

MARK SCHEME for the May/June 2014 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
	GCE AS/A LEVEL – May/June 2014	9702	31

- 1 (a) Value of L_0 in range 0.045 m–0.070 m (4.5 to 7.0 cm). [1]
If out of range, compare to Supervisor's value $\pm 20\%$.
- (b) (iii) Value of $L > L_0$. [1]
- (c) Six sets of readings of m and L scores 5 marks, five sets scores 4 marks, etc. [5]
Incorrect trend then -1 . Correct trend is L decreases as m increases for all m values.
Major help from Supervisor -2 . Minor help from Supervisor -1 .
- Range: at least one value of m less than 200 g and one value more than 200 g. [1]
- Column headings: [1]
Each column heading must contain a quantity and an appropriate unit. The presentation of quantity and unit must conform to accepted scientific convention, e.g. $\theta/^\circ$, L/m , m^2/kg^2 , e/m , $e^2(\text{m}^2)$.
- Consistency: [1]
All values of L must be given to the nearest mm only.
- Significant figures: [1]
Significant figures for every row of m^2 same as (or one greater than) the s.f. in m as recorded in table.
- Calculation: [1]
Values of e^2 calculated correctly to the number of significant figures given by the candidate.
- (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 must be plotted.
Diameter of plots 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 $\pm 0.0005 \text{ m}^2$ of e^2 from a straight line.
- (ii) Line of best fit: [1]
Judge by balance of all points on the grid about the candidates' 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.
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:
 Check 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:
 Check read-off of the intercept directly from the graph.

- (e) $P = -$ value of the gradient and $Q =$ value of the y-intercept. [1]
 Do not allow fractions. Do not allow substitution methods.

- (f) Check substitution and value of M in range 0.100–0.500 kg with unit. [1]

[Total: 20]

- 2 (b) (ii) Value of x in the range 25.0–35.0 cm with unit. [1]

x to the nearest mm [1]

- (iii) Absolute uncertainty in x in range 2 mm–5 mm. [1]
 If repeated readings have been taken, then the uncertainty can be half the range (not zero) only if working shown.
 Correct method of calculation to obtain percentage uncertainty.

- (c) (ii) Value of T with unit. [1]
 Evidence of repeats. [1]

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

- (d) (ii) Second value of x . [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) Justification of significant figures in k linked to significant figures in x and T /time. (Do not allow “raw readings”.) [1]

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

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(f)	(i) Limitations (4 max)	(ii) Improvements (4 max)	Do not credit
A	Two readings not enough to draw a conclusion.	Take more readings for different lengths <u>and</u> plot a graph or take more readings <u>and</u> compare k values.	Not enough repeat readings. Few readings. Idea of repeats. “Too few readings/two readings” on its own.
B	Difficulty linked to timing with reason, e.g. time small/short/vibrates fast/high frequency/oscillates fast/swings fast. or <u>Large</u> uncertainty in time with reason. or Human reaction time with reason, e.g. short time.	Improved <u>method</u> of timing, e.g. video with timer/video and view frame by frame/light gate placed at the centre/motion sensor at side of blade (to timer/datalogger display).	“Human errors / reaction time” on their own. “Light gate” on its own. Moves fast. Video and playback. Fans. Longer blade. Simultaneous release of blade and start timer. Amplitude. High speed camera or slow motion cameras.
C	Unevenness of oscillation or G-clamp moving.	Improved method of smoother oscillation, e.g. use of wooden block either side of hacksaw blade. Method of fixing G-clamp, e.g. clamp G-clamp (to table).	
D	Difficulty judging centre of masses (due to slots).	Use masses without slots / measure to the top and bottom and average.	Blu Tack. Masses different heights.
E	Difficult to measure x <u>with reason</u> , e.g. difficult to know where to start x as jaws of clamp are rounded / blade may not be vertical (due to clamp).	Improved method to measure x , e.g. description of use of set square	Uncertainty in metre rule. Parallax error.
F	Small range for x for measurable times		

[Total: 20]

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/32

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

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- 1 (a) (i) Value of l_0 in range $4.0\text{ cm} \leq l_0 \leq 8.0\text{ cm}$. [1]
- (b) (iii) Value of h to nearest mm, in the range $40.0\text{ cm} \leq h \leq 50.0\text{ cm}$. [1]
- (c) Six sets of values for h and l scores 5 marks, five sets scores 4 marks, etc. [5]
 Incorrect trend –1. Help from Supervisor –1.
- Range: [1]
 h values must include 20 cm or less.
- Column headings: [1]
 Each column heading must contain a quantity and an appropriate unit.
 The presentation of quantity and unit must conform to accepted scientific convention, e.g. $1/h^2/\text{cm}^{-2}$ or $1/h^2\text{ (1/cm}^2\text{)}$ but not $1/h^2(\text{cm}^2)$.
- Consistency: [1]
 All values of h and l must be given to the nearest mm only.
- Significant figures: [1]
 Every value of $1/h^2$ must be given to the same s.f. as (or one greater than) the s.f. in the corresponding h .
- Calculation: [1]
 Values of $(l-l_0)^2$ 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 must be no more than 3 large squares apart.
- Plotting: [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 must be plotted (at least 5) for this mark to be scored. Scatter of points must be within $\pm 10\text{ cm}^2$ of $(l-l_0)^2$ from a straight line.
- (ii) Line of best fit: [1]
 Judge by balance of all points 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 plot 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 must be at least 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:
 Read-off from a point on the line is 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.

- (e) p = value of the gradient, and q = value of the intercept. [1]
 Dimensionally correct units for p and q . [1]

[Total: 20]

- 2 (a) (i) Value for d to nearest mm, in range $1.0\text{ cm} \leq d \leq 2.0\text{ cm}$. [1]
 (ii) Correct calculation of l . [1]
- (b) (ii) Value for t in range $4.0\text{ s} \leq t \leq 10.0\text{ s}$, with unit. [1]
 Evidence of repeat readings of t . [1]
- (c) (iii) Value for A to nearest mm, with unit. [1]
- (d) Absolute uncertainty in A in range 2 to 5 mm. [1]
 If repeated readings have been taken, then absolute uncertainty could be half the range (but not zero) only if working shown.
 Correct method of calculation to obtain percentage uncertainty.
- (e) Second value of t . [1]
 Second value of A . [1]
- (f) (i) Two values of k calculated correctly. [1]
 kl in range 0.20 to 0.30 cm s^{-2} . [1]
 (ii) Justification based on the number of s.f. in d , n , t and A (not just “raw readings”). [1]
- (iii) Valid 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 are not enough to draw a valid conclusion	Take more readings (for different masses) <u>and</u> plot a graph, or take more readings <u>and</u> compare k values	Not enough repeat readings Few readings Idea of repeats “Too few readings/two readings” on its own
B	Difficult to measure d , with reason, e.g. parallax error/ measuring outside diameter/loop gets in the way	Use <u>vernier</u> calipers/micrometer Measure inside and outside diameter and find average	“Parallax error” on its own “Calipers” on its own
C	Difficult to judge exactly when 10 oscillations completed	Video + timer/video and view frame-by-frame. Use distance sensor in stated and correct position Use a (fiducial) marker at centre of oscillation/equilibrium position Light gate at equilibrium position/centre of oscillation	Human/reaction time error High speed cameras/slow motion cameras Oscillations too fast
D	Mass swings as it oscillates/non-uniform oscillation/spring moves along bolt	Use tube to act as a guide Use deeper groove on bolt Fix top of spring to bolt with, e.g. Blu-tack/Sellotape	
E	Difficult to judge when contact is lost/hard to see gap	Use pressure sensor on bolt Use video close-up/zoom lens/ magnifying glass Video + slow-motion, linked to observing gap Better/more sensitive method of adjusting height of bolt, e.g. lab jack	“Video + slow motion” on its own
F	n is not a whole number	Measure n to nearest $\frac{1}{4}$ turn	

Do not credit use of an assistant, fans, air conditioning, or use of computers/data loggers on its own.

[Total: 20]

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- 1 (a) Value of L with unit in range $90.0 \text{ cm} \leq L \leq 110.0 \text{ cm}$. [1]
- (d) (ii) Value of I with unit in the range $50 \text{ mA} \leq I \leq 150 \text{ mA}$. [1]
Allow Supervisor's value $\pm 20\%$.
- (e) Six sets of readings of x and I scores 5 marks, five sets scores 4 marks etc. [5]
Incorrect trend –1 (correct trend is I increases as x increases for all values of x).
Major help from Supervisor –2. Minor help from Supervisor –1.
- Range: $\Delta x \geq 70 \text{ cm}$. [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. x/cm or $x(\text{cm})$, $x^2/(x+L)/\text{m}$ but not $x^2/(x+L)/\text{m}^2/\text{m}$, $1/I \text{ (A}^{-1}\text{)}$, $1/I \text{ (1/A)}$ but not $1/I \text{ (A)}$ or $1/I(\text{A})^{-1}$.
- Consistency: [1]
All values of x must be given to the nearest mm only.
- Significant figures: [1]
Significant figures for every row of $x^2/(x+L)$ same as (or one greater than) the s.f. in x .
- Calculation: [1]
Values of $x^2/(x + L)$ calculated correctly to the number of significant figures given by the candidate.
- (f) (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 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 $\pm 0.25 \text{ A}^{-1}$ of $1/I$ from a straight line.

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- (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 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. The method of calculation must be correct.

- y-intercept: [1]
 Either:
 Check 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:
 Check read-off of the intercept directly from the graph.

- (g) $P = -$ the value of the gradient and $Q =$ the value of the y-intercept. [1]
 Do not allow fractions. Do not allow a substitution method.

- Unit for P ($A^{-1}m^{-1}$) and Q (A^{-1}) consistent with value. [1]

[Total: 20]

- 2 (b) (i) Value of y in range $8.0\text{ cm} \leq y \leq 12.0\text{ cm}$ with unit. [1]

- (ii) Absolute uncertainty in y in range $2\text{ mm} - 5\text{ mm}$. [1]
 If repeated readings have been taken, then allow uncertainty to be half the range (but not zero) only if working shown.
 Correct method of calculation to obtain percentage uncertainty.

- (iii) Value of x to the nearest mm with unit. [1]

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

- (c) (iii) Value of T with unit in range $1.5\text{ s} \leq T \leq 3.0\text{ s}$. [1]
 Evidence of repeats. [1]

- (d) Second value of R . [1]
 Second value of T . [1]
 Correct trend for T with respect to R (T decreases as R decreases). [1]

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

Page 4	Mark Scheme	Syllabus	Paper
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(ii) Correct justification of significant figures in k linked to significant figures in x and y and time (do not allow “raw readings”). [1]

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

(f)	(i) Limitations (4 max)	(ii) Improvements (4 max)	Do not credit
A	Two readings not enough to draw a conclusion.	Take more readings (for different radii) <u>and</u> plot a graph or take more readings <u>and</u> compare k values.	Not enough repeat readings. Few readings. Idea of repeats. “Too few readings/two readings” on its own.
B	Only a few cycles possible/(heavily) damped/ball does not return to the original height.	Use a longer track/heavier ball.	Smoother or lubricated track.
C	Difficult to judge exactly when an oscillation is complete.	Improved method of timing e.g. video with timer/video and view frame by frame/measure time from centre of oscillation/put marker at the centre of oscillation/light gate at centre.	“Ball too fast” on its own. Human reaction time. Video and play back. High speed cameras or slow motion cameras. Use of motion sensor.
D	Difficult to measure y <u>with reason</u> e.g. not sure where horizontal is at the top/ruler not vertical/allowing for the thickness/lips of the track/can't hold ruler steady.	Improved method of measuring y e.g. use a ruler across the top/tie a string across the top/set square on bench/use of plumbline/measure two heights and find difference/use of micrometer for thickness of track/clamp ruler to measure y /clamp ruler vertically.	Parallax error. Not clear where the lowest point of track is.
E	Limitation of track e.g. is not entirely circular/portion of track in clamps is straight/too stiff to bend/track twisted/skewed.	Improved method of supporting track e.g. attach track to board/clamp in more places.	Changing track e.g. more flexible or rubber track. Difficult to clamp. “Friction on track” on its own.
F	Difficulty in placing ball at the same point each time/difficulty in releasing the ball with no force.	Method of marking the same point on the track/method of releasing the ball e.g. use card as a gate/electromagnet release and steel ball	If electromagnetic release do not allow ‘metal’ ball. Clamp or robotic arm. Burning through string.

Do not credit measurement of x , use of an assistant, fans, air conditioning, use of computers/dataloggers on its own.

[Total: 20]

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/34

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

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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	34

- 1 (a) (i) Value for θ in range 80° to 100° , with unit. [1]
- (b) (ii) Value for t in range 10 to 40 s, with unit. [1]
- Evidence of repeat readings of t . [1]
- (c) Five sets of values for θ and t scores 4 marks, four sets scores 3 marks etc. [4]
 Incorrect trend –1. Help from Supervisor –1.
- Range: [1]
 θ values must include 75° or less and 105° or more.
- Column headings: [1]
 Each column heading must contain a quantity and an appropriate unit.
 The presentation of quantity and unit must conform to accepted scientific convention
 e.g. t^2/s^2 or $t^2 (s^2)$, $\theta(^\circ)$ or $\theta(\text{deg})$ etc. $\sin^2(\theta/2)$ must have no unit.
- Consistency: [1]
 All values of t must be given to the nearest 0.1 s, or all to the nearest 0.01 s.
- Significant figures: [1]
 Every value of t^2 must be given to the same s.f. as (or one greater than) the s.f. in the corresponding t .
- Calculation: [1]
 Values of $\sin^2(\theta/2)$ 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 must 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”).
 Plotting must be accurate to 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 within $\pm 20 s^2$ of a straight line in the $y(t^2)$ direction.

Page 3	Mark Scheme	Syllabus	Paper
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- (ii) Line of best fit: [1]
 Judge by balance of all points on the grid about the candidate's line (at least 4 points).
 There must be an even distribution of points either side of the line along the full length.
 Allow one anomalous plot only if clearly indicated 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 x and y directions.

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

- (e) q = candidate's gradient and p = candidate's intercept. [1]

Correct units for q and p (s^2 for q and s^2 for p). [1]

[Total: 20]

Page 4	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	34

- 2 (a)** r in range 5.0 mm to 12.0 mm and to nearest 0.1 mm or better. [1]
- (b) (i)** Value for l in range 61.0 mm to 65.0 mm. [1]
- (ii)** Value for e in range 6.0 mm to 8.0 mm. [1]
- (c) (ii)** Value for x . [1]
Evidence of repeat readings of x . [1]
- (iii)** Absolute uncertainty in x in range 2 to 9 mm. [1]
If repeated readings have been taken, then absolute uncertainty could be half the range (but not zero) only if working is shown.
Correct method of calculation to obtain percentage uncertainty.
- (iv)** Calculated value of θ correct. [1]
 θ given to 2 or 3 significant figures. [1]
- (d)** Second values of e and x . [1]
- (e) (i)** Two values of k calculated correctly. [1]
Both values for k in range 0.80 to 1.20. [1]
- (ii)** Valid comment consistent with the calculated values of k , testing against a criterion specified by the candidate. [1]

Page 5	Mark Scheme	Syllabus	Paper
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(f)	Limitations (4 max)	Improvements (4 max)	Do not credit
A	Two readings are not enough to draw a valid conclusion	Take more readings and plot graph/ take more readings and compare k values	Repeat readings / too few readings / two readings
B	Difficult to align groove with line / difficult to estimate centre of groove	Mark centre line of groove / method of aligning groove (e.g. use lines on paper / use graph paper / transparent ramp)	
C	e is small so uncertainty in e is large / small change in e gives large change in θ	Use larger spheres <u>to enable larger e</u>	Just “use larger spheres”
D	Parallax error <u>when measuring x</u>	Use set square (<u>with detail of workable method</u>)	
E	Difficult to locate centre of sphere <u>when measuring x</u>	Measure to edge of sphere and add r	Difficult to locate centre of sphere when measuring r
F	Sphere rolls slightly after hitting tape / sphere does not stick	Use video with scale (in view) / Description of workable improvement (e.g. powder on strip / plasticine surface)	High speed camera / slow motion camera / video camera / stickier surface / magnets

[Total: 20]

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/35

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- 1 (b) (iii) Values of a in range 53.0 cm – 57.0 cm and $b < a$ with unit. [1]
- (iv) Value of L in the range 12.0 cm – 16.0 cm with unit. [1]
- (d) Six sets of readings of a and b scores 5 marks, five sets scores 4 marks, etc. [5]
 Incorrect trend –1 (correct trend is b increases as a increases).
 Help from Supervisor –1.
- Range: $\Delta a \geq 39$ cm. [1]
- Column headings: [1]
 Each column heading must contain a quantity and unit.
 The presentation of quantity and unit must conform to accepted scientific convention, e.g. $(1/b)/\text{m}^{-1}$.
- Consistency: [1]
 All values of a and b must be given to the nearest mm.
- Significant figures: [1]
 Significant figures for every row of values of $1/b$ same as (or one greater than) b as recorded in table.
- Calculation: [1]
 Values of a/b 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 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 $\pm 0.001 \text{ cm}^{-1}$ (0.1 m^{-1}) of $1/b$ 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 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:
 Check 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:
 Check read-off of the intercept directly from the graph.

- (f) Value of $P = -\text{gradient}$ and value of $Q = \text{intercept}$. [1]

- (g) Value of M in range 40–200 g with unit. No POT error allowed. [1]

[Total: 20]

- 2 (a) (ii) Values of d to the nearest 0.01 mm with unit. [1]
 $6.00 \text{ mm} \leq d \leq 10.00 \text{ mm}$. If out of range allow Supervisor's value $\pm 2.00 \text{ mm}$. [1]
 Evidence of repeat readings. [1]
- (iii) Absolute uncertainty in d in range 0.05 mm–2.00 mm. [1]
 If repeated readings have been taken, then the uncertainty could be half the range (but not zero) only if the working is shown.
 Correct method of calculation to get percentage uncertainty.
- (c) (iv) Value of $x_1 > x$ with unit to the nearest mm. [1]
- (v) Correct calculation of e . [1]
- (d) (ii) Second value of d . [1]
 Second value of x_1 . [1]
 Second value of $e < \text{first value of } e$. [1]
- (e) (i) Two values of k calculated correctly. [1]
- (ii) Justification based on the number of significant figures in e (or $x_1 - x$) and d . [1]
- (iii) Valid comment relating to the calculated values of k , testing against a criterion specified by the candidate. [1]

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(f)	(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 diameters <u>and</u> plot a graph	Repeat readings Few readings Too few readings/ only two readings
B	Large uncertainty in extension because extension small	Use longer/ thinner cylinders or thinner central portion/ time for hanging longer/ greater mass to give greater extension	
C	Difficult to roll uniform cylinder/ cylinder not symmetrical/ not uniform diameter/ density or consistency not the same	Viable suggestion for improvement, e.g. spacers, mould, force through hole	
D	Reading of x_1 is imprecise because marks have widened	Improved method of marking without a dent	
E	Difficulty with clamping the plasticine, e.g. breaks prematurely/ twists in clamp	Improved method to attach weight to plasticine, e.g string loop through handles/ place clamp lengthways	
F	Micrometer digs into plasticine and <u>may weaken it/ gives incorrect diameter reading</u>	Improved method to measure d , e.g. travelling microscope/ work out diameter from volume or circumference	
G	Difficulties relating to the properties of the plasticine over time, e.g. high temperature making too soft/ picking up impurities/ re-breaking at fractured points/ as roll temperature increases and affects	Use new piece of plasticine each time/ roll and leave until reaches room temperature	

[Total: 20]