

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9702 PHYSICS

9702/31

Paper 3 (Advanced Practical Skills 1),
maximum raw mark 40

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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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9702	31

- 1 (a) (iv) Value of d in range 19.5 cm to 20.5 cm with unit. [1]
- (c) (ii) Value of N with evidence of repeat readings. [1]
- (e) Six sets of readings of d and N scores 5 marks, five sets scores 4 marks etc. [5]
 Incorrect trend –1. Help from Supervisor –1.
- Range: [1]
 Smallest value of $d < 9.5$ cm.
- Column headings: [1]
 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. d^{-1}/m^{-1} .
- Consistency: [1]
 All values of d must be given to the nearest mm.
- Significant figures: [1]
 Every value of $1/d$ must be given to the same number of significant figures as (or one more than) the number of significant figures in the corresponding value of d .
- Calculation: [1]
 $\sqrt{N}$ calculated correctly to the number of significant figures given by the candidate.
- (f) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 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.
- Plotting: [1]
 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.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be awarded.
 Scatter of points must be no more than ± 0.5 in the $\sqrt{N}$ direction from a straight line.
- (ii) Line of best fit: [1]
 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.
 Lines must not be kinked or thicker than half a square.

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9702	31

- (iii) Gradient: [1]
 The hypotenuse of the triangle must be greater than half the length of the drawn line. Do not allow $\Delta x / \Delta y$. Sign of gradient must match graph drawn.
 Both read-offs must be accurate to half a small square in both the x and y directions.

- y-intercept: [1]
 Either:
 Correct read-offs from a point on the line substituted into $y = mx + c$ or an equivalent expression. Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Intercept read directly from the graph, with read-off accurate to half a small square.

- (g) Value of A = candidate's gradient and value of B = candidate's intercept. [1]

- Unit for A correct (e.g. m or cm or mm) and consistent with value. [1]
 No unit given for B .

- 2 (a) (ii) Value for x to the nearest mm. [1]

- x in the range 0.155 m to 0.165 m. [1]

- (b) (i) Correct calculation of C in m (correct to 2 s.f.). [1]

- (ii) Justification for significant figures in C linked to significant figures in x and h . [1]

- (c) (ii) Value for R with unit. [1]

- Evidence of repeat readings. [1]

- (iii) Absolute uncertainty in R in range 5 mm to 20 mm and correct method of calculation to obtain 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]

- (d) Second value of x . [1]

- Second value of R . [1]

- Second value of $R < \text{first value of } R$. [1]

- (e) (i) Two values of k calculated correctly. [1]

- (ii) Valid comment consistent with the calculated values of k , testing against a criterion specified by the candidate. [1]

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9702	31

(f)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Not enough readings to draw a conclusion	Take many readings for different holes <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	Few readings/ only one reading/ not enough readings for an accurate result/ “repeat readings” on its own/ take more readings and (calculate) average k
B	Ball rolls off block/ball does not move along straight line from the wood/rod does not hit marble square on each time/rod hits marble at an angle	Small groove in the wood to place the marble	
C	Difficult to measure distance rod is pulled back/difficult to hold rod still before release	Use another stand or stop	
D	Difficult to measure R with reason e.g. marble skids in sand leaving elongated hole/can't fit ruler in sand tray/parallax error	Improved method for measuring R e.g. video with scale/use carbon paper/ink on marble/put scale on the sand	
E	Difficult to flatten sand/know when sand is horizontal	Use a straight edge/ use a spirit level	
F	Difficult to measure x with reason e.g. wooden rod moves	Method of measuring x / clamp rule close by/ draw scale on rod	

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9702	33

- 1 (b) (i) Value for L to the nearest mm, with unit. [1]
- (c) Second value of $h >$ first value of h . [1]
- (d) (ii) Six sets of readings of m , h and θ scores 5 marks, five sets scores 4 marks etc. [5]
 Help from Supervisor –1.
 Incorrect trend –1. Correct trend is h increases as m increases.
- Range: [1]
 Range of values to include $m_{\min} < 60\text{ g}$ and $m_{\max} > 80\text{ g}$.
- Column headings: [1]
 Each column heading must contain a quantity and a unit.
 The presentation of quantity and unit must conform to accepted scientific convention e.g. $h/\cos\theta\text{ (cm)}$.
- Consistency: [1]
 All values of h must be given to the nearest mm.
- Significant figures: [1]
 Every value of $h/\cos\theta$ must be given to 2 or 3 significant figures only.
- Calculation: [1]
 Values of $h/\cos\theta$ calculated correctly to the number of significant figures given by the candidate.
- (e) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 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.
- Plotting: [1]
 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.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be awarded.
 Scatter of points must be no more than 10g in the m direction of a straight line.
- (ii) Line of best fit: [1]
 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.
 Lines must not be kinked or thicker than half a square.

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9702	33

- (iii) Gradient: [1]
 The hypotenuse of the triangle must be greater than half the length of the drawn line.
 Do not allow $\Delta x / \Delta y$. Sign of gradient must match graph drawn.
 Both read-offs must be accurate to half a small square in both the x and y directions.

- y-intercept: [1]
 Either:
 Correct read-offs from a point on the line substituted into $y = mx + c$ or an equivalent expression.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Intercept read directly from the graph, with read-off accurate to half a small square.

- (f) Value of A = candidate's gradient and value of B = candidate's intercept. [1]
 Unit for A correct (e.g. m kg^{-1} or cm g^{-1}) and unit for B correct (m or cm or mm). [1]

- 2 (a) (iii) Values of x , y and z to the nearest mm with unit. [1]

- Value of $z >$ value of x . [1]

- (iv) Absolute uncertainty in y of 1 mm to 4 mm and correct method of calculation to obtain percentage uncertainty. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if working is clearly shown. [1]

- (b) Correct calculation of C with consistent unit. [1]

- (c) (ii) Value for T with unit in range $5.0 \text{ s} > T > 0.5 \text{ s}$. [1]

- Evidence of repeat readings for T . [1]

- (iv) Justification for significant figures in T^2 linked to significant figures in the (raw) times. [1]

- (d) Second values of x , y and z . Value of y within 5 mm of value in (a)(iii). [1]

- Second value of T . [1]

- Second value of $T <$ first value of T . [1]

- (e) (i) Two values of k calculated correctly. [1]

- (ii) Valid comment consistent with the calculated values of k , testing against a criterion specified by the candidate. [1]

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	Cambridge International AS/A Level – October/November 2015	9702	33

(f)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Not enough readings to draw a conclusion	Take many readings (for different masses) <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	“Repeat readings” on its own/ few readings/ only one reading/ not enough readings for an accurate result/ take more readings and (calculate) average k
B	Rod is bent <u>when loaded</u>	Use smaller masses/ rigid/stiff/thick rod	Just “rod is bent”/ shorter rod
C	Difficult to get horizontal	Use a spirit level or named instrument.	
D	Difficult to measure distances with reason e.g. rod unstable/awkward with metre rule/rod moves/holding ruler mid-air	Add a scale on rod/ use travelling microscope/ clamp ruler	Parallax Do not award if reason given is bent rod.
E	y not constant with a reason e.g. spring/loop moves around during oscillations	Cut groove or drill hole in wooden rod/ tape to wooden rod	
F	Difficult to judge the start/end of an oscillation or Difficult to judge <u>when</u> to start/stop the stopwatch	(Fiducial) marker at centre/ video <u>and</u> timer/view frame by frame/ motion sensor placed below/above	More oscillations/ high speed camera/ reaction time/ human error
G	Oscillation in more than one plane/irregular oscillations		Wind/draughts/ switch off air conditioning/ close doors and windows

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9702 PHYSICS

9702/34

Paper 3 (Advanced Practical Skills 2),
maximum raw mark 40

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	Cambridge International AS/A Level – October/November 2015	9702	34

- 1 (b) (i) Value of θ to the nearest degree and in the range 135° to 165° . [1]
- (ii) Value of L in range 5.0 to 10.0cm, with unit. [1]
- (d) Six sets of readings of θ and L scores 5 marks, five sets scores 4 marks etc. [5]
 Incorrect trend –1. Help from Supervisor –1.
- Range: [1]
 $\theta_{\max} \geq 160^\circ$ and $\theta_{\min} \leq 140^\circ$.
- Column headings: [1]
 Each column heading must contain a quantity and a unit. The presentation of quantity and unit must conform to accepted scientific convention e.g. $\theta/^\circ$.
 $1/\sin(\theta - 90^\circ)$ must have no unit.
- Consistency: [1]
 All values of L must be given to the nearest mm.
- Significant figures: [1]
 Every value of $1/\sin(\theta - 90^\circ)$ must be given to 2 or 3 significant figures only.
- Calculation: [1]
 Values of $1/\sin(\theta - 90^\circ)$ calculated correctly to the number of significant figures given by the candidate.
- (e) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 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.
- Plotting: [1]
 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.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be awarded.
 Scatter of points must be no more than ± 0.3 (to scale) cm in the L direction from a straight line.
- (ii) Line of best fit: [1]
 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.
 Lines must not be kinked or thicker than half a square.

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	Cambridge International AS/A Level – October/November 2015	9702	34

- (iii) Gradient: [1]
 The hypotenuse of the triangle must be greater than half the length of the drawn line.
 Do not allow $\Delta x / \Delta y$. Sign of gradient must match graph drawn.
 Both read-offs must be accurate to half a small square in both the x and y directions.

- y -intercept: [1]
 Either:
 Correct read-offs from a point on the line substituted into $y = mx + c$ or an equivalent expression.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Intercept read directly from the graph, with read-off accurate to half a small square.

- (f) Value of a = candidate's gradient and value of b = candidate's intercept. [1]
 Unit for a is correct (e.g. cm^{-1}) and no unit for b . [1]

- 2 (a) (i) All values of d to nearest mm, with unit, in range 5 to 30 mm. [1]
 Value of l greater than value of d . [1]
 (ii) Correct calculation of V with consistent unit. [1]

- (b) Justification for significant figures in V linked to significant figures in d and l . [1]
 (c) (iii) t in range 5.00 s to 30.00 s, with unit. [1]
 Evidence of repeat readings of t . [1]

- (d) Absolute uncertainty in t in range 0.5 s to 5.0 s and correct method of calculation to obtain percentage uncertainty. If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) if working is clearly shown. [1]

- (e) Second values of d and l . [1]
 Second value of t . [1]
 Second value of $t < \text{first value of } t$. [1]

- (f) (i) Two values of k calculated correctly. [1]
 (ii) Valid comment consistent with the calculated values of k , testing against a criterion specified by the candidate. [1]

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9702	34

(g)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Not enough readings to draw a conclusion	Take more readings <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	Few readings/ only one reading/ not enough readings for an accurate result/ “repeat readings” on its own/ take more readings and (calculate) average k
B	d is small/large uncertainty in d	Improved method of measuring d e.g. micrometer/vernier calipers/digital calipers/travelling microscope	Difficult to measure d / parallax error/ “calipers” on its own/ use bigger/larger components
C	Volume of component not accurate, with reason e.g. component not cylindrical/has groove.	Method to find volume of component e.g. use liquid displacement method	
D	Difficult to judge/know/see when LED goes out.	Use dark(ened) room/ light meter/ light sensor/ cardboard tube over LED/ voltmeter to measure time for p.d. to fall below specific value	Use video
E	Poor/dirty/loose contacts	Method of cleaning contacts e.g. iron wool	

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- 1 (b) (i) Value of a with consistent unit and in the range 0 to 50.0 cm. [1]
- (v) Value of V with unit to nearest 0.001 V and in range 0 to 2 V. [1]
- (c) Six sets of readings of a , b and V scores 5 marks, five sets scores 4 marks etc. [5]
 Incorrect trend –1. Minor help from Supervisor –1. Major help from Supervisor –2.
- Range: [1]
 $a_{\max} - a_{\min} \geq 30.0$ cm.
- Column headings: [1]
 Each column heading must contain a quantity and a unit. The presentation of quantity and unit must conform to accepted scientific convention. e.g. a/m or $a(\text{m})$, $1/V/V^{-1}$.
- Consistency: [1]
 All values of a and b must be given to the nearest mm.
- Significant figures: [1]
 Every value of $1/V$ must be given to the same number of significant figures as (or one more than) the number of significant figures in the corresponding value of V .
- Calculation: [1]
 Values of $1/V$ calculated correctly to the number of significant figures given by the candidate.
- (d) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 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.
- Plotting: [1]
 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.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be awarded.
 Scatter of points must be no more than ± 0.050 m (5.0 cm) to scale in the b direction from a straight line.
- (ii) Line of best fit: [1]
 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.
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- (iii) Gradient: [1]
 The hypotenuse of the triangle must be greater than half the length of the drawn line. Do not allow $\Delta x / \Delta y$. Sign of gradient must match graph drawn. Both read-offs must be accurate to half a small square in both the x and y directions.

- y-intercept: [1]
 Either:
 Correct read-off from a point on the line substituted into $y = mx + c$ or an equivalent expression.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Intercept read directly from the graph, with read-off accurate to half a small square.

- (e) Value of P = candidate's gradient and value of Q = candidate's intercept. [1]
 Unit for P is correct (e.g. $\text{m}^{-1} \text{V}^{-1}$) and unit for Q is correct (e.g. V^{-1}). [1]

- 2 (b) (iv) All values of x with unit to nearest mm. Average $x \leq 20.0 \text{ cm}$. [1]

- (c) (i) Value of θ to the nearest degree in the range 25° to 35° . [1]

- (ii) Absolute uncertainty in θ in range 2° to 5° and correct method of calculation to obtain percentage uncertainty. If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) if working is clearly shown. [1]

- (iii) Correct calculation of $\cos^2(\theta/2)$. No unit. [1]

- (iv) Justification for significant figures in $\cos^2(\theta/2)$ linked to significant figures in θ . [1]

- (d) (ii) T in range 0.5 s to 2.5 s , with unit. [1]

- Evidence of repeat readings of T . [1]

- (f) Second value of θ . [1]

- Second values of T_1 and T_2 . [1]

- Second value of $T_1 / T_2 < \text{first value of } T_1 / T_2 \text{ when rounded to 2 s.f.}$ [1]

- (g) (i) Two values of k calculated correctly. [1]

- (ii) Valid comment consistent with the calculated values of k , testing against a criterion specified by the candidate. [1]

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(h)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Not enough readings to draw a conclusion	Take more readings <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	Few readings/ only one reading/ not enough readings for an accurate result/ “repeat readings” on its own/ take more readings and (calculate) average k
B	Difficult to measure θ or read protractor with reason e.g. rod is above protractor/rod obscures view	Improved method of measuring θ e.g. shadow projection with light above/thinner rod/rod with smaller diameter/plumb-lines hung from rod/larger protractor/360° protractor	Just “difficult to measure θ ”/ smaller rod/ “protractor reads to 1°”
C	<u>Oscillations or T</u> affected by... e.g. air movement force on release different forces angle of release unwanted modes of oscillation	Improved method of release e.g. card gate or switch off air conditioning/close windows/closed room	Release by electromagnet/ cutting string/ damping/ air resistance/ friction
D	Large percentage uncertainty in time/period T is short	Valid method to improve timing e.g. use video with timer/frame by frame/motion sensor and position at side of cradle or <u>Increase T</u> by... e.g. heavier nail/longer nail/string	Oscillations too fast/ high/low speed camera/ video on its own/ human reaction time/ just “difficult to determine time”/ fiducial marker
E	Valid problem linked to magnetism e.g. nail weakly magnetised/metal stand attracts nail/interference by Earth’s magnetic field.	Valid method to overcome problem linked with magnetism e.g. stroke nail more times/use of coil	Nail loses magnetism
F		Method of fixing paper/protractor/magnets e.g. tape/Blu-tack/draw protractor on paper	Just “stick paper” without method

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- 1 (a) Value of H in the range 13.0 cm to 17.0 cm. [1]
- (c) (iii) Value of F to nearest 0.1 N. [1]
- (iv) Value of x correct and in range 3.5 cm to 4.5 cm. [1]
- (d) Six sets of readings of h_w , h_b and F scores 4 marks, five sets scores 3 marks etc. [4]
 Incorrect trend –1. Help from Supervisor –1.
- Range: [1]
 $x_{\max} - x_{\min} \geq 6.0$ cm.
- Column headings: [1]
 Each column heading must contain a quantity and a unit.
 The presentation of quantity and unit must conform to accepted scientific convention, e.g. $(H-x)^3/\text{cm}^3$.
- Consistency: [1]
 All values of h_w and h_b must be given to the nearest mm.
- Significant figures: [1]
 Significant figures for $(H-x)^3$ must be the same as, or one greater than, the number of s.f. for $(H-x)$.
- Calculation: [1]
 Values of $(H-x)^3$ calculated correctly.
- (e) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 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.
- Plotting: [1]
 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.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be awarded.
 Scatter of points must be less than ± 0.2 N from a straight line in the F direction.
- (ii) Line of best fit: [1]
 Judged 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.
 Lines must not be kinked or thicker than half a square.

Page 3	Mark Scheme	Syllabus	Paper
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- (iii) Gradient: [1]
 The hypotenuse of the triangle used must be greater than half the length of the drawn line.
 The method of calculation must be correct.
 Both read-offs must be accurate to half a small square in both the x and y directions.

- y -intercept: [1]
 Either:
 Correct read-offs from a point on the line substituted into $y = mx + c$ or an equivalent expression.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Intercept read directly from the graph, with read-off accurate to half a small square in the y direction.

- (f) Value of a = candidate's gradient and value of b = candidate's intercept. [1]
 Unit for a is correct (e.g. N cm^{-3}) and unit for b is correct (e.g. N). [1]

- 2 (a) (i) All values of d to nearest 0.001 cm and in range 0.100 cm to 0.500 cm. [1]
 (ii) All values of D to nearest 0.1 cm. [1]

- (b) Values of l , h and s present.
 Value of h to nearest 0.1 cm and in range 7.5 cm to 8.5 cm, with unit. [1]

- (c) (ii) t on answer line in range 1.00 s to 20.00 s, with unit. [1]
 Evidence of repeated readings for t . [1]

- (iii) Absolute uncertainty in t in range 0.2 s to 0.5 s and correct method of calculation to obtain percentage uncertainty. If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown. [1]

- (iv) Calculation of g correct to the second s.f., with consistent unit (e.g. ms^{-2}). [1]

- (d) (ii) Second values of d and t . [1]
 t greater for smaller d . [1]

- (e) (i) Two values of k calculated correctly. [1]
 (ii) Justification for significant figures in k linked to significant figures in t and d . [1]
 (iii) Valid comment consistent with the calculated values of k , tested against a criterion specified by the candidate. [1]

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9702	36

(f)	(i) Limitations (4 max.)	(ii) Improvements (4 max.)	Do not credit
A	Not enough readings to draw a conclusion	Take more readings <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	“Repeat readings” on its own/ few readings/ only one reading/ take more readings and (calculate) average k / two readings not enough for accurate results
B	Parallax error when measuring h or D	Use calipers/ use set square as pointer	Rule not vertical when measuring h
C	Plastic deforms when measuring larger d /diameter with tubing	Use larger diameter axle instead of tubing	
D	Push force to start flywheel may vary/push force may affect time	Release mechanism, with detail/ use steeper ramp	“Force may be too large”/ start before top line
E	Flywheel doesn’t travel straight/ flywheel hits (sides of) track	Sensible method of preventing collision, e.g. level the track sideways/widen the track	Reduce friction/ mark both sides of track
F		Use video with timer/ view frame by frame/ use light gates <u>at start and end</u> / use longer track	Reaction time