

**MARK SCHEME for the October/November 2010 question paper
for the guidance of teachers**

9702 PHYSICS

9702/31

Paper 31 (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) (i) No help from Supervisor. [1]
- (ii) Values of a and b with consistent units to the nearest mm. [1]
- (b) Six sets of readings of a , b and R scores 5 marks, five sets scores 4 marks etc. [5]
 Incorrect trend then -1 . Correct trend b/a increases, R increases.
 Major help from supervisor -1 .
- Range: used $R = 8000\ \Omega$ or $7000\ \Omega$. [1]
- Column headings (R/Ω , a/m , b/m , b/a). [1]
 Must have R and either b/a or a and b columns.
 Each column heading must contain a quantity and a unit where appropriate.
 Ignore any units in the body of the table.
 There must be some distinguishing mark between the quantity and the unit (solidus is expected but accept, for example, $R\ (\Omega)$).
- Consistency of presentation of readings. [1]
 All values of raw a and b must be given to the nearest mm.
- Significant figures. [1]
 Significant figures for b/a must be the same as, or one more than, the least number of s.f. used in a or b .
- Correct calculation of b/a . [1]
- (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 which is being plotted. Ignore units.
 Scale markings should be no more than three large squares apart.
- All observations must be plotted. Ignore any plot off the grid. [1]
 Write a ringed total of plotted points.
 Ring and check a suspect point.
 Work to an accuracy of half a small square.
 Do not accept blobs (points with diameter > 0.5 small square).
- (ii) Line of best fit. [1]
 Judge by balance of at least 5 trend points about candidate's line.
 There must be an even distribution of points either side of the line along the full length.
 Line must not be kinked. Do not allow lines thicker than half a small square.
- Quality. [1]
 Scatter of points must be less than $\pm 200\ \Omega$ in the R – axis about a straight line.
 All points in the table must be plotted (at least 5) for this mark to be awarded.
- (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.

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(d) Gradient = $\frac{1}{X}$ [1]

Value of X in range 3000–3600 Ω with unit.

(e) $\frac{b}{a} = 1$ [1]

Correct reading off graph. [1]

[Total: 20]

2 (c) (ii) Measurement of h to nearest mm with consistent unit. $0.900 \text{ m} < h < 1.100 \text{ m}$ [1]

(d) (ii) Value of $m_A - m_B = 20 \text{ g}$ with consistent unit. [1]

(iii) Value of t with unit. $t < 5$ seconds [1]

Evidence of repeated measurements of t . [1]

(e) Absolute uncertainty in t in range 0.1–0.6 s. [1]

If repeated readings have been taken, then the uncertainty can be half the range.

Correct method of calculation to get percentage uncertainty. [1]

(f) Second value of $m_A - m_B = 40 \text{ g}$ [1]

Second value of t . [1]

Quality: second value of $t < \text{first value of } t$. [1]

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

(ii) Justification of sf in k linked t and $(m_A - m_B)$ or m_A and m_B or masses. [1]

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

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(h) Identifying limitations marks and suggesting improvements

(i) Limitations	[4]	(ii) Improvements	[4]	Do not credit
A _p Two readings are not enough (to draw a conclusion)		A _s Take more readings <u>and</u> plot a graph/calculate more values of k .		One reading/few readings/take more readings and average.
B _p Masses hit each other/masses slipping off.		B _s Use larger pulley/method of securing masses to hanger.		
C _p Uncertain starting position		C _s Method of fixing rule e.g. clamp rule/electromagnetic release mechanism		
D _p Difficult to measure time as time short/reaction time large compared with time.		D _s Drop through greater height/expand on trap door mechanism/light gate with timer/motion sensor with data logger/video timer with timer.		
E _p Friction at pulley		E _s Lubricate pulley		Friction between pulley and string
F _p Retort stand moves		F _s Method of fixing to the bench e.g. clamp/add weights		
G _p Mass (values) not accurate		G _s Use balance/method of measuring mass		

Do not credit parallax error.

[Total: 20]

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- 1 (a) (ii) Value of raw h to the nearest mm (unit needed). $h > 20$ cm. [1]
- (b) Evidence of repeat times: of one swing repeated several times or the time for a number of swings recorded at least once (not fixed time and count n). [1]
Value of $0.5 < T < 3$ s.
- (c) Six sets of readings of x and T scores 5 marks, five sets scores 4 marks etc. [5]
Incorrect or no trend then -1 (Correct trend x increases, T^2 decreases). SH -1 .
Write a ringed total next to the table.
- Maximum value of x at least $h/2$. [1]
- Column headings (x / m , x / mm , T / s , T^2/s^2). [1]
Must have x and T^2 columns.
Each column heading must contain a quantity and a unit.
Ignore any units in the body of the table.
There must be some distinguishing mark between the quantity and the unit (solidus is expected but accept, for example, $x (\text{m})$).
- Consistency of presentation of raw readings. [1]
All values of raw x must be given to the nearest mm and all values of raw time to the same number of d.p. (either 1 or 2).
- Significant figures. [1]
Significant figures for T^2 must be the same as, or one more than, the least number of significant figures used in the raw time data. Also if raw time is given to the nearest hundredth of a second accept one less significant figure in T^2 .
- Correct calculation of T^2 . Do not allow t^2 . [1]

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- (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. Ignore units.
Scale markings should be no more than three large squares apart.
- All observations must be plotted on the grid. [1]
Write a ringed total of plotted points.
Ring and check a suspect plot.
Work to an accuracy of half a small square.
Do not accept blobs (points with diameter > 0.5 small square).
- (ii) Line of best fit. [1]
Judge by balance of at least 5 points about the candidate's line.
There must be an even distribution of points either side of the line along the full length.
Line must not be kinked. Do not allow lines thicker than half a small square.
- Quality. [1]
Scatter of points must be less than ± 1 cm (to scale) in the x (cm) direction of a straight line. All points in table must be plotted (at least 5) for this mark to be awarded.
- (iii) Gradient. [1]
Negative sign must be seen on answer line consistent with graph.
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.
- 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. Allow ecf of gradient value.
Or:
Check read-off of intercept directly from the graph.
- (e) Value of $\frac{A}{B} = \frac{y - \text{intercept}}{|\text{gradient}|}$ (Expect value to be approximately equal to h). [1]
- Unit for A/B correct (e.g. m) consistent with value. [1]
Allow candidate's value $0.5 h < A/B < 1.5 h$.

[Total: 20]

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- 2** Measurement of d_A in range $0.20 \text{ mm} < d_A < 0.40 \text{ mm}$ to nearest 0.01 mm or 0.001 mm with consistent unit. If OOR allow $SV \pm 0.10 \text{ mm}$. [1]
- Evidence of repeated measurements of d (or in (e)). [1]
- (c) (i)** Measurement of L to nearest mm with consistent unit. [1]
- (ii)** Absolute uncertainty in L is $2 \text{ mm}–10 \text{ mm}$. [1]
If repeated readings have been taken, then the uncertainty can be half the range.
Correct method of calculation to get percentage uncertainty. [1]
- (d) (ii)** Measurement of V_A . Any supervisor's help –1. [1]
- (e)** Value of d_B . Major help from supervisor –1. [1]
- (f) (ii)** Measurement of V_B to at least nearest 0.1 V with unit. $V < 2 \text{ V}$. If $> 2 \text{ V}$ check SV. [1]
Quality: $V_B < V_A$. [1]
- (g) (i)** Values of k calculated correctly. [1]
- (ii)** Justification of sf in k linked to L and d and V . [1]
- (iii)** Valid conclusion based on the calculated values of k . [1]
Candidate must test against a stated criterion.

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(h)

(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A _p Two readings are not enough (to draw a conclusion).	A _s Take more readings <u>and</u> plot a graph/calculate more values of k .	One reading/few readings/take more readings and average.
B _p Difficult to measure length because (give a reason) e.g. clips have a width/clip slips. Difficult to make L the same (for both experiments).	B _s Use sliding jockeys/narrower clips/solder contacts/use longer wire (to reduce % error).	
C _p Voltmeter scale not sensitive enough/not precise enough/only reads to 0.1 or 0.05 V.	C _s Use digital voltmeter/use a voltmeter that reads to 0.01 V.	Voltmeter not accurate enough. More accurate voltmeter.
D _p Wires kinked/Wires not straight/Difficult to keep wire straight/difficult to prevent short circuiting.	D _s Method of keeping wire (during experiment) straight e.g. tape to ruler, hang weights off end, clamp wire.	Parallax error.
E _p Difficult to make I the same (for both experiments).	E _s Method to obtain continuous variation in the current e.g. (slide wire) potentiometer/potential divider/finer wire rheostat/longer rheostat.	
F _p Contact resistance/fluctuating ammeter or voltmeter readings.	F _s Method of cleaning contacts e.g. sand clips. Tighten clips.	

Ignore reference to parallax error, zero error on meters, heating effects of wire, cell runs down, video the experiment.

[Total: 20]

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9702/34

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- 1 (c) Measurements for h_1 and h_2 to nearest mm [1]
Check raw values if readings are repeated.
- The difference between h_1 and h_2 is < 2 mm. [1]
- (d) (iii) Six sets of readings of n , h_1 and h_2 scores 5 marks, five sets scores 4 marks etc. [5]
Incorrect trend then –1.
Help from supervisor then –1.
- Range – [1]
 n values must include 10 or greater.
- Column headings – [1]
Each column heading must contain a quantity and a unit where appropriate.
There must be some distinguishing mark between the quantity and the unit.
E.g. h_1/cm or $h_1(\text{cm})$ but not $1/((h_1 - h_2)/\text{cm})$.
- Consistency of presentation of raw readings – [1]
All values of h_1 and h_2 must be given to the same precision.
- Significant figures – [1]
S.f. for $1/(h_1 - h_2)$ must be the same as, or one more than, the s.f. in the difference $(h_1 - h_2)$.
- Calculation – [1]
 $1/(h_1 - h_2)$ calculated correctly.
- (Graph) 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 which is being plotted. Ignore units.
Scale markings must be no more than 3 large squares apart.
- Plotting of points – [1]
All observations must be plotted.
Do not accept blobs (points with diameter $>$ half a small square).
Ring and check a suspect plot. Tick if correct. Re-plot if incorrect.
Work to an accuracy of half a small square.
- Line of best fit – [1]
Judge by balance of at least 5 trend points about the candidate's line. There must be an even distribution of points either side of the line along the full length.
Line must not be kinked.
- Quality – [1]
Scatter of points must be less than ± 0.02 on the $1/n$ axis about the examiner's line.
All points must be plotted (at least 5) for this mark to be scored.

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- (e) (iii) Gradient
The hypotenuse must be at least half the length of the drawn line. [1]
Both read-offs must be accurate to half a small square.

Intercept [1]
Check that the read-off or the method of calculation is correct.

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

Units for a and b are correct. [1]
E.g. cm^{-1} or m^{-1} but must be consistent with the values.
Allow no unit for b if $b = 0$.

[Total: 20]

- 2 (a) (i) Value of d in range 5 cm to 15 cm. [1]
Help from supervisor then -1 .

Evidence of repeated measurements of d . [1]

- (ii) Correct calculation of A . [1]
Do not allow a value in terms of π .

- (b) (i) Measurement for x in range $0.8 \text{ cm} < x < 1.0 \text{ cm}$ to nearest mm. [1]

- (ii) Absolute uncertainty 1 or 2 mm (or half the range of repeats), and correct method of calculation. [1]

- (c) (ii) Measurement for h to nearest mm. [1]

- (d) (iii) Value for $t > 1 \text{ s}$ and given to 0.1 s or 0.01 s. [1]
Check raw data if there are repeats.

- (iv) Correct calculation of R , with consistent unit (e.g. $\text{cm}^3 \text{s}^{-1}$). [1]

- (e) (i) Values for x , V and h . [1]

- (ii) Correct trend (R increases with h). [1]

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

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

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(g)

	(i) Problems 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.	More readings and calculate the average/ only one reading.
B	Bottle not circular/ diameter at P different to that at Q.	Collect water and measure volume/remeasure diameter at P.	
C	Bottle deforms when measuring d .	Use vernier callipers <u>to measure d</u> .	Use string to measure d .
D	Difficult to see water level/meniscus problems/refraction problems.	Use coloured water/liquid.	Use oil.
E	Labels get wet/ink runs	Use waterproof labels/ink	
F	Difficult to judge when to start/stop timing.	Use video, <u>with timing method</u> .	Human reaction time error.
G	Large uncertainty in x .	Use travelling microscope <u>to measure x</u> .	
X	Another valid point E.g. Flowrate calculated is not the flowrate at h .	E.g. Measure h to point midway between marks.	Move marks closer together.

Ignore 'parallax problems' unless there is a convincing diagram.

Ignore 'use assistant'.

Ignore 'use distance sensor' unless there is a convincing diagram.

Ignore 'use a computer/datalogger/light gates'.

Ignore 'bottle not vertical'.

[Total: 20]

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9702/35

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- 1 (a) (i) Value of d to the nearest 0.01 mm or 0.001 mm with consistent unit. [1]
 $0.20 < d < 0.60$ mm.
- (b) (iii) Value of x in range 40 cm–60 cm with consistent unit. [1]
Value of I with units.
- (c) Six sets of readings of x and I scores 5 marks, five sets scores 4 marks etc. Incorrect trend then –1. Minor help from supervisor –1 ; major help from supervisor –2 [5]
- Range [1]
 $x_{\max} > 70$ cm; $x_{\min} < 30$ cm
- 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 (solidus is expected but accept, for example, $1/I$ (A^{-1}). Do not allow $1/I$ (A))
- Consistency of presentation of raw readings. [1]
All values of x must be given to the nearest mm.
- Significant figures [1]
S.F. in $1/I$ must be the same as, or one more than, the least number of significant figures used in raw I .
- Calculation [1]
Correct calculation of $1/I$.

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(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 which is being plotted. Ignore units.
Scale markings should be no more than three large squares apart.

Plotting of points [1]

All observations must be plotted on the grid.
Do not accept blobs (points with diameter > 0.5 small square).
Ring and check a suspect plot.
Work to an accuracy of half a small square.

(ii) Line of best fit [1]

Judge by the balance of at least 5 points about the candidate's line.
There must be an even distribution of points either side of the line along the full length.
Lines must not be kinked. Do not accept lines thicker than half a small square.

Quality [1]

All points in the table (minimum 5) must be plotted for this mark to be scored. All points must be within 2 cm (to scale) in x direction of a straight line.

(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.

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. Allow ecf of gradient value.

Or:

Check read-off of intercept directly from graph.

(e) Values obtained in (a)(ii) and (d)(iii) substituted correctly into equation: $\frac{M}{N} = \frac{\rho}{AR}$ [1]

Do not allow substitution methods to find M or N

Value for ρ in range: $1 \times 10^{-7} \Omega \text{ m} - 5 \times 10^{-6} \Omega \text{ m}$ with consistent unit. [1]

[Total: 20]

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- 2 (a) (ii)** Measurement of x to nearest mm. $x < 15.0$ cm with consistent unit. [1]
–1 for supervisor's help.
- (b) (iii)** Measurement of θ (less than 90°) with unit. [1]
- (iv)** Absolute uncertainty in θ in the range 2° – 10° . [1]
If repeated readings have been taken, then the uncertainty can be half the range.
Correct method of calculation of percentage uncertainty.
- (v)** $m = 50$ g with consistent unit [1]
 $M = 60$ g with consistent unit [1]
- (vi)** Correct calculation of m/M (0.83 or 0.833). No units. [1]
- (c)** Measurement of θ [1]
 $m = 40$ g; $M = 70$ g [1]
Quality: $\theta_2 > \theta_1$ [1]
- (d) (i)** Correct calculation of two values of k . [1]
- (ii)** Justification of sf in k linked to θ , m and M [1]
- (iii)** Valid conclusion based on the calculated values of k . [1]
Candidate must test against a stated criterion.

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(e) Identifying limitations (4 marks) and suggesting improvements (4 marks)

	(i) Limitations [4]	(ii) Improvements [4]	Do not credit
A	Two readings are not enough (to draw a conclusion).	Take more readings and plot a graph/calculate more k values (and compare).	Few readings. Take more readings and calculate average. Only one reading.
B	Difficult to balance <u>with reason</u> e.g. unstable or effect of fans/draughts/a.c.	Drill hole higher up/switch off fans/a.c./close windows.	Closed room.
C	Difficult to <u>judge</u> when wooden strip horizontal/parallel (to the bench).	<u>Method</u> of ensuring strip is horizontal/parallel to bench e.g. use a spirit level or metre rule(s) to measure height of both ends/sight against window. Allow <u>detailed</u> use of set square.	Strip not straight/parallel/horizontal. Use set square.
D	Difficult keeping x constant/weights move.	<u>Method</u> of fixing cotton loop to rule e.g. tape, glue.	
E	Difficult to measure θ <u>because</u> hard to judge vertical/movement of hand.	Use a plumb line/clamped ruler/clamp protractor.	Bigger protractor. Paper behind protractor.
F	<u>Friction</u> at pulley/between nail and wooden strip.	Use lubricant/method of reducing friction.	Friction. Better pulley/smooth(er) string/thin(ner) string. Friction between string and pulley. Lubrication between string and pulley.
G	Mass (values) not accurate.	Use balance/method of weighing mass.	Weigh masses.

Do not credit 'parallax problems', 'use assistant' or references to sensors, computers or videos.

[Total: 20]

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9702 PHYSICS

9702/36

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- 1 (c) Measurements for all raw l in range 19.5 to 20.5 cm. [1]
- (e) (i) Measurements for all raw h_1 and h_2 to nearest mm. [1]
- (iii) Measurement for raw d to nearest mm, with unit, in range 1.5 to 2.5 cm. [1]
- (f) **Five** sets of readings of h_1 , h_2 and d scores 4 marks, four sets scores 3 marks etc. [4]
 Incorrect trend then –1.
 Help from supervisor then –1.
- Range – [1]
 d values used must include $d_{\min} \leq 3$ cm and $d_{\max} \geq 8$ cm
- Column headings – [1]
 Each column heading must contain a quantity and a unit where appropriate.
 There must be some distinguishing mark between the quantity and the unit.
 e.g. $\theta/^\circ$, $1/\tan \theta$, $\sin \theta$, $\sin (\theta/^\circ)$ not $\sin \theta/^\circ$, not $(1/\tan \theta)/^\circ$
- Consistency of presentation of raw readings – [1]
 All h values in the table must be given to the same precision.
- Significant figures – [1]
 S.f. for $1/\tan \theta$ must be the same as, or one more than, the minimum s.f. given for $(h_1 - h_2)$ and l .
- Calculation – [1]
 $1/\tan \theta$ calculated correctly.
- (Graph) 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 correctly labelled with the quantity that is being plotted. Ignore units.
 Scale markings must be no more than three large squares apart.
- Plots – [1]
 All observations must be plotted.
 Ring and check a suspect plot. Tick if correct.
 Re-plot if incorrect. Work to an accuracy of half a small square.
 Diameter of plots must be $\leq$ half a small square (no blobs).
- Line of best fit – [1]
 Judge by balance of all plots, at least 4 trend points, about the candidate's line.
 There must be an even distribution of points either side of the line along the full length.
 Line must not be kinked.
- Quality – [1]
 Scatter of points must be less than ± 0.25 cm in the d direction about the examiner's line.
 All points in table must be plotted (at least 4) for this mark to be scored.

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- (g) (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.

Intercept [1]
Check that the read-off from graph or the method of calculation (substitution of correct read offs into $y = mx + c$) is correct.

- (h) Value of a = gradient and value of b = intercept. [1]
Unit for a ($\text{m}^{-1} \text{cm}^{-1}$ or mm^{-1}) consistent with value and b (no unit). [1]

[Total: 20]

- 2 (b) (i) Raw length and width to nearest mm with unit. Help from supervisor –1 [1]
Values of length and width in range 1 cm to 10 cm. [1]
Correct calculation of A , with consistent unit. [1]
- (ii) S.f. in A same as/one more than the (smallest) s.f. in length and width [1]
(not just “raw readings”).
- (d) (i) Measurement of F , with unit, $F < 10 \text{ N}$. [1]
Evidence of repeated measurements of F . [1]
- (ii) Uncertainty in measurements of F stated, in range 0.1 to 0.5 N. [1]
- (e) Values of second length and second width. [1]
Correct calculation of A . [1]
Measurement of F . [1]
Second F = first F (within 1 N). [1]
- (f) Justification of a valid conclusion based on two values of F being within (or outside) [1]
the uncertainty in (d)(ii).

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(g)

	(i) Limitations 4 max	(ii) Improvements 4 max	No credit/not enough
A	Two readings not enough (to draw a conclusion)/too few readings/only two readings.	Take many readings for different areas <u>and</u> plot a graph/compare more F values	Repeat readings Few readings One reading NOT average F
B	Maximum force reached without warning(suddenly)/reading over quickly, link to short <u>time</u>	<u>Method</u> of recording maximum reading e.g. force sensor + data logger/video recording <u>to find force</u> /meter which retains max reading/ use masses and pulley system	Position sensors /parallax/computer methods/bald human reaction time error/ increase force slowly/fast paper/high speed camera/ slow camera
C	Reason for the problem of detecting paper movement/ difficult to look at meter and paper at same time.	<u>Method</u> to indicate movement e.g. contrasting colours of paper/drawing a reference mark	Difficult to know when paper moves. Fast movement
D	Position of eraser (and weights) not fixed/ Mass(weight) of eraser changes/irregularity of rubber shape (not rectangular)	<u>Method</u> to ensure same position e.g. mark position on top paper/ <u>method</u> to ensure constant mass e.g. use malleable strip which can be bent to change A / change total masses to account for change in mass of rubber/pile up unused rubber pieces on top/improved <u>method</u> to measure rubber e.g. vernier caliper	Keep mass constant
E	Variation in direction of force/misalignment of paper strips (which affects F).	<u>Method</u> to ensure direction is constant e.g. align strips along straight edge/draw a line to follow/method to equalise levels	
F	Uneven bench surface (leading to contact area being less than A).	<u>Method</u> to ensure smoother surface e.g. use named surface e.g. glass or melamine/sand the surface	Use smoother surface

X: Increase mass so increase the force (reducing % uncertainty in force).

Do not credit references to zero error/accuracy/digital meter friction between papers/re-zeroing after each experiment/2 people/paper tearing/clip deforming.

[Total: 20]