# Experiment: Magnetic field-Distance Relationship Time allocated: 45 min

**Background Information:**

The magnetic flux density () is the strength of a magnetic field at a point in space measured in teslas (T). Along the long axis of a bar magnet, the magnetic flux density can be determined using the following expression:

Where:

* ()

Bar Magnet

The magnetic moment (M) of a bar magnet is a measure of the magnet’s intrinsic strength; it determines the force that the magnet can exert on other magnets. A larger magnetic moment indicates a stronger bar magnet.

The magnetic flux density for a bar magnet is proportional to . The strengths of other types of fields in Physics covered in this course (gravitational and electrical) are proportional to . Electric and gravitational fields can be produced from point source; a single point in space which can be considered as the source of the field (e.g. proton for electric fields or the centre of mass for a gravitational field). Magnetic fields are produced in a dipole arrangement; the separated N pole and S pole work together to produce the field. As long as the distance is significantly large compared to the length of the magnet, such that both poles contribute a similar amount to the magnetic field, this dipole arrangement is the reason why the flux density-distance relationship for magnetic fields is different to electric and gravitational fields of a point source.

**The Experiment:**

Students performed an investigation to check the relationship between the flux density and the distance from a bar magnet by using the following procedure:

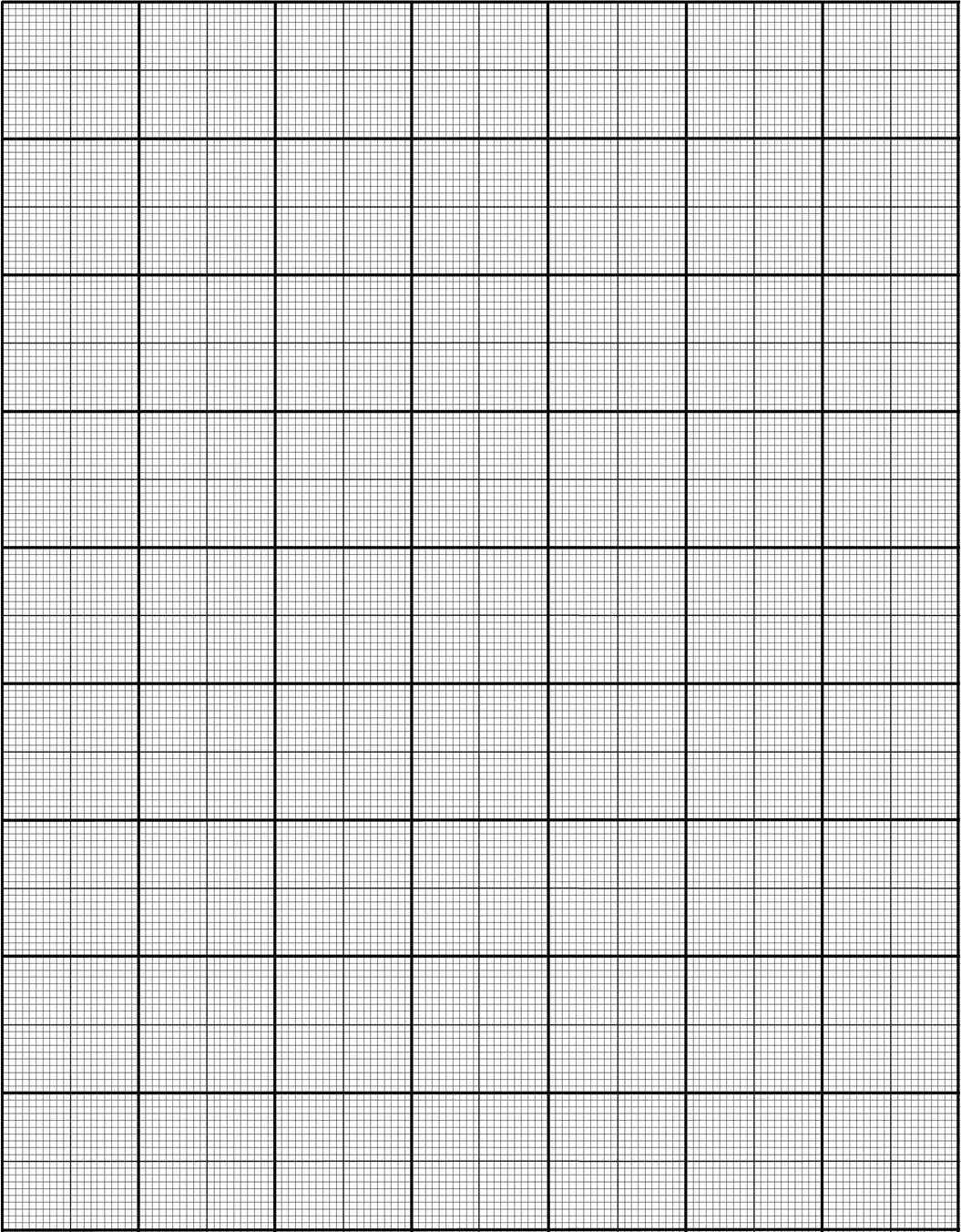
1. *Place a magnet standing upright on a flat surface, with the N pole at the top.*
2. *Have a student hold a ruler close to, but not touching, the top of the magnet, aligned vertically.*
3. *Have another student use a magnetic probe to measure the flux density at the 10 cm mark of the ruler.*
4. *Repeat step 3, increasing the distance each time.*

Here is the students’ table of results:

|  |  |  |  |
| --- | --- | --- | --- |
| Distance from top of magnet (m) | Distance from middle of magnet (m) | Magnetic flux density (mT) |  |
| 0.060 | 0.100 | 170 |  |
| 0.080 | 0.120 | 100 |  |
| 0.110 | 0.150 | 50 |  |
| 0.140 | 0.180 | 30 |  |
| 0.180 | 0.220 | 16 |  |

**Questions**

1. Produce a linear graph from the independent and dependent variables in the table, using the background information as a guide. You may need to adjust the data to ensure the graph is linear. You may fill in the blank column of the table to assist you. [7 marks]



1. Describe what knowledge has been gained by producing a linear graph from manipulated data, compared to plotting the raw results. [1 mark]
2. From the graph, calculate the gradient of your line of best fit. Include units. [3 marks]
3. Using the gradient, determine the magnetic moment of the bar magnet the students used in this experiment. [3 marks]
4. The students repeated the experiment with a different bar magnet that had twice the magnetic moment of the original. Onto your graph, sketch the expected trend line that would be produced by using this new bar magnet. [2 marks]
5. Based on the method the students followed and the data provided in the table, estimate the uncertainty of their distance measurements. Justify your estimation. [3 marks]
6. The students had extra data which they left out of their table as it did not fit the expected trend. Here is a scale diagram of the equipment for this particular result.

Magnetic Flux Probe

Connected to data logger

1 cm

N

8 cm

S

The results obtained are below:

|  |  |  |
| --- | --- | --- |
| Distance from top of magnet (m) | Distance from middle of magnet (m) | Magnetic flux density (mT) |
| 0.010 | 0.050 | 1700 |

* 1. **Via a calculation**, determine what the expected magnetic flux density is 1 cm above the magnet, as predicted by the other results of this experiment. Calculate the percentage difference between this expected result and the actual result taken from 1 cm above the magnet.

[3 marks]

* 1. This result is actually much closer to what would be expected if magnetic fields behaved the same way as electric and gravitational fields produced by a point source. Explain why. [3 marks]