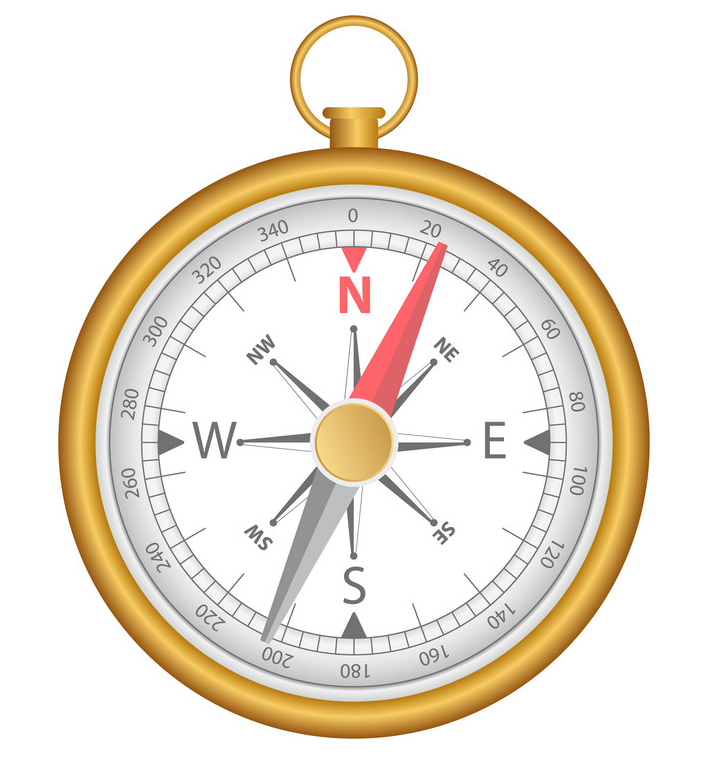
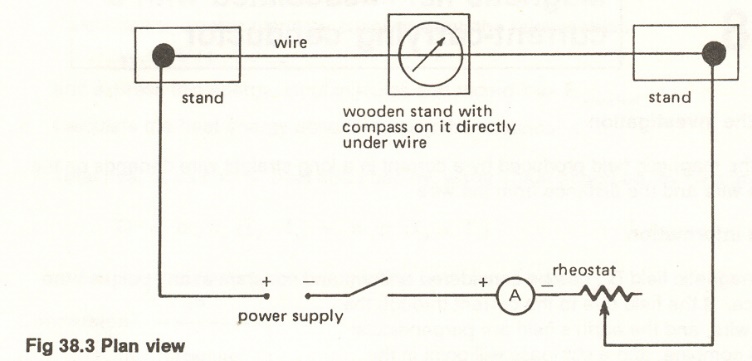
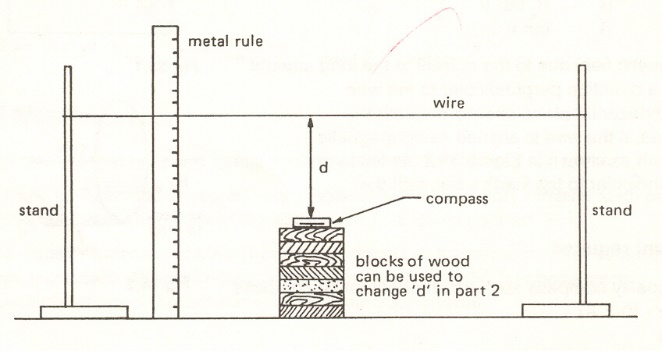
# Unit 3 Physics

# Task 5:

# The Magnetic Field of a Current-Carrying Wire & Earth’s Magnetic Field - Validation



The following experiment was set up to investigate the factors that affect the magnetic field around a long straight wire.



1. Why is the long straight wire set up in a north-south direction?

The wire is set up parallel to Earth’s magnetic field, such that the magnetic field produced by the wire will be perpendicular to Earth’s field.

(1 mark)

1. In the instructions to the experiment, it suggested that non ferro-magnetic material be used for the stands and block. Explain why this recommendation was made.

Ferromagnetic materials can distort (or concentrate) magnetic fields (or flux lines), which would affect the results of the experiment.

(1 mark)

The following results were obtained when the compass was held at a constant distance from the wire of **15.0 cm** and the current varied.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Current (A) | Deflection Right | Deflection Left | Av. Deflection | Tan of Average |
| 5 | 160 | 160 | 160 | 0.287 |
| 4 | 120 | 140 | 130 | 0.231 |
| 3 | 100 | 100 | 100 | 0.176 |
| 2 | 80 | 70 | 7.50 | 0.132 |
| 1 | 40 | 40 | 40 | 0.0699 |

1. Why is the compass deflection measured on both sides of the wire and not one side?

To reduce the impact of random error on the measurement by averaging the result.

(1 mark)

1. Graph tan Ө vs. current overleaf (note that tan Ө does not have units). (4 marks)

\*You may rotate the graph page horizontally if required. Include a line-of-best-fit.

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1. Calculate the gradient of the line you have obtained. 0.0533 (accept 0.051 – 0.055) (1 mark)
2. If extended, should we ideally expect the line go through the origin? Yes (1 mark)

*\*It’s worth noting for the students that we usually don’t assume a LOBF goes through the origin, unless we know it must that it ought to by definition, as we do here. However, we don’t force it to go through the origin, as a non-zero y-intercept may be a result of systematic error in measurement, but that does not necessarily mean that the gradient is incorrect, and forcing the line through the origin artificially steepens the gradient.*

1. Explain why/why not:

When I = 0, tan θ = 0 (when current is off, deflection should be 0, and tan 0⁰ = 0)

(1 mark)

|  |  |
| --- | --- |
| μ0 = permeability of air = 4π x 10 -7 NA-2 | I = the current through the wire (A) |
| Bi  = magnetic field strength around the wire (T) | d = distance from the wire (m) |
| BEH = horizontal component of the Earth’s  magnetic field (T) | tan θ = tan of the average deflection |

1. By combining the two equations obtain an expression for BEH that does not include Bi.

(2 marks)

(1 – working)

(1 – solution)

1. Using values of μ0 and d given, and the gradient of the line calculated in Question 5, obtain a value for BEH using the equation derived above. (2 marks)

|  |  |
| --- | --- |
|  | (1 – working, showing how to use gradient) |

Answer: 2.50 x 10-5 T

(1 – solution; allow follow-through marks if they used incorrect gradient)

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1. In the location that the experiment was carried out the angle of dip to the horizontal was measured at 68.00. Calculate the strength of the earth’s magnetic field at this location.

68⁰

B

BEH

(2 marks)

(1 mark for working – diagram not necessary, 1 mark for solution)

Answer: 6.07 x 10-5 T

In another experiment the current was kept constant at 4.0A and the distance between the wire and the compass was varied. The following results were obtained.

|  |  |  |  |
| --- | --- | --- | --- |
| Distance (m) | Av. Deflection | Tan Av. Deflection |  |
| 0.335 | 80 | 0.141 | 2.985 |
| 0.285 | 100 | 0.176 | 3.509 |
| 0.246 | 11.50 | 0.203 | 4.065 |
| 0.182 | 140 | 0.249 | 5.495 |
| 0.125 | 190 | 0.344 | 8.000 |
| 0.062 | 300 | 0.577 | 16.129 |

1. Explain what you would do to the data to obtain a straight-line graph. Use the equation in Question 8 to justify why this strategy should give you a straight line (2 marks)

Plot tan θ vs. 1/d (1 mark), as tan θ 1/d.

|  |  |
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(1 mark for justifying proportionality)

1. Carry out your strategy and place the appropriate data in the spare column in the table.

(2 marks for correct 1/d calculations, -1 per mistake)(2 marks)

1. Graph your data overleaf. (4 marks)

\*You may rotate the graph page horizontally if required. Include a line-of-best-fit.

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1. Determine the gradient of the line: 0.0323 (1 mark)

\*Again, we might ideally expect LOBF to go through origin; as 1/d🡺 0, d 🡺 ∞, so deflection angle θ 🡺 0, and ∴ tan θ 🡺 0, however we don’t force it to go through the origin.

1. Show how the gradient of the straight line can be used with the equation from Question 8 to obtain another value for BEH (Use the values of μ0 and I that are given). (2 marks)

(1 mark for correctly incorporating gradient into expression)

Answer: 2.48 x 10-5 T

(1 mark for solution)

END OF VALIDATION

Spare Graph Page (if required):

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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