

Activity P37: Time of Flight versus Initial Speed (Photogate)

Concept	<i>DataStudio</i>
Projectile motion	P37 Time of Flight.DS

Equipment Needed	Qty	Equipment Needed	Qty
Photogate (CI-6838 or ME-9204)	2	Photogate Mounting Bracket (ME-6821)	1
C-clamp	1	Projectile Launcher (ME-6800)	1
Extension Cable (PI-8117)	1	Time-of-Flight Accessory (ME-6810)	1

What Do You Think?

Can you predict how long a ball will stay in the air? Does a change in its initial speed change the “time of flight”? If so, how?



Take time to answer this question in the Lab Report section.

Background

The vertical motion of a freely falling ball launched horizontally off a table of height **d** is independent of any horizontal motion the ball may have. Thus the time for a ball to fall to the ground is independent of its horizontal speed. The distance **d** a ball falls from rest as a function of the time of fall **t** is given by:

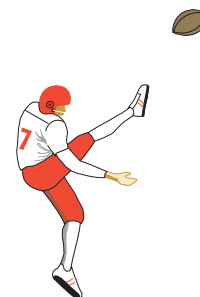
$$d = \frac{1}{2}gt^2$$

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

Thus the time for a ball to fall straight down a distance **d** from rest to the ground is given by:

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

If a ball launched horizontally with a non-zero initial speed takes the same amount of time to reach the ground as a ball that drops from rest from the same height, this equation also gives the time of flight for any ball launched horizontally regardless of the initial speed of the ball.



SAFETY REMINDERS

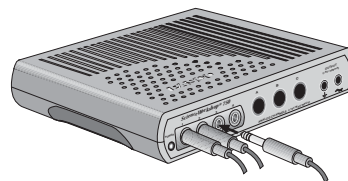
- Follow all directions for using the equipment.

THINK SAFETY
ACT SAFELY
BE SAFE!

Procedure

Use two Photogates measure the initial speed of a ball that is fired from a Projectile Launcher. Use the Time-of-Flight pad to measure the time of flight for the ball. Use *DataStudio* to record and display the time-of-flight and the initial speed.

Compare the time-of-flight for different values of initial speed when the launcher is aimed horizontally to the time-of-flight for different values of initial speed when the launcher is aimed at an angle above horizontal.



PART I: Computer Setup

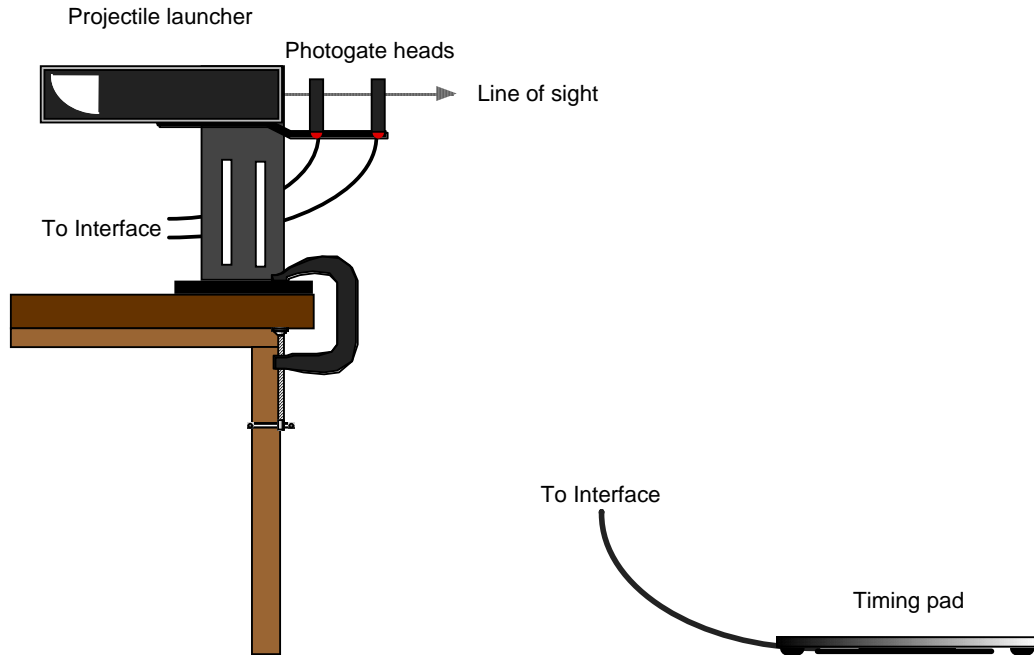
1. Connect the *ScienceWorkshop* interface to the computer, turn on the interface, and turn on the computer.
2. Connect the stereo phone plug of one Photogate into Digital Channel 1 on the interface. Connect the stereo phone plug of the second Photogate into Digital Channel 2 on the interface. Connect the Extension Cable's stereo phone plug into Digital Channel 3 on the interface.
3. Open the file titled as shown:

<i>DataStudio</i>
P37 Time of Flight.DS

- The *DataStudio* file has a Table display of 'Time of Flight' vs. 'Initial Speed' and a Workbook display. Read the instructions in the Workbook.

PART II: Sensor Calibration and Equipment Setup

- You do not need to calibrate the Photogates or the Time-of-Flight pad
1. 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.
 2. Adjust the angle of the launcher to zero degrees so the plastic ball will be launched horizontally.
 3. Slide the photogate mounting bracket into the T-slot on the bottom side of the projectile launcher. Mount the Photogate that is connected to Digital Channel 1 on the bracket in the position closest to the end of the launcher. Mount the Photogate that is connected to Digital Channel 2 on the bracket in the position farthest from the end of the launcher.
 4. Connect the Time-of-Flight pad's stereo phone plug into the end of the extension cable.



PART IIIA: Data Recording – Horizontal Launch Angle

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 timing pad on the floor. Put the timing pad on the floor where the ball hits.
3. Reload the ball into the projectile launcher, and cock the launcher to the short range position.
4. Start recording data. (In *DataStudio*, click 'Start')
5. Shoot the ball on the short-range position. After the ball hits the Time-of-Flight pad, do the following:
 - In *DataStudio*, click 'Stop'. **Result:** Run #1 appears in the Summary list.
6. Reload the ball into the launcher, but cock the launcher to the middle range position. Test-fire the ball to determine the new location to put the Time-of-Flight pad. Move the pad.
7. Reload the ball into the launcher and put the launcher in the middle range position.
8. When you are ready, resume recording data.
9. Shoot the ball with the launcher in the middle range position. After the ball hits the Time-of-Flight pad, click 'Stop' (in *DataStudio*)
10. Reload the ball into the launcher, but cock the launcher to the long-range position. Test-fire the ball to determine the new location to put the Time-of-Flight pad. Move the pad.
11. Repeat the data recording process as you did for the short and middle ranges.
12. After completing the data recording for the long-range position, end data recording.
 - In *DataStudio*, the Summary list shows three runs of data.

PART IIIB: Data Recording – Non-horizontal Launch Angle

1. Adjust the angle of the projectile launcher to 30 degrees above horizontal.
 2. Test-fire the ball on the short-range position. Move the timing pad.
 3. When you are ready, begin data recording. Shoot the ball on the short-range position at 30 degrees above horizontal.
 4. After the ball hits the timing pad, click ‘Stop’ in *DataStudio*
 5. Repeat the process for the middle range position.
 6. Repeat the process for the long-range position.
 7. End data recording.
- In *DataStudio*, the Summary list shows six runs of data.

Analyzing the Data – *DataStudio*

1. Use the ‘Data’ menu in the Table display toolbar to select ‘Run #1’ for the ‘Initial Speed’ and for the ‘Time-of-Flight’. Record the values for speed and time-of-flight for the first projectile launcher range in the Launch Angle Horizontal Data Table in the Lab Report section.
2. Repeat the process to select ‘Run #2’ and then ‘Run #3’. Record the values.
3. Use the ‘Data’ menu in the Table display toolbar to select ‘Run #4’ for the ‘Initial Speed’ and for the ‘Time-of-Flight’. Record the values for speed and time-of-flight for the first projectile launcher range in the Launch Angle 30° above Horizontal Data Table in the Lab Report section.
4. Repeat the process to select ‘Run #5’ and ‘Run #6’. Record the values.

Use your results to answer the questions in the Lab Report section.

Activity P37: Time of Flight versus Initial Speed**What Do You Think?**

Can you predict how long a ball will stay in the air? Does a change in its initial speed change the “time of flight”? If so, how?

Data Table**Launch Angle Horizontal**

Range	Initial Speed (m/s)	Time of Flight (s)	Position(m) in the Vertical Motion	Position(m) in the Horizontal Motion
Short				
Middle				
Long				

Launch Angle 30° above Horizontal

Range	Initial Speed (m/sec)	Time of Flight (sec)	Position (m) in the Vertical Motion	Position (m) in the Horizontal Motion
Short				
Middle				
Long				

Questions

1. How do the values for the time of flight for the short, middle, and long range distances compare when the ball was launched horizontally?
2. How do the values for the time of flight for the short, middle, and long range distances compare when the ball was launched at 30 degrees above the horizon?
3. Why would time of flight depend on the angle of the launch?

Name _____

Class _____

Date _____