**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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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)** | $\rho$: $kg\,m^{-3}$, *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) 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 $E = \frac{1}{2}mv^2$ 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$^{-1}$<br>*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] |

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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) = $3.2 \times 10^{-3}$ A | A1 | [1] |
| | | **(ii)** | current in diode = $4.4 \times 10^{-3}$ (A)<br>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 $R_1$ = $0.7/4.4 \times 10^{-3}$<br>= 160 (159) Ω | (A1) | [2] |
| | | **(iii)** | power = $IV$ **or** $I^2R$ **or** $V^2/R$ | C1 | |
| | | | ratio = $(4.4 \times 0.5)/(3.2 \times 1.2)$<br>**or** $[(4.4)^2 \times 114]/[(3.2)^2 \times 375]$<br>**or** $[(0.5)^2 \times 375]/[114 \times (1.2)^2]$<br>= 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<br>0.85 m | A1<br>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 × $A$ = $4.5 \times 10^8 \times 15 \times 10^{-6}$ = 6800 (6750) N | A1 | [2] |
| | **(b)** | $\rho = m/V$ | C1 | |
| | | weight = $mg = \rho Vg = \rho ALg$<br>$6750 = 7.8 \times 10^3 \times 15 \times 10^{-6} \times L \times 9.81$ | C1 | |
| | | $L = 5.9\ (5.88) \times 10^3$ m | A1 | |
| | | **or** | | |
| | | maximum mass = 6750/9.81 = 688 kg<br>mass per unit length = $\rho A$ = 0.117 kg m$^{-1}$<br>$L = 688/0.117 = 5.9 \times 10^3$ m | (C1)<br>(C1)<br>(A1) | |
| | | **or** | | |
| | | maximum mass = 6750/9.81 = 688 kg<br>volume = $m/\rho$ = 0.0882 m$^3$ = $LA$<br>$L = 0.0882/15 \times 10^{-6} = 5.9 \times 10^3$ m | (C1)<br>(C1)<br>(A1) | [3] |
| **8** | **(a)** | mass-energy<br>proton number or charge<br>nucleon number | B2 | [2] |
| | **(b) (i)** | $E_k = ½\, mv^2$ and $p = mv$ with working leading to<br>[via $E_k = ½ m^2v^2/m$ or $½ m(p/m)^2$]<br>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 | |
| | | $2 \times [E_k]_{Th} \times 234 = 2 \times 6.69 \times 10^{-13} \times 4$ | C1 | |
| | | $[E_k]_{Th} = 1.14 \times 10^{-14}$ J<br>= 71(.5) keV | A1 | |
| | | **or** | | |
| | | calculation of speed of α-particle = $1.42 \times 10^7$ m s$^{-1}$<br>calculation of momentum of α-particle/nucleus = $9.43 \times 10^{-20}$ N s | (C1) | |
| | | $[E_k]_{Th}$ = $1.14 \times 10^{-14}$ J<br>= 71(.5) keV | (C1)<br>(A1) | [3] |