Experiment P-17
Magnetic Field Strength

Physics

Objectives

- To learn about basic properties of magnets.
- To study the relationship between magnetic field strength and the distance from the magnet.

Modules and Sensors

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

Equipment and Accessories

▪ Magnet in plastic case
▪ Alnico bar magnet
▪ Ruler

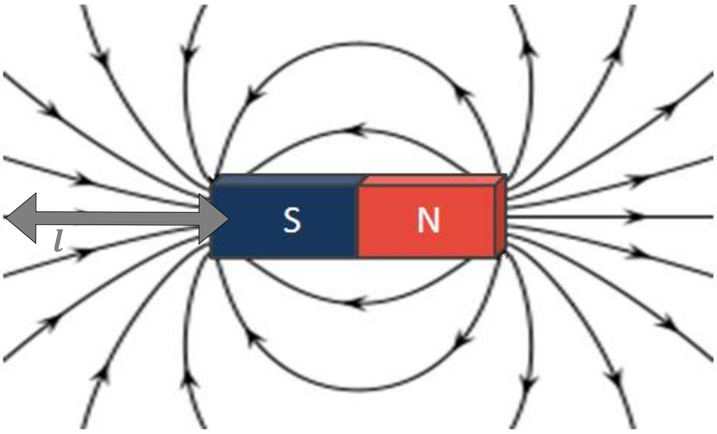
- The items above are included in the NeuLog Magnets kit, MAG-KIT. The magnet in the plastic case is also included in the NeuLog Mechanics kit, MEC-KIT.

Introduction

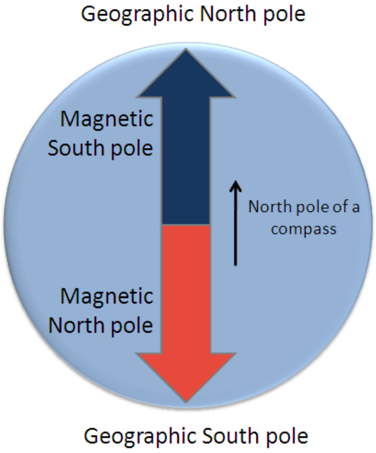
A bar magnet has two ends, known as magnetic poles. One pole is called the north pole of the magnet and the other pole is called the south pole of the magnet. 'Unlike magnet poles' attract each other and 'like magnet poles' repel each other. Magnets also attract other materials which are not normally magnetic (various sorts of metals).

Magnetic fields are force fields produced by electric currents. The magnetic force only act on charged particles in motion. A magnetic field can be represented as lines of force. These lines indicate the direction of the field in a given area, and their number per unit area is proportional to the field strength in that area. The field is stronger near the pole (where the lines converge), and the strength diminishes with the inverse square of the distance from it. The letter $\boldsymbol{B}$ symbolizes the magnetic field strength and $\boldsymbol{l}$ symbolizes the distance from the pole. This is an approximate formula in which the results are better as you get closer to the magnet.

$$\boldsymbol{B} \propto \frac{\mathbf{1}}{\boldsymbol{l}^{2}}$$



The Earth has a magnetic field similar to that of a bar magnet. The north pole of a compass needle (a magnet) is attracted to the magnetic south pole of the Earth, which is the geographic north.

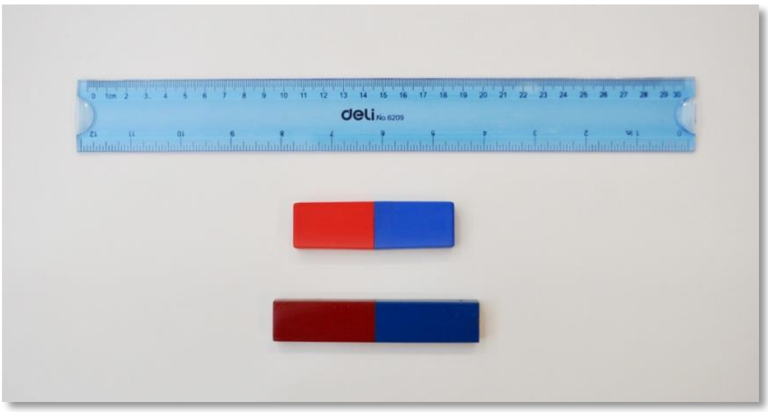


In this experiment we will measure the magnetic field strength of a bar magnet as a function of the inverse square of the distance from it.

Procedure

Experiment setup

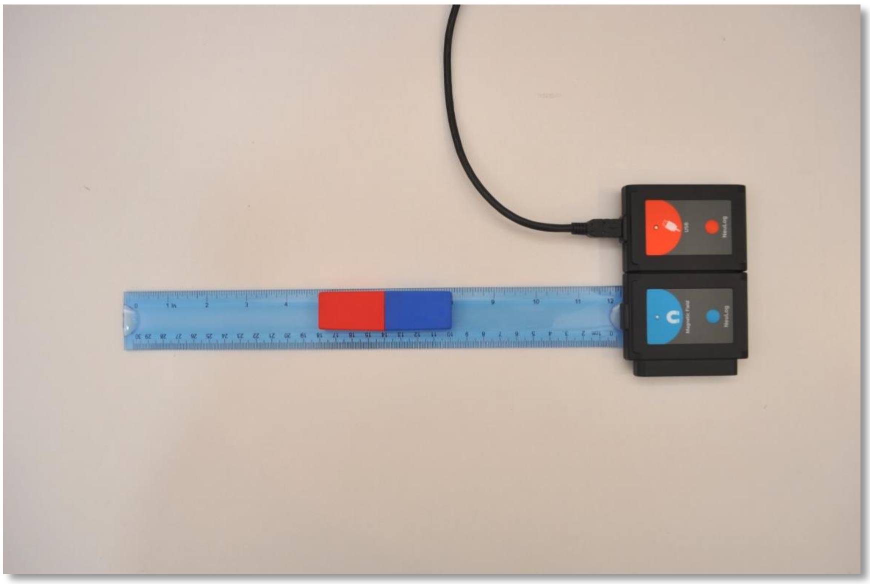
1. Set up the experiment as shown in the picture below.



2. Prepare the two magnets and a ruler.

   What happens when you get the two red north poles of the magnets close to each other? What about the two blue south poles? What happens when you get a blue south pole and a red north pole close to each other?

3. Place the ruler in front of the magnetic field sensor. The sensor should be close to the 0 cm line.



4. Place the magnet (with the plastic case) on the ruler. The blue south pole of the magnet should be directed toward the sensor and the magnet's edge should be 14 cm from the sensor.

Sensor setup

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

6. Check that the magnetic field 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.

7. Run the NeuLog application and check that the magnetic field sensor is identified.

Settings

8. Click on the **On-line Experiment** icon in the NeuLog main icon bar.

9. This experiment is done in single step mode so the experiment duration and sample rate will not be set.

Testing and measurements

10. Click on the **Single Step** icon for measuring the magnetic field strength at 14 cm from the magnet.

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

12. Change the "Manual values" column name to "Distance [cm]" (clicking on the title of the column will allow you to do so).

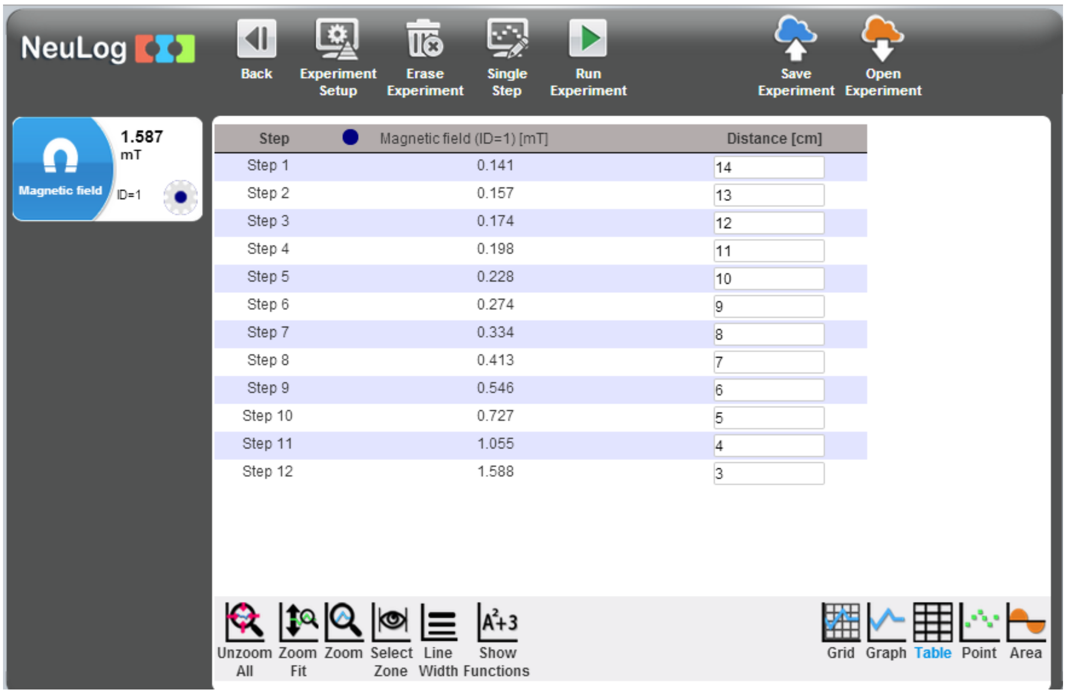
13. Move the magnet closer to the sensor for measuring the strength at 13 cm from the magnet and click on the **Single Step** icon .

14. Continue with the measurements according to the following table.

Measurement number	Distance [cm]
1	14
2	13
3	12
4	11
5	10
6	9
7	8
8	7
9	6
10	5
11	4
12	3

15. Insert the distance values into the "Distance [cm]" column. For this measurement we will assume that the force field lines conversion is at the edge of the magnet.

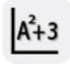
16. Your data should be similar to the following.



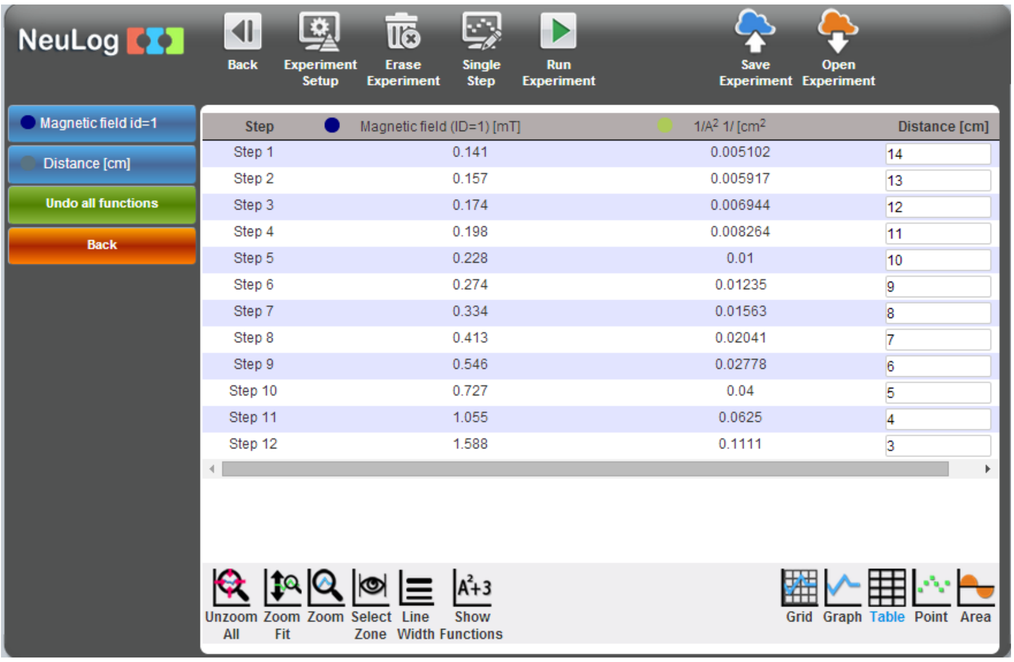
Step	Magnetic field (ID=1) [mT]	Distance [cm]
Step 1	0.141	14
Step 2	0.157	13
Step 3	0.174	12
Step 4	0.198	11
Step 5	0.228	10
Step 6	0.274	9
Step 7	0.334	8
Step 8	0.413	7
Step 9	0.546	6
Step 10	0.727	5
Step 11	1.055	4
Step 12	1.588	3

17. Save your data.

18. We can see that the magnetic field strength increases as the magnet gets closer to the sensor. The levels increase at a growing rate (exponentially).

19. In order to investigate the relationship between the magnetic field strength and the distance from the magnet, click on the **Show Functions** icon , then click on the **Distance [cm]** button on the left side of the screen**.** Choose the **1/A²** option.

20. A '1/(Distance)² [1/cm²]' column should appear on your table.



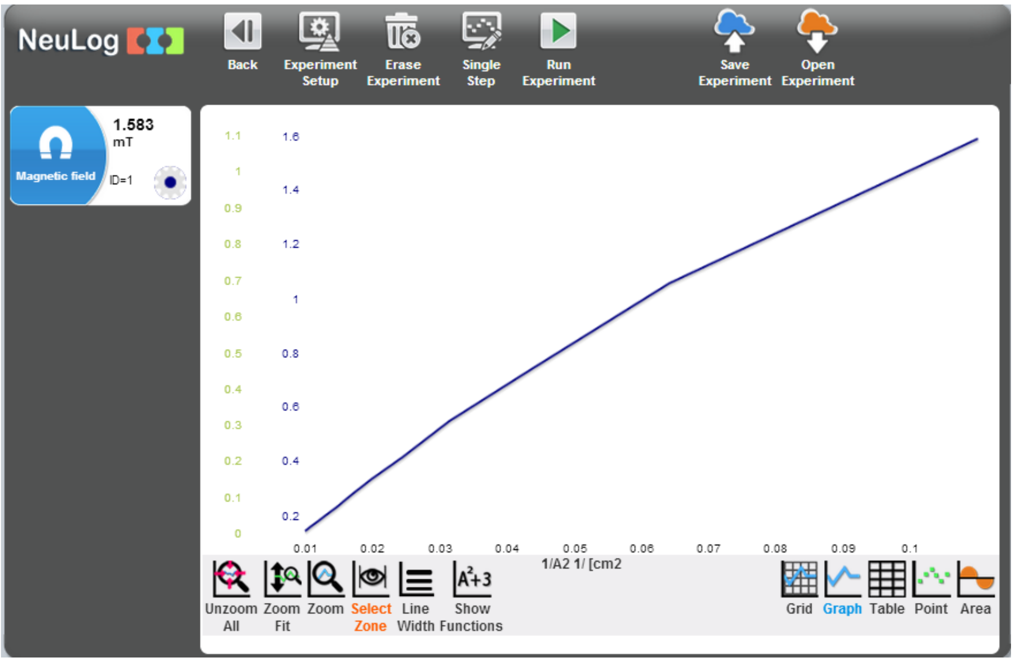
Step	Magnetic field (ID=1) [mT]	1/A² 1/[cm²]	Distance [cm]
Step 1	0.141	0.005102	14
Step 2	0.157	0.005917	13
Step 3	0.174	0.006944	12
Step 4	0.198	0.008264	11
Step 5	0.228	0.01	10
Step 6	0.274	0.01235	9
Step 7	0.334	0.01563	8
Step 8	0.413	0.02041	7
Step 9	0.546	0.02778	6
Step 10	0.727	0.04	5
Step 11	1.055	0.0625	4
Step 12	1.588	0.1111	3

21. Click on the **Graph** icon .

22. Click on the **Experiment Setup** icon and change the X-axis to 1/Distance^2.

23. In order to focus on the desired range, click on the **zoom** icon and locate the mouse cursor at a point above the graph and press its left button; keep it pressed and create a rectangle that includes the whole graph.

24. Your graph should be similar to the following:



25. We can see that we get a linear relationship between the magnetic field strength and the inverse square of the distance from the magnet.

Challenge research

26. Repeat the experiment with the alnico bar magnet.

Summary questions

1. Suppose you have an unmarked magnet. How can you find out where is the north pole and where is the south pole of the magnet?

2. Which magnet is stronger? How stronger is it compared to the weaker magnet?

3. How could you check which magnet is stronger without a sensor?

4. How can you make your own magnet? Point out two ways.