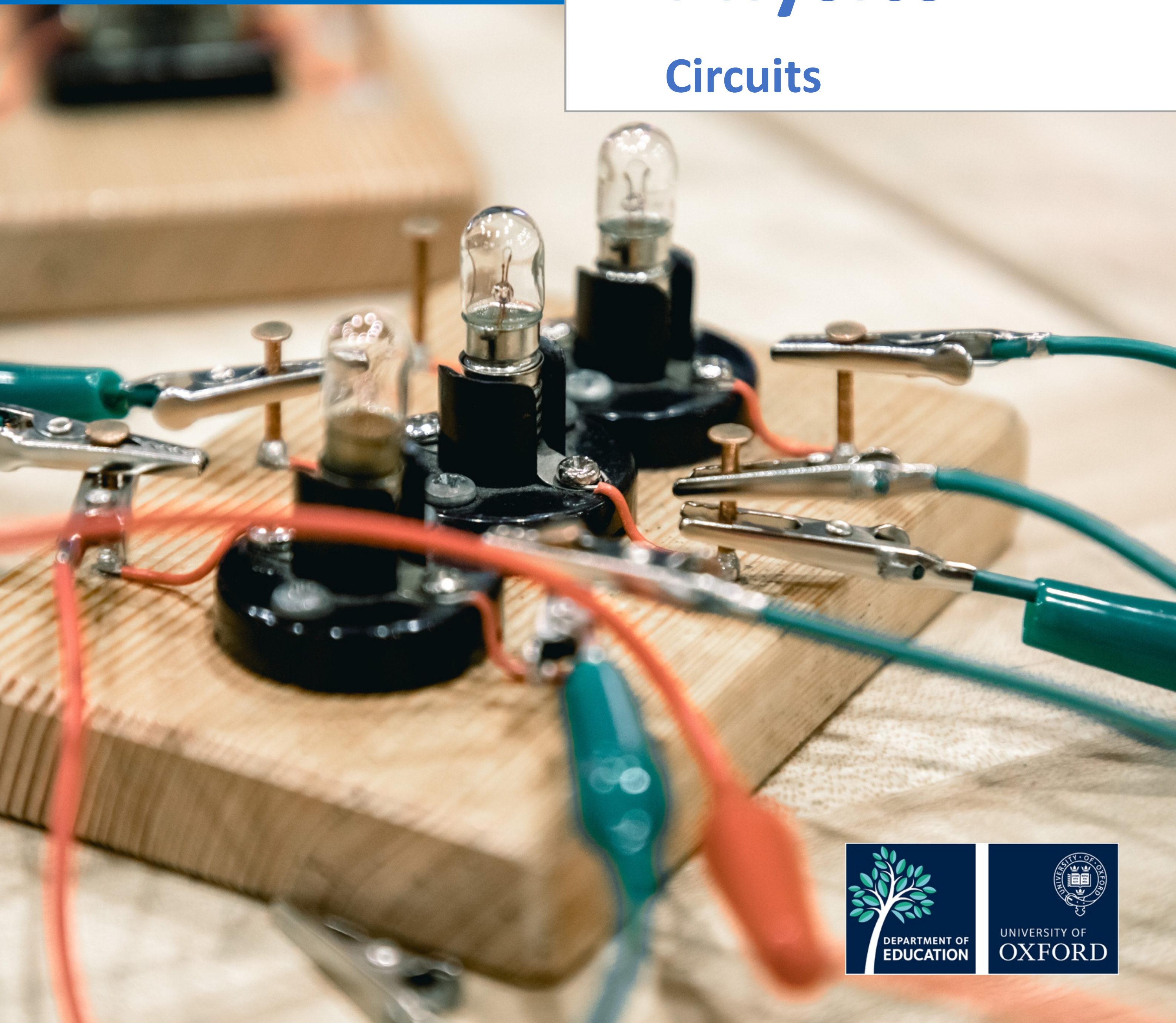
project calibrate

Summative Assessment Resources for Practical Science

Physics

Circuits



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About Project Calibrate
Project Calibrate is a research and development collaboration between University of Oxford and AQA, and aims to foster effective teaching, learning and assessment of practical science. The resource pack contains five summative assessments developed as part of the project to assess learners' understanding of and skills in GCSE practical science. The underlying framework of practical science is Brandon's matrix which highlights a variety of methods used in science. According to Brandon, there are four main categories of scientific methods (described on the next page). Four assessment tasks were designed using each category. The fifth assessment task includes all four categories and engages the learners in an evaluation of the different scientific methods.

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Brandon’s Matrix

Brandon provides an account of diversity in scientific methods. His framework has been adapted by Project Calibrate (see Table 1) and illustrates that not all experiments rely on hypothesis testing, and that not all descriptive work is non-manipulative. Brandon represents the connections between experiments and observations in terms of a matrix (i.e. two-by-two table) in which an investigation (experiment/observation) is related to whether or not it involves manipulation, and whether or not it involves hypothesis testing or parameter measurement.

Table 1. Adaptation of Brandon’s matrix

Experiment or observation		
	Change variable	**Don’t change variable**
Test hypothesis	Manipulative hypothesis testing	Non-manipulative hypothesis testing
Describe or measure	Manipulative description or parameter measurement	Non-manipulative description or parameter measurement

The importance of the matrix is that it challenges the traditional linear model of the scientific method in the science curriculum. A fairly typical depiction in school of how science is done involves the so-called ‘scientific method’, which is described as a process through which scientists produce robust evidence by applying procedures such as experimentation and observation. According to this model, scientists begin with a question they want to answer. They then design an experiment and, by carefully tracing independent and dependent variables, they produce findings that help them answer the question. However, such a step-wise and linear description of the scientific method is simplistic and hardly a realistic representation of how scientists actually do science. Rather, scientists engage in a wide array of methods some of which include hypothesis testing, and some other approaches including those where there is no manipulation of variables (Erduran & Dagher, 2014).

A contemporary example about Brandon’s matrix involves the Covid-19 pandemic (Erduran, Childs & Baird, 2020). Scientists collect data on how the virus might be influencing a patient’s breathing over a period of time. Such observation is simply based on the recording of parameters where there is no manipulation of variables in the sense of an experimental design. Sometimes the data might be subjected to hypothesis testing about correlation between incubation period and extent of lung disease, but without an experiment resulting in non-manipulative hypothesis testing. Scientists may conduct randomised control trials in which a drug could be treated as a variable in interventions that also include control groups to test the placebo effect. All of these different approaches are used in science, and there is no one single method but rather a diversity of scientific methods.

References

Brandon, R. (1994). Theory and experiment in evolutionary biology. *Synthese*, 99, 59-73.

Erduran, S., Childs, A., & Baird, J. (2020). Practical science and pandemics. https://www.bera.ac.uk/blog/practical-science-and-pandemics

Erduran, S., & Dagher, Z. (2014). *Reconceptualising the nature of science for science education: Scientific knowledge, practices and other family categories*. Dordrecht: Springer.

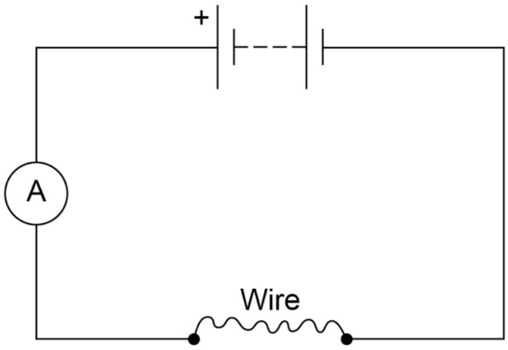
Physics: Circuits

Question 1 [manipulative hypothesis testing]

A student investigates how the length of a piece of wire affects the resistance of the piece of wire.

Figure 1 shows an incomplete circuit diagram for the student's investigation.

Figure 1



The student uses a piece of wire that is 1 metre long.

1.1 Give two other pieces of equipment the student should use in the investigation.

[2 marks]

1. ____

2. ____

1.2 The student tests different lengths of wire by measuring the resistance of the wire.

Suggest a number of different lengths of wire the student should test.

[1 mark]

Number of different lengths = __________

1.3 For each test the student increases the length of the wire by the same amount.

What interval should the student use when increasing the length of the wire?

Give the unit.

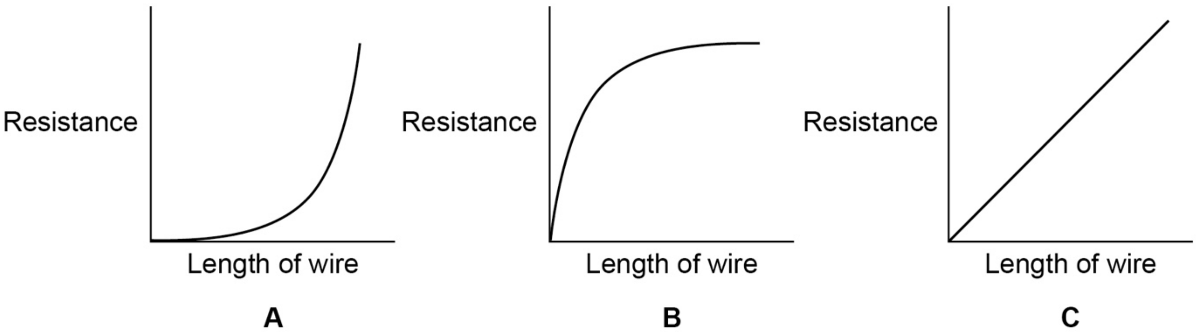
[2 marks]

Interval = ___________

Unit ___________

The student predicts the results of the investigation will be one of the three graphs, **A**, **B** or **C** shown in **Figure 2**

Figure 2



1.4 Write a hypothesis for the investigation that would allow any of the graphs **Figure 2** to be correct.

[1 mark]

____

____

1.5 Write a hypothesis for the investigation that would allow **only** graph **C** in **Figure 2** to be correct.

[1 mark]

____

____

____

1.6 The student identifies other variables in the investigation;

- diameter of the wire
- material of the wire
- temperature of the wire

Why should these variables be controlled in this investigation?

[1 mark]

____

____

____

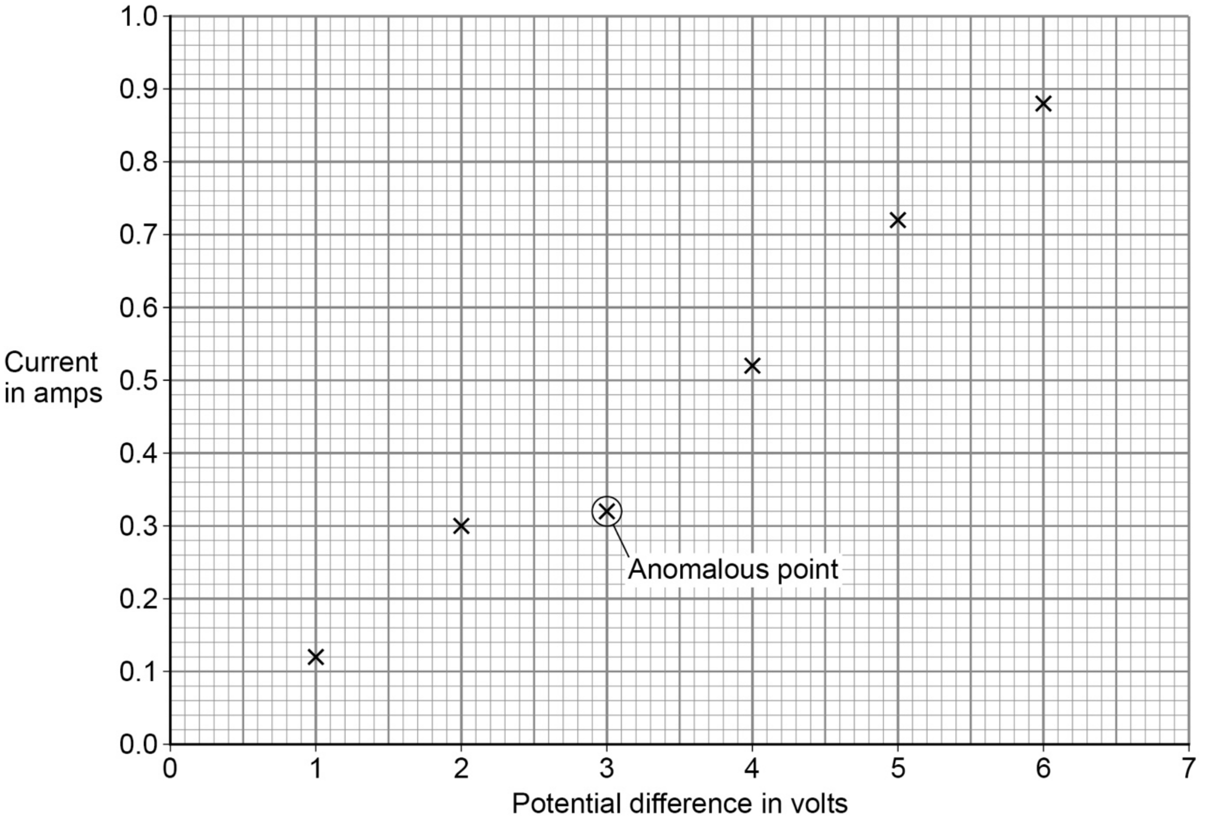
[Total = 8 marks]

Question 2 [non-manipulative parameter measurement]

A student investigated the resistance of a piece of copper wire.

Figure 3 shows the results.

Figure 3



2.1 Which variable was kept constant during the investigation?

[1 mark]

Tick (✓) **one** box.

Current ☐

Length of wire ☐

Potential difference ☐

Time ☐

2.2 Give the reason the student has **not** drawn a bar chart.

[1 mark]

____

2.3 The data has been plotted accurately on the graph.

What is the most likely cause of the anomalous point?

[1 mark]

____

2.4 Use **Figure 3** to suggest an improvement to the investigation.

[1 mark]

____

____

2.5 Draw a line of best fit on **Figure 3**.

[1 mark]

2.6 Use **Figure 3** to determine the resistance of the piece of copper wire.

[3 marks]

____

____

____

____

Resistance = ____________ Ω

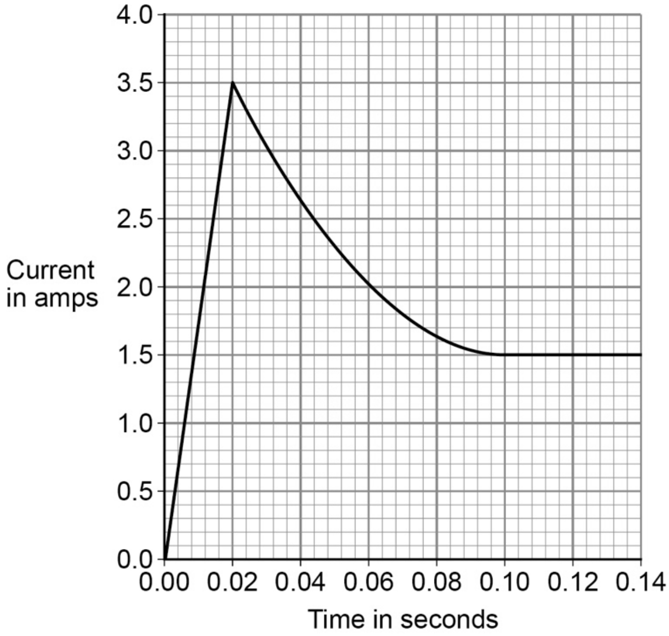
[Total = 8 marks]

Question 3 [non-manipulative hypothesis testing]

A student investigated how the current in a filament lamp varied with time from when it is switched on.

Figure 4 shows the results.

Figure 4



3.1 The data shown in **Figure 4** was measured using a data logger and a computer.

Explain why a data logger and a computer were used.

[2 marks]

____

____

____

____

3.2 The potential difference across the lamp is constant.

Use **Figure 4** to describe how the resistance changes after the filament lamp is switched on.

[3 marks]

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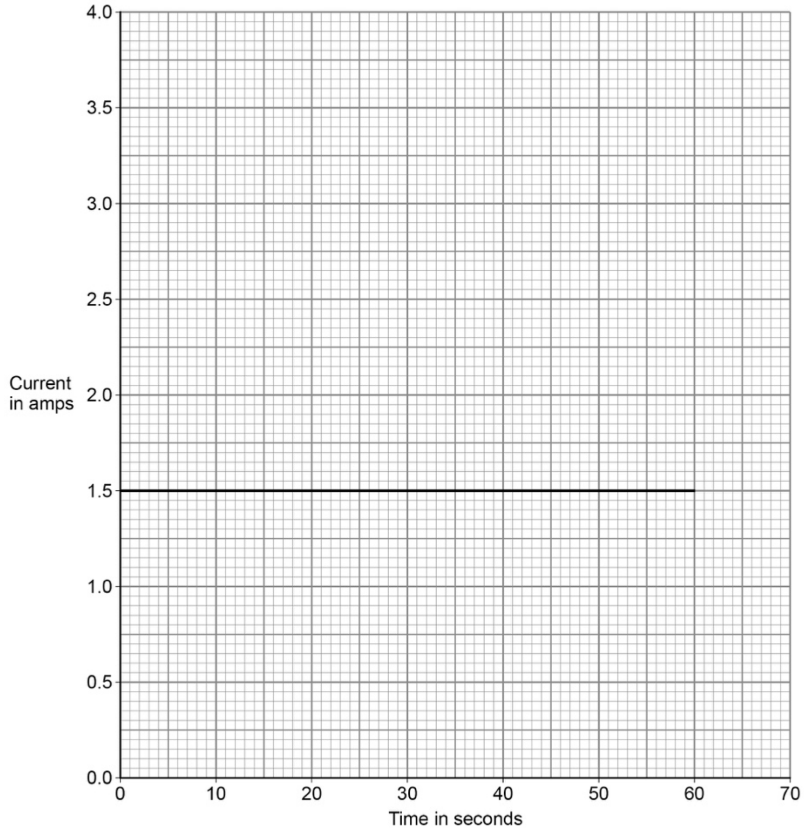
Figure 5 shows more data the student gathered for the same filament bulb.

Figure 5



3.3 The student makes the following conclusion;

'The current in a filament lamp is constant'

[2 marks]

Use information from **Figure 4** and **Figure 5** to support the student's conclusion.

____

____

____

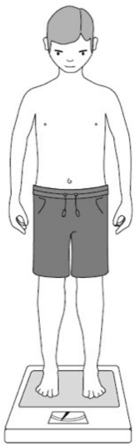
____

[Total = 7 marks]

Question 4 [manipulative parameter measurement]

Figure 6 shows a student using a set of electronic 'Body Fat Scales'.

Figure 6



The scales pass a small current through the student. The current is measured and the value is used to estimate the percentage of body fat.

4.1 Suggest why the scales only give an estimate of the body fat percentage.

[1 mark]

____

4.2 Explain why the student's feet should be bare and dry when standing on the scales.

[2 marks]

____

____

____

____

The scales work because different body tissues have different resistances.

Table 1 gives the resistances of equal sized samples of different of body tissues.

Table 1

Tissue type	Resistance in Ohms
Bone	18 000
Fat	3900
Muscle	170

4.3 The student uses the scales for a year. The size of the current that passes through the student's body decreases by a large amount over the year.

Explain the most likely reason why the current decreases by a large amount.

[2 marks]

____

____

____

____

4.4 Explain why the scales are useful for adults even though the readings are not very accurate.

[3 marks]

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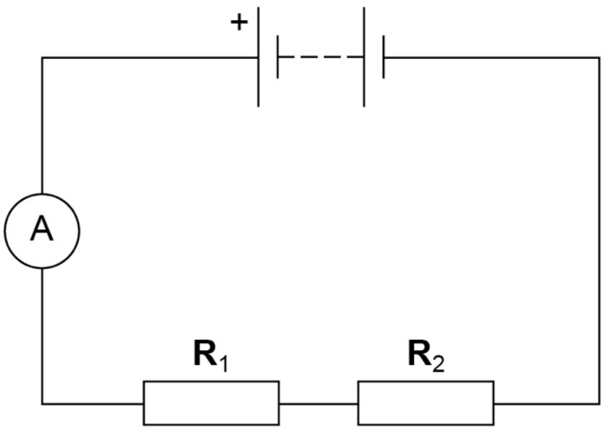
[Total = 8 marks]

Question 5 [combined task]

Figure 7 shows a circuit diagram for a circuit a student built.

Figure 7



The student carries out 3 different investigations.

A Measure the current at different positions in the circuit.

B Measure the total resistance of the circuit.

C Measure the total resistance of the circuit using a variety of different resistors for R_1 and R_2.

5.1 Name one variable that should be controlled during all the investigations.

[1 mark]

____

5.2 Give a hypothesis for investigation **A**

[1 mark]

____

____

____

5.3 Explain the difference between investigation **B** and investigation **C**.

[2 marks]

____

____

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____

5.4 Describe an experiment the student could carry out that is similar to investigation **C**, and would allow a hypothesis to be tested.

[4 marks]

Hypothesis ____

____

Description of investigation ____

____

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____

[Total = 8 marks]

Mark Scheme

Question 1

Question	Answers	Extra information	Mark	AO/ Spec. Ref
1.1	Any two form • voltmeter • ruler • variable resistor • (fixed) resistor		**2**	AO2/ WS2.2
1.2	any sensible suggestion	allow 5-10	**1**	AO2/ WS2.2
1.3	allow 5, 10 or 20 cm	answer must be consistent with 1.2 allow m if consistent with number given	**1** **1**	AO2/ WS2.2
1.4	as the length of the wire increases the resistance increases.		**1**	AO3/ WS2.1 WS3.6
1.5	the resistance of a wire is directly proportional to the length of the wire		**1**	AO3/ WS2.1 WS3.6
1.6	(if the any of the variables changed) they would also affect the resistance		**1**	AO3/ WS2.2
Total			**8**	

Question 2

Question	Answers	Extra information	Mark	AO/ Spec. Ref
2.1	Length of wire		**1**	AO1 / WS3.1
2.2	the data is continuous	allow the data is not categoric	**1**	AO2 / WS3.1
2.3	the value of the current was read of the ammeter incorrectly	allow the value of current was recorded incorrectly	**1**	AO3 / WS3.7
2.4	measure the current for a potential difference of 3 V again repeat the readings and take a mean	allow use a meter with a greater resolution	**1**	AO2 / WS3.7
2.5	line of best fit ignoring the anomalous point		**1**	AO2 / WS3.1
=2.6	pair of correct values read from the line of best fit i.e., (3.5, 0.5) R = 3.5 / 0.5 R = 7.0 (Ω)	point must lie on the line of best fit allow values correctly read from incorrect line of best fit allow correct substitution of their values from the graph allow 6.5 – 7.5 (Ω)	**1** **1** **1**	AO2 / WS3.1 WS3.3 WS4.6
Total			**9**	

Question 3

Question	Answers	Extra information	Mark	AO/ Spec. Ref
3.1	measurements can be taken on a shorter time scale (than a human) so change in current in a very short time can be measured	allow change could not be measured by a human	**1** **1**	AO3 / WS3.1
3.2	up to 0.02 seconds the resistance is low so the current increases to a maximum current causes resistance to increase between 0.02 and 0.10 Seconds resistance is constant after 0.10 seconds		**1** **1** **1**	AO2 / WS3.5
3.3	the current only varies initially over a very short time period of 0.10 s over a longer time scale (of 60 s) the current is constant		**1** **1**	AO3 / WS3.6
Total			**7**	

Question 4

Question	Answers	Extra information	Mark	AO/ Spec. Ref
4.1	the scales do not measure the amount of body fat directly	allow other factors to affect the size of the current	**1**	AO3 / WS3.7
4.2	any footwear of water on the feet would affect the resistance/current which would change the reading for body fat percentage		**1** **1**	AO3 / WS3.7
4.3	the student has grown which increases the amount of bone because bone has a much higher resistance it is the most likely cause of the large decrease		**1** **1**	AO3 / WS3.5
4.4	stopped growing so bone mass should be reasonably constant even though inaccurate, can spot patterns over time so can see increases/decreases in percentage of muscle/fat		**1** **1** **1**	AO3 / WS3.7
Total			**8**	

Question 5

Question	Answers	Extra information	Mark	AO/ Spec. Ref
5.1	the potential difference of the battery/power supply		**1**	AO2 / WS2.2
5.2	the current is the same in all parts of a series circuit.		**1**	AO2 / WS2.1
5.3	investigation **B** is non-manipulative and only provides evidence for one combination of resistors investigation **C** is manipulative and provides some evidence towards a general rule on adding resistors		**1** **1**	AO2 / WS2.2
5.4	**<u>Hypothesis</u>** the total resistance of two resistors in series is the sum of the individual resistances **<u>Description</u>** measure the individual resistances of different resistors measure the sum of the resistors in series compare the numerical sum of the different combinations with measured values	allow use of resistors of known value	**1** **1** **1** **1**	AO2/ AO3 / WS2. 2
Total			**8**	

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