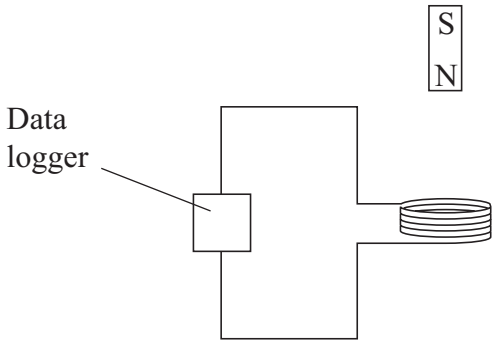
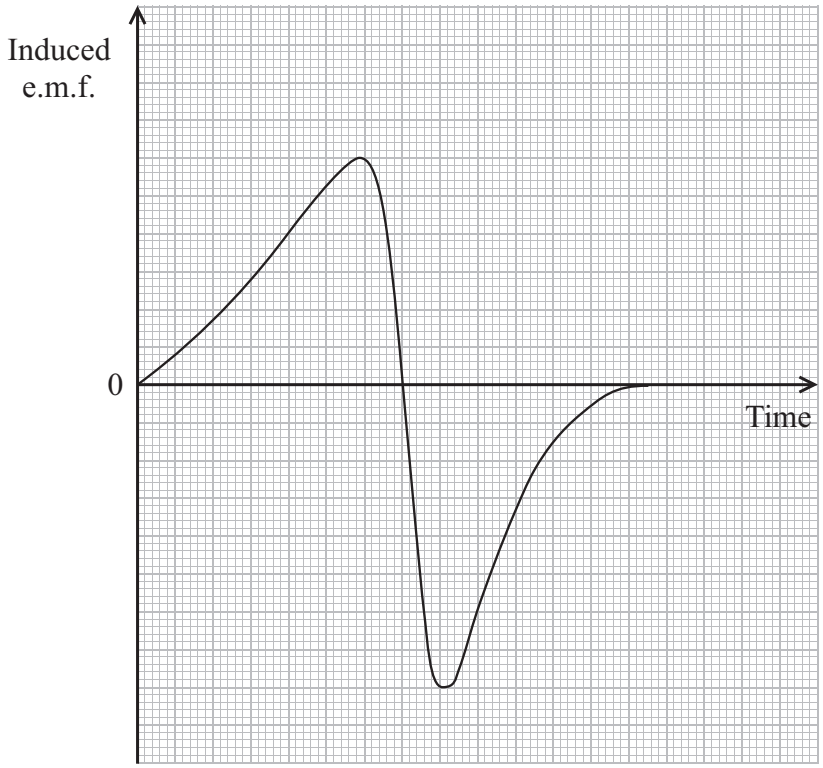
1 A teacher demonstrates electromagnetic induction by dropping a bar magnet through a flat coil of wire connected to a data logger.



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

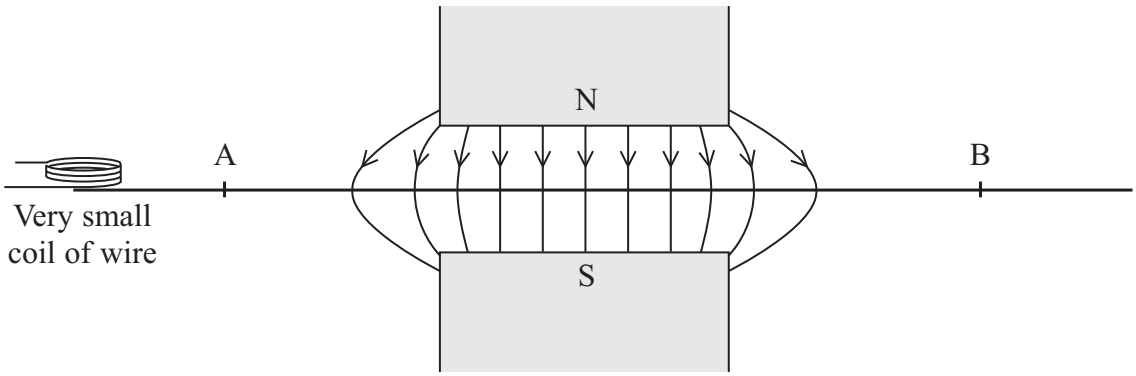


*(a) Explain the shape of the graph and the relative values on both axes.

(6)

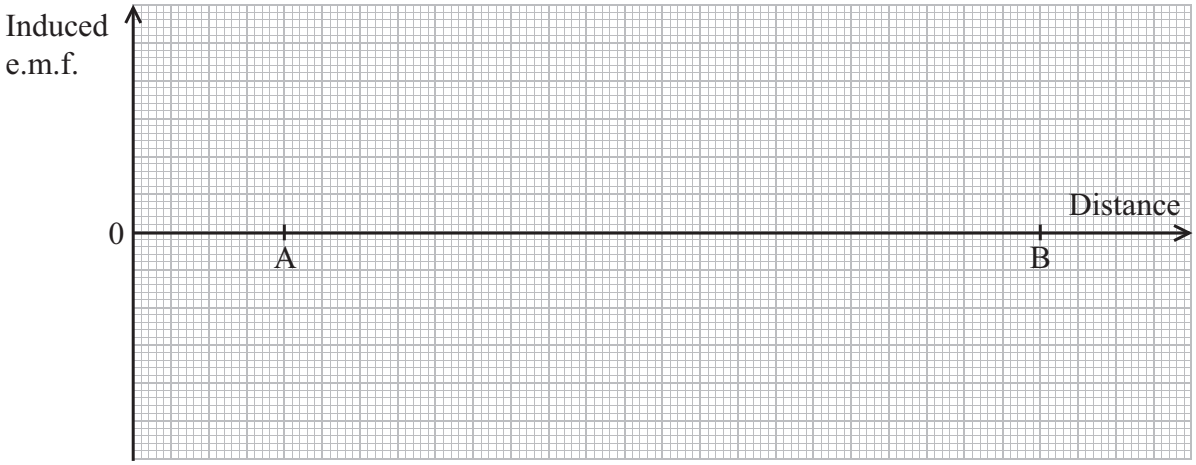
(b) The teacher then sets up another demonstration using a large U-shaped magnet and a very small coil of wire which is again connected to a data logger.

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.



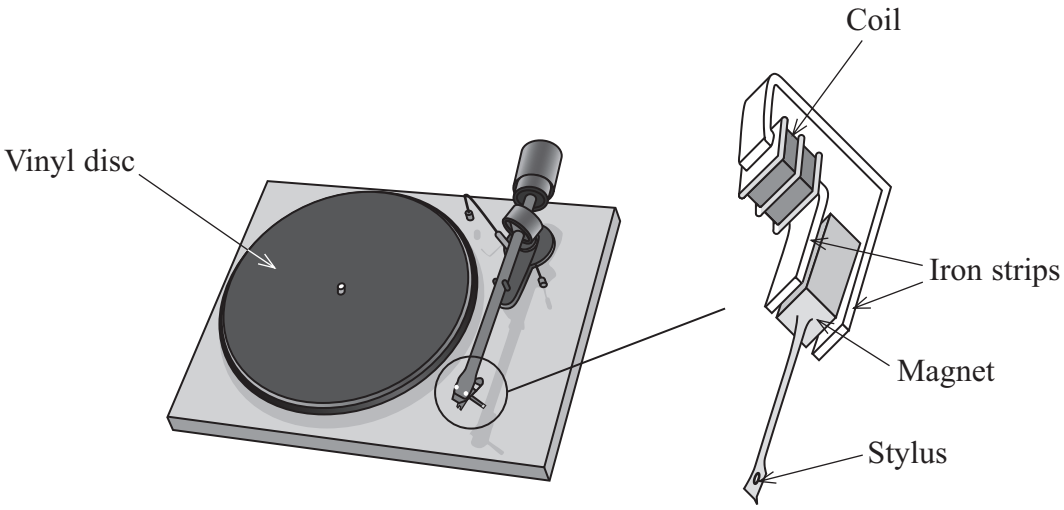
Sketch a graph to show how the e.m.f. induced across the coil varies as the coil moves from A to B at a constant speed.

(4)



(Total for Question 10 marks)

2 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 .....

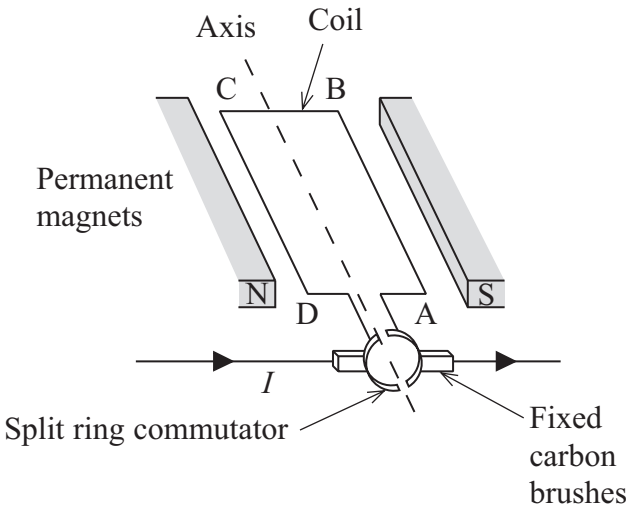
(ii) As the stylus moves towards the centre of the LP the encoded bumps must be fitted into a shorter length of groove.

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)

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)

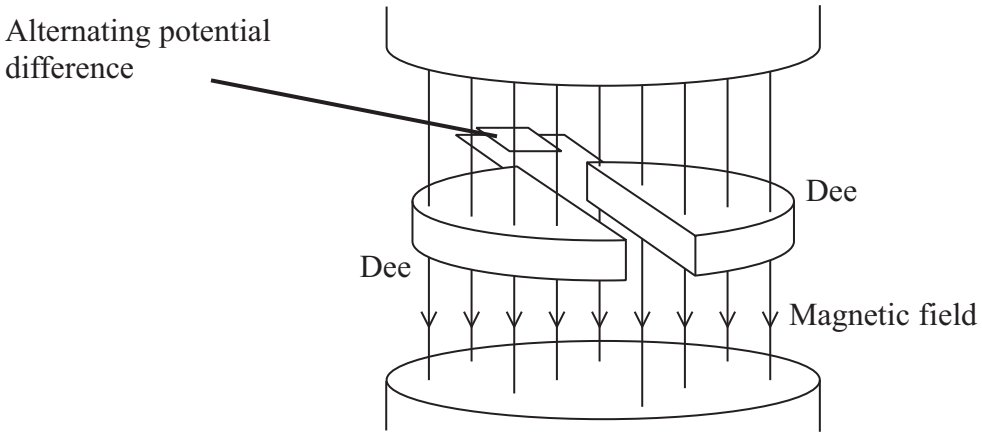
*(b) When the motor is first switched on the current I is large. As the coil turns faster, the current decreases.

Explain these observations.

(4)

(Total for Question 8 marks)

4 (a) A cyclotron can be used to accelerate charged particles.



Explain the purpose of the magnetic field in a cyclotron. You may add to the diagram if you wish.

(2)

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(b) A beam of low-speed protons are introduced into a cyclotron.

(i) Show that the number of revolutions per second, f, completed by the protons is given by

$$f \quad \frac{eB}{2\pi m}$$

where e is the electronic charge
B is the uniform magnetic flux density within the cyclotron
m is the mass of the proton.

(3)

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(ii) An alternating potential difference is placed across the two dees to increase the energy of the protons.

Explain why the potential difference that is used is alternating.

(2)

(iii) Initially, whilst the proton speeds are low, the frequency at which the potential difference has to alternate is constant.

Explain how the frequency must change as the protons gain more and more energy.

(2)

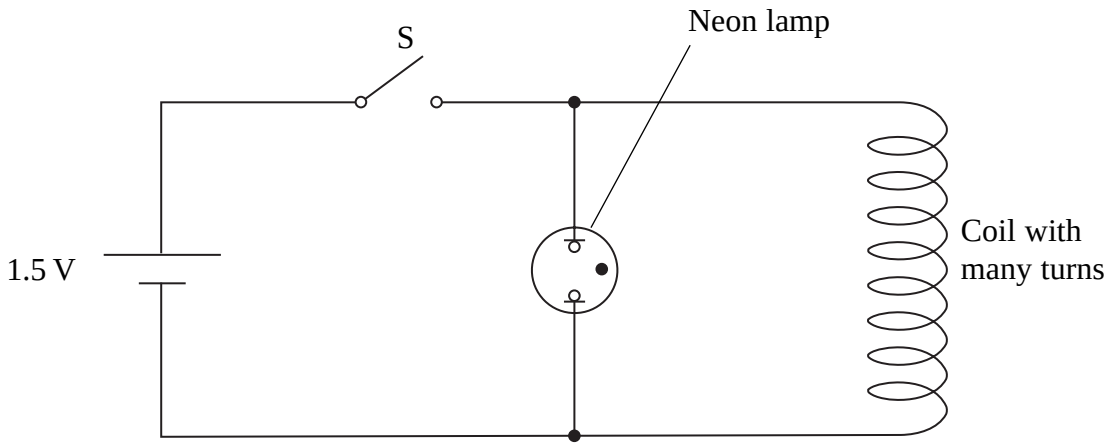
(c) In the Large Hadron Collider at CERN, protons follow a circular path with speeds close to the speed of light. X-rays can be produced by free protons which are accelerating.

Explain why this provides a source of X-rays even though the speeds of the protons are constant.

(2)

(Total for Question 11 marks)

5 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)