Name _____ Class _____ Date _____

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

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:

$$d = \frac{1}{2} g t^2$$

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.

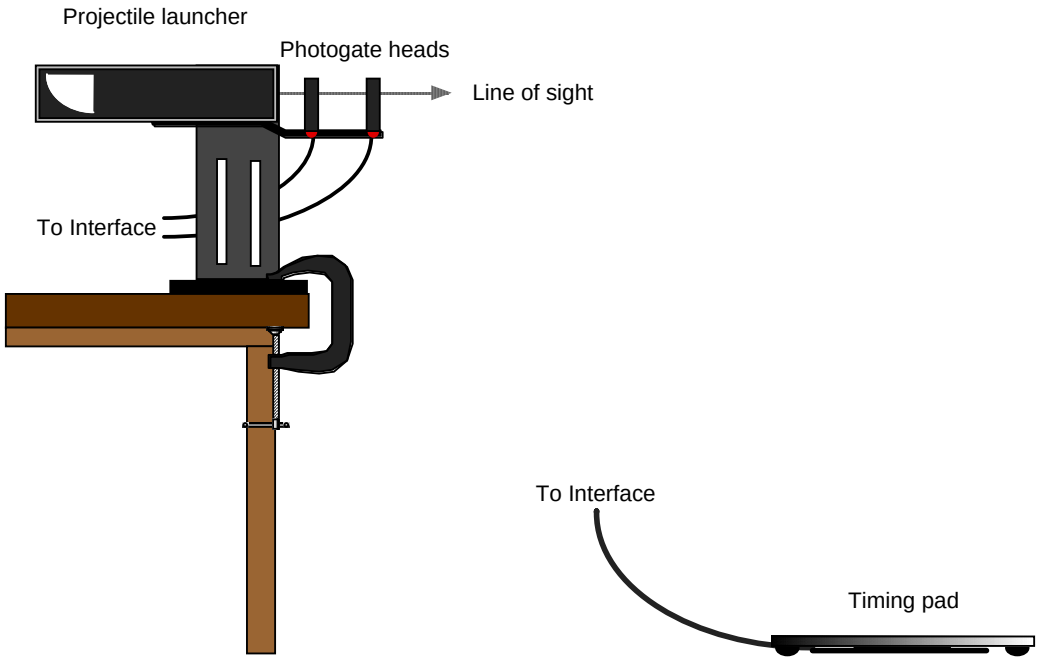
Procedure

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 *ScienceWorkshop* or *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: Sensor Calibration and Equipment Setup

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



PART IIA: 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'. In *ScienceWorkshop*, click 'REC'.)
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*) or click 'PAUSE' (in *ScienceWorkshop*).

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.
- In *ScienceWorkshop*, the Data list shows 'Run #1'.

PART IIIA: 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* or click 'PAUSE' in *ScienceWorkshop*.
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.
- In *ScienceWorkshop*, the Data list shows 'Run #1' and 'Run #2'.

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/sec)	Time of flight Exp (s)	Distance Exp (m)	Distance Theory (m)	% Error Distance
Short					
Middle					
Long					

Launch Angle 15° above Horizontal

Range	Initial Speed (m/sec)	Time of flight Exp (s)	Distance Exp (m)	Distance Theory (m)	% Error Distance
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?