# GCE AS MARKING SCHEME

**SUMMER 2024**

**AS**
**PHYSICS – UNIT 1**
**2420U10-1**

## About this marking scheme

The purpose of this marking scheme is to provide teachers, learners, and other interested parties, with an understanding of the assessment criteria used to assess this specific assessment.

This marking scheme reflects the criteria by which this assessment was marked in a live series and was finalised following detailed discussion at an examiners' conference. A team of qualified examiners were trained specifically in the application of this marking scheme. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners. It may not be possible, or appropriate, to capture every variation that a candidate may present in their responses within this marking scheme. However, during the training conference, examiners were guided in using their professional judgement to credit alternative valid responses as instructed by the document, and through reviewing exemplar responses.

Without the benefit of participation in the examiners' conference, teachers, learners and other users, may have different views on certain matters of detail or interpretation. Therefore, it is strongly recommended that this marking scheme is used alongside other guidance, such as published exemplar materials or Guidance for Teaching. This marking scheme is final and will not be changed, unless in the event that a clear error is identified, as it reflects the criteria used to assess candidate responses during the live series.

**GCE AS PHYSICS**

**UNIT 1 – MOTION, ENERGY AND MATTER**

**SUMMER 2024 MARK SCHEME**

## GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response question).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| **1** | (a) | | The [vector] sum of the momenta of bodies in a system stays constant [even if forces act between the bodies] accept overall momentum remains constant (1)<br>provided there is no external / resultant force (1) accept closed system<br>**Accept**: Total momentum of a system (or bodies) before a collision (or explosion) = total momentum after collision (explosion)... (1) ....provided no external / resultant forces act (1) accept closed system | 2 | | | 2 | | |
| | (b) | (i) | Correct application of C of M e.g.<br>Expression for momentum before collision: $0.20 \times 9$ [= 1.8] (1)<br>Expression for momentum after collision: $(0.20 \times -2) + 0.40v$ (1)<br>Convincing algebra: $v$ = [+] 5.5 [m s$^{-1}$] (1)<br>Error in 'signs' (e.g. for rebounding snowball gains no credit and **no ecf** for final answer)<br>**Alternative:**<br>$\Delta p$ for snowball = -2.2 [N s] i.e. 0.2(-2 – (+9)) (1)<br>$\Delta p$ for hat = + 2.2 [N s] (1) **ecf**<br>Hence $v_{\text{hat}} = \frac{2.2}{0.4}$ = 5.5 [m s$^{-1}$] (1) | | 3 | | 3 | 3 | |
| | | (ii) | $\Delta p_{\text{hat}} = 5.5 \times 0.40 = 2.2$ [N s] **ecf** on $v$ from (b)(i) (1)<br>$F = \frac{2.2}{0.14}$ = 15.7 [N] (Accept 16 N) (1)<br>**Alternative:**<br>$a_{\text{hat}} = \frac{5.5}{0.14}$ = 39.3 [m s$^{-2}$] **ecf** on $v$ from (b)(i) (1)<br>$F = 0.4 \times 39.3 = 15.7$ [N] (1) | | 2 | | 2 | 2 | |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| | (c) | | Explanation:<br>Momentum change (decrease) of snowball is reduced / less (compared to (b)(i)) (1)<br>Momentum change (increase) of hat is reduced / less or compared with 2.2 [N s] (1)<br>Therefore velocity (increase) of hat is less (than in (b)(i)) **and** so Natalie is incorrect (1)<br>If calculation and conclusion only, award maximum 2 marks (treat as neutral): e.g. $1.8 = 0.6v$ (1)<br>$v = 3$ [m s$^{-1}$] and hence Natalie is incorrect (1) | | | 3 | 3 | | |
| | | | **Question 1 total** | **2** | **5** | **3** | **10** | **5** | **0** |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| **2** | (a) | | A and C and E identified as correct (2)<br>2 correct gains one mark<br>-1 for each additional tick > 3 ticks | 2 | | | 2 | | |
| | (b) | (i) | $x$ = (cos 25° × 12) – 5.44 seen **or** $x$ = 5.44 **or** 6 cos 25° **or** use of sin 25 and Pythagoras<br>**or** argument based on C of G of extendable arm in middle therefore $x$ = 2.00 + 3.44 | | 1 | | 1 | 1 | |
| | | (ii) | C.M.= $2.2 \times 10^4 \times 2.00$ (or $4.4 \times 10^4$ seen) (1)<br>A.C.M.= ($W \times 8.88$ **ecf**) + ($3.0 \times 10^3 \times 3.44$) (1)<br>Correct algebra and $W$ shown = 3793 [N] (1)<br>3767 [N] if approximation of 5.5 used<br>3810 [N] if approximation of 5.4 used | | 3 | | 3 | 3 | |
| | | (iii) | 3800 **ecf** – 1700 = 2100 [N] (1)<br>Conversion of mass-force i.e. $m = \frac{F}{g}$ (1)<br>= 214 [kg] (1)<br>Conclusion reasonable and consistent with their figures (1)<br><br>**Alternative:**<br>2 people mass approx 200 kg (1)<br>Conversion of mass-force i.e. $F = mg$ (1)<br>Adding both forces – giving around 3700 [N] depending on mass (1)<br>Conclusion reasonable and consistent with their figures **ecf** on comparison with (b)(ii) (1) | | | 4 | 4 | 2 | |
| | | | **Question 2 total** | **2** | **4** | **4** | **10** | **6** | **0** |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| **3** | (a) | (i) | Mean acceleration = 0.75[3] [$m\,s^{-2}$] (1)<br>Absolute uncertainty = $\frac{(0.79 - 0.71)}{2}$ = ± 0.04 [$m\,s^{-2}$] (1) | | 2 | | 2 | 2 | 2 |
| | | (ii) | 5% (accept 5.3%) (**ecf**) no s.f. penalty | | 1 | | 1 | 1 | 1 |
| | (b) | (i) | $\frac{0.6}{60}$ or $\frac{0.1}{10}$ so % uncertainty = 1 [%] | | 1 | | 1 | 1 | 1 |
| | | (ii) | Total mass = $\frac{60 \times 10^{-3} \times 9.81}{0.75[3]\ \textbf{ecf}}$ = 0.78 [kg] (1)<br>Mass of glider = 0.78(**ecf**) – 0.06 = 0.72 [kg] (1)<br>Total % uncertainty = 6.3% (accept 6%) (**ecf** from (a)(ii) and (b)(i)) (1)<br>Absolute uncertainty in mass of glider = ± 0.045 or ± 0.05 or 0.04 if 6% used (ignore sig figs and **ecf** if total mass used - expect ± 0.047 (6%) or 0.049 (6.3%)) (1)<br>Mass of glider = 0.72 **ecf (**even if 0.78 used) ± 0.04 or 0.05 [kg] seen (1) Sig figs need to be consistent and to a max of 2 sig figs for the uncertainty Accept:<br>0.722 - 0.725 ± 0.043 - 0.050 [kg] (NOT 0.72 ± 0.050 kg)<br>720 ± 40 [g]<br>720 ± 50 [g]<br>722 - 725 ± 43 - 50 [g] | | 5 | | 5 | 5 | 5 |
| | (c) | | Reasonable suggestion e.g. release mechanism - no detail required or equivalent<br>Move light gate to the right<br>Increase mass <u>of glider</u> or decrease slotted mass. Don't accept increase mass only.<br>Measure acceleration between two light gates<br>Accept more repeat readings | | | 1 | 1 | | 1 |
| | | | **Question 3 total** | **0** | **9** | **1** | **10** | **9** | **10** |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| 4 | (a) | | 3 protons **and** 4 neutrons (1)<br>3 leptons **and** 7 baryons (1)<br>10 'up' **and** 11 'down' quarks (1) | 3 | | | 3 | | |
| | (b) | (i) | Quark-antiquark combination | 1 | | | 1 | | |
| | | (ii) | $(+\frac{2}{3} - \frac{2}{3})$ **or** $(+\frac{1}{3} - \frac{1}{3}) = 0$ seen **or**<br>charge of particle **and** its antiparticle is 0 | | 1 | | 1 | | |
| | | (iii) | udd → udd → $\bar{u}$d  uud<br>4 × 1 mark for each box | 4 | | | 4 | | |
| | | (iv) | Production: $\bar{u}u$ (or 0) + u = u (1)<br>Decay: u = $\bar{u}$ + uu (1)<br>**Alternative:**<br>Production: -1+1 +1 = [+]1 (1)<br>Decay: 1 = -1+1+1 (1) | | 2 | | 2 | | |
| | (c) | | **Required:**<br>• [Very] short decay time (1)<br><br>**Any × (1):**<br>• Individual quark flavours (numbers) conserved<br>• No neutrino and no gamma emissions<br>• Only {quarks / hadrons} involved | 2 | | | 2 | | |
| | | | **Question 4 total** | **10** | **3** | **0** | **13** | **0** | **0** |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| 5 | (a) | | $\frac{\text{[Total] displacement}}{\text{time}}$<br>Accept rate of change of displacement | 1 | | | 1 | | |
| | (b) | (i) | Speed = $\frac{3.14 \times 1.25}{4}$ [= 0.98 m s$^{-1}$] | 1 | | | 1 | 1 | |
| | | (ii) | Velocity = $\frac{2.5}{4}$ [= 0.63 m s$^{-1}$] (1)<br>South (1) accept downwards arrow | 1 | 1 | | 2 | 1 | |
| | | (iii) | Acceleration = rate of change of velocity (or implied) (1)<br>Velocity [constantly] changing (1)<br>since direction is [constantly] changing so Seren is correct (1)<br>Accept Ieuan is incorrect<br>Award 2 marks max for circular motion stated (1)<br>Centripetal acceleration or acceleration towards centre (1) | | | 3 | 3 | | |
| | (c) | | Calculation of time for decelerating e.g. by $x = \frac{(u+v)t}{2}$<br>so $t$ = 2.4 [s] (1) N.B. can be awarded from the graph<br>Appropriate $v$-$t$ graph vertical axis (0 to 1 or 2) (1)<br>Straight horizontal line on $v$-$t$ graph from (0,1) to (2,1) **and** decreasing steadily (4.4,0) (1) **ecf** on 4.4 if calculated<br>Appropriate displacement-time vertical axis (0 to about 4 m) (**ecf**) (1) or part of the scale, be tolerant<br>Straight line from (0,0) to (2,2) (1) allow if exceeds 2.2<br>Smooth curve from (2,2) to (4.4, 3.2) **and** horizontal at (4.4, 3.2) (1) accept horizontal line continuing beyond 4.4 | 1 | 1<br>1<br>1<br>1<br>1 | | 6 | 6 | |
| | | | **Question 5 total** | **4** | **6** | **3** | **13** | **8** | **0** |

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>6</td><td>(a)</td><td></td><td>Indicative response:<br>Before jumping, all of the energy is in the form of gravitational potential energy (GPE). As the jumper falls, the original GPE is transferred to KE. When the cord starts to stretch the KE continues to increase initially, as does the elastic potential energy (EPE). Both GPE and KE will decrease as the cord stretches further, until eventually the KE becomes (momentarily) zero at the lowest point of the jump. At this point the decrease in GPE is equal to the EPE in the cord. As the jumper starts to move upwards the EPE is transferred back to KE and GPE. The jumper does not reach the initial height above the ground, as some energy is transferred to air molecules (and / or reference to hysteresis).<br>Additional comments: Some energy is transferred to air molecules. Explanation of why jumper does not reach original height after first bounce.<br>N.B. Table below is to aid marking – candidates must write in extended prose to gain 6 marks.<br><table><tr><th>Position</th><th>$E_g$</th><th>$E_k$</th><th>$E_{el}$</th></tr><tr><td>At start (before jump)</td><td>Max or $mgh$ where $h$ is height above ground</td><td>0</td><td>0</td></tr><tr><td>Free fall, cord slack</td><td>Decreasing</td><td>Increasing</td><td>0</td></tr><tr><td>Cord stretching</td><td>Decreasing</td><td>Continues to increase initially before decreasing.</td><td>Increasing</td></tr><tr><td>At bottom of first bounce</td><td>Minimum - don’t accept zero unless explained. Accept $-mg\Delta x$ where $\Delta x$ is distance fallen</td><td>0</td><td>Maximum or $\Delta E_{el} = -mg\Delta x$</td></tr></table></td><td>2</td><td>4</td><td></td><td>6</td><td></td><td></td></tr>
</table>

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| | | | **5-6 marks**<br>Comprehensive analysis of all 3 energy forms. Reference to energy loss due to air resistance and / or hysteresis.<br>*There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.*<br><br>**3-4 marks**<br>Comprehensive account of two energy forms or a limited account of all three. No reference to energy losses.<br>*There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.*<br><br>**1-2 marks**<br>Limited account of one or two energy forms. No reference to energy losses.<br>*There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.*<br><br>**0 marks**<br>*No attempt made or no response worthy of credit.* | | | | | | |
| 6 | (b) | (i) | Returns to original shape (unstretched length) | 1 | | | 1 | | 1 |
| | | (ii) | [Work done to] straighten (untangle / unravel) polymer chains / molecules<br>Accept C-C bonds are rotated | 1 | | | 1 | | 1 |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| | | (iii) | Valid method for calculating the area (1)<br>Correct value based on valid method (expect 6.0 ± 0.4 [J]) (1)<br><br>Valid methods are:<br>Counting squares expect 6 large squares, expect 24 of the ¼ squares and expect 600 tiny squares<br>**OR**<br>Trapezium (0,0), (0.3, 0), (0.3, 30), (0.2, 30) Note that this is equivalent to a triangle and a quadrilateral. Expect:<br>½ × (0.1 + 0.3) × 30 OR ½ × 0.2 × 30 + 0.1 × 30<br>**OR**<br>Trapezium (0,0), (0.3, 0), (0, 10), (0.2, 30) Note that this is equivalent to a triangle and a quadrilateral. Expect very similar numbers: ½ × (10 + 30) × 0.3 OR ½ × 20 × 0.3 + 10 × 0.3<br>**OR**<br>Triangle (0,0), (0.3, 0), (0.3, 40) Expect the numbers: ½ × 0.3 × 40<br>**OR**<br>Triangle and trapezium method. Expect the numbers: ½ × 0.1 × 20 + ½ × (20 + 30) × 0.2 (= 1 J + 5 J)<br>**OR** Anything else which is clearly correct award the marks e.g. triangle-trapezium-trapezium all with a base of 0.1 gives 6.1 [J]<br><br>The final mark is for the correct answer 6.0 ± 0.4 [J] | | 2 | | 2 | 2 | 2 |
| | | (iv) | Hysteresis (1)<br>Difference between energy stored in the rubber band when it is stretched and [useful] energy recovered from it when it is unstretched. Or energy dissipated (or described) [lost] in one cycle of loading and unloading (1) | 2 | | | 2 | | 2 |
| | | | **Question 6 total** | **6** | **6** | **0** | **12** | **2** | **6** |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| 7 | (a) | | Study of {space / stars / galaxies} (1) don't accept planets<br>For the 2nd mark either:<br>At {different / various} {wavelengths / frequencies / energies} of the em spectrum<br>**OR**<br>Of various regions of the em spectrum | 2 | | | 2 | | |
| | (b) | | W in base units → $kg\,m^2\,s^{-3}$ **or** J → $kg\,m^2\,s^{-2}$ **or** N → $kg\,m\,s^{-2}$ (1)<br>Units of $\sigma$ = $kg\,s^{-3}\,K^{-4}$ (1) | 1 | 1 | | 2 | 2 | |
| | (c) | (i) | Use of $T = \frac{W}{\lambda_{max}}$ (re-arrangement and substitution) i.e.<br>$T = \frac{2.9 \times 10^{-3}}{674 \times 10^{-9}}$ (1)<br>$T$ = 4303 K (1) **unit mark** | | 2 | | 2 | 2 | |
| | | (ii) | Red / orange | 1 | | | 1 | | |
| | (d) | | Correct substitution into $P = A\sigma T^4$ i.e.<br>$P = 5.67 \times 10^{-8} \times 4\pi \times (1.39 \times 10^{10})^2 \times (4303)^4$ **ecf** on $T$<br>**Or** $P = 4.72 \times 10^{28}$ [W] seen (1)<br>Recall $I = \frac{P}{4\pi D^2}$ (1)<br>**Alternative 1** - Substitution and rearrange i.e.<br>$D = \sqrt{\frac{4.72 \times 10^{28}\,\mathbf{ecf}}{4\pi \times 3.09 \times 10^{-8}}}$ (1)<br>$D = 3.49 \times 10^{17}$ [m] (1)<br>$D$ in light years = $\frac{3.49 \times 10^{17}}{9.46 \times 10^{15}}$ = 36.8[5 ly] so claim correct **ecf** on $D$ (1) | | | 5 | 5 | 5 | |

| Question | | | Marking details | Marks available | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | AO1 | AO2 | AO3 | Total | Maths | Prac |
| | | | **Alternative 2** – Substitution and rearrange i.e.<br>$I = \frac{4.72 \times 10^{28}\ \textbf{ecf}}{4\pi \times (37 \times 9.46 \times 10^{15})^2}$ (1)<br>$= 3.07 \times 10^{-8}$ [W m$^{-2}$] (1)<br>Compare with $3.09 \times 10^{-8}$ [W m$^{-2}$] so claim correct or valid conclusion if **ecf** used<br><br>**Alternative 3** – Substitution and rearrange i.e.<br>$P = 3.09 \times 10^{-8} \times 4\pi \times (37 \times 9.46 \times 10^{15})^2$ (1)<br>$= 4.72 \times 10^{28}$ [W]<br>Compare intensities so claim correct or valid conclusion if **ecf** used (1)<br><br>**To summarise:**<br><br>Correct substitution into Stefan's law (1)<br><br>Quoting or using $I = \frac{P}{4\pi d^2}$ (1)<br><br>Correct substitution and algebra (1)<br><br>Correct almost final value (1)<br>Comparison and valid comment (1) | | | | | | |
| | | | **Question 7 total** | **4** | **3** | **5** | **12** | **9** | **0** |

## AS UNIT 1 – MOTION, ENERGY AND MATTER

## SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

| Question | AO1 | AO2 | AO3 | TOTAL MARK | MATHS | PRAC |
|---|---|---|---|---|---|---|
| **1** | 2 | 5 | 3 | 10 | 5 | 0 |
| **2** | 2 | 4 | 4 | 10 | 6 | 0 |
| **3** | 0 | 9 | 1 | 10 | 9 | 10 |
| **4** | 10 | 3 | 0 | 13 | 0 | 0 |
| **5** | 4 | 6 | 3 | 13 | 8 | 0 |
| **6** | 6 | 6 | 0 | 12 | 2 | 6 |
| **7** | 4 | 3 | 5 | 12 | 9 | 0 |
| **TOTAL** | **28** | **36** | **16** | **80** | **39** | **16** |