



GCE

Physics A

H556/03: Unified physics

A Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor
3. Log-in to RM Assessor and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or the RM Assessor messaging system, or by email.
5. **Crossed Out Responses**
Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses

When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)

Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)

If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)

Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add a tick to confirm that the work has been seen.

7. There is a NR (**No Response**) option. Award NR (No Response):
- if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')
 - OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.
- Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).
8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.
9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.
10. For answers marked by levels of response:
- a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
 - b. **To determine the mark within the level**, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. Annotations

Annotation		Meaning
	Correct response	Used to indicate the point at which a mark has been awarded (one tick per mark awarded).
	Incorrect response	Used to indicate an incorrect answer or a point where a mark is lost.
AE	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.
BOD	Benefit of doubt given	Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.
BP	Blank page	Use BP on additional page(s) to show that there is no additional work provided by the candidates.
CON	Contradiction	No mark can be awarded if the candidate contradicts himself or herself in the same response.
ECF	Error carried forward	Used in <u>numerical answers only</u> , unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP.
L1	Level 1	L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded.
L2	Level 2	L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded.
L3	Level 3	L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded.
POT	Power of 10 error	This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors.
SEEN	Seen	To indicate working/text has been seen by the examiner.
SF	Error in number of significant figures	Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. Penalised only once in the paper.

Annotation		Meaning
TE	Transcription error	This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulae booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks.
XP	Wrong physics or equation	Used in <u>numerical answers only</u> , unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer.
^	Omission	Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough).

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
✓	Used to indicate the point at which a mark has been awarded (one tick per mark awarded).
/	Separates marking points
Not	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.
Ignore	Statements which are irrelevant
Allow	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject Specific Marking Instructions

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

- M** marks These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.
- A** marks These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.
- C** marks These are compensatory method marks which can be scored 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 it. 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 given.
- B** marks These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

SIGNIFICANT FIGURES

If the data given in a question is to 2 sf, then allow an answer to 2 or more significant figures.

If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.

Any exception to this rule will be mentioned in the Guidance.

Question			Answer	Mark	Guidance
1	(a)	(i)	$V (= Ed) = 0.2 \times 10^{-3} \times 20,000 \times 10^3$ or $V = 4000 \text{ (V)}$	C1	Allow $F (= QE) = 1.6 \times 10^{-19} \times 0.2 \times 10^{-3}$ or $F = 3.2 \times 10^{-23} \text{ (N)}$
			$W (= QV) = 1.6 \times 10^{-19} \times 4000$	C1	Allow $W (= Fd) = 3.2 \times 10^{-23} \times 20,000 \times 10^3$
			$6.4 \times 10^{-16} \text{ (J)}$	A1	
1	(a)	(ii)	electrons move in opposite direction to (electric) field/conventional current (so electric field is) upwards	M1 A1	Allow electrons are negatively charged
1	(b)		$11.7 - 9.4 (= 2.3 \text{ eV})$ $\lambda = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{2.3 \times 1.6 \times 10^{-19}}$ $5.4 \times 10^{-7} \text{ (m)}$ Correct reasoning to select 540 nm - the middle wavelength (from red, green, UV) - the middle frequency - the middle photon energy - the middle-sized electron transition	C1 C1 A1 B1	Allow $13.6 - 11.7 (= 1.9 \text{ eV})$ or $13.6 - 9.4 (= 4.2 \text{ eV})$ Allow a <u>full</u> substitution with an energy level change of 9.4, 11.7 or 13.6 eV for this C1 mark only Allow an answer consistent with 1.9 eV or 4.2 eV (i.e. 296 nm or 654 nm gains 3 marks) Allow up to 4 marks for working backwards from stating wavelength of green light is ~550 nm i.e. $E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{550 \times 10^{-9} \times 1.6 \times 10^{-19}}$ $E = 2.3 \text{ eV}$ $11.7 - 9.4 (= 2.3 \text{ eV})$

Question			Answer	Mark	Guidance
1	(c)		(conventional) current opposite to electron flow or (right) to left (magnetic field) out of the page	B1 B1	Allow annotation of figure to show circular magnetic field lines around current or arrow labelled current towards left on Fig 1.1
1	(d)		heating effect ionisation of atoms / lightning strikes	B1 B1	 Allow (ionisation causes) horizontal force / acceleration of gas (due to $F = BIL$ / motor effect)
			Total	13	

Question			Answer	Mark	Guidance
2	(a)		(oscillating) force acting on (current carrying) wire in magnetic field	B1	Ignore $F = BIl \sin \theta$ unless quantities defined Ignore wire moves/oscillates
			(produces) waves travelling in opposite directions (along the wire) which interfere /superpose	B1	Allow forms nodes / anti-nodes for interfere Allow produces a (progressive) wave which reflects (from a fixed bridge) and interferes Allow bridge needs to be placed at integer number of half wavelengths (for a standing wave to form)
2	(b)	(i)	B/flux density (only) affects size of force / amplitude (of stationary wave)	B1	Ignore flux density does not affect frequency / wavelength / speed / period accept <u>maximum</u> displacement for amplitude
2	(b)	(ii)	measure length of wire (with ruler) and measure mass of wire using balance	B1	Allow any other valid method that includes measurement
			mass per unit length is mass divided by length	B1	Allow any other valid analysis eg finding gradient of a suitable graph
2	(c)	(i)	worst acceptable line drawn through all error bars	B1	Must pass through +/- half a small square of: RH extreme of bottom bar and LH extreme of top bar for steepest line or LH extreme of bottom bar and RH extreme of <u>penultimate</u> bar for shallowest line

2	(c)	(ii)	(calculated) gradient of line of worst fit (calculated) absolute uncertainty in gradient (calculated) percentage uncertainty	M1 C1 A1	Accept gradient within the ranges 2.40 to 2.70 for shallow line or 3.00 to 3.30 for steep line. Accept 0.15 – 0.45 Accept 5.0% to 16.0%
2	(c)	(iii)	$f = \frac{\text{gradient}}{2\sqrt{\mu}}$ $\left(f = \frac{2.81}{2\sqrt{8.0 \times 10^{-4}}} = \right) 49.7 \text{ (Hz)}$ (% uncertainty =) (c)(ii) + 1 correctly evaluated	C1 A1 B1	Allow any subject and any substituted gradient for this C1 mark only Accept 50 (Hz) (2 sig figs) on answer line if 49.7 or 49.67 seen in working Note $f = 49.674$ eg (11 + 1 =) 12 (%)
2	(c)	(iv)	% difference (= $\frac{50.0 - 49.7}{50.0} \times 100\%$) = 0.6 % correct comparison of values for % uncertainty and % difference and appropriate comment	M1 A1	ECF their f from (c)(iii) for 49.7 but not $f = 50(.0)$ Note if 49.67 is used % diff is 0.66 % Accept calculated upper (and lower) bound of f i.e. $49.7 \times (1 + \% \text{ uncertainty from (c)(iii)/100})$ eg $49.7 \times 1.12 = 56 \text{ Hz}$ Accept calculated upper bound > 50 Hz therefore accurate / falls within the range of stated bounds eg 56 Hz > 50 Hz so accurate
			Total	14	

Question			Answer	Mark	Guidance
3	(a)		(motion of truck) moves/spins coil/wire in magnetic field	B1	Allow (motion of truck) moves/spins magnet in coil of wire or description of relative motion between coil and magnet/magnetic field
			(rate of) change in flux linkage (causes induced e.m.f. driving a current through the battery)	B1	Allow lines of flux are cut (inducing an emf)
			Any one from: • <u>work done</u> by gravity / weight (reduces GPE) • <u>work done</u> on charge by magnetic field (transfer to electric energy) • <u>work done</u> by charge passing through battery (transfer to chemical energy)	B1	
3	(b)		Any 3 from: • (internal energy is) sum of kinetic and potential energy of particles (in the wax) • increase in temperature in solid wax corresponds to particles increasing their kinetic energy (but potential energy remains constant) • change of state corresponds to particles increasing their potential energy • increase in temperature in liquid wax corresponds to particles increasing their kinetic energy (but potential energy remains constant)	B1x3	Accept KE for kinetic energy and PE for potential energy throughout Allow $KE \propto \text{temperature}$ Allow during change of state work is being done against intermolecular attractive forces Note only award KE mark once unless one comment is clearly for solid wax and the other for liquid wax i.e. before and after melting

3	(c)	Level 3 (5–6 marks) Clear correct calculations, including efficiency, for both sand and wax and clear quantitative discussion comparing the two methods or limited quantitative discussion and discussion of pros/cons of both methods <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Some correct calculations for both sand and wax including a specific heat capacity calculation OR Limited calculation(s) for sand and/or wax and some discussion of pros/cons <i>There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Limited calculation(s) OR Limited discussion <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>	6 × B1	Use level of response annotations in RM Assessor No ticks Indicative scientific points may include: Calculations • $\Delta GPE = mg\Delta h \approx 1 \times 9.81 \times 1000 = 9.8 \text{ kJ}$ • $\text{useful} = 0.7 \times 10 \text{ kJ} = 6.9 \text{ kJ}$ • $\Delta E = mc\Delta\theta = 1 \times 2.6 \times (51-18) = 86 \text{ kJ}$ • $\Delta E = mL = 1 \times 160 = 160 \text{ kJ}$ • $\Delta E = mc\Delta\theta = 1 \times 3.0 \times (70-51) = 57 \text{ kJ}$ • Total E for wax = 300 kJ • useful for wax = $0.95 \times 300 \approx 290 \text{ kJ}$ Discussion • Thermal system stores ~40 times as much energy per kg of material • GPE pros: readily available material; no new infrastructure required; energy stored in batteries can be directly released to the grid; energy can be stored indefinitely • GPE cons: requires mountainous terrain; slow response time • Thermal pros: high energy density; easily scaled up or automated; can be built in any location • Thermal cons: energy stored cannot readily be converted to electrical energy for the grid; limited storage time as wax cools
		Total	12	

Question			Answer	Mark	Guidance
4	(a)		(below pivot to provide restoring force so that) needle rests vertically (with the pointer at the bottom) when there is no charge	B1	Must be clear that needle is vertical when at rest eg $\theta = 0^\circ$
			(short distance so that moment due to weight is as small as possible) to increase sensitivity	B1	Allow to increase the resolution / to be able to clearly discriminate between charge values
4	(b)	(i)	Relevant comment and curved line of best fit drawn through 0.3 kV (by eye/ ± 1 small square) at 0 deflection	B1	Allow statement that curved line of best fit would pass through 0.3 kV if line is missing/incomplete
4	(b)	(ii)	value read from their lbf at 45 degrees their value read at 45 degrees corrected for zero error $Q = CV = 20 \times 10^{-12} \times 1300 (= 2.6 \times 10^{-8} \text{ C})$ $2.6 \times 10^{-8} \div 1.6 \times 10^{-19}$ 1.6×10^{11} (electrons)	B1 B1 C1 A1	Allow 1.60 ± 0.05 kV if no line has been drawn Expect 1.30 ± 0.05 for range stated above Allow any value for V between 0 and 4.5 kV Expect $(2.5 \text{ to } 2.7) \times 10^{-8}$ for ranges above $(1.6 \text{ to } 1.7) \times 10^{11}$ Note answers in the range $(1.9 - 2.1) \times 10^{11}$ gain both calculation marks (zero error not applied). Accept this answer given to one sig fig. An answer of 2×10^{11} (one sig fig) gains 4 marks if $(1.6 \text{ to } 1.7) \times 10^{11}$ seen in working Note an answer of $(1.6 \text{ to } 1.7) \times 10^{11}$ gains 4 marks

15

5	(b)	(ii)	Level 3 (5–6 marks) Clear description of how both gamma and X-rays are produced and clear comparison of practical considerations, including safety <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Clear description how both gamma and X-rays are produced OR Clear description of how gamma <u>or</u> X-rays are produced and limited advantages/disadvantages of practical considerations OR Limited description of how both gamma and X-rays are produced and clear advantages/disadvantages of practical considerations <i>There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.</i> Level 1 (1–2 marks) Limited description or Limited comparison <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>	6 × B1	Use level of response annotations in RM Assessor Indicative scientific points may include: Description Gamma rays production - radioactive <u>decay</u> of unstable nuclei - following alpha or beta decay (from) production of Tc-99m, Co-60 - from the de-excitation of <u>nuclei</u> - from <u>annihilation</u> of particle-antiparticle (pairs) X-ray production - electrons accelerated to a high velocity / by large p.d. - electrons collide with anode/metal target - kinetic energy converted to X-ray photons - formed when <u>electrons</u> (in target) de-excite - produced by deceleration of fast electrons Comparison - Safety: similar penetration and ionisation properties so shielding requirements are similar / short exposure time / precautions when handling/storing sources - X-ray: source requires large equipment / requires large electrical power / can be turned on and off / energy of X-rays can be controlled - Gamma source: can be small / no electrical power source required / continuous/spontaneous emission / must be replaced at regular intervals / intensity decreases over time
			Total	9	

Question			Answer	Mark	Guidance
6	(a)	(i)	$\text{strain} = \frac{\text{extension}}{\text{original length}}$	B1	Allow (strain is) extension per unit length Allow compression for extension Allow $\varepsilon = \frac{x}{L}$ with terms defined
6	(a)	(ii)	use of area = πr^2 $F = \text{Young modulus} \times \text{strain} \times \text{area}$ $F = 130 \times 10^9 \times 10^{-21} \times \pi \times (1.0 \times 10^{-3})^2$ $4(.08) \times 10^{-16} \text{ (N)}$	C1 C1 A1	Allow use of $\pi d^2/4$ or $\pi (d/2)^2$ Note area = $3.14 \times 10^{-6} \text{ (m}^2\text{)}$ Allow calculation using $E = \sigma / \varepsilon$ and $F = \sigma A$ i.e. stress = $130 \times 10^9 \times 10^{-21} = 1.3 \times 10^{-10}$ and $F = 1.3 \times 10^{-10} \times \pi \times (1.0 \times 10^{-3})^2$ Allow 2 marks for $4(.08) \times 10^n \text{ (N)}$
6	(a)	(iii)	strain is <u>very small</u> / <u>very small</u> force required to produce similar strain difficult to distinguish signal from background noise / signal will be hidden by the effect of other forces	B1 B1	Ignore references to measuring instruments/detectors

6	(b)	(i)	$F = -\frac{GM^2}{D^2}$	B1	Accept correct formula without negative sign
6	(b)	(ii)	one from: $\frac{Mv^2}{D/2} = \frac{GM^2}{D^2}$ $v = \frac{\pi D}{T}$ one from: $E = -\frac{GM^2}{D} + 2\left(\frac{1}{2}Mv^2\right)$ $E = -\frac{GM^2}{D} + 2\left(\frac{1}{4}\frac{GM^2}{D}\right)$ steps leading to $E = k (\pi^2 G^2 M^5)^{1/3} (1/T^{2/3})$	M1 M1 A1	Allow m for M throughout GPE must be negative for this marking point Note this comes from substituting $v^2 = \frac{GM}{2D}$ eg use of $v^2 = \frac{GM}{2D}$ and $v = \frac{\pi D}{T}$ to obtain $D^3 = \frac{GMT^2}{2\pi^2}$ and $E^3 = -\frac{G^3 M^6}{8D^3}$

6	(b)	(iii)	A to C = $0.4247 - 0.4173 (= 7.4 \times 10^{-3})$ or C to E = $0.4293 - 0.4247 (= 4.6 \times 10^{-3})$ $E = -2.04 \times 10^{46} \times (7.4 \times 10^{-3})^{-2/3} (= -5.38 \times 10^{47})$ or $E = -2.04 \times 10^{46} \times (4.6 \times 10^{-3})^{-2/3} (= -7.38 \times 10^{47})$ $(7.38 - 5.37) \times 10^{47} = 2(.0) \times 10^{47} \text{ J}$	C1	Accept 7.2×10^{-3} to 7.6×10^{-3} Accept 4.4×10^{-3} to 4.8×10^{-3}
				C1	Accept -5.28×10^{47} to -5.47×10^{47} Accept -7.17×10^{47} to -7.60×10^{47}
				A1	Accept 1.69×10^{47} to 2.32×10^{47}
6	(b)	(iv)	$\Delta t = 0.4273 - 0.4214 = 5.9 \times 10^{-3} \text{ s}$ $P (= \frac{E}{t}) = \frac{2.01 \times 10^{47}}{5.9 \times 10^{-3}} = 3.4 \times 10^{49} \text{ (W)}$	C1	Accept 5.8×10^{-3} to 6.1×10^{-3}
				A1	Allow calculation using value of E calculated in 6(b)iii Expect 3.30×10^{49} to 3.47×10^{49} if 2.01×10^{47} used
			Total	15	

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