New York City College of Technology
The City University of New York

Pendulum

Laboratory activity description
Physics Department
Physics PHYS 1433, PHYS 1441, Summer session, 2020.

Introduction

The goal of the lab is to study oscillation of a real pendulum and find out if a simple mathematical theory can be used to describe your observation.

Pendulum is a swinging object. An example is kids swing.

Figure 1. Picture by Jeremy Bishop, www.unsplash.com

A mathematical model of a pendulum (so called, *simple pendulum* or *mathematical pendulum*) is a representation of a real pendulum by a point mass, m, attached to a weightless, non-stretchable line of length l:

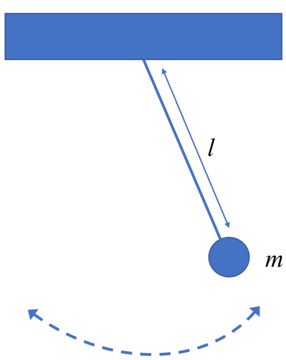

Figure 2. Mathematical model of a pendulum: a mass m on a weightless line of length.

A mathematical theory predicts that *the period of* oscillation, T, (that is, time needed by a pendulum to make one cycle and return back to its initial point) measured in seconds is

$$T = 2\,\pi\sqrt{\frac{l}{g}} \tag{1}$$

where $g=9.8\ m/s^2$ is the acceleration due to gravity.

A couple of videos in YouTube are:
https://www.youtube.com/watch?v=02w9lSii_Hs and
https://www.youtube.com/watch?v=qbvP4C6EP-Y

In this lab we will measure the period of a simple pendulum that we can find at home and compare the measured oscillation period with that predicted by equation (1) above.

Assignment

Find two objects in your room, which can be used as a pendulum. Some examples are a charger on its cord or a shoe on its lace:

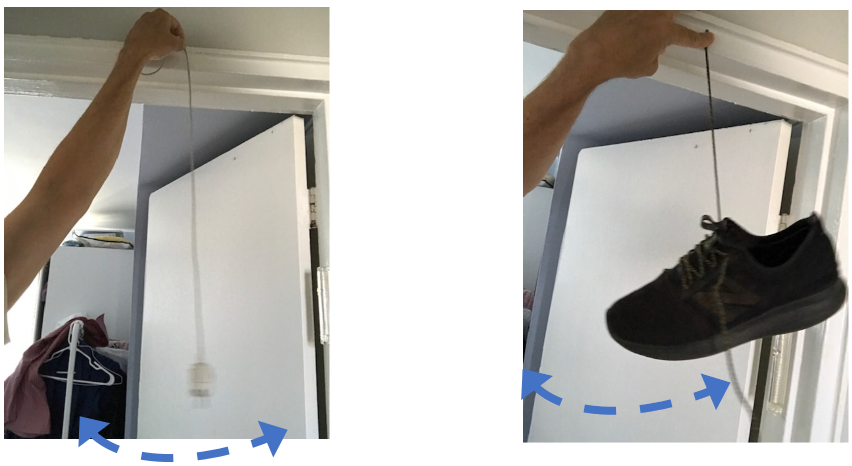

Figure 3. Example of everyday objects that you can find in your room and use as a pendulum in this lab. You do not need to use specifically these objects. These are just examples. Just pick a mass on a line that can swing back and forth.

These might also be two different chargers, for example a charger of a cell phone and charger of a laptop (or a tab).

1) For the first object, fix the pivot point (the top point of the rope that does not move), kick the pendulum and measure time it takes for the pendulum to oscillate 10-15 times. You can use the stopwatch on your phone or a stopwatch in internet. From your measurement determine the period of oscillation, T, in seconds. (To calculate the period T, you can divide the total time it takes for 10 oscillations by the number of oscillations 10.) This is an idea how to oscillate your pendulum:
   https://youtu.be/d1wUITNCLa4

   Measure the length l of the line. You can use a ruler, measuring tape or an internet ruler.

   Calculate the period of oscillations, T, predicted by the mathematical theory, eq. (1).

Write down your results in Table 1.

2) Repeat the same experiment and calculation for the second object, and write down the results in Table 1.

	Length of the line, l, meters	Measured period of oscillation, T, seconds	Period of oscillations calculated from the theory of a simple pendulum from Eq. (1)	% Difference Between the measured period (3rd column) and the predicted period (4th column)
Object 1 (describe what is it)				
Object 2 (describe what is it)				

Table

3) Determine, how far the mathematical prediction for the period T (column 4 in the table) deviates from the result of your measurement (column 3 in the table).

To characterize tis deviation, use the percent difference

$$\%\,Difference = \frac{|T_{measured} - T_{predicted}|}{\frac{1}{2}(T_{measured} + T_{predicted})} \text{ x } 100\%$$

Write down your result in the last column of Table 1.

4) Answer the question: Is the mathematical model, given by equation (1) and Figure 1, accurate enough to describe the oscillation of your real pendulum?

   Is % Difference that you obtained greater than 10%? If yes, what factors important in your experiment are not considered in the mathematical model? List possible factors in your report.

5) Your two object (pendulums) probably have different masses. Answer the question in your report:
   With your experiment, can you determine if the period of the oscillation of the object depends on the object's mass? If yes, how does the period depend on the pendulum mass? If it doesn't, why? Explain in writing.

6) Write and submit your report. In the report, show your work – how you obtained the data in the table 1. Make a conclusion summarizing your findings and answering the questions 4) and 5).

The lab handout is prepared by German Kolmakov.