Name: Bliss Snert **Date:** April 15, 2010

Lab Number and Title: M3 – Pendulum Relationships

Lab Report Scoring Sheet

Dimension	Student Assessment* (A_s)	Lab Instructor Assessment* (A_i)	$(A_s - A_i)^2$
Format (Max 2 points)	**2**		
Purpose Statement (Max 1 point)	**1**		
Apparatus Descript (Max 2 points)	**2**		
Procedure (Max 5 points)	**5**		
Data Tables (Max 3 points)	**3**		
Analysis of Data (Max 5 points)	**5**		
Graphs (Max 2 points)	**2**		
Conclusion (Max 3 points)	**3**		
Accuracy (Max 2 points)	**2**		
Instructor base score:			Σ
Deviation Penalty:** (10% reduction in lab instructor base score if D > 0.3)			D
Lab instructor final score:			

See back for instructor comment(s) if any.

* Partial points are possible, typically 0.5, 1.5, and 2.5, etc.

** Deviation is a measure of the differences between all nine individual student and instructor assessments defined as follows: $D = \sum (A_s - A_i)^2/9$

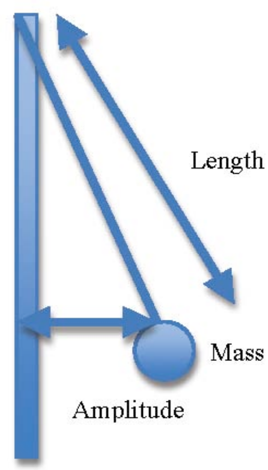
Your Name: Bliss Snert **Date:** April 15, 2010

Lab Partner(s): Katy O'Hare **Time (Section):** 2-5pm (Section 9)

Laboratory Number and Title: M3 – Pendulum Relationships

Purpose Statement: The purpose of this lab activity was to determine the relationship between the variables in a pendulum (length, mass, amplitude) and its period.

Apparatus Description: We used a simple pendulum consisting of a string, a weight, and a ring stand. See the image below. The length is the distance from the top of the spring to the center of mass of the weight. The amplitude was the angle the string made with the vertical ring stand. It is measured in degrees from the top of the triangle. The mass of the bob varied with the objects we hung on the string.



Procedure:

1. We first tested to see if the mass, *m,* of the pendulum bob had any impact on the period, *P,* of the system. We held the length of the string and the amplitude the same so we had only one independent variable (the mass of the bob) and one dependent variable (the period). We put different masses on the string and found that no matter how much we varied the mass, the period really didn't change significantly. Because the non-relationship was clear, we did not make a graph.
2. Next, we tested to see if the amplitude, *A,* made any difference in period for a given combination of length and mass. The lab instructor told us to restrict our angles to less than 20 degrees. Doing so, we found that different amplitudes (independent variable) had only a very tiny effect on the period (dependent variable). The lab instructor told us to ignore this consideration, but he did note that angles larger than 20 degrees do have a small but measurable affect on the period. We did not make a graph because there didn't seem to a significant relationship when the amplitude is less than 20 degrees.
3. Finally, we tested to see if the length of the pendulum, *L,* had an effect on the period when the other variables were held steady. (We really didn't need to do this as we had already shown that the period is pretty much independent of mass and amplitude so long as it is less than 20 degrees.) Because it was hard to get the periods precisely for one back-and-forth swing of the pendulum (one period), we timed ten back-and-forth swings and measured the whole time. We then divided by 10 to get an average period. The data that we recorded are included on the graphs in the appendix.
4. When we plotted the length versus period, we found a non-linear relationship. See Graph 1.
5. Our instructor noted that we could linearize this relationship either by plotting P^2 versus L or P versus $L^{1/2}$. We chose to do the latter. See Graph 2.

Data Tables: Our data tables are contained on Graphs 1 and 2. See the appendix.

Analysis of Data: We were able to linearize our data by plotting P^2 versus *L.* (We first made a calculated column formula and then re-graphed our data that resulted in a linear relationship.)

Now, if *L* shrinks to zero, then the period would have to be zero as well. (You can see from the graph that as *L* becomes smaller, so does *P*.) Because of this, we did a physical fit. That is, we did not use an linear fit ($y = mx + b$); rather, we chose to use a proportional fit ($y = Ax$) because when *x* (Length) is zero then *y* (Period) has to be zero. The relationship between P^2 and *L* was found as follows using *Graphical Analysis* and as shown in Graph 2.

$y = Ax$ (algebraic relationship of a proportional fit)

$P = k\sqrt{L}$ where $k = 3.99 s/\sqrt{m}$ *(physical fit)*

There was no y-intercept in this graph other than zero and so this cannot be interpreted in any meaningful fashion. The slope has units of seconds per square root of meter, but his has no physical significance.

Graphs: See Graphs 1 and 2 appended at the end of this report; each includes its own data table.

Conclusion. The purpose of this lab activity was to determine the relationship between the variables associated with a pendulum (mass, amplitude, and length) and its period. We concluded that neither mass of the pendulum bob nor the amplitude of the swing (restricted to less than 20 degree) has a significant impact on the period of a pendulum. We did conclude, however, that the relationship between the period of a pendulum and its length is significant and is roughly as follows:

$$P^2 = 3.99 \frac{s^2}{m} L$$

Accuracy: According to the lab instructor, the theoretical value of *k* is $4.02 s^2/m$. We found an experimental value of $3.99 s^2/m$. Because we are comparing a theoretical value with an experimental value, we determined the % error. Note that we excluded the units in the calculation for simplicity.

percent error = [(theoretical– experimental)/theoretical]*100%
percent error = [(4.02-3.99)/4.02]*100%
percent error = 0.75%

This relationship is accurate to within 0.75% of the theoretical relationship:

$$P^2 = 4.02 \frac{s^2}{m} L = \frac{4\pi^2}{g} L$$

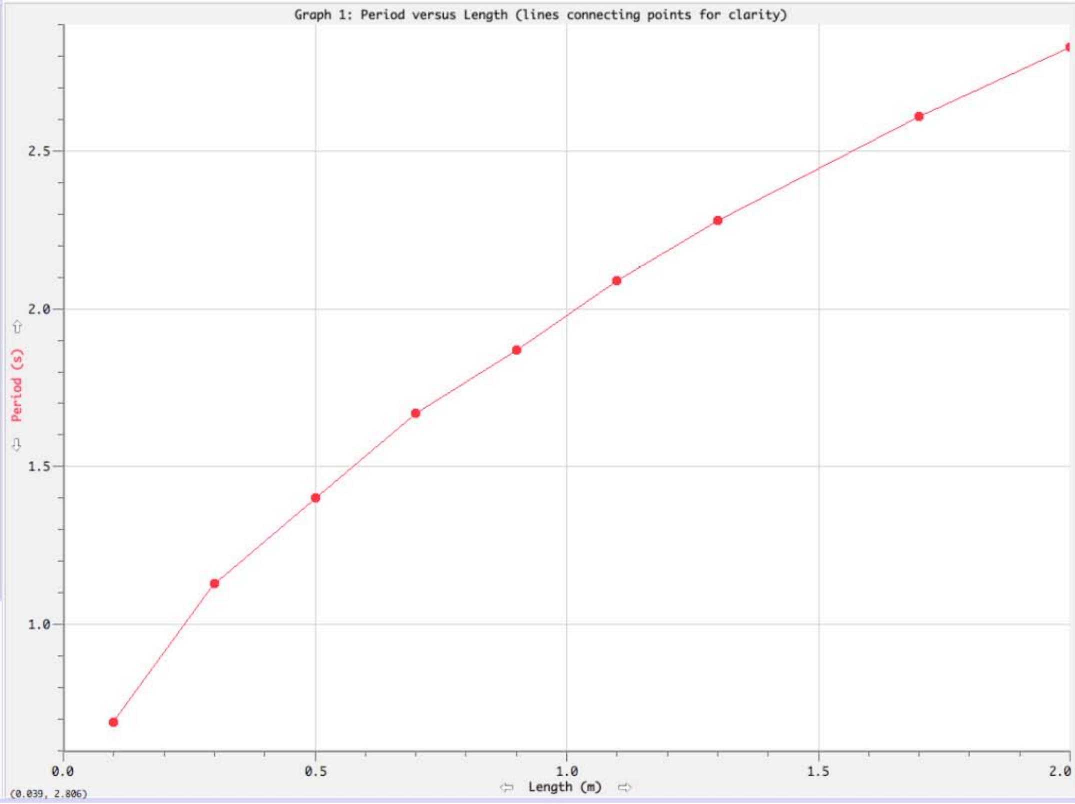
which is the same as $P = 2\pi \sqrt{\frac{L}{g}}$, the standard form of the relationship.

Appendix: Graphs 1 and 2 each with its own data table. Data points are connected in Graph 1 only to show the side-opening parabolic nature of the graph.

	Length (m)	Period (s)
1	0.1	0.69
2	0.3	1.13
3	0.5	1.40
4	0.7	1.67
5	0.9	1.87
6	1.1	2.09
7	1.3	2.28
8	1.7	2.61
9	2.0	2.83
10		

Data Set

Notes:



	Length (m)	Period (s)	Period^2 (s^2)
1	0.1	0.69	0.476
2	0.3	1.13	1.277
3	0.5	1.40	1.960
4	0.7	1.67	2.789
5	0.9	1.87	3.497
6	1.1	2.09	4.368
7	1.3	2.28	5.198
8	1.7	2.61	6.812
9	2.0	2.83	8.009
10			

Data Set

Notes: