Lab 1: The Pendulum

Physics 352 - Spring 2020

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Introduction

The pendulum is one of the oldest, most useful, and best studied of man's creations. It has been used to do everything from marking the passage of time to illustrate the rotation of the earth. And while it is elegant in its physical beauty, it large presence in the undergraduate physics curriculum is due to its simple illustration of periodic motion. But the simple picture is truly far from the complete picture. In this lab, we will use the pendulum as a means to design experiments, consider sources of error, and witness the limits of simplifying approximations.

Overview

In this lab your goal is to explore how the period of a pendulum's oscillation varies with other physical parameters and use a theoretical backing to calculate a physical constant.

Your goal is to determine if the simple pendulum is an adequate model to explain how the pendulum's period depend on two different properties: its length and its amplitude of oscillation. You and your group will design an experiment to illustrate these relationships and apply the simple pendulum model. Based on your results, you will make a judgement on the model's appropriateness and provide alternatives where appropriate.

In particular, I would like you to comment on how effective the model is at large vs small angles.

Apparatus

The simple pendulum is an ideal (aka not-physical) machine consisting of a point mass hung at the end of a rigid, non-stretchable, massless string. When displaced by a small angle θ and released, it will oscillate back and forth indefinitely with each oscillation taking the same time. Since such a device does not exist, you will be using a close approximation.

Figure 1 illustrates the pendulum apparatus you will use. The body of the pendulum is a long, single piece of 0.05" diameter stainless-steel wire. The mass is a 1.25" diameter stainless steel sphere

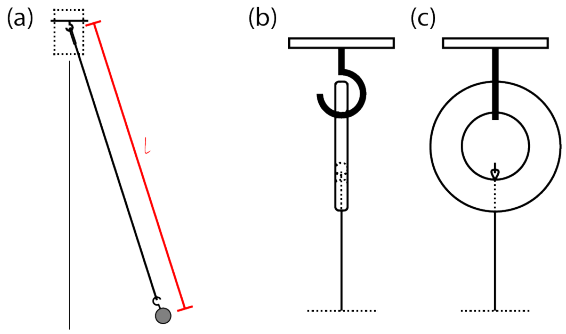

Figure 1: (a) Diagram of pendulum (not to scale). Vertical line indicates the vertical and red measurement l indicates the proper pendulum length. Dashed box is shown enlarged in b-c. (b) Front-view of washer hanger apparatus. Dashed lines indicate objects passing through the washer. (c) Profile view identical to (b).

with a hook. The pendulum is attached to the pivot hook by means of a washer with a hole drilled through one wall. The washer pivoting on the hook should experience very little friction.

The length of the pendulum is defined to be the distance from the pivot point to the center of mass of the pendulum as a whole. The length is NOT simply the length of the wire.

As you will be varying the length, I ask that any experimental procedure you write begin by complete measurements of the longest length you plan to measure. Then shorter pendulums can be made by cutting the wire to a smaller length. This is simply to go through wire as slowly as possible.

The procedure for measuring the period of oscillation is up to you. There are a variety of methods available and I encourage you to think about how to perform your measurements with the smallest uncertainty possible.

Measurements

To determine how the period of the pendulum is related to its length and amplitude, I expect that you will measure the pendulum's period and vary both its length and its amplitude. For each of these, it will be important that you keep the other constant so that it will not be a factor. It is also essential that each data point represents multiple measurements.

1. **Period vs Length** Please present plots showing the relationship at three different amplitudes. You should have no fewer than seven points per plot and each data point should represent at least five measurements.

2. **Period vs Amplitude** Please present plots showing the relationship at three different lengths. You should have no fewer than seven points per plot and each data point should represent at least five measurements. Make sure each plot covers a the same angles up to at least $45°$.

Each plot should feature a line of best fit. You should report the values for the coefficients in the body of your text and use your fit to determine the local gravitation constant g.

As you will not be able to physically perform measurements (Thanks Covid), I will be performing your measurements for you to the degree that I am able. So please plan your experiments with this in mind. I have the following measuring equipment:

- Position Sensor x2
- Force Sensor x2
- Photogate x3
- Timer
- Meterstick x2
- Lots of lab stands

Timeline and Report

This project will take place over the next three weeks. The timeline is a bit confusing but there is slightly less than one week to plan, one week to measure, one week to analyze. A timeline of all the relevant dates and events is shown below.

Week one will be theory and planning. I have posted a video overview of the theoretical basis for the simple pendulum model and the full pendulum. Your group will work together to produce a flow chart and a first draft of the Theory and Experiment section for your write-up. The write-up will undergo peer review by others in the class and you will receive feedback.

At the beginning of week two, I will meet with each group to discuss your plan for the measurement. I'll then perform your measurements (within reason) and send the data back to you for analysis.

Date	Event
Th, Mar. 26	Flowcharts due in Moodle for review by Dr. Carr
Su, Mar. 29	Experiment and Theory portions of paper are due in Moodle for peer review
Mo, Mar. 30	Meet with Dr. Carr via Teams to reveiw experiment
Tu, Mar. 31	Peer review of Experiment and Theory due.
We-Th, Apr 1-2	Receive data from Dr. Carr
Fr, Apr. 3	Graphs with fits due in Moodle for review by Dr. Carr
Tu, Apr 7	Analysis and Conclusion portions of paper are due in Moodle for peer review
Th, Apr 9	Peer review of Analysis and Conclusion due.
Mo, Apr 13	Final version of paper is due.

Table 1: Timeline of due dates for the Pendulum Lab

The rest of week two and the beginning of week 3 is your chance to write your Analysis and Conclusion sections for your paper. They will be due mid-week to allow for peer review. A final draft of the paper will be due Monday of the following week.