PH1202

Physics Laboratory II

Experiment Number - 1

Determination of the acceleration due to gravity

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1 Aim

In this project, we will have to determine the value of the acceleration due to gravity at our place (wherever we are) by measuring the time period of a simple pendulum.

2 Equipments

The experiment required the use of the following equipments

1. Inextensible String
2. Bob (here, Ball)
3. Rigid Support
4. Stopwatch/Timer

3 Description and Image of the Setup

Figure 1: Image of the Setup

First a thread was hung from a rigid support (here, cloth hanger). Then, a ball was tied to the free end of the string as a bob. Then, we measure the time taken for 20 oscillations (5 to 6 readings) by taking different lengths of the string. After that we try to calculate the value of g (acceleration due to gravity) using the formula:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

The readings were as follows:

4 Readings/Tables

For string length 55.75 cm:-

Sl. No.	Oscillations	Total Time Taken	Time per Oscillation (sec)	Average
1	20	30.26	1.513	
2	20	29.50	1.475	
3	20	30.89	1.5445	
4	20	30.76	1.538	
5	20	30.55	1.5275	
6	20	30.72	1.536	
7	20	31.20	1.56	1.53
8	20	30.9	1.545	
9	20	30.19	1.5095	
10	20	30.75	1.5375	
11	20	30.35	1.5175	
12	20	30.99	1.5495	

For string length 71.25 cm:-

Sl. No.	Oscillations	Total Time Taken	Time per Oscillation (sec)	Average
1	20	34.41	1.72	
2	20	34.37	1.72	
3	20	34.40	1.72	
4	20	34.37	1.72	1.71
5	20	34.21	1.71	
6	20	34.12	1.71	
7	20	34.17	1.71	

For string length 96.05 cm:-

Sl. No.	Oscillations	Total Time Taken	Time per Oscillation (sec)	Average
1	20	39.72	1.99	1.99
2	20	39.70	1.99	
3	20	39.71	1.99	
4	20	39.69	1.98	
5	20	39.72	1.99	
6	20	39.74	1.99	

For string length 120.00 cm:-

Sl. No.	Oscillations	Total Time Taken	Time per Oscillation (s)	Average
1	20	44.61	2.23	2.22
2	20	44.81	2.24	
3	20	44.20	2.21	
4	20	44.43	2.22	
5	20	44.09	2.20	

For string length 139.75 cm:-

Sl. No.	Oscillations	Total Time Taken	Time per Oscillation (sec)	Average
1	20	47.87	2.39	2.38
2	20	47.57	2.38	
3	20	47.67	2.38	
4	20	47.49	2.37	
5	20	47.44	2.37	
6	20	47.32	2.37	
7	20	47.42	2.37	
8	20	47.52	2.38	
9	20	47.34	2.37	
10	20	47.47	2.37	

5 Calculations and Results

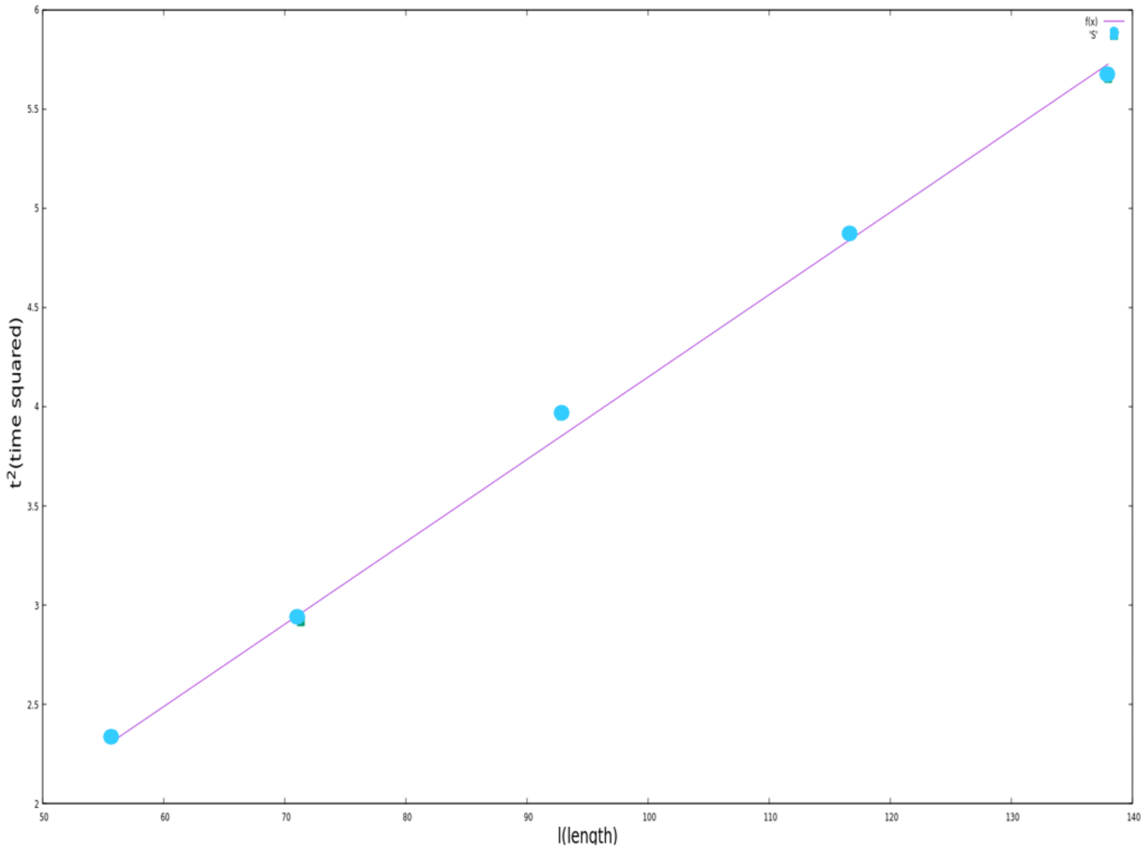

Figure 2: Graph of t^2 vs. l

From the formula $T = 2\pi\sqrt{\frac{l}{g}}$, we get,

$$T^2 = 4\pi^2 \frac{l}{g}$$

$$\Rightarrow g = 4\pi^2 \frac{l}{T^2}$$

$$Slope = \frac{T^2}{l} = \frac{4\pi^2}{g} = 0.041038 \ cm^{-1}s^2 \ (from \ graph)$$

$$\Rightarrow \frac{4\pi^2}{g} = 0.041038 \ cm^{-1}s^2$$

$$\Rightarrow g = \frac{4\pi^2}{0.041038} \ cms^{-2} = 961.997 \ cms^{-2} \approxeq 9.62 \ ms^{-2}$$

$$\boxed{g \approxeq 9.62 \ ms^{-2}}$$

6 Error Analysis

The true/literature value of acceleration due to gravity is taken as **9.8** ms^{-2}.

$$\begin{aligned} Absolute\ Error &= |\texttt{True Value - Calculated Value}| \\ &= |9.8 - 9.62| \\ &= 0.18\ ms^{-2} \end{aligned}$$

$$\begin{aligned} Percentage\ Error &= \frac{Absolute\ Error}{True\ Value} \times 100\% \\ &= \frac{0.18}{9.8} \times 100\% \\ &\approx 1.84\% \end{aligned}$$

7 Systemic Error Analysis

From the equation,

$$g = \frac{4\pi^2 l}{T^2}$$

Since we are using Physical Instruments to measure the parameters l and T, we are bound to have error/uncertainty in our calculated value of g. Using Partial Derivatives in the above equation, we get,

$$\frac{\delta(g)}{g} = \left|\frac{1}{l}\right| \delta l + \left|\frac{2}{T}\right| \delta T$$

Now, substituting different parameters and least counts of instruments as individual errors in the equation, we obtain:-

1. For $l = 139.75\ cm$
$$\frac{\delta g}{g} = 0.9\%$$
2. For $l = 120.00\ cm$
$$\frac{\delta g}{g} = 0.98\%$$
3. For $l = 96.05\ cm$
$$\frac{\delta g}{g} = 1.1\%$$
4. For $l = 71.25\ cm$
$$\frac{\delta g}{g} = 1.3\%$$
5. For $l = 55.75\ cm$
$$\frac{\delta g}{g} = 1.5\%$$

8 Discussion

The nature of the plot is a straight line which is also true as per the equation,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

To reduce the error we have allowed the ball to oscillate for some time to reduce the effect of torsion. We will also need to consider the motion to be planar. We also need to make sure that the oscillations need to be performed with the string at a very small angle from the equilibrium position. Otherwise, the above formula will not hold.

9 Sources of Error

a There might be slight torsion in the string used.

b The string might be slightly extensible.

c Ball might not have uniform mass distribution and may not be perfectly spherical.

d Air resistance might come into play, but here it is neglected.

e Human sources of Error like stopping the stopwatch at exactly 20 oscillations of the pendulum, etc.