Topic 5 – Guidance for Practical 1

Factors affecting resistance – a. Length of wire

Safety

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Teachers and technicians should always follow their school and departmental safety policies. You must ensure that you consult your employer's model risk assessments and modify them as appropriate to meet local circumstances before starting any practical work. Risk assessments will depend on your own skills and experience, the skills and experience of your students, and the facilities available to you. Everyone has a responsibility for his or her own safety and for the safety of others. The notes below should not be regarded as a risk assessment.

You should carry out the practical yourself before presenting it to students. Make sure you are comfortable with the procedures, and can anticipate any difficulties your students may encounter.

Guidance

Students will practice constructing electrical circuits, taking electrical measurements, using graphical methods to determine experimental values and calculating percentage uncertainties in measurements and calculations.

Students should have practised building circuits before this experiment.

Apparatus and materials

Each group will need:

- constantan wire (1.25 m)
- micrometer
- sandpaper
- metre rule
- heat-proof tile
- connecting wires
- crocodile clips (× 2)
- ammeter and voltmeter (or two digital multimeters)
- power supply
- switch
- variable resistor

Setting up the practical

Wires of other materials can be used, for example nichrome, manganin or copper.

Answers to questions

1 The temperature of the wire would increase, and temperature of the material is one of the factors affecting the electrical resistance of a material. Generally, resistance increases with temperature.

2 Percentage uncertainty of measurements: $\% \delta a = \left(\frac{\delta a}{a}\right) \times 100\%$

Percentage uncertainty in calculated values: if $a = b\,c$ or $a = \frac{b}{c}$, then $\% \delta a = \% \delta b + \% \delta c$

3 Students should determine the uncertainty of the gradient, δ(grad), from the error bars in their graphs (by drawing best-fit lines with minimum and maximum gradient). Then they can use this value to calculate the uncertainty of ρ and its percentage uncertainty.

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Topic 5 – Guidance for Practical 2

Factors affecting resistance – b. Thickness of wire

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You should carry out the practical yourself before presenting it to students. Make sure you are comfortable with the procedures, and can anticipate any difficulties your students may encounter.

Guidance

Students will practice constructing electrical circuits, taking electrical measurements, linearising graphs, using graphical methods to determine experimental values and calculating percentage uncertainties in measurements and calculations.

Some students might need assistance with connecting components in series and in parallel, so it would be useful to practice circuit building before this practical.

Apparatus and materials

Each group will need:

- constantan wires of varying thickness (20–40 swg) and length 60 cm
- micrometer
- sandpaper
- metre rule
- heat-proof tile
- connecting wires
- crocodile clips (× 2)
- ammeter and voltmeter (or two digital multimeters)
- power supply
- switch
- variable resistor

Setting up the practical

Wires of other materials can be used: for example, nichrome, manganin or copper.

Answers to questions

1 Calculate $\frac{1}{A}$.
R on the y-axis and $\frac{1}{A}$ on the x-axis.
Gradient = ρL.

2 Percentage uncertainty of measurements: $\% \delta a = \left(\frac{\delta a}{a}\right) \times 100\%$
Percentage uncertainty in calculated values: if $a = b\,c$ or $a = \frac{b}{c}$, then $\% \delta a = \% \delta b + \% \delta c$.

3 The uncertainty of the gradient, δ(grad), can be found from the error bars in their graphs and used to calculate the uncertainty of ρ.

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Topic 5 – Guidance for Practical 3

Experimental determination of internal resistance of a cell

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You should carry out the practical yourself before presenting it to students. Make sure you are comfortable with the procedures, and can anticipate any difficulties your students may encounter.

Guidance

Students will practice constructing electrical circuits, taking electrical measurements and using graphical methods to determine experimental values and uncertainties.

Apparatus and materials

Each group will need:

- 1.5 V cell
- 5 Ω resistor
- variable resistor
- switch
- ammeter and voltmeter (or two digital multimeters)
- connecting wires

Answers to questions

1 Terminal pd V_t on the y-axis against current I on the x-axis.
gradient = $-r$
y-intercept = E

2 In this case the terminal pd of both cells is measured therefore the gradient will be equal to -2r and the y-intercept equal to 2E.

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Topic 5 – Guidance for Practical 4

Simulation experiment to determine the relationship between electric field strength and distance from point charges

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You should carry out the practical yourself before presenting it to students. Make sure you are comfortable with the procedures, and can anticipate any difficulties your students may encounter.

Guidance

Students will practice electric field measurements in a simulation environment, plot graphs and use them to draw conclusions about relationships between quantities.

Students sometimes get confused on how to use the tape measure to measure the distance. The two crosses of the tape measure mark the start and end points.

Apparatus and materials

Each student will need:

- laptop with access to the internet

Setting up the practical

The measurements in this simulation experiment are easy and do not take long. But the students have to draw a lot of graphs, which can be very time-consuming if they do it on graph paper and do not use Excel or other graph-plotting software.

Answers to questions

1 **a** A curve representing an inverse square law relationship.
To linearise the graph students should plot E vs $\frac{1}{r^2}$.
b The (non-linear) curve is shifted upwards on the y-axis.

2 It affects the direction of the vector of the electric field strength.

3 Two equal positive charges: E pointing towards midpoint, maximum close to the charges and becomes zero at the midpoint between the two charges.
Two unequal positive charges: E maximum close to the double charge, its value dropping to a minimum but not reaching zero between midpoint and single charge and increasing closer to the single charge. Vectors pointing towards minimum.
One negative and one positive charge: Vector direction always towards the negative charge, maximum close to the two charges and reaches a minimum but not zero at the midpoint between the two charges.

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