1 Faraday's and Lenz's laws of electromagnetic induction state that

$$\varepsilon = -\frac{\mathrm{d}(N\Phi)}{\mathrm{d}t}$$

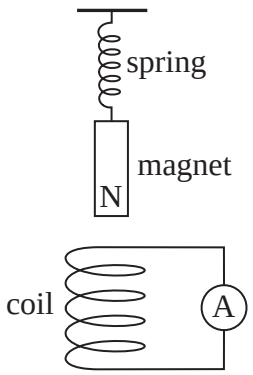
(a) (i) State the meaning of the term $N\Phi$ and give its unit.

(2)

(ii) State the significance of the negative sign.

(1)

(b) A student sets up the apparatus shown.



The magnet is pulled down until its north pole is just at the top end of the coil. The magnet is released and initially accelerates upwards away from the coil.

*(i) With reference to the laws of electromagnetic induction explain why a current is produced in the coil as the magnet moves upwards.

(3)

(ii) Explain why the magnitude of the current varies as the magnet moves upwards.

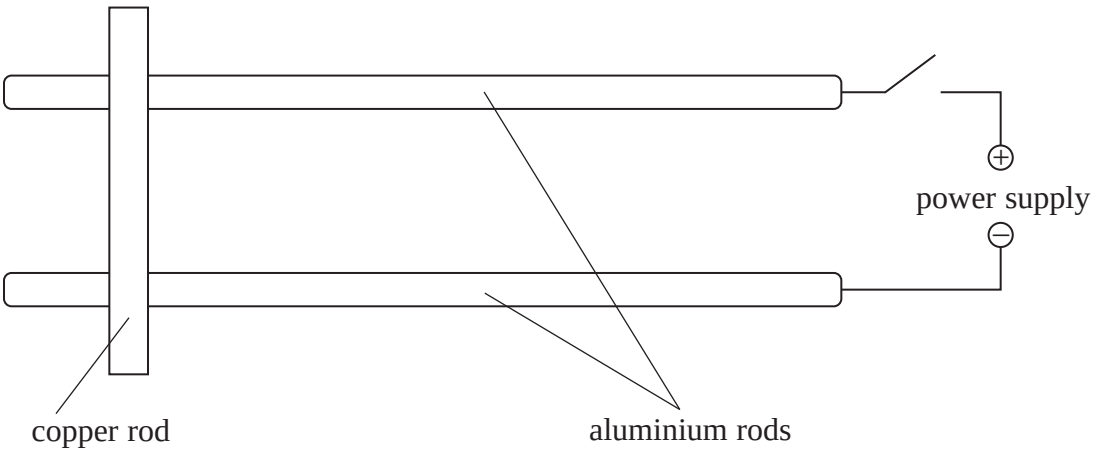
(2)

(iii) Suggest an advantage of replacing the ammeter with a data logger.

(1)

(Total for Question = 9 marks)

2 The apparatus shown in the diagram can be used to demonstrate that a force acts on a current-carrying conductor when the conductor is in a magnetic field.



The apparatus is placed in a magnetic field. When the switch is closed, the copper rod rolls along the aluminium rods.

(a) Add to the diagram to indicate the direction of the current in the copper rod.

(1)

(b) State the direction of the magnetic field that will make the copper rod move to the right.

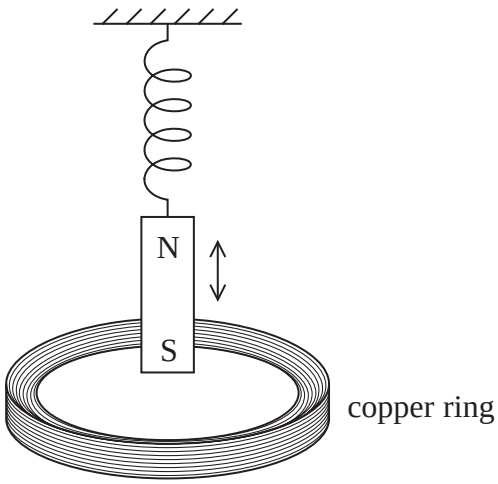
(2)

(Total for Question = 3 marks)

3 (a) State Faraday's law of electromagnetic induction.

(2)

*(b) A magnet is attached to the end of a spring as shown in the diagram.



The magnet is displaced vertically and released so that it oscillates.
Explain why this produces an alternating current in the copper ring.

(4)

(c) The average vertical component of the magnetic flux density through the coil varies at a maximum rate of 0.035 T s^{-1}.
Calculate the maximum current in the copper ring.

radius of copper ring = 5.0 cm
resistance of copper ring = 6.7×10^{-5} Ω

(4)

Maximum current =

(Total for Question = 10 marks)

4 (a) A magnetic field can be measured with a device called a Hall probe. The probe is connected to a voltmeter. When the probe is placed at right angles to a magnetic field, a potential difference is recorded on the voltmeter. The potential difference increases with increasing magnetic flux density.

A wire carries a constant current. A Hall probe is used to investigate how the magnetic flux density produced by the wire varies with distance from the wire.

The potential difference V was recorded for a range of distances r.

***r*/cm**	***V*/V**
1.0	0.725
1.5	0.483
2.0	0.363
2.5	0.29
3.0	0.242
3.5	0.21

(i) Criticise these results.

(2)

(ii) It is suggested that V and r are related by the equation

$$V = \frac{k}{r}$$

where k is a constant.

(1) Determine by calculation whether this suggestion is valid.

(2)

(2) A graph of $\frac{1}{V}$ is plotted against r.

State how the graph would indicate that the equation is correct.

(1)

(b) The Hall probe can be replaced with a small coil of wire which is connected to a sensitive voltmeter. The plane of the coil is at right angles to the magnetic field produced by the current-carrying wire.

(i) Explain, with reference to Faraday's law, why the voltmeter reading would be zero.

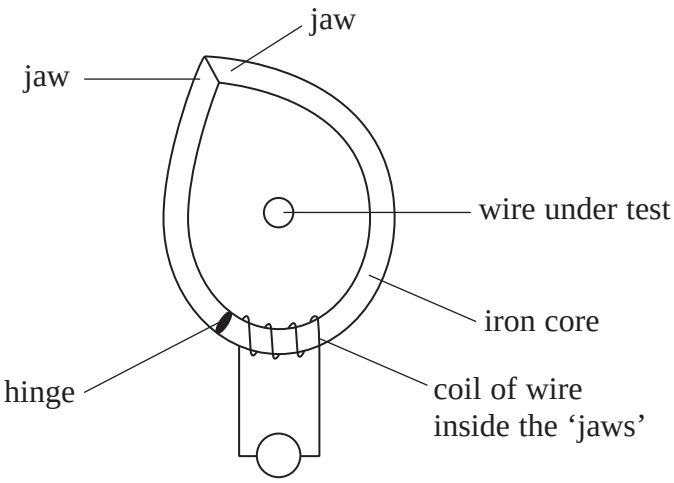
(2)

(ii) State **three** different ways in which an e.m.f. could be induced in this coil.

(3)

(Total for Question = 10 marks)

5 The photograph shows a digital clamp meter or ‘amp-clamp’. This can be used to measure the current in the live wire coming from the mains supply without breaking the circuit.



The ‘jaws’ of the clamp are opened, placed around the wire carrying the current and then closed. Inside the ‘jaws’ is an iron core with a coil of wire wrapped around it.

*(a) Explain how an e.m.f. would be produced in the coil of wire inside the amp-clamp when the ‘jaws’ are placed around a wire carrying an alternating current.

(4)

(b) State why the amp-clamp cannot be used with a steady direct current.

(1)

(c) The amp-clamp cannot be used with a cable that is used to plug a domestic appliance like a lamp into the mains supply.

Explain why not.

(2)

(d) (i) Explain why the amp-clamp can be used to determine the magnitude of different alternating currents with the same frequency.

(2)

(ii) The amp-clamp may **not** be reliable when comparing alternating currents of different frequencies.

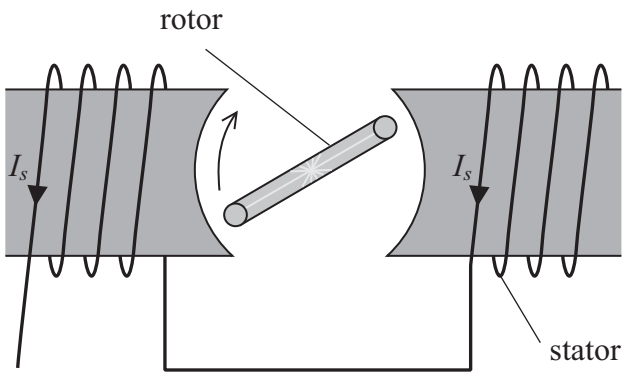
Suggest why not.

(2)

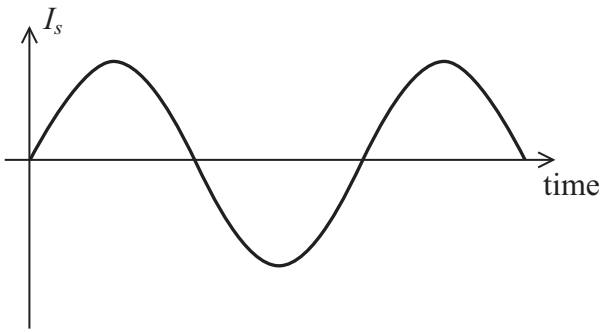
(Total for Question = 11 marks)

6 The diagram represents a simple induction motor. An alternating current I_s is supplied to a stationary coil (stator). This coil is wrapped around an iron core.

A rotating coil (rotor) is shown end on in the diagram.



(a) The graph shows the variation of the alternating current I_s with time.



*(i) Explain how current is induced in the rotor coil.

(4)

(ii) Explain why the rotor turns.

(2)

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.....

(iii) State **two** ways of making the rotor turn faster.

(2)

1 .....

.....

2 .....

.....

(b) An induction motor is used to rotate the turntable in a record deck. Long-play records require the turntable to rotate at 33 revolutions per minute.

(i) Calculate the angular velocity of the turntable.

(3)

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.....

.....

Angular velocity .....

(ii) Calculate the acceleration of a speck of dust at the outside edge of a rotating record.

radius of record 12.5 cm

(2)

.....

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.....

.....

Acceleration .....

(Total for Question 13 marks)

***7** Faraday's and Lenz's laws are summarised in the list of formulae as

$$\varepsilon \quad \frac{\mathrm{d}(N\phi)}{\mathrm{d}t}$$

(a) State the meaning of the term $N\phi$.

(2)

(b) Explain the significance of the minus sign.

(3)

(Total for Question = 5 marks)