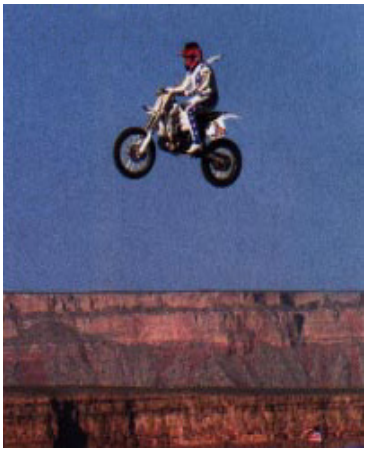


Up and Over

Student Instruction Sheet

Challenge

Determine how launching a projectile horizontally at varying initial velocities affects its time-of-flight. And determine if and how the horizontal and vertical components of motion are related.

Equipment and Materials

• Computer with USB Port	• Projectile Launcher, Short Range
• (2) PASPORT USB interfaces	• 30 Meter Measuring Tape
• (2) PASPORT Photogate Ports	• Phone Jack Extender Cord
• DataStudio software	• C-clamp, large
• (2) Photogate Heads	• USB hub (optional)
• Time-of-Flight Accessory Kit	• *Student Instruction Sheet*
• Photogate Mounting Bracket	• *Student Response Sheet*

Note: If your computer does not have two USB ports, you will need a USB Hub.

Safety Precautions

Remember, follow the directions for using the equipment.

Background

The distance, *d*, a projectile falls from rest is given by the equation:

$$d = \frac{1}{2}gt^2$$

where g is the acceleration due to gravity in free fall.

Rearranging this equation gives you the time, *t*, it takes for the projectile to fall a distance straight down from rest to the ground:

$$t = \sqrt{2\frac{d}{g}}$$

When a projectile flies through the air it has a horizontal component of motion as it travels outward, and a vertical component of motion as it travels upward and then falls downward. Does the one component affect the other? If the projectile is launched horizontally (so there is no upward motion) do the equations above still apply? Does the projectile's time-of-flight still only depend on the vertical distance it falls and constant gravitational acceleration? This would mean that a projectile launched horizontally at 5 m/s would take the same time to land as one launched at 10 m/s. Even more mind boggling is that it would mean that a bullet fired from a gun and a bullet dropped from the same height as the gun would land at the same time. Could this be so?

In this activity you will launch a projectile horizontally three times, increasing its initial speed with each run. You will also measure the time it takes to hit the ground and determine if there is difference from one run to the next.

Predict

Before beginning the eLab, complete the prediction portion of the *Student Response Sheet*.

Explore

Computer Setup

1. Launch the DataStudio program.
2. Select **Open Activity** from the Welcome to DataStudio window.
3. Navigate to the folder containing the DataStudio configuration files and open the file **12 Projectile Motion CF.ds**.
4. Connect the two PASPORT USB interfaces to the computer's USB ports or to a USB hub.
5. Connect each of the two Photogate Ports to the USB interfaces

6. Connect the plugs from the two photogate heads into channels 1 and 2, respectively, of one Photogate Port.

7. Connect one end of the phone jack extender cable to the Time-of-Flight pad cable. Connect the other end to Channel 1 of the second Photogate Port.

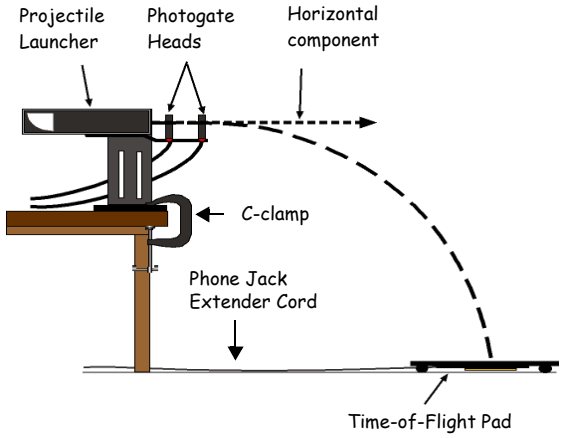
8. Choose the appropriate DataStudio configuration file entitled

04 Acceleration CF.ds

Note: Configuration files automatically launch the appropriate display(s), sampling rate(s), etc.

Equipment Setup

1. Set up the equipment as shown in the figure.



2. Clamp the base of the projectile launcher to the edge of a sturdy table. Aim the launcher away from the table toward the center of an open area at least 3 meters away.

3. Adjust the angle of the launcher to zero degrees so the plastic ball will be launched horizontally.

4. Slide the photogate mounting bracket into the T-slot on the bottom side of the projectile launcher. Mount one Photogate to the bracket in the position closest to the end of the launcher. Mount the other Photogate to the bracket in the other position.

Note: Make sure the Photogates that are mounted on the front of the projectile launcher are separated by 10 centimeters (0.10 m). If the distance of separation is different, adjust the value. Click the **Setup** button and choose **Change Value**. Insert your value. Also make sure that the photogate heads are aligned to the barrel so that the diameter of the ball breaks the photogate beam.

Record Data

Part 1: Horizontal, Short Range

1. Put the plastic ball into the projectile launcher. Cock the launcher to the *short-range* position.
2. Test fire the ball to determine where to place the Time-of-Flight pad on the floor. Put the pad on the floor where the ball hits.
3. Test fire that ball again to verify that the ball lands on the Time-of-Flight pad.
4. Reload the ball into the projectile launcher, and cock the launcher to the *short-range* position. Click the **Start** (Start) button to begin recording data.
5. Shoot the ball on the *short-range* position. After the ball hits the Time-of-Flight pad, click the **Stop** (Stop) button. Record the initial speed and time of flight on the *Student Response Sheet*.

Part 2: Horizontal, Medium Range

- Repeat steps 1 through 5 of the data recording process for the *medium-range* position, being sure to reload the ball BEFORE you click the Start button.

Part 3: Horizontal, Long Range

- Repeat steps 1 through 5 of the data recording process for the *long-range* position, being sure to reload the ball BEFORE you click the Start button.

Analyze

1. Save your DataStudio file (on the **File** menu, click **Save Activity As**...) to the location specified by your teacher.
2. Answer the questions and define the vocabulary words on the *Student Response Sheet*.
3. Follow your teacher's instructions regarding cleaning up your workstation.

Student Response Sheet

Name:_____

Date:_____

Up and Over

Vocabulary

Use available resources to find the definitions of the following terms:

projectile motion: _____

_____

Predict

1. Which will take longer to land, a ball launched horizontally at one speed, or a ball launched horizontally at an even greater speed? Explain your answer.

_____

_____

_____

2. Which will take longer to land, a ball launched horizontally at a certain velocity, or a ball dropped (with no initial velocity) from the same height as the one launched? Explain your answer.

_____

_____

_____

Data

1. Measure (in meters) and record the vertical distance, *d,* that the ball travels (i.e. the distance from the launcher's barrel to the floor).

d = _____m

Record the initial speed and time of flight for each of the projectile launches.

Relative Horizontal Distance	Initial (Horizontal) Speed (m/s)	Time of Flight (s)
Short		
Medium		
Long		

Analyze

1. As the initial speed increases how did each of the following values change?

Time-of-Flight_____

Horizontal Distance _____

2. Using your measurement for the vertical distance, *d,* and the equation for time of flight (found in the background information), determine the theoretical time it would take for the ball to drop from rest. Show your calculations.

_____

_____

3. How does the theoretical time of flight of a ball dropped from the height, *d,* compare to the time of flight of a ball launched horizontally from the same height?

_____

_____

_____

Synthesize

1. What can you conclude about time of flight for a projectile that is launched at a horizontal angle with different initial horizontal speeds?

_____

_____

_____

2. The horizontal distance is also known as the range. What factors need to be considered to determine (or calculate) the range of a projectile launched horizontally?

_____

_____

3. What factors must be considered to determine (or calculate) the vertical motion of a projectile launched horizontally

_____

_____

4. What is the link between the vertical and horizontal motion of the projectile?

_____

_____

5. Which takes longer to land, a ball shot horizontally from the projectile launcher or a ball dropped from the same height as the launcher's barrel?

_____

_____

6. Compare your results with your predictions?

_____

_____