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90937

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NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 1 Physics, 2014

90937 Demonstrate understanding of aspects of electricity and magnetism

2.00 pm Tuesday 25 November 2014
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of electricity and magnetism.	Demonstrate in-depth understanding of aspects of electricity and magnetism.	Demonstrate comprehensive understanding of aspects of electricity and magnetism.

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 L1–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 2–9 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 22

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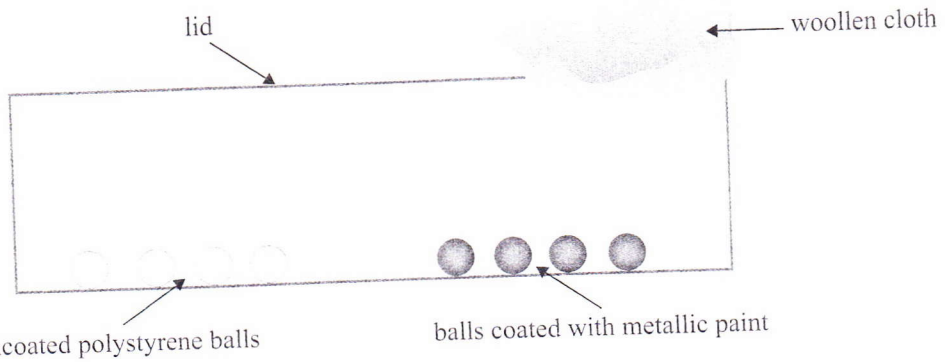
QUESTION ONE: JUMPING JACK TOY

A toy consists of small polystyrene balls inside a sealed plastic container. Some of the polystyrene balls are uncoated and others are coated with metallic paint. All the balls are uncharged and they have the same mass.



When a child rubs the lid of the container with a woollen cloth, the lid becomes negatively charged. The balls now jump up and stick to the lid of the container.

(a) Explain how the lid of the container becomes negatively charged.

When the woolen cloth is rubbed on the lid, the friction between the cloth and the lid causes a transfer of electrons from the cloth to the lid. This makes the lid negatively charged, since there are more negative electrons than positive protons.

m

(b) Explain why the balls jump up and stick to the lid of the container.

The balls jump up and stick to the lid of the container because the negatively charged lid induces a positive charge in the balls (since like charges repel, the negative charge in the balls is pushed away, leaving a positive charge (positively charged) on them). Since opposite charges attract, the balls jump up and stick to the negatively charged lid of the container.

e

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(c) After a short time some of the balls begin to fall down.

(i) State which type of balls – uncoated polystyrene, or polystyrene coated with metallic paint – will fall first.

Polystyrene coated with metallic paint

(ii) Explain your answer.

This type of ball would fall first because the metallic paint is a good conductor of charge. Therefore it takes less time for the negative charge in the lid to transfer to the balls coated in metallic paint. This makes the balls ~~neutrally~~ negatively charged faster than the uncoated polystyrene balls. Since there is no attraction between the lid and the now ~~neutrally~~ negatively charged balls, they fall down (as like charges repel).

e

(d) Some balls are still stuck to the lid of the container.

Explain what happens to the balls that are still stuck to the lid when a child touches the lid of the container with his bare hand.

- when child touches electrons flow into hand
- no charge

When a child touches the lid of the container with his bare hand, the balls that are still stuck to the lid fall down because the negatively charged electrons in the lid transfer into the child's hand. This makes the lid neutrally charged, so there is no attraction between the lid and the balls, so the balls fall down.

M

E8

QUESTION TWO: HEATERS AND TOASTERS

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A heating element inside a heater in a camper van is labelled as "200 W; 12 V", and it is connected across a 12 volt battery.

(a) Calculate the resistance of the heating element.

$V = IR$

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

$= \frac{12}{16.67}$

$= 0.72$

$P = VI$

$200 = 12I$

$\frac{200}{12} = I$

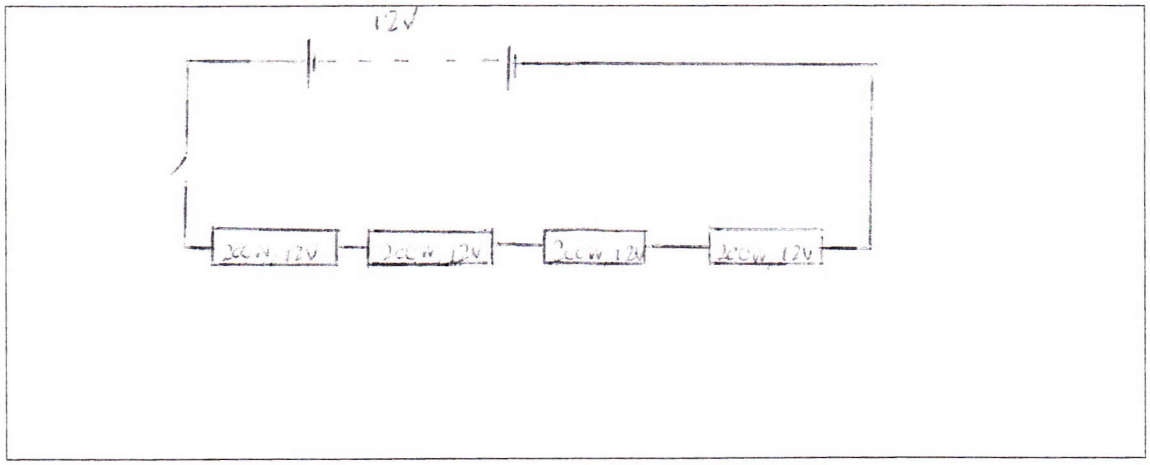
$= 16.67A$

Resistance: $0.72\ \Omega$ M

(b) Four of these heating elements, each labelled as "200 W; 12 V", are now connected together in series with a switch and a 12 volt battery.

(i) In the space given below, draw the circuit diagram for the four heating elements in series with a switch and the 12 volt battery.

Use the symbol for a resistor to represent heating elements in your circuit diagram.



(ii) Explain why the same current flows through all heating elements when the switch is turned on. M

The same current flows through all heating elements when the switch is turned on because in a series circuit, there is only one pathway for the current to flow through.

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(c) Even though the power rating for each element is 200 W, the combined power of the four heating elements in **series** is not 800 W, when connected to a 12 V battery.

Use physics concepts to explain why the combined power of the four elements in series is not 800 W.

In a series circuit, the voltage is spread equally among the components.
Power of one heating element in series VI
$= 3 \times 16.67$
$= 50W$
Since the same current flows through all four heating elements in series, then the power of one heating element in series is a $\frac{1}{4}$th of the power it reads at the rating
Power of all four $= 4VI = 200W$.

M

(d) A household toaster consists of four heating elements that are connected in **parallel**. The toaster is connected to the 240 V mains supply. When the toaster is switched on, a current of 2.5 A is drawn from the mains supply.

For copyright purposes, this image cannot be reproduced here.

http://www.ohgizmo.com/wp-content/uploads/2010/05/kenwood_toaster.jpg

Calculate the electrical energy used by a **single** heating element in the toaster when it is turned on for 2 minutes.

$P = VI$ $P = \frac{E}{t}$
therefore $VI = \frac{E}{t}$
$VIt = E$
$240 \times 2.5 \times (2 \times 60) = E$
$72{,}000J = E$ (total)
$E(\text{single}) = \frac{72{,}000}{4}$
$= 18000J$

in parallel
- same voltage across all components
- different current (split equally assuming elements have same resistance)

e

Energy: 18000 J

E7

QUESTION THREE: ELECTRIC BELL

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Adapted from: http://upload.wikimedia.org/wikipedia/commons/c/c1/DoorBell_001.jpg

The photo shows the internal parts of an electric bell. When the bell is turned on, a current of 0.16 A flows through the wire X that connects the bell to the power supply.

(a) Calculate the magnetic field strength due to the current, at a distance of 1.0 cm from the wire X.

$B = \frac{kI}{d}$

$= \frac{2e^{-7} \times 1.6e^{-1}}{1e^{-2}}$

$= 3.2e^{-6}$

M

Magnetic field strength: $3.2e^{-6}$ T

(b) The electric bell has two coils of wire, A and B, connected in series. When the bell is turned on, a current of 0.16 A flows through the coils, and the total power used by both coils is 1.92 W. Coil A has a resistance of 32 Ω.

Calculate the resistance of coil B.

$P = VI$ $\quad V = IR_T$ $\quad R_T = R_A + R_B$

$1.92 = V \times 0.16$ $\quad 12 = 0.16 \times R_T$ $\quad 75 = 32 + R_B$

$V = 12V$ $\quad R_T = 75\Omega$ $\quad R_B = 43\Omega$

e

Resistance: 43 Ω

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(c) The diagram shows the circuit for an electric bell. The moving arm is made from metal and is attached to a spring. At the instant the switch is closed, the current flows through the circuit in the direction as shown in the diagram.

Explain in detail the process that causes the bell to sound repeatedly from the instant when the switch is closed.

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Adapted from: www.schoolphysics.co.uk/age11-14/glance/Electricity%20and%20magnetism/Electric_bell/index.html

When the switch is turned on, the circuit is completed which activates the electromagnet. This electromagnet attracts the iron moving arm towards it, which pulls the moving arm away from the contacts, while the striker hits the gong. When the arm is pulled, there is no contact between the moving arm and the contacts, breaking the circuit. This turns the electromagnet off, and the spring pushes the moving arm back towards the contacts. When they touch, the circuit is complete again, repeating this process.

M

Question Three continues on the following page.

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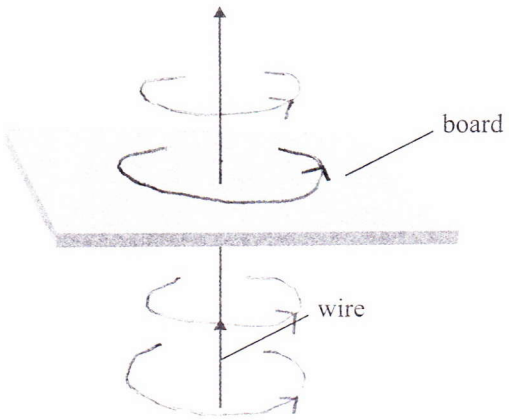
(d) A straight wire that carries a large current in the upward direction passes through a horizontal board, as shown in the diagram below.



(i) On the diagram above, draw the **shape** and **direction** of the magnetic field produced by the current-carrying wire.

(ii) Describe how you would check this direction experimentally.

I would check this direction experimentally by placing a magnet into contact with the magnetic field

a

E7

Excellence exemplar for 90937 2014	Total Score	22

Q	Grade score	Annotation
1	8	b. This is an E answer. The student clearly explained the separation of charge in the sphere, and linked this to the forces caused by the negatively charged lid. The diagram alongside (c) supported this explanation. c. This is an E answer because the falling of the ball was linked to the conducting property of metal and like charges repelling. This is compared with the uncoated balls to give complete answer.
2	7	c. This is an M answer because the splitting of voltage in series circuit has been related to the power of individual components. An E answer would recognise that there are additional components and so the resistance has increased, resulting in lower current. d. This is an E answer as the calculations are all correct. The answer is well laid out and the thinking communicated clearly.
3	7	a. This is an M answer. However this answer should be written in standard form 3.2×10^{-6} rather than as calculator readout. b. This is an E answer correct calculation. c. This is an M answer as it gives a good, succinct explanation and uses ordered sentences to show understanding. To gain an E the answer ha to clearly link the magnetisation of the coil to the current flowing, which is the key physics concept in this question.