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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: $\text{kg m}^2\text{ s}^{-2}$
or
power or P: $\text{kg m}^2\text{ s}^{-3}$ M1

intensity or I: $\text{kg m}^2\text{ s}^{-2}\text{ m}^{-2}\text{ s}^{-1}$ (from use of energy expression)
or
$\text{kg m}^2\text{ s}^{-3}\text{ m}^{-2}$ (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 $(n + ½) \times 360°$ or $(n + ½) \times 2\pi$ rad or path difference of $(n + ½)\lambda$ 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 $2\pi n$ 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]

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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 $v = 40\,\text{m s}^{-1}$, $R = 0.6\,(\text{N})$ 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

$= 180 - 35 \cos 60°$

$= 160\ (163)\,\text{N}$ A1 [2]

(ii) work done = $35 \sin 60° \times 20$ C1

$= 610\ (606)\ \text{J}$ A1 [2]

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(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 A1
0.85 m A1 [2]

(ii) A at open end, N at closed end, with an N and A in between, equally spaced (by eye) B1 [1]

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7 **(a)** stress or $\sigma = F/A$ C1

max. tension = UTS $\times$ A = $4.5 \times 10^8 \times 15 \times 10^{-6}$ = 6800 (6750) N A1 [2]

(b) $\rho = m/V$ C1

weight = $mg = \rho Vg = \rho ALg$
$6750 = 7.8 \times 10^3 \times 15 \times 10^{-6} \times L \times 9.81$ C1

$L = 5.9\ (5.88) \times 10^3$ m A1

or

maximum mass = 6750 / 9.81 = 688 kg (C1)
mass per unit length = $\rho A = 0.117$ kg m^{-1} (C1)
$L = 688 / 0.117 = 5.9 \times 10^3$ m (A1)

or

maximum mass = 6750 / 9.81 = 688 kg (C1)
volume = $m/\rho = 0.0882$ m^3 = LA (C1)
$L = 0.0882 / 15 \times 10^{-6} = 5.9 \times 10^3$ 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) $p = (2E_k m)^{½}$ hence $(2[E_k m]_\alpha)^{½} = (2[E_k m]_{Th})^{½}$ C1

$2 \times [E_k]_{Th} \times 234 = 2 \times 6.69 \times 10^{-13} \times 4$ C1

$[E_k]_{Th} = 1.14 \times 10^{-14}$ 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]

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