NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Physics 2025

91173 Demonstrate understanding of electricity and electromagnetism

Credits: Six

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of electricity and electromagnetism.	Demonstrate in-depth understanding of electricity and electromagnetism.	Demonstrate comprehensive understanding of electricity and electromagnetism.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Sheet L2–PHYSR.

In your answers use clear numerical working, words, and / or diagrams as required.

Numerical answers should be given with an appropriate SI unit.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in the margins (▨). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.
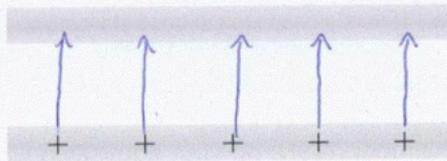
Merit   TOTAL   **16**

QUESTION ONE: ELECTRIC FIELDS

Inkjet printers use a voltage across parallel plates to aim electrically charged ink droplets at the paper. The plates are 1.00 mm apart.

(a) Draw the field lines between the electric plates and the charge of the top plate.

> If you need to redraw your response, use the diagram on page 11.

(b) Calculate the voltage across the plates when an ink droplet with a charge of 4.80×10^{-10} C is subjected to a force of 9.60×10^{-4} N.

$$F = E q$$
$$E = \frac{F}{q}$$
$$= \frac{960 \times 10^{-4}}{9.80 \times 10^{-10}}$$
$$= 2000000$$
$$= 2 \times 10^{6} \text{ T}$$

$$E = \frac{V}{d}$$
$$V = E d$$
$$= 2 \times 10^{6} \times 1 \times 10^{-3}$$
$$= 2000 \text{ V}$$

(c) The voltage across the plates is changed to 4000 V.

An ink droplet of mass 1.02×10^{-11} kg, carrying 4.00×10^9 excess electrons is released from the negative plate.

Calculate its velocity as it reaches the positive plate.

$$\Delta E_p = E_k \qquad = 4.00 \times 10^9 \times 1.60 \times 10^{-19}$$
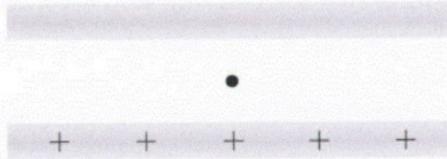$$= 6.4 \times 10^{-10} \, C$$

$$E_p = Eqd \qquad \qquad E = \frac{V}{d}$$
$$= 4.0 \times 10^6 \times 6.4 \times 10^{-10} \times 1 \times 10^{-3} = \frac{4000}{1 \times 10^{-3}}$$
$$= 2.56 \times 10^{-6} \, J \qquad \qquad = 4.0 \times 10^6 \, Vm^{-1}$$

$$E_k = \frac{1}{2}mv^2$$
$$v = \sqrt{\frac{E_k}{\frac{1}{2}m}}$$
$$= \sqrt{\frac{2.56 \times 10^{-6}}{\frac{1}{2} \times 1.02 \times 10^{-11}}}$$
$$= 708.49 \, ms^{-1}$$

(d)   A charged ink droplet is held stationary between the two charged parallel plates.


Discuss how it is possible for the ink droplet to be stationary between the plates.

In your answer:

- identify the forces on the ink droplet and their directions
- describe how the forces combine to keep the ink droplet stationary
- explain what type of charge the ink droplet must have to remain stationary.

The forces on the ink droplet are the electric field lines. The charge of the ink droplet must be nutral as both positive and negative hold it in place making it stationary.
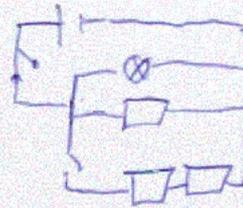
QUESTION TWO: CIRCUITS

An air fryer consists of a heating element, two fans, and a lamp.

In the diagram below, the heating element is represented by a rheostat, and the two identical fans are represented by the resistors.

240 V

A

1000 Ω

B

480 Ω   480 Ω
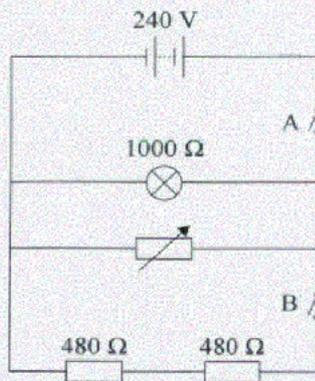
Initially switch A is closed and switch B is open, so the element and lamp are on, and the fans off.

(a) Calculate the current in the lamp.

$$V = IR$$

$$\frac{V}{R} = I$$

$$\frac{240}{1000} = 0.24\ A$$

(b) Use physics principles to explain what adjustment would need to be made to the rheostat's resistance to increase the power output of the element.

The rheostats resistance would have to be as low as possible as current looks for the path of least resistance meaning more power would go to the element as there is more current.

(c)   Both switches are now closed and the heating element set so that it produces 1800 W.
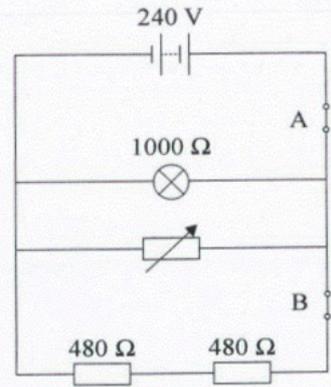
240 V

(i)   Show the resistance of the element is 32 Ω.

A

1000 Ω

B

480 Ω   480 Ω

$$V = IR$$

voltage stays the same

$$\frac{U}{I} = R$$

$$\frac{240}{7.5} = 32$$

$$\frac{P}{V} = I \quad \frac{1800}{240} = 7.5A$$

$$P = IV$$

$$32 \, \Omega$$

(ii)   Calculate how many coulombs of charge are produced by the power supply in 5 minutes.

$$R_t = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{1000} + \frac{1}{32} + \frac{1}{480 + 480}$$

$$\frac{1}{R_t} = 0.0333$$

$$R_t = \frac{1}{0.0333}$$

$$= 30 \, \Omega$$

$$V = IR$$

$$\frac{V}{R} = I$$

$$\frac{240}{30} = 8A$$

$$I = \frac{q}{t}$$

$$It = q$$

$$8 \times 300 = 2400C$$

(d)   One day, the lamp stops working.

Use physics principles to explain what effect the lamp not working would have on the current in the circuit and the power output of the element.

Effect on current in the circuit: With the lamp gone the overall resistance of the ~~to~~ circut will rise. This means that the current will be lower.

Effect on power output of the element: With a lower current the then there will be lower power to the heating element.

QUESTION THREE: MAGNETS

A current-carrying wire is placed between the poles of a horseshoe magnet so that the current crosses the magnetic field at right angles. This creates a force on the wire in the direction shown.

Force

A ⊗ B

Wire carrying current
into the page
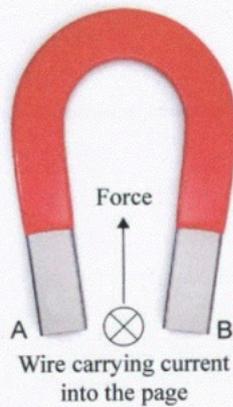
(a) Which of the poles labelled A and B in the diagram above is the north pole?

A is the north pole

(b) The diagram shows the main features of an electric motor with 40 turns of wire in the coil. The arrow on the diagram shows the 15 N of force acting on the whole side AB when a current flows in the coil.

(i) In which direction is the current flowing in the coil?

The current is flowing from ~~B to A~~
B to A

(ii) State the size and direction of the force on:

side CD ~~From D to B~~ down into the pause
lots of force

side BC ~~up out of the pause~~. no force
at all

(iii) Use physics principles to explain the differences in the forces in part (ii).

as BC runs parallel to the ^magnetic field
there are no forces acting on it.
as CD is perpendicular to the field
lines and is able to cut through them
a strong force acts on the wire.

(c)   The magnetic field strength is 1.7 T. The length of AB is 50 cm.

Calculate the current in one strand of wire on side AB.

$F = BN$ $F = BIL$

$B = 1.7 T$ $\dfrac{F}{BL} = I$

$d = 0.5 cm$

$\dfrac{15}{1.7 \times 0.5} = 17.65 A$

(d)   By removing the voltage source, the motor is turned into a generator.

(i)   Calculate the speed with which the side AB must be moving to generate a maximum of 12 volts in the entire coil of 40 turns of wire.

$V = BvL$

$\dfrac{V}{BL} = V$

$\dfrac{12}{1.7 \times (0.5 \times 40)} = 0.35 \, ms^{-1}$

(ii) Use physics principles to explain what position side AB needs to be in to produce the maximum voltage.

Side AB must be perpendicular to the magnetic field which will produce the maximum amount of voltage.

SPARE DIAGRAM

If you need to redraw your response to Question One (a), use the diagram below. Make sure it is clear which answer you want marked.
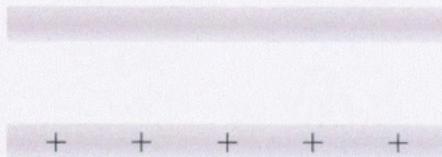
Merit

Subject: L2 Physics

Standard: 91173

Total score: 16

Q	Grade score	Marker commentary
One	M6	Calculations are done efficiently, showing Merit level understanding. However, the explanation in (d) fails to address any of the required bullet points.
Two	M5	The calculations are carried out to a merit level. However, in the explanations in (b) and (d), the candidate has not linked the answers to the fixed circuit voltage.
Three	A4	The candidate has made a common mistake and misidentified the north pole. In (b)(ii), the candidate has not stated the size of the force as required.