SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.
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 (3 marks)

A particle of mass m and charge q travelling at velocity v enters a uniform magnetic field B, as shown in Figure 1.

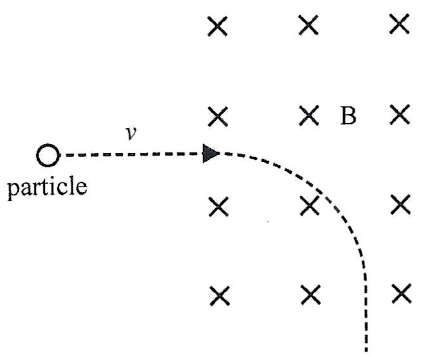


Figure 1

a. Is the charge q positive or negative? Give a reason for your answer. 1 mark

44%

Negative

Magnetic field into the page, force down so according to RHSR charge is negative

b. Explain why the path of the particle is an arc of a circle while the particle is in the magnetic field. 2 marks

10%

Force acting on the charge is constant in magnitude and always perpendicular to velocity which results in circular motion.

Question 6 (7 marks)

A home owner on a large property creates a backyard entertainment area. The entertainment area has a low-voltage lighting system. To operate correctly, the lighting system requires a voltage of 12 V_{RMS}. The lighting system has a resistance of 12 Ω.

a. Calculate the power drawn by the lighting system. 1 mark

84%

$P = \frac{V^2}{R} = \frac{12^2}{12} = 12$

12 W

To operate the lighting system, the home owner installs an ideal transformer at the house to reduce the voltage from 240 V_{RMS} to 12 V_{RMS}. The home owner then runs a 200 m long heavy-duty outdoor extension lead, which has a total resistance of 3 Ω, from the transformer to the entertainment area.

b. The lights are a little dimmer than expected in the entertainment area.

Give **one** possible reason for this and support your answer with calculations. 4 marks

5%

Voltage delivered to the lighting system is less than 12V as there will be voltage drop across the lead. $R_{total} = 12 + 3 = 15\Omega$

$I = \frac{V}{R_t} = \frac{12}{15} = 0.8 A$

$V_{Lead} = IR = 0.8 \times 3 = 2.4 V$

$V_{Light} = 12 - 2.4 = 9.6 V$

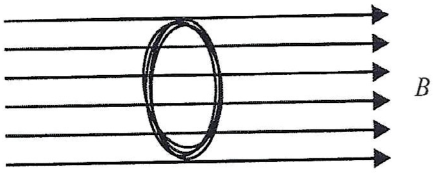
c. Using the same equipment, what changes could the home owner make to improve the brightness of the lights? Explain your answer. 2 marks

20%

Move transformer to the lights end of the lead. This will reduce current in the lead and so less power will be lost.

Question 5 53%

A coil consisting of 20 loops with an area of 10 cm^2 is placed in a uniform magnetic field B of strength 0.03 T so that the plane of the coil is perpendicular to the field direction, as shown in the diagram below.



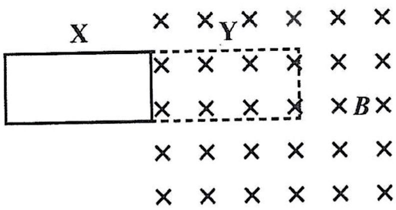
The magnetic flux through the coil is closest to

A. 0 Wb
(B.) 3.0×10^{-5} Wb
C. 6.0×10^{-4} Wb
D. 3.0×10^{-1} Wb

$\Phi = BA = 0.03 \times 10 \times 10^{-4}$

Question 6 89%

A single loop of wire moves into a uniform magnetic field B of strength 3.5×10^{-4} T over time $t = 0.20$ s from point X to point Y, as shown in the diagram below. The area A of the loop is 0.05 m^2.



The magnitude of the average induced EMF in the loop is closest to

A. 0 V
B. 3.5×10^{-6} V
(C.) 8.8×10^{-5} V
D. 8.8×10^{3} V

Question 7 16%

An ideal transformer has an input DC voltage of 240 V, 2000 turns in the primary coil and 80 turns in the secondary coil.

The output voltage is closest to

(A.) 0 V
B. 9.6 V
C. 6.0×10^{3} V
D. 3.8×10^{7} V

Transformer does not work with DC current.

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.

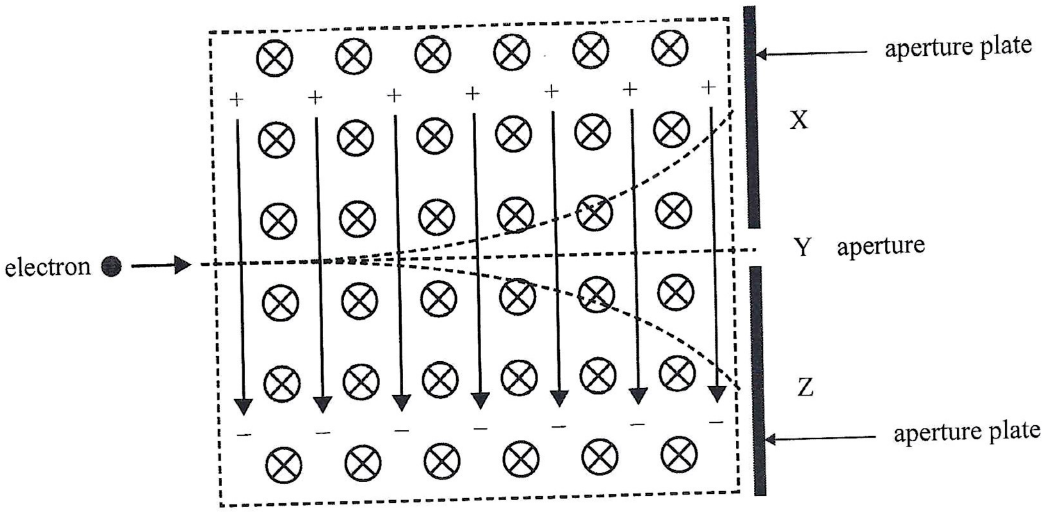


Figure 2

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%

$qE = qV_0B$

$V_0 = \frac{E}{B}$

b. Calculate the magnitude of the velocity, v_0, of an electron that travels straight through the aperture to point Y if E = 500 kV m^{-1} and B = 0.25 T. Show your working. 2 marks

75%

$V_0 = \frac{E}{B}$

$V_0 = \frac{500 \times 10^3}{0.25} = 2 \times 10^6$

2.0×10^6 m s^{-1}

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.** 2 marks

10 %

F_E remains unchanged

As $v \uparrow$ F_B increases so $F_B > F_E$

Question 5 (9 marks)

A rectangular wire loop with dimensions 0.050 m × 0.035 m is placed between two magnets that create a uniform magnetic field of strength 0.2 mT. The loop is rotated with a frequency of 50 Hz in the direction shown in Figure 4. The ends of the loop are connected to a split-ring commutator to create a DC generator. The loop is initially in the position shown in Figure 4.

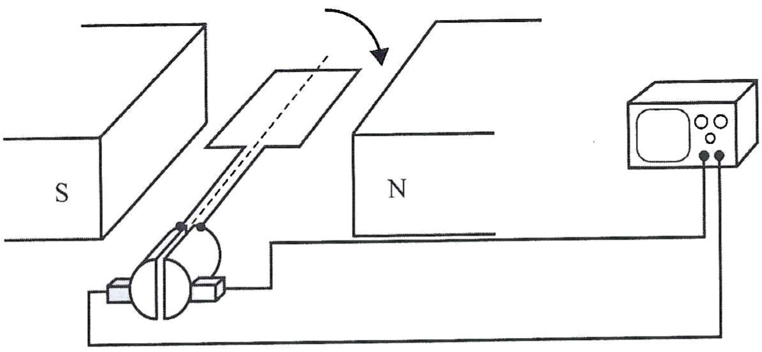


Figure 4

a. In which direction – clockwise or anticlockwise – will the induced current travel through the loop for the first quarter turn as seen from above? 1 mark

34%

Anticlockwise

B ← and Φ increases, so induced B → and due to RHGR anticlockwise

b. Calculate the average EMF measured in the loop for the first quarter turn. 3 marks

51%

$\mathcal{E} = -N \frac{\Delta\Phi}{t}$ $t = \frac{1/50}{4} = 0.005$

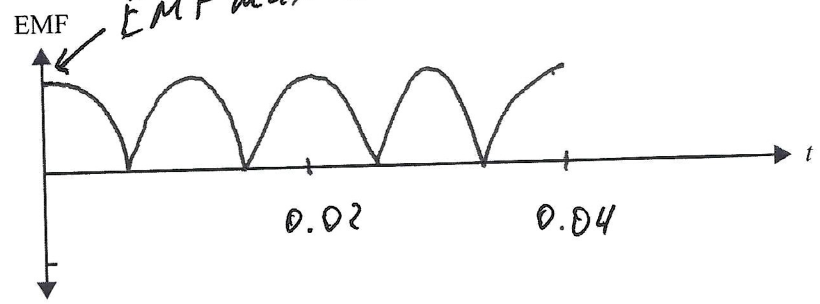
$\mathcal{E} = -1 \times \frac{0.2 \times 10^{-3} \times 0.05 \times 0.035}{0.005} = 7 \times 10^{-5}$ V

7×10^{-5} V

c. On the axes provided below, sketch the output EMF versus time, *t*, for the first two rotations. Include a scale on the horizontal axis. 3 marks

7%

EMF max when $\Phi = 0$



d. Suggest **two** modifications that could be made to the apparatus shown in Figure 4 that would increase the output EMF of the DC generator. 2 marks

79%

2 out of: - increase field strength
- increase number of turns
- increase the area of coil
- increase rotation rate or decrease period of rotation

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.

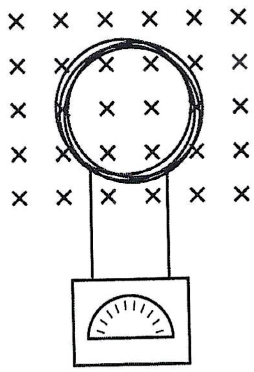


Figure 5a

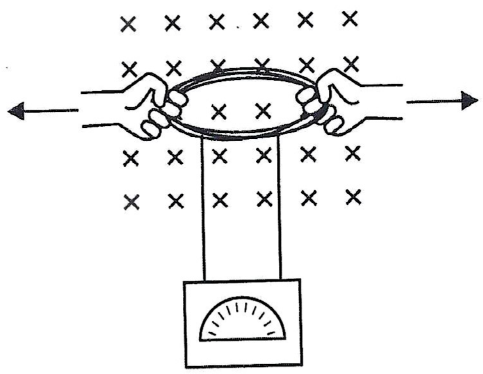


Figure 5b

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

61%

Decrease

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%

As area ↓, Φ changed and so current is induced. Φ is into the page and decreasing so induced B is into the page. Using RHGR current is clockwise

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.

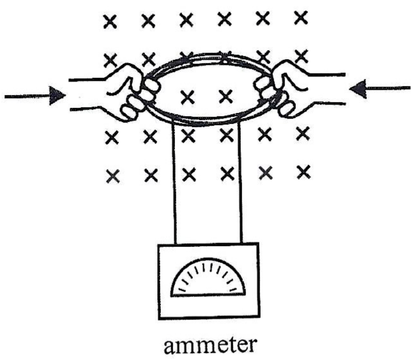


Figure 6a

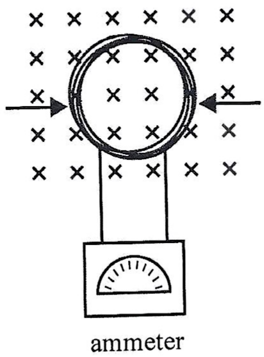


Figure 6b

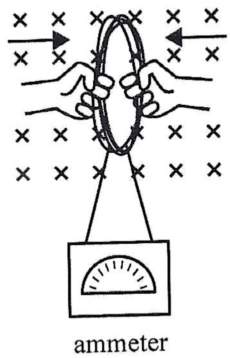


Figure 6c

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

23%

Area ↑ then ↓, so Φ ↑ then ↓ so
current anticlockwise then clockwise