Abstract:

For this lab, the Simple Pendulum is investigated by measuring the oscillation period. By changing the mass of the pendulum bob, the length of the pendulum string, and the initial angle of oscillation, the oscillation period can be found. The results show that the period of oscillation is dependent only on the length of the string. Since there was no significant change in the period of oscillation of different masses or angles then it is shown that as the length of the string increases, the period of oscillation is proportional to the square root of the string length.

Purpose:

The Simple Pendulum is a machine constructed with a mass attached to an inelastic string hanging from a point and being allowed to swing back and forth in place while passing over a pulley to observe the acceleration. In this lab, the effects of changing different physical aspects on the oscillation of a simple pendulum were investigated.

Theory:

A Simple Pendulum is a machine constructed with a mass attached to an inelastic string hanging from a point. When the mass is moved away from the equilibrium point, the pendulum bob will oscillate in a periodic motion. The time that it takes to make one complete oscillation is defined as the period T which is given by the equation:

Where T is dependent only on the acceleration due to gravity and the length of the string. This equation is restricted to a simple pendulum that is oscillating at small angles. It can be shown that if the amplitude of the motion is kept small the motion of the Simple Pendulum will be a simple harmonic motion.

Part 1: Investigation of Mass Dependence

Procedure:

Three pendulum bobs of different mass compositions were selected. The bobs were attached to a fixed-length of string to determine if the mass has any effect on the measured period. Using a photogate the time was measured for each bob to complete one oscillation. Five trials were performed for each mass.

Data:

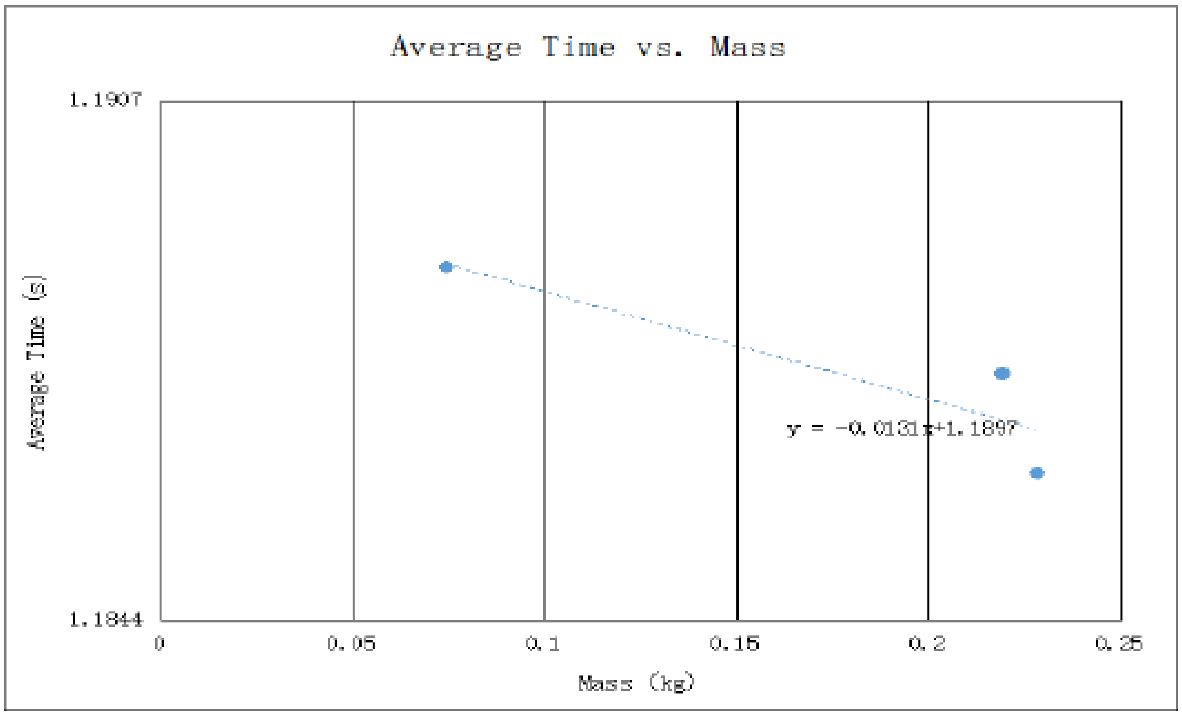
Length of string (same for all trials): L=0.36m

Initial angle of Oscillation (same for all trials): $\Theta=5^0$

Mass (kg)	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trial 4 (s)	Trial 5 (s)
0.0742	1.1978	1.1714	1.1945	1.1981	1.1818
0.2190	1.1961	1.1746	1.1881	1.1823	1.1961
0.2281	1.1552	1.1901	1.1910	1.1964	1.1985

	Mass 1	Mass 2	Mass 3
Average Time (s)	1.1887 s	1.1874 s	1.1862 s
Maximum Error	0.0094 s	0.0087 s	0.0123 s
Minimum Error	0.0173 s	0.0128 s	0.0310 s

Analysis:



Discussion:

Using the equation for one period of oscillation given earlier, there would be no dependence on the mass of the objects. According to class notes, a mass dependence is not expected. According the results, there is no apparent mass dependence for a simple pendulum. The period ranges less than 1% of the measured values.

Part 2: Time vs. Length

Procedure:

A pendulum was constructed from the smallest bob used in part one. The oscillation period was recalculated using five different lengths of string. The string length was measured from the top of the pendulum to the center of the bob using a standard ruler. There were five trials for each length.

Data:

Steel bob used: m=0.0233 kg

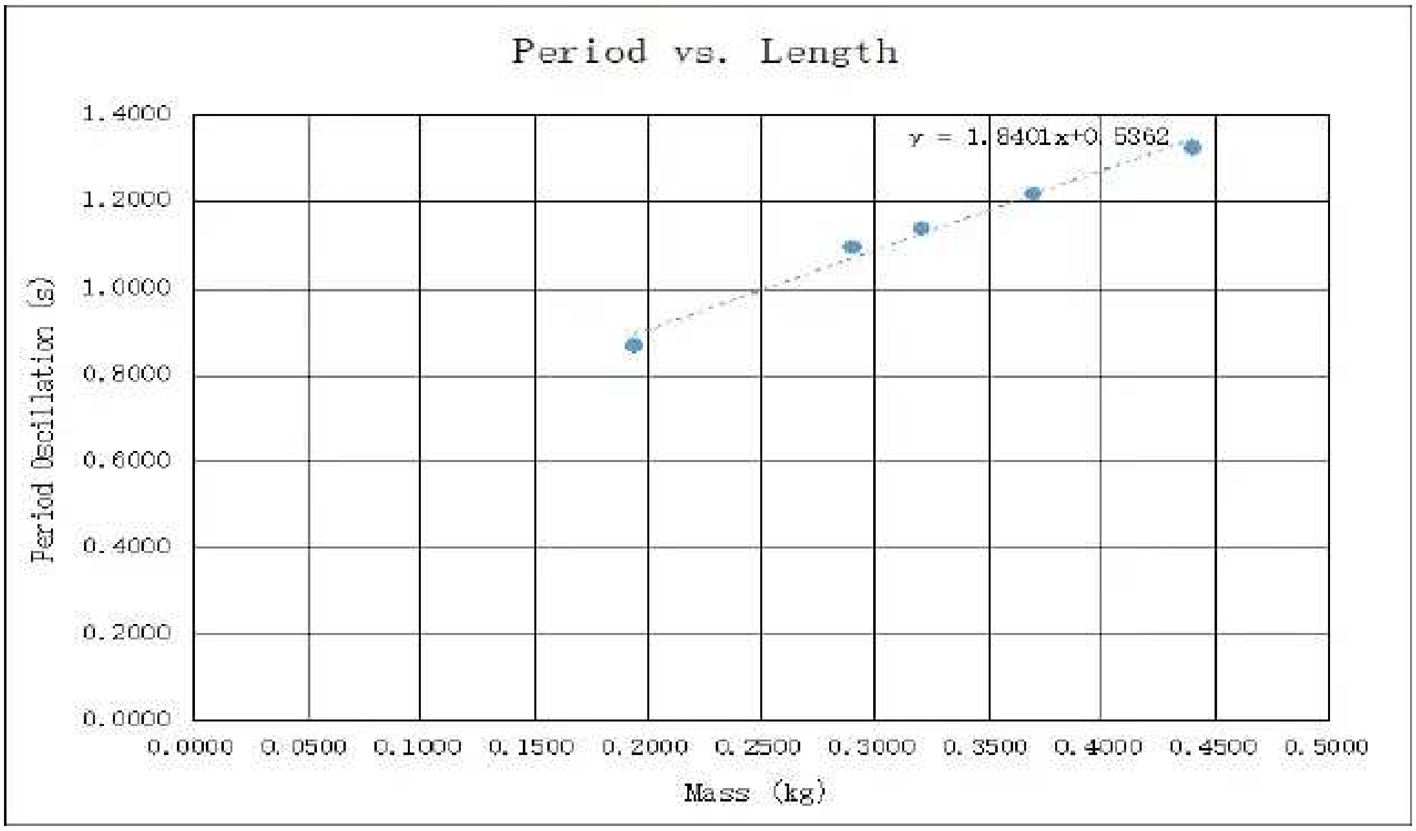
Angle of Oscillation: ϴ=5⁰

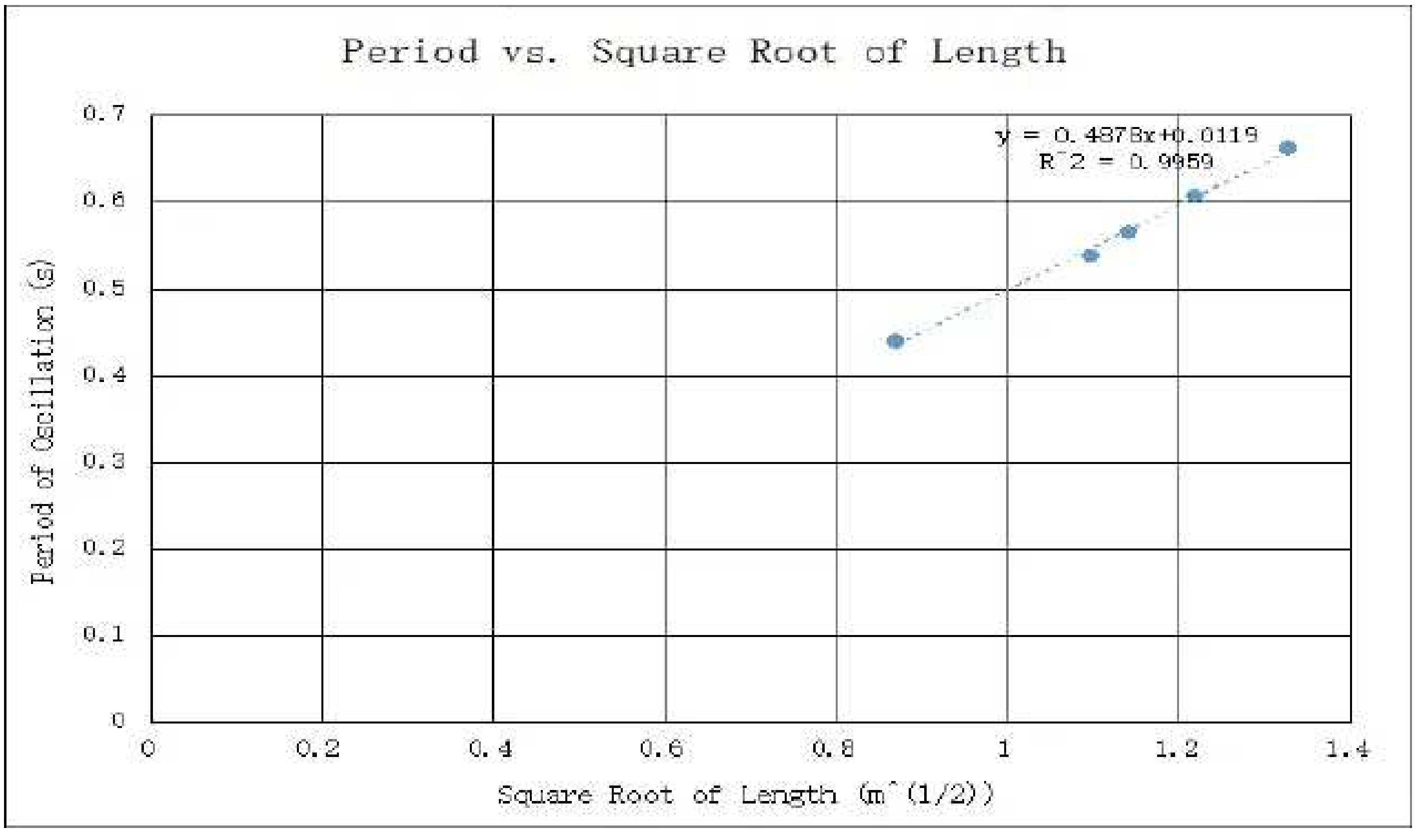
Length (m)	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trial 4 (s)	Trial 5 (s)
0.4400	1.3242	1.3272	1.3282	1.3286	1.3247
0.3700	1.2186	1.2186	1.2194	1.2168	1.2183
0.3200	1.1416	1.1443	1.1376	1.1387	1.1407
0.2900	1.0970	1.0961	1.0971	1.0971	1.0933
0.1940	0.8643	0.8712	0.8837	0.8642	0.8621

Average Oscillation (s)	Maximum Oscillation (s)	Minimum Oscillation (s)
1.3266	0.0020	0.0024
1.2183	0.0011	0.0015
1.1406	0.0037	0.0030
1.0961	0.0010	0.0028
0.8691	0.0146	0.0070

Analysis:

Graphs of Period vs Length, and Square root of length are shown below. In order to plot the period vs the square root of length, the appropriate values have been calculate.





Length (m)		Average Measured Period (s)
0.4400	0.6630	1.3266
0.3700	0.6083	1.2183
0.3200	0.5657	1.1406
0.2900	0.5385	1.0961
0.1940	0.4405	0.8691

Discussion:

The Period vs Length and the Period vs Square Root of Length graphs show a definite trend in that the period increases as the length increases. As discussed in the Theory section, the period of a Simple Pendulum is given by

Therefore, it was expected that T would depend on and not L. The period should be proportional to and the slope of the straight line should be the factor in front of which is.

The Expected Slope:

Measured Slope: 0.4878

Percent Error = =63.4%

These errors could be from inherent errors in the measuring of time, length (due to precision of the ruler), and the measurement of the angle (due to measurement).

Part 3 Time vs Angle

Procedure:

One of the main assumptions in deriving the equations for a Simple Pendulum is the small-angle approximation, which leads to the period being independent of the maximum angular amplitude. The oscillation period was calculated using the weight from Part 2 while increasing the angle of displacement. This was performed in ten different trials using ten different angles.

Length of String (Used through all trials): L=0.44m

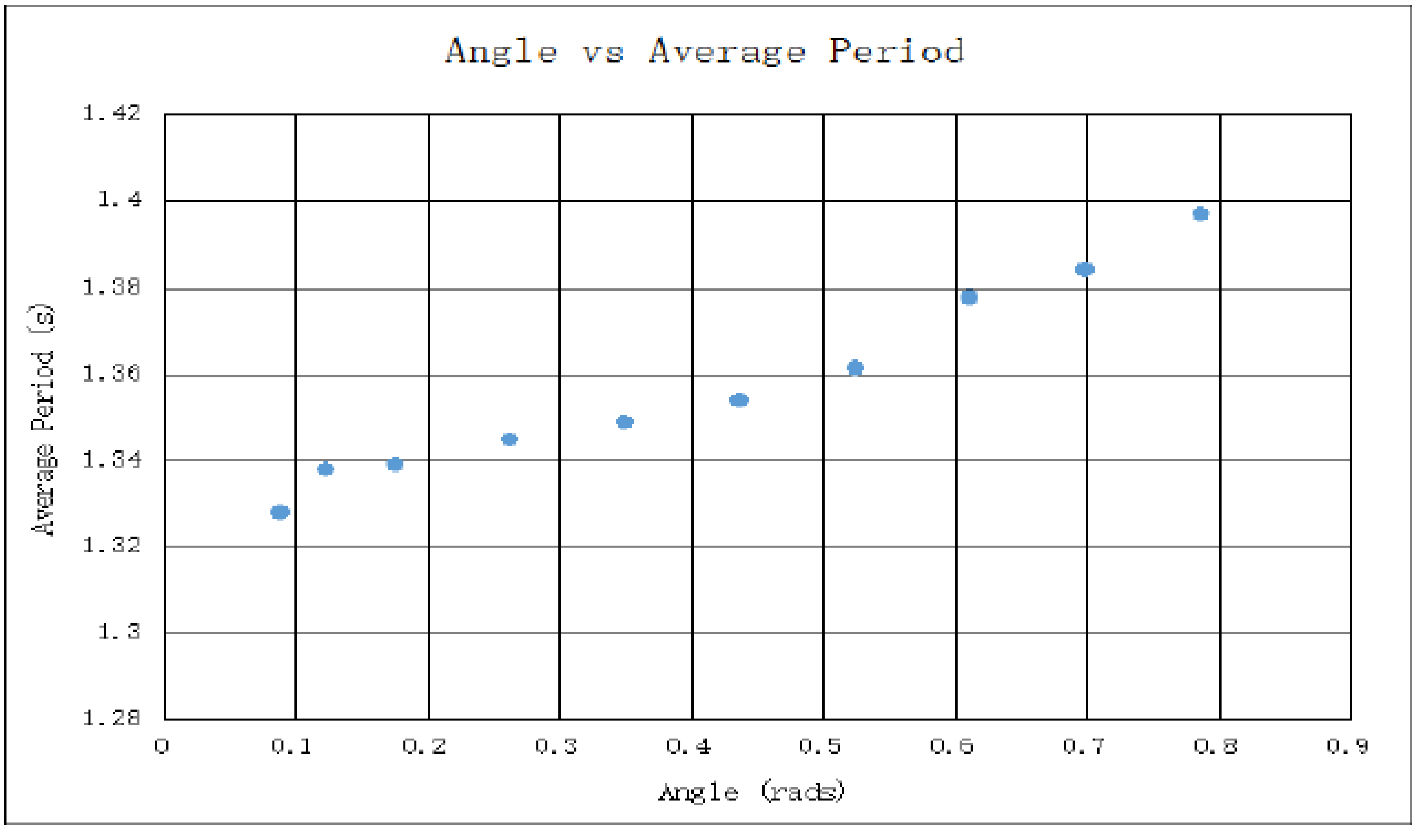
Mass of Weight (Used Through all trials): m=0.02333kg

ϴ (^{0})	Trial 1	Trial 2	Trial 3
7	1.3361	1.3418	1.3365
5	1.3272	1.3286	1.3286
10	1.3396	1.3370	1.3410
15	1.3435	1.3423	1.3494
20	1.3464	1.3506	1.3496
25	1.3540	1.3548	1.3537
35	1.3788	1.3770	1.3775
40	1.3859	1.3829	1.3842
45	1.3949	1.3955	1.4014
30	1.3625	1.3599	1.3622

ϴ (^{0})	Average Period	Maximum (s)	Minimum (s)

	(s)		
7	1.3381	0.0037	0.002
5	1.3281	0.0005	0.0009
10	1.3392	0.0018	0.0022
15	1.3451	0.0043	0.0028
20	1.3489	0.0020	0.0025
25	1.3542	0.0006	0.0005
35	1.3778	0.0010	0.0008
40	1.3843	0.0016	0.0014
45	1.3973	0.0041	0.0024
30	1.3615	0.0010	0.0016

Analysis:



Discussion:

Based on the results, the small angle approximation for the Simple Pendulums for angles <10⁰ sinϴ is approximately ϴ as shown in class. This is due to the angle being so small it is practically zero.

Conclusion:

Although this lab was simple, it was an effective way to study the period of a simple pendulum. We were able to show experimentally in

Part 1 and Part 3 that the period of the pendulum does not rely on the mass or angle of the pendulum. It was also shown experimentally in Part 2 that the pendulum does depend on the square root of the length. The lab procedure was easy to follow. Even though there was a high percent error, the percent error could be found in the measurements of the lengths and angles. These errors are basic

human errors that are hard to come by.