

The following is a sample of problems that can be assigned to students following completion of Unit 7, Lesson 1, Investigation 1.

On Your Own

Applications

1. A first-time diver was a bit nervous about his first dive at a swimming pool. To ease his worries about hitting the water after a fall of 15 feet, he decided to push a tennis ball off the edge of the platform to see the effect of landing in the water.
 - a. What rule shows how the ball's height above the water h is related to elapsed time in the dive t ?
 - b. Estimate the time it will take the ball to hit the water.

2. Katie, a goalie for Riverside High School's soccer team, needs to get the ball downfield to her teammates on the offensive end of the field. She punts the ball from a point 2 feet above the ground with an initial upward velocity of 40 feet per second.



- a. Write a function rule that relates the ball's height above the field h to its time in the air t .
- b. Use this function rule to estimate the time when the ball will hit the ground.
- c. How much more or less time in the air would the ball have if Katie were to kick it right off the ground, but with the same initial upward velocity?

3. The opening of the "cannon" pictured at the right is 16 feet above the ground. The daredevil who is shot out of the cannon reaches a maximum height of 55 feet after about 1.56 seconds and hits a net that is 9.5 feet off the ground after 3.25 seconds. Use this information to answer the following questions.



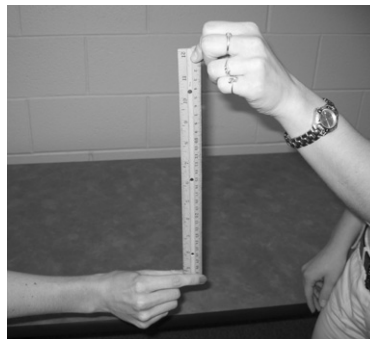
- a. What is the daredevil's height above the ground h at a time t seconds after the cannon is fired?

- b. At what upward velocity is the daredevil shot from the cannon?
 - c. If, for some unfortunate reason the net slipped to the ground at the firing of the cannon, when would the daredevil hit the ground?
4. When a punkin' chunker launches a pumpkin, the goal is long distance, not height. The relationship between horizontal distance d (in feet) and time t (in seconds) might be given by a function rule like $d = 70t$, when the height is given by $h = 20 + 50t - 16t^2$.
- a. How long will the pumpkin be in the air?
 - b. How far will the pumpkin travel from the chunker by the time it hits the ground?
 - c. When will the pumpkin reach its maximum height, and what will that height be?
 - d. How far from the chunker will the pumpkin be (horizontally) when it reaches its maximum height?

Connections

9. The following experiment can be used to measure a person's *reaction time*, the amount of time it takes a person to react to something he or she sees.

Hold a ruler at the end that reads 12 inches and let it hang down. Have the subject hold his or her thumb and forefinger opposite the 0-inch mark (without touching the ruler!). Tell your subject that you will drop the ruler within the next 10 seconds and that he or she is supposed to grasp the ruler as quickly as possible after it is dropped.



The spot on the ruler where it is caught indicates the distance that the ruler dropped.

- a. What function describes the distance the ruler has fallen after t seconds?
- b. Use what you know about the relationship between feet and inches and your function from Part a to estimate the reaction time of a person who grasps the ruler at the 4-inch mark.
- c. Conduct this experiment several times and estimate the reaction times of your subjects.

Extensions

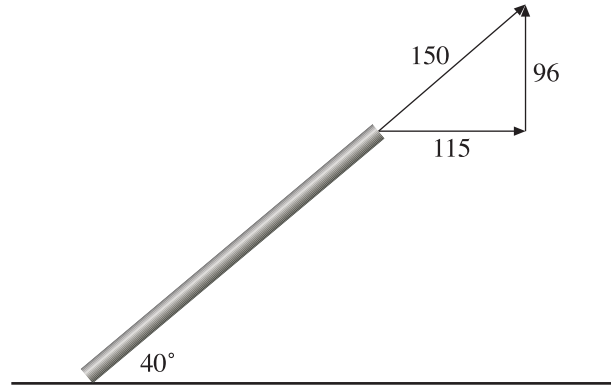
19. For anything that moves, *average speed* can be calculated by dividing the total distance traveled by the total time taken to travel that distance.

For example, a diver who falls from a 35-foot platform in about 1.5 seconds has an average speed of $\frac{35}{1.5}$ or about 23.3 feet per second. That diver will not be falling at that average speed throughout the dive.



- a. If a diver falls from 35 feet to approximately 31 feet in the first 0.5 seconds of a dive, what estimate of speed would seem reasonable for the diver midway through that time interval—that is, how fast might the diver be moving at 0.25 seconds?
- b. The relation between height above the water and the diver's time in flight can be described by the function $h = 35 - 16t^2$, if time is measured in seconds and distance in feet. Use that function rule to make a table of *(time, height)* data and then estimate the diver's speed at a series of points using your data. Make a table and a graph of the *(time, speed)* estimates.
- c. What do the patterns in *(time, speed)* data and the graph tell you about the diver's speed on the way to the water?
- d. About how fast is the diver traveling when he hits the water?
- e. Write a rule for speed s as a function of time t that seems to fit the data in your table and graph. Use your calculator or computer software to check the function against the data in Part b.

20. When a pumpkin is shot from an air cannon chunker, its motion has two components—vertical and horizontal. Suppose that a pumpkin is shot at an angle of 40° with initial velocity of 150 feet per second and initial height 30 feet. The vertical component of its velocity will be about 96 feet per second; the horizontal component of its velocity will be about 115 feet per second.



- What function gives the height h of the pumpkin shot at any time t seconds after it leaves the chunker?
- What function gives the horizontal distance d traveled by the pumpkin at any time t seconds after it leaves the chunker?
- Use the functions in Parts a and b to find the horizontal distance traveled by the pumpkin by the time it hits the ground.
- Rewrite the relation between time and distance in Part b to give time as a function of distance.
- Combine the rule giving time as a function of horizontal distance and the rule giving height as a function of time to write a function rule giving height as a function of horizontal distance. (*Hint:* Replace each occurrence of t by an equivalent expression involving d .)
- Use the function developed in Part e to estimate the distance traveled by the pumpkin when it hits the ground. Then compare the result obtained in this way to your answer to Part c.