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Level 2 Physics, 2018

91173 Demonstrate understanding of electricity and electromagnetism

9.30 a.m. Friday 9 November 2018
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 2–12 in the correct order and that none of these pages is blank.

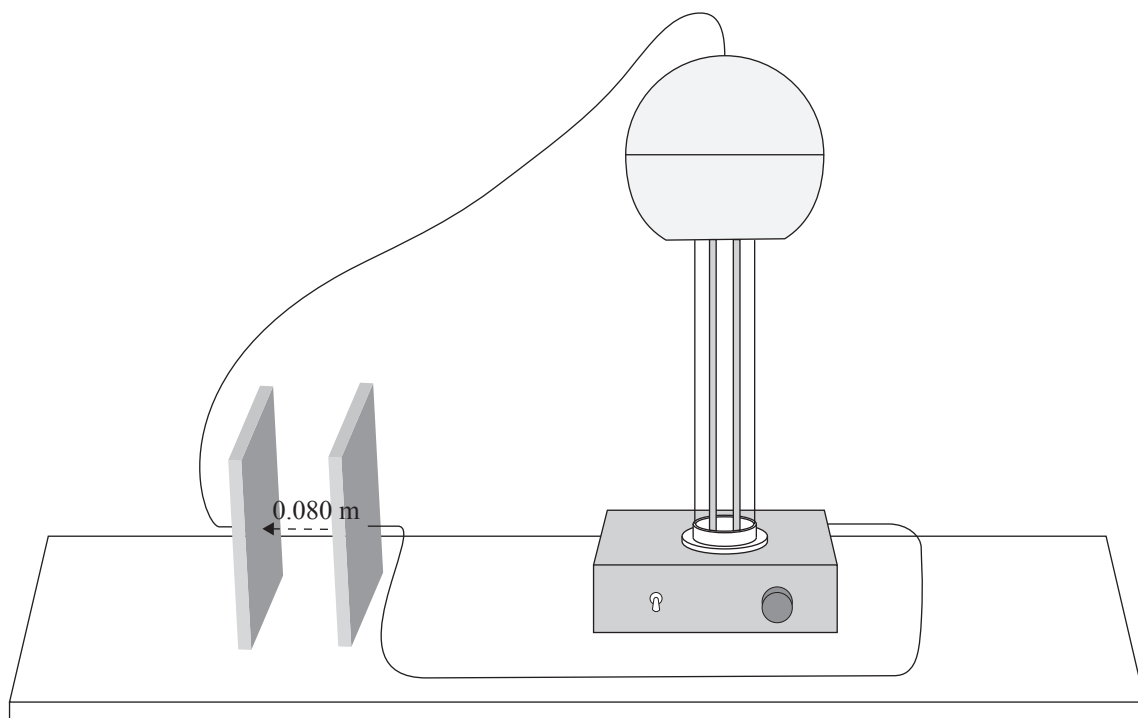
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL

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QUESTION ONE: THE CANDLE AND THE VAN DE GRAAFF GENERATOR

Sam has connected his school's Van de Graaff generator (high voltage DC power source) to two parallel metal plates that are 0.080 m apart.



- (a) An electric field strength of $2.50 \times 10^6 \text{ V m}^{-1}$ is established between the plates when the Van de Graaff generator is turned on.

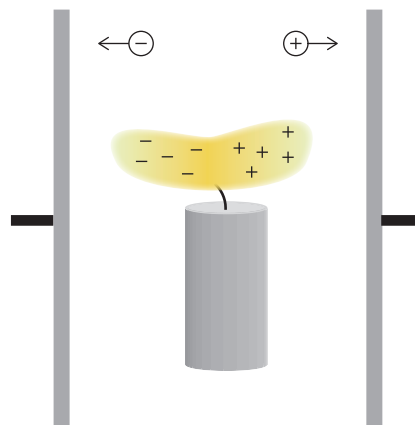
Calculate the voltage between the plates.

The flame of a candle contains both positively and negatively charged particles.

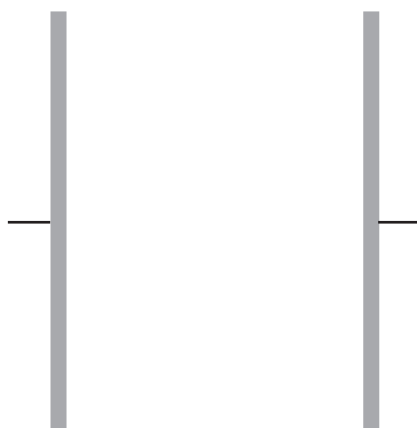


When Sam places a burning candle between the two parallel metal plates connected to the Van de Graaff generator, the flame spreads out as shown in the diagram.

The negatively charged particles within the flame move to the left and the positively charged particles move to the right.

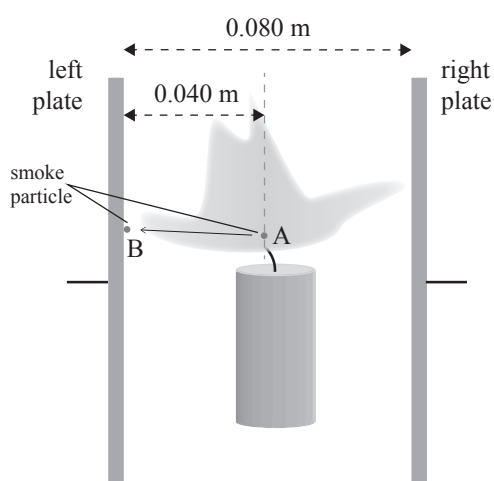


- (b) Draw the electric field formed between these two parallel metal plates, clearly indicating which plate is positive.



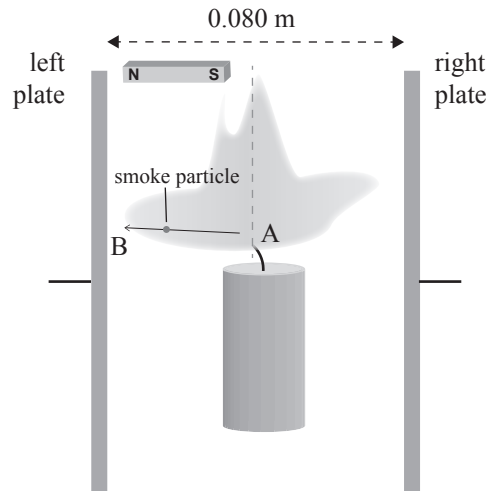
- (c) Sam then extinguishes the candle, causing a moving trail of smoke to appear. The negatively charged smoke particles travel to the left and the positively charged smoke particles travel to the right.

An initially stationary negatively charged smoke particle with a charge of $6.52 \times 10^{-13} \text{ C}$ is positioned centrally at point A. The smoke particle is accelerated to the left, due to the $2.50 \times 10^6 \text{ V m}^{-1}$ electric field.



Using conservation of energy, calculate the speed of the $4.5 \times 10^{-6} \text{ kg}$ smoke particle the instant before it collides with the left hand plate (point B) that is 0.040 m away from point A.

- (d) A strong permanent bar magnet is then placed high above the smoke trail, so the north pole is pointing towards the left. The negatively charged smoke particles are travelling from the candle to the left hand plate (point A to point B).



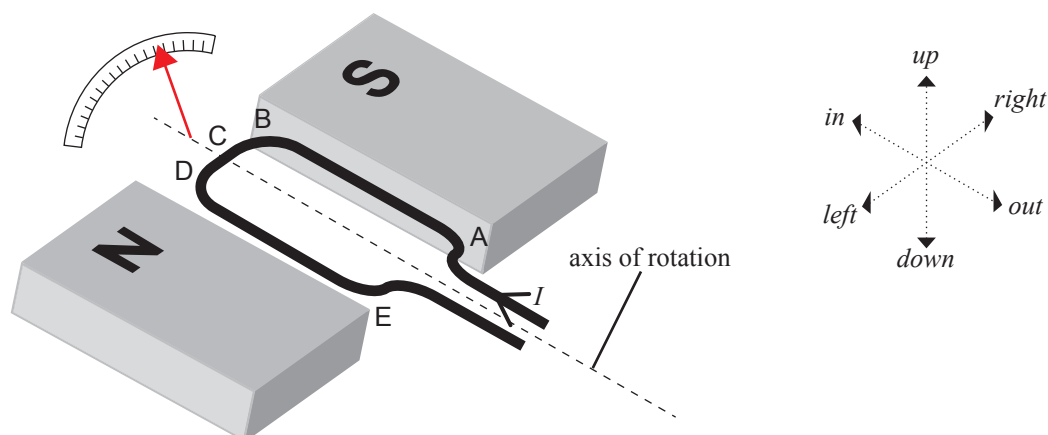
- (i) State two changes, not involving the magnet, that could be made to increase the velocity of the negatively charged smoke particle.
- _____
- _____
- (ii) For one of the changes, clearly explain the relevant physics of how the change increases the velocity of the negatively charged smoke particle.
- _____
- _____
- _____
- (iii) Discuss what could be done with the magnet to affect the motion of the negatively charged smoke particle.
- _____
- _____
- _____
- _____

QUESTION TWO: THE AMMETER

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The diagram below shows a simplified version of the inside of an analogue ammeter.

Current passes through the coil (ABCDE) within a magnetic field, causing a magnetic force that moves the needle, indicating the amount of current passing through the meter.



- (a) A current of 2.5 A passes anticlockwise through the ammeter (ABCDE).

State the direction of the force (if any) on each section of wire.

No calculations are necessary.

- (i) AB down
- (ii) BC no force
- (iii) DE up

- (b) A **total** force of 0.60 N is produced on the wire within the ammeter when 2.5 A is passed through its coil.

Calculate the effective length of the **coiled** wire between points A and B.

The magnetic field strength within the ammeter is 0.20 T.

$$F = BIL$$

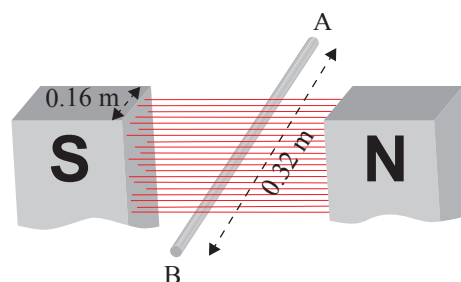
$$0.6 = 0.2 \times 2.5 \times L$$

$$L = 0.6 / (0.2 \times 2.5)$$

$$L = 1.2 \text{ m}$$

- (c) At a later time, a metal rod is moved downwards between the poles of a horse-shoe magnet at a constant speed of 7.5 m s^{-1} across a strong 3.5 T magnetic field.

The rod AB is 0.32 m and the sides of the horseshoe magnet are 0.16 m wide.



Calculate the voltage induced in the rod AB, and state which end is positive.

$$V = BvL$$

$$V = 3.5 * 7.5 * 0.16$$

$$V = 4.2$$

End ____ is positive.

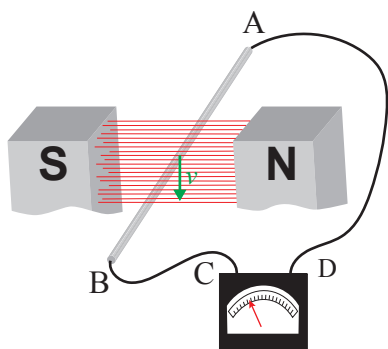
- (d) Sam completed the experiment three more times, maintaining the same speed and magnet. In the experiments below, he attached a conducting wire with non-zero resistance through a sensitive ammeter, wanting to determine which experiment would induce a current.

Experiment 1: Rod AB moves downwards inside the magnetic field, wires AD and BC complete the circuit outside the magnetic field

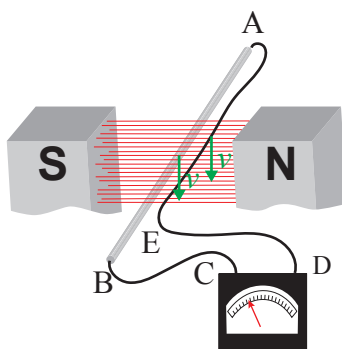
Experiment 2: Rod AB and wire AE both move downwards inside the magnetic field. Wires BC and ED complete the circuit outside the magnetic field

Experiment 3: Rod AB moves downwards inside the magnetic field. Wire EF remains stationary inside the magnetic field. Wires BC, AF, and ED complete the circuit outside the magnetic field.

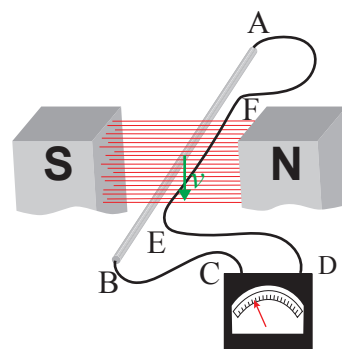
Experiment 1



Experiment 2



Experiment 3



- (i) For experiments 2 and 3, state whether a voltage is induced in the wire AB.

- (ii) For each of the experiments, justify whether current flows through the closed loop, explaining the underlying physics principles involved.

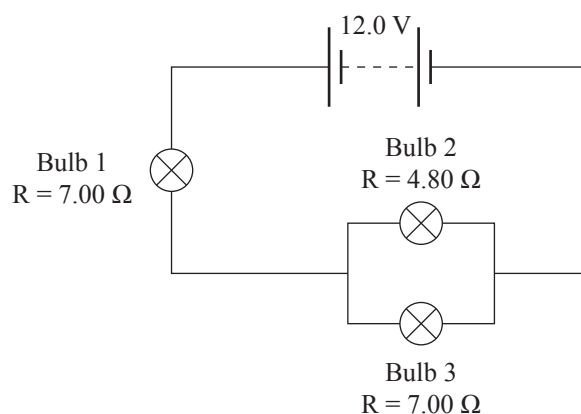
Experiment 1: _____

Experiment 2: _____

Experiment 3: _____

QUESTION THREE: CIRCUITS

Use the following circuit diagram to answer the questions below.



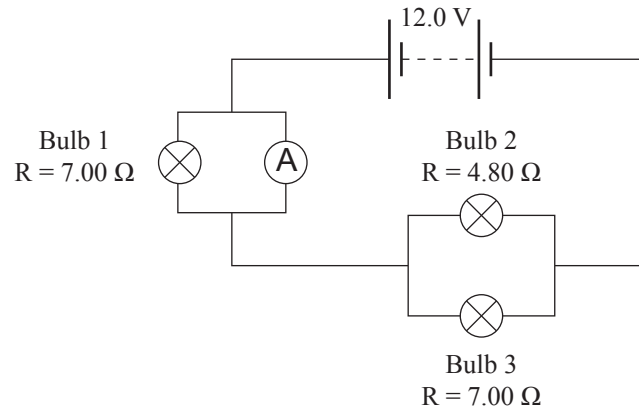
- (a) Show that the total resistance of the above circuit is approximately $10\ \Omega$.

- (b) Calculate the voltages across bulb 1 and bulb 2.

- (c) Bulbs 2 and 3 are not the same brightness.

Discuss which bulb is brighter, and why.

- (d) An ideal ammeter (with negligible resistance) is added to the previous circuit as shown below.



Discuss the effect adding the ammeter has on the current, the voltage, and hence the brightness of each bulb.

Extra space if required.
Write the question number(s) if applicable.

QUESTION
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