Two Dimensional Motion Activity
(Projectile Motion)

Purpose

A projectile launched into the air either horizontally or at an angle represents Two Dimensional Motion. Using a launcher and two photogates, the initial velocity of a projectile (a steel ball with a diameter of 25 mm) will be determined. By launching the ball to the floor from a known height, the group will also determine the initial velocity of the projectile by measuring the range of the projectile. The group should confirm the initial velocity of the projectile by comparing the values of the initial velocities obtained by the different methods. After the group has determined and confirmed a valid initial velocity, the group will be required to hit a target that is positioned vertically above the floor at a known height. The group's grade will depend largely on where the ball strikes the target.

Note that there is no step by step procedure written for this activity. In order to obtain all of the information to successfully complete this activity, the entire document should be read prior to beginning the activity. This includes reviewing the data sheet.

Pre-Lab (10 Points)

Part I (15pts total)

A photogate is a device that uses a beam of light and a detector to act as a switch. When the beam of light is broken, the detector can send a signal to a controller that could activate a multitude of devices. In this case, we will use two photogates to start and stop a set of three timers.

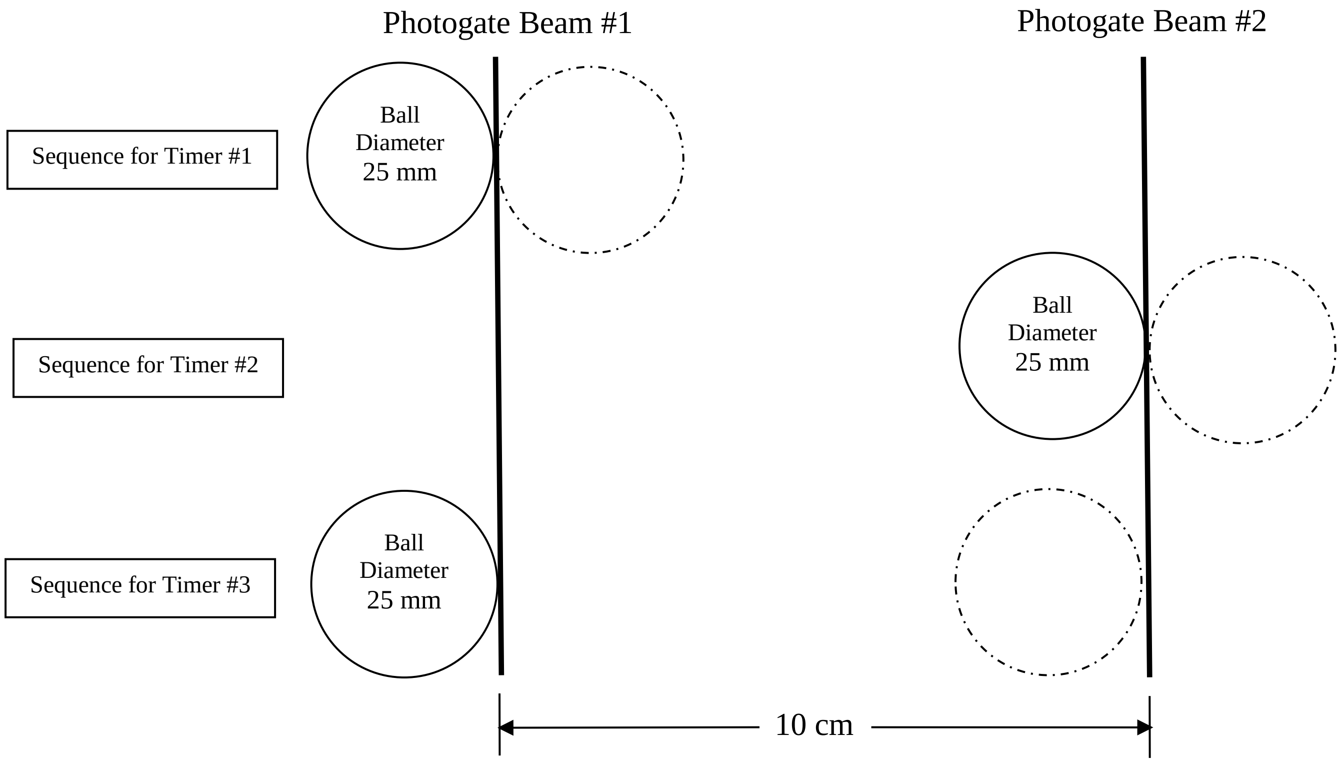
Physically connect the photogates to the PASCO interface, and make sure the interface is turned on. It is important that the photogate nearest the launcher be connected to port #1 and the second photogate be connected to port #2.

Log on to the computer and choose the COSAM pool. Double click the 'phy-lab' icon on the desk top, and open the PASCO Capstone program. Under File, select Open Experiment, choose the file folder named "capstone-activities", and then select the "2D Motion Activity Cap". This file contains a pre-set version of Pasco Capstone that has the timers preconfigured. When selected, this version will allow you to determine the time it takes the projectile (the 25 mm steel ball) to pass through the photogates. Upon collecting data, the first column will contain the time it takes the projectile to pass through Photogate #1. The first timer begins when the ball blocks the photogate beam and the timer stops when the photogate beam is no longer blocked. Similarly, the second column will contain the time it takes the projectile to pass through Photogate #2. The third column will contain the time it takes the projectile to travel from Photogate #1 to Photogate #2. The third timer begins when the beam of the first photogate is blocked, and the timer stops when the beam of the second photogate is blocked. At the bottom of each column the max, min, and mean will be calculated.

The diagram on the next page should provide some insight on each timer's sequence. The solid circle indicates the position of the ball when a timer begins, and the dotted circle indicates the position of the ball when the timer will stop.

Prior to launching, make sure that the path of launch is clear and that no one will be struck by the projectile while it is in flight. Also take care of keeping track of your projectile. ***<u>Lost projectiles will result in a 10 percent grade deduction.</u>***

Make sure someone is ready to catch the projectile after it impacts the floor. Use the ***<u>Medium Range</u>*** setting on the launcher for all of the launches



Load the steel ball into the launcher by compressing the spring to the "Medium Range" setting. The spring is properly set to the Medium Range when the yellow band that is attached to the spring can be observed in the oblong cutout located above the "Medium Range" label on the launcher. The steel ball should remain in contact with the spring. The steel ball should not roll forward. When the trigger is pulled, the steel ball must move forward with the spring. Perform a test launch, and witness where the projectile impacts the floor. Center a piece of blank paper over the point of impact, and tape the paper in place with masking tape. Perform one more test launch to make sure the paper has been located properly, and make adjustments if necessary. After the blank page is in the correct position, lay a piece of carbon paper on top of the blank paper. ***<u>Do not tape the carbon paper in place.</u>*** The carbon paper should just lie on top of the blank piece of paper that has been taped to the floor. When the ball strikes the carbon paper, the point of impact will be recorded on the blank piece of paper.

After the ***Preview*** button is clicked, data can be kept by clicking the ***Keep Sample*** checkmark or data collection can be terminated by clicking the button with the red square. However, if the button with the red square is clicked prior to clicking the ***Keep*** button, the last data set will be lost. If the data from the last trial is flawed, do not click the **Keep** button; just rerun the trial without clicking a button, and the data set will be automatically overwritten with the new data set. Do not click the red square button to terminate data collection until the group has at least five valid data sets. If the group terminates data collection before acquiring at least five valid data sets, the TA may require the group to recollect data.

After the ball has been loaded and before each launch, flick your finger through photogate #2. If photogate #1 is blocked while loading the launcher, the timer from photogate #1 to photogate #2 could begin running before the ball blocks photogate #1. By flicking a finger through photogate #2 prior to each launch, the timer between photogate #1 and photogate #2 should begin when the ball blocks photogate #1. Prior to clicking the **Keep** button, the group should confer to make sure the data listed in the table is valid prior to clicking the **Keep** button. In particular, make sure the data in each column is consistent. If the time in the third column is greater, than 0.0400 seconds, the timer from photogate #1 to photogate #2 was probably running prior to launch or the spring was set to “low range”.

Calculate the average velocity of the projectile while it passes through photogate #1, photogate #2, and while it travels from photogate #1 to photogate #2. Since there is no net force acting on the ball in the horizontal direction, each of these three velocities should be in relative agreement with each other, and they should be the same as the initial velocity of the projectile as it leaves the spring.

After measuring the launch height, calculate the range of the projectile for each of the three velocities.

Part II (15pts total)

After the velocities and ranges have been calculated from the times collected by the photogates, carefully measure the range using the provided meter sticks and plumb bob.

Using the measured height and measured range of launch, back-calculate the velocity of the projectile as it left the launcher.

Part III (60pts total)

After the initial velocity of the projectile has been determined by the group, the TA will remove your projectile from the work station, and the TA will select a height for the target that the group will try to hit. The goal will be to determine the distance between the target and the launcher in order to strike the bull’s-eye. After the group has determined the distance, the group should use the provided meter stick and plumb bob to accurately determine the physical location that the backstop holding the target will need to be placed in order to hit the bull’s-eye. Using masking tape, mark the floor appropriately such that the backstop can be positioned by the TA. When the TA returns to the work station, the TA will position the backstop based on the location indicated by the masking tape, and the target will be placed at the appropriate height. Once the target has been positioned, no further adjustments to the launcher or the target will be allowed. The group will launch the projectile three times, and the groups score will be based on the average of the two best launches.

Before leaving, any paper that was taped to the floor must be removed, meter sticks should be returned to their proper storage location, and your work station should be in proper order.

This page was left blank intentionally so that the Data Sheet would begin on a new sheet of paper if the procedure was printed utilizing the front and back of the paper.

Name: ______________________________ **Banner ID:** ______________________________

Lab Group ID: ______________________ **Number of Lab Partners:** _________________

Data Sheet
Two Dimensional Motion Activity

Hints:

1. Be mindful of which photogate is plugged into which port.
2. Prior to clamping the launcher to the table, determine the launch height.
3. Use the provided clamp to securely fasten the launcher to the bench. This will help prevent errors from recoil.
4. Make sure the launcher is set to launch horizontally.
5. Use the ***Medium Range*** setting on the launcher for all of the launches.
6. Make sure the ball is in contact with the spring prior to launching.
7. Release the trigger by pulling up on the string using a smooth motion and consistent force from launch to launch.
8. Prior to each launch, make sure the photogates are aligned perpendicular to the photogate support bracket.
9. Flick a finger through the second photogate prior to every launch to make sure the timer between the two photogates is not running.
10. Do not press the stop button until you have collected five valid data sets from at least five launches.
11. Think about which part of the projectile will strike the floor and which part will strike the vertical target.
12. The height and range should be measured from the location the ball is released from the spring. See the diagram on the side of the launcher.

Pre Lab (10 Points) _________________

Part I (15pts total)

Use the back of the data sheets to show all calculations used to determine the initial velocities and ranges below or attach separate sheets of paper as necessary. Also print and attach the table of times from Capstone.

Measured Launch Height			
	Time in 1st Photogate	Time in 2nd Photogate	Time between 1st and 2nd Photogates
Average Time			
Initial Velocity (2 points each)			
Range (3 points each)			

Part II (15pts total)

Measured Average Range: ___________________

Compare your calculated ranges from Part I to the average measured range. (5 points)

Initial velocity of the projectile back-calculated using the measured height and measured range of launch: You must show your work. _____________ (10 points)

How does your back-calculated velocity compare to the velocities calculated from the photogate data?

Part III (60pts total)

Determine the initial velocity the group will use to calculate the distance the target must be placed from the launcher and explain why the value was chosen.

Initial Velocity the group will use: ______________

The height of the bull's-eye measured from the floor as specified by the TA:

(The TA will circle one): 30cm 35cm 40cm

After the TA indicates the height of the target, the TA will remove the projectile from the workstation and place it in a container that corresponds to the number below.

Ball # ________________

Distance from the launcher the target must be placed as calculated by the group: ______________________
(All work must be attached)

Once the target has been placed, neither the target nor the launcher can be adjusted. This includes adjustments to the launcher's position or launch angle.

Average of the best two out of three launches: ______________

(Attach the target to the data sheet)

Remove all paper and tape from the floor before leaving.