Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/31**

Paper 3 Advanced Practical Skills 1 **October/November 2020**

MARK SCHEME

Maximum Mark: 40

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 descriptors 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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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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Question	Answer	Marks
1(a)	Value(s) of p in the range 9.0–15.0 cm with unit.	**1**
1(b)	Value of m in the range 10.0–14.0 g.	**1**
1(c)	Six sets of readings of m (different values) and p with correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	**5**
	Range: $\Delta m \geqslant 80$ g.	**1**
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention, e.g. m / g, $\sqrt{p}$ / m^{½}.	**1**
	Consistency: All values of p must be given to the nearest mm.	**1**
	Significant figures: All values of $\sqrt{m}$ must be given to the same number of significant figures as, or one greater than, the number of s.f. of the m values as recorded in table.	**1**
	Calculation: Values of $\sqrt{p}$ are correct.	**1**

Question	Answer	Marks
1(d)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	**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.	**1**
	Quality: All points in the table must be plotted on the grid. Trend of points must be correct. It must be possible to draw a straight line that is within ±0.1 on the $\sqrt{p}$ axis of all plotted points.	**1**
1(d)(ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	**1**

Question	Answer	Marks
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct, e.g. not $\Delta x / \Delta y$. Gradient sign on answer line matches graph drawn. Both read-offs must be accurate to half a small square in both the *x* and *y* directions.	**1**
	y-intercept: Correct read-off from a point on the line substituted correctly 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* = zero, accurate to half a small square.	**1**
1(e)	Value of *A* = candidate's gradient **and** value of *B* = candidate's intercept. The values must not be fractions.	**1**
	Unit for *A* correct (e.g. $cm^{0.5}\ g^{-0.5}$ or $cm^{½}\ g^{-½}$) **and** unit for *B* correct (e.g. $cm^{0.5}$ or $cm^{½}$).	**1**

Question	Answer	Marks
2(a)(i)	Value(s) of raw θ to the nearest degree.	**1**
2(a)(ii)	Correct calculation of $\sin\theta$.	**1**
2(a)(iii)	Justification for significant figures in $\sin\theta$ linked to s.f. in θ.	**1**
2(b)(i)	Value of time *t* in range 0.5–3.0 s.	**1**
	Evidence of repeat values of *t*.	**1**
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty in *t* in range 0.2–0.5 s. If repeat readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	**1**
2(c)(i)	Second value of θ recorded.	**1**
	Second value of θ less than 70.0°.	**1**
2(c)(ii)	Second value of *t* recorded.	**1**
	Second value of *t* greater than first value of *t*.	**1**
2(d)(i)	Two values of *k* calculated correctly. The final *k* values must not be fractions.	**1**
2(d)(ii)	Valid comment consistent with the calculated values of *k*, testing against a criterion stated by the candidate.	**1**

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Question	Answer	Marks
2(e)(i)	A Two readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficulty in measuring time *t* with a reason, e.g. time interval is short/percentage uncertainty is large/difficult to release shape and start stop-watch simultaneously/difficult to judge when to stop timing. C Difficulty linked to the practical set up of the board, e.g. holding with one clamp, board is not square to bench/board is not stable/board tilts to side. D Difficulty linked to release, e.g. force applied varies/starting position may vary/adhesive putty sticks (affects friction). E Difficulty with the angle with reason, e.g. setting or adjusting the angle when changing the clamp/difficult to make fine adjustments to the angle. *1 mark for each point up to a maximum of 4.*	**4**
2(e)(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 to measure *t*, e.g. timer and pressure/contact switch at release point and/or at bottom or video with timer/frame-by-frame. C Improved method to support board, e.g. use more than one clamp/clamp both sides/support with a block. D Improved method of release, e.g. use of a stop/use of a card gate. E Improved method to make fine adjustments to angle, e.g. scissor jack/use of screw thread on a clamp. *1 mark for each point up to a maximum of 4.*	**4**

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Question	Answer	Marks
1(a)	Values of raw diameter either all recorded to 0.01 cm or all to 0.001 cm **and** final value in range 1.00–10.00 cm.	**1**
	Evidence of repeat measurements.	**1**
1(b)	p in range 15.0 cm $\leqslant p \leqslant$ 19.0 cm **and** F in range 1.0 N $\leqslant F \leqslant$ 5.0 N.	**1**
1(c)	Six (or more) sets of readings of p and F (different values of non-zero p) with the correct trend and without help from the Supervisor scores 3 marks, five sets scores 2 marks, etc.	**3**
	Range: Must include values of $p \leqslant$ 8.0 cm and $p \geqslant$ 42.0 cm.	**1**
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. ($p + r$) / cm	**1**
	Consistency: <u>All</u> raw values of p must be given to the nearest 0.1 cm.	**1**
	Consistency: <u>All</u> raw values of F must be given to the nearest 0.1 N.	**1**
	Calculation: Values of ($p + r$) are correct.	**1**

Question	Answer	Marks
1(d)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	**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.	**1**
	Quality: All points in the table (at least 5) must be plotted on the grid. Trend of points must be correct. It must be possible to draw a straight line that is within ±0.20 N (to scale) on the *F* axis (normally *y*-axis) of all plotted points.	**1**
1(d)(ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	**1**
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct, e.g. not Δx / Δy. Gradient sign on answer line matches graph drawn. Both read-offs must be accurate to half a small square in both the *x* and *y* directions.	**1**
	y-intercept: Correct read-off from a point on the line substituted correctly 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 $p + r =$ zero, accurate to half a small square.	**1**

Question	Answer	Marks
1(e)	$Q = \frac{W}{\text{gradient}} = \frac{3.00}{\text{gradient}}$	**1**
	$S = Q \times y\text{-intercept} = \frac{3.00 \times y\text{-intercept}}{\text{gradient}}$	**1**
	Units for Q and S correct (e.g. m and N m).	**1**

Question	Answer	Marks
2(a)(i)	Raw L to the nearest 0.1 cm **and** final value in the range 11.5–12.5 cm.	**1**
2(a)(ii)	Percentage uncertainty based on an absolute uncertainty ΔL in the range 2–5 mm. If repeat readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	**1**
2(b)(i)	All raw times measured either to the nearest 0.1 s or all to the nearest 0.01 s.	**1**
	Evidence of measurement of nT repeated where $n \geqslant 5$.	**1**
	Value of T in the range $0.5\,\text{s} \leqslant T \leqslant 1.0\,\text{s}$.	**1**
2(b)(ii)	Calculation of T^2 correct.	**1**
2(b)(iii)	Justification of the number of significant figures in terms of the number of s.f. in (raw) time <u>only</u>.	**1**
2(c)	Second values of L and T.	**1**
	Second value of T < first value of T.	**1**
2(d)(i)	Two values of k calculated correctly. The final k values must not be fractions.	**1**
2(d)(ii)	Valid comment consistent with the calculated values of k, testing against a criterion stated by the candidate.	**1**
2(e)	Correct calculation of g using candidate's second k **and** in range $2.0\,\text{m s}^{-2} \leqslant g \leqslant 20.0\,\text{m s}^{-2}$.	**1**

Question	Answer	Marks
2(f)(i)	A Two readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficulty in measuring time or *T* with a reason, e.g. judging when to start or stop the stop-watch, judging start/end/complete oscillation. C Difficulty in measuring *L* with a reason, e.g. wire is not straight/is kinked/has rounded corners. D Corners are not at right angles **or** square not complete/joined **or** shape changes when suspended/during oscillation. E Oscillations are not in one plane **or** square catches on drawing pin. *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 Method of improving time or *T*, e.g. fiducial marker at centre/video (or record or film) <u>and</u> timer (or frame-by-frame)/place a grid behind the apparatus. C Method of improving *L*, e.g. use thicker/stiffer wire or use a former/shaping block. D Method of improving the setting of 90° corners, e.g. use a set square or protractor with appropriate reason **or** method of fixing ends, e.g. use adhesive putty/tape with appropriate reason. E Method of improving oscillation, e.g. longer pin/use of guide with detail/groove in pin/use a nail/use a hook. *1 mark for each point up to a maximum of 4.*	**4**

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1(a)	Value of raw x to the nearest mm **and** final value in range 38.0–42.0 cm.	**1**
1(b)	Value of θ in range 60°–100°.	**1**
1(c)	Six (or more) sets of readings of x and θ with correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks etc. Values of x should be different and non-zero.	**5**
	Range: $x_{min} \leqslant 20.0$ cm **and** $x_{max} \geqslant 45.0$ cm.	**1**
	Column headings: Each column heading must contain a quantity, a separating mark and a unit where appropriate. Heading for $\cos\theta$ must have no unit. The presentation of quantity and unit must conform to accepted scientific convention e.g. x / cm.	**1**
	Consistency: All values of raw θ must be given to the nearest degree.	**1**
	Significant figures: Values of $\cos\theta$ should be to the same number of s.f. as (or one more than) the number of s.f. in the corresponding value of θ.	**1**
	Calculation: Values of $\cos\theta$ calculated correctly.	**1**

Question	Answer	Marks
1(d)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	**1**
	Plotting of points: All observations must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square. Plots must be accurate to within half a small square in both *x* and *y* directions.	**1**
	Quality: All points in the table must be plotted (at least 5) for this mark to be awarded. Trend of points should be correct. Scatter of plotted points must be no more than ±0.05 from a straight line on the $\cos\theta$ axis.	**1**
1(d)(ii)	Line of best fit: Judged by balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length. One anomalous point is allowed only if clearly indicated (i.e. circled or labelled) by the candidate. Lines must not be kinked or thicker than half a square.	**1**
1(d)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct, e.g. not Δx / Δy. The sign of the gradient must match the graph drawn. Both read-offs must be accurate to half a small square in both the *x* and *y* directions.	**1**
	y-intercept: Correct read-off from a point on the line 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* = zero accurate to half a small square in *y* direction.	**1**

Question	Answer	Marks
1(e)	*a* equal to candidate's gradient **and** *b* equal to candidate's intercept. Values must not be written as fractions.	**1**
	Unit for *a* correct (e.g. cm^{-1}) and consistent with value **and** no unit given for *b*.	**1**

Question	Answer	Marks
2(a)(i)	Value of raw *x* to nearest mm **and** final value in range 20–24 mm with unit.	**1**
2(a)(ii)	Values of raw *D* and *d* to nearest mm **and** final value of *D* in the range 38–42 mm.	**1**
2(a)(iii)	Correct calculation of *L*.	**1**
2(a)(iv)	Justification based on significant figures in *x*, *D* and (*D* – *d*).	**1**
2(b)(i)	Raw values of times all to 0.1 s or all to 0.01 s **and** value of *T* in range 0.5–2.5 s.	**1**
	Evidence of repeats: at least two values of time.	**1**
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty in time value of 0.2–0.5 s. If repeat readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	**1**
2(c)	Second values of *x* and *T*.	**1**
	Quality: second *T* > first *T*.	**1**
2(d)(i)	Two values of *k* calculated correctly. The final values of *k* must not be fractions.	**1**
2(d)(ii)	Valid comment relating to the calculated values of *k*, testing against a criterion specified by the candidate.	**1**
2(e)	Correct calculation of *g*.	**1**

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Question	Answer	Marks
2(f)(i)	A Two readings are not enough to draw a (valid) conclusion (**not** "not enough for accurate results", "few readings"). B Difficult to measure diameters or *x* with reason e.g. parallax/zero not at end of ruler/*x* varies around roller/nuts or bolt prevent placement of ruler. C θ small so large uncertainty/large % uncertainty in θ. D Oscillations die away quickly. E Difficult to measure time/*T* because it is difficult to judge the end/beginning/completion of an oscillation. F Roller slips down board. *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 Use metre rule/calipers/micrometer/blocks either side of washer/use pointers with detail. C Method to reduce uncertainty in θ e.g. use of trigonometry with detail/increase θ. D Method to increase the number of oscillations e.g. smoother board/named smooth material for board/sand board. E Method of improving timing e.g. fiducial marker at centre of oscillation or video/record/film with timer/frame-by-frame. F Method of reducing slipping e.g. rougher/named higher friction surface/smaller θ. *1 mark for each point up to a maximum of 4.*	**4**

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/35**

Paper 3 Advanced Practical Skills 1 **October/November 2020**

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.

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This document consists of **8** 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 descriptors 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).
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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Question	Answer	Marks
1(a)	Value of I with unit in the range 30.0–50.0 mA.	**1**
1(b)	Six (or more) sets of readings of R and I (different values of R) with the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	**5**
	Range: Must use $R = 204\ \Omega$ **and** $22.7\ \Omega$.	**1**
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention, e.g. $1/I$ (mA^{-1}).	**1**
	Consistency of presentation: All raw values of I must be given to 0.1 mA or all to 0.01 mA.	**1**
	Significant figures: All values of $1/I$ must be given to the same number of s.f. as (or one more than) the number of s.f. in raw I.	**1**
	Calculation: Values of $1/I$ are correct.	**1**
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	**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.	**1**
	Quality: All points in the table must be plotted (at least 5) on the grid for this mark to be awarded. Trend of points must be correct. It must be possible to draw a straight line that is within $\pm 4\ \Omega$ (to scale) on the R axis (normally x-axis) of all plotted points.	**1**

Question	Answer	Marks
1(c)(ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	**1**
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct, e.g. not Δx / Δy. Gradient sign on answer line matches graph drawn. Both read-offs must be accurate to half a small square in both the x and y directions.	**1**
	y-intercept: Correct read-off from a point on the line substituted correctly 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 R = zero, accurate to half a small square.	**1**
1(d)	E = 1 / gradient	**1**
	$X = E \times y$-intercept **or** X = y-intercept / gradient	**1**
	Units for E and X correct (e.g. V and Ω).	**1**

Question	Answer	Marks
2(a)(i)	$p = 7.0 \pm 0.2$ cm $q = 21.0 \pm 0.2$ cm $w = 24.0 \pm 0.2$ cm	**1**
	All raw values recorded to the nearest millimetre.	**1**
2(a)(ii)	Correct calculation of $\frac{2q}{p+q}$.	**1**
2(b)(i)	Value of d.	**1**
2(b)(ii)	Percentage uncertainty based on an absolute uncertainty Δd in the range 2–5 mm. If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) if working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	**1**
2(b)(iii)	Value of (w – d) correctly calculated from w and d.	**1**
2(c)(i)	Valid method, e.g. measure q / 2 in several places and draw a straight line with a ruler.	**1**
2(c)(ii)	Second q recorded to the nearest mm <u>and</u> half original value of $q \pm 1$ mm.	**1**
2(c)(iii)	Second value of d recorded.	**1**
	Second value of d is larger than first value of d.	**1**
2(d)(i)	Two values of k calculated correctly. The final k values must not be fractions.	**1**
2(d)(ii)	Valid comment consistent with the calculated values of k, testing against a criterion stated by the candidate.	**1**

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Question	Answer	Marks
2(e)(i)	A Two readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficult to judge when top edge of card is horizontal/difficult to keep card horizontal. C Difficult to accurately locate the centre of the paper clip, e.g. clip too large/clip not vertical/sides of clip not straight. D Difficulty with the attachment, e.g. paper clip does not grip/card falls. E Difficult to measure *d* with reason, e.g. touching disturbs equilibrium/ruler held by hand in mid-air/parallax error. F Card bends easily **or** corners on card may not be at right angles. *1 mark for each point up to a maximum of 4.*	**4**
2(e)(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 Method to improve judgement of horizontal, e.g. use of spirit level/clamped ruler with detailed method to ensure horizontal/place a grid behind the apparatus with method to ensure horizontal/turn off air conditioning. C Method to improve location of centre of paper clip, e.g. use narrower paper clip/measure to either side of clip and average/use calipers to measure width of clip. D Improved method of suspension, e.g. place pin through card/hole with needle/add adhesive putty. E Improved method to measure *d*, e.g. clamp ruler/write scale on card/carefully remove with paper clip and measure on bench. F Use of named more rigid material **or** detailed use of a set square or protractor. *1 mark for each point up to a maximum of 4.*	**4**

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Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/36**

Paper 3 Advanced Practical Skills 2 **October/November 2020**

MARK SCHEME

Maximum Mark: 40

Published

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Question	Answer	Marks
1(a)	Value of *y* in range 5.0–50.0 cm.	**1**
1(b)	Six sets of readings of *R* and *y* with correct trend and without help from the Supervisor scores 4 marks, five sets scores 3 marks etc.	**4**
	Range: *R* values must include 100 Ω and 820 Ω.	**1**
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate The presentation of quantity and unit must conform to accepted scientific convention e.g. 1 / *y* (cm^{-1}).	**1**
	Consistency: All values of raw *y* must be given to the nearest mm.	**1**
	Significant figures: All values of 1 / *y* should have the same number of s.f. as (or one more than) its corresponding raw *y* value.	**1**
	Calculation: Values of 1 / *y* calculated correctly.	**1**

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Question	Answer	Marks
1(c)(i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions) Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	**1**
	Plotting of points: All observations must be plotted on the grid. Diameter of plotted points must be ≤ half a small square. Plots must be accurate to within half a small square in both *x* and *y* directions.	**1**
	Quality: All points in the table must be plotted (at least 5) for this mark to be awarded. Trend must be correct. Scatter of plotted points must be no more than ± 25 Ω from a straight line in the *R* direction.	**1**
1(c)(ii)	Line of best fit: Judge by balance of all points on the grid (at least 5) about the candidate's line. There must be an even distribution of points either side of the line along the full length. One anomalous point is allowed only if clearly indicated (i.e. circled or labelled) by the candidate. Lines must not be kinked or thicker than half a square.	**1**
1(c)(iii)	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct. Sign of the gradient value must match the gradient of the graph. Both read-offs must be accurate to half a small square in both the *x* and *y* directions.	**1**
	y-intercept: Correct read-off from a point on the line 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 *R* = zero accurate to half a small square in *y* direction.	**1**

Question	Answer	Marks
1(d)	Value of *a* equal to candidate's gradient **and** value of *b* equal to candidate's intercept. Values must not be written as fractions.	**1**
	Units for *a* (e.g. $cm^{-1}\,\Omega^{-1}$) and *b* (e.g. cm^{-1}) correct and consistent with values.	**1**
1(e)(i)	*W* to the nearest mm and in the range 88.0–92.0 cm.	**1**
1(e)(ii)	*P* calculated correctly.	**1**

Question	Answer	Marks
2(a)	Value of *L* to nearest mm and in range 28.0–30.0 cm.	**1**
	Value of *H* to nearest mm.	**1**
2(b)	Percentage uncertainty based on an absolute uncertainty in *H* value of 2–5 mm. If repeat readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	**1**
2(c)	Raw values of times all to 0.1 s or all to 0.01 s **and** value of *T* in range 0.90–1.60 s.	**1**
	Repeated readings: at least two values of 5*T* or more.	**1**
2(d)(i)	Second values of *L* and *H*.	**1**
2(d)(ii)	Second value of *T*.	**1**
	Quality: second value of *T* > first value of *T*.	**1**
2(e)(i)	Two values of *k* calculated correctly.	**1**
2(e)(ii)	Justification based on the number of significant figures in <u>all</u> of: raw times, *L* and *H*.	**1**
2(e)(iii)	Valid comment relating to the calculated values of *k*, testing against a criterion specified by the candidate.	**1**
2(f)	Correct calculation of *g* with consistent unit.	**1**

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Question	Answer	Marks
2(g)(i)	A Two readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”). B Difficult to hold ruler in bent position while sticking on the tape. C Tape difficult to handle because of stickiness. D Difficulty measuring *H* (or height) with detail e.g. *H* varies across width of curved ruler/difficulty locating highest point of curved ruler/parallax problem/ruler not vertical/zero not at end of vertical ruler. E Difficulty measuring *T* (or time) with detail e.g. judging complete oscillation/judging start of oscillation/judging end of oscillation. F Difficulty measuring *L* with detail e.g. *L* varies across width of curved ruler/*L* hidden behind tape. G *H* changes when strip is put on top of curved ruler. *1 mark for each point up to a maximum of 4.*	**4**
2(g)(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 Push ruler against stop fixed to bench (when fixing tape). C Hold ruler between clamped blocks (instead of using tape). D Measure *H* using e.g. travelling microscope/set square/ruler with scale starting at end/ruler and set square (or spirit level)/depth gauge on calipers/measure from zero mark to end of ruler and add to reading. E Video (or record or film) with timer in view (or frame-by-frame)/position (fiducial) marker at centre of motion. G Measure *H* with strip in place/use lower mass strip/use stiffer (curved) ruler. *1 mark for each point up to a maximum of 4.*	**4**

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