HONORS PHYSICS – PROBLEM SET
ONE DIMENSIONAL MOTION
DISPLACEMENT AND VELOCITY

1. On the graph in Figure 2-18, what is the total distance traveled during the recorded time interval? What is the displacement?

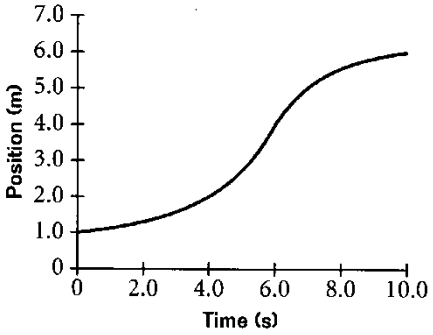

Figure 2-18

2. On a position-time graph such as Figure 2-18, what represents the velocity?

3. Sketch a position-time graph for each of the following situations:
   a. an object at rest
   b. an object with constant positive velocity
   c. an object with constant negative velocity

4. Use the position-time graph in Figure 2-19 to answer the following questions:
   a. During which time interval(s) is the velocity decreasing?
   b. During which time interval(s) is the velocity increasing?

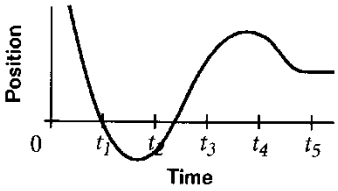

Figure 2-19

Finding the average velocity

5. Heather and Matthew take 34 min to walk eastward along a straight road to a store 2.0 km away. What is their average velocity in m/s?

6. Eugene is 75.0 km due south of Salem. If Joe rides from Salem to Eugene on his bike in 6.00 h, what is his average velocity?

7. If the bus stop is 0.68 km down the street from the museum and it takes you 9.5 min to walk north from the bus stop to the museum entrance, what is your average velocity?

8. Simpson drives his car with an average velocity of 24 m/s toward the east. How long will it take him to drive 560 km on a perfectly straight highway?

9. How much time would Simpson save by increasing his average velocity to 26 m/s east?

10. A bus traveled south along a straight path for 3.2 h with an average velocity of 88 km/h, stopped for 20.0 min, then traveled south for 2.8 h with an average velocity of 75 km/h.
    a. What is the average velocity for the total trip?
    b. What is the displacement for the total trip?

11. El Paso is 1142 km south of Denver. If a bus makes the trip in 15.08 h, what is its average velocity?

12. If you live 10.0 km from your school and the bus takes 0.53 h to reach the school driving due east, what is the average velocity of the bus?

13. Figure 2-20 is the position-time graph for a squirrel running along a clothesline.

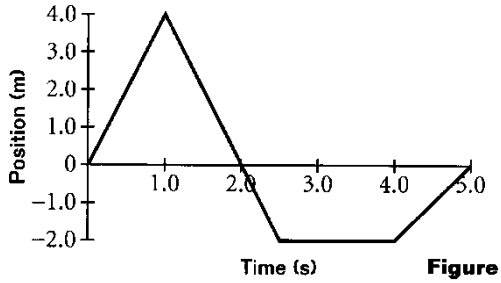

Figure 2-20

    a. What is the squirrel's displacement during the time interval from t = 0.0 s to t = 3.0 s?
    b. What is the squirrel's average velocity during this interval?

14. The Olympic record for the marathon is 2 h, 9 min, 21 s. The marathon distance is 42.19 km. Determine the average speed in m/s of a runner achieving this record. (5.436 m/s)

15. Two cars are traveling on a desert road, as shown in Figure 2-21. After 5.0 s, they are side by side at the next telephone pole. The distance between the poles is 70.0 m. Identify the following quantities:
    a. the displacement of car A after 5.0 s (70.0 m)
    b. the displacement of car B after 5.0 s (140.0 m)
    c. the average velocity of car A during 5.0 s (14 m/s)
    d. the average velocity of car B during 5.0 s (28 m/s)

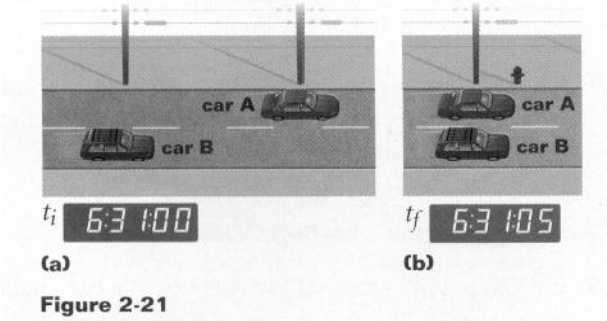

Figure 2-21

16. Sally travels by car from one city to another. She drives for 30.0 min at 80.0 km/h, 12.0 min at 105 km/h, and 45.0 min at 40.0 km/h, and she spends 15.0 min eating lunch and buying gas.
    a. Determine the average speed for the trip. (53.5 km/h)
    b. Determine the total distance traveled. (91.0 km)

17. Emily takes a trip, driving with a constant velocity of 89.5 km/h to the north except for a 22.0 min rest stop. If Emily's average velocity is 77.8 km/h to the north, how long does the trip take?

18. To qualify for the finals in a racing event, a race car must achieve an average speed of 250 km/h on a track with a total length of 1600 m. If a particular car covers the first half of the track at an average speed of 230 km/h, what minimum average speed must it have in the second half of the event to qualify?

19. A tortoise can run with a speed of 10.0 cm/s, and a hare can run exactly 20 times as fast. In a race, they both start at the same time, but the hare stops to rest for 2.00 min. The tortoise wins by 20.0 cm.
    a. How long does the race take?
    b. What is the length of the race?

20. Runner A is initially 6.0 km west of a flagpole and is running with a constant velocity of 9.0 km/h due east. Runner B is initially 5.0 km east of the flagpole and is running with a constant velocity of 8.0 km/h due west. How far are the runners from the flagpole when their paths cross? (0.2 km west of the flagpole)

VELOCITY AND ACCELERATION

21. Sketch the velocity-time graphs for the following motions.
    a. a city bus moving with a constant velocity
    b. a wheelbarrow speeding up at a uniform rate moving in the positive direction
    c. a tiger speeding up at a uniform rate moving in the negative direction
    d. an iguana slowing down at a uniform rate moving in the positive direction
    e. a camel slowing down at a uniform rate moving in the negative direction

Average acceleration

22. When the shuttle bus comes to a sudden stop to avoid hitting a dog, it slows from 9.00 m/s to 0.00 m/s in 1.50 s. Find the average acceleration of the bus.

23. A car traveling initially at 7.0 m/s accelerates to a velocity of 12.0 m/s in 2.0 s. What is the average acceleration of the car? (2.5 m/s^2)

24. Turner's treadmill starts with a velocity of -1.2 m/s and speeds up at regular intervals during a half-hour workout. After 25 min, the treadmill has a velocity of -6.5 m/s. What is the average acceleration of the treadmill during this period? (-3.5×10^{-3} m/s^2)

25. If a treadmill starts at a velocity of -2.7 m/s and has a velocity of -1.3 m/s after 5.0 min, what is the average acceleration of the treadmill?

26. With an average acceleration of -0.50 m/s^2 , how long will it take a cyclist to bring a bicycle with an initial velocity of +13.5 m/s to a complete stop?

27. A car traveling in a straight line has a velocity of +5.0 m/s. After 4.0 s, its velocity is +8.0 m/s. What is the car's average acceleration in this time interval?

Displacement with constant acceleration

28. A car accelerates uniformly from rest to a speed of 23.7 km/h in 6.5 s. Find the distance the car travels during this time. (21 m)

29. When Maggie applies the brakes of her car, the car slows uniformly from 15.00 m/s to 0.00 m/s in 2.50 s. How many meters before a stop sign must she apply her brakes in order to stop at the sign? (18.8 m)

30. A jet plane lands with a velocity of +100 m/s and can accelerate at a maximum rate of -5.0 m/s^2 as it comes to rest. Can this plane land at an airport where the runway is 0.80 km long?

31. A driver in a car traveling at a speed of 78 km/h sees a cat 100 m away on the road. How long will it take for the car to accelerate constantly to a stop in exactly 99 m?

32. A car enters the freeway with a speed of 23 km/h and accelerates to a speed of 86 km/h in 3.5 min. How far does the car move while accelerating? (3.2 km)

Velocity and displacement with constant acceleration

33. A car with an initial speed of 23.7 km/h accelerates at a uniform rate of 0.92 m/s^2 for 3.6s. Find the final speed and the displacement of the car during this time.

34. An automobile with an initial speed of 4.30 m/s accelerates at the rate of 3.00 m/s^2. Find the final speed and the displacement after 5.0 s. (19.3 m/s, 59.0 m)

35. A car starts from rest and travels for 5.0 s with a uniform acceleration of -1.5 m/s^2. What is the final velocity of the car? How far does the car travel in this time interval? (-7.5 m/s, 19 m)

36. A driver of a car traveling at 15 m/s applies the brakes, causing a uniform acceleration of -2.0 m/s^2. If the brakes are applied for 2.5 s, what is the velocity of the car at the end of the braking period? How far has the car moved during the braking period? (10.0 m/s, 32 m)

37. A car traveling at +7.0 m/s accelerates at the rate of +0.80 m/s^2 for an interval of 2.0 s. Find v_f. (8.6 m/s)

38. A snowmobile has an initial velocity of +3.0 m/s.
    a. If it accelerates at the rate of +0.50 m/s^2 for 7.0 s, what is the final velocity?
    b. If it accelerates at the rate of -0.60 m/s^2, how long will it take to reach a complete stop?

39. A car moving westward along a straight, level road increases its velocity uniformly from +16 m/s to +32 m/s in 10.0 s.
    a. What is the car's acceleration?
    b. What is its average velocity,
    c. How far did it move while accelerating?

40. A ball initially at rest rolls down a hill with an acceleration of 3.3 m/s^2. If it accelerates for 7.5 s, how far will it move?

41. A plane starting at rest at the south end of a runway undergoes a constant acceleration of +1.6 m/s^2 for a distance of 1600 m before takeoff.
    a. What is the plane's velocity at takeoff?
    b. What is the time required for takeoff?

42. A bus slows down uniformly from 75.0 km/h (21 m/s) to 0.0 km/h in 220 m. How long does it take to stop? (21 s)

43. A car accelerates from rest at -3.00 m/s^2.
    a. What is the velocity at the end of 5.0 s? (-15 m/s)
    b. What is the displacement after 5.0 s? (-38 m)

44. A car starts from rest and travels for 5.0 s with a uniform acceleration of +1.5 m/s^2. The driver then applies the brakes, causing a uniform acceleration of -2.0 m/s^2. If the brakes are applied for 3.0 s, how fast is the car going at the end of the braking period, and how far has it gone from its start? (1.5 m/s, 32 m)

45. A car accelerates uniformly from rest to a speed of 65 km/h (18 m/s) in 12 s. Find the distance the car travels during this time. (110 m)

46. A boy sledding down a hill accelerates at 1.40 m/s^2. If he started from rest, in what distance would he reach a speed of 7.00 m/s? (17.5 m)

47. The velocity-time graph for an object moving along a straight path is shown in Figure 2-23. Find the average accelerations during the time intervals 0.0 s to 5.0s, 5.0s to 15.0 s, and 0.0s to 20.0s.

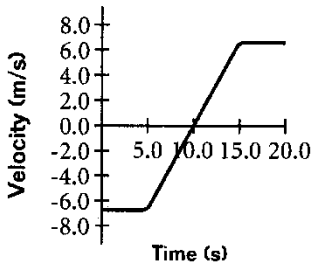

Figure 2-23

48. A speedboat increases its velocity from 25 m/s to the west to 35 m/s to the west in a distance of 250 m.
    a. Find the magnitude of the boat's acceleration.
    b. Find the time it takes the boat to travel this distance.

49. A plane lands with a velocity of +120 m/s and accelerates at a maximum rate of -6.0 m/s^2.
    a. From the instant the plane touches the runway, what is the minimum time needed before it can come to rest?
    b. Can this plane land on a naval aircraft carrier where the runway is 0.80 km long?

FALLING OBJECTS

Falling object

50. Stephanie serves the volleyball from a height of 0.80 m and gives it an initial velocity of +7.6 m/s straight up.
    a. How high will it go?
    b. How long will it take the ball to reach its maximum height? (Hint: At maximum height, v = 0 m/s.)

51. A tennis ball is thrown vertically upward with an initial velocity of +8.0 m/s.
    a. What will its speed be when it returns to its starting point? (8.0 m/s)
    b. How long will it take for it to reach its starting point? (1.63 s)

52. A flowerpot falls from a windowsill 25.0 m above the sidewalk.
    a. How fast is the flowerpot moving when it strikes the ground?
    b. How much time does a passerby on the sidewalk below have to move out of the way before the flowerpot hits the ground?

53. A robot probe drops a camera off the rim of a 239-meter-deep crater on Mars, where the free-fall acceleration is -3.7 m/s^2. Find the time required for the camera to reach the crater floor and the velocity with which it hits. (11 s, -42 m/s)

54. Maria throws an apple vertically upward from a height of 1.3 m with an initial velocity of +2.4 m/s.

a. Will the apple reach Maria's friend in a treehouse 5.3 m above the ground?
b. If the apple is not caught, how long will the apple be in the air before it hits the ground?

55. A worker drops a wrench from the top of a tower 80.0 m tall. With what velocity does the wrench strike the ground? (-39.6 m/s)

56. A physics student throws a softball straight up into the air. The ball was in the air for a total of 3.56 s before it was caught at its original position.
    a. What was the initial velocity of the ball?
    b. How high did it rise?

57. A gumdrop is released from rest at the top of the Empire State Building, which is 381 m tall. Disregarding air resistance, calculate the displacement and velocity of the gumdrop after 1.00, 2.00, and 3.00s.

58. A small sandbag is dropped from rest from a hovering hot-air balloon.
    a. After 2.0 s, what is the velocity of the sandbag?
    b. After 2.0 s, how far below the hot-air balloon is the sand bag?

59. A ball thrown vertically upward is caught by the thrower after 5.0 s.
    a. Find the initial velocity of the ball.
    b. Find the maximum height it reaches.

60. A peregrine falcon dives at a pigeon. The falcon starts downward from rest with free-fall acceleration. If the pigeon is 76.0 m below the initial position of the falcon, how long does it take the falcon to reach the pigeon? Assume that the pigeon remains at rest. (3.94 s)

61. A ball is thrown upward from the ground with an initial speed of 25 m/s; at the same instant, a ball is dropped from rest from a building 15 m high. After how long will the balls be at the same height? (0.60 s)

62. A ball is thrown vertically upward with a speed of 25.0 m/s from a height of 2.0 m.
    a. How high does the ball rise?
    b. How long does it take to reach its highest point?
    c. How long does the ball take to hit the ground after it reaches its highest point?
    d. What is the ball's velocity when it returns to the level from which it started?

63. A rocket moves upward, starting from rest with an acceleration of $+29.4\ m/s^2$ for 4.00 s. It runs out of fuel at the end of the 4.00 s but does not stop. How high does it rise above the ground? (931 m)

64. Two students are on a balcony 19.6 m above the street. One student throws a ball vertically downward at 14.7 m/s. At the same instant, the other student throws a ball vertically upward at the same speed. The second ball just misses the balcony on the way down.
    a. What is the difference in the time the balls spend in the air? (3.0 s)
    b. What is the velocity of each ball as it strikes the ground? (-24.5 m/s)
    c. How far apart are the balls 0.800 s after they are thrown? (23.6 m)

MIXED REVIEW PROBLEMS

65. If the average speed of an orbiting space shuttle is 31 800 km/h, determine the time required for it to circle Earth. Make sure you consider the fact that the shuttle is orbiting about 320.0 km above Earth's surface. Assume that Earth's radius is 6380 km.

66. A train travels between stations 1 and 2, as shown in Figure 2-25. The engineer of the train is instructed to start from rest at station 1 and accelerate uniformly between points A and B, then coast with a uniform velocity between points B and C and finally accelerate uniformly between points C and D until the train stops at station 2. The distances AB, BC, and CD are all equal, and it takes 5.00 min to travel between the two stations. Assume that the uniform accelerations have the same magnitude, even when they are opposite in direction.
    a. How much of this 5.00 min period does the train spend between points A and B?
    b. How much of this 5.00 min period does the train spend between points B and C?
    c. How much of this 5.00 min period does the train spend between points C and D?

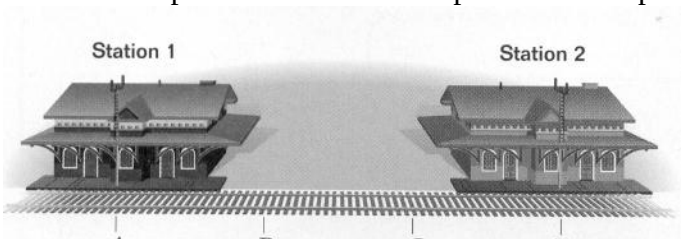

Figure 2-25

67. Two cars travel westward along a straight highway, one at a constant velocity of 85 km/h, and the other at a constant velocity of 115 km/h.
    a. Assuming that both cars start at the same point, how much sooner does the faster car arrive at a destination 16 km away? (0.05 h)
    b. How far must the cars travel for the faster car to arrive 15 min before the slower car? (81 km)

68. A small first-aid kit is dropped by a rock climber who is descending steadily at 1.9 m/s. After 2.5 s, what is the velocity of the first-aid kit, and how far is the kit below the climber?

69. A small fish is dropped by a pelican that is rising steadily at 0.50 m/s.
    a. After 2.5 s, what is the velocity of the fish? (-24 m/s)
    b. How far below the pelican is the fish after 2.5 s? (31 m)

70. A ranger in a national park is driving at 56 km/h when a deer jumps onto the road 65 m ahead of the vehicle. After a reaction time of t s, the ranger applies the brakes to produce an acceleration of -3.0 m/s^2. What is the maximum reaction time allowed if the ranger is to avoid hitting the deer? (1.6 s)

71. A speeder passes a parked police car at 30.0 m/s. The police car starts from rest with a uniform acceleration of 2.44 m/s^2.
    a. How much time passes before the speeder is overtaken by the police car?
    b. How far does the speeder get before being overtaken by the police car?

72. An ice sled powered by a rocket engine starts from rest on a large frozen lake and accelerates at +13.0 m/s^2. At t_1 the rocket engine is shut down and the sled moves with constant velocity v until t_2. The total distance traveled by the sled is 5.30×10^3 m and the total time is 90.0 s. Find t_1, t_2, and v. (5 s, 85 s, +60 m/s)

73. At the 5800 m mark, the sled in the previous question begins to accelerate at -7.0 m/s^2. Use your answers from previous problem to answer the following questions.
    a. What is the final position of the sled when it comes to rest? (6100 m)
    b. How long does it take for the sled to come to rest? (9 s)

74. A tennis ball with a velocity of +10.0 m/s to the right is thrown perpendicularly at a wall. After striking the wall, the ball rebounds in the opposite direction with a velocity of -8.0 m/s to the left. If the ball is in contact with the wall for 0.012 s, what is the average acceleration of the ball while it is in contact with the wall? (-1.5×10^3 m/s^2)

75. A parachutist descending at a speed of 10.0 m/s loses a shoe at an altitude of 50.0 m.
    a. When does the shoe reach the ground? (2.33 s)
    b. What is the velocity of the shoe just before it hits the ground? (-32.9 m/s)

76. A mountain climber stands at the top of a 50.0 m cliff hanging over a calm pool of water. The climber throws two stones vertically 1.0 s apart and observes that they cause a single splash when they hit the water. The first stone has an initial velocity of +2.0 m/s.
    a. How long after release of the first stone will the two stones hit the water? (3.40 s)
    b. What is the initial velocity of the second stone when it is thrown? (-9.2 m/s)
    c. What will the velocity of each stone be at the instant both stones hit the water? (-31.4 m/s, -33 m/s)

77. A model rocket is launched straight upward with an initial speed of 50.0 m/s. It accelerates with a constant upward acceleration of 2.00 m/s^2 until its engines stop at an altitude of 150 m.
    a. What is the maximum height reached by the rocket? (310 m)
    b. When does the rocket reach maximum height? (8.5 s)
    c. How long is the rocket in the air? (16.4 s)

78. A professional race-car driver buys a car that can accelerate at +5.9 m/s^2. The racer decides to race against another driver in a souped-up stock car. Both start from rest, but the stock-car driver leaves 1.0 s before the driver of the sports car. The stock car moves with a constant acceleration of +3.6 m/s^2.
    a. Find the time it takes the sports-car driver to overtake the stock-car driver. (4.6 s)
    b. Find the distance the two drivers travel before they are side by side. (38 m)
    c. Find the velocities of both cars at the instant they are side by side. (17 m/s, 21 m/s)

79. Two cars are traveling along a straight line in the same direction, the lead car at 25 m/s and the other car at 35 m/s. At the moment the cars are 45 m apart, the lead driver applies the brakes, causing the car to have an acceleration of -2.0 m/s^2.
    a. How long does it take for the lead car to stop? (13 s)
    b. Assume that the driver of the chasing car applies the brakes at the same time as the driver of the lead car. What must the chasing car's minimum negative acceleration be to avoid hitting the lead car? (-2.9 m/s^2)
    c. How long does it take the chasing car to stop? (12 s)

80. One swimmer in a relay race has a 0.50 s lead and is swimming at a constant speed of 4.00 m/s. The swimmer has 20.0 m to swim before reaching the end of the pool. A second swimmer moves in the same direction as the leader. What constant speed must the second swimmer have in order to catch up to the leader at the end of the pool? (4.44 m/s)