

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

9702/41

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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Section A

- 1 (a) force per unit mass (*ratio idea essential*) B1 [1]
- (b) graph: correct curvature M1
from $(R, 1.0g_S)$ & 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
 $x = 54R_E$ A1 [3]
- (iii) graph: $g = 0$ at least $\frac{2}{3}$ 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]

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- 3 (a) (i) resonance B1 [1]
- (ii) amplitude 16 mm and 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
 $= 13.4 \text{ ms}^{-2}$ A1 [3]
- (ii) $F = ma$ C1
 $= 150 \times 10^{-3} \times 13.4$
 $= 2.0 \text{ N}$ 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) $V = Q / 4\pi\epsilon_0 r$ B1 [1]
- (ii) $C = Q / V = 4\pi\epsilon_0 r$ and $4\pi\epsilon_0$ is constant M1
so $C \propto r$ A0 [1]
- (c) (i) $r = C / 4\pi\epsilon_0$ C1
 $r = (6.8 \times 10^{-12}) / (4\pi \times 8.85 \times 10^{-12})$ C1
 $= 6.1 \times 10^{-2} \text{ m}$ A1 [3]
- (ii) $Q = CV = 6.8 \times 10^{-12} \times 220$
 $= 1.5 \times 10^{-9} \text{ C}$ A1 [1]
- (d) (i) $V = Q/C = (1.5 \times 10^{-9}) / (18 \times 10^{-12})$
 $= 83 \text{ V}$ 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
 $= 1.65 \times 10^{-7} - 6.2 \times 10^{-8}$
 $= 1.03 \times 10^{-7} \text{ J}$ 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)
 $= 1.03 \times 10^{-7} \text{ J}$ (A1)

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- 5 (a) field into (the plane of) the paper B1 [1]
- (b) force due to magnetic field provides 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) semicircle with diameter greater than 12.8 cm B1 [1]
- (ii) new flux density = $\frac{22}{20} \times 0.454$ 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) in core 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 = $4.57 \times 10^{19} \text{ J}$
 $\lambda = hc / E$ 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 approximately same mass 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]

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Section B

- 9 (a) (i) non-inverting (amplifier) B1 [1]
- (ii) $(G =) 1 + R_2 / R_1$ B1 [1]
- (b) (i) gain = $1 + 100 / 820$
output = 17 mV C1
A1 [2]
- (ii) 9V 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 × speed of wave (in the medium) B1 [1]
- (ii) $\rho = (7.0 \times 10^6) / 4100$
 $= 1700 \text{ kg m}^{-3}$ A1 [1]
- (b) (i) $I = I_T + I_R$ B1 [1]
- (ii) 1. $\alpha = (0.1 \times 10^6)^2 / (3.1 \times 10^6)^2$
 $= 0.001$ C1
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
 $= 10 \lg (\{2.9 \times 10^{-6}\} / \{3.4 \times 10^{-9}\})$
 $= 29 \text{ dB}$ A1
- maximum length = $(29 - 24) / 12$ C1
 $= 0.42 \text{ km} = 420 \text{ m}$ A1 [4]
- or signal-to-noise ratio at receiver = $10 \lg (P_2 / P_1)$ (C1)
at receiver, 24 = $10 \lg (P / \{3.4 \times 10^{-9}\})$
 $P = 8.54 \times 10^{-7} \text{ W}$ (A1)
- power loss in cables = $10 \lg (\{2.9 \times 10^{-6}\} / \{8.54 \times 10^{-7}\})$ (C1)
 $= 5.3 \text{ dB}$
- length = $5.3 / 12 \text{ km}$
 $= 440 \text{ m}$ (A1)

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(ii) use an amplifier
coupled to the microphone
(*repeater amplifiers scores no mark*)

M1
A1 [2]

12 (a) (carrier wave) transmitted from Earth to satellite (1)
satellite receives greatly attenuated signal (1)
signal amplified and transmitted back to Earth
at a different (carrier) frequency B1
different frequencies prevent swamping of uplink signal B1
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*) (1)

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 M1
or limited use in any one orbit A1
more satellites required for continuous operation [4]

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- maximum length = $(29 - 24) / 12$ C1
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- or signal-to-noise ratio at receiver = $10 \lg (P_2 / P_1)$ (C1)
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(ii) use an amplifier
coupled to the microphone
(*repeater amplifiers scores no mark*)

M1
A1 [2]

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satellite receives greatly attenuated signal (1)
signal amplified and transmitted back to Earth
at a different (carrier) frequency B1
different frequencies prevent swamping of uplink signal B1
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*) (1)

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 M1
or limited use in any one orbit A1
more satellites required for continuous operation [4]

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Section A

- 1 (a) (i) rate of change of angle / angular displacement swept out by radius M1 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 $\langle E_K \rangle = \frac{1}{2} m\langle c^2 \rangle$ B1
 $n = N/N_A$ or $k = R/N_A$ B1
 $\langle E_K \rangle = \frac{3}{2} \times R/N_A \times T$ A0 [3]
- (c) (i) reaction represents *either* build-up of nucleus from light nuclei M1
or build-up of heavy nucleus from nuclei A1 [2]
so fusion reaction
- (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 B1
or proton and deuterium nucleus are positively charged / repel A1 [1]

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- 3 (a) (i) 8.0 cm A1 [1]
- (ii) $2\pi f = 220$
 $f = 35$ (condone unit) C1
A1 [2]
- (iii) line drawn mid-way between AB and CD (allow ± 2 mm) B1 [1]
- (iv) $v = \omega a$
 $= 220 \times 4.0$
 $= 880 \text{ cm s}^{-1}$ C1
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) $v = \omega \sqrt{a^2 - x^2}$
 $= 220 \times \sqrt{4.0^2 - 2.0^2}$
 $= 760 \text{ cm s}^{-1}$
(incorrect value for x, 0/2 marks) C1
A1 [2]
- 4 (a) (i) work done moving unit positive charge from infinity to the point M1
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 = 1.8×10^{-11} (allow 1.8 ± 0.05) A1 [2]
- (ii) either energy = $\frac{1}{2}CV^2$ or energy = $\frac{1}{2}QV$ and $Q = CV$ 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]

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- 5 (a) magnetic flux = BA
 $= 89 \times 10^3 \times 5.0 \times 10^2 \times 2.4 \times 10^2$
 $= 1.07 \times 10^4 \text{ Wb}$ C1
A1 [2]
- (b) (i) e.m.f. = $\Delta\phi / \Delta t$ C1
(for $\Delta\phi = 1.07 \times 10^4 \text{ Wb}$), $\Delta t = 2.4 \times 10^2 / 1.8 = 1.33 \times 10^2 \text{ s}$ C1
e.m.f. = $(1.07 \times 10^4) / (1.33 \times 10^2)$
 $= 8.0 \times 10^3 \text{ V}$ A1 [3]
- (ii) current = $8.0 \times 10^3 / 0.12$ M1
 $\approx 70 \text{ mA}$ A0 [1]
- (c) force on wire = BIL
 $= 89 \times 10^3 \times 70 \times 10^3 \times 5.0 \times 10^2$ C1
 $\approx 3 \times 10^4 \text{ (N)}$ 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 = $I_{\text{RMS}}^2 R$ M1
 $I_0 = \sqrt{2} \times I_{\text{RMS}}$ M1
maximum power = $2 \times$ average power
ratio = 0.5 A1 [3]
- 7 (a) force due to E -field is equal and opposite 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 $E = hf$ and $c = f\lambda$ C1
either threshold wavelength = $(6.63 \times 10^{-34} \times 3.0 \times 10^8) / (5.8 \times 10^{-19})$
 $= 340 \text{ nm}$
or energy of 340 nm photon = $4.4 \times 10^{-19} \text{ J}$
or threshold frequency = $8.7 \times 10^{14} \text{ Hz}$
or $450 \text{ nm} \rightarrow 6.7 \times 10^{14} \text{ Hz}$ A1
appropriate comment comparing wavelengths / energies / frequencies B1
so no effect on photo-electric current B1 [4]

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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 single exposure B1
CT scan: exposure of a slice from many different angles M1
repeated for different slices A1
CT scan involves a (much) greater exposure 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)** $I / I_0 = \exp(-1.5 \times 2.9)$ C1
 $= 0.013$ A1 [2]
- (ii)** $I / I_0 = \exp(-4.6 \times 0.95)$
 $= 0.013$ 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]

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- 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

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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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
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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 \times 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]

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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	<table border="1"> <tr> <td>1.9777</td> <td>0.292 or 0.2923</td> </tr> <tr> <td>1.9294</td> <td>0.265 or 0.2648</td> </tr> <tr> <td>1.8751</td> <td>0.241 or 0.2405</td> </tr> <tr> <td>1.8129</td> <td>0.210 or 0.2095</td> </tr> <tr> <td>1.7404</td> <td>0.170 or 0.1703</td> </tr> <tr> <td>1.6532</td> <td>0.127 or 0.1271</td> </tr> </table>	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
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														
	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 \geq half a small square. Penalise 'blobs' \geq 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 \geq 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 \geq 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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	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	$a = 10^y$ intercept	y -intercept must be used. Expect an answer of about 0.19. If FOX expect answer of about 1.3.
	C4	$b =$ gradient <u>and</u> in the range 0.495 to 0.520 <u>and</u> 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 = $\frac{1}{2}$ (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 = $\frac{1}{2}$ (y -intercept of steepest worst line – y -intercept of shallowest worst line)

(d) [U5]

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

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

9702/52

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

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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 \times 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]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
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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	<table border="1"> <tr> <td>1.9777</td> <td>0.292 or 0.2923</td> </tr> <tr> <td>1.9294</td> <td>0.265 or 0.2648</td> </tr> <tr> <td>1.8751</td> <td>0.241 or 0.2405</td> </tr> <tr> <td>1.8129</td> <td>0.210 or 0.2095</td> </tr> <tr> <td>1.7404</td> <td>0.170 or 0.1703</td> </tr> <tr> <td>1.6532</td> <td>0.127 or 0.1271</td> </tr> </table>	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
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														
	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 \geq half a small square. Penalise 'blobs' \geq 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 \geq 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 \geq 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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	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	$a = 10^y$ intercept	y -intercept must be used. Expect an answer of about 0.19. If FOX expect answer of about 1.3.
	C4	$b =$ gradient <u>and</u> in the range 0.495 to 0.520 <u>and</u> 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 = $\frac{1}{2}$ (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 = $\frac{1}{2}$ (y -intercept of steepest worst line – y -intercept of shallowest worst line)

(d) [U5]

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

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

9702 PHYSICS

9702/53

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

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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
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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: $\rho = A \times \text{gradient}$ or $t \times \text{gradient}/c$ [1]
Other alternatives possible, e.g. $\rho = d \times \text{gradient}/t$

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]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
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2 Analysis, conclusions and evaluation (15 marks)

Part	Mark	Expected Answer	Additional Guidance										
(a)	A1	$\frac{t}{C}$	Must be negative. Allow $\frac{15}{C}$.										
(b)	T1 T2	<table border="1"> <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>	150	1.28 or 1.281	100	1.61 or 1.609	66.7	1.86 or 1.856	50.0	1.97 or 1.974	33.3	2.08 or 2.079	T1 for 1/R column – ignore sf and rounding errors T2 for ln(V/V) column – must be values given A mixture is allowed
150	1.28 or 1.281												
100	1.61 or 1.609												
66.7	1.86 or 1.856												
50.0	1.97 or 1.974												
33.3	2.08 or 2.079												
	U1	From ± 0.05 or ± 0.06 to ± 0.02 or ± 0.03	Allow more than one significant figure.										
(c) (i)	G1	Five points plotted correctly	Must be within half a small square; penalise \geq half a small square. Ecf allowed from table. Penalise 'blobs' \geq half a small square.										
	U2	Error bars in ln(V/V) plotted correctly.	All plots to have error bars; penalise \geq half a small square. Check first and last point. Must be accurate within half a small square.										
(ii)	G2	Line of best fit	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.										
	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 Must be negative	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 \geq half a small square. Do not penalise POT.										
	U3	Uncertainty in gradient	Method of determining absolute uncertainty. Difference in worst gradient and gradient.										
(d) (i)	C2	$C = -15/\text{gradient}$	Gradient must be used. Allow ecf from (c)(iii). Do not penalise POT.										
	C3	$2.14 \times 10^3 F$ to $2.24 \times 10^3 F$ <u>and</u> to 2 or 3 sf	Must be in range – penalise POT. Allow equivalent unit including $s \Omega^{-1}$, $C V^{-1}$, $A s V^{-1}$										

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(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 3000Ω . $R = 6.514/\text{candidate's } C$; allow ecf from (d)(i)
	U5	Determines absolute uncertainty	Determines worst value of R or (d)(ii) $\times R$

[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 = $\frac{1}{2}$ (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

$$2. \Delta R = \left(\frac{\Delta \text{gradient}}{\text{gradient}} \right) R = \left(\frac{\Delta C}{C} \right) R$$