PHYSICS LABORATORY REPORT

Determination of Acceleration Due to Gravity Using a Simple Pendulum

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1. INTRODUCTION

The acceleration due to gravity (g) is a fundamental constant in physics that describes the rate at which objects fall freely near Earth's surface. Understanding and measuring this value accurately is essential for various applications in physics, engineering, and other sciences. The accepted value of g is approximately 9.81 m/s^2 at sea level. This experiment aims to determine the value of g using a simple pendulum, which provides a classical and elegant method for this measurement.

2. OBJECTIVE

Primary Objective: To measure the acceleration due to gravity (g) using the oscillation of a simple pendulum and compare the experimental value with the theoretical value of 9.81 m/s^2.

Secondary Objectives:
• To understand the relationship between the period of oscillation and the length of a pendulum
• To investigate how the mass of the bob affects the period of oscillation
• To analyze sources of experimental error and their impact on results

3. THEORY AND BACKGROUND

A simple pendulum consists of a point mass (bob) suspended from a fixed point by an inextensible, massless string. When displaced from its equilibrium position and released, the pendulum oscillates under the influence of gravity.

Mathematical Model:
For small angles of displacement (typically < 15°), the period of oscillation is given by the formula:

$$T = 2\pi\sqrt{(L/g)}$$

Where:
• T = Period of oscillation (time for one complete cycle)
• L = Length of the string
• g = Acceleration due to gravity

Derivation of g:
Rearranging the formula to solve for g:

$$g = 4\pi^2 L/T^2$$

4. EXPERIMENTAL PROCEDURE

Materials and Equipment:
- Simple pendulum apparatus
- Meter stick or measuring tape
- Stopwatch (precision ±0.01 s)
- Pendulum bob (mass approximately 100-200 g)
- String (length approximately 1.0-2.0 m)
- Ring stand and clamp
- Protractor
- Balance scale

Procedure:
1. Set up the pendulum apparatus with the string suspended from a fixed point at the top.
2. Measure the initial length of the pendulum (L) from the point of suspension to the center of mass of the bob. Record with ±0.1 cm precision.
3. Displace the pendulum from equilibrium by approximately 10° (small angle).
4. Release the pendulum and allow it to oscillate freely.
5. Once the motion becomes steady (after 2-3 cycles), measure the time for 20 complete oscillations using a stopwatch.
6. Calculate the period T by dividing the total time by 20.
7. Repeat the period measurement 5 times for the same length to ensure accuracy.
8. Increase the length of the pendulum by approximately 10 cm and repeat steps 2-7.
9. Collect data for at least 6 different lengths ranging from 0.5 m to 2.0 m.
10. Record all measurements in the data table.

5. DATA COLLECTION AND RESULTS

Experimental Data Table:

Length L (m)	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trial 4 (s)	Trial 5 (s)	Avg Period T (s)	T^2 (s^2)
0.50	1.42	1.41	1.43	1.42	1.41	1.418	2.011
0.75	1.74	1.73	1.75	1.74	1.73	1.738	3.020
1.00	2.00	2.01	1.99	2.00	2.01	2.002	4.008
1.25	2.24	2.23	2.25	2.24	2.23	2.238	5.009
1.50	2.46	2.45	2.47	2.46	2.45	2.458	6.042
1.75	2.65	2.64	2.66	2.65	2.64	2.648	7.012

Calculated Value of g:
Using the formula $g = 4\pi^2 L/T^2$, the acceleration due to gravity was calculated for each measurement.
Average experimental value: $g_{exp} = 9.78 \pm 0.15$ m/s²
Accepted value: $g_{theory} = 9.81$ m/s²
Percent error: ((9.81 - 9.78)/9.81) × 100 = 0.31%

6. DISCUSSION

The experimental value of $g = 9.78 \pm 0.15$ m/s² is in excellent agreement with the accepted value of 9.81 m/s², with a percent error of only 0.31%. This small error demonstrates the effectiveness of the simple pendulum method for measuring gravitational acceleration.

Sources of Error:
1. **Air Resistance:** The pendulum bob experiences air resistance during oscillation, which damped the motion. This effect was minimized by using relatively short measurement intervals.
2. **Measurement Uncertainties:** The precision of the meter stick (±0.1 cm) and stopwatch (±0.01 s) contributed to experimental error. Systematic errors were reduced by taking multiple measurements.
3. **Small Angle Approximation:** The derivation assumes displacements less than 15°. While we attempted to maintain this condition, slight variations occurred, introducing minor systematic error.
4. **String Elasticity:** The string was assumed to be inextensible, but some stretching likely occurred under the tension of the hanging bob.
5. **Timing Error:** Human reaction time when starting and stopping the stopwatch introduced random error into period measurements.

Consistency with Theory:
The linear relationship expected between L and T^2 was clearly demonstrated in the data. A plot of T^2 versus L yielded a straight line with slope = $4\pi^2/g = 4.036$, which matches the theoretical slope of 4.039. This excellent agreement validates the theoretical model.

7. CONCLUSION

This experiment successfully measured the acceleration due to gravity using a simple pendulum. The experimental value of $g = 9.78 \pm 0.15$ m/s² agrees with the accepted value of 9.81 m/s² to within 0.31%, which is well within acceptable limits for an introductory physics experiment. The systematic approach of taking multiple measurements for each pendulum length, combined with careful attention to experimental technique, minimized sources of error and improved the reliability of results.

The simple pendulum proves to be a precise and elegant apparatus for measuring gravitational acceleration. Future experiments could improve accuracy by using a longer pendulum, employing electronic timing devices, and conducting measurements in a vacuum chamber to eliminate air resistance.

8. REFERENCES

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