 3.0 m/s in 2.0 s. A car accelerates from 38.0 to 41.0 m/s also in 2.0 s. **(a)** Find the acceleration (magnitude only) of the jogger. **(b)** Determine the acceleration (magnitude only) of the car. **(c)** Does the car travel farther than the jogger during the 2.0 s? If so, how much farther?

26. GO A VW Beetle goes from 0 to 60.0 mi/h with an acceleration of +2.35 m/s^2. **(a)** How much time does it take for the Beetle to reach this speed? **(b)** A top-fuel dragster can go from 0 to 60.0 mi/h in 0.600 s. Find the acceleration (in m/s^2) of the dragster.

27.   The left ventricle of the heart accelerates blood from rest to a velocity of +26 cm/s.

(a) If the displacement of the blood during the acceleration is +2.0 cm, determine its acceleration (in cm/s^2). **(b)** How much time does blood take to reach its final velocity?

28. (a) What is the magnitude of the average acceleration of a skier who, starting from rest, reaches a speed of 8.0 m/s when going down a slope for 5.0 s? **(b)** How far does the skier travel in this time?

29. ssm   A jetliner, traveling northward, is landing with a speed of 69 m/s. Once the jet touches down, it has 750 m of runway in which to reduce its speed to 6.1 m/s. Compute the average acceleration (magnitude and direction) of the plane during landing.

30. ▶❚ **mmh**   The Kentucky Derby is held at the Churchill Downs track in Louisville, Kentucky. The track is one and one-quarter miles in length. One of the most famous horses to win this event was Secretariat. In 1973 he set a Derby record that would be hard to beat. His average acceleration during the last four quarter-miles of the race was +0.0105 m/s^2. His ve-

locity at the start of the final mile ($x = +1609$ m) was about $+16.58$ m/s. The acceleration, although small, was very important to his victory. To assess its effect, determine the difference between the time he would have taken to run the final mile at a constant velocity of $+16.58$ m/s and the time he actually took. Although the track is oval in shape, assume it is straight for the purpose of this problem.

31. ssm mmh A cart is driven by a large propeller or fan, which can accelerate or decelerate the cart. The cart starts out at the position $x = 0$ m, with an initial velocity of $+5.0$ m/s and a constant acceleration due to the fan. The direction to the right is positive. The cart reaches a maximum position of $x = +12.5$ m, where it begins to travel in the negative direction. Find the acceleration of the cart.

32. mmh Two rockets are flying in the same direction and are side by side at the instant their retrorockets fire. Rocket A has an initial velocity of $+5800$ m/s, while rocket B has an initial velocity of $+8600$ m/s. After a time t both rockets are again side by side, the displacement of each being zero. The acceleration of rocket A is -15 m/s^2. What is the acceleration of rocket B?

*33. ▶❙❙ mmh A car is traveling at 20.0 m/s, and the driver sees a traffic light turn red. After 0.530 s (the reaction time), the driver applies the brakes, and the car decelerates at 7.00 m/s^2. What is the stopping distance of the car, as measured from the point where the driver first sees the red light?

*34. GO mmh A race driver has made a pit stop to refuel. After refueling, he starts from rest and leaves the pit area with an acceleration whose magnitude is 6.0 m/s^2; after 4.0 s he enters the main speedway. At the same instant, another car on the speedway and traveling at a constant velocity of 70.0 m/s overtakes and passes the entering car. The entering car maintains its acceleration. How much time is required for the entering car to catch the other car?

*35. ▶❙❙ In a historical movie, two knights on horseback start from rest 88.0 m apart and ride directly toward each other to do battle. Sir George's acceleration has a magnitude of 0.300 m/s^2, while Sir Alfred's has a magnitude of 0.200 m/s^2. Relative to Sir George's starting point, where do the knights collide?

*36. GO Two soccer players start from rest, 48 m apart. They run directly toward each other, both players accelerating. The first player's acceleration has a magnitude of 0.50 m/s^2. The second player's acceleration has a magnitude of 0.30 m/s^2. **(a)** How much time passes before the players collide? **(b)** At the instant they collide, how far has the first player run?

*37. mmh A car is traveling at a constant speed of 33 m/s on a highway. At the instant this car passes an entrance ramp, a second car enters the highway from the ramp. The second car starts from rest and has a constant acceleration. What acceleration must it maintain, so that the two cars meet for the first time at the next exit, which is 2.5 km away?

*38. Along a straight road through town, there are three speed-limit signs. They occur in the following order: 55, 35, and 25 mi/h, with the 35-mi/h sign located midway between the other two. Obeying these speed limits, the smallest possible time t_A that a driver can spend on this part of the road is to travel between the first and second signs at 55 mi/h and between the second and third signs at 35 mi/h. More realistically, a driver could slow down from 55 to 35 mi/h with a constant deceleration and then do a similar thing from 35 to 25 mi/h. This alternative requires a time t_B. Find the ratio t_B/t_A.

*39. GO Refer to Multiple-Concept Example 5 to review a method by which this problem can be solved. You are driving your car, and the traffic light ahead turns red. You apply the brakes for 3.00 s, and the velocity of the car decreases to $+4.50$ m/s. The car's deceleration has a magnitude of 2.70 m/s^2 during this time. What is the car's displacement?

**40. A Boeing 747 "Jumbo Jet" has a length of 59.7 m. The runway on which the plane

lands intersects another runway. The width of the intersection is 25.0 m. The plane decelerates through the intersection at a rate of 5.70 m/s² and clears it with a final speed of 45.0 m/s. How much time is needed for the plane to clear the intersection?

**41. ssm A locomotive is accelerating at 1.6 m/s². It passes through a 20.0-m-wide crossing in a time of 2.4 s. After the locomotive leaves the crossing, how much time is required until its speed reaches 32 m/s?

42. A train has a length of 92 m and starts from rest with a constant acceleration at time $t = 0$ s. At this instant, a car just reaches the end of the train. The car is moving with a constant velocity. At a time $t = 14$ s, the car just reaches the front of the train. Ultimately, however, the train pulls ahead of the car, and at time $t = 28$ s, the car is again at the rear of the train. Find the magnitudes of **(a) the car's velocity and **(b)** the train's acceleration.

Section 2.6 Freely Falling Bodies

43. ssm The greatest height reported for a jump into an airbag is 99.4 m by stuntman Dan Koko. In 1948 he jumped from rest from the top of the Vegas World Hotel and Casino. He struck the airbag at a speed of 39 m/s (88 mi/h). To assess the effects of air resistance, determine how fast he would have been traveling on impact had air resistance been absent.

44. A dynamite blast at a quarry launches a chunk of rock straight upward, and 2.0 s later it is rising at a speed of 15 m/s. Assuming air resistance has no effect on the rock, calculate its speed **(a)** at launch and **(b)** 5.0 s after launch.

45. The drawing shows a device that you can make with a piece of cardboard, which can be used to measure a person's reaction time. Hold the card at the top and suddenly drop it. Ask a friend to try to catch the card between his or her thumb and index finger. Initially, your friend's fingers must be level with the asterisks at the bottom. By noting where your friend catches the card, you can determine his or her reaction time in milliseconds (ms). Calculate the distances d_1, d_2, and d_3.
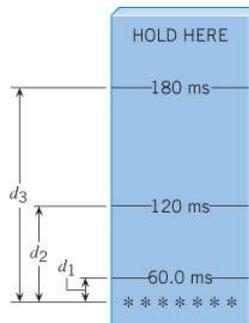
46. GO mmh A ball is thrown vertically upward, which is the positive direction. A little later it returns to its point of release. The ball is in the air for a total time of 8.0 s. What is its initial velocity? Neglect air resistance.

47. Review Conceptual Example 14 before attempting this problem. Two identical pellet guns are fired simultaneously from the edge of a cliff. These guns impart an initial speed of 30.0 m/s to each pellet. Gun A is fired straight upward, with the pellet going up and then falling back down, eventually hitting the ground beneath the cliff. Gun B is fired straight downward. In the absence of air resistance, how long after pellet B hits the ground does pellet A hit the ground?

48. mmh An astronaut on a distant planet wants to determine its acceleration due to gravity. The astronaut throws a rock straight up with a velocity of +15 m/s and measures a time of 20.0 s before the rock returns to his hand. What is the acceleration (magnitude and direction) due to gravity on this planet?

49. ssm A hot-air balloon is rising upward with a constant speed of 2.50 m/s. When the balloon is 3.00 m above the ground, the balloonist accidentally drops a compass over the side of the balloon. How much time elapses before the compass hits the ground?

50. Go A ball is thrown straight upward and rises to a maximum height of 16 m above its launch point. At what height above its launch point has the speed of the ball decreased to one-half of its initial value?

51. A diver springs upward with an initial speed of 1.8 m/s from a 3.0-m board. **(a)** Find the velocity with which he strikes the water. *[Hint: When the diver reaches the water, his displacement is y = –3.0 m (measured from the board), assuming that the downward direction is chosen as the negative direction.]* **(b)** What is the highest point he reaches above the water?

52. Go A ball is thrown straight upward. At 4.00 m above its launch point, the ball's speed is one-half its launch speed. What maximum height above its launch point does the ball attain?

53. ssm From her bedroom window a girl drops a water-filled balloon to the ground, 6.0 m below. If the balloon is released from rest, how long is it in the air?

54. Before working this problem, review Conceptual Example 14. A pellet gun is fired straight downward from the edge of a cliff that is 15 m above the ground. The pellet strikes the ground with a speed of 27 m/s. How far above the cliff edge would the pellet have gone had the gun been fired straight upward?

55. ▶II Consult Multiple-Concept Example 5 in preparation for this problem. The velocity of a diver just before hitting the water is –10.1 m/s, where the minus sign indicates that her motion is directly downward. What is her displacement during the last 1.20 s of the dive?

*56. ▶II A golf ball is dropped from rest from a height of 9.50 m. It hits the pavement, then bounces back up, rising just 5.70 m before falling back down again. A boy then catches the ball on the way down when it is 1.20 m above the pavement. Ignoring air resistance, calculate the total amount of time that the ball is in the air, from drop to catch.

*57. mmh A woman on a bridge 75.0 m high sees a raft floating at a constant speed on the river below. Trying to hit the raft, she drops a stone from rest when the raft has 7.00 m more to travel before passing under the bridge. The stone hits the water 4.00 m in front of the raft. Find the speed of the raft.

*58. Go Two stones are thrown simultaneously, one straight upward from the base of a cliff and the other straight downward from the top of the cliff. The height of the cliff is 6.00 m. The stones are thrown with the same speed of 9.00 m/s. Find the location (above the base of the cliff) of the point where the stones cross paths.

*59. ssm Consult Multiple-Concept Example 8 to explore a model for solving this problem. **(a)** Just for fun, a person jumps from rest from the top of a tall cliff overlooking a lake. In falling through a distance H, she acquires a certain speed v. Assuming free-fall conditions, how much farther must she fall in order to acquire a speed of 2v? Express your answer in terms of H. **(b)** Would the answer to part (a) be different if this event were to occur on another planet where the acceleration due to gravity had a value other than 9.80 m/s²? Explain.

*60. Go Two arrows are shot vertically upward. The second arrow is shot after the first one, but while the first is still on its way up. The initial speeds are such that both arrows reach their maximum heights at the same instant, although these heights are different. Suppose that the initial speed of the first arrow is 25.0 m/s and that the second arrow is fired 1.20 s after the first. Determine the initial speed of the second arrow.

*61. ▶II **ssm** A cement block accidentally falls from rest from the ledge of a 53.0-m-high building. When the block is 14.0 m above the ground, a man, 2.00 m tall, looks up and notices that the block is directly above him. How much time, at most, does the man have to get out of the way?

*62. ⏸ A model rocket blasts off from the ground, rising straight upward with a constant acceleration that has a magnitude of 86.0 m/s² for 1.70 seconds, at which point its fuel abruptly runs out. Air resistance has no effect on its flight. What maximum altitude (above the ground) will the rocket reach?

**63. While standing on a bridge 15.0 m above the ground, you drop a stone from rest. When the stone has fallen 3.20 m, you throw a second stone straight down. What initial velocity must you give the second stone if they are both to reach the ground at the same instant? Take the downward direction to be the negative direction.

**64. A roof tile falls from rest from the top of a building. An observer inside the building notices that it takes 0.20 s for the tile to pass her window, which has a height of 1.6 m. How far above the top of this window is the roof?

Section 2.7 Graphical Analysis of Velocity and Acceleration

65. ssm A person who walks for exercise produces the position–time graph given with this problem. **(a)** Without doing any calculations, decide which segments of the graph (A, B, C, or D) indicate positive, negative, and zero average velocities. **(b)** Calculate the average velocity for each segment to verify your answers to part (a).
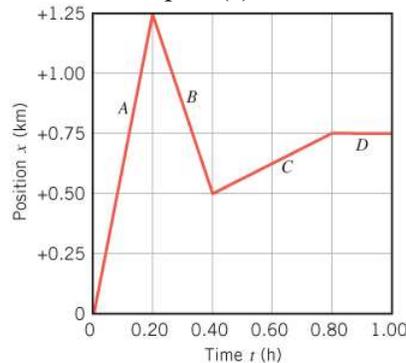

66. Starting at $x = -16$ m at time $t = 0$ s, an object takes 18 s to travel 48 m in the $+x$ direction at a constant velocity. Make a position–time graph of the object's motion and calculate its velocity.

67. mmh A snowmobile moves according to the velocity–time graph shown in the drawing. What is the snowmobile's average acceleration during each of the segments A, B, and C?
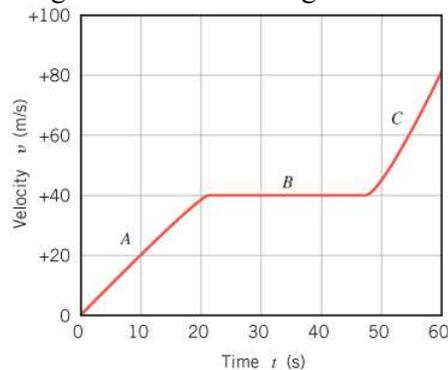
68. A bus makes a trip according to the position–time graph shown in the drawing. What is the average velocity (magnitude and direction) of the bus during each of the segments A, B, and C? Express your answers in km/h.
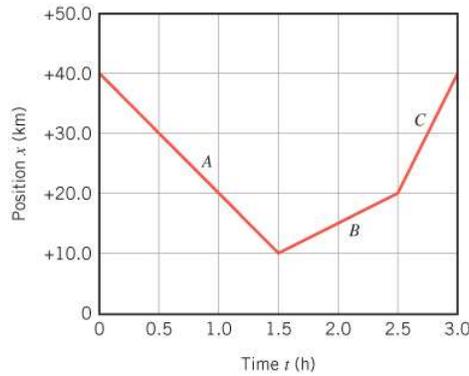
69. A bus makes a trip according to the position–time graph shown in the illustration. What is the average acceleration (in km/h²) of the bus for the entire 3.5-h period shown in the graph?
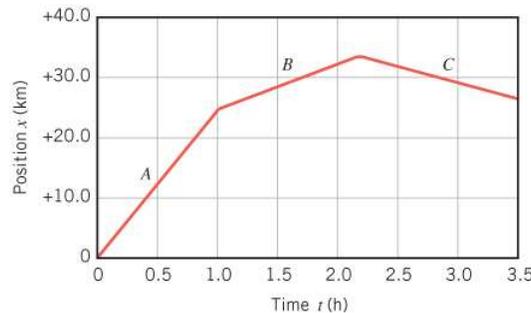
70. A runner is at the position $x = 0$ m when time $t = 0$ s. One hundred meters away is the finish line. Every ten seconds, this runner runs half the remaining distance to the finish line. During each ten-second segment, the runner has a constant velocity. For the first forty seconds of the motion, construct **(a)** the position–time graph and **(b)** the velocity–time graph.

71. ssm Two runners start one hundred meters apart and run toward each other. Each runs ten meters during the first second. During each second thereafter, each runner runs ninety percent of the distance he ran in the previous second. Thus, the velocity of each person changes from second to second. However, during any one second, the velocity remains constant. Make a position–time graph for one of the runners. From this graph, determine **(a)** how much time passes before the runners collide and **(b)** the speed with which each is running at the moment of collision.

ADDITIONAL PROBLEMS

72. **GO** The data in the following table represent the initial and final velocities for a boat traveling along the x axis. The elapsed time for each of the four pairs of velocities in the table is 2.0 s. Review the concept of average acceleration in Section 2.3 and then determine the average acceleration (magnitude and direction) for each of the four pairs. Note that the algebraic sign of your answers will convey the direction.

	Initial velocity v_0	Final velocity v
(a)	+2.0 m/s	+5.0 m/s
(b)	+5.0 m/s	+2.0 m/s
(c)	−6.0 m/s	−3.0 m/s
(d)	+4.0 m/s	−4.0 m/s

73. ssm In preparation for this problem, review Conceptual Example 6. From the top of a cliff, a person uses a slingshot to fire a pebble straight downward, which is the negative direction. The initial speed of the pebble is 9.0 m/s. **(a)** What is the acceleration (magnitude and direction) of the pebble during the downward motion? Is the pebble decelerating? Explain. **(b)** After 0.50 s, how far beneath the cliff top is the pebble?

74. In 1954 the English runner Roger Bannister broke the four-minute barrier for the mile with a time of 3:59.4 s (3 min and 59.4 s). In 1999 the Moroccan runner Hicham el-Guerrouj set a record of 3:43.13 s for the mile. If these two runners had run in the same race, each running the entire race at the average speed that earned him a place in the record books, el-Guerrouj would have won. By how many meters?

75. ssm   A speed ramp at an airport is basically a large conveyor belt on which you can stand and be moved along. The belt of one ramp moves at a constant speed such that a person who stands still on it leaves the ramp 64 s after getting on. Clifford is in a real hurry, however, and skips the speed ramp. Starting from rest with an acceleration of 0.37 m/s^2, he covers the same distance as the ramp does, but in one-fourth the time. What is the speed at which the belt of the ramp is moving?

76. mmh   At the beginning of a basketball game, a referee tosses the ball straight up with a speed of 4.6 m/s. A player cannot touch the ball until after it reaches its maximum height and begins to fall down. What is the minimum time that a player must wait before touching the ball?

77. Electrons move through a certain electric circuit at an average speed of 1.1×10^{-2} m/s. How long (in minutes) does it take an electron to traverse 1.5 m of wire in the filament of a light bulb?

78. In 1998, NASA launched *Deep Space 1* (DS-1), a spacecraft that successfully flew by the asteroid named 1992 KD (which orbits the sun millions of miles from the earth). The propulsion system of DS-1 worked by ejecting high-speed argon ions out the rear of the engine. The engine slowly increased the velocity of DS-1 by about +9.0 m/s per day. **(a)** How much time (in days) would it take to increase the velocity of DS-1 by +2700 m/s? **(b)** What was the acceleration of DS-1 (in m/s^2)?

79. ▶❚❚ **mmh**   A cheetah is hunting. Its prey runs for 3.0 s at a constant velocity of +9.0 m/s. Starting from rest, what constant acceleration must the cheetah maintain in order to run the same distance as its prey runs in the same time?

***80.** Multiple-Concept Example 8 illustrates the concepts that are pertinent to this problem. A cab driver picks up a customer and delivers her 2.00 km away, on a straight route. The driver accelerates to the speed limit and, on reaching it, begins to decelerate at once. The magnitude of the deceleration is three times the magnitude of the acceleration. Find the lengths of the acceleration and deceleration phases.

***81. ssm**   A woman and her dog are out for a morning run to the river, which is located 4.0 km away. The woman runs at 2.5 m/s in a straight line. The dog is unleashed and runs back and forth at 4.5 m/s between his owner and the river, until the woman reaches the river. What is the total distance run by the dog?

***82.** 🟢GO The leader of a bicycle race is traveling with a constant velocity of +11.10 m/s and is 10.0 m ahead of the second-place cyclist. The second-place cyclist has a velocity of +9.50 m/s and an acceleration of +1.20 m/s^2. How much time elapses before he catches the leader?

***83.** ▶❚❚   A golfer rides in a golf cart at an average speed of 3.10 m/s for 28.0 s. She then gets out of the cart and starts walking at an average speed of 1.30 m/s. For how long (in seconds) must she walk if her average speed for the entire trip, riding and walking, is 1.80 m/s?

***84.** 🟢GO   Two cars cover the same distance in a straight line. Car A covers the distance at a constant velocity. Car B starts from rest and maintains a constant acceleration. Both cars cover a distance of 460 m in 210 s. Assume that they are moving in the +x direction. Determine **(a)** the constant velocity of car A, **(b)** the final velocity of car B, and **(c)** the acceleration of car B.

***85.** ▶❚❚ **mmh**   A police car is traveling at a velocity of 18.0 m/s due north, when a car

zooms by at a constant velocity of 42.0 m/s due north. After a reaction time of 0.800 s the policeman begins to pursue the speeder with an acceleration of 5.00 m/s². Including the reaction time, how long does it take for the police car to catch up with the speeder?

**86. mmh   A hot-air balloon is rising straight up at a constant speed of 7.0 m/s. When the balloon is 12.0 m above the ground, a gun fires a pellet straight up from ground level with an initial speed of 30.0 m/s. Along the paths of the balloon and the pellet, there are two places where each of them has the same altitude at the same time. How far above ground are these places?

**87. ssm   In a quarter-mile drag race, two cars start simultaneously from rest, and each accelerates at a constant rate until it either reaches its maximum speed or crosses the finish line. Car A has an acceleration of 11.0 m/s² and a maximum speed of 106 m/s. Car B has an acceleration of 11.6 m/s² and a maximum speed of 92.4 m/s. Which car wins the race, and by how many seconds?

**88. A football player, starting from rest at the line of scrimmage, accelerates along a straight line for a time of 1.5 s. Then, during a negligible amount of time, he changes the magnitude of his acceleration to a value of 1.1 m/s². With this acceleration, he continues in the same direction for another 1.2 s, until he reaches a speed of 3.4 m/s. What is the value of his acceleration (assumed to be constant) during the initial 1.5-s period?

*89. GO ssm   A jet is taking off from the deck of an aircraft carrier, as shown in the image. Starting from rest, the jet is catapulted with a constant acceleration of +31 m/s² along a straight line and reaches a velocity of +62 m/s. Find the displacement of the jet.


(a)
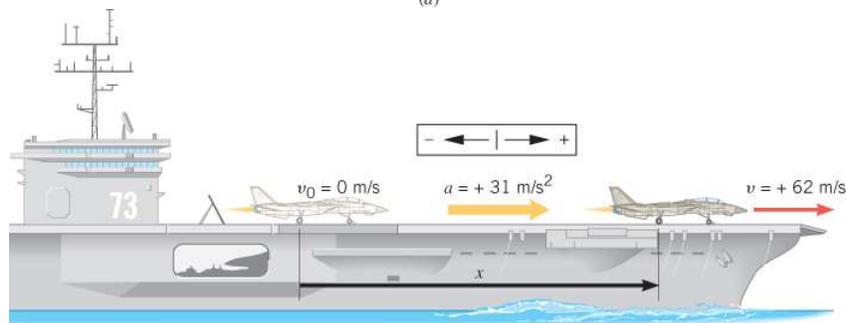
(b)

Problem 89

(a) A jet is being launched from an aircraft carrier. (b) During the launch, a catapult accelerates the jet down the flight deck.

CONCEPTS AND CALCULATIONS PROBLEMS

In this chapter we have studied the displacement, velocity, and acceleration vectors. The concept questions are designed to review some of the important concepts that can help in anticipating some of the characteristics of the numerical answers.

*90. ►❚❚ A skydiver is falling straight down, along the negative *y* direction. **(a)** During the initial part of the fall, her speed increases from 16 to 28 m/s in 1.5 s, as in part *a* of the figure. **(b)** Later, her parachute opens, and her speed decreases from 48 to 26 m/s in 11 s, as in part *b* of the drawing. *Concepts:* (i) Is her average acceleration positive or negative when her speed is increasing in part *a* of the figure? (ii) Is her average acceleration positive or negative when her speed is decreasing in part *b* of the figure? *Calculations:* In both instances (parts *a* and *b* of the figure) determine the magnitude and direction of her average acceleration.
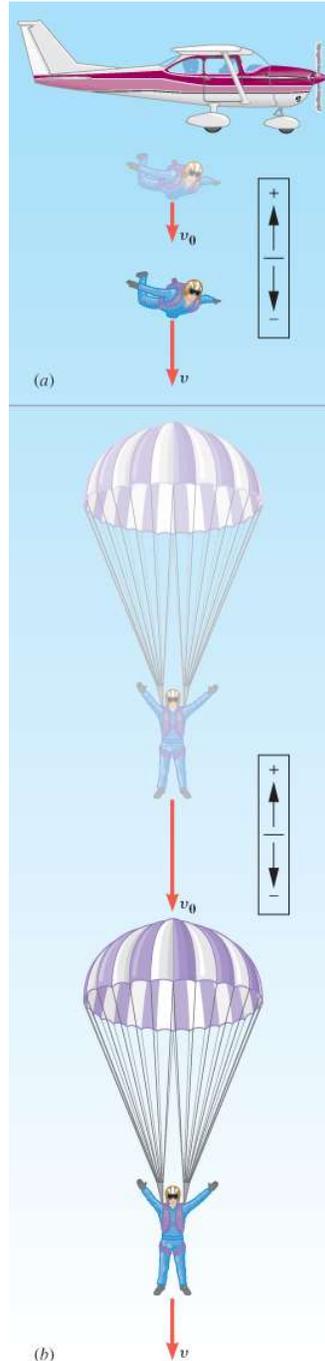
Problem 90

*91. ►❚❚ **ssm** A Problem 90 top-fuel dragster starts from rest and has a constant acceleration of 40.0 m/s². *Concepts:* (i) At time *t* the dragster has a certain velocity. Keeping in mind

that the dragster starts from rest, when the time doubles to $2t$, does the velocity also double? (ii) When the time doubles to $2t$, does the displacement of the dragster also double? *Calculations:* What are the **(a)** final velocities and **(b)** displacements of the dragster at the end of 2.0 s and at the end of twice this time, or 4.0 s?