Name: ____

Resistivity (old)

Questions

Date:

Time:

Total marks available:

Total marks achieved: ______

Questions

Q1.

Select one answer from A to D and put a cross in the box (☒)

The heating element for an electric fire is made from a wire of resistance *R*. It is replaced with a wire of the same material which has the same length but is twice the diameter. The resistance of this second wire is

☐ **A** ¼ *R*

☐ **B** ½ *R*

☐ **C** 2*R*

☐ **D** 4*R*

(Total for Question = 1 mark)

Q2.

When a wire is stretched it becomes longer and thinner. This changes the electrical resistance of the wire. The resistance strain gauge is based on this idea.

Explain what effect stretching a length of wire would have on its resistance, using an equation to justify your answer.

(3)

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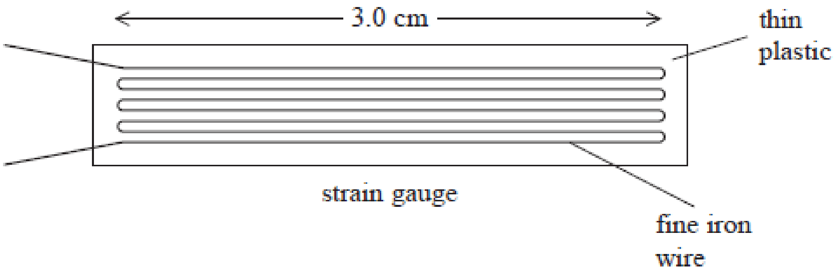
(Total for question = 3 marks)

Q3.

When a wire is stretched it becomes longer and thinner. This changes the electrical resistance of the wire. The resistance strain gauge is based on this idea.

The diagram shows a resistance strain gauge. The wire in the gauge is arranged in a zigzag pattern.



The length of the zigzag pattern is 3.0 cm and the cross-sectional area of the iron wire is 8.5×10^{-8} m^2.

Show that the total resistance of the wire in the strain gauge is about 0.3 Ω.

resistivity of iron = 9.9×10^{-8} Ω m

(3)

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(Total for question = 3 marks)

Q4. A strain gauge measures changes in the resistance of a metal under strain to find the applied force. The kitchen balance in the photograph uses strain gauges to measure the weight of cooking ingredients.

A student tests this method by measuring the resistance of a wire before a force is applied and while it is under tension.

(a) Calculate the initial resistance of the wire.

length of wire = 1.0 m

cross sectional area of wire = 2.9×10^{-8} m^2

resistivity of wire = 4.9×10^{-7} Ω m

(2)

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Resistance of wire = ...

(b) The student applies a force to the wire and measures the new length. He calculates the increase in the resistance to be 0.035 Ω. He measures the increase in resistance and finds it to be 0.070 Ω.

The student suggests that the difference between these two values is because the cross-sectional area of the wire changes under strain.

Explain why a change in cross-sectional area would cause this difference.

(3)

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(Total for Question = 5 marks)

Q5.

When a wire is stretched it becomes longer and thinner. This changes the electrical resistance of the wire. The resistance strain gauge is based on this idea.

(i) A wire of length *l* and cross-sectional area *A* is stretched. Assuming the volume *V* of the wire remains constant, then

$$V = lA = \text{constant}$$

Show that the resistance of the wire is directly proportional to l^2 .

(2)

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(ii) The length of the zigzag pattern when stretched increases to 3.02 cm.

Calculate the increase in resistance of the wire in the gauge.

(3)

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Increase in resistance of wire = ...

(Total for question = 5 marks)

Q6.

The photograph shows a marble statue. The statue is protected by a lightning conductor.

During a storm, a flash of lightning passes between a cloud and the lightning conductor.
As a result a current of 15000 A flows for a time of 3.0×10^{-2} s.

(a) Calculate the charge that flows in the lightning conductor during this time.

(2)

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Charge = ...

(b) The lightning conductor is 1 m taller than the statue and is made from copper, which has a resistivity of 1.7×10^{-8} Ω m. The lightning conductor has a cross-sectional area of 1.5×10^{-4} m^2 and a resistance of 2.7×10^{-3} Ω.

Calculate the height of the statue and state an assumption that you have made.

(4)

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Height of statue = ...

Assumption:

....

(c) Suggest why the lightning conductor is taller than the statue.

(1)

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(Total for Question = 7 marks)

Q7.

The black core of a pencil is referred to as pencil lead.

Pencil lead is a non-metallic material which has a resistivity of 5.4×10^{-3} Ω m at room temperature.

(a) A piece of pencil lead has a length of 15 cm and a cross-sectional area of 1.5×10^{-6} m^2.

Show that its resistance is approximately 500 Ω.

(3)

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(b) (i) Pencil lead has a negative temperature coefficient of resistance.

Explain what this means.

(2)

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*(ii) A piece of pencil lead is connected in series with an ammeter and a power supply.

The power supply is turned on. After a few minutes, although the potential difference across the pencil lead does not change, the current in the circuit increases significantly.

Explain why the current increases.

(3)

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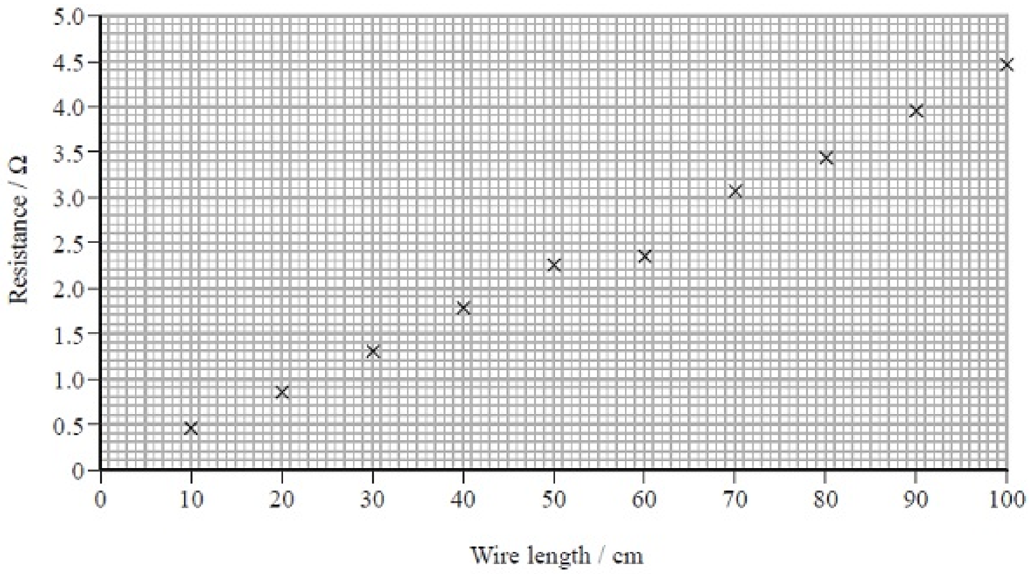
(Total for Question = 8 marks)

Q8. A student carried out a series of measurements to determine how the resistance of a wire varies with its length.

The student obtained the following results.

Wire length / cm	Current / A	Potential difference / V	Resistance / Ω
100	0.15	0.67	4.47
90	0.16	0.63	3.94
80	0.17	0.58	3.41
70	0.17	0.52	3.06
60	0.18	0.42	2.33
50	0.18	0.40	2.22
40	0.19	0.34	1.79
30	0.20	0.26	1.30
20	0.22	0.18	0.82
10	0.22	0.10	0.45

The student plotted the results on a graph.



(a) Calculate the resistivity of the wire used.

cross-sectional area of wire = 1.06×10^{-7} m^2

(4)

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Resistivity = ...

(b) One precaution taken by the student was to keep the current small.

Explain why this precaution was necessary.

(2)

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(c) Explain **one** other precaution which should be taken by the student to ensure the accuracy of the results in the table.

(2)

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(Total for Question = 8 marks)

Q9.

The photograph shows a typical hairdryer.

(a) The hairdryer contains a heating element which consists of a long nichrome wire wound around an insulator. The heating element operates at 230 V and has a power rating of 1 kW.

Show that the resistance of the heating element is about 50 Ω.

(3)

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(b) The nichrome wire has a cross-sectional area of 1.3×10^{-7} m^2.

Calculate the length of the wire.

resistivity of nichrome = 1.1×10^{-6} Ω m

(2)

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Length = ...

(c) The nichrome wire has a diameter of 0.40 mm. A manufacturer wishes to make a hairdryer of the same resistance but using half the length of wire.

Calculate the diameter of nichrome wire that must be used.

(3)

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Diameter = ...

(Total for Question = 8 marks)

Q10.

The instruction booklet for an electric garden shredder includes the following advice.

When using an extension cable, the following dimensions should be observed:

Cross-sectional area of conductor / mm^2	Maximum cable length / m
1.00	40
1.50	60
2.50	100

(a) Describe the relationship between area and length in the table.

(1)

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(b) The cable for the shredder contains two conductors in series, the live wire and the neutral wire. A cable of length 40 m has a total conductor length of 80 m.

(i) Show that the resistance of a copper conductor of length 80 m and cross-sectional area 1.00 mm^2 is about 1.3 Ω.

resistivity of copper = 1.68×10^{-8} Ω m

(2)

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(ii) When in use the current for the shredder is 11 A.
Calculate the rate of energy dissipation by the 40 m, 1.00 mm^2 cable when it is used with the shredder.

(2)

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Rate of energy dissipation = ...

(iii) Calculate the total potential difference across the conductors in the 40 m cable when it is used with the shredder.

(2)

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Potential difference = ...

(c) Suggest why the advice in the instruction booklet is included.

(2)

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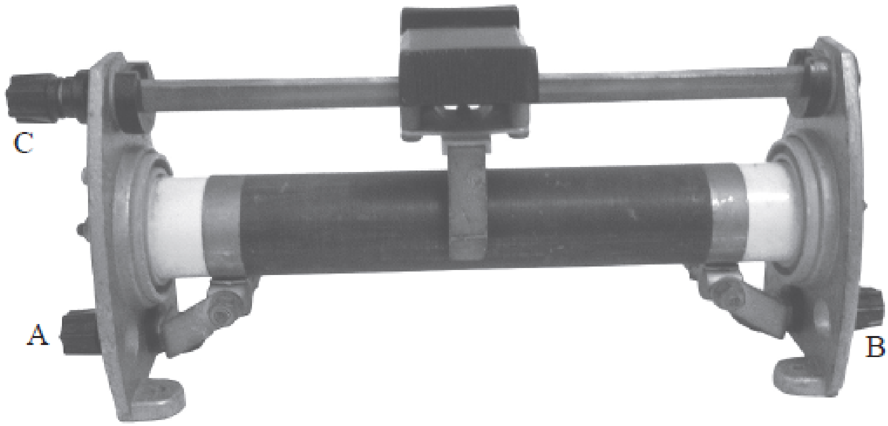
(Total for question = 9 marks)

Q11.

Photograph 1 shows a rheostat (a variable resistor).

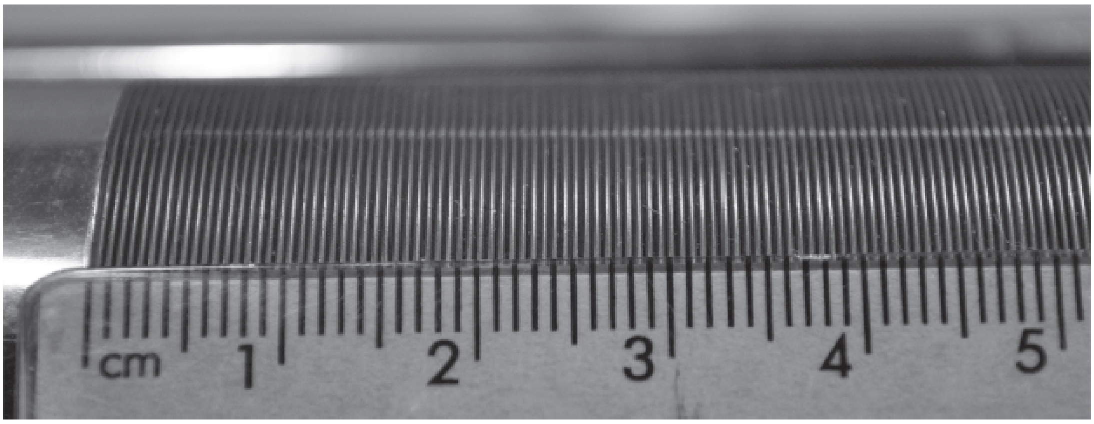


Photograph 1

The rheostat is made of a long resistance wire coiled around an insulating cylinder. The turns of wire are also separated from each other by insulation of negligible thickness. The ends of the wire are connected to the sockets A and B at either end and there is a sliding contact in the centre connected to the socket C. The resistance between A and C is varied by moving the sliding contact.

(a) A student decides to determine the resistivity of the material from which the wire is made by measuring the dimensions of the wire and its resistance.

Photograph 2 shows a section of the rheostat and a scale.



Photograph 2

(i) Take measurements from the photograph and use them to show that the cross-sectional area of the wire is about 2×10^{-7} m^2.

(3)

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(ii) Calculate the resistivity of the material from which the wire is made.

resistance of wire = 22 Ω

length of wire = 12 m

(3)

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Resistivity = ...

(iii) Suggest an advantage for the student of using a photograph rather than taking direct measurements.

(1)

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(b) The coil of the rheostat is 10.2 cm long. A potential difference of 12 V is applied across AB and the slider C is 7.0 cm from the end of the coil near A.

(2)

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Potential difference = ...

(Total for question = 9 marks)

Q12.

The aircraft industry uses an instrument called a resistance strain gauge to determine the strain in propellers.

The resistance strain gauge is based on the principle that the electrical resistance of a wire changes when it is stretched.

(a) A stretched wire becomes longer and thinner. Using an equation to justify your answer, explain what effect stretching a length of wire would have on its resistance.

(3)

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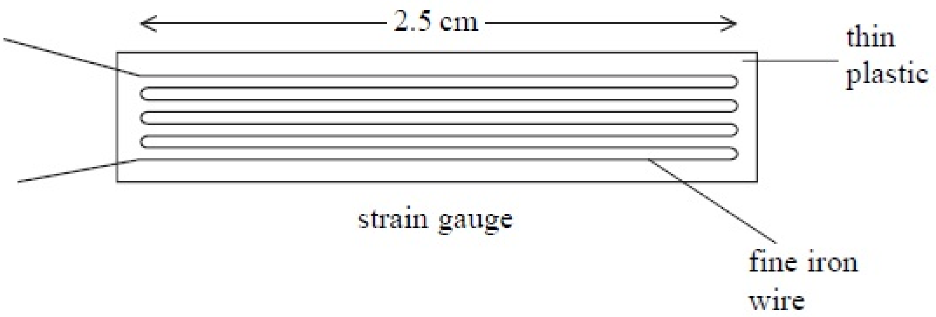
(b) The diagram shows a typical resistance strain gauge. The wire in the gauge is arranged in a zigzag pattern.



The length of the zigzag pattern is 2.50 cm and the cross-sectional area of the iron wire is 9.0×10^{-8} m^2. The resistivity of iron is 9.9×10^{-8} Ω m.

Show that the total resistance of the strain gauge is about 0.2 Ω.

(3)

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(c) (i) A wire of length *l* and cross-sectional area *A* is stretched. Assuming the volume *V* of the wire remains constant

$$V = lA = \text{constant}$$

Show that the resistance of the wire is directly proportional to l^2.

(2)

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(ii) The length of the zigzag pattern, when under strain, increases to 2.51 cm.

Calculate the increase in resistance of the wire in the gauge.

(3)

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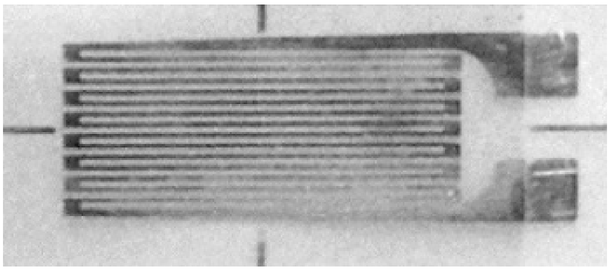
Increase in resistance = ...

(d) In practice, very small changes in length are to be determined and the gauge itself has to be reasonably small. Consequently, the gauge is made of a length of very fine iron wire which is arranged in a zigzag pattern between two thin sheets of plastic.



What is the benefit of the iron wire being in this pattern?

(2)

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(Total for Question = 13 marks)