**Investigate Some Aspect of a Simple Harmonic Motion**

**Aim:** To determine the relationship between the length of a simple pendulum and the period of its oscillation.

**Background Information:** The oscillation of a simple pendulum is an example of simple harmonic motion (for small angles of oscillation, i.e. less than 10˚). The time period of this motion is given by the equation:

$T=2π √\frac{l}{g}$ [[1]](#footnote-1)

T = period of oscillation, s

l = length of pendulum, m

g = acceleration due to gravity, m.s-2

This equation indicates that the period of oscillation is proportional to the square root of pendulum length,

$$T∝ √l$$

**Hypothesis:** That as the length of a simple pendulum increases, the period of oscillation will also increase. In particular, that period will be proportional to the square root of pendulum length.

**Independent Variable:** The independent variable is the length of the pendulum, measured in metres. This will be changed by altering the length of string attaching the pendulum bob to the retort stand. The lengths used in this investigation will be: 0.2 m, 0.3 m, 0.4 m, 0.5 m, and 0.6 m.

**Dependent Variable:** The dependent variable is time period, measured in seconds. This will be measured by timing 10 complete oscillations then dividing this time by 10 to give the period of one oscillation.

**Controlled Variables:**

Mass of pendulum bob The same 50 g pendulum bob will be used for all experiments.

Pendulum arm The same type of string will be used for the pendulum in all experiments. A new piece of string will be used for each value of the independent variable to minimise any effects of wear, fraying or stretching of the string.

Pendulum suspension The pendulum string will be tied to the arm of a retort stand arranged so the pendulum hangs over the edge of the desk.

Release angle The pendulum will be released from an angle of 10˚. A protractor will be taped to the retort stand to allow this angle to be measured.

Method of release The pendulum bob will be pulled out to an angle of 10˚ with the string taught, then released manually.

Method of timing The period of 10 full oscillations will be measured using a stopwatch. Timing will commence at the moment the pendulum bob is released.

Environment The experiment will be done over the period of one hour in the same room to minimise changes in temperature, humidity and air pressure. The windows and doors will be kept shut and foot traffic minimised to reduce air currents in the room.

**Equipment:**

* 50 g mass
* 3 m string
* metre ruler (accuracy to 1 mm)
* retort stand
* desk
* stopwatch (accuracy to 1/100 s)
* protractor
* scissors
* tape
* pen and paper
* calculator

**Method:**

1. Place retort stand on desk and adjust so the clamp arm is hanging out over the edge of the desk as far as possible.
2. Measure and cut a piece of string 0.30 m long (0.2 m + 0.1 m for knots).
3. Tie one end of the string around the 50 g mass.
4. Tie the other end around the arm of the retort stand so that the length from the suspension point to the centre of mass of the pendulum bob is 0.2 m.
5. Tape the protractor to the vertical arm of the retort stand so that a release angle of 10˚ can be measured easily.
6. Take the stopwatch in one hand and pull the pendulum bob back 10˚ with the other.
7. Simultaneously release the pendulum bob and start the stopwatch, count 10 complete oscillations then stop the stopwatch.
8. Record results.
9. Repeat steps 7 and 8 five times.
10. Repeat steps 2-9 for each of the other lengths of string (0.3 m, 0.4 m, 0.5 m, and 0.6 m).

**Results:**

Table 1: Table of raw data showing the time for 10 oscillations of a simple pendulum at each of five different lengths of the pendulum, and processed data giving the average time period and half-range uncertainty for one oscillation.

|  |  |  |
| --- | --- | --- |
| **String length, m****(± 0.001 m)** | **Time for 10 oscillations, s (± 0.3 s)** | **Average time period for 1 oscillation, s (± half range)** |
| **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** | **Trial 5** |
| 0.2 | 9.62 | 9.35 | 9.47 | 9.23 | 9.46 | 0.94 ± 0.02 |
| 0.3 | 11.44 | 11.73 | 11.67 | 11.35 | 11.48 | 1.15 ± 0.02 |
| 0.4 | 13.42 | 13.63 | 13.77 | 13.25 | 13.59 | 1.35 ± 0.03 |
| 0.5 | 14.66 | 14.64 | 14.93 | 14.57 | 14.82 | 1.47 ± 0.02 |
| 0.6 | 16.43 | 16.52 | 16.18 | 16.65 | 16.61 | 1.65 ± 0.02 |

**Estimation of Uncertainties:**

We estimated the uncertainty in length to be the smallest scale division on the ruler (0.001 m).

We estimated the uncertainty in time period using the half-range method.

**Conclusion:**

The mathematical relationship between the length of my simple pendulum and the period of its oscillation was:

$$T=2.1\sqrt{l}$$

So, for a simple pendulum, the period of oscillation is proportional to the square root of the length of the pendulum.

We varied the length of our pendulum from 0.2 m to 0.6 m. For a pendulum of length 0.2 m, the average period for one oscillation was 0.94 s. For a pendulum of length 0.6 m, the average period for one oscillation was 1.65 s. These results demonstrate that the period of oscillation increases with length of a pendulum. From Graph 1, it can be seen that, although period increases with the length of the pendulum, the realationship is not linear. Plotting a ‘power’ curve though our data gave a square-root relationship (x0.5059) with an R2 value of 0.998, indicating that the curve was a very close fit to the data. A square-root relationship between period and length is consistent with equation for a simple pendulum

$$T=2π √\frac{l}{g}$$

Substitution of the value of gravity (g=9.81 ms-2) into this gives a relationship of $T=2.0\sqrt{l}$, which is very similar to my equation. I believe that my method allowed for the effective control of all major variables. In addition, the small size of the error bars on the graph and the high R2 value of the trendline lend further confidence to my equation.

Evaluation and Improvements:

Describe weaknesses and limitations in your experiment and give a realistic improvements for each.

**References:**

Giancoli, D. C. *Physics: Principles with Applications*, 5th ed. New Jersey: Prentice Hall, 1980, 309-346.

1. D. C. Giancoli, *Physics: Principles with Applications*, p. 319. [↑](#footnote-ref-1)