

**LAB**  
**1** Laboratory  
Activity

# Projectile Motion

What do a volleyball, baseball, tennis ball, soccer ball, and football have in common? Each is used in a sport and each is a projectile after it is tapped, thrown, kicked, or hit. A projectile is any object that is thrown or shot into the air. If air resistance is ignored, the only force acting on a projectile is the force of gravity.

The path followed by a projectile is called a trajectory. Figure 1a shows the shape of the trajectory of a toy rocket. Because the force of gravity is the only force acting on it, the toy rocket has an acceleration of  $9.80 \text{ m/s}^2$  downward. However, the motion of the projectile is upward and then downward. Figure 1b shows the size and direction of the vertical velocity of a toy rocket at different moments along its trajectory. The rocket's velocity upward begins to decrease immediately after launch and the rocket begins to slow down. The rocket continues to slow down. And then, for an instant at the highest point of its trajectory, it stops moving because its velocity upward is zero. As the rocket begins to fall, its velocity begins to increase downward.

As you can see, the shape of the upward trajectory of the rocket is a mirror-image of the shape of its downward trajectory. Can the trajectory of a toy rocket be used to learn something about the motion of a projectile? In this experiment you will find out.

## Strategy

You will measure the flight times of a projectile.  
You will analyze the flight times of a projectile.

## Materials

toy water rocket and launcher  
bucket of water  
3 stopwatches

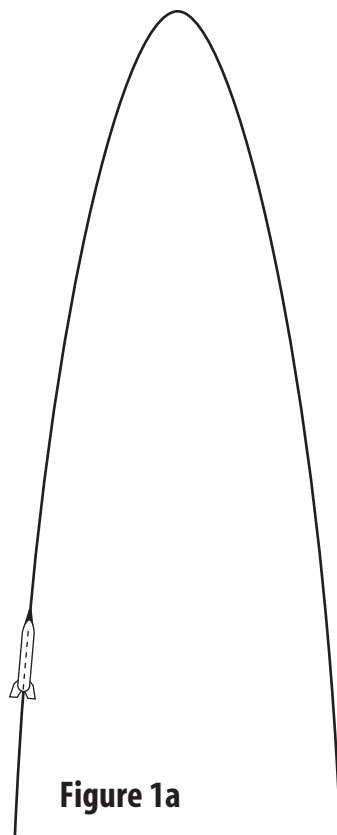


Figure 1a

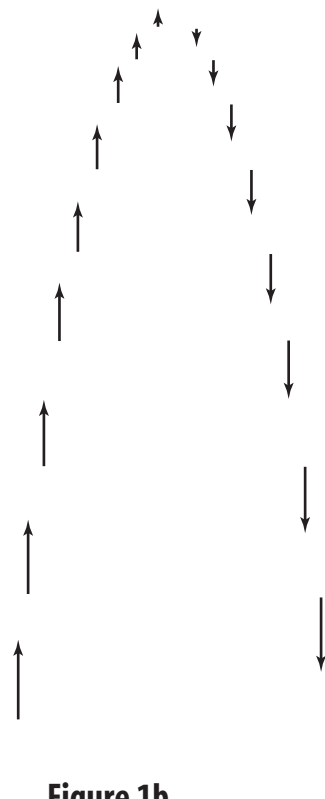


Figure 1b

## Laboratory Activity 1 (continued)

### Procedure

1. Wear goggles during this experiment.
2. Fill the water rocket to the level line shown on the rocket's body. Always fill the rocket to the same level during each flight in the experiment.
3. Attach the pump/launcher to the rocket as shown in the manufacturer's directions.
4. Pump the pump/launcher 10 times.  
**CAUTION:** *Do not exceed 20 pumps or the maximum number suggested by the manufacturer, whichever is lower. Be sure to hold the rocket and pump/launcher so that the rocket is not directed toward yourself or another person.*
5. Launch the rocket vertically. Predict the time for the rocket to rise to its highest point, and the time for it to fall back to Earth. Now predict these times if the rocket is pumped 15 times. Record your predictions as time up and time down in the Data and Observations section.
6. Retrieve the rocket. Fill the rocket with water as in step 2. Pump the pump/launcher 10 times. Record the number of pumps in Table 1.
7. At a given signal to the timers, launch the rocket. Your teacher will have timers measure specific parts of the flight using stopwatches. Record the values measured by the timers as total time, time up, and time down in Table 1.
8. Repeat steps 6 and 7 twice.
9. Repeat steps 6 and 7 three more times, increasing the number of pumps to 15 for each launch. **CAUTION:** *Do not exceed the maximum number of pumps suggested by the manufacturer.*

### Data and Observations

1. Calculate the average total time, time up, and average time down for the two sets of launches. Record these values in Table 2.
2. Use Graph 1 to construct a bar graph comparing the average time up, average total time, and average time down for the two sets of launches. Plot the number of pumps used in each set of launches on the  $x$ -axis and the three average times (up, total, down) on the  $y$ -axis. Label the  $x$ -axis *Number of pumps* and the  $y$ -axis *Time (s)*. Clearly label the average time up, average total time, and average time down for each set of launches.

10 pumps—Prediction of time up: \_\_\_\_\_; time down \_\_\_\_\_

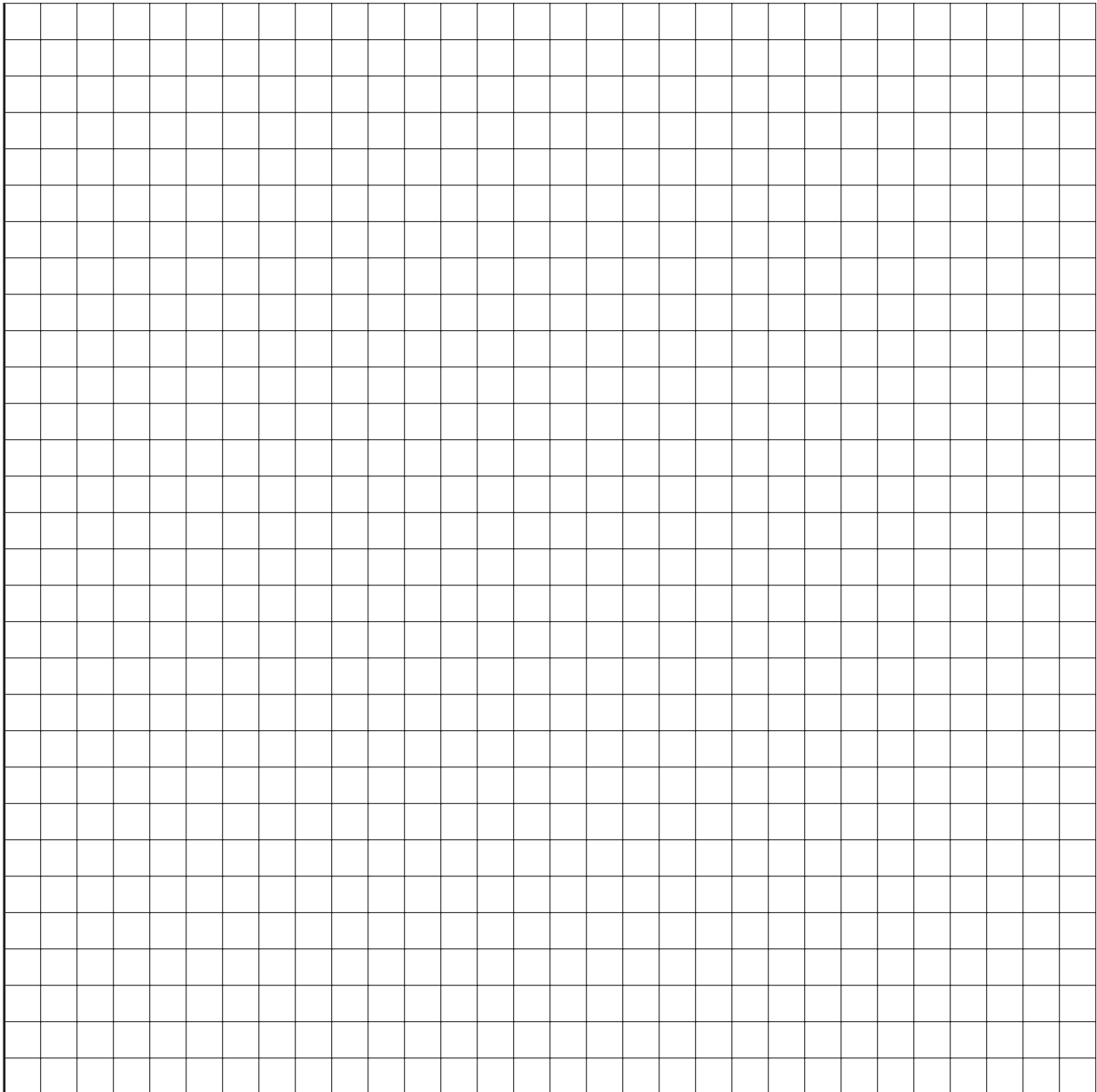
15 pumps—Prediction of time up: \_\_\_\_\_; time down \_\_\_\_\_

**Table 1**

Number of pumps	Total time (s)	Time up (s)	Time down (s)

**Laboratory Activity 1** (continued)**Table 2**

Number of pumps	Average total time (s)	Average time up (s)	Average time down (s)

**Graph 1**

**Laboratory Activity 1 (continued)****Questions and Conclusions**

1. How well did your predictions agree with the measured times?

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2. Do your graphs support the statement that the time for a projectile to reach its highest point is equal to the time for the projectile to fall back to Earth? Explain.

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3. Why was the number of pumps used to launch the rocket kept the same during each set of launches?

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4. Why would you expect the flight times to be greater for the launches that were done using 15 pumps than those that were done with 10 pumps?

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**Strategy Check**

\_\_\_\_\_ Can you measure and analyze the flight times of a projectile?

\_\_\_\_\_ Can you predict the trajectory of a projectile?