

**AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)**

**FACULTY OF SCIENCE & TECHNOLOGY**

**DEPARTMENT OF PHYSICS**

**PHYSICS LAB 1**

**Summer 2020-2021**

**Section: J, Group: 6**

**LAB REPORT 1:**

To determine the acceleration due to gravity applying linear least square regression method by using a simple pendulum.

**Supervised By**

**BITHI PAUL**

**Submitted By**

|  |  |  |
| --- | --- | --- |
| **Name** | **ID** | **Contribution** |
| Nokibul Arfin Siam | 21-44793-1 | Compilation and Calculations.  Talked about apparatus and procedure |
|  |  |  |
| Ahmed Farhan Amin | 21-44804-1 | Have presented our discussions and reference.  Written the theoretical explanation and graph drawing. |
| G.M.Alvi Siddique | 20-43659-2 | Provided the experimental data . |
| Shayakh Al Araf Slowk | 21-44591-1 | Calculation and results. |

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## Theory

Acceleration is a [vector quantity](http://www.physicsclassroom.com/Class/1DKin/U1L1b.cfm) that is defined as the rate at which an object changes its [velocity,](http://www.physicsclassroom.com/Class/1DKin/U1L1d.cfm) and acceleration due to gravity is the acceleration gained by an object due to gravitational force. In this Experiment, we will determine the acceleration due to gravity applying linear least square regression method by using a simple pendulum.

A simple pendulum is one which can be considered to be a point mass suspended from a string or rod of negligible mass. It is a resonant system with a single resonant frequency. The time period of small-angle oscillation of a simple pendulum can be shown to be

T = 2π√ (L/g)

where L is the effective length (length from the point of suspension to the center of the bob) and time period (time of one complete oscillation) of a simple pendulum, respectively in a place where the acceleration due to gravity is g.

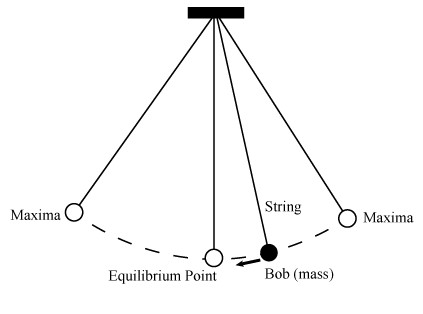


Figure 1.1: A swinging simple pendulum with an effective length L and amplitude θ.

The time period equation of a simple pendulum can be rearranged as

T^2 = (4π^2/g) L

Comparing this equation with the straight line equation that goes through the origin (y = mx) the value of acceleration due to gravity can be determined by

g = (4π^2/m)

where m is the slope of the T2 vs L graph.

The "[least squares"](https://www.investopedia.com/terms/l/least-squares.asp) method is a form of mathematical regression analysis used to determine the [line of best fit](https://www.investopedia.com/terms/l/line-of-best-fit.asp) for a set of data, providing a visual demonstration of the relationship between the data points. Each point of data represents the relationship between a known independent variable (x) and an unknown dependent variable (y).

For those two types (independent and dependent) of variables x and y = f(x), the linear least square regression method can be used for N number of data points. The equation for the best fitted line is y = mx + c,

where m is the slope and c is the interception in the y axis. Here the number of data points is taken as N=7.

The formula for determining the slope of the regression line is,

m = (Slope equation)

and intercept c = y̅ - m x̅, where x̅ and y̅ are mean value of x and y.

In the slope equation :

∑𝑖 𝑥𝑖 = 𝑥1 + 𝑥2 + 𝑥3 + 𝑥4 + 𝑥5 + 𝑥6 + 𝑥7,

∑𝑖 𝑦𝑖 = 𝑦1 + 𝑦2 + 𝑦3 + 𝑦4 + 𝑦5 + 𝑦6 + 𝑦7,

∑𝑖 𝑥𝑖𝑦𝑖 = 𝑥1𝑦1 + 𝑥2𝑦2 + 𝑥3𝑦3 + 𝑥4𝑦4 + 𝑥5𝑦5 + 𝑥6𝑦6 + 𝑥7𝑦7,

(∑𝑖 𝑥𝑖)2 = (𝑥1 + 𝑥2 + 𝑥3 + 𝑥4 + 𝑥5 + 𝑥6 + 𝑥7)2,

𝑥

## Apparatus

* Meter scale.
* Metal bob.
* Thin rigid string.
* Stand and clamp.
* Electronic timer or stopwatch.
* Vernier caliper

## Procedure

## 

1. **Set up the apparatus as shown in the diagram.**
2. **Tie the metal ball at one end of the string and hang the string from the stand. Measure the length of the sting starting from the center of the ball, using the meter rule.**
3. **Take 150cm at first.**
4. **Move the metal ball 10 degrees from its original position and without applying any extra force just release the ball and let it oscillate.**
5. **Use the stopwatch to record the time for 20 oscillations from when the ball is just released and divide it by 20.**
6. **Repeat this for different lengths of string and record the length and corresponding time taken.**
7. **Using the Linear Least Square Regression Method (LLSRM) find the regression line and from the value of slope find g from the relation: slope = 4π2 /g**.
8. **Plot the same graph in excel and also find the value of g from the equation of the graph.**

## 

## Experimental Data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Effective Length  L (cm) | Time for 20 oscillation  t (s) | Time period  T = t/20  (s) | T2  (s2) | L2  (cm2) | L× T2  (cm – sec2 ) |
| 150 | 48.85 | 2.4425 | 5.96580625 | 22500 | 894.8709375 |
| 140 | 46.88 | 2.344 | 5.494336 | 19600 | 769.20704 |
| 130 | 45.63 | 2.2815 | 5.20524225 | 16900 | 676.6814925 |
| 120 | 43.90 | 2.195 | 4.818025 | 14400 | 578.163 |
| 110 | 42.68 | 2.134 | 4.553956 | 12100 | 500.93516 |
| 100 | 39.19 | 1.9595 | 3.83964025 | 10000 | 383.964025 |
| 90 | 38.10 | 1.905 | 3.629025 | 8100 | 326.61225 |

 = 840 =33.506031 = 103600 4130.433905

## Analysis and Calculation

Finding the slope, m and intercept, c by using the linear least square regression method.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| N |  |  |  |  |  | m | c |
| 7 | 840 cm | 33.506031 (s^2) | 4130.433905 (cm –sec^2) | (840)^2 = 705600 | 103600 | 0.039182 | 0.084736 |
| Equation:  y = 0.039182 x + 0.084736 | | | | | | | |

1. **The value of g using the LLSRM:**

= = 0.039182 s2 /cm

 120 cm

 = = 4.786576 s2

Intercept, c = `y – m`x

= 4.786576 – 0.039182(120)

= 0.084736

Acceleration due to gravity by LLSRM, =

gL = 1007.5651 cm/s2

1. **The value of g from the graph of Excel:**

Slope of the regression line, m = 0.

Acceleration due to gravity by Excel, =

gE = 1007.1025 cm/s2

1. **Percentage of difference in g between Excel and LLSRM:**

= = - 0.0459 %

## Result

|  |  |  |
| --- | --- | --- |
| Method | Value of g (m/s2) | Comment |
| LLSRM | 1007.5651 | The values are very close with a difference of just  0.0459 % . |
| Excel | 1007.1025 |

## Discussion

1.There might be some instrumental error in slide calipers so that there were some difficulties while measuring the bob.

2. While doing these measurements the human error is to be expected. This can be avoided by repeating the time measurement and averaging the values.

3.We also worry that we were not able to accurately measure the angle from which the pendulum was released, as we did not use a protractor.

4. A photogate could be used in the future, to measure the period with higher precision. A nice extension to this experiment would be the use of different metal bobs, of different diameter and/or mass. This would allow us to calculate the effect of air resistance on this experiment.

5.There might be some error while measuring the thread.

6.The string was not properly straight .

## References

Class Lecture, Lab Manuals, Videos.

Fundamentals of Physics (10th edition)- Halliday, Resnick, and Walker.

Practical Physics- Dr. Giasuddin Ahmed and Md Shahabuddin

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