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91173

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

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Physics 2023

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 2–12 in the correct order and that none of these pages is blank.

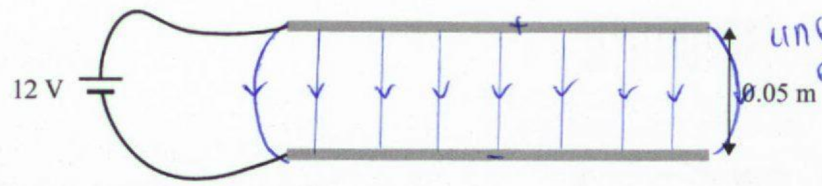
Do not write in any cross-hatched area (DO NOT WRITE IN THIS AREA). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence 24

QUESTION ONE: PARALLEL PLATES

A set of parallel plates 0.05 m apart are connected to 12 V.



lines are equidistance

(a) Show that the value of the electric field strength between the plates is 240, and state its unit.

$E = \frac{V}{d}$ $E = \frac{12}{0.05}$ $E = 240\ Vm^{-1}$

Unit: Vm^{-1}

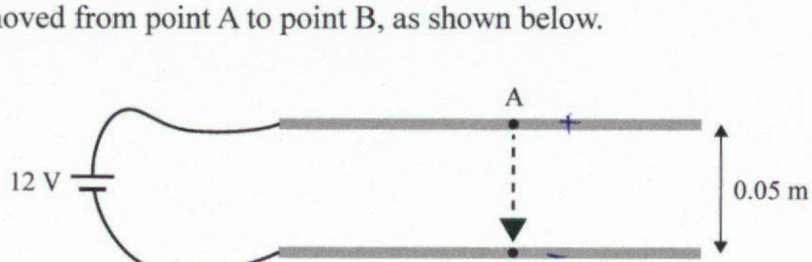
(b) On the diagram above, draw the electric field lines to represent the field between the plates.

If you need to redraw your response, use the diagram on page 8.

(c) Use physics principles to explain how the electric force on an electron would vary as it moved from the negative plate to the positive plate.

The electric force on an electron as it moves from the negative plate to the positive plate will be constant the whole time because $F = Eq$. The charge of an electron is always -1.6×10^{-19} C and the electric field strength is constant because $E = \frac{V}{d}$ voltage and distance between the plates has not changed. Thus, since E and q are the same as the electron moves, the electric force on the electron is also constant.

(d) An electron is moved from point A to point B, as shown below.



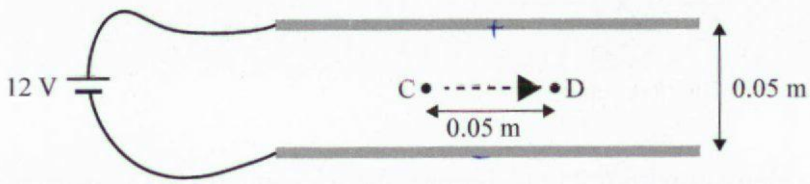
(i) Calculate the change in electric potential energy as the electron moves from point A to point B on the diagram opposite below.

$\Delta E_p = Eqd$

$= 240 \times -1.6 \times 10^{-19} \times 0.05$

$\Delta E_p = 1.92 \times 10^{-18}$ J

The electron is now moved 0.05 m from point C to point D.



(ii) What is the change in electrical potential energy as the electron moved from point C to point D?

$\Delta E_p = Eqd$

$= 240 \times -1.6 \times 10^{-19} \times 0$

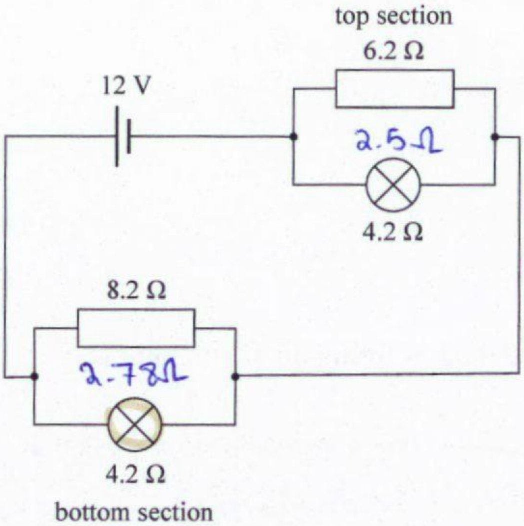
$\Delta E_p = 0$ J

(iii) Use physics principles to explain any difference in the change in electrical potential energies found in parts (i) and (ii).

In (i), the ΔE_p was 1.92×10^{-18} J because work was done by an external force to push the electron towards the negative plate and thus gains electrical potential energy which would convert into E_k if the electron is released. However in (ii), the electron is not moving in (parallel) to the electric field so it does not gain any electrical potential energy because work is not done to push it against the electric field or electrostatic force.

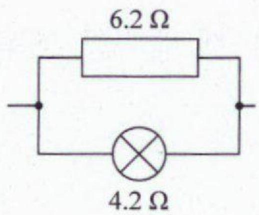
QUESTION TWO: CIRCUITS

A simplified version of the circuit in a camping oven is shown below. The oven consists of two sections.



6.375V

(a) The top section has an element with 6.2 Ω resistance and a lamp with 4.2 Ω resistance.



Show that the total resistance of the top section is 2.5 Ω.

$R_T = \left(\frac{1}{6.2} + \frac{1}{4.2}\right)^{-1}$

$R_T = 2.5\,\Omega$

(b) Calculate the current flowing from the power supply to the oven when both sections are working.

$I_T = V_T / R_T$

$I_T = 12 / 5.28$

$I_T = 2.27\ A$

(c) While both sections are working correctly, the lamp in the bottom section develops a fault and its resistance decreases.

Use physics principles to explain what happens to the brightness of the other lamp.

when the lamp in the bottom section develops a fault, its resistance decreases (e.g. to 3Ω). The total resistance of the circuit decreases from 5.28Ω to 4.7Ω. Since supply voltage is the same, the total current increases from 2.27A 2.55A. Therefore, the top section draws /uses more voltage from 5.675V to 6.375V and the bulb also draws more current as total current has increased. So current through the bulb in the top section increases from 1.35A to 1.52A. Since current and voltage through the lamp/bulb in the top section increased, P=IV so power increases and power determines brightness thus the brightness of the lamp increases! the power of bulb in top increased from 7.66W to 9.69W.

(d) The lamp in the bottom section now stops working.

Calculate the amount of energy converted to heat in two minutes by the 8.2 Ω resistor.

$P = \frac{\Delta E}{t}$ $P = IV$ $V = IR$

$R_T = 10.7\Omega$ $I_T = 12/10.7 = 1.12A$

$P = I^2R$

$P = 1.12^2 \times 8.2$ through 8.2Ω

$P = 10.3W$

$P = \Delta E/t$

$\Delta E = P \times t$

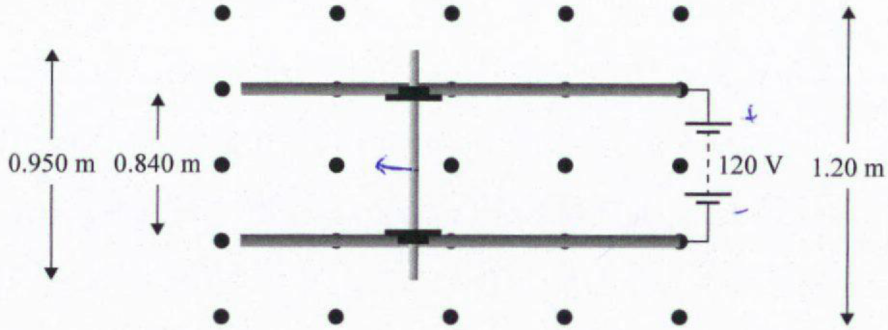
$\Delta E = 10.3 \times 120$

$\Delta E = 1236J$

QUESTION THREE: ELECTROMAGNETISM

The diagram below shows a metal axle that is free to roll on two parallel metal rails. The rails and the axle are in a magnetic field. The ends of the rails are connected to a 120 V power supply.

Strength of magnetic field $= 8.10 \times 10^{-3}$ T
Length of axle $= 0.950$ m
Distance between parallel metal rails $= 0.840$ m
Width of magnetic field $= 1.20$ m
Total effective resistance $= 42.1\ \Omega$
Voltage of power supply $= 120$ V



Source: https://upload.wikimedia.org/wikipedia/commons/7/76/Rollingstock_axle.jpg

(a) Draw an arrow on the diagram above to show the direction of the electromagnetic force that acts on the axle when the power supply is switched on.

If you think the direction of the force is out of the page, into the page, or there is no force, state this clearly.

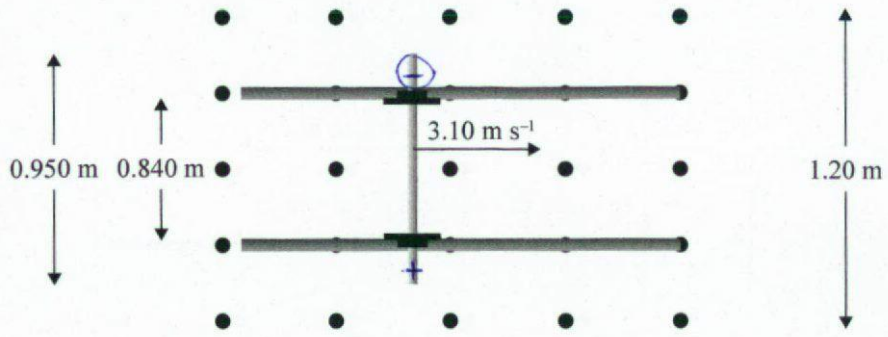
(b) Calculate the strength of the magnetic force on the axle when the power supply is turned on.

$F = BIL$

$F = 8.1 \times 10^{-3} \times 2.85 \times 0.84$

$F = 0.02$ N

(c) The power supply is removed, and the metal axle is given a push so that it is moving to the right at 3.10 m s^{-1}, as shown in the diagram.



(i) Clearly mark the negative end of the axle on the diagram above.

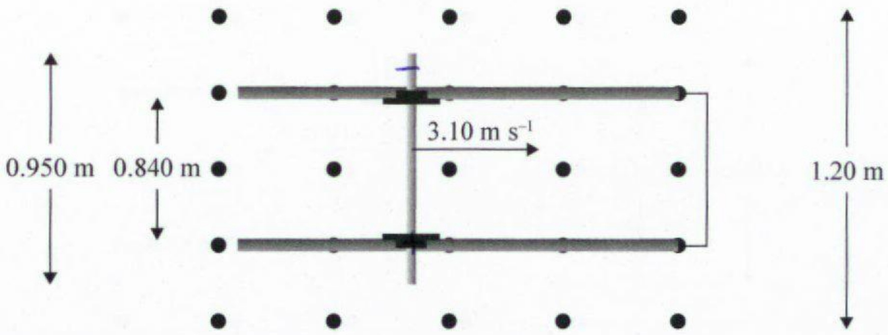
(ii) Calculate the voltage induced in the axle immediately after it is set moving.

$V = BvL \quad V = 8.1 \times 10^{-3} \times 3.1 \times 0.95$

$V = 0.024 V$

Question Three continues on the next page.

(d) With the power supply still disconnected, a wire is connected between the rails, and the axle is given a push so that it is moving to the right at 3.10 m s^{-1}.



Describe the motion of the axle after it is set moving.

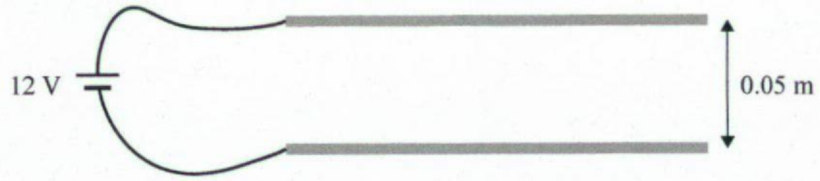
The axle will roll but it will slow down until it comes to a stop.

Justify your answer using electromagnetism physics principles.

When the axle is pushed, the electrons inside the axle will experience a force ~~B~~ F = Bqv because they are moving in a magnetic field. The electrons move to the top, leaving positives on the bottom. There's a separation of charges thus an potential difference / induced voltage. The wire between the rails allows current to flow from positive end to negative end the long way (anti-clockwise) as it allows a complete circuit for current to flow. Now there is an induced current, there will be a Lorentz force on the axle because F = BIL and this opposes the axle's motion, slowing it down. When the axle stops and reaches 0 ms^{-1}, the induced voltage and current will also disappear and the axle becomes stationery.

SPARE DIAGRAMS

If you need to redraw your response to Question One (b), 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.

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QUESTION NUMBER

91173

Standard	91173			Total score	24

Q	Grade score	Marker commentary
1	E8	1a: The candidate correctly calculated the electric field strength and supplied a correct unit. (a) 1b. The candidate correctly drew the parallel and evenly spaced arrows going downward between the plates. The arrows left and entered the plates at right angles. There were curved field lines at the end of the plate. (m) 1c: The candidate explains why the force on a n electron is constant. (m) 1d. i. The candidate has correctly calculated the change in electro-potential energy. ii. The candidate has clearly stated 0J. iii. The candidate has clearly linked work is only done when the electron moves parallel to the field and not when it moves perpendicular to the field. (ee) The candidate scored e,e,m,m,a making E8 for the question.
2	E8	2a: The candidate has correctly used the formula for adding resistors in parallel to get the required answer. (a) 2b. The candidate has correctly calculated the total current in the circuit. (m) 2c. The candidate has described the effect the faulty lamp would have on the total resistance of the circuit and how this would affect the circuit current given the supply voltage was constant. They then link this to how the voltage of the top lamp would change and how the power and hence brightness of the top lamp would change. (e) 2d. The candidate has correctly found the energy output.(e) The candidate scored e,e,m,a making E8 for the question
3	E8	3a: The candidate has correctly identified the direction of the force by drawing an arrow to the left. (a) 3b: The candidate has correctly used F=BIL to calculate the force on the axle. (m) 3c: The candidate has correctly identified the negative end of the axle and used V=BvL to find the voltage. (e) 3d: The candidate has correctly identified that a voltage I induced across the axle and because there is a circuit a current will flow. They also state that the because there is a current there will be a force that opposes the motion. (e) The candidate scored e,e,m,a making E8 for the question