Magnetic Fields and EM Induction - Questions by Topic

Q1.

A current-carrying wire is placed into a magnetic field. If the magnetic force experienced by the wire balances the weight of the wire, the wire will float.

The direction of the magnetic field is from west to east.

For the wire to float, it is placed

☐ **A** parallel to the magnetic field so the current flows from east to west.

☐ **B** parallel to the magnetic field so the current flows from west to east.

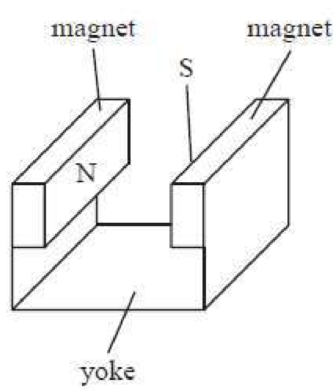
☐ **C** perpendicular to the magnetic field so the current flows from north to south.

☐ **D** perpendicular to the magnetic field so the current flows from south to north.

(Total for question = 1 mark)

Q2.

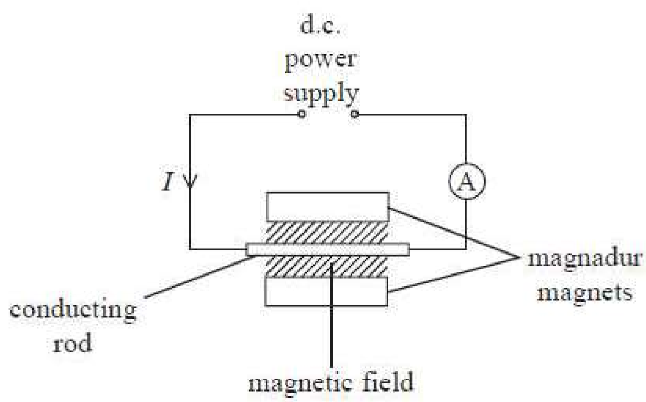
A student set up an experiment to determine the magnetic flux density between two magnadur magnets. A magnadur magnet has its north and south poles on opposite large rectangular faces. The two magnets were attached to a yoke, with opposite poles facing, as shown in the diagram.



The student zeroed the balance and then placed the magnets and yoke on it. The reading increased to 136.38 g.

A conducting rod connected to a d.c. power supply was held stationary between the magnets as shown. An ammeter was used to measure the current through the conducting rod.

The circuit diagram shows the arrangement when viewed from above.



The power supply was switched on. The student increased the current through the conducting rod and the corresponding reading on the balance was recorded.

The following results were obtained.

Current / A	Reading on balance / g
0	136.38
0.5	136.52
1.0	136.66
1.5	136.79
2.0	136.93
2.5	137.06

(a) Add an arrow to the circuit diagram to indicate the direction of the magnetic field between the magnets. Justify your answer.

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(b) Describe how the results can be used to determine the magnetic flux density by a graphical method. You are not expected to do the calculations.

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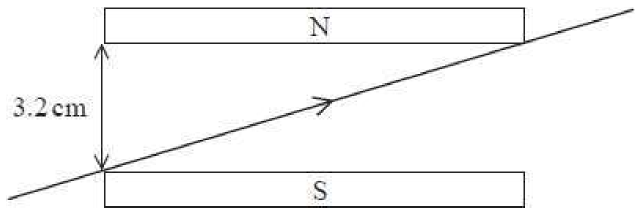
(Total for question = 10 marks)

Q3.

A current-carrying wire is placed between the poles of a U-shaped magnet as shown in the diagram.



(a) Determine the magnitude of the force on the wire due to the magnetic field. You may assume the field is uniform.

current in wire = 820 mA
length of wire in field = 6.9 cm
magnetic flux density = 0.074 T

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Magnitude of force = ...

(b) Explain the direction of this force on the wire.

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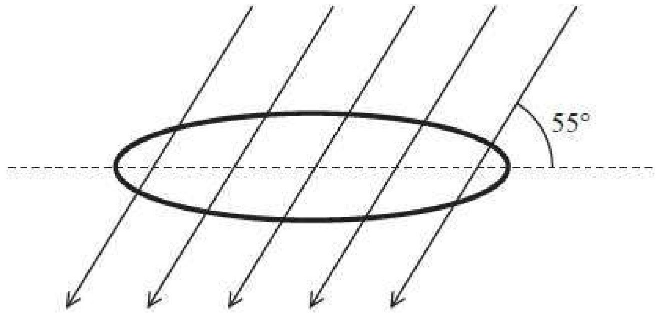
(Total for question = 5 marks)

Q4.

A magnetic field of flux density 4.0×10^{-3} T passes through a coil of wire, at an angle of 55° to the plane of the coil. The coil has an area of 2.5×10^{-3} m^2.

Calculate the magnetic flux through the coil.

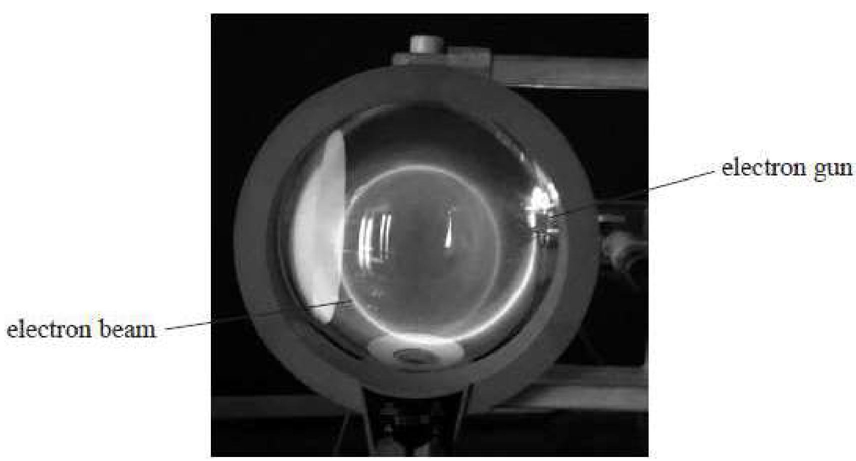


- ☐ **A** 5.7×10^{-6} Wb
- ☐ **B** 8.2×10^{-6} Wb
- ☐ **C** 1.0×10^{-5} Wb
- ☐ **D** 1.4×10^{-5} Wb

(Total for question = 1 mark)

Q5.

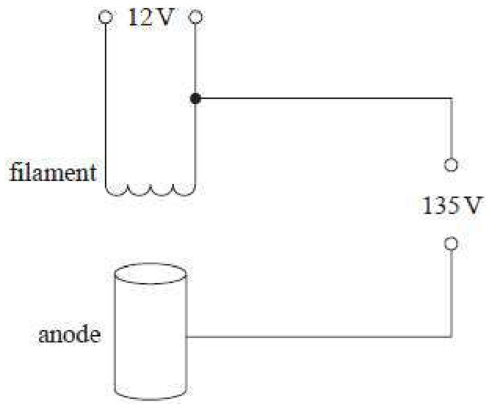
The photograph shows the path of an electron beam in a fine beam tube.



The fine beam tube contains helium gas at very low pressure. When electrons strike the helium atoms the resulting excitation is responsible for the glow tracing the path of the electron beam.

The electron beam is emitted downwards from an electron gun.

(a) The electron gun contains a heated filament above an anode as shown. There is a potential difference of 135 V between the anode and the filament.



(i) Describe how the electron beam is produced.

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(ii) Show that the speed of the electrons leaving the electron gun is about 7×10^6 m s^{-1}.

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(b) The electron beam follows the path shown in the photograph. A horizontal magnetic field is applied in the direction into the page.

(i) Show that a particle of momentum *p* follows a circular path of radius *r* given by

$$r = p/BQ$$

where *Q* is the charge on the particle and *B* is the magnetic flux density.

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(ii) Calculate *B*.

diameter of circular path = 7.3 cm

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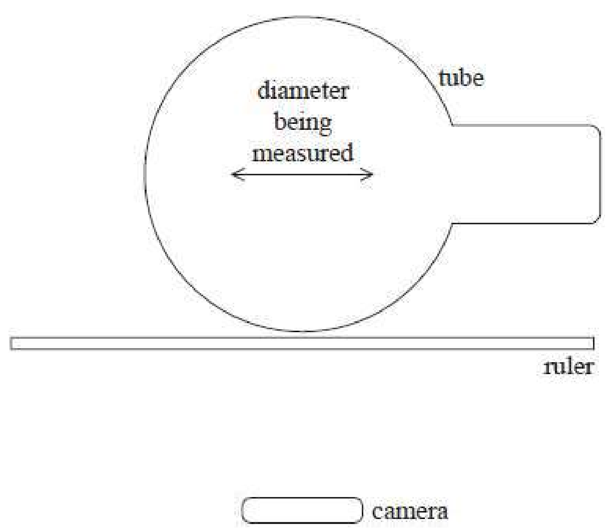
B = ...

(c) The diameter of the circular path was measured by holding a metre rule in front of the tube and taking a photograph, as shown.



Discuss the suitability of this method.

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(d) Suggest why the electron beam continues along a path of decreasing diameter with decreasing intensity.

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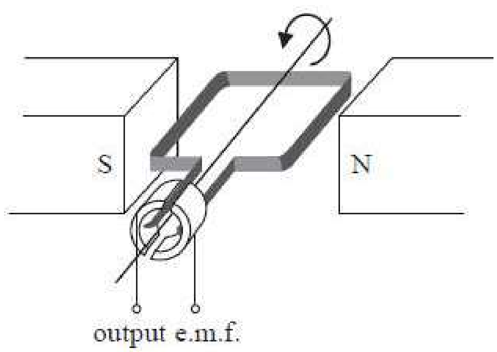
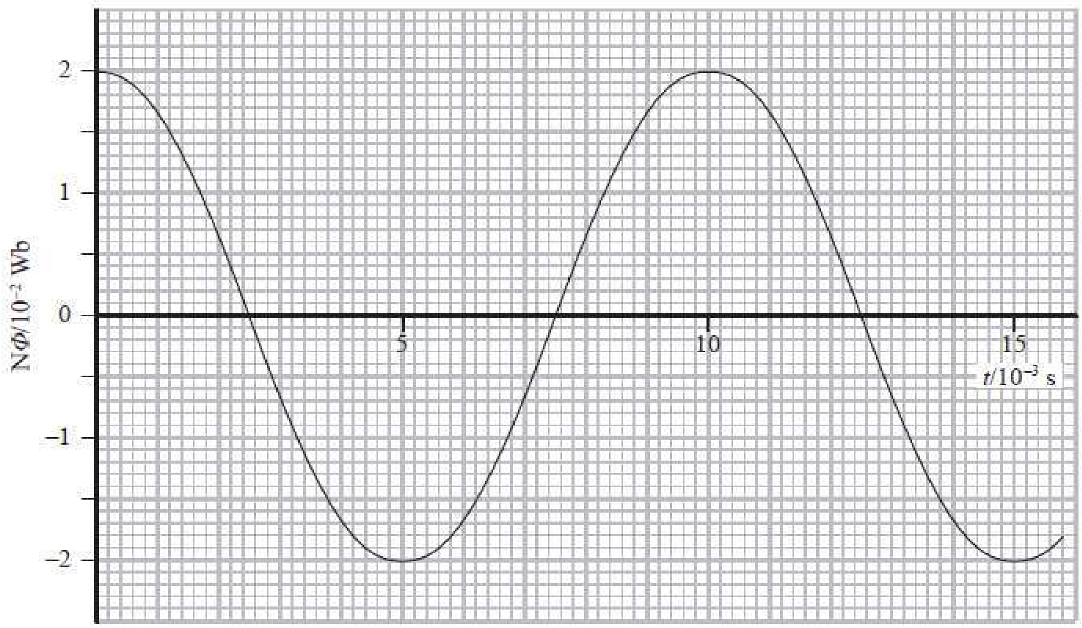
(Total for question = 12 marks)

Q6.

The diagram shows a simple generator. It has a flat coil of negligible resistance which can be rotated in a magnetic field. The coil has 500 turns and an area of 2.5×10^{-3} m^2.



The graph shows the variation of the magnetic flux linkage NΦ with time t as the coil is rotated at a steady frequency in a uniform magnetic field.



(a) Determine the frequency of rotation of the coil.

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Frequency = ...

(b) Determine the magnetic flux density of the field.

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Magnetic flux density = ...

(c) Determine the maximum e.m.f. induced in the coil.

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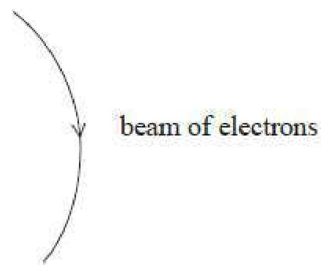
Maximum e.m.f. = ...

(Total for question = 7 marks)

Q7.

A beam of electrons is made to travel in a circular path by applying a magnetic field across the path of the beam.



Which of the following is the direction of the magnetic field required to maintain this circular path for the electron beam?

(1)

☐ **A** out of the page

☐ **B** into the page

☐ **C** left to right

☐ **D** right to left

(Total for question = 1 mark)

Q8.

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

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(b) Vehicles such as buses may be powered by electric motors. The motors on these buses use batteries which need to be charged often. This is normally done by connecting to a fixed electrical supply whilst the bus is parked.

The photograph shows a bus on a road in South Korea. This road enables the batteries to charge whilst the bus is in motion.

Under the road there are electric cables, connected to a 440V 60 Hz supply. These generate magnetic fields. There is a coil inside the charging device which is located below the floor of the bus. This enables the batteries on the bus to charge.

*(i) Explain how this system works.

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(ii) It is not necessary for the cable to be installed under the entire length of the road. The batteries used to power these buses can be much smaller than those used in other electric buses

Explain why the cables do not need to be installed under the entire length of the road and why the batteries can be smaller.

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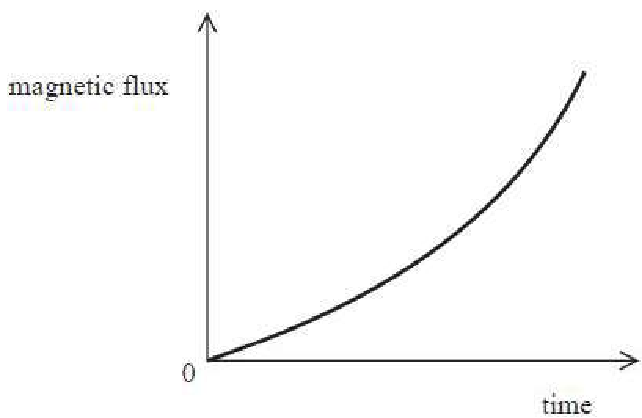
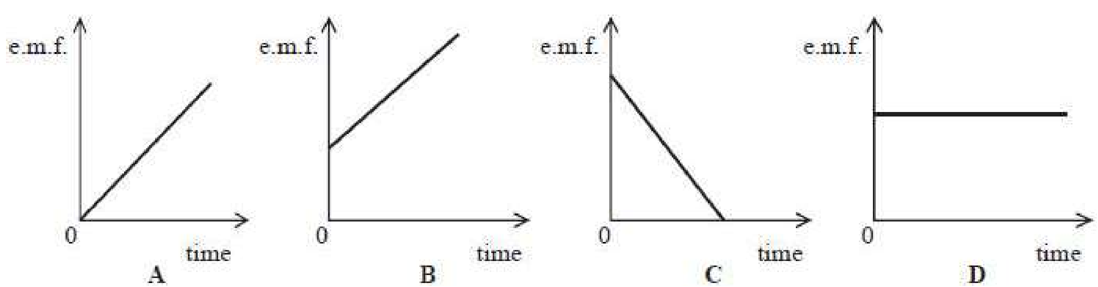
(Total for question = 8 marks)

Q9.

The graph shows how the magnetic flux passing through a coil varies with time.



Which of the following graphs could show how the magnitude of the e.m.f. induced in the coil varies with time?



☐ **A**

☒ **B**

☒ **C**

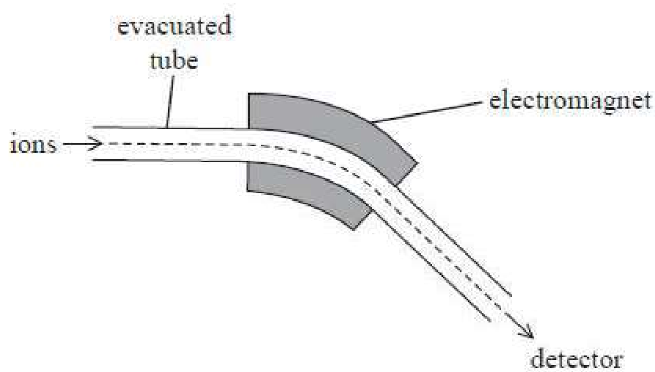
☒ **D**

(Total for question = 1 mark)

Q10.

A mass spectrometer is a device used to identify atoms by measuring the mass–charge ratio $\frac{m}{Q}$ of their ions.

Ionised atoms in a vacuum are accelerated from rest through a potential difference *V* and then enter an evacuated tube.



(a) An ion of mass *m* is accelerated to a velocity *v*.
Show that the mass–charge ratio of the ion is given by

$$\frac{m}{Q} = \frac{2V}{v^2}$$

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*(b) The electromagnet shown in the diagram provides a magnetic field which is used to deflect

the ion along the tube of the spectrometer.

Explain how a magnetic field can be used to deflect the ion into a circular path.

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(c) An atom of bromine is ionised by the removal of one electron. It is accelerated through a potential difference of 3.0 kV and then enters the tube. The ionised atom is deflected by a magnetic field of magnetic flux density 0.15 T.

Calculate the radius of curvature *r* of the tube.

mass of bromine ion = 80 u

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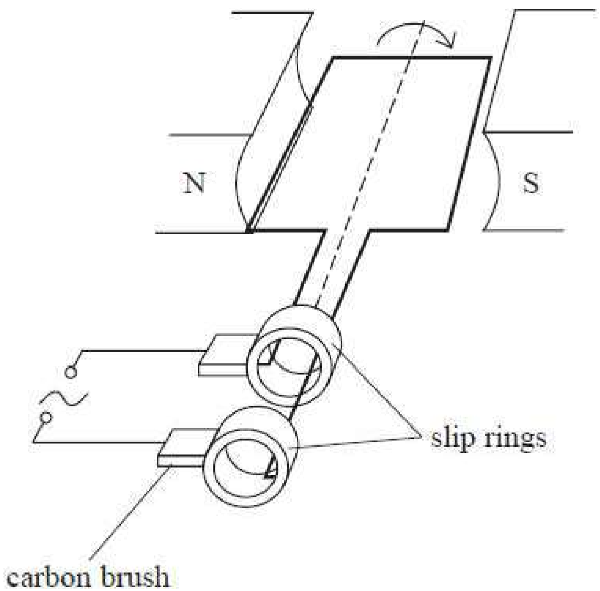
r = ...

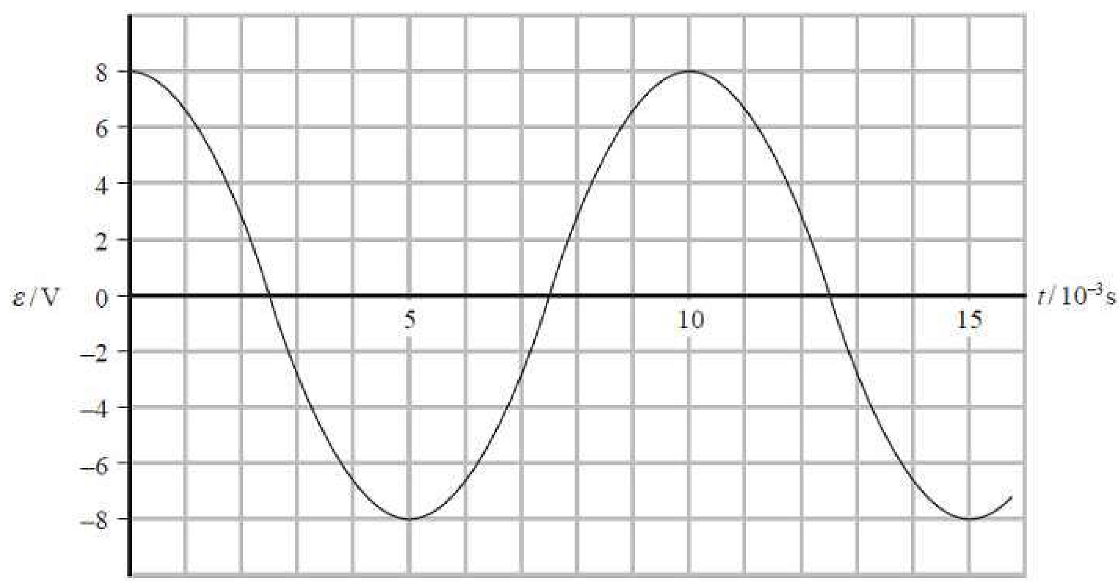
(Total for question = 9 marks)

Q11.

A simple electric generator consists of a coil that is rotated within a uniform magnetic field as shown.



The graph shows the variation of e.m.f ε with time t as the coil is rotated at a steady frequency.



* (a) Explain why the value of ε varies between a maximum value and zero.

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(b) (i) Explain why the area under the graph represents the change in flux linkage.

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(ii) Determine the magnetic flux density between the poles of the magnet.

number of turns on coil = 500

area of coil = 2.5×10^{-3} m^2

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Magnetic flux density = ...

(c) The speed at which the coil rotates is halved.

Sketch a graph on the axes below to show how the new ε varies with time.

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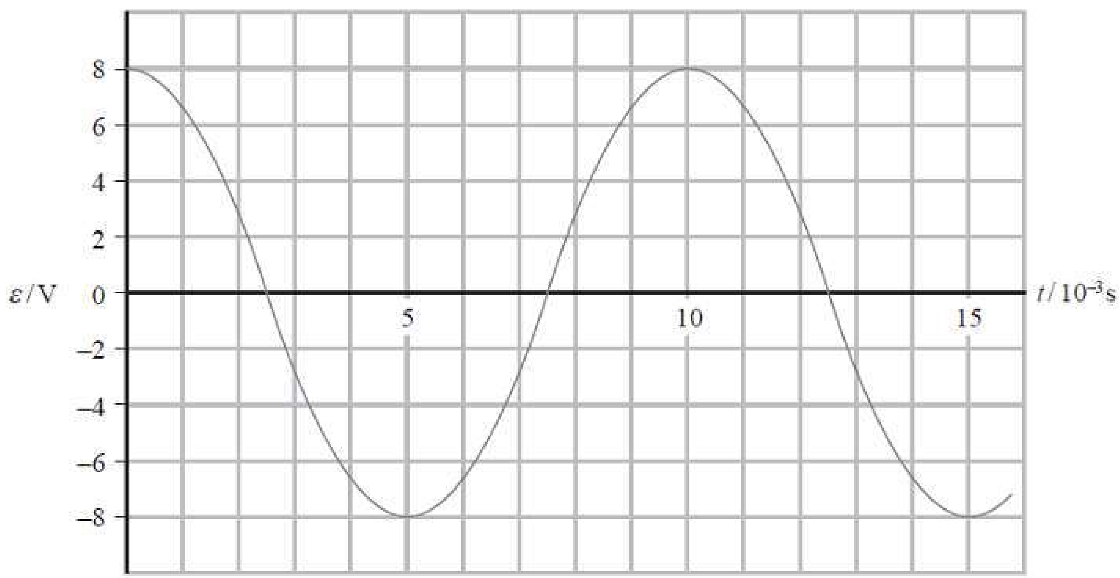

(d) A force is required to rotate the coil.

Explain why the size of the force increases when a lamp is connected to the output of the generator.

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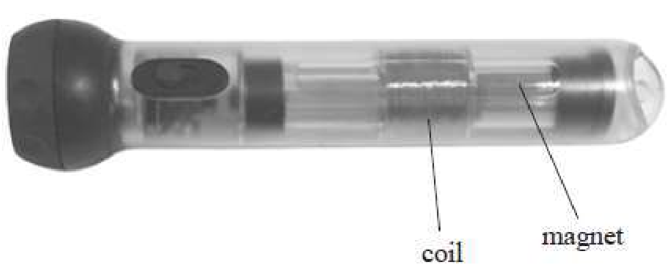
(Total for question = 13 marks)

Q12.

The photograph shows a torch with batteries that are recharged by shaking the torch.



Inside the torch is a coil of wire and a magnet that can move freely through the coil in alternate directions when the torch is shaken. The coil is connected to a rechargeable battery.

(a) Explain how shaking the torch produces an electric current.

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(b) Explain, with reference to Lenz's law, how the magnet does work as it enters the coil.

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(c) The circuit in the torch contains a diode between the coil and the battery.

Explain why the diode is needed if the battery is to charge.

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(Total for question = 9 marks)