10. (II) An airplane travels 2100 km at a speed of 800 km/h, and then encounters a tailwind that boosts its speed to 1000 km/h for the next 1800 km. What was the total time for the trip? What was the average speed of the plane for this trip? [*Hint:* Think carefully before using Eq. 2–10d.]

11. (II) Calculate the average speed and average velocity of a complete round-trip in which the outgoing 200 km is covered at 90 km/h, followed by a one-hour lunch break, and the return 200 km is covered at 50 km/h.

12. (III) A bowling ball traveling with constant speed hits the pins at the end of a bowling lane 16.5 m long. The bowler hears the sound of the ball hitting the pins 2.50 s after the ball is released from his hands. What is the speed of the ball? The speed of sound is 340 m/s.

SECTION 2–4

13. (I) A sports car accelerates from rest to 95 km/h in 6.2 s. What is its average acceleration in m/s^2?

14. (I) At highway speeds, a particular automobile is capable of an acceleration of about $1.6\ m/s^2$. At this rate, how long does it take to accelerate from 80 km/h to 110 km/h?

15. (I) A sprinter accelerates from rest to 10.0 m/s in 1.35 s. What is her acceleration (*a*) in m/s^2, and (*b*) in km/h^2?

16. (II) A sports car is advertised to be able to stop in a distance of 50 m from a speed of 90 km/h. What is its acceleration in m/s^2? How many *g*'s is this ($g = 9.80\ m/s^2$)?

17. (III) The position of a racing car, which starts from rest at $t = 0$ and moves in a straight line, has been measured as a function of time, as given in the following table. Estimate (*a*) its velocity and (*b*) its acceleration as a function of time. Display each in a table and on a graph.

t(s)	0	0.25	0.50	0.75	1.00	1.50	2.00	2.50
x(m)	0	0.11	0.46	1.06	1.94	4.62	8.55	13.79

t(s)	3.00	3.50	4.00	4.50	5.00	5.50	6.00
x(m)	20.36	28.31	37.65	48.37	60.30	73.26	87.16

SECTIONS 2–5 AND 2–6

18. (I) The principal kinematic equations, Eqs. 2–10a through 2–10d, become particularly simple if the initial speed is zero. Write down the equations for this special case. (Also put $x_0 = 0$.)

19. (I) A car accelerates from 12 m/s to 25 m/s in 6.0 s. What was its acceleration? How far did it travel in this time? Assume constant acceleration.

20. (I) A car slows down from 20 m/s to rest in a distance of 85 m. What was its acceleration, assumed constant?

21. (I) A light plane must reach a speed of 30 m/s for takeoff. How long a runway is needed if the (constant) acceleration is $3.0\ m/s^2$?

22. (II) A world-class sprinter can burst out of the blocks to essentially top speed (of about 11.5 m/s) in the first 15.0 m of the race. What is the average acceleration of this sprinter and how long does it take her to reach that speed?

23. (II) A car slows down from a speed of 25.0 m/s to rest in 5.00 s. How far did it travel in that time?

24. (II) In coming to a stop, a car leaves skid marks 80 m long on the highway. Assuming a deceleration of $7.00\ m/s^2$, estimate the speed of the car just before braking.

25. (II) A car traveling 45 km/h slows down at a constant $0.50\ m/s^2$ just by "letting up on the gas." Calculate (*a*) the distance the car coasts before it stops, (*b*) the time it takes to stop, and (*c*) the distance it travels during the first and fifth seconds.

26. (II) A car traveling at 90 km/h strikes a tree. The front end of the car compresses and the driver comes to rest after traveling 0.80 m. What was the average acceleration of the driver during the collision? Express the answer in terms of "*g*'s," where $1.00\ g = 9.80\ m/s^2$.

27. (II) Determine the stopping distances for an automobile with an initial speed of 90 km/h and human reaction time of 1.0 s: (*a*) for an acceleration $a = -4.0\ m/s^2$; (*b*) for $a = -8.0\ m/s^2$.

28. (III) Show that the equation for the stopping distance of a car is $d_S = v_0 t_R - v_0^2/(2a)$, where v_0 is the initial speed of the car, t_R is the driver's reaction time, and *a* is the constant acceleration (and is negative).

29. (III) A speeding motorist traveling 120 km/h passes a stationary police officer. The officer immediately begins pursuit at a constant acceleration of 10.0 km/h/s (note the mixed units). How much time will it take for the police officer to reach the speeder, assuming that the speeder maintains a constant speed? How fast will the police officer be traveling at this time?

30. (III) A person driving her car at 50 km/h approaches an intersection just as the traffic light turns yellow. She knows that the yellow light lasts only 2.0 s before turning to red, and she is 30 m away from the near side of the intersection (Fig. 2–29). Should she try to stop, or should she make a run for it? The intersection is 15 m wide. Her car's maximum deceleration is $-6.0\ m/s^2$, whereas it can accelerate from 50 km/h to 70 km/h in 6.0 s. Ignore the length of her car and her reaction time.

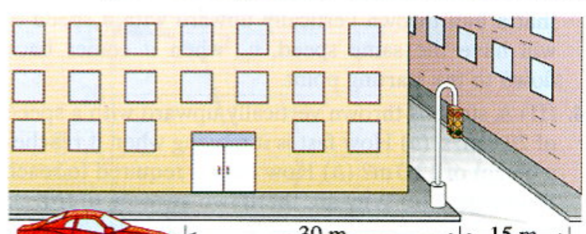

FIGURE 2–29 Problem 30.

31. (III) A runner hopes to complete the 10,000-m run in less than 30.0 min. After exactly 27.0 min, there are still 1100 m to go. The runner must then accelerate at $0.20\ m/s^2$ for how many seconds in order to achieve the desired time?

SECTION 2–7 [neglect air resistance]

32. (I) Calculate the acceleration of the baseball in Example 2–9 in "g's."

33. (I) If a car rolls gently ($v_0 = 0$) off a vertical cliff, how long does it take it to reach 90 km/h?

34. (I) A stone is dropped from the top of a cliff. It is seen to hit the ground below after 3.50 s. How high is the cliff?

35. (I) Calculate (*a*) how long it took King Kong to fall straight down from the top of the Empire State Building (380 m high), and (*b*) his velocity just before "landing"?

36. (II) A foul ball is hit straight up into the air with a speed of about 25 m/s. (*a*) How high does it go? (*b*) How long is it in the air?

37. (II) A kangaroo jumps to a vertical height of 2.7 m. How long was it in the air before returning to Earth?

38. (II) A ballplayer catches a ball 3.3 s after throwing it vertically upward. With what speed did he throw it, and what height did it reach?

39. (II) Draw graphs of (*a*) the speed and (*b*) the distance fallen, as a function of time, for an object falling under the influence of gravity from $t = 0$ to $t = 5.00$ s. Ignore air resistance and assume $v_0 = 0$.

40. (II) The best rebounders in basketball have a vertical leap (that is, the vertical movement of a fixed point on their body) of about 120 cm. (*a*) What is their initial "launch" speed off the ground? (*b*) How long are they in the air?

41. (II) A helicopter is ascending vertically with a speed of 5.50 m/s. At a height of 105 m above the Earth, a package is dropped from a window. How much time does it take for the package to reach the ground?

42. (II) For an object falling freely from rest, show that the distance traveled during each successive second increases in the ratio of successive odd integers (1, 3, 5, etc.). (This was first shown by Galileo.) See Figs. 2–16 and 2–19.

43. (II) If air resistance is neglected, show (algebraically) that a ball thrown vertically upward with a speed v_0 will have the same speed, v_0, when it comes back down to the starting point.

44. (II) A stone is thrown vertically upward with a speed of 20.0 m/s. (*a*) How fast is it moving when it reaches a height of 12.0 m? (*b*) How long is required to reach this height? (*c*) Why are there two answers to (*b*)?

45. (II) Estimate the time between each photoflash of the apple in Fig. 2–16 (or number of photoflashes per second). Assume the apple is about 10 cm in diameter.

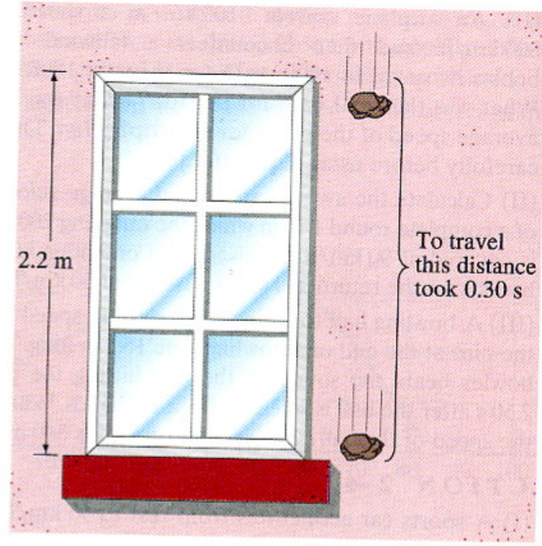

FIGURE 2–30 Problem 46.

46. (III) A falling stone takes 0.30 s to travel past a window 2.2 m tall (Fig. 2–30). From what height above the top of the window did the stone fall?

47. (III) A rock is dropped from a sea cliff and the sound of it striking the ocean is heard 3.4 s later. If the speed of sound is 340 m/s, how high is the cliff?

48. (III) Suppose you adjust your garden hose nozzle for a hard stream of water. You point the nozzle vertically upward at a height of 1.5 m above the ground (Fig. 2–31). When you quickly move the nozzle away from the vertical, you hear the water striking the ground next to you for another 2.0 s. What is the water speed as it leaves the nozzle?

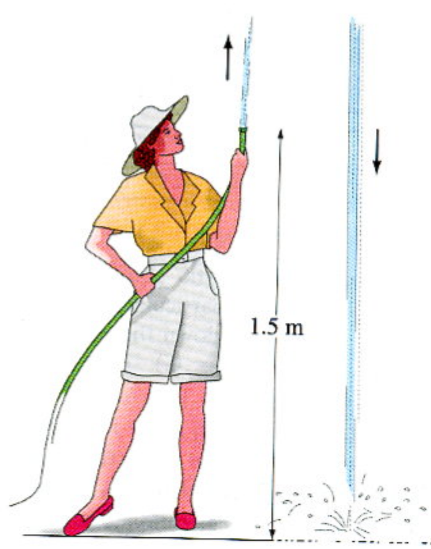

FIGURE 2–31 Problem 48.

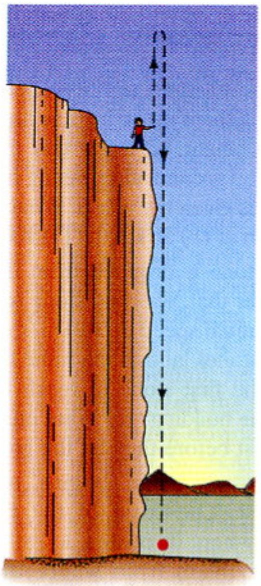

FIGURE 2–32 Problem 49.

49. (III) A stone is thrown vertically upward with a speed of 12.0 m/s from the edge of a cliff 75.0 m high (Fig. 2–32). (*a*) How much later does it reach the bottom of the cliff? (*b*) What is its speed just before hitting? (*c*) What total distance did it travel?

50. (III) A baseball is seen to pass upward by a window 25 m above the street with a vertical speed of 12 m/s. If the ball was thrown from the street, (*a*) what was its initial speed, (*b*) what altitude does it reach, (*c*) when was it thrown, and (*d*) when does it reach the street again?

* SECTION 2–8

* 51. (I) The position of a rabbit along a straight tunnel as a function of time is plotted in Fig. 2–26. What is its instantaneous velocity (*a*) at $t = 10.0$ s and (*b*) at $t = 30.0$ s? What is its average velocity (*c*) between $t = 0$ and $t = 5.0$ s, (*d*) between $t = 25.0$ s and $t = 30.0$ s, and (*e*) between $t = 40.0$ s and $t = 50.0$ s?

* 52. (I) In Fig. 2–26, (*a*) during what time periods, if any, is the object's velocity constant? (*b*) At what time is its velocity the greatest? (*c*) At what time, if any, is the velocity zero? (*d*) Does the object run in one direction or in both along its tunnel during the time shown?

* 53. (I) Figure 2–27 shows the velocity of a train as a function of time. (*a*) At what time was its velocity greatest? (*b*) During what periods, if any, was the velocity constant? (*c*) During what periods, if any, was the acceleration constant? (*d*) When was the magnitude of the acceleration greatest?

* 54. (II) A high-performance automobile can accelerate approximately as shown in the velocity–time graph of Fig. 2–33. (The short flat spots in the curve represent shifting of the gears.) (*a*) Estimate the average acceleration of the car in second gear and in fourth gear. (*b*) Estimate how far the car traveled while in fourth gear.

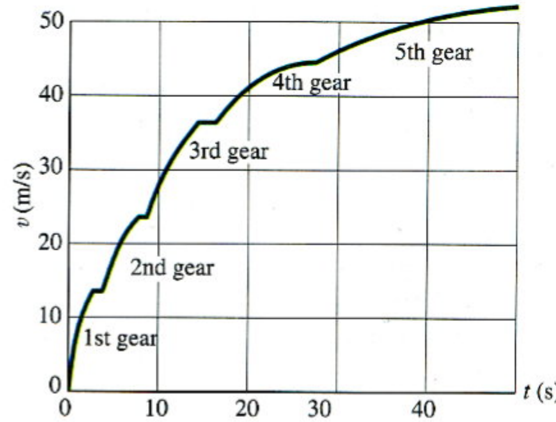

FIGURE 2–33 The velocity of a high-performance automobile as a function of time, starting from a dead stop. The jumps in the curve represent gear shifts. (Problems 54 and 55.)

* 55. (II) Estimate the average acceleration of the car in the previous problem (Fig. 2–33) when it is in (*a*) first, (*b*) third, and (*c*) fifth gear. (*d*) What is its average acceleration through the first four gears?

* 56. (II) In Fig. 2–27, estimate the distance the object traveled during (*a*) the first minute and (*b*) the second minute.

* 57. (II) Construct the v vs. t graph for the object whose displacement as a function of time is given by Fig. 2–26.

* 58. (II) Construct an x vs. t graph for the object whose velocity as a function of time is given by Fig. 2–27.

* 59. (II) Figure 2–34 is a position versus time graph for the motion of an object along the x axis. As the object moves from A to B: (*a*) Is the object moving in the positive or negative direction? (*b*) Is the object speeding up or slowing down? (*c*) Is the acceleration of the object positive or negative? Next, for the time interval from D to E: (*d*) Is the object moving in the positive or negative direction? (*e*) Is the object speeding up or slowing down? (*f*) Is the acceleration of the object positive or negative? (*g*) Finally, answer these same three questions for the time interval from C to D.

FIGURE 2–34 Problem 59.