# Experiment: Projectile Motion Time allocated: 40 min

**Aim**

To experimentally determine the value of the acceleration due to gravity () using the motion of a projectile.

**Background**

In the absence of air resistance, the only force acting on a projectile is gravity. This makes predicting the motion of a projectile fairly simple. For example, the range of a projectile which returns to the same starting height it was launched from can be calculated using:

where

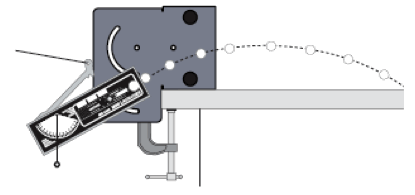
* is the horizontal range
* is the launch velocity
* is the gravitational acceleration
* is the angle the projectile is launched at

This relationship between horizontal range and launch angle will be used to determine the gravitational acceleration.

**Equipment**

1. Projectile launcher
2. Ball
3. Metre ruler

**Diagram of Setup**



Ball

Projectile Launcher

**Procedure**

1. Align the end of the projectile launcher such that the ball exits in line with the table surface and clamp the launcher to the table.
2. Record the launch angle of the projectile from the protractor on the projectile launcher.
3. Launch the ball and watch where the ball first hits the table. Record the horizontal range as the distance from the launch edge of the table to this point. Repeat for 3 trials.
4. Adjust the launch angle and repeat steps 2-3 over different launch angles.

**Results**

Launch Velocity: 1.5 m s-1

|  |  |  |  |
| --- | --- | --- | --- |
| Launch angle (degrees) |  | Average Horizontal Range (m) |  |
| 10 |  | 0.08 |  |
| 15 |  | 0.12 |  |
| 25 |  | 0.19 |  |
| 35 |  | 0.23 |  |
| 45 |  | 0.24 |  |

1. Using the equipment list, procedure and table of results as a guide, estimate the size of the **absolute** uncertainty of the horizontal range measurements. Justify your choice. [3 marks]

±0.5 mm

This is half of the smallest interval that the ruler shows 1-2

or ±0.5 cm as this is the error indicated in the results table

**OR**

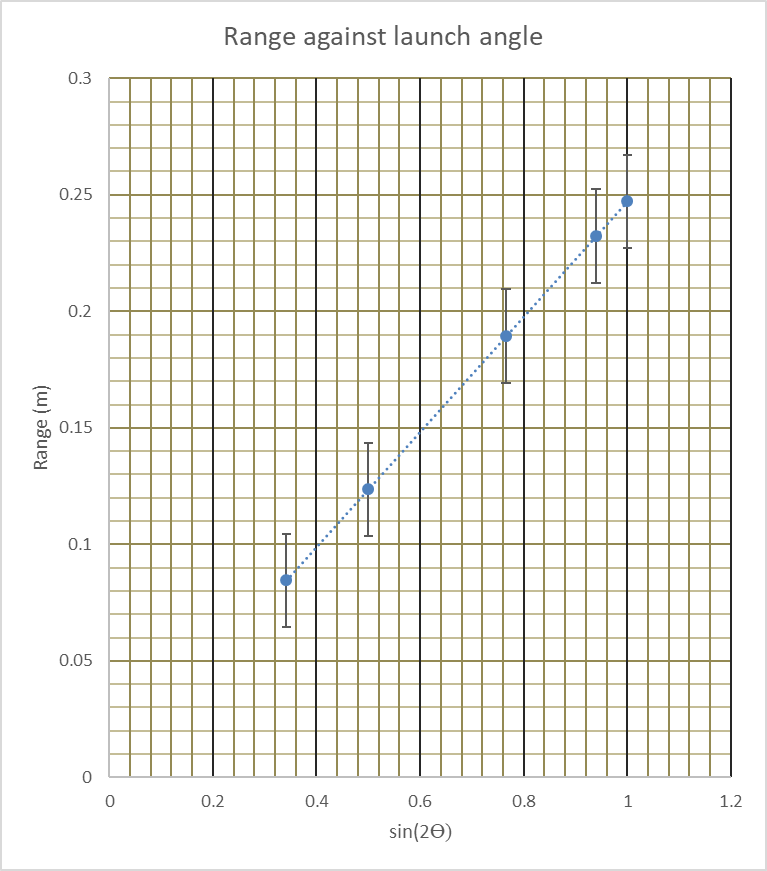
±1-3 cm

Trying to pinpoint exactly where the ball lands would likely produce errors of this magnitude/ measuring from the table edge is not where the ball was launched from exactly 1-3

1. Produce a **linear** graph to show the relationship between launch angle and the horizontal range of the projectile. Use the formula in the background information to help guide you to produce a **linear** graph. Include error bars for both axes – you may assume your horizontal axis values have an uncertainty of ±10%. Extra columns are provided in the table to assist you, but are not required to be used.

[6 marks]

* Labelled axes 1
* units (must be dimensionless for sine) 1
* Suitable choice of axes to produce linear graph 1
* Accuracy of points 1
* Size of error bars, based on q 1. 1
* Line of best fit through error bars 1



1. Determine the gradient of the graph. Include units. [3 marks]

Shows working 1

Clearly uses graph data, not table 1

Units (m) 1

(Approx 0.25 m for good line of best fit)

1. **Using the gradient**, determine the experimental value for the acceleration due to gravity ().

[2 marks]

1

1

No marks for using table data/single point and applying formula

1. Determine the percentage difference between your experimentally determined value of the acceleration due to gravity and the accepted value of the acceleration due to gravity near the Earth’s surface.

[1 mark]

(+ or – acceptable) 1

1. Your gravitational acceleration is either too high or too low compared to the accepted value.
   1. By considering the range of the error bars in your graph,
      1. produce a new line of best fit that may achieve a gravitational acceleration closer to the accepted value. Draw in the new line of best fit and clearly label the lines of best fit as “original” and “adjusted”. [1 marks]

Adjusted line is through error bars and is: 1

* Shallower if calculated g is too low (expected for correct work so far)
* Steeper if calculated g was too high
  + 1. Calculate the gravitational acceleration from this new line of best fit. [2 marks]

Calculated gradient 1

Calculated g 1

* 1. Based on your findings to part (a), comment on whether this experiment has confirmed that the gravitational acceleration could be 9.8 m s-2. [2 marks]

Comments on whether range of calculated g spans the accepted value. E.g.: 1

“Original g was below 9.8 m s-2 and the adjusted g is more than 9.8 m s-2”

States that the accepted value of 9.8 is possible within uncertainty: 1

“Therefore this experiment has shown that 9.8 m s-2 could have been the acceleration due to gravity “