

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
GCE Advanced Subsidiary Level and GCE Advanced Level

**MARK SCHEME for the October/November 2009 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) First values for h and z , to the nearest mm. [1]
- (b) Measurements – Add up the number of sets of values of z and h and put a ringed total by the table. [4]
 Four marks for six sets of readings of z and h , three for five sets, etc.
 (–1 if help given by supervisor, –1 if wrong trend i.e. $h \uparrow z \downarrow$)
- Maximum value for $z - h$ greater than 6.0 cm [1]
- Column headings [1]
 Each column heading must contain a quantity and a unit where appropriate.
 Ignore units in the body of the table.
 There must be some distinguishing mark between the quantity and the unit (i.e. solidus is expected, but accept, for example, h (mm)).
- Consistency of presentation of raw readings [1]
 All raw values of h and z must be given to the same number of decimal places.
- (c) (i) (Graph) Axes [1]
 Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
 Scale markings should be no more than 3 large squares apart.
 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 being plotted. Ignore units.
 Allow reversed axes but do not allow the wrong graph.
- (Graph) Plotting [1]
 All observations must be plotted. Put a ringed total of plotted points.
 Ring and check a suspect plot. Tick if correct. Re-plot if incorrect.
 Work to an accuracy of half a small square.
 Penalise 'blobs' – dia. of plots must be $\leq \frac{1}{2}$ a small square.
- (Graph) Line of best fit [1]
 Judge by scatter of at least 5 trend points about the candidate's line.
 There must be a fair scatter of points either side of the line.
 Indicate best line if candidate's line is not the best line.
- (Graph) Quality of results [1]
 Judge by scatter of points about the best fit line.
 All points in the table (of which there must be at least 5) must be within ± 0.3 cm (to scale) on the h axis.
- (ii) Gradient [1]
 The hypotenuse must be at least half the length of the drawn line. [1]
 Read-offs must be accurate to half a small square. If incorrect write in the correct value. [1]
 Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$).

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- (d) (i) Raw value(s) for d to nearest 0.1 mm or 0.01 mm [1]
 $18.00 \text{ mm} \leq d \leq 27.00 \text{ mm}$. Unit required.
Repeated readings for d . [1]
- (ii) A calculated correctly. Allow ecf. Check value. If incorrect, write in the correct value. [1]
Significant figures for A must be the same as, or one more than, the sig. figs. of the raw values of d . [1]
- (e) Method – value from (c) (ii) equated to $k/\rho Ag + 1$ [1]
Substitution methods lose both (e) marks
Calculation - value for k in range 4 to 6 Nm^{-1} . (allow $3.50 \leq k \leq 6.49$). [1]
(or refer to supervisor's value). Unit required. Ignore SF.
This mark is conditional on achieving the previous mark.

[Total: 20]

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- 2 (a) (i) First value of l , with unit, to nearest mm. ($40 \leq l \leq 60$ cm) [1]
(-1 if help given by supervisor)
- (b) (i) First value of d ($18 \text{ cm} \leq d \leq 22 \text{ cm}$) with consistent unit. [1]
- (ii) Method of measuring d accurately – two details of procedure e.g: [2]
- Method of consistent release of marble
 - Use of named item(s) as marker(s)
 - Refining position of marker
 - Place ruler underneath and view vertically from above.
- Do not allow 'repeats'
- (iii) Percentage uncertainty in d . [1]
Range of absolute uncertainty: $2 \text{ mm} \leq \Delta d \leq 10 \text{ mm}$.
If repeated readings have been done then the uncertainty can be half the range.
Correct ratio idea required. $\times 100\%$ implied.
- (c) (i) First value of k , substitution correct. Consistent unit. [1]
- (ii) Justification for s.f. in value of k . [1]
- Either: k must be given to same no. of SF, or one more than, l and d .
- Or: k must be given to same no. of SF, or one more than, l or d ,
whichever has the least no. of SF.
- (d) Second values of l and d . [1]
- Evidence of repeat readings for first or second value of d . [1]
- Second d less than first d . [1]
- (e) Percentage difference (or fractional difference) in k values calculated. [1]
- Sensible conclusion consistent with uncertainty of 20% [1]
in values of k , or candidate's stated uncertainty.

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(f) Identifying limitations and suggesting improvements:

	(f) (i) Limitations/ sources of error (max 4 marks)	(f) (ii) Improvements (max 4 marks))	Ignore:
A	Only two readings/two readings are not enough (to draw a valid conclusion)	Take more readings and plot a graph/calculate more k values	repeat readings
B	Hard to measure d because ball moves too quickly/ too fast/only stationary for short time ...	Use video and play back slowly/ frame by frame Use slow motion camera Use position sensor/motion sensor Allow light gates, adjusting position until beam interrupted	Use a high-speed camera/computer/data logger
C	Difficulty in releasing marble consistently/ from rest/without applying a force	Description of a mechanism to release marble e.g. slot in tube + card	Change angle
D	Parallax error in measurement of d	Description of method of reducing parallax error requiring additional equipment e.g. shadow projection	view at eye level view from above use a marker
E	Incorrect alignment/ inconsistent collisions/ different paths down tube	Use narrower tube	
F	Motion of ball affected by air movement/ ball swings around	Turn off fans/air con. Shield from draughts	Use a closed room/vacuum refs to air resistance heavier ball
G	Difficult to measure l because it is hard to judge the position of the centre of the ball	Measure diameter of ball using vernier calipers Measure l to top and bottom of ball and average.	

[Total:20]

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**MARK SCHEME for the October/November 2009 question paper
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9702 PHYSICS

9702/32

Paper 32 (Advanced Practical Skills 2),
maximum raw mark 40

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- 1 (a) First value for h to nearest mm [1]
- (b) Measurements table [4]
 Four marks for six sets of readings for m and h ,
 three for five sets, etc. (–1 if trend is positive, –1 if help from supervisor)
- Table – range [1]
 Values of m must be ≥ 10 g and ≤ 100 g. Values must include 10 or 20 g and 90 or 100 g with no interval greater than 20 g.
- Table – column headings [1]
 Each column heading must contain a quantity and a unit where appropriate.
 Ignore units in the body of the table.
 There must be some distinguishing mark between the quantity and the unit (i.e. solidus is expected, but accept, for example, m (g)).
- Table – consistency of presentation of raw readings [1]
 All values of h must be given to the same number of decimal places.
- (c) (i) (Graph) 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.
 Allow reversed axes but do not allow wrong graph.
 Gaps between labels must not be greater than three large squares.
- (Graph) Plotting – [1]
 All observations must be plotted.
 Ring and check a suspect plot. Tick if correct. Re-plot if incorrect (i.e. if plot is more than half a small square from the correct position).
 Do not allow plots with diameter greater than half a small square.
- (Graph) Line of best fit – [1]
 Judge by scatter of at least 5 trend plots about the candidate's line.
 There must be a fair scatter of points either side of the line.
 Indicate best line if candidate's line is not the best line.
- (Graph) Quality of results – [1]
 Judge by scatter of points about a best fit line
 All points in the table (which must be at least 5) must be within 0.5 ' h -scale cm' of a straight line.
 Do not award if wrong trend.
- (ii) Gradient – [1]
 The hypotenuse must be at least half the length of the drawn line. [1]
- Read-offs must be no more than half a small square from the line (if incorrect, write in correct value). [1]
 Check for $\Delta y/\Delta x$.
 Check value is consistent with trend.

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- (d) (i) Measurement – value for raw d in range 18.00 to 27.00 mm (or SV ± 2.00 mm), and given to nearest 0.1 mm or nearest 0.01 mm. Unit must be given. [1]

Measurement – repeated readings for d . [1]

- (ii) A calculated correctly. Allow ecf. Check value. Penalise power of ten error. If incorrect, write in the correct value. [1]

S.f. in A the same as or one more than the s.f. in raw d . [1]

- (e) Gradient value from (c)(ii) equated to $-(k+\rho Ag)$. Allow ecf. Penalise sign error. [1]

Value for k in range 3.50 to 6.49 Nm^{-1} (or SV $\pm 30\%$). [1]

Ignore sign. Unit required.

Do not award this mark if the gradient has not been used.

[Total: 20]

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- 2 (a)** Value of l , with unit, to nearest mm. [1]
If SV help, then –1.
- (b) (i)** First value of a (≤ 25 cm) [1]
- (ii)** First value of b (less than a) [1]
- (c) (i)** Use named item as marker for rebound distance/ [1]
Place ruler under path and view vertically from above/
Use second brick as releasing point.
- (ii)** Percentage uncertainty in b [1]
If repeated readings have been done then the uncertainty could be half the range,
otherwise absolute uncertainty must be at least 2 mm and no more than 10 mm.
Correct ratio idea required.
- (d)** First value of k substitution correct and value <1 . There must be no unit. [1]
S.f. in value of k – must be 2 or 3 s.f. (but allow 4 s.f. if all raw data is to 3 s.f.) [1]
- (e)** Second values of a and b . [1]
Evidence of repeat readings for first or second value of b [1]
Second value of b shows correct trend. [1]
- (f)** Calculation of % difference (or equivalent) in k values. [1]
Valid conclusion based on the two values of k (e.g. k is constant because values close),
consistent with 20% difference as border between 'close' and 'not close' unless candidate
has defined his own % difference. [1]

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(g) Identifying limitations and improvements

	(g) (i) Difficulties (one from each box – max. 4)	(g) (ii) Improvements (one from each box – max. 4)	But <u>not</u>
A	Two sets of readings not enough.	Take more readings and plot a graph / calculate more k values.	Repeated readings.
B	Difficult to judge rebound point/distance <u>because</u> of movement / short static time.	Use video with slow playback / use position sensor to measure rebound / use sound of ball striking a block to judge rebound / use lightgate and refine its position.	Use computer or data logger / attach pointer to ball / change length of string / time rebound instead of measuring.
C	Difficult to release without exerting a force/movement.	Named, <u>realistic</u> method of release without a force (e.g. remote-controlled clamp).	
D	Parallax error in measuring rebound distance.	Observe shadow on screen.	View at eye level.
E	Inconsistent bounce / ball bounces at an angle.	Use smoother brick.	Use heavier ball.
F	Motion affected by air movement / ball swings around.	Turn off fans or air con / shield from draughts.	Air resistance / carry out in vacuum / constraining guides.
G	When measuring l it is difficult to judge centre of ball.	Suitable method for measuring diameter of ball.	

[8]

[Total: 20]

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9702/33

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maximum raw mark 40

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- 1 (b) (i) Value for l between 0.010 and 0.080 m (1.0–8.0 cm), or ± 2.0 cm of supervisor's value.
Raw value(s) **to nearest mm.** [1]

- (c) Two values of height given. [1]

Check calculation. Ignore POT error. If method incorrect to work out v ,
final (f) mark not available. [1]

- (d) No help from supervisor. [1]

Six sets of values scores 3 marks, five sets scores 2 marks etc. [3]

Add up number of sets of readings for M and l and put a ringed total by the table.
Wrong trend -1 (Correct trend M increases, l increases).

Range of M includes 100g or 150g **and** 400g or 450g. [1]

Each column heading must contain a quantity and a unit where appropriate. [1]

Ignore units in the body of the table.

There must be a distinguishing mark between the quantity and the unit.
(solidus is expected, accept brackets e.g. M/kg , l/m , v/m , M/v / kg m^{-1})

Consistency of presentation of raw readings.

All values of raw l are given to the same number of decimal places. [1]

Significant figures for M/v must be the same as, or one more than the least number of
significant figures used in M or v . Check each row. If $v = \text{constant}$, quality mark not
available AND final (f) mark not available. [1]

Check the specified value of M/v correct. (Expect around $1\text{--}3\text{ kg m}^{-1}$ or $10\text{--}30\text{ g cm}^{-1}$) [1]
Ignore POT. If incorrect write in correct value. Allow small rounding errors.

Graph

- (e) (i) Axes [1]

Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.

Scale markings should be no more than three large squares apart.

Scales must be chosen so that the plotted points must occupy at least half the graph
grid in both x and y directions. Allow inverted axes. Do not allow wrong graph.

Scales must be labelled with the quantity which is being plotted. Ignore units.

All observations must be plotted. Put a ringed total of plotted points. [1]

Ring and check a suspect plot. Tick if correct. Re-plot if incorrect.

Work to an accuracy of not greater than half a small square.

Do not allow blobs (i.e. diameter $>$ half a small square).

- (e) (ii) Line of best fit [1]

Judge by scatter of points about the candidate's line.

There must be a fair scatter of points either side of the line.

At least 5 trend plots required.

Quality. This mark is not available for the wrong graph or wrong trend. [1]

Judge by scatter of all the points about a best fit line.

All points in the table (of which there must be at least 5 plots) must be plotted.

Allow ± 0.3 cm to scale on the x -axis. (If $v = \text{constant}$, quality mark not available AND
final (f) mark not available.)

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- (e) (iii) Gradient. Check dy/dx [1]
 The hypotenuse must be at least half the length of the drawn line on the graph grid.
 Read-offs must be read to at least half a small square.
 If read-off incorrect write in correct value. Be prepared to check both read-offs. If both incorrect do not allow ecf in the y -intercept if using one of the read-offs from the gradient.

Intercept. Check substitution only. Check both read-offs to half a small square. [1]
 or read from graph to half a small square as long as no false origin.

- (f) Look for **values** of y -intercept and gradient used correctly to find C . [1]
 i.e. $\text{grad} = qk$ AND $y\text{-intercept} = qC$ or $y\text{-intercept} = (\text{grad}/k) \times C$.

Value of C in range 0 to ± 1 N, consistent with unit or refer to supervisor's results. [1]
 Correct method needed.
 If method of working out v incorrect or if $v = \text{constant}$ in table, this mark is not available.

[Total: 20]

- 2 (a) Evidence of repeat measurements of d . [1]

Value of raw d (s) given to nearest 0.1 mm or 0.01 mm (-1 if help given by supervisor). [1]

- (b) Percentage uncertainty in d . [1]
 If repeated readings have been done then the uncertainty could be half the range, otherwise absolute uncertainty must be 0.1 mm or 0.01 mm consistent with above.
 Correct ratio idea required.

- (d) Method of calculation of l correct. $1.5\pi d$ [1]

Significant figures in l same or one more than the raw values of d . Ignore units. [1]

- (e) Value of m_1 in range 60 to 300 g, consistent with unit. [1]
 If Supervisor notes that hanger moved at 50 g allow $m_1 = 50$ g.

- (f) Evidence of repeat readings for first or second value of m . [1]

Second value of m . [1]

Second value of l greater than first l . [1]

Second value of $m \geq 2 \times m_1$. [1]

- (g) Calculation of the two values of m^2/t^3 or equivalent. [1]
 Check one value and correct substitutions.

Conclusion consistent with candidate's k values. [1]
 Use 20% permitted variation in k if candidate does not suggest a value.

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(h) (i) and (ii)

Sources of error or limitation. [4]	Improvements. Use of other apparatus or different procedures. [4]
A_p Only two readings/Two readings are not enough (to draw a valid conclusion).	A_s Take many (sets of) readings <u>and plot a graph/find more values of k's</u> . Be clear NOT just repeat readings.
B_p <u>Circumference/</u> l imprecise <u>because</u> helical/coiled/slanted/spiral/thickness of thread/non-uniform diameter of rod.	B_s Mark string and measure length/wrap so coils are closer/allow for thickness of thread/diameter to be taken at different places along/diameter taken at different angles (at same position).
C_p Use of (10g) increments imprecise.	C_s Use smaller mass increments/use newtonmeter/other valid method (water or sand).
D_p Difficulty to <u>judge/tell</u> when the string starts to slip/gradual movement.	D_s Practical method of detecting movement: fixed marker or scale/motion sensor/(travelling) microscope/measure height from table.
E_p Large scatter in repeated readings of mass/non-uniform surface bar/varying friction.	E_s
F_p <u>Difficult to add masses</u> without swinging/pushing the hanger/masses do not fit hanger.	F_s Lower masses slowly/support underneath and remove hand slowly/scissor jack.

Ignore reference to light gates, video, reaction time, repeat readings, micrometer, fans, parallax or sanding.

[Total: 20]

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9702 PHYSICS

9702/34

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maximum raw mark 40

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- 1 (b) Value for V_0 in range 1.3 to 1.7V, with unit [1]
- (c) (ii) First value of V less than V_0 [1]
- (d) No help from Supervisor (-1 for minor help, -2 for major help) [2]
- (d) Measurements table [3]
Six sets of readings of R and V scores 3 marks, five sets scores 2 marks etc.
Wrong trend in table then -1.
- (d) Table - range [1]
Values of R must include one of 100/220 Ω and one of 3300/4700 Ω .
- (d) Table - 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.
Ignore units in the body of the table. $R/(1000+R)$ has no unit.
- (d) Table - consistency of presentation of raw readings. [1]
All values of raw V must be given to the same number of decimal places.
- (d) Table – calculated values [1]
Check the specified value of $R/(1000+R)$ is calculated correctly.
If incorrect, write in the correct value. Ignore rounding errors.
- (d) Table - significant figures [1]
S.f. for $1/V$ must be the same as, or one more than, s.f. for raw V .
Check each row in the table.
- (e) (i) (Graph) 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 plotted. Ignore units. Allow inverted axes, -1 wrong quantities plotted. No more than 3 large squares between scale markings.
- (Graph) Plotting – [1]
All observations must be plotted. Ring and check a suspect plot, tick if correct. Re-plot if incorrect. Plots should be no more than $\frac{1}{2}$ a small square from correct position in x or y direction. Diameter must be less than or equal to $\frac{1}{2}$ small square.
- (e) (ii) (Graph) Line of best fit – [1]
At least 5 trend plots are needed.
Judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line. Indicate best line if candidate's line is not the best line. If trend curved allow a smooth drawn curve not straight line.
- (Graph) Quality of results – [1]
All table points must be plotted (minimum of 5 needed). Judge by scatter of **all** plots which must be within $\pm 0.02 \text{ V}^{-1}$ of assessors line.

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(e) (iii) Gradient – [1]
 The hypotenuse of the Δ must be at least half the length of the drawn line.
 Both read-offs must be accurate to half a small square. Check for $\Delta y / \Delta x$.
 Check sign is consistent with trend.

(e) (iii) Intercept – [1]
 Correctly read-off from graph (indicate a false origin) or the method of calculation is correct (check substitution of point on line).

(f) Method of calculation of P is correct with gradient and intercept values used. [1]

(f) Value for P in range 630 to 730 Ω , with unit. [1]
 Substitution loses both marks.

[Total: 20]

2 (c) (i) Value of $l < 25\text{cm}$, with unit. [1]

(c) (i) l to nearest mm. [1]

(c) (iii) Evidence of repeated measurements of h_{final} [1]

(c) (iii) Value of h_{final} in range 5.0 to 50.0 cm. [1]

(d) Percentage uncertainty in h_{final} . [1]
 If repeated readings have been done then the uncertainty could be half the range, otherwise absolute uncertainty must be in range 2 mm to 20 mm.
 Correct ratio idea required.

(e) E_p to no more than 3 s.f. [1]

(e) Value for E_p consistent with unit. [1]

(f) Second value of l greater than first value. [1]

(f) Second value of h_{final} [1]

(f) Second value of h_{final} shows correct trend (i.e. $l \uparrow h \uparrow$ or $l \downarrow h \downarrow$). [1]

(g) Check calculation of the two values of $E_p/\sqrt{l}$ or equivalent. [1]

(g) Valid conclusion based on the calculated values. Consistent with 20% or with candidate's stated criterion. [1]

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(h)

	Limitation (4 max)	Improvement (4 max)
A	Two sets of readings are not enough / only two sets	Take more readings <u>and</u> plot a graph
B	Difficult to take measurements (h/l) because the ruler moves / is not vertical	Clamp rule / ensure rule is vertical using a set square on the bench
C	Change in properties / deterioration of the thread due to repeated drops	Use a new thread each time
D	Poor accuracy due to size of increment / only note measured h_{final} values not the values between.	Use smaller increments
E	Obtaining constant loop length for repeats at one value of loop length / variation in h_{final} values for repeats at one loop length	Sensible method to ensure constant loop length for repeats
F	Tangling cotton	

Do not allow 'repeated readings', centres of mass, or nail, knots, time ideas.
Do not allow use of video, 'use a computer to improve experiment', sensors.
Do not allow amount of tape/plasticine/glue, thinner/thicker thread, fans.
Do not allow 'eye level'.

[Total: 20]