



Experiment P-46 Simple Pendulum



Objectives

- To learn about the period and frequency of a simple pendulum.
- To understand the difference between a simple pendulum and a real life pendulum.
- To examine the effects of length and mass on the pendulum's period.

Modules and Sensors

- PC + NeuLog application
- USB-200 module 
- NUL-226 Rotary motion logger sensor 

Equipment and Accessories

▪ Utility stand	1
▪ Right angle clamp	1
▪ Extension clamp	1
▪ 35 cm thread	1
▪ 10 g slotted mass	2

- The items above are included in the NeuLog Mechanics kit, MEC-KIT.

Introduction

A simple pendulum is a hypothetical apparatus consisting of a point mass hanged on a thread. The thread's mass is negligible and it is free to vibrate without friction. The motion of the hanged mass is harmonic, it swings back and forth at a constant amplitude. This is true as long as the angle from the original position is small. The amplitude of a real life pendulum swing declines over time because it is subjected to friction.

A pendulum's **period** is the time it takes to the hanged mass to swing back and forth. The period of a simple pendulum depends on the length of the thread and the gravitational acceleration (g); not on the mass of the pendulum. A pendulum with a long thread has a greater period than one with a shorter thread. The period and the frequency ($1/\text{period}$) are independent of the initial angular position (for small swings).

The following equations describe the period (T) and the frequency (f) of a simple pendulum:

$$T = 2\pi \sqrt{\frac{L}{g}}$$

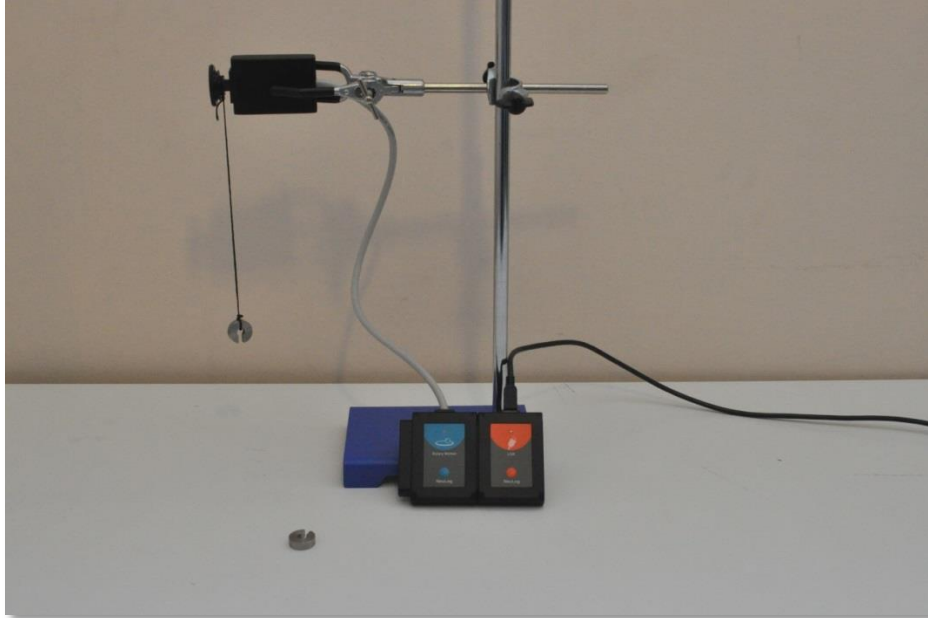
$$f = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

In this experiment, we will measure the angular position over time of a swinging hanged mass connected to a rotary motion sensor through a thread. Different lengths and different masses will be examined, and the expected period will be compared with the measured period.

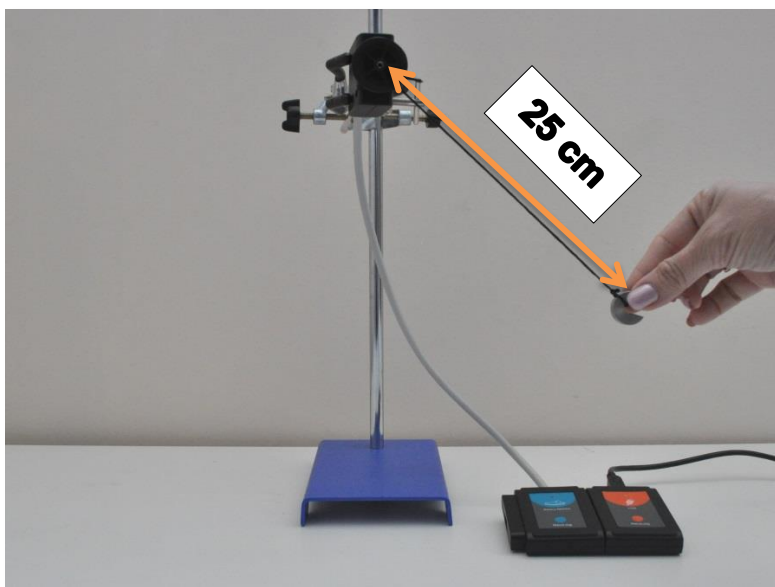
Procedure

Experiment setup



1. Set up the experiment as shown in the picture below.



2. Tie one end of the thread to the 10 g mass and the other end to the rotary motion sensor. The length of the thread should be 25 cm (including the part between the thread and the rotary sensor axis) as in the picture below.



Sensor setup

3. Connect the USB-200 module  to the PC.
4. Check that the rotary motion logger sensor  is connected to the USB-200 module.

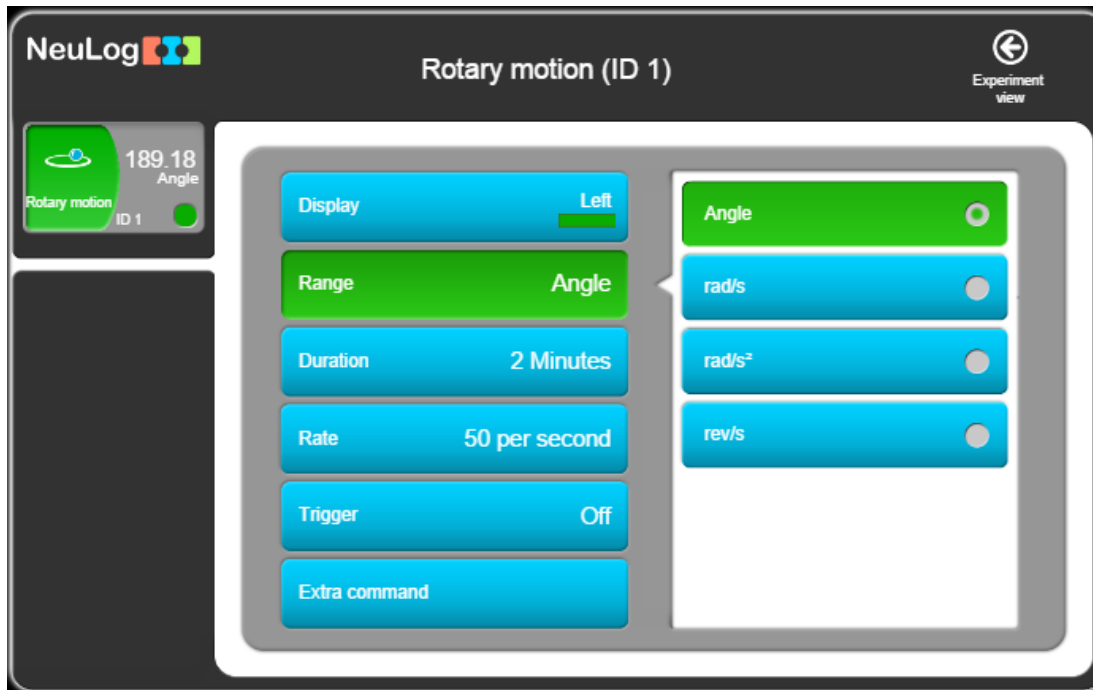
Note:



The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

5. Run the NeuLog application and check that the rotary motion sensor is identified.

Settings

- Click on the rotary motion **sensor's module** box.
- Select the Angle button to change the sensor's mode.





- Click on the  icon to go back to the graph.
- Click on the **Run experiment** icon  and set the:
Experiment duration to 2 minutes
Sampling rate to 50 per second

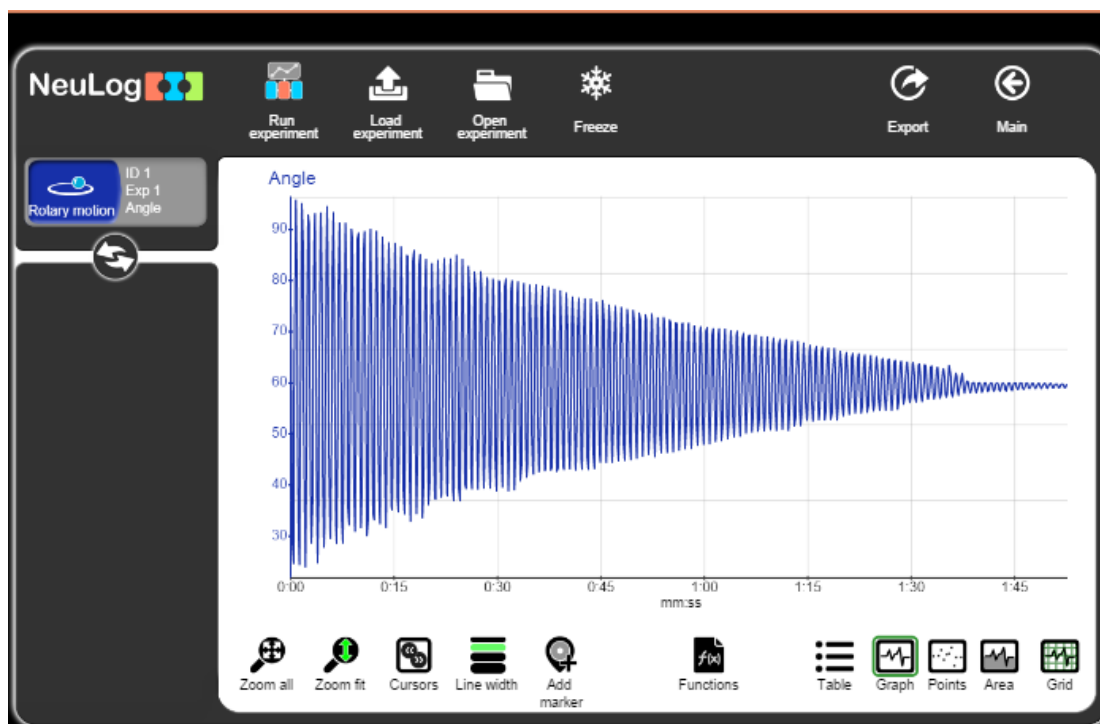
Testing and measurements



10. Before starting the experiment, fill in the "Expected period [s]" column in the table below (use the simple pendulum equation).

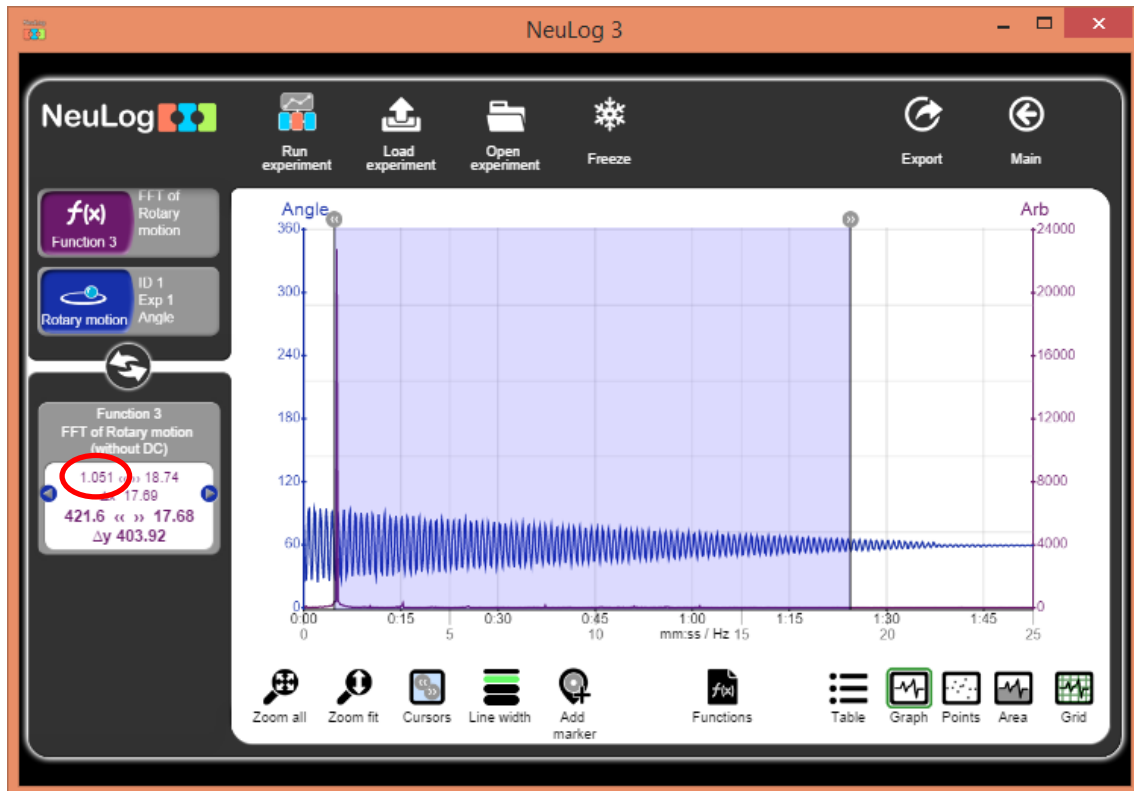
Thread length [m]	Hanged mass [g]	Expected period [s]	Measured period [s]
0.25	10		
0.2	10		
0.2	20		

11. Hold the 10 g mass about 60 degrees to the right of the starting position (in which the weight is hanging down).
12. Click on the **Extra command** button on the **Sensor's Module** box menu and then click on **Reset**.
13. Move the 10 g mass towards the ground checking that the numbers increase but they are not higher than 300°. If they are higher than 300°, reset the sensor from the other side and check again.
14. Hold the 10 g mass about 30 degrees to the right of the starting position again (make sure the angle is around 30°).
15. Let go of the 10 g mass and click on the **Record** icon  to start the measurement.

16. At the end of the measurement, click on the **Zoom fit** icon .
17. Your graph should be similar to the following:



18. Save your graph.
19. Click on the **Cursors** icon  and select the part where the angle is relatively high.
20. Click on the **Functions** icon  and select **FFT of A (without DC)**
21. Put one of the cursors on the FFT peak to see its value.



Look at the frequency calculation. The frequency units are Hz, which is defined as the number of cycles per second.

22. We can see that in the sample experiment the frequency is 1.051 Hz = 1.051 cycles/second.

The period (of one cycle) = $1/1.001$ second = 0.99 second (~1 second)

23. Calculate the period according to the example above and fill the "Measured period [s]" column with your answer.
24. Set up the 10 g mass on a 20 cm thread and repeat the experiment.
25. Set up two 10 g masses on a 20 cm thread and repeat the experiment.

Summary questions

1. Did the length of the thread affect the period? How?
2. Did the hanged mass affect the period? How?
3. Was the measured period any different from the expected period? If there was a difference, what could be the cause?
4. Which factor caused the mass to stop swinging?
5. According to your results, suggest an application for a pendulum and explain.