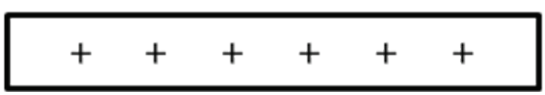
Question 1 **(3 marks)**

Draw the resultant electric field with at least 5 lines for each of the following situations.

Two opposite but equally-charged spheres

A charged sphere near a charged conductive plate
 

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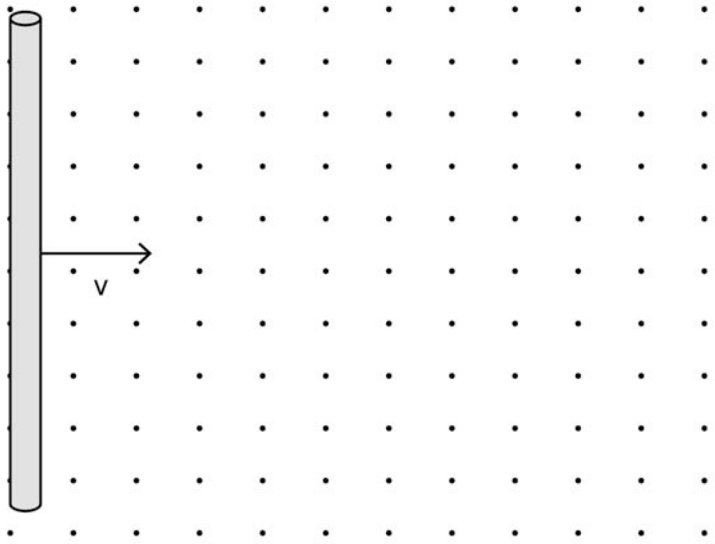
Question 3 **(3 marks)**

A 12.5 cm long piece of copper wire is moved at a constant velocity of 6.56 m s^{-1} through a magnetic field of 0.150 T. Calculate the potential difference between the ends of the wire and indicate on the diagram which end of the wire is positive.



B field out of the page

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Question 15 **(10 marks)**

An uncharged drop of oil is given 7 excess electrons. It is then introduced into the space between two horizontal plates 25.0 mm apart with a potential difference between them of 1.50 kV. The drop of oil remains stationary.

(a) Calculate the magnitude of the electric field strength between the plates. (2 marks)

(b) Is the top plate positive or negative? Explain your reasoning. (2 marks)

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(c) Calculate the magnitude of the electric force acting on the oil drop. (3 marks)

(d) Calculate the mass of the oil drop. (3 marks)

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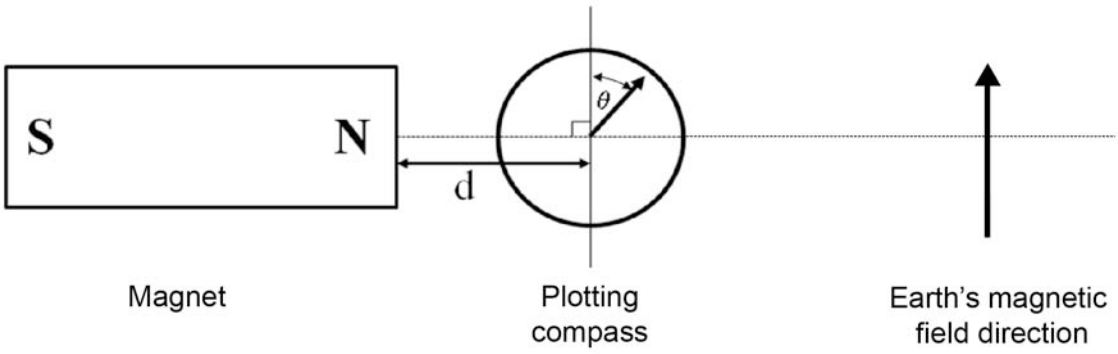
Question 21 **(19 marks)**

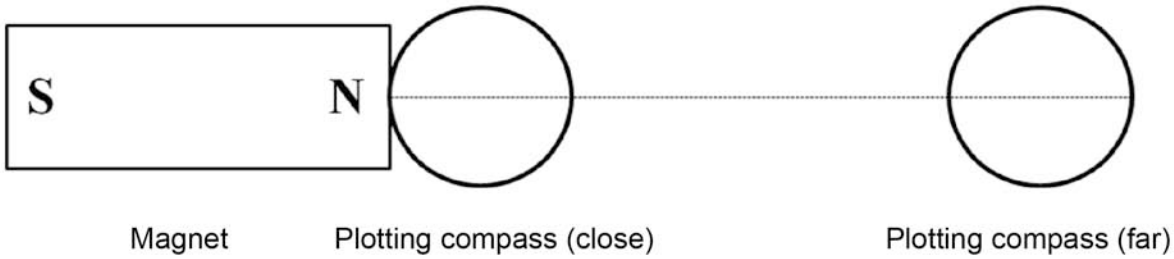
A student performed an experiment to investigate how the magnetic field strength of a bar magnet varied with distance from the magnet along a line through the long axis of the magnet. She measured the angle θ between the pointer of a plotting compass and geographic north, as she moved the plotting compass to various distances (d) away from the magnet. She measured the angle θ at intervals of 3.0 cm, as shown in Diagram A.

Diagram A



(a) On Diagram B, draw arrows on each of the plotting compasses to indicate the angle you would expect the needle of the compass to make when it is close to, and when it is far (more than 50 cm) from, the bar magnet. (2 marks)

Diagram B



(b) Both the Earth's magnetic field and the bar magnet's magnetic field affect the compass. Draw a vector diagram that shows these two magnetic fields and the resultant magnetic field experienced by the plotting compass shown in Diagram A. Use your diagram to derive a relationship between the Earth's magnetic field, the magnet's magnetic field and the angle θ. (3 marks)

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(c) Calculate the strength of the magnetic field due to the bar magnet at a point on the axis, 10.0 cm from the end of the bar magnet, if the value of θ at this point is 82°, and the Earth's magnetic field strength is 2.0×10^{-5} T. (2 marks)

Question 21 continues on the next page

Parts (d), (e) and (f) of this question assess your understanding of uncertainty in measurements, interpretation of graphs and use of appropriate significant figures.

The compass that the student used to measure the angle θ was marked in divisions of 1°. The student could see when the needle was between divisions but could not judge accurately how close to a division it was. The student decided to express all her measurements of θ with an uncertainty of $\pm$ 1°. The student was confident that she placed the centre of the compass on the ruler accurately so decided not to express her measurements of d with any uncertainty.
The student's results are shown in the table below.

Distance from magnet (m)	$\frac{1}{d^2}$ **(m^{-2})**	**θ (°)**	**Tan θ**
0.15		58 ± 1	$1.60 \pm$
0.18		42 ± 1	0.90 ± 0.03
0.21		40 ± 1	0.84 ± 0.03
0.24		33 ± 1	0.65 ± 0.02
0.27		27 ± 1	0.51 ± 0.02
0.30		23 ± 1	0.42 ± 0.02

(d) Complete the table by filling in the values for $\frac{1}{d^2}$ and the uncertainty range for the value of tan θ for θ = 58°. You must show your calculation for determining the uncertainty range. (3 marks)

(e) Plot the graph of tan θ versus $\frac{1}{d^2}$ on the graph paper on page 31. Include error bars and a line of best fit. (5 marks)

(f) Mark and label the point on your graph where the strength of the Earth's magnetic field is equal to the strength of the magnetic field of the bar magnet. Use this point to determine the distance from the magnet where these fields are equal. (4 marks)

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