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Level 1 Physics 2021

90937 Demonstrate understanding of aspects of electricity and magnetism

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.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

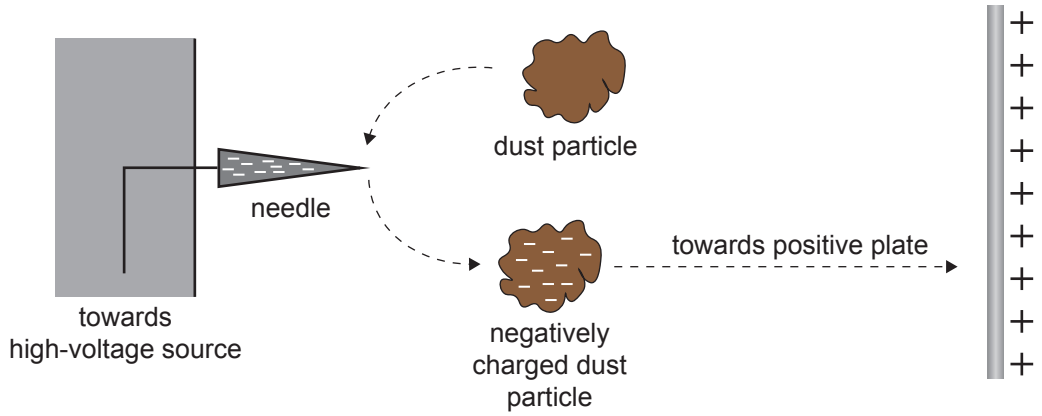
Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

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

QUESTION ONE: THE IONISER

An air ioniser is a device that uses static electricity to remove dust from the air.

As shown in the diagram below, this works by first making dust particles negatively charged when they come in contact with the tip of a fine needle. The needle is connected to a powerful high-voltage source that makes it negatively charged. The dust particles are then attracted to a positively charged metal plate and thereby removed from the air.



(a) Explain why the needle must be made of a conducting material.

(b) How are the dust particles negatively charged, and how does this affect their motion?

If negatively charged particles touch a positively charged metal plate, they discharge and become electrically neutral.

(c) One discharge event takes 0.008 s and involves an energy transfer of 0.4 mJ (4×10^{-4} J). The discharge current is 2.0 μA (2.0×10^{-6} A).

Calculate the voltage between the charged particle and the metal plate.

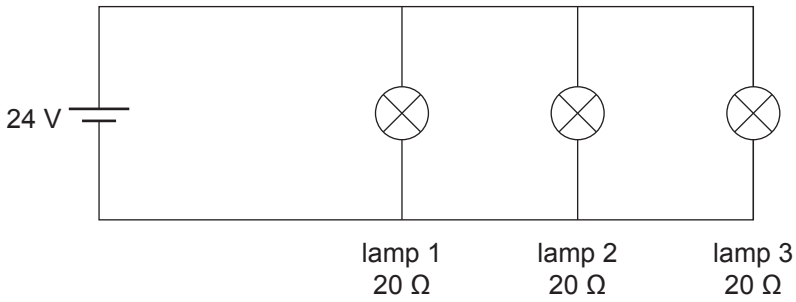
(d) The discharged dust particles remain attached to the positively charged metal plate. This causes a build-up of dust on the plate.

Explain in terms of electrical charges why the plate needs to be cleaned periodically.

QUESTION TWO: AT THE OFFICE

Source: https://vke.nl/product/idoo-pendent/

An office room uses a separate 24 V power supply to run a set of three LED lamps for a large desk. A part of the circuit is shown in the diagram below.

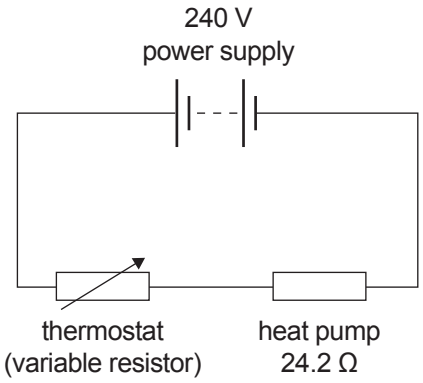


(a) State the voltage that is supplied to each lamp.

(b) (i) Show that the current through lamp 1 is 1.2 A.

(ii) Calculate the current supplied to the set of three lamps by the power supply.

The temperature in the room is controlled by a thermostat. This is a variable resistor in series with a heat pump set in cooling mode, as shown in the diagram below. When the room heats up, the resistance of the thermostat decreases.



(c) Describe and explain how the current through the heat pump changes as the office room heats up.

(d) When the room heats up, the resistance of the thermostat drops to 1.9 Ω.

Calculate the power rating of the heat pump at this temperature.

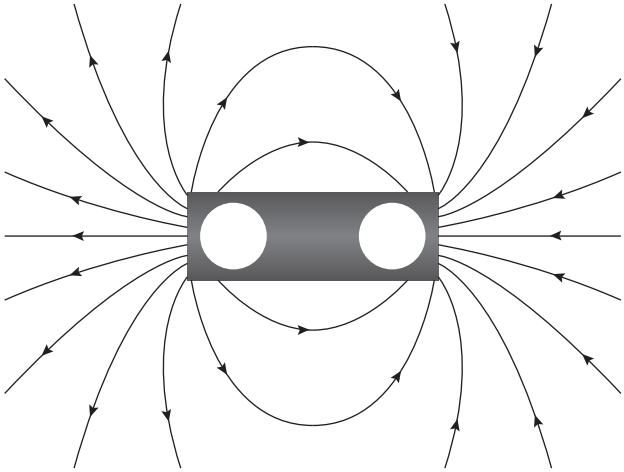
Start by showing that the total current drawn from the power supply is 9.195 A.

QUESTION THREE: THE HOVERCAR

In Masdar City, Abu Dhabi, the Personal Rapid Transit (PRT) trialled a fleet of small vehicles that use electromagnetism to hover over tracks that have magnets buried beneath them.

Source: https://divisare.com/projects/150752-foster-partners-nigel-young-masdar-institute

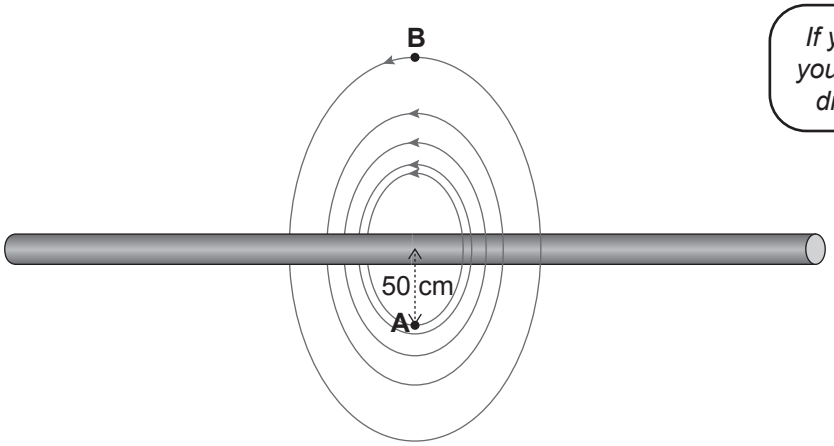
(a) In the diagram below, label the North and South poles.



If you need to redraw your response, use the diagram on page 9.

A length of wire in the PRT vehicle is shown in the diagram below. The strength of the magnetic field at point A (50 cm away from the wire) is 3.36×10^{-6} T.

If you need to redraw your response, use the diagram on page 9.



(b) (i) Draw an arrow on the diagram above to show the direction of the current through the wire.

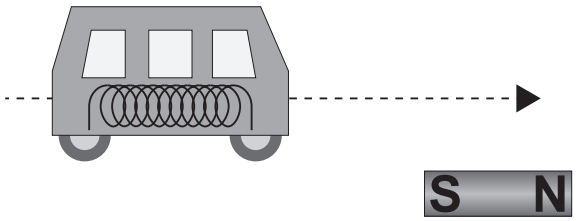
(ii) Calculate the size of the current through the wire.

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

(c) Compare the strength and direction of the magnetic field at point A and point B.

Question Three continues on the following page.

(d) The diagram below shows the solenoid in the vehicle gliding towards a magnet in the tracks.



If you need to redraw your response, use the diagram on page 9.

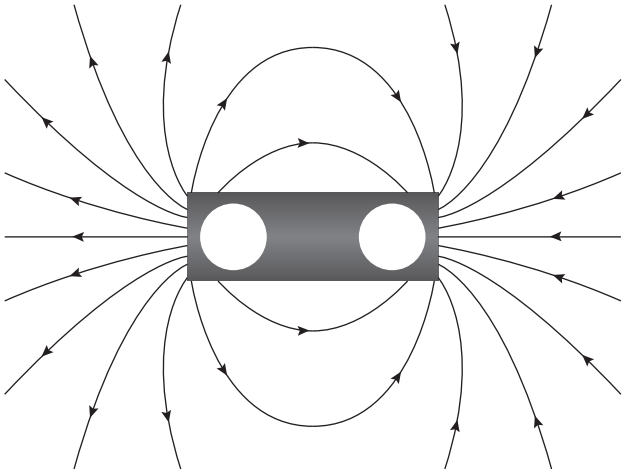
Describe and explain the direction of the current in the solenoid circuit that pulls the vehicle to the right.

In your answer, you should:

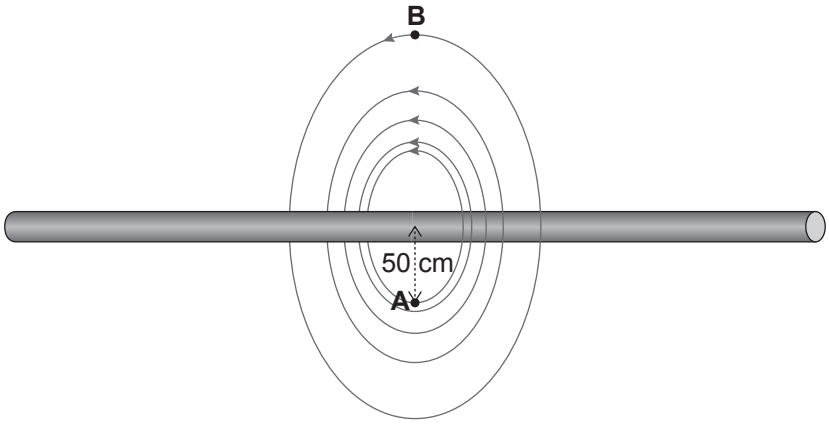
- label the poles of the solenoid (with N, S, or none) required for the field of the solenoid to pull the vehicle to the right
- state the required direction of the current in the solenoid circuit (clockwise, counter-clockwise, or none)
- describe the forces between the solenoid in the vehicle and the permanent magnet.

SPARE DIAGRAMS

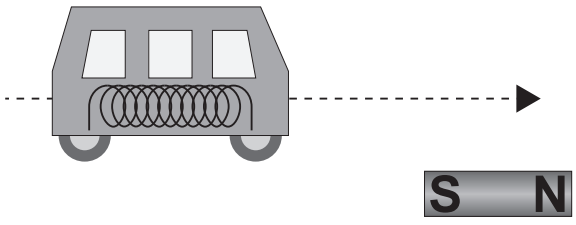
If you need to redraw your response to Question Three (a), use the diagram below. Make sure it is clear which answer you want marked.



If you need to redraw your response to Question Three (b), use the diagram below. Make sure it is clear which answer you want marked.



If you need to redraw your response to Question Three (d), use the diagram below. Make sure it is clear which answer you want marked.



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

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