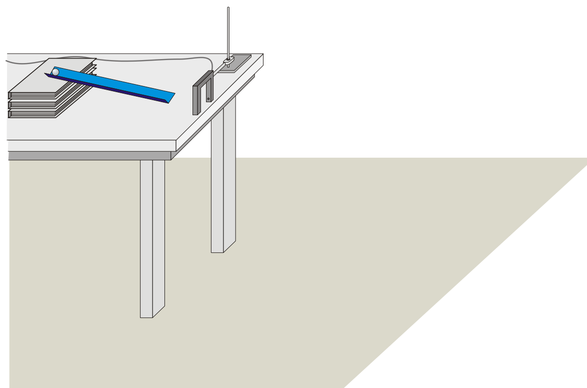
**Projectile Motion Lab   Name:___________________ Block:____ Date:______**

# “Pummel the Purple”

You have probably watched a ball roll off a table and strike the floor. What determines where it will land? Could you predict where it will land? In this experiment, you will roll a ball down a ramp and determine the ball’s velocity with a Photogate. You will use this information and your knowledge of physics to predict where the ball will land when it hits the floor.



## OBJECTIVES

- Measure the velocity of a ball using a Photogate.
- Apply concepts from two-dimensional kinematics to predict the impact point of a ball in projectile motion.
- Take into account trial-to-trial variations in the velocity measurement when calculating the impact point.

## MATERIALS

| | | |
|---|---|---|
| LabQuest 2 | plumb bob | masking tape |
| Carbon Paper | ramp | meter stick |
| 1Vernier Photogate | ring stand | ball(2.5cm diameter) |
| target | right-angle clamp | |

## PRELIMINARY QUESTIONS

1. If you were to drop a ball, releasing it from rest, what information would be needed to predict how much time it would take for the ball to hit the floor?

   What assumptions must you make?

2. If the ball in Question 1 is traveling at a known horizontal velocity when it starts to fall, explain how you would calculate how far it will travel horizontally before it hits the ground?

3. When an object passes through a Photogate, it blocks the passage of light from one side to the other. The interface can accurately measure the duration of time that a gate is blocked. If you wanted to know the velocity of the object, what additional information would you need?

## PROCEDURE

1. Set up a low ramp made of angle molding on a table so that a ball can roll down the ramp, across a short section of table, and off the table edge as shown in the figure or on video.

2. Position the Photogate so the ball rolls through the Photogate while rolling on the horizontal table surface (but *not* on the ramp). Approximately center the detection line of the Photogate on the middle of the ball. To prevent accidental movement of the Photogate, use tape or a C clamp to secure the ring stands in place.

3. Mark a starting position on the ramp so that you can repeatedly roll the ball from the same place. Roll the ball down the ramp through the Photogate and off the table. Catch the ball as soon as it leaves the table. **Note**: Do not let the ball hit the floor during these trials, or during the following velocity measurements. Make sure that the ball does not strike the side of the Photogate. Move the Photogate if necessary.

4. Set up the Photogate and LabQuest2 to collect data in Gate mode.
   a. Connect the Photogate (DIG 1 port) to LabQuest2 and choose New from the File menu.
   b. On the current (Meter) screen, tap Mode. Change the Photogate Mode to Gate.
   c. You must enter length of the object, which for us is the diameter of the ball, in meters (0.025 m).
   d. Select OK.

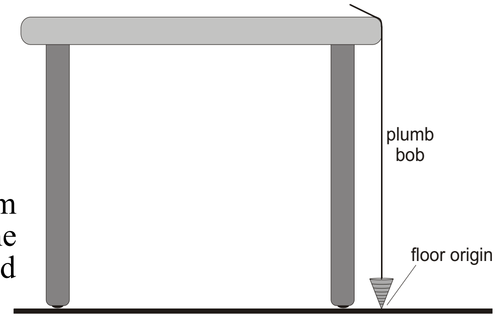
6. Observe the live readings. Block the Photogate with your hand; note that the Photogate is shown as Blocked on the screen. Remove your hand and the display should change to Unblocked.

7. LabQuest2 will measure the length of time from when the photogate is first blocked until it is un-blocked. You can see how this works by blocking the gate briefly with your hand.
   a. Start data collection.
   b. Check to see that the Photogate are responding properly by moving your finger through the Photogate. LabQuest2 will plot a time interval ($\Delta t$) value for each instance you run your finger through the Photogate.
   c. Stop data collection.

8. Collect data.
   a. Start data collection.
   b. Roll the ball from the mark on the ramp, through the Photogate, and catch the ball immediately after it leaves the table.
   c. Repeat nine times. Take care not to bump the Photogate, or your velocity data will not be precise.
   d. After the last trial, stop data collection.

9. Tap Table. Record the velocity for each pass through the photogate in the data table.

10. Inspect your velocity data. Did you get the same value every time? To determine the average, maximum, and minimum values, tap Graph, then tap Analyze, then choose Statistics , Velocity. What one value would be most representative of all ten measurements?




11. Carefully measure the distance from the tabletop to the floor and record it as the table height, *h*, in the data table. Use a plumb bob to locate the point on the floor just beneath the point where the ball will leave the table. Mark this point with tape; it will serve as your *floor origin*.

12. Use your average velocity value to calculate the distance from the floor origin to the impact point where the ball will hit the floor. Use your projectile motion strategy as discussed previously in class. Record the value in your data table as the predicted impact point.

    Mark your predicted impact point on the floor with tape and position a target at the predicted impact point. Be sure the impact point is along the line of the track.

13. To account for the variations you saw in the Photogate velocity measurements, repeat the calculation in the preceding step for the minimum and maximum velocity. These two additional points show the limits of impact range that you might expect, considering the variation in your velocity measurement. Mark these points on the target as well, and record the values in your data table. Cover your target with a piece of carbon paper.

14. After your instructor gives you permission, release the ball from the marked starting point, and let the ball roll off the table and onto the floor. Measure the distance from the floor origin to the actual impact and enter the distance in the data table.

## DATA TABLE

| Trial | Velocity (m/s) |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |

| | |
|---|---|
| Maximum velocity | m/s |
| Minimum velocity | m/s |
| Average velocity | m/s |
| Table height | m |
| Predicted impact point | m |
| Minimum impact point distance | m |
| Maximum impact point distance | m |
| Actual impact point distance | m |

## ANALYSIS

1. How far off were you? Calculate % Error.

2. Did you account for air resistance in your prediction? If so, how? If not, how would air resistance change the distance the ball flies?

3. Do you think air resistance was the cause of your error or do you suspect another reason? (Should the effect of air resistance on the ball be large or small? Is your error large or small?) <u>If you suspect another error, please describe it *and* describe its effect on how far the ball flies.</u> (Next to learning about projectile motion, these are the most important questions your teacher wants you to be able to answer—take some time with them.)

## EXTENSION

1. Derive one equation for the horizontal and vertical coordinates of the ball's motion in this experiment.