

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

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 (a) (iii) Value of x in the range 0.50 – 0.60 m. [1]
- (b) (ii) Value of T with unit: $0.9\text{ s} < T < 1.3\text{ s}$. [1]
Evidence of repeats. [1]
- (c) Six sets of readings of x and T scores 4 marks, five sets scores 3 marks etc. [4]
Incorrect trend –1. Minor help from Supervisor –1; major help –2.
- Range of x at least 25 cm. [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. x/m or $x(\text{m})$ or x in m.
- Consistency of presentation of raw readings: [1]
All values of x must be given to the nearest mm.
- Significant figures: [1]
Significant figures for $\sqrt{x}$ should be the same as, or one more than, s.f. for x .
- Calculation: $\sqrt{x}$ calculated correctly. [1]
- (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 on the grid 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 not be greater than three large squares apart.
- Plotting of points: [1]
All the observations in the table must be plotted.
Check the points are plotted correctly.
Work to an accuracy of half a small square.
Do not accept 'blobs' (points with diameter greater than half a small square).
- 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 $0.04\text{ m}^{1/2}$ ($0.4\text{ cm}^{1/2}$) on the $\sqrt{x}$ axis from a straight line.
- (ii) Line of best fit: [1]
Judge by the 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 if clearly indicated (e.g. 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.
 Do not allow $\Delta x/\Delta y$.

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. Allow ecf of gradient value.
 Or:
 Check the read-off of the intercept directly from the graph.

- (e) Value of P = candidate's gradient and Q = value of candidate's intercept. Do not allow fractions. [1]

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

[Total: 20]

- 2 (a) (iii) Value of F_0 with unit. [1]
 Evidence of repeats. [1]

- (iv) Absolute uncertainty in F_0 in range 0.4 – 1 N. [1]
 If repeated readings have been taken, then the uncertainty can be half the range.
 Correct method of calculation of percentage uncertainty. [1]

- (v) Value of μ given to 2 or 3 s.f. [1]

- (b) (ii) Value of θ with unit to the nearest degree. [1]

- (iii) Correct calculation of $(\sin \theta + \mu \cos \theta)$. [1]

- (c) (ii) Value of F . [1]

- (d) Second value of θ . [1]
 Second value of $\theta <$ first value of θ . [1]
 Second value of $F <$ first value of F . [1]
 Allow $F_2 > F_1$ if $\theta_2 > \theta_1$.

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

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

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(f)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	No credit/not enough
A	two readings are not enough (to draw a conclusion)	take more readings and plot a graph/ calculate more k values and <u>compare</u>	few readings/ take more readings and calculate average k / only one reading
B	some parts of board rougher than others/ surface of board is uneven/ board not flat	method to ensure same section of board used in each experiment (e.g. mark one section)	board is rough/ there is friction between the block and the board/ use a smoother surface/ references to oil/lubricants
C	large (percentage) uncertainty in F	use larger/heavier masses	values of F very similar
D	difficulty in arranging newton-meter parallel to board/pulling in line with board	use (long) piece of string to connect the newton-meter to the block	newton-meter touching board when attached
E	block moves suddenly/without warning (so difficult to read newton-meter at the instant the block starts to move) value of F changes when block moves	use system of pulley and weights/ sand to measure F / use a newton-meter with a max hold facility/ use video and playback/ use force sensor and datalogger/computer	
F	board tends to slip/ board not stable/ supporting block can topple	method described to secure board/block/support e.g. clamp the board, fix the supporting block to the bench with tape/blu-tack	
G	cannot zero newton-meter when used horizontally	use system of pulley and weights/ sand to measure F / use force sensor and datalogger/computer	zero error in newton-meter

Ignore 'parallax problems', 'use assistant' or references to draughts, fans, a.c.

[Total: 20]

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- 1 (a) Value of L in range $0.80\text{ m} > L > 0.60\text{ m}$. Consistent with unit. [1]
- (b) (iii) Value of h_0 , less than 50 cm, to the nearest mm. [1]
- (c) Six sets of readings of d and h scores 5 marks, five sets scores 4 marks etc. Help from Supervisor –1. [5]
- Range of d : [1]
To include 25.0 cm (0.250 m) or more **and** 10.0 cm (0.100 m) or less
- Column headings: [1]
Each column heading must contain a quantity and a unit
The unit must conform to accepted scientific convention e.g. d/m , $d(\text{m})$ or d in m, $(h - h_0)/\text{m}$, $(L/2 - d)^2/\text{m}^2$
- Consistency: [1]
All values of d and h must be given to the nearest mm.
- Significant figures: [1]
All values of $(L/2 - d)^2$ to 2 or 3 s.f.
- Calculation: [1]
Values of $(L/2 - d)^2$ 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 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.
Diameter of plots must be $<$ half a small square (no blobs).
Plots 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 less than 0.5 cm (0.005 m) of $(h - h_0)$ 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 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 x and y directions.
 Do not allow $\Delta x / \Delta y$.

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

- Unit for a (e.g. m) and b (e.g. m^2) consistent with values. [1]

[Total: 20]

- 2 (b) (i) Value of ball diameter or d to the nearest 0.1 mm (or 0.01 mm). [1]
 Values of ball diameter and d in range $5 \text{ mm} < d < 25 \text{ mm}$. [1]

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

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

- (c) (ii) Value of F , with unit. [1]
 Evidence of repeat measurements of F here or in (d)(ii). [1]

- (d) (ii) Second value of d . [1]
 Second value of A is given to the same number of s.f. (or one more s.f.) than d_2 . [1]
 Second value of F . [1]
 Quality: When d increases (second d value is larger than first d value) F also increases (second F value is larger than first F value) and vice versa. [1]

- (e) (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]

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(f)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	No credit/not enough
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 sphere or disc/diameter of sphere or disc varied	method to make uniform spheres/discs e.g. moulds	pre-sized spheres/ repeat diameter measurement and average
C	reason for difficulty in measuring d e.g. viewed through ruler/parallax error in d	method to improve measurement of d e.g. travelling microscope	eyes in line
D	difficult to pull newton-meter parallel to ruler/bench	method to ensure force is parallel to ruler e.g. use a long string/pulley and weights*	
E	difficult to judge reading on <u>newton-meter</u> when detaches with reason e.g. ruler moves suddenly/without warning (so difficult to read newton-meter at the instant the ruler starts to move)/force drops to zero immediately after detachment	method to <u>read force</u> at detachment e.g. newton meter with a 'max hold' facility/video and playback or freeze frame/ use system of pulley and weights or sand to measure F^* / use force sensor and datalogger or computer*	video to take reading/ digital (electronic) newton meter/ parallax related to newton meter/ difficult to measure force/ issue of viewing ruler and meter simultaneously
F	contact area less than calculated disc area/bulging disc		
G	difficult to zero newton-meter when used <u>horizontally</u>	improved method to measure F : e.g. use system of pulley and weights or sand*/use force sensor with datalogger or computer*	zero error in newton-meter/ just a pulley

Do not allow: reaction time/human error/using vernier caliper/helpers/use of micrometer screw gauge/effect of temperature/change in stickiness of Blu-Tack.

*This answer can be credited as D, E or G (but not more than once).

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- 1 (a) (ii) Value of h_0 in range $0.70\text{ m} > h_0 > 0.50\text{ m}$. Consistent with unit. [1]
- (b) (iii) Value of h , less than h_0 in (a)(ii), with unit. [1]
- (c) Five sets of readings of h and m scores 5 marks, four sets scores 4 marks etc. [5]
Major help from Supervisor –2 (setting up apparatus). Minor help from Supervisor –1.
- Range of m : [1]
To include 0.350 kg .
- Column headings: [1]
Each column heading must contain a quantity and a unit.
The unit must conform to accepted scientific convention e.g. m / kg , $m(\text{kg})$ or m in kg ,
 $(h_0 - h)/m / \text{m kg}^{-1}$, $1/m / \text{kg}^{-1}$
- Consistency: [1]
All values of h must be given to the nearest mm .
- Significant figures: [1]
Significant figures for every row of values of $1/m$ same as or one greater than m as recorded in the table.
- Calculation: [1]
Values of $(h_0 - h)/m$ 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 of points: [1]
All observations in the table 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 4) for this mark to be awarded. Scatter of points must be less than 0.5 kg^{-1} (0.0005 g^{-1}) of $1/m$ 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 4 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 x and y directions.
Do not allow $\Delta x / \Delta y$.

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

Unit for P (e.g. m) consistent with value, and Q (m kg^{-1}) [1]

[Total: 20]

2 (b) (ii) Value of θ_0 to the nearest degree or 0.5° in range $70^\circ \neq \theta \neq 80^\circ$ [1]

(iii) Value of θ with unit, $\theta < \theta_0$ [1]

(iv) Correct calculation of $(\theta_0 - \theta)$ [1]

(c) (i) Value of raw d with unit to nearest mm. [1]

(ii) Absolute uncertainty in $2 \text{ mm} < d < 5 \text{ mm}$. [1]

If repeated readings have been taken, then the absolute uncertainty can be half the range. Correct method shown to find the percentage uncertainty.

(d) Second value of θ_0 within 1°C of first value of θ_0 . [1]

Second value of θ . [1]

Second value of $\Delta\theta >$ first value of $\Delta\theta$ (check second value of $d >$ first value of d). [1]

Evidence of repeat readings of d here or in (c)(i). [1]

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

(ii) Justification of s.f. in k linked to significant figures in d and $\Delta\theta$. [1]

(iii) Sensible 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.	No credit/not enough
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	heat lost <u>through sides and /or bottom</u>	method to reduce heat loss/ lag/ insulate/ polystyrene container	use of lid/ heat loss in warming bowl/cup/ draughts/ heat loss to surroundings
C	temperature change is small/ $\Delta\theta$ values too close	time for longer/ higher starting temperature/ greater range of surface areas	
D	large (percentage) uncertainty in $\Delta\theta$	use thermometer with greater sensitivity or precision/ use thermometer that can read to 0.1°C	use more accurate thermometer/ thermometer not precise enough/ not just 'digital thermometer'
E	water in bowl barely covers (bulb of) thermometer	use larger volume of water/ use of thermocouple/ other <u>small</u> temperature <u>sensor</u> (e.g. probe)	not just 'digital thermometer' any reference to stirrer/ non-uniform temperature/ thermometer touching base
F	parallax error in measuring <u>d</u> / reason for difficulty in access in measuring <u>d</u>	use dividers/calipers	string measurements to measure d
G	difficult to mark level with reason	method of making mark stay e.g. depth gauge/ calibrated marks/ marker on outside	

Do not allow: use of coloured ink/reaction time/fans/draughts/water left behind/beakers not accurate/ helpers.

[Total: 20]

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- 1 (a) (iii) Value for I_0 in range 2.0 to 4.0 mA, with unit. [1]
- (b) (ii) First value of I (greater than I_0). [1]
- (c) Six sets of readings of R and I scores 5 marks, five sets scores 4 marks etc. [5]
Major help from Supervisor –2. Minor help from Supervisor –1. Incorrect trend then –1.
- Range: [1]
Values of R must include 0.22 k Ω or 0.33 k Ω **and** 3.3 k Ω or 4.7 k Ω .
- Column headings: [1]
Each column heading must contain a quantity and a unit.
There must be some distinguishing mark between the quantity and the unit.
- Consistency: [1]
Values of I must be given either all to the nearest 0.1 mA or all to the nearest 0.01 mA.
- Significant figures: [1]
Every value of $1/R$ must be given to either 2 or 3 significant figures.
- Calculated values: [1]
 $1/R$ calculated correctly.
- (d) (i) Axes: [1]
Sensible scales must be used (no awkward scales such as 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 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.
Diameter of plots must be < half a small square (no blobs). Plotting must be accurate to half a small square.
- Quality: [1]
Range of I must be at least 2 mA, and all points must be within 0.5 mA of a straight line.
All points in the table must be plotted (at least 5) for this mark to be scored.
- (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.
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.

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- (d) (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.
 Do not allow $\Delta x / \Delta y$.

y -intercept: [1]
 Either:
 Correct read off from a point on the line is substituted into $y = mx + c$.
 Or:
 Check read-off of the intercept directly from the graph.

- (e) Calculation of b is correct, [1]
 i.e. $b = (\text{candidate's gradient value}) / (\text{candidate's intercept value})$.

Value for b in range $0.8 \text{ k}\Omega$ to $1.2 \text{ k}\Omega$, with unit. [1]

[Total: 20]

- 2 (b) Value of d in range 0.80 to 0.99 mm , to nearest 0.01 mm , with unit. [1]
 Evidence of repeated measurements for d . [1]

- (c) Percentage uncertainty in d based on absolute uncertainty of 0.01 mm . [1]
 Correct calculation to get percentage uncertainty.

- (d) (iv) Value of θ in range 91° to 180° to nearest degree, with unit. [1]
 Evidence of repeated measurements for θ . [1]

- (v) Correct calculation of $\sin(180^\circ - \theta)$. [1]
 $\sin(180^\circ - \theta)$ given to 2 or 3 s.f. [1]

- (e) Second value of d . [1]
 Second value of θ . [1]
 Quality: θ larger for smaller d . [1]

- (f) (i) Correct calculation of two values of k . [1]
 (ii) Valid conclusion based on the calculated values of k . Candidate must test correctly against a stated criterion. [1]

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(g)

	(i) Limitations 4 max.	(ii) Improvements 4 max.	No credit/not enough
A	two results not enough	take more readings and <u>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	θ (or angle, or scale reading, or protractor reading, or pointer reading) is difficult to measure, with reason linked to rapid motion or short time	video and view playback/ slow motion camera/ video <u>to read angle</u> / add a 'max hold' pointer/ angle sensor with data logger (or computer)	just 'use a computer'/ 'reading' difficult to measure
C	parallax error in <u>θ measurement</u>	use mirror scale/ <u>description of</u> method to reduce error	view at right angles/ trial and improvement
D	θ (or reading) is difficult (or inaccurate, or imprecise) <u>because pointer is thick</u>	–	use thinner pointer/ use larger scale
E	pointer attachment moves	<u>description of</u> secure method of attachment	
F	–	<u>description of</u> method of fixing block to bench	

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- 1 (b) (ii) Ammeter reading with unit, in range $1 \text{ mA} < I < 1 \text{ A}$. Must see $n = 3$. [1]
- (c) Six sets of readings of I and n scores 5 marks, five sets scores 4 marks etc.
 Incorrect trend then –1. Correct trend is I decreases as n increases.
 Major help from Supervisor –2. Minor help from Supervisor –1. [5]
- Range of 6 or 7. [1]
- Column heading: [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 , $I (\text{A})$, $I \text{ in A}$, $n + 1 / I / \text{A}^{-1}$.
- Consistency: [1]
 All values of I must be given to the nearest 0.1 mA or better.
- Significant figures: [1]
 Significant figures for every row of values of $(n + 1) / I$ same as or one greater than s.f. in I , as recorded in the table.
- Calculation: [1]
 Values of $(n + 1) / I$ 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 observations in the table 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]
 Judge by scatter of all points about best fit line. All points in the table must be plotted for this mark to be scored. At least 5 plots needed.
 All points must be within 0.2 of n from a best 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.
- (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.
 Do not allow $\Delta x / \Delta y$.

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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 intercept directly from the graph.

(e) Value of P = candidate's gradient. Value of Q = candidate's intercept. [1]
Do not allow fractions.

(f) Value of V in range $1V \leq V \leq 2V$. [1]

(g) R with appropriate unit Ω or VA^{-1} . Expect 50Ω or $0.05 V mA^{-1}$ or $0.05 k\Omega$ [1]

[Total: 20]

2 (b) (ii) Value of x with unit to the nearest mm in range: $40.0 \text{ cm} \leq x \leq 60.0 \text{ cm}$. [1]

(c) (ii) Value of x_1 with consistent unit. [1]

(iii) Correct calculation of d_1 with unit. [1]

(iv) Absolute uncertainty in d_1 in range 2 – 5 mm. [1]

If repeated readings have been taken, then the absolute uncertainty can be half the range. Correct method shown to find the percentage uncertainty

(d) (ii) Value of x_2 . [1]

(e) (iii) Value of $1 \text{ s} < T < 4 \text{ s}$. [1]

Evidence of repeats. [1]

(f) Second value of T . [1]

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

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

(ii) Justification of sf in k linked to significant figures in d and T . [1]

(iii) Sensible comment relating to 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.	No credit/not enough
A	two results not enough	take more readings with discs of <u>other materials / mass</u> and plot a graph/ calculate more k values and <u>compare</u>	repeat readings few readings
B	reason why difficult to record/ measure x_2/x_1 directly	use a taller /narrower shape take measurement to each end and average/ hole in middle to see x_1/x_2 / hang masses with string	
C	difficult to get circular shape/flat top/ same shape/ two shapes not the same because of groove in 100g mass	use a mould/ use a plane surface to press down on plasticine	use rubber masses
D	pivot/100g mass moved while x_2 being determined	method of securing 100g mass to rule/ rubber pivot	fix pivot and ruler
E	oscillation not in one plane only		
F	difficult to determine end/start of oscillation/ difficult to turn through 90° each time	use of (fiducial) marker(s)/ video with timer	use a protractor

[Total: 20]