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91173 Demonstrate understanding of electricity and electromagnetism

2.00 pm Tuesday 18 November 2014
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 2–10 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.

Achievement

TOTAL

10

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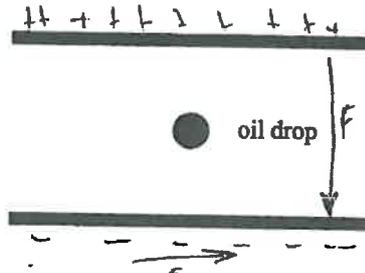
QUESTION ONE: MILLIKAN'S OIL DROP EXPERIMENT

- Charge on electron: $-1.6 \times 10^{-19} \text{ C}$
 Mass of electron: $9.11 \times 10^{-31} \text{ kg}$
 Charge on proton: $+1.6 \times 10^{-19} \text{ C}$
 Mass of proton: $1.67 \times 10^{-27} \text{ kg}$

In 1909 Robert Millikan performed an experiment to determine the size of the charge on an electron. He put a charge on a tiny drop of oil, and measured how strong an applied electric field had to be in order to stop the oil drop from falling.

Janet is doing a similar experiment. She has an electrically charged oil drop held stationary in an electric field, so that it floats.

The oil drop has a net negative charge of $24 \times 10^{-10} \text{ C}$, and is placed in a uniform electric field of strength 610 N C^{-1} directed vertically. The oil drop "floats" (is held suspended) between the plates. (Assume any buoyancy effect of air to be negligible.)



- (a) Name the forces (including directions) acting on the oil drop while it is suspended between the plates.

Force between charge

Electric Force not identified

- (b) Calculate the mass of the oil drop. (Use $g = 9.8 \text{ N kg}^{-1}$ and $F = mg$.)

$$F = Eq$$

$$610 \text{ N C}^{-1} \times 24 \times 10^{-10} \text{ C} = 1.464 \times 10^{-6} \text{ N} = F$$

$$F = mg \quad 1.464 \times 10^{-6} = m \times 9.8 \text{ N kg}^{-1} = 1.494 \times 10^{-7}$$

$$m = 1.494 \times 10^{-7}$$

Mass Correctly found

- (c) Explain what the same charged oil drop would do if the plates were brought closer together. Assume the charge on the oil drop remains the same, and the voltage across the plates remains unchanged.

The two charges will come together very close and it can make a change to the oil drop, it could make the oil drop start moving.

Needed to stated the electric field strength would increases and thus the force

- (d) A free electron and a free proton are placed in identical electrical fields (same electric field strength).

Compare:

- the strength of the electric force on each particle
- the acceleration of each particle (you may neglect gravity and use $a = \frac{F}{m}$).

Give reasons to justify your comparisons.

$$\text{Electric force: } F = Eq \quad 610 \text{ NC}^{-1} \times -1.6 \times 10^{-19} \text{ C} = -9.76 \times 10^{-17} \text{ N} \quad \text{Electron} =$$

$$\text{Electron electric force} = -9.76 \times 10^{-17} \text{ NC}^{-1} \text{ NC}^{-1}$$

$$F = Eq \quad 610 \text{ NC}^{-1} \times 1.6 \times 10^{-19} \text{ C} = 9.76 \times 10^{-17}$$

$$\text{Proton electric force} = 9.76 \times 10^{-17}$$

Acceleration:

$$a = \frac{F}{m}$$

$$\text{Electron} = \frac{-9.76 \times 10^{-17} \text{ NC}^{-1}}{9.11 \times 10^{-31} \text{ kg}} = -1.07 \times 10^{14} \text{ ms}^{-1}$$

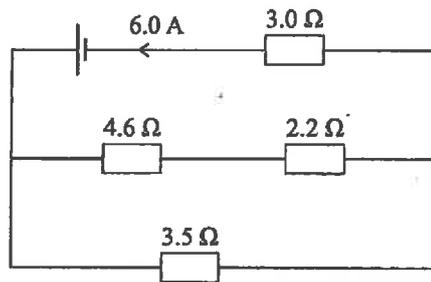
$$\text{proton} = \frac{9.76 \times 10^{-17}}{1.67 \times 10^{-27} \text{ kg}} = 5.84 \times 10^{10} \text{ ms}^{-1}$$

Has used 610 for the field strength and calculations to show the force is the same on the electron and proton and then the acceleration of the electron is higher than the proton

MS

QUESTION TWO: RESISTORS IN A DC CIRCUIT

Sandra is investigating electrical circuits in the lab. She connects various resistors in combination. The current drawn from the supply is 6.0 A.



- (a) Calculate the effective resistance of the circuit.

$$3.0 + 4.6 + 2.2 + 3.5 = 13.3 \Omega$$

Has incorrectly calculated the resistance with all resistors in series

- (b) Calculate the size of the voltage across the 3.5 Ω resistor.

$$V = IR$$

$$6 \times 3.5 = 21 \text{ V}$$

Has assumed 6A flows through the 3.5 ohm resistor

- (c) Express your answer to Question Two (b) to the correct number of significant figures. Give a reason for your choice of significant figures.

$$21 \text{ V (2 sf)} \quad \text{Because all the numbers are in 2 sf.}$$

Correctly rounded and stated 2sf with a reason

- (d) Explain which resistor, the 4.6Ω or the 2.2Ω resistor, would convert the greater amount of energy per second into heat.

$$R_1 = 4.6 \times 6 \times 4.6 = 27.6 \text{ V}$$

$$P = IV = 6 \times 27.6 = 165.6 \text{ J}$$

$$P = \frac{\Delta E}{t} = 165.6 = \frac{\Delta E}{1}$$

$$R_2 = V = IR = 6 \times 2.2 = 13.2 \text{ V}$$

$$13.2 \times 6 = 79.2 \text{ J}$$

Used incorrect current.

Implied current was the same by using the same current and found the power

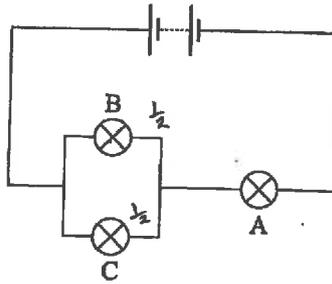
$R_1 = 4.6 \Omega$ will give out greater amount of heat in a second
than 2.2Ω .

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QUESTION THREE: LAMPS AND RESISTORS IN A DC CIRCUIT

Stephen connects identical lamps, as shown in the diagram below.



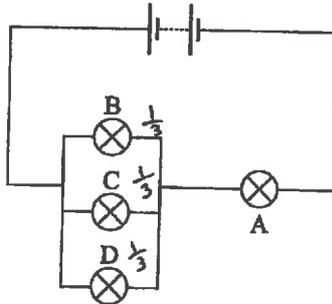
- (a) Lamp B blows.

State what happens to the brightness of lamp A.

It will shut down as it will increase its brightness.

- (b) Stephen replaces lamp B with a new one.

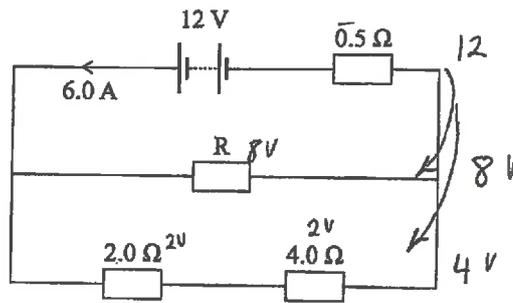
Explain what would happen to the voltage across lamp B and the voltage across lamp A if another identical lamp, D, was added in parallel, as shown in the diagram below.



In the first one lamp A only had to $\frac{1}{2}$ its voltage now it has to $\frac{1}{3}$ its voltage and share it with every bulb.

Mixed up voltage and current

Stephen then takes a selection of resistors and connects them as shown in the diagram below.



- (c) Calculate the voltage across the 0.5Ω resistor.

12V.

Didn't allow for the voltage drop across the 0.5 ohm resistor

- (d) Calculate the resistance of resistor R.

Begin your answer by calculating the voltage across each branch.

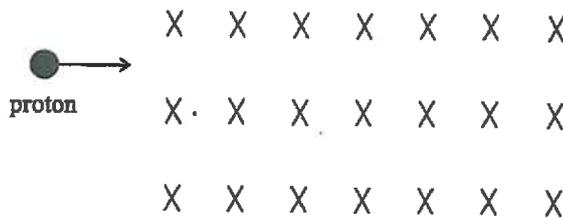
$$V = IR$$

$$8 = 6 \times R = 1.33 \Omega$$

NO

QUESTION FOUR: ELECTROMAGNETISM

A proton of charge $+1.6 \times 10^{-19}$ C moves at right angles across a magnetic field of strength 0.65 T. The constant speed of the proton (in the magnetic field) is 4.8×10^3 m s⁻¹.

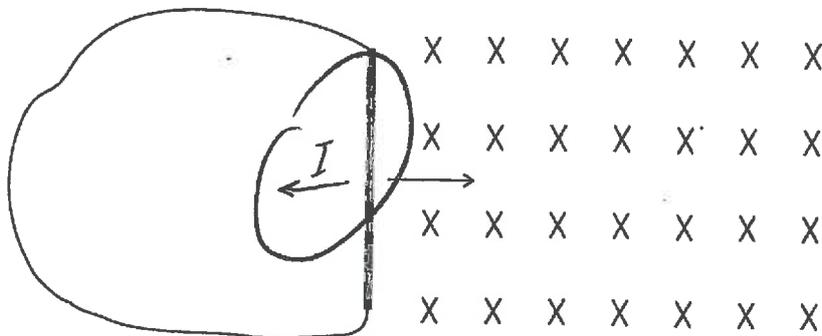


- (a) Calculate the size of the magnetic force on the proton while it is in the field.

$$F = Bqv \quad 0.65 \text{ T} \times 1.6 \times 10^{-19} \text{ C} \times 4.8 \times 10^3 \text{ m s}^{-1} = 4.992 \times 10^{-16}$$

$$F = 4.9 \times 10^{-16}$$

A piece of conducting rod whose ends are connected by a wire as shown, is moved through a magnetic field that is directed into the page. The direction in which the rod is moved is indicated by an arrow.



Incorrect use of a right hand rule

- (b) On the diagram draw an arrow to show the direction of the induced current (conventional current) around the loop formed by the rod and wire.
- (c) Explain why there will be an induced current in the rod and wire due to movement of the rod across the magnetic field.

Because the rod is passing the current when it is trying to go through the magnetic field.

The current is causing interference to the rod and the rod is interfering with the current's path way. That's why they can be induced current in the rod.

Needed to mention the force on the electrons in the wire

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B

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(d) In the situation above, the length of the rod is 0.40 m and the magnetic field strength is 0.85 T . The rod is moved with a speed of 4.6 m s^{-1} through the field. The combined resistance of the rod and wire is 0.68Ω .

By calculating the voltage induced, calculate the size of the force that must be applied to the rod to keep it moving at a steady speed through the magnetic field.

$$V = BLv = 0.85 \text{ T} \times 4.6 \text{ m s}^{-1} \times 0.40 \text{ m} = 1.564$$

$$V = 1.5 \text{ V (2.s.f.)}$$

S

$$V = IR$$
$$1.5 \text{ V} = I \times 0.68 \Omega = I = 2.2$$

12