

MARK SCHEME for the May/June 2013 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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	GCE AS/A LEVEL – May/June 2013	9702	31

- 1 (a) Value of L in the range 0.790–0.810 m. [1]
- (c) (ii) Value of d to the nearest mm and $d < 0.600$ m. [1]
- (d) Six sets of readings of m and d scores 5 marks, five sets scores 4 marks etc. [5]
 Correct trend is d decreases as m increases.
 Help from Supervisor –1.
- Range of m : $m_{\min} = 0$ g or 10 g; $m_{\max} \geq 100$ g. [1]
- 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. $1/d/\text{m}^{-1}$.
- Consistency: [1]
 All values of d must be given to the nearest mm.
- Significant figures: [1]
 Significant figures for every row of values of $1/d$ same as, or one greater than, d as recorded in table.
- Calculation: [1]
 Values of $1/d$ 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 that is being plotted.
 Scale markings should be no more than three large squares apart.
- Plotting of points: [1]
 All observations in the table must be plotted.
 Diameter of plotted points must be $\leq$ half a small square (no “blobs”).
 Work 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 $\pm 0.05 \text{ m}^{-1}$ of $1/d$ 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. Line must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 The hypotenuse of the triangle 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:
 Correct read-off 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:
 Correct read-off of the intercept directly from the graph.

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

- (g) Value of k in range 1.0–2.0. [1]

[Total: 20]

- 2 (a) (ii) Value of θ with unit. Help from Supervisor –1. [1]
 θ in range 72° – 92° . [1]

- (iii) Absolute uncertainty in θ in range 2° – 10° .
 If repeated readings have been taken, then the uncertainty can be half the range (but NOT zero if values are equal). Correct method of calculation to obtain percentage uncertainty. [1]

- (iv) Correct calculation of $\sin \theta$. Ignore unit. Do not allow $\sin \theta = \text{O/H}$ ideas as triangle not a right-angled triangle. [1]

- (b) Value of T with unit in range $1.0 \leq T \leq 2.0 \text{ s}$. [1]
 Evidence of repeats here or in (c)(ii). [1]

- (c) (ii) Second value of θ . [1]
 Second value of T . [1]
 Second value of $T < \text{first value of } T$. [1]

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

- (ii) Justification of s.f. in k linked to significant figures in T (or t) and θ . [1]

- (iii) 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 max. 4	(ii) Improvements max. 4	Do not credit
A	two readings not enough (to draw a conclusion)	take more readings <u>and</u> plot a graph/ 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	end of nail slips in bracket/bracket moves/is not stable	use something with a sharper point e.g. cocktail stick/dent in bracket (to seat head of nail) valid method to fix bracket e.g. use blu-tack/glue/use bigger/heavier bracket/fix bracket/ clamp to bench	method of fixing nail
C	difficult to measure T with reason e.g. heavily damped/oscillations die away quickly		‘too few oscillations’ on its own/ T small
D	difficult to judge start of/end of/complete oscillation	use a fixed/fiducial marker /improved timing method e.g. video with timer/video and view frame-by-frame multiflash photography with strobe rate	human error/ reaction time /record time for more oscillations marker fixed to rod /marker placed at extreme of oscillation use light gate
E	difficult to read θ /angle/protractor with reason e.g. difficult to hold steady in the air	clamp protractor	parallax error use a larger protractor
F	fans/air conditioning affect oscillations		

[Total: 20]

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/32

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

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1 (b) (ii) Value of t in the range $10.0 \text{ s} \leq t \leq 20.0 \text{ s}$. [1]

Evidence of repeat measurements of t . [1]

(c) Six sets of readings of S and t scores 5 marks, five sets scores 4 marks etc. [5]

If trend wrong or no S or t column –1.

Major help from Supervisor –2 (setting up circuit). Minor help from Supervisor –1.

Range: [1]

Values of S must include $22 \text{ (k}\Omega\text{)}$ or $10 \text{ (k}\Omega\text{)}$ and $1.2 \text{ (k}\Omega\text{)}$ or $1.0 \text{ (k}\Omega\text{)}$.

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. $1/t / \text{s}^{-1}$ $1/S / \text{k}\Omega^{-1}$ $1/S \text{ (k}\Omega^{-1}\text{)}$ t / s $t \text{ (s)}$.

($1/t \text{ (s)}$ $1/S \text{ (k}\Omega\text{)}$ $1/S \text{ (k}\Omega\text{)}^{-1}$ are not allowed.)

Consistency: [1]

All values of raw t must be given to the same precision (either 0.1 s or 0.01 s).

Significant figures: [1]

Significant figures for every row of values of $1/S$ must be the same as or one greater than the s.f. in S as recorded in table.

Calculation: [1]

Values of $1/t$ 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 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 of points: [1]

All observations in the table must be plotted.

Points must be plotted to an accuracy of half a small square.

Diameter of points must be $\leq$ half a small square (no “blobs”).

Quality: [1]

All points in the table must be plotted (at least 5) for this mark to be awarded.

Judge by the scatter of all the points about the straight line. Points must be less than $0.05 \text{ k}\Omega^{-1}$ from a straight line on the $1/S$ axis.

(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.

Line must not be kinked or thicker than half a small square.

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- (iii) Gradient: [1]
 The hypotenuse of the triangle 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:
 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 off directly from the graph.

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

Unit for a correct and consistent with value e.g. $\text{k}\Omega\text{s}^{-1}$, Ωs^{-1} . [1]

[Total: 20]

- 2 (a) (i) Measurement of d with unit in range 0.5 mm – 2.5 mm. [1]

Evidence of repeated readings of d . [1]

- (ii) Absolute uncertainty in d in the range 0.2 – 0.5 mm. [1]
 If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero if values are equal).
 Correct method of calculation to get percentage uncertainty.

- (c) (i) Measurement of r_1 recorded to nearest 0.1cm^3 , and in range 1 to 5cm^3 . [1]

- (ii) Value for n . [1]

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

- (d) Justification of s.f. in V linked to significant figures in $(r_1 - r_2)$ and in n . [1]

- (e) (ii) Second value of d . [1]

- (iii) Second value of n . [1]

Quality: V larger for larger d . [1]

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

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

Page 4	Mark Scheme	Syllabus	Paper
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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 <u>and</u> plot a graph/take many readings and calculate more k values <u>and</u> <u>compare</u>	repeat readings/few readings/take more readings and (calculate) average k /only one reading
B1	large uncertainty in d <u>because</u> d is small	improved method to measure d e.g. measure OD and wall thickness/image of cross-section <u>with</u> scale	flexible tube/rigid tube/wire in tube/micrometer/ d is small
B2	difficult to measure d <u>with reason</u> e.g. tube distorts/difficult to insert both prongs inside tube/difficult to judge when jaws are in line with edges of d	use travelling microscope/measure volume <u>and</u> calculate d /use a magnifying glass <u>with</u> scale	
C	difficult to count bubbles <u>with reason</u> e.g. plunger moves unsteadily/plunger sticks/bubbles unexpected/bubbles emerge too quickly	method to improve control e.g. use a G-clamp or screw <u>to move plunger</u> /use a narrower diameter syringe <u>with reason</u> (e.g. smaller force needed so better control)	bubbles difficult to count/lubrication
D	difficult to watch the syringe scale and the bubbles at the same time	description of method to allow simultaneous measurement e.g. use video <u>with playback</u> /use video to allow slow motion/use video to see bubbles	parallax/use assistant/change syringe scale/high speed camera/slow motion camera/light gates
E	difficult to keep end of tube at 2 cm depth	method to keep tube at 2 cm depth e.g. use of clamp/Blu-Tack/tape	stick tube/attach tube/water in tube/comments about Blu-Tack seal

[Total: 20]

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maximum raw mark 40

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1 (a) (i) Value of raw d in the range $0.15 \text{ mm} \leq d \leq 0.44 \text{ mm}$. [1]

(b) (v) Value of l in range $0.1 \text{ m} < l < 1 \text{ m}$. Value of V in range $0.1 \text{ V} \leq V \leq 2.0 \text{ V}$. [1]

(d) Six sets of readings of l and V scores 5 marks; five sets scores 4 marks etc. [5]
Major help from Supervisor –2 (setting up apparatus). Minor help from Supervisor –1.

Range of l : $\Delta l \geq 60 \text{ cm}$. [1]

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. $1/l / \text{m}^{-1}$, $V/l / \text{V m}^{-1}$.
Do not allow $1/l (\text{m})$, $V(V) / l (\text{m})$.

Consistency: [1]
All values of raw l must be given to the nearest mm.

Significant figures: [1]
Significant figures for every row of values of $1/l$ same as or one greater than l as recorded in table.

Calculation: [1]
Values of V/l 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 that is being plotted.
Scale markings should be no more than three large squares apart.

Plotting of points: [1]
All observations in the table must be plotted.
Diameter of points 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.

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 0.1 m^{-1} from a straight line on the $1/l$ axis.

(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. Line must not be kinked or thicker than half a small square.

Page 3	Mark Scheme	Syllabus	Paper
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- (iii) Gradient: [1]
 The hypotenuse of the triangle 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:
 Correct read-off 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:
 Correct read-off of the intercept directly from the graph.

- (f) (i) Value of M = candidate's gradient. Value of N = –(candidate's intercept). [1]
 (ii) Answer in range ρ : $2.0 \leq \rho \leq 20.0 \times 10^{-7} \Omega \text{m}$. Consistent with units. [1]

[Total: 20]

- 2 (a) (ii) Measurement of raw H in range $10.0 \text{ cm} < H < 20.0 \text{ cm}$ consistent with unit. [1]
 (b) (ii) Measurement of raw h_1 to nearest mm with unit. [1]
 (iii) Absolute uncertainty in h_1 in the range 2–5 mm. If repeated readings have been taken, then the absolute uncertainty can be half the range. Correct method of calculation to get percentage uncertainty. [1]
 (c) (iii) Measurement of h_2 less than h_1 . [1]
 Evidence of repeat readings here or in (e). [1]
 (d) Correct calculation of F with no units. [1]
 (e) Second value of h_1 . [1]
 Second value of h_2 . [1]
 Second value of $h_2 < \text{first value of } h_2$. [1]
 (f) (i) Two values of k calculated correctly. [1]
 (ii) Justification of s.f. in k linked to significant figures in h_1 and $(h_1 - h_2)$. [1]
 (iii) Sensible comment relating to the calculated values of k , testing against a criterion specified by the candidate. [1]

Page 4	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9702	33

(g)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	Do not credit
A	two readings not enough (to draw a conclusion)	take many readings <u>and</u> plot a graph/calculate more k values <u>and compare</u>	repeat readings /few readings /take more readings and (calculate) average k /only one reading
B	discontinuous movement at bottom	method of providing continuous ramp e.g. tape join	alignment /stick /fix
C	parallax error (or wtte) in h_1 or h_2 or heights	ruler and set square with detail e.g. set square from ruler to track or ball	ruler perpendicular to bench /parallax error in height
D	difficult to measure h_1/h_2 <u>with reason</u> e.g. cannot see bottom of marble/bottom of track not at bottom of marble/thickness of track not taken into account	measure to top of marble. /measure diameter of marble and subtract it from height to top of marble	H /clear ramps
E	difficult to release marble without applying a force	description of mechanical method of releasing marble e.g. card gate	string method /use of helpers
F	difficult to measure h_2 <u>with reason</u> related to <u>time</u> e.g. short time interval/doesn't stay still at h_2 for long	method of improved measurement of h_2 e.g. video with (clamped) rule/multiflash photography with (clamped) rule/trial and improvement method/position sensor at top of ramp/grid behind runway/scale on runway	too fast/ball travelling too quick, etc. /high speed camera or slow motion camera

[Total: 20]

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/34

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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9702	34

- 1 (b) (i) Value of d in the range 0.480 – 0.500 m, with unit. [1]
- (c) Six sets of readings of d and F scores 6 marks, five sets scores 5 marks etc. [6]
 Incorrect trend or no d data –1.
 Minor help from Supervisor –1, major help –2.
- Range: $d_{\max} - d_{\min} \geq 30$ cm. [1]
- 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. $1/d$ / m^{-1} .
- Consistency: [1]
 All values of d must be given to the nearest mm and all values of F must be given to the nearest 0.1 N.
- Significant figures: [1]
 Significant figures for every row of values of $1/d$ same as, or one greater than, d as recorded in table.
- Calculation: [1]
 Values of $1/d$ 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 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 of points: [1]
 All observations in the table must be plotted on the grid.
 Points must be plotted to an accuracy of half a small square.
 Diameter of plotted points must be $\leq$ half a small square (no blobs).
- Quality: [1]
 All points in the table must be plotted on the grid (at least 5) for this mark to be awarded. Judge by the scatter of all the points about a straight line.
 Scatter of points must be less than $\pm 0.001 \text{ cm}^{-1}$ from a straight line in the $1/d$ direction.
- (ii) Line of best fit: [1]
 Judge by balance of all the 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.
 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.

Page 3	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9702	34

- (iii) Gradient: [1]
 The hypotenuse of the triangle 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:
 Correct read-off from a point on the line substituted into $y = mx + c$ or an equivalent expression, with read-off 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 both x and y directions.

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

Unit for a correct and consistent with value, e.g. N cm. [1]
 Unit for b is correct and consistent with value, e.g. N.

[Total: 20]

- 2 (a) (i) All values of D to nearest 0.01 cm or all to nearest 0.001 cm, and in range 3.0 to 5.0 mm. [1]

Evidence of repeat readings of D . [1]

- (ii) Absolute uncertainty in D in range 0.02 to 0.05 cm and correct method of calculation to obtain percentage uncertainty. [1]
 If repeated readings have been taken, then the absolute uncertainty can be half the range (but not zero if values are equal).

- (c) (i) l in range 19.0 to 21.0 cm, with unit, to nearest mm. [1]

- (iii) t in range 2.0 to 10.0 s and value(s) to nearest 0.1 s or 0.01 s. [1]

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

- (d) Justification for s.f. in v linked to s.f. in D and t . [1]

- (e) (ii) Second value of l . [1]
 Second value of t . [1]
 Second value of $t >$ first value of t . [1]

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

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

Page 4	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9702	34

(g)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	Do not credit
A	two readings are not enough (to draw a conclusion)	take more readings <u>and</u> plot a graph / take more readings and 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
B1	large uncertainty in D <u>because D is small</u>	measure outside diameter and wall thickness / measure an image showing the cross-section and a scale	use micrometer
B2	tube distorts when measuring D	use travelling microscope / measure volume and calculate D	
C	tube not straight so difficult to make tube vertical / tube not straight so difficult to measure length	tape to a straight rod / increase attached mass	use stiffer tube
D	difficult to judge moment (or operate stopwatch) <u>when level reaches syringe graduations</u>	use video with timer / view video frame by frame / collect water for a timed interval and measure volume / use light gates and timer <u>with practical detail</u> / use different diameter syringe <u>with reason</u> / use position sensor above water surface	‘reaction time’ on its own / human error / ‘light gates’ on its own / slow motion (or high speed) camera
E	difficult to see water level	use coloured water (or dye) / use clear syringe / view against black background	
F	clay stretches (or squashes) tube	measure length after attaching clay	

References to parallax error are ignored for this experiment.

[Total: 20]

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/35

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

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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9702	35

- 1 (a) (ii) Value of T in range $0.4 \leq T \leq 1.4$ s. [1]
Evidence of repeats. [1]
- (b) Six sets of readings of m and t (or T) scores 5 marks, four sets scores 4 marks etc. [5]
Help from Supervisor –1.
- Range of m : $\Delta m \geq 0.600$ kg [1]
- 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. $1/T^2/\text{s}^{-2}$.
Do not allow $1/T^2(\text{s})^2$
- Consistency: [1]
All values of raw t must all be given to the nearest 0.1 s or 0.01 s.
- Significant figures: [1]
Significant figures for every row of values of $1/T^2$ same as or one greater than t (or T) as recorded in table.
- Calculation: [1]
Values of $1/T^2$ 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 should be no more than three large squares apart.
- Plotting of points: [1]
All observations in the table must be plotted.
Diameter of points must be $\leq$ half a small square (no “blobs”).
Work 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 0.1 s^{-2} of $1/T^2$ 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. Line must not be kinked or thicker than half a small square.
- (iii) Gradient: [1]
The hypotenuse of the triangle 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.

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y-intercept: [1]

Either:

Correct-read off 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:

Correct read-off of the intercept directly from the graph.

(d) Value of P = candidate's gradient. Value of Q = candidate's intercept. [1]

Unit for P ($\text{kg}^{-1} \text{s}^{-2}$) correct and consistent with value and Q (s^{-2}) [1]

[Total: 20]

2 (a) (i) Value of L in range $8.0 \leq L \leq 12.0$ cm with consistent unit to the nearest mm. [1]

(ii) Absolute uncertainty $1 \leq \Delta L \leq 3$ mm.
If repeated readings have been taken, then the uncertainty can be half the range.
Correct method of calculation to get percentage uncertainty. [1]

(b) (iii) Value of raw N_1 an integer. [1]

(c) (iii) Value of $N_2 \geq N_1$. [1]

Evidence of repeats for N_1 or N_2 either here or in (b)(iii). [1]

(d) Correct calculation of F . [1]

(e) Second value of L . [1]
Second values of N_2 and N_1 . [1]
Second (average) value of $N_1 >$ first (average) value of N_1 . [1]

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

(ii) Justification of s.f. in k linked to significant figures in L and $(N_1 - N_2)$ and m . [1]

(iii) Sensible comment relating to the calculated values of k , 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 more readings <u>and plot a graph</u> /calculate more k values and compare	repeat readings/few readings/only one reading/take more readings and average k
B	friction at pulley	method of reducing friction of pulley with location	
C	wet string added to force/mass of string not accounted for	waterproof/nylon/wire	
D	can only measure to nearest 0.4g / paperclip	use smaller masses e.g. half paperclips, riders, graph paper	newton meter
E	change in N are very small	reasoned explanation for changing length of wire	helpers parallax errors
F	copper wire is not flat/straight/exit not parallel to water level	circular wire shape	change liquid/wire

[Total: 20]