Determination on the Effect of Angle on the Range of a Projectile
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Introduction

Parabolic motion has been studied for a long time dating all the way back to the time in which Galileo was conducting experiments. In this lab report, the range a foam disk launcher shot was tested by altering the angle of trajectory followed by measuring the range. The range that the foam disk went was measured in centimeters and multiple shots were taken at each angle and then averaged.

Galileo was the first person who accurately described projectile motion. Because of the drawings of Niccolo Tartaglia, Galileo realized that a projectile followed a curved path which is called a *parabola*.\(^1\) It was later found out by Galileo that the *parabola* has an exact mathematical shape. Also, he stated that a projectile was acted upon by two forces, vertical and horizontal. The vertical force was from gravity, which pulled it to Earth at 9.8 m/s. That is why a parabola is a precise mathematical equation.\(^2\)

Observations were conducted before the experiment was started. First, observations were made on two racquetballs, one being pushed from a table, and another being dropped vertically to the floor. As soon as the one pushed across the table went off the edge, the other was dropped vertically. They both hit the ground at the same time, because gravity’s force on them was the same. A racquetball was also observed by tossing it with the same velocity at different angles between two people. At a 0º angle, it went horizontally until the end of its flight when it lost its momentum and started to curve toward the ground. In fact, even the foam disks were observed. Since there was no wind in the laboratory, it made for a stable environment. But, when the disk was launched at a 45º angle, its rotation made it curve backwards. As well, in this experiment an online game, “The Balloon Game”, was played where the effect of angle and velocity were studied in terms of how they affected parabolic motion.\(^3\) In this game, it was observed that the range of the projectile increased up to 45 degrees but then decreased beyond 45 degrees, with 45 degrees being optimal.
This experiment was started by using some hard plastic disk launchers and some lightweight foam disks. The disk launcher was set a meter of the ground and was shot three times each at a 0º, 20º, 45º, 70º, and 90º angles. It was hypothesized that the greatest distance would be from a 0º angle, but the greatest distance came from when the launcher was shot at 45 degrees. The average of the three shot distances was taken and was used to make a graph which made a parabolic arch on a graph. The distance that the foam disks went was measured in centimeters and was rounded to the nearest centimeter.

**Materials and Method**

- Shooting Disc Gun
- Meter Stick
- Protractor
- Three discs
- Tablet PC

1. Load a shooting disc gun with three discs.
2. Put the meter stick on top of the ground (this is where the projectiles will be fired from).
3. Set up the shooting disc gun so that it is on top of the meter stick.
4. With the protractor, measure the degree that the shooting disc gun is shooting from.
5. First set up the protractor at a zero degree angle (pointing straight out), and then shoot the three discs from this angle.
6. Measure the distance all three of the discs traveled and find the mean. Record this for the average distance for a projectile being shot at zero degrees.
7. Repeat steps #5 and #6, however each time, vary the angle. The five angles that will be tested out in this procedure are: 0 degrees, 20 degrees, 45 degrees, 70 degrees, and 90 degrees.
8. Create a table and then graph this data using Microsoft Excel.
Results and Discussion

The purpose of this experiment was to determine the effect of angle on projectile motion range. Initially foam disc guns were used in this experiment. After observing that the projectile path was altered due to the spinning nature of the projectiles, it was determined that a different type of gun should be used, a foam bullet launcher (Nerf Gun).

The materials and methods listed previously in this lab report were conducted and the data was entered into Table 1. As seen in Table 1, the average range for angles (in degrees) 0, 20, 45, 70, and 90 was 527 cm., 747 cm., 882 cm., 888 cm., and 72 cm. respectively (in order). This suggests that as the angle increased up to 70 degrees, there was an increase in range, but then at 90 degrees there was a decrease in range.

<table>
<thead>
<tr>
<th>Angle (Degrees)</th>
<th>Range #1 (cm)</th>
<th>Range #2 (cm)</th>
<th>Range #3 (cm)</th>
<th>Average (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>482</td>
<td>530</td>
<td>570</td>
<td>527</td>
</tr>
<tr>
<td>20</td>
<td>740</td>
<td>763</td>
<td>737</td>
<td>747</td>
</tr>
<tr>
<td>45</td>
<td>805</td>
<td>940</td>
<td>900</td>
<td>882</td>
</tr>
<tr>
<td>70</td>
<td>850</td>
<td>894</td>
<td>920</td>
<td>888</td>
</tr>
<tr>
<td>90</td>
<td>20</td>
<td>57</td>
<td>140</td>
<td>72</td>
</tr>
</tbody>
</table>

Table 1. Data collected from Projectile Motion experiment
Graph 1. Graphed Data from the Projectile Motion Experiment

As seen in Graph 1, a parabola can be drawn by analyzing the data points on a graph. This graph suggests that there is an increase in range up to around 45 degrees but then there is a decrease in range from there up to 90 degrees. This data suggests that the optimal angle for maximal range is 45 degrees. This is probably true because at this angle there is a balance of vertical velocity and horizontal velocity. At 0 degrees the projectile gun only creates a horizontal force while at 90 degrees it only creates a vertical force, neither of which creates maximal range. This was also observed in the water balloon game when observations were made prior to conducting the experiment.

In conclusion, the hypothesis for this experiment was proven to be incorrect as it was hypothesized that 0 degrees would create the greatest range. Instead, it seems that is likely that 45 degrees will produce the greatest range. Error in this experiment was caused by human error in shooting the guns, wind, and other various environmental differences while conducting the experiment. A future experiment might involve using projectiles of the same mass with different outer textures. Using these objects, one could study the effect of texture and therefore air resistance on projectile motion range.

Joselyn J. Todd, Example Lab, 9/12/2006
Sources (Note that this is a change. All sources can be listed at the end. List in the order that they have been used and number them as such as superscripts.)

