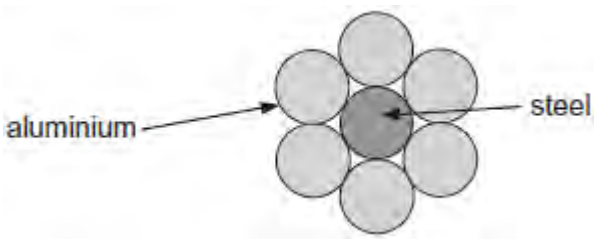
Q1. A cable used in high-voltage power transmission consists of six aluminium wires surrounding a steel wire. A cross-section is shown below.



The resistance of a length of 1.0 km of the steel wire is 3.3 Ω. The resistance of a length of 1.0 km of **one** of the aluminium wires is 1.1 Ω.

(a) The steel wire has a diameter of 7.4 mm.
Calculate the resistivity of steel. State an appropriate unit.

resistivity = ... unit .....

(4)

(b) Explain why only a small percentage of the total current in the cable passes through the steel wire.

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(3)

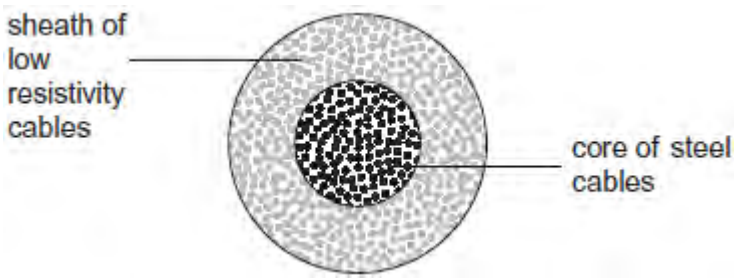
(c) The potential difference across a length of 1.0 km of the cable is 75 V.

Calculate the total power loss for a 1.0 km length of cable.

Total power loss ..... W

(3)
(Total 10 marks)

Q2. The overhead cables used to transmit electrical power by the National Grid usually consist of a central core of steel cables surrounded by a sheath of cables of low resistivity material, such as aluminium.



What is the main purpose of the steel core?

A To force more current into the outer sheath.

B To provide additional current paths through the cables.

C To reduce the power lost from the cables.

D To increase the mechanical strength of the cables.

(Total 1 mark)

Q3. A cylindrical conductor of length l, diameter D, and resistivity ρ has a resistance R.

What is the resistance of another cylindrical conductor of length l, diameter $\frac{D}{2}$, and resistivity ρ?

A $8R$ ⬭

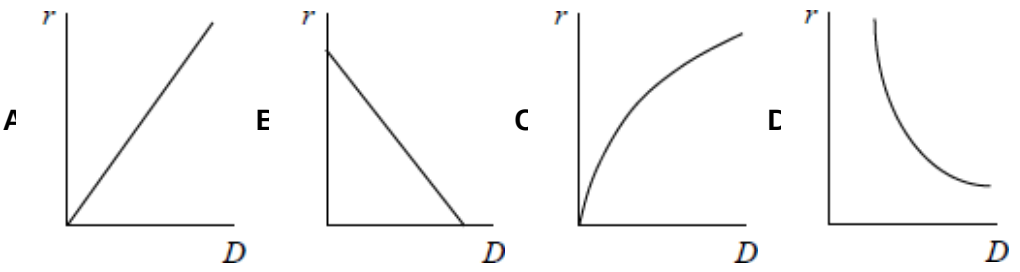
B $4R$ ⬭

C $2R$ ⬭

D R ⬭

(Total 1 mark)

Q4. Which graph shows how the resistance per unit length r of a wire varies with diameter D of the wire?



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

Q5. The critical temperature of tin is −269 °C. The resistivity of tin increases as its temperature rises from −269 °C.

(a) (i) Define resistivity.

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(2)

(ii) State the significance of the critical temperature of a material.

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(2)

(b) A sample of tin in the form of a cylinder of diameter 1.0 mm and length 4.8 m has a resistance of 0.70 Ω.

Use these data to calculate a value of the resistivity of tin.
State an appropriate unit for your answer.

resistivity ..... unit .....

(4)
(Total 8 marks)

Q6. At room temperature a metal has a resistivity of 4.5×10^{-7} Ωm. A wire made from this metal has a radius of 0.70 mm.

(a) (i) Calculate the resistance of a 2.5 m length of the wire at room temperature.

resistance .....Ω

(3)

(ii) Calculate the power dissipated in this length of wire when it carries a current of 20 mA. Assume the resistance of the wire is constant.

power .....W

(2)

(b) The wire becomes superconducting as it is cooled. Draw a sketch graph on the axes below to show how the wire's resistivity would vary with temperature as it is cooled from room temperature θ_r.

(3)

(c) Explain why the efficiency of electrical power transmission is improved when conventional wires are replaced with superconducting wires.

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(1)

(Total 9 marks)

Q7. A copper connecting wire is 0.75 m long and has a cross-sectional area of 1.3×10^{-7} m^2.

(a) Calculate the resistance of the wire.

resistivity of copper = 1.7×10^{-7} Ωm

resistance = ... Ω

(2)

(b) A 12 V 25 W lamp is connected to a power supply of negligible internal resistance using two of the connecting wires. The lamp is operating at its rated power.

(i) Calculate the current flowing in the lamp.

current = ... A

(1)

(ii) Calculate the pd across each of the wires.

pd = ... V

(1)

(iii) Calculate the emf (electromotive force) of the power supply.

emf = ... V

(2)

(c) The lamp used in part (b) is connected by the same two wires to a power supply of the same emf but whose internal resistance is not negligible.

State and explain what happens to the brightness of the lamp when compared to its brightness in part (b).

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(2)
(Total 8 marks)

Q8. (a) State what is meant by a superconducting material.

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(2)

(b) State an application of a superconductor and explain why it is useful in this application.

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(2)
(Total 4 marks)

Q9. (a) The rating of a car headlamp is 12 V, 55 W.

The resistance in this headlamp is due to a thin piece of wire. At its working temperature, the wire has a length of 5.0×10^{-2} m and a cross-sectional area of 1.9×10^{-8} m^2.

Calculate, at the working temperature, the resistivity of the metal used to make the wire.

State an appropriate unit for your answer.

resistivity .....unit .....

(5)

(b) (i) Define the term electromotive force (emf).

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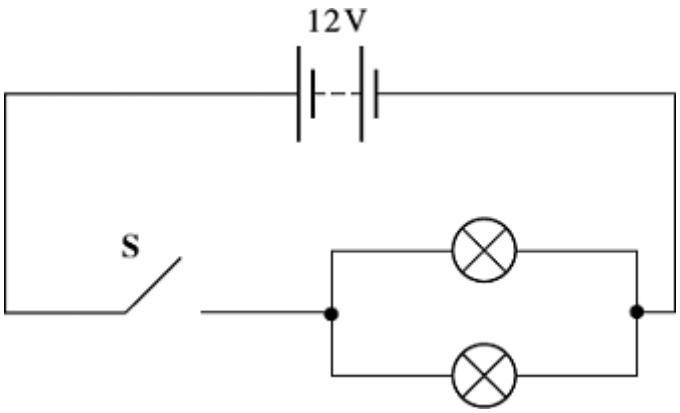
(2)

(ii) The figure below is a circuit diagram illustrating how two of these headlamps are connected to a car battery.



The car battery has an emf of 12 V.

When the switch **S** is closed there is a current of 9.1 A through the battery and a potential difference of 11.9 V across the headlamps.
Calculate the internal resistance of the car battery.

internal resistance ..... Ω

(2)

(c) A fault develops in one of the headlamps in the figure above causing its resistance to decrease.
State and explain how this fault affects the brightness of the other headlamp.

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(3)
(Total 12 marks)