

**MARK SCHEME for the October/November 2011 question paper
for the guidance of teachers**

9702 PHYSICS

9702/21

Paper 2 (AS Structured Questions), maximum raw mark 60

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- 1 (a) density = mass / volume B1 [1]
- (b) density of liquids and solids same order as spacing similar / to about 2×
density of gases much less as spacing much more
or density of gases much lower hence spacing much more B1 [2]
- (c) (i) density = $68 / [50 \times 600 \times 900 \times 10^{-9}]$
= 2520 (allow 2500) kg m⁻³ C1
A1 [2]
- (ii) $P = F / A$ C1
= $68 \times 9.81 / [50 \times 600 \times 10^{-6}]$ C1
= 2.2×10^4 Pa A1 [3]
- 2 (a) torque is the product of one of the forces and the distance between forces
the perpendicular distance between the forces M1
A1 [2]
- (b) (i) torque = $8 \times 1.5 = 12$ Nm A1 [1]
- (ii) there is a resultant torque / sum of the moments is not zero
(the rod rotates) and is not in equilibrium M1
A1 [2]
- (c) (i) $B \times 1.2 = 2.4 \times 0.45$ C1
 $B = 0.9(0)$ N A1 [2]
- (ii) $A = 2.4 - 0.9 = 1.5$ N / moments calculation A1 [1]
- 3 (a) (i) horizontal velocity = $15 \cos 60^\circ = 7.5 \text{ m s}^{-1}$ A1 [1]
- (ii) vertical velocity = $15 \sin 60^\circ = 13 \text{ m s}^{-1}$ A1 [1]
- (b) (i) $v^2 = u^2 + 2as$
 $s = (13)^2 / (2 \times 9.81) = 8.6(1)$ m A1 [1]
using $g = 10$ then max. 1
- (ii) $t = 13 / 9.81 = 1.326$ s or $t = 9.95 / 7.5 = 1.327$ s A1 [1]
- (iii) velocity = $6.15 / 1.33$ M1
= 4.6 m s^{-1} A0 [1]
- (c) (i) change in momentum = $60 \times 10^{-3} [-4.6 - 7.5]$ C1
= $(-)0.73$ N s A1 [2]
- (ii) final velocity / kinetic energy is less after the collision or
relative speed of separation < relative speed of approach
hence inelastic M1
A0 [1]

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- 4 (a) electrical potential energy (stored) when charge moved and gravitational potential energy (stored) when mass moved
due to work done in electric field and work done in gravitational field B1 [2]
B1
- (b) work done = force $\times$ distance moved (in direction of force)
and force = mg M1
 $mg \times h$ or $mg \times \Delta h$ A1 [2]
- (c) (i) $0.1 \times mgh = \frac{1}{2} mv^2$ B1
 $0.1 \times m \times 9.81 \times 120 = 0.5 \times m \times v^2$ B1
 $v = 15.3 \text{ ms}^{-1}$ A0 [2]
- (ii) $P = 0.5 m v^2 / t$ C1
 $m / t = 110 \times 10^3 / [0.25 \times 0.5 \times (15.3)^2]$ C1
 $= 3740 \text{ kg s}^{-1}$ A1 [3]
- 5 (a) ohm = volt / ampere B1 [1]
- (b) $\rho = RA / l$ or unit is $\Omega \text{ m}$ C1
units: $\text{VA}^{-1} \text{ m}^2 \text{ m}^{-1} = \text{N m C}^{-1} \text{ A}^{-1} \text{ m}^2 \text{ m}^{-1}$ C1
 $= \text{kg m}^2 \text{ s}^{-2} \text{ A}^{-1} \text{ s}^{-1} \text{ A}^{-1} \text{ m}^2 \text{ m}^{-1}$
 $= \text{kg m}^3 \text{ s}^{-3} \text{ A}^{-2}$ A1 [3]
- (c) (i) $\rho = [3.4 \times 1.3 \times 10^{-7}] / 0.9$ C1
 $= 4.9 \times 10^{-7} (\Omega \text{ m})$ A1 [2]
- (ii) max = 2.0 V A1
min = $2 \times (3.4 / 1503.4) = 4.5 \times 10^{-3} \text{ V}$ A1 [2]
- (iii) $P = V^2 / R$ or $P = VI$ and $V = IR$ C1
 $= (2)^2 / 3.4$
 $= 1.18$ (allow 1.2) W A1 [2]
- (d) (i) power in Q is zero when $R = 0$ B1 [1]
- (ii) power in Q = 0 / tends to zero as $R = \text{infinity}$ B1 [1]

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- 6** (a) extension is proportional to force (for small extensions) B1 [1]
- (b) (i) point beyond which (the spring) does not return to its original length when the load is removed B1 [1]
- (ii) gradient of graph = 80 N m^{-1} A1 [1]
- (iii) work done is area under graph / $\frac{1}{2} Fx$ / $\frac{1}{2} kx^2$
 $= 0.5 \times 6.4 \times 0.08 = 0.256$ (allow 0.26) J C1
A1 [2]
- (c) (i) extension = $0.08 + 0.04 = 0.12 \text{ m}$ A1 [1]
- (ii) spring constant = $6.4 / 0.12 = 53.3 \text{ N m}^{-1}$ A1 [1]
- 7** (a) nuclei with the same number of protons and a different number of neutrons B1
B1 [2]
- (b) (i) (mass + energy) (taken together) is conserved (B1)
momentum is conserved (B1)
one point required max. 1 B1 [1]
- (ii) $a = 1$ and $b = 0$ B1
 $x = 56$ B1
 $y = 92$ B1 [3]
- (c) proton number = 90 B1
nucleon number = 235 B1 [2]

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- 1 (a) average velocity = $540 / 30$
= 18 m s^{-1} C1
A1 [2]
- (b) velocity zero at time $t = 0$ B1
positive value and horizontal line for time $t = 5 \text{ s}$ to 35 s B1
line / curve through $v = 0$ at $t = 45 \text{ s}$ to negative velocity B1
negative horizontal line from 53 s with magnitude less than positive value and
horizontal line to time = 100 s B1 [4]
- 2 (a) (i) force is rate of change of momentum B1 [1]
- (ii) work done is the product of the force and the distance moved in the direction
of the force B1 [1]
- (b) (i) $W = Fs$ or $W = mas$ or $W = m(v^2 - u^2) / 2$ or $W = \text{force} \times \text{distance } s$ A1 [1]
- (ii) $as = (v^2 - u^2) / 2$ any subject M1
 $W = mas$ hence $W = m(v^2 - u^2) / 2$ M1
RHS represents terms of energy or with $u = 0$ $\text{KE} = \frac{1}{2}mv^2$ A1 [3]
- (c) (i) work done = $\frac{1}{2} \times 1500 \times [(30)^2 - (15)^2]$ (=506250) C1
distance = $\text{WD} / F = 506250 / 3800 = 133 \text{ m}$ A1 [2]
or $F = ma$ $a = 2.533 \text{ (ms}^{-2}\text{)}$ C1
 $v^2 = u^2 + 2as$ $s = 133 \text{ m}$ A1
- (ii) the change in kinetic energy is greater or the work done by the force has to
be greater, hence distance is greater (for same force) A1 [1]
- allow: same acceleration, same time, so greater average speed and greater
distance
- 3 (a) (i) stress = force / (cross-sectional) area B1 [1]
- (ii) strain = extension / original length or change in length / original length B1 [1]
- (b) point beyond which material does not return to the original length / shape / size
when the load / force is removed B1 [1]

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- (c) UTS is the maximum force / original cross-sectional area
wire is able to support / before it breaks M1
A1 [2]
- allow one: maximum stress the wire is able to support / before it breaks
- (d) (i) straight line from (0,0)
correct shape in plastic region M1
A1 [2]
- (ii) only a straight line from (0,0) B1 [1]
- (e) (i) ductile: initially force proportional to extension then a large extension for
small change in force B1
brittle: force proportional to extension until it breaks B1 [2]
- (ii) 1. does not return to its original length / permanent extension (as entered
plastic region) B1
2. returns to original length / no extension (**as no plastic region / still in
elastic region**) B1 [2]
- 4 (a) electric field strength = force / positive charge B1 [1]
- (b) (i) at least three equally spaced parallel vertical lines B1
direction down B1 [2]
- (ii) $E = 1500 / 20 \times 10^{-3} = 75000 \text{ V m}^{-1}$ A1 [1]
- (iii) $F = qE$ C1
($W = mg$ and) $qE = mg$ C1
 $q = mg / E = 5 \times 10^{-15} \times 9.81 / 75000$
 $= 6.5 \times 10^{-19} \text{ C}$ A1
negative charge A1 [4]
- (iv) $F > mg$ or F now greater B1
drop will move upwards B1 [2]
- 5 (a) (i) $I_1 + I_3 = I_2$ A1 [1]
- (ii) $E_1 = \frac{I_2 R_2}{2} + \frac{I_1 R_2}{2} + I_1 R_1 + I_1 r_1$ A1 [1]
- (iii) $E_1 - E_2$ B1
 $= -I_3 r_2 + I_1 (R_1 + r_1 + R_2 / 2)$ B1 [2]
- (b) p.d. across BJ of wire changes / resistance of BJ changes B1
there is a difference in p.d across wire and p.d. across cell E_2 B1 [2]
- 6 (a) waves overlap B1
(resultant) displacement is the sum of the displacements of each of the waves B1 [2]

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- (b) waves travelling in opposite directions overlap / incident and reflected waves overlap

(allow superpose or interfere for overlap here)

waves have the same speed and frequency

B1

B1 [2]

- (c) (i) time period = 4×0.1 (ms)

$$f = 1 / T = 1 / 4 \times 10^{-4} = 2500 \text{ Hz}$$

C1

A1 [2]

- (ii) 1. the microphone is at an antinode and goes to a node and then an antinode / maximum amplitude at antinode and minimum amplitude at node

B1

[1]

2. $\lambda / 2 = 6.7$ (cm)

C1

$$v = f\lambda$$

C1

$$v = 2500 \times 13.4 \times 10^{-2} = 335 \text{ m s}^{-1}$$

A1

[3]

incorrect λ then can only score second mark

- 7 (a) (i) the half life / count rate / rate of decay / activity is the same no matter what external factors / environmental factors **or** two named factors such as temperature and pressure changes are applied

B1

[1]

- (ii) the observations of the count rate / count rate / rate of decay / activity / radioactivity during decay shows variations / fluctuations

B1

[1]

(b)

property	α -particle	β -particle	γ -radiation
charge	(+)2e	–e	0
mass	$4u$	$9.11 \times 10^{-31} \text{ kg}$	0
speed	0.01 to 0.1 c	up to 0.99 c	c

one mark for each correct line

B3

[3]

- (c) collision with molecules

B1

causes ionisation (of the molecule) / electron is removed

B1

[2]

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- 1 (a) scalar has magnitude/size, vector has magnitude/size and direction B1 [1]
- (b) acceleration, momentum, weight B2 [2]
(–1 for each addition or omission but stop at zero)
- (c) (i) horizontally: $7.5 \cos 40^\circ / 7.5 \sin 50^\circ = 5.7(45) / 5.75$ not 5.8 N A1 [1]
(ii) vertically: $7.5 \sin 40^\circ / 7.5 \cos 50^\circ = 4.8(2)$ N A1 [1]
- (d) *either* correct shaped triangle M1
correct labelling of two forces, three arrows and two angles A1
or correct resolving: $T_2 \cos 40^\circ = T_1 \cos 50^\circ$ (B1)
 $T_1 \sin 50^\circ + T_2 \sin 40^\circ = 7.5$ (B1)
 $T_1 = 5.7(45)$ (N) A1
 $T_2 = 4.8$ (N) A1 [4]
(allow ± 0.2 N for scale diagram)
- 2 (a) 1. constant velocity / speed B1 [1]
2. *either* constant / uniform decrease (in velocity/speed)
or constant rate of decrease (in velocity/speed) B1 [1]
- (b) (i) distance is area under graph for both stages C1
stage 1: distance $(18 \times 0.65) = 11.7$ (m)
stage 2: distance $= (9 \times [3.5 - 0.65]) = 25.7$ (m)
total distance $= 37.4$ m A1 [2]
(–1 for misreading graph)
{for stage 2, allow calculation of acceleration (6.32 ms^{-2})
and then $s = (18 \times 2.85) + \frac{1}{2} \times 6.32 (2.85)^2 = 25.7$ m}
- (ii) *either* $F = ma$ *or* $E_K = \frac{1}{2}mv^2$ C1
 $a = (18 - 0)/(3.5 - 0.65)$ $E_K = \frac{1}{2} \times 1250 \times (18)^2$ C1
- $F = 1250 \times 6.3 = 7900$ N *or* $F = \frac{1}{2} \times 1250 \times (18)^2 / 25.7 = 7900$ N A1 [3]
or initial momentum $= 1250 \times 18$ (C1)
 $F = \text{change in momentum} / \text{time taken}$ (C1)
 $F = (1250 \times 18) / 2.85 = 7900$ (A1)
- (c) (i) stage 1: *either* half / less distance as speed is half / less
or half distance as the time is the same
or sensible discussion of reaction time B1 [1]
- (ii) stage 2: *either* same acceleration and $s = v^2 / 2a$ *or* v^2 is $\frac{1}{4}$
 $\frac{1}{4}$ of the distance B1 [2]
B1 [2]

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- 3 (a) (i) power = work done per unit time / energy transferred per unit time / rate of work done B1 [1]
- (ii) Young modulus = stress / strain B1 [1]
- (b) (i) 1. $E = T / (A \times \text{strain})$ (allow strain = ϵ) C1
 $T = E \times A \times \text{strain} = 2.4 \times 10^{11} \times 1.3 \times 10^{-4} \times 0.001$ M1
 $= 3.12 \times 10^4 \text{ N}$ A0 [2]
2. $T - W = ma$ C1
 $[3.12 \times 10^4 - 1800 \times 9.81] = 1800a$ C1
 $a = 7.52 \text{ ms}^{-2}$ A1 [3]
- (ii) 1. $T = 1800 \times 9.81 = 1.8 \times 10^4 \text{ N}$ A1 [1]
2. potential energy gain = mgh C1
 $= 1800 \times 9.81 \times 15$
 $= 2.7 \times 10^5 \text{ J}$ A1 [2]
- (iii) $P = Fv$ C1
 $= 1800 \times 9.81 \times 0.55$ C1
input power = $9712 \times (100/30) = 32.4 \times 10^3 \text{ W}$ A1 [3]
- 4 (a) p.d. = $\frac{\text{energy transformed from electrical to other forms}}{\text{unit charge}}$ B1
- e.m.f. = $\frac{\text{energy transformed from other forms to electrical}}{\text{unit charge}}$ B1 [2]
- (b) (i) sum of e.m.f.s (in a closed circuit) = sum of potential differences B1 [1]
- (ii) $4.4 - 2.1 = I \times (1.8 + 5.5 + 2.3)$ M1
 $I = 0.24 \text{ A}$ A1 [2]
- (iii) arrow (labelled) I shown anticlockwise A1 [1]
- (iv) 1. $V = I \times R = 0.24 \times 5.5 = 1.3(2) \text{ V}$ A1 [1]
2. $V_A = 4.4 - (I \times 2.3) = 3.8(5) \text{ V}$ A1 [1]
3. either $V_B = 2.1 + (I \times 1.8)$ or $V_B = 3.8 - 1.3$ C1
 $= 2.5(3) \text{ V}$ A1 [2]

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- 5 (a) transverse waves have vibrations that are perpendicular / normal to the direction of energy travel B1
longitudinal waves have vibrations that are parallel to the direction of energy travel B1 [2]
- (b) vibrations are in a single direction M1
either applies to transverse waves
or normal to direction of wave energy travel
or normal to direction of wave propagation A1 [2]
- (c) (i) 1. amplitude = 2.8 cm B1 [1]
2. phase difference = 135° or 0.75π rad or $\frac{3}{4}\pi$ rad or 2.36 radians (three sf needed)
numerical value M1
unit A1 [2]
(ii) amplitude = 3.96 cm (4.0 cm) A1 [1]
- 6 (a) (i) greater deflection M0
greater electric field / force on α -particle A1 [1]
(ii) greater deflection M0
greater electric field / force on α -particle A1 [1]
- (b) (i) *either* deflections in opposite directions M1
because oppositely charged A1
or β less deflection (M1)
 β has smaller charge (A1) [2]
(ii) α smaller deflection M1
because larger mass A1 [2]
(iii) β less deflection because higher speed B1 [1]
- (c) *either* $F = ma$ and $F = Eq$ or $a = Eq / m$ C1
ratio = *either* $\frac{(2 \times 1.6 \times 10^{-19}) \times (9.11 \times 10^{-31})}{(1.6 \times 10^{-19}) \times 4 \times (1.67 \times 10^{-27})}$
or $[2e \times 1 / 2000 \text{ u}] / [e \times 4u]$ C1
ratio = $1 / 4000$ or 2.5×10^{-4} or 2.7×10^{-4} A1 [3]