UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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

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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 Ω or 7000 Ω. [1]

Column headings (R/Ω, *a*/m, *b*/m, *b*/*a*). [1]
Must have *R* and either *b*/*a* <u>or</u> *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* (Ω).

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 ± 200 Ω 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.

(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 m $<$ h $<$ 1.100 m [1]

(d) (ii) Value of $m_A - m_B$ = 20 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 g [1]

Second value of t. [1]

Quality: second value of t < 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.

(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]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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

9702 PHYSICS

9702/33 Paper 31 (Advanced Practical Skills 1), maximum raw mark 40

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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 (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]

(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 $\frac{A}{B}$ $\frac{y \quad \text{intercept}}{|\text{gradient}|}$ (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]

2 Measurement of d_A in range 0.20 mm < d_A < 0.40 mm to nearest 0.01 mm or 0.001 mm with consistent unit. If OOR allow SV ± 0.10 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 mm–10 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 V. If > 2 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* <u>and</u> *d* <u>and</u> *V*. [1]

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

(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 and 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]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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

9702 PHYSICS

9702/34 Paper 32 (Advanced Practical Skills 2), maximum raw mark 40

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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(cm) but not $1/((h_1 - h_1)$/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.

(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 $t > 1$ 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. cm^{3} 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]

(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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GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2010 question paper

for the guidance of teachers

9702 PHYSICS

9702/35 Paper 31 (Advanced Practical Skills 1), maximum raw mark 40

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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 <u>raw</u> 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 $1/I$.

(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: $\frac{M}{N} \quad \frac{\rho}{AR}$ [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]

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.

(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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GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2010 question paper

for the guidance of teachers

9702 PHYSICS

9702/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

1 **(a)** force per unit mass (*ratio idea essential*) B1 [1]

(b) graph: correct curvature M1
from (R,1.0 g_S) & at least one other correct point A1 [2]

(c) **(i)** fields of Earth and Moon are in opposite directions M1
either resultant field found by subtraction of the field strength
or any other sensible comment A1
so there is a point where it is zero A0 [2]
(*allow* $F_E = -F_M$ *for 2 marks*)

(ii) $GM_E / x^2 = GM_M / (D - x)^2$ C1
$(6.0 \times 10^{24}) / (7.4 \times 10^{22}) = x^2 / (60R_E - x)^2$ C1
$x = 54\,R_E$ A1 [3]

(iii) graph: $g = 0$ at least ⅔ distance to Moon B1
g_E and g_M in opposite directions M1
correct curvature (by eye) and $g_E > g_M$ at surface A1 [3]

2 **(a)** **(i)** no forces (of attraction or repulsion) between atoms / molecules / particles B1 [1]

(ii) sum of kinetic and potential energy of atoms / molecules M1
due to random motion A1 [2]

(iii) (random) kinetic energy increases with temperature M1
no potential energy
(so increase in temperature increases internal energy) A1 [2]

(b) **(i)** zero A1 [1]

(ii) work done $= p\Delta V$ C1
$= 4.0 \times 10^5 \times 6 \times 10^{4}$
$= 240$ J (*ignore any sign)* A1 [2]

(iii)

change	work done / J	heating / J	increase in internal energy / J
P → Q	**+240**	–600	**–360**
Q → R	0	+720	**+720**
R → P	**–840**	+480	**–360**

(*correct signs essential*)
(*each horizontal line correct, 1 mark – max 3*) B3 [3]

3 (a) (i) resonance B1 [1]

(ii) amplitude 16 mm <u>and</u> frequency 4.6 Hz A1 [1]

(b) (i) $a = (–)\omega^2 x$ and $\omega = 2\pi f$ C1
$a = 4\pi^2 \times 4.6^2 \times 16 \times 10^{\ 3}$ C1
$= 13.4\,\mathrm{m\,s}^{\ 2}$ A1 [3]

(ii) $F = ma$ C1
$= 150 \times 10^{\ 3} \times 13.4$
$= 2.0\,\mathrm{N}$ A1 [2]

(c) line always 'below' given line and never zero M1
peak is at 4.6 Hz (or slightly less) and flatter A1 [2]

4 (a) charge / potential (difference) (*ratio must be clear)* B1 [1]

(b) (i) $V = Q / 4\pi\varepsilon_0 r$ B1 [1]

(ii) $C = Q / V = 4\pi\varepsilon_0 r$ and <u>$4\pi\varepsilon_0$ is constant</u> M1
so $C \propto r$ A0 [1]

(c) (i) $r = C / 4\pi\varepsilon_0 r$ C1
$r = (6.8 \times 10^{\ 12}) / (4\pi \times 8.85 \times 10^{\ 12})$ C1
$= 6.1 \times 10^{\ 2}\,\mathrm{m}$ A1 [3]

(ii) $Q = CV = 6.8 \times 10^{\ 12} \times 220$
$= 1.5 \times 10^{\ 9}\,\mathrm{C}$ A1 [1]

(d) (i) $V = Q/C = (1.5 \times 10^{\ 9}) / (18 \times 10^{\ 12})$
$= 83\,\mathrm{V}$ A1 [1]

(ii) *either* energy = $\tfrac{1}{2}CV^2$ C1
$\Delta E = \tfrac{1}{2} \times 6.8 \times 10^{\ 12} \times 220^2 – \tfrac{1}{2} \times 18 \times 10^{\ 12} \times 83^2$ C1
$= 1.65 \times 10^{\ 7} – 6.2 \times 10^{\ 8}$
$= 1.03 \times 10^{\ 7}\,\mathrm{J}$ A1 [3]
or energy = $\tfrac{1}{2}QV$ (C1)
$\Delta E = \tfrac{1}{2} \times 1.5 \times 10^{\ 9} \times 220 – \tfrac{1}{2} \times 1.5 \times 10^{\ 9} \times 83$ (C1)
$= 1.03 \times 10^{\ 7}\,\mathrm{J}$ (A1)

5	**(a)**	field into (the plane of) the paper	B1	[1]
	(b)	force due to magnetic field <u>provides</u> the centripetal force	B1	
		$mv^2 / r = Bqv$	C1	
		$B = (20 \times 1.66 \times 10^{27} \times 1.40 \times 10^5) / (1.6 \times 10^{19} \times 6.4 \times 10^{2})$	B1	
		$= 0.454\,\mathrm{T}$	A0	[3]
	(c) (i)	<u>semicircle</u> with diameter greater than 12.8 cm	B1	[1]
	(ii)	new flux density = $\frac{22}{20} \times 0.454$	C1	
		$B = 0.499\,\mathrm{T}$	A1	[2]
6	**(a) (i)**	e.g. prevent flux losses / improve flux linkage	B1	[1]
	(ii)	flux in core is changing	B1	
		e.m.f. / current (induced) <u>in core</u>	B1	
		induced current in core causes heating	B1	[3]
	(b) (i)	that value of the direct current producing same (mean) power / heating	M1	
		in a resistor	A1	[2]
	(ii)	power in primary = power in secondary	M1	
		$V_P I_P = V_S I_S$	A1	[2]
7	**(a) (i)**	e.g. electron / particle diffraction	B1	[1]
	(ii)	e.g. photoelectric effect	B1	[1]
	(b) (i)	6	A1	[1]
	(ii)	change in energy = 4.57×10^{19} J		
		$\lambda = hc / E$	C1	
		$= (6.63 \times 10^{34} \times 3.0 \times 10^8) / (4.57 \times 10^{19})$		
		$= 4.4 \times 10^{7}\,\mathrm{m}$	A1	[2]
8	**(a)**	splitting of a heavy nucleus (*not atom/nuclide*)	M1	
		into two (lighter) nuclei of <u>approximately same mass</u>	A1	[2]
	(b)	${}^{1}_{0}\mathrm{n}$		
		${}^{4}_{2}\mathrm{He}$ (*allow* ${}^{4}_{2}\alpha$)	M2	
		${}^{7}_{3}\mathrm{Li}$	A1	[3]
	(c)	emitted particles have kinetic energy	B1	
		range of particles in the control rods is short / particles stopped in rods / lose kinetic energy in rods	B1	
		kinetic energy of particles converted to thermal energy	B1	[3]

Section B

9 **(a)** **(i)** non-inverting (amplifier) — B1 [1]

(ii) (G =) $1 + R_2 / R_1$ — B1 [1]

(b) **(i)** gain = 1 + 100 / 820 — C1
output = 17 mV — A1 [2]

(ii) 9 V — A1 [1]
(R_2 / R_1 scores 0 in **(a)(ii)** but possible 1 mark in each of **(b)(i)** and **(b)(ii)**
($1 + R_1 / R_2$) scores 0 in **(a)(ii)**, no mark in **(b)(i)**, possible 1 mark in **(b)(ii)**
($1 – R_2 / R_1$) or R_1 / R_2 scores 0 in **(a)(ii), (b)(i)** and **(b)(ii)**)

10 **(a)** **(i)** density × <u>speed of wave</u> (in the medium) — B1 [1]

(ii) ρ = $(7.0 \times 10^{6}) / 4100$
= $1700\,\text{kg m}^{3}$ — A1 [1]

(b) **(i)** $I = I_T + I_R$ — B1 [1]

(ii) **1.** α = $(0.1 \times 10^{6})^2 / (3.1 \times 10^{6})^2$ — C1
= 0.001 — A1 [2]

2. $\alpha \approx 1$ — A1 [1]

(c) *either* very little transmission at an air-skin boundary — M1
(almost) complete transmission at a gel-skin boundary — M1
when wave travels in or out of the body — A1 [3]
or no gel, majority reflection — (M1)
with gel, little reflection — (M1)
when wave travels in or out of the body — (A1)

11 **(a)** **(i)** unwanted random power / signal / energy — B1 [1]

(ii) loss of (signal) power / energy — B1 [1]

(b) **(i)** *either* signal-to-noise ratio at mic. = $10\lg(P_2 / P_1)$ — C1
= $10\lg(\{2.9 \times 10^{6}\} / \{3.4 \times 10^{9}\})$
= 29 dB — A1
maximum length = (29 – 24) / 12 — C1
= 0.42 km = 420 m — A1 [4]

or signal-to-noise ratio at receiver = $10\lg(P_2 / P_1)$ — (C1)
at receiver, 24 = $10\lg(P / \{3.4 \times 10^{9}\})$
P = 8.54×10^{7} W — (A1)
power loss in cables = $10\lg(\{2.9 \times 10^{6}\} / \{8.54 \times 10^{7}\})$ — (C1)
= 5.3 dB
length = 5.3 / 12 km
= 440 m — (A1)

(ii) use an amplifier			M1	
coupled to the microphone			A1	[2]
(*repeater amplifiers scores no mark*)				

12	**(a)** (carrier wave) transmitted from Earth to satellite	(1)			
	satellite receives greatly attenuated signal	(1)			
	signal amplified and transmitted <u>back to Earth</u>			B1	
	at a different (carrier) frequency			B1	
	different frequencies prevent swamping of uplink signal	(1)			
	e.g. of frequencies used (6/4 GHz, 14/11 GHz, 30/20 GHz)	(1)			
	(*two B1 marks plus any two other for additional physics*)			B2	[4]

(b) advantage:	e.g.	much shorter time delay		M1	
		because orbits are much lower		A1	
	e.g.	whole Earth may be covered	(M1)		
		in several orbits / with network	(A1)		
disadvantage:	e.g.	*either* must be tracked			
		or limited use in any one orbit		M1	
		more satellites required for continuous operation		A1	[4]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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

9702 PHYSICS

9702/42 Paper 4 (A2 Structured Questions), maximum raw mark 100

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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UNIVERSITY of CAMBRIDGE International Examinations

Section A

1 **(a)** force per unit mass (*ratio idea essential*) B1 [1]

(b) graph: correct curvature M1
from (R,1.0 g_S) & at least one other correct point A1 [2]

(c) **(i)** fields of Earth and Moon are in opposite directions M1
either resultant field found by subtraction of the field strength
or any other sensible comment A1
so there is a point where it is zero A0 [2]
(*allow* $F_E = -F_M$ *for 2 marks*)

(ii) $GM_E / x^2 = GM_M / (D - x)^2$ C1
$(6.0 \times 10^{24}) / (7.4 \times 10^{22}) = x^2 / (60R_E - x)^2$ C1
$x = 54\,R_E$ A1 [3]

(iii) graph: $g = 0$ at least ⅔ distance to Moon B1
g_E and g_M in opposite directions M1
correct curvature (by eye) and $g_E > g_M$ at surface A1 [3]

2 **(a)** **(i)** no forces (of attraction or repulsion) between atoms / molecules / particles B1 [1]

(ii) sum of kinetic and potential energy of atoms / molecules M1
due to random motion A1 [2]

(iii) (random) kinetic energy increases with temperature M1
no potential energy
(so increase in temperature increases internal energy) A1 [2]

(b) **(i)** zero A1 [1]

(ii) work done $= p\Delta V$ C1
$= 4.0 \times 10^5 \times 6 \times 10^{\ 4}$
$= 240\,\text{J}$ (*ignore any sign)* A1 [2]

(iii)

change	work done / J	heating / J	increase in internal energy / J
P → Q	**+240**	–600	**–360**
Q → R	0	+720	**+720**
R → P	**–840**	+480	**–360**

(*correct signs essential*)
(*each horizontal line correct, 1 mark – max 3*) B3 [3]

3 **(a)** **(i)** resonance — B1 [1]

(ii) amplitude 16 mm <u>and</u> frequency 4.6 Hz — A1 [1]

(b) **(i)** $a = (-)\omega^2 x$ and $\omega = 2\pi f$ — C1
$a = 4\pi^2 \times 4.6^2 \times 16 \times 10^{3}$ — C1
$= 13.4\,\mathrm{m\,s}^{2}$ — A1 [3]

(ii) $F = ma$ — C1
$= 150 \times 10^{3} \times 13.4$
$= 2.0\,\mathrm{N}$ — A1 [2]

(c) line always 'below' given line and never zero — M1
peak is at 4.6 Hz (or slightly less) and flatter — A1 [2]

4 **(a)** charge / potential (difference) (*ratio must be clear)* — B1 [1]

(b) **(i)** $V = Q / 4\pi\varepsilon_0 r$ — B1 [1]

(ii) $C = Q / V = 4\pi\varepsilon_0 r$ and <u>$4\pi\varepsilon_0$ is constant</u> — M1
so $C \propto r$ — A0 [1]

(c) **(i)** $r = C / 4\pi\varepsilon_0 r$ — C1
$r = (6.8 \times 10^{12}) / (4\pi \times 8.85 \times 10^{12})$ — C1
$= 6.1 \times 10^{2}\,\mathrm{m}$ — A1 [3]

(ii) $Q = CV = 6.8 \times 10^{12} \times 220$
$= 1.5 \times 10^{9}\,\mathrm{C}$ — A1 [1]

(d) **(i)** $V = Q/C = (1.5 \times 10^{9}) / (18 \times 10^{12})$
$= 83\,\mathrm{V}$ — A1 [1]

(ii) *either* energy = $\frac{1}{2}CV^2$ — C1
$\Delta E = \frac{1}{2} \times 6.8 \times 10^{12} \times 220^2 - \frac{1}{2} \times 18 \times 10^{12} \times 83^2$ — C1
$= 1.65 \times 10^{7} - 6.2 \times 10^{8}$
$= 1.03 \times 10^{7}\,\mathrm{J}$ — A1 [3]

or energy = $\frac{1}{2}QV$ — (C1)
$\Delta E = \frac{1}{2} \times 1.5 \times 10^{9} \times 220 - \frac{1}{2} \times 1.5 \times 10^{9} \times 83$ — (C1)
$= 1.03 \times 10^{7}\,\mathrm{J}$ — (A1)

5 **(a)**	field into (the plane of) the paper	B1	[1]
(b)	force due to magnetic field <u>provides</u> the centripetal force	B1	
	$mv^2 / r = Bqv$	C1	
	$B = (20 \times 1.66 \times 10^{27} \times 1.40 \times 10^5) / (1.6 \times 10^{19} \times 6.4 \times 10^{2})$	B1	
	$= 0.454\,\text{T}$	A0	[3]
(c) **(i)**	<u>semicircle</u> with diameter greater than 12.8 cm	B1	[1]
(ii)	new flux density = $\dfrac{22}{20} \times 0.454$	C1	
	$B = 0.499\,\text{T}$	A1	[2]
6 **(a)** **(i)**	e.g. prevent flux losses / improve flux linkage	B1	[1]
(ii)	flux in core is changing	B1	
	e.m.f. / current (induced) <u>in core</u>	B1	
	induced current in core causes heating	B1	[3]
(b) **(i)**	that value of the direct current producing same (mean) power / heating	M1	
	in a resistor	A1	[2]
(ii)	power in primary = power in secondary	M1	
	$V_P I_P = V_S I_S$	A1	[2]
7 **(a)** **(i)**	e.g. electron / particle diffraction	B1	[1]
(ii)	e.g. photoelectric effect	B1	[1]
(b) **(i)**	6	A1	[1]
(ii)	change in energy = 4.57×10^{19} J		
	$\lambda = hc / E$	C1	
	$= (6.63 \times 10^{34} \times 3.0 \times 10^8) / (4.57 \times 10^{19})$		
	$= 4.4 \times 10^{7}\,\text{m}$	A1	[2]
8 **(a)**	splitting of a heavy nucleus (*not atom/nuclide*)	M1	
	into two (lighter) nuclei of <u>approximately same mass</u>	A1	[2]
(b)	${}^{1}_{0}\text{n}$		
	${}^{4}_{2}\text{He}$ (*allow* ${}^{4}_{2}\alpha$)	M2	
	${}^{7}_{3}\text{Li}$	A1	[3]
(c)	emitted particles have kinetic energy	B1	
	range of particles in the control rods is short / particles stopped in rods / lose kinetic energy in rods	B1	
	kinetic energy of particles converted to thermal energy	B1	[3]

Section B

9 **(a)** **(i)** non-inverting (amplifier) B1 [1]

(ii) (G =) 1 + R_2 / R_1 B1 [1]

(b) **(i)** gain = 1 + 100 / 820 C1
output = 17 mV A1 [2]

(ii) 9 V A1 [1]
(R_2 / R_1 scores 0 in **(a)(ii)** but possible 1 mark in each of **(b)(i)** and **(b)(ii)**
(1 + R_1 / R_2) scores 0 in **(a)(ii)**, no mark in **(b)(i)**, possible 1 mark in **(b)(ii)**
(1 – R_2 / R_1) or R_1 / R_2 scores 0 in **(a)(ii), (b)(i)** and **(b)(ii)**)

10 **(a)** **(i)** density × <u>speed of wave</u> (in the medium) B1 [1]

(ii) ρ = (7.0 × 10^6) / 4100
= 1700 kg m ^{3} A1 [1]

(b) **(i)** $I = I_T + I_R$ B1 [1]

(ii) **1.** α = (0.1 × 10^6)^2 / (3.1 × 10^6)^2 C1
= 0.001 A1 [2]

2. $\alpha \approx 1$ A1 [1]

(c) *either* very little transmission at an air-skin boundary M1
(almost) complete transmission at a gel-skin boundary M1
when wave travels in or out of the body A1 [3]
or no gel, majority reflection (M1)
with gel, little reflection (M1)
when wave travels in or out of the body (A1)

11 **(a)** **(i)** unwanted random power / signal / energy B1 [1]

(ii) loss of (signal) power / energy B1 [1]

(b) **(i)** *either* signal-to-noise ratio at mic. = 10 lg (P_2 / P_1) C1
= 10 lg ({2.9 × 10 ^{6}} / {3.4 × 10 ^{9}})
= 29 dB A1
maximum length = (29 – 24) / 12 C1
= 0.42 km = 420 m A1 [4]

or signal-to-noise ratio at receiver = 10 lg (P_2 / P_1) (C1)
at receiver, 24 = 10 lg(P / {3.4 × 10 ^{9}})
P = 8.54 × 10 ^{7} W (A1)
power loss in cables = 10 lg({2.9 × 10 ^{6}} / {8.54 × 10 ^{7}}) (C1)
= 5.3 dB
length = 5.3 / 12 km
= 440 m (A1)

(ii) use an amplifier			M1	
coupled to the microphone			A1	[2]
(*repeater amplifiers scores no mark*)				

12	**(a)** (carrier wave) transmitted from Earth to satellite	(1)			
	satellite receives greatly attenuated signal	(1)			
	signal amplified and transmitted <u>back to Earth</u>			B1	
	at a different (carrier) frequency			B1	
	different frequencies prevent swamping of uplink signal	(1)			
	e.g. of frequencies used (6/4 GHz, 14/11 GHz, 30/20 GHz)	(1)			
	(*two B1 marks plus any two other for additional physics*)			B2	[4]

(b) advantage:	e.g.	much shorter time delay		M1	
		because orbits are much lower		A1	
	e.g.	whole Earth may be covered	(M1)		
		in several orbits / with network	(A1)		
disadvantage:	e.g.	*either* must be tracked			
		or limited use in any one orbit		M1	
		more satellites required for continuous operation		A1	[4]

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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1	**(a)**	**(i)**	rate of change of angle / angular displacement	M1	
			swept out by radius	A1	[2]
		(ii)	$\omega \times T = 2\pi$	B1	[1]
	(b)		centripetal force is provided by the gravitational force	B1	
			either $mr(2\pi/T)^2 = GMm/r^2$ *or* $mr\omega^2 = GMm/r^2$	M1	
			$r^3 \times 4\pi^2 = GM \times T^2$	A1	
			$GM/4\pi^2$ is a constant (c)	A1	
			$T^2 = cr^3$	A0	[4]
	(c)	**(i)**	*either* $T^2 = (45/1.08)^3 \times 0.615^2$ *or* $T^2 = 0.30 \times 45^3$	C1	
			T = 165 years	A1	[2]
		(ii)	speed = $(2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$	C1	
			= 35 km s ^{1}	A1	[2]
2	**(a)**		atoms / molecules / particles behave as elastic (identical) spheres	(1)	
			volume of atoms / molecules negligible compared to volume of containing vessel	(1)	
			time of collision negligible to time between collisions	(1)	
			no forces of attraction or repulsion between atoms / molecules	(1)	
			atoms / molecules / particles are in (continuous) random motion	(1)	
			(*any four, 1 each*)	B4	[4]
	(b)		$pV = \frac{1}{3}Nm\langle c^2\rangle$ and $pV = nRT$ *or* $pV = NkT$	B1	
			$\frac{1}{3}Nm\langle c^2\rangle = nRT$ or $= NkT$ and $\langle E_K\rangle = ½m\langle c^2\rangle$	B1	
			$n = N/N_A$ *or* $k = R/N_A$	B1	
			$\langle E_K\rangle = \dfrac{3}{2} \times R/N_A \times T$	A0	[3]
	(c)	**(i)**	reaction represents *either* build-up of nucleus from light nuclei		
			or build-up of heavy nucleus from nuclei	M1	
			so fusion reaction	A1	[2]
		(ii)	proton and deuterium nucleus will have equal kinetic energies	B1	
			$1.2 \times 10^{14} = \frac{3}{2} \times 8.31 / (6.02 \times 10^{23}) \times T$	C1	
			$T = 5.8 \times 10^8$ K	A1	[3]
			(*use of $E = 2.4 \times 10^{14}$ giving 1.16×10^9 K scores 1 mark*)		
		(iii)	*either* inter-molecular / atomic / nuclear forces exist		
			or proton and deuterium nucleus are positively charged / repel	B1	[1]

3 (a) (i) 8.0 cm — A1 [1]

(ii) $2\pi f = 220$ — C1
$f = 35$ (*condone unit*) — A1 [2]

(iii) line drawn mid-way between AB and CD (*allow* ±*2 mm*) — B1 [1]

(iv) $v = \omega a$ — C1
$= 220 \times 4.0$
$= 880$ cm s ^{1} — A1 [2]

(b) (i) 1. line drawn 3 cm above AB (*allow* ±*2 mm*) — B1 [1]
2. arrow pointing upwards — B1 [1]

(ii) 1. line drawn 3 cm above AB (*allow* ±*2 mm*) — B1 [1]
2. arrow pointing downwards — B1 [1]

(iii) $v = \omega\sqrt{(a^2 - x^2)}$
$= 220 \times \sqrt{(4.0^2 - 2.0^2)}$ — C1
$= 760$ cm s ^{1} — A1 [2]
(*incorrect value for x, 0/2 marks*)

4 (a) (i) work done moving unit positive charge — M1
from infinity <u>to the point</u> — A1 [2]

(ii) charge / potential (difference) (*ratio must be clear*) — B1 [1]

(b) (i) capacitance = $(2.7 \times 10^{\ 6}) / (150 \times 10^3)$ — C1
(*allow any appropriate values*)
capacitance = $1.8 \times 10^{\ 11}$ (*allow 1.8* ±*0.05)* — A1 [2]

(ii) *either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ <u>*and*</u> $Q = CV$ — C1
energy $= \frac{1}{2} \times 1.8 \times 10^{\ 11} \times (150 \times 10^3)^2$ *or* $\frac{1}{2} \times 2.7 \times 10^{\ 6} \times 150 \times 10^3$
$= 0.20$ J — A1 [2]

(c) *either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left
or full formula treatment — C1
energy lost = 0.15 J — A1 [2]

5 **(a)**	magnetic flux $= BA$		
	$= 89 \times 10^{3} \times 5.0 \times 10^{2} \times 2.4 \times 10^{2}$	C1	
	$= 1.07 \times 10^{4}$ Wb	A1	[2]
(b) **(i)**	e.m.f. $= \Delta\phi / \Delta t$	C1	
	(for $\Delta\phi = 1.07 \times 10^{4}$ Wb), $\Delta t = 2.4 \times 10^{2} / 1.8 = 1.33 \times 10^{2}$ s	C1	
	e.m.f. $= (1.07 \times 10^{4}) / (1.33 \times 10^{2})$		
	$= 8.0 \times 10^{3}$ V	A1	[3]
(ii)	current $= 8.0 \times 10^{3} / 0.12$	M1	
	≈ 70 mA	A0	[1]
(c)	force on wire $= BIL$		
	$= 89 \times 10^{3} \times 70 \times 10^{3} \times 5.0 \times 10^{2}$	C1	
	$\approx 3 \times 10^{4}$ (N)	M1	
	suitable comment e.g. this force is too / very small (to be felt)	A1	[3]
6 **(a)**	power / heating depends on I^2	M1	
	so independent of current direction	A1	[2]
(b)	*either* maximum power $= I_0^2 R$ *or* average power $= I_{RMS}^2 R$	M1	
	$I_0 = \sqrt{2} \times I_{RMS}$	M1	
	maximum power = 2 × average power		
	ratio = 0.5	A1	[3]
7 **(a)**	force due to *E*-field is <u>equal and opposite</u> to force due to *B*-field	B1	
	$Eq = Bqv$	B1	
	$v = E/B$	B1	[3]
(b)	*either* charge and mass are not involved in the equation in **(a)**		
	or F_E and F_B are both doubled		
	or *E, B* and *v* do not change	M1	
	so no deviation	A1	[2]
8 **(a)**	minimum frequency for electron to be emitted (from surface)	M1	
	of electromagnetic radiation / light / photons	A1	[2]
(b)	$E = hc / \lambda$ *or* $E = hf$ <u>and</u> $c = f\lambda$	C1	
	either threshold wavelength $= (6.63 \times 10^{34} \times 3.0 \times 10^{8}) / (5.8 \times 10^{19})$		
	$= 340$ nm		
	or energy of 340 nm photon $= 4.4 \times 10^{19}$ J		
	or threshold frequency $= 8.7 \times 10^{14}$ Hz		
	or 450 nm $\rightarrow 6.7 \times 10^{14}$ Hz	A1	
	appropriate comment comparing wavelengths / energies / frequencies	B1	
	so no effect on photo-electric current	B1	[4]

Section B

9 **(a)** **(i)** edges can be (clearly) distinguished B1 [1]

(ii) e.g. size of X-ray source / anode / target / aperture
scattering of X-ray beam
pixel size
(*any two, 1 each*) B2
further detail e.g. use of lead grid B1 [3]

(b) X-ray image involves a <u>single</u> exposure B1
CT scan: exposure of a <u>slice</u> from many different angles M1
repeated for different slices A1
CT scan involves a (much) <u>greater exposure</u> B1 [4]

10 **(a)** e.g. infinite input impedance / resistance
zero output impedance / resistance
infinite gain
infinite bandwidth
infinite slew rate
(*any three, 1 each*) B3 [3]

(b) **(i)** with switch open, V is less (positive) than V^+ M1
output is positive A1
with switch closed, V is more (positive) than V^+ so output is negative A1 [3]
(*allow similar scheme if V more positive than V^+ treated first*)

(ii) **1.** diodes connected correctly between output and earth M1
2. green identified correctly A1 [2]
(*do not allow this mark if not argued in **(i)***)

11 **(a)** **(i)** I / I_0 = exp(–1.5 × 2.9) C1
= 0.013 A1 [2]

(ii) I / I_0 = exp(–4.6 × 0.95)
= 0.013 A1 [1]

(b) attenuation (coefficients) in muscle and in fat are similar B1
attenuation (coefficients) in bone and muscle / fat are different B1
contrast depends on difference in attenuation B1 [3]

12	**(a)**	**(i)**	**1.** signal has same variation (with time) as the data	B1	
			2. consists of (a series of) 'highs' and 'lows'	B1	
			either analogue is continuously variable (between limits) *or* digital has no intermediate values	B1	[3]
		(ii)	e.g. can be regenerated / noise can be eliminated extra data can be added to check / correct transmitted signal (*any two reasonable suggestions, 1 each*)	B2	[2]
	(b)	**(i)**	analogue signal is sampled at (regular time) intervals	B1	
			sampled signal is converted into a binary number	B1	[2]
		(ii)	one channel is required for each bit (of the digital number)	B1	[1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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

9702 PHYSICS

9702/51 Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

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UNIVERSITY of CAMBRIDGE
International Examinations

1 **Planning (15 marks)**

Defining the problem (3 marks)

P1 *f* is the independent variable and *V* is the dependent variable or vary *f* and measure *V* [1]
P2 Keep the current in coil X constant [1]
P3 Keep the number of turns on coil (Y)/area of coil Y constant
Do not credit reference to coil X only. [1]

Methods of data collection (5 marks)

M1 Two independent coils labelled X and Y. [1]
M2 Alternating power supply/signal generator connected to coil X in a workable circuit. [1]
M3 Coil Y connected to voltmeter/c.r.o. in a workable circuit. [1]
M4 Use c.r.o. to determine period/frequency or read off signal generator. [1]
M5 Method to keep current constant in coil X: adjust signal generator/use of rheostat. [1]

Method of analysis (2 marks)

A1 Plot a graph of *V* against *f*. [1]
A2 Relationship valid if straight line through origin [1]

Safety considerations (1 mark)

S1 Reference to hot coils – switch off when not in use/use gloves/do not touch coils. Must refer to hot coils. [1]

Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]

1. Use large current in coil X/large number of coils on coil Y (to increase emf).
2. Use iron core (to increase emf).
3. Detail on measuring emf e.g. height × *y*-gain.
4. Avoid other alternating magnetic fields.
5. Detail on measuring frequency from c.r.o. to determine period and hence *f*.
6. Use of ammeter/c.r.o. and resistor to check current is constant
7. Use insulated wire for coils.
8. Keep coil Y and coil X in the same relative positions.

Do not allow vague computer methods.

[Total: 15]

2 Analysis, conclusions and evaluation (15 marks)

Part	Mark	Expected Answer	Additional Guidance
(a)	A1	Gradient = b y-intercept = lg a	Allow log a but not ln a
(b)	T1 T2	1.9777 — 0.292 or 0.2923 1.9294 — 0.265 or 0.2648 1.8751 — 0.241 or 0.2405 1.8129 — 0.210 or 0.2095 1.7404 — 0.170 or 0.1703 1.6532 — 0.127 or 0.1271	T1 for lg l column – ignore rounding errors; min 2 dp. T2 for lg T column – must be values given A mixture is allowed
	U1	From ± 0.004 or ± 0.005 to ± 0.006 or ± 0.007	Allow more than one significant figure.
(c) (i)	G1	Six points plotted correctly	Must be within half a small square; penalise ≥ half a small square. Penalise 'blobs' ≥ half a small square. Ecf allowed from table.
	U2	Error bars in lg (T/s) plotted correctly.	All error bars must be plotted. Check first and last point. Must be accurate within half a small square; penalise ≥ half a small square.
(ii)	G2	Line of best fit	If points are plotted correctly then lower end of line should pass between (1.65, 0.124) and (1.65, 0.128) **and** upper end of line should pass between (2.00, 0.300) and (2.00, 0.306). Allow ecf from points plotted incorrectly; five trend plots needed – examiner judgement.
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through <u>all</u> the error bars.	Line should be clearly labelled or dashed. Should pass from top of top error bar to bottom of bottom error bar **or** bottom of top error bar to top of bottom error bar. Mark scored only if all error bars are plotted.
(iii)	C1	Gradient of best fit line	The triangle used should be at least half the length of the drawn line. Check the read offs. Work to half a small square; penalise ≥ half a small square.
	U3	Uncertainty in gradient	Method of determining absolute uncertainty Difference in worst gradient and gradient.
(iv)	C2	y-intercept	Must be negative. Check substitution of point from line into $c = y – mx$. Allow ecf from **(c)(iii)**.

	U4	Uncertainty in *y*-intercept	Method of determining absolute uncertainty Difference in worst *y*-intercept and *y*-intercept. Do not allow ecf from false origin read-off (FOX). Allow ecf from **(c)(iv)**.
(d)	C3	$a = 10^{y \text{ intercept}}$	*y*-intercept must be used. Expect an answer of about 0.19. If FOX expect answer of about 1.3.
	C4	*b* = gradient and in the range 0.495 to 0.520 and to 2 or 3 sf	Allow 0.50 to 0.52 to 2 sf Penalise 1 sf or ≥4 sf
	U5	Absolute uncertainty in *a* and *b*	Difference in *a* and worst *a*. Uncertainty in *b* should be the same as the uncertainty in the gradient.

[Total: 15]

Uncertainties in Question 2

(c) (iii) Gradient [U3]

1. Uncertainty = gradient of line of best fit – gradient of worst acceptable line
2. Uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

(c) (iv) [U4]

1. Uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line
2. Uncertainty = ½ (*y*-intercept of steepest worst line – *y*-intercept of shallowest worst line)

(d) [U5]

1. Uncertainty = $10^{\text{best } y \text{ intercept}} - 10^{\text{worst } y \text{ intercept}}$

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Method of analysis (2 marks)

A1 Plot a graph of *V* against *f*. [1]
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Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]

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2. Use iron core (to increase emf).
3. Detail on measuring emf e.g. height × *y*-gain.
4. Avoid other alternating magnetic fields.
5. Detail on measuring frequency from c.r.o. to determine period and hence *f*.
6. Use of ammeter/c.r.o. and resistor to check current is constant
7. Use insulated wire for coils.
8. Keep coil Y and coil X in the same relative positions.

Do not allow vague computer methods.

[Total: 15]

2 Analysis, conclusions and evaluation (15 marks)

Part	Mark	Expected Answer	Additional Guidance
(a)	A1	Gradient = *b* *y*-intercept = lg *a*	Allow log *a* but not ln *a*
(b)	T1 T2	1.9777 — 0.292 or 0.2923 1.9294 — 0.265 or 0.2648 1.8751 — 0.241 or 0.2405 1.8129 — 0.210 or 0.2095 1.7404 — 0.170 or 0.1703 1.6532 — 0.127 or 0.1271	T1 for lg *l* column – ignore rounding errors; min 2 dp. T2 for lg *T* column – must be values given A mixture is allowed
	U1	From ± 0.004 or ± 0.005 to ± 0.006 or ± 0.007	Allow more than one significant figure.
(c) (i)	G1	Six points plotted correctly	Must be within half a small square; penalise ≥ half a small square. Penalise 'blobs' ≥ half a small square. Ecf allowed from table.
	U2	Error bars in lg (*T*/s) plotted correctly.	All error bars must be plotted. Check first and last point. Must be accurate within half a small square; penalise ≥ half a small square.
(ii)	G2	Line of best fit	If points are plotted correctly then lower end of line should pass between (1.65, 0.124) and (1.65, 0.128) **and** upper end of line should pass between (2.00, 0.300) and (2.00, 0.306). Allow ecf from points plotted incorrectly; five trend plots needed – examiner judgement.
	G3	Worst acceptable straight line. Steepest or shallowest possible line that passes through <u>all</u> the error bars.	Line should be clearly labelled or dashed. Should pass from top of top error bar to bottom of bottom error bar **or** bottom of top error bar to top of bottom error bar. Mark scored only if all error bars are plotted.
(iii)	C1	Gradient of best fit line	The triangle used should be at least half the length of the drawn line. Check the read offs. Work to half a small square; penalise ≥ half a small square.
	U3	Uncertainty in gradient	Method of determining absolute uncertainty Difference in worst gradient and gradient.
(iv)	C2	*y*-intercept	Must be negative. Check substitution of point from line into $c = y - mx$. Allow ecf from **(c)(iii)**.

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(d)	C3	$a = 10^{y \text{ intercept}}$	*y*-intercept must be used. Expect an answer of about 0.19. If FOX expect answer of about 1.3.
	C4	*b* = gradient and in the range 0.495 to 0.520 and to 2 or 3 sf	Allow 0.50 to 0.52 to 2 sf Penalise 1 sf or ≥4 sf
	U5	Absolute uncertainty in *a* and *b*	Difference in *a* and worst *a*. Uncertainty in *b* should be the same as the uncertainty in the gradient.

[Total: 15]

Uncertainties in Question 2

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2. Uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

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1. Uncertainty = *y*-intercept of line of best fit – *y*-intercept of worst acceptable line
2. Uncertainty = ½ (*y*-intercept of steepest worst line – *y*-intercept of shallowest worst line)

(d) [U5]

1. Uncertainty = $10^{\text{best } y \text{ intercept}} - 10^{\text{worst } y \text{ intercept}}$

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1 **Planning (15 marks)**

Defining the problem (3 marks)

P1 c, d or A is the independent variable and R is the dependent variable or vary c, d or A and measure R. [1]

P2 If c varied then (t and) d or A kept constant, if d varied then (t and) c or A kept constant, if A varied then c or d kept constant. [1]

P3 Keep temperature constant. [1]

Methods of data collection (5 marks)

M1 Circuit diagram to measure resistance. [1]

M2 Use micrometer screw gauge to measure d or t. (Allow digital or vernier callipers) [1]

M3 Measure c with a ruler/metre rule. [1]

M4 Method of making contact with the strip e.g. use electrodes of at least same dimension as c or d or t or conducting paint methods. Do not allow crocodile clips, unless it is clear that the whole area of the end of the strip is covered. [1]

M5 Method to determine resistance. [1]

Method of analysis (2 marks)

A1 Plot a graph of R against c, $1/d$ or $1/A$ depending on orientation. Other alternatives possible, e.g. R against $1/c$ depending on orientation [1]

A2 Must be consistent with A1: $\rho = A \times$ gradient or $t \times$ gradient/c [1]
Other alternatives possible, e.g. $\rho = d \times$ gradient/t

Safety considerations (1 mark)

S1 Reference sharp edges or cutting metals, e.g. wear gloves. [1]

Additional detail (4 marks)

D1/2/3/4 Relevant points might include [4]

1. Insulate aluminium strip
2. Take many readings of t or d and average
3. Use a protective resistor/circuit designed to reduce current
4. Rearrange equation to determine graph using c, d and t or A
5. Determine typical resistance of aluminium strip
6. Likely meter range of ammeter/voltmeter/ohmmeter
7. Detail on cutting strip e.g. mark using set square

Do not allow vague computer methods.

[Total: 15]

2 Analysis, conclusions and evaluation (15 marks)

<table>
<tr><th>Part</th><th>Mark</th><th>Expected Answer</th><th>Additional Guidance</th></tr>
<tr><td>(a)</td><td>A1</td><td>$\dfrac{t}{C}$</td><td>Must be negative. Allow $\dfrac{15}{C}$.</td></tr>
<tr><td>(b)</td><td>T1
T2</td><td><table><tr><td>150</td><td>1.28 or 1.281</td></tr><tr><td>100</td><td>1.61 or 1.609</td></tr><tr><td>66.7</td><td>1.86 or 1.856</td></tr><tr><td>50.0</td><td>1.97 or 1.974</td></tr><tr><td>33.3</td><td>2.08 or 2.079</td></tr></table></td><td>T1 for 1/R column – ignore sf and rounding errors
T2 for ln (V/V) column – must be values given
A mixture is allowed</td></tr>
<tr><td></td><td>U1</td><td>From ± 0.05 or ± 0.06 to ± 0.02 or ± 0.03</td><td>Allow more than one significant figure.</td></tr>
<tr><td>(c) (i)</td><td>G1</td><td>Five points plotted correctly</td><td>Must be within half a small square; penalise ≥ half a small square. Ecf allowed from table. Penalise 'blobs' ≥ half a small square.</td></tr>
<tr><td></td><td>U2</td><td>Error bars in ln(V/V) plotted correctly.</td><td>All plots to have error bars; penalise ≥ half a small square. Check first and last point. Must be accurate within half a small square.</td></tr>
<tr><td>(ii)</td><td>G2</td><td>Line of best fit</td><td>If points are plotted correctly then upper end of line should pass between (20, 2.16) and (20, 2.18) and lower end of line should pass between (160, 1.20) and (160, 1.225). Allow ecf from points plotted incorrectly – examiner judgement.</td></tr>
<tr><td></td><td>G3</td><td>Worst acceptable straight line. Steepest or shallowest possible line that passes through <u>all</u> the error bars.</td><td>Line should be clearly labelled or dashed. Should pass from top of top error bar to bottom of bottom error bar or bottom of top error bar to top of bottom error bar. Mark scored only if all error bars are plotted.</td></tr>
<tr><td>(iii)</td><td>C1</td><td>Gradient of best fit line
Must be negative</td><td>The triangle used should be at least half the length of the drawn line. Check the read offs. Work to half a small square; penalise ≥ half a small square. Do not penalise POT.</td></tr>
<tr><td></td><td>U3</td><td>Uncertainty in gradient</td><td>Method of determining absolute uncertainty. Difference in worst gradient and gradient.</td></tr>
<tr><td>(d) (i)</td><td>C2</td><td>C = –15/gradient</td><td>Gradient must be used.
Allow ecf from (c)(iii). Do not penalise POT.</td></tr>
<tr><td></td><td>C3</td><td>2.14×10^{3} F to 2.24×10^{3} F
<u>and</u> to 2 or 3 sf</td><td>Must be in range – penalise POT.
Allow equivalent unit including s Ω^{1}, C V^{1}, A s V^{1}</td></tr>
</table>

(ii)	U4	Determines % uncertainty in *C*	Uses worst gradient or worst calculated *C* value. Do not check calculation.
(e)	C4	Determines *R* correctly	Expect to see an answer about 3000 Ω. *R* = 6.514/candidate's *C*; allow ecf from **(d)(i)**
	U5	Determines absolute uncertainty	Determines worst value of *R* or **(d)(ii)** × *R*

[Total: 15]

Uncertainties in Question 2

(c) (iii) Gradient [U3]

1. Uncertainty = gradient of line of best fit – gradient of worst acceptable line
2. Uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)

(d) (ii) [U4]

1. Works out worst *C* then determines % uncertainty
2. Works out percentage uncertainty in gradient

(e) [U5]

1. Works out worst *R* then determines difference
2. $\Delta R = \left(\dfrac{\Delta \text{gradient}}{\text{gradient}}\right) R = \left(\dfrac{\Delta C}{C}\right) R$