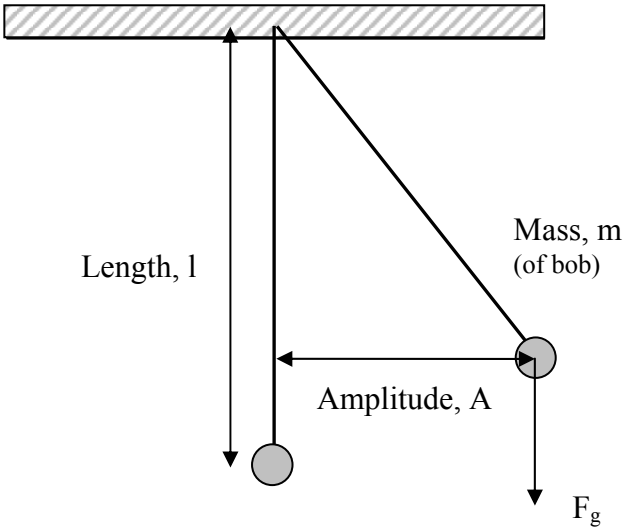
PHYSICS LAB
The Pendulum - Computer Simulation

Introduction

A swinging pendulum is a good example of periodic motion, a motion that repeats over and over. When the variables that influence a pendulum's period are kept constant, a pendulum can be used to keep very accurate time. What are these variables?

A diagram of a pendulum is shown to the right. It consists of a mass (the bob) attached to a string so that the mass can swing back and forth. The following variables might affect the period of the pendulum.



Driving Force – The force of gravity is the obvious driving force that causes the bob to swing back and forth. Note that only part of the gravity produces the driving force.

Length – The length is defined as the distance from the point of suspension to the middle of the bob.

Amplitude – The amplitude is defined as the shortest distance from the center of mass of the bob to the string when it is in the rest position (vertical).

Mass – The mass is the mass of the bob. We can assume that the mass of the string is negligible.

Air Resistance – Air resistance produces a friction when objects move through the air, which would be in opposition to the driving force.

Period – The period is the time for the pendulum to make one complete swing, from its starting position back to that same position.

Objectives

1) Determine the relationships between the period and the length, amplitude, and mass.
2) Develop an equation relating the period to the length, amplitude, and mass.
3) Postulate the effects of air resistance and gravity on the period of a pendulum.

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Complete the lab by following the procedure and data analysis below.

Procedure

Work in groups of two or as directed by your instructor. Each lab group will turn in one lab report. Each group member is responsible for collecting and analyzing the data for a portion of the lab as follows:

Partner 1: Part 1 - T versus A
Partner 2: Part 2 - T versus m
Partner 2: Part 3 - T versus l
Partner 1: Part 4 - T versus combination of A, m, and l.

1) Place the name of the group member who has worked on each part on the data table and question sheet for that section.

2) Open the Pendulum Lab simulation software. You can click on the Help button for instructions on how to run the simulation. Some of those directions are also given below.

3) Set your input variables (F_c, m, and R) by dragging the sliders at the bottom of the screen with the mouse. Set the values so that they match those given in the data table that you are working on. The data tables are given below. Always keep the acceleration of gravity set to 10 m/sec^2.

4) Click on the start button to set the pendulum in motion.

5) NOTE: In order to get an accurate reading of the period, it is necessary to find the time for 10 periods and then divide by 10. This significantly reduces the error due to human reaction time. The red sensor at the bottom of the screen flashes as the bob passes over. Use this to help find the period.

6) Start the stopwatch on the right side of the screen by pressing the start button as the object has just caused the red sensor to flash. Click the stop button when the sensor flashes after 10 periods. Divide this time by 10 and place it in the appropriate data table.

7) Repeat steps 3 thru 6 until you have taken all of the necessary data.

Continue on to the data analysis section.

Data Analysis

Each partner will make a graph of each of their sets of data and answer the following questions. Remember to graph the actual period, not the period x 10. Place the slope calculations and equations on the linear graphs. Any revised data required to straighten out the graphs should be placed on the non-linear graph. Parts 1 through 3 must be completed before part 4 can be started.

Part 1 – Period versus Amplitude Partner 1 = _____

Find the period for each of the amplitudes listed below and fill in the data table. Note that the length and mass should remain constant.

Amplitude, A (% of l)	50	60	70	80
Period, T (s)				
Length =		Mass =		

Calculations

Find the equation that relates A (x-variable) and T (y-variable) by using graphical analysis. Show all work.

Questions

1) _____ Is there a relationship between A and T (yes or no).

2) _____ If so, what is the equation between A and T.

3) Discuss what effect air resistance, if any, would have on the period of a pendulum. In your discussion, specifically answer whether air resistance would cause the period to increase or decrease.

Part 2 – Period versus Mass Partner 2 = _____

Find the period for each of the masses listed below and fill in the data table. Note that the amplitude and length should remain constant.

Mass, m (kg)	2	4	6	8	10
Period, T (s)					
Amplitude =			Length =		

Calculations

Find the equation that relates m (x-variable) and T (y-variable) by using graphical analysis. Show all work.

Questions

1) _____ Is there a relationship between m and T (yes or no).

2) _____ If so, what is the equation between m and T?

3) Discuss what effect an increase in gravity, if any, would have on the period of a pendulum. In your discussion, specifically answer whether an increase in gravity would cause the period to increase or decrease.

Part 3 – Period versus Length Partner 3 = _____

Find the period for each of the lengths listed below and fill in the data table. Note that the amplitude and mass should remain constant.

Length, l (m)	0.25	1	4	16
Period, T (s)				
Amplitude =		Mass =		

Calculations

Find the equation that relates l (x-variable) and T (y-variable) by using either graphical analysis. Show all work.

Questions

1) _____ Is there a relationship between l and T (yes or no).

2) _____ If so, what is the equation between T and l?

Part 4 – Period versus A, m, and l. Partner 4 = _____

Calculations

1) Write one equation that relates all of the variables in the previous experiments - T, A, m, and l. Remember that T is the y variable. Any variable that has no effect should not be included. Show all work.

Final equation =

Part 5 – All Partners (Group)

1) _____ A pendulum has a period of 0.5 s. If the length of the pendulum is doubled, what will the period be? Show work below.

2) _____ A pendulum has a period of 1.5 s. If the amplitude is doubled, what will the new period be? Show work below.

3) Discuss the changes in a pendulum's period if it were to be moved from the earth to the moon. Specifically predict whether the period would decrease or increase.