

## Lab: Horizontally Launched Projectile

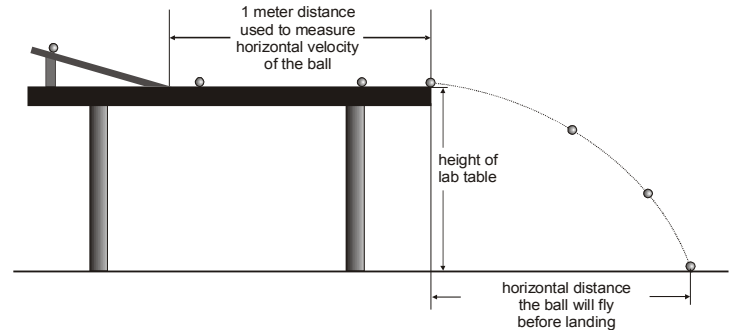
The objective of this lab is to use the physics of projectile motion to predict the distance a horizontally launched projectile will travel before hitting the ground. We'll roll a steel ball down a ramp on a lab table and measure its velocity across the table. We'll assume that the ball will not slow down much as it makes its way across the table top, and use this velocity as the horizontal launch velocity. Using this velocity and the height of the lab table above the floor, we'll use the physics of projectile motion we've been learning to predict how far away from the table edge the ball will hit the ground.

### Procedure Part 1: Determine the horizontal velocity of the ball across the table

- Record the angle of your ramp here: \_\_\_\_\_

- Position the ramp so that the end of the ramp is about 1 meter from the edge of the table. Carefully measure the distance from the end of the ramp to the table edge.

$x_{table} =$  \_\_\_\_\_



- Now measure the time it takes for the ball to travel the distance from the bottom of the ramp to the edge of the lab table.

- Make a mark on the ramp so you release the ball from the same spot each time
- Roll the ball down the ramp and across the table top, but catch it before it hits the ground.

***Do not let the ball hit the floor!***

- Use the stopwatch to measure the time it takes for the ball to roll from the **bottom of the ramp to the edge of the table**
- Repeat this at least 10 times and record the results in the table at right.

- Use  $v_{horizontal} = \frac{x_{table}}{\text{average time}}$  to find the horizontal speed of the ball:

$v_{horizontal} =$  \_\_\_\_\_ m/s

| trial      | time |
|------------|------|
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
|            |      |
| <b>avg</b> |      |

### Procedure Part 2: Determine the vertical velocity of the ball to drop to the floor

- Measure the distance from the tabletop to the floor and record it here:

$y =$  \_\_\_\_\_ m

- Next, we'll find the time,  $t$ , for the ball to fall from the tabletop to the floor. Use the equation

$\Delta y = v_i \Delta t + \frac{a t^2}{2}$ . Take  $v_i$  to be 0 and  $a$  to be  $9.8 \text{ m/s}^2$ . You must first solve this equation for  $t$ .

$t =$  \_\_\_\_\_ s

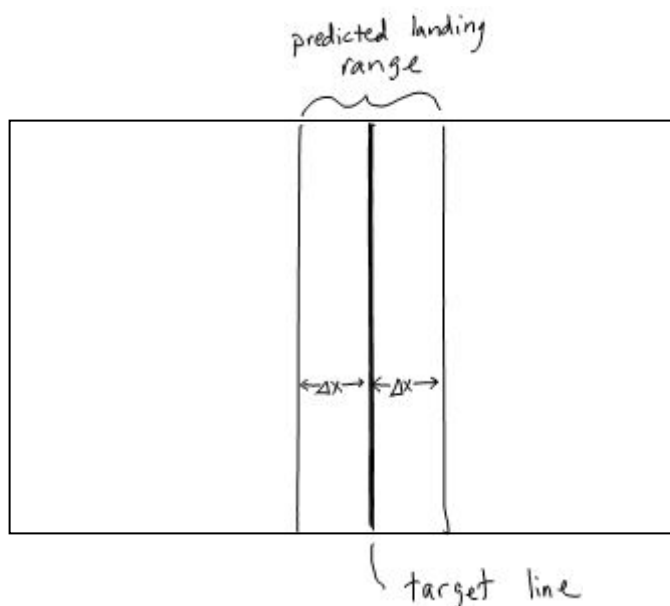
### Procedure Part 3: Calculate the distance the ball will fly

1. Using  $x_{\text{floor}} = v_{\text{horizontal}} t$  calculate the horizontal distance across the floor the ball will fly before landing. Use  $v_{\text{horizontal}}$  from part 1 and  $t$  from part 2,

$$\Delta x_{\text{floor}} (\text{predicted}) = \underline{\hspace{2cm}} \text{ m}$$

### Procedure Part 4: Test your prediction

1. Your target is going to be a piece of white paper. Put an 'X' in the middle of the paper to mark the landing spot.
2. Locate your target on the lab floor by measuring the distance from the edge of the table to the spot on the floor where you predict the ball will land. Place the piece of paper with the 'X' on the floor at that location.
3. Place a piece of carbon paper over the target paper. Roll the ball off the ramp to see if it lands in between the lines you've drawn on your paper.
4. Measure the distance to the landing spot. Include an estimate of uncertainty:



$$x_{\text{floor}} (\text{actual}) = \underline{\hspace{2cm}} \text{ m}$$

5. Calculate the difference between your predicted distance and the actual distance.
6. Calculate the percent difference between your prediction and the actual distance.

### Lab Questions

1. People who have not studied physics sometime question whether the horizontal and vertical motion of a projectile really are independent. Does this lab give you evidence to support this concept? Support your answer.
2. Imagine that we increased the height of the ramp to 20 cm, making the ramp a much steeper slope.
  - a. How would this affect the horizontal velocity of the ball off the end of the table?
  - b. How would it affect the drop time of the ball?
  - c. How would it affect the distance the ball flies?
3. Imagine that we increased the height of the table from the floor:

- a. How would this affect the horizontal velocity of the ball off the end of the table?
  - b. How would it affect the drop time of the ball?
  - c. How would it affect the distance the ball flies?
4. What if you used a ball with twice as much mass, but similar size:
    - a. How would this affect the horizontal velocity of the ball off the end of the table?
    - b. How would it affect the drop time of the ball?
    - c. How would it affect the distance the ball flies?
  5. Could you use the distance a horizontally launched projectile flies to find the initial velocity of the projectile? Describe how.
  6. How do you think the results would change if you used a ping-pong ball instead of a steel ball?
  7. Identify at least three plausible sources of systematic error that could be affecting our results.
  8. One possible source of systematic error is that we assume the ball does not slow down as it rolls across the table. If the ball does slow down, how could we modify this experiment so we still predict the distance accurately?