Experiment P-2
Walking Analysis

Physics

Objectives

- To learn about motion parameters.
- To study the motion parameters of walking.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-213 Motion logger sensor
- BAT-200 Battery module

Equipment and Accessories

▪ 3 m measuring tape
▪ Sellotape

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

Introduction

The position (or displacement) of a moving object is marked by the letter x. The object's velocity is marked by the letter v. The velocity is determined by the ratio between the change in position and the time it took for the object to move. The formula is:

$$\mathbf{v\ (average)} = \frac{\mathbf{x\ (final)\ -\ x\ (initial)}}{\mathbf{t\ (final)\ -\ t\ (initial)}}$$

When the velocity is constant it can be described as in the formula above. When the velocity changes with time, dividing the change in position by the time will give us the object's average velocity. In order to calculate the object's momentary velocity (v(t)), we divide a very small section of the position change by the time difference.

Acceleration is the rate at which an object changes its velocity and it is marked by the letter a. The acceleration is determined by the ratio between the change in velocity and the time it took. The formula is:

$$\mathbf{a\ (average)} = \frac{\mathbf{v\ (final)\ -\ v\ (initial)}}{\mathbf{t\ (final)\ -\ t\ (initial)}}$$

The formula above describes average acceleration (or constant acceleration). In order to calculate the object's momentary acceleration (a(t)), we divide a very small section of the velocity change by the time difference.

In this activity we will measure the student's position and velocity while he/she walks back and forth from a wall.

Procedure

Experiment setup

1. Place a 3 m measuring tape perpendicular to the wall.

2. Use the sellotape to mark two lines on the floor, at 2 m and at 0.5 m from the wall.

Sensor setup

3. Connect the USB-200 module to the PC.

4. Check that the motion 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.

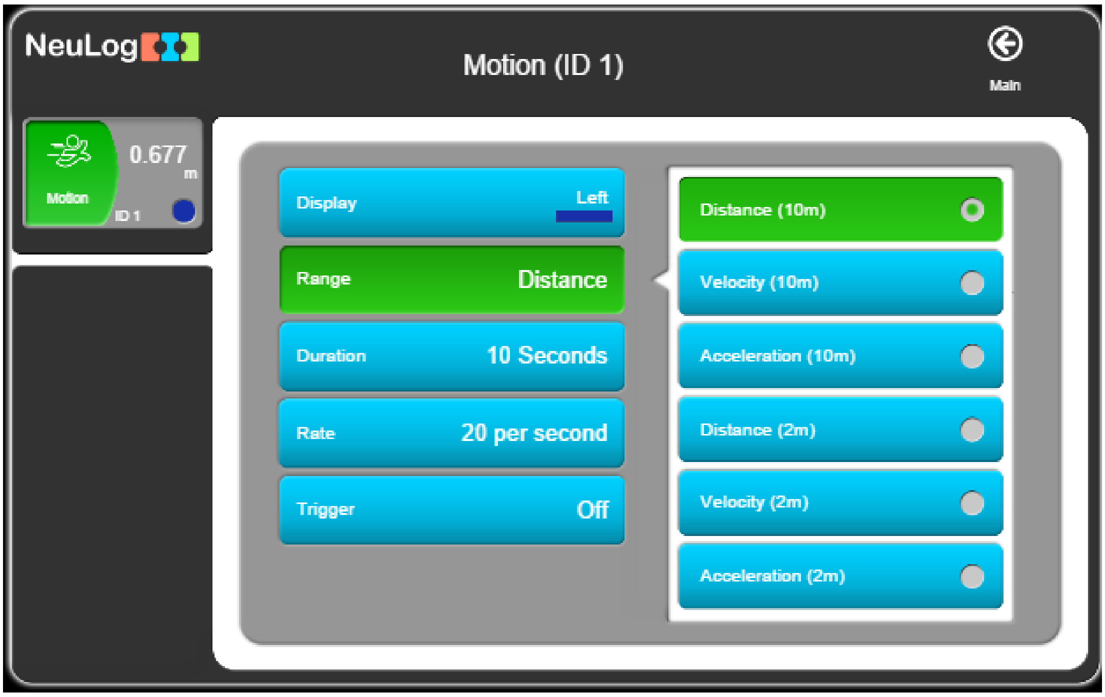
5. Run the NeuLog application and check that the motion sensor is identified.

Settings

6. Click on the **Sensor's Module** box.

7. Click on the **Range** button.

8. Select the Distance (10m) button to change the sensor's mode to position.



9. Set the:

   Experiment duration to 30 seconds
   Sampling rate to 20 per second

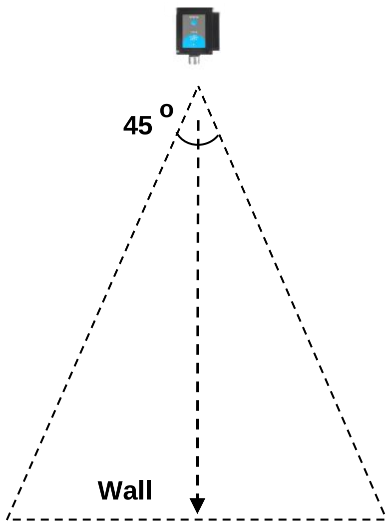
Testing and measurements

Note:

The sensor measures the distance from an object by sending a short pulse of sound that we cannot hear (ultrasonic) and measures the time it takes the echo to return.

The sound beam angle is approximately 45°. The sensor measures the time of the first received echo.

Make sure to remove any items located In the beam range, between the motion sensor and the wall.



10. Move the motion sensor towards and away from the wall and check that it measures the distance of the sensor from the wall.

    The position (distance from the sensor) is displayed on the module box in the screen.

11. Disconnect the sensor from the USB-200 module and connect it to the battery module.

12. Stand two meters away from the wall, at the beginning of the 2 m mark, while holding the sensor in front of you.

13. Begin the measurement by pressing the sensor's **Start/stop** button. The sensor's LED should turn on.

14. Walk in a constant rate and stop at the 0.5 m mark.

15. Walk back without turning around so the sensor is still facing the wall.

16. Continue to walk back and forth until the measurement is over.

Note:

You should see that the sensor's red LED is on during the measurement. If the LED turns off it means the experiment time is over.

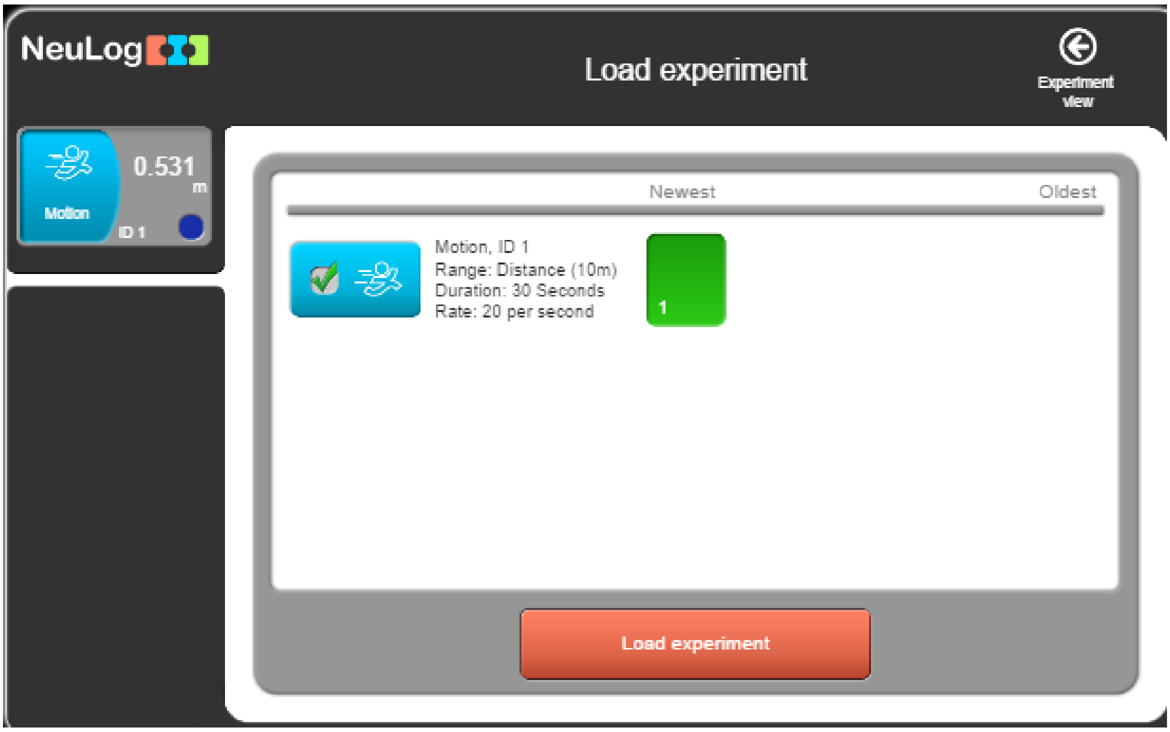
The measured data will be stored in the sensor's memory.

17. Disconnect the sensor from the battery module.

18. Connect the motion sensor to the USB-200 module.

19. Click on the **Load Experiment** icon .

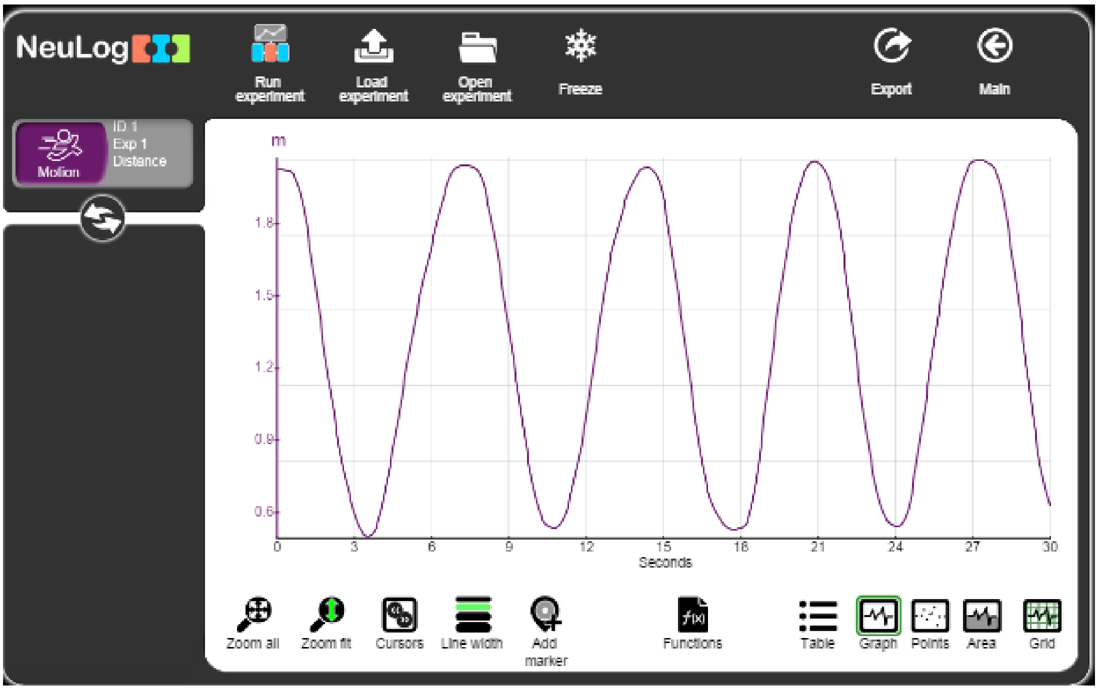
The menu shows a list of experiments stored in the sensor's memory (up to 5).



20. Choose the required experiment and click on the **Load Experiments** button.

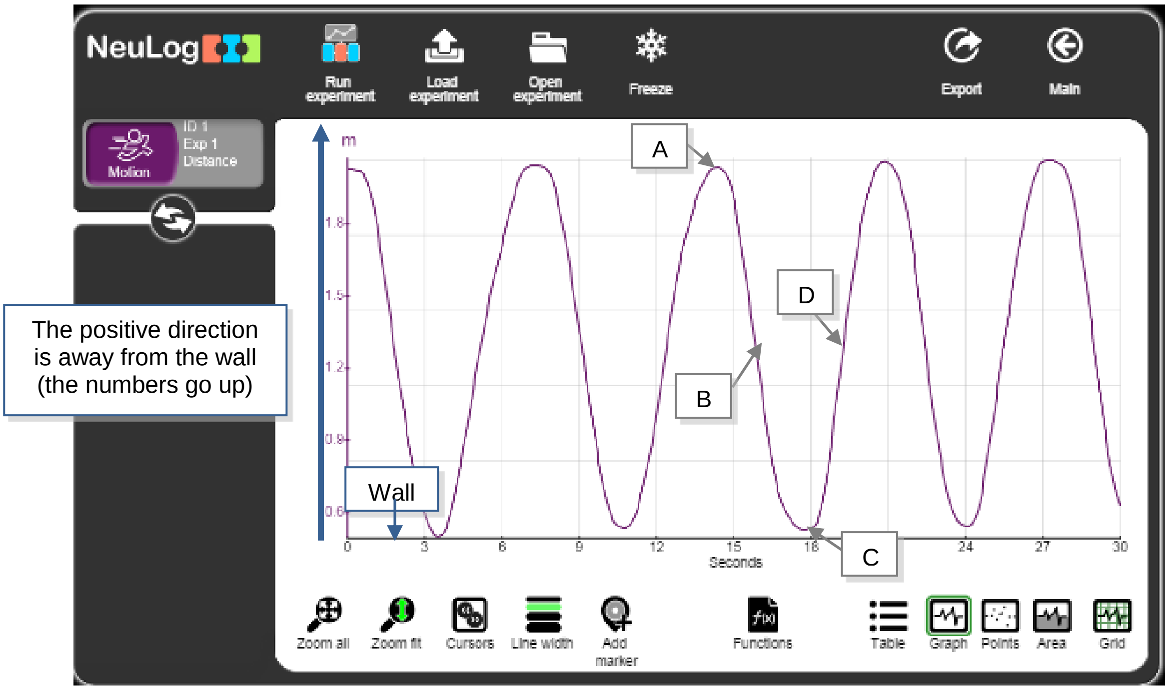
21. Click on the **Zoom fit** icon .

22. Your graph should be similar to the following:



23. Click on the **Export** Icon  and then on the **Save value table (.CSV)** button to save your graph.

24. Click on the  icon to go back to the graph.



25. What is the student's position (distance from the wall) in points A, B, C and D?

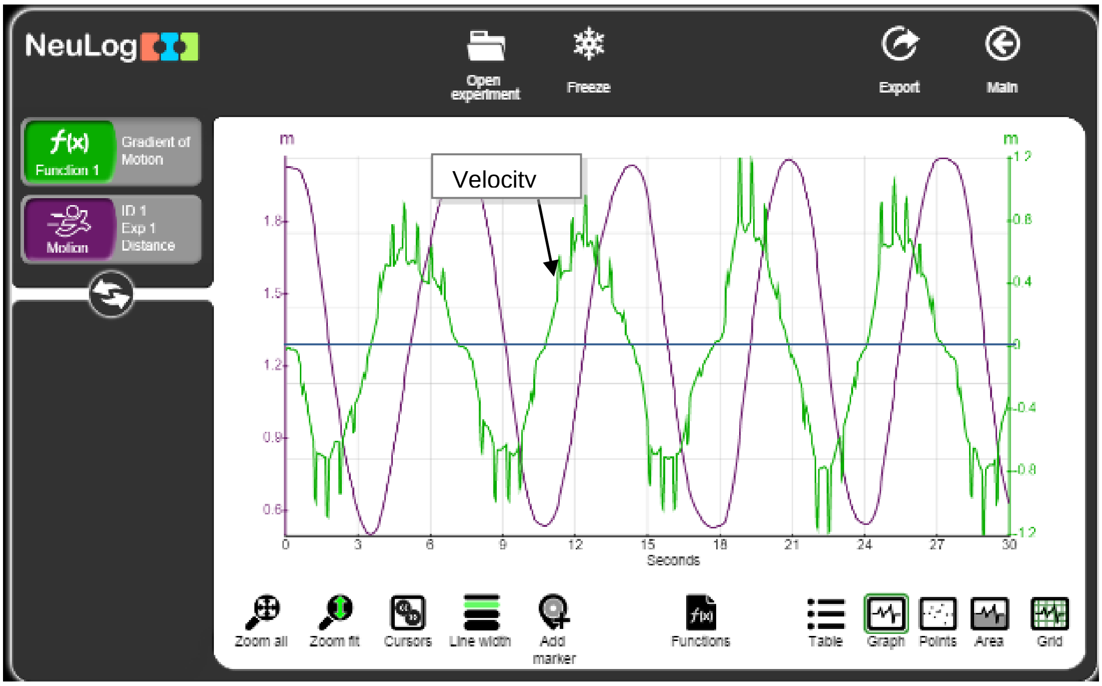
26. What is the student's velocity in points A, B, C and D: zero, positive, or negative (pay attention to the positive direction)?

27. How do you think the velocity graph will look like?

28. Click on the **Functions** icon .

29. Click on the **Functions** button on the left of the screen and then click on the **Gradient of A** button.

30. Your graph should be similar to the following:



31. This graph is similar to the position vs. time graph but the minimum and maximum points in the velocity vs. time graph actually represents different positions.

Challenge research

32. Repeat the position and velocity measurements, but this time move faster or slower than before.

Summary questions

1. What is the student's position at the maximum and the minimum point of the velocity graph?

2. What is the difference in the velocity while walking towards the wall rather than away from it? Refer to the -/+ sign and the total value. If there is a difference between the values, explain it.

3. After conducting the challenge research, explain the differences between the two graphs (compare position and velocity).