

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

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Section A

- 1 (a) force per unit mass (*ratio idea essential*) B1 [1]
- (b) graph: correct curvature
from $(R, 1.0g_S)$ & at least one other correct point M1
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
 $= 50 \times 10^{-3} \times 13.4$
 $= 2.0 \text{ N}$ 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 \times 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]