Question 7 (11 marks)

Students in a Physics practical class investigate the piece of electrical equipment shown in Figure 5. It consists of a single rectangular loop of wire that can be rotated within a uniform magnetic field. The loop has dimensions 0.50 m × 0.25 m and is connected to the output terminals with slip rings. The loop is in a uniform magnetic field of strength 0.40 T.

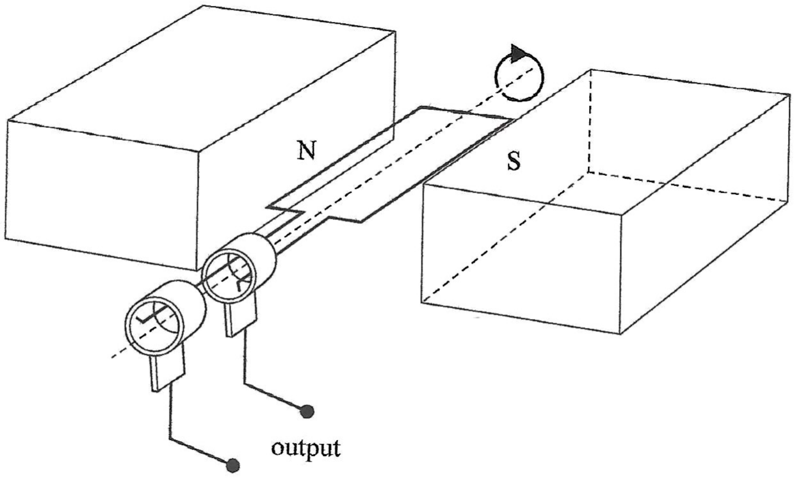


Figure 5

a. Circle the name that best describes the piece of electrical equipment shown in Figure 5. 1 mark 44%

alternator DC generator DC motor AC motor

b. **i.** What is the magnitude of the flux through the loop when it is in the position shown in Figure 5? 1 mark 82%

0	Wb

ii. Explain your answer to **part b.i.** 1 mark 67%

Plane of the loop is parallel to magnetic field or Normal to the loop is at 90° to the field and according to $\Phi = BA\cos\theta$ flux is 0.

Question 3 (6 marks)

Electron microscopes use a high-precision electron velocity selector consisting of an electric field, E, perpendicular to a magnetic field, B.

Electrons travelling at the required velocity, v_0, exit the aperture at point Y, while electrons travelling slower or faster than the required velocity, v_0, hit the aperture plate, as shown in Figure 2.

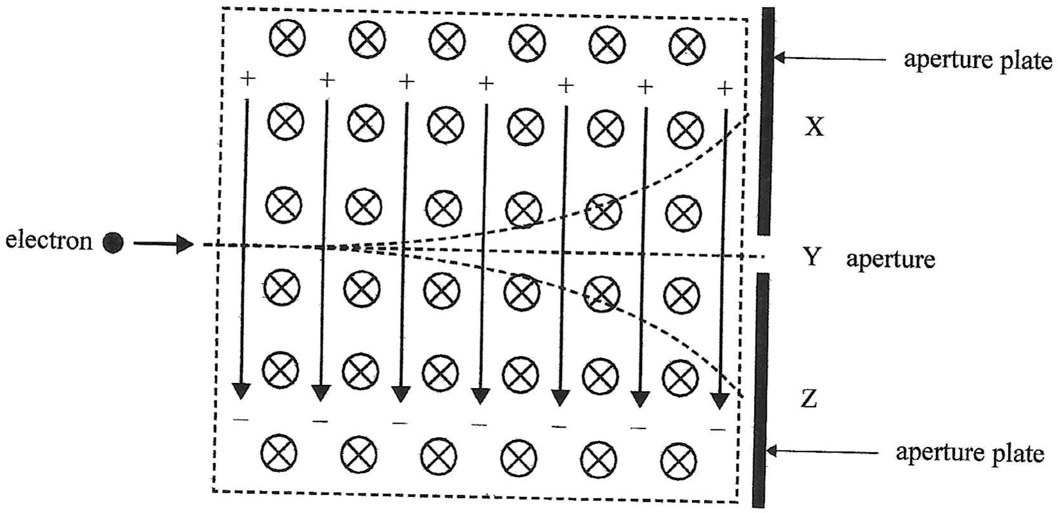


Figure 2

a. Show that the velocity of an electron that travels straight through the aperture to point Y is given by $v_0 = \frac{E}{B}$.

1 mark

46%

$F_{electric} = F_{magnetic}$

$qE = qv_0B$

$v_0 = \frac{E}{B}$

c. **i.** At which of the points – X, Y or Z – in Figure 2 could electrons travelling faster than v_0 arrive? 1 mark

42 %

Z

ii. Explain your answer to **part c.i.**

10 %

2 marks

Increasing v will increase Fmagnetic. (1m)

Felectric remains unchanged so $F_m > F_e$ (1m)

Question 6 (6 marks)

Two Physics students hold a coil of wire in a constant uniform magnetic field, as shown in Figure 5a. The ends of the wire are connected to a sensitive ammeter. The students then change the shape of the coil by pulling each side of the coil in the horizontal direction, as shown in Figure 5b. They notice a current register on the ammeter.

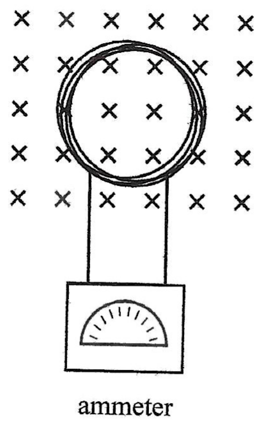


Figure 5a

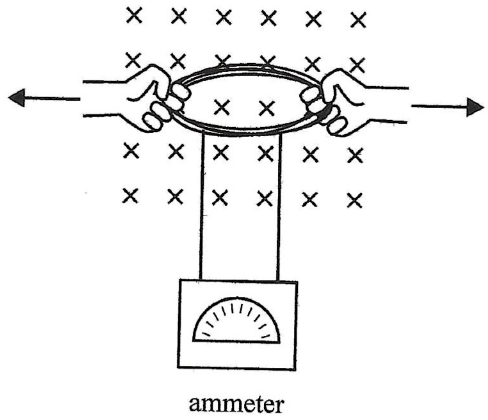


Figure 5b

a. Will the magnetic flux through the coil increase, decrease or stay the same as the students change the shape of the coil?

1 mark

Decrease

Area decrease so flux decrease

61%

b. Explain, using physics principles, why the ammeter registered a current in the coil and determine the direction of the induced current.

3 marks

22%

Flux decreased (1m) so according to Faraday's law current will be induced. Magnetic field is into the page and flux decreased so induced magnetic field is in the page. (1m) Using RHGR current is clockwise. (1m)

c. The students then push each side of the coil together, as shown in Figure 6a, so that the coil returns to its original circular shape, as shown in Figure 6b, and then changes to the shape shown in Figure 6c.

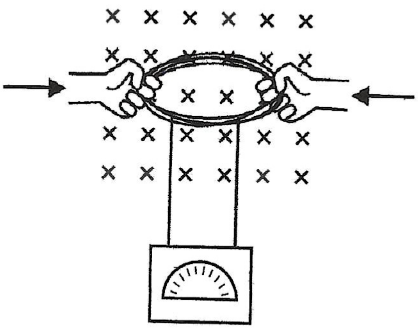


Figure 6a

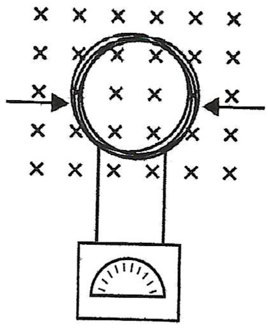


Figure 6b

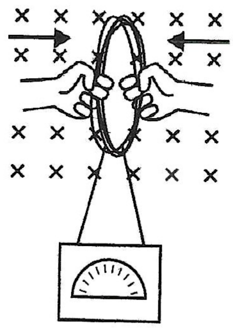


Figure 6c

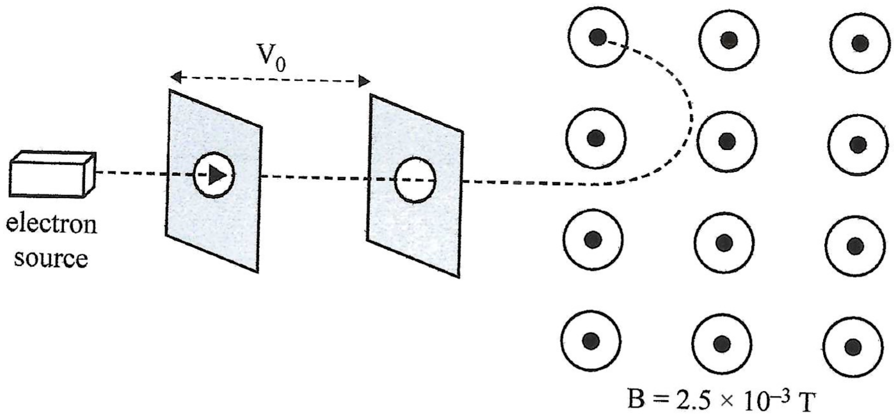
Describe the direction of any induced currents in the coil during these changes. Give your reasoning. 2 marks

Anticlockwise then clockwise (1m) 23%

Flux increases then decreases (1m)

Question 2 (8 marks)

An electron is accelerated from rest by a potential difference of V_0. It emerges at a speed of 2.0×10^7 m s^{-1} into a magnetic field, B, of strength 2.5×10^{-3} T and follows a circular arc, as shown in Figure 2.



b. Explain why the path of the electron in the magnetic field follows a circular arc. 2 marks

Magnetic force acting on electron has constant magnitude and always perpendicular to velocity of electron (1m) (1m)

Question 5 (9 marks)

Figure 5 shows a stationary electron (e^-) in a uniform magnetic field between two parallel plates. The plates are separated by a distance of 6.0×10^{-3} m, and they are connected to a 200 V power supply and a switch. Initially, the plates are uncharged. Assume that gravitational effects on the electron are negligible.

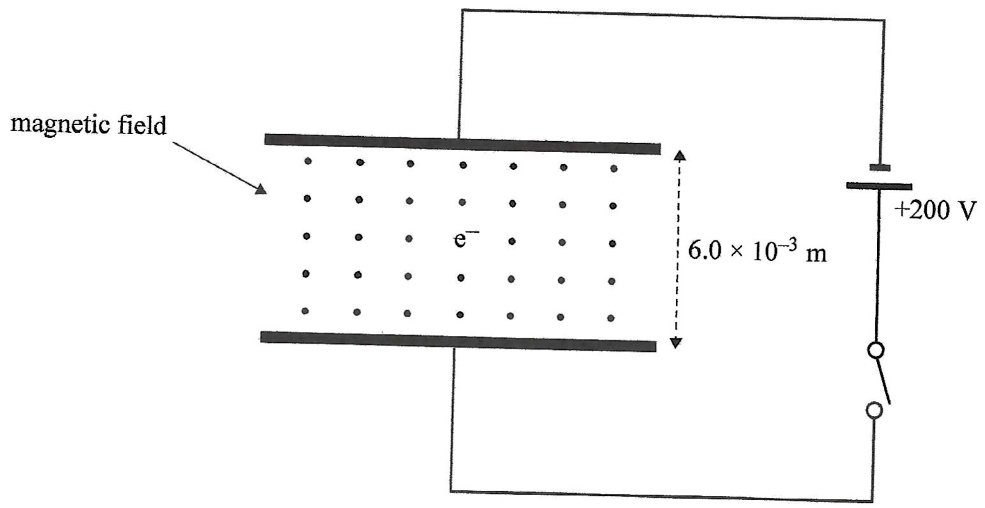


Figure 5

a. Explain why the magnetic field does not exert a force on the electron. Justify your answer with an appropriate formula.

2 marks

Magnetic force $F = qvB$ (1m)

33%

As $v = 0$ force is 0 (1m)

The switch is now closed.

b. Determine the magnitude and the direction of any electric force now acting on the electron. Show your working. 3 marks

$F = qE \quad E = \frac{V}{d}$ 30%

$F = \frac{qV}{d} = \frac{200 \times 1.6 \times 10^{-19}}{6 \times 10^{-3}}$ (1m)

$= 5.3 \times 10^{-15}$ N (1m)

Direction down (1m) as negative electron attracted to positive plate. Electric field is up.

5.3×10^{-15} N	Direction Down

c. Ravi and Mia discuss what they think will happen regarding the size and the direction of the magnetic force on the electron after the switch is closed.

Ravi says that there will be a magnetic force of constant magnitude, but it will be continually changing direction.

Mia says that there will be a constantly increasing magnetic force, but it will always be acting in the same direction.

Evaluate these two statements, giving clear reasons for your answer. 4 marks

Ravi is correct about change of direction, wrong about constant magnitude (1m) 7%

Mia is correct about increasing magnitude, wrong about not changed direction (1m)

Electron is accelerated by electric field so $F = qvB$ will be increasing (1m)

The direction will be changing as it is perpendicular to the velocity (1m)

Question 5 (2 marks)

A bar magnet is moved towards a single closed loop of conducting wire with the bar magnet's south pole closest to the loop, as shown in Figure 3. The loop is stationary.

Figure 3

The area and the shape of the loop remain constant and the magnet is not changed.

Explain, in terms of magnetic flux, how a current is induced in the loop.

Field created by magnet is non-uniform. As magnet moves closer flux through the loop will be increaseng. According to Faraday's law EMF is induced. $\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 m s^{-2}.

Question 1 (5 marks)

Figure 1 shows four positions (1, 2, 3 and 4) of the coil of a single-turn, simple DC motor. The coil is turning in a uniform magnetic field that is parallel to the plane of the coil when the coil is in Position 1, as shown.

When the motor is operating, the coil rotates about the axis through the middle of sides *LM* and *NK* in the direction indicated. The coil is attached to a commutator. Current for the motor is passed to the commutator by brushes that are not shown in Figure 1.

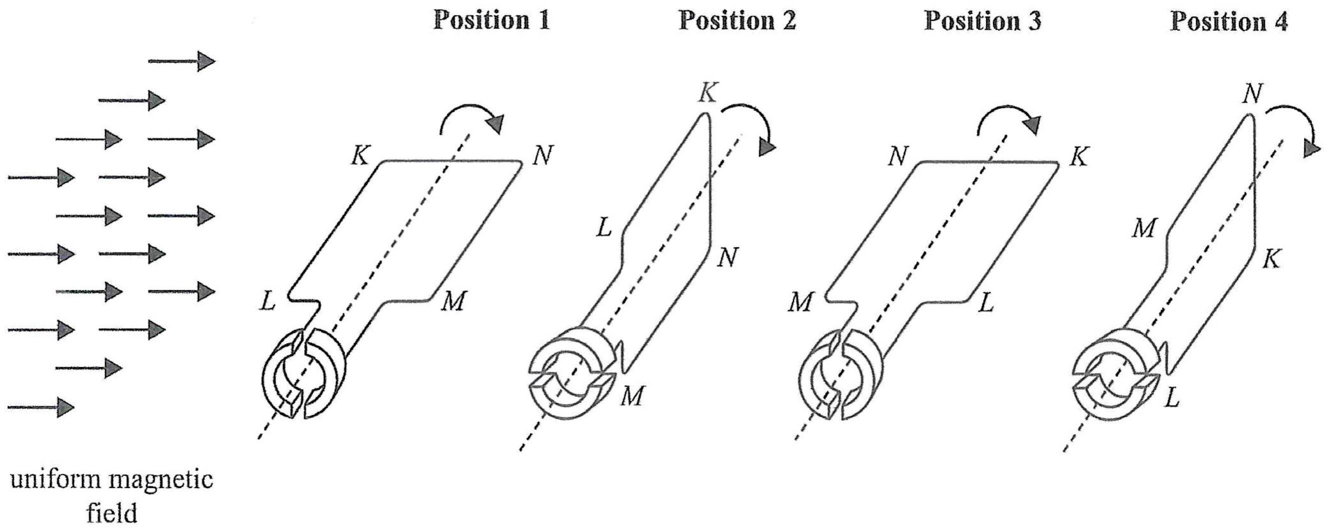


Figure 1

a. When the coil is in Position 1, in which direction is the current flowing in the side *KL* – from *K* to *L* or from *L* to *K*? Justify your answer. 2 marks

49%

Force on KL is up. Using RHSR (1m)
current is from K to L (1m)

Question 4 (6 marks) 7 %

A square loop of wire connected to a resistor, R, is placed close to a long wire carrying a constant current, *I*, in the direction shown in Figure 4.

The square loop is moved three times in the following order:

- Movement A – Starting at Position 1 in Figure 4, the square loop rotates one full rotation at a steady speed about the *x*-axis. The rotation causes the resistor, R, to first move out of the page.
- Movement B – The square loop is then moved at a constant speed, parallel to the current carrying wire, from Position 1 to Position 2 in Figure 4.
- Movement C – The square loop is moved at a constant speed, perpendicular to the current carrying wire, from Position 2 to Position 3 in Figure 4.

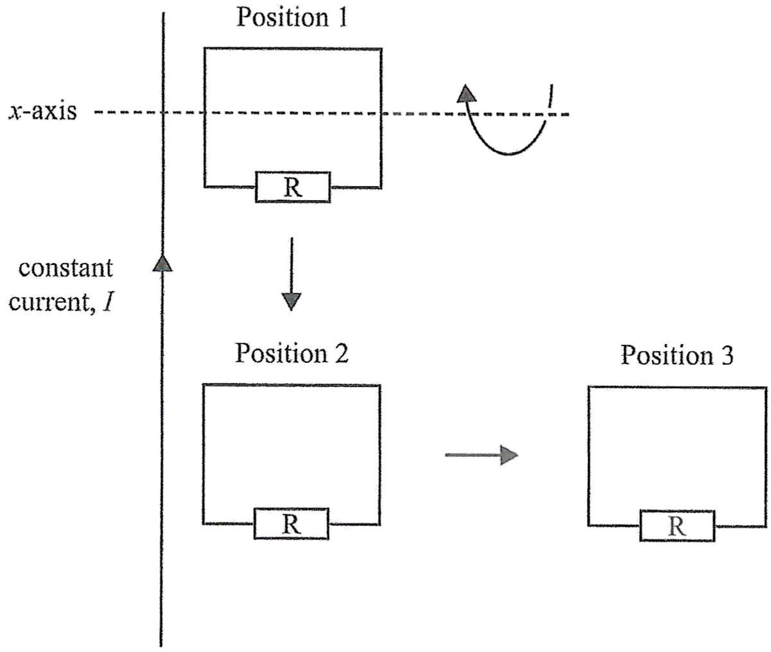
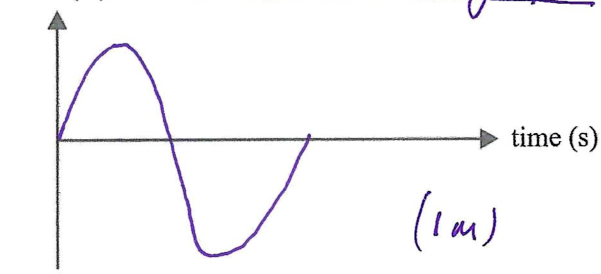


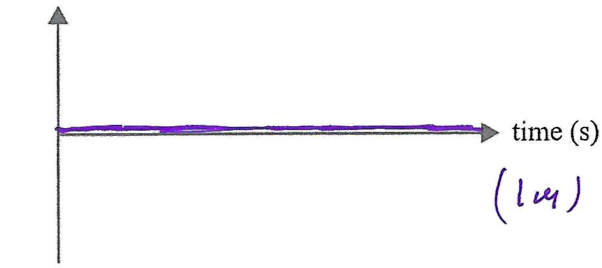
Figure 4

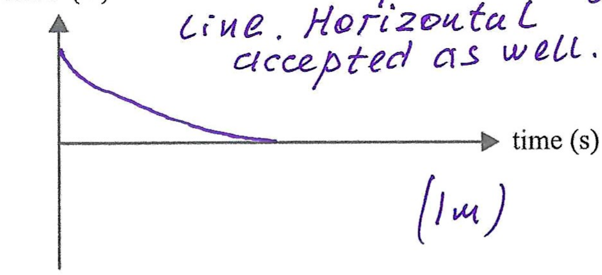
Complete the table below to show the effects of each of the three movements by:

- sketching any EMF generated in the square loop during the motion on the axes provided (scales and values are not required)
- stating whether any induced current in the square loop is 'alternating', 'clockwise', 'anticlockwise' or has 'no current'.

<table>
<tr><th>Movement</th><th>Possible induced EMF</th><th>Direction of any induced current (alternating/clockwise/ anticlockwise/no current)</th></tr>
<tr><td>A

rotation about x-axis</td><td>Must be sin graph

(1m)</td><td>Alternating (1m)</td></tr>
<tr><td>B

moving from Position 1 to Position 2</td><td>
(1m)</td><td>No current
(1m)</td></tr>
<tr><td>C

moving from Position 2 to Position 3</td><td>Can be any decreasing line. Horizontal accepted as well.

(1m)</td><td>Clockwise
(1m)
Need to apply Lenz's law:</td></tr>
</table>

Field into the page (from RHGR) and decreasing. Induced field into the page.
RHGR – current clockwise

Question 2 (3 marks)

A positively charged particle carrying a charge of $+1.5 \times 10^{-8}$ C enters a region between two large, charged plates with opposite charges, as shown in Figure 2.

The potential difference between the plates is 2.0 kV, and the kinetic energy of the charged particle as it enters the hole is 2.8×10^{-5} J. Ignore gravitational effects and air resistance.

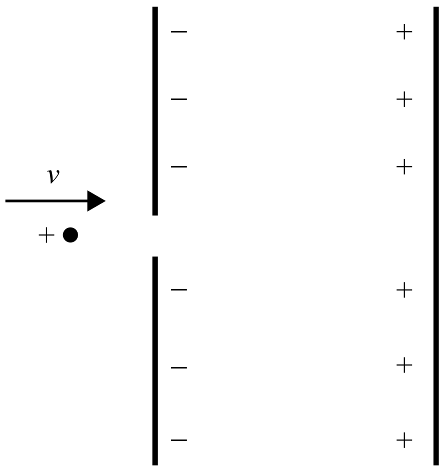


Figure 2

Ariel and Jamie discuss what they think will happen to the particle after it enters the region between the two equally but oppositely charged plates.

Ariel says that the particle has insufficient kinetic energy to reach the positively charged plate and will travel part of the way before returning towards the negatively charged plate.

Evaluate Ariel and Jamie's statements, giving clear reasons for your answer.

$E_K = qV$ when particle stop (1)

$V = \frac{2.8 \times 10^{-5}}{1.5 \times 10^{-8}} = 1.87 \times 10^{3}$ (1)

As $1.87 < 2$ particle will momentarily stop before reaching positive plate and then will move towards negative plate. (1)

Ariel is correct, Jamie is wrong.

Question 3 (3 marks)

Two thin, light aluminium tubes, A and B, are supported in a vertical wooden rack, as shown in Figure 3. Both of the aluminium tubes rest horizontally on wooden pegs.

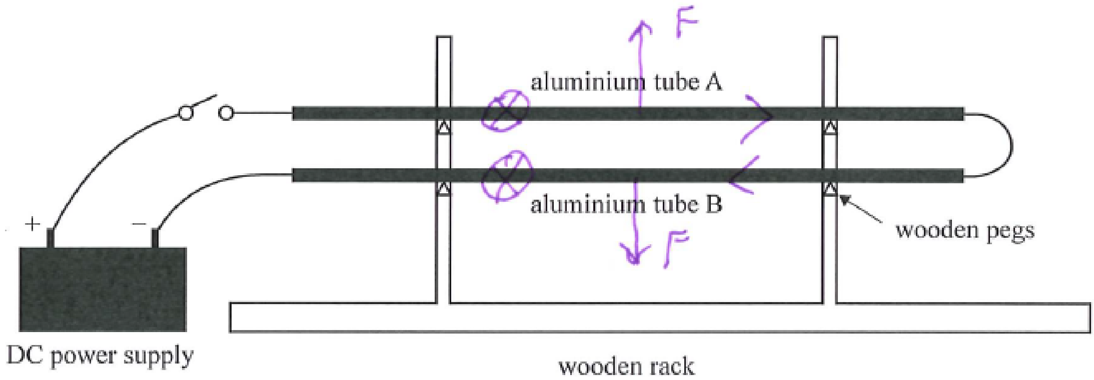


Figure 3

The two thin, light aluminium tubes form a series circuit with a DC power supply. It was observed that one of the tubes jumped upwards when the DC power supply was switched on.

Identify which tube jumped upwards and explain why this occurred.

Aluminium tube | A | (1)

As current in tubes is in the opposite directions, they will repel (1) as magnetic fields are directed into the page so force on A is ↑, on B is ↓ as shown on the picture. (1)

Question 4 (4 marks)

Two electrons, e_1 and e_2, are emitted, one after the other, from point P in a uniform magnetic field, as shown in Figure 4.

Both electrons travel perpendicular to the magnetic field, but in opposite directions. Throughout their journey, both electrons remain within the magnetic field.

Electron e_1 travels at twice the speed of e_2. Relativistic effects can be ignored as both electrons are travelling at low speeds. Electrostatic effects at point P can be ignored as the two electrons are emitted at different times.

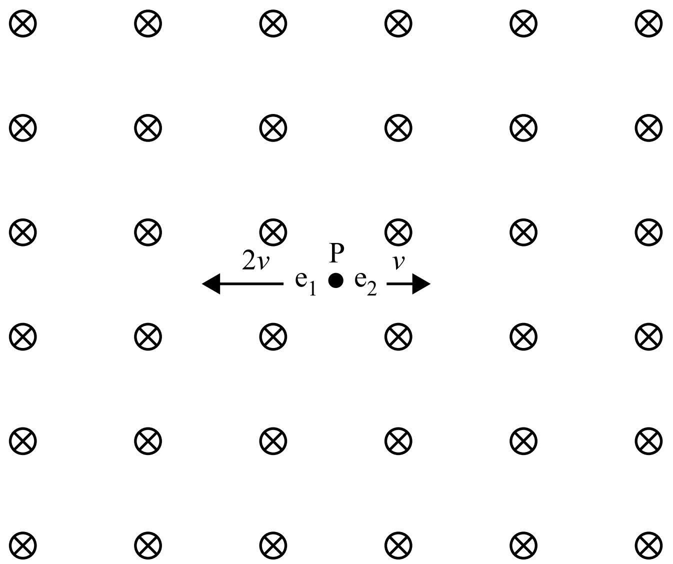


Figure 4

Which one of the following three outcomes occurs?

- Outcome 1 – Electron e_1 returns to point P in the shortest time.
- Outcome 2 – Electron e_2 returns to point P in the shortest time.
- Outcome 3 – Both electrons take the same time to return to point P.

Outcome | 3 | (1)

Explain your answer.

$F = \frac{mv^2}{r} = qvB \quad v = \frac{2\pi r}{T} \quad (1)$

$\frac{mv}{r} = qB \quad \frac{v}{r} = \frac{2\pi}{T}$

$\frac{2\pi m}{T} = qB$

$T = \frac{2\pi m}{qB}$ (1) T is independent of v,

so Outcome 3.

Question 8 (7 marks)

Sarah and Raminda construct a simple alternator, as shown in Figure 8.

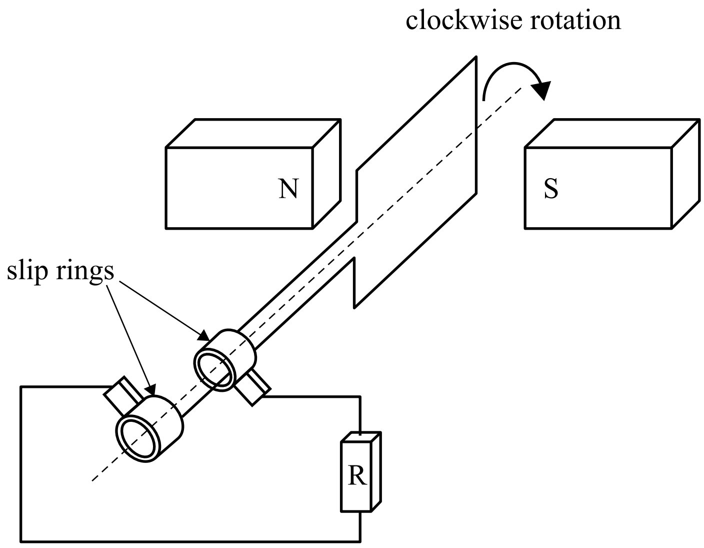


Figure 8

c. To increase the magnitude of the EMF produced by the alternator, Raminda suggests making a number of changes to the alternator.

Sarah insists that each change be investigated one at a time.

In the spaces provided, indicate whether each suggestion will increase, decrease or have no effect on the EMF produced by the alternator. 4 marks

Suggested change	Effect on EMF (increases, decreases or has no effect)
reduce the resistance of resistor R	No effect
increase the strength of the permanent magnets	Increases $\Phi\uparrow, \Delta\Phi\uparrow$
reduce the period of rotation of the coil to 25 ms	Increases $\frac{\Delta\Phi}{\Delta t}\uparrow$
increase the number of turns of the rotating coil	Increases $\varepsilon = n\frac{\Delta\Phi}{\Delta t}$

Question 10 (6 marks)

A single rectangular loop of wire containing a cut out section labelled EF moves to the right at a constant speed of 2.4 m s^{-1}, as shown in Figure 10a. At time $t = 0$, the right-hand edge of the loop enters a constant magnetic field into the page.

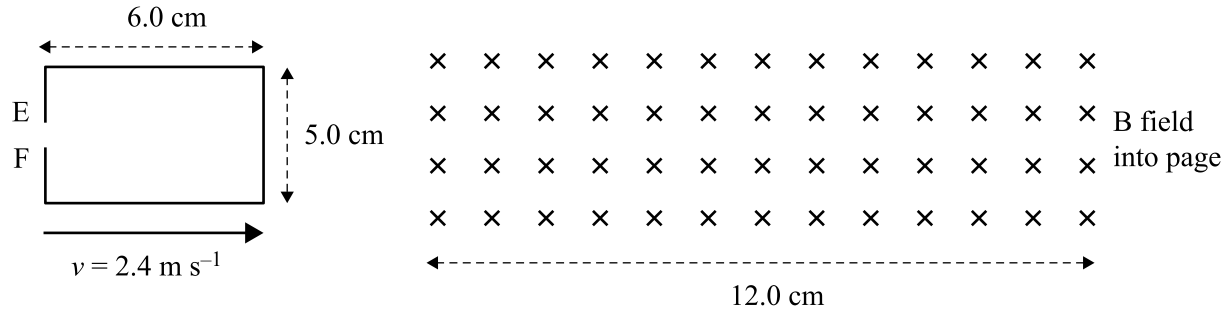


Figure 10a

The induced EMF produced as a function of time is shown in the graph in Figure 10b.

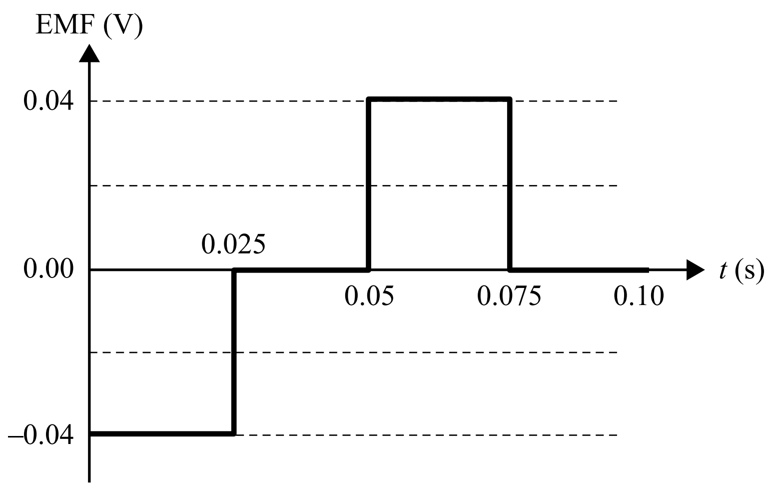


Figure 10b

While the loop enters, and is partially within, the field, an EMF is generated between points E and F.

a. Which point, E or F, is positive? 1 mark

$\boxed{E}$

Magnetic field into the page and flux ↑, so induced field is out of the page. Using RHGR current in the loop from F to E so if it will be connected to outside circuit current will be in the external circuit from E to F. ∴ E "+"

b. Explain why the induced EMF is constant during the time period 0.00 s to 0.025 s. 2 marks

As loop travels at constant speed
rate of change of the flux and so
induced EMF will be constant.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

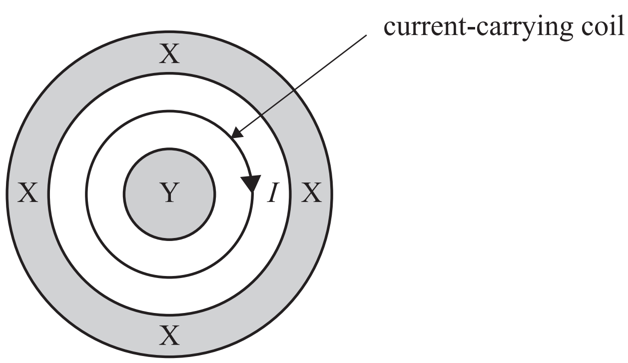
No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Question 1

One type of loudspeaker consists of a current-carrying coil within a radial magnetic field, as shown in the diagram below. X and Y are magnetic poles, and the direction of the current, I, in the coil is clockwise as shown.



The force, F, acting on the current-carrying coil is directed into the page.

Which one of the following statements correctly identifies the magnetic polarities of X and Y?

A. X is a north pole and Y is a south pole.

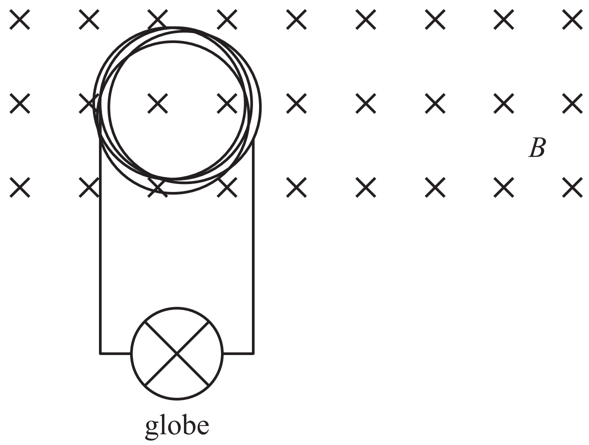
B. X is a south pole and Y is a north pole.

C. Both X and Y are north poles.

D. Both X and Y are south poles.

Use the following information to answer Questions 5 and 6.

The diagram below shows a stationary circular coil of conducting wire connected to a low-resistance globe in a uniform, constant magnetic field, *B*.



Question 5

The magnetic field is switched off.

Which one of the following best describes the globe in the circuit **before** the magnetic field is switched off, **during** the time the magnetic field is being switched off and **after** the magnetic field is switched off?

	Before	During	After
A.	Off	On	Off
B.	On	On	Off
C.	On	Off	Off
D.	Off	On	On

Question 3 (5 marks)

Two long, straight current-carrying wires, P and Q, are parallel, as shown in Figure 2a. The current in the wires is the same in magnitude and opposite in direction.

Figure 2b shows the wires as viewed from above.

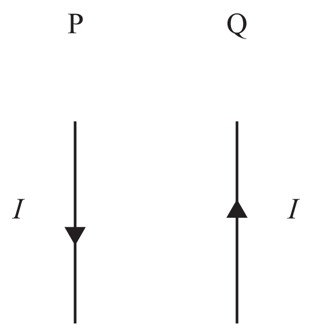


Figure 2a – Front view

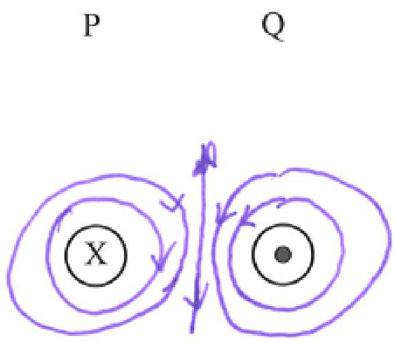


Figure 2b – Top view

a. On Figure 2b, sketch the magnetic field around the wires, showing the direction of the magnetic field. Use at least five field lines. 3 marks

b. Do the two wires, P and Q, attract or repel each other? Explain your reasoning. 2 marks

Repel

Using RHSR

Question 5 (3 marks)

Figure 4a shows a single square loop of conducting wire placed just outside a constant uniform magnetic field, B. The length of each side of the loop is 0.040 m. The magnetic field has a magnitude of 0.30 T and is directed out of the page.

Over a time period of 0.50 s, the loop is moved at a constant speed, v, from completely outside the magnetic field, Figure 4a, to completely inside the magnetic field, Figure 4b.

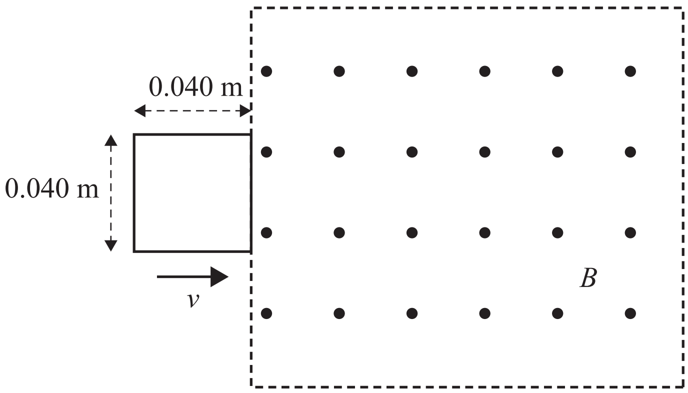


Figure 4a

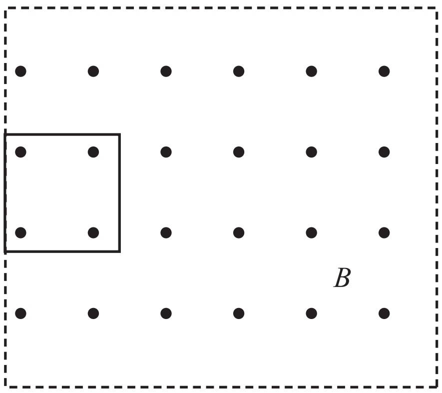


Figure 4b

b. On the small square loop in Figure 5, show the direction of the induced current as the loop moves into the area of the magnetic field. 1 mark

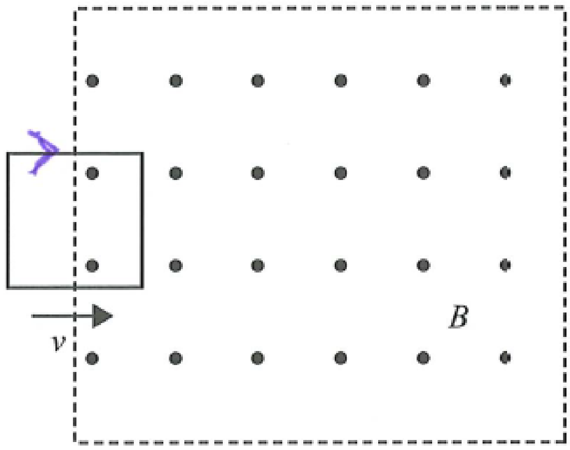


Figure 5

Question 6 (3 marks)

Kim and Charlie are attempting to create a DC generator and have arranged the magnets along the axis of rotation of the wire loop, J, K, L and M, as shown in Figure 6. They are having some trouble getting it to work. They rotate the loop in the direction of the arrow, as shown in Figure 6.

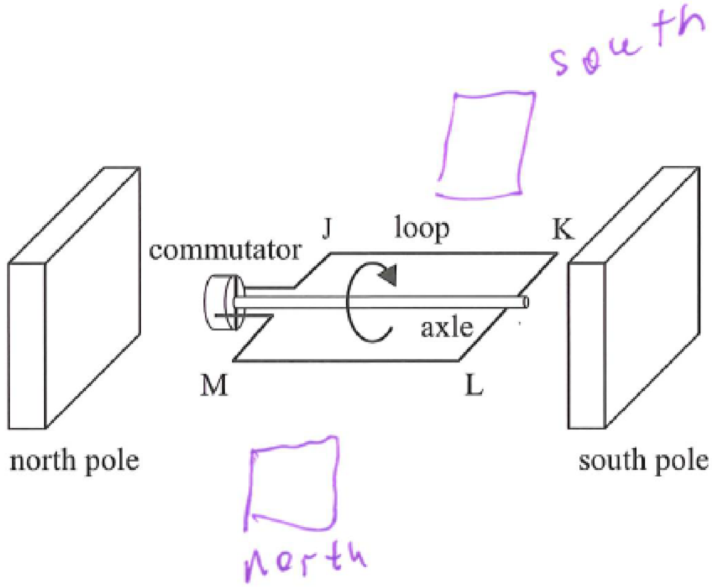


Figure 6

a. Using physics concepts, explain why this orientation of the magnets will not generate an EMF.

$\Phi = 0$ $\Phi = BA\cos\theta$ $\theta = 90^\circ$

No change in flux

b. Kim and Charlie decide to move the magnets so that an EMF is generated. On Figure 6, draw the positions of the magnets to ensure that an EMF is generated. 1 mark