CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/31**

Paper 3 Advanced Practical Skills 1 **May/June 2025**

MARK SCHEME

Maximum Mark: 40

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.

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Generic Marking Principles

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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.

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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

Annotation	Meaning
AE	arithmetic error
AWK	awkward scale used on graph
BOD	benefit of the doubt given
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^	information missing or insufficient for credit
POT	power of ten error

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Annotation	Meaning
RO	read-off from graph
SH	supervisor's help given
SR	supervisor's report taken into account
SV	supervisor's value/sample results taken into account
TE	transcription error
IR	value in range
OOR	value out of range

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Question	Answer	Marks
1(a)	Final value of n_0 with no unit **and** in the range $10 \leqslant n_0 \leqslant 30$.	**1**
	Evidence of repeats.	**1**
1(b)(i)	$n < n_0$.	**1**
1(b)(ii)	Correct calculation of N.	**1**
1(c)	Five sets of readings of M (different values) and n with correct trend (M increases, n decreases) and without help from Supervisor scores 4 marks, four sets scores 3 marks, etc.	**4**
	Range of M: Must include M_{min} = 10 g **and** $M_{max} \geqslant 60$ g.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. M / g.	**1**
	Significant figures: All values of N^3 given to 3 significant figures.	**1**
	Calculation: Correct calculation of N^3.	**1**
1(d)(i)	Axes: Axes must be labelled with the required quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).	**1**
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both x and y directions.	**1**
	Quality: All N^3 values are positive and trend of points must be positive. All points in the table (at least 4 points) must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within $\pm$ 5 g on the M-axis of all plotted points.	**1**

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Question	Answer	Marks
1(d)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 4 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 5 or more points are plotted and they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.	**1**
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the x and y directions. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.	**1**
	y-intercept: Intercept read directly from the graph, with read-off at $M = 0$, accurate to half a small square in y direction. **or** Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	**1**
1(e)	Value of P = candidate's gradient value **and** value of Q = candidate's intercept value. Values must not be written as fractions or given to only one significant figure.	**1**
	Units for P: g^{-1} or kg^{-1} consistent with their readings **and** no units for Q.	**1**

Question	Answer	Marks
2(a)	At least two values of raw *d* all to the nearest mm **and** final *d* in the range 5.9–6.1 cm.	**1**
2(b)(i)	Value of T_A on answer line in the range 2.0–10.0 s with unit.	**1**
	Repeats: At least two measurements of T_A.	**1**
2(b)(ii)	Percentage uncertainty based on absolute uncertainty in T_A in range 0.5–3.0 s. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from **(b)(i)**) × 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	**1**
2(c)(i)	Value of T_B.	**1**
2(c)(ii)	Correct calculation of *W* with no unit **and** *W* > 1.	**1**
2(c)(iii)	Justification for significant figures in *W* linked to significant figures in T_A and T_B (only).	**1**
2(d)	Second value of *d*.	**1**
	Second values of T_A and T_B.	**1**
	Second value of *W* > first value of *W*.	**1**
2(e)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions or given to only one significant figure.	**1**
2(f)	Calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 20%, leading to a consistent conclusion.	**1**

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Question	Answer	Marks
2(g)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Reason for difficulty in producing the rectangle of paper e.g. hard to make the sides parallel (or perpendicular) / hard to cut the sides straight / difficult to cut lengths accurately / cutting by hand with scissors (produces wavy sides) / paper twists / folds when cutting (because it is thin). C Difficulty with measuring *T* with reason e.g. two edges are not parallel when they meet / difficult to ensure the stopwatch is started at the same time as the paper is placed (or dropped) on to the water / experiment cannot be repeated using the <u>same</u> piece of paper. D Difficulty with the paper staying central in the bowl e.g. paper floats / moves and touches the edge of bowl. E Reason for difficulty with placing the paper onto the water surface e.g. paper is tilted / is dropped / hard to lower the paper parallel to the water / water surface is disturbed / ripples when placing paper / paper gets wet before entering water / paper is curled before placing on water. *1 mark for each point up to a maximum of 4.*	**4**
2(g)(ii)	A Take more readings (for different values of *d*) <u>and</u> plot a graph **or** take more readings <u>and</u> compare *k* values (**not** “repeat readings” on its own). B (To produce the rectangles) use a template / a grid **or** place tracing paper on graph paper **or** use a set square to draw (the rectangle) **or** use a guillotine / paper or box cutter / knife / scalpel with a straight edge (or ruler). C Video / film / record with timer in view. D Use wider bowl **or** have the water surface further down from the top of the bowl. E Place paper on a flat sheet of metal / glass / filter paper and place that sheet on surface of water **or** valid method of flattening the paper before putting into the water e.g. place weight on paper. *1 mark for each point up to a maximum of 4.*	**4**

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SV	supervisor's value/sample results taken into account
TE	transcription error
IR	value in range
OOR	value out of range

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Question	Answer	Marks
1(a)	Value for x in range 8.0–14.0 cm with unit.	**1**
	Non-zero value for I less than 2.00 mA with unit.	**1**
1(b)	Six sets of readings of x (different values) and I with correct trend (as x increases, I decreases) and without help from Supervisor scores 5 marks, five sets scores 4 marks etc.	**5**
	Range: $x_{min} \leqslant 5.0$ cm **and** $x_{max} \geqslant 16.0$ cm.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $\sqrt{I}$ (mA^{½}), $\sqrt{I}$ / mA^{½}.	**1**
	Consistency: All values of x must be given to the nearest millimetre.	**1**
	Significant figures: Values of $\sqrt{I}$ must be given to the same number of s.f. as (or one more than) the number of s.f. in I.	**1**
	Calculation: Values of $\sqrt{I}$ calculated correctly.	**1**
1(c)(i)	Axes: Axes must be labelled with the required quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).	**1**
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both x and y directions.	**1**
	Quality: General trend of points must be negative. All points in the table must be plotted (at least 5) for this mark to be awarded. It must be possible to draw a straight line that is within ± 2.0 cm (to scale) on the x-axis of all plotted points.	**1**

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Question	Answer	Marks
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 6 or more points are plotted and they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.	**1**
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the x and y directions. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.	**1**
	y-intercept: Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions. **Or** Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in y direction.	**1**
1(d)	a = candidate's gradient value **and** b = candidate's intercept value. Values must not be written as fractions or given to only one significant figure.	**1**
	Units for a and b are correct (e.g. $mA^{½}\,cm^{-1}$ for a and $mA^{½}$ for b).	**1**

Question	Answer	Marks
2(a)(i)	Value of *B* in range 7.50–9.50 cm with unit **and** to nearest mm.	**1**
2(a)(ii)	Percentage uncertainty based on absolute uncertainty in range 2–5 mm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from **(a)(i)**) × 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	**1**
2(b)(i)	Value for *d* in range 2.00–6.00 mm with unit **and** to nearest 0.1 mm.	**1**
2(b)(ii)	Value for *L* in range 20.0–40.0 cm with unit.	**1**
	Value of *T* in range 2.00–9.00 (s).	**1**
	Repeat readings for *T*: at least two values of *nT* where $n \geqslant 2$.	**1**
2(c)	Second values of *d* and *L*.	**1**
	Second value of *T*.	**1**
	Second *d* smaller than first *d*.	**1**
2(d)(i)	Two values of *k* calculated correctly. Values not written as fractions or given to only one significant figure.	**1**
2(d)(ii)	Justification for significant figures in *k* linked to significant figures in *B*, *L*, *d* and *T*.	**1**
2(e)	Correct calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 20%, leading to a consistent conclusion.	**1**

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Question	Answer	Marks
2(f)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficult to measure *B* with a reason e.g. difficult to judge the position of the centres of the masses / masses not parallel to each other on wire / *B* changes when clip and masses are suspended. C Difficult to measure *L* with a reason e.g. parallax error / rubber cord moves <u>when touched by rule</u> / clip moves <u>when touched by rule</u>. D Difficult to measure *d* with a reason e.g. jaws of calipers compress width of rubber cord. E Difficult to measure *T* with a reason e.g. because oscillations die away (very) quickly / amplitude of oscillations decreases quickly / oscillations are heavily damped / difficult to judge start and/or end of oscillations. F Difficulty with oscillation (of cord/clip/masses) e.g. oscillations in more than one mode / vertical or side-to-side oscillations /oscillation affected if rubber cord is not attached at centre of lower clip / wire moves in the clip during oscillation. *1 mark for each point up to a maximum of 4.*	**4**

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Question	Answer	Marks
2(f)(ii)	A Take more readings <u>and</u> plot a graph **or** take more readings <u>and</u> compare *k* values (**not** "repeat readings" on its own). B Improved method of measuring *B* e.g. measure from left (or right) hand side of one mass to left (or right) hand side of the other mass / measure *B* when clip is suspended. C Method to improve measurement of *L* e.g. clamp rule (to measure *L*) / use pointers attached to rule or attached to edges of clips. D Method to improve measurement of *d* e.g. use a micrometer (to measure *d*) / use travelling microscope (to measure *d*). E Method to improve measurement of *T* e.g. twist masses through larger angle before releasing / use marker placed at midpoint/equilibrium point/rest point of oscillation / record/film/video oscillation <u>with</u> timer in view. F Workable method to improve release of clip/masses e.g. mark centre of clip for attaching to the rubber cord / marker to indicate initial height / marker to indicate initial position of centre of clip vertically under cord. *1 mark for each point up to a maximum of 4.*	**4**

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Annotations

Annotation	Meaning
AE	arithmetic error
AWK	awkward scale used on graph
BOD	benefit of the doubt given
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SR	supervisor's report taken into account
SV	supervisor's value/sample results taken into account
TE	transcription error
IR	value in range
OOR	value out of range

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Question	Answer	Marks
1(a)	Value of E to the nearest 0.001 V with unit.	**1**
1(b)	Value of L with unit in the range 25.0–35.0 cm **and** $V < E$.	**1**
1(c)	Six sets of readings of L (different values) and V with correct trend (L increases as V decreases) and without help from Supervisor scores 4 marks, five sets scores 3 marks, etc.	**4**
	Range of L: $L_{min} \leqslant 35.0$ cm **and** $L_{max} \geqslant 80.0$ cm.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $\frac{E-V}{L}$ / V cm^{-1}.	**1**
	Consistency: All values of L must be to the nearest mm.	**1**
	Significant figures: All values of $\frac{E-V}{L}$ must be given to 3 or 4 significant figures.	**1**
	Calculation: Correct calculation of $\frac{E-V}{L}$.	**1**

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Question	Answer	Marks
1(d)(i)	Axes: Axes must be labelled with the required quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).	**1**
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both *x* and *y* directions.	**1**
	Quality: Trend of points must be positive. All points in the table (at least 5 points) must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within $\pm$ 0.02 V on the *V*-axis of <u>all</u> plotted points.	**1**
1(d)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 6 or more points are plotted and they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.	**1**
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the *x* and *y* directions. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.	**1**
	y-intercept: Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in *y* direction. **or** Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both *x* and *y* directions.	**1**

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Question	Answer	Marks
1(e)	*P* = candidate's gradient value **and** *Q* = –candidate's intercept value. Values must not be written as fractions or given to only one significant figure.	**1**
	Units for *P*: cm^{-1} or m^{-1} consistent with their readings **and** units for *Q*: V cm^{-1} or V m^{-1} consistent with their readings.	**1**
1(f)	Line W of larger gradient on left of original line, not crossing on graph grid.	**1**

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Question	Answer	Marks
2(a)(i)	Final value of *d* in the range 1.6–2.6 cm with unit and raw value(s) to the nearest mm.	**1**
2(a)(ii)	Percentage uncertainty based on absolute uncertainty in *d* in range 2–5 mm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from **(a)(i)**) × 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	**1**
2(b)(i)	Value of *x* in the range 65.0–75.0 cm to the nearest mm.	**1**
2(b)(ii)	(*N* =) <u>4.95</u>	**1**
2(c)	Value of *T* (on answer line) in the range 0.70–1.20 s with unit.	**1**
	Repeats: At least two measurements of *nT* where $n \geqslant 5$.	**1**
2(d)	Second values of *d* and *x*.	**1**
	Second value of *T*.	**1**
	Second value of *T* < first value of *T*.	**1**
2(e)(i)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions or given to only one significant figure.	**1**
2(e)(ii)	Justification for significant figures in *k* linked to significant figures in time, *d* and *x*.	**1**
2(f)	Correct calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 15%, leading to a consistent conclusion.	**1**

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Question	Answer	Marks
2(g)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficult to measure *d* with a reason e.g. parallax error (with sphere on rule) / ruler not precise an instrument to use **or** large percentage uncertainty in *d*. C Difficult to measure *x* with a reason e.g. difficult to locate centres of rods / rods may not be parallel. D Difficult to measure time or *T* with a reason e.g. judge start / end / completion of an oscillation. E Difficulty with the chain during oscillation e.g. chain slips (along rod) during oscillation / chain falls off the rod whilst oscillating / other modes of oscillation of the chain / movement of rods or stands during oscillation of the chain / difficult to maintain *x* to be constant whilst chain oscillating. F Difficulty with sphere e.g. not a uniform sphere / sphere falling off (paper clip) / sphere changes shape when handled. *1 mark for each point up to a maximum of 4.*	**4**

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Question	Answer	Marks
2(g)(ii)	A Take more readings (for different values of *x* and *n*) <u>and</u> plot a graph **or** take more readings <u>and</u> compare *k* values (**not** "repeat readings" on its own). B Use (vernier/digital) calipers **or** use blocks (either side of sphere) with detail. C Clamp rule (to measure *x*). D Video / film / record with timer in view **or** use marker at the centre of the oscillation. E Workable method to prevent chain from slipping e.g. groove in rod **or** workable method to mitigate unwanted modes of oscillation e.g. increase the number of paper clips **or** reduce the distance between the rods **or** use metal rods **or** clamp stands (to the bench). F Use a stiffer material for the balls e.g. use baked clay / metal balls **or** use a mould / preformed balls *1 mark for each point up to a maximum of 4.*	**4**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/34**

Paper 3 Advanced Practical Skills 2 **May/June 2025**

MARK SCHEME

Maximum Mark: 40

Published

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

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GENERIC MARKING PRINCIPLE 1:

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- 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.

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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).
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TE	transcription error
IR	value in range
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Question	Answer	Marks
1(a)(i)	Values of L_1 and L_2 with consistent unit **and** L_2 in the range 15.0–18.0 cm.	**1**
1(a)(ii)	Value of T on answer line in the range 0.70–1.50 s with unit.	**1**
	Repeats: At least two measurements of $\underline{n}T$ where $n \geqslant 5$.	**1**
1(b)	Six sets of readings of L_1 (different values), L_2 and T with correct trend (as L_1 decreases, L_2 **and** average T decreases) and without help from Supervisor scores 3 marks, five sets scores 2 marks etc.	**3**
	Range: At least one value of $L_2 \leqslant 6.0$ cm.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $(\sqrt{L_1} + \sqrt{L_2})$ / $cm^{½}$.	**1**
	Consistency: All values of L_1 and L_2 must be given to the nearest mm.	**1**
	Significant figures: All values of $(\sqrt{L_1} + \sqrt{L_2})$ given to 3 significant figures.	**1**
	Calculation: $(\sqrt{L_1} + \sqrt{L_2})$ calculated correctly.	**1**

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Question	Answer	Marks
1(c)(i)	Axes: Axes must be labelled with the required quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).	**1**
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both *x* and *y* directions.	**1**
	Quality: Trend of points must be positive. All points in the table must be plotted (at least 5 points) for this mark to be awarded. It must be possible to draw a straight line that is within ± 0.5 $cm^{½}$ on the $(\sqrt{L_1} + \sqrt{L_2})$-axis of all plotted points.	**1**
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 6 or more points are plotted and they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.	**1**
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the *x* and *y* directions. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.	**1**
	y-intercept: Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in *y* direction. **or** Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both *x* and *y* directions.	**1**

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Question	Answer	Marks
1(d)	*a* = candidate's gradient value **and** *b* = candidate's intercept value. Values must not be written as fractions or given to only one significant figure.	**1**
	Units for *a* and *b* correct (e.g. s $cm^{-½}$ for *a* and s for *b*).	**1**
1(e)	Correct calculation for *g* with consistent unit.	**1**

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Question	Answer	Marks
2(a)(i)	Value for *D* in range 5.00–7.00 mm, with unit	**1**
	Evidence of repeated measurements of *D*.	**1**
2(a)(ii)	Value for *d* in range 4.50–5.50 mm with unit **and** to at least the nearest 0.1 mm.	**1**
2(b)(i)	Value of time in the range 0.8–20.0 s with unit **and** to the nearest 0.1 s or better.	**1**
	Evidence of repeated measurements of *t*.	**1**
2(b)(ii)	Percentage based on absolute uncertainty in *t* of 0.2–0.5 s. Correct method of calculation to obtain percentage uncertainty e.g. (absolute uncertainty / value from **(b)(i)**) × 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	**1**
2(c)	Second value of *d*.	**1**
	Second value of *t*.	**1**
	Value for second *t* < first *t*.	**1**
2(d)(i)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions.	**1**
2(d)(ii)	Justification based on the significant figures in *t* and ($D^2 - d^2$).	**1**
2(e)	Calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 10%, leading to a consistent conclusion.	**1**

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Question	Answer	Marks
2(f)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Large <u>percentage</u> uncertainty in *t* / time. C Difficult to measure *t* / fall time / time between markers since it is difficult to judge when ball reaches the tape / marker. D Difficult to measure *D* with reason e.g. tube cross section not circular / tube changes shape when measuring / internal jaws of calipers too big. E Difficult to measure *d* with reason e.g. difficult to hold ball in jaws of calipers. F Difficulty with balls e.g. difficult to remove balls with magnet / balls hit side of tube when falling. *1 mark for each point up to a maximum of 4.*	**4**
2(f)(ii)	A Take more readings <u>and</u> plot a graph **or** take more readings <u>and</u> compare *k* values (**not** “repeat readings” on its own). B Increase the fall distance / use a long(er) tube. C Record / film / video with timer in view. D Use glass / rigid tube / use travelling microscope. E Use micrometer screw gauge. F Use strong(er) magnet / have more balls (of each size). *1 mark for each point up to a maximum of 4.*	**4**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/35**

Paper 3 Advanced Practical Skills 1 **May/June 2025**

MARK SCHEME

Maximum Mark: 40

Published

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SV	supervisor's value/sample results taken into account
TE	transcription error
IR	value in range
OOR	value out of range

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Question	Answer	Marks
1(a)	Value of T_0 in the range 1.0–1.4 s with unit.	**1**
	At least two sets of nT where $n \geqslant 5$.	**1**
1(b)	$T < T_0$.	**1**
1(c)	Six sets of readings of h and time with correct trend (T increases as h increases) and without help from Supervisor scores 5 marks, five sets scores 4 marks etc.	**5**
	Range of h : $h_{min} \leqslant 4.0$ cm **and** $h_{max} \geqslant 8.0$ cm.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention.	**1**
	Consistency: All values of h must be given to the nearest mm.	**1**
	Calculation: Correct calculation of T / T_0.	**1**
1(d)(i)	Axes: Axes must be labelled with the correct quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the x and y directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).	**1**
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both x and y directions.	**1**
	Quality: Trend of points must be positive. All points in the table (at least 5 points) must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within $\pm$ 5 mm (to scale) on the h-axis of all plotted points.	**1**

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Question	Answer	Marks
1(d)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 6 or more points are plotted and they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.	**1**
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the x and y directions. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.	**1**
	y-intercept: Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in y direction. **or** Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both x and y directions.	**1**
1(e)	P = candidate's gradient value **and** Q = candidate's intercept value. Values must not be written as fractions or given to only one significant figure	**1**
	Units for P: cm^{-1} or m^{-1} consistent with readings **and** no units for Q.	**1**

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Question	Answer	Marks
2(a)	All raw value(s) of *t* to the nearest 0.01 mm **or** all raw values to the nearest 0.001 mm **and** final value in the range 0.80(0)–1.20(0) mm.	**1**
2(b)(i)	All raw *x* to the nearest mm **and** final value of *x* in the range 9.5–10.5 cm.	**1**
2(b)(ii)	Raw value of *y* to the nearest mm.	**1**
	Value of *y* in the range 3.0–5.0 cm.	**1**
2(b)(iii)	Percentage uncertainty based on absolute uncertainty in *y* in range 2–5 mm. Correct method of calculation to find percentage uncertainty. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	**1**
2(b)(iv)	Correct calculation of y^2 / m^2.	**1**
2(b)(v)	Justification for significant figures in y^2 / m^2 linked to significant figures in *y* and *m* only.	**1**
2(c)	Second values of *t*, *m* and *x*.	**1**
	Second value of *y*.	**1**
	Second value of *y* > first value of *y*.	**1**
2(d)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions or given to only one significant figure.	**1**
2(e)	Calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 20%, leading to a consistent conclusion.	**1**

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Question	Answer	Marks
2(f)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficult to draw lines with a reason e.g. because card is hanging / card or string moves when line being made / card not vertical. C Mass of putty not taken into account. D Difficulty in measuring *x* with a reason e.g. judging centre of the mass / placing the centre of the mass where required / mass covers up the mark made for *x*. E Difficulty in locating centre of gravity or difficulty in accuracy of *y* with a reason e.g. string is too thick / card sticks on the nail / nail is too thick. *1 mark for each point up to a maximum of 4.*	**4**
2(f)(ii)	A Take more readings <u>and</u> plot a graph **or** take more readings <u>and</u> compare *k* values (**not** “repeat readings” on its own). B Make a mark and then take off and draw line on the card on the bench **or** clamp rule vertically. C Measure mass of putty and add to the masses / measure the total mass of the masses and the putty **or** use a specified lighter adhesive e.g. tape or glue. D Measure to near and far side and average for *x.* E Use thinner string / thinner nail / use a pin / make hole bigger or smoother. *1 mark for each point up to a maximum of 4.*	**4**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/37**

Paper 3 Advanced Practical Skills 1 **May/June 2025**

MARK SCHEME

Maximum Mark: 40

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

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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).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

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
AE	arithmetic error
AWK	awkward scale used on graph
BOD	benefit of the doubt given
CON	contradiction in response, mark not awarded
✓	correct point or mark awarded
ECF	error carried forward applied
FO	false origin used on graph
✗	incorrect point or mark not awarded
^	information missing or insufficient for credit
POT	power of ten error

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Annotation	Meaning
RO	read-off from graph
SH	supervisor's help given
SR	supervisor's report taken into account
SV	supervisor's value/sample results taken into account
TE	transcription error
IR	value in range
OOR	value out of range

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Question	Answer	Marks
1(a)	Value of E to the nearest 0.001 V with unit.	**1**
1(b)	Value of L with unit in the range 25.0–35.0 cm **and** $V < E$.	**1**
1(c)	Six sets of readings of L (different values) and V with correct trend (L increases as V decreases) and without help from Supervisor scores 4 marks, five sets scores 3 marks, etc.	**4**
	Range of L: $L_{min} \leqslant 35.0$ cm **and** $L_{max} \geqslant 80.0$ cm.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $\frac{E-V}{L}$ / V cm^{-1}.	**1**
	Consistency: All values of L must be to the nearest mm.	**1**
	Significant figures: All values of $\frac{E-V}{L}$ must be given to 3 or 4 significant figures.	**1**
	Calculation: Correct calculation of $\frac{E-V}{L}$.	**1**

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Question	Answer	Marks
1(d)(i)	Axes: Axes must be labelled with the required quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).	**1**
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both *x* and *y* directions.	**1**
	Quality: Trend of points must be positive. All points in the table (at least 5 points) must be plotted on the grid for this mark to be awarded. It must be possible to draw a straight line that is within $\pm$ 0.02 V on the *V*-axis of <u>all</u> plotted points.	**1**
1(d)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 6 or more points are plotted and they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.	**1**
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the *x* and *y* directions. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.	**1**
	y-intercept: Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in *y* direction. **or** Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both *x* and *y* directions.	**1**

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Question	Answer	Marks
1(e)	*P* = candidate's gradient value **and** *Q* = –candidate's intercept value. Values must not be written as fractions or given to only one significant figure.	**1**
	Units for *P*: cm^{-1} or m^{-1} consistent with their readings **and** units for *Q*: V cm^{-1} or V m^{-1} consistent with their readings.	**1**
1(f)	Line W of larger gradient on left of original line, not crossing on graph grid.	**1**

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Question	Answer	Marks
2(a)(i)	Final value of *d* in the range 1.6–2.6 cm with unit and raw value(s) to the nearest mm.	**1**
2(a)(ii)	Percentage uncertainty based on absolute uncertainty in *d* in range 2–5 mm. Correct method of calculation to find percentage uncertainty e.g. (absolute uncertainty / value from **(a)(i)**) × 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	**1**
2(b)(i)	Value of *x* in the range 65.0–75.0 cm to the nearest mm.	**1**
2(b)(ii)	(*N* =) <u>4.95</u>	**1**
2(c)	Value of *T* (on answer line) in the range 0.70–1.20 s with unit.	**1**
	Repeats: At least two measurements of *nT* where $n \geqslant 5$.	**1**
2(d)	Second values of *d* and *x*.	**1**
	Second value of *T*.	**1**
	Second value of *T* < first value of *T*.	**1**
2(e)(i)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions or given to only one significant figure.	**1**
2(e)(ii)	Justification for significant figures in *k* linked to significant figures in time, *d* and *x*.	**1**
2(f)	Correct calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 15%, leading to a consistent conclusion.	**1**

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Question	Answer	Marks
2(g)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficult to measure *d* with a reason e.g. parallax error (with sphere on rule) / ruler not precise an instrument to use **or** large percentage uncertainty in *d*. C Difficult to measure *x* with a reason e.g. difficult to locate centres of rods / rods may not be parallel. D Difficult to measure time or *T* with a reason e.g. judge start / end / completion of an oscillation. E Difficulty with the chain during oscillation e.g. chain slips (along rod) during oscillation / chain falls off the rod whilst oscillating / other modes of oscillation of the chain / movement of rods or stands during oscillation of the chain / difficult to maintain *x* to be constant whilst chain oscillating. F Difficulty with sphere e.g. not a uniform sphere / sphere falling off (paper clip) / sphere changes shape when handled. *1 mark for each point up to a maximum of 4.*	**4**

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Question	Answer	Marks
2(g)(ii)	A Take more readings (for different values of *x* and *n*) <u>and</u> plot a graph **or** take more readings <u>and</u> compare *k* values (**not** "repeat readings" on its own). B Use (vernier/digital) calipers **or** use blocks (either side of sphere) with detail. C Clamp rule (to measure *x*). D Video / film / record with timer in view **or** use marker at the centre of the oscillation. E Workable method to prevent chain from slipping e.g. groove in rod **or** workable method to mitigate unwanted modes of oscillation e.g. increase the number of paper clips **or** reduce the distance between the rods **or** use metal rods **or** clamp stands (to the bench). F Use a stiffer material for the balls e.g. use baked clay / metal balls **or** use a mould / preformed balls *1 mark for each point up to a maximum of 4.*	**4**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/38**

Paper 3 Advanced Practical Skills 2 **May/June 2025**

MARK SCHEME

Maximum Mark: 40

Published

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SV	supervisor’s value/sample results taken into account
TE	transcription error
IR	value in range
OOR	value out of range

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Question	Answer	Marks
1(a)(i)	Values of L_1 and L_2 with consistent unit **and** L_2 in the range 15.0–18.0 cm.	**1**
1(a)(ii)	Value of T on answer line in the range 0.70–1.50 s with unit.	**1**
	Repeats: At least two measurements of $\underline{n}T$ where $n \geqslant 5$.	**1**
1(b)	Six sets of readings of L_1 (different values), L_2 and T with correct trend (as L_1 decreases, L_2 **and** average T decreases) and without help from Supervisor scores 3 marks, five sets scores 2 marks etc.	**3**
	Range: At least one value of $L_2 \leqslant 6.0$ cm.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. $(\sqrt{L_1} + \sqrt{L_2})$ / $cm^{½}$.	**1**
	Consistency: All values of L_1 and L_2 must be given to the nearest mm.	**1**
	Significant figures: All values of $(\sqrt{L_1} + \sqrt{L_2})$ given to 3 significant figures.	**1**
	Calculation: $(\sqrt{L_1} + \sqrt{L_2})$ calculated correctly.	**1**

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Question	Answer	Marks
1(c)(i)	Axes: Axes must be labelled with the required quantities. Scales must be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions. Scale markings are no more than 2 cm (one large square) apart. Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions).	**1**
	Plotting of points: All observations in the table must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Points must be plotted to an accuracy of half a small square in both *x* and *y* directions.	**1**
	Quality: Trend of points must be positive. All points in the table must be plotted (at least 5 points) for this mark to be awarded. It must be possible to draw a straight line that is within ± 0.5 $cm^{½}$ on the $(\sqrt{L_1} + \sqrt{L_2})$-axis of all plotted points.	**1**
1(c)(ii)	Line of best fit: 'Best fit' is judged by the balance of all points on the grid (at least 5 points) about the candidate's line. There must be an even distribution of points either side of the line along the full length. Lines must not be kinked or thicker than half a square. Some candidates may choose to identify an anomalous point. If 6 or more points are plotted and they identify **one** point as anomalous (e.g. by circling or labelling) then this point is to be disregarded when judging the line of best fit.	**1**
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Both read-offs must be accurate to half a small square in both the *x* and *y* directions. Method of calculation must be correct, not $\Delta x / \Delta y$. Gradient sign on answer line must be consistent with graph drawn.	**1**
	y-intercept: Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in *y* direction. **or** Correct read-off from a point on the line is substituted into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both *x* and *y* directions.	**1**

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Question	Answer	Marks
1(d)	*a* = candidate's gradient value **and** *b* = candidate's intercept value. Values must not be written as fractions or given to only one significant figure.	**1**
	Units for *a* and *b* correct (e.g. s $cm^{-½}$ for *a* and s for *b*).	**1**
1(e)	Correct calculation for *g* with consistent unit.	**1**

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Question	Answer	Marks
2(a)(i)	Value for *D* in range 5.00–7.00 mm, with unit	**1**
	Evidence of repeated measurements of *D*.	**1**
2(a)(ii)	Value for *d* in range 4.50–5.50 mm with unit **and** to at least the nearest 0.1 mm.	**1**
2(b)(i)	Value of time in the range 0.8–20.0 s with unit **and** to the nearest 0.1 s or better.	**1**
	Evidence of repeated measurements of *t*.	**1**
2(b)(ii)	Percentage based on absolute uncertainty in *t* of 0.2–0.5 s. Correct method of calculation to obtain percentage uncertainty e.g. (absolute uncertainty / value from **(b)(i)**) × 100. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	**1**
2(c)	Second value of *d*.	**1**
	Second value of *t*.	**1**
	Value for second *t* < first *t*.	**1**
2(d)(i)	Two values of *k* calculated correctly. The final *k* values must not be written as fractions.	**1**
2(d)(ii)	Justification based on the significant figures in *t* and ($D^2 - d^2$).	**1**
2(e)	Calculation of percentage difference between candidate's two *k* values. Comparison of percentage difference with 10%, leading to a consistent conclusion.	**1**

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Question	Answer	Marks
2(f)(i)	A Two (sets of) readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Large <u>percentage</u> uncertainty in *t* / time. C Difficult to measure *t* / fall time / time between markers since it is difficult to judge when ball reaches the tape / marker. D Difficult to measure *D* with reason e.g. tube cross section not circular / tube changes shape when measuring / internal jaws of calipers too big. E Difficult to measure *d* with reason e.g. difficult to hold ball in jaws of calipers. F Difficulty with balls e.g. difficult to remove balls with magnet / balls hit side of tube when falling. *1 mark for each point up to a maximum of 4.*	**4**
2(f)(ii)	A Take more readings <u>and</u> plot a graph **or** take more readings <u>and</u> compare *k* values (**not** “repeat readings” on its own). B Increase the fall distance / use a long(er) tube. C Record / film / video with timer in view. D Use glass / rigid tube / use travelling microscope. E Use micrometer screw gauge. F Use strong(er) magnet / have more balls (of each size). *1 mark for each point up to a maximum of 4.*	**4**

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