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Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9702 PHYSICS

9702/23 Paper 2 (AS Structured Questions), maximum raw mark 60

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1 **(a)** energy or W: kg m^2 s^{-2}
or
power or P: kg m^2 s^{-3} — M1

intensity or I: kg m^2 s^{-2} m^{-2} s^{-1} (from use of energy expression)
or
kg m^2 s^{-3} m^{-2} (from use of power expression)

indication of simplification to kg s^{-3} — A1 [2]

(b) **(i)** ρ: kg m^{-3}, c: m s^{-1}, f: s^{-1}, x_0: m — M1

substitution of terms in an appropriate equation and simplification to show K has no units — A1 [2]

(ii) $I = 20 \times 1.2 \times 330 \times (260)^2 \times (0.24 \times 10^{-9})^2$ — C1

$= 3.1 \times 10^{-11}$ (W m^{-2}) — C1

$= 31$ (30.8) pW m^{-2} — A1 [3]

2 **(a)** **(i)** (the loudspeakers) are connected to the same signal generator — B1 [1]

(ii) **1.** the waves (that overlap) have phase difference of zero or path difference of zero and so
either constructive interference
or displacement larger — B1 [1]

2. the waves (that overlap) have phase difference of (n + ½) × 360° or (n + ½) × 2π rad or path difference of (n + ½)λ and so
either destructive interference
or displacements cancel/smaller — B1 [1]

3. the waves (that overlap) are in phase or have phase difference of n360° or 2πn rad or path difference of $n\lambda$ and so
either constructive interference
or displacement larger — B1 [1]

(b) time period = 0.002 s or 2 ms — C1

wave drawn is half time period — B1

amplitude 1.0 cm (same as Fig. 2.2) — B1 [3]

3	**(a) (i) 1.**	$s = ut + ½at^2$		
		$192 = ½ \times 9.81 \times t^2$	C1	
		t = 6.3 (6.26) s	A1	[2]
	2.	max E_k (= mgh) = 0.27 × 9.81 × 192	C1	
		or		
		calculation of v (= 61.4) and use of E_K (= ½ mv^2) = ½ × 0.27 × $(61.4)^2$	(C1)	
		max E_k = 510 (509) J	A1	[2]
	(ii)	velocity is proportional to time **or** velocity increases at a constant rate		
		as acceleration is constant or resultant force is constant	B1	[1]
	(iii)	use of $v = at$ or $v^2 = 2as$ or $E = ½mv^2$ to give v = 61(.4) m s^{-1}	B1	[1]
	(b) (i)	R increases with velocity	B1	
		resultant force is $mg - R$ **or** resultant force decreases	B1	
		acceleration decreases	B1	[3]
	(ii)	at v = 40 m s^{-1}, R = 0.6 (N)	C1	
		0.27 × 9.8 – 0.6 = 0.27 × a		
		a = 7.6 (7.58) m s^{-2}	A1	[2]
	(iii)	R = weight for terminal velocity	B1	
		either weight requires velocity to be about 80 m s^{-1} *or* at 60 m s^{-1}, R is less than weight		
		so does not reach terminal velocity	B1	[2]
4	**(a) (i)**	reaction/vertical force = weight – P cos 60°	C1	
		= 180 – 35 cos 60°		
		= 160 (163) N	A1	[2]
	(ii)	work done = 35 sin 60° × 20	C1	
		= 610 (606) J	A1	[2]

	(b)	**(i)**	work done by force *P* = work done against frictional force	B1	[1]
		(ii)	horizontal component of *P* is equal and opposite to frictional force	B1	
			vertical component of *P* + normal reaction force equal and opposite to weight	B1	[2]
5	**(a)**	**(i)**	resistance = V/I	B1	
			very high/infinite resistance at low voltages	B1	
			resistance decreases as *V* increases	B1	[3]
		(ii)	p.d. from graph 0.50 (V)	C1	
			resistance = $0.5/(4.4 \times 10^{-3})$		
			= 110 (114) Ω	A1	[2]
	(b)	**(i)**	current (= 1.2 / 375) = 3.2×10^{-3} A	A1	[1]
		(ii)	current in diode = 4.4×10^{-3} (A) total resistance = $1.2/4.4 \times 10^{-3}$ = 272.7 (Ω)	C1	
			resistance of R_1 = 272.7 – 113.6 = 160 (159) Ω	A1	
			or		
			p.d. across diode = 0.5 V and p.d. across R_1 = 0.7 V	(C1)	
			resistance of R_1 = $0.7/4.4 \times 10^{-3}$ = 160 (159) Ω	(A1)	[2]
		(iii)	power = IV **or** I^2R **or** V^2/R	C1	
			ratio = $(4.4 \times 0.5)/(3.2 \times 1.2)$ **or** $[(4.4)^2 \times 114]/[(3.2)^2 \times 375]$ **or** $[(0.5)^2 \times 375]/[114 \times (1.2)^2]$ = 0.57	A1	[2]
6	**(a)**		waves from loudspeaker (travel down tube and) are reflected at closed end	B1	
			two waves (travelling) in opposite directions with same frequency/wavelength overlap	B1	[2]
	(b)	**(i)**	0.51 m 0.85 m	A1 A1	[2]
		(ii)	A at open end, N at closed end, with an N and A in between, equally spaced (by eye)	B1	[1]

7	**(a)**	stress or $\sigma = F/A$	C1	
		max. tension = UTS × A = 4.5 × 10^8 × 15 × 10^{-6} = 6800 (6750) N	A1	[2]
	(b)	$\rho = m/V$	C1	
		weight = mg = ρVg = ρALg 6750 = 7.8 × 10^3 × 15 × 10^{-6} × L × 9.81	C1	
		L = 5.9 (5.88) × 10^3 m	A1	
		or		
		maximum mass = 6750/9.81 = 688 kg mass per unit length = ρA = 0.117 kg m^{-1} L = 688/0.117 = 5.9 × 10^3 m	(C1) (C1) (A1)	
		or		
		maximum mass = 6750/9.81 = 688 kg volume = m/ρ = 0.0882 m^3 = LA L = 0.0882/15 × 10^{-6} = 5.9 × 10^3 m	(C1) (C1) (A1)	[3]
8	**(a)**	mass-energy proton number or charge nucleon number	B2	[2]
	(b) (i)	$E_k = ½mv^2$ and $p = mv$ with working leading to [via $E_k = ½m^2v^2/m$ or $½m(p/m)^2$] to $E_k = \dfrac{p^2}{2m}$	B1	[1]
	(ii)	$p = (2E_km)^{½}$ hence $(2[E_km]_\alpha)^{½} = (2[E_km]_{Th})^{½}$	C1	
		2 × $[E_k]_{Th}$ × 234 = 2 × 6.69 × 10^{-13} × 4	C1	
		$[E_k]_{Th}$ = 1.14 × 10^{-14} J = 71(.5) keV	A1	
		or		
		calculation of speed of α-particle = 1.42 × 10^7 m s^{-1} calculation of momentum of α-particle/nucleus = 9.43 × 10^{-20} N s	(C1)	
		$[E_k]_{Th}$ = 1.14 × 10^{-14} J = 71(.5) keV	(C1) (A1)	[3]