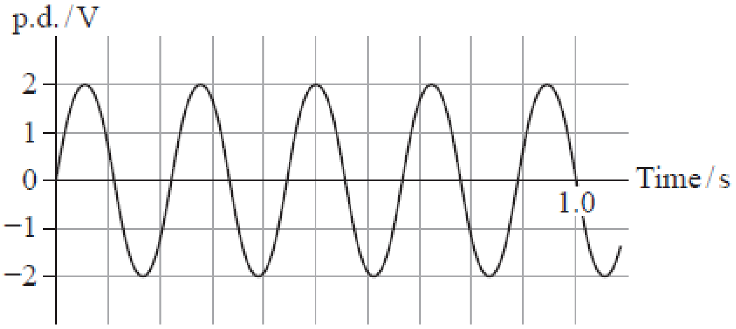
Questions

Q1.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The graph shows how a potential difference (p.d.) varies with time.



Which of the following is correct?

☐ **A** The frequency is 4.5 Hz.

☐ **B** The peak value is 4.0 V.

☐ **C** The period is 0.20 s.

☐ **D** The root mean square value of p.d. is 1.0 V.

(Total for question = 1 mark)

Q2.

Mains electricity in the UK is 230 V rms.

The peak voltage of the mains supply is given by

☒ **A** $\frac{230}{\sqrt{2}}$ V

☒ **B** $230\sqrt{2}$ V

☒ **C** $\frac{\sqrt{2}}{230}$ V

☒ **D** $\frac{230}{2}$ V

(Total for question = 1 mark)

Q3.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of the following is a unit of magnetic flux?

☒ **A** $N\ C^{-1}$

☒ **B** $T\ m^{-2}$

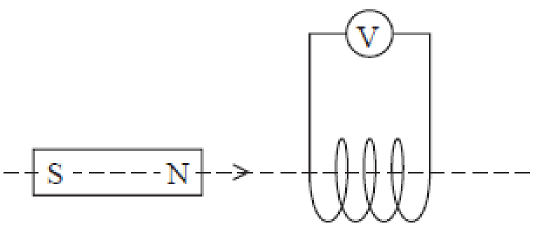
☒ **C** V s

☒ **D** $Wb\ m^{2}$

(Total for question = 1 mark)

Q4.

A magnet is passed along the axis of a short coil of wire.



An e.m.f. is induced across the ends of the coil.

Which of the following would increase the maximum e.m.f. induced?

☒ **A** decreasing the area of the coil

☒ **B** decreasing the number of turns per metre in the coil

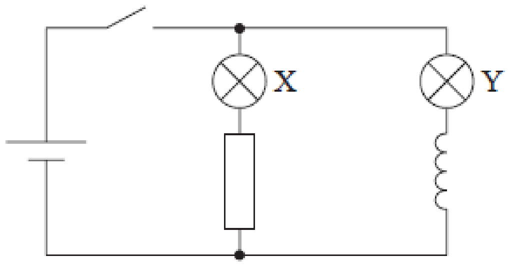
☒ **C** increasing the speed of the magnet

☒ **D** reversing the polarity of the magnet

(Total for question = 1 mark)

Q5.

A circuit is set up as shown in the diagram. Lamps X and Y are identical.
The coil has a soft iron core. The resistor and the coil have the same resistance.



The switch is closed and lamp X lights instantly.

Which statement best describes lamp Y after the switch is closed?

(1)

☒ **A** Lights after a delay with a final brightness less than X

☒ **B** Lights after a delay with a final brightness the same as X

☒ **C** Lights instantly with less brightness than X

☒ **D** Lights instantly with the same brightness as X

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A wire carries an alternating current of peak value 3 A.

Which of the following is the root-mean-square value of this current?

☐ **A** 1.5 A

☐ **B** 2.1 A

☐ **C** 4.2 A

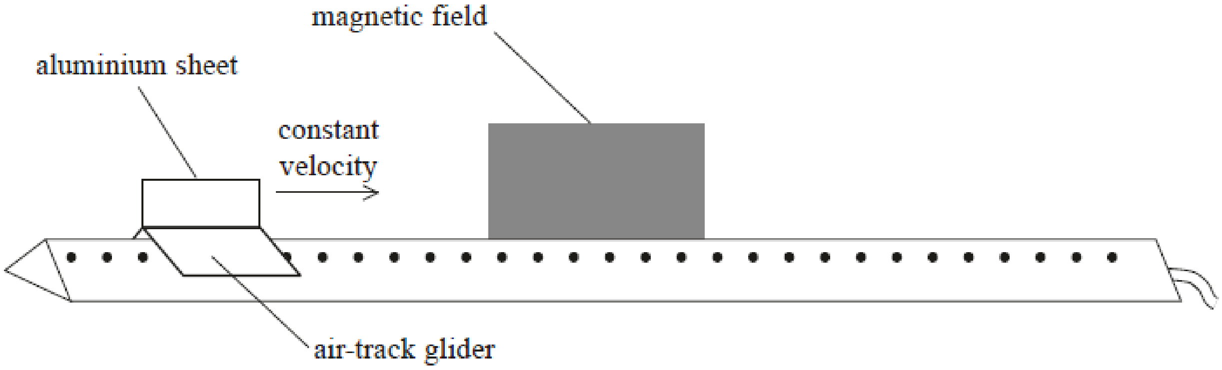
☐ **D** 9.0 A

(Total for question = 1 mark)

Q7.

A rectangular sheet of aluminium is attached to an air-track glider as shown.

The glider moves towards a region of uniform magnetic field at a constant velocity. When the glider enters the magnetic field, the magnetic flux is perpendicular to the aluminium sheet.



Which row of the table describes the velocity of the glider as it enters the magnetic field, when it is completely within the magnetic field and as it leaves the magnetic field?

	Enters the magnetic field	Within the magnetic field	Leaves the magnetic field
☐ **A**	constant	decreasing	constant
☐ **B**	decreasing	constant	increasing
☐ **C**	decreasing	constant	decreasing
☐ **D**	decreasing	decreasing	decreasing

(Total for question = 1 mark)

Q8.

Power supplies provide either alternating or direct currents and potential differences.

A power supply produces an alternating potential difference (p.d.). The p.d. has a period of 0.02 s and a peak value of 4.0 V.

(i) Calculate the frequency of the supply.

(1)

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Frequency = ...

(ii) Calculate the root-mean-square p.d.

(1)

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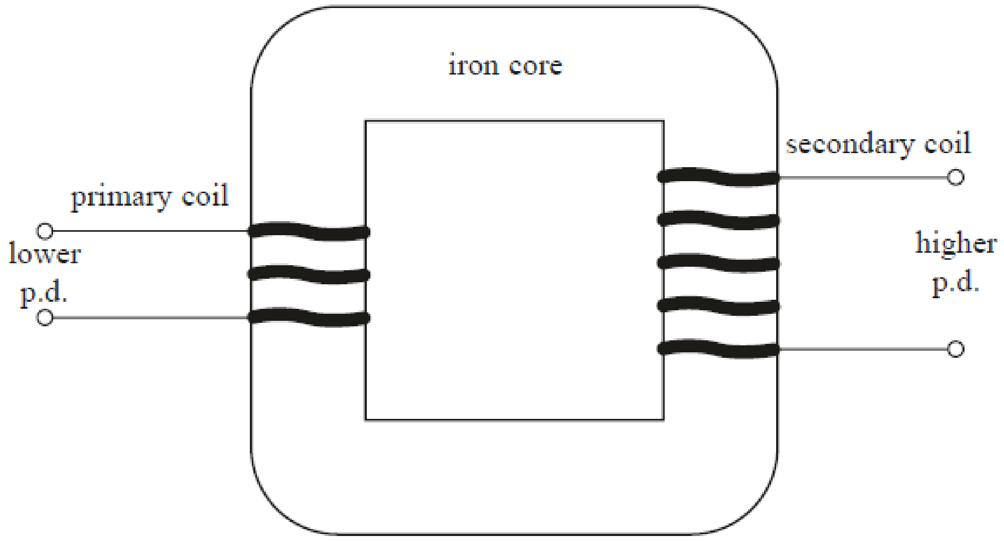
Root-mean-square pd = ...

(Total for question = 2 marks)

Q9.

Electrical transmission systems are used to transmit electrical power from place to place. Transformers are used to change potential differences (p.d.) and power transmission cables are used to transmit power.

The diagram shows a step-up transformer.



A step-up transformer is used to convert a lower p.d. to a higher p.d. An alternating p.d. is applied to the primary coil.

Explain how a higher p.d. is produced across the secondary coil.

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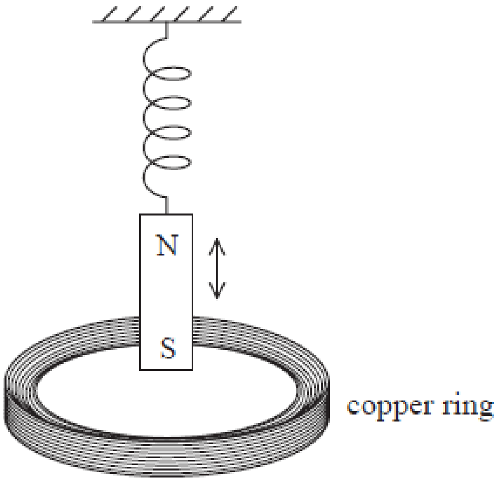
(Total for question = 4 marks)

Q10.

* 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.

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

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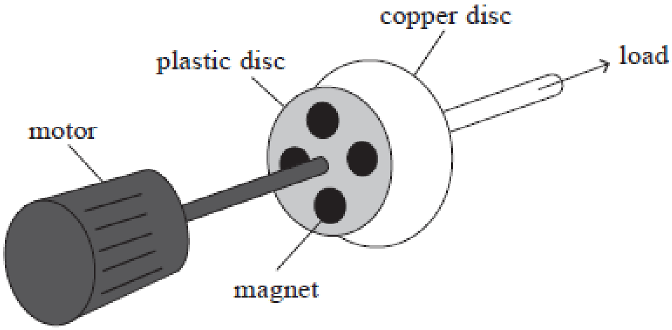
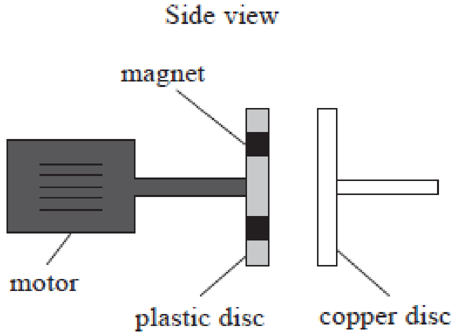
Maximum current = ...

Q11.

A device called a clutch can be used to connect a motor to a load. The diagram shows a design called an eddy current clutch.





Several magnets are embedded in the plastic disc and it is rotated by the motor.

The table shows how the turning effect exerted on a load varies with ω for a particular distance between the copper disc and the plastic disc.

ω / rad s^{-1}	Turning effect / N cm
52.4	1.0
104.7	2.0
157.1	2.8

Explain the trend shown by the data.

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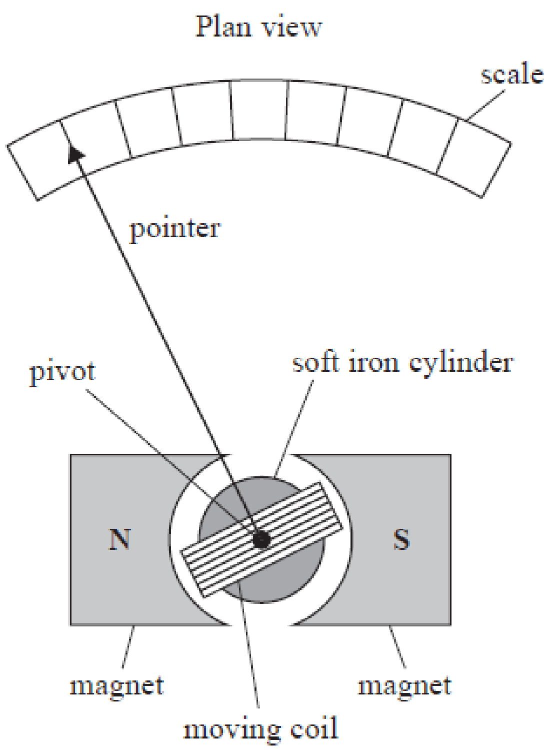
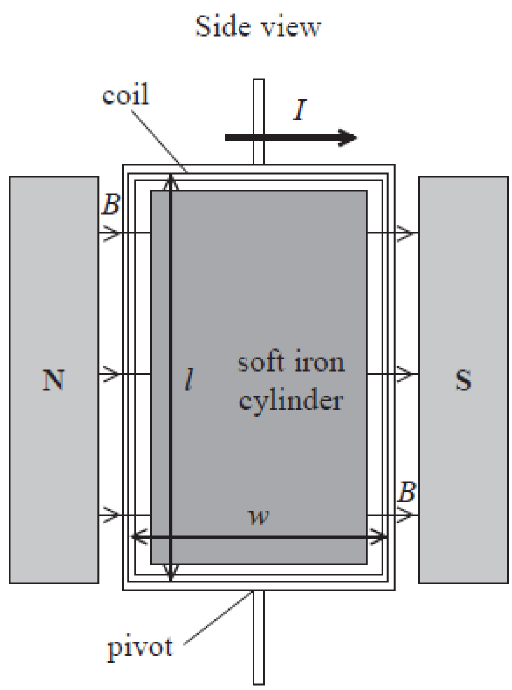
(Total for question = 4 marks)

The diagrams show the plan view and side view of a moving coil ammeter.





The coil within a very sensitive moving coil ammeter can be damaged when the ammeter is transported. The two ends of the coil are connected together when the ammeter is transported. This reduces the movement of the coil and makes it less likely to be damaged.

A student suggests that this is due to Faraday's law and Lenz's law.

Explain how these laws apply to this situation.

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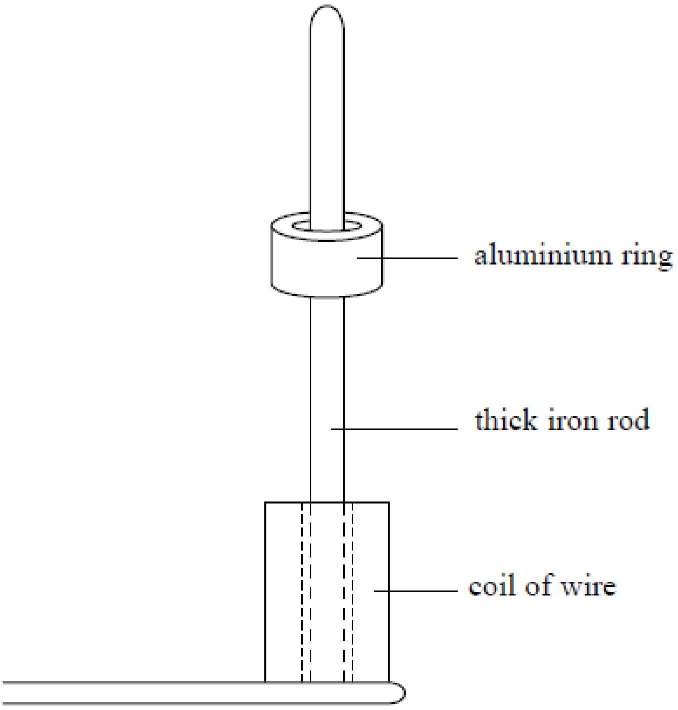
(Total for question = 4 marks)

Q13.

A coil of wire is placed around the lower end of an iron rod. The coil is supplied with an alternating current.

A thick aluminium ring is placed around the iron rod above the coil. The coil remains in the position shown.



An alternating current is induced in the aluminium ring.

Explain, using Lenz's law, why the aluminium ring remains in the position shown.

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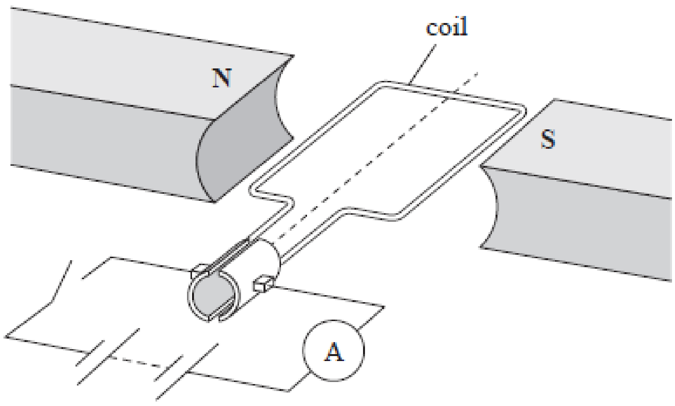
(Total for question = 4 marks)

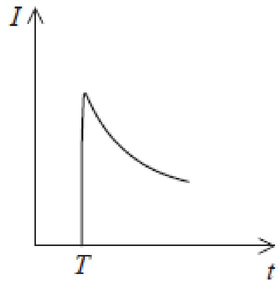
Q14.

* A simple electric motor consists of a coil that is free to rotate in a magnetic field.

A student connects the motor to an ammeter and a battery.



The graph shows how the current *I* in the coil varies with time *t*. The switch is closed at time *T*.



Explain why the current rises to a maximum then decreases.
Your answer should include a reference to Faraday and Lenz's laws.

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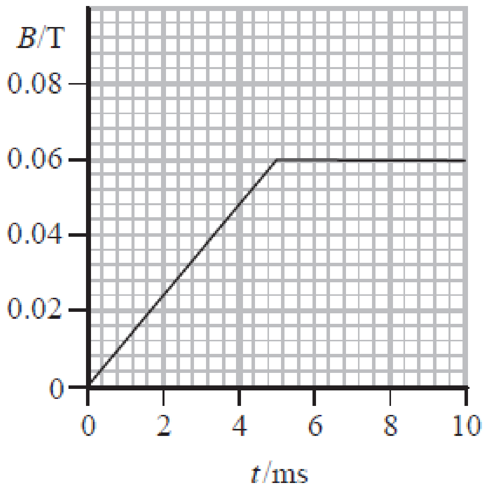
(Total for question = 6 marks)

Q15.

A coil of 300 turns each of area 1.5×10^{-4} m^2 is placed in a magnetic field with its plane at right angles to the field. The graph shows how the magnetic flux density *B* of the field varies with time *t*.



The e.m.f. induced in the coil during the first 5 ms is

☒ **A** 5.4×10^{-1} V

☒ **B** 4.5×10^{-2} V

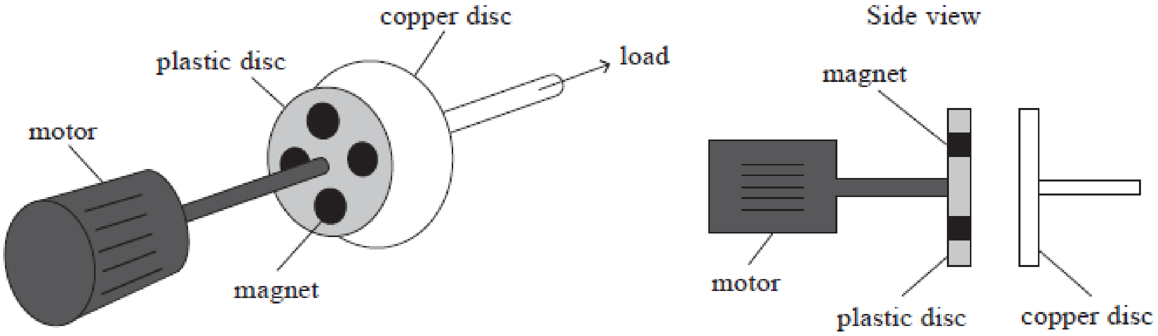
☒ **C** 1.8×10^{-3} V

☒ **D** 5.4×10^{-4} V

(Total for question = 1 mark)

Q16.

A device called a clutch can be used to connect a motor to a load. The diagram shows a design called an eddy current clutch.



Several magnets are embedded in the plastic disc and it is rotated by the motor.

(i) Explain why a current is induced in the copper disc when the motor is switched on.

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(ii) Explain, using Lenz's law, why the copper disc rotates.

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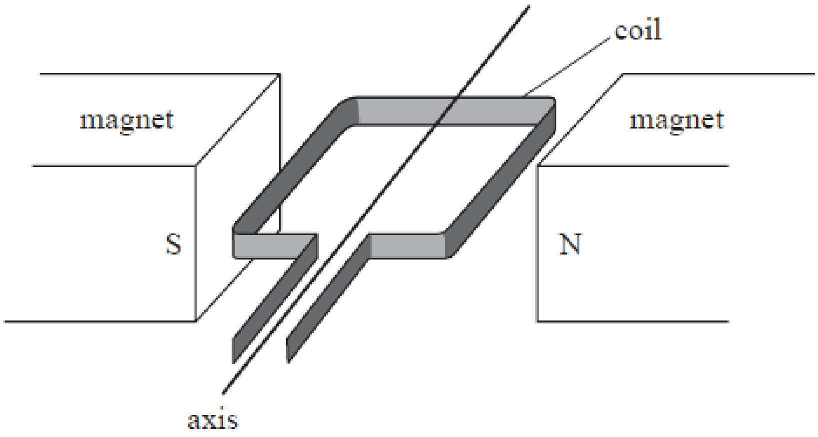
(Total for question = 5 marks)

Q17.

*****Hybrid electric vehicles (HEV) use the same device both as a generator to charge the car battery and as an electric motor to support the propulsion system. A simplified diagram of the device is shown. The coil can rotate freely around the axis.



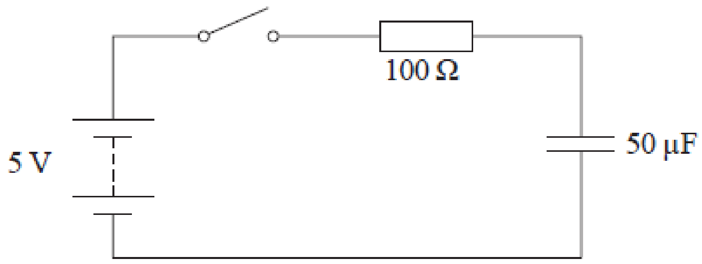
Describe how the device can be used as both a generator and an electric motor.

(6)

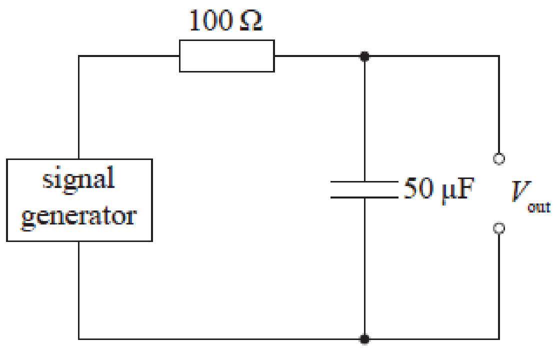
(Total for question = 6 marks)

Q18.

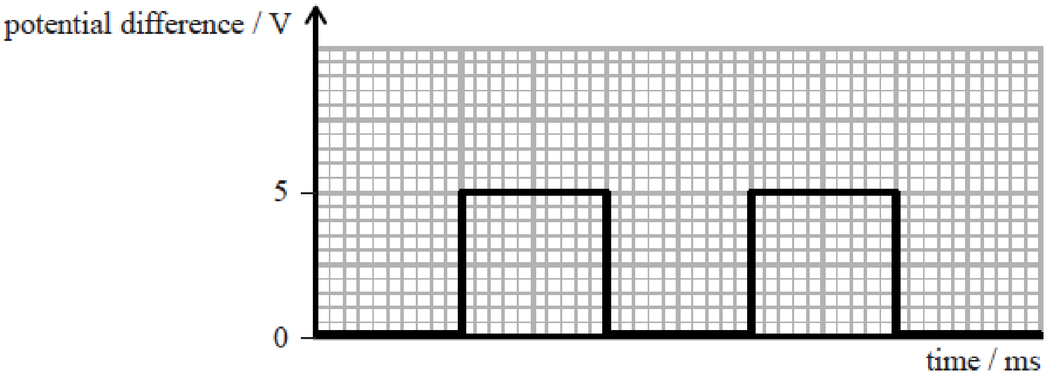
A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



The battery and switch are replaced by a signal generator providing a square wave output of peak potential difference 5 V. The signal generator has negligible internal resistance.



The graph shows the square wave output of the signal generator. The frequency of the square wave is 20 Hz.



On the graph add values to the time axis and sketch a graph of the potential difference, V_{out}, across the capacitor for two cycles of the square wave. Assume the capacitor is initially uncharged.

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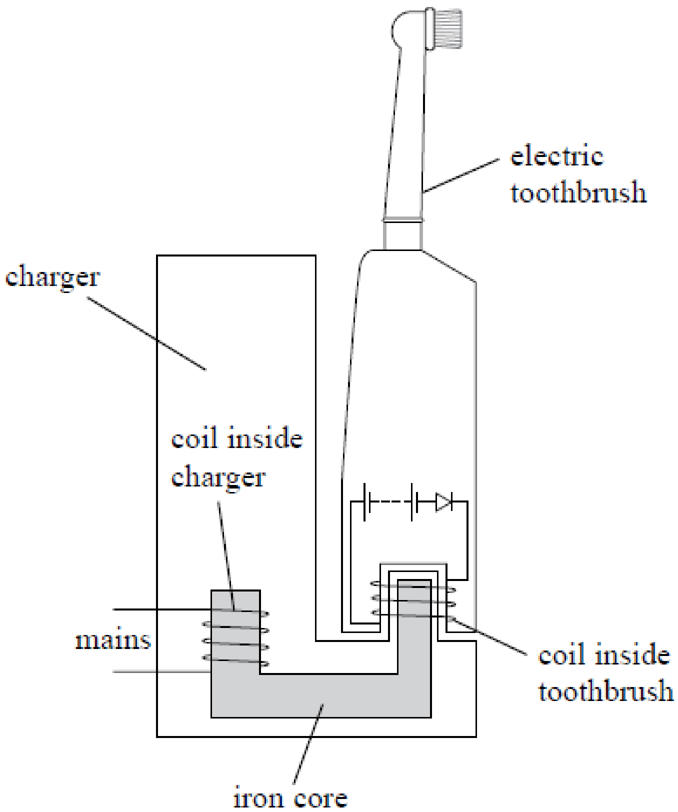
(Total for question = 5 marks)

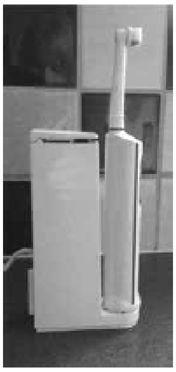
Q19.

The diagram shows the inside of an electric toothbrush and a charger.

The charger contains a coil wrapped around an iron core. The coil is plugged into the mains a.c. supply.

The toothbrush also contains a coil that sits around the iron core when the toothbrush is placed on the charger to recharge the battery of the toothbrush.





* Describe how the charger is able to charge the low-voltage battery.

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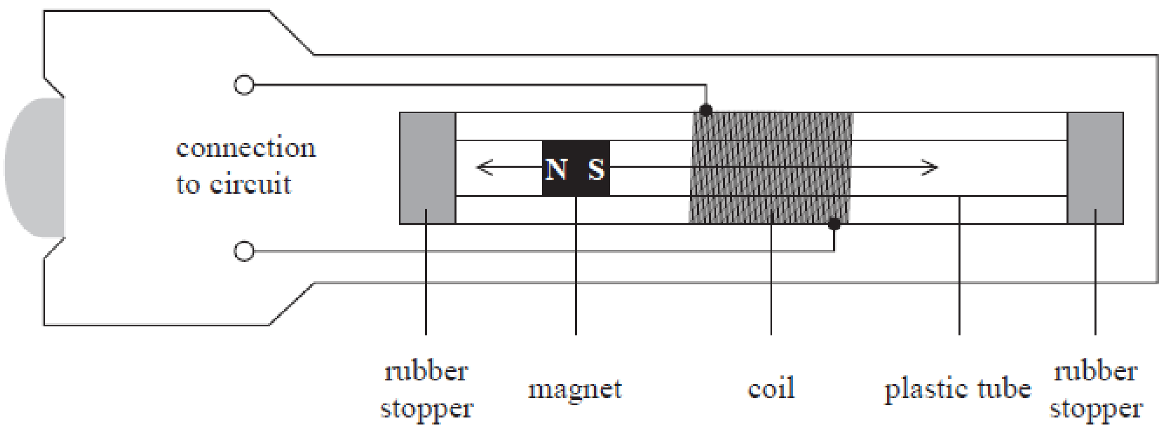
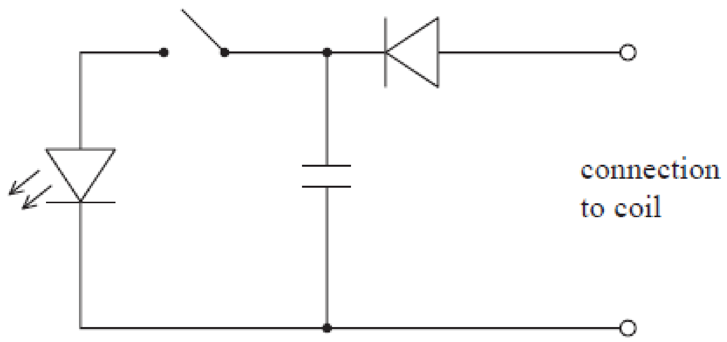
(Total for question = 6 marks)

Q20.

*The diagram shows a 'shaker torch'. When the torch is shaken, a strong magnet moves forwards and backwards through a copper coil, powering a light-emitting diode (LED).



Each time the magnet moves through the coil a current pulse is generated. The coil is connected to a capacitor via a diode, as shown.



Explain how the shaker torch is able to light the LED.

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(Total for question = 6 marks)

Q21.

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

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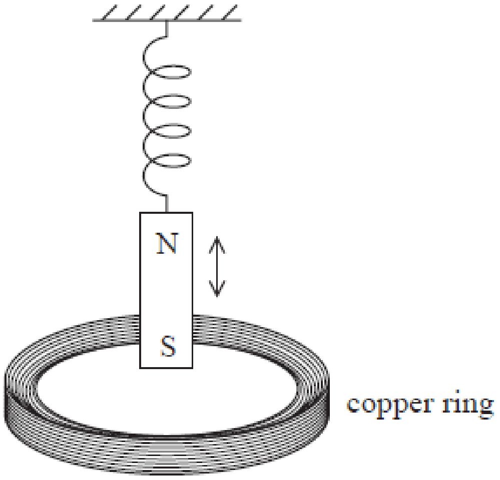
*(b) A magnet is attached to the end of a spring as shown in the diagram.



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

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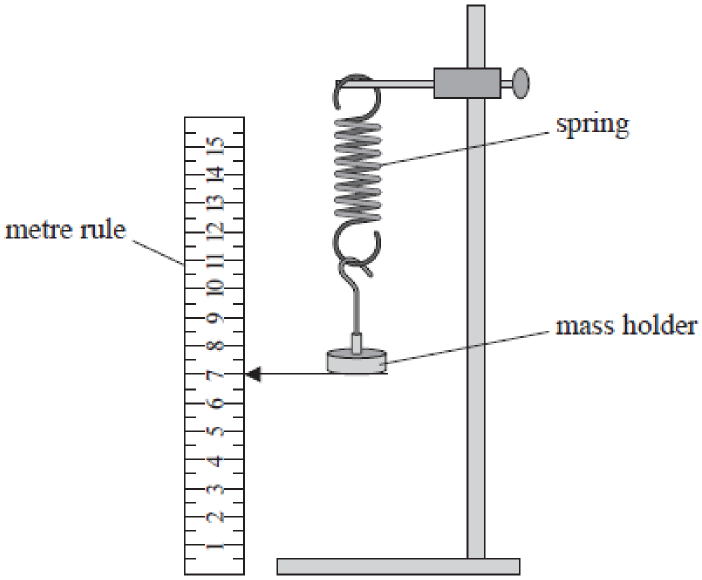
Q22.

A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached.

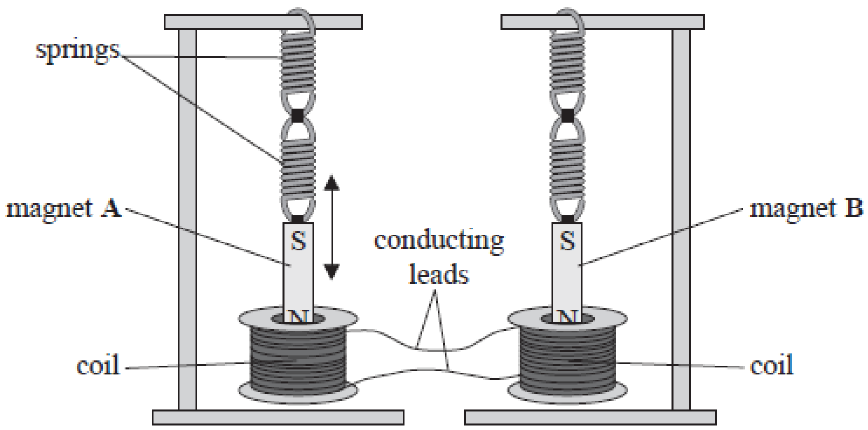


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

The student produced the following table.

Mass added / g	Extension / cm	Stretching force / N
50	1.9	0.49
70	3	0.69
90	3.5	0.9
110	4.5	1.08
130	5.3	1.28
150	5.8	1.47

* Identical bar magnets are suspended from identical springs, with the North pole of each magnet inside a coil of wire as shown. The two coils are connected together with conducting leads.



Magnet A is displaced so that it oscillates vertically. The North pole of magnet A moves into and out of the coil of wire with simple harmonic motion. As this motion continues, magnet B starts to oscillate. The amplitude of oscillation of magnet B increases over time.

Explain why magnet B starts to oscillate with an increasing amplitude.

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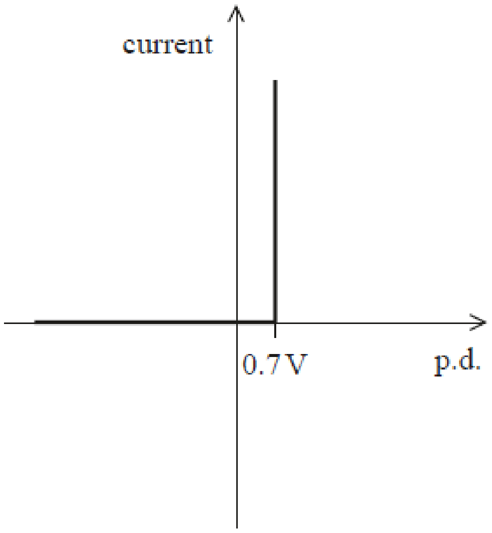
(Total for question = 6 marks)

Q23.

The graph shows how current varies with potential difference (p.d.) for an ideal diode.



An alternating p.d. V_{IN} has a peak value of 3.4 V.

(i) Calculate the r.m.s. value.

(2)

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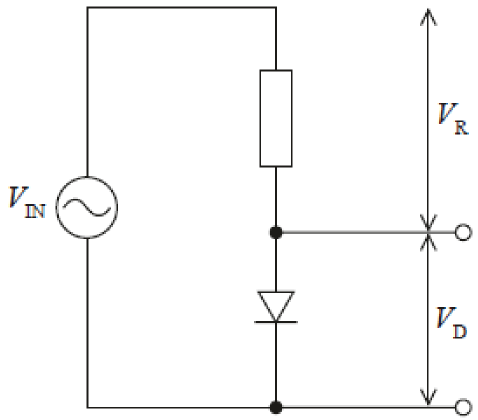
r.m.s. value = ...

(ii) V_{IN} is applied to a diode and resistor as shown.



The p.d. across the resistor is V_R and the p.d. across the diode is V_D. V_D is the output.

Explain why $V_{IN} = V_R + V_D$ at any given time.

(2)

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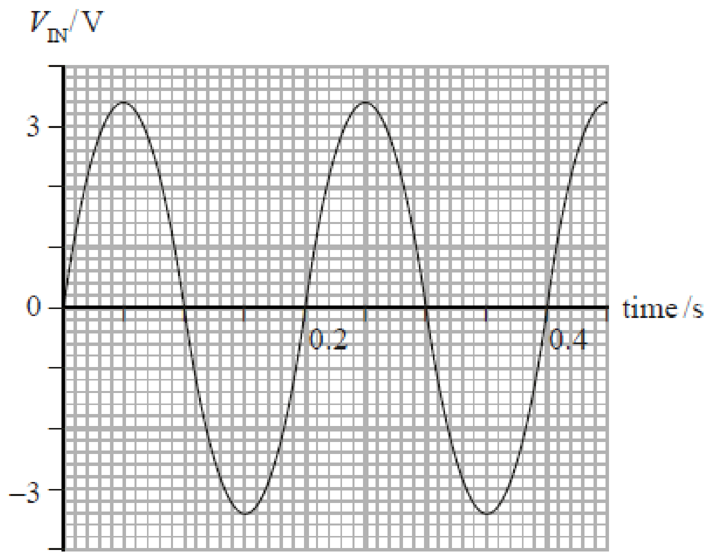
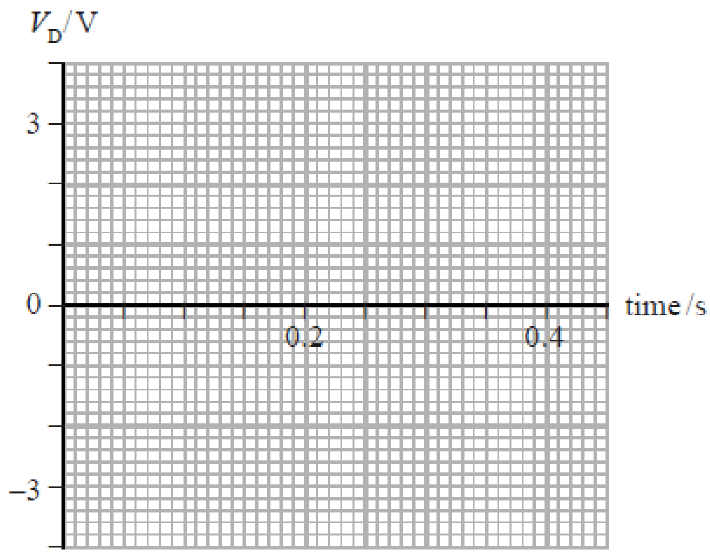
(iii) The graph shows how V_{IN} varies with time.

Sketch a graph of V_D against time using the axes provided below.

(3)



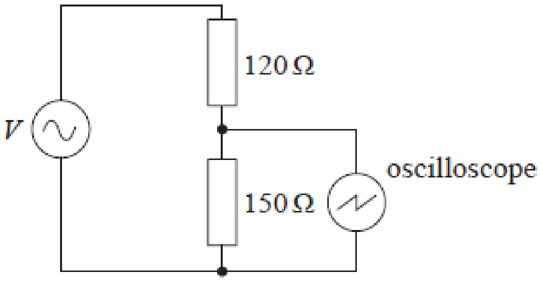


(Total for question = 7 marks)

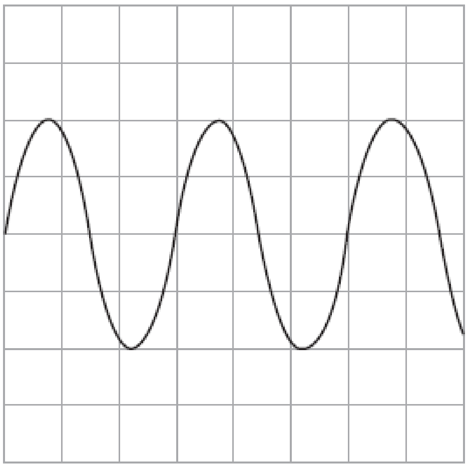
Q24.

A student connected the output from a source of alternating potential difference (p.d.) to a series resistor combination.

She connected an oscilloscope across the 150 Ω resistor as shown.



The trace obtained on the oscilloscope is shown below.



(i) Determine the peak p.d. across the 150 Ω resistor.

y-sensitivity of oscilloscope = 2.0 V per division

(2)

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Peak p.d. across 150 Ω resistor = ...

(ii) Calculate the root mean square (r.m.s.) value of the current in the circuit.

(3)

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r.m.s. value of current = ...

(iii) Calculate the power dissipated in the circuit.

(3)

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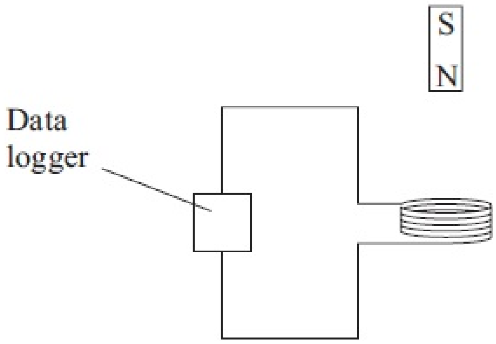
Power dissipated in circuit = ...

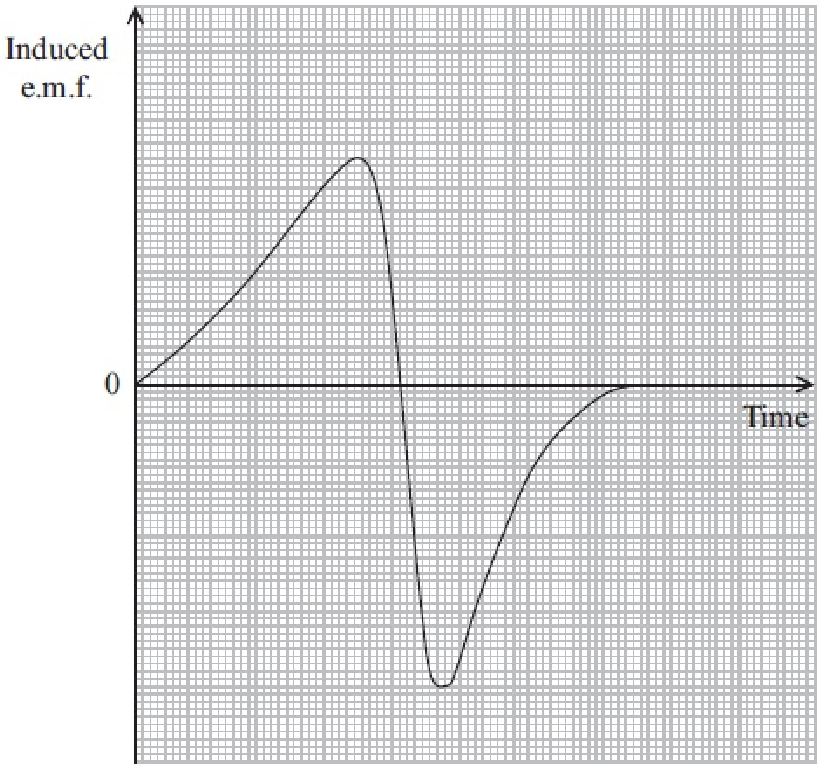
(Total for question = 8 marks)

Q25.

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.

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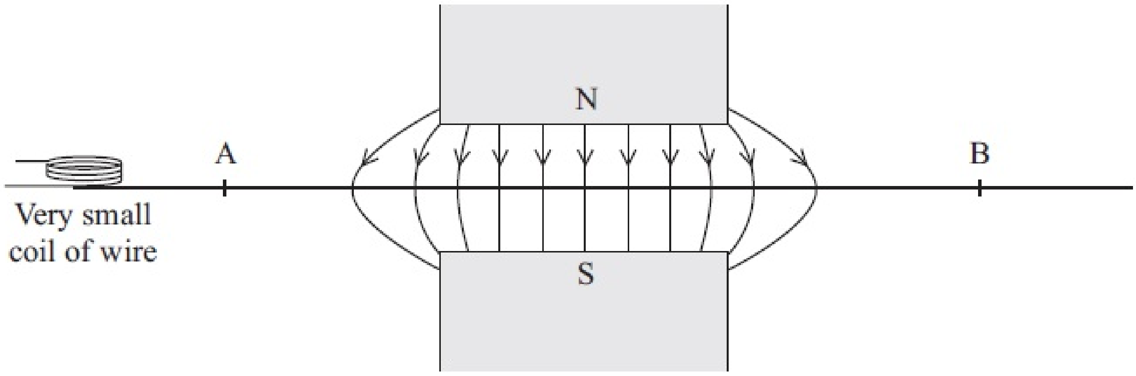
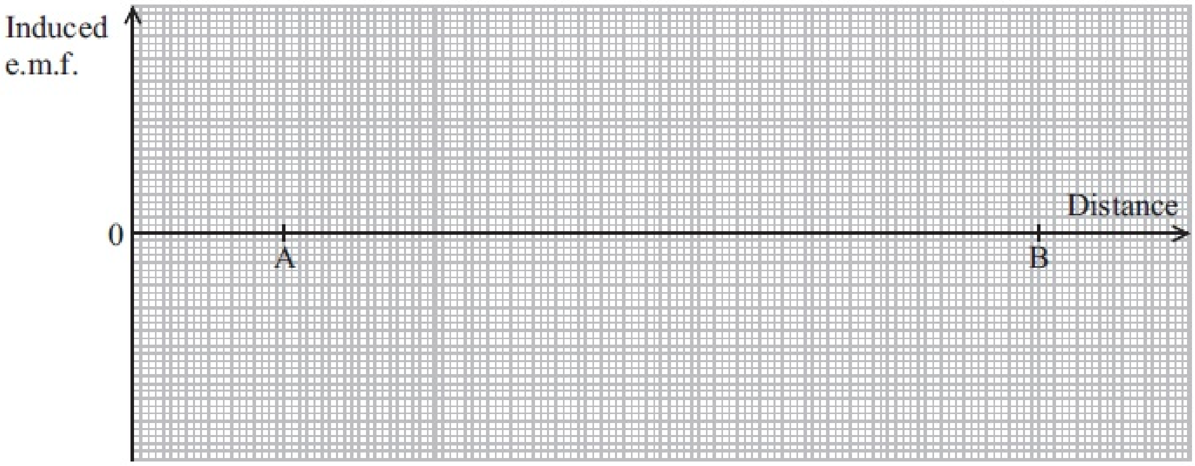
*(b) The teacher then sets up another demonstration using a large U-shaped magnet and a very small coil of wire which is again connected to a data logger.

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)

Q26.

(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)

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(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)

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

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

(1)

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(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)

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

(3)

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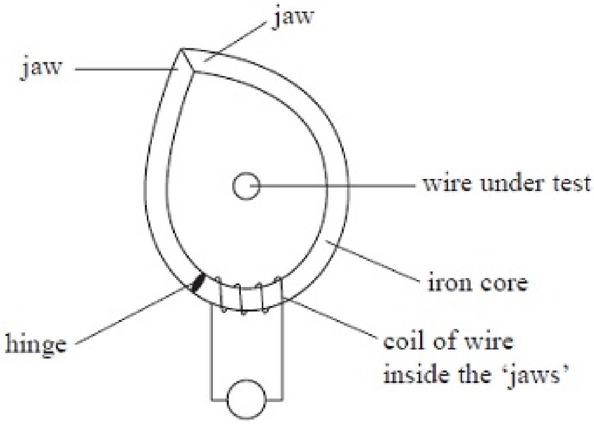
(Total for question = 10 marks)

Q27. 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)

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

(1)

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(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)

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

(2)

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

Suggest why not.

(2)

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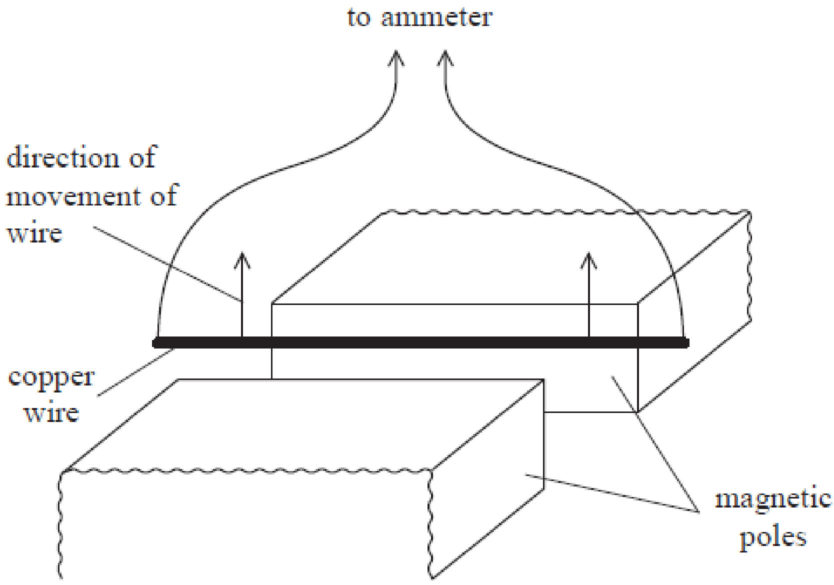
(Total for Question = 11 marks)

Q28.

A student is investigating electromagnetic induction using a U-shaped magnet. The magnetic flux density between the poles of the magnet is 74 mT. The magnetic field outside the region of the poles is negligible.
She places a stiff copper wire between the poles of the magnet as shown in the diagram.
The wire is connected to an ammeter of resistance 0.25 Ω



(a) The rectangular poles measure 6.0 cm × 2.4 cm.

Show that the magnetic flux between the poles of the magnet is about 1×10^{-4} Wb.

(3)

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(b) The student holds the wire as shown in the diagram and moves it vertically upwards at a constant speed of 1.2 m s^{-1}
Calculate the e.m.f. induced in the wire when it is moving.

(3)

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Induced e.m.f. = ...

(c) According to Lenz's law, a force will act on the wire to oppose the motion of the wire.

Calculate the magnitude of the force that opposes the motion and comment on this value.

(4)

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Magnitude of force = ...

Comment

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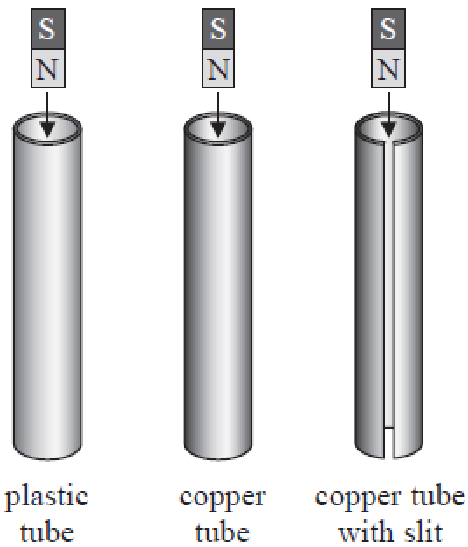
(Total for question = 10 marks)

Q29.

A teacher carries out a demonstration to illustrate the laws of electromagnetic induction.
She uses three tubes of identical dimensions. One is made of plastic, one copper and one copper with a slit cut into its length.



(a) The teacher releases a magnet from rest at the top of the plastic tube and it takes 0.45 s to fall through the tube.
Calculate the average acceleration of the magnet as it falls through the tube.

length of tube = 0.75 m

(2)

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Average acceleration = ...

*(b) The teacher suggests that the magnet would take longer to fall through the copper tube as a consequence of the laws of electromagnetic induction.

Assess the validity of this suggestion.

(6)

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(c) Before the teacher releases the magnet through the copper tube with a slit along its length, she asks the class to consider how the time taken will compare with the time for the other copper tube. The class predicts that the time will be the same.

Explain, using electromagnetic induction, whether this prediction is correct.

(3)

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(d) The times for the magnets to fall through the tubes were measured manually using an electronic timer.

Explain how suitable this is as a means of recording these times.

(2)

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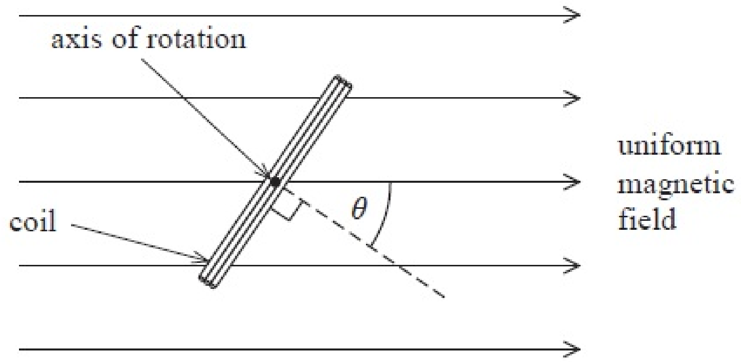
(Total for question = 13 marks)

Q30. The diagram shows an end view of a simple electrical generator. A rectangular coil of wire is rotated in a uniform magnetic field of magnetic flux density 3.0×10^{-2} T. The axis of rotation is at right angles to the field direction.



(a) The coil has 200 turns and an area of 2.0×10^{-4} m^2.

Calculate the magnetic flux linkage for the coil when $\theta = 0°$.

(2)

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Flux linkage = ...

(b) The coil is rotated at a constant rate of 2 revolutions per second.

(i) Calculate the average e.m.f. induced in the time taken for the coil to rotate from θ = 0° to θ = 90°

(3)

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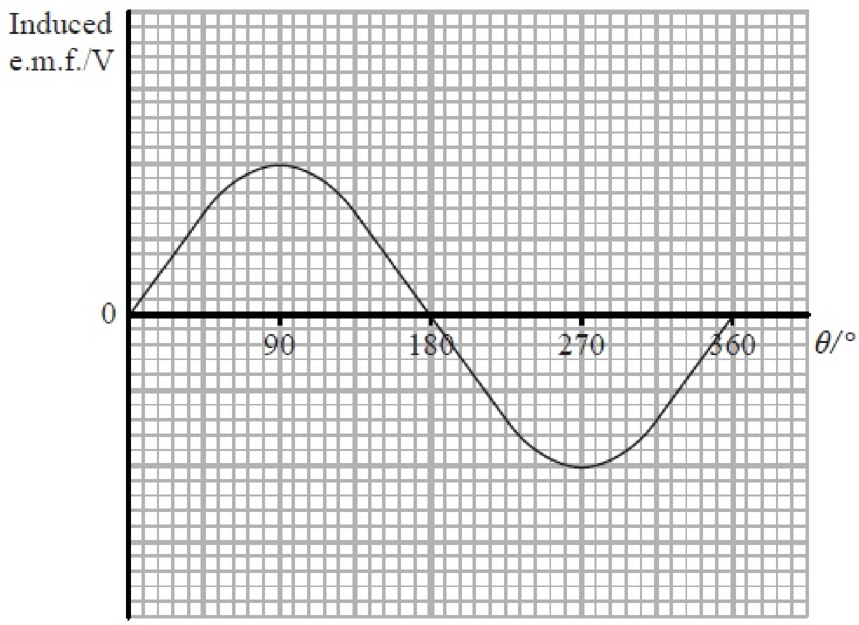
Average e.m.f. = ...

(ii) The graph shows how the induced e.m.f. varies over one cycle of rotation of the coil.



Explain why the magnitude of the e.m.f. is smallest and greatest at the values of θ shown in the graph.

(3)

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(iii) State and explain how the graph would differ if the coil rotated at a slower rate.

(2)

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(c) Vehicles such as electric cars are driven by electric motors. These vehicles use regenerative braking to reduce the speed of the vehicle. The motor is operated as a generator during braking and the output from the generator is used to recharge the batteries of the car.

(i) Explain how using the motor as a generator slows the car down.

(2)

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(ii) In practice, these vehicles also use friction braking as well as regenerative braking. This is because regenerative braking on its own will not fully stop a car. Suggest why.

(2)

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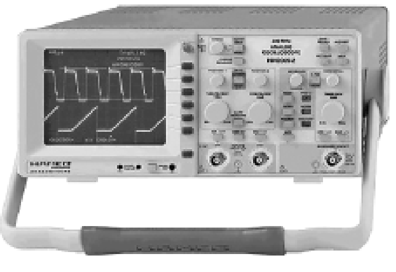
(Total for Question = 14 marks)

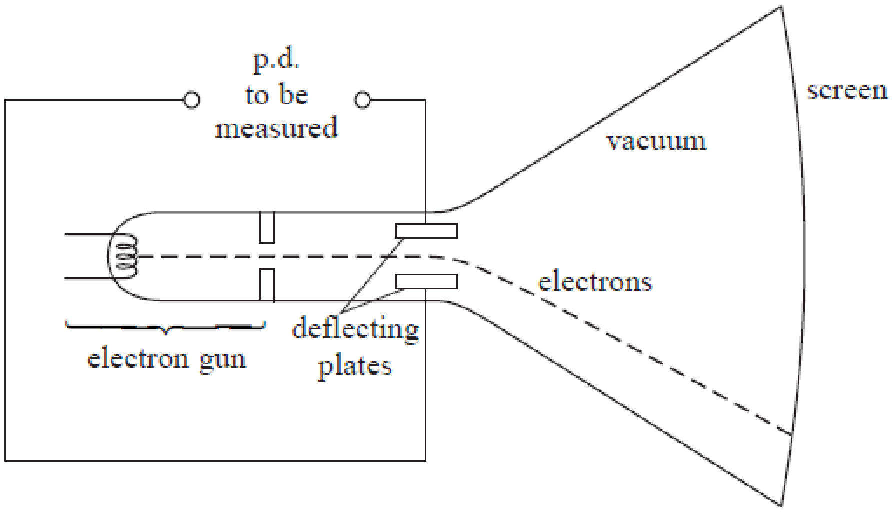
Q31.

Cathode ray tubes are used in oscilloscopes.



The diagram shows a simplified cathode ray tube that can be used to determine the magnitude and polarity of a potential difference (p.d.).

The cathode ray tube consists of an electron gun, a pair of deflecting plates and a fluorescent screen.



(a) The electron gun includes a filament. When this filament is heated, electrons are released and are accelerated by a p.d. of 1.5 kV to form an electron beam.

(i) Name the process by which electrons are released from the heated filament.

(1)

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(ii) Show that the maximum velocity of the electrons is about 2×10^7 m s^{-1}.

(2)

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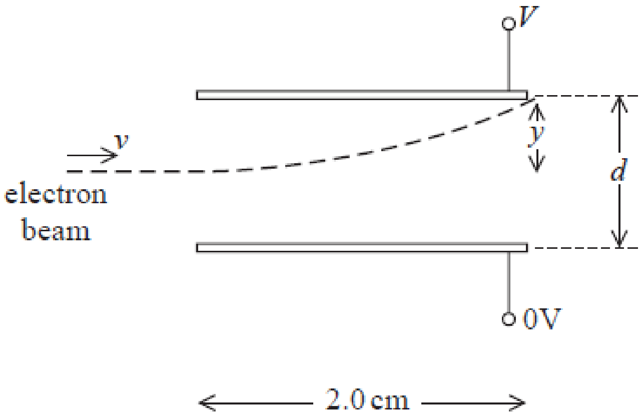
(b) The electron beam then enters a uniform electric field between the two parallel horizontal deflecting plates. The magnitude and direction of the deflection is determined by the p.d. *V* that is applied across the plates.

The diagram shows one possible path of the electron beam as it passes between the plates.



(i) Show that the acceleration of an electron, of mass m and charge Q, is given by

$$\frac{VQ}{dm}$$

(2)

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(ii) Calculate the magnitude of the vertical deflection y of the beam as it leaves the plates.

V = 50 V
d = 0.01 m

(5)

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y = ...

(c) A laboratory oscilloscope with the time base turned off operates in the same way as this simplified cathode ray tube. A student uses an oscilloscope in this way to monitor an alternating p.d. of 53 V_{rms}

On the grid, draw the trace that would be seen on the screen.

(4)

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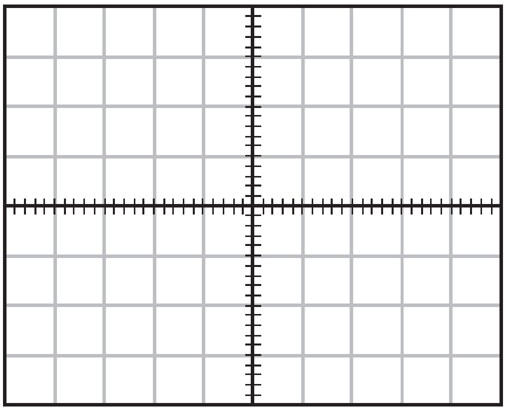

1 square = 25 V

(Total for question = 14 marks)