Pre-Lab Questions 4

Topic: Simple Pendulum

Objective: 1. To enable the students to identify the physical parameters of a simple pendulum.
2. To enable the students to identify the independent and dependant variables involved in experimentally checking theoretical predictions.

After successfully answering these questions, the students will be able to

1. Identify the physical parameters of a simple pendulum.
2. Identify the independent and dependent variables involved in investigating the relationships between the parameters of a simple pendulum.
3. Plan how to experimentally check the theoretical predictions.
4. Describe the meaning of small-angle approximation.

PRE-LAB QUESTIONS 4

Answer the following questions and submit your group answers to the instructor.

1. What is a simple pendulum?

2. What are the physical parameters in the investigation of a simple pendulum? *The term parameter refers to anything in the physical system that can be measured*.

3. What is the period of a simple pendulum?

4. What is the difference between an independent variable and dependent variable? Provide an example of each.

5. How does the period of a pendulum vary theoretically with
(a) angular displacement, (b) mass of bob, and (c) length?

6. How will you experimentally check the theoretical predictions in Question 5?

7. What is meant by small-angle approximation?

8. What is meant when we say dependent variable y does not depend on independent variable x? In other words, y is independent of x.

9. If $y = 2\pi\sqrt{\frac{x}{k}}$ and k is a constant, what graph should you plot so that you will get a straight line and the value k could be determined from the gradient of the line?

Experiment 4

Topic: Simple Pendulum

Objective: 1. To investigate the relationship between the period of a simple pendulum to its (a) angular displacement, (b) mass of bob, and (c) length.

2. To determine g from the first order approximation $T = 2\pi\sqrt{\frac{L}{g}}$

Learning Outcomes of Experiment 4

After doing the experiment, the students will be able to

1. experimentally determine the relationship between the period of a simple pendulum to its angular displacement, mass of bob and length.
2. experimentally determine g from the first order approximation equation.
3. check the validity of theoretical predictions by experiments.
4. vary physical parameters in order to investigate theoretical predictions.
5. use approximation to facilitate experimental investigation.
6. write a report on the experiment.
7. state the appropriate and reasonable sources of error or factors that contributed to the uncertainties in the results.

Introduction

No theory or model of nature is valid unless its predictions are in agreement with experimental results (Wilson & Hernández, 2010). In this experiment, the validity of theoretical equations that describe the behavior of a simple pendulum will be tested.

A simple pendulum is a mechanical system that performs periodic motion which consists of a pendulum bob of mass m suspended by a light string of length L which swings through an angle θ as shown in Fig. 1.

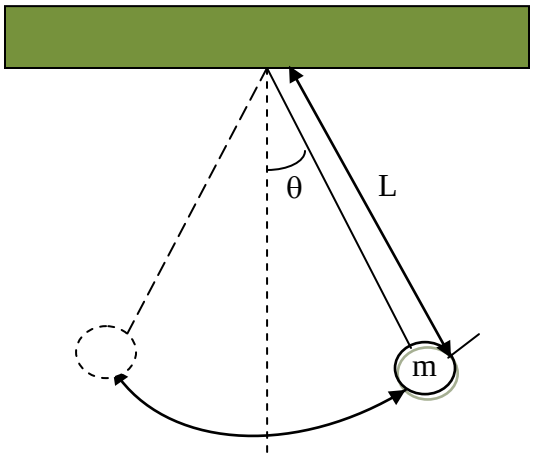

Fig. 1

By applying the physics principles and mathematics, the equation for the period of a simple pendulum oscillating in a single plane is given by:

$$T = 2\pi\sqrt{\frac{L}{g}}\left(1 + \frac{1}{4}sin^2\frac{\theta}{2} + \frac{9}{64}sin^4\frac{\theta}{2} + \ ...\right) \text{……..(1)}$$

For small angle, the higher terms of the infinite series $\frac{1}{4}sin^2\frac{\theta}{2} + \frac{9}{64}sin^4\frac{\theta}{2} + \ ...$ << 1.

Therefore, an approximation of equation (1) can be written as:

$$T = 2\pi\sqrt{\frac{L}{g}} \quad \text{……(2)}$$

Instructions

To investigate the relationship between T and θ.

1. Carry out an experiment to investigate the relationship between period (T) and angular displacement (θ) of a simple pendulum.

2. Compute the percentage error between the experimental results of T and the theoretical values of T calculated using equation (1) and (2) for each value of θ.

3. State your conclusions.

To investigate the relationship between T and m.

1. Carry out an experiment to investigate the relationship between the period (T) and the mass of the pendulum bob (m).

2. State your conclusions.

To investigate the relationship between T and L.

1. Carry out an experiment to investigate the relationship between the period (T) and the length of the pendulum (L).

2. Compute the percent error between the experimental values of T and the theoretical values using equation (2) for each pendulum length ($g = 9.80\ m/s^2$)

3. Draw conclusions about the validity and applicability of equation (2).

To determine g by using equation (2).

1. The values of g vary slightly at different latitudes and altitudes on the earth. Carry out an experiment to determine g in your lab by using equation (2).

2. Determined g by calculating the gradient of an appropriate graph relating T and L.

Format of the Laboratory Report

1. *Objective* : State the objective of the experiment.
2. *Apparatus* : State the instruments used.
3. *Theory* : State the physics and related equations underlying your investigation.
4. *Procedures* : Describe the steps that you take to perform the experiment.
5. *Data* : Present the data appropriately. Organize the data in tables if possible. Use a correct and consistent significant figures. State the units and uncertainties of each quantity.
6. *Results* : Show the relevant calculations.
7. *Conclusions* : Indicate what is measured, the uncertainties and the sources of uncertainties.

Post Laboratory Questions

1. Is air resistance or friction a systematic or random source of error?

2. Would air resistance causes the period measured from the experiment larger or smaller than the theoretical value?

3. What would be the period of a simple pendulum of length 1.0 m?

4. What would be the period of a 1.0 m length pendulum if it were oscillating on the moon? ($g_{moon} = \frac{1}{6} g_{earth}$)

Reference

Wilson, J.D. and Hernández-Hall, A.C. (2010). Physics Laboratory Experiments. 7th Edition. Brooks/Dale Cengage Learning. Boston, MA.