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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.** $s = ut + \frac{1}{2}at^2$		
			$192 = \frac{1}{2} \times 9.81 \times t^2$	C1	
			$t = 6.3\ (6.26)\ \text{s}$	A1	[2]
			2. max E_k (= mgh) = $0.27 \times 9.81 \times 192$	C1	
			or		
			calculation of v (= 61.4) and use of E_K (= $\frac{1}{2}mv^2$) = $\frac{1}{2} \times 0.27 \times (61.4)^2$	(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 $E = \frac{1}{2}mv^2$ to give $v = 61(.4)\ \text{m s}^{-1}$	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 $v = 40\ \text{m s}^{-1}$, $R = 0.6$ (N)	C1	
			$0.27 \times 9.8 - 0.6 = 0.27 \times a$		
			$a = 7.6\ (7.58)\ \text{m s}^{-2}$	A1	[2]
		(iii)	R = weight for terminal velocity	B1	
			either weight requires velocity to be about $80\ \text{m s}^{-1}$ *or* at $60\ \text{m s}^{-1}$, 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 = $1.2 / 4.4 \times 10^{-3} = 272.7\,(\Omega)$	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 (C1)
mass per unit length = ρA = 0.117 kg m^{-1} (C1)
L = 688 / 0.117 = 5.9 × 10^3 m (A1)

or

maximum mass = 6750 / 9.81 = 688 kg (C1)
volume = m/ρ = 0.0882 m^3 = LA (C1)
L = 0.0882 / 15 × 10^{-6} = 5.9 × 10^3 m (A1) [3]

8 **(a)** mass-energy
proton number or charge
nucleon number B2 [2]

(b) **(i)** $E_k = ½ mv^2$ 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 (C1)
= 71(.5) keV (A1) [3]