CAMBRIDGE
International Education

# Cambridge International AS & A Level

**PHYSICS** **9702/21**

Paper 2 AS Level Structured Questions **May/June 2024**

MARK SCHEME

Maximum Mark: 60

**Published**

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This document consists of **15** printed pages.

| Question | Answer | Marks |
|---|---|---|
| 1(a) | units of $F_D$: kg m s$^{-2}$ | **M1** |
| | units of $\rho$: kg m$^{-3}$<br>**and**<br>units of $A$: m$^2$<br>**and**<br>units of $v$: m s$^{-1}$ **or** units of $v^2$: m$^2$ s$^{-2}$ | **M1** |
| | kg m s$^{-2}$ = $C$ kg m s$^{-2}$ **and** comment '(so) $C$ has no units' / unit terms cancelled<br>**or**<br>$C$ = kg m s$^{-2}$ / (kg m$^{-3}$ m$^2$ m$^2$ s$^{-2}$) **and** comment '(so) $C$ has no units' / unit terms cancelled | **A1** |
| 1(b) | one arrow vertically downward labelled weight to within 10° of the vertical | **B1** |
| | one arrow vertically upwards labelled drag / drag force / $F_D$ / air resistance / viscous force to within 10° of the vertical | **B1** |
| 1(c) | (at terminal velocity) $F_D = mg$ | **C1** |
| | $F_D = 0.049 \times 9.81$<br>$= 0.48$ N | **A1** |
| 1(d) | area = $\pi \times (0.060 / 2)^2$ | **C1** |
| | $0.48 = ½ \times C \times 1.2 \times \pi \times (0.060 / 2)^2 \times 25^2$ | **C1** |
| | $C = 0.45$ | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 2(a) | change in displacement / time (taken) | **B1** |
| 2(b)(i) | horizontal velocity = $22 \times \cos 40°$ | **C1** |
| | time taken $= 36 / (22 \times \cos 40°)$<br>$= 2.1$ s | **A1** |
| 2(b)(ii) | $u = 22 \times \sin 40°$<br>$= 14\ \text{m s}^{-1}$ | **A1** |
| 2(b)(iii) | $s = ut + ½\, at^2$<br>$= (14 \times 2.1) + (½ \times −9.81 \times 2.1^2)$ | **C1** |
| | $= 7.8$ (m) | **C1** |
| | (therefore) height of wall $= 7.8 + 1.2$<br>$= 9.0$ m | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 2(b)(iii) | **or** | |
| | *other methods possible e.g.*<br>time to maximum height = (0 – 14) / –9.81 (= 1.43 s)<br>time from maximum height to wall = 2.1 – 1.43 (= 0.67 s)<br>maximum height above release = $(14 \times 1.43) + (½ \times -9.81 \times 1.43^2)$<br>= 9.99 (m) | **(C1)** |
| | height from maximum to wall = $0.5 \times 9.81 \times 0.67^2$ (= 2.2 m)<br>height above release = 9.99 – 2.2<br>= 7.8 (m) | **(C1)** |
| | height of wall = 1.2 + 7.8<br>= 9.0 m | **(A1)** |

| Question | Answer | Marks |
|---|---|---|
| 3(a) | sum / total momentum before (a collision) = sum / total momentum after (a collision)<br>**or**<br>sum / total momentum (of a system) is constant | **M1** |
| | if no (resultant) external force (acts) / for an isolated system | **A1** |
| 3(b) | along direction of motion:<br><br>$10m = 2mv \cos 30° + 3mw \cos 30°$ | **C1** |
| | perpendicular to direction of motion:<br><br>$2mv \cos 60° = 3mw \cos 60°$<br><br>($v = 3w / 2$) | **C1** |
| | $v = 2.9\ \text{m s}^{-1}$ | **A1** |
| | $w = 1.9\ \text{m s}^{-1}$ | **A1** |
| 3(c) | $E_K = ½ \times m \times v^2$<br><br>$(= ½ \times 4.2 \times 6.0^2)$<br><br>(= 76 J) | **C1** |
| | force = work done / distance | **C1** |
| | force = 76 / 0.050<br><br>= 1500 N | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 3(c) | **or** | |
| | $a = (-)u^2 / 2s$<br>$= (-)6.0^2 / (2 \times 0.050)$<br>$( = (-)360\ \mathrm{m\ s^{-2}})$ | **(C1)** |
| | $F = ma$ | **(C1)** |
| | $F = 4.2 \times 360$<br>$= 1500\ \mathrm{N}$ | **(A1)** |
| | **or** | |
| | $a = (-)u^2 / 2s$<br>$= (-)6.0^2 / (2 \times 0.050)$<br>$( = (-)360\ \mathrm{m\ s^{-2}})$ | **(C1)** |
| | $t = -u / a$<br>$= -6.0 / -360\ (= 0.017\ \mathrm{s})$<br>$F = \Delta p / t$ | **(C1)** |
| | $F = (0 - 4.2 \times 6) / 0.017$<br>$= 1500\ \mathrm{N}$ | **(A1)** |

| Question | Answer | Marks |
|---|---|---|
| 4(a) | extension / <u>original</u> length | **B1** |
| 4(b)(i) | Young modulus = stress / strain | **C1** |
| | = $(18 / 4.5 \times 10^{-7}) / (1.4 \times 10^{-3} / 4.0)$ | **C1** |
| | = $(4.0 \times 10^{7}) / (3.5 \times 10^{-4})$<br>= $1.1 \times 10^{11}$ Pa | **A1** |
| 4(b)(ii) | straight line through the origin | **B1** |
| | ending at the point (3.5, 4.0) | **B1** |
| 4(c) | see table below | **B2** |

| | greater in second wire | less in second wire | the same in both wires |
|---|---|---|---|
| stress | | ✓ | |
| strain | | ✓ | |

| Question | Answer | Marks |
|---|---|---|
| 5(a) | wave(s) (travel along string and) reflect at fixed point / wall / Q / end / vibration generator / P | **B1** |
| | incident and reflected waves superpose | **B1** |
| 5(b) | 0.80 m | **A1** |
| 5(c) | same wavelength as original throughout **and** passing through intersection of solid and dashed lines | **B1** |
| | reflected in dashed line **and** of same amplitude | **B1** |
| 5(d) | 180° | **A1** |
| 5(e) | $v = f\lambda$ **and** $f = 1 / T$<br>**or**<br>$v = \lambda / T$ | **C1** |
| | $v = 6.25 \times 0.80$ **or** $0.80 / 0.16$<br>$= 5.0\ \text{m s}^{-1}$ | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 6(a) | <u>sum of</u> current(s) entering a junction = <u>sum of</u> current(s) leaving (the same junction)<br>**or**<br>(algebraic) sum of current (s) at a junction is zero | **B1** |
| 6(b) | (by Kirchhoff's second law) $V = V_1 + V_2$ | **B1** |
| | so $IR_T = IR_1 + IR_2$ (and cancelling $I$ gives) $R_T = R_1 + R_2$<br>**or**<br>$V / I = V_1 / I + V_2 / I$ (and substituting $R$ gives) $R_T = R_1 + R_2$ | **B1** |
| 6(c) | current in circuit = 1.35 / (10 + 15) (= 0.054 A) | **C1** |
| | $r = (E - V) / I$ | **C1** |
| | = (1.5 – 1.35) / 0.054<br><br>= 2.8 Ω | **A1** |
| | **or** | |
| | by potential divider principle $\frac{0.15}{1.35} = \frac{r}{25}$ | **(C2)** |
| | $r$ = 2.8 Ω | **(A1)** |
| | **or** | |
| | $I$ = 1.35 / (10 + 15) (= 0.054 A) | **(C1)** |
| | total resistance = 1.50 / 0.054 (= 27.8 Ω)<br><br>$r$ = 27.8 – 25 | **(C1)** |
| | $r$ = 2.8 Ω | **(A1)** |

| Question | Answer | Marks |
|---|---|---|
| 6(d)(i) | the (total) resistance (of the circuit) has decreased (and e.m.f. is unchanged) | **M1** |
| | (the current (in the cell) will) increase | **A1** |
| 6(d)(ii) | (as the current is greater and so there is a) larger p.d. across the internal resistance | **M1** |
| | (terminal p.d. will) decrease | **A1** |

| Question | Answer | Marks |
|---|---|---|
| 7(a) | ${}^{66}_{29}\mathrm{Cu}$ | **B1** |
| 7(b)(i) | the energy of the decay is fixed / constant | **B1** |
| | the energies of the beta particles have a (continuous) range of values / varies / not constant | **B1** |
| | another particle / an (anti)neutrino must possess the extra / remaining energy (difference between energy of the decay and the $\beta$ kinetic energy) | **B1** |
| 7(b)(ii) | (electron) antineutrino | **B1** |
| 7(b)(iii) | ${}^{66}_{29}\mathrm{Cu} \rightarrow {}^{66}_{30}\mathrm{Zn} + {}^{0}_{-1}\beta + {}^{0}_{0}\overline{\upsilon_e}$<br><br>values for Cu and Zn correct with no other extra particles on either side of the equation | **B1** |
| | second term correct ( ${}^{0}_{-1}\beta$ ) | **B1** |
| | third term correct ( ${}^{0}_{0}\overline{\upsilon_e}$ ) | **B1** |