CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

MARK SCHEME

Maximum Mark: 30

Published

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
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Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6	<u>Calculation specific guidance</u> Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	<u>Guidance for chemical equations</u> Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Annotations guidance for centres

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We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
BOD	benefit of the doubt given
✓ 1	correct awarding one mark from additional detail 1. similar numbered ticks are used for additional detail 2, 3, 4 etc.
✓	correct point or mark awarded
P	defining the problem mark
ECF	error carried forward applied
SF	error in number of significant figures
I	incorrect or insufficient point ignored while marking the rest of the response
✗	incorrect point or mark not awarded
U	incorrect unit
^	information missing or insufficient for credit

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Annotation	Meaning
MO	methods of data collection mark
SEEN	point has been noted, but no credit has been given or blank page seen
R	repeat of point previously awarded mark

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Question	Answer	Marks
1	**Defining the problem**	
	vary *f* and measure *V* **or** *f* is the independent variable and *V* is the dependent variable	**1**
	keep *E* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • circuit with a.c. supply • oscilloscope connected in parallel with the resistor • workable circuit • oscilloscope and a.c. supply labelled	**1**
	labelled signal generator or variable frequency power supply connected across the terminals	**1**
	method to determine *V* or *E* from oscilloscope, e.g. multiply amplitude / height of wave by *y*-gain on oscilloscope	**1**
	method to determine *f* from oscilloscope, e.g. determine period *T* by multiplying number of divisions in 1 cycle or horizontal distance in 1 cycle by the time base **and** $f = 1/T$	**1**
	Method of Analysis	
	plot a graph of $\frac{1}{V}$ against *f* or equivalent, e.g. *f* against $\frac{1}{V}$ Allow logarithms e.g. lg *V* against lg *f*.	**1**
	relationship valid if a straight line is produced passing through the origin (for lg *V* against lg *f*: relationship valid if a straight line is produced with gradient = –1)	**1**

Question	Answer	Marks
1	$\frac{1}{V}$ against f | f against $\frac{1}{V}$ $K = \frac{lES}{AN^2} \times \text{gradient}$ | $K = \frac{lES}{AN^2} \times \frac{1}{\text{gradient}}$ (for lg V against lg f: $K = \frac{ElS}{AN^2} \times 10^{-y\text{-intercept}}$).	**1**
	Additional detail including safety considerations	**6**
	D1 precaution linked to hot coil or hot resistor or prevention of burns from coil or resistor, e.g. use gloves / switch off power supply when not measuring V to prevent burns from coil / resistor	
	D2 keep N **and** A **and** l **and** S constant	
	D3 method to keep S constant, e.g. switch off power supply between readings to prevent heating of resistor or to allow resistor to cool	
	D4 method to determine A, e.g. use calipers / micrometer to measure diameter (of coil) / d **and** $A = \frac{\pi d^2}{4}$	
	D5 repeat measurements of diameter d along the length of the coil / in different directions **and** determine the average value of d	
	D6 method to determine the value of S, e.g. separate circuit diagram showing resistor connected to ohmmeter, or circuit diagram showing resistor connected to a power supply with an ammeter and voltmeter **and** $S = V / I$	
	D7 measure l with a ruler / calipers	
	D8 oscilloscope drawn connected across terminals / across signal generator **and** description to determine E	
	D9 adjust y-gain for maximum amplitude **or** adjust time base for length of one wave or measure n waves and divide measured time by n	

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Question	Answer	Marks
1	D10 method to keep E constant, e.g. check p.d. and alter supply **or** method to keep l constant, e.g. tape coil **or** method to keep A constant, e.g. wind wire on a cylinder	

Question	Answer	Marks
2(a)	gradient = $\frac{R}{E}$ y-intercept = $\frac{Z}{E}$	**1**
2(b)	$\frac{1}{I}$ / 10^3 A^{-1} 2.20 or 2.198 1.90 or 1.905 1.72 or 1.724 1.57 or 1.575 1.46 or 1.460 1.31 or 1.307 Values of $\frac{1}{I}$ / 10^3 A^{-1} correct as shown above.	**1**

Question	Answer	Marks
2(b)	Uncertainties in $\frac{1}{I}$ / 10^3 A^{-1} from ± 0.02 or ± 0.03 decreasing to ± 0.01.	**1**
2(c)(i)	Six points from **(b)** plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.	**1**
	Error bars in $\frac{1}{I}$ plotted correctly. All error bars to be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	**1**
2(c)(ii)	Straight line of best fit drawn. Thickness of the line must be less than half a small square. Do not accept line from top point to bottom point. Line must pass between (0.101, 1.40) and (0.104, 1.40) **and** between (0.189, 2.10) and (0.194, 2.10)	**1**
	Worst acceptable straight line drawn (steepest or shallowest possible line that passes through all the error bars). Thickness of the line must be less than half a small square. All error bars must be plotted.	**1**
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be greater than half the length of the drawn line.	**1**
	Gradient determined of worst acceptable line with clear substitution of data points into $\Delta y / \Delta x$. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**

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Question	Answer	Marks
2(c)(iv)	*y*-intercept determined by substitution of correct point with consistent power of ten in *m* and *y* into $y = mx + c$.	**1**
	y-intercept of worst acceptable line determined by substitution into $y = mx + c$. uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line *y*-intercept – shallowest worst line *y*-intercept) Do not accept ECF from false origin method.	**1**
2(d)(i)	*R* determined using gradient **and** *R* and *Z* given to 2 or 3 significant figures. R = gradient × 5.8	**1**
	Z determined using *y*-intercept **and** *R* and *Z* given with units with appropriate powers of ten. Z = *y*-intercept × 5.8 unit of *R*: Ω or V A^{-1} unit of *Z*: Ω or V A^{-1}	**1**
2(d)(ii)	Percentage uncertainty determined using ΔE = 0.2 (V) with method shown. $\Delta R\% = \left(\frac{\Delta E}{E} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$ **or** $\Delta R\% = \left(\frac{0.2}{5.8} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$	**1**

Question	Answer	Marks
2(e)	I determined to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitution. $I = \dfrac{1}{\dfrac{\text{gradient}}{20} + y\text{-intercept}}$ **or** $I = \dfrac{E}{\left(\dfrac{R}{20} + Z\right)}$	**1**

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SEEN	point has been noted, but no credit has been given or blank page seen
R	repeat of point previously awarded mark

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Question	Answer	Marks
1	**Defining the problem**	
	vary *m* and measure *v* **or** *m* is the independent variable and *v* is the dependent variable	**1**
	keep *h* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • axle resting on support(s) (on stands) • supports placed on bench • light gate (connected to timer) positioned at a distance *h* • light gate labelled and *h* indicated	**1**
	vertical metre rule clamped to a stand in a position close to block to measure *h*	**1**
	method to determine *v* using an interrupt length, e.g. *v* = length of block / time recorded by the timer	**1**
	method to measure *m*, e.g. use a (top-pan) balance	**1**
	Method of analysis	
	plot a graph of $\frac{1}{v^2}$ against $\frac{1}{m}$ or equivalent Do not accept logarithms.	**1**

Question	Answer	Marks
1	$\frac{1}{v^2}$ against $\frac{1}{m}$ | $\frac{1}{m}$ against $\frac{1}{v^2}$ $P = \frac{1}{h \times y\text{-intercept}}$ | $P = -\frac{\text{gradient}}{y\text{-intercept} \times h}$ **or** $P = \frac{\pi r^2 z \times \text{gradient}}{2Qh}$	**1**
	$\frac{1}{v^2}$ against $\frac{1}{m}$ | $\frac{1}{m}$ against $\frac{1}{v^2}$ $Q = \frac{\pi r^2 z}{2Ph \times \text{gradient}}$ **or** $Q = \frac{\pi r^2 z \times y\text{-intercept}}{2 \times \text{gradient}}$ | $Q = -\frac{\pi r^2 z \times y\text{-intercept}}{2}$	**1**
	Additional detail including safety considerations	**6**
	D1 precaution linked to falling block resulting in damage to block / bench, e.g. use a cushion / sand tray to prevent damage to bench **or** precaution linked to stands falling, e.g. clamp stand(s) to the bench prevent stand falling	
	D2 keep *r* **and** *z* <u>constant</u>	
	D3 method to determine *r* e.g. use calipers / ruler to measure diameter *d* **and** $r = d / 2$	
	D4 measure *z* with a micrometer / calipers	

Question	Answer	Marks
1	D5 set square correctly positioned between rule and bench to ensure that rule to measure *h* is vertical	
	D6 method to keep *h* constant by identifying constant initial position of the bottom of the block, e.g. clamped pin / rod to indicate the starting point each time or (fiducial) marker on rule	
	D7 description of method to ensure that axle can rotate, e.g. axle is lubricated at the supports to enable axle to rotate, axle is not fixed at the supports so axle can rotate	
	D8 use a large length of block to reduce (percentage) uncertainty in interrupt time or increase the time light gate is interrupted	
	D9 repeat experiment for the same value of *m* **and** determine the average *v*	
	D10 relationship valid <u>if</u> a straight line is produced (with *y*-intercept = $\frac{1}{hP}$). Do not accept line passing through the origin.	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = $\frac{C}{EA}$

y-intercept = $\frac{1}{E}$</td><td>1</td></tr>
<tr><td>2(b)</td><td><table><tr><th>V / V</th><th>$\frac{1}{V}$ / V^{-1}</th></tr><tr><td>4.25</td><td>0.235 or 0.2353</td></tr><tr><td>3.70</td><td>0.270 or 0.2703</td></tr><tr><td>3.25</td><td>0.308 or 0.3077</td></tr><tr><td>2.90</td><td>0.345 or 0.3448</td></tr><tr><td>2.60</td><td>0.385 or 0.3846</td></tr><tr><td>2.35</td><td>0.426 or 0.4255</td></tr></table>
Values of V / V and $\frac{1}{V}$ / V^{-1} correct as shown above.</td><td>1</td></tr>
<tr><td></td><td>Uncertainties in V all ± 0.05
and
uncertainties in $\frac{1}{V}$ from ± 0.002 or ± 0.003 increasing to ± 0.009.</td><td>1</td></tr>
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2(c)(i)	Six points from **(b)** plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.	**1**
	Error bars in $\frac{1}{V}$ plotted correctly. All error bars must be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	**1**
2(c)(ii)	Straight line of best fit drawn. Thickness of the line must be less than half a small square. Do not accept line from top point to bottom point. Line must pass between (2.65, 0.26) and (2.80, 0.26) **and** between (6.30, 0.40) and (6.50, 0.40).	**1**
	Worst acceptable straight line drawn (steepest or shallowest possible line that passes through all the error bars). Thickness of the line must be less than half a small square. All error bars must be plotted.	**1**
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be greater than half the length of the drawn line.	**1**
	Gradient determined of worst acceptable line with clear substitution of data points into $\Delta y / \Delta x$. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**
2(c)(iv)	y-intercept determined by substitution of correct point into $y = mx + c$.	**1**
	y-intercept of worst acceptable line determined by substitution into $y = mx + c$. uncertainty = y-intercept of line of best fit – y-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line y-intercept – shallowest worst line y-intercept) Do not accept ECF from false origin method.	**1**

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Question	Answer	Marks
2(d)(i)	*E* determined using *y*-intercept **and** *E* and *C* given to 2 or 3 significant figures. $E = \frac{1}{y\text{-intercept}}$	**1**
	C determined using gradient **and** *E* and *C* given with correct units with appropriate powers of ten. $C = \frac{A \times \text{gradient}}{y\text{-intercept}}$ **or** $C = A \times E \times \text{gradient}$ unit of *E*: V unit of *C*: F	**1**
2(d)(ii)	Percentage uncertainty determined with method shown. $\Delta C\% = \left(\frac{\Delta A}{A} + \frac{\Delta\text{gradient}}{\text{gradient}} + \frac{\Delta y\text{-intercept}}{y\text{-intercept}}\right) \times 100$ **or** $\Delta C\% = \left(\frac{\Delta A}{A} + \frac{\Delta\text{gradient}}{\text{gradient}} + \frac{\Delta E}{E}\right) \times 100$ with method to determine ΔE shown	**1**
2(e)	*V* determined to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitution. $V = \frac{1}{10 \times \text{gradient} + y\text{-intercept}}$ **or** $V = \frac{EA}{10C + A}$	**1**

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1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
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3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
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6	<u>Calculation specific guidance</u> Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	<u>Guidance for chemical equations</u> Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Annotations guidance for centres

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We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
BOD	benefit of the doubt given
✓ 1	correct awarding one mark from additional detail 1. similar numbered ticks are used for additional detail 2, 3, 4 etc.
✓	correct point or mark awarded
P	defining the problem mark
ECF	error carried forward applied
SF	error in number of significant figures
I	incorrect or insufficient point ignored while marking the rest of the response
✗	incorrect point or mark not awarded
U	incorrect unit
^	information missing or insufficient for credit

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Annotation	Meaning
MO	methods of data collection mark
SEEN	point has been noted, but no credit has been given or blank page seen
R	repeat of point previously awarded mark

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Question	Answer	Marks
1	**Defining the problem**	
	vary *f* and measure *V* **or** *f* is the independent variable and *V* is the dependent variable	**1**
	keep *E* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • circuit with a.c. supply • oscilloscope connected in parallel with the resistor • workable circuit • oscilloscope and a.c. supply labelled	**1**
	labelled signal generator or variable frequency power supply connected across the terminals	**1**
	method to determine *V* or *E* from oscilloscope, e.g. multiply amplitude / height of wave by *y*-gain on oscilloscope	**1**
	method to determine *f* from oscilloscope, e.g. determine period *T* by multiplying number of divisions in 1 cycle or horizontal distance in 1 cycle by the time base **and** $f = 1/T$	**1**
	Method of Analysis	
	plot a graph of $\frac{1}{V}$ against *f* or equivalent, e.g. *f* against $\frac{1}{V}$ Allow logarithms e.g. lg *V* against lg *f*.	**1**
	relationship valid if a straight line is produced passing through the origin (for lg *V* against lg *f*: relationship valid if a straight line is produced with gradient = –1)	**1**

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Question	Answer	Marks
1	$\frac{1}{V}$ against f | f against $\frac{1}{V}$ $K = \frac{lES}{AN^2} \times \text{gradient}$ | $K = \frac{lES}{AN^2} \times \frac{1}{\text{gradient}}$ (for lg V against lg f: $K = \frac{ElS}{AN^2} \times 10^{-y\text{-intercept}}$).	**1**
	Additional detail including safety considerations	**6**
	D1 precaution linked to hot coil or hot resistor or prevention of burns from coil or resistor, e.g. use gloves / switch off power supply when not measuring V to prevent burns from coil / resistor	
	D2 keep N **and** A **and** l **and** S constant	
	D3 method to keep S constant, e.g. switch off power supply between readings to prevent heating of resistor or to allow resistor to cool	
	D4 method to determine A, e.g. use calipers / micrometer to measure diameter (of coil) / d **and** $A = \frac{\pi d^2}{4}$	
	D5 repeat measurements of diameter d along the length of the coil / in different directions **and** determine the average value of d	
	D6 method to determine the value of S, e.g. separate circuit diagram showing resistor connected to ohmmeter, or circuit diagram showing resistor connected to a power supply with an ammeter and voltmeter **and** $S = V / I$	
	D7 measure l with a ruler / calipers	
	D8 oscilloscope drawn connected across terminals / across signal generator **and** description to determine E	
	D9 adjust y-gain for maximum amplitude **or** adjust time base for length of one wave or measure n waves and divide measured time by n	

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Question	Answer	Marks
1	D10 method to keep *E* constant, e.g. check p.d. and alter supply **or** method to keep l constant, e.g. tape coil **or** method to keep *A* constant, e.g. wind wire on a cylinder	

Question	Answer	Marks
2(a)	gradient = $\frac{R}{E}$ *y*-intercept = $\frac{Z}{E}$	**1**
2(b)	$\frac{1}{I}$ / 10^3 A^{-1} 2.20 or 2.198 1.90 or 1.905 1.72 or 1.724 1.57 or 1.575 1.46 or 1.460 1.31 or 1.307 Values of $\frac{1}{I}$ / 10^3 A^{-1} correct as shown above.	**1**

Question	Answer	Marks
2(b)	Uncertainties in $\frac{1}{I}$ / 10^3 A^{-1} from ± 0.02 or ± 0.03 decreasing to ± 0.01.	**1**
2(c)(i)	Six points from **(b)** plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.	**1**
	Error bars in $\frac{1}{I}$ plotted correctly. All error bars to be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	**1**
2(c)(ii)	Straight line of best fit drawn. Thickness of the line must be less than half a small square. Do not accept line from top point to bottom point. Line must pass between (0.101, 1.40) and (0.104, 1.40) **and** between (0.189, 2.10) and (0.194, 2.10)	**1**
	Worst acceptable straight line drawn (steepest or shallowest possible line that passes through all the error bars). Thickness of the line must be less than half a small square. All error bars must be plotted.	**1**
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be greater than half the length of the drawn line.	**1**
	Gradient determined of worst acceptable line with clear substitution of data points into $\Delta y / \Delta x$. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**

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Question	Answer	Marks
2(c)(iv)	*y*-intercept determined by substitution of correct point with consistent power of ten in *m* and *y* into *y* = *mx* + *c*.	**1**
	y-intercept of worst acceptable line determined by substitution into *y* = *mx* + *c*. uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line *y*-intercept – shallowest worst line *y*-intercept) Do not accept ECF from false origin method.	**1**
2(d)(i)	*R* determined using gradient **and** *R* and *Z* given to 2 or 3 significant figures. *R* = gradient × 5.8	**1**
	Z determined using *y*-intercept **and** *R* and *Z* given with units with appropriate powers of ten. *Z* = *y*-intercept × 5.8 unit of *R*: Ω or V A^{-1} unit of *Z*: Ω or V A^{-1}	**1**
2(d)(ii)	Percentage uncertainty determined using Δ*E* = 0.2 (V) with method shown. $\Delta R\% = \left(\frac{\Delta E}{E} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$ **or** $\Delta R\% = \left(\frac{0.2}{5.8} + \frac{\Delta\text{gradient}}{\text{gradient}}\right) \times 100$	**1**

Question	Answer	Marks
2(e)	I determined to a minimum of 2 significant figures from **(c)(iii)** and **(c)(iv)** or **(d)(i)** with correct substitution. $I = \dfrac{1}{\dfrac{\text{gradient}}{20} + y\text{-intercept}}$ **or** $I = \dfrac{E}{\left(\dfrac{R}{20} + Z\right)}$	**1**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/54**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

MARK SCHEME

Maximum Mark: 30

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **12** printed pages.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
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SEEN	point has been noted, but no credit has been given or blank page seen
R	repeat of point previously awarded mark

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Question	Answer	Marks
1	**Defining the problem**	
	vary θ and measure *d* **or** θ is the independent variable and *d* is the dependent variable	**1**
	keep *z* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • sheet supported with stand or block(s) • path of ball (from sheet to bench) **or** distance *d* indicated • at least two labels from ball, bench, sheet, block/clamp/stand/support	**1**
	description of method to determine position of ball as it makes contact with the bench, e.g. paint ball, sand, video and playback in slow motion / frame by frame (with rule in view)	**1**
	measure *d* with a rule **and** measure *z* with a rule or calipers	**1**
	measure θ with a protractor **or** determine θ using (a rule for) appropriate distances with correct trigonometric relationship	**1**
	Method of analysis	
	plot a graph of *d* against sin (4θ) or equivalent Do not accept logarithms.	**1**

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Question	Answer	Marks
1	<table><tr><td>d against $\sin(4\theta)$</td><td>$\sin(4\theta)$ against d</td></tr><tr><td>$P = \frac{g \times \text{gradient}}{v^2}$</td><td>$P = \frac{g}{v^2 \times \text{gradient}}$</td></tr></table>	**1**
	<table><tr><td>d against $\sin(4\theta)$</td><td>$\sin(4\theta)$ against d</td></tr><tr><td>$Q = \frac{y\text{-intercept}}{\sqrt{z}}$</td><td>$Q = -\frac{Pv^2 \times y\text{-intercept}}{g\sqrt{z}}$ **or** $Q = -\frac{y\text{-intercept}}{\text{gradient} \times \sqrt{z}}$</td></tr></table>	**1**
	Additional detail including safety considerations	**6**
	D1 precaution linked to prevent <u>ball rolling</u> (off surface), e.g. use of cushion / sand box / barrier <u>to stop ball</u> (rolling onto the floor) **or** precaution linked to (bouncing) <u>ball</u> or <u>sand (</u>spray) e.g. use of goggles <u>to protect eyes</u>	
	D2 keep v <u>constant</u>	
	D3 method to keep v constant, e.g. keep the distance the ball falls constant to <u>keep v constant</u>	
	D4 method to determine v or v^2, e.g. use of $v = \sqrt{2g \times (\text{height ball falls})}$ **or** $v^2 = 2g \times (\text{height ball falls})$	

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Question	Answer	Marks
1	D5 set square correctly positioned between rule and bench to ensure that rule is vertical to measure *z* or determine initial height of ball	
	D6 method to ensure *z* is constant, e.g. as θ is changed, (re-)mark point of contact or change release point of ball	
	D7 description of method to ensure ball is released above point of contact on sheet, e.g. use a plumb line from the ball through point of contact with sheet or (vertical) rule (and set square)	
	D8 drop ball from large height to obtain greater values of *d*	
	D9 repeat experiment for each θ **and** average *d*	
	D10 relationship valid <u>if</u> a straight line produced (with *y*-intercept of e.g. $\left(Q\sqrt{Z}\right)$). Do not accept line passing through the origin.	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>gradient = n

y-intercept = lg k</td><td>1</td></tr>
<tr><td>2(b)</td><td><table><tr><th>lg μ</th><th>lg λ</th></tr><tr><td>0.66 or 0.663 ± 0.04</td><td>2.70 or 2.699</td></tr><tr><td>0.73 or 0.732 ± 0.03</td><td>2.90 or 2.903</td></tr><tr><td>0.92 or 0.924 ± 0.02</td><td>3.51 or 3.505</td></tr><tr><td>1.04 or 1.041 ± 0.04</td><td>3.85 or 3.845</td></tr><tr><td>1.20 or 1.204 ± 0.03</td><td>4.40 or 4.398</td></tr><tr><td>1.26 or 1.255 ± 0.02 or ± 0.03</td><td>4.58 or 4.580</td></tr></table>Values of lg μ and lg λ correct as shown above.</td><td>1</td></tr>
<tr><td></td><td>Uncertainties in lg μ correct as shown above.</td><td>1</td></tr>
<tr><td>2(c)(i)</td><td>Six points from (b) plotted correctly.
Must be within half a small square. Diameter of points must be less than half a small square.</td><td>1</td></tr>
<tr><td></td><td>Error bars in lg μ plotted correctly.
All error bars must be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.</td><td>1</td></tr>
</table>

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Question	Answer	Marks
2(c)(ii)	Straight line of best fit drawn. Thickness of the line must be less than half a small square. Do not accept line from top point to bottom point. Line must pass between (0.82, 3.20) and (0.84, 3.20) **and** between (1.13, 4.20) and (1.16, 4.20).	**1**
	Worst acceptable straight line drawn (steepest or shallowest possible line that passes through all the error bars). Thickness of the line must be less than half a small square. All error bars must be plotted.	**1**
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$. Distance between data points must be greater than half the length of the drawn line.	**1**
	Gradient determined of worst acceptable line with clear substitution of data points into $\Delta y / \Delta x$. uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**
2(c)(iv)	*y*-intercept determined by substitution of correct point with consistent power of ten in *m* and *x* into $y = mx + c$.	**1**
	y-intercept of worst acceptable line determined by substitution into $y = mx + c$. uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line **or** uncertainty = ½ (steepest worst line *y*-intercept – shallowest worst line *y*-intercept) Do not allow methods using a false origin.	**1**

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Question	Answer	Marks
2(d)	Value of k determined using y-intercept. $k = 10^{y-\text{intercept}}$	**1**
	$n =$ gradient **and** n and k given to 2 or 3 significant figures.	**1**
	absolute uncertainty in n = absolute uncertainty in gradient **and** absolute uncertainty in k = ($10^{y\text{-intercept}} - 10^{y\text{-intercept of WAL}}$) Correct method must be seen.	**1**
2(e)	M determined to a minimum of 2 significant figures from **(d)** or **(c)(iii)** and **(c)(iv)** with correct substitution **and** correct power(s) of ten. Do not accept incorrect POT for n or k. Correct substitution must be seen. $\mu = \sqrt[n]{\frac{\lambda}{k}} = \sqrt[\text{gradient}]{\frac{0.46}{\textbf{(d)}}}$ **or** $\lg\mu = \frac{\lg 0.46 - y\text{-intercept}}{\text{gradient}}$ **or** $\lg\mu = \frac{\lg 0.46 - \lg k}{\text{gradient}}$ **and** $M = \mu \times 2.0 \times 10^{30}$	**1**