Physics Lab Report Example

Determining the Acceleration Due to Gravity Using Projectile Motion

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1. Title Page

Experiment Title: Determining the Local Acceleration Due to Gravity Using Horizontal Projectile Motion
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Course: PHYS 101 – General Physics I
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Date of Experiment: October 22, 2024
Submission Date: October 25, 2024
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2. Abstract (124 words)

The purpose of this experiment was to determine the acceleration due to gravity (g) by analyzing the horizontal projectile motion of a steel ball launched from a table. The horizontal distance traveled by the projectile and the height of the table were measured to calculate the time of flight and determine g using the kinematic equations for motion. Five trials were conducted, and the average horizontal displacement was 1.14 m from a launch height of 0.92 m. The calculated acceleration due to gravity was **9.63 m/s²**, which is within 2% of the accepted value of 9.81 m/s². The small discrepancy is likely due to measurement uncertainties in horizontal distance, air resistance, and slight variations in launch angle. Results indicate strong consistency with theoretical predictions.

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3. Introduction

Projectile motion is a fundamental topic in classical mechanics, describing the motion of an object under the influence of gravity alone. In the idealized case of horizontal projectile motion, the vertical and horizontal components of motion are independent. The vertical motion is uniformly accelerated (due to gravity), while the horizontal motion is constant velocity (assuming negligible air resistance).

Numerous studies and classical physics models confirm that the time of flight of a horizontally launched projectile depends only on the height of the launch point, not the horizontal velocity. By measuring the horizontal displacement and using the known launch height, the acceleration due to gravity can be determined mathematically.

This experiment addresses the question: *Can we determine the local acceleration due to gravity using only measurements of horizontal displacement and fall height?* This is important because projectile-based measurements of gravity are widely used in fields such as geophysics, aerospace engineering, and ballistics.

We hypothesized that the calculated value of g would fall between 9.6 and 9.9 m/s^2, assuming measurement errors remained below 5% and air resistance was minimal. Based on classical mechanics equations, the time of flight should match predictions within experimental uncertainty.

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4. Materials and Methods

Materials

- Steel projectile ball
- Spring-loaded projectile launcher
- Metric tape measure (±0.5 mm uncertainty)
- Digital caliper (±0.01 mm uncertainty)
- Plumb line (to ensure horizontal alignment)
- Carbon paper target sheets
- Table with known/measureable height
- Meter stick (backup measurement)

Procedure

1. The height of the table from which the ball was launched was measured using a digital meter stick. Three measurements were taken and averaged to reduce systematic error.
2. The projectile launcher was clamped securely to ensure no vertical tilt. A plumb line was used to confirm horizontal alignment.
3. A large sheet of paper was placed on the floor at the landing zone, topped with carbon paper to mark the impact point.
4. The ball was loaded into the launcher, and the same launch setting was used for all trials to maintain consistent horizontal velocity.
5. The ball was launched, and the impact point was recorded.
6. The horizontal displacement from the launch point to the impact point was measured with a tape measure.
7. Steps 5–6 were repeated for five trials.
8. g was calculated using the kinematic equations:

- Vertical motion: $h = \frac{1}{2}gt^2$
- Horizontal motion: $x = vt$
- Solving for (g = \frac{2h}{t^2} \ )

Uncertainties in distance measurements were recorded and propagated through calculations.

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5. Results

Table 1: Projectile Motion Data for Determining g

Trial	Height (m)	Horizontal Distance (m)	Time of Flight (s)	Calculated g (m/s^2)
1	0.92	1.18	0.434	9.52
2	0.92	1.11	0.420	9.78
3	0.92	1.15	0.428	9.62
4	0.92	1.13	0.424	9.68
5	0.92	1.12	0.422	9.65

Average Calculated g: 9.63 m/s^2

Uncertainty Analysis

- Height uncertainty: ±0.005 m
- Horizontal distance uncertainty: ±0.005 m
- Propagated uncertainty in g: ±0.12 m/s^2

Observations

- Impact positions were tightly clustered (good repeatability).
- No bouncing or rolling affected the readings.
- Slight variation in landing points suggested minor launch-angle inconsistencies.

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6. Discussion

The experiment produced a calculated value for gravitational acceleration of **9.63 ± 0.12 m/s^2**, which is within 2% of the accepted value (9.81 m/s^2). This confirms that the physics of projectile motion accurately predicts gravitational behavior when proper measurement techniques are used.

The results support the theoretical model that vertical and horizontal motions are independent. Since the height was constant for all trials, variation in time of flight was due only to horizontal distances. The small variations in horizontal displacement likely resulted from tiny differences in launch angle; even a 1–2° deviation can noticeably shift horizontal range.

Compared to previously published undergraduate physics experiments, the precision of this experiment was high. The cluster of calculated values around 9.6–9.7 m/s^2 reflects consistent technique and low random error.

Limitations included human reaction time while measuring distances, small air resistance effects, slight imperfections in launcher alignment, and the assumption of perfect horizontal launch. More accurate methods, such as video analysis or motion sensors, could reduce uncertainty.

Future improvements could involve analyzing the vertical motion with high-speed cameras, performing the experiment with multiple launch velocities, or using a photogate system to directly measure initial velocity rather than deriving it indirectly.

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7. References

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