Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 5 (May/June 2016), Question 2
Cambridge International AS & A Level Physics 9702

Version 1.0

In order to help us develop the highest quality resources, we are undertaking a continuous programme of review; not only to measure the success of our resources but also to highlight areas for improvement and to identify new development needs.

We invite you to complete our survey by visiting the website below. Your comments on the quality and relevance of our resources are very important to us.

www.surveymonkey.co.uk/r/GL6ZNJB

Would you like to become a Cambridge International consultant and help us develop support materials?

Please follow the link below to register your interest.

www.cambridgeinternational.org/cambridge-for/teachers/teacherconsultants/

Select page

HIGH | MIDDLE | LOW

2 A student is investigating how the resistance of a wire depends on the diameter of the wire.

The circuit is set up as shown in Fig. 2.1.

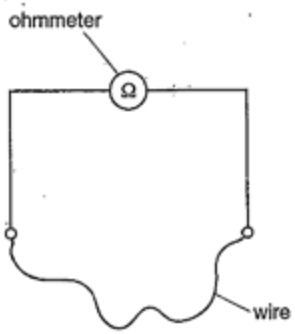


Fig. 2.1

The resistance R of the wire is measured using an ohmmeter.

The experiment is repeated for wires of the same material and same length L but different diameter d.

It is suggested that R and d are related by the equation

$$R = \frac{4\rho L}{\pi d^2}$$

where ρ is a constant.

(a) A graph is plotted of R on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$R = \frac{4\rho L}{\pi} \times \frac{1}{d^2}$

$m = \frac{4\rho L}{\pi}$

gradient = $\frac{4\rho L}{\pi}$ [1]

Your Mark

2(a) 2(b) 2(c)(i) 2(c)(ii) 2(c)(iii) 2(d)(i) 2(d)(ii) 2(e)

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.

EXAMINER COMMENTS | MARK SCHEME

1.2075 ± 0.03
3.1387 ± 0.11

(b) Values of d and R are given in Fig. 2.2.

$d/10^{-3}$m	R/Ω	$\frac{1}{d^2}/10^6\,m^{-2}$
0.91 ± 0.01	1.6	1.21 ± 0.03
0.56 ± 0.01	4.4	3.19 ± 0.1
0.46 ± 0.01	6.6	4.73 ± 0.2
0.38 ± 0.01	9.7	6.93 ± 0.4
0.32 ± 0.01	13.9	9.77 ± 0.6
0.27 ± 0.01	19.5	13.72 ± 1

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}/10^6\,m^{-2}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) (i) Plot a graph of R/Ω against $\frac{1}{d^2}/10^6\,m^{-2}$.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Line of best fit
(4.73, 6.6) (13.72, 19.5)
triangle drawn

$\frac{19.5 - 6.6}{(13.72 - 4.73) \times 10^6} = 1.43 \times 10^{-6}$

worst acceptable straight line
(1.18, 1.6) (14.72, 19.5)

$\frac{19.5 - 1.6}{(14.72 - 1.18) 10^6} = 1.32 \times 10^{-6}$

absolute uncertainty: $(1.43 - 1.32)/10^{-6}$
$= 0.11 \times 10^{-6}$

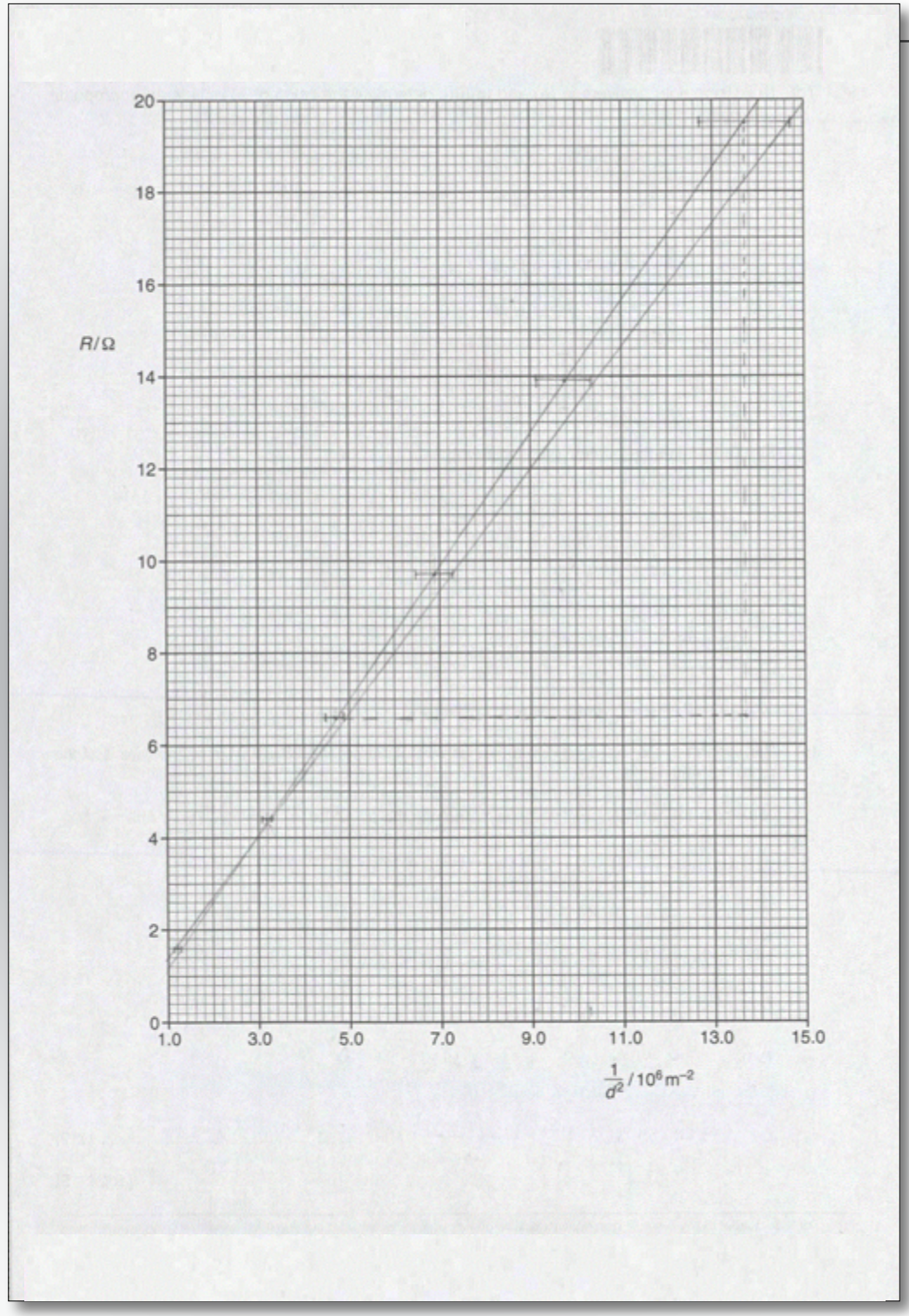
$(1.43 \pm 0.1) \times 10^{-6}$

gradient = ... [2]

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.



Select page

HIGH | MIDDLE | LOW

Your Mark

2(a) ☐

2(b) ☐

2(c)(i) ☐

2(c)(ii) ☐

2(c)(iii) ☐

2(d)(i) ☐

2(d)(ii) ☐

2(e) ☐

Q2	Mark scheme		
	Mark	**Expected Answer**	**Additional Guidance**
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^{7}.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

EXAMINER COMMENTS

MARK SCHEME

$\rho = \frac{m\pi}{4L}$

$\frac{\Omega}{m^{-1}} = \Omega m^{1} = \Omega m$

8 $\rho = \frac{n\pi}{4L}$

(d) (i) Using your answers to **(a)** and **(c)(iii)**, determine the value of ρ. Include an appropriate unit.

Data: $L = 1.00 \pm 0.01$ m.

$m = \frac{4\rho L}{\pi}$ $\rho = 1.13 \times 10^{-6}\ \Omega m$

$1.43 \times 10^{-6} = \frac{4\rho \times 1}{\pi}$

$\frac{1}{4}$

$\rho =$ 1.13 x10⁻⁶ Ωm [2]

(ii) Determine the percentage uncertainty in ρ.

$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + \frac{\Delta L}{L}$

$\frac{\Delta\rho}{\rho} = \frac{0.1 \times 10^{-6}}{1.43 \times 10^{-6}} + \frac{0.01}{1}$

$\frac{\Delta\rho}{\rho} = 0.09$

% uncertainty = 0.09 x 100 = 9 %

percentage uncertainty in $\rho =$ 9 % [1]

(e) The experiment is repeated with a thinner wire of diameter 0.23 ± 0.01 mm. The wire is of the same material and length.

Determine the resistance R of the wire. Include the absolute uncertainty in your answer.

$R = \frac{4\rho L}{\pi d^2}$

$R = \frac{4 \times (1.13 \times 10^{-6}) \times 1}{\pi \times 0.23^2} = 2.71 \times 10^{-5}$

$\frac{\Delta R}{R} = \frac{\Delta\rho}{\rho} + \frac{\Delta L}{L} + 2\frac{\Delta d}{d}$

$\Delta R = 5.42 \times 10^{-6}$

$= 0.09 + \frac{0.01}{1} + 2\left(\frac{0.01}{0.23}\right)$

≈ 0.2

$R =$ (2.71 ± 0.5) x10⁻⁵ Ω [2]

[Total: 15]

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^{7}.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

Select page

HIGH | MIDDLE | LOW

2 A student is investigating how the resistance of a wire depends on the diameter of the wire.

The circuit is set up as shown in Fig. 2.1.

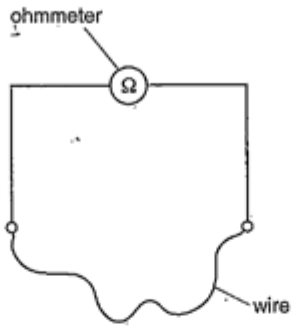


Fig. 2.1

The resistance R of the wire is measured using an ohmmeter.

The experiment is repeated for wires of the same material and same length L but different diameter d.

It is suggested that R and d are related by the equation

$$R = \frac{4\rho L}{\pi d^2}$$

where ρ is a constant.

(a) A graph is plotted of R on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$R = \frac{4\rho L}{\pi d^2}$

$R = \left(\frac{4\rho L}{\pi}\right)\frac{1}{d^2}$

gradient = $\frac{4\rho L}{\pi}$ .....[1]

Your Mark

2(a) ☐

2(b) ☐

2(c)(i) ☐

2(c)(ii) ☐

2(c)(iii) ☐

2(d)(i) ☐

2(d)(ii) ☐

2(e) ☐

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.

EXAMINER COMMENTS | MARK SCHEME

Select page

HIGH | MIDDLE | LOW

(b) Values of d and R are given in Fig. 2.2.

$d/10^{-3}$ m	R/Ω	$\frac{1}{d^2}/10^6\ m^{-2}$
0.91 ± 0.01	1.6	1.20 ± 0.03
0.56 ± 0.01	4.4	3.20 ± 0.10
0.46 ± 0.01	6.6	4.70 ± 0.20
0.38 ± 0.01	9.7	6.90 ± 0.40
0.32 ± 0.01	13.9	9.80 ± 0.60
0.27 ± 0.01	19.5	13.70 ± 1.00

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}/10^6\ m^{-2}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) (i) Plot a graph of R/Ω against $\frac{1}{d^2}/10^6\ m^{-2}$.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Gradient of best fit = $\frac{19-5}{(13.4-3.6)\times10^6}$

$= \frac{14}{9.8\times10^6}$

$= 1.43\times10^{-6}\ \Omega\ m^2$

Gradient of the worst fit :

$= \frac{18.6-2}{(14-1.4)\times10^6}$

$= \frac{16.6}{12.6\times10^6}$

$= 1.32\times10^{-6}\ \Omega\ m^2$

Absolute uncertainty = $(1.43-1.32)\times10^{-6}$

$= 0.11\times10^{-6}$

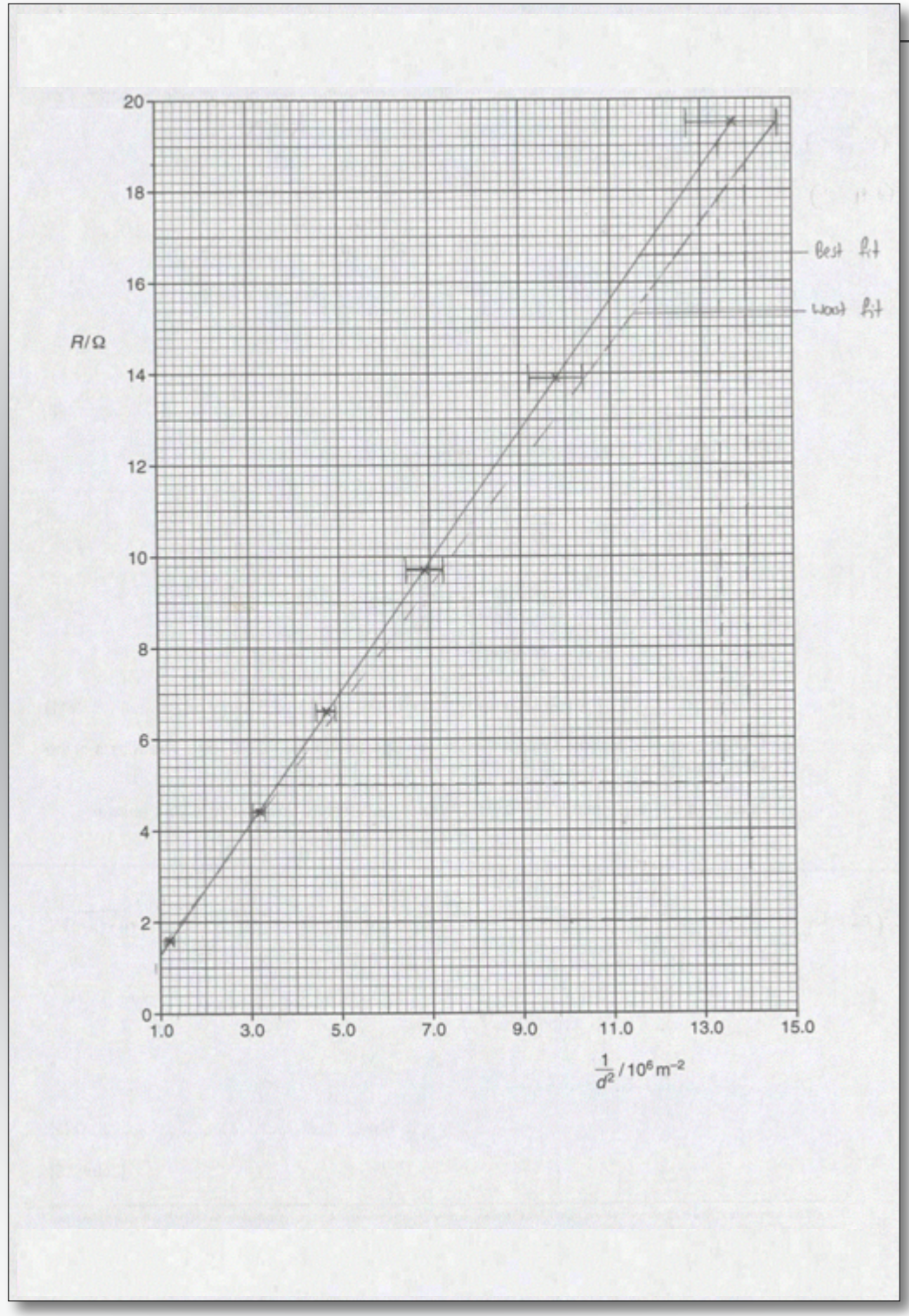
gradient = $(1.43 \pm 0.11)\times10^{-6}\ \Omega\ m^2$ [2]

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / $10^6\ m^{-2}$	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.

EXAMINER COMMENTS | MARK SCHEME



Select page

HIGH | MIDDLE | LOW

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2	Mark scheme		
	Mark	**Expected Answer**	**Additional Guidance**
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^{7}.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

(d) (i) Using your answers to (a) and (c)(iii), determine the value of ρ. Include an appropriate unit.

Data: $L = 1.00 \pm 0.01$ m.

Gradient $= \frac{\pi\rho L}{A}$

$\rho = \frac{(1.43\times10^{-6})(\pi)}{4}$

$= 1.12\times10^{-6}$

$\frac{\pi\rho L}{A} = 1.43\times10^{-6}$

$\frac{\rho(4)(1)}{\pi} = 1.43\times10^{-6}$

$\rho =$ 1.12×10^{-6}. [2]

(ii) Determine the percentage uncertainty in ρ.

$\frac{\Delta\rho}{\rho} = \frac{\Delta G}{G} + \frac{\Delta L}{L}$

$= \frac{0.11\times10^{-6}}{1.43\times10^{-6}} + \frac{0.01}{1.00}$

$= 0.087$

$\% = \frac{\Delta\rho}{\rho}\times100$

$= 0.087\times100$

$= 8.7\%$

percentage uncertainty in $\rho =$ 8.7 % [1]

(e) The experiment is repeated with a thinner wire of diameter 0.23 ± 0.01 mm. The wire is of the same material and length.

Determine the resistance R of the wire. Include the absolute uncertainty in your answer.

$R = \left(\frac{4\rho L}{\pi}\right)\frac{1}{d^2}$

$R = (G_w)\frac{1}{d^2}$

$= (1.43\times10^{-6})\left(\frac{1}{(0.23\times10^{-3})^2}\right)$

$= 27.03$

$R = (G_w)\frac{1}{d^2}$

$= (1.32\times10^{-6})\left(\frac{1}{(0.23\times10^{-3})^2}\right)$

$= 24.95$

Absolute uncertainty $= 27.03 - 24.95$

$= 2.08$

$R =$ 27.03 ± 2.08 Ω [2]

[Total: 15]

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2	Mark scheme		
	Mark	**Expected Answer**	**Additional Guidance**
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in gradient	Percentage uncertainty in ρ + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^{7}.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

EXAMINER COMMENTS | MARK SCHEME

Select page

HIGH | MIDDLE | LOW

2 A student is investigating how the resistance of a wire depends on the diameter of the wire.

The circuit is set up as shown in Fig. 2.1.

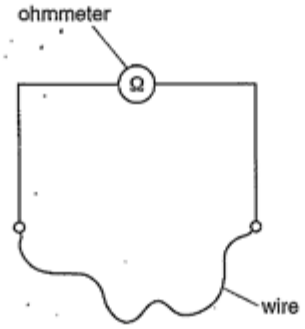


Fig. 2.1

The resistance R of the wire is measured using an ohmmeter.

The experiment is repeated for wires of the same material and same length L but different diameter d.

It is suggested that R and d are related by the equation

$$R = \frac{4\rho L}{\pi d^2}$$

where ρ is a constant.

(a) A graph is plotted of R on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$R = \frac{4\rho L}{\pi d^2}$ $\quad y = mx + c$ $\quad R = \frac{4\rho}{\pi}\frac{1}{d^2} + c$

$y = mx + c$

$R = \frac{4\rho L}{\pi}\frac{1}{d^2}$

gradient = $\frac{4\rho L}{\pi}$ .....[1]

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.

EXAMINER COMMENTS | MARK SCHEME

Select page

HIGH | MIDDLE | LOW

(b) Values of d and R are given in Fig. 2.2.

$d/10^{-3}$ m	R/Ω	$\frac{1}{d^2}/10^6 - 2$
0.91 ± 0.01	1.6	1.21 ± 0.02
0.56 ± 0.01	4.4	3.18 ± 0.11
0.46 ± 0.01	6.6	4.73 ± 0.29
0.38 ± 0.01	9.7	6.93 ± 0.36
0.32 ± 0.01	13.9	9.77 ± 0.61
0.27 ± 0.01	19.5	13.72 ± 1.02

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}/10^6 m^{-2}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) (i) Plot a graph of R/Ω against $\frac{1}{d^2}/10^6 m^{-2}$.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

best fit

$\frac{y^2-y^1}{x^2-x^1} = \frac{19-4}{(13.4-3.6)\times10^6} = \frac{15}{9.4\times10^6}$

$= 1.60 \times 10^{-6}$

$= 1.60 - 1.7$

$= 1 \times 10^{-7}$

$\frac{y^2-y^1}{x^2-x^1} = \frac{19-5}{(12.4-4.2)\times10^6} = \frac{14}{8.2\times10^6}$

$= 1.7 \times 10^{-6}$

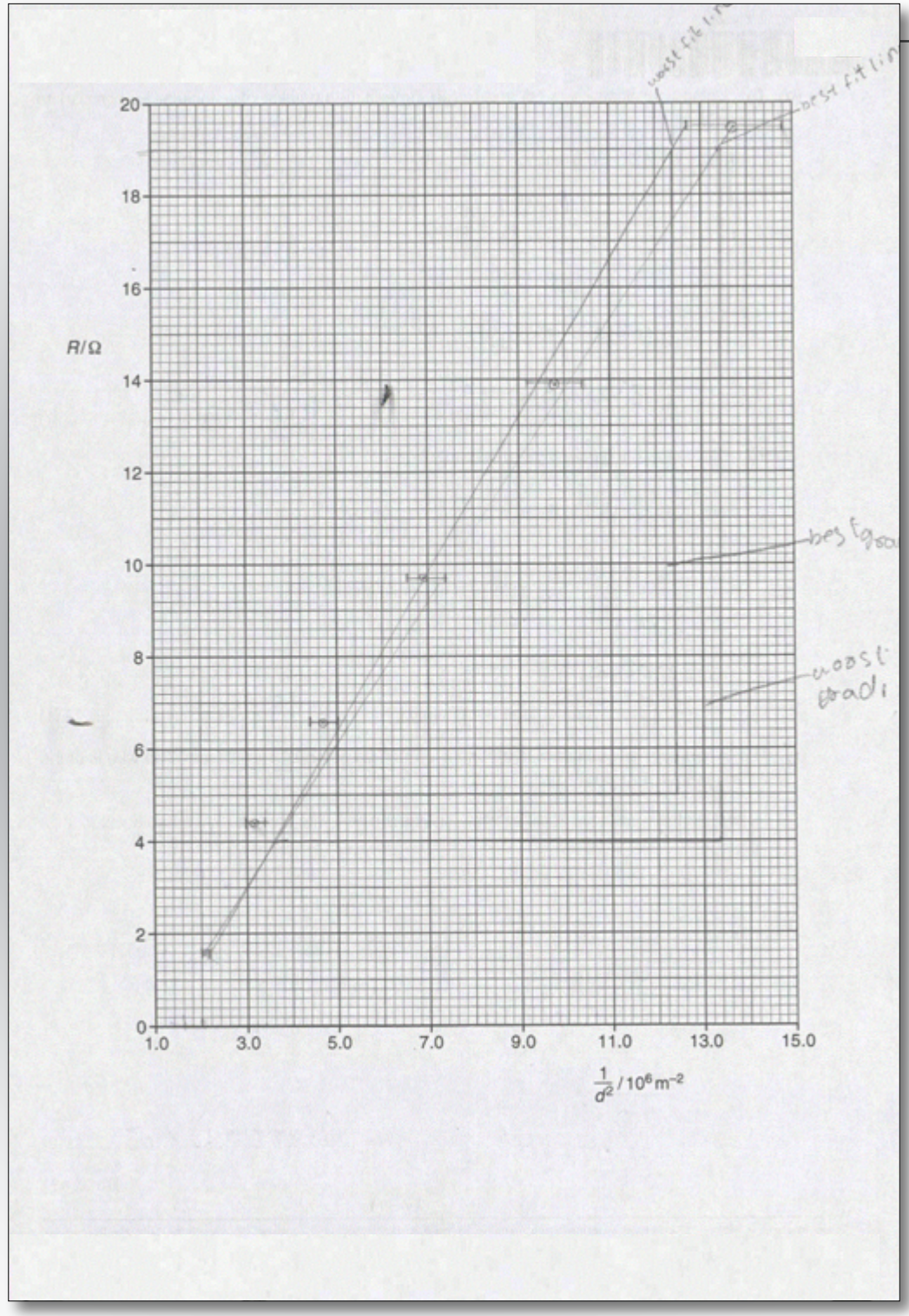
gradient = $(1.60 \pm 0.1)\times10^{-6}$ [2]

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(a)	A1	$\frac{4\rho L}{\pi}$	
(b)	T1	$\frac{1}{d^2}$ / 10^6 m^{-2}	
	T2	1.2 or 1.21 3.2 or 3.19 4.7 or 4.73 6.9 or 6.93 9.8 or 9.77 14 or 13.7	All values to 2 s.f. or 3 s.f. Allow a mixture of significant figures. Must be values in table.
	U1	From ± 0.03 to ± 1	Allow more than one significant figure. Allow zero for first uncertainty and up to 1.2 for largest uncertainty.
(c)(i)	G1	Six points plotted correctly	Must be within half a small square. Do not allow "blobs". ECF allowed from table.
	U2	Error bars in $\frac{1}{d^2}$ plotted correctly	All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.

EXAMINER COMMENTS | MARK SCHEME



Select page

HIGH | MIDDLE | LOW

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^{7}.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

EXAMINER COMMENTS

MARK SCHEME

(d) (i) Using your answers to (a) and (c)(iii), determine the value of ρ. Include an appropriate unit.

Data: $L = 1.00 \pm 0.01$ m.

$R = \frac{4\rho L}{\pi d^2}$

$\rho = \frac{5.03 \times 10^{-6}}{4}$

$\rho = 1.25 \times 10^{-6}$

$\rho = \frac{4\rho}{\pi}$

$(1.6 \times 10^{-6}) = \frac{4\rho}{\pi}$

$5.03 \times 10^{-6} = 4\rho$

$\rho =$ 1.26 × 10⁻⁶ [2]

(ii) Determine the percentage uncertainty in ρ.

$\frac{\Delta L}{L} = \frac{2\Delta L}{L}$

$\frac{0.025}{1.26} \times 100$

$\frac{\Delta L}{1.26 \times 10^{-6}} = \frac{2 \times 0.01}{1.00}$

0.025×10^{-6}

percentage uncertainty in $\rho =$ 1.98 % [1]

(e) The experiment is repeated with a thinner wire of diameter 0.23 ± 0.01 mm. The wire is of the same material and length.

Determine the resistance R of the wire. Include the absolute uncertainty in your answer.

$R = \frac{4\rho L}{\pi d^2}$

$= \frac{4(1.26 \times 10^{-6})(1.00)}{\pi\, 0.23}$

$= \frac{5.04 \times 10^{-6}}{\pi\, 0.23}$

$= 6.97 \times 10^{-6}$

$\frac{\Delta L}{L} = \frac{2\Delta L}{L}$

$\frac{\Delta L}{6.97 \times 10^{-6}} = \frac{2 \times 0.01}{1.00}$

$= 1.39 \times 10^{-7}$

$R =$ (6.97 ± 0.1) × 10⁻⁶ Ω [2]

[Total: 15]

	Your Mark
2(a)	
2(b)	
2(c)(i)	
2(c)(ii)	
2(c)(iii)	
2(d)(i)	
2(d)(ii)	
2(e)	

Q2 Mark scheme

	Mark	Expected Answer	Additional Guidance
(c)(ii)	G2	Line of best fit	Lower end of line must pass between (2.6, 4.0) and (3.0, 4.0) and upper end of line must pass between (12.4, 18.0) and (13.0, 18.0).
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through all the error bars.	Line should be clearly labelled or dashed. Examiner judgement on worst acceptable line. Must be steepest/shallowest line. Mark scored only if error bars are plotted.
(c)(iii)	C1	Gradient of line of best fit	The triangle used should be at least half the length of the drawn line. Check the read-offs. Work to half a small square. Do not penalise POT. (Should be about 1.4 –1.5 × 10^{-6}.)
	U3	Absolute uncertainty in gradient	Method of determining absolute uncertainty: difference in worst gradient and gradient.
(d)(i)	C2		Must use gradient value. Do not penalise POT (Should be about 1 × 10–6.)
	C3	Ω m	Correct unit and correct power of ten.
(d)(ii)	U4	Percentage uncertainty in ρ	Percentage uncertainty in gradient + 1%.
(e)	C4	R in the range 25.5 to 28.4 and given to 2 or 3 s.f.	Allow 26 or 27 or 28. Allow ECF for POT error in **(d)(i)** e.g. 2.7 × 10^{7}.
	U5	Absolute uncertainty in R	Percentage uncertainty must be greater than 8.6%.

Cambridge Assessment International Education
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom
t: +44 1223 553554 f: +44 1223 553558
e: info@cambridgeinternational.org www.cambridgeinternational.org