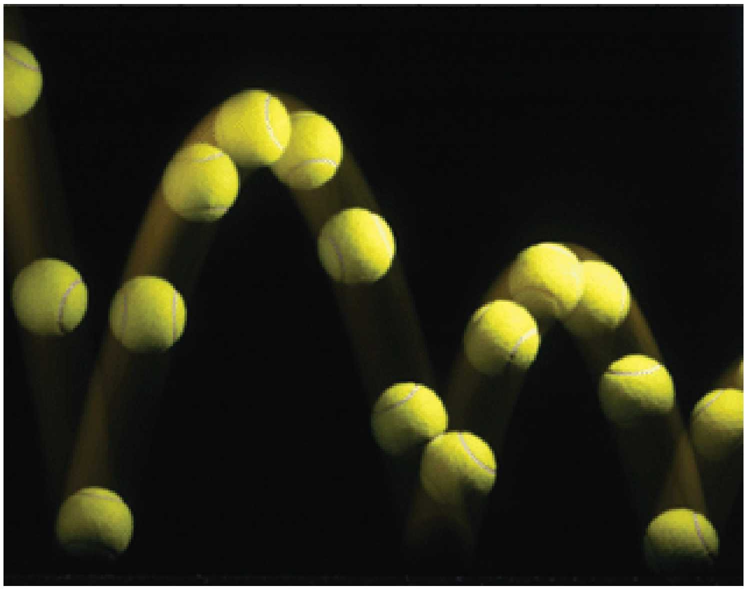
Projectile Motion Lab



Goals:

A. To find, in three different ways, the initial speed v_0 of the ball launched by a spring gun.

B. To find the angle that will maximize the horizontal distance travelled by the projectile launched off of the table.

Equipment:

- Spring gun
- Ball
- Meter sticks
- Carbon paper

Safety:

In this lab you will launch a plastic ball with a projectile launcher. Make sure the space is clear in front of the ball launcher when firing. Keep one group member at the end of your "firing line" to stop people from passing through while firing. When you launch the ball vertically, make sure the space below the ball is clear.

Part A: Finding the launch speed of a projectile

In this part you will be launching the projectile (plastic ball) horizontally off the table (A1), vertically (A2), and at an angle off the table (A3). For each setup you will determine the launch *speed* v_0. You will then compare your three results.

A1 – Horizontal Launch

You will be launching the ball horizontally off of the table onto the floor and measure the projectile's horizontal and vertical displacements. The observed data can be used to estimate the launch speed of the projectile.

1. Place the projectile launcher on the table so the projectile is launched horizontally. Before taking data, do a couple of trial runs so you have an idea of where the projectile will land.
2. Use cardboard to protect the walls if the ball is bouncing into the wall.
3. Tape some paper on the floor about where the ball is landing. Two pieces of tape are enough to prevent it from moving between measurements.
4. Place some carbon paper on top of the paper (face down).
5. Measure and record the projectile's vertical displacement (include units).
6. Now take data: Launch the ball six times to measure the projectile's horizontal displacement. You may find it useful to hang a plumb-bob (a weight at the end of a string) from the edge of the projectile launcher in order to make accurate measurements. Record your data in the table provided below. Include units.

Trial	Horizontal Displacement
1	
2	
3	
4	
5	
6	
average	

Vertical Displacement

In the space below draw a sketch of your setup. Artistic ability is not important. What IS important is identifying all the equipment used, the layout, all variables used, and a coordinate system.

A2 – Vertical Launch

You will be launching the ball vertically and measure the projectile's vertical displacement. The observed data can be used to estimate the launch speed of the projectile.

1. In the North-East corner of the lab there is a setup for the vertical launch. Head over there with your lab group.
2. You should see a projectile launcher placed on the ground. Set it up so it launches the projectile vertically. Do a couple trial runs so everyone in the group understands how it works.
3. Now record data. Launch the projectile vertically six times and measure the *maximum* height the projectile reaches. Record your data in the table below, include units.

Trial	**Maximum Height**
1	
2	
3	
4	
5	
6	
average	

In the space below, draw a sketch of the setup, similar to what you did in part A1. Include all variables used, don't forget a coordinate system. Discuss whether the vertical displacement of the ball is equal to the maximum height reached by the ball.

A3 –Launch at an angle

You will be launching the ball at an angle off of the table onto the floor and measure the projectile's horizontal and vertical displacements. The observed data can be used to estimate the launch speed of the projectile.

1. Set up the projectile launcher to fire at an angle of 45 degrees.
2. Make sure there is enough space (you might place the launch away from the edge of the table).
3. Repeat the steps from part A1 (horizontal launch), and record your data in the table below.

Trial	**Horizontal Distance**
1	
2	
3	
4	
5	
6	
average	

Vertical Displacement

As in parts A1 and A2, draw a sketch of the setup. Don't forget the coordinate system, and all variables used.

Before finishing, check off with your instructor that you have completed the data collection correctly. Get his/her initials in the box to the right.

Report - Part A1

Draw a picture of your experiment, include the ‘important points’, all variables, and a coordinate system (just as when solving a lecture problem). This picture will look similar to the one you produced in the lab.

Using the 2-D kinematic equations of motion to derive an equation that has initial speed v_0 as an output and your measured quantities as inputs. Your equation should only include variables, no values or measured quantities. Show your work clearly and put the end result in the box provided.

Using your equation above and the average horizontal distance and vertical displacement measured in lab to calculate the initial speed of the projectile.

Average Horizontal Distance:	
Vertical Displacement:	
Initial Speed:	

Report - Part A2

Draw a picture of your experiment, include the ‘important points’, all variables, and a coordinate system (just as when solving a lecture problem). This picture will look similar to the one you produced in the lab.

Using the 2-D kinematic equations of motion to derive an equation that has initial speed v_0 as an output and your measured quantities as inputs. Your equation should only include variables, no values or measured quantities. Show your work clearly and put the end result in the box provided.

Using your equation above and the average vertical displacement measured in lab to calculate the initial speed of the projectile.

Average Vertical Displacement:	
Initial Speed:	

Report - Part A3

Draw a picture of your experiment, include the 'important points', all variables, and a coordinate system (just as when solving a lecture problem). This picture will look similar to the one you produced in the lab.

Using the 2-D kinematic equations of motion to derive an equation that has initial speed v_0 as an output and your measured quantities as inputs. Your equation should only include variables, no values or measured quantities. Show your work clearly and put the end result in the box provided.

Using your equation above and the average horizontal distance and vertical displacement measured in lab to calculate the initial speed of the projectile.

Average Horizontal Distance:	
Vertical Displacement:	
Initial Speed:	

Report – Error Calculations

Using your horizontal launch speed as the ‘gold standard’, find the percentage errors for the vertical and angle launch speeds.

Repeat your results from parts A1 to A3 here:

	Launch speed in m/s
Horizontal: $v0_{horizontal}$	
Vertical: $v0_{vertical}$	
Angled: $v0_{angled}$	

Calculate the percentage error for the vertical launch from:

$$\frac{|v0_{horizontal} - v0_{vertical}|}{v0_{horizontal}} * 100\% =$$

Calculate the percentage error for the angled launch from:

$$\frac{|v0_{horizontal} - v0_{angled}|}{v0_{horizontal}} * 100\% =$$

Briefly discuss your results: