Name ______________________________ Period __________ Date __________



# Bull's Eye Lab 2.1

## Purpose

The purpose of this activity is to investigate projectile motion and to predict the landing point of a projectile. .

## Required Equipment

- Meter stick or meter tape
- Ramp
- Timer
- Plumb line
- Bottle

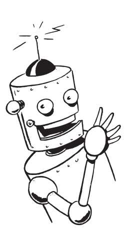
## Discussion

Your task in this experiment will be to calculate where to place a bottle so that a steel ball will land directly into the bottles opening when released from a ramp. The final test of your work will be to position a the bottle at the calculated landing spot and have the ball lands directly inside the container on the first try. The secret to this challenge will be to keep the vertical and horizontal motions of the ball separate from one another as you do your calculations. The secret to understanding projectile motion is using the vertical height to finding the time of fall. Once you know how long the ball will be in the air you can calculate how far the ball will travel or it's range. Your first task will be to calculate the speed of the ball coming off the ramp; then, calculate how long the ball will be in the air, and then finally to calculate the distance away from the ramp where the ball will land.



## The Setup

1. Setup your track as demonstrated by your instructor. The idea is to setup your track so that a steel bearing rolls from an incline ramp and onto a flat track. This track needs to be secured so that it does not move throughout the activity or it may effect your result.
2. The flat section of the ramp is where you will time your steel bearing in order to calculate it's horizontal velocity. The horizontal flat section of the ramp should be at least 0.3-m (30-cm) in length or more.
3. Find a position on the angled ramp where you will release the steel bearing, mark this location.
4. Make several practice release of the bearing so that you can perfect your technique. The bearing must be released from the same location and in the same way each time. The same person should release the bearing each time in order to eliminate any error in technique.



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## Calculate the Horizontal Velocity

**5.** Release the bearing and time it's motion only on the flat section. Record your data in the table bellow.

| | Timing Distance (m) | Time (s) |
|---|---|---|
| trial #1 | | |
| trial #2 | | |
| trial #3 | | |
| trial #4 | | |
| trial #5 | | |
| | Ave Time | |

**6.** Calculate the horizontal speed of the bearing as it travels on the track.

$$v_h = \frac{d_h}{t} \longrightarrow v_{horizontal} = \frac{d_{timing\ distance}}{t_{ave\ time\ on\ ramp}}$$

**Show your work:**

Horizontal Velocity: __________

## Fall Height

**7.** Carefully measure and record the height from the table to the floor.

Height of table (m): ______________________

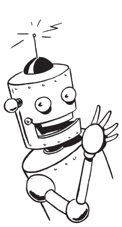
**8.** Carefully measure and record the height of the bottle.

Bottle height (m): ______________________

**9.** The bearing does not fall all the way to the floor, the bearing only falls to the top of the bottle. Calculate the actual fall height by subtracting the height of the bottle from the height of the table.

Fall Height (m): ______________________





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## Calculating the Fall Time

**10.** The time that the bearing is in the air is determined by the actual fall height. As the bearing comes off the end of the ramp it's vertical component of its motion is 0-m/s. Using the formula bellow, calculate the time it will take for the bearing to fall to the top of the bottle.

$$\Delta h = v_o t + \frac{1}{2} g(\Delta t)^2 \longrightarrow h_{\text{fall height}} = v_{vo} t_{\text{fall time}} + \frac{1}{2} g(t_{\text{fall time}})^2 \longrightarrow t_{\text{fall time}} = \sqrt{\frac{2h_{\text{fall height}}}{g}}$$

**Show your work:**

Fall Time (s): ______________________

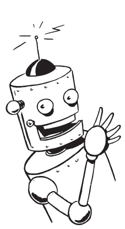
## Calculate the Range

**11.** The range is the horizontal distance of travel away from the end of the ramp. The range depends on the time of fall and how fast the bearing is traveling when it leaves the edge of the ramp (its horizontal velocity). Use the range equation to predict where to place the bottle so that the bearing lands in its opening.

$$d_h = v_h t \longrightarrow d_{\text{horizontal range}} = v_{\text{horizontal}} t_{\text{fall time}}$$

**Show your work:**





Calculated Horizontal Range (m): ______________________

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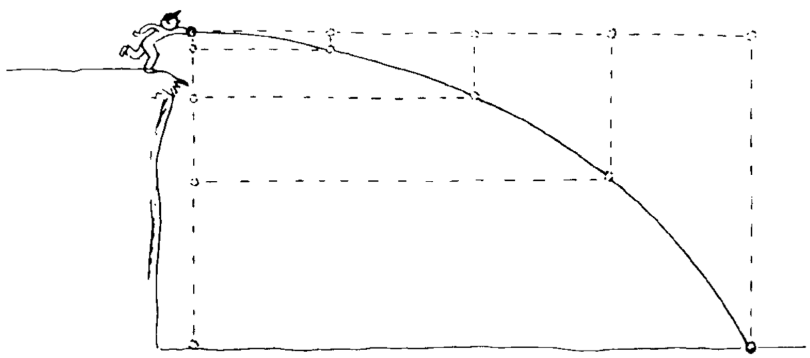


## Bull's Eye Challenge

**12.** After calculating the horizontal range, carefully measure and mark, on the floor, the location where you want to place the center of the bottle.

**13.** You will need to be very careful with your measurements, if you are off by even the smallest amount the bearing can miss the bottle's opening. A plumb line can be used to mark the exact end of the ramp so you know where to start your measurements.

**14.** Carbon paper can be used to find various landing points in order to make sure the bottle is placed in line with the track.

**15.** When you are ready, tell your instructor so they can monitor your attempt. Important! If the bearing does not make it on the first attempt, you can adjust your position and tray again.

**16.** If the ball did not land in the bottle of the first try, carefully measure the actual range from where the bottle was actually placed.

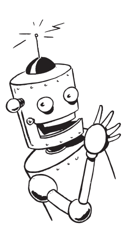
Actual Horizontal Range (m): ______________________

## Percent Error

**17.** If the bearing lands in the bottle of the first attempt then your percent error is zero. But, if you had to adjust the bottle you will need to calculate your percent error. Use the formula bellow.

$$\%\ \text{Error} = \left(\frac{\text{Calculated Distance} - \text{Actaul Distance}}{\text{Actaul Distance}}\right) \times 100$$

**Show your work:**



Percent Error: __________