PEARSON EDEXCEL A-LEVEL PHYSICS · 9PH0

PHYSICS



EXAM QUESTION PACK

TOPIC 7: ELECTRIC AND MAGNETIC FIELDS

MAGNETIC FIELDS AND ALTERNATING CURRENT

SCORE	PERCENTAGE
/479	%

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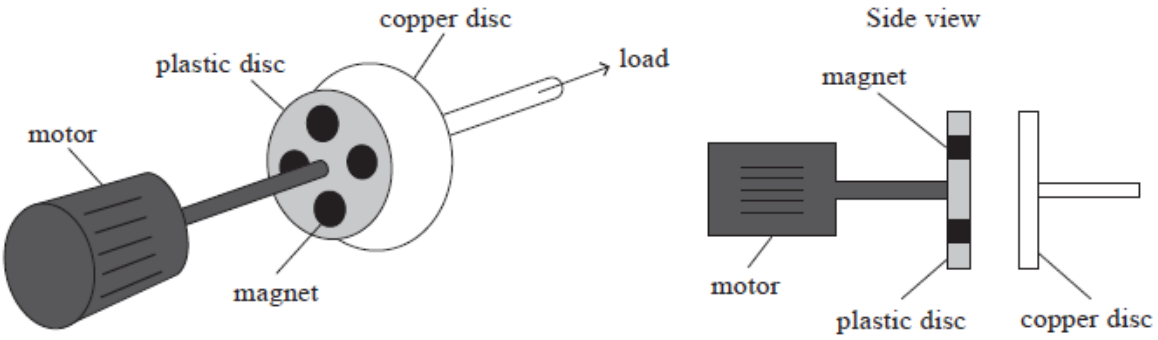
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Q1.

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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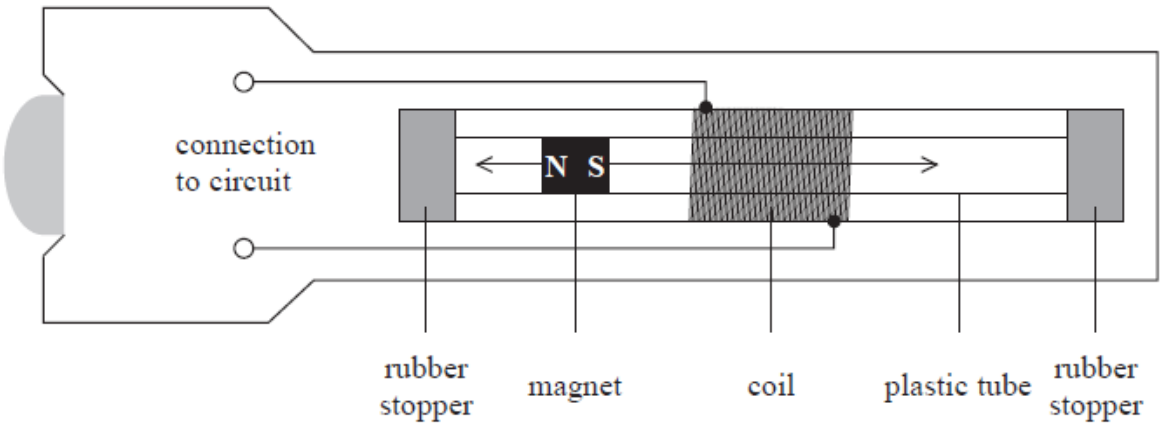
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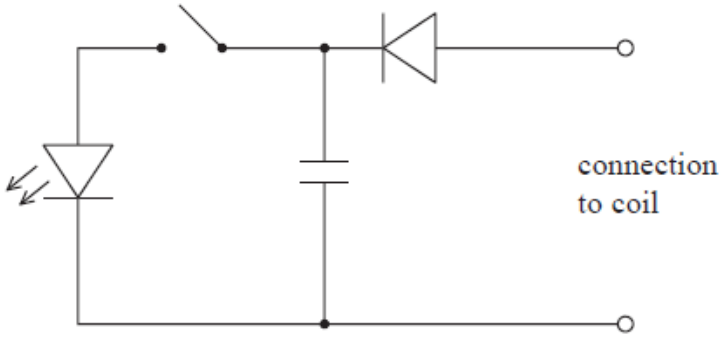
(Total for question = 5 marks)

Q2.

*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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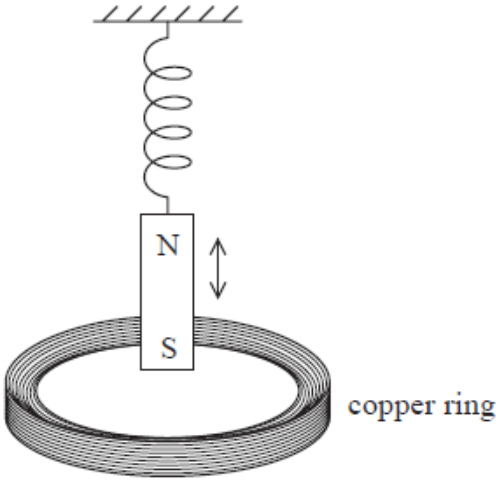
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(Total for question = 6 marks)

Q3.

* 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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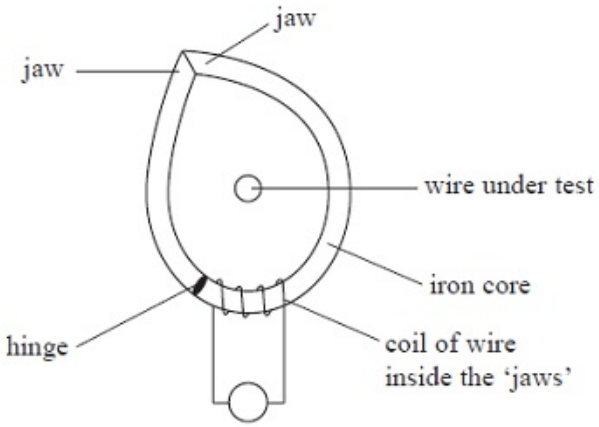
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Maximum current = ...

Q4. 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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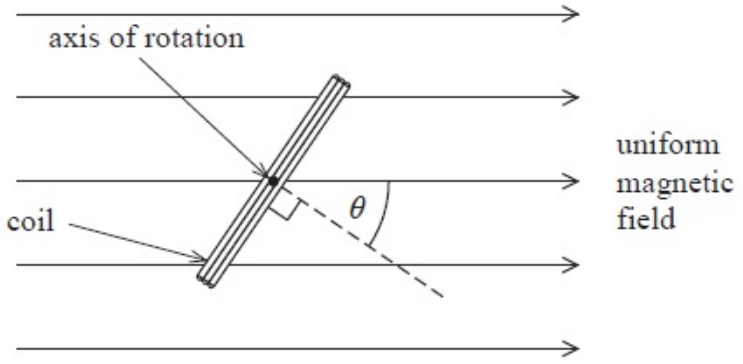
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(Total for Question = 11 marks)

Q5. 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 $\theta = 0°$ to $\theta = 90°$

(3)

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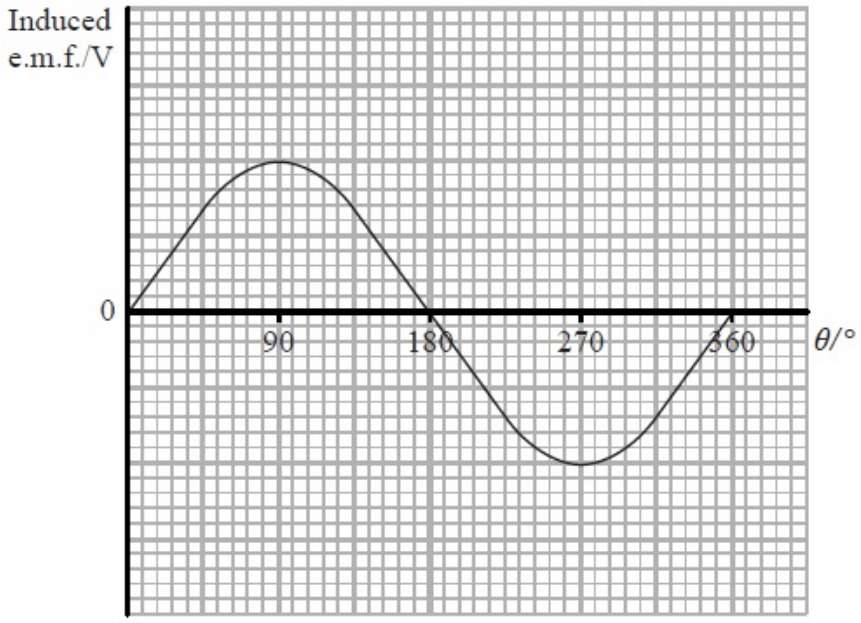
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Average e.m.f. = ...

(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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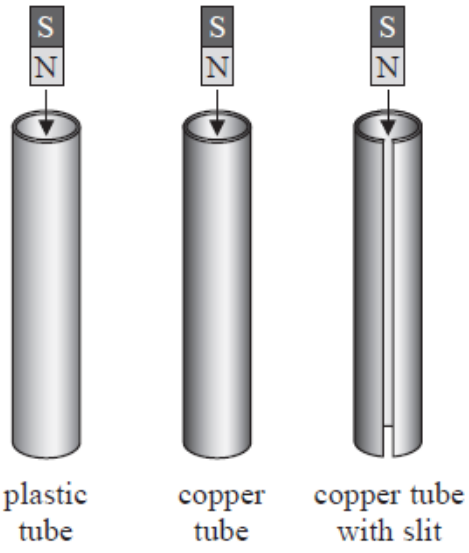
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(Total for Question = 14 marks)

Q6.

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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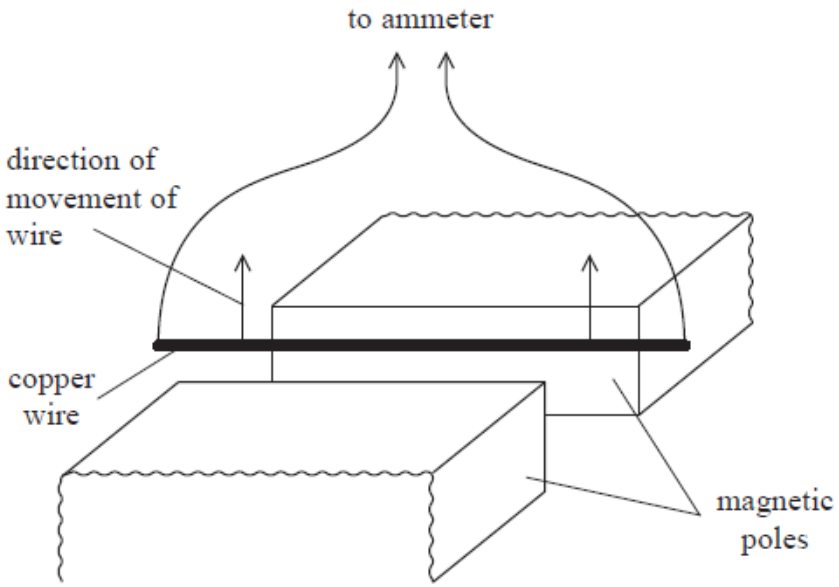
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(Total for question = 13 marks)

Q7.

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

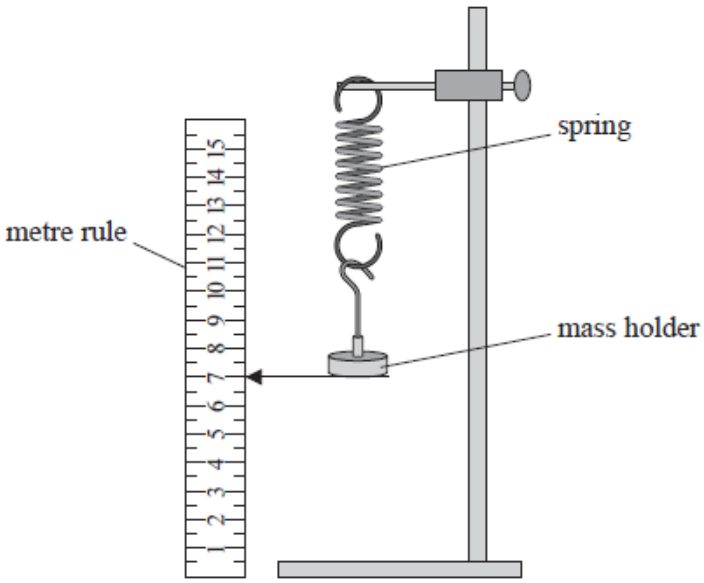
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(Total for question = 10 marks)

Q8.

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

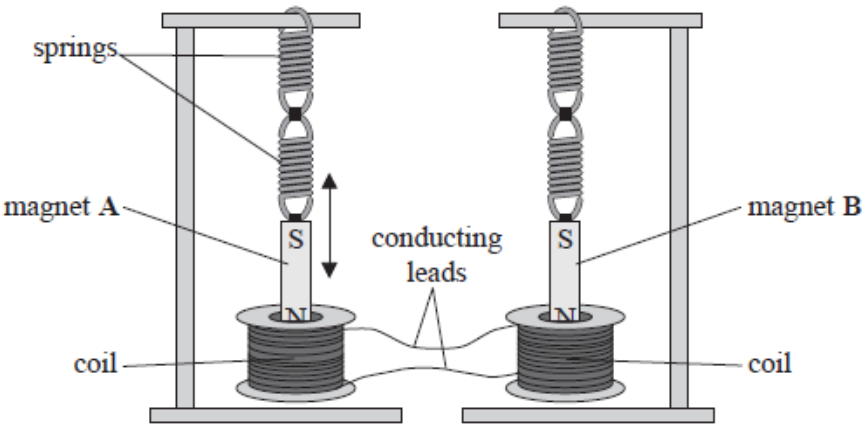


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

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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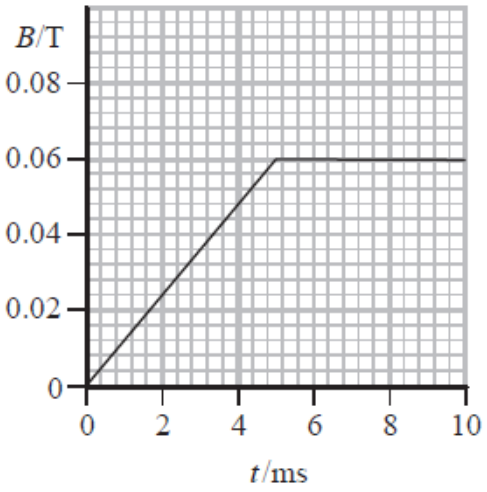
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(Total for question = 6 marks)

Q9.

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

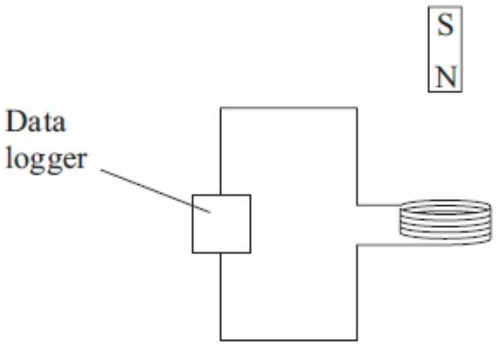
☒ **C** 1.8×10^{-3} V

☒ **D** 5.4×10^{-4} V

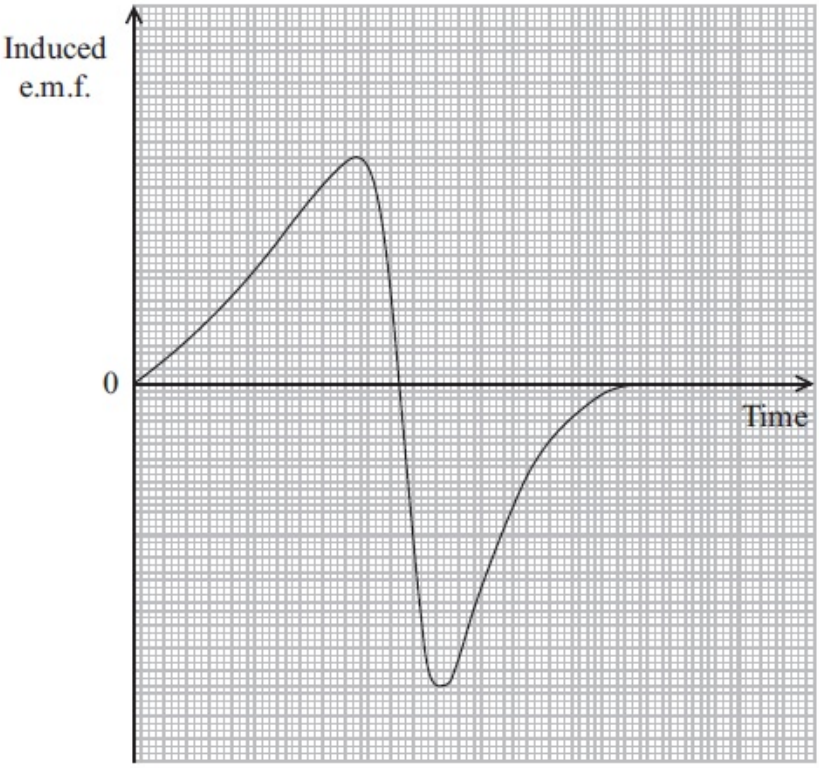
(Total for question = 1 mark)

Q10.

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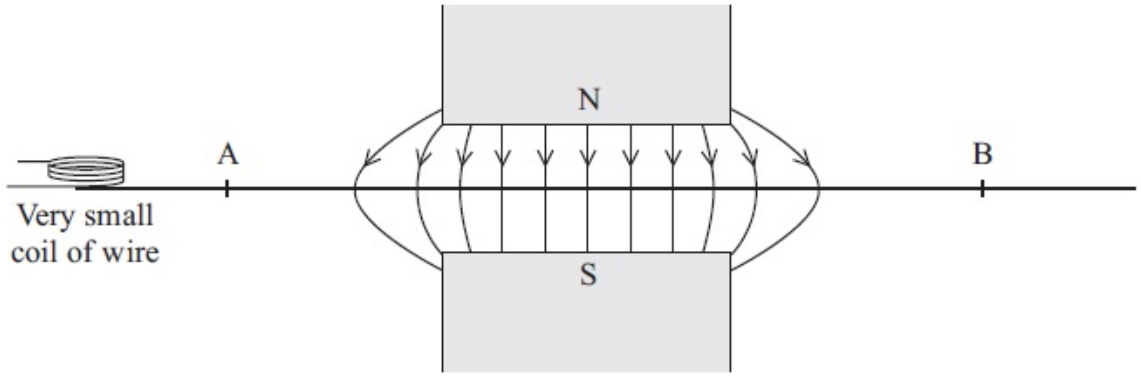
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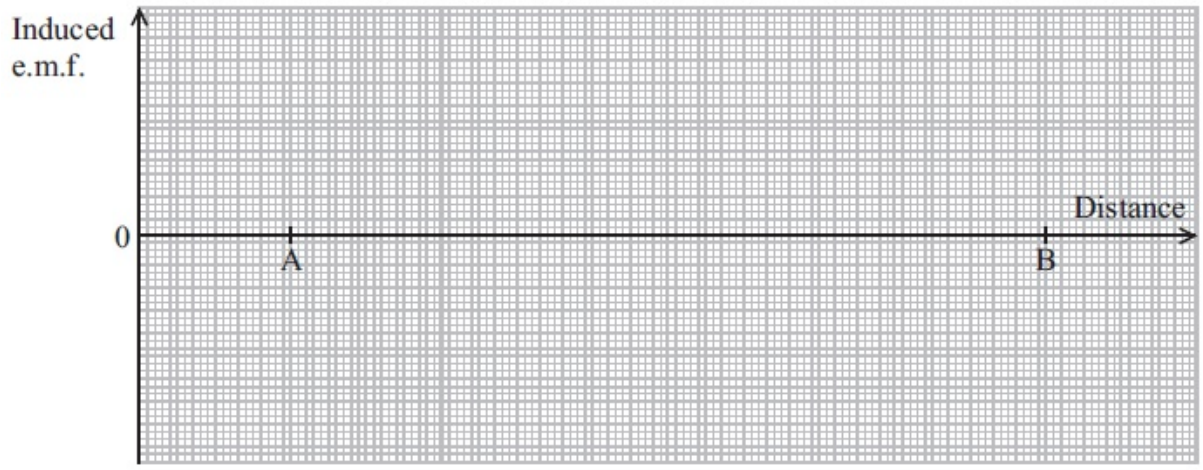
*(b) The teacher then sets up another demonstration using a large U-shaped magnet and a very small coil of wire which is again connected to a data logger.

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)

Q11.

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)

Q12.

The International Space Station (ISS) is in a low Earth orbit. Astronauts in ISS have an apparent weight of zero. In order to determine their mass, the astronauts must secure themselves to a platform which is set into oscillation and moves with simple harmonic motion.





The platform continues to move with simple harmonic motion at the same frequency, but its amplitude is doubled.

Explain how the maximum kinetic energy of the platform will change.

(2)

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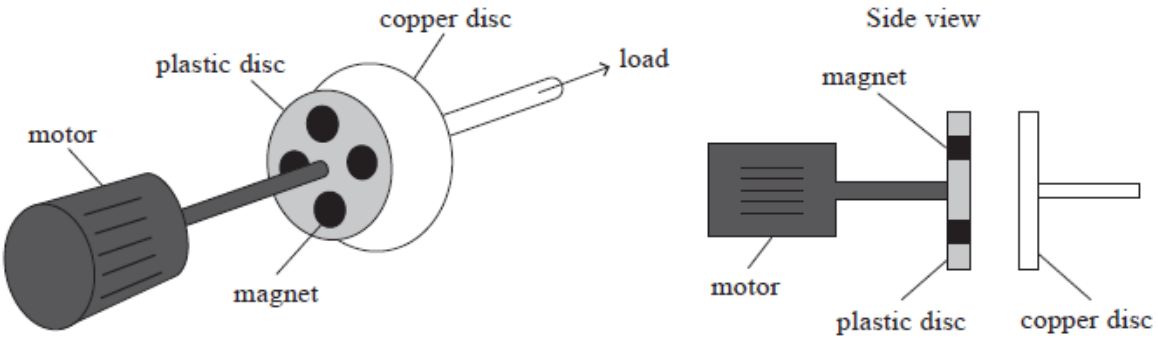
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(Total for question = 2 marks)

Q13.

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.

(4)

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(Total for question = 4 marks)

Q14.

A unit for magnetic flux is the

- ☒ **A** Wb
- ☒ **B** Wb m^2
- ☒ **C** T
- ☒ **D** T m^{-2}

(Total for question = 1 mark)

Q15.

Show that the unit of magnetic flux density (Tesla) in SI base units is kg A^{-1} s^{-2}.

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(Total for question = 2 marks)

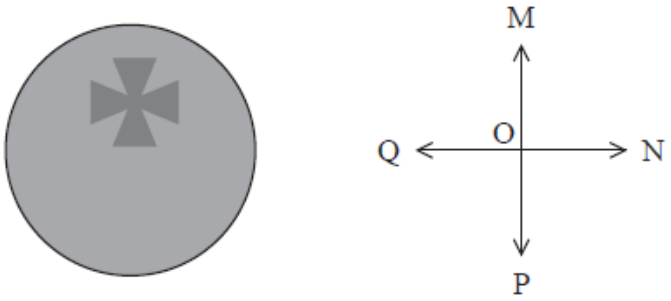
Q1.

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 ☒.

A demonstration is carried out using a beam of electrons in an evacuated tube.

When electrons hit a fluorescent screen, light is emitted. A piece of metal, in the shape of a Maltese cross, stops electrons and produces a shadow on the screen as shown.

The screen is viewed by an observer at point X in the diagram above. A magnetic field is directed at the beam of electrons. This causes the shadow to move upwards on the screen in the direction OM.



In which of the following directions is the magnetic field acting as seen by this observer?

(1)

☒ **A** OM

☒ **B** ON

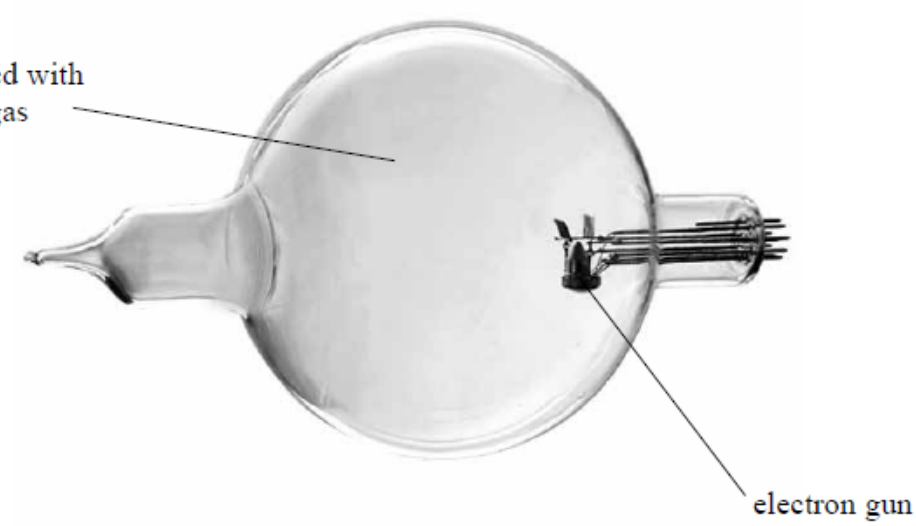
☒ **C** OP

☒ **D** OQ

(Total for question = 1 mark)

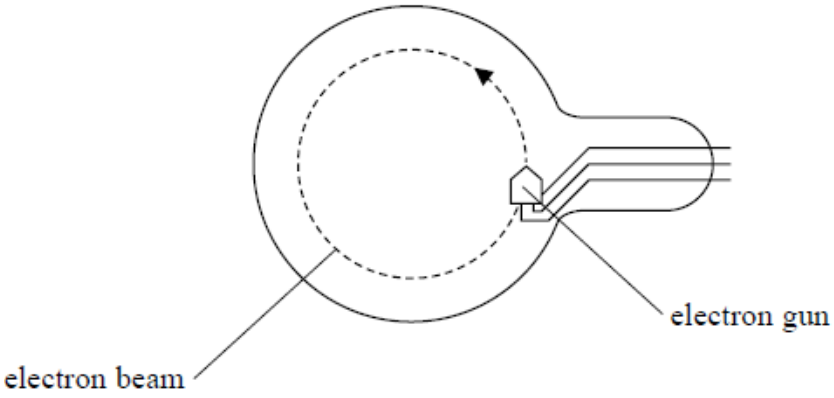
Q2.

An electron beam tube can be used to demonstrate the deflection of electrons in a uniform magnetic field. The tube contains a very low pressure gas so that electron paths can be seen.



(Source: http://www.klingereducational.com/images/products/thumbs/555571.jpg)

Electrons are emitted from the electron gun travelling vertically upwards into a region of uniform horizontal magnetic flux density.



Explain why the electrons follow a circular path.

(3)

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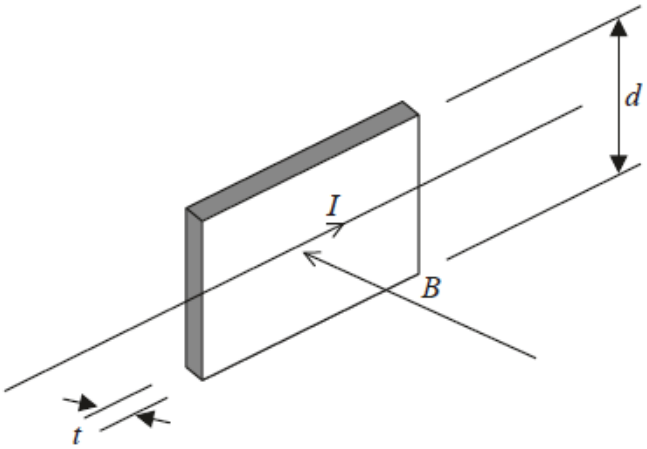
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(Total for question = 3 marks)

Q3.

Tiny sensors in smartphones could be used to determine the position of the phone on the Earth's surface by measuring the Earth's magnetic flux density.

A current *I* and a magnetic field of flux density *B* are applied to a slice of semiconductor as shown. The slice has thickness *t* and depth *d*.



Electrons collect at the top edge of the slice and the bottom edge becomes positively charged. As a result a potential difference known as a Hall voltage V_{HALL} develops.

Explain why electrons will collect at the top edge of the slice.

(2)

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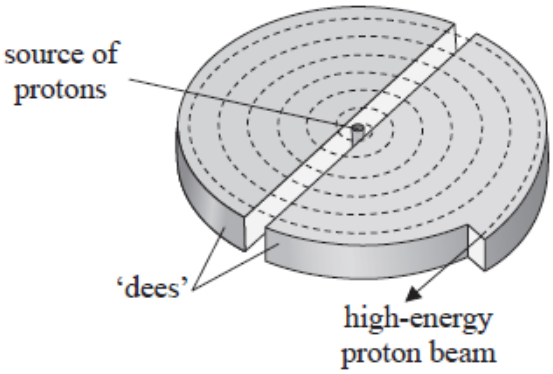
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(Total for question = 2 marks)

Q4.

Proton beam therapy is being introduced in the UK as a new cancer treatment.

A beam of protons is accelerated by a cyclotron to an energy of 23 MeV and is then focused onto a tumour.



* Explain how the cyclotron produces the high-energy proton beam.

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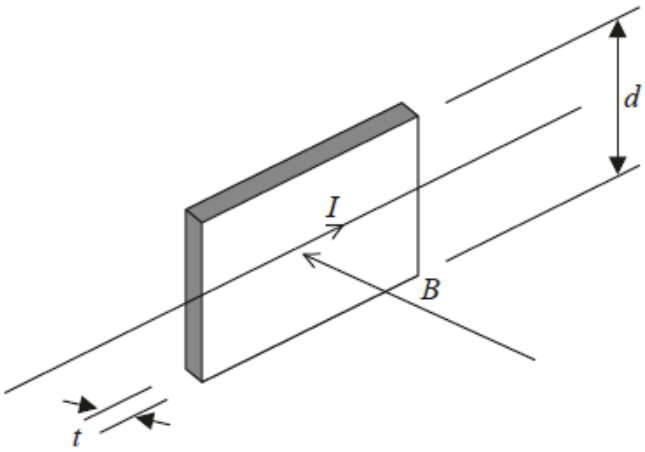
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(Total for question = 6 marks)

Q5.

Tiny sensors in smartphones could be used to determine the position of the phone on the Earth's surface by measuring the Earth's magnetic flux density.

A current *I* and a magnetic field of flux density *B* are applied to a slice of semiconductor as shown. The slice has thickness *t* and depth *d*.



Electrons collect at the top edge of the slice and the bottom edge becomes positively charged. As a result a potential difference known as a Hall voltage V_{HALL} develops.

Electrons continue to collect at the top edge of the slice, until the force on a moving electron due to the magnetic field is equal to the force on the electron due to the electric field.

Derive the following equation for V_{HALL}:

$$V_{HALL} = \frac{BI}{nte}$$

where n is the number of charge carriers per unit volume of the semiconductor.

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(Total for question = 4 marks)

Q6.

An alpha particle and a beta particle both move into the same uniform magnetic field which is perpendicular to their direction of motion. The beta particle travels at 15 times the speed of the alpha particle.

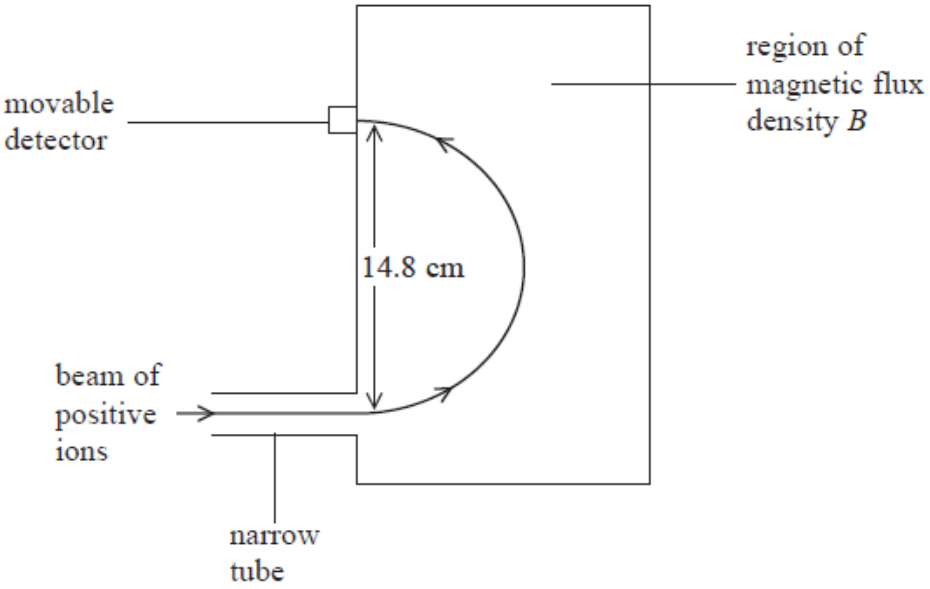
The ratio of the force on the beta particle to the force on the alpha particle is

- **A** 3.7
- **B** 7.5
- **C** 30
- **D** 60

(Total for question = 1 mark)

Q7.

A mass-spectrometer is an instrument that is used to measure the masses of molecules. Molecules of a gas are ionised and travel through a vacuum in a narrow tube. The ions enter a region of uniform magnetic flux density *B* where they are deflected in a semicircular path as shown.



(a) State why it is necessary for the molecules to be ionised.

(1)

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(b) State the direction of the magnetic field.

(1)

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(c) The ions have a charge of $+e$ and a speed of 1.20×10^5 m s^{-1}. When B has a value of 0.673 T, the ions are detected at a point where the diameter of the arc is 14.8 cm.

Calculate the mass of an ion.

(3)

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Mass of an ion = ...

(d) Ions with a smaller mass but the same charge and speed are also present in the beam. On the diagram sketch the path of these ions.

(1)

(Total for question = 6 marks)

Q8.

The photograph is an image of the paths of particles obtained from an early particle detector, the cloud chamber.



Modern particle detectors such as the ones at CERN still work on the basic principle that charged

particles cause ionisation of the material through which they pass. These ionisations can be tracked and recorded. Magnetic fields are used to deflect the particles so that their properties can be investigated.

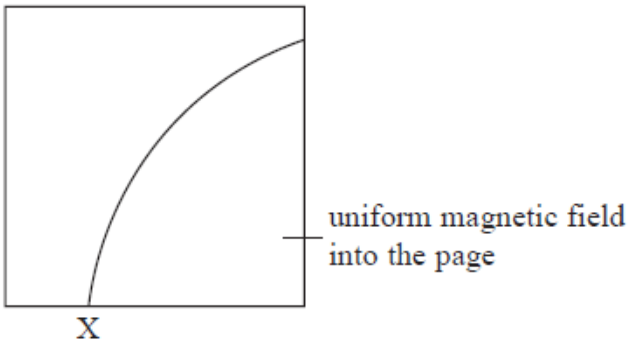
(a) State what is meant by ionisation in this context.

(1)

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(b) The diagram below shows the ionisation path of a particle when it is in the region of a uniform magnetic field. The particle enters the field at X.



State how we know that the particle is negatively charged.

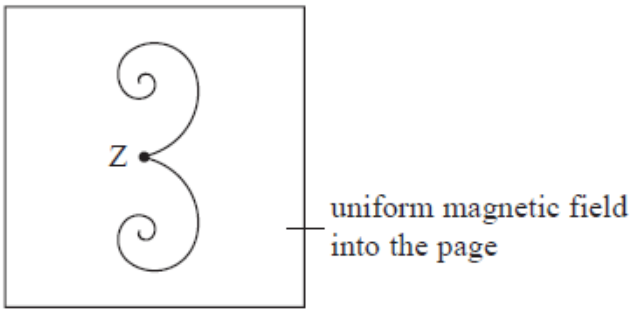
(1)

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(c) The diagram below shows an event occurring in the same magnetic field.



Point Z is where a high energy photon interaction occurs which causes two particles to be formed.

Describe, with reasons, what can be deduced about the photon and the two particles that are formed in this interaction.

(5)

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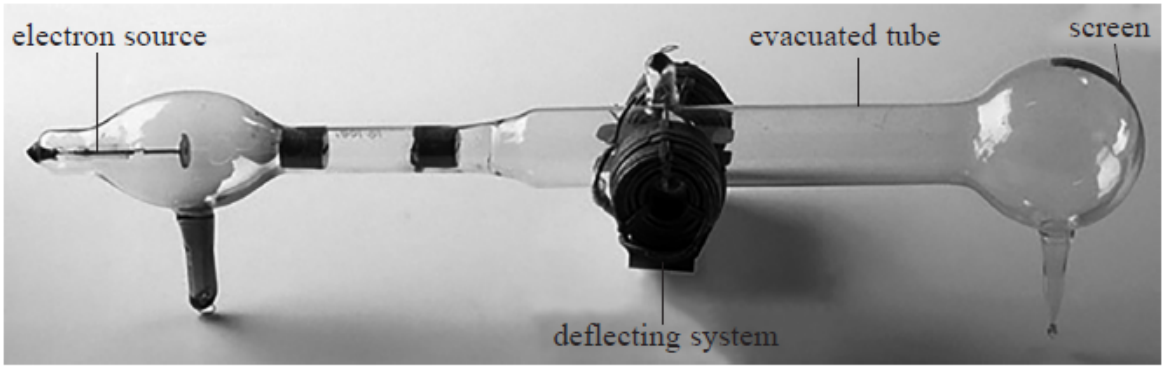
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(Total for question = 7 marks)

Q9.

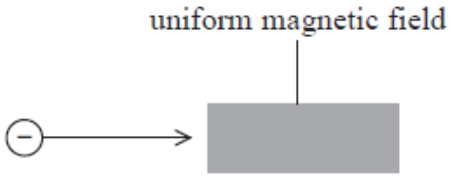
At the end of the 19th century, J.J. Thompson used electric and magnetic fields to deflect beams of charged particles. A photograph of his apparatus is shown.



© Science Museum London

Electrons were accelerated through a potential difference to produce a beam of high-energy electrons. The beam was then deflected in perpendicular directions by the magnetic and electric fields. The final position of the beam on the screen was determined by the charge and mass of the electrons.

An electron is travelling left to right and enters a region of uniform magnetic field as shown below. The direction of the magnetic field is perpendicular to the direction of travel of the electron.



(i) The magnetic field deflects the electron in the direction up the page.

Explain the direction of the magnetic field that would produce this deflection.

(2)

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(ii) Explain why the electron would travel in a circular path if no other forces acted on it.

(2)

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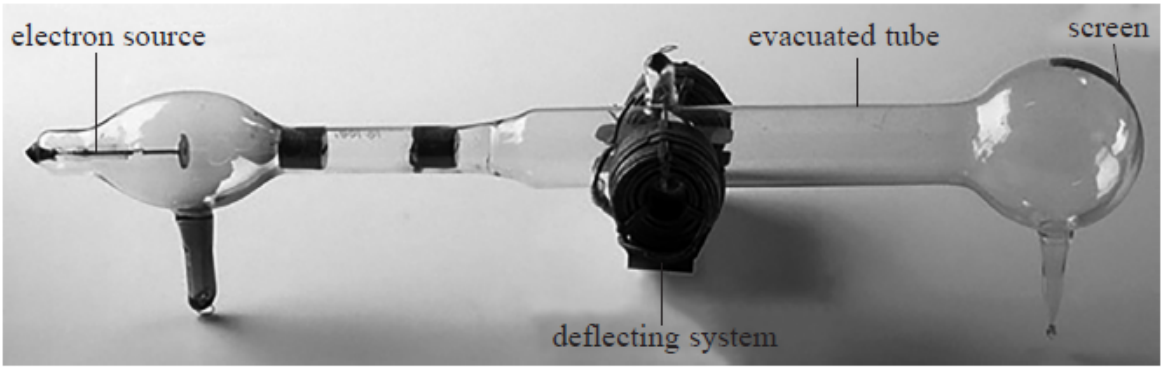
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(Total for question = 4 marks)

Q10.

At the end of the 19th century, J.J. Thompson used electric and magnetic fields to deflect beams of charged particles. A photograph of his apparatus is shown.



© Science Museum London

Electrons were accelerated through a potential difference to produce a beam of high-energy electrons. The beam was then deflected in perpendicular directions by the magnetic and electric fields. The final position of the beam on the screen was determined by the charge and mass of the electrons.

In a modern version of Thompson's experiment, a uniform electric field of electric field strength E is applied so that the electric and magnetic forces on the electrons are equal and in opposite directions.

(i) Show that for electrons to be undeflected their velocity must be given by

$$v = \frac{E}{B}$$

where B is the magnetic flux density of the magnetic field.

(2)

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(ii) The beam is produced by accelerating electrons through a potential difference of 250 V.

The electric field strength is 1.4×10^4 V m^{-1}. The magnetic flux density is 1.5×10^{-3} T.

Calculate the value of the specific charge e/m for the electron using this data.

(3)

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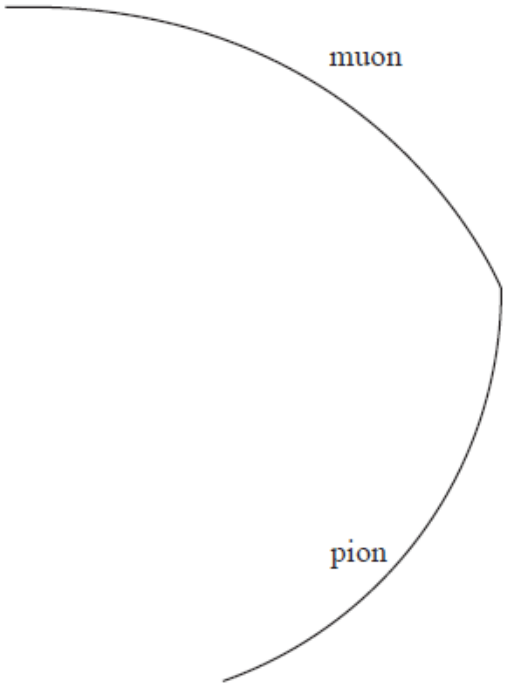
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e/m = ...

(Total for question = 5 marks)

Q11.

A negatively charged pion decays into a muon and an antineutrino. The diagram shows tracks in a particle detector formed in such an event.



The momentum of the pion just before it decays is 9.1×10^{-20} N s.

Determine the magnetic flux density of the magnetic field which acts in the detector and state its direction.

Scale of diagram 1 cm represents 10 cm

pion charge = -1.6×10^{-19} C

(4)

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Magnetic flux density = ...

Direction of magnetic field = ...

(Total for question = 4 marks)

Q12. A charged, non-magnetic particle is moving in a magnetic field.

Which of the following would **not** affect the magnetic force acting on the particle

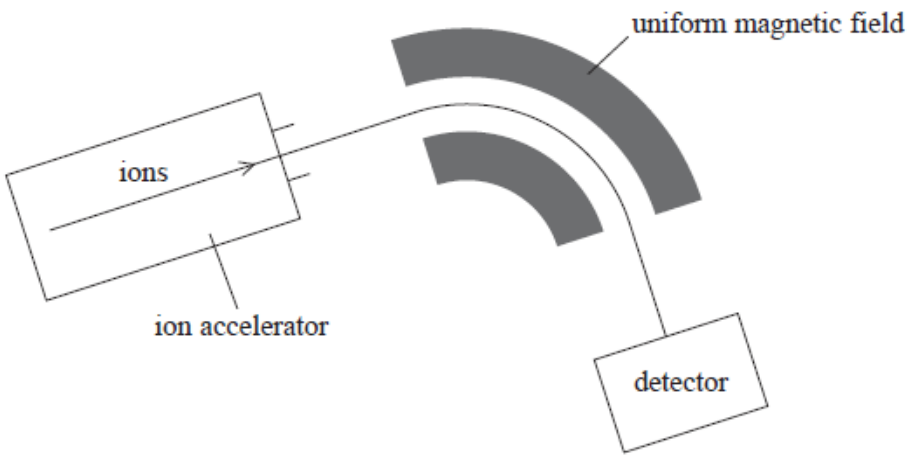
- ☒ **A** the magnitude of the charge on the particle
- ☒ **B** the strength of the magnetic field
- ☒ **C** the velocity component parallel to the magnetic field direction
- ☒ **D** the velocity component perpendicular to the magnetic field direction

(Total for Question = 1 mark)

Q13.

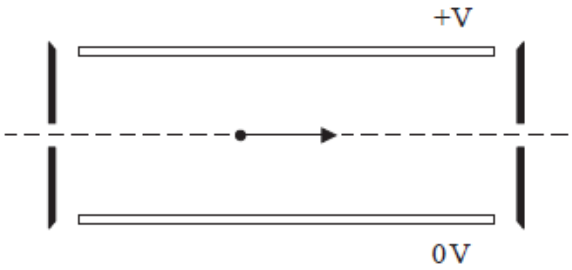
Mass spectrometry is a technique used to separate ions based on their charge to mass ratio.

The atoms in a sample are ionised and then accelerated and formed into a fine beam.
This beam is passed into a region of uniform magnetic field and the ions are deflected by different amounts according to their mass.



Analysis of mass spectrometer data shows that chlorine exists in nature as two isotopes, chlorine-35 and chlorine-37.

In most mass spectrometers the ions are passed through a velocity selector, after being accelerated, to produce a beam of ions of a particular velocity.
The velocity selector consists of a pair of parallel plates, across which a potential difference (p.d.) is applied to create an electric field.



In one mass spectrometer the plates are 2.5 cm apart and a p.d. of 135 V is applied.

A magnetic field is also applied to produce a force on the ions in the opposite direction to the force from the electric field. For one particular speed the ions travel in a straight line and emerge from the selector.

(i) Add to the diagram to indicate the directions of the electric field and the magnetic field.

(2)

(ii) The magnetic flux density applied to the velocity selector is 24.5 mT.

Deduce whether this magnetic flux density is suitable to produce a beam of chlorine-35 ions of speed 2.2×10^5 m s^{-1}.

(4)

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(Total for question = 6 marks)

Q14.

An electron and an alpha particle enter a uniform magnetic field which is acting perpendicular to their motion. The electron is travelling at four times the velocity of the alpha particle. The force on the electron is *F*.

The force on the alpha particle is

☒ **A** *F*/2

☒ **B** *F*

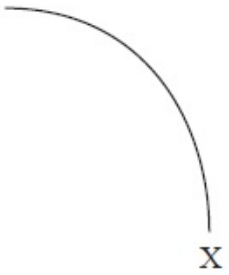
☒ **C** 4*F*

☒ **D** 16*F*

(Total for question = 1 mark)

Q15. Scientists studying anti-matter recently observed the creation of a nucleus of anti-helium 4, which consists of two anti-protons and two anti-neutrons.

The diagram represents the path of a proton through a magnetic field starting at point X.



Add to the diagram the path of an anti-helium 4 nucleus also starting at point X and initially travelling at the same velocity as the proton.

Explain any differences between the paths.

(5)

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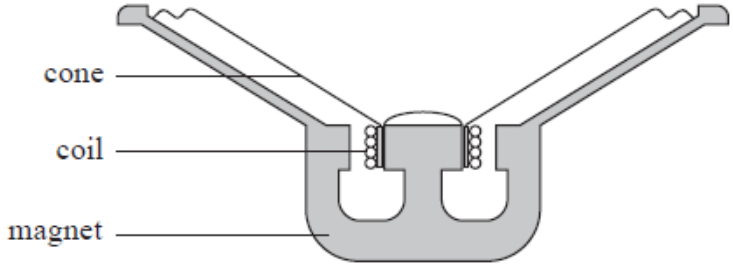
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(Total for Question = 5 marks)

Q1.

*****A simple loudspeaker consists of a cone, a coil of wire and a magnet. The cone and coil are attached to each other and are free to move. An alternating current in the coil causes the cone to oscillate. The loudspeaker is mounted in a wooden box. A cross-section through the loudspeaker is shown.



A student made the following observations:

- when an alternating potential difference (p.d.) is applied to the coil, the cone oscillates
- the frequency of oscillation is the same as the frequency of the p.d.
- at particular frequencies, the box vibrates with a large amplitude.

Explain these observations.

(6)

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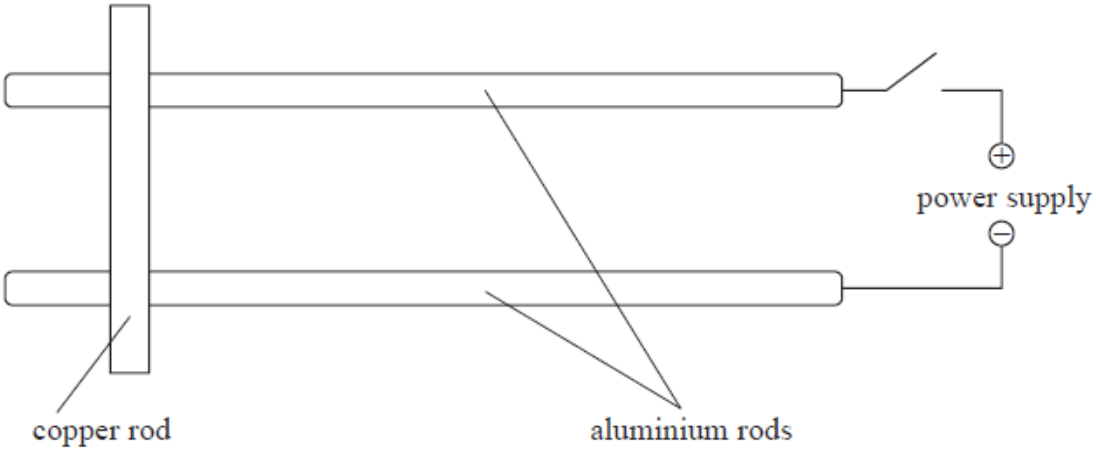
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(Total for question = 6 marks)

Q2.

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)

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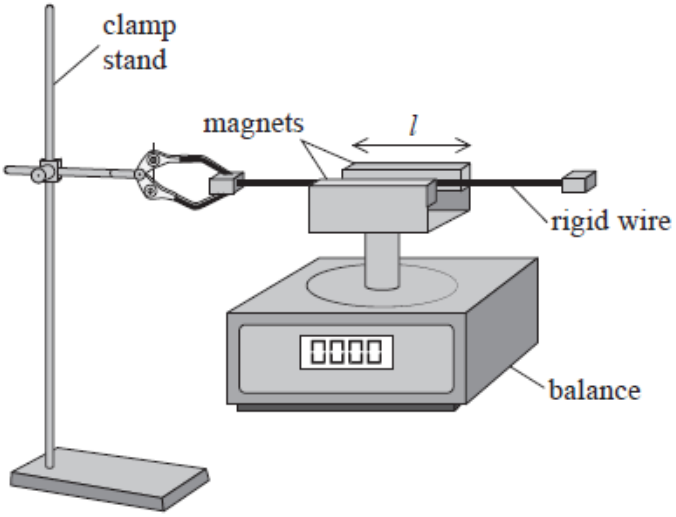
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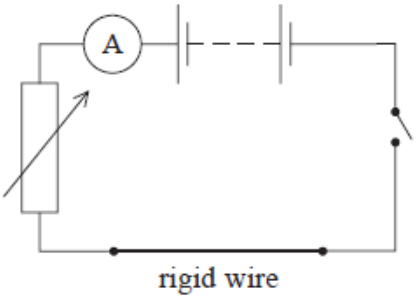
(Total for question = 3 marks)

Q3.

A student set up the apparatus shown. A length of rigid wire was held horizontally by a clamp in

a uniform magnetic field of flux density *B*.
The circuit connected to the rigid wire is also shown.





With the switch open, the balance was set to zero. When the switch was closed a current *I* in the circuit was recorded by the ammeter and the reading on the balance increased.

The length *l* of wire in the magnetic field was 15.5 cm. When the current in the circuit was 4.55 A, the reading on the balance increased by 5.65 g.

Calculate the magnetic flux density *B* in the region of the rigid wire.

(3)

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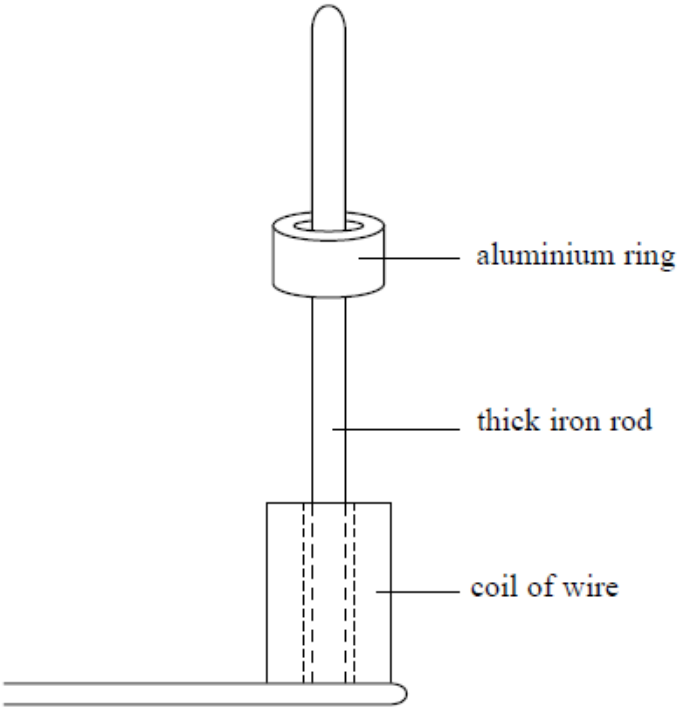
B = ...

(Total for question = 3 marks)

Q4.

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.



The current is switched off and the aluminium ring comes to rest on top of the coil.
The supply to the coil is changed and a direct current (dc) is switched on. An upwards force *F* acts on the ring for 0.05 s accelerating it to a final speed, *v*. The ring then moves freely through a height of 30 cm.

Mean diameter of ring = 4.8 cm
Mass of ring = 0.019 kg
Magnetic field strength = 0.032 T

(i) Use conservation of energy to calculate the speed *v* of the ring after 0.05 s.

(2)

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v = ...

(ii) Use the idea of impulse to calculate the magnitude of the mean force *F* acting on the ring and hence the mean current *I* in the ring.

(6)

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F = ...

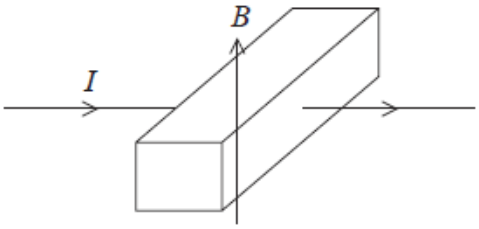
I = ...

(Total for question = 8 marks)

Q5.

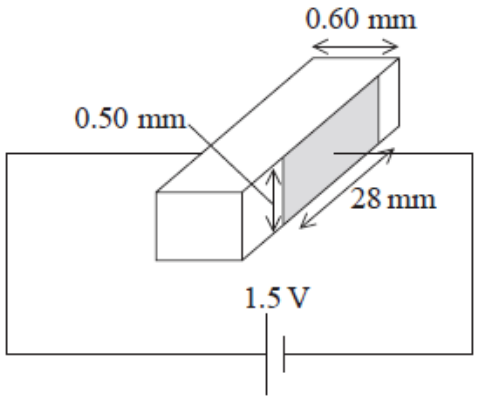
Some liquids conduct electricity. This property can be used to pump these liquids through pipes.

A short section of a rectangular pipe containing a liquid is shown in the diagram. The pipe is placed in a magnetic field of flux density B and a current I is passed through the liquid as shown.



A practical demonstration of this principle used two rectangular electrodes, opposite each other on either side of the pipe, a distance of 0.60 mm apart. The dimensions of the electrodes are shown in the diagram.

The electrodes were connected to a 1.5 V cell.
Salt water was pumped using a magnetic field of magnetic flux density 0.40 T.



(i) Show that the current through the salt water is about 20 mA.

resistivity of salt water = 1.6 Ω m

(4)

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(ii) Hence calculate the force on the salt water.

(2)

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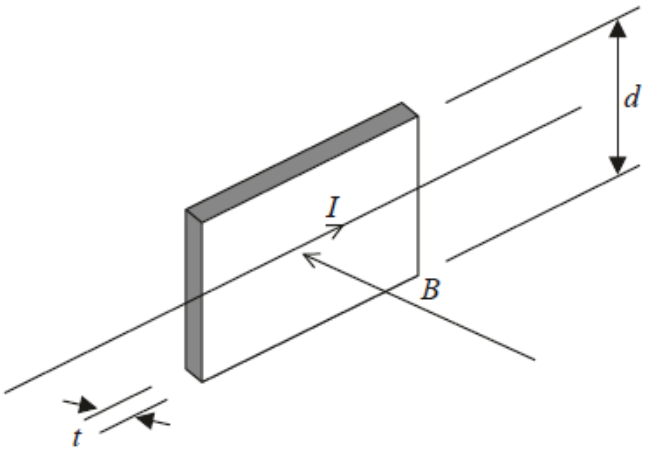
Force = ...

(Total for question = 6 marks)

Q6.

Tiny sensors in smartphones could be used to determine the position of the phone on the Earth's surface by measuring the Earth's magnetic flux density.

A current *I* and a magnetic field of flux density *B* are applied to a slice of semiconductor as shown. The slice has thickness *t* and depth *d*.



Electrons collect at the top edge of the slice and the bottom edge becomes positively charged. As a result a potential difference known as a Hall voltage V_{HALL} develops.

Show that the units are the same on each side of the equation

$$V_{HALL} = \frac{BI}{nte}$$

(3)

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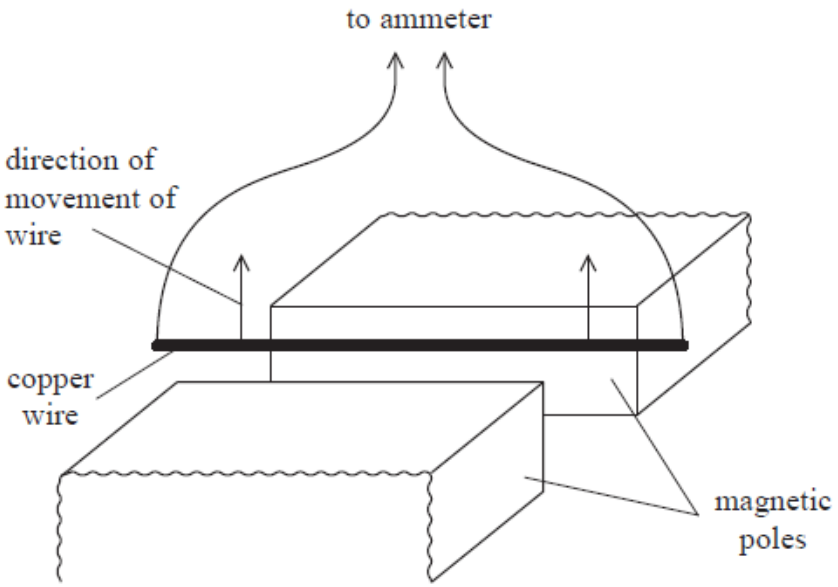
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(Total for question = 3 marks)

Q7.

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

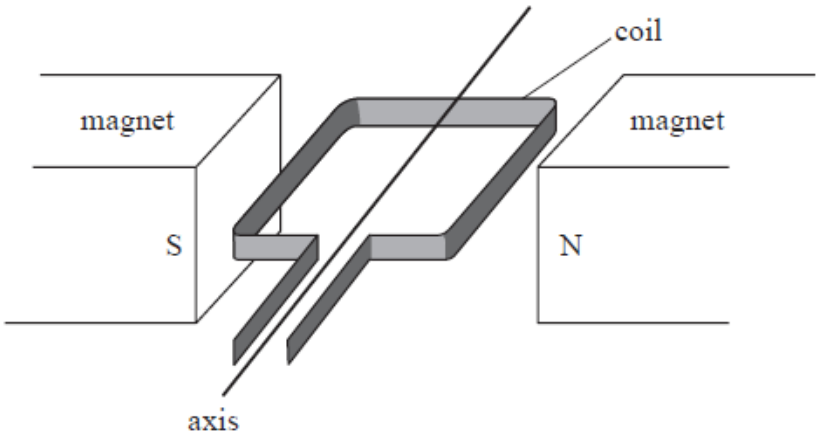
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(Total for question = 10 marks)

Q8.

*****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)

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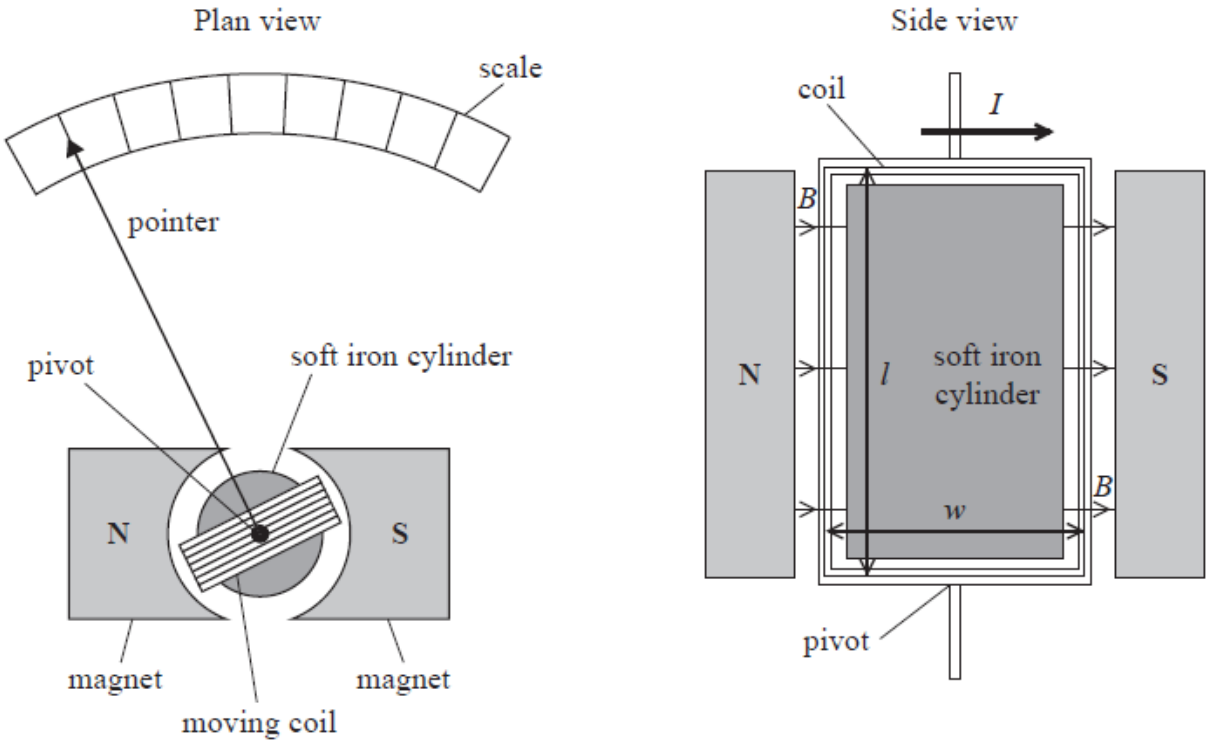
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(Total for question = 6 marks)

Q9.

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



The fixed soft iron cylinder and magnets produce a uniform magnetic field of magnetic flux density *B*. The coil is able to rotate within this magnetic field. The coil has width *w* and length *l*.

There is a current I in the coil in the direction shown in the side view diagram.

(i) Explain which way the coil will rotate.

(2)

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(ii) Show that the moment M on the coil about the pivot, due to the magnetic field, is given by

$$M = BAIN$$

where
A is the cross-sectional area of the coil
N is the number of turns of wire on the coil.

(4)

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(Total for question = 6 marks)

Q10.

A current of 1.50 A flows in a straight wire of length 0.450 m. The wire is placed in a uniform magnetic field of flux density 2.00×10^{-3} T which acts perpendicular to the wire.
Under these conditions the magnetic force balances the weight of the wire.

Calculate the mass of the wire.

☒ **A** 1.32×10^{-2} kg

☒ **B** 1.35×10^{-3} kg

☒ **C** 1.38×10^{-4} kg

☒ **D** 1.35×10^{-4} kg

(Total for question = 1 mark)

Q11. The magnetic force F that acts on a current-carrying conductor in a magnetic field is given by the equation

$$F = BIl.$$

(a) State the condition under which this equation applies.

(1)

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(b) The unit for magnetic flux density B is the tesla.

Express the tesla in base units.

(2)

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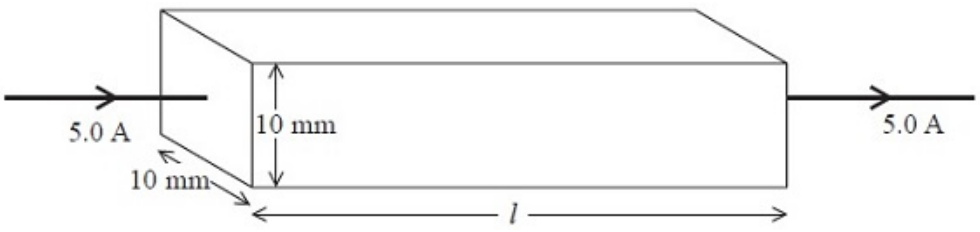
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(c) The diagram shows a rectangular bar of aluminium which has a current of 5.0 A through it.



The bar is placed in a magnetic field so that its weight is supported by the magnetic field.

Calculate the minimum value of the magnetic flux density B needed for this to occur.

density of aluminium = 2.7×10^{3} kg m^{-3}

(3)

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Minimum B = ...

(d) State the direction of the magnetic field.

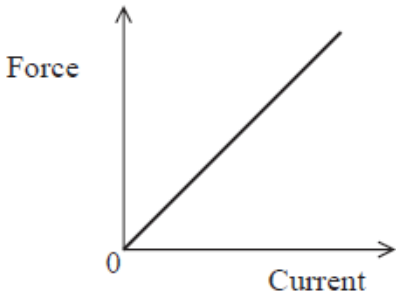
(1)

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(Total for Question = 7 marks)

Q12.

A current-carrying conductor with length l is placed at right angles to a magnetic field with magnetic flux density B. The graph shows how the force on the wire varies with the current passing through it.



The gradient of the graph is equal to

☒ **A** B

☒ **B** Bl

☒ **C** $\frac{1}{B}$

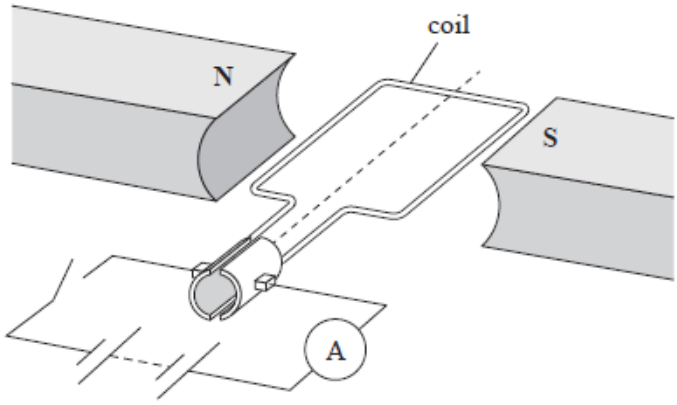
☒ **D** $\frac{B}{l}$

(Total for question = 1 mark)

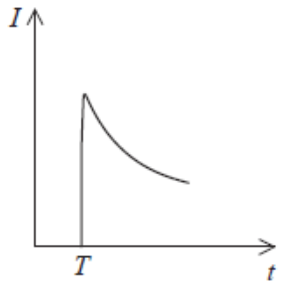
Q13.

* 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.

(6)

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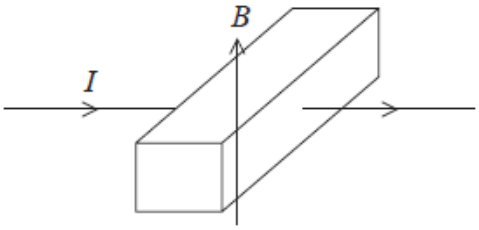
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(Total for question = 6 marks)

Q14.

Some liquids conduct electricity. This property can be used to pump these liquids through pipes.

A short section of a rectangular pipe containing a liquid is shown in the diagram. The pipe is placed in a magnetic field of flux density *B* and a current *I* is passed through the liquid as shown.



Add an arrow to the diagram above to show the direction in which the liquid will move.

(1)

(Total for question = 1 mark)

Q15.

A conductor of length 50 mm carries a current of 3.0 A at 30º to a magnetic field of magnetic flux density 0.40 T.

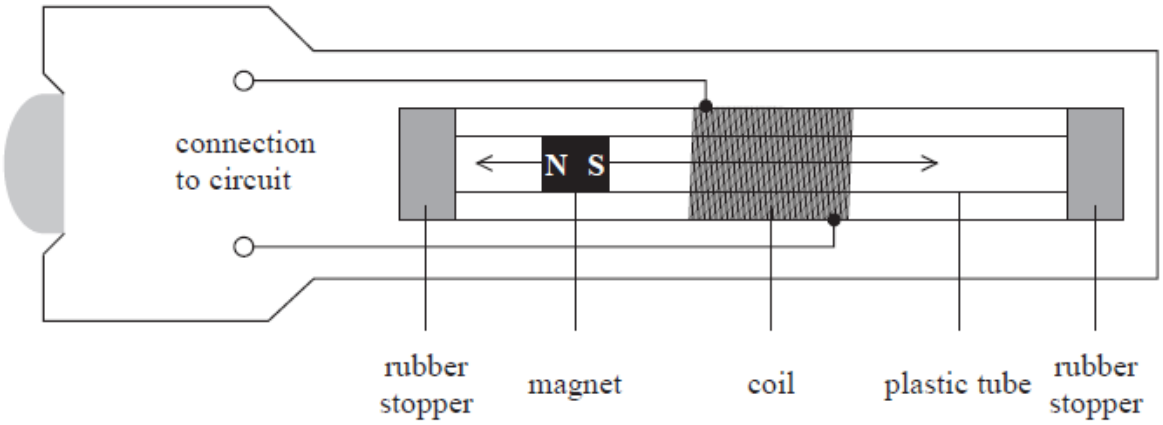
The magnitude of the magnetic force acting on the conductor is

- ☒ **A** 0.030 N
- ☒ **B** 0.050 N
- ☒ **C** 30 N
- ☒ **D** 52 N

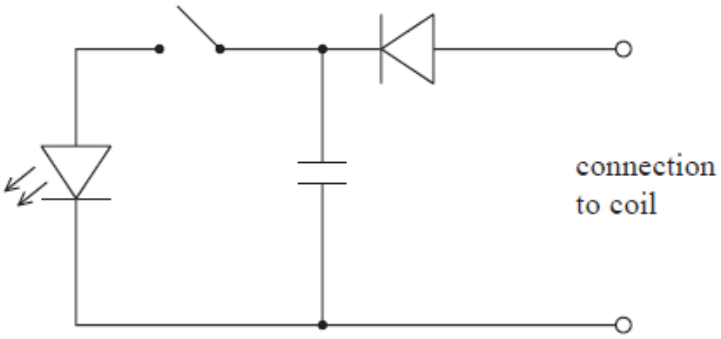
(Total for question = 1 mark)

Q1.

*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.

(6)

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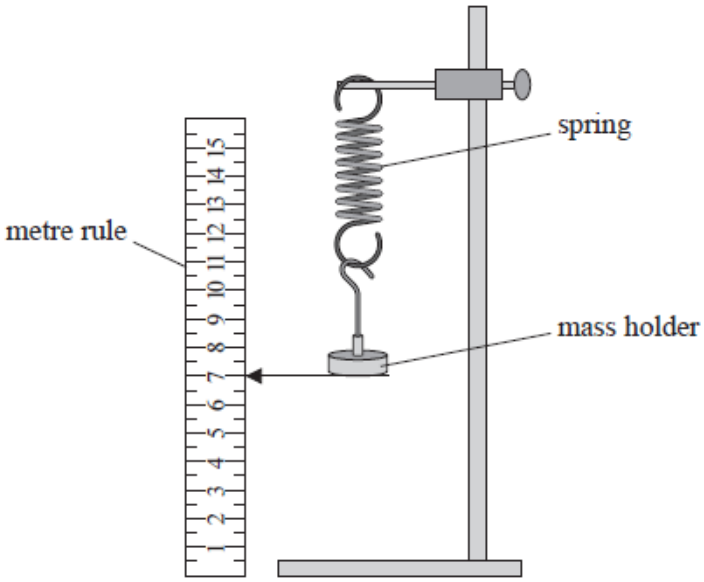
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(Total for question = 6 marks)

Q2.

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

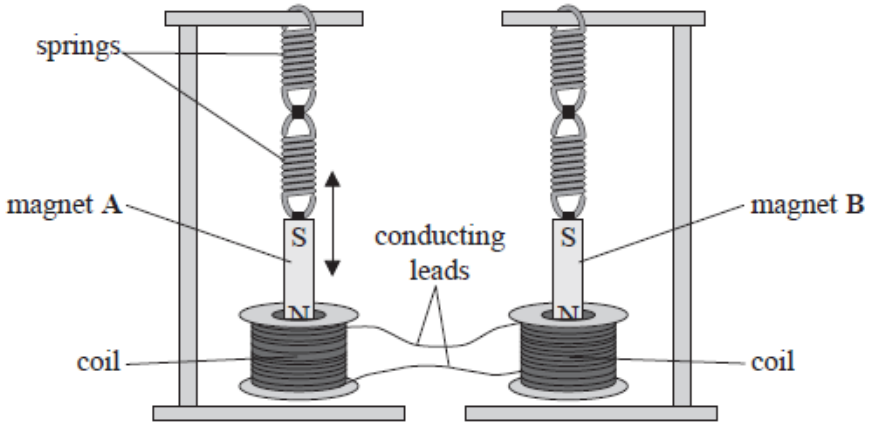


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

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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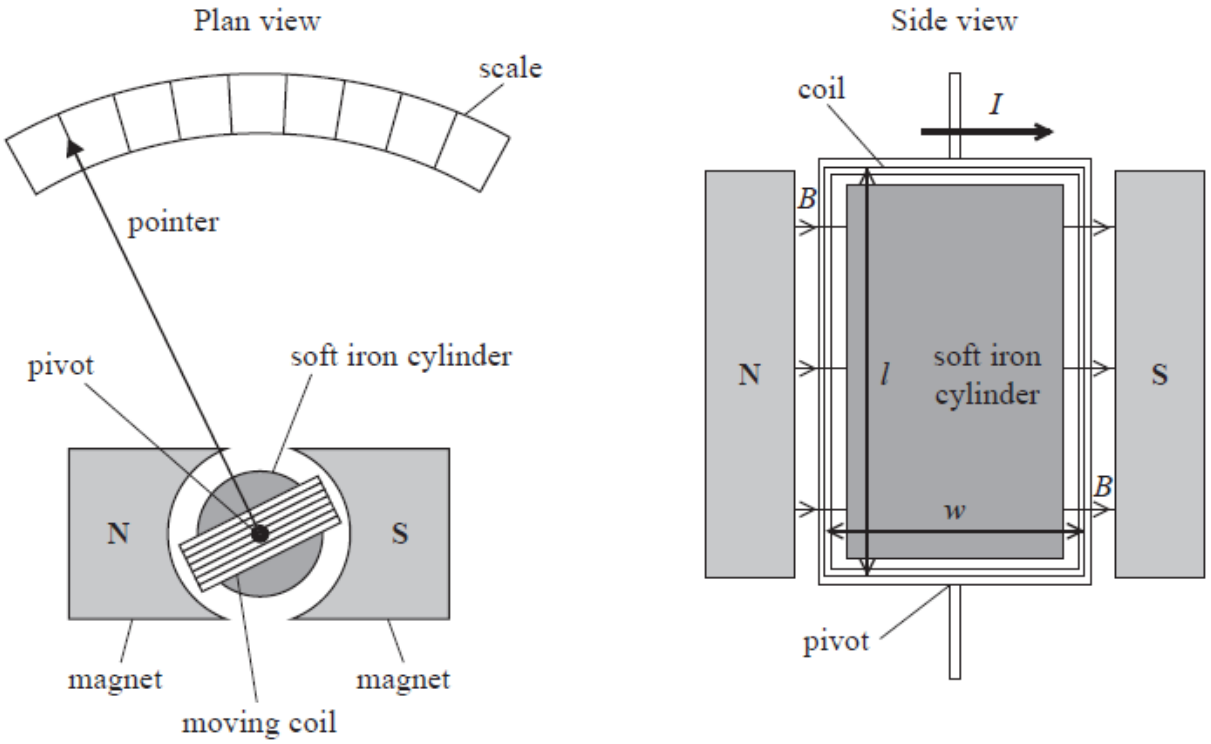
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(Total for question = 6 marks)

Q3.

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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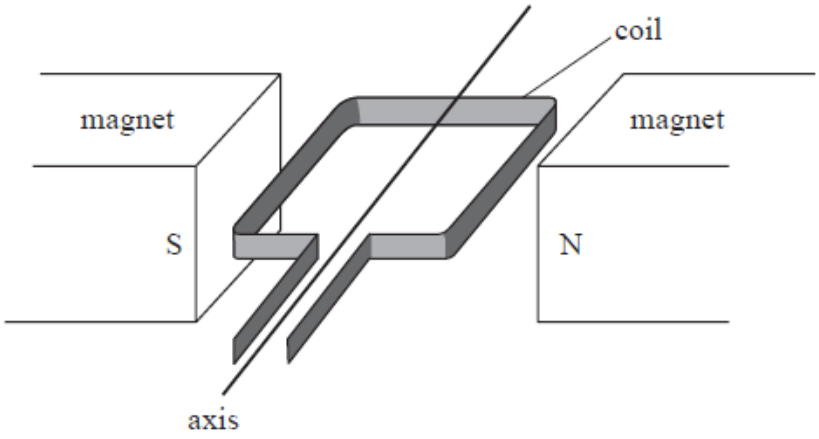
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(Total for question = 4 marks)

Q4.

*****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.

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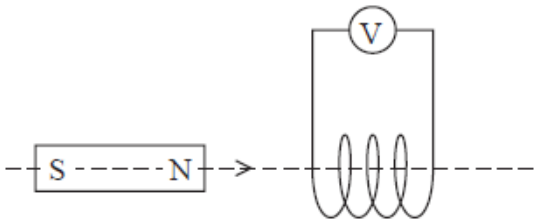
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(Total for question = 6 marks)

Q5.

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

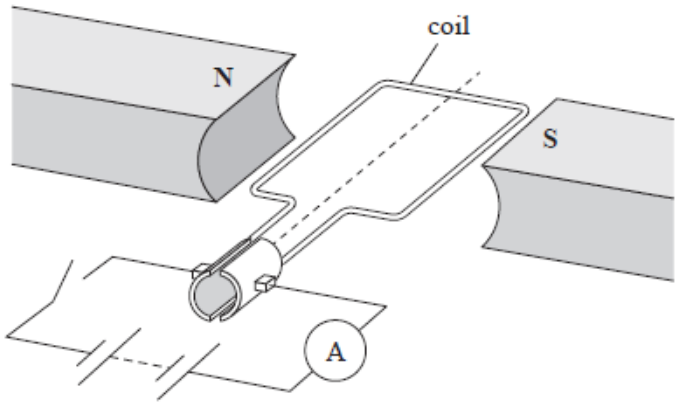
☒ **D** reversing the polarity of the magnet

(Total for question = 1 mark)

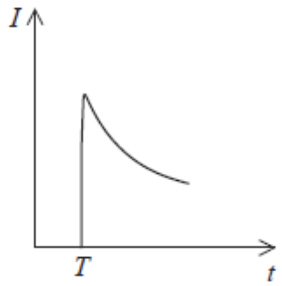
Q6.

* 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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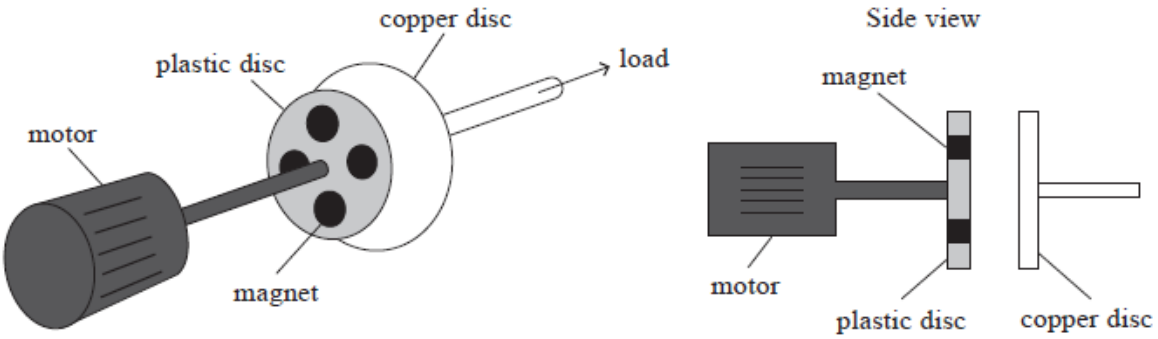
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(Total for question = 6 marks)

Q7.

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.

(4)

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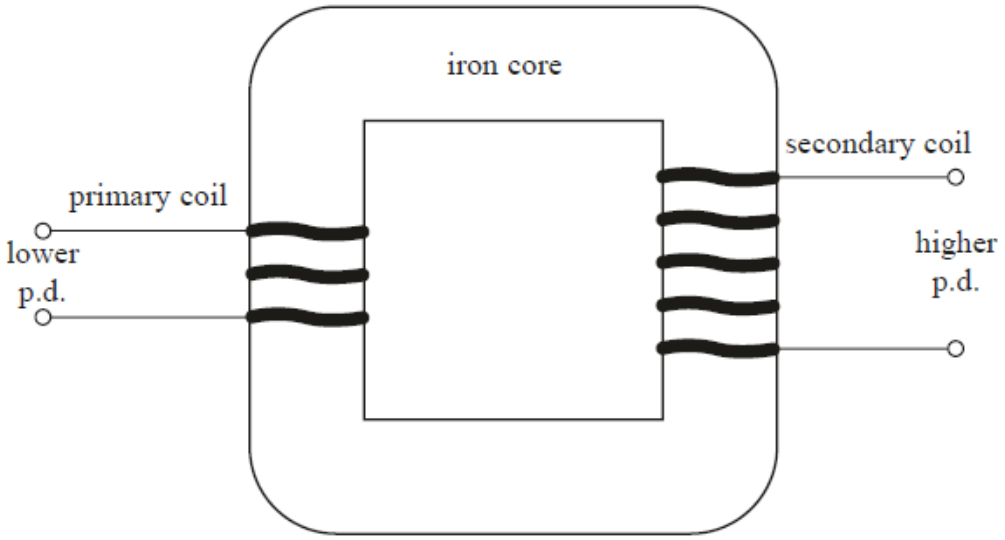
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(Total for question = 4 marks)

Q1.

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.

(4)

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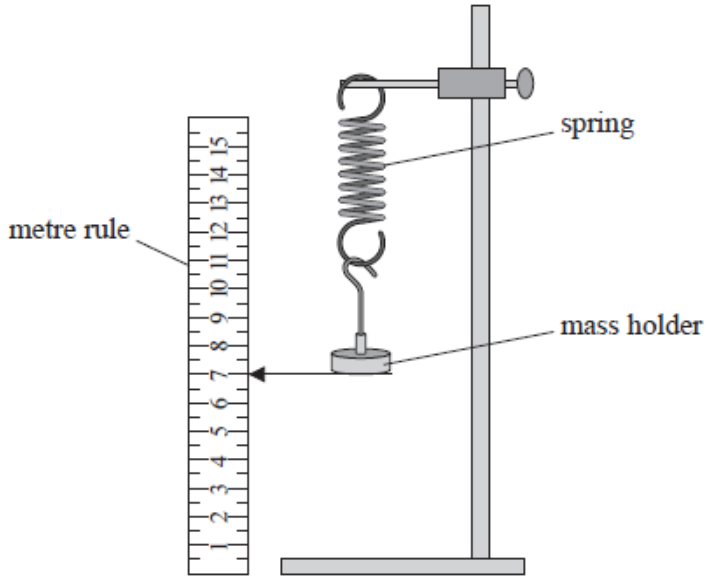
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(Total for question = 4 marks)

Q2.

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

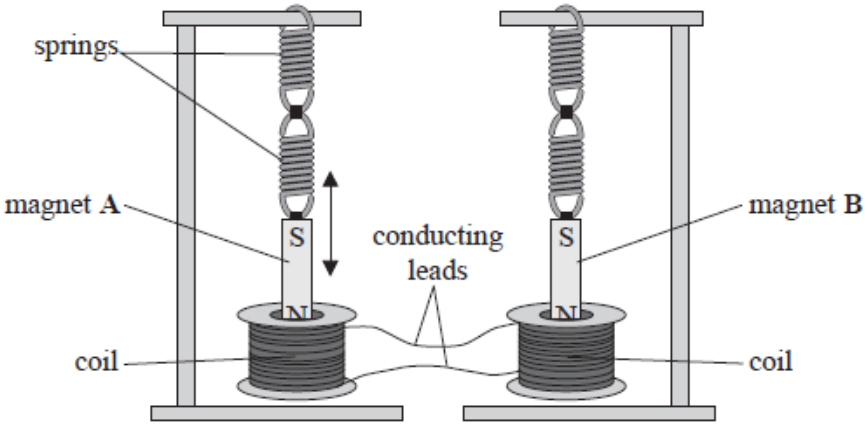


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

The student produced the following table.

Mass added / g	Extension / cm	Stretching force / N
50	1.9	0.49
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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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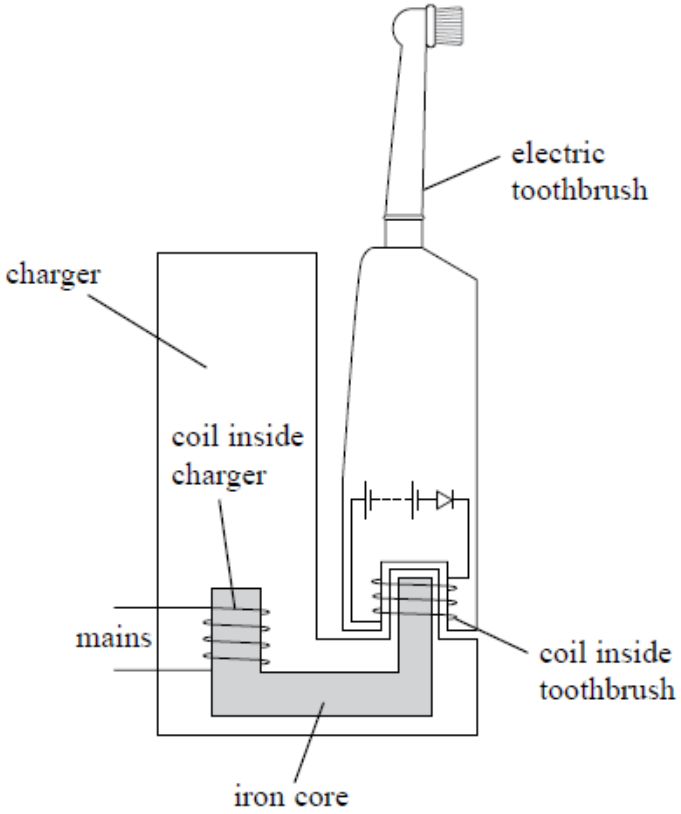
(Total for question = 6 marks)

Q3.

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.

(6)

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(Total for question = 6 marks)

Q4.

(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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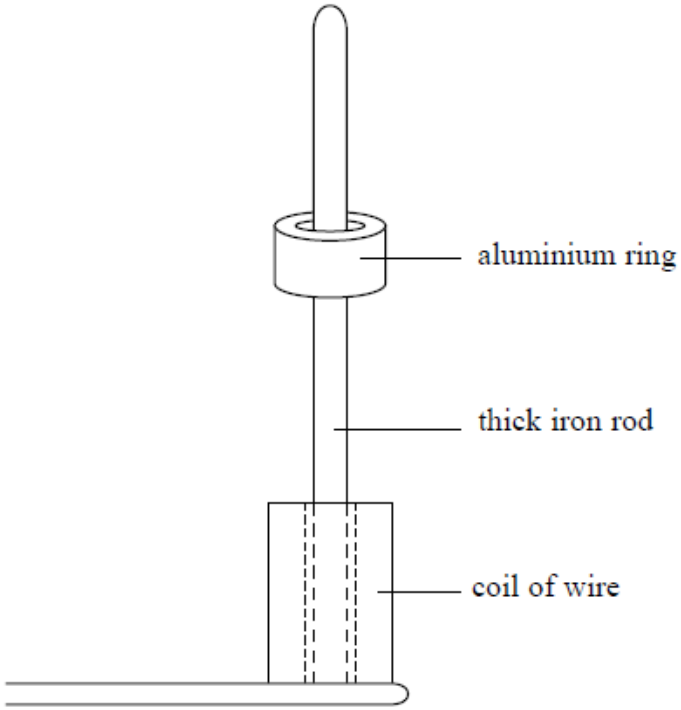
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(Total for question = 10 marks)

Q5.

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.

(4)

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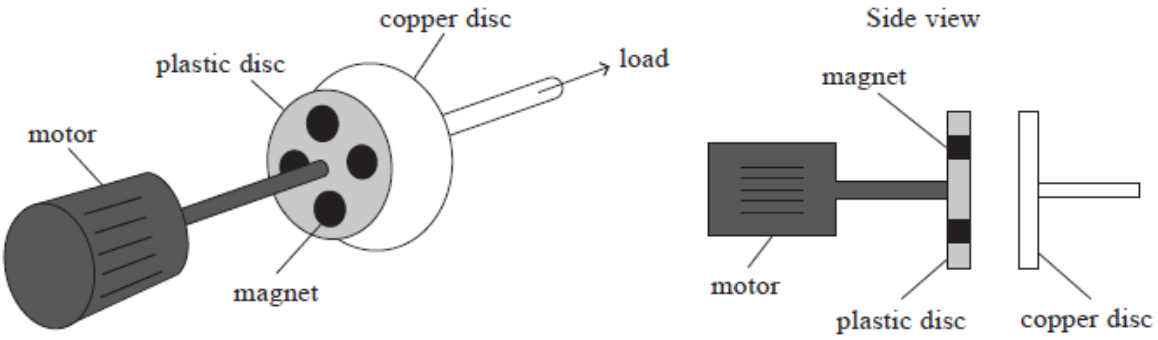
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(Total for question = 4 marks)

Q1.

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.

(2)

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

(3)

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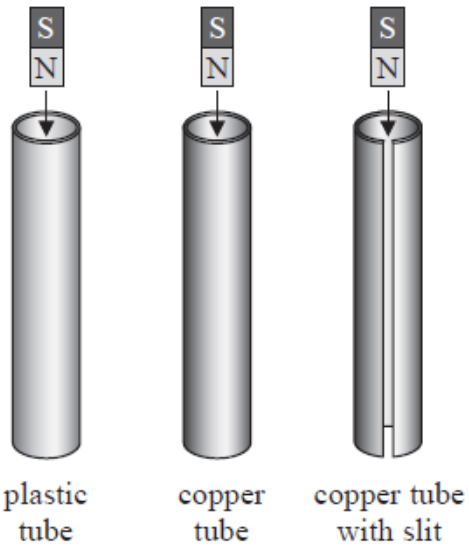
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(Total for question = 5 marks)

Q2.

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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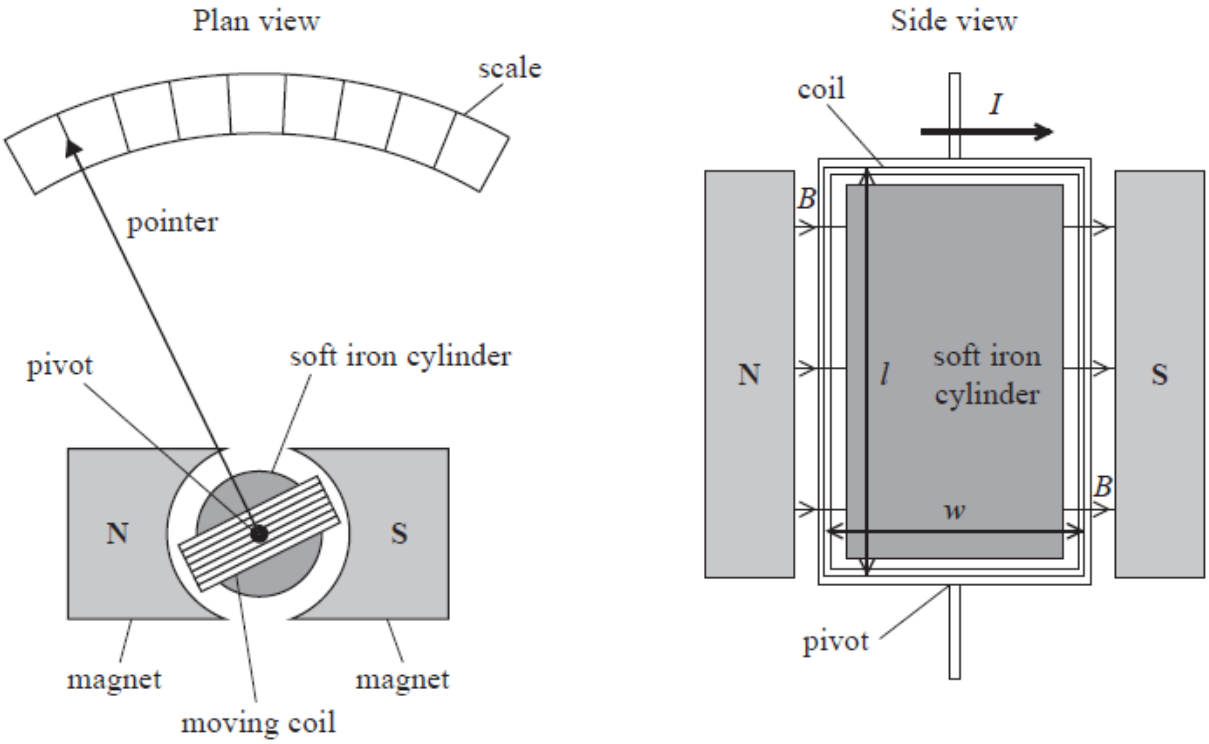
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(Total for question = 13 marks)

Q3.

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.

(4)

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(Total for question = 4 marks)

Q4.

The International Space Station (ISS) is in a low Earth orbit. Astronauts in ISS have an apparent weight of zero. In order to determine their mass, the astronauts must secure themselves to a platform which is set into oscillation and moves with simple harmonic motion.





The platform continues to move with simple harmonic motion at the same frequency, but its amplitude is doubled.

Explain how the maximum kinetic energy of the platform will change.

(2)

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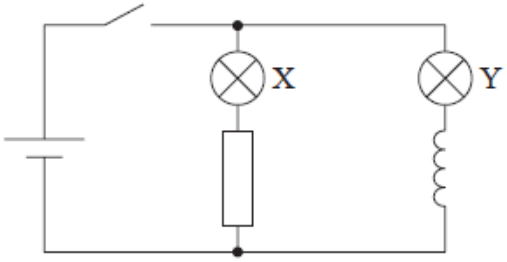
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(Total for question = 2 marks)

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

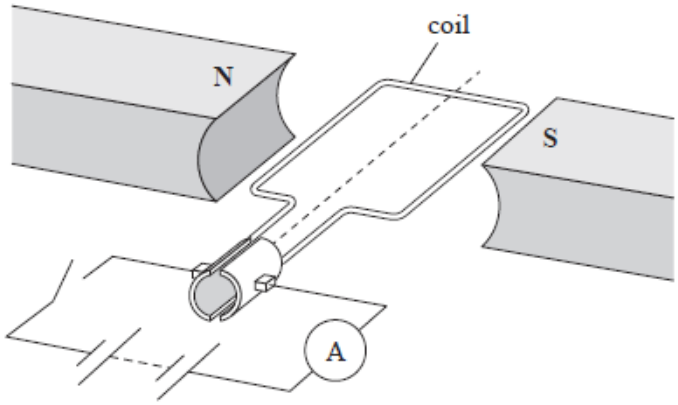
☒ **D** Lights instantly with the same brightness as X

(Total for question = 1 mark)

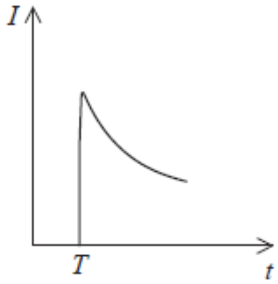
Q6.

* 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.

(6)

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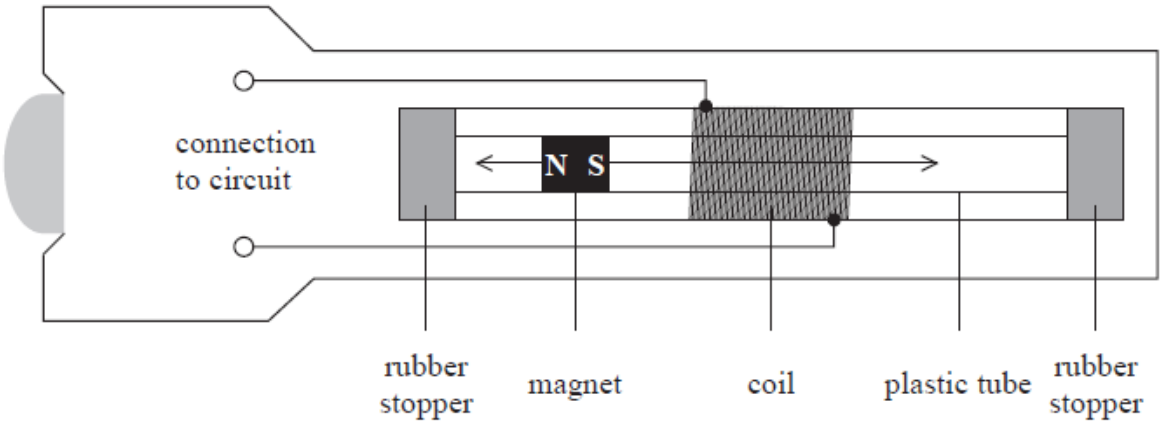
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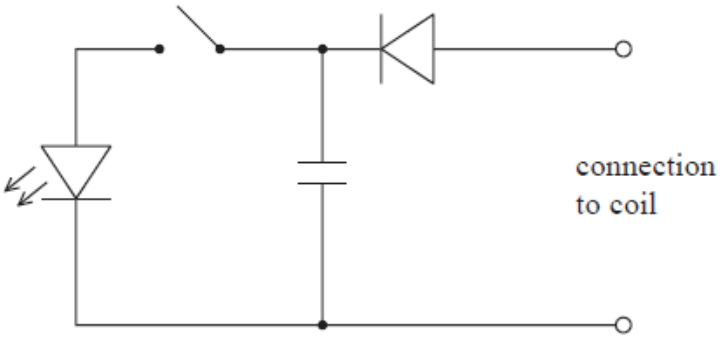
(Total for question = 6 marks)

Q1.

*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.

(6)

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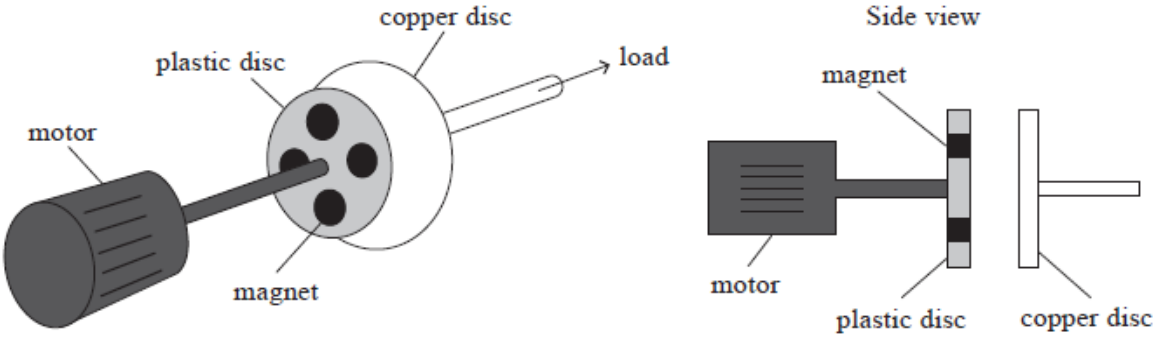
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(Total for question = 6 marks)

Q2.

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.

(2)

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

(3)

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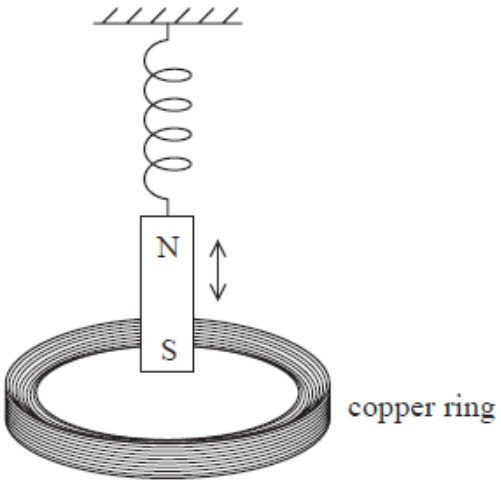
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(Total for question = 5 marks)

Q3.

* 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

(4)

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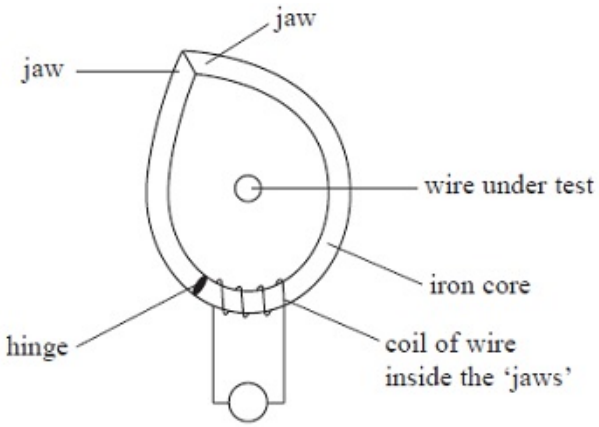
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Maximum current = ...

Q4. 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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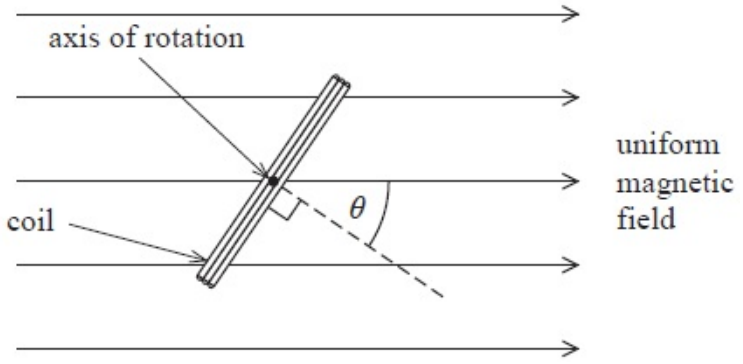
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(Total for Question = 11 marks)

Q5. 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 $\theta = 0°$ to $\theta = 90°$

(3)

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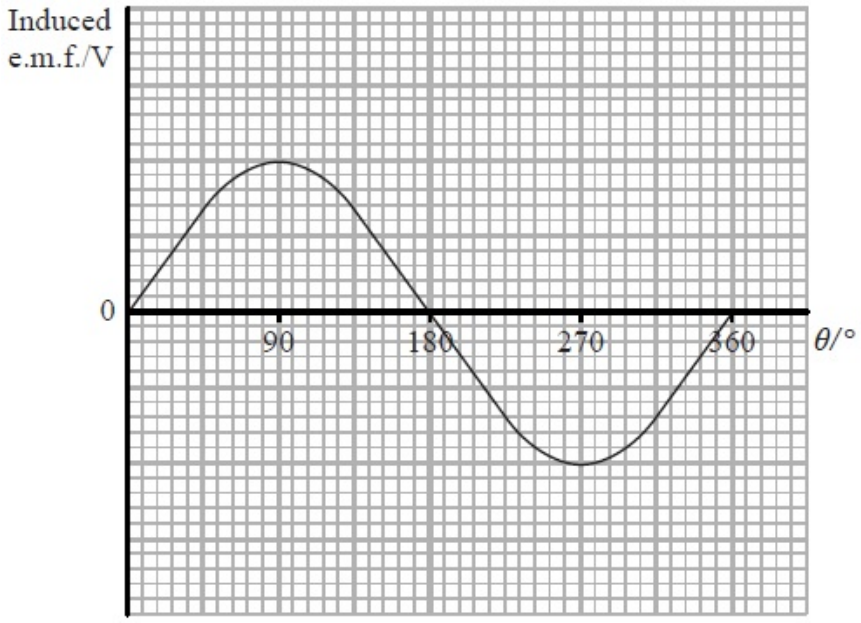
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Average e.m.f. = ...

(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)

Q6.

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

(2)

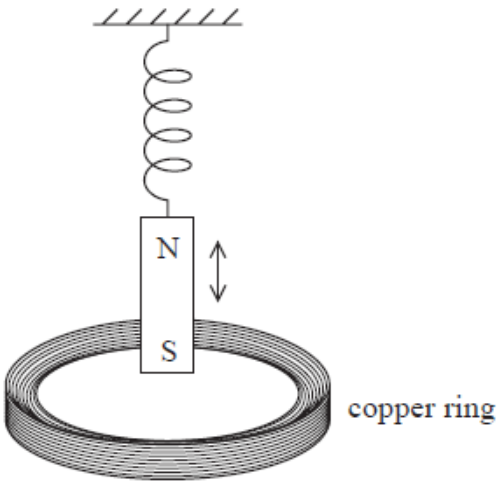
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*(b) A magnet is attached to the end of a spring as shown in the diagram.



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

(4)

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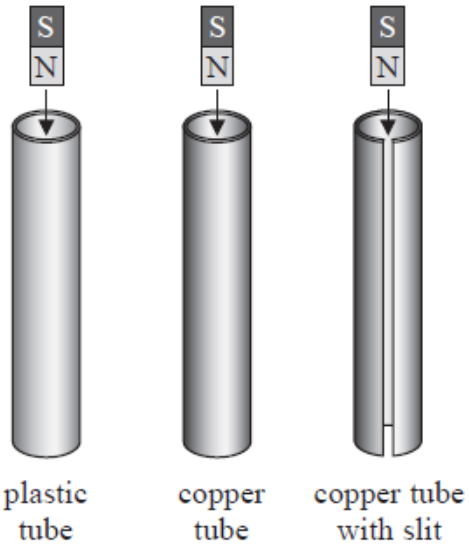
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Q7.

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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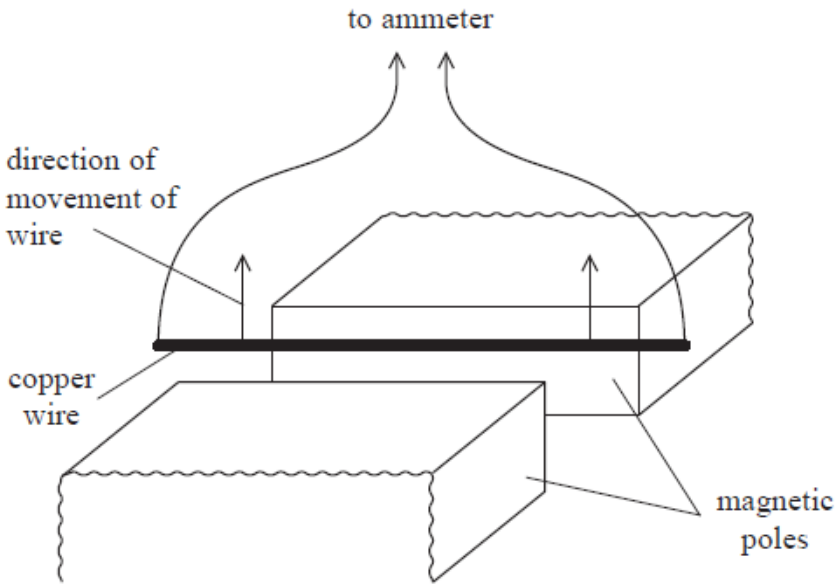
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(Total for question = 13 marks)

Q8.

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

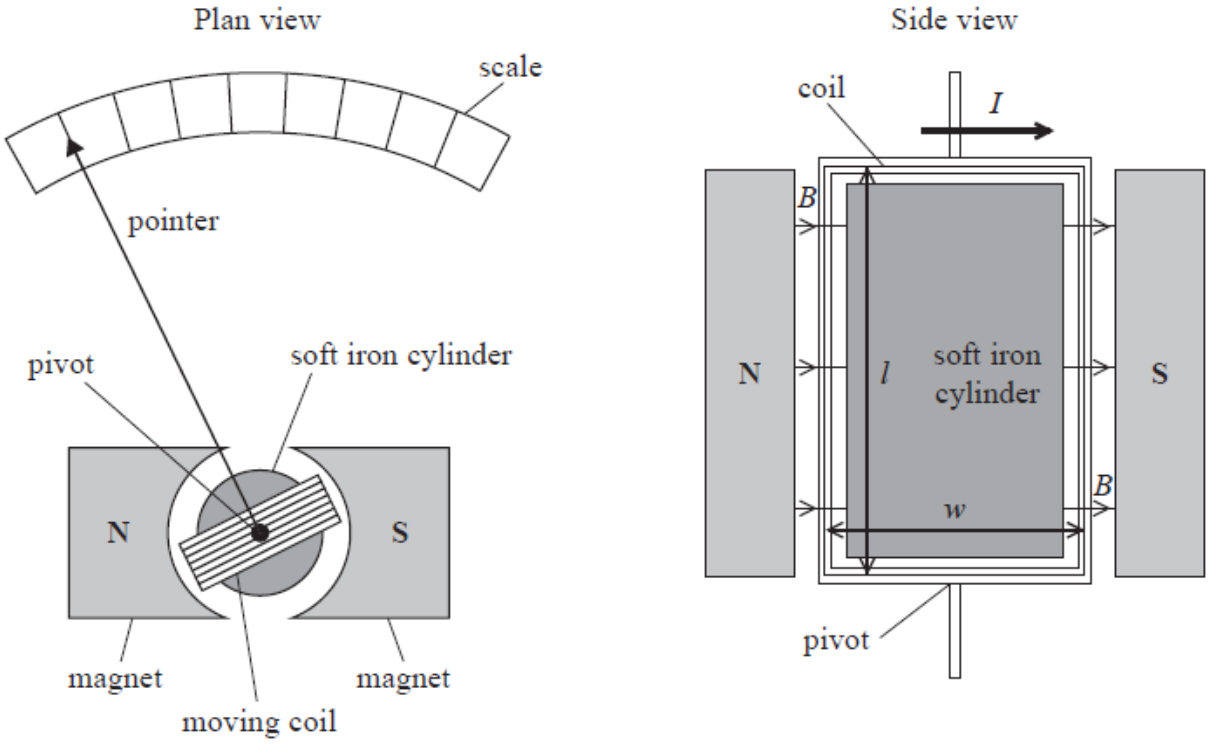
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(Total for question = 10 marks)

Q9.

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.

(4)

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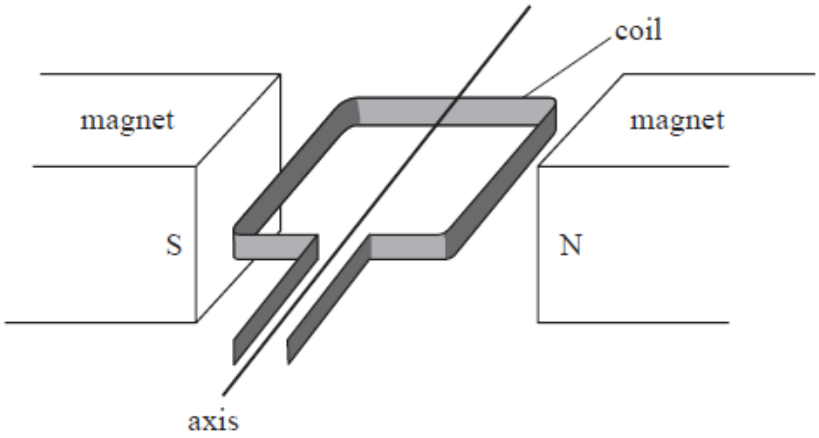
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(Total for question = 4 marks)

Q10.

*****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)

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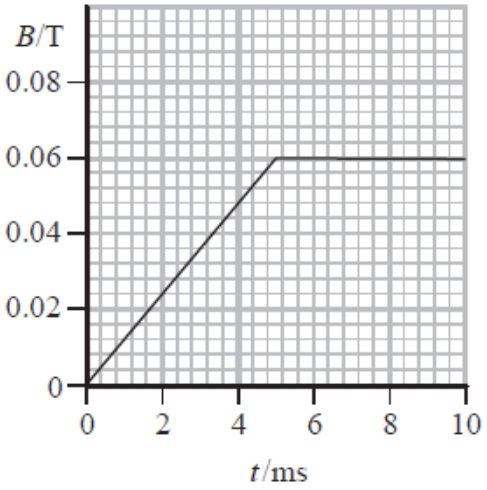
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(Total for question = 6 marks)

Q11.

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)

Q12.

(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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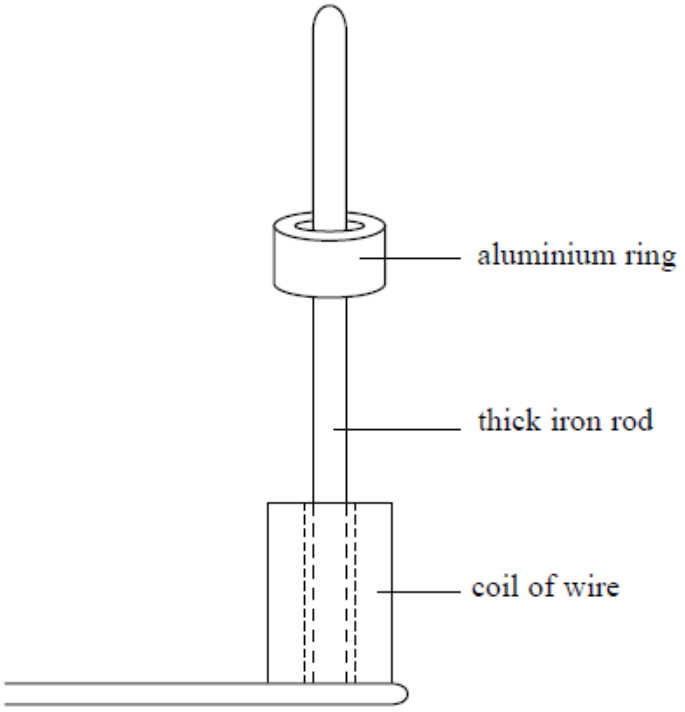
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(Total for question = 10 marks)

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.

(4)

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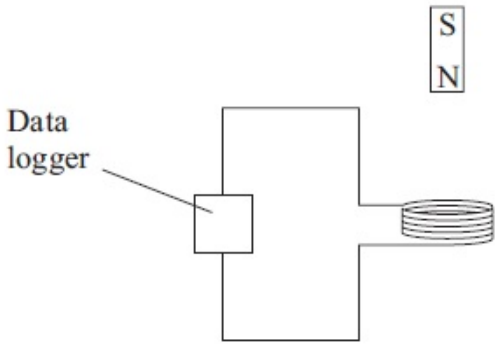
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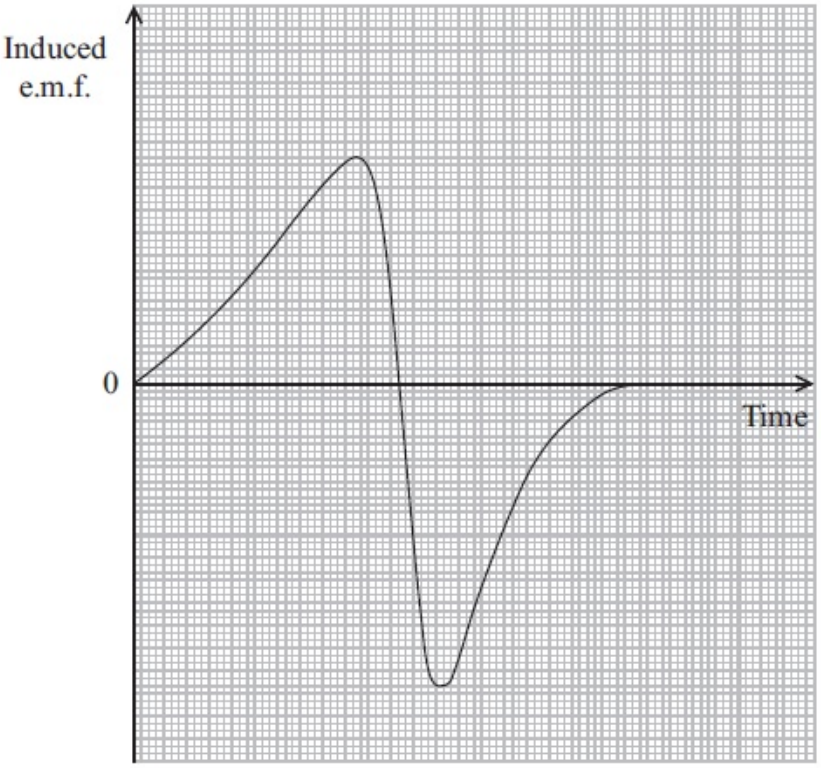
(Total for question = 4 marks)

Q14.

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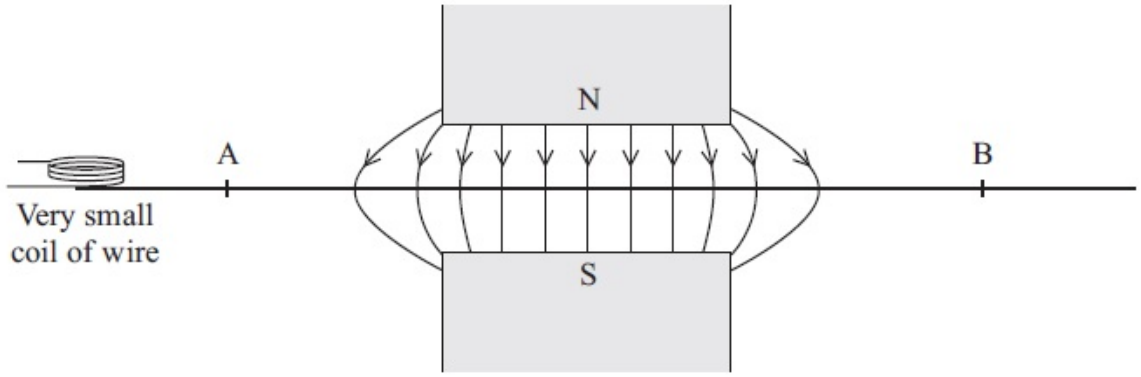
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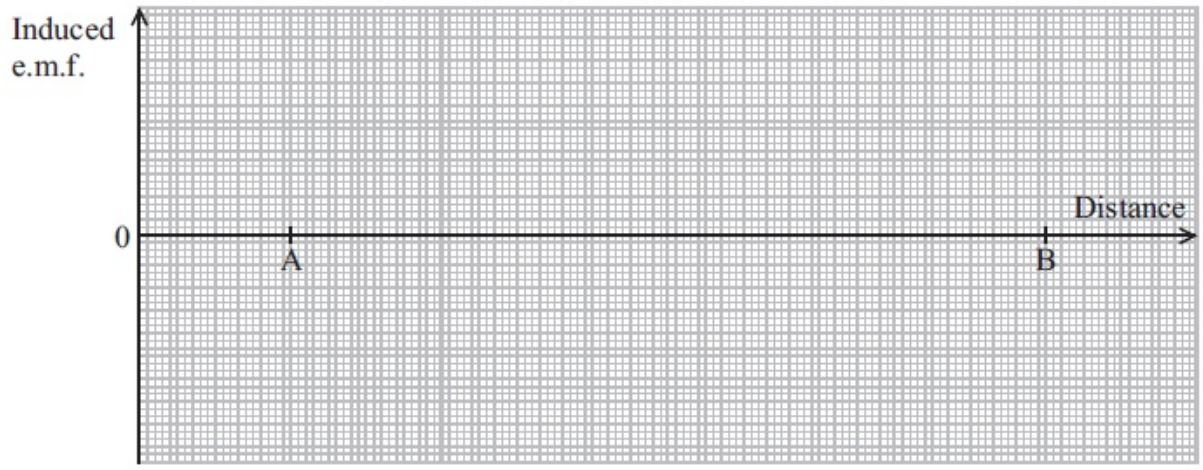
*(b) The teacher then sets up another demonstration using a large U-shaped magnet and a very small coil of wire which is again connected to a data logger.

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)

Q15.

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** $V\ s$

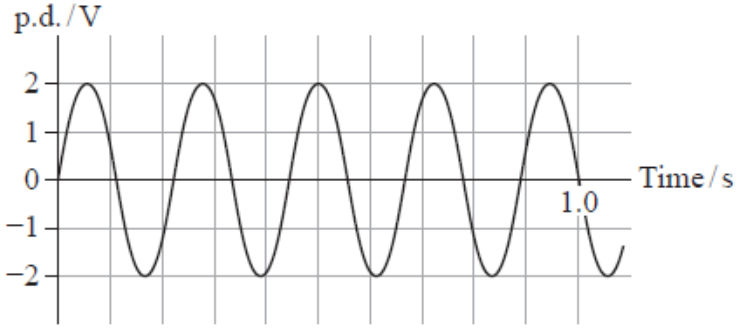
☒ **D** $Wb\ m^{2}$

(Total for question = 1 mark)

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.

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)

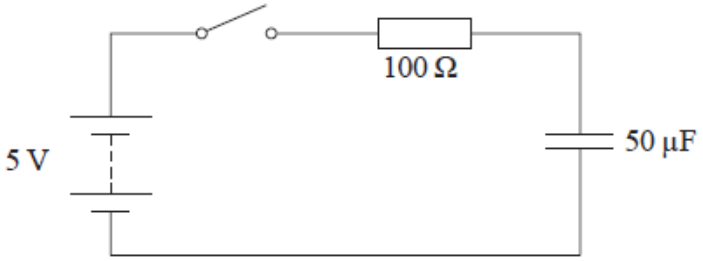
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Root-mean-square pd = ...

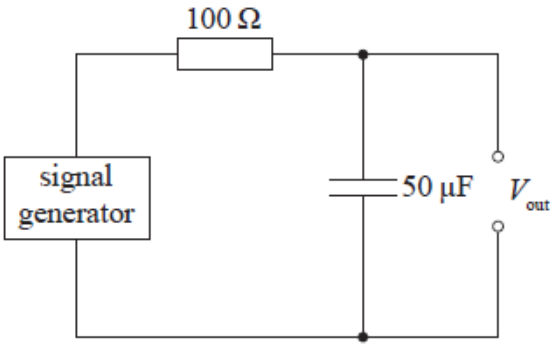
(Total for question = 2 marks)

Q3.

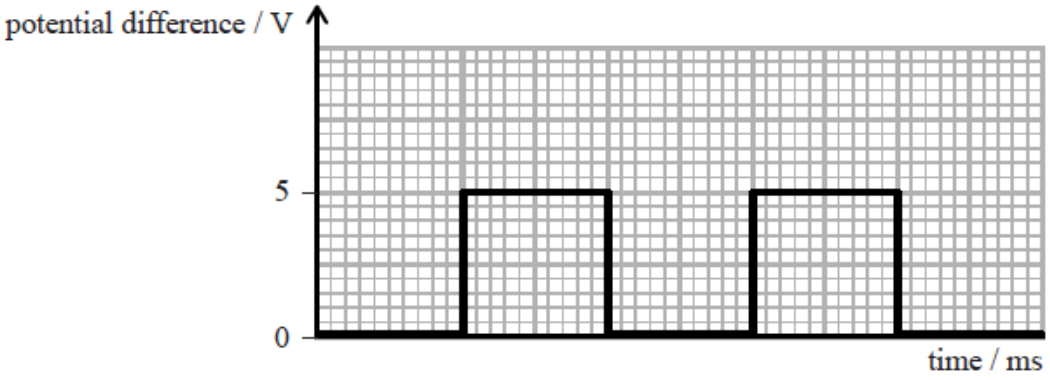
A circuit consists of a battery of e.m.f. 5 V and negligible internal resistance, a switch, a 100 Ω resistor and an uncharged 50 μF capacitor.



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.

(5)

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(Total for question = 5 marks)

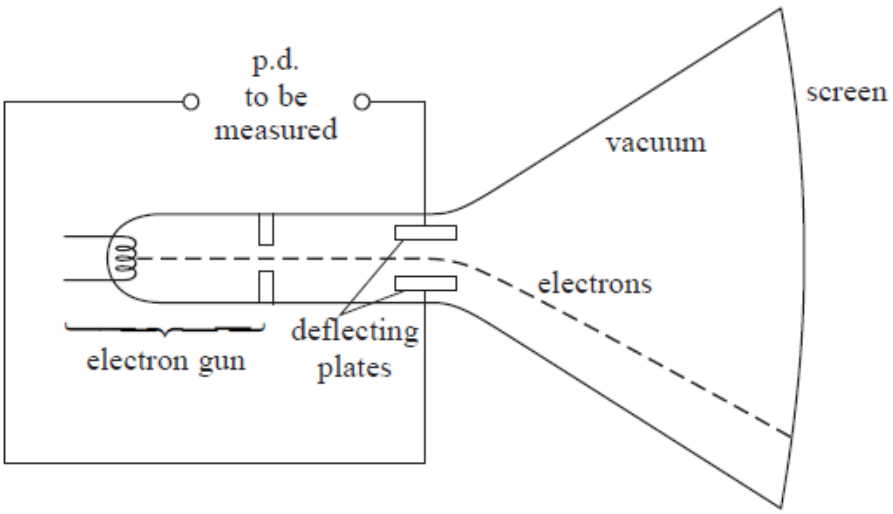
Q4.

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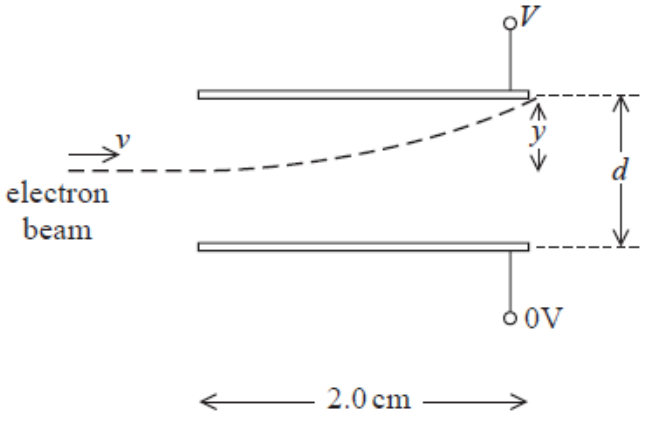
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(b) The electron beam then enters a uniform electric field between the two parallel horizontal deflecting plates. The magnitude and direction of the deflection is determined by the p.d. *V* that is applied across the plates.

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 = ...

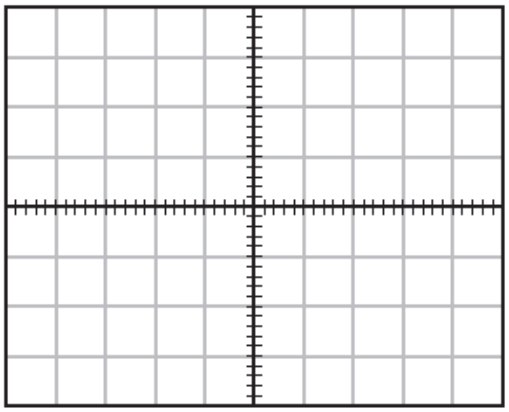
(c) A laboratory oscilloscope with the time base turned off operates in the same way as this simplified cathode ray tube. A student uses an oscilloscope in this way to monitor an alternating p.d. of 53 V_{rms}

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

(4)

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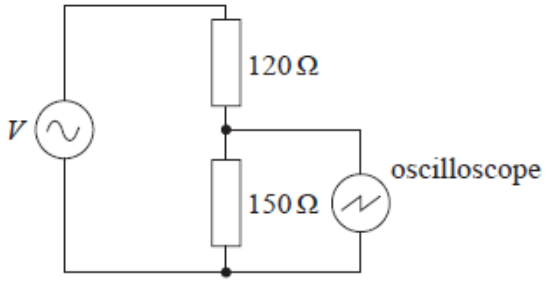
1 square = 25 V

(Total for question = 14 marks)

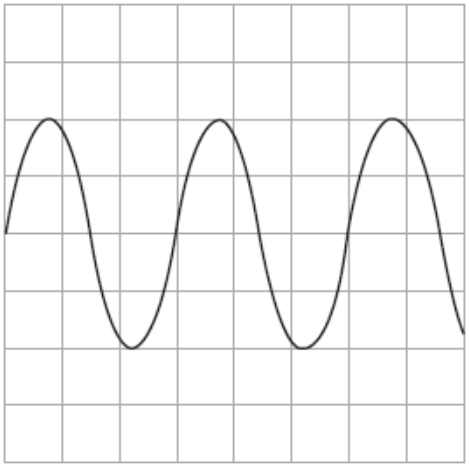
Q5.

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)

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

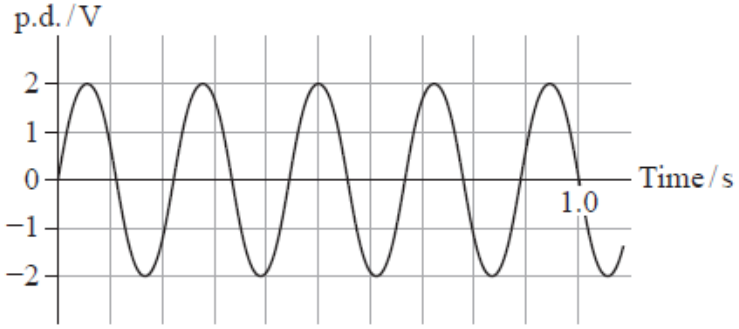
☐ **D** 9.0 A

(Total for question = 1 mark)

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.

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)

.....

Frequency = ...

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

(1)

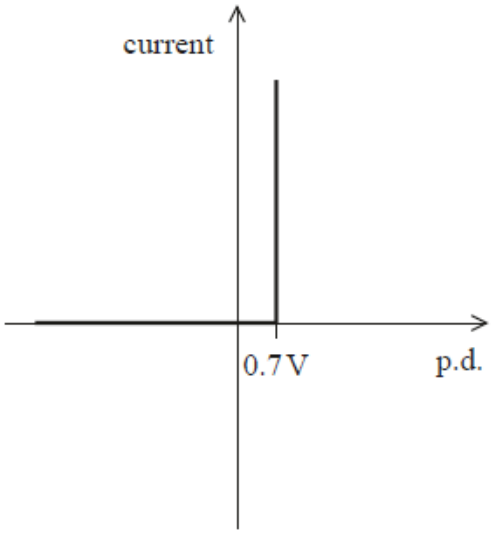
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Root-mean-square pd = ...

(Total for question = 2 marks)

Q3.

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.

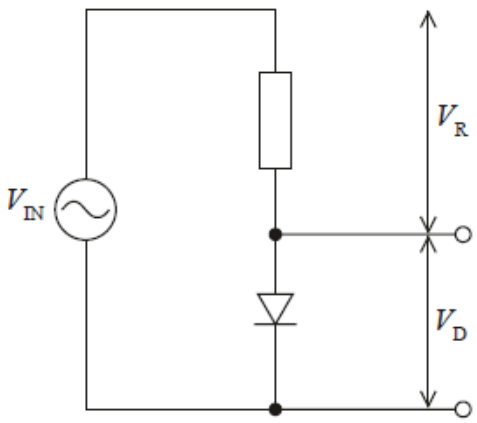
(i) Calculate the r.m.s. value.

(2)

.....

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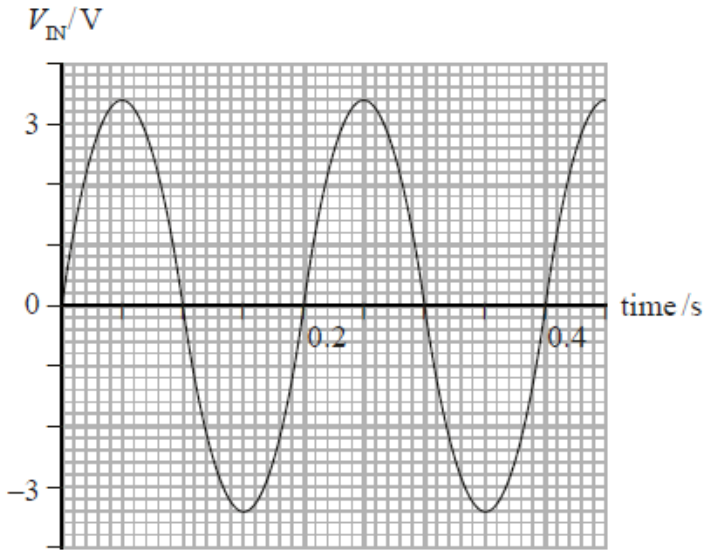
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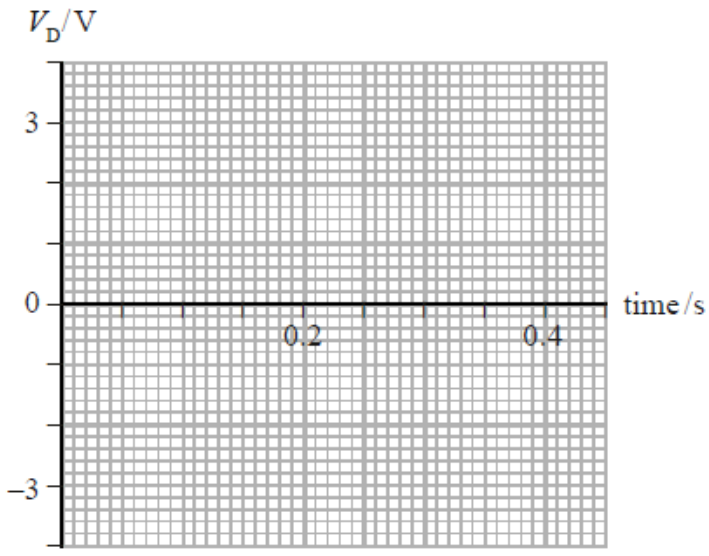
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(iii) The graph shows how V_{IN} varies with time.

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

(3)





(Total for question = 7 marks)

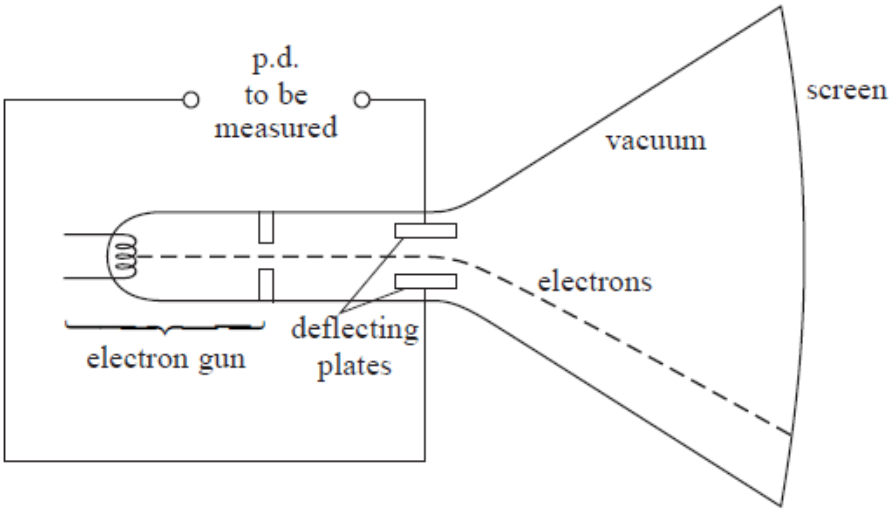
Q4.

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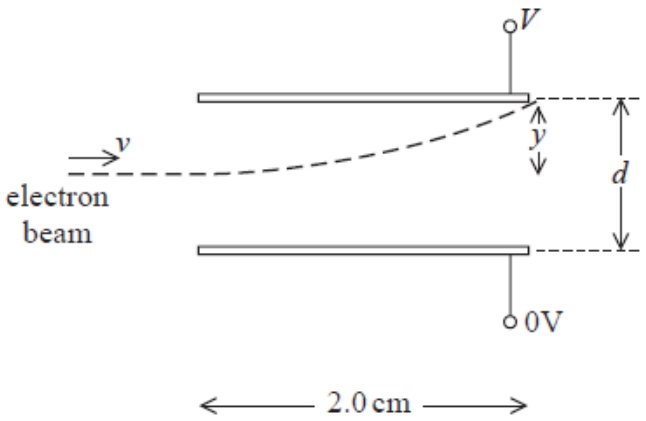
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(b) The electron beam then enters a uniform electric field between the two parallel horizontal deflecting plates. The magnitude and direction of the deflection is determined by the p.d. V that is applied across the plates.

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 = ...

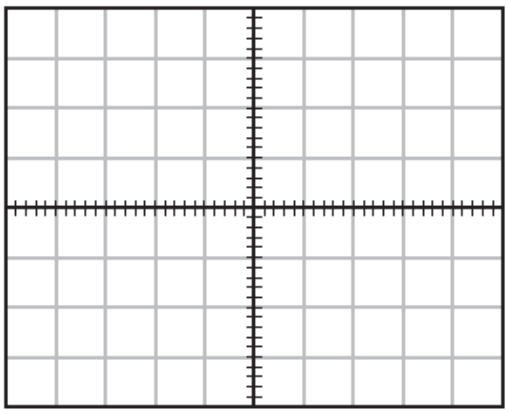
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On the grid, draw the trace that would be seen on the screen.

(4)

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1 square = 25 V

(Total for question = 14 marks)

Q5.

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)

Q6.

A standard candle, within a nearby star cluster, is a distance *D* from the Earth. It produces a radiation flux *F* at the surface of the Earth.

The flux at the surface of the Earth, for a standard candle of the same luminosity in a second star cluster, is 4*F*.

The distance of the second star cluster from the Earth is

☒ **A** $4D$

☒ **B** $2D$

☒ **C** $\frac{D}{2}$

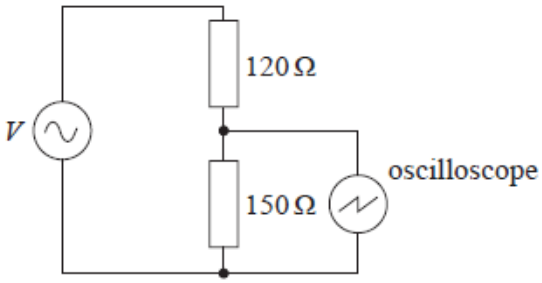
☒ **D** $\frac{D}{4}$

(Total for question = 1 mark)

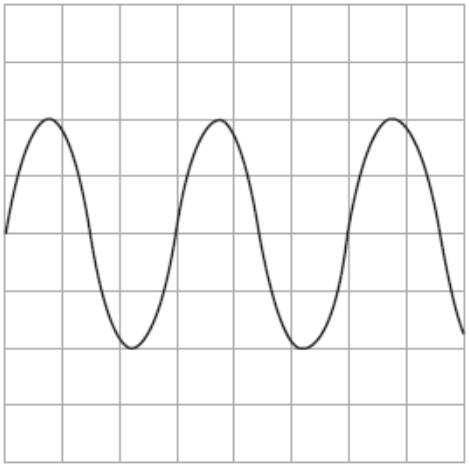
Q7.

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)

.....

.....

.....

Peak p.d. across 150 Ω resistor = ...

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

(3)

.....

.....

.....

.....

.....

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

(iii) Calculate the power dissipated in the circuit.

(3)

.....

.....

.....

.....

Power dissipated in circuit = ...

(Total for question = 8 marks)

Q8.

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)