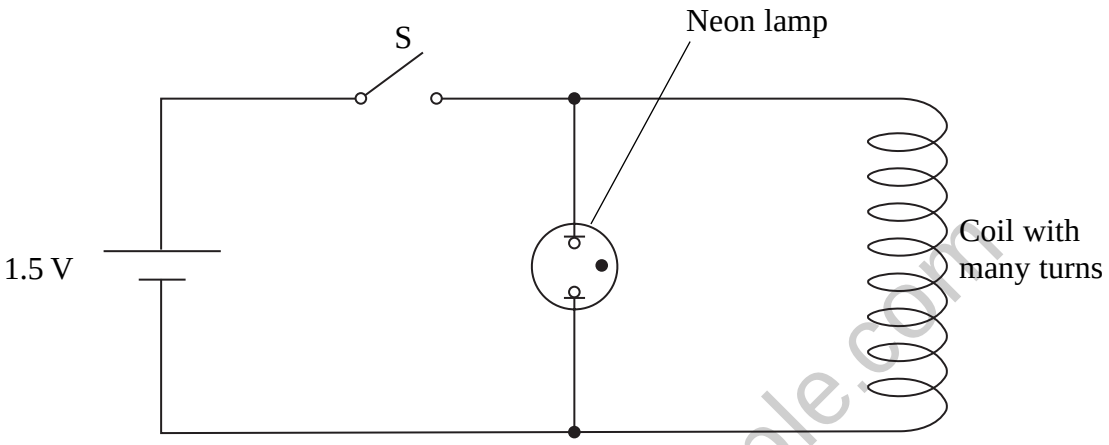
**1** A 1.5 V cell is connected to a switch S, a neon lamp and a coil with many turns as shown. Nothing is observed when the switch is closed but the neon lamp flashes as soon as it is opened.
The neon lamp flashes when the potential difference across it is about 200 V.




Use Faraday's law to explain why the lamp flashes once when the switch S is **opened**.

**(4)**

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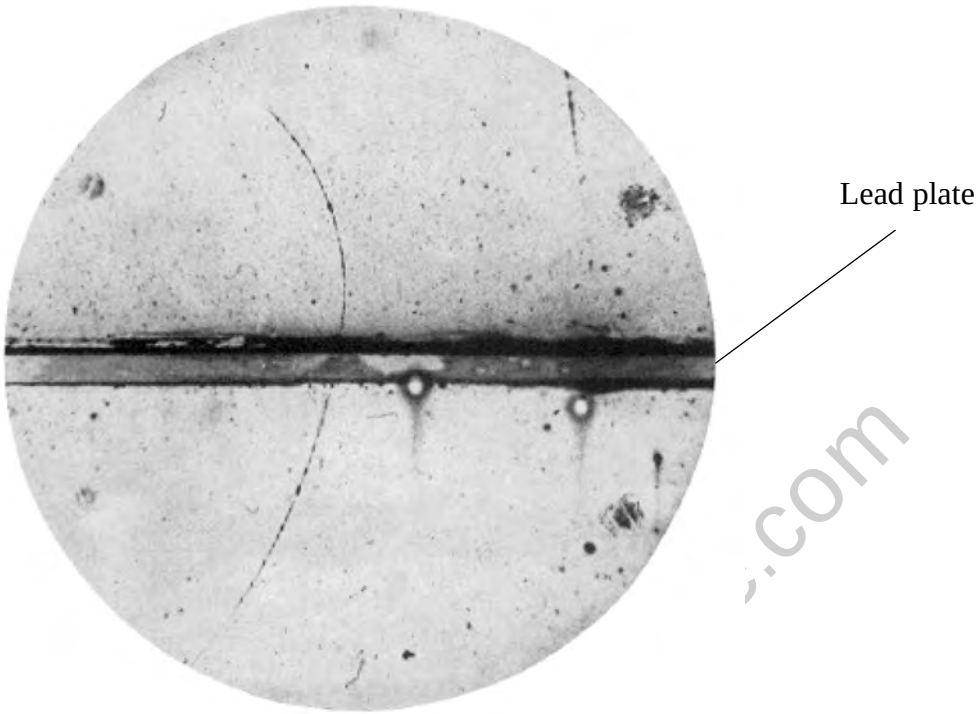
**(Total for Question = 4 marks)**

**2** The photograph shows the track of a positively charged particle either side of a lead plate.




The particle was deflected by a magnetic field of magnetic flux density 1.5 T. The field is perpendicular to the plane of the photograph.

(a) (i) Estimate the actual radius of the track above the lead plate.

The lead plate is 6 mm thick.

**(3)**

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Radius = .....

(ii) Calculate the momentum of this particle above the lead plate.
Particle charge = $1.6 \times 10^{-19}$ C

**(2)**

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Momentum = .....

(b) Explain whether this particle was moving up or down through the lead plate.

**(3)**

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(c) On the list below circle the correct direction of the magnetic field.

**(1)**

Into the page  from left to right  down the page  out of the page  up the page

(d) This particle was identified as a positron.

(i) Calculate the speed of the positron while it is moving above the lead plate.

**(2)**

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Speed = .....

(ii) Comment on your answer.

**(2)**

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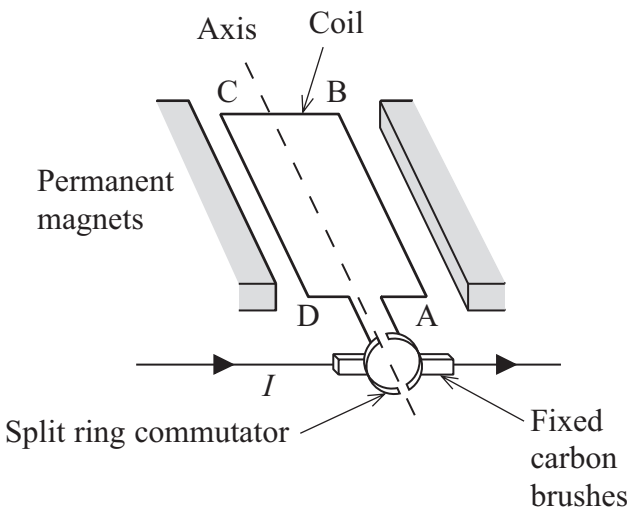
**(Total for Question = 13 marks)**

**3** The simplified diagram shows a d.c. electric motor. The split ring commutator consists of two copper semicircular sections attached to either end of a coil. Fixed carbon brushes rub against, and make electrical connections to, the split ring commutator.




(a) Explain why the coil turns and why it continues to rotate. Add to the diagram to help your explanation.

**(4)**

*(b) When the motor is first switched on the current $I$ is large. As the coil turns faster, the current decreases.

Explain these observations.

**(4)**

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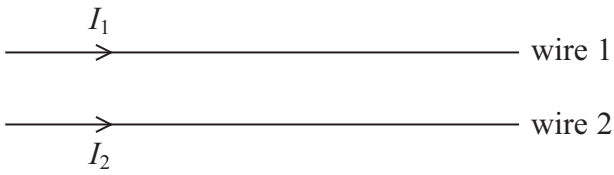
**(Total for Question 3 = 8 marks)**

***4** In 1820 Hans Oersted did an experiment with an electric current in a wire. He noticed that whenever the current was on, it affected a compass needle lying near the wire.

A few years later, André Ampere observed that two parallel wires attract each other if they are carrying current in the same direction.



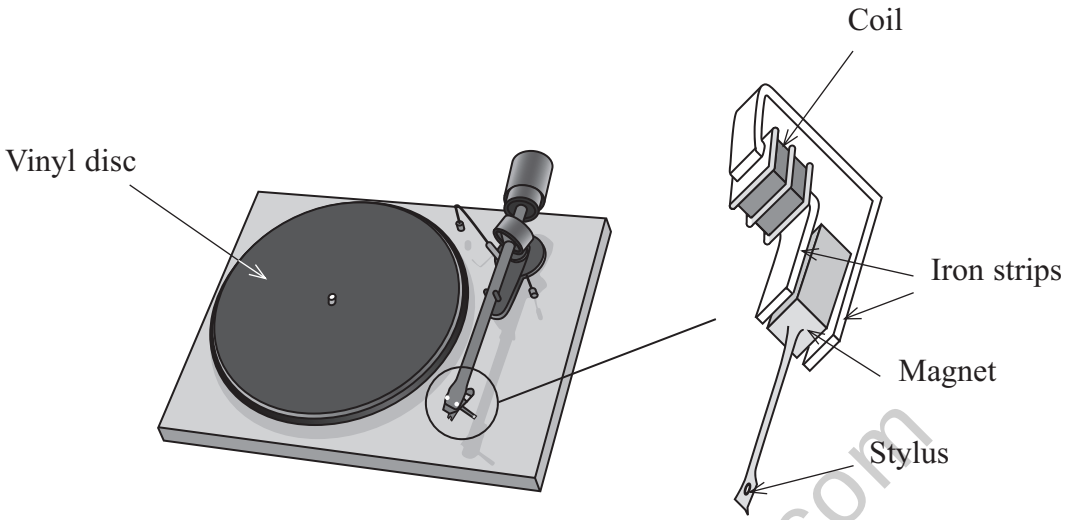

Explain André Ampere's observation. You may wish to add to the diagram.

**(5)**



**(Total for Question = 5 marks)**

**5** A vinyl disc is used to store music. When the disc is played, a stylus (needle) moves along in a groove in the disc. The disc rotates and bumps in the groove cause the stylus to vibrate.




The stylus is attached to a small magnet which is near to a coil of wire. When the stylus vibrates, there is a potential difference across the terminals of the coil.

(a) Explain the origin of this potential difference.

**(4)**

(b) The potential difference is then amplified and sent to a loudspeaker. Long-playing vinyl discs (LPs) have to be rotated at 33 rpm (revolutions per minute) so that the encoded bumps in the groove lead to the correct sound frequencies.

(i) Calculate the angular velocity of an LP.

**(2)**

Angular velocity = .....

(ii) As the stylus moves towards the centre of the LP the encoded bumps must be fitted into a shorter length of groove.

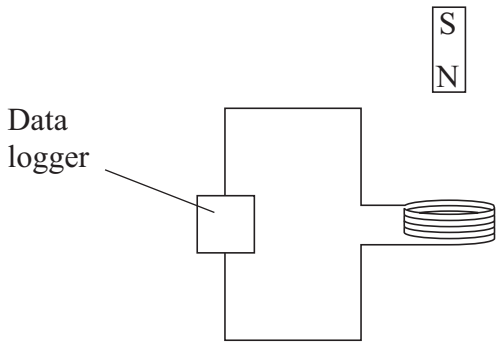
Explain why the encoding of bumps in the groove becomes more compressed as the stylus moves towards the centre.

**(3)**

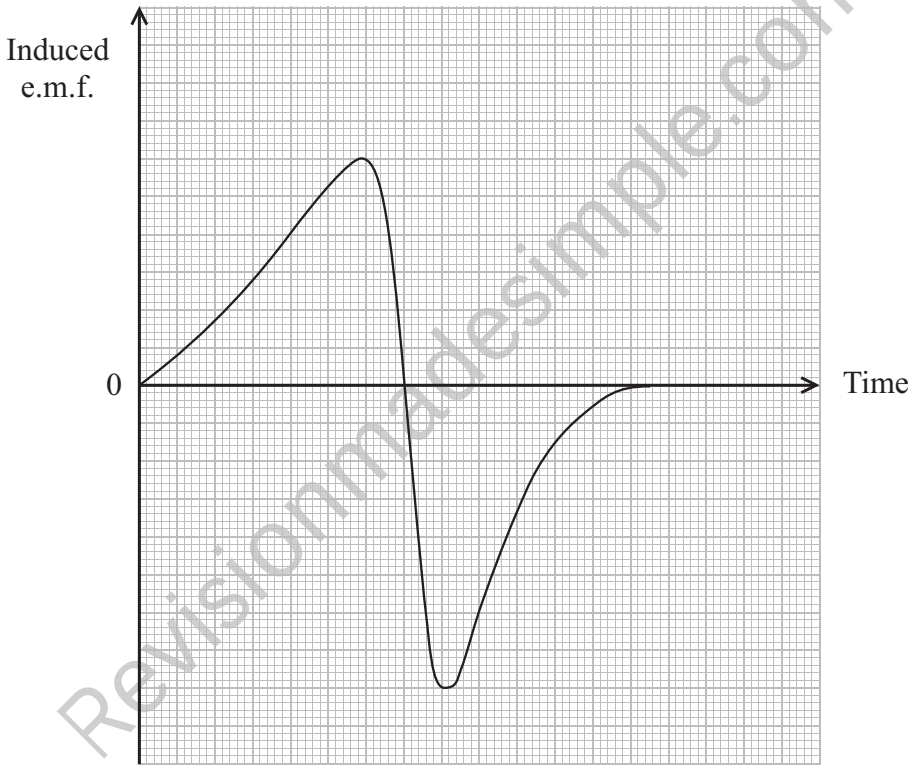


**(Total for Question = 9 marks)**

**6** A teacher demonstrates electromagnetic induction by dropping a bar magnet through a flat coil of wire connected to a data logger.




The data from the data logger is used to produce a graph of induced e.m.f. across the coil against time.






*(a) Explain the shape of the graph and the relative values on both axes.

**(6)**

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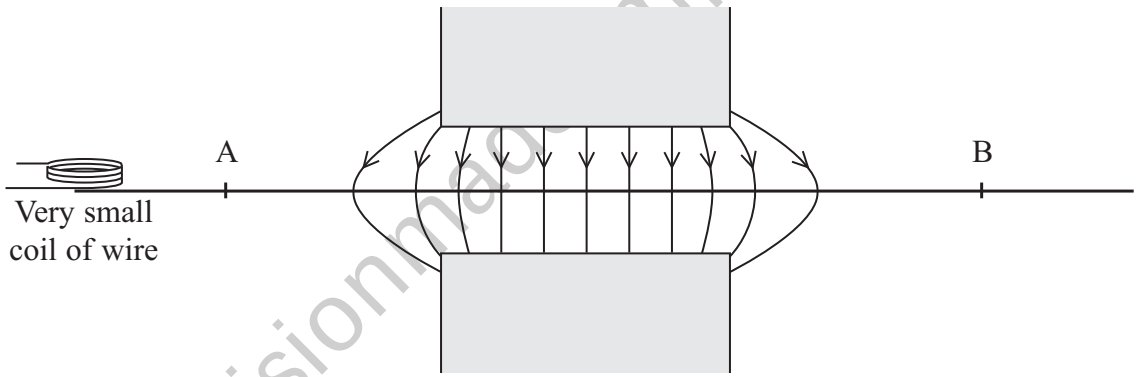
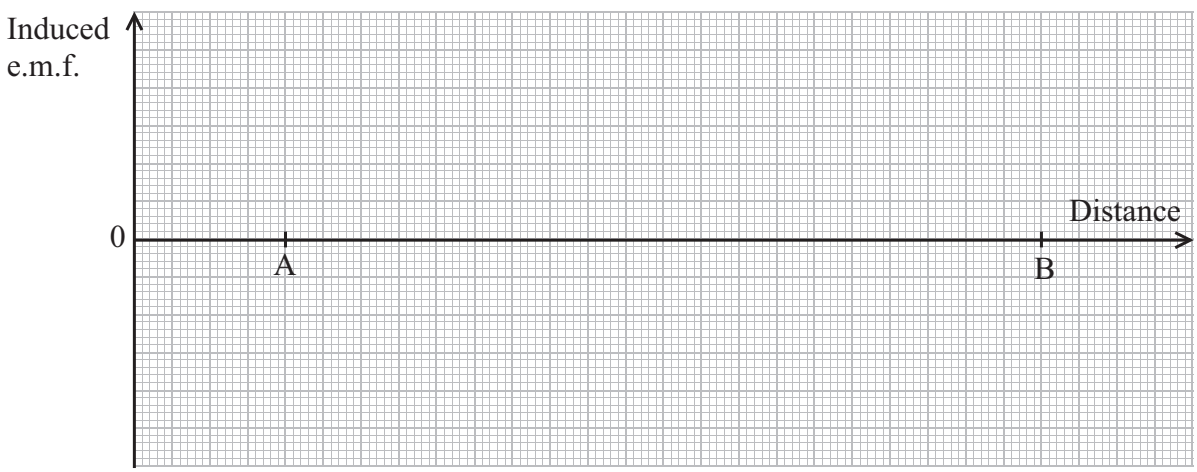
(b) The teacher then sets up another demonstration using a large U-shaped magnet and a very small coil of wire which is again connected to a data logger.

The north pole is vertically above the south pole and the coil is moved along the line AB which is midway between the poles. The magnetic field due to the U-shaped magnet has been drawn. The plane of the coil is horizontal.



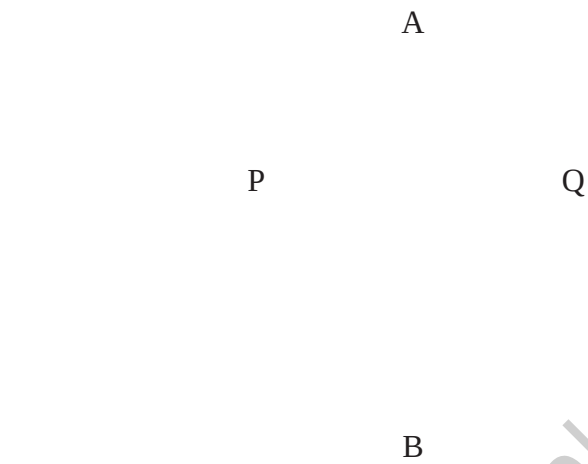

Sketch a graph to show how the e.m.f. induced across the coil varies as the coil moves from A to B at a constant speed.

**(4)**




**(Total for Question = 10 marks)**

*7 The diagram shows the track of a charged particle in a magnetic field. The field is at right angles to the plane of the paper and its direction is out of the plane of the paper. AB is a thin sheet of lead that the particle passes through.




Work out the direction of movement of the particle and the sign of the charge of the particle. Explain clearly how you reached your conclusions.

**(4)**

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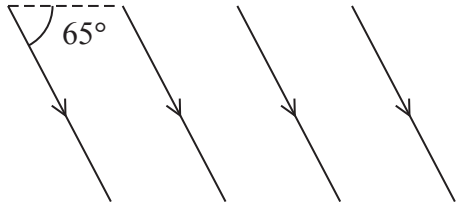
**(Total for Question = 4 marks)**

**8** The diagram shows the direction of the Earth's magnetic field over a region of the Earth where the magnetic flux density is $4.4 \times 10^{-5}$ T. The magnetic field in a vertical plane, acts at 65° to the horizontal.




(a) Calculate the magnitude of the vertical component of the Earth's magnetic flux density in this region.

**(1)**

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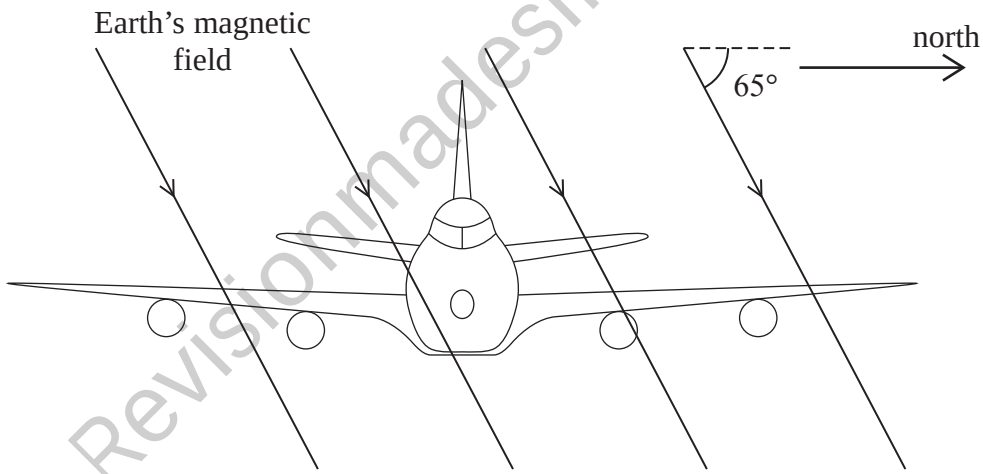
Magnitude of vertical component = .....

(b) An aeroplane's wings and fuselage are made of metal which contains conduction electrons that are free to move. The aeroplane flies west to east from North America to Europe. At the beginning of the flight the wing tips become charged.



(i) Assuming that the wings act as a continuous conductor, explain why the wing tips become charged.

**(2)**

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(ii) Identify which wing tip will become positive. Mark this on the diagram with an ×.

**(1)**

(iii) Once the aeroplane has reached a constant speed there is no further build up of charge.

Explain why.

**(2)**

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(iv) The shape of the Earth's magnetic field is as though there were a bar magnet at the centre of the Earth, aligned approximately on the North-South axis.

If the plane flies west to east, but above the equator, the wing tips do not become charged.

Explain why.

**(2)**

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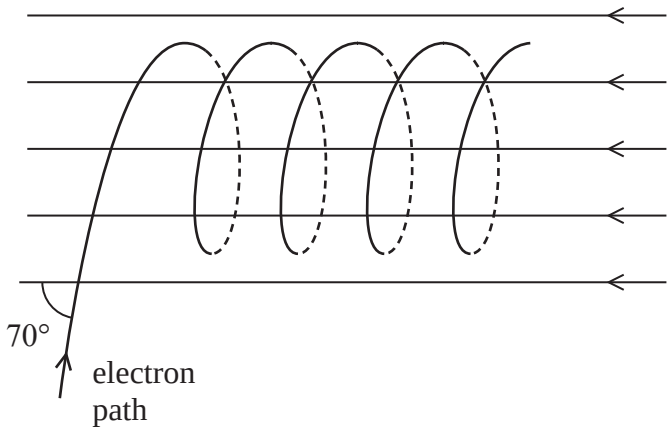
**(Total for Question = 8 marks)**

**9** An electron travelling at $8.0 \times 10^6$ m s$^{-1}$ enters a uniform magnetic field, at an angle of 70° to the field. The electron moves in a helical path as shown in the diagram.




(a) (i) Calculate the component of the electron's initial velocity that is perpendicular to the magnetic field.

**(1)**

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Perpendicular component = .....

(ii) Calculate the component of the electron's initial velocity that is parallel to the magnetic field.

**(1)**

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Parallel component = .....

(iii) Explain why the electron moves in the helical path.

**(2)**

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(b) (i) Show that the radius of the loop of the helical path is about $3 \times 10^{-3}$ m.

magnetic flux density of the field = 0.015 T

**(3)**

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(ii) Calculate the time taken for the electron to complete one loop.

**(2)**

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Time for one loop = .....

(iii) Calculate the distance between two adjacent loops in the helical path.

**(2)**

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Distance = .....

(c) Describe how the path would be different if the electron entered the magnetic field at an angle less than 70°.

**(2)**

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**(Total for Question = 13 marks)**