
PHYSICS

9702/31

Paper 3 Advanced Practical Skills 1

May/June 2016

MARK SCHEME

Maximum Mark: 40

Published

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- 1 (a) (ii) Value of x with consistent unit and in the range 36.0 cm to 39.0 cm. [1]
- (c) Value of T with unit in range $0.300\text{ s} < T < 1.00\text{ s}$. [1]
- (d) Five sets of readings of x and time with correct trend scores 5 marks, four sets scores 4 marks etc. [5]
 Help from Supervisor –1.
- Range: [1]
 $x_{\text{max}} - x_{\text{min}} \geq 30\text{ cm}$.
- 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. x/m or $x(\text{cm})$, T^2/s^2 or $T^2(\text{s}^2)$.
- Consistency: [1]
 All values of x must be given to the nearest mm.
- Significant figures: [1]
 Every value of T^2 must be given to the same number of s.f. as (or one more than) the number of s.f. in the corresponding raw values of time.
- Calculation: [1]
 T^2 calculated correctly to the number of s.f. given by the candidate.
- (e) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions.
 Scales must be labelled with the quantity that is being plotted.
 Scale markings should be no more than three large squares apart.
- Plotting of points: [1]
 All observations in the table must be plotted.
 Diameter of plotted points must be $\leq$ half a small square (no “blobs”).
 Points must be plotted to an accuracy of half a small square.
- Quality: [1]
 All points in the table must be plotted on the grid (at least 5) for this mark to be awarded.
 All points must be no more than $\pm 5\text{ cm}$ (to scale) in the x direction 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 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.
 Lines must not be kinked or thicker than half a square.
- (iii) Gradient: [1]
 The hypotenuse of the triangle must be greater than half the length of the drawn line.
 The method of calculation must be correct. Do not allow $\Delta x / \Delta y$.
 Sign of gradient must match graph drawn.
 Both read-offs must be accurate to half a small square in both the x and y directions.
- y-intercept: [1]
 Either:
 Correct read-off from a point on the line substituted into $y = mx + c$ or an equivalent expression.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Intercept read directly from the graph (accurate to half a small square).
- (f) Value of P = candidate's gradient and value of Q = candidate's intercept. [1]
 Do not allow fractions.
- Unit for P correct (e.g. $\text{s}^2 \text{m}^{-1}$) and unit for Q correct (e.g. s^2). [1]
- 2 (a) All values of w to nearest mm, with final value in range 0.200 m to 0.300 m. [1]
- (b) (ii) Value(s) of θ to the nearest degree. Final value $< 45^\circ$ with unit. [1]
- (iii) Percentage uncertainty in θ based on an absolute uncertainty in range 1° to 3° .
 If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.
 Correct method of calculation to obtain percentage uncertainty. [1]
- (c) (iii) Value of y in range 0.20 m to 0.50 m. [1]
 Evidence of repeat readings. [1]
- (d) (i) Correct calculation of D . [1]
- (ii) Correct justification for s.f. in D linked to s.f. in w and y . [1]

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(e) (ii) Second value of θ . [1]

Second value of y . [1]

Quality: Second value of $y >$ first value of y (if $\theta_2 > \theta_1$). [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]

(g)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take more readings <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	Few readings/ only one reading/ not accurate result/ “repeat readings” on its own
B	Difficulty with starting position e.g. starting position of container not parallel to edge	Improved method for initial placement or release e.g. use of block with detail (aligned with side)	Change shape of container
C	Small range of angles possible/cylinder slips when angle too high/cylinder moves off wrong edge on board	Workable method to increase friction e.g. sheet of paper on board/ sanding board/ use a rougher board/ roughen edge of container	“No friction” on its own/ smoother board/ use longer board
D	Difficult to measure y or locate position where container moves off edge with reason e.g. moves off edge too fast/short time to observe moving off edge	Improved method for measuring y e.g. use marker or scale on board/use video and playback <u>with scale</u> / paint on lid/ calibrate board	Effects of moving air/fans/ “frame by frame”
E	Difficulty with set up e.g. board moves/clamp moves/board not an even height across width/board not aligned correctly	Method to improve stability of board e.g. use two clamps/ Blu-Tack to fix board to bench/ spirit level across board/ support board on long blocks	G-clamp to bench
F	Difficult to release without applying force	Improved method of release e.g. card gate/block with detail of removal	Electromagnetic release

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- 1 (b) (i) Value for θ in range 20° to 30° to nearest degree, with unit. [1]
- (iv) Value for T in range 0.50 s to 1.50 s. [1]
- Evidence of repeat readings. At least two measurements of nT , with $n \geq 3$. [1]
- (d) Six sets of values for θ and T with correct trend scores 4 marks, five sets scores 3 marks etc. No θ values over 90° . [4]
Help from Supervisor –1.
- Range: [1]
 θ values must include 30° or less and 70° 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. $\theta/^\circ$, $\theta(^\circ)$ or $\theta(\text{deg})$ etc. $1/\sqrt{\tan \theta}$ must have no unit.
- Consistency: [1]
All raw values of time must be given to the nearest 0.1 s, or all to the nearest 0.01 s.
- Significant figures: [1]
Every value of $1/\sqrt{\tan \theta}$ must be given to 2 or 3 s.f.
- Calculation: [1]
Values of $1/\sqrt{\tan \theta}$ calculated correctly to the number of s.f. given by the candidate.
- (e) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions.
Scales must be labelled with the quantity that is being plotted.
Scale markings must 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”).
Plotted points must be accurate to half a small square.
- Quality: [1]
All points in the table (at least 5) must be plotted for this mark to be awarded.
All points must be no more than ± 0.02 s (in the $y(T)$ direction) of a straight line.
- (ii) Line of best fit: [1]
Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length.
Allow one anomalous plot 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]
 Sign of gradient must match graph drawn.
 The hypotenuse of the triangle used must be greater than half the length of the drawn line.
 The method of calculation must be correct.
 Both read-offs must be accurate to half a small square in both x and y directions.

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

- (f) Value of p = candidate's gradient and value of q = candidate's intercept. [1]
 Do not allow fractions.

- Correct units for p and q (both should have the unit s). [1]

- 2 (a) (i) h to nearest mm and in range 2.5 cm to 3.5 cm. [1]

- (ii) Raw values for d to nearest mm. [1]

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

- (c) (i) Value for t in range 20.0 s to 90.0 s, with unit. [1]

- Evidence of repeat measurements of t . [1]

- (ii) Correct calculation of R to the s.f. used by the candidate (must be 2 or more s.f.). [1]

- (d) (ii) Value for x_1 to nearest mm, with unit. [1]

- (e) Second values of h and d and t . [1]

- Second values of x_1 and x_2 . [1]

- Quality: $(x_2 - x_1)$ greater for shorter 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]

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(g)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings are not enough to draw a conclusion	Take more readings <u>and</u> plot graph/ obtain more k values and compare	“Repeat readings” on its own/few readings/only one reading/take more readings and find average k
B	Parallax error <u>when measuring d</u>	Measure on bench between two set squares/ use (vernier) calipers/ use string to find circumference then calculate d	
C	Bottle distorts <u>when measuring d</u> / d varies along bottle/ base of bottle not flat	Collect water lost between marks and measure volume	
D	Difficult to judge/see/operate stopwatch when water level reaches mark	Use video with timer in view/ use frame counting/ use coloured water	Reaction time Light gates
E	Wooden strip moves continuously when water is falling on it	Use video with scale in view	
F	Difficult to measure height because rule not vertical/rule touches strip	Use set square on bench/ clamp rule	Only short time to measure x
G	Water soaks into wooden strip/ water stays on wooden strip	Use waterproof strip	Use new strip/ dry the strip
H	R not constant between lines	Move lines closer to top/ have lines closer together	

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- 1 (b) (ii) Value for y with unit in range $2.0 \leq y \leq 8.0$ cm. [1]
- (iii) Raw values of θ to the nearest degree.
Value of θ in the range 40° to 50° . [1]
- (d) Six sets of readings of m , y and θ with correct trend scores 5 marks, five sets scores 4 marks etc. [5]
Help from supervisor –1.
- Range: [1]
Range of values to include $m \leq 150$ g and $m \geq 400$ g.
- 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. $m \sin \theta$ / g or θ ($^\circ$).
- Consistency: [1]
All values of y must be given to the nearest mm only.
- Significant figures: [1]
Every value of $m \sin \theta$ must be given to 2 or 3 s.f.
- Calculation: [1]
Values of $m \sin \theta$ calculated correctly to the number of s.f. given by the candidate.
- (e) (i) Axes: [1]
Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions.
Scales must be labelled with the quantity that is being plotted.
Scale markings should be no more than three large squares apart.
- Plotting of points: [1]
All observations must be plotted.
Diameter of plotted points must be $\leq$ half a small square (no “blobs”).
Plotted points must be accurate to half a small square.
- Quality: [1]
All points in the table (at least 5) must be plotted on the grid for this mark to be awarded.
All points must be within ± 0.25 cm in the y direction of a straight line.
- (ii) Line of best fit: [1]
Judge by balance of all points on the grid about the candidate’s line (at least 5 points). There must be an even distribution of points either side of the line along the full length.
Allow one anomalous point only if clearly indicated by the candidate.
Lines must not be kinked or thicker than half a square.

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

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

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

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

- 2 (a) (ii) All raw values of d either to the nearest 0.01 or 0.001 mm with unit and in the range 0.250 mm to 0.450 mm. [1]

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

- (b) (iii) Value of L with appropriate unit in range $10.0 \text{ cm} \leq L \leq 20.0 \text{ cm}$. [1]

- (iv) Percentage uncertainty in L based on absolute uncertainty of 2 mm to 8 mm.
 If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.
 Correct method of calculation to obtain percentage uncertainty. [1]

- (c) (i) Correct calculation of C to the s.f. given by the candidate. [1]

- (ii) Correct justification for s.f. in C linked to s.f. in d and L . [1]

- (d) (ii) Raw values for time to the nearest 0.1 s or better.
 T with unit and in range $0.5 \text{ s} \leq T \leq 2.0 \text{ s}$. [1]

- (e) (ii) Second values of d and L . [1]

Second value of T . [1]

Quality: If $d_1 > d_2$ then second value of $T >$ first value of T . [1]

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(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]

(g)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take many readings <u>and</u> plot a graph/ obtain more k values and <u>compare</u>	“Repeat readings” on its own/few readings/only one reading/not enough readings for accurate value
B	Difficult to judge beginning and/or end of a cycle/a complete cycle	Draw a line/mark on the mass/ (fiducial) marker <u>at equilibrium position</u>	
C	Wire not straight/kinked	Method of straightening wire e.g. use larger mass	
D	Difficult to measure L with reason e.g. metre rule awkward to position/parallax error	Improved method of measuring L e.g. marking L before putting into clip/ detailed method using set squares or ruler/ use a length guide (e.g. 15 cm wood)/ use string with detail/ use tape measure	Vernier calipers on its own/ set square on its own/ 30 cm ruler on its own
E	Wire slips (in clip)	Better method of gripping wire e.g. wrap wire around clamp/ use two wooden blocks and wire	Any reference to attaching the mass to the wire
F	Mass swings as well as rotates/ clip moves around rod/ there is a force on release	Better method of attaching clip to rod e.g. glue	
G	Shorter/thicker wire has too few cycles/dampens quickly/ (percentage) uncertainty greater for shorter/thicker wire	Video and timer/replay frame by frame	Repeats Longer wire

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- 1 (b) (ii) $0.9V_S$ calculated correctly and to the same number of s.f. as, or one more than, the s.f. of V_S in (b)(i). [1]
- (c) (ii) Value for t in range 1.0 s to 9.0 s. [1]
- (d) (ii) Six sets of values for V_C and t with correct trend scores 5 marks, five sets scores 4 marks etc. [5]
 Minor help from supervisor –1, major help from supervisor –2.
- Range: [1]
 Range of values to include $V_C \leq 3.0 \text{ V}$ and $V_C \geq 8.0 \text{ V}$.
- 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. V_C/V or $V_C (\text{V})$.
- Consistency: [1]
 All values of t must be given to the nearest 0.1 s, or all to the nearest 0.01 s.
- (e) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions.
 Scales must be labelled with the quantity that is being plotted.
 Scale markings must be no more than three large squares apart.
- Plotting of points: [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”).
 Plotted points must be accurate to half a small square.
- (ii) Line of best fit: [1]
 Judge by balance of all points on the grid about the candidate's curve (at least 5 points). There must be an even distribution of points either side of the curve 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.
- (f) (ii) Tangent drawn at $V_C = 0.5V_S$.
 Tangent must touch curve at the candidate's value of $0.5V_S$ from (f)(i). [1]

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- (iii) Gradient: [1]
 The hypotenuse of the triangle used must be greater than half the length of the drawn line.
 The method of calculation must be correct.
 Both read-offs must be accurate to half a small square in both x and y directions.
- y-intercept: [1]
 Either:
 Correct read-off from a point on the tangent is substituted into $y = mx + c$.
 Read-offs must be accurate to half a small square in both x and y directions.
 Or:
 Intercept read off directly from the graph (accurate to half a small square).
- (g) Value of a = candidate's gradient and value of b = candidate's intercept. [1]
 Correct units for a (e.g. V s^{-1}) and b (s). [1]
- (h) Correct calculation of T . [1]
 Quality: T in the range 8.0 s to 14.0 s, with consistent unit. [1]
- 2 (a) d in the range 0.5 mm to 0.9 mm, to nearest 0.1 mm or to 0.01 mm, with unit. [1]
- (b) (iii) Value for x in the range 11–19 mm, with unit. [1]
 Evidence of repeat readings of x . [1]
- (c) Absolute uncertainty in x in range 2 mm to 5 mm.
 If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.
 Correct method of calculation to obtain percentage uncertainty. [1]
- (e) (ii) h_1 recorded to nearest mm, with consistent unit. [1]
 (iv) Correct calculation of k to the number of s.f. given by the candidate. [1]
 Value of k given to the same number of s.f. as, or one more than, the number of s.f. in $(h_1 - h_2)$ or m , whichever is lower. [1]
- (f) Second values of x and n . [1]
 Second values of h_1 and h_2 . [1]
 Quality: Value of $(h_1 - h_2)$ for smaller x less than the value of $(h_1 - h_2)$ for larger x . [1]

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

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

(h)	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings are not enough to draw a conclusion	Take more readings and plot graph/ take more readings and compare c values	Repeat readings/ few readings/ only one reading /not enough readings for accurate value
B	d is small/ large (percentage) uncertainty in d	Use a micrometer (to measure diameter)	Digital calipers
C	n not an integer	Estimate n to the nearest $\frac{1}{4}$ turn	
D	Diameter not constant/ coils vary in diameter/ coils not equally spaced/ coils not circular	Method of making equally-spaced coils e.g. make small marks/grooves on wooden rod Use motor to wind spring by rotating rod	Spring not straight Use 'factory' spring
E	Difficult to measure diameter (x) with reason e.g. calipers distort coils/end of coil gets in the way of ruler	Use thin ruler/graph paper placed between loops of spring	
F	$h_1 - h_2$ small, so <u>uncertainty large</u>	Use larger mass/larger range of masses Travelling microscope with reference to $h_1 - h_2$ Use wires of longer length to increase $h_1 - h_2$	

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- 1 (a) (ii) Value for L to the nearest mm with unit and in range $38.0\text{ cm} \leq L \leq 42.0\text{ cm}$. [1]
- (b) (iv) Value of I with unit in the range 25 mA to 100 mA. [1]
- (c) Six sets of readings of x and I with correct trend scores 4 marks, five sets scores 3 marks etc. [4]
 Minor help from Supervisor –1, major help –2.
- Range of x : [1]
 $\Delta x \geq 30.0\text{ cm}$.
- 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. $1/I/\text{A}^{-1}$ or $1/I(\text{A}^{-1})$ or $1/I / 1/\text{A}$. Do not allow $1/I(\text{A})$.
- Consistency: [1]
 All values of I given to 0.1 mA.
- Significant figures: [1]
 Every value of $1/I$ must be given to the same number of s.f. as (or one more than) the number of s.f. in the corresponding value of I .
- Calculation: [1]
 Values of $1/I$ calculated correctly to the number of s.f. given by the candidate.
- (d) (i) Axes: [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions.
 Scales must be labelled with the quantity that is being plotted.
 Scale markings should be no more than three large squares apart.
- Plotting of points: [1]
 All observations must be plotted.
 Diameter of plotted points must be $\leq$ half a small square (no “blobs”).
 Plotted points must be accurate to half a small square.
- Quality: [1]
 All points in the table must be plotted on the grid for this mark to be awarded.
 All points must be within 2.0 cm (to scale) on the x -axis 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.
 Lines must not be kinked or thicker than half a small square.

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

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

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

Unit for P correct (e.g. $A^{-1} m^{-1}$, $A^{-1} cm^{-1}$, $A^{-1} mm^{-1}$, $mA^{-1} m^{-1}$, $mA^{-1} cm^{-1}$ or $mA^{-1} mm^{-1}$).
 Unit for Q correct (e.g. A^{-1} or mA^{-1}) and consistent with value. [1]

- (f) Value of R in the range 5Ω to 20Ω . [1]

- 2 (a) (ii) Value of C in the range 35.0 cm to 40.0 cm with unit. [1]

- (iii) Value of d to the nearest mm with unit in range 4.0 cm to 6.0 cm . [1]

- (iv) Correct calculation of $(C - d)$. [1]

- (b) (ii) Value of θ to the nearest degree with unit, and $\theta < 90^\circ$. [1]

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

- (c) Correct calculation of $(\tan \theta - 1)$. Do not allow a unit. [1]

Answer given to 2 s.f. or 3 s.f. [1]

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

Second value of θ . [1]

Quality: Second value of $\theta >$ first value of θ . [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]	(ii) Improvements [4]	Do not credit
A	Two readings not enough to draw a conclusion	Take more readings <u>and</u> plot a graph/ take more readings and compare k values	Repeat readings/ few readings/ only one reading/ not enough readings for accurate value
B	Difficult to measure angle with reason e.g. lack of vertical reference line/parallax/nail in the way/apparatus moves when protractor in place	Method of providing vertical reference e.g. use a plumbline/ drill hole at origin of protractor and mount on nail/ method of fixing protractor/ use a grid with angles marked/ larger protractor	
C	Range of θ is too small	More holes <u>further apart</u>	
D	Difficult to measure C whilst balancing strip	Mark position of pivot/ add scale to wooden strip	
E	Difficulty in mechanical set up e.g. alignment of strip and string/horizontal string (parallel to table)	Method of improvement e.g. spirit level linked to string/axle of pulley/ add weights to stands	
F	Friction at nail (or axle of pulley)	Lubricate the nail/pulley axle	