# Experiment P-10
# Ohm's Law

Physics

## Objectives

- To study the relationship between the voltage applied to a given resistor and the intensity of the current running through it.

## Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-201 Voltage logger sensor
- NUL-202 Current logger sensor

## Equipment and Accessories

| | |
|---|---|
| ▪ Circuit board | 1 |
| ▪ 6 V cell holder | 1 |
| ▪ Knife switch | 1 |
| ▪ Black 4 mm connector cable | 1 |
| ▪ Red 4 mm connector cable | 1 |
| ▪ 10 Ω mounted resistor | 1 |
| ▪ 47 Ω mounted resistor | 1 |
| ▪ 1.5 V battery (type D) | 4 |

- The items above are included in the NeuLog Electricity kit, ELE-KIT.

## Introduction

Electric current is the rate of charge flow past a given point in an electric circuit. It is measured in Coulombs/second which is called Amperes (symbol: A).

A current flows through a conductor as long as there is an excess of electrons at one end of the conductor and a deficiency at the opposite end. The electrical source creates this excess of electrons. The potential is the ability of the source to perform electrical work. The work accomplished in a circuit is the result of the difference of potential (the voltage) at the two ends of the conductor. It is measured in Volts (symbol: V).

When free electrons move through the circuit, they encounter atoms that oppose to the flow. This opposition to the flow is called resistance and it is measured in Ohms (symbol: Ω). The amount of resistance depends on the material's size, shape and temperature.

Ohm's law was first observed by George Ohm in 1827. It defines the relationship between these three fundamental factors: current, voltage and resistance. According to this law the current is directly proportional to the voltage and inversely proportional to the resistance.

The mathematical equation that describes this relationship is:

$$\mathbf{I} = \frac{\mathbf{V}}{\mathbf{R}}$$

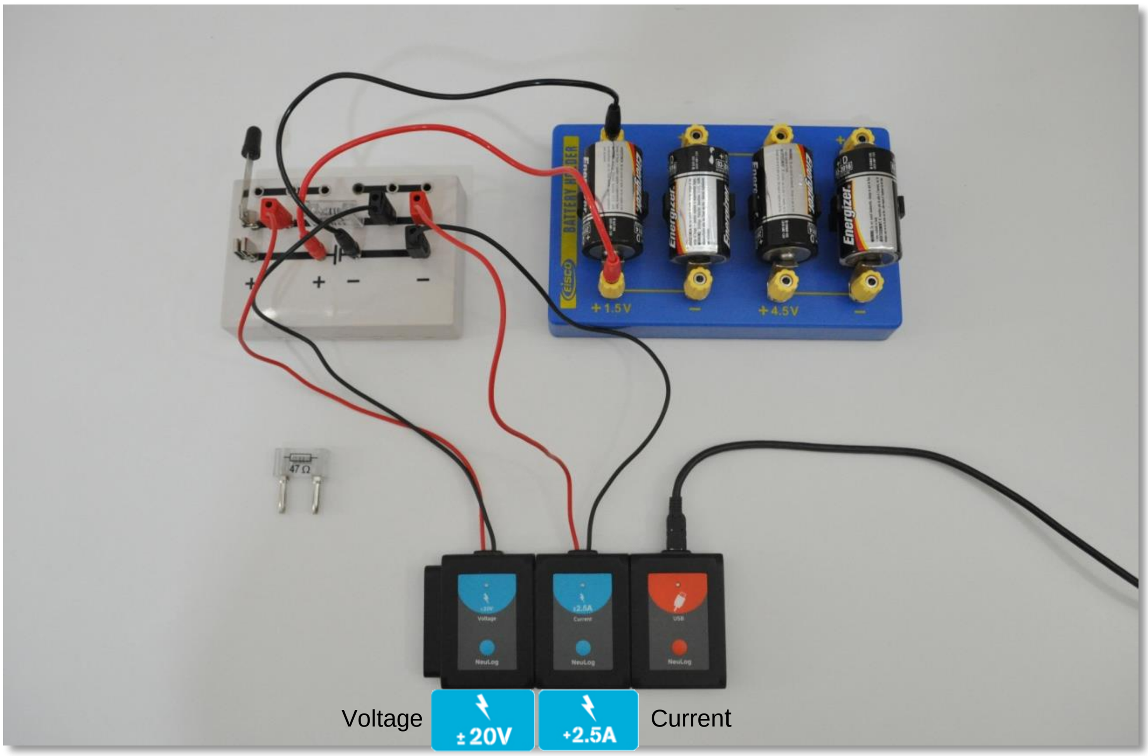
Where:
**I**= current (amperes)
**V**= voltage (volts)
**R**= Resistance (ohms)

In this experiment you will be able to find out this relationship by applying a variable voltage to a given resistance and by measuring the generated electric current and voltage.

# Procedure

## Experiment setup

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




2. Connect the 10 Ω resistor to the middle of the circuit board.

3. Connect the knife switch next to the "+" at the side of the board, while leaving it open.

4. Connect the black cable of the current sensor next to the "-" at the side of the board.

5. Connect the red cable of the current sensor to the socket next to the black cable which is located on the next board line.

6. Connect the black cable of the voltage sensor between the 10 Ω and the red cable of the current sensor.

7. Connect the red cable of the voltage sensor between the 10 Ω resistor and the knife switch.

8. Connect a red 4 mm connector cable to the "+" side of the battery sign.

9. Connect a black 4 mm black cable to the "-" side of the battery sign.

10. Place four 1.5 V (type D) batteries in the 6 V cell holder (the "+" side of the battery should be on the "+" side of the cell holder).

11. Connect the other end of the red 4 mm connector cable to the socket next to the "+ 1.5 V" writing at the 6 V cell holder.

12. Connect the other end of the black 4 mm connector cable to the socket on the other side of the battery (the socket next to the "-" writing).

## Sensor setup

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

14. Check that the voltage and current sensors are connected to the USB-200 module in a chain.

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.

15. Run the NeuLog application and check that the sensors are identified.

## Testing and measurements

16. Click on the **Single Step** icon for the first measurement. This will show and store the current (A) measured with 0 V.

17. Click on the **Table** icon on the bottom part of the screen. A table will be displayed for data record.

18. Close the switch to apply 1.5 V to the circuit and click the **Single step** icon again.

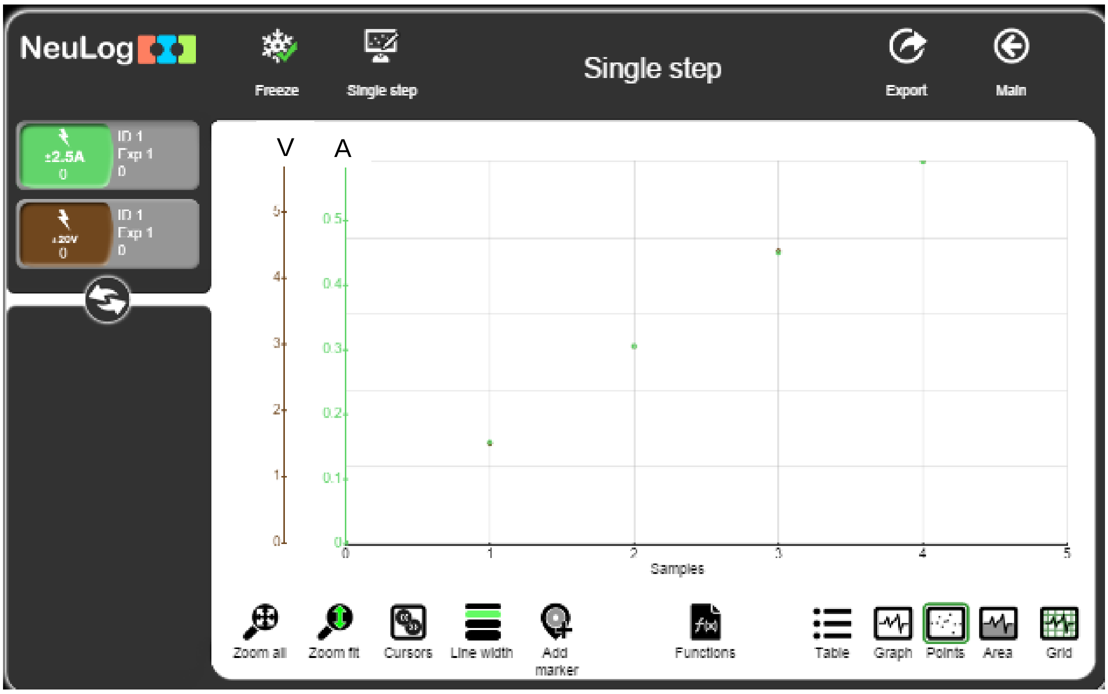
19. Move the red 4 mm connector cable to the socket next to the "+ 3 V" writing and click on the **Single step** icon again, for a new measurement.

20. Repeat the measurement in single step mode for 4.5 V and 6 V by moving the red cable to the matching sockets.

21. Open the knife switch.

22. Click on the **Graph** icon .

23. Your graph should be similar to the following:



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

25. The measured voltage values are very close to the battery voltage values but always lower. That is because the internal resistance of the batteries reduces them.

    The current increases as the voltage increases (more batteries are added to a circuit).

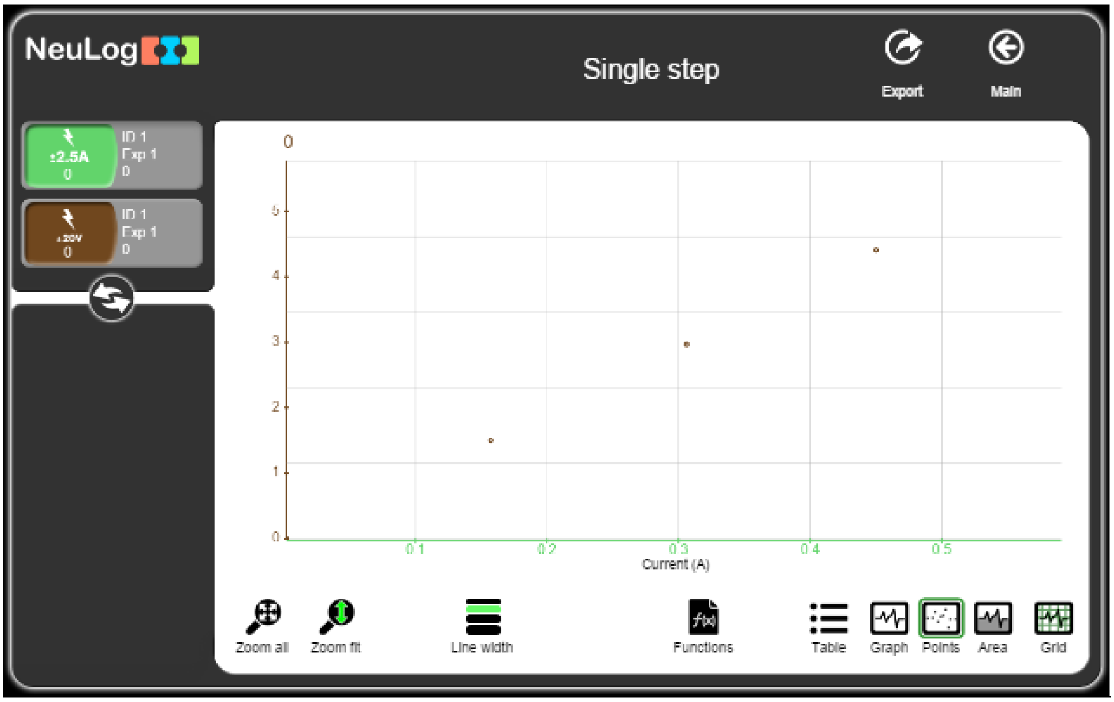
26. Click on the **Functions** icon and then on the X axis button.

27. Click on the sensor button and choose Current.

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

29. In order to investigate the relationship between current and voltage, the x axis in the graph represents the current and the y axis represents the voltage.

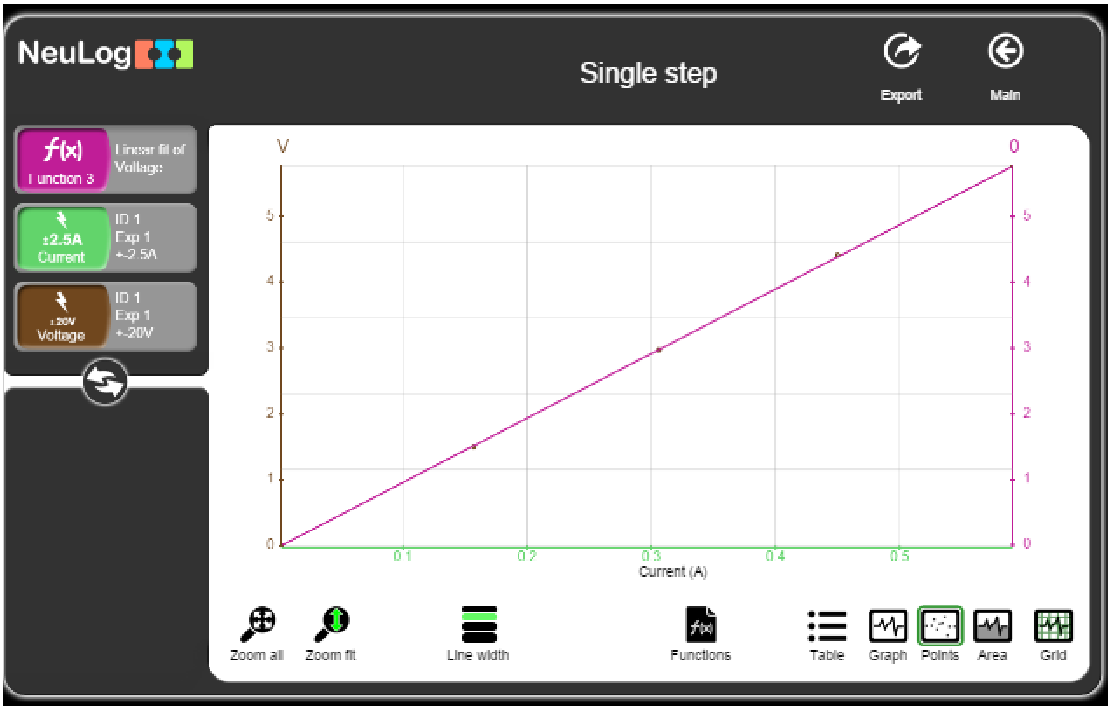
30. Your graph should be similar to the following:



31. Click on the **Functions** icon  and make sure that the voltage sensor is picked as Parameter A.

32. Click on the **Functions** button and then on **Linear fit of A**.

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




34. Click on the Linear fit module box; you will see the linear fit equation.

35. <u>The equation describing the relationship between x and y is:</u>


y= 9.8X-0.03

If we replace x and y with I and V, we will get the following equation:

V= 9.8 I- 0.03

The slope of the equation is the resistance of the circuit Ω.
R= 9.8 Ω (~10 Ω)

The results in our example fit ohm's law equation $\mathbf{I} = \frac{\mathbf{V}}{\mathbf{R}}$

## Challenge research

36. Repeat the experiment with a 47 Ω resistor instead of the 10 Ω resistor.

37. Repeat the experiment with the 10 Ω resistor but this time connect the end of the black 4 mm connector cable to the socket next to the "+ 1.5 V" writing and connect the end of the red 4 mm connector cable into the socket on the other side of the battery (next to the "-" writing). Continue to move the black cable to the "+ 3 V", "+ 4.5 V", and "+ 6 V" sockets.

## Summary questions

1. What happened to the current values after switching the resistors?

2. What happened to the voltage values after switching the resistors?

3. What was the resistance according to the slope of the graph after switching the resistors?

4. What happened to the circuit after switching the cables? How did it affect the results?