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91173

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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.

Excellence

TOTAL 27

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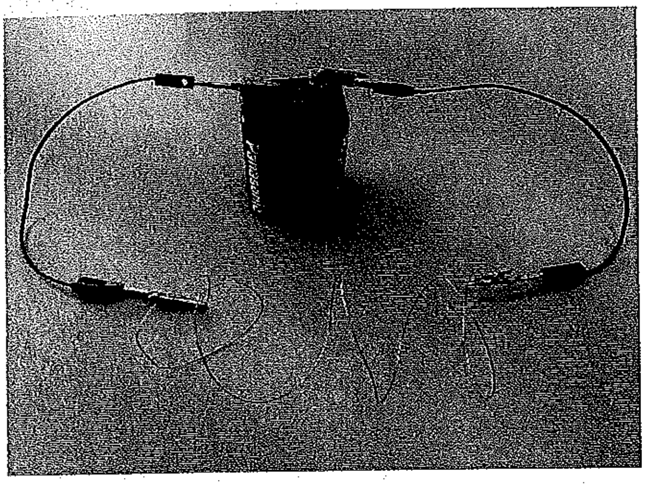
QUESTION ONE: ELECTRIC FIELD IN A WIRE

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.

$q = -1.6\times10^{-19}$ $V = 6.0\,v$ $d = 1.0\,m$

$E = \frac{V}{d}$ $E = \frac{6}{1}$ $E = 6\,Nm^{-1}$

A

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

The size of the force remains constant as $F = Eq$ and neither E or q change. So the size of the force doesn't change from $F = Eq$ $F = 6 \times -1.6\times10^{-19}$

$F = 9.6\times10^{-19}\,N$.

M

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

$\Delta E_p = Eqd$ $-9.6\times10^{-20} = 6\times-1.6\times10^{-19}\times d$

$\frac{-9.6\times10^{-20}}{6\times-1.6\times10^{-19}} = d$

$d = 0.1\,m$.

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.

The size of the force on the electron will be ~~than~~ 4 times greater. This is because the voltage is doubled and the distance is $\frac{1}{2}$ and so the Electric field strength is four times bigger and $F = Eq$. ~~E~~ q stays the same but E is 4x bigger so F is 4x bigger.

12v

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E

E8

QUESTION TWO: THE ELECTROMAGNETIC SWING

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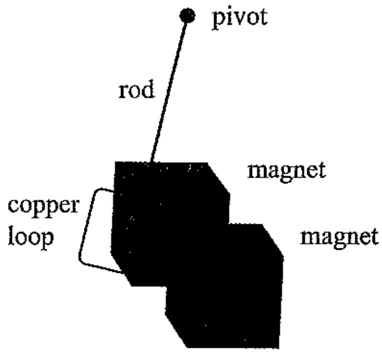
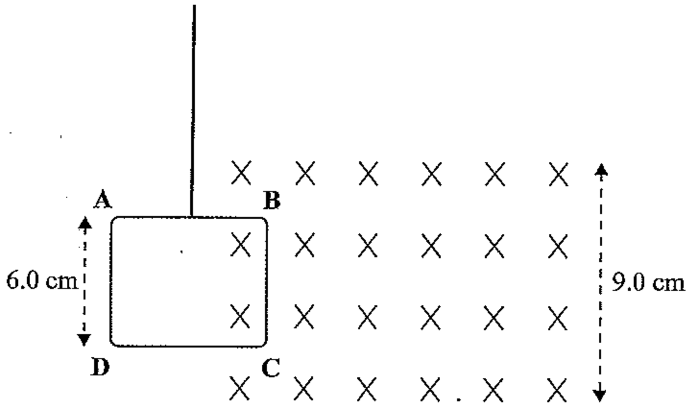
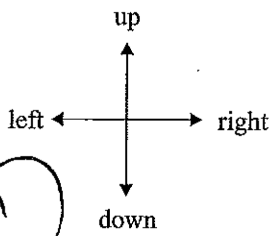
Monique builds a swing to show electromagnetic induction. It comprises a light rod, pivoted at the top so it can swing, and a loop of copper wire at the bottom. She places two strong magnets at the lowest point of the motion with opposite poles facing each other.

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.



Incorrect use of rh rule.

N

Direction: Up

(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.

~~B/A~~ $B = 3\times10^{-3}$ $mV = 0.15\ mV$ $d = 0.06\ m$

$V =$

$V = BvL$

~~V~~ $V =$

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

$\frac{1.5\times10^{-3}}{3\times10^{-3}\times 0.06} = v$ $\quad V = 0.03\ ms^{-1}$

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.

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

The size of the current doubles. Because $F = Bqv$ so if ~~ϵ~~ v is doubled ~~x~~ is doubles and $\frac{F}{BL} = I$ so I is two times greater. ~~B~~ Also ~~when~~ v ~~x~~ is doubled ~~neither~~ only the Force changes. B and L stay the same.

states current doubles, then gives incorrect evidence.

A

(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.

Assuming the loop is moving to the right ~~on~~ the Current in the loop will be 0 as both the right and left sides of the ~~current~~ loop will have current travelling upward so one clockwise and the other anti clockwise. This means the two currents will cancel out and there will be no net current in the loop.

e

E7

QUESTION THREE: THE SMOKE DETECTOR

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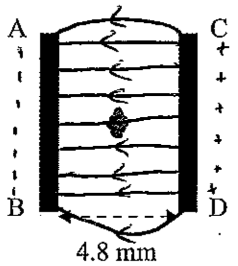
Charge on an electron = -1.6×10^{-19} C

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.

$m = 1.7 \times 10^{-7}$ $q = -1.6 \times 10^{-19}$ $F = 5.88 \times 10^{-16}$

$F = Eq$ $\frac{5.88 \times 10^{-16}}{-1.6 \times 10^{-19}} = E = 3675\ NC^{-1}$

Forgot to use $2e^-$

(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.

0N because the ~~stat~~ Smoke particle is stationary so there for the force is 0. As $F = Bqv$ and $v = 0$ so $F = 0$.

$2.4mm = 0.24cm$ $0.0024m$

~~tem~~ $10cm = 0.1m$ $1cm = 0.01m$ $0.0048m$

(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.

~~$\Delta d = 0.0024\ 0.0024m$~~ ~~$E_p$~~ $\Delta d = 2.4\times10^{-3}m$

$m = 1.7\times10^{-7}kg$

$E = 3675NC^{-1}$

$E_p = Eqd$ $E_p = -3675 \times -1.9\times10^{-19} \times 2.4\times10^{-3}$

$E_p = 1.7\times10^{-18}J.$

$E_p = E_k$

$E_k = \frac{mv^2}{2}$ ~~$E_k\ \frac{1.7\times10^{-18}}{}$~~ $=$

$\sqrt{\frac{1.7\times10^{-18}\times2}{1.7\times10^{-7}}} = v$

$v = 4.5\times10^{-6}ms^{-1}$

applied correct concept

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

$2E_k = mv^2$

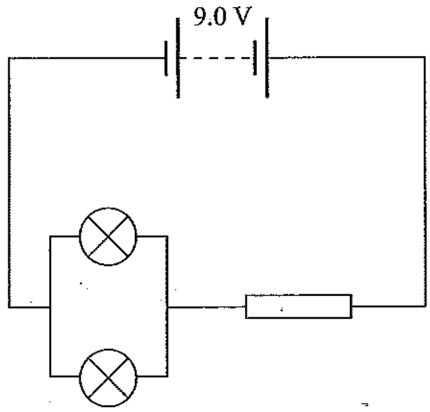
9.

M6

QUESTION FOUR: CIRCUITS

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.

$P = IV \quad \frac{2}{6} = I \quad I = 0.67A.$

Both $I = 0.67A.$

(b) Calculate the resistance of the resistor that he should use so that the lamps are at their normal brightness. $V=6 \quad I=1.3 \quad V=IR \quad R=\frac{V}{I} \quad R=4.5\Omega$

$V = IR \quad R = \frac{9}{0.67} \quad R = 13.4\Omega \qquad 13.4 - 9.0 = 4.4\Omega$

$R = \frac{V}{I} \quad R = \frac{6}{0.67} = 9.0\Omega$

(c) What will happen to the current in the resistor if one lamp "blows"? Explain your answer. $I = \frac{V}{R} \qquad I = \frac{V}{R}$

The current in the resistor would be less because the overall $I = \frac{V_s}{R_T}$ and the R_T would be greater without the other lamp so the I_T would be less and I_T goes through the resistor so the I would be less.

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

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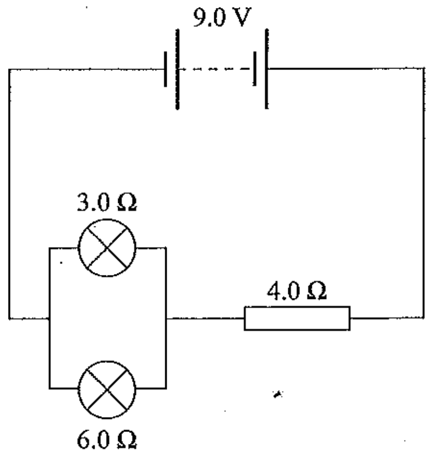


$V = IR$

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

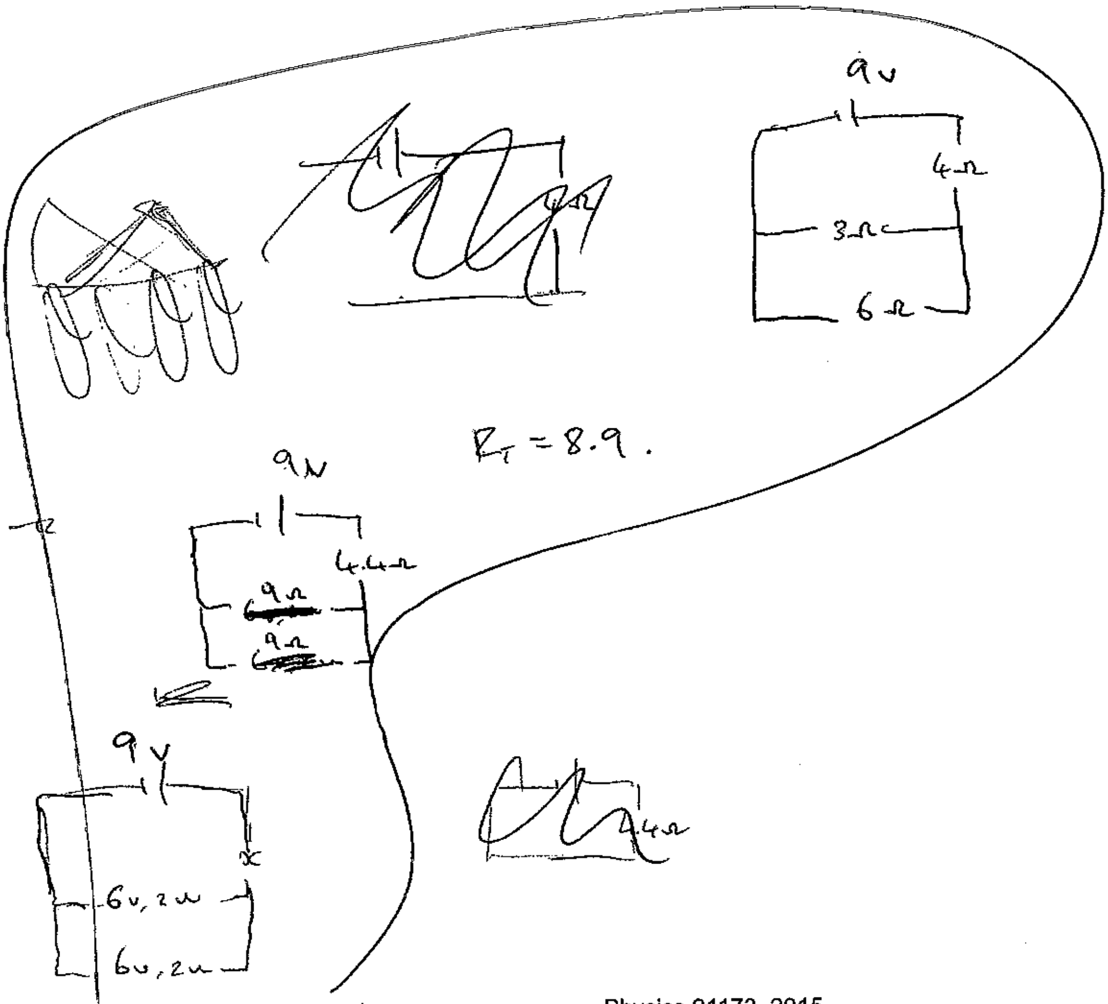
$R_T = \frac{1}{R_T} = \frac{1}{3} + \frac{1}{6}$ $R_T = 2\ \Omega$

$R_T = 2 + 4$ $R_T = 6\ \Omega$

$I_t = \frac{V_s}{R_T}$ Total $I = \frac{9}{6}$ $I = 1.5\text{A}.$

$V = IR$ $V = 1.5 \times 4$ $V = 6\text{v}$

e



$R_T = 8.9.$

M6