Name: Carl J. Wenning **Date:** 2/01/2010

Lab Report Scoring Sheet

(Submission sequence: 1)

Dimension	Student Assessment* (A_s)	Instructor Assessment* (A_i)	$(A_s - A_i)^2$
Cover Sheet (Max 3 points)	**3**		
Purpose Statement (Max 2 points)	**2**		
Apparatus Description (Max 2 points)	**2**		
Procedure (Max 3 points)	**3**		
Data (Max 3 points)	**3**		
Analysis of Data (Max 3 points)	**3**		
Graphs (Max 3 points)	**3**		
Accuracy (Max 3 points)	**3**		
Conclusion (Max 3 points)	**3**		
Instructor base score:			Σ
Deviation Penalty:** (10% reduction in instructor base score if ***D*** > 0.3)			***D***
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: $Deviation = \sum (A_s - A_i)^2 / 9$

Your Name: Carl J. Wenning

Lab Partner(s):

Laboratory Number and Title: M3 – Pendulum Relationships

Lab Report Cover Sheet

(Submission sequence: 2)

Each student must turn in his or her own lab report. Data and graphs may be identical to that of your lab partner(s), but other elements must be unique (e.g., no group reports). In the spaces below, answer the questions using complete sentences, proper grammar, and spell check. <u>This cover sheet constitutes an abstract, not the actual lab report. Limit your responses to each question to one or two sentences generally. Be certain to staple together all components of your lab report, and include the completed ***Lab Report Scoring Sheet*** on top.</u>

1) What was the purpose of this lab exercise? (i.e., "In this experiment we verified Snell's law.")

➔ In this lab exercise we experimentally determined the relationship between the length of a pendulum and its period of oscillation.

2) Give a short statement of your findings. (i.e., "We discovered that...)

➔ We found the following relationship: $P = k\sqrt{L}$

3) Give a short summary of the procedure you followed.

➔ We first determined that weight of the suspended mass and size of the swing didn't make any significant difference in the period so long as we restricted the swing to small angles. We then fixed the mass and amplitude of the pendulum and measured period (P) as a function of length (L). We made of graph of P vs. L. The relationship was not linear, so we squared the P and re-plotted it against L and found the relationship in response 2 above.

4) What degree of accuracy you were able to achieve in your work? (i.e., "We verified that the angle of incidence equals the angle of reflection to within an experimental accuracy of 2%.")

➔ The experimental value we found for *k* was $3.99 s/\sqrt{m}$. The theoretical value is $4.04 s/\sqrt{m}$. This amounts to an error of 1.24%

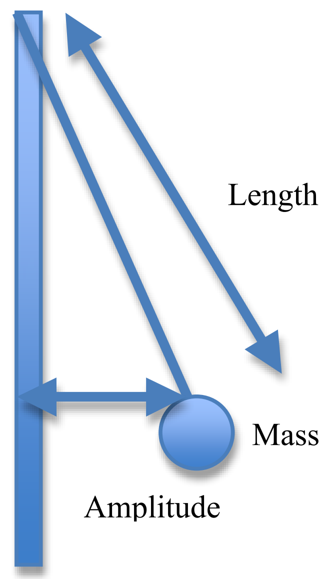
5) What are the possible sources of random error? (i.e., "The error in the result arises from an inability to accurately measure...").

➔ Difficulties were encountered with the use of the stopwatch. Human reaction time is limited, and starting and stopping the watch produced a bit of error that we simply could not eliminate even though we averaged our results over 10 periods.

Lab Report: Carl Wenning **Labe number and name: 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. The mass of the bob varied with the objects we hung on the string.



Procedure:

1. We first tested to see if the mass of the pendulum bob had any impact on 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. Because the relationship was clear, we did not make a graph.
2. Next, we tested to see if the amplitude made any difference for a given combination of length and mass. The 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 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 had an effect on the period when the other constants are 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. These are the data that we recorded.
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: Our data are contained on Graphs 1 and 2.

Analysis of Data: We were able to linearize our data by plotting P^2 versus L. (We first made a calculated column formula.)

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 a 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 on Graph 2.

y = Ax (algebraic relationship of a proportional fit)

Period = $k\sqrt{L}$ 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.

Accuracy: According to the instructor, the theoretical value of k is $4.04 s/\sqrt{m}$. We found an experimental value of $3.99 s/\sqrt{m}$. Because we are comparing a theoretical value with an experimental value, we determined the % error. Note that we excluded the units for simplicity.

$$\%error = |theoretical - experimental| / theortical * 100\%$$
$$\%error = |4.04 - 3.99| / 4.04 * 100\%$$
$$\%error = 1.24\%$$

Conclusion. The purpose of this lab activity was to determine the relationship between the variables of a pendulum and its period. We concluded that neither mass of the pendulum bob nor the amplitude of the swing (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 as follows:

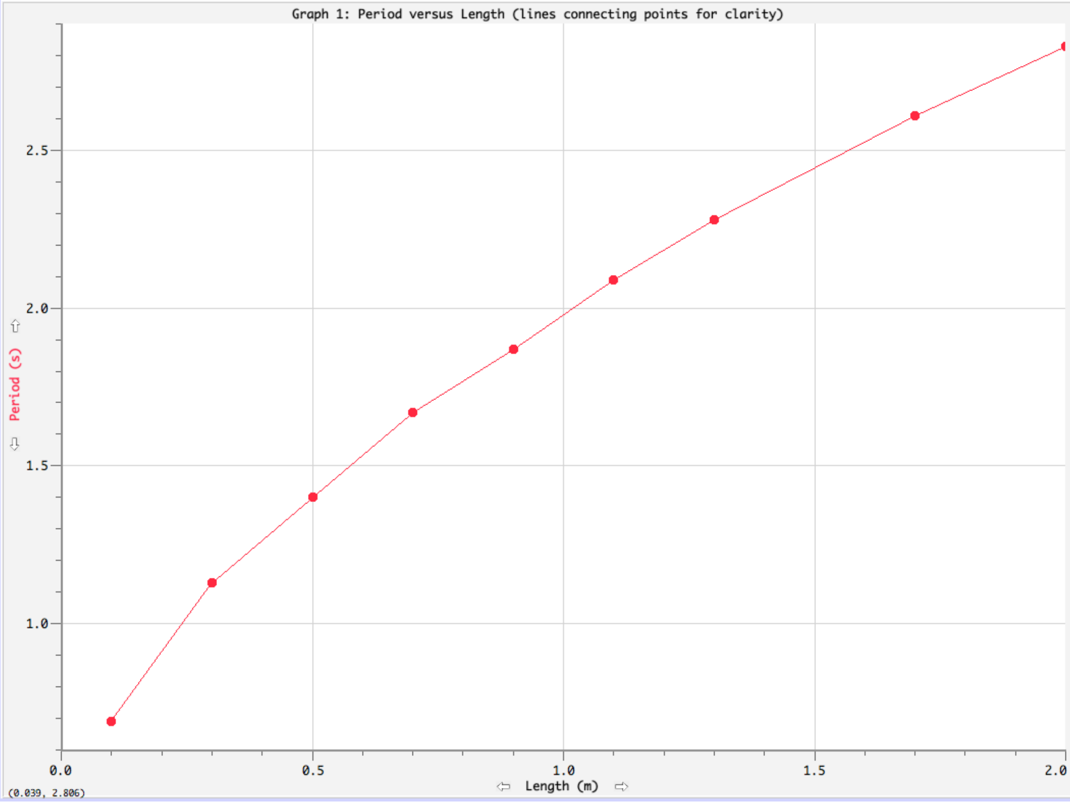
$$P^2 = 3.99 \frac{s^2}{m} L$$

This relationship is accurate to within 1.24% of the theoretically correct equation:

$$P^2 = 4.04 \frac{s}{m^2} L$$

	Data Set	
	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		

Notes:



	Data Set		
	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			

Notes: