Report 1: Simple Harmonic Motion (SHM) in the Form of a Pendulum

Class (e.g. A21, C18, etc.)	Group Number (e.g. Group 1, 2, etc.)
C23	**4**

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Module Title: Foundation Science A		**Module Convenor:** Stephen Ntiri Asomani
Coursework Title: Report 1: Simple Harmonic Motion in the Form of a Pendulum.		**Module Code:** CELEN039

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ABSTRACT:

- The relationship between a pendulums length and time period can be accurately modelled using Christiaan Huygens's law; T=2Πl/g^1/2
- A pendulum was measured the time of completing ten cycles at a fixed angle of radians. And the experiment was repeated each time reducing the same length of this pendulum.
- Period of oscillation was positively related to pendulum length. The conclusion was in perfect agreement with Christiaan Huygens's law: T=2ΠL/g^1/2

OBJECTIVES:

The objective of this part of the experiment is to investigate the relationship between the period of oscillation of a pendulum and its length.

INTRODUCTION:

- Oscillation occurs when an object is shifted from an equilibrium point in a way that causes a force toward the equilibrium point that is in the opposite direction of the movement. Simple harmonic motion is the simplest model of oscillation. Dutch physicist and astronomer Huygens invented the pendulum clock based on the principle of isochronism of pendulum discovered by Italian physicist and astronomer Galileo.
- The relationship between a pendulums length and time period can be accurately modelled using Christiaan Huygens's law; T=2ΠL/g^1/2
- Due to the calculation period, only the place where the maximum displacement is considered, namely the amplitude A, is a scalar (the same below), thus: F=kA;
- According to the centripetal force formula F=mω^2r;
- Since the radius is the amplitude, then F=mω^2A;
- The definition is kA=mω^2A;
- Subtract A from both sides, and you get k=m omega ^2;
- This form of deformation ω^2=k/m;
- Omega ^ 2 = 1 / m/k;
- 1 / (m/k) omega =);
- T=2π(1/ω) is obtained by the diagonal velocity formula ω=2π/T;
- Plug in the previous calculation to get T=2 π √(m/k);
- Notice that this is the general formula for finding the period of simple harmonic motion. They just don't teach it. Now let's derive the simple pendulum formula.
- When the swing Angle is very small, it can be approximated: sinθ=F/mg=x/L;
- F=m*g*x/L;
- Refer to the simple harmonic motion definition F=k*x, one-to-one correspondence. k=mg/l;
- k is substituted into the general harmonic motion period formula T=2 π √(m/k);
- T=2 π √(m/(mg/L));
- Eliminate m and simplify to T=2 π √(L/g).

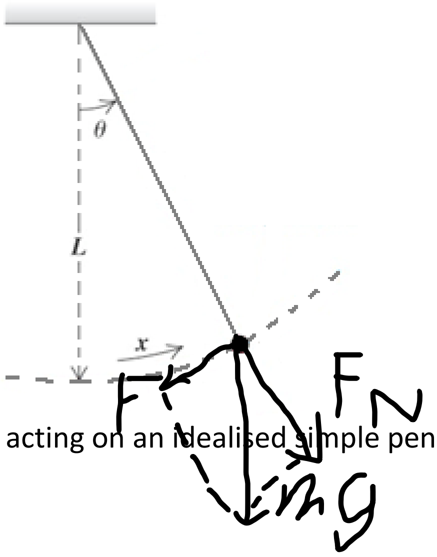

Figure 1. Forces acting on an idealised simple pendulum.

ASSUMPTIONS:

- A pendulum can move in simple harmonic motion.
- The system is frictionless.
- The string is massless.
- The only thing affecting the pendulum is gravity, which has a constant force of 9.8m/s^2.

APPARATUS

- Pendulum bob
- String
- Test frame
- Stopwatch
- Ruler

PROCEDURE

Using the apparatus above, set the length of the pendulum to 65 cm and record this value as measurement 1 in Table 1.

Start the pendulum bob swinging through an angular amplitude of 0.1 radians (approximately 6-degree angle). The angular amplitude was represented by θ in figure 1, and associated displacement (x) from the equilibrium position was referred to as the amplitude of the pendulum.

Measure the time for the pendulum bob to complete 10 periods, then calculate the corresponding average time for 1 period, record these values in Table 1.

Repeat the step above for different lengths of the pendulum. For example, the length of the pendulum should be reduced by approximately 2.5cm for each new measurement.

Calculate the predicted time period for the pendulum for each value of length and record these values in Table 1.

There were uncertainties associated with measured and predicted values. And we can use the formulae provided to calculate the uncertainty in the measured and predicted values.

Finally, the predicted value would agree with the measured value if there were values, they have in common when considering the uncertainty.

RESULTS:

T_m = 10T/10

$$T_p = 2\pi\sqrt{\frac{l}{g}}$$

$$T_{p1} = 2\pi\sqrt{\frac{L_1}{g}} = 2 \times 3.14 \times \sqrt{\frac{0.65}{9.81}} = 2 \times 3.14 \times 0.257 = 1.617$$

Table 1. Measured and predicted period.

	L (m)	$L^{1/2}$ $(m^{1/2})$	$10T$ (s)	Measured period T_m (s)	Predicted period T_p (s)
1	**0.65**	0.806	15.95	1.595	1.617
2	**0.625**	0.791	15.63	1.563	1.585
3	**0.60**	0.775	15.30	1.530	1.553
4	**0.575**	0.758	15.04	1.504	1.520
5	**0.55**	0.742	14.70	1.470	1.486
6	**0.525**	0.725	14.48	1.448	1.452
7	**0.50**	0.707	14.07	1.407	1.417
8	**0.475**	0.689	13.78	1.378	1.381

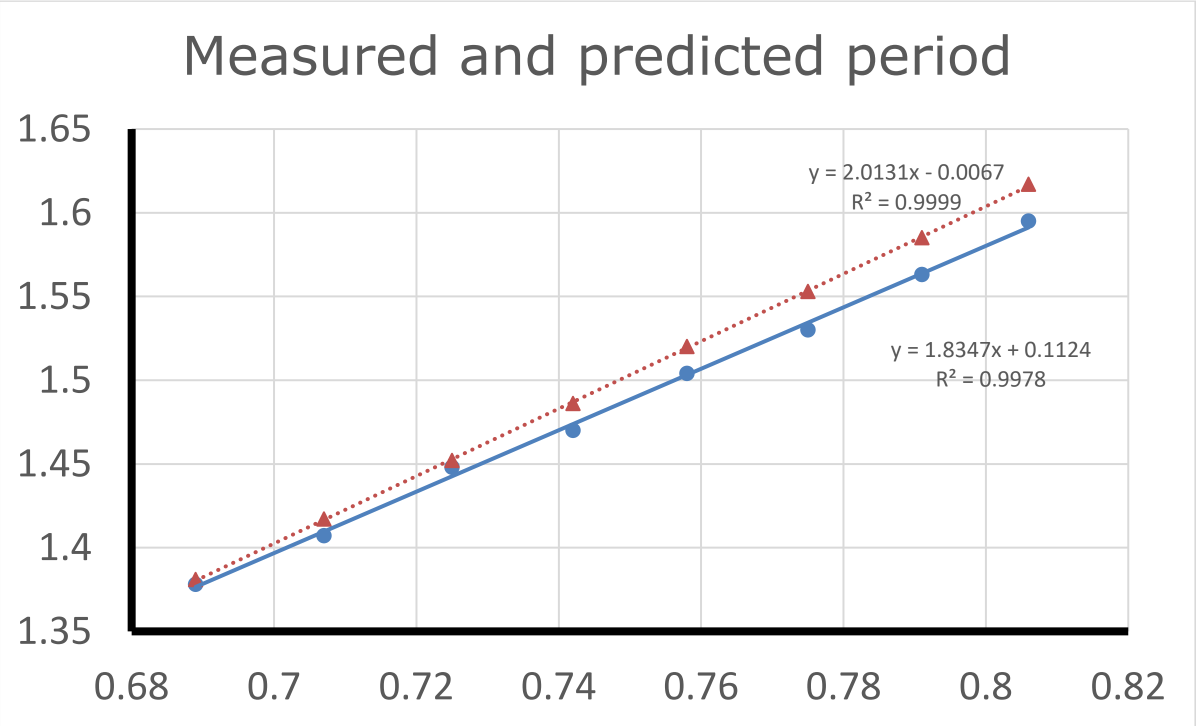

Table 2. Measured and predicted values for the trendline coefficients.

	Predicted Value	**Measured Value**
Gradient $(\mathbf{m^{-1/2} \cdot s})$	2.013	1.8347
Intercept $(\mathbf{s})$	0.9999	0.9978

UNCERTAINTY ANALYSIS:

Table 3. Uncertainty associated with measured and predicted period.

Measurement no.	$\boldsymbol{\delta L}$ (m)	$\boldsymbol{\delta L^{1/2}}$ $(\mathbf{m^{1/2}})$	$\boldsymbol{\delta 10T}$ $(\mathbf{s})$	$\boldsymbol{\delta T_m}$ $(\mathbf{s})$	$\boldsymbol{\delta T_p}$ $(\mathbf{s})$
1	**0**	0	0.2	0.02	0.0005
2	**0**	0	0.2	0.02	0.0003
3	**0**	0	0.2	0.02	0.0002
4	**0**	0	0.2	0.02	0.0004
5	**0**	0	0.2	0.02	0.0005
6	**0**	0	0.2	0.02	0.0005
7	**0**	0	0.2	0.02	0.0002
8	**0**	0	0.2	0.02	0.0004

DISCUSSION

From examining Table 1 it become clear that only one out of eight of the measured period values come within the corresponding predicted period value range; Since more than half of the measured values agreed with the predicted values, there was sufficient evidence to support the hypothesis from this experiment. The length L and the time T are both agree with the predicted values. Overall, the results from experiment are support the hypothesis.

The value of the coefficient of determination was found to be 0.9263 which implied that 92.63% of the variance of y can be explained by x. The product moment correlation coefficient was found to be 0.9263 suggesting a strong positive correlation between the length and period. Therefore, both correlation coefficients suggested a relationship between the rope's length and the period and provides evidence to support the hypothesis.

Having analyzed the results from Table 1, and Figure 2, there was a clear trend that as the value of length reduced, the measured period values become lower than the predicted values. This suggested there was an issue with the mathematical model used for the experiment is wrong or an error in the experiment technique. The results which did not agree with predicted values were all smaller than expected, therefore the most likely causes of this discrepancy are:

-the assumption that the acceleration due to gravity was constant at 9.8 m/s2 might not to be true, the value could be larger which would cause a smaller period to be record.

CONCLUSION:

To conclude, in this experiment, only one result obtained was found not to be within the corresponding predicted period value ranges, while for the other seven were found to be within the corresponding predicted period value ranges. In addition, neither of the values from the trendline agreed with the predicted values. It is suggested a strong relationship between the two variables plotted in figure 2. So the system can be used to prove the results.

The gravitational acceleration is higher, the rope has weight, and the whole system is not frictionless. More accurate instruments will be needed to calculate these values.