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91173



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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.

Excellence

TOTAL 24

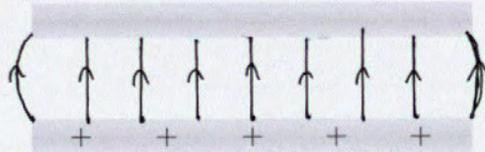
QUESTION ONE: ELECTRIC FIELDS

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



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.

- (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.

~~Handwritten scribbles~~

$$F = Eq$$

$$F = \frac{V}{d} q$$

$$V = \frac{Fd}{q}$$

~~Handwritten scribbles~~

$$V = \frac{9.6 \times 10^{-4} \times 0.001}{4.8 \times 10^{-10}}$$

$$V = 2000 \text{ V}$$

- (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.

$$E = \frac{4000}{.001} \quad q = 4 \times 10^9 \times 1.6 \times 10^{-19}$$

$$E = 4 \times 10^6 \text{ Vm}^{-1} \quad q = 6.4 \times 10^{-10}$$

$$E_p = E_k$$

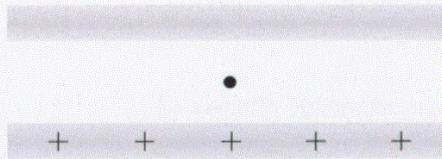
$$Eqd = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2Eqd}{m}}$$

$$v = \sqrt{\frac{2 \times 4 \times 10^6 \times 6.4 \times 10^{-10} \times .001}{1.02 \times 10^{-11}}}$$

$$v = 108 \text{ m s}^{-1} \text{ (3sf)}$$

- (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:

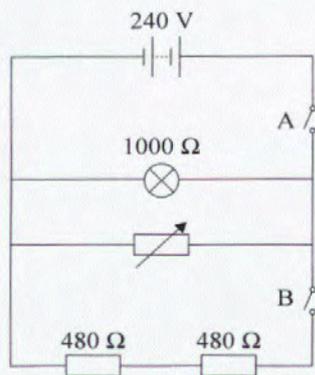
- identify the forces on the ink droplet and their directions
- describe how the forces combine to keep the ink droplet stationary
- explain what type of charge the ink droplet must have to remain stationary.

The ~~electron~~^{ink drop} is experiencing a force downwards due to gravity, and an equal force upwards due to electrostatic forces. The downwards force due to gravity and the upwards electrostatic force ~~is~~^{are} cancelled out, leaving the ink droplet stationary, as the net force acting upon it equals 0. The ink droplet must have a positive charge in this case, as it needs to experience a force ~~away from~~ upwards, which is away from the positive plate and towards the negative plate, to remain stationary, hence positive charge.

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.

~~$V = IR$ Assuming that the rheostat's resistance is equal to the resistance of the lamp~~

~~$240 = I \times 1000$~~

~~$240 = I \times 1000$~~ $240 = I \times 1000$ $V = IR$

~~$I = .24 A$~~ $I = .24 A$

- (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.

To increase the power output of the element, you could decrease the resistance of the rheostat, as the voltage supplied to it is constant, so as $P = \frac{V^2}{R}$, as R decreases the power output of the element would increase. The voltage supplied is 240V, $P = \frac{57600}{R}$ or $P = \frac{57600}{\frac{1}{2}R} = 2 \frac{57600}{R}$ hence less resistance means a higher power output.

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

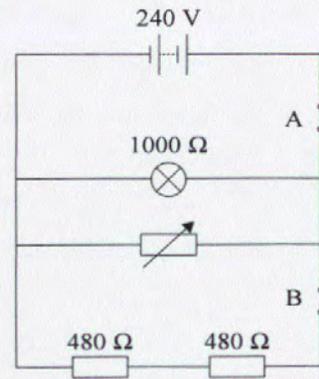
- (i) Show the resistance of the element is 32Ω .

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

$$1800 = \frac{51600}{R}$$

$$R = \frac{51600}{1800}$$

$$R = 32 \Omega$$



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

~~RAM~~

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

$$V = IR$$

$$R_{\text{Total}} = \left(\frac{1}{1000} + \frac{1}{32} + \frac{1}{960} \right)^{-1}$$

$$R_{\text{Total}} = 30.0 \Omega \text{ (3sf)}$$

$$I = \frac{240}{30.0}$$

$$I = 7.99 \text{ A}$$

$$7.99 \times 60 \times 5 = q$$

$$q = 2397 \text{ C}$$

- (d) One day, the lamp stops working.

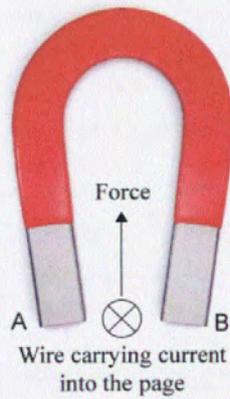
Use physics principles to explain what effect the lamp not working would have on the current in the circuit and the power output of the element.

Effect on current in the circuit: The lamp not working would increase the total resistance of the circuit. As the circuit voltage is ~~not~~ constant, an increased current resistance results in a lower current in the circuit. (If the lamp breaks the $240 = I \times (\frac{1}{32} + \frac{1}{960})^{-1}$ } current can no longer flow down that ~~branch~~ ^{branch})
 $I = 7.75 \text{ A}$

Effect on power output of the element: $P = IV$, ~~or~~ $P = \frac{V^2}{R}$ $P = \frac{51600}{32}$
 $P = 1800 \text{ W}$. As the voltage supplied to the element remains constant, (as it is a parallel circuit) and the resistance of the element is unchanged, the power output of the element will remain unchanged at 1800W.

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.



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

B 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.



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?

From the positive to the negative (in conventional current)
 So $D \rightarrow C \rightarrow B \rightarrow A$
 or ~~anticlockwise~~ clockwise

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

side CD Downwards at 15N

side BC No force

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

Side CD the current is cutting perpendicular to the magnetic field. The ~~wire~~ current carrying wire generates a magnetic field, which creates areas of stronger and weaker magnetic field, with the stronger side being ~~to~~ above the wire, and the weaker side below.
 Side BC the current carrying wire is parallel with the magnetic field lines, hence it does not create a magnetic field, and ^{so it} experiences no force.

Question Three continues
on the next page.

- (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.

$$B = 1.7 \text{ T}$$

$$L = \cancel{50 \text{ cm}} 20 \text{ m}$$

$$F = 15 \text{ N up}$$

$$F = BIL$$

$$I = \frac{F}{BL}$$

$$I = \frac{15}{1.7 \times 20}$$

$$I = .44 \text{ A (3sf)}$$

- (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.

$$V = BvL \quad L = 1 \times 40 = 40 \text{ m}$$

$$v = \frac{V}{BL}$$

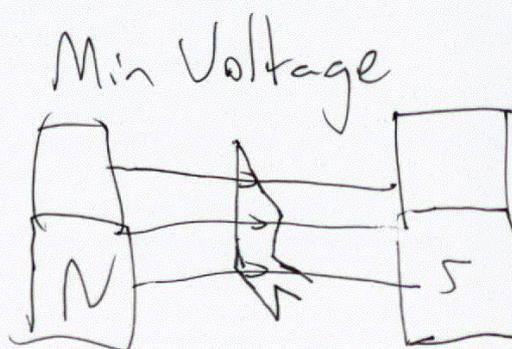
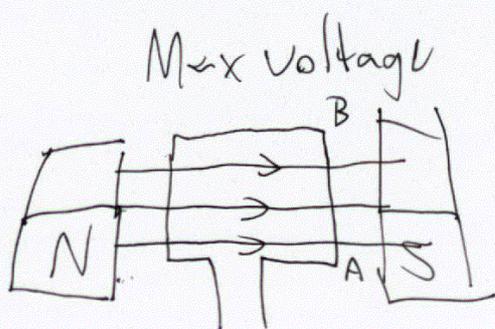
$$v = \frac{12}{1.7 \times 40}$$

$$v = .176 \text{ m s}^{-1}$$

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

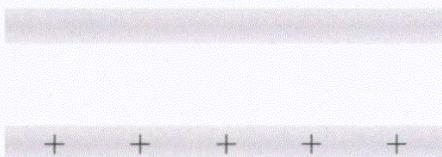
Side AB needs to be in its current position to generate its maximum voltage. The maximum voltage is produced when side AB is perpendicular to the magnetic field, as shown in the diagram.

When the wire is not perpendicular to the magnetic field, the induced voltage is given by $V = BvL \sin \theta$, with θ being the angle from the normal and the coil. When the wire is perpendicular, $\theta = 90^\circ$, and the maximum voltage is induced, and when the wire has completed a quarter turn, pictured below, $\theta = 0$, hence ~~no~~ voltage induced is 0, and is the position that produces the minimum 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.



Excellence

Subject: L2 Physics

Standard: 91173

Total score: 24

Q	Grade score	Marker commentary
One	E8	This is a well organised response exemplifying understanding at the Excellence level. It is very logically written, with no extraneous material and exhibits clear comprehension.
Two	E8	This response demonstrates comprehensive understanding of parallel circuits.
Three	E8	The numerical parts of this response are presented clearly and concisely, demonstrating comprehensive understanding of the underlying principles. The response to (d) is clear and reinforced with a sketch.