

MARK SCHEME for the October/November 2012 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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- 1 (b) (ii) Values of raw L in range $2.0 \text{ cm} \leq L \leq 8.0 \text{ cm}$ consistent with unit. [1]
- (iii) Value of $\theta < 90^\circ$ with unit. No raw value greater than 0.5° precision. [1]
- (c) Five sets of readings of L , m and θ scores 5 marks, four sets scores 4 marks etc. [5]
 Incorrect trend then –1.
 Major help from Supervisor –2. Minor help from Supervisor –1.
- Range: $m_{\min} \leq 0.100 \text{ kg}$, $m_{\max} \geq 0.350 \text{ kg}$. [1]
- Column headings: [1]
 Each column heading must contain a quantity and a unit where appropriate.
 The unit must conform to accepted scientific convention e.g. m/kg , $m \sin \theta / \text{kg}$, $\theta / ^\circ$.
- Consistency: [1]
 All values of L must be given to the nearest mm.
- Significant figures: [1]
 All values of $m \sin \theta$ must have the same number of significant figures as, or one more than, the least number of significant figures in m and θ .
- Calculation: [1]
 Values of $m \sin \theta$ calculated correctly.
- (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 must be no more than three large squares apart.
- Plotting of points: [1]
 All observations in the table must be plotted on the graph grid.
 Diameter of plots must be $\leq$ half a small square (no blobs).
 Check that the points are plotted correctly. Work to an accuracy of half a small square in both the x and y directions.
- Quality: [1]
 All points in the table must be plotted (at least 4) for this mark to be scored.
 Judge by the scatter of all the points about a straight line.
 All points must be within $\pm 0.01 \text{ kg}$ in the $m \sin \theta$ direction of a straight line.
- (ii) Line of best fit: [1]
 Judge by balance of all the points on the grid (at least 4) about the candidate's line.
 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. Line must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 The sign of the gradient must match the graph. The hypotenuse of the triangle used must be at least half the length of the drawn line.
 Both read-offs must be accurate to half a small square in both the x and y directions.
 The method of calculation must be correct.

y intercept: [1]
 Either:
 Check correct read-off from a point on the line and substitution into $y = mx + c$.
 Read-off must be accurate to half a small square in both the x and y directions.
 Or:
 Check the read-off of the intercept directly from the graph.

- (e) Value of P = candidate's gradient. Value of Q = candidate's intercept. [1]
 Do not allow a value presented as a fraction.

Unit for P (m kg^{-1} or cm kg^{-1} or mm kg^{-1} or mg^{-1} or cm g^{-1} or mm g^{-1}) and Q (m or cm or mm) correct and consistent with value. [1]

[Total: 20]

- 2 (a) (ii) Value of circumference in range 30.0 – 50.0 cm to the nearest mm with unit. [1]
- (iii) Absolute uncertainty in circumference is between 2 mm – 6 mm. [1]
 If repeated readings have been taken, then the absolute uncertainty can be half the range. Correct method used to calculate the percentage uncertainty.
- (iv) Value of circumference within 2 cm of first value. [1]
- (b) (ii) Raw time values to at least 0.1 s or 0.01 s, value of $0.5 \text{ s} < T < 2.0 \text{ s}$. [1]
 Evidence of repeats. [1]
- (c) (i) Second value of T . [1]
 Second value of $T >$ first value of T . [1]
- (ii) Third value of T . [1]
- (d) (ii) Correct calculation of two values of k . [1]
 Correct calculation of third value of k . [1]
- (iii) Justification of significant figures in k linked to significant figures in time and m (not just "raw readings") [1]
- (iv) Sensible comment relating to the calculated values of k , testing against a criterion specified by the candidate. [1]

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(e)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	Do not credit
A	three results not enough /not enough results	take more readings <u>and plot a graph</u>	two results not enough /repeat readings /few readings
B	string too wide for markings on rule	use thinner string	
C	rules have different thicknesses so effective length of loop changes/ /different lengths so not a fair test	use rulers of similar thicknesses/ readings/method to take thickness into account /use rulers of the same length	
D	times are small /large uncertainty in time	use longer strings/improved method of timing	
E	difficult to judge start/ end of/complete oscillation	Position/motion sensor facing the rule /video with timer	position sensor at end or in middle
F	swings of 30 cm ruler highly damped		
G	difficult to make two loops of the same circumference	method by which this can be achieved	
H	large uncertainty in mass	method of measuring mass more precisely	accurate balance

[Total: 20]

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9702 PHYSICS

9702/33

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

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- 1 (b) (i) Value of h in range $0.085\text{ m} \leq h \leq 0.095\text{ m}$ consistent with unit. [1]
- (c) Value of T in range $0.6\text{ s} \leq T \leq 1.5\text{ s}$ consistent with unit. [1]
Evidence of repeats. [1]
- (d) Six sets of readings of h and T or raw times scores 4 marks, five sets scores 3 marks etc. Help from Supervisor –1. [4]
- Range: $h_{\max} - h_{\min} \geq 15.5\text{ cm}$ [1]
- Column headings:
Each column heading must contain a quantity and a unit where appropriate.
The unit must conform to accepted scientific convention e.g. $T^2h / \text{s}^2\text{m}$ (or ms^2) and h^2 / m^2 . [1]
- Consistency:
All raw values of h must be given to the nearest mm. [1]
- Significant figures:
All values of h^2 must have the same number of significant figures as, or one more than, the number of significant figures in h . [1]
- Calculation:
Values of T^2h calculated correctly. [1]
- (e) (i) Axes: [1]
Sensible scales must be used, no awkward scales (e.g. 3:10).
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 must be no more than three large squares apart.
- Plotting of points: [1]
All observations in the table must be plotted on the graph grid.
Diameter of plots must be $\leq$ half a small square (no “blobs”).
Check that the points are plotted correctly. Work to an accuracy of half a small square in both the x and y directions.
- Quality: [1]
All points in the table must be plotted (at least 5) for this mark to be scored. Judge by the scatter of all the points about a straight line.
All points must be within $\pm 0.0025\text{ m}^2$ (25 cm^2) in the h^2 direction of a straight line.
- (ii) Line of best fit: [1]
Judge by balance of all the 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.
Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. Line must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 The sign of the gradient must match the graph.
 The hypotenuse of the triangle should be greater than half the length of the drawn line.
 Both read-offs must be accurate to half a small square in both the x and y directions.
 The method of calculation must be correct.

y intercept: [1]
 Either:
 Correct read-off from a point on the line and substitution into $y = mx + c$.
 Read-off must be accurate to half a small square in both the x and y directions.
 Or:
 Correct read-off of the intercept directly from the graph.

- (f) Value of P = candidate's gradient. Value of Q = candidate's intercept. [1]
 Do not allow a value presented as a fraction.

Unit for P ($\text{s}^2 \text{m}^{-1}$ or $\text{s}^2 \text{cm}^{-1}$ or $\text{s}^2 \text{mm}^{-1}$) and Q ($\text{s}^2 \text{m}$ or $\text{s}^2 \text{cm}$ or $\text{s}^2 \text{mm}$) correct and consistent with value. [1]

[Total: 20]

- 2 (a) (ii) Value of L in range: $5.0 \text{ cm} \leq L \leq 15.0 \text{ cm}$ with unit to nearest mm. [1]

- (b) (ii) Value of s in range: $50.0 \text{ cm} \leq s \leq 70.0 \text{ cm}$ with unit. [1]
 Supervisor's help –1.
 Evidence of repeat measurements. [1]

- (iii) Absolute uncertainty in s is between $2 \text{ cm} - 10 \text{ cm}$. [1]
 If repeated readings have been taken, then the absolute uncertainty can be half the range. Correct method used to calculate the percentage uncertainty.

- (iv) Correct calculation of x . [1]

- (c) Raw value(s) of t greater than 1 s to a precision of 0.1 or 0.01 s with unit. [1]

- (d) (i) Correct calculation of v using either value of x with consistent unit. [1]

- (ii) Justification of significant figures in v linked to significant figures in t and x or $(s - L)$ (not just "raw readings"). [1]

- (e) (iii) Second value of t . [1]
 Second value of s . [1]
 Quality: correct trend; If s increases, t increases. [1]

- (f) Sensible comment relating to the calculated values of v , testing against a criterion specified by the candidate. [1]

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(g)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	Do not credit
A	two readings not enough (to draw a conclusion)	take many readings (for different masses) <u>and</u> plot a graph /calculate more v values and <u>compare</u>	'repeat readings' /few readings /take more readings and calculate average v
B	the car does not travel in a straight line	method of determining the distance e.g. video + scale/method of marking a path /method of guiding trolley in straight line	
C	times are short /large uncertainty in t	use a longer slope /use a steeper slope	trolley too fast
D	difficult to judge when trolley stopped/ difficult to start the stopwatch <u>when</u> all wheels on bench/ <u>when</u> trolley at B/ <u>when</u> trolley horizontal	improved method of timing eg video <u>with</u> timer or frame by frame/motion sensor placed at end of path/ticker tape timer	light gate(s) /reaction time /human error
E	there is a drop when the trolley reaches the end of the board/at B there is a loss of velocity/kinetic energy	method to smooth transition e.g. thinner board/bevelled edge/thin card placed at transition	
F	difficult <u>to release</u> without applying a force/ velocity /difficult to position head at B after releasing trolley A	method of releasing trolley e.g. card/barrier or electromagnet	air resistance
G	calculation of x doesn't take back of trolley into account	detailed method of measuring from wheel to the back of the trolley	measuring l

[Total: 20]

MARK SCHEME for the October/November 2012 series

9702 PHYSICS

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

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- 1 (a) (iii) Value for I_0 in range 100 to 200 mA, with consistent unit. [1]
- (b) l in range 40.0 to 60.0 cm, with consistent unit. [1]
- (c) Six sets of readings of l and I scores 5 marks, five sets scores 4 marks etc. [5]
 –1 for minor help from Supervisor, –2 for major help.
 Incorrect trend / no l data / no I data then –1
- Range: $l_{\max} - l_{\min} \geq 60$ cm. [1]
- Column headings: [1]
 Each column heading must contain a quantity and a unit.
 The unit must conform to accepted scientific convention e.g. I /mA or I (mA)
 or $1/I$ (mA⁻¹) but not $1/I$ (mA) and not $1/I$ (mA)⁻¹.
- Consistency: [1]
 All values of l must be given to the nearest mm
- Significant figures: [1]
 All values of $1/I$ must be given to the same number of s.f. (or one more than)
 the s.f. in the corresponding values of I .
- Calculated values: [1]
 Values of $1/I$ calculated correctly.
- (d) (i) Axes: [1]
 Sensible scales must be used, no awkward scales (e.g. 3:10).
 Scales must be chosen so that the plotted points must 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 must be no more than 3 large squares apart.
- Plotting of points: [1]
 All the observations in the table must be plotted on the grid.
 Diameter of plots must be $\leq$ half a small square.
 Points must be plotted accurately. Work to an accuracy of half a small square
 in both x and y directions.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be scored.
 Quality is assessed by the scatter of the points about a straight line – all
 points must be within 0.025 m² (in the l^2 direction) of the line.
- (ii) Line of best fit: [1]
 Judge by balance of all the 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.
 Line must not be kinked or thicker than half a square.

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(iii) Gradient: [1]

Value must be negative if graph gradient is negative.

The hypotenuse of the triangle must be greater than half the length of the drawn line.

Both read-offs must be accurate to half a small square in both x and y directions.

Method of calculation must be correct.

y -intercept:

[1]

Either:

Correct read-off from a point on the line, and substitution 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.

(e) Value of a = candidate's gradient and value of b = candidate's intercept. [1]

A value presented as a fraction is not allowed.

Unit for a consistent with value, e.g. $\text{mA}^{-1}\text{cm}^{-2}$.

[1]

[Total: 20]

2 (a) Value of d in range 68.0 to 72.0 cm, with unit [1]

(c) (i) h_1 and h_2 recorded to nearest mm and $h_1 > h_2$. [1]

(ii) Correct calculation of $\sin \theta$. [1]

(d) Justification for s.f. linked to s.f in $(h_1 - h_2)$ and s.f. in d . [1]

(e) Raw values of t in range 1 to 20 s, with unit. [1]

Evidence of repeated measurements for t . [1]

(f) Percentage uncertainty in t based on absolute uncertainty of 0.1 or 0.2 or 0.3 s (or half the range if it isn't zero). [1]

Correct method of calculation to get percentage uncertainty.

(g) (ii) Second values of h_1 and h_2 . [1]

Second value of t . [1]

Quality: t smaller for larger $(h_1 - h_2)$. [1]

Page 4	Mark Scheme	Syllabus	Paper
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(h) (i) Correct calculation of two values of k . [1]

(ii) Valid conclusion based on the calculated values of k . Candidate must test against a stated criterion. [1]

(i)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	Do not credit
A	two results not enough	take more readings <u>and plot a graph</u> / Calculate more k values and <u>compare</u>	'repeat readings' on its own / 'few readings' / 'take more readings and (calculate) average k ' / 'only one reading'
B	rolling is erratic / marble not round / track uneven		too much friction
C	parallax error in measuring h	description of valid method of reducing parallax error in h (e.g. extend mark to wood or track / pointer on rule / travelling microscope*)	view at right angles / eye level / use shadow method
D	difficult to <u>stop</u> stopwatch at correct moment / reaction time (or human error) <u>linked to stopping</u> of stopwatch	use video of marble and clock / lightgate and timer motion sensor at end of track / view frame by frame	'timegates' / 'timergates' / just 'reaction time'
E	small difference between h_1 and h_2 / large uncertainty in $h_1 - h_2$	use longer track* / use (named) more precise method (e.g. travelling microscope*)	vernier caliper
F	difficult to release marble without applying a force / velocity	<u>description of mechanical method of releasing</u> (e.g. electromagnet with <u>steel</u> / <u>magnetic material</u> ball)	use a clamp / remote controlled clamp
G	t is small / large uncertainty in t / ball moves fast so difficult to time accurately	use longer track* / increase d	human reaction error

* only credited once each.

Do not allow 'repeated readings'

Do not allow 'use a computer to improve the experiment'

[Total: 20]

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- 1 (a) (iv) Value for $I_1 < 200 \text{ mA}$, with consistent unit. [1]
- (v) Value for I_2 with unit of current. [1]
 $I_2 > I_1$ [1]
- (b) Six sets of readings of I_1 , I_2 and x scores 4 marks, five sets scores 3 marks etc. [4]
 Incorrect trend –1.
 Major help from Supervisor –2. Minor help from Supervisor –1.
- Range: $x_{\max} - x_{\min} \geq 0.500 \text{ m}$. [1]
- Column headings: [1]
 Each column heading must contain a quantity and a unit where appropriate.
 The unit must conform to accepted scientific convention
 e.g. I / A or $I(\text{A})$, $1/x \text{ (m}^{-1}\text{)}$, I_1/I_2
- Consistency: [1]
 All values of x must be given to the nearest mm.
- Significant figures: [1]
 All values of I_2/I_1 must have the same significant figures as, or one more than, the least number of significant figures in raw I_1 and I_2
- Calculation: [1]
 Values of I_2/I_1 calculated correctly.
- (c) (i) Axes: [1]
 Sensible scales must be used, no awkward scales (e.g. 3:10).
 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 must be no more than three large squares apart.
- Plotting of points: [1]
 All observations in the table must be plotted on the graph grid.
 Diameter of plots must be $\leq$ half a small square.
 Check that the points are plotted correctly. Work to an accuracy of half a small square in both the x and y directions.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be scored. Judge by the scatter of all the points about a straight line.
 All points must be within $\pm 0.25 \text{ m}^{-1}$ in the $1/x$ direction of a straight line.
- (ii) Line of best fit: [1]
 Judge by balance of all the 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.
 Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate.
 Line must not be kinked or thicker than half a small square.

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

- y intercept: [1]
 Either:
 Correct read-off from a point on the line and substitution into $y = mx + c$.
 Read-off must be accurate to half a small square in both the x and y directions.
 Or:
 Correct read-off of the intercept directly from the graph.

- (d) Value of P = candidate's gradient and value of Q = candidate's intercept. [1]
 Do not allow a value presented as a fraction.

- Unit for P (m or cm or mm, consistent with value) and Q (no unit) correct. [1]

[Total: 20]

- 2 (a) (i) Value for D in range 10 to 20 mm to the nearest mm, with unit. [1]

- (ii) Percentage uncertainty in D based on an absolute uncertainty of 0.5, 1, 2 or 3 mm. [1]
 If repeated readings have been taken, then the absolute uncertainty can be half the range. Correct method used to calculate the percentage uncertainty.

- (b) (ii) Value of x to the nearest mm, in range 1.3 – 1.7 cm, with unit. [1]

- (iii) Correct calculation of V with consistent unit. [1]

- (c) (iv) Raw time values to 0.1 s or 0.01 s. Value of T in range 0.1 – 1.0 s. [1]

- Evidence of repeat measurements. [1]

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

- (e) Second value of T . [1]

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

- (f) (i) Correct calculation of two values of k . [1]

- (ii) Justification of significant figures in k linked to significant figures in D , x and time (not just "raw readings"). [1]

- (iii) Sensible comment relating to the calculated values of k , testing against a specified criterion. [1]

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(g)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	Do not credit
A	two results not enough	take more readings <u>and plot a graph/</u> calculate more k values and <u>compare</u>	“repeat readings” on its own few readings/ only one reading take more readings and (calculate) average k
B	parallax error in D / difficult to measure D <u>because</u> loop is in the way	use <u>Vernier</u> calipers/micrometer/travelling microscope to measure D^*	use string
C	V not accurate because D not internal diameter	measure thickness/diameter of wire using micrometer use travelling microscope/ <u>Vernier</u> calipers to measure D^*	
D	mass swings side-to-side/ horizontal movement/ moves in more than one plane/non- uniform oscillation		
E	times are small/large uncertainty in T	use bigger mass improved timing method e.g. motion/position sensor below weight/video with timer/video and view frame-by-frame**	light gates/ human error/reaction time/ time more cycles/ high frequency oscillations
F	difficult to judge start of/end of/complete oscillation	fixed/fiducial marker improved timing method e.g. motion/position sensor below weight/video with timer/video and view frame-by-frame**	marker fixed to spring/ marker placed at extreme(s) of oscillation light gates
G	metal strip bends/ not horizontal	use stiffer strip/ thicker strip/support strip at both ends.	strip not straight/ move spring/use stronger strip

* Credit in B_s or C_s , but not both.

** Credit in E_s or F_s , but not both.

[Total: 20]

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2012 series

9702 PHYSICS

9702/36

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

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CAMBRIDGE
International Examinations

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- 1 (b) (ii) Value of raw x in range $2\text{ mm} \leq x \leq 15\text{ mm}$. Consistent with unit. [1]
- (c) (iv) Value of R in range $1\text{ k}\Omega$ to $200\text{ k}\Omega$ [1]
- (d) Six sets of readings of p and R scores 5 marks, five sets scores 4 marks etc. [5]
 Minor help from supervisor –1, major help –2.
 Incorrect trend / no p values / no R values then –1.
- Range of p : $p_{\max} - p_{\min} \geq 15\text{ cm}$ [1]
- Column headings: [1]
 Each column heading must contain a quantity and a unit.
 The unit must conform to accepted scientific convention e.g. d / cm , $d^{1.5} / \text{m}^{1.5}$, $d^{1.5} (\text{m}^{1.5})$ or $d^{1.5}$ in $\text{m}^{1.5}$, $\sqrt{d^3} / \sqrt{\text{m}^3}$, $R / \text{k}\Omega$
- Consistency of presentation of raw readings: [1]
 All raw values of p must be given to the nearest mm.
- Significant figures: [1]
 All values of $d^{1.5}$ must be given to the same s.f. as (or one more than) the s.f. in d .
- Calculation: [1]
 Values of $d^{1.5}$ calculated correctly.
- (e) (i) Axes: [1]
 Sensible scales must be used, no awkward scales (e.g. 3:10).
 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 which is being plotted.
 Scale markings must be no more than 3 large squares apart.
- Plotting of points: [1]
 All observations in the table must be plotted on the graph grid.
 Diameter of plots must be $\leq$ half a small square (no “blobs”).
 Points must be plotted correctly to an accuracy of half a small square in both x and y directions.
- Quality: [1]
 All points in the table must be plotted (at least 5) for this mark to be scored.
 Judge by the scatter of all points about a straight line.
 All points must be within $0.005\text{ m}^{1.5} = 5\text{ cm}^{1.5} = 160\text{ mm}^{1.5}$ of a straight line, in the $d^{1.5}$ direction.
- (ii) Line of best fit: [1]
 Judged by balance of all points on the grid (at least 5 points) about the candidate’s line. There must be an even distribution of points either side of the line along the full length.
 One anomalous point is allowed only if clearly indicated (i.e. circled or labelled) by the candidate.
 Line must not be kinked or thicker than half a small square.
- (e) (iii) Gradient:

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Sign of gradient must match graph. [1]
The hypotenuse of the triangle should be greater than half the length of the drawn line.
Both read-offs must be accurate to half a small square in both x and y directions.
The method of calculation must be correct.

y -intercept: [1]
Either:
Check correct read-offs from a point on the line and substituted into $y = mx + c$.
Read off must be accurate to half a small square in both x and y directions.
Or:
Check read-off of the intercept directly from the graph.

(f) Value of a = candidate's gradient. Value of b = candidate's intercept. [1]
Do not allow a value presented as a fraction.

Unit for a (e.g. $\text{k}\Omega \text{ cm}^{-1.5}$). [1]

[Total: 20]

2 (a) (i) Value of raw d to nearest mm only, with unit. [1]

(ii) Absolute uncertainty between 2 mm and 5 mm. [1]
If repeated readings have been taken, then the absolute uncertainty can be half the range.
Correct method used to calculate the percentage uncertainty.

(iv) Value(s) of raw h in range $13.0 \text{ cm} \leq h \leq 17.0 \text{ cm}$, with unit. [1]

(b) (i) Value(s) of raw t in range 1.0 s to 10.0 s, with unit, to at least 0.1 s. [1]

Evidence of repeat readings of t . [1]

(ii) Correct calculation of v , with consistent unit. [1]

(iii) Valid justification for s.f. in v based on s.f. in t and h . [1]
Not just 'raw readings'.

(c) (i) Second value of d . [1]

(ii) Second value of t . [1]

Quality: Correct trend. When d decreases (i.e. second d value is less than first d value) t also decreases (i.e. second t value is less than first t value) or vice versa. [1]

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(d) (i) Correct calculation of two values of k . [1]

(ii) Sensible comment relating to the calculated values of k , testing against a criterion specified by the candidate. [1]

(e)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	Do not credit
A	two results not enough	take more readings <u>and plot a graph</u> / calculate more k values and <u>compare</u>	'repeat readings' on its own / 'few readings' / 'take more readings and (calculate) average k ' / 'only one reading'
B	difficult to form a perfect cylinder / diameter of cylinder varied	method to make uniform cylinder e.g. moulds / pastry cutter idea placing <u>all</u> plasticine inside	pre-sized cylinders / pastry cutter idea removing off-cuts (mass must stay constant) / repeat diameter and average / no change of material
C	cylinder does not rise steadily / oscillates as rises/hits sides / problem linked to sticking pulley	method to overcome sticking pulley e.g. lubricant	use wider tube
D	difficult to <u>start/stop</u> the watch at the instant when cylinder passes mark(s) / reaction time error linked to <u>start/stop</u> of stopwatch	method to improve time measurement e.g. light gates <u>with timer</u> / video <u>with timer or frame by frame</u> / motion sensor below X	video to take reading / parallax linked to marks or h / reaction time error on its own / timer gates / video and playback knowing / judging when to start/stop stopwatch
E	difficult to time as the time is small / large uncertainty in time / cylinder moves too fast <u>linked</u> to time	method to increase time e.g. increase h / longer tube / more plasticine / decrease mass of X	larger tube
F	difficult to measure diameter of cylinder due to curved shape of sides	improved method for measurement e.g. (vernier) calipers / set squares with detail	parallax error in d / calipers linked to h

Do not allow: repeated readings / human error using stopwatch / helpers / use a computer / use of micrometer screw gauge

[Total: 20]