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Level 1 Physics, 2015

90937 Demonstrate understanding of aspects of electricity and magnetism

9.30 a.m. Thursday 19 November 2015
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 room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 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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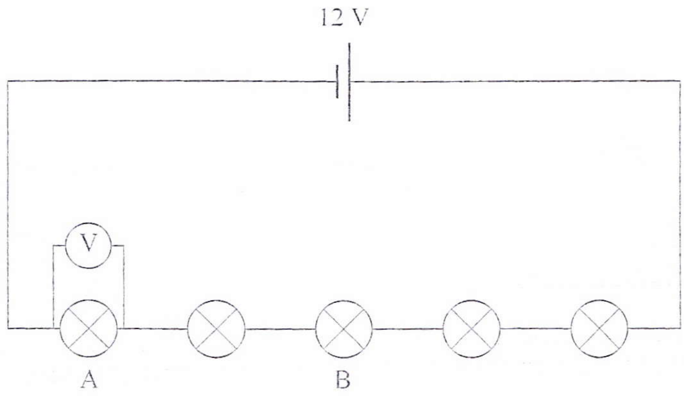
QUESTION ONE: DC ELECTRICITY

A road-side stall in a street fair is lit with five **identical** 6.0 V bulbs. The bulbs are connected in series to a 12 V battery, and in this circuit the resistance of each bulb is 2.5 Ω. A voltmeter is connected across the bulb A, as shown in the diagram below.

Circuit 1



(a) (i) What is the reading on the voltmeter?

2.4V

(ii) Give an explanation for part (i).

As the bulbs are in series, ~~and as the~~ voltage must be shared between components. And, as the bulbs all have the same resistance, the supply voltage of 12V will be equally split/distributed into to the 5 bulbs (giving each 2.4V)

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(b) Calculate the current through the circuit.

$I = \frac{V}{R}$ $V_{total} = 12V$ $R_{total} = (2.5 \times 5) = 12.5\,\Omega$

$\therefore I = \left(\frac{12}{12.5}\right)$

$= 0.96$

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Current: 0.96 A

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(c) In the following circuit, two **identical** 6.0 V bulbs, similar to the ones used in Circuit 1, are connected in series across a 12 V battery.

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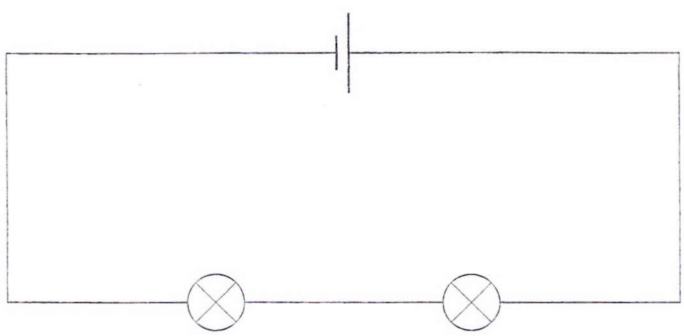
Circuit 2



Compare the brightness of bulbs in this circuit to the brightness of bulbs in Circuit 1.

Explain your answer.

The brightness of the bulbs in this circuit is greater, i.e. brighter. This is because as there are 3 less bulbs (with resistances equal to the previous bulbs) ~~which means~~ which means there is less resistance. As the supply voltage stays constant at 12V, decreased resistance will mean increased current flowing through the circuit. As $P = IV$, ~~the power~~ and as current is greater in this circuit, the power of this circuit and, hence, the brightness of the bulbs increases.

as $\left(I = \frac{V}{R}\right)$

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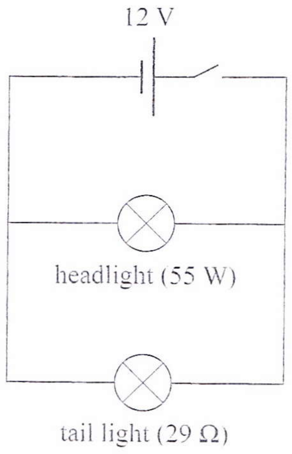
(d) The diagram below shows the wiring of the headlight and the tail light in a quad bike. Both bulbs are designed to work across a 12 V battery. When the switch is turned on, the power output of the headlight is 55 W and the working resistance of the tail light is 29 Ω.



(i) Calculate the total current drawn from the battery when the switch is closed.

Current in headlight : $I = \frac{P}{V}$, $P = 55W$, $V = 12V$

$\therefore I = \left(\frac{55}{12}\right) = 4.58\ A$

Current in ~~tailight~~ tail light : $I = \frac{V}{R}$, $V = 12V$, $R = 29\Omega$

$\therefore I = \left(\frac{12}{29}\right) = 0.41\ A$

$\therefore$ Total Current $= (4.55 + 0.41) = 4.99\ A$

e

Total current: 4.99A

(ii) The headlight has printed on it "12 V, 55 W".

What does "12 V, 55 W" mean?

(12V) - It means that the maximum voltage it can take is 12V of energy (if it exceeds this, it will blow). 55W refers to the power of the headlight - i.e. how much electrical energy it draws from a battery / the rate at which it uses electrical energy.

For E8 the answer needs to make a clear link between the power used by the lamp and the voltage of the supply

E7

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QUESTION TWO: STATIC ELECTRICITY

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Zoe uses a plastic brush to groom her dog. She notices that on dry days the hair sticks out after she has brushed it, as shown in the picture below.

www.pamperedpuppy.com/doggydesktops/

(a) Explain what causes the dog's hair to stick out after Zoe has removed the brush.

Friction causes the dog's hair to become charged then stick out. When the brush makes contact with the dog's hair, it ~~may~~ rubs ~~off~~ ~~for~~ electrons ~~and~~ off the dog; thus, positively charging the dog's hair as it has ~~an excess~~ a lack of electrons.* As the dog's hair all have the same charge,* they repel each other as like charges repel - thus, causing the dog's hair to stick out.

* The charge remains as the hair is a poor conductor of electricity - meaning it cannot conduct charge.

* (~~most~~ likely a positive charge as electrons ~~become~~ rubbed off)

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(b) After brushing, Zoe notices that when she holds the brush closer to the dog, the hair moves towards the brush.

Explain why the hair moves towards the brush when Zoe holds the brush closer to the hair.

When the brush rubbed against the dog's hair, it gained electrons (electrons moved to the brush) and became negatively charged. As the plastic brush, is an insulator / poor conductor of electricity, it retains this negative charge (static electricity). As it is negatively charged, it will attract the positively charged hair as opposite charges attract. Thus, the reason why the hair moves towards the brush.

e

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(c) Explain what would happen to her dog's hair if Zoe now strokes it with her bare hand.

Z The dog's hair would gradually fall down due to earthing. This occurs because when Zoe ~~&~~ makes contact with her dog's hair, electrons are conducted/ transferred/ move to the dog's hair; thus, making the dog's hair electrically neutral. As the hair loses its charge, it falls back into place.

(discharge occurs with electrons 'jumping' to dog's hair from Zoe's body/hand) *

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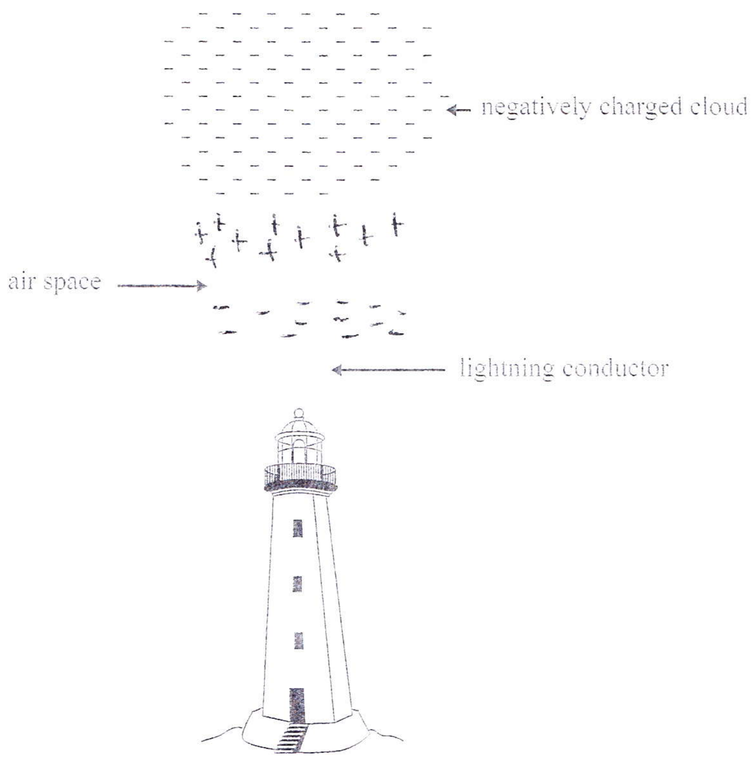
(d) The diagram shows a large, negatively charged thundercloud passing over a lighthouse with a lightning conductor.



(i) On the diagram, draw the charge distribution in the **air space** between the lightning conductor and the charged cloud.

(ii) Explain what causes the charges to be distributed as shown in your diagram.

Charging by induction causes the charges to be distributed in the air~~space~~ space. The negatively charged cloud repels electrons closest to it - meaning these electrons move down. This results in the top of the air~~p~~ space being positively charged (due to lack of electrons) and the bottom, closest to the lightning conductor, being negatively charged (due to excess ~~protons~~ electrons).

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(iii) Lightning strikes can damage the structure of a building. The lightning conductor protects the building from lightning strikes.

Explain how the lightning conductor gives protection to the building from lightning strikes.

In your explanation you should include:

- the type of material used for a lightning conductor
- why this material is used as the lightning conductor
- how the lightning conductor works.

A metal should be used for a lightning conductor. This is because metals are good conductors of electricity due to ~~electrons~~ the weak attraction of electrons to the nucleus - meaning electrons move more easily in a metal.
The lightning conductor protects buildings from lightning strikes by absorbing the impact of the lightning bolt. For instance, the negatively charged cloud causes the top of the conductor to become positively charged (due to induction - as electrons move down). The charges are attracted (as opposite charges attract) and an electrical discharge takes place with electrons flowing down from the cloud. When the conductor receives this, it protects the building as excess electrons are quickly conducted away to its surroundings - thus, meaning it loses its charge easily and becomes electrically neutral - which, hence, protects the rest of the building from the energy carried by the excess electrons.

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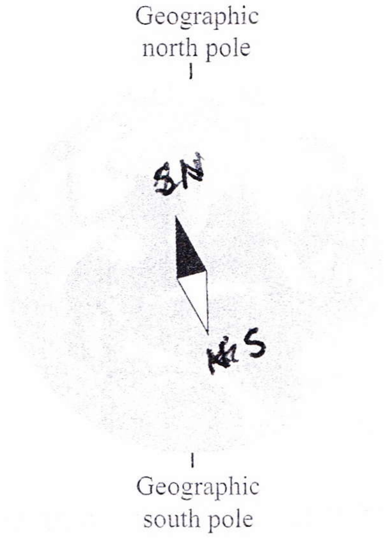
For E8 the answer needs to either explain the reason for the lightning conductor being high up or explain the process of earthing charge.

E7

QUESTION THREE: MAGNETIC EFFECTS

The diagram below shows the **geographic** north and south poles of the Earth.



Adapted from: http://jeweell.com/data_images/out/75/1134759-earth.jpg

(a) The Earth behaves like a giant magnet and creates a magnetic field around itself.

Describe what is meant by the term "magnetic field".

A ~~region~~ magnetic field is a region / area where a force is felt due to the interaction of opposite poles.

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This answer needs to be clear that the force is a magnetic force/ experienced by magnetic materials

(b) A compass needle on Earth points in the direction as shown in the diagram.

(i) On the above diagram, using letters "N" and "S", label the north and the south poles of the **compass needle**.

(ii) Explain why the compass needle points in the direction shown in the diagram.

~~The compass needle points in the directions shown as its poles which point to represent the 'true' north and 'true' south poles point of the Earth as opposed to the and, as it is attracted to the geographic north & south~~

The compass needle points in the directions shown as they are magnetically attracted to the 'true' magnetic north and 'true' south poles of the Earth - which are in the reverse direction of the geographic north and south poles of the Earth.

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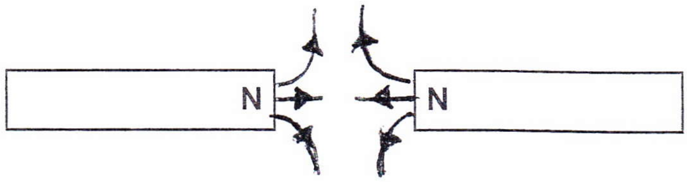
(c) The diagram below shows two magnetic north poles placed close to each other.



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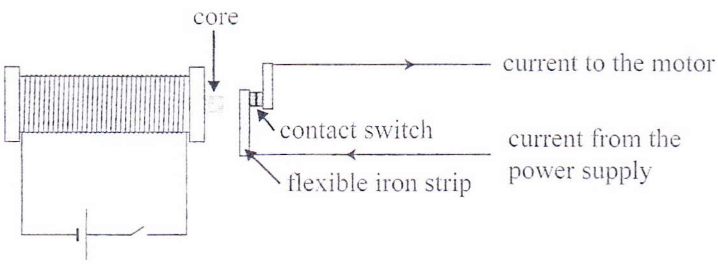
On the diagram, draw lines to show the **pattern** of the magnetic field formed between the two north poles.

Use **arrows** to indicate the direction of the magnetic field.

(d) The diagram shows an electromagnetic relay switch used to **switch off** an electric motor in a factory. The relay consists of a coil outside an inner core. It is placed at a fixed distance from a contact switch, which turns the electric motor on or off. One arm of the switch is made from a flexible iron strip, and is placed near the core of the electromagnetic relay.



(i) Name a suitable material for the core, and give a reason for your answer.

Iron would be a suitable material. This is because it has ferromagnetic properties which allows it to be magnetised & become a magnet. And, it would also be suitable as it does not become a permanent magnet when current flows through it - meaning its strength can be changed depending on the size of the current flowing through the circuit.

(its atoms can be (aligned) to form magnetic domains) and form poles

(ii) The switch is now turned on.

Explain how the relay works.

* A relay is an electrically-operated switch

* When the switch is turned on, current flows through the circuit & the solenoid - thus magnetising the iron core & creating an electromagnet. This then, by magnetic induction, pulls & attracts the flexible iron strip. This disconnects the circuit as the connection at the contact switch is broken. This disables current going to the motor & stops it from working. Thus, this is how the relay works to stop the motor.

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Question Three continues on the following page.

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(iii) When the motor is operating, the current-carrying cable to the motor produces a magnetic field of 1.6×10^{-5} T at a distance of 25 cm from the cable.

Calculate the size of the current in the cable.

$I = \frac{Bd}{k}$, $B = 1.6 \times 10^{-5}$ T , $d = \left(\frac{25}{100}\right) = 0.25$ m

$k = 2.0 \times 10^{-7}$ T m A^{-1}

$\therefore I = \frac{(1.6 \times 10^{-5} \times 0.25)}{(2.0 \times 10^{-7})}$

$= 20$ A

Current: 20 A

E8