

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 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  $\frac{2}{3}$  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  | <b>+240</b>   | -600        | <b>-360</b>                     |
| Q → R  | 0             | +720        | <b>+720</b>                     |
| R → P  | <b>-840</b>   | +480        | <b>-360</b>                     |
- (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 in a resistor M1  
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 =  $1 + 100 / 820$  C1  
output = 17 mV 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.  $\alpha = (0.1 \times 10^6)^2 / (3.1 \times 10^6)^2$  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  
 $= 10 \lg (\{2.9 \times 10^{-6}\} / \{3.4 \times 10^{-9}\})$   
 $= 29 \text{ dB}$  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 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 back to Earth 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 M1  
*or* limited use in any one orbit A1 [4]  
more satellites required for continuous operation