**Abbreviations**

| | |
|---|---|
| **/** | Alternative and acceptable answers for the same marking point. |
| **( )** | Bracketed content indicates words which do not need to be explicitly seen to gain credit but which indicate the **context** for an answer. The context does not need to be seen but if a context is given that is incorrect then the mark should not be awarded. |
| **___** | Underlined content must be present in answer to award the mark. This means either the exact word or another word that has the same technical meaning. |

**Mark categories**

| | |
|---|---|
| **B** marks | These are independent marks, which do not depend on other marks. For a **B** mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer. |
| **M** marks | These are method marks upon which **A** marks later depend. For an **M** mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer. If a candidate is not awarded an **M** mark, then the later **A** mark cannot be awarded either. |
| **C** marks | These are compensatory marks which can be awarded even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known them. For example, if an equation carries a **C** mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C** mark is awarded.<br>If a correct answer is given to a numerical question, all of the preceding **C** marks are awarded automatically. It is only necessary to consider each of the **C** marks in turn when the numerical answer is not correct. |
| **A** marks | These are answer marks. They may depend on an **M** mark or allow a **C** mark to be awarded by implication. |

**Annotations**

| | |
|---|---|
| ✓ | Indicates the point at which a mark has been awarded. |
| **X** | Indicates an incorrect answer or a point at which a decision is made not to award a mark. |
| **XP** | Indicates a physically incorrect equation ('incorrect physics'). No credit is given for substitution, or subsequent arithmetic, in a physically incorrect equation. |

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| | |
|---|---|
| **ECF** | Indicates 'error carried forward'. Answers to later numerical questions can always be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a section of a numerical question, ECF can be given after AE, TE and POT errors, but **not** after XP. |
| **AE** | Indicates an arithmetic error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| **POT** | Indicates a power of ten error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| **TE** | Indicates incorrect transcription of the correct data from the question, a graph, data sheet or a previous answer. For example, the value of $1.6 \times 10^{-19}$ has been written down as $6.1 \times 10^{-19}$ or $1.6 \times 10^{19}$.<br>Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| **SF** | Indicates that the correct answer is seen in the working but the final answer is incorrect as it is expressed to too few significant figures. |
| **BOD** | Indicates that a mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done ('benefit of doubt'). |
| **CON** | Indicates that a response is contradictory. |
| **I** | Indicates parts of a response that have been seen but disregarded as irrelevant. |
| **M0** | Indicates where an A category mark has not been awarded due to the M category mark upon which it depends not having previously been awarded. |
| **^** | Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank. |
| **SEEN** | Indicates that a page has been seen. |

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| Question | Answer | Marks |
|---|---|---|
| 1(a) | $m = \rho V$ **or** $\rho AL$ | **C1** |
| | $W = mg$ | **C1** |
| | $(A =)\ 24 / (9.81 \times 850 \times 0.18) = 0.016\ (m^2)$ | **A1** |
| | **or** | |
| | $P = F / A$ | **(C1)** |
| | $P = \rho gh$ | **(C1)** |
| | $(A =)\ 24 / (9.81 \times 850 \times 0.18) = 0.016\ (m^2)$ | **(A1)** |
| 1(b)(i) | (upthrust =) 24 + 8(.0) = 32 (N) | **A1** |
| 1(b)(ii) | $(\Delta)p = 32 / 0.016\ (= 2000)$ | **C1** |
| | $(\Delta)p = \rho g(\Delta)h$<br>$\rho = 2000 / (9.81 \times 0.17)$ | **C1** |
| | $= 1200\ kg\ m^{-3}$ | **A1** |
| 1(c)(i) | $E = ½Fx$ **or** $E = ½kx^2$ **or** $E$ = area under graph | **C1** |
| | $(\Delta)E = (½ \times 8.0 \times 0.40) – (½ \times 4.0 \times 0.20)$<br>**or**<br>$(½ \times 20 \times 0.40^2) – (½ \times 20 \times 0.20^2)$<br>**or**<br>$½ \times (4.0 + 8.0) \times 0.20$ | **C1** |
| | $= 1.2$ J | **A1** |
| 1(c)(ii) | length = 30 cm | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 2(a) | force × displacement in the direction of the force | **B1** |
| 2(b) | units: kg m $s^{-2}$ × m = kg $m^2$ $s^{-2}$ | **A1** |
| 2(c) | $T_1$: K and $T_2$: K | **C1** |
| | $A$: $m^2$ and $t$: s and $L$: m | **C1** |
| | $c$ = (kg $m^2$ $s^{-2}$ m) / ($m^2$ K s)<br>= kg m $s^{-3}$ $K^{-1}$ | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 3(a) | change in displacement / time (taken) | **B1** |
| 3(b) | by calculation:<br>$v^2 = 42^2 + 23^2 - (2 \times 42 \times 23 \times \cos 54°)$<br>**or**<br>$v^2 = (42 - 23 \cos 54°)^2 + (23 \sin 54°)^2$<br>**or**<br>$v^2 = (42 - 23 \sin 36°)^2 + (23 \cos 36°)^2$ | **C1** |
| | $v = 34\ \text{m s}^{-1}$ | **A1** |
| | **or** | |
| | by scale diagram: triangle of vector velocities drawn | **(C1)** |
| | $v = 34\ \text{m s}^{-1}$ (*allow* $\pm 1\ \text{m s}^{-1}$ *if scale diagram used*) | **(A1)** |
| 3(c)(i) | $(\Delta)E = mg(\Delta)h$ **or** $(\Delta)E = W(\Delta)h$ | **C1** |
| | $h = 6100/46$ (= 133 m) | **C1** |
| | $\theta = \sin^{-1}(133/280)$<br>$= 28°$ | **A1** |
| 3(c)(ii) | force = 6100 / 280 **or** 46 sin 28° | **C1** |
| | = 22 N | **A1** |
| 3(d) | $v_{(s)} = 280 / 14$ (= $20\ \text{m s}^{-1}$) | **C1** |
| | $f_o = f_s\, v / (v - v_s)$<br>$f_s = 450 \times (340 - 20) / 340$ | **C1** |
| | = 420 Hz | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 4(a) | to the left/from the right/from B to A/opposite (direction) to ($\alpha$-particle) velocity | **B1** |
| 4(b) | $v^2 = u^2 + 2as$<br>$s = (4.1 \times 10^6)^2 / (2 \times 2.7 \times 10^{14})$ | **C1** |
| | $= 0.031$ m | **A1** |
| 4(c) | $E = F / Q$ **or** $E = ma / Q$ | **C1** |
| | $= (4 \times 1.66 \times 10^{-27} \times 2.7 \times 10^{14}) / (2 \times 1.60 \times 10^{-19})$ | **C1** |
| | $= 5.6 \times 10^6$ V m$^{-1}$ | **A1** |
| 4(d) | straight line with negative gradient that intercepts both the momentum and $t$ axes | **B1** |
| 4(e) | force (on $\alpha$-particle) | **B1** |
| 4(f)(i) | $E = ½mv^2$ | **C1** |
| | $= ½ \times 9.11 \times 10^{-31} \times (4.1 \times 10^6)^2$ | **C1** |
| | $= 7.7 \times 10^{-18}$ J | **A1** |
| 4(f)(ii) | particles have opposite charges | **B1** |
| | (so) forces (on charges) are opposite (directions) | **B1** |
| | $\beta^-$ has less/half the charge so less/half the force | **B1** |
| 4(f)(iii) | (electron) antineutrino | **B1** |

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| Question | Answer | Marks |
|---|---|---|
| 5(a) | maximum displacement (of a point/particle on string/wave) | **B1** |
| 5(b) | $v = \lambda / T$<br>**or**<br>$v = f\lambda$ **and** $f = 1 / T$ | **C1** |
| | $T = 690 \times 10^{-9} / 3.00 \times 10^{8}$ | **C1** |
| | $= 2.3 \times 10^{-15}$ s | **A1** |
| 5(c)(i) | $\lambda = ax / D$ | **C1** |
| | $G = x / D$<br><br>(so) $a = \lambda / G$ | **A1** |
| 5(c)(ii) | straight line from origin always below printed line | **M1** |
| | line is half the height of printed line at maximum $D$ | **A1** |

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| Question | Answer | Marks |
|---|---|---|
| 6(a) | $R = \rho L / A$ | **C1** |
| | $(R =)\ 5(.0) \times 10^{-7} \times 2(.0) / 3.3 \times 10^{-7} = 3.0\ \Omega$ | **A1** |
| 6(b)(i) | $I = 1.2 / 3.0$<br>$= 0.40$ A | **A1** |
| 6(b)(ii) | $r = (1.50 - 1.20) / 0.40$ **or** $1.50 / 0.40 - 3.0$ | **C1** |
| | $= 0.75\ \Omega$ | **A1** |
| 6(c) | $E / 1.20 = 1.4 / 2.0$ | **C1** |
| | $E = 0.84$ V | **A1** |
| | **or** | |
| | $R_{XP} = (1.4 / 2.0) \times 3.0\ (= 2.1\ \Omega)$<br>$E = 2.1 \times 0.40$ | **(C1)** |
| | $E = 0.84$ V | **(A1)** |
| 6(d) | (second wire has) larger resistance/resistance increases | **M1** |
| | p.d. across XY is larger/increases (for second wire)<br>**or**<br>p.d. across the (second) wire is larger/increases | **M1** |
| | (so) length XP (for second wire) is shorter | **A1** |

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