Yr 12 Physics Practical Test   Name: Solutions

The Magnetic Field Associated With a Long Straight Wire: Time = 1 hour

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

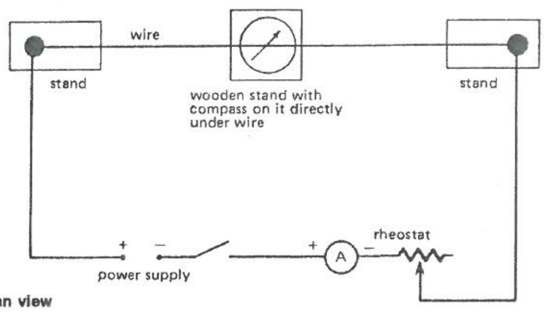
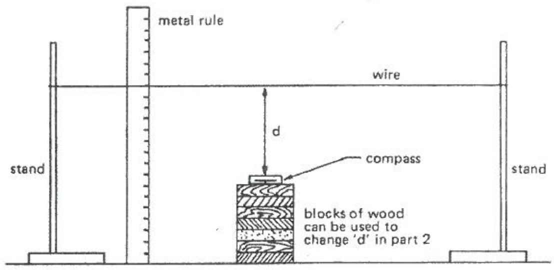


Fig 38.3 Plan view



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

To be parallel to Earth's mag. field so that mag. field from wire will be at 90° to Earth's field.

(1 mark)

2 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.

Ferro-magnetic materials will distort the direction of a magnetic field as the flux lines would 'rather' travel through the material than through air.

(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	16^0	16^0	16^0	0.287
4	12^0	14^0	13^0	0.231
3	10^0	10^0	10^0	0.176
2	8^0	7^0	7.5^0	0.132
1	4^0	4^0	4^0	0.0699

3 Why is the compass deflection on both sides of the wire measured instead of just on one side?

To average any errors in measurement due to possible distortions of the fields

(1 mark)

4 In this experiment, which is the manipulated or independent variable? Current

(1 mark)

5 Should the manipulated variable be graphed on the x or y axis? X (1 mark)

6 Graph the results as appropriate (note that tan Θ does not have units). (3 marks)

7 Calculate the gradient of the line you have obtained. 0·0540 (1 mark)

8 If extended, should the line go through the origin? Yes (1 mark)

9 Explain why. Zero current will not produce a mag. field so the compass will continue to point North. (1 mark)

$$B_i = \frac{\mu_0 I}{2\pi d} \quad - (1) \qquad \text{and} \qquad \tan\theta = \frac{B_i}{B_{EH}} \quad - (2)$$

B_i = magnetic field strength around the wire (T) I = the current through the wire (A)

B_{EH} = horizontal component of the Earth's magnetic field (T) d = distance from the wire (m) μ_0 = permeability of air = $4\pi \times 10^{-7}$ NA^{-2} tan θ = tan of the average deflection

10 By combining the two equations obtain an expression for B_{EH} that does not include B_i. (2 marks)

Subst. (1) into (2)

$$\tan\theta = \frac{\left(\frac{\mu_0 I}{2\pi d}\right)}{B_{EH}} \rightarrow \tan\theta = \frac{\mu_0 I}{2\pi d . B_{EH}}$$

$$\rightarrow B_{EH} = \frac{\mu_0 I}{2\pi d . \tan\theta}$$

11 Using values of μ_0 and d given, and the gradient of the line calculated in question 7, obtain a value for B_{EH} using the equation derived above. (2 marks)

$$\text{gradient} = \frac{\tan\theta}{I}$$

$$d = 15cm = 0.15m$$

$$\mu_0 = 4\pi \times 10^{-7} NA^{-2}$$

$$B_{EH} = \frac{4\pi \times 10^{-7}}{2\pi \times 0.15} \times \frac{1}{\text{gradient}}$$

$$= \frac{2 \times 10^{-7}}{0.15} \times \frac{1}{0.054}$$

$$= \underline{2.47 \times 10^{-5}\ T}$$

12 In the location that the experiment was carried out the angle of dip to the horizontal was measured at 68.0^0. Calculate the strength of the earth's magnetic field at this location. (2 marks)

$$B_{EH} = B_E \cos 68^\circ$$

$$B_E = \frac{B_{EH}}{\cos 68^\circ} = \frac{2.47 \times 10^{-5}}{\cos 68^\circ}$$

$$= \underline{6.59 \times 10^{-5}\ T}$$

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	$\frac{1}{d}$
0.335	8^0	0.141	2.985
0.285	10^0	0.176	3.509
0.246	11.5^0	0.203	4.065
0.182	14^0	0.249	5.495
0.125	19^0	0.344	8.00
0.062	30^0	0.577	16.129

13 Explain what you would do to the data to obtain a straight line graph. Use the equation in Q 9 to justify why this strategy should give you a straight line $\boxed{\tan\theta \propto \frac{1}{d}}$

$$B_i = \frac{\mu_0 I}{2\pi d} \quad \text{and} \quad \tan\theta = \frac{B_i}{B_{EH}} \rightarrow B_i = B_{EH}\tan\theta$$

$$\therefore B_{EH}\tan\theta = \frac{\mu_0 I}{2\pi d} \rightarrow \tan\theta = \frac{1}{d}\cdot\frac{\mu_0 I}{2\pi B_{EH}}$$

2 ~~(3~~ marks)

14 Carry out your strategy and place the appropriate data in the spare column in the table. (1 mark)

graph (2 marks)

15 What is the gradient of the straight line? 0.05 (1 mark)

16 Show how the gradient of the straight line can be used with the equation from question 11 to obtain another value for B_e.(Use the values of μ_0 and I that are given) 2 ~~(3~~ marks)

$$\text{gradient} = \frac{\tan\theta}{1/d} = \tan\theta \times d$$

$$B_{EH} = \frac{\mu_0 I}{2\pi d.\tan\theta} = \frac{\mu_0 I}{2\pi.\text{gradient}} = \frac{4\pi\times10^{-7}\times 4}{2\pi\times 0.05}$$

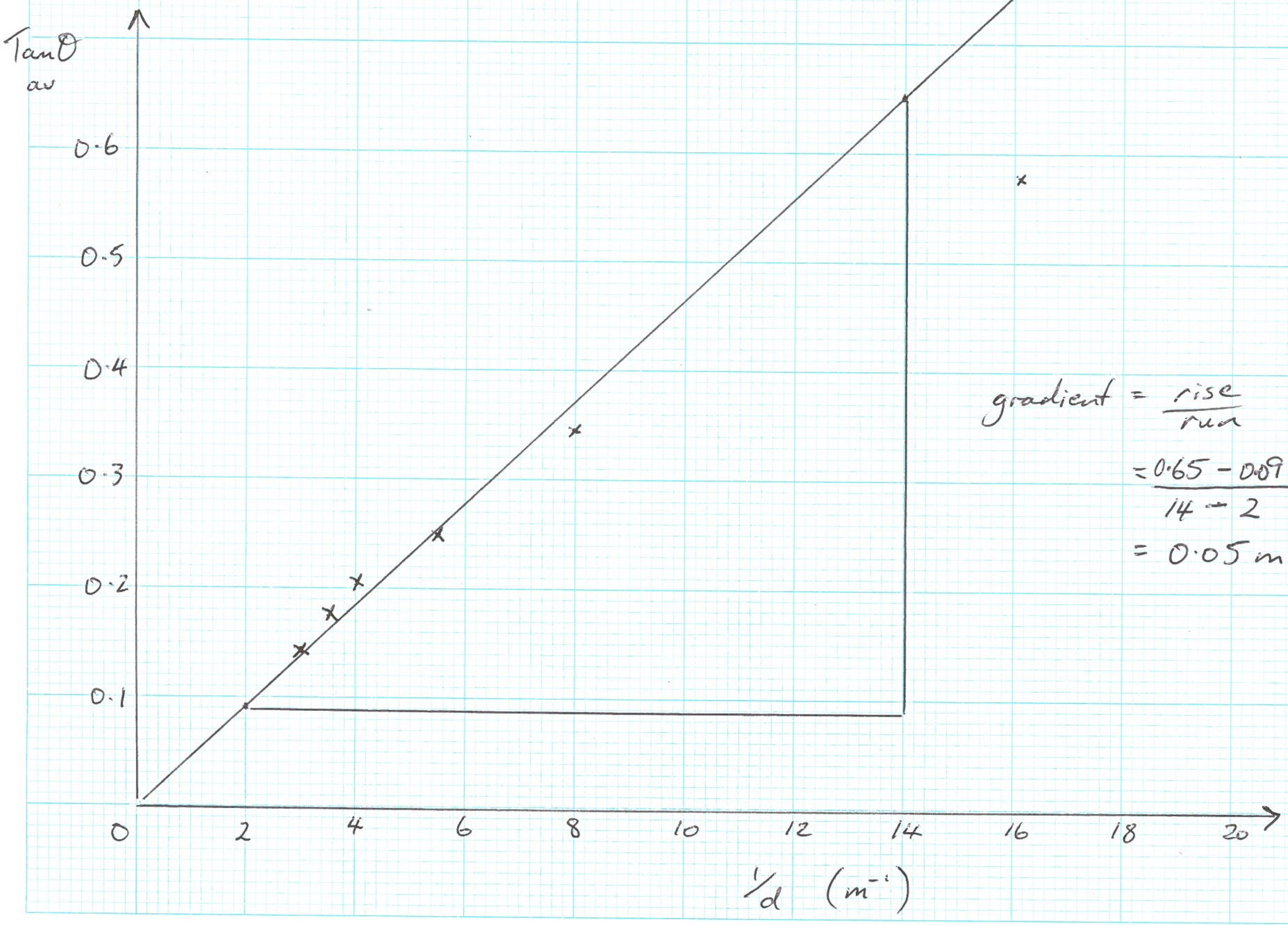
$$= \frac{2\times10^{-7}\times 4}{0.05} = 1.6\times10^{-5}\ T$$

$$B_E = \frac{B_{EH}}{\cos 68^0} = \underline{4.27\times10^{-5}\ T}$$

Total: 25 marks

Qn 15

Tan(Av. deflection) Vs $\frac{1}{distance}$



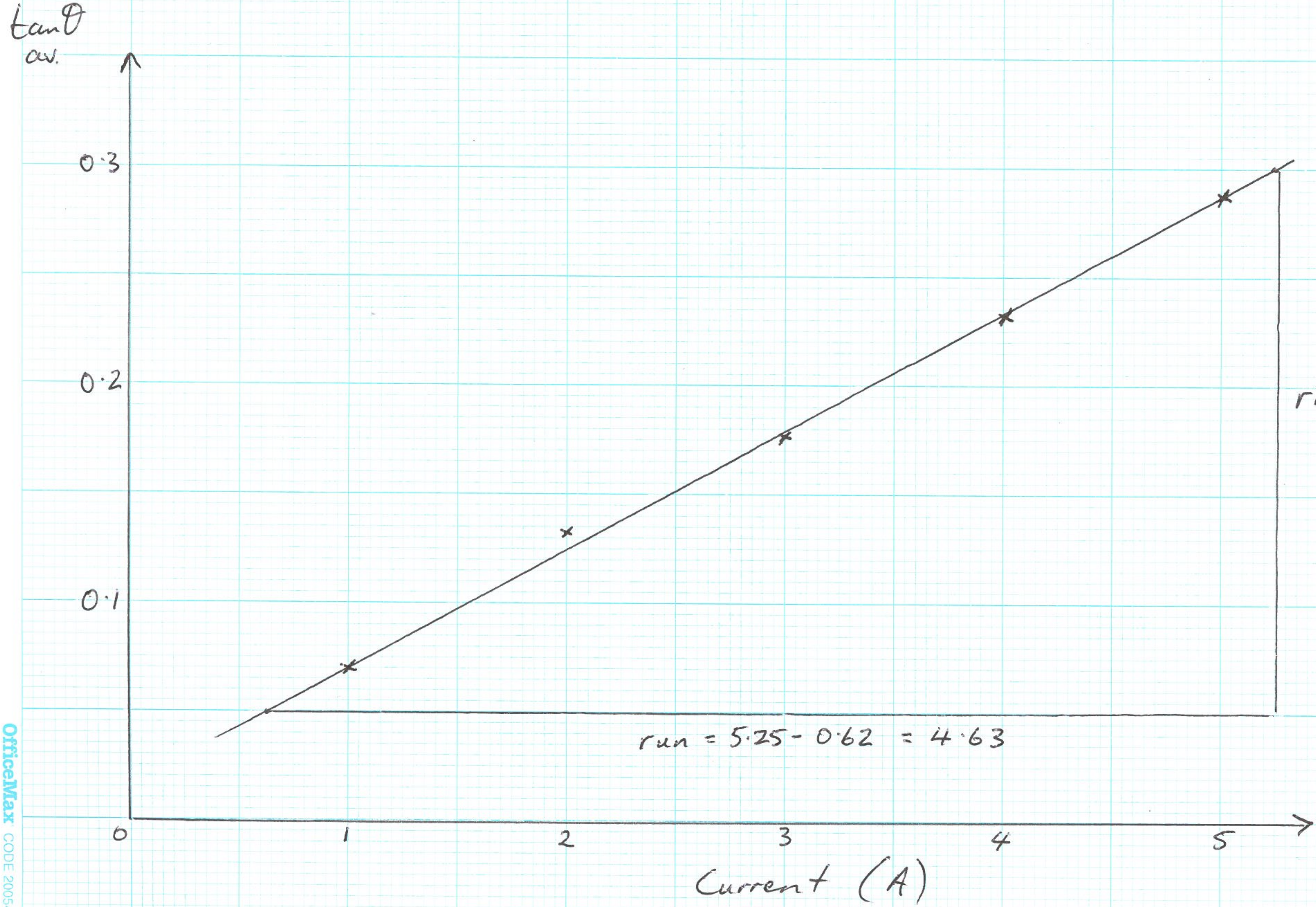
gradient $= \frac{rise}{run}$

$= \frac{0.65 - 0.09}{14 - 2}$

$= 0.05\,m$

Qn 6.

Tan(Av. deflection) Vs Current



rise = 0·3 - 0·05
= 0·25

gradient = $\frac{rise}{run}$

$= \frac{0.25}{4.63}$

$= 0.0540$