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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 $P$: $\text{kg m}^2 \text{s}^{-3}$  \hspace{1cm} 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 $\text{kg s}^{-3}$  \hspace{1cm} A1 \ [2]

(b) (i) $\rho$: $\text{kg m}^{-3}$, $c$: $\text{m s}^{-1}$, $f$: $\text{s}^{-1}$, $x_0$: $\text{m}$  \hspace{1cm} M1

   substitution of terms in an appropriate equation and simplification to show $K$
   has no units  \hspace{1cm} A1 \ [2]

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

   $= 3.1 \times 10^{-11} \text{ (W m}^{-2})$  \hspace{1cm} C1

   $= 31 (30.8) \text{ pW m}^{-2}$  \hspace{1cm} A1 \ [3]

2  (a) (i) (the loudspeakers) are connected to the same signal generator  \hspace{1cm} B1 \ [1]

   (ii) 1. the waves (that overlap) have phase difference of zero or path difference

   of zero and so

   \hspace{1cm} \hspace{1cm} \hspace{1cm} either constructive interference

   \hspace{1cm} \hspace{1cm} \hspace{1cm} or displacement larger  \hspace{1cm} B1 \ [1]

   2. the waves (that overlap) have phase difference of $(n + \frac{1}{2}) \times 360^\circ$ or

   $(n + \frac{1}{2}) \times 2\pi \text{ rad}$ or path difference of $(n + \frac{1}{2})\lambda$ and so

   \hspace{1cm} \hspace{1cm} \hspace{1cm} either destructive interference

   \hspace{1cm} \hspace{1cm} \hspace{1cm} or displacements cancel/smaller  \hspace{1cm} B1 \ [1]

   3. the waves (that overlap) are in phase or have phase difference of $n360^\circ$

   or $2\pi n \text{ rad}$ or path difference of $n\lambda$ and so

   \hspace{1cm} \hspace{1cm} \hspace{1cm} either constructive interference

   \hspace{1cm} \hspace{1cm} \hspace{1cm} or displacement larger  \hspace{1cm} B1 \ [1]

(b) time period = 0.002 s or 2 ms  \hspace{1cm} C1

   wave drawn is half time period  \hspace{1cm} B1

   amplitude 1.0 cm (same as Fig. 2.2)  \hspace{1cm} B1 \ [3]
3 (a) (i) 1. \( s = ut + \frac{1}{2}at^2 \)

\[
192 = \frac{1}{2} \times 9.81 \times t^2
\]

\( t = 6.3 \) (6.26) s

2. \( \text{max } E_k (= mg h) = 0.27 \times 9.81 \times 192 \)

or

\( \text{max } E_k = 510 \) (509) J

(ii) velocity is proportional to time or velocity increases at a constant rate

as acceleration is constant or resultant force is constant

(iii) use of \( v = at \) or \( v^2 = 2as \) or \( E = \frac{1}{2}mv^2 \) to give \( v = 61.4 \) m s\(^{-1} \)

(b) (i) \( R \) increases with velocity

resultant force is \( mg - R \) or resultant force decreases

acceleration decreases

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

\[
0.27 \times 9.8 - 0.6 = 0.27 \times a
\]

\( a = 7.6 \) (7.58) m s\(^{-2} \)

(iii) \( R = \text{weight for terminal velocity} \)

\( \text{either weight requires velocity to be about } 80 \text{ m s}^{-1} \)

\( \text{or at } 60 \text{ m s}^{-1}, R \) is less than weight

so does not reach terminal velocity

4 (a) (i) reaction/vertical force = \( \text{weight} - P \cos 60^\circ \)

\[
= 180 - 35 \cos 60^\circ
\]

\( = 160 \) (163) N

(ii) work done = \( 35 \sin 60^\circ \times 20 \)

\( = 610 \) (606) J
(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) \( \Omega \) \( A1 \) [2]

(b)  (i) current (= \( 1.2/375 \)) = \( 3.2 \times 10^{-3} \) A \( A1 \) [1]

(ii) current in diode = \( 4.4 \times 10^{-3} \) (A)

total resistance = \( 1.2/4.4 \times 10^{-3} \) = 272.7 (\( \Omega \)) \( C1 \)

resistance of \( R_1 \) = 272.7 – 113.6 = 160 (159)\( \Omega \) \( A1 \)

or

p.d. across diode = 0.5 V and p.d. across \( R_1 \) = 0.7 V \( \text{(C1)} \)

resistance of \( R_1 \) = \( 0.7/4.4 \times 10^{-3} \)

= 160 (159)\( \Omega \) \( \text{(A1)} \) [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 \( \text{A1} \) [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 \( A1 \) [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 $\sigma = F/A$

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

(b) $\rho = m/V$

weight = $mg = \rho V g = \rho ALg$

$6750 = 7.8 \times 10^3 \times 15 \times 10^{-6} \times L \times 9.81$

$L = 5.9 \ (5.88) \times 10^3 \text{m}$

or

maximum mass = $6750/9.81 = 688 \text{kg}$

mass per unit length = $\rho A = 0.117 \text{kg} \text{m}^{-1}$

$L = 688/0.117 = 5.9 \times 10^3 \text{m}$

or

maximum mass = $6750/9.81 = 688 \text{kg}$

volume = $m/\rho = 0.0882 \text{m}^3 = LA$

$L = 0.0882/15 \times 10^{-6} = 5.9 \times 10^3 \text{m}$

8 (a) mass-energy
proton number or charge
nucleon number

(b) (i) $E_k = \frac{1}{2} mv^2$ and $p = mv$ with working leading to

$[\text{via } E_k = \frac{1}{2} m \frac{p^2}{m} \text{ or } \frac{1}{2} m (p/m)^2]$

to $E_k = \frac{p^2}{2m}$

(ii) $p = (2E_k m)^{\frac{1}{2}}$ hence $(2[E_k m]_{Th})^{\frac{1}{2}} = (2[E_k m]_{Th})^{\frac{1}{2}}$

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

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

$= 71(0.5) \text{ keV}$

or

calculation of speed of $\alpha$-particle = $1.42 \times 10^7 \text{ m s}^{-1}$
calculation of momentum of $\alpha$-particle/nucleus = $9.43 \times 10^{-20} \text{ Ns}$

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

$= 71(0.5) \text{ keV}$