Part 2: Data Collection and Analysis

Pre-lab Lesson/handouts:

- Graphing Guidelines (*handout + lesson*)
- Determining Relationships from Graphs (*handout + lesson re: straight line graphs and y = mx + b)*
  - *Complete and hand in this worksheet for the teacher to check*

Activity:

Apparatus:

- various masses, from 50g to 500g
- string
- ring stand
- meter stick
- stop watch
- electronic balance
- scissors
- mm rule graph paper
- *for demonstration only: Photogate timer*

1. **Collect data** and complete the data tables*:*

   a) ***Period "T" (s) vs Mass "M" (kg),*** while keep length and displacement angle the same in every trial (L and θ are controlled)

Period "T" (s) vs Mass "M" (kg) of a Simple Pendulum

(Constant length, Displacement Angle less than 15 degrees)

1	2	3	4	5	6
	Trial 1	Trial 2	Trial 3	(Average of the 3 trials)	
Mass "M" (kg)	Time for 10 cycles "t"(s)	Time for 10 cycles "t"(s)	Time for 10 cycles "t"(s)	Time for 10 cycles "t_{ave}"(s)	Period "T"(s) = time for one cycle = $t_{ave}/10$ *[column 5 divided by 10]*
0.050					
0.100					
0.150					
0.200					
0.250					
0.300					
0.400					
0.500					
0.550					
0.600					

b) ***Period "T" (s) vs Length "L" (m),*** while keep mass and displacement angle the same in every trial (M and θ are controlled; θ should be kept small, at 15° or less)

Period "T" (s) vs Length "L" (m) of a Simple Pendulum

with a mass of 0.200 kg, and Displacement Angle less than 15 degrees

1	2	3	4	5	6	7	8
(ideal – try to get the string close to this length)	(measured ***actual*** value)	Trial 1	Trial 2	Trial 3	(Average of the 3 measured trials)	(calculated from measured value)	(calculated from measured value)
Length "L" of pendulum (m) [ideal]	Length "L" of pendulum (m) (to the centre of mass of the pendulum)	Time for 10 cycles "t"(s)	Time for 10 cycles "t"(s)	Time for 10 cycles "t"(s)	Time for 10 cycles "t"$_{ave}$(s)	Period "T"(s) = time for one cycle = t_{ave}/10 *[column 6 divided by 10]*	Period squared "T^2"(s^2) *[column 7, squared]*
1.00							
0.90							
0.80							
0.70							
0.60							
0.50							
0.40							
0.30							
0.20							
0.10							

c) **Draw graphs** for each of the data tables (place ***Period "T" on the y axis*** in each case)

i. Period "T" (s) vs Mass "m" (kg)

ii. Period "T" (s) vs Length "L" (m)

***** **Submit these graphs to your teacher** asap. If there are errors you can make corrections and resubmit *****

2. Data Analysis:

a) For each of the graphs, describe the mathematical shape in words (is the graph a straight line, or smooth curve? If it is a curve, describe the shape of the curve).

  a. Period "T" (s) vs Mass "m" (kg)

  b. Period "T" (s) vs Length "L" (m)

b) If any of the graphs appear to be "straight line", generate the equation of the line in the form ***y = mx + b***

c) Based on the shapes of the graphs complete the following statements:

  a. Period "T" (s) vs Mass "m" (kg): *"It appears that the period of a Simple Pendulum _________ (does/does not) depend on mass".*

  Explain your reasoning for choosing "does" or "does not" in this case (refer to the shape of the graph):

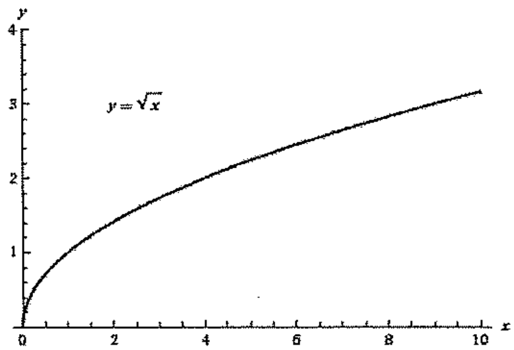
  b. Period "T" (s) vs Length "L" (m): *"It appears that the period of a Simple Pendulum _________ (does/does not) depend on the length of the pendulum".*

  Explain your reasoning for choosing "does" or "does not" in this case (refer to the shape of the graph):

Part 3: Refining the Analysis

Period "T" (s) vs Length "L" (m): The period of a Simple Pendulum ***DOES*** depend on length, but not linearly. The graph of *T vs L* is a smooth curve, not a straight line. Mathematical analysis and pattern finding is much easier with straight line graphs, so physicists typically prefer working with straight line graphs. One method for trying to create a straight line graph from non-linear relationships (straightening the curve), is to try squaring one of the variables. If the mathematical relationship between the variables is quadratic, the new graph, with one variable squared, will form a straight line.

According to accepted theory of Simple Pendulums, if enough data points are shown, the graph of *T vs L* looks much the graph below. So, squaring the variable on the y axis (T, in your case), and graphing ***T^2 vs L***, should result in a straight line graph.



To attempt to straighten your graph you will graph ***T^2 vs L***, in addition to ***T vs L***.

1) State which of the variable (period vs length) is **dependent**, and which is **independent**: (refer to the guidelines at the end of the assignment re: identifying variables)
   a. Dependent: ________________________________
   b. Independent: ________________________________

2) Calculate the slope of the ***Period Squared "T^2" vs length "L" of a Pendulum*** graph. (show all work)

   ____

3) State the equation of the line of the ***Period Squared "T^2" vs length "L" of a Pendulum*** graph (in the form *y = mx + b*).

   ____

4) The theoretical equation for the period of a pendulum is: $\mathbf{T^2 = [4\pi^2/g]L}$. Compare the pendulum equation with the general format of the equation of straight line graphs, *y = mx + b*

   a. Which of the variables in the theoretical equation represents the "y" value? ____________

   b. Which of the variables represents the "m" value (slope)? ____________

   c. What is the theoretical value of "b", the y intercept? ____________

5) % error calculation:

a. Use your answer in 4(b) to calculate the accepted value for the slope of the T^2 vs L graph (note: g = 9.80m/s^2):

____

b. State your experimentally determined slope of the T^2 vs L graph (restate your answer to question 2)

____

c. Determine the percent error of your experimentally generated slope, comparing your results with the theoretically expected value for the slope of the graph. (show your work)

% error = [(experimental value – accepted value)/accepted value]×100% = ?

Identifying Independent **and** ***Dependent*** **Variables**

(summarized from: http://nces.ed.gov/nceskids/help/user_guide/graph/variables.asp)

An **independent variable** is a variable that isn't changed by the other variables you are trying to measure. For example, someone's age might be an independent variable. Other factors (such as what they eat, how much they go to school, how much television they watch) aren't going to change a person's age. In fact, when you are looking for some kind of relationship between variables you are trying to see if the independent variable causes some kind of change in the other variables, or dependent variables.

A **dependent variable** is something that depends on other factors. For example, a test score could be a dependent variable because it could change depending on several factors such as how much you studied, how much sleep you got the night before you took the test, or even how hungry you were when you took it. Usually when you are looking for a relationship between two things you are trying to find out what makes the dependent variable change the way it does.

Many people have trouble remembering which the independent variable is and which the dependent variable is. An easy way to remember is to insert the names of the two variables you are using in this sentence in the way that makes the most sense. Then you can figure out which is the independent variable and which is the dependent variable:

*"**(Independent variable)** may cause a change in **(Dependent Variable)** and it isn't possible that **(Dependent Variable)** could cause a change in **(Independent Variable)**".*

For example: *"(Amount of sunlight) may cause a change in (plant growth) and it isn't possible that (plant growth) could cause a change in (amount of sunlight)".*

We see that "*amount of sunlight*" must be the independent variable and "*plant growth*" must be the dependent variable because the sentence doesn't make sense the other way around.