2

91173

911730

SUPERVISOR'S USE ONLY

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Level 2 Physics, 2015

91173 Demonstrate understanding of electricity and electromagnetism

9.30 a.m. Tuesday 17 November 2015
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

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

Merit

TOTAL 20

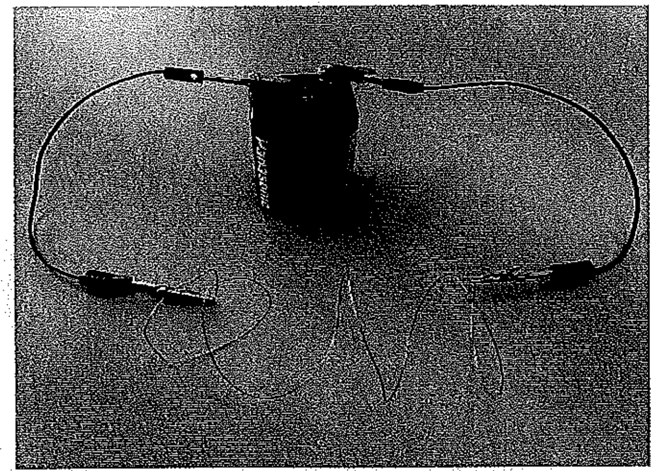
ASSESSOR'S USE ONLY

QUESTION ONE: ELECTRIC FIELD IN A WIRE

ASSESSOR'S USE ONLY

Charge on an electron = -1.6×10^{-19} C

Hamish connects a circuit as shown in the picture below. The circuit comprises a 6.0 V battery, 1.0 m of Nichrome resistance wire and two connecting wires. The battery produces a uniform electric field in the Nichrome resistance wire.



Assume that the connecting wires have no resistance.

(a) Calculate the strength of the electric field in the Nichrome resistance wire.

$\cancel{E}\ E = \frac{6}{1} \quad = 6\ \text{Vm}^{-1}$

$E = \frac{V}{d}$

a

(b) Explain what happens to the size of the electric force on an electron as it travels through the Nichrome resistance wire.

$F = Eq$

$E = \frac{V}{d}$

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

The size of the force stays the same as the force is determined by the electric field strength and charge. Both of these remain the same as an electron travels through the wire.

M

(c) Calculate the distance moved by an electron as it loses 9.6×10^{-20} J of electrical potential energy.

$\Delta E_p = Eqd$

$9.6 \times 10^{-20} = 6 \times (1.6 \times 10^{-19}) \times d$

$\boxed{d = 0.1\ \text{m}}$

M

(d) Hamish then adds another 6.0 V battery in series AND shortens the wire to 0.50 m.

Write a comprehensive explanation on what will happen to the size of the force on the electron.

Calculations are not needed.

ASSESSOR'S USE ONLY

The size of the force acting on the electron will increase.

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

$F = Eq$

$F = \frac{V}{d} q$ ← the charge remains the same.

As the voltage has now doubled and is being divided by / travelling through a smaller distance, the ~~force~~ resulting force on the electron will be greater.

M

$E = \frac{V}{d}$

$F = Eq$

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

Combined voltage = 12V

Wire = 0.50

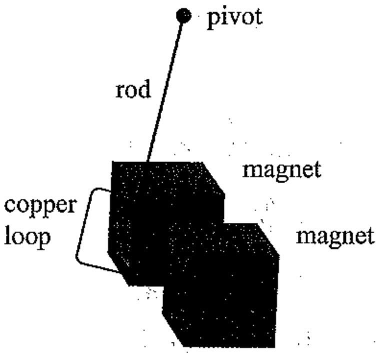
needs to say F is 4X

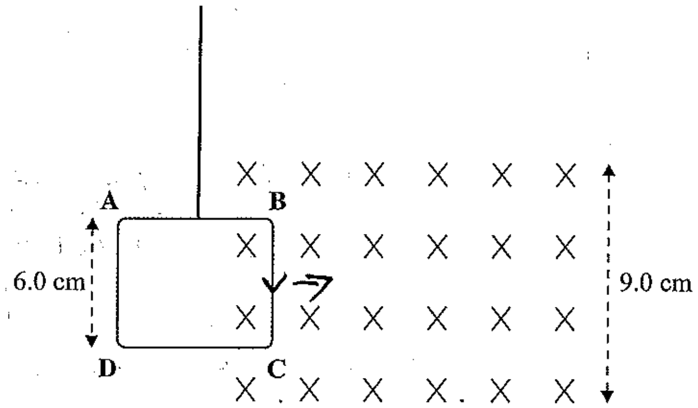
E8

QUESTION TWO: THE ELECTROMAGNETIC SWING

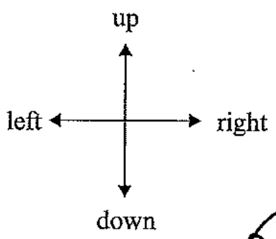
Monique builds a swing to show electromagnetic induction. It comprises a light rod, pivoted at the top so it can swing, and a loop of copper wire at the bottom. She places two strong magnets at the lowest point of the motion with opposite poles facing each other.

The diagrams below show the loop entering the magnetic field.





(a) Determine the direction of the force acting on **electrons** in the wire BC, due to their motion in the magnetic field.



Direction: ~~left~~ ~~up~~ right

(b) At the instant shown in the diagram, the voltage across the wire BC is 0.15 mV. (V)

Calculate the speed of the wire loop.

The magnetic field strength is 3.0×10^{-3} T. (B)

$B = 3 \times 10^{-3}$ T
$V = 0.15$ mV 0.015 V
$q = -1.6 \times 10^{-19}$ C
v ?
$L = 0.06$ m

$V = BvL$

$0.015 = (3 \times 10^{-3}) \times v \times 0.06$

$\boxed{v = 83.3 \approx 83 \text{ ms}^{-1}}$

ASSESSOR'S USE ONLY

(c) Monique repeats the experiment, but starts the swing from a greater height. The speed of the loop at the point shown in the diagram is doubled.

Explain what happens to the size of the current in the loop.

$F = Bqv$ → If the speed increases and the magnetic field strength and charge remain same, the force on charged particles will increase.

$F = BIL$

$BIL = Bqv$ Therefore if the force increase the current will also ~~dt~~ increase. As there is a

$IL = qv$ direct relationship between Force

$\frac{IL}{q} = v$ Relationship Current, Magnetic field strength and length of wire.

→ Magnetic field ~~strength~~ strenght ~~and~~ and the length of wire will stay the same.

wrong concept

(d) A short time later the whole loop is inside the magnetic field.

?

Write a comprehensive explanation about the current in the loop when the whole loop is in the magnetic field.

~~The overall force acting on the charged particles will increase as Once the whole loop is in the magnetic field, the~~

$F = Bqv$

$F = BIL$

$\frac{IL}{q} = v$

When whole loop in magnetic field, length of wire ~~with~~ where magnetic force is acting increases. Therefore the force increases. Therefore current also increases.

All current will flow, as magnetic force is around it.

N

N

N2

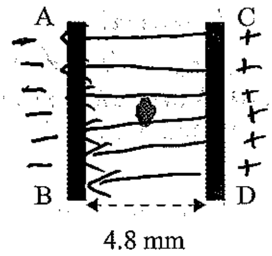
ASSESSOR'S USE ONLY

QUESTION THREE: THE SMOKE DETECTOR

Charge on an electron = -1.6×10^{-19} C

One type of smoke detector comprises a pair of metal plates 4.8 mm apart, connected to a battery. Alpha particles from a radioactive source ionise particles of smoke between the plates. This causes the smoke particles to lose one or more electrons and become charged.

The diagram below shows a positively charged smoke particle. The force on the particle is towards AB.



(a) Draw lines showing the electric field between the plates.

Include the direction of the field lines.

The mass of the smoke particle is 1.7×10^{-7} kg (m)

(b) A particular smoke particle loses two electrons. It then experiences a force of 5.88×10^{-16} N due to the electric field.

Calculate the strength of the electric field.

~~$F = Eq$~~

~~$5.88 \times 10^{-16} = E \times (1.7 \times 10^{-7} \times -1.6 \times 10^{-19} (2 \times 1.6 \times 10^{-19}))$~~

~~$= 48\ 1837.5\ NC^{-1}$ (4dp)~~

$F = Eq$ $\quad 5.88 \times 10^{-6} = E \times 2(1.6 \times 10^{-19})$ $\quad E = 1.8 \times 10^{13}\ NC^{-1}$

(c) Maria brings a magnet close to the smoke detector. The magnet produces a magnetic field of strength 3.0×10^{-2} T, which, with reference to the diagram above, is directed into the page.

State the size of the force due to the magnet on the stationary smoke particle.

Explain your answer.

The size of the force will be zero. This is because no charged particles are actually moving through the magnetic field to experience a force.

(d) The smoke particle becomes ionised by losing two electrons when it is 2.4 mm from plate AB.

ASSESSOR'S USE ONLY

Calculate the speed of the smoke particle when it reaches the plate AB.

Assume that only the electric force acts on the smoke particle.

$B = 3 \times 10^{-2}\,T$

$F = 5.88 \times 10^{-10}\,N$

$F = Bqv$

$5.88 \times 10^{-10} = (3 \times 10^{-2}) \times (1.6 \times 10^{-19}) \times v$

$\boxed{v = 1.22 \times 10^{11}\,ms^{-1}}$

N1

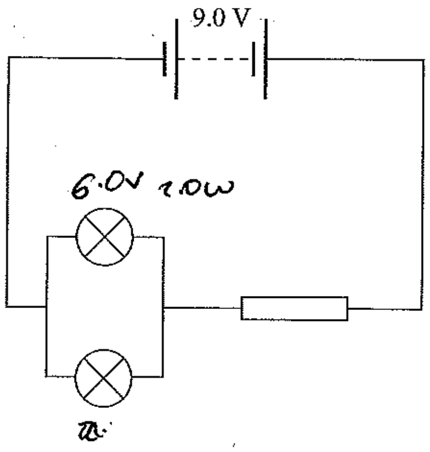
M5

QUESTION FOUR: CIRCUITS

ASSESSOR'S USE ONLY

Kahu has two identical lamps marked 6.0 V, 2.0 W. He wants to connect them to a 9.0 V battery. He realises that he will have to connect a resistor to reduce the voltage across the lamps.

He connects the circuit shown below.



(a) Calculate the current in each lamp when it is operating at its normal brightness.

$P = IV$ $\boxed{I = 0.33A}$

$2 = I \times 6$

(b) Calculate the resistance of the resistor that he should use so that the lamps are at their normal brightness.

$V = IR$

$9 = 0.67 \times R$

$R = 13.5\ \Omega$

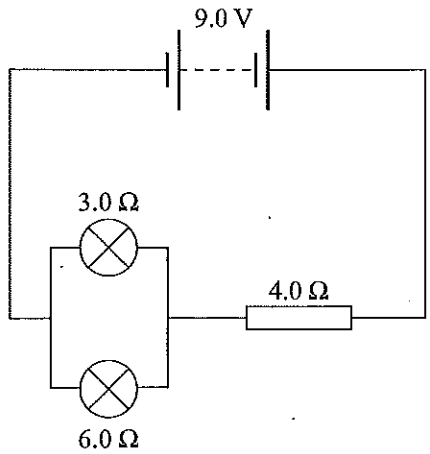
(c) What will happen to the current in the resistor if one lamp "blows"?

Explain your answer.

~~The current will increase. This is because less current will be travelling through the parallel circuit, therefore more current will travel through the resistor.~~

$V = IR$ If the lamp blows, the overall voltage of the circuit will increase. Therefore as $V = IR$, the current will also increase for when it travels through the resistor.

Kahu sets up a new circuit with different lamps and resistor, as shown in the diagram below.



(d) Calculate the voltage across the 4.0 Ω resistor.

$R_T = \frac{3 \times 6}{3+6} + 4$

$R_T = 6\,\Omega$

$V = IR$

$9 = I \times 6$

$I = 1.5A$

$V = 1.5 \times 4$

$\boxed{V = 6V}$

ASSESSOR'S USE ONLY

MS

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Merit

TOTAL 22

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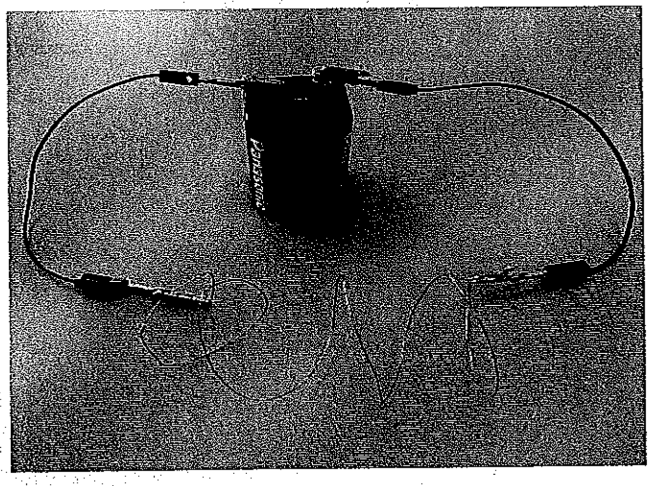
QUESTION ONE: ELECTRIC FIELD IN A WIRE

ASSESSOR'S USE ONLY

Charge on an electron = -1.6×10^{-19} C

Hamish connects a circuit as shown in the picture below. The circuit comprises a 6.0 V battery, 1.0 m of Nichrome resistance wire and two connecting wires. The battery produces a uniform electric field in the Nichrome resistance wire.



Assume that the connecting wires have no resistance.

(a) Calculate the strength of the electric field in the Nichrome resistance wire.

$E = \frac{V}{d}$

$= \frac{6.0}{1.0}$

$= 6.0 \text{ Vm}^{-1}$

A

(b) Explain what happens to the size of the electric force on an electron as it travels through the Nichrome resistance wire.

It increase as there is an electric field in the Nichrome resistance wire and $F = Eq$.

needed to realise uniform means constant.

N

(c) Calculate the distance moved by an electron as it loses 9.6×10^{-20} J of electrical potential energy.

$\Delta E_p = Eqd$

$d = \frac{\Delta E_p}{Eq}$

$= \frac{9.6 \times 10^{-20}}{(6.0 \times 1.6 \times 10^{-19})}$

$= 0.10\text{m}$ (2 s.f.)

M

(d) Hamish then adds another 6.0 V battery in series AND shortens the wire to 0.50 m.

Write a comprehensive explanation on what will happen to the size of the force on the electron.

Calculations are not needed.

~~The force on the electron will increase.~~ ~~This is because~~ The electric field strength will increase as $E=\frac{V}{d}$ and the voltage is being increased and the distance is being decreased. As $F=Eq$, a higher electric field strength will mean a higher force. Therefore, the force on the electron will increase.

needs to say 4×

ASSESSOR'S USE ONLY

M

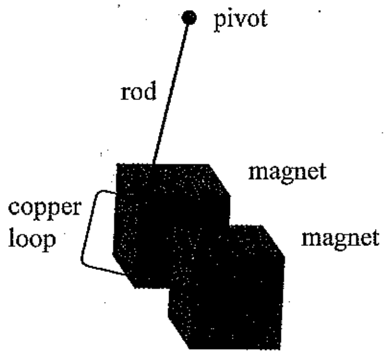
M5

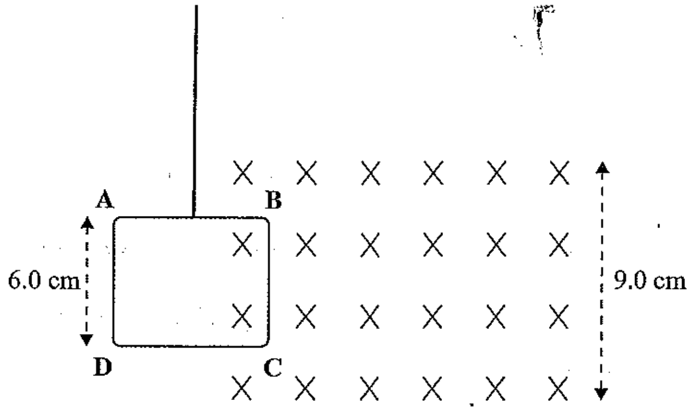
QUESTION TWO: THE ELECTROMAGNETIC SWING

ASSESSOR'S USE ONLY

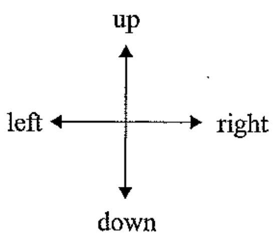
Monique builds a swing to show electromagnetic induction. It comprises a light rod, pivoted at the top so it can swing, and a loop of copper wire at the bottom. She places two strong magnets at the lowest point of the motion with opposite poles facing each other.

The diagrams below show the loop entering the magnetic field.





(a) Determine the direction of the force acting on **electrons** in the wire BC, due to their motion in the magnetic field.



Direction: down

(b) At the instant shown in the diagram, the voltage across the wire BC is 0.15 mV.

Calculate the speed of the wire loop.

The magnetic field strength is 3.0×10^{-3} T.

$V = BvL$

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

$= \frac{0.15}{(3.0 \times 10^{-3} \times 0.06)}$

$= 833$

$= 830 \text{ ms}^{-1}$ (2 s.f.)

M

(c) Monique repeats the experiment, but starts the swing from a greater height. The speed of the loop at the point shown in the diagram is doubled.

ASSESSOR'S USE ONLY

Explain what happens to the size of the current in the loop.

It increases as $I = \frac{q}{t}$.

n

(d) A short time later the whole loop is inside the magnetic field.

Write a comprehensive explanation about the current in the loop when the whole loop is in the magnetic field.

The current will not be able to flow when the loop is inside the magnetic field as all the positive charge will go to the top and all the negative charge will go to the bottom due to the right hand slap rule.

states 0. current and charge separation needs to add induced voltages cancel.

M

M6

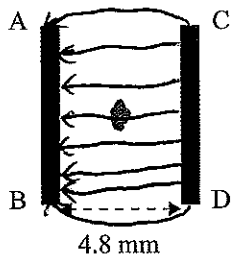
ASSESSOR'S USE ONLY

QUESTION THREE: THE SMOKE DETECTOR

Charge on an electron = -1.6×10^{-19} C

One type of smoke detector comprises a pair of metal plates 4.8 mm apart, connected to a battery. Alpha particles from a radioactive source ionise particles of smoke between the plates. This causes the smoke particles to lose one or more electrons and become charged.

The diagram below shows a positively charged smoke particle. The force on the particle is towards AB.



(a) Draw lines showing the electric field between the plates.

Include the direction of the field lines.

The mass of the smoke particle is 1.7×10^{-7} kg

(b) A particular smoke particle loses two electrons. It then experiences a force of 5.88×10^{-16} N due to the electric field.

Calculate the strength of the electric field.

$F = Eq$

$E = \frac{F}{q}$

$= \frac{5.88 \times 10^{-16}}{(2 \times 1.6 \times 10^{-19})}$

$= 1838$

$= 1800\ NC^{-1}$ (2 s.f.)

(c) Maria brings a magnet close to the smoke detector. The magnet produces a magnetic field of strength 3.0×10^{-2} T, which, with reference to the diagram above, is directed into the page.

State the size of the force due to the magnet on the stationary smoke particle.

Explain your answer.

5.88×10^{-16} N. The particle is stationary so the forces must be ~~[illegible]~~ balanced.

Applies incorrect concept

q

M

A

(d) The smoke particle becomes ionised by losing two electrons when it is 2.4 mm from plate AB.

Calculate the speed of the smoke particle when it reaches the plate AB.

Assume that only the electric force acts on the smoke particle.

$\Delta E_p = Eqd$

$= 1838 \times 3.2 \times 10^{-19} \times 0.0024$

$= 1.411968 \times 10^{-18}\ J = E_k$

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

$v^2 = \frac{E_k}{\frac{1}{2}m}$

$= \frac{1.411968 \times 10^{-18}}{\frac{1}{2} \times 1.7 \times 10^{-7}}$

$= 1.661138824 \times 10^{-11}$

$v = 4.07570708 4 \times 10^{-6}$

$= 4.1 \times 10^{-6}\ ms^{-1}$ (2 s.f.)

ASSESSOR'S USE ONLY

E

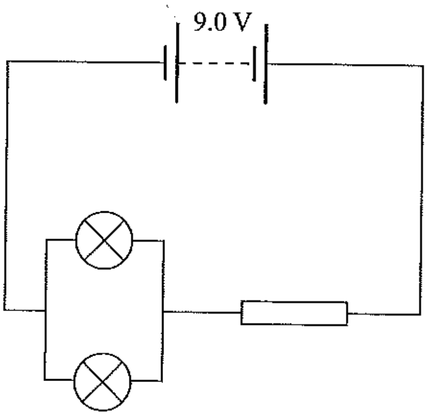
E7

QUESTION FOUR: CIRCUITS

ASSESSOR'S USE ONLY

Kahu has two identical lamps marked 6.0 V, 2.0 W. He wants to connect them to a 9.0 V battery. He realises that he will have to connect a resistor to reduce the voltage across the lamps.

He connects the circuit shown below.



(a) Calculate the current in each lamp when it is operating at its normal brightness.

$P = IV$

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

$= \frac{2.0}{6.0} = 0.33\text{A}$ (2 s.f.)

(b) Calculate the resistance of the resistor that he should use so that the lamps are at their normal brightness.

$V = IR$

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

$= \frac{3}{0.33} = 9.0\ \Omega$ (2 s.f.)

uses incorrect current

(c) What will happen to the current in the resistor if one lamp "blows"?

Explain your answer.

The current in the resistor will increase if one lamp blows as it will become a series circuit and the current in a series circuit is constant.

Needs to realise removing the lamp alters the total R and the current.