
PHYSICS

9702/31

Paper 3 Advanced Practical Skills 1

October/November 2018

MARK SCHEME

Maximum Mark: 40

Published

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- 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).

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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
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GENERIC MARKING PRINCIPLE 6:

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Question	Answer	Marks
1(a)	Value of x with unit in the range 23.5–24.5 cm.	1
1(b)	Value of T with unit in the range 1.0–1.5 s and to 0.1 s or better.	1
1(c)	Six sets of readings of x (different values) and time without help from the Supervisor and showing the correct trend scores 5 marks, five sets scores 4 marks etc.	5
	Range: Minimum value of $x < 10.5$ cm.	1
	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of the quantity and the unit must conform to accepted scientific convention e.g. $T^2x / \text{s}^2\text{m}$.	1
	Consistency: All raw values of x must be given to the nearest mm only.	1
	Significant figures: All values of x^2 must be given to the same number of significant figures as (or one more than) the number of significant figures in raw values of x .	1
	Calculation: Correct calculation of T^2x .	1
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 $\leq$ half a small square (no “blobs”). Points must be plotted to an accuracy of half a small square.	1
	Quality: General trend of points on graph must be positive. All points in the table (at least 5) must be plotted on the grid. It must be possible to draw a straight line that is within $\pm 0.005 \text{ m}^2$ on the x -axis of all plotted points.	1

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Question	Answer	Marks
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 (i.e. circled or labelled). Line 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. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient on answer line must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$. Read-off must be 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.	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 ($\text{s}^2 \text{m}^{-1}$, $\text{s}^2 \text{cm}^{-1}$ or $\text{s}^2 \text{mm}^{-1}$) and unit for B correct ($\text{s}^2 \text{m}$, $\text{s}^2 \text{cm}$ or $\text{s}^2 \text{mm}$).	1

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Question	Answer	Marks
2(a)(i)	Value of M with unit and to the nearest 0.1 g or better.	1
2(a)(ii)	Correct calculation of m dividing the value in (a)(i) by 25.	1
2(a)(iii)	Justification for significant figures in m linked to the s.f. in M .	1
2(b)(i)	Value of S in range $1.0\text{ g} \leq S \leq 2.0\text{ g}$ with consistent unit.	1
2(b)(ii)	Correct calculation of c .	1
2(c)(i)	Values p and q such that $p + q = 25$.	1
	Evidence of repeated values of p .	1
2(c)(ii)	Percentage uncertainty in p based on absolute uncertainty of 1 or 2. If repeated readings have been taken, then the 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(d)	Second values of p and q .	1
	Quality: second value of q less than first value of q .	1
2(e)(i)	Two values of k calculated correctly.	1
2(e)(ii)	Valid comment consistent with calculated values of k , testing against a criterion stated by the candidate.	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 Difficulty linked to board during movement of clips e.g. paper clips flip over when moving affecting friction/clips move to the side/clips catch on end of board/board irregular and clips catch on edge/board moves on table as well as clips. C Difficulty linked to placing or keeping the spheres on the clips e.g. spheres fall off/clips too small to hold the sphere/difficult to get two neighbouring paper clips level enough to take the two spheres/spheres touch table. D Difficulty linked to size of clips with a reason e.g. large increments of mass gives large uncertainty in the value of p or q/the exact force needed to cause movement may not be equal to a whole number of clips. E Masses of clips or spheres may be different. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take many readings (for different values of n) <u>and</u> plot a graph or take more values of k <u>and</u> compare. B Workable method e.g. provide a guide/over a pulley wheel/tape or clamp board to bench/sand the end of the board/sand out irregularities. C Workable method of adding/holding spheres e.g. use cuboid/disc shaped plasticine/tie paper clips together with thin cotton to keep flat. D Improved method to deal with large clips e.g. use more and smaller/lighter clips. E Check masses using a balance. <i>1 mark for each point up to a maximum of 4.</i>	4

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Question	Answer	Marks
1(a)	Value of I with unit and in the range $0.010\text{ A} \leq I \leq 0.200\text{ A}$.	1
1(b)	Value of y with unit and in the range $20.0\text{--}75.0\text{ cm}$.	1
1(c)	Six sets of readings of P , Q (different pairs) and y without help from the Supervisor scores 4 marks, five sets scores 3 marks etc.	4
	Range: Resistor values include the pair (15Ω and 12Ω) and the pair (27Ω and 22Ω).	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. y/m and $PQ/(P + Q)/\Omega$.	1
	Consistency: All values of y must be given to the nearest mm only.	1
	Significant figures: Values of $PQ/(P + Q)$ must be given to 2 or 3 significant figures.	1
	Calculation: Values of $PQ/(P + Q)$ are correct.	1
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 $\leq$ half a small square (no “blobs”). Points must be plotted to an accuracy of half a small square.	1
	Quality: General trend of points on graph must be negative. All points in the table (at least 5) must be plotted on the grid. It must be possible to draw a straight line that is within $\pm 0.050\text{ m}$ (to scale) on the y -axis of all plotted points.	1

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Question	Answer	Marks
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 (i.e. circled or labelled). Line 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. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient on answer line must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$. Read-off must be 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.	1
1(e)	Value of $M = -$ candidate's gradient and value of $N =$ candidate's intercept. The values must not be fractions.	1
	Units for M (e.g. $\text{m}\Omega^{-1}$ or $\text{cm}\Omega^{-1}$ or $\text{mm}\Omega^{-1}$) and N (e.g. m or cm or mm) correct.	1
1(f)	Correct calculation of E with unit.	1

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Question	Answer	Marks
2(a)	Value of S with unit in the range $0.5\text{ cm} \leq S \leq 2.5\text{ cm}$ and to the nearest mm.	1
2(b)(i)	Values of S_1 and S_2 and $S_1 > S_2$.	1
	Value of raw θ to the nearest degree and value of $\theta < 45^\circ$ on answer line.	1
2(b)(ii)	Percentage uncertainty in θ based on an absolute uncertainty of $3\text{--}10^\circ$. If repeated readings have been taken, then the 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)(iii)	Correct calculation of $e_1 \cos \theta$ and $e_2 \sin \theta$.	1
2(b)(iv)	Justification for significant figures in $e_1 \cos \theta$ linked to s.f. in: $(S_1 - S)$ and θ or e_1 and θ or S , S_1 and θ .	1
2(c)	Second values of S_1 and S_2 .	1
	Quality: Second values of S_1 and S_2 greater than first values of S_1 and S_2 .	1
	Second value of θ .	1
2(d)(i)	Two values of β calculated correctly.	1
2(d)(ii)	Valid comment consistent with the calculated values of β , testing against a criterion stated by the candidate.	1
2(e)	Correct calculation of k using second value of β with a correct unit.	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 judge the vertical. C Difficult to determine θ/angle because of parallax error or cannot see the lines defining the angle. D Difficult to determine θ/angle because cannot hold the protractor steady. E Difficult to measure S_1 or S_2 with reason e.g. springs move or mass moves. F The stands tilt/topple/slide or the bosses twist on loading. <i>1 mark for each point up to a maximum of 4.</i>	4
2(f)(ii)	A Take many readings (for different values of m) <u>and</u> plot a graph or take more values of β <u>and</u> compare (not “repeat readings” on its own). B Method to get vertical reference e.g. plumb line/use of set square on bench with metre rule/use spirit level <u>vertically</u>. C Use a larger protractor/have a protractor drawn on card at the back/use projection ideas/take a photograph and measure angle. D Clamp protractor (valid method). E Clamp ruler/take photograph with scale or ruler in the frame. F Use G-clamps/clamp the stands/use heavy weights/lower the bosses. <i>1 mark for each point up to a maximum of 4.</i>	4

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1(a)	Value of V with unit and in the range $2.00\text{ V} \leq V \leq 4.00\text{ V}$.	1
1(b)	Value of t with unit and in range 1.00–25.00 s.	1
	Evidence of repeat readings of t .	1
1(c)	Six sets of readings of n and t collected with correct trend (t decreases as n increases) and collected without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	5
	Range: $n_{\max} \geq 7$ and $n_{\min} = 1$.	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. t/s . There must be no unit for n or $\frac{1}{n}$.	1
	Consistency: All values of t must be given to 0.01 s or all to 0.1 s.	1
	Calculation: Values of $\frac{1}{n}$ calculated correctly.	1

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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 points must be $\leq$ half a small square (no “blobs”). Points must be accurate to within half a small square in both x and y directions.	1
	Quality: General trend of points on graph must be positive. All points in the table (at least 5) must be plotted for this mark to be awarded. It must be possible to draw a straight line that is within ± 1.0s from a straight line in the t direction.	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 (i.e. circled or labelled). Line 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. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient on answer line must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$. Read-off must be 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.	1

Question	Answer	Marks
1(e)	Value of a equal to candidate's gradient and value of b equal to candidate's intercept. The values must not be fractions.	1
	Unit for a is s and unit for b is s.	1

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Question	Answer	Marks
2(a)(i)	Raw value(s) for d with unit and to nearest 0.01 mm. Answer on answer line in range $20.00 \text{ mm} \leq d \leq 30.00 \text{ mm}$.	1
2(a)(ii)	Value for w with unit and in range 10.0–15.0 mm.	1
2(b)(i)	Value for x to nearest mm. Answer in range $55.0 \text{ cm} \leq x \leq 65.0 \text{ cm}$.	1
2(b)(ii)	Value for t with unit and in range 2.00–4.00 s.	1
2(b)(iii)	Percentage uncertainty in t based on an absolute uncertainty in the range 0.2–0.5 s. If repeated readings have been taken, then the 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)(iv)	Correct calculation of v with consistent unit.	1
2(b)(v)	Justification linked to significant figures in x and t .	1
2(c)	Second value of w .	1
	Second value of t .	1
	Quality: t greater for greater w .	1
2(d)(i)	Two values of k calculated correctly.	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 Large percentage uncertainty in w or large uncertainty in w because w is small or w varies along the length of the track. C Difficult to align sphere in correct starting position. D Sphere won't start without push/force applied when releasing sphere. E Large percentage uncertainty in t or large uncertainty in t because t is small. <i>1 mark for each point up to a maximum of 4.</i>	4
2(e)(ii)	A Take more readings <u>and</u> plot a graph or calculate more k values and <u>compare</u> (not “repeat readings” on its own). B Use (vernier/digital) calipers (to measure w). C Use a stop/card gate. D Use steeper slope/use steel ball and electromagnet. E1 Use longer track/use shallower slope. E2 Improved method of measuring t, e.g. use light gates at top and bottom/use motion sensor in direction of rolling or video/film/record experiment with timer in view/view frame-by-frame. <i>1 mark for each point up to a maximum of 4.</i>	4

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Question	Answer	Marks
1(a)	Answer line value of $0.5\text{ cm} \leq x_0 \leq 2.5\text{ cm}$ with unit.	1
1(b)	Value of raw θ to the nearest degree with unit and answer line value of $\theta < 90^\circ$.	1
1(c)	Six sets of readings of x and θ (different values) with the correct trend and without help from Supervisor scores 5 marks, five sets scores 4 marks etc.	5
	Range: Values of θ must include one value greater than <u>and</u> one value less than the value of θ in (b).	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. x/cm , e/cm , $e/\cos \theta (\text{m})$, $\theta / ^\circ$, $\tan \theta$ without a unit.	1
	Consistency: All raw values of x must be given to the nearest mm only.	1
	Significant figures: All values of $e/\cos \theta$ must be given to the same number of significant figures as (or one more than) the number of significant figures in e or θ , whichever is the smaller.	1
	Calculation: Values of $e/\cos \theta$ are correct.	1

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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 $\leq$ half a small square. Points must be plotted to an accuracy of half a small square.	1
	Quality: Trend of points on graph must be negative. All points in the table (at least 5) must be plotted on the grid. It must be possible to draw a straight line that is within ± 0.05 (to scale) on the $\tan \theta$ axis (normally x-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). There must be at least 5 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. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient on answer line must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$. Read-off must be accurate to half a small square in both x and y directions. or Intercept read directly from the graph, with read-off at $\tan \theta = 0$, accurate to half a small square.	1

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Question	Answer	Marks
1(e)	Value of N = candidate's gradient and value of M = candidate's intercept. The values must not be fractions.	1
	Units for N and M correct (e.g. m or cm or mm).	1

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Question	Answer	Marks
2(a)(i)	All values of raw d to the nearest 0.01 mm and answer line value of d in the range $0.50 \text{ mm} \leq d \leq 5.00 \text{ mm}$.	1
	Evidence of repeats.	1
2(a)(ii)	Absolute uncertainty in d in the range 0.02–0.2 mm. If repeated readings have been taken, then the 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(a)(iii)	Correct calculation of A with correct unit.	1
2(a)(iv)	Justification for significant figures in A linked to significant figures in d .	1
2(b)(i)	Value of p .	1
2(b)(ii)	Correct calculation of $(p + q)/2$.	1
2(c)	Second value of d .	1
	Second values of p and q .	1
	Quality: Second value of $(p + q)/2$ less than first value of $(p + q)/2$.	1
2(d)(i)	Two values of k calculated correctly.	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 with measuring d with a reason e.g. string is soft/string is compressed (by micrometer)/diameter not uniform along length. C Difficulty linked to placing paper clips on hanger with a reason e.g. clips slide off/added force from hand/dropping clips starts movement/difficult not to touch hanger when releasing clips/hanger too small for clips. D Idea of increments being too large e.g. large increments of mass (large uncertainty in the value of p or q) or only a small number of clips are added or exact force needed to cause movement may not equal a whole number of clips or mass of each paper clip is too large E Mass of clips may be different or two strings are of different material <i>1 mark for each point up to a maximum of 4.</i>	4
2(e)(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 Workable improved method e.g. wrap string round a rod and measure many d/use travelling microscope. C Workable method of adding or holding paper clips e.g. add a hook to each mass hanger/use a wider mass hanger or tweezers. D Improved method of loading e.g. use <u>smaller</u> clips/<u>lighter</u> clips/<u>smaller</u> masses to add to mass hanger or use of sand/water with detail. E Method to check clips have the same mass e.g. use a balance. <i>1 mark for each point up to a maximum of 4.</i>	4

PHYSICS

9702/36

Paper 3 Advanced Practical Skills 2

October/November 2018

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 October/November 2018 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **8** printed pages.

PUBLISHED**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.

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.

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Question	Answer	Marks
1(a)	Value of L_0 with unit. Value on answer line in the range 1.50–2.50 cm.	1
1(b)	Value of θ with unit, to the nearest degree and $\theta \leq 90^\circ$.	1
1(c)	Six sets of readings of θ and L with the correct trend and without help from the Supervisor scores 5 marks, five sets scores 4 marks, etc.	5
	Range: $\theta_{\max} \geq 30^\circ$ and $\theta_{\min} \leq 15^\circ$.	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. L/mm . There must be no unit for $(\sin \theta)(\cos \theta)$.	1
	Consistency: All values of L must be given to the nearest mm only.	1
	Significant figures: Number of significant figures for every value of $(\sin \theta)(\cos \theta)$ same as, or one greater than, the number of s.f. of θ as recorded in table.	1
	Calculation: Values of $(\sin \theta)(\cos \theta)$ calculated correctly.	1

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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 $\leq$ half a small square (no “blobs”). Points must be plotted to an accuracy of half a small square.	1
	Quality: General trend of points on graph must be positive. All points in the table (at least 5) must be plotted on the grid. It must be possible to draw a straight line that is within ± 0.05 on the x-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 (i.e. circled or labelled). Line 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. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions. Sign of gradient on answer line must match graph.	1
	y-intercept: Correct read-off from a point on the line substituted into $y = mx + c$. Read-off must be 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.	1

Question	Answer	Marks
1(e)	Value of a equal to candidate's gradient and given to two or more significant figures. and Value of b equal to candidate's intercept. The values must not be fractions.	1
	Unit for a correct and unit for b correct (e.g. m, cm, mm).	1

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Question	Answer	Marks
2(a)	Value of h_0 with unit and to the nearest mm.	1
2(b)(i)	Value of h less than h_0 .	1
2(b)(ii)	Correct calculation of y , with unit.	1
2(c)	Percentage uncertainty based on an absolute uncertainty in y of 3–6 mm. If repeated readings have been taken, then the 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(d)	Value for T on answer line in range 0.2–0.9 s, with unit.	1
	Evidence of repeat readings of time. There must be at least two measurements of nT where $n \geq 5$.	1
2(e)	Second value of h .	1
	Second value of T .	1
	Quality: T greater for greater y .	1
2(f)(i)	Two values of c calculated correctly.	1
2(f)(ii)	Valid comment consistent with the calculated values of c , testing against a criterion specified by the candidate.	1
2(g)	Correct calculation of g with consistent unit.	1

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Question	Answer	Marks
2(h)(i)	A Two readings are not enough to draw a (valid) conclusion (not “not enough for accurate results”, “few readings”). B Rule may not be vertical (when measuring heights). C Difficult to measure h_0 because blade not horizontal/blade is bent/h_0 varies along blade. D Difficult to measure h because mass is in the way/parallax when measuring h/difficult to judge position of the centre of the mass. E Difficult to determine T with a reason e.g. difficult to judge start/end/completion of oscillations or difficult to count oscillations. <i>1 mark for each point up to a maximum of 4.</i>	4
2(h)(ii)	A Take many readings <u>and</u> plot a graph or take more values of c <u>and</u> compare (not “repeat readings” on its own). B Method to check rule vertical, e.g. use set square <u>on floor</u>/use plumb line/use spirit level. C Mark position for centre of the mass on blade then measure h_0 at that position. D Improved method of measuring h, e.g. (clamp) rule and use set square <u>as pointer</u>/hang mass from thread/use a mass that is narrower than the blade/measure blade height at both sides of mass and average. E Video/film/record with timer in view (or use frame-by-frame)/use motion sensor above (or below) the blade or use larger masses to give longer T/to make counting easier. <i>1 mark for each point up to a maximum of 4.</i>	4