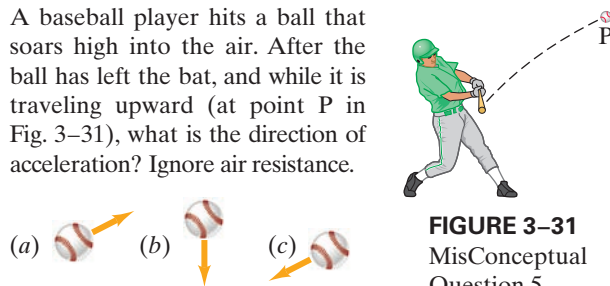


## Questions

- One car travels due east at 40 km/h, and a second car travels north at 40 km/h. Are their velocities equal? Explain.
- Can you conclude that a car is not accelerating if its speedometer indicates a steady 60 km/h? Explain.
- Give several examples of an object's motion in which a great distance is traveled but the displacement is zero.
- Can the displacement vector for a particle moving in two dimensions be longer than the length of path traveled by the particle over the same time interval? Can it be less? Discuss.
- During baseball practice, a player hits a very high fly ball and then runs in a straight line and catches it. Which had the greater displacement, the player or the ball? Explain.
- If  $\vec{V} = \vec{V}_1 + \vec{V}_2$ , is  $V$  necessarily greater than  $V_1$  and/or  $V_2$ ? Discuss.
- Two vectors have length  $V_1 = 3.5$  km and  $V_2 = 4.0$  km. What are the maximum and minimum magnitudes of their vector sum?
- Can two vectors, of unequal magnitude, add up to give the zero vector? Can *three* unequal vectors? Under what conditions?
- Can the magnitude of a vector ever (a) equal, or (b) be less than, one of its components?
- Does the odometer of a car measure a scalar or a vector quantity? What about the speedometer?
- How could you determine the speed a slingshot imparts to a rock, using only a meter stick, a rock, and the slingshot?
- In archery, should the arrow be aimed directly at the target? How should your angle of aim depend on the distance to the target?
- It was reported in World War I that a pilot flying at an altitude of 2 km caught in his bare hands a bullet fired at the plane! Using the fact that a bullet slows down considerably due to air resistance, explain how this incident occurred.
- You are on the street trying to hit a friend in his dorm window with a water balloon. He has a similar idea and is aiming at you with *his* water balloon. You aim straight at each other and throw at the same instant. Do the water balloons hit each other? Explain why or why not.
- A projectile is launched at an upward angle of  $30^\circ$  to the horizontal with a speed of 30 m/s. How does the horizontal component of its velocity 1.0 s after launch compare with its horizontal component of velocity 2.0 s after launch, ignoring air resistance? Explain.
- A projectile has the least speed at what point in its path?
- Two cannonballs, A and B, are fired from the ground with identical initial speeds, but with  $\theta_A$  larger than  $\theta_B$ . (a) Which cannonball reaches a higher elevation? (b) Which stays longer in the air? (c) Which travels farther? Explain.
- A person sitting in an enclosed train car, moving at constant velocity, throws a ball straight up into the air in her reference frame. (a) Where does the ball land? What is your answer if the car (b) accelerates, (c) decelerates, (d) rounds a curve, (e) moves with constant velocity but is open to the air?
- If you are riding on a train that speeds past another train moving in the same direction on an adjacent track, it appears that the other train is moving backward. Why?
- Two rowers, who can row at the same speed in still water, set off across a river at the same time. One heads straight across and is pulled downstream somewhat by the current. The other one heads upstream at an angle so as to arrive at a point opposite the starting point. Which rower reaches the opposite side first? Explain.
- If you stand motionless under an umbrella in a rainstorm where the drops fall vertically, you remain relatively dry. However, if you start running, the rain begins to hit your legs even if they remain under the umbrella. Why?

## MisConceptual Questions

- You are adding vectors of length 20 and 40 units. Which of the following choices is a possible resultant magnitude?
  - 0.
  - 18.
  - 37.
  - 64.
  - 100.
- The magnitude of a component of a vector must be
  - less than or equal to the magnitude of the vector.
  - equal to the magnitude of the vector.
  - greater than or equal to the magnitude of the vector.
  - less than, equal to, or greater than the magnitude of the vector.
- You are in the middle of a large field. You walk in a straight line for 100 m, then turn left and walk 100 m more in a straight line before stopping. When you stop, you are 100 m from your starting point. By how many degrees did you turn?
  - $90^\circ$ .
  - $120^\circ$ .
  - $30^\circ$ .
  - $180^\circ$ .
 (e) This is impossible. You cannot walk 200 m and be only 100 m away from where you started.
- A bullet fired from a rifle begins to fall
  - as soon as it leaves the barrel.
  - after air friction reduces its speed.
  - not at all if air resistance is ignored.
- A baseball player hits a ball that soars high into the air. After the ball has left the bat, and while it is traveling upward (at point P in Fig. 3–31), what is the direction of acceleration? Ignore air resistance.
- One ball is dropped vertically from a window. At the same instant, a second ball is thrown horizontally from the same window. Which ball has the greater speed at ground level?
  - The dropped ball.
  - The thrown ball.
  - Neither—they both have the same speed on impact.
  - It depends on how hard the ball was thrown.



**FIGURE 3–31**  
MisConceptual  
Question 5.

7. You are riding in an enclosed train car moving at 90 km/h. If you throw a baseball straight up, where will the baseball land?  
 (a) In front of you.  
 (b) Behind you.  
 (c) In your hand.  
 (d) Can't decide from the given information.
8. Which of the three kicks in Fig. 3–32 is in the air for the longest time? They all reach the same maximum height  $h$ . Ignore air resistance.  
 (a), (b), (c), or (d) all the same time.

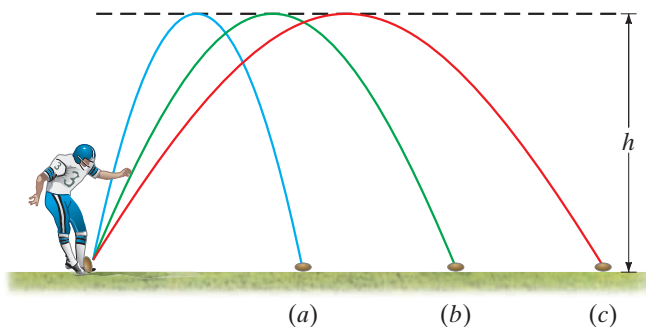


FIGURE 3–32 MisConceptual Question 8.

9. A baseball is hit high and far. Which of the following statements is true? At the highest point,  
 (a) the magnitude of the acceleration is zero.  
 (b) the magnitude of the velocity is zero.  
 (c) the magnitude of the velocity is the slowest.  
 (d) more than one of the above is true.  
 (e) none of the above are true.

10. A hunter is aiming horizontally at a monkey who is sitting in a tree. The monkey is so terrified when it sees the gun that it falls off the tree. At that very instant, the hunter pulls the trigger. What will happen?  
 (a) The bullet will miss the monkey because the monkey falls down while the bullet speeds straight forward.  
 (b) The bullet will hit the monkey because both the monkey and the bullet are falling downward at the same rate due to gravity.  
 (c) The bullet will miss the monkey because although both the monkey and the bullet are falling downward due to gravity, the monkey is falling faster.  
 (d) It depends on how far the hunter is from the monkey.
11. Which statements are *not* valid for a projectile? Take up as positive.  
 (a) The projectile has the same  $x$  velocity at any point on its path.  
 (b) The acceleration of the projectile is positive and decreasing when the projectile is moving upwards, zero at the top, and increasingly negative as the projectile descends.  
 (c) The acceleration of the projectile is a constant negative value.  
 (d) The  $y$  component of the velocity of the projectile is zero at the highest point of the projectile's path.  
 (e) The velocity at the highest point is zero.
12. A car travels 10 m/s east. Another car travels 10 m/s north. The relative speed of the first car with respect to the second is  
 (a) less than 20 m/s.  
 (b) exactly 20 m/s.  
 (c) more than 20 m/s.

For assigned homework and other learning materials, go to the MasteringPhysics website.



## Problems

### 3–2 to 3–4 Vector Addition

1. (I) A car is driven 225 km west and then 98 km southwest ( $45^\circ$ ). What is the displacement of the car from the point of origin (magnitude and direction)? Draw a diagram.
2. (I) A delivery truck travels 21 blocks north, 16 blocks east, and 26 blocks south. What is its final displacement from the origin? Assume the blocks are equal length.
3. (I) If  $V_x = 9.80$  units and  $V_y = -6.40$  units, determine the magnitude and direction of  $\vec{V}$ .
4. (II) Graphically determine the resultant of the following three vector displacements: (1) 24 m,  $36^\circ$  north of east; (2) 18 m,  $37^\circ$  east of north; and (3) 26 m,  $33^\circ$  west of south.
5. (II)  $\vec{V}$  is a vector 24.8 units in magnitude and points at an angle of  $23.4^\circ$  above the negative  $x$  axis. (a) Sketch this vector. (b) Calculate  $V_x$  and  $V_y$ . (c) Use  $V_x$  and  $V_y$  to obtain (again) the magnitude and direction of  $\vec{V}$ . [Note: Part (c) is a good way to check if you've resolved your vector correctly.]
6. (II) Vector  $\vec{V}_1$  is 6.6 units long and points along the negative  $x$  axis. Vector  $\vec{V}_2$  is 8.5 units long and points at  $+55^\circ$  to the positive  $x$  axis. (a) What are the  $x$  and  $y$  components of each vector? (b) Determine the sum  $\vec{V}_1 + \vec{V}_2$  (magnitude and angle).

7. (II) Figure 3–33 shows two vectors,  $\vec{A}$  and  $\vec{B}$ , whose magnitudes are  $A = 6.8$  units and  $B = 5.5$  units. Determine  $\vec{C}$  if (a)  $\vec{C} = \vec{A} + \vec{B}$ , (b)  $\vec{C} = \vec{A} - \vec{B}$ , (c)  $\vec{C} = \vec{B} - \vec{A}$ . Give the magnitude and direction for each.

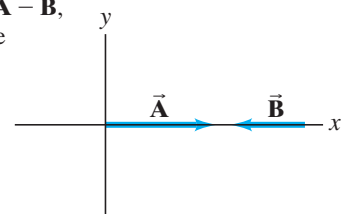


FIGURE 3–33 Problem 7.

8. (II) An airplane is traveling 835 km/h in a direction  $41.5^\circ$  west of north (Fig. 3–34).  
 (a) Find the components of the velocity vector in the northerly and westerly directions. (b) How far north and how far west has the plane traveled after 1.75 h?

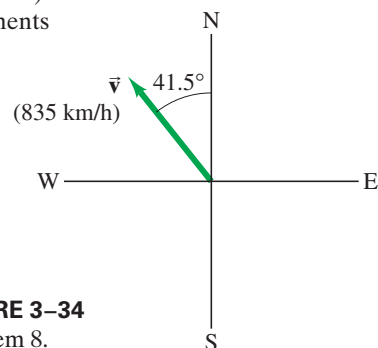
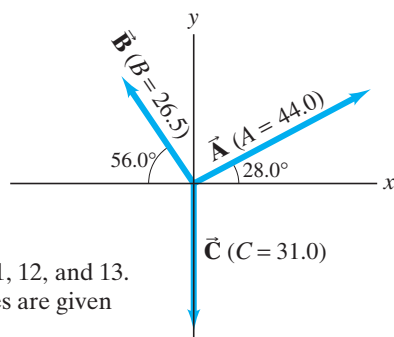


FIGURE 3–34 Problem 8.

9. (II) Three vectors are shown in Fig. 3–35. Their magnitudes are given in arbitrary units. Determine the sum of the three vectors. Give the resultant in terms of (a) components, (b) magnitude and angle with the  $+x$  axis.



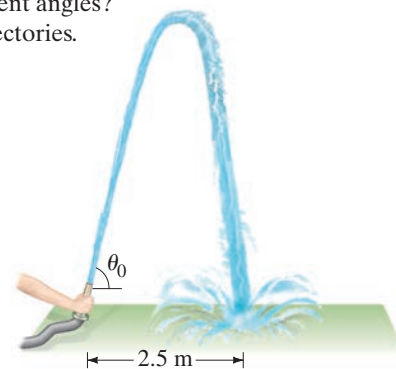
**FIGURE 3–35**

Problems 9, 10, 11, 12, and 13.  
Vector magnitudes are given in arbitrary units.

10. (II) (a) Given the vectors  $\vec{A}$  and  $\vec{B}$  shown in Fig. 3–35, determine  $\vec{B} - \vec{A}$ . (b) Determine  $\vec{A} - \vec{B}$  without using your answer in (a). Then compare your results and see if they are opposite.
11. (II) Determine the vector  $\vec{A} - \vec{C}$ , given the vectors  $\vec{A}$  and  $\vec{C}$  in Fig. 3–35.
12. (II) For the vectors shown in Fig. 3–35, determine (a)  $\vec{B} - 3\vec{A}$ , (b)  $2\vec{A} - 3\vec{B} + 2\vec{C}$ .
13. (II) For the vectors given in Fig. 3–35, determine (a)  $\vec{A} - \vec{B} + \vec{C}$ , (b)  $\vec{A} + \vec{B} - \vec{C}$ , and (c)  $\vec{C} - \vec{A} - \vec{B}$ .
14. (II) Suppose a vector  $\vec{V}$  makes an angle  $\phi$  with respect to the  $y$  axis. What could be the  $x$  and  $y$  components of the vector  $\vec{V}$ ?
15. (II) The summit of a mountain, 2450 m above base camp, is measured on a map to be 4580 m horizontally from the camp in a direction  $38.4^\circ$  west of north. What are the components of the displacement vector from camp to summit? What is its magnitude? Choose the  $x$  axis east,  $y$  axis north, and  $z$  axis up.
16. (III) You are given a vector in the  $xy$  plane that has a magnitude of 90.0 units and a  $y$  component of  $-65.0$  units. (a) What are the two possibilities for its  $x$  component? (b) Assuming the  $x$  component is known to be positive, specify the vector which, if you add it to the original one, would give a resultant vector that is 80.0 units long and points entirely in the  $-x$  direction.

### 3–5 and 3–6 Projectile Motion (neglect air resistance)

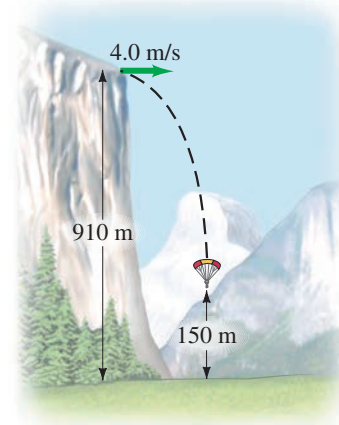
17. (I) A tiger leaps horizontally from a 7.5-m-high rock with a speed of 3.0 m/s. How far from the base of the rock will she land?
18. (I) A diver running 2.5 m/s dives out horizontally from the edge of a vertical cliff and 3.0 s later reaches the water below. How high was the cliff and how far from its base did the diver hit the water?
19. (II) Estimate by what factor a person can jump farther on the Moon as compared to the Earth if the takeoff speed and angle are the same. The acceleration due to gravity on the Moon is one-sixth what it is on Earth.
20. (II) A ball is thrown horizontally from the roof of a building 7.5 m tall and lands 9.5 m from the base. What was the ball's initial speed?
21. (II) A ball thrown horizontally at 12.2 m/s from the roof of a building lands 21.0 m from the base of the building. How high is the building?
22. (II) A football is kicked at ground level with a speed of 18.0 m/s at an angle of  $31.0^\circ$  to the horizontal. How much later does it hit the ground?
23. (II) A fire hose held near the ground shoots water at a speed of 6.5 m/s. At what angle(s) should the nozzle point in order that the water land 2.5 m away (Fig. 3–36)? Why are there two different angles? Sketch the two trajectories.



**FIGURE 3–36**

Problem 23.

24. (II) You buy a plastic dart gun, and being a clever physics student you decide to do a quick calculation to find its maximum horizontal range. You shoot the gun straight up, and it takes 4.0 s for the dart to land back at the barrel. What is the maximum horizontal range of your gun?
25. (II) A grasshopper hops along a level road. On each hop, the grasshopper launches itself at angle  $\theta_0 = 45^\circ$  and achieves a range  $R = 0.80$  m. What is the average horizontal speed of the grasshopper as it hops along the road? Assume that the time spent on the ground between hops is negligible.
26. (II) Extreme-sports enthusiasts have been known to jump off the top of El Capitan, a sheer granite cliff of height 910 m in Yosemite National Park. Assume a jumper runs horizontally off the top of El Capitan with speed 4.0 m/s and enjoys a free fall until she is 150 m above the valley floor, at which time she opens her parachute (Fig. 3–37). (a) How long is the jumper in free fall? Ignore air resistance. (b) It is important to be as far away from the cliff as possible before opening the parachute. How far from the cliff is this jumper when she opens her chute?



**FIGURE 3–37**

Problem 26.

27. (II) A projectile is fired with an initial speed of 36.6 m/s at an angle of  $42.2^\circ$  above the horizontal on a long flat firing range. Determine (a) the maximum height reached by the projectile, (b) the total time in the air, (c) the total horizontal distance covered (that is, the range), and (d) the speed of the projectile 1.50 s after firing.

28. (II) An athlete performing a long jump leaves the ground at a  $27.0^\circ$  angle and lands 7.80 m away. (a) What was the takeoff speed? (b) If this speed were increased by just 5.0%, how much longer would the jump be?
29. (II) A baseball is hit with a speed of 27.0 m/s at an angle of  $45.0^\circ$ . It lands on the flat roof of a 13.0-m-tall nearby building. If the ball was hit when it was 1.0 m above the ground, what horizontal distance does it travel before it lands on the building?
30. (II) A rescue plane wants to drop supplies to isolated mountain climbers on a rocky ridge 235 m below. If the plane is traveling horizontally with a speed of 250 km/h (69.4 m/s), how far in advance of the recipients (horizontal distance) must the goods be dropped (Fig. 3–38)?

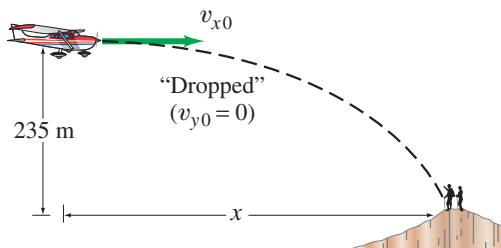


FIGURE 3–38 Problem 30.

31. (III) Suppose the rescue plane of Problem 30 releases the supplies a horizontal distance of 425 m in advance of the mountain climbers. What vertical velocity (up or down) should the supplies be given so that they arrive precisely at the climbers' position (Fig. 3–39)? With what speed do the supplies land?

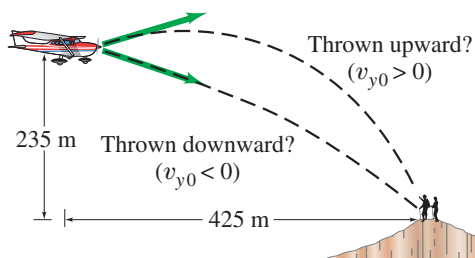


FIGURE 3–39 Problem 31.

32. (III) Show that the time required for a projectile to reach its highest point is equal to the time for it to return to its original height if air resistance is negligible.
33. (III) Suppose the kick in Example 3–6 is attempted 36.0 m from the goalposts, whose crossbar is 3.05 m above the ground. If the football is directed perfectly between the goalposts, will it pass over the bar and be a field goal? Show why or why not. If not, from what horizontal distance must this kick be made if it is to score?

34. (III) Revisit Example 3–7, and assume that the boy with the slingshot is *below* the boy in the tree (Fig. 3–40) and so aims *upward*, directly at the boy in the tree. Show that again the boy in the tree makes the wrong move by letting go at the moment the water balloon is shot.

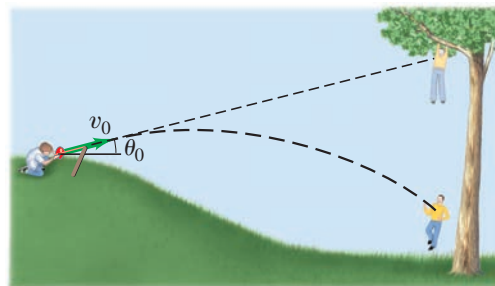


FIGURE 3–40 Problem 34.

35. (III) A stunt driver wants to make his car jump over 8 cars parked side by side below a horizontal ramp (Fig. 3–41). (a) With what minimum speed must he drive off the horizontal ramp? The vertical height of the ramp is 1.5 m above the cars and the horizontal distance he must clear is 22 m. (b) If the ramp is now tilted upward, so that “takeoff angle” is  $7.0^\circ$  above the horizontal, what is the new minimum speed?

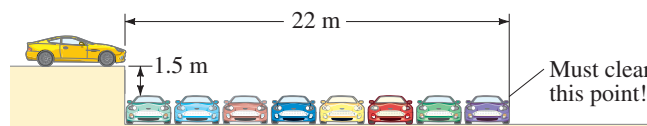


FIGURE 3–41 Problem 35.

### 3–8 Relative Velocity

36. (I) Huck Finn walks at a speed of 0.70 m/s across his raft (that is, he walks perpendicular to the raft's motion relative to the shore). The heavy raft is traveling down the Mississippi River at a speed of 1.50 m/s relative to the river bank (Fig. 3–42). What is Huck's velocity (speed and direction) relative to the river bank?

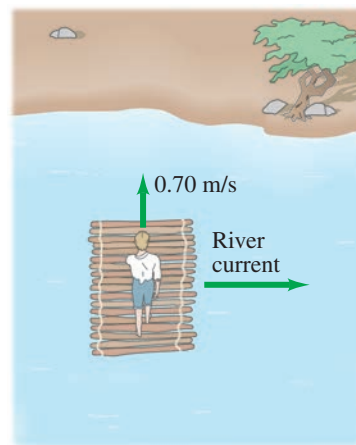


FIGURE 3–42 Problem 36.



37. (II) Two planes approach each other head-on. Each has a speed of 780 km/h, and they spot each other when they are initially 10.0 km apart. How much time do the pilots have to take evasive action?
38. (II) A passenger on a boat moving at 1.70 m/s on a still lake walks up a flight of stairs at a speed of 0.60 m/s, Fig. 3–43. The stairs are angled at  $45^\circ$  pointing in the direction of motion as shown. What is the velocity of the passenger relative to the water?

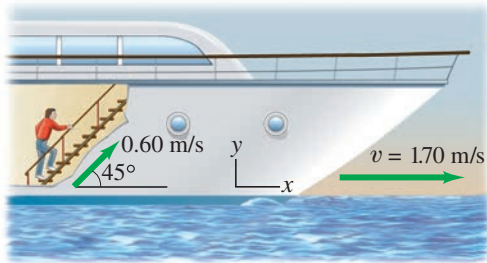


FIGURE 3–43 Problem 38.

39. (II) A person in the passenger basket of a hot-air balloon throws a ball horizontally outward from the basket with speed 10.0 m/s (Fig. 3–44). What initial velocity (magnitude and direction) does the ball have relative to a person standing on the ground (a) if the hot-air balloon is rising at 3.0 m/s relative to the ground during this throw, (b) if the hot-air balloon is descending at 3.0 m/s relative to the ground?



FIGURE 3–44  
Problem 39.

40. (II) An airplane is heading due south at a speed of 688 km/h. If a wind begins blowing from the southwest at a speed of 90.0 km/h (average), calculate (a) the velocity (magnitude and direction) of the plane, relative to the ground, and (b) how far from its intended position it will be after 11.0 min if the pilot takes no corrective action. [Hint: First draw a diagram.]
41. (II) In what direction should the pilot aim the plane in Problem 40 so that it will fly due south?
42. (II) A swimmer is capable of swimming 0.60 m/s in still water. (a) If she aims her body directly across a 45-m-wide river whose current is 0.50 m/s, how far downstream (from a point opposite her starting point) will she land? (b) How long will it take her to reach the other side?

43. (II) A boat, whose speed in still water is 2.50 m/s, must cross a 285-m-wide river and arrive at a point 118 m upstream from where it starts (Fig. 3–45). To do so, the pilot must head the boat at a  $45.0^\circ$  upstream angle. What is the speed of the river's current?

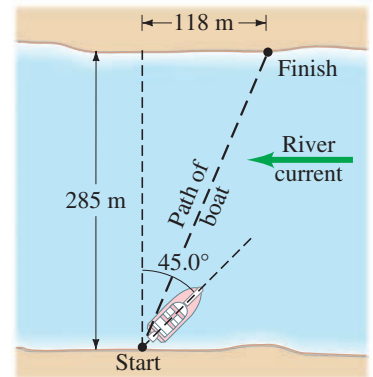


FIGURE 3–45  
Problem 43.

44. (II) A child, who is 45 m from the bank of a river, is being carried helplessly downstream by the river's swift current of 1.0 m/s. As the child passes a lifeguard on the river's bank, the lifeguard starts swimming in a straight line (Fig. 3–46) until she reaches the child at a point downstream. If the lifeguard can swim at a speed of 2.0 m/s relative to the water, how long does it take her to reach the child? How far downstream does the lifeguard intercept the child?

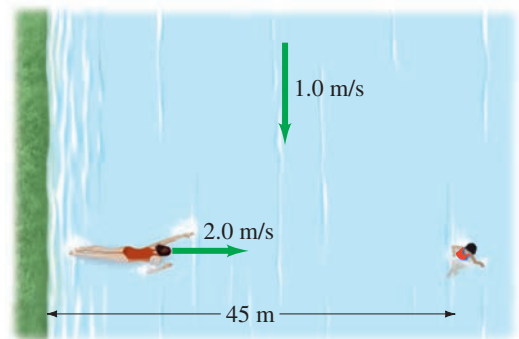


FIGURE 3–46 Problem 44.

45. (III) Two cars approach a street corner at right angles to each other (Fig. 3–47). Car 1 travels at a speed relative to Earth  $v_{1E} = 35$  km/h, and car 2 at  $v_{2E} = 55$  km/h. What is the relative velocity of car 1 as seen by car 2? What is the velocity of car 2 relative to car 1?

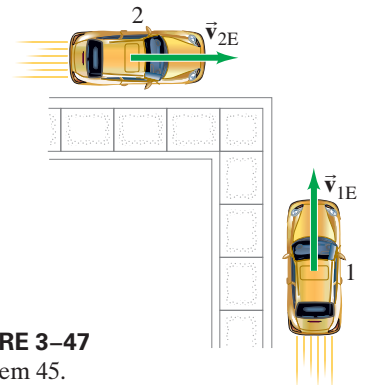


FIGURE 3–47  
Problem 45.

## General Problems

46. Two vectors,  $\vec{V}_1$  and  $\vec{V}_2$ , add to a resultant  $\vec{V}_R = \vec{V}_1 + \vec{V}_2$ . Describe  $\vec{V}_1$  and  $\vec{V}_2$  if (a)  $V_R = V_1 + V_2$ , (b)  $V_R^2 = V_1^2 + V_2^2$ , (c)  $V_1 + V_2 = V_1 - V_2$ .
47. On mountainous downhill roads, escape routes are sometimes placed to the side of the road for trucks whose brakes might fail. Assuming a constant upward slope of  $26^\circ$ , calculate the horizontal and vertical components of the acceleration of a truck that slowed from 110 km/h to rest in 7.0 s. See Fig. 3–48.

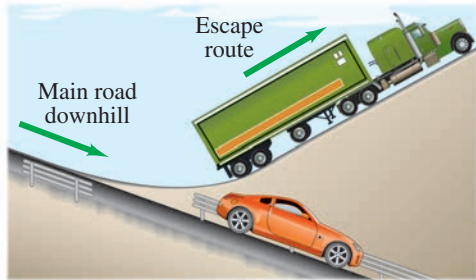


FIGURE 3–48 Problem 47.

48. A light plane is headed due south with a speed relative to still air of 185 km/h. After 1.00 h, the pilot notices that they have covered only 135 km and their direction is not south but  $15.0^\circ$  east of south. What is the wind velocity?
49. Romeo is throwing pebbles gently up to Juliet's window, and he wants the pebbles to hit the window with only a horizontal component of velocity. He is standing at the edge of a rose garden 8.0 m below her window and 8.5 m from the base of the wall (Fig. 3–49). How fast are the pebbles going when they hit her window?

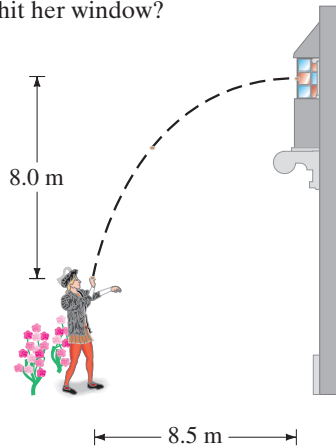


FIGURE 3–49 Problem 49.

50. *Apollo* astronauts took a “nine iron” to the Moon and hit a golf ball about 180 m. Assuming that the swing, launch angle, and so on, were the same as on Earth where the same astronaut could hit it only 32 m, estimate the acceleration due to gravity on the surface of the Moon. (We neglect air resistance in both cases, but on the Moon there is none.)

51. (a) A long jumper leaves the ground at  $45^\circ$  above the horizontal and lands 8.0 m away. What is her “takeoff” speed  $v_0$ ? (b) Now she is out on a hike and comes to the left bank of a river. There is no bridge and the right bank is 10.0 m away horizontally and 2.5 m vertically below. If she long jumps from the edge of the left bank at  $45^\circ$  with the speed calculated in (a), how long, or short, of the opposite bank will she land (Fig. 3–50)?

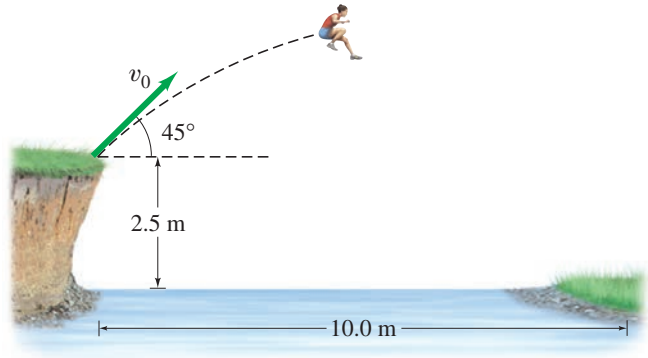


FIGURE 3–50 Problem 51.

52. A projectile is shot from the edge of a cliff 115 m above ground level with an initial speed of 65.0 m/s at an angle of  $35.0^\circ$  with the horizontal, as shown in Fig. 3–51. (a) Determine the time taken by the projectile to hit point P at ground level. (b) Determine the distance  $X$  of point P from the base of the vertical cliff. At the instant just before the projectile hits point P, find (c) the horizontal and the vertical components of its velocity, (d) the magnitude of the velocity, and (e) the angle made by the velocity vector with the horizontal. (f) Find the maximum height above the cliff top reached by the projectile.

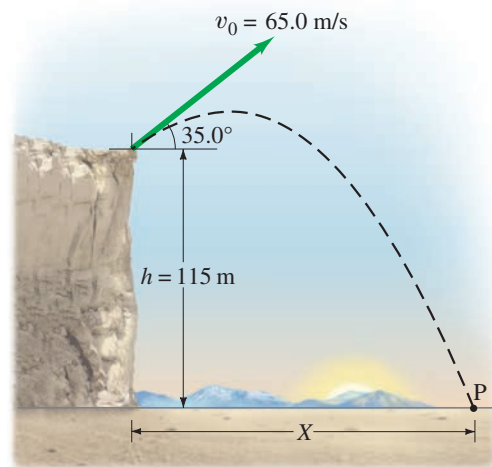


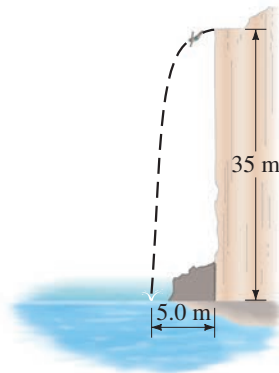
FIGURE 3–51 Problem 52.

53. Raindrops make an angle  $\theta$  with the vertical when viewed through a moving train window (Fig. 3–52). If the speed of the train is  $v_T$ , what is the speed of the raindrops in the reference frame of the Earth in which they are assumed to fall vertically?



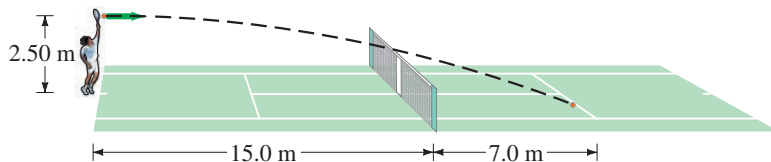
**FIGURE 3–52**  
Problem 53.

54. A hunter aims directly at a target (on the same level) 38.0 m away. (a) If the arrow leaves the bow at a speed of 23.1 m/s, by how much will it miss the target? (b) At what angle should the bow be aimed so the target will be hit?
55. The cliff divers of Acapulco push off horizontally from rock platforms about 35 m above the water, but they must clear rocky outcrops at water level that extend out into the water 5.0 m from the base of the cliff directly under their launch point. See Fig. 3–53. What minimum pushoff speed is necessary to clear the rocks? How long are they in the air?



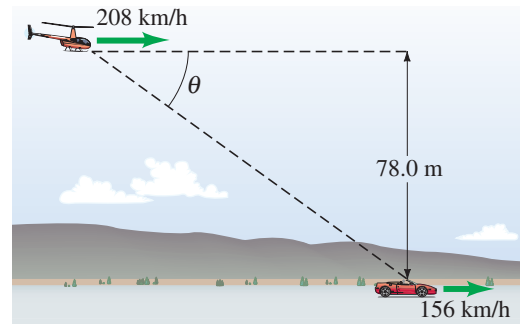
**FIGURE 3–53**  
Problem 55.

56. When Babe Ruth hit a homer over the 8.0-m-high right-field fence 98 m from home plate, roughly what was the minimum speed of the ball when it left the bat? Assume the ball was hit 1.0 m above the ground and its path initially made a  $36^\circ$  angle with the ground.
57. At serve, a tennis player aims to hit the ball horizontally. What minimum speed is required for the ball to clear the 0.90-m-high net about 15.0 m from the server if the ball is “launched” from a height of 2.50 m? Where will the ball land if it just clears the net (and will it be “good” in the sense that it lands within 7.0 m of the net)? How long will it be in the air? See Fig. 3–54.



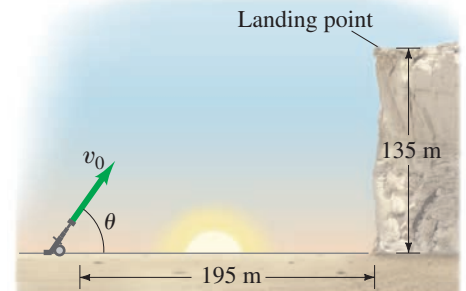
**FIGURE 3–54** Problem 57.

58. Spymaster Chris, flying a constant 208 km/h horizontally in a low-flying helicopter, wants to drop secret documents into her contact’s open car which is traveling 156 km/h on a level highway 78.0 m below. At what angle (with the horizontal) should the car be in her sights when the packet is released (Fig. 3–55)?



**FIGURE 3–55** Problem 58.

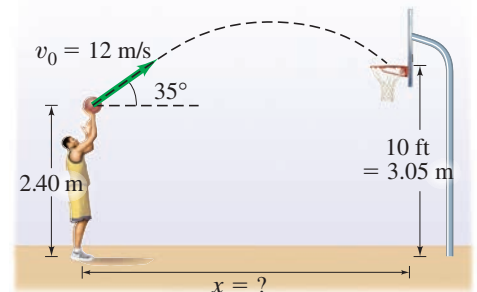
59. A boat can travel 2.20 m/s in still water. (a) If the boat points directly across a stream whose current is 1.20 m/s, what is the velocity (magnitude and direction) of the boat relative to the shore? (b) What will be the position of the boat, relative to its point of origin, after 3.00 s?
60. A projectile is launched from ground level to the top of a cliff which is 195 m away and 135 m high (see Fig. 3–56). If the projectile lands on top of the cliff 6.6 s after it is fired, find the initial velocity of the projectile (magnitude and direction). Neglect air resistance.



**FIGURE 3–56**  
Problem 60.

61. A basketball is shot from an initial height of 2.40 m (Fig. 3–57) with an initial speed  $v_0 = 12$  m/s directed at an angle  $\theta_0 = 35^\circ$  above the horizontal. (a) How far from the basket was the player if he made a basket? (b) At what angle to the horizontal did the ball enter the basket?

**FIGURE 3–57**  
Problem 61.



62. A rock is kicked horizontally at 15 m/s from a hill with a  $45^\circ$  slope (Fig. 3–58). How long does it take for the rock to hit the ground?

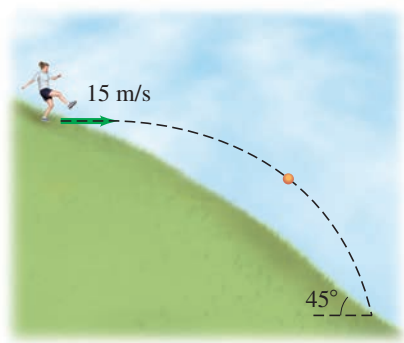


FIGURE 3–58 Problem 62.

63. A ball is shot from the top of a building with an initial velocity of 18 m/s at an angle  $\theta = 42^\circ$  above the horizontal. (a) What are the horizontal and vertical components of the initial velocity? (b) If a nearby building is the same height and 55 m away, how far below the top of the building will the ball strike the nearby building?
64. If a baseball pitch leaves the pitcher's hand horizontally at a velocity of 150 km/h, by what % will the pull of gravity change the magnitude of the velocity when the ball reaches the batter, 18 m away? For this estimate, ignore air resistance and spin on the ball.

## Search and Learn

1. Here is something to try at a sporting event. Show that the maximum height  $h$  attained by an object projected into the air, such as a baseball, football, or soccer ball, is approximately given by

$$h \approx 1.2t^2 \text{ m,}$$

where  $t$  is the total time of flight for the object in seconds. Assume that the object returns to the same level as that from which it was launched, as in Fig. 3–59. For example, if you count to find that a baseball was in the air for  $t = 5.0$  s, the maximum height attained was  $h = 1.2 \times (5.0)^2 = 30$  m. The fun of this relation is that  $h$  can be determined without knowledge of the launch speed  $v_0$  or launch angle  $\theta_0$ . Why is that exactly? See Section 3–6.

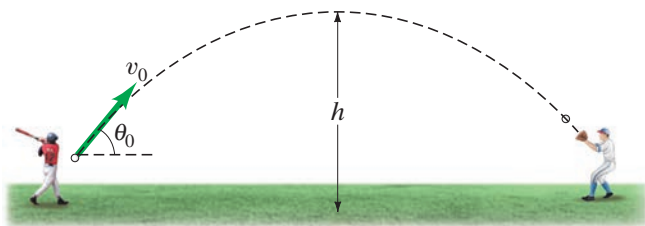


FIGURE 3–59 Search and Learn 1.

2. The initial angle of projectile A is  $30^\circ$ , while that of projectile B is  $60^\circ$ . Both have the same level horizontal range. How do the initial velocities and flight times (elapsed time from launch until landing) compare for A and B?
3. You are driving south on a highway at 12 m/s (approximately 25 mi/h) in a snowstorm. When you last stopped, you noticed that the snow was coming down vertically, but it is passing the windows of the moving car at an angle of  $7.0^\circ$  to the horizontal. Estimate the speed of the vertically falling snowflakes relative to the ground. [Hint: Construct a relative velocity diagram similar to Fig. 3–29 or 3–30. Be careful about which angle is the angle given.]

## ANSWERS TO EXERCISES

A:  $3.0\sqrt{2} \approx 4.2$  units.

B: (a).

C: They hit at the same time.

D: (i) Nowhere; (ii) at the highest point; (iii) nowhere.

E: (d). It provides the initial velocity of the box.

F: (a)  $v = v_{x0} = 16.0$  m/s, horizontal; (b)  $9.80$  m/s<sup>2</sup> down.