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Draw a cross through the box (☒) if you have NOT written in this booklet

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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.

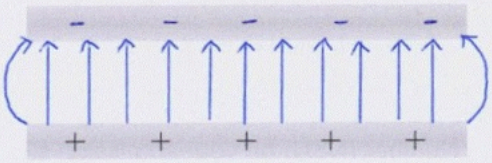
Achievement TOTAL 11

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. d

Adapted from: https://pressbooks.online.ucf.edu/osuniversityphysics2/chapter/applications-of-electrostatics/

(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.

V q

(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

$$E = \frac{F}{q}$$
$$= \frac{9.60 \times 10^{-4}}{4.80 \times 10^{-10}}$$
$$= 2.0 \times 10^{6}$$

$$V = E \times d$$
$$= (2.0 \times 10^{6}) \times 0.001$$
$$= 2000 \text{ V}$$

(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.

$\Delta E_p = Eqd$

$= (1.6 \times 10^{13})(4.00 \times 10^{9})(0.001)$

$= 6.4 \times 10^{19}$

$\Delta E = V \times q$

$= (4000)(4.00 \times 10^{9})$

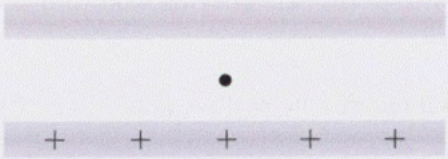
$= 1.6 \times 10^{13}$

$v = \sqrt{\frac{2(E)}{m}}$

$= \sqrt{\frac{2(6.4 \times 10^{19})}{1.02 \times 10^{-11}}}$

$= 3.54 \text{ ms}^{-1}$

(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.

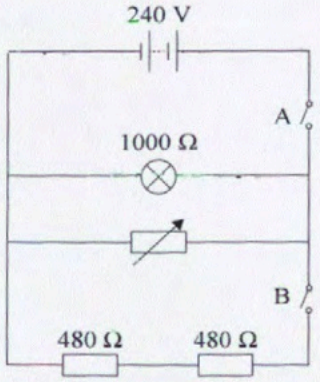
In your answer:

- 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.

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.



Source: https://instantpot.com/products/instant-vortex-5-7-quart-air-fryer

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.

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

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

$= \left(\frac{31}{6000}\right)^{-1}$

$= 194\ \Omega$

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

$= \frac{240}{194}$

$= 1.24$ A

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

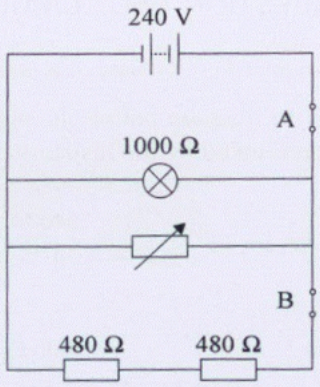
$= \frac{240}{1000}$

$= 0.24$ 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 resistance must decrease according to $V = IR$ for both the voltage and current to increase therefore affecting $P = IV$. With both of these increasing, the Power increases.

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



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

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

$= \frac{1800}{240}$

$= 7.5$ A

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

$= \frac{240}{7.5}$

$= 32\ \Omega$

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

~~charge of an electron = 1.60 × 10^-19~~

~~I = V/R~~

$R_T = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

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

$= \left(\frac{31}{6000}\right)^{-1}$

$= 194\ \Omega$

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

$= \frac{240}{194}$

$= 1.2$ A

$q = I \times t$

$= 1.2 \times 5$

$= 6$ C

(d) One day, the lamp stops working.

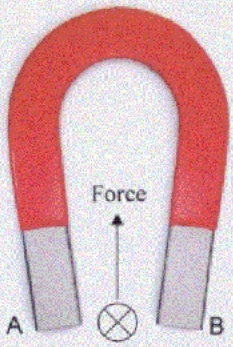
Use physics principles to explain what effect the lamp not working would have on the current in the circuit and the power output of the element.

Effect on current in the circuit:

Effect on power output of the 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.



Wire carrying current into the page

(a) Which of the poles labelled A and B in the diagram above is the north pole?

A

(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.

F

Adapted from: https://pmt.physicsandmathstutor.com/download/Physics/GCSE/Topic-Qs/OCR-B/3-Electric-Circuits/Set-A/P3.6%20How%20do%20electric%20motors%20work%20%28H%20only%29.pdf

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

north to south

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

side CD

side BC

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

Question Three continues on the next page.

B L

(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.

$I = \frac{F}{B \times L}$

$= \frac{15}{(1.7)(0.05)}$

$= 176.5$ 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.

$0.05 \times 40 = 2$ m

$v = \frac{V}{B \times L}$

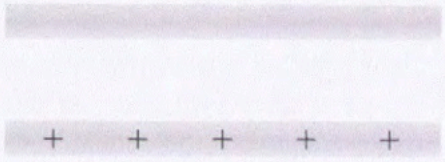
$= \frac{12}{(1.7)(2)}$

$= 3.5\ ms^{-1}$

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



Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

~~14~~ / 17 / 19

km	1000	
m	1	
cm	/10	0.01
mm	/100	0.001

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Achievement

Subject: L2 Physics

Standard: 91173

Total score: 11

Q	Grade score	Marker commentary
One	A4	This response is clearly at the Achievement level of demonstrating an understanding of electricity. The candidate is able to perform straightforward calculations in (b), and has incorrectly used the number of electrons as the charge in (c). The candidate did not attempt (d).
Two	A4	The straightforward answers to (a) and the first part of (c), together with a superficial understanding of parallel circuits, illustrate a clear example of an Achievement level response.
Three	A3	This response shows an Achievement level understanding by selecting and using the appropriate formula for (c) and (d). The explained responses to this question are incomplete and do not address the questions asked.