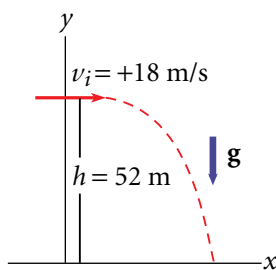


32. A person standing at the edge of a seaside cliff kicks a stone over the edge with a speed of 18 m/s. The cliff is 52 m above the water's surface, as shown at right. How long does it take for the stone to fall to the water? With what speed does it strike the water?

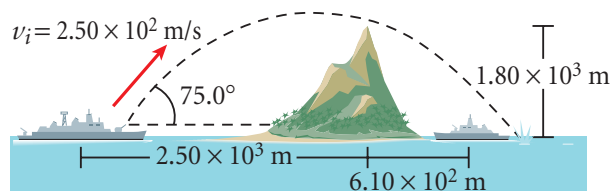


33. A spy in a speed boat is being chased down a river by government officials in a faster craft. Just as the officials' boat pulls up next to the spy's boat, both boats reach the edge of a 5.0 m waterfall. If the spy's speed is 15 m/s and the officials' speed is 26 m/s, how far apart will the two vessels be when they land below the waterfall?

*For problems 34–37, see Sample Problem E.*

34. A shell is fired from the ground with an initial speed of  $1.70 \times 10^3$  m/s (approximately five times the speed of sound) at an initial angle of  $55.0^\circ$  to the horizontal. Neglecting air resistance, find
- the shell's horizontal range
  - the amount of time the shell is in motion
35. A place kicker must kick a football from a point 36.0 m (about 40.0 yd) from the goal. As a result of the kick, the ball must clear the crossbar, which is 3.05 m high. When kicked, the ball leaves the ground with a speed of 20.0 m/s at an angle of  $53^\circ$  to the horizontal.
- By how much does the ball clear or fall short of clearing the crossbar?
  - Does the ball approach the crossbar while still rising or while falling?
36. When a water gun is fired while being held horizontally at a height of 1.00 m above ground level, the water travels a horizontal distance of 5.00 m. A child, who is holding the same gun in a horizontal position, is also sliding down a  $45.0^\circ$  incline at a constant speed of 2.00 m/s. If the child fires the gun when it is 1.00 m above the ground and the water takes 0.329 s to reach the ground, how far will the water travel horizontally?

37. A ship maneuvers to within  $2.50 \times 10^3$  m of an island's  $1.80 \times 10^3$  m high mountain peak and fires a projectile at an enemy ship  $6.10 \times 10^2$  m on the other side of the peak, as illustrated below. If the ship shoots the projectile with an initial velocity of  $2.50 \times 10^2$  m/s at an angle of  $75.0^\circ$ , how close to the enemy ship does the projectile land? How close (vertically) does the projectile come to the peak?



## RELATIVE MOTION

### Review Questions

38. Explain the statement "All motion is relative."
39. What is a frame of reference?
40. When we describe motion, what is a common frame of reference?
41. A small airplane is flying at 50 m/s toward the east. A wind of 20 m/s toward the east suddenly begins to blow and gives the plane a velocity of 70 m/s east.
- Which vector is the resultant vector?
  - What is the magnitude of the wind velocity?
42. A ball is thrown upward in the air by a passenger on a train that is moving with constant velocity.
- Describe the path of the ball as seen by the passenger. Describe the path as seen by a stationary observer outside the train.
  - How would these observations change if the train were accelerating along the track?

### Practice Problems

*For problems 43–46, see Sample Problem F.*

43. A river flows due east at 1.50 m/s. A boat crosses the river from the south shore to the north shore by maintaining a constant velocity of 10.0 m/s due north relative to the water.
- What is the velocity of the boat as viewed by an observer on shore?