

Experiment P-27




Current Variations and Generation of a Magnetic Field



Objectives

- To learn about electromagnets.
- To build an electromagnet with a nail, a wire and an electrical circuit device.
- To investigate how the current affects the magnetic field of the electromagnet.

Modules and Sensors

- PC + NeuLog application
- USB-200 module 
- NUL-202 Current logger sensor 
- NUL-214 Magnetic field logger sensor 

Equipment and Accessories

▪ Circuit Board	1
▪ 6V cell holder	1
▪ 1.5 V battery (type D)	4
▪ Knife switch	1
▪ 1 m electrical wire	1
▪ Red 4 mm connector cable	1
▪ Red crocodile clip cable	1
▪ Black crocodile clip and 4 mm connector cable	1
▪ 10Ω mounted resistor	1
▪ Large iron nail	1
▪ Sellotape	1

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

Introduction

Electromagnets are devices that create a magnetic field through the application of an electric current. An electromagnet consists of a conductive wire wrapped around a piece of metal. A current is introduced from a battery or another voltage source, and flows through the wire. This creates a magnetic field around the wire, magnetizing the metal. It is possible to turn the magnet on and off by completing or interrupting the circuit; this is why electromagnets are so useful.

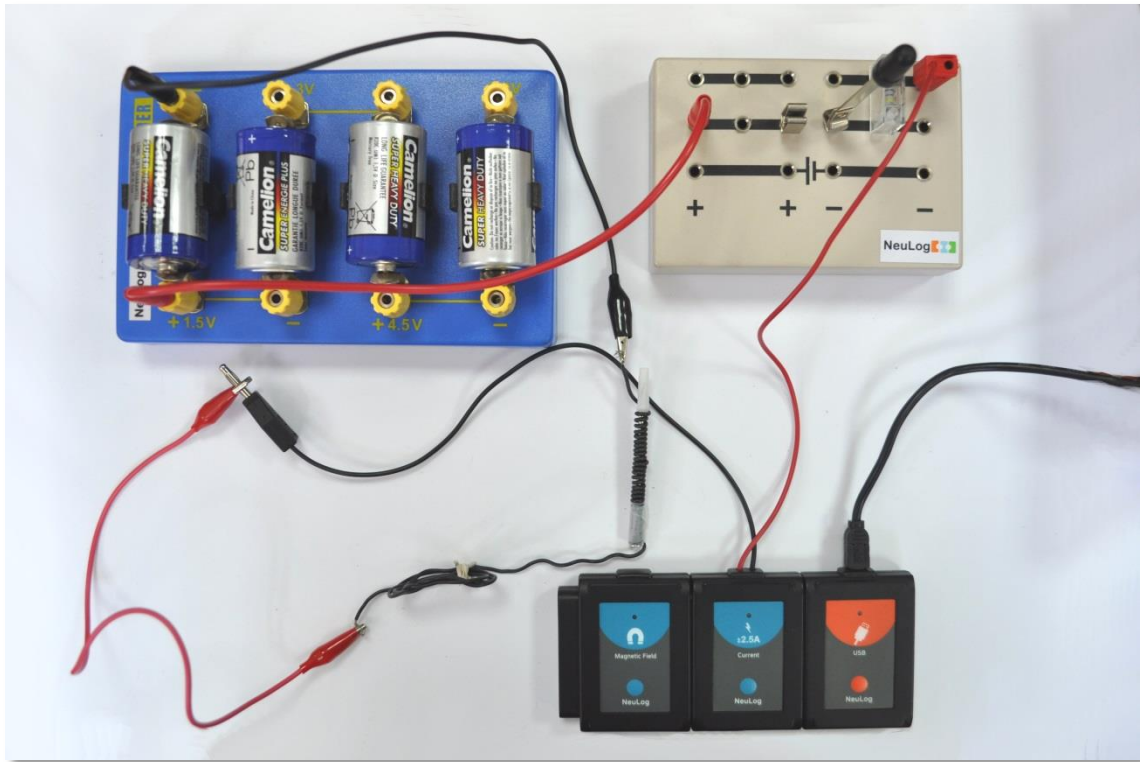
The atoms of certain metals such as iron, nickel and cobalt, each behave like tiny magnets. They normally point in random directions and the magnetic fields tend to cancel each other. The magnetic field produced by the wire wrapped around the core forces some of the atoms to point in one direction. All of the tiny magnetic fields add together, creating a stronger magnetic field. As the current flowing increases, the number of aligned atoms increases and the magnetic field becomes stronger. This happens until all the atoms are aligned and the magnet is saturated (then the magnetic field stays the same).

In this activity, you will build an electromagnet and use a magnetic field sensor to measure the magnetic field strength as a function of the current that flows through the wire. Current will be measured using the current sensor.

Procedure

Experiment setup




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



2. Connect the knife switch to the middle of the circuit board while leaving it open.
3. Connect the 10 Ω resistor next to the knife switch (one connector on the top row and the other on the second row).
4. Connect the red cable of the current sensor next to the 10 Ω resistor (on the top row).
5. Connect a red 4 mm connector cable to the left side of the second row and its other side to the socket next to the "+ 1.5 V" writing at the 6 V cell holder.
6. Connect the black cable of the current sensor to the red crocodile clip cable.
7. Connect the red crocodile clip cable to the electrical wire.

8. Connect the other side of the electric wire to the black crocodile clip and 4 mm connector cable and then connect the 4 mm connector to the socket next to the "-" writing at the left side of the 6 V cell holder.
9. 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).
10. Tightly turn the wire as many times as possible around the nail.
11. Use the sellotape to fixate the wire around the nail.

Sensor setup







12. Connect the USB-200 module  to the PC.
13. Check that the current  and the magnetic field  sensors are 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.

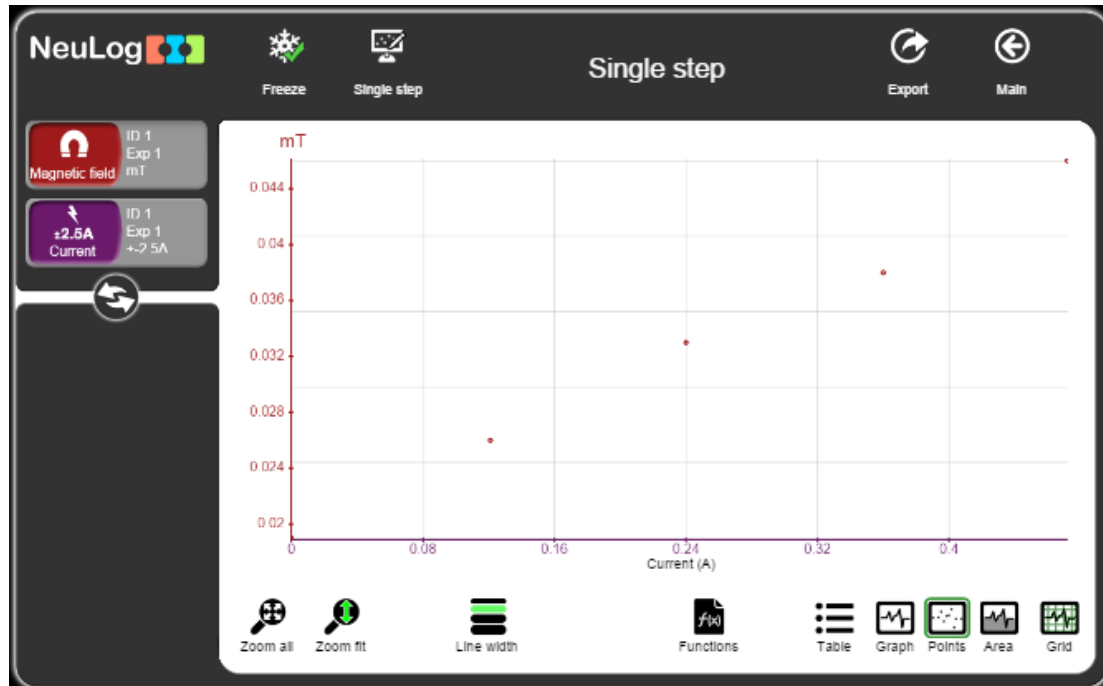
14. Run the NeuLog application and check that the sensors are identified.

Testing and measurements

15. Rotate the magnetic field sensor to a point where the measured magnetic field is closest to zero (the sensor measures the Earth's magnetic field).
16. Place the nail about 5 mm from the magnetic field sensing part (see the picture on the "Experiment setup" section).
17. Click on the **Single Step** icon  before you close the knife switch. This will give the magnetic field value when no current flows in the circuit.
18. Close the knife switch.
19. If you see that the magnetic field is negative, rotate the nail to the other direction or turn the wire around the nail in the opposite direction.
20. Click on the **Single Step** icon .
21. Move the red crocodile cable connector to the socket next to the "+ 3 V" writing at the 6 V cell holder.
22. Click on the **Single Step** icon .
23. Move the red crocodile cable connector to the socket next to the "+ 4.5 V" writing at the 6 V cell holder.
24. Click on the **Single Step** icon .
25. Move the red crocodile cable connector to the socket next to the "+ 6 V" writing at the 6 V cell holder.
26. Open the knife switch.
27. Click on the **Functions** icon  and then click on the X axis button.
28. Click on the sensor button and choose Current.
29. Click on the  icon to go back to the graph.

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

31. Your graph should be similar to the following:



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

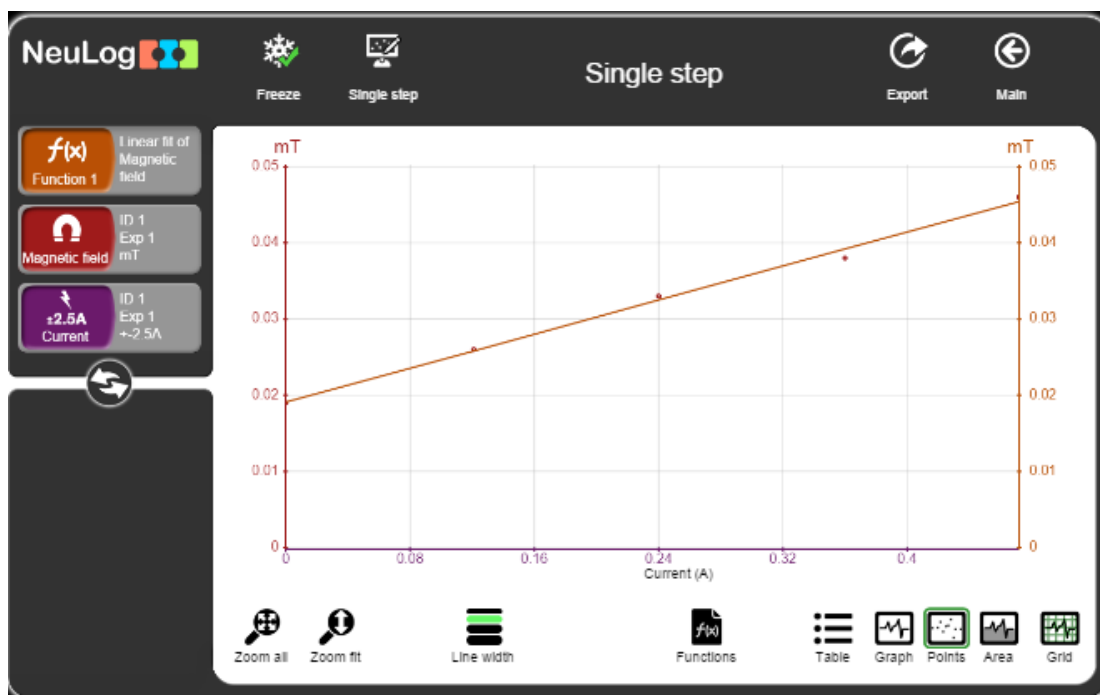
33. We can see that as the current increases, the magnetic field increases linearly.

34. Click on the **Functions** icon  and make sure that the magnetic field sensor is picked as Parameter A.

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

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

37. Your graph should be similar to the following:



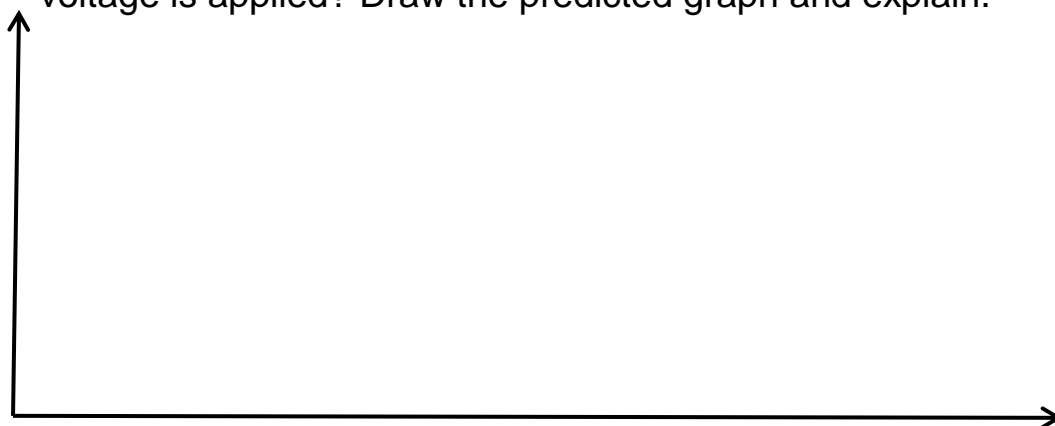
38. Click on the Linear fit module box; you will see the linear fit equation.

Function 1
Linear fit of Magnetic field
 $0.0558x + 0.0191$

39. The equation of the sample experiment is shown above. With this equation we can predict what is going to be the magnetic field for any current value in this range (up to 0.472 A).

Summary questions

1. How do you think the graph will look like when a higher voltage is applied? Draw the predicted graph and explain.



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2. What is your prediction for the magnetic field with a current of 0.2 A flowing through the wire? Use your equation.
 3. Explain how does an electric bell with an electromagnet works.
 4. If you would repeat this experiment with just half the nail covered with the wire, how would your results change? How would this affect the linear fit equation?