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Level 2 Physics 2020

91173 Demonstrate understanding of electricity and electromagnetism

9.30 a.m. Monday 16 November 2020
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 2–11 in the correct order and that none of these pages is blank.

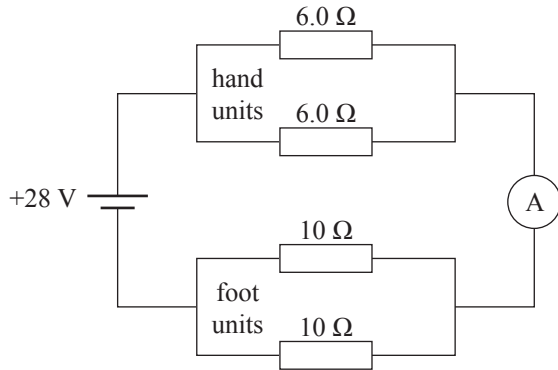
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL

ASSESSOR'S USE ONLY

QUESTION ONE: FIRST CLASS CABINS

In a first class cabin, the seats are fitted with four heating units; two for the hands, and two for the feet. The hand units have a resistance of 6.0Ω , and the foot units 10Ω . The heating circuit is connected to the 28 V supply.



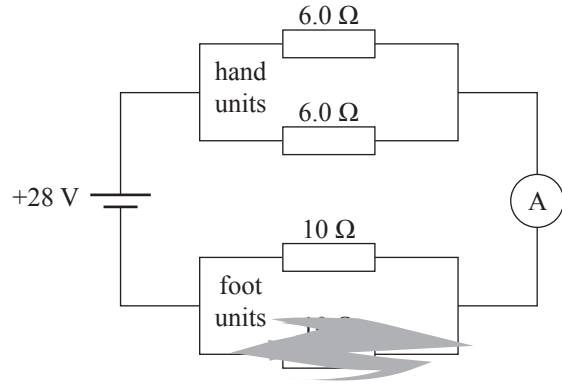
- (a) Show the combined resistance of the hand units is 3.0Ω .

- (b) Calculate the current flowing through the ammeter.

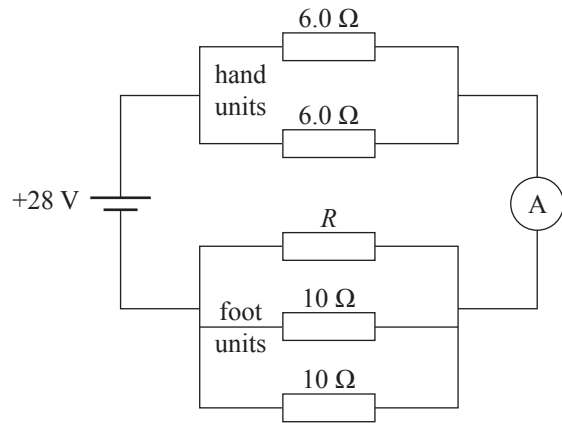
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- (c) One of the foot units stops working.

Explain what effect this would have on the current through a single hand unit.



- (d) As an upgrade, the airline adds an additional heating unit (labelled R) to the seat. When the new heating unit is added, the power output from the supply is 120 W.



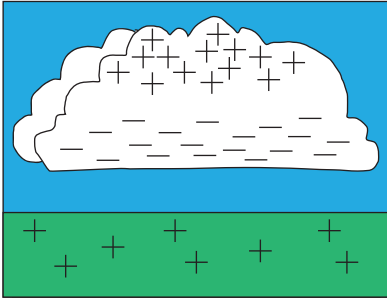
What is the value of the resistance, R , of the new heating unit?

QUESTION TWO: LIGHTNING

Mass of electron = 9.11×10^{-31} kg

Charge on electron = -1.60×10^{-19} C

Lightning is typically caused by a build-up of electrons in clouds being released to Earth. The bottom of the cloud is negatively charged, and the ground under the cloud becomes positively charged.



The cloud and the ground can be modelled by a pair of parallel plates.

----- base of cloud

+++++ ground

The voltage difference between a particular cloud and the ground is 1.75×10^8 V, and the electric field strength is 8.57×10^4 V m⁻¹.

- (a) Find the height of the cloud above the ground.

- (b) A weather balloon is released from the ground.

The balloon has a charge of $3.70 \mu\text{C}$ (3.70×10^{-6} C).

Calculate the size and direction of the electrostatic force exerted on the balloon when it is halfway between the cloud and the ground.

- (c) How does the electrostatic force on an electron change as it travels from the cloud to the ground?

Use physics principles to explain your answer.

- (d) An electron is discharged downwards from the base of the cloud with a speed of $1.20 \times 10^5 \text{ m s}^{-1}$.

It reaches a speed of $4.20 \times 10^5 \text{ m s}^{-1}$.

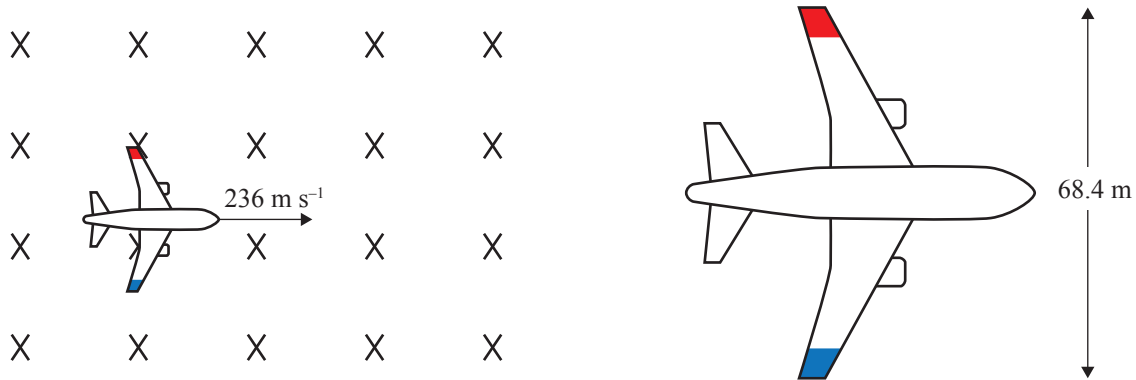
Calculate the distance it could have travelled from the cloud to have reached this speed.

QUESTION THREE: THE PLANE

A plane with metal wings has one wing tip painted blue and the other wing tip red.

The wingspan is 68.4 m.

The plane is flying horizontally at 850 km h^{-1} (236 m s^{-1}) in a region where the Earth's magnetic field is vertical and has a strength of $40.0 \mu\text{T}$ ($40.0 \times 10^{-6} \text{ T}$).



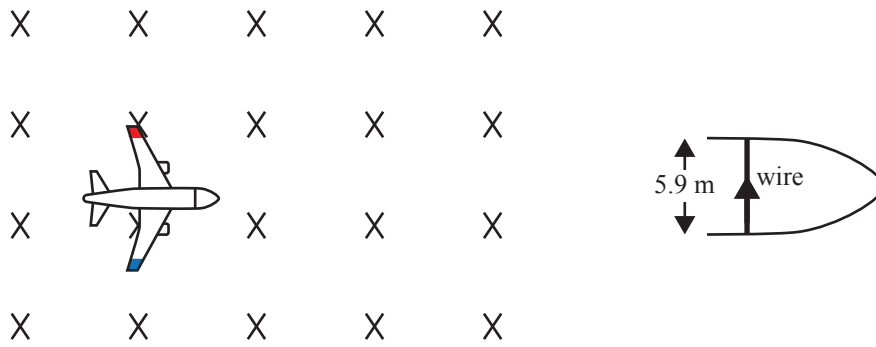
- (a) Show the voltage induced between the ends of the wings is 0.646 V.

- (b) Complete the following table.

Assume each change is made to the original plane separately.

Change	Effect on size of induced voltage	Which colour wing tip is positive
Speed of plane increases		
Plane is flown in opposite direction at the same speed		
Plane climbs vertically upwards from the earth		

- (c) Inside the plane, an electrical feeder wire runs under the floor of the cabin.



The wire is connected to a 28 V supply, and the circuit has 5.0Ω resistance.

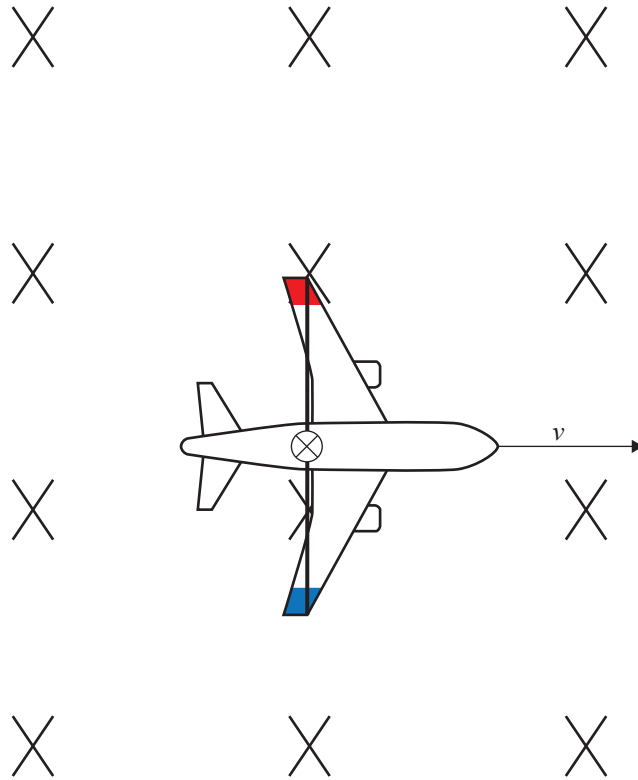
If the current is flowing in the direction shown in the wire, calculate the magnitude, and state the direction, of the force on the wire due to the Earth's magnetic field.

Direction is (circle one):

into page **out of page** **up (\uparrow)** **down (\downarrow)** **left (\leftarrow)** **right (\rightarrow)**

**Question Three continues
on the following page.**

- (d) An engineer designs a speed-warning device that consists of a wire connecting the wing tips and a 0.5 V lamp. The engineer states that the faster the plane goes, the brighter the lamp will glow.



Use physics principles to explain and justify if and how this arrangement would work as a speed-warning device.

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