

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series

9702 PHYSICS

9702/21

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

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- 1 (a) power = work/time or energy/time or (force × distance)/time B1
 $= \text{kg m s}^{-2} \times \text{m s}^{-1} = \text{kg m}^2 \text{s}^{-3}$ A1 [2]
- (b) power = VI [or V^2/R and $V = IR$ or I^2R and $V = IR$] B1
(units of V): $\text{kg m}^2 \text{s}^{-3} \text{A}^{-1}$ B1 [2]
- 2 (a) speed = distance/time and velocity = displacement/time B1
speed is a scalar as distance has no direction **and**
velocity is a vector as displacement has direction B1 [2]
- (b) (i) constant acceleration or linear/uniform increase in velocity until 1.1 s B1
rebounds or bounces or changes direction B1
decelerates to zero velocity at the same acceleration as initial value B1 [3]
- (ii) $a = (v - u)/t$ or use of gradient implied C1
 $= (8.8 + 8.8)/1.8$ or appropriate values from line or $= (8.6 + 8.6)/1.8$ B1
 $= 9.8 \text{ (9.78) ms}^{-2}$ or $= 9.6 \text{ ms}^{-2}$ A1 [3]
- (iii) 1. distance = first area above graph + second area below graph C1
 $= (1.1 \times 10.8)/2 + (0.9 \times 8.8)/2 (= 5.94 + 3.96)$ C1
 $= 9.9 \text{ m}$ A1 [3]
2. displacement = first area above graph – second area below graph C1
 $= (1.1 \times 10.8)/2 - (0.9 \times 8.8)/2$
 $= 2.0 \text{ (1.98) m}$ A1 [2]
- (iv) correct shape with straight lines and all lines above the time axis or all below M1
correct times for zero speeds (0.0, 1.15 s, 2.1 s) and peak speeds
(10.8 ms^{-1} at 1.1 s and 8.8 ms^{-1} at 1.2 s and 3.0 s) A1 [2]
- 3 (a) $4.5 \times 50 - 2.8 \times M (= \dots)$ C1
 $(\dots) = -1.8 \times 50 + 1.4 \times M$ C1
 $(M =) 75 \text{ g}$ A1 [3]

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- (b) total initial kinetic energy/KE not equal to the total final kinetic energy/KE
or relative speed of approach is not equal to relative speed of separation
so not elastic or is inelastic B1 [1]
- (c) force on X is equal and opposite to force on Y (Newton III) M1
force equals/is proportional to rate of change of momentum (Newton II) M1
time of collision same for both balls hence change in momentum is the same A1 [3]
- 4 (a) (i) two sets of co-ordinates taken to determine a constant value (F/x) M1
 F/x constant hence obeys Hooke's law A1 [2]
or
gradient calculated and one point on line used (M1)
to show no intercept hence obeys Hooke's law (A1)
- (ii) gradient or one point on line used e.g. $4.5/1.8 \times 10^{-2}$ C1
($k =$) 250 N m^{-1} A1 [2]
- (iii) work done or $E_p =$ area under graph or $\frac{1}{2}Fx$ or $\frac{1}{2}kx^2$ C1
 $= 0.5 \times 4.5 \times 1.8 \times 10^{-2}$ or $0.5 \times 250 \times (1.8 \times 10^{-2})^2$ C1
 $= 0.041$ (0.0405) J A1 [3]
- (b) $KE = \frac{1}{2}mv^2$
 $\frac{1}{2}mv^2 = 0.0405$ or $KE = 0.0405$ (J) C1
($v = [2 \times 0.0405 / 1.7]^{1/2} =$) 0.22 (0.218) m s^{-1} A1 [2]
- 5 (a) very high/infinite resistance for negative voltages up to about 0.4 V B1
resistance decreases from 0.4 V B1 [2]
- (b) initial straight line from (0,0) into curve with decreasing gradient but not to horizontal M1
repeated in negative quadrant A1 [2]
- (c) (i) $R = 12^2/36 = 4.0 \Omega$ A1
or
 $I = P/V = 36/12 = 3.0 \text{ A}$ and $R = 12/3.0 = 4.0 \Omega$ (A1) [1]

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- (ii) lost volts = $0.5 \times 2.8 = 1.4$ (V) or $E = 12 = 2.8 \times (R + r)$ C1
- $R = V/I = (12 - 1.4)/2.8$ or $(R + r) = 4.29 \Omega$ C1
- $= 3.8$ (3.79) Ω or $R = 3.8 \Omega$ A1 [3]
- (d) resistance of the lamp increases with increase of V or I B1 [1]
- 6 (a) diffraction is the spreading of a wave as it passes through a slit or past an edge B1
- when two (or more) waves superpose/meet/overlap M1
- resultant displacement is the sum of the displacement of each wave A1 [3]
- (b) $n\lambda = d \sin \theta$ and $v = f\lambda$ C1
- max order number for $\theta = 90^\circ$
- hence $n (= f/vN) = 7.06 \times 10^{14} / (3 \times 10^8 \times 650 \times 10^3)$ M1
- $n = 3.6$
- hence number of orders = 3 A1 [3]
- (c) greater wavelength so fewer orders seen A1 [1]
- 7 (a) a region/space/area where a (stationary) charge experiences an (electric) force B1 [1]
- (b) (i) at least four parallel equally spaced straight lines perpendicular to plates B1
- consistent direction of an arrow on line(s) from left to right B1 [2]
- (ii) electric field strength $E = V/d$ C1
- $E = (450/16 \times 10^{-3})$
- $= 28 \times 10^3$ (28 125) V m^{-1} A1 [2]
- (iii) $W = Eqd$ or Vq C1
- $q = 3.2 \times 10^{-19}$ (C) C1
- $W = 28\,125 \times 3.2 \times 10^{-19} \times 16 \times 10^{-3}$ or $450 \times 3.2 \times 10^{-19}$
- $= 1.4(4) \times 10^{-16}$ J A1 [3]
- (iv) ratio = $\frac{450 \times 3.2 \times 10^{-19}}{450 \times -1.6 \times 10^{-19}}$ (evidence of working required)
- $= (-) 2$ A1 [1]

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- 1 (a) (work =) force $\times$ distance or force $\times$ displacement or ($W =$) $F \times d$ M1
units of work: $\text{kg m s}^{-2} \times \text{m} = \text{kg m}^2 \text{s}^{-2}$ A1 [2]
- (b) (p.d. =) $\frac{\text{work (done) or energy (transformed) (from electrical to other forms)}}{\text{charge}}$ B1 [1]
- (c) $R = V/I$ B1
units of V : $\text{kg m}^2 \text{s}^{-2} / \text{As}$ and units of I : A C1
or
 $R = P/I^2$ [or $P = VI$ and $V = IR$] (B1)
units of P : $\text{kg m}^2 \text{s}^{-3}$ and units of I : A (C1)
or
 $R = V^2/P$ (B1)
units of V : $\text{kg m}^2 \text{s}^{-2} / \text{As}$ and units of P : $\text{kg m}^2 \text{s}^{-3}$ (C1)
units of R : $(\text{kg m}^2 \text{s}^{-2} / \text{A}^2 \text{s}) = \text{kg m}^2 \text{s}^{-3} \text{A}^{-2}$ A1 [3]
- 2 (a) speed decreases/stone decelerates to rest/zero at 1.25 s B1
speed then increases/stone accelerates (in opposite direction) B1 [2]
- (b) (i) $v = u + at$ (or $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$) C1
 $= 0 + (3.00 - 1.25) \times 9.81$ C1
 $= 17.2 \text{ (17.17) ms}^{-1}$ A1 [3]
- (ii) $s = ut + \frac{1}{2}at^2$
 $s = \frac{1}{2} \times 9.81 \times (1.25)^2 [= 7.66]$ C1
 $s = \frac{1}{2} \times 9.81 \times (1.75)^2 [= 15.02]$ C1
(distance = 7.66 + 15.02)
 $[v = u + at = 0 + 9.81 \times (2.50 - 1.25) = 12.26 \text{ ms}^{-1}]$
or
 $s = \frac{1}{2} \times 9.81 \times (1.25)^2 [= 7.66]$ (C1)
 $s = 12.26 \times 0.50 + \frac{1}{2} \times 9.81 \times (3.00 - 2.50)^2 [= 7.36]$ (C1)
(distance = 2 $\times$ 7.66 + 7.36)
Example alternative method:
 $s = (v^2 - u^2)/2a = (12.26^2 - 0)/2 \times 9.81 [= 7.66]$ (C1)
 $s = (v^2 - u^2)/2a = (17.17^2 - 12.26^2)/2 \times 9.81 [= 7.36]$ (C1)
(distance = 2 $\times$ 7.66 + 7.36)

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	22.7 (22.69 or 23)m	A1	[3]
(iii)	($s = 15.02 - 7.66 =$) 7.4 (7.36)m (<i>ignore sign in answer</i>)	A1	
	down	A1	[2]
(c)	straight line from positive value of v to t axis	M1	
	same straight line <u>crosses</u> t axis at $t = 1.25$ s	A1	
	same straight line continues with same gradient to $t = 3.0$ s	A1	[3]
3	(a) (i) (vertical component = $44 \sin 30^\circ =$) 22 N	A1	[1]
	(ii) (horizontal component = $44 \cos 30^\circ =$) 38(.1) N	A1	[1]
	(b) $W \times 0.64 = 22 \times 1.60$	C1	
	($W =$) 55 N	A1	[2]
	(c) F has a horizontal component (not balanced by W) or F has 38 N acting horizontally or 38 N acts on wall or vertical component of F does not balance W or F and W do not make a closed triangle of forces	B1	[1]
	(d) line from P in direction towards point on wire vertically above W and direction up	B1	[1]
4	(a) ($p =$) mv	C1	
	$\Delta p (= -6.64 \times 10^{-27} \times 1250 - 6.64 \times 10^{-27} \times 1250) = 1.66 \times 10^{-23}$ N s	A1	[2]
	(b) (i) molecule collides with wall/container and there is a change in momentum	B1	
	change in momentum / time is force or $\Delta p = Ft$	B1	
	<u>many/all/sum of</u> molecular collisions over surface/area of container produces pressure	B1	[3]
	(ii) more collisions per unit time so greater pressure	B1	[1]
5	(a) curved line showing decreasing gradient with temperature rise	M1	
	smooth line not touching temperature axis, not horizontal or vertical anywhere	A1	[2]
	(b) (i) (no energy lost in battery because) no/negligible internal resistance	B1	[1]

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(ii) $I = V/R$

$= 8/15 \times 10^3$ or $1.6/3.0 \times 10^3$ or $2.4/4.5 \times 10^3$ or $12/22.5 \times 10^3$ C1

$= 0.53 \times 10^{-3} \text{ A}$ A1 [2]

(iii) p.d. across X = $12 - 8.0 - 3.0 \times 10^3 \times 0.53 \times 10^{-3}$ (= 2.4 V) C1

$R_X = 2.4 / (0.53 \times 10^{-3})$ C1

or

$R_{\text{tot}} = 12 / 0.53 \times 10^{-3}$ (= $22.5 \times 10^3 \Omega$) (C1)

$R_X = (22.5 - 15.0 - 3.0) \times 10^3$ (C1)

$4.5(2) \times 10^3 \Omega$ A1 [3]

(iv) resistance decreases hence current (in circuit) is greater M1

p.d. across X and Y is greater hence p.d across Z decreases A1

or explanation in terms of potential divider:

R_Z decreases so $R_Z / (R_X + R_Y + R_Z)$ is less (M1)

therefore p.d. across Z decreases (A1) [2]

6 (a) progressive waves transfer/propagate energy **and** stationary waves do not B1

amplitude constant for progressive wave **and** varies (from max/antinode to min/zero/node) for stationary wave B1

adjacent particles in phase for stationary wave **and** out of phase for progressive wave (B1) [2]

(b) (i) wave / microwave from source/S reflects at reflector/R B1

reflected and (further) incident waves overlap/meet/superpose B1

waves have same frequency/wavelength/period **and** speed (so stationary waves formed) B1 [3]

(ii) detector/D is moved between reflector/R and source/S (or v.v.) B1

maximum, minimum/zero, (maximum... etc.) observed on meter/deflections/readings/measurements/recordings B1 [2]

(iii) determine/measure the distance between adjacent minima/nodes or maxima/antinodes **or** across specific number of nodes/antinodes B1

wavelength is twice distance between adjacent nodes/minima or maxima/antinodes (or other correct method of calculation of wavelength from measurement) B1 [2]

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(c) $v = f\lambda$ C1

$$f = 3.0 \times 10^8 / (2.8 \times 10^{-2}) [= 1.07 \times 10^{10} \text{ Hz}]$$
 C1

11 (10.7) GHz A1 [3]

7 (a) 92 protons and 143 neutrons B1 [1]

(b)

	value
a	1
b	0
c	141
d	55

(a and b both required)

B1
B1
B1 [3]

(c) kinetic energy (of products) or gamma/ γ (radiation or photon) B1 [1]

(d) (total) mass on left-hand side/reactants is greater than (total) mass on right-hand side/products M1

difference in mass is (converted to) energy A1 [2]

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- 1 (a) 150 or 1.5×10^2 Gm A1 [1]
- (b) distance = $2 \times (42.3 - 6.38) \times 10^6$ (= 7.184×10^7 m) C1
(time =) $7.184 \times 10^7 / (3.0 \times 10^8) = 0.24$ (0.239) s A1 [2]
- (c) units of pressure P : $\text{kg m s}^{-2} / \text{m}^2 = \text{kg m}^{-1} \text{s}^{-2}$ M1
units of density ρ : kg m^{-3} and speed v : m s^{-1} M1
simplification for units of C : $C = v^2 \rho / P$ units: $(\text{m}^2 \text{s}^{-2} \text{kg m}^{-3}) / \text{kg m}^{-1} \text{s}^{-2}$
and cancelling to give no units for C A1 [3]
- (d) energy and power (*both underlined and no others*) A1 [1]
- (e) (i) vector triangle of correct orientation M1
three arrows for the velocities in the correct directions A1 [2]
- (ii) length measured from scale diagram 5.2 ± 0.2 cm or components of
boat speed determined parallel and perpendicular to river flow C1
velocity = 2.6 m s^{-1} (allow $\pm 0.1 \text{ m s}^{-1}$) A1 [2]
- 2 (a) constant rate of increase in velocity/acceleration from $t = 0$ to $t = 8$ s B1
constant deceleration from $t = 8$ s to $t = 16$ s or constant rate of increase in
velocity in the opposite direction from $t = 10$ s to $t = 16$ s B1 [2]
- (b) (i) area under lines to 10 s C1
(displacement =) $(5.0 \times 8.0) / 2 + (5.0 \times 2.0) / 2 = 25$ m
or $\frac{1}{2} (10.0 \times 5.0) = 25$ m A1 [2]
- (ii) $a = (v - u) / t$ or gradient of line C1
= $(-15.0 - 5.0) / 8.0$
= $(-) 2.5 \text{ m s}^{-2}$ A1 [2]
- (iii) $\text{KE} = \frac{1}{2} m v^2$ C1
= $0.5 \times 0.4 \times (15.0)^2 = 45$ J A1 [2]
- (c) (distance =) 25 (m) (= $ut + \frac{1}{2} at^2$) = $0 + \frac{1}{2} \times 2.5 \times t^2$ C1
($t = 4.5$ (4.47) s therefore) time to return = 14.5 s A1 [2]

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- 3 (a) (power =) work done / time (taken) or rate of work done A1 [1]
- (b) (i) $F - R = ma$ C1
- $F = 1500 \times 0.82 + 1200$ C1
- $= 2400$ (2430) N A1 [3]
- (ii) $P = Fv$ C1
- $= (2430 \times 22) = 53\,000$ (53 500) W A1 [2]
- (c) (there is maximum power from car and) resistive force = force produced by car hence no acceleration
or
suggestion in terms of power produced by car and power wasted to overcome resistive force B1 [1]
- 4 (a) (i) diameter and extension: micrometer (screw gauge) or digital calipers B1
- length: tape measure or metre rule B1
- load: spring balance or Newton meter B1 [3]
- (ii) to reduce the effect of random errors or to plot a graph to check for zero error in measurement of extension or to see if limit of proportionality is exceeded B1 [1]
- (b) plot a graph of F against e and determine the gradient B1
- $E = (\text{gradient} \times l) / [\pi d^2 / 4]$ B1 [2]
- 5 (a) $R = \rho l / A$ C1
- $= (5.1 \times 10^{-7} \times 0.50) / \pi (0.18 \times 10^{-3})^2 = 2.5$ (2.51) Ω M1 [2]
- (b) (i) resistance of CD = $8 \times$ resistance of AB = $20(\Omega)$ C1
- circuit resistance = $[1/5.0 + 1/20]^{-1} = 4.0(\Omega)$ C1
- current = $V/R = 6.0/4.0$ C1
- $= 1.5\text{ A}$ A1 [4]
- (ii) power in AB = $I^2 R$ or power = V^2/R C1
- $= (1.2)^2 \times 2.5 = 3.6\text{ W}$ $= (3.0)^2/2.5 = 3.6\text{ W}$ A1 [2]

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	(iii) potential drop A to M = $1.25 \times 1.2 = 1.5 \text{ V}$	M1	
	potential drop C to N = 3.0 V p.d. MN = 1.5 V	A1	[2]
6	(a) (i) coherent: constant phase difference	B1	
	interference is the (overlapping of waves and the) sum of/addition of displacement of two waves	B1	[2]
	(ii) wavelength = 3.2 m (allow $\pm 0.05 \text{ m}$)	M1	
	$f (= v/\lambda = 240 / 3.2) = 75 \text{ Hz}$	A1	[2]
	(iii) 90° (allow $\pm 2^\circ$) or $\pi/2 \text{ rad}$	A1	[1]
	(iv) sketch has amplitude $3.0 \pm 0.1 \text{ cm}$	M1	
	correct displacement values at previous peaks to produce correct shape	A1	[2]
	(b) (i) $\lambda = ax/D$	C1	
	$x = (546 \times 10^{-9} \times 0.85) / 0.13 \times 10^{-3} (= 3.57 \times 10^{-3} \text{ m})$	C1	
	$AB = 8.9 (8.93) \times 10^{-3} \text{ m}$	A1	[3]
	(ii) shorter wavelength for blue light so separation is less	B1	[1]
7	(a) (i) (rate of decay) not affected by any external factors or changes in temperature and pressure etc.	B1	[1]
	(ii) two protons and two neutrons	B1	[1]
	(b) (i) (total) mass before decay/on left-hand side is greater than (total) mass on right-hand side/after the decay	M1	
	the difference in mass is released as kinetic energy of the products	A1	[2]
	(may also be some γ radiation) (to conserve mass-energy)		
	(ii) $(6.2 \times 10^6 \times 1.6 \times 10^{-19} =) 9.9(2) \times 10^{-13} \text{ J}$	A1	[1]