Understanding the Concepts

8. What is the role of an air bag placed where a falling object is expected to land? How can an air bag prevent injury to someone who jumps from a height?

9. An object moving along the $x$-axis on a straight horizontal rail starts by moving rapidly to the right, slows, and comes to a stop, then starts moving more and more rapidly to the left. True or false: This description is consistent with motion with constant acceleration (even around the region where the object reverses the direction of its motion).

13. The velocity of an object moving in one dimension is measured at equal distance intervals. It is found that the magnitude of the velocity is proportional to the square root of the distance traveled. What can you say about the motion?

15. True or false: A freely falling body is moving with four times the speed when it has fallen twice as far.

18. A beanbag is tossed straight up. It rises, reaches a maximum height, then falls back down. What is the acceleration of the beanbag at its maximum height?

23. Consider a super-ball that drops from a certain height onto a rigid surface. It starts off with zero velocity at time $t = 0$ s. Sketch the velocity as a function of time from the time that the ball is dropped to just before it hits the floor at time $t = 10$ s. Assuming that the starting velocity on the rebound has the same magnitude (though opposite direction) as the ball when it reaches the ground, sketch the velocity as a function of time after the rebound. Do all this on the same graph. When will the ball have zero velocity again? What will its position be at that time?

Problems

(Note: All problems are taken from Fishbane, Chapter 2. Hand in solutions to bold problems.)

1. A grasshopper jumps along a groove aligned with the $x$-axis. Starting at the origin, the grasshopper’s first jump has a displacement $+32$ cm, the second jump has a displacement $-27$ cm, the third a displacement $-23$ cm, and the fourth a displacement $+39$ cm. What is the net displacement? At what position is the grasshopper after all four jumps?

9. An automobile driver travels north for 2 min at 30 mph, then stops at a red light for 30 s before proceeding again for 3 min at 45 mph. He then stops at a stop sign for 3 s, drives forward at 30 mph for 2 min, and finally stops for gas. (a) How far does the automobile travel? (b) What is the average velocity? Use units of miles and minutes.

14. Traffic signals are placed along a straight road at positions $x = 0$ m, $x = 600$ m, and $x = 1200$ m. (Fig. 2–27). The time intervals during which the signals are green are shown by the thick lines in the figure. (a) Draw the displacement-versus-time curves (fastest and slowest) for a car that passes through all the lights when the car moves with constant speed. (b) Draw a similar set of lines for a car traveling in the opposite direction. (c) Assuming that the lights are timed such that a car passes through all lights in the middle of the time interval, what is the speed for which the lights are timed? (d) What is the fastest constant speed of a car that makes it through all the signals, assuming it arrives at the first light at the optimal moment?

Fig. 2-27: Problem 2.14 (please turn)
18. A bicyclist is pedaling at a constant speed of 10 m/s when she decides to slow down. She stops pedaling and sits up, and the combined effects of wind resistance and road friction cause a negative acceleration of -0.3 m/s². If this acceleration does not change, how long would it take her to slow to 5 m/s?

23. Suppose the position of a particle is described by \( x = A \sin(\omega t) \). Calculate the velocity and acceleration of the particle as a function of time.

29. A car traveling 25 mph must reach a minimum of 50 mph within a 1000-ft access lane. What must the car’s constant acceleration be?

36. The speed of a landing airplane is 80 m/s. After touching ground it rolls a distance of 400 m on the runway at a constant velocity. It then decelerates at 3.0 m/s² until it stops. (a) Sketch the displacement–time and velocity–time curves. (b) Calculate the distance traveled on the ground and the time interval between touch-down and full stop.

47. An electron in the picture tube of a TV set traveling in a straight line accelerates uniformly from speed \( 3 \times 10^4 \) m/s to \( 5 \times 10^6 \) m/s along a length of 2 cm. (a) How much time does the electron spend in this 2-cm region? (b) What is the magnitude of the electron’s acceleration?

62. A ball is thrown upward from the ground. It passes a window 10 m above the ground and is seen to descend past the window 2.2 s after it went by on its way up (Fig. 2–34). It reaches the ground 3.6 s after it was thrown. Use this information to calculate the acceleration due to gravity, \( g \).

69. A powerful rocket moves for a short time with an acceleration that grows with time according to the formula \( a = \alpha t^2 \). If the rocket is to accelerate from rest in this way until it reaches a speed \( v_f \), how long must the acceleration be maintained?

79. A tennis ball is dropped from a height of 10 m. It falls onto an electrical switch and bounces back to a height of 9 m. The switch is connected to an electronic device that shows that the time of contact between the ball and the switch was 0.002 s. Calculate (a) the velocity with which the ball hit the switch, (b) the velocity with which the ball left the switch, and (c) the average acceleration during the time of contact with the switch.