GCE

Physics A

H156/02: Depth in physics

AS Level

Mark Scheme for June 2024

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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.

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 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 posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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. Award No Response (NR) if:
    - there is nothing written in the answer space

Award Zero '0' if:
    - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

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. **Level of response (LoR)**

Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1 (L1), Level 2 (L2) or Level 3 (L3), **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

Once the level is located, award the higher or lower mark.

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

- the **science** content determines the **level**
- the **communication statement** determines the **mark within a level**.

Levels of response questions on this paper are **3** and **8**.

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 numerical answers only, 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 numerical answers only, 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
/	alternative and acceptable answers for the same marking point
Reject	Answers which are not worthy of credit
Not	Answers which are not worthy of credit
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.

General rule: For substitution into an equation, allow any subject - unless stated otherwise in the guidance

Question			Answer	Mark	Guidance
1	(a)		$\frac{2\pi \times 1.19(\times 10^3)}{4.29 \times 10^4}$ 0.17 (m s^{-1})	C1 A1	**Allow** one mark for 1.7 to any power of ten 0.174
1	(b)		Similarity: same magnitude or same speed or (still) 0.17 (m s^{-1}) Difference: (different) direction or (approximately) opposite direction	B1 B1	**Allow ECF** from **(a)** for 0.17 **Not** same velocity **Allow** negative
1	(c)	(i)	$\frac{11\times60+25}{11\times60+55}$ OR $\frac{4.29\times10^4-30\times60}{4.29\times10^4}$ OR $\frac{11\times60\times60+25\times60}{4.29\times10^4}$ (=0.9580…)	M1 A0	$\frac{685}{715}$, $\frac{4.11\times10^4}{4.29\times10^4}$
1	(c)	(ii)	$r_N{}^3 = 0.958^2 \times 1.19^3$ OR $\left(\frac{11\times60\times60+25\times60}{4.29\times10^4}\right)^2 \times 1.19^3$ OR 1.55 (×10^9) r_N =1.156 to any power of ten r_N =1.16 (km) given to 3 significant figures	C1 C1 A1	**Allow** any rearrangement $r_N = 1.19\sqrt[3]{0.958^2}$ **Allow ECF** from **(c)(i)** minimum 3sf **Note** must be km
			Total	7	

Question			Answer	Mark	Guidance
2	(a)		(Net) force is (proportional to) the rate of change of momentum	B1	**Allow** $F = \frac{\Delta p}{\Delta t}$ with symbols defined **Ignore** *F*=*ma* (special case)
2	(b)	(i)	(0.16 × 20 =) 3.2 N s or kg m s^{-1}	B1 B1	
2	(b)	(ii)	$\left(\frac{3.2}{0.033} =\right)$ 97 (N)	B1	**Allow ECF** from **(b)(i)**
2	(c)	(i)	(For a perfectly elastic collision) kinetic energy is conserved	B1	**Allow** (total) kinetic energy before (the collision) is equal to the (total) kinetic energy after (the collision)
2	(c)	(ii)	Conservation of momentum: 0.16 × 20 = (*m* + 0.16) × 8 + 0.16 × –12 (*m* + 0.16) × 8 = 5.12 or (*m* + 0.16) = 0.64 0.48 (kg) OR Conservation of kinetic energy: ½ × 0.16 × 20^2 =½ × (*m* + 0.16) × 8^2 +½ × 0.16 × (–)12^2 32 × (*m* + 0.16) = 20.48 or 0.64 0.48 (kg)	 C1 C1 A1 C1 C1 A1	**Allow ECF** from **(b)(i)** for this method **Allow** 0.16 × 20 = (*M*) × 8 + 0.16 × –12 **Allow** 8*M* = 5.12 **Note** 0.64 gains two marks 32 = 32 × (*m* + 0.16) + 11.52 **Allow** 32*M* = 20.48 **Note** 0.64 gains two marks
			Total	8	

Question			Answer	Mark	Guidance
3*			**Level 3 (5–6 marks)** Clear description of method to measure *h* and *t* **and** graph analysed to determine *g* and the percentage uncertainty in *g* *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some description of method to measure *h* and *t* **and** analysis of graph attempted to determine *g* and percentage uncertainty in *g* **or** Clear description of method to measure *h* and *t* **and** limited analysis of graph to determine *g* **or** Limited description of method to measure *h* or *t* **and** graph analysed to determine *g* and the percentage uncertainty in *g* *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description of the method to measure *h* or *t* **or** Limited analysis to determine *g* *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*	**B1× 6**	Use level of response annotations in RM Assessor **Indicative scientific points may include:** **Description of method to** measure *h* and *t* • Use of <u>metre</u> rule(r) / tape measure (not ruler) • Place rule in retort stand • Use of set square / fiducial marker • Timer (or datalogger / computer with detail) connected to electromagnet / trapdoor • Switch off electromagnet to start timer and drop ball • When ball hits trapdoor timer is stopped. • Allow for diameter of ball in height measurement • Resolution of instruments millimetre /millisecond **Ignore** light gates, video **Analysis of data** • Gradient = $\sqrt{\frac{2}{g}}$ or $g = \frac{2}{\text{gradient}^2}$ • Evidence of method of determining gradient • Gradient in the range 0.44 to 0.47 • Determines *g* (≈9.5 m s^{-2}) • Correct power of ten and unit • Draws worst acceptable line • Determines gradient of worst acceptable line • Calculates absolute uncertainty in gradient • Determines *g* from worst acceptable line • Determines percentage uncertainty in gradient • Percentage uncertainty in *g* either 2 × percentage uncertainty in gradient or from *g* values

Question			Answer	Mark	Guidance
			0 marks *No response or no response worthy of credit.*		
			Total	**6**	

Question			Answer	Mark	Guidance
4	(a)	(i)	Calipers Repeat measurements in <u>different</u> / <u>several</u> positions <u>and</u> determine the mean (thickness)	B1 B1	**Allow** micrometer **NOT** rule(r) **Allow** places / points for positions **Allow** a specified number of positions for different **Allow** average for mean
4	(a)	(ii)	$\frac{1}{2} \times 0.600 \times 0.750 \times 2.83 (\times 10^{-2})$ OR 6.3675 ($\times 10^{-3}$) 630 (kg m^{-3})	C1 A1	 **Allow** one mark for 6.3 or 6.25 (power of ten) **Allow** one mark for 310 or 313 (incorrect volume)
4	(b)	(i)	the point where the <u>weight</u> of the prism appears to act	B1	**Allow** gravitational force / gravity force for weight **Not** gravity, mass
4	(b)	(ii)	One straight line drawn from mid-point of one side (by eye) to opposite apex At least two straight lines, each drawn from mid-point of one side (by eye) to opposite apex, and C (labelled) in the range 4.8 cm to 5.2 cm from the centre of PQ candidate's vertical distance from PQ $\times$ 0.05 = in the range 0.24 m to 0.26 m	C1 M1 A1	 **Not** 0.25 $\div$ 0.05
4	(c)	(i)	Sum of the forces / net / resultant force (in any direction) = 0 Sum of the moments / net / resultant moment = 0 Sum of the moments / net / resultant moment <u>about any point</u> = 0	B1 M1 A1	**Allow** (total) upward force = (total) downwards force **Allow** (total) clockwise moment = (total) anticlockwise moment **Allow** torque for moment

Question			Answer	Mark	Guidance
4	(c)	(ii)	Weight = 3.98 × 9.81 OR 39 3.98 × 9.81 × 0.25 = *F* × 0.75 13 (N)	C1 C1 A1	**Allow** 3.98 × 10 OR 40 (since change in final answer is negligible) **Allow** two marks for 1.3 (omits *g*)
			Total	14	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>5</td><td>(a)</td><td>(i)</td><td>510 (THz)</td><td>B1</td><td>Allow correct answer in answer space</td></tr>
<tr><td>5</td><td>(a)</td><td>(ii)</td><td><table><tr><th>Glass</th></tr><tr><td>1.97×10^8</td></tr><tr><td>387</td></tr><tr><td>510</td></tr></table>
One correct scores one mark
All correct and in the table scores two marks</td><td>B1
B1</td><td>Allow ECF for wavelength for correct speed of wave / same frequency as (a)(i)
Allow 386, for 387
Allow 2sf answers, e.g.<table><tr><td>2.0×10^8</td></tr><tr><td>390</td></tr><tr><td>510</td></tr></table>ECF from (a)(i)
Ignore units in table</td></tr>
<tr><td>5</td><td>(b)</td><td>(i)</td><td>Normal drawn 90° to the surface at P (by eye) and angle between normal and incident ray labelled i and angle between normal and refracted ray labelled r</td><td>B1</td><td></td></tr>
<tr><td>5</td><td>(b)</td><td>(ii)</td><td>Any four from:
Use a single slit / yellow filter (in the ray box)
Use of dim lighting / darkened room
Draw around the glass block
Use a protractor to measure 90° for the normal OR to measure angles
Draw crosses / use pins (a long way apart) on the <u>incident</u> ray / mark incident ray (with ruler)
Mark point Q
(Remove block and) then join P to <u>marked</u> point Q</td><td>4 x B1</td><td></td></tr>
<tr><td>5</td><td>(b)</td><td>(iii)</td><td>$\sin r = \frac{\sin 49.9}{1.52}$ OR $r = \sin^{-1}\left(\frac{\sin 49.9}{1.52}\right)$ OR
$\sin r = 0.503$ OR $r = \sin^{-1}(0.503)$</td><td>M1

A0</td><td></td></tr>
</table>

Question			Answer	Mark	Guidance
5	(b)	(iv)	Angle of incidence, i = (90-30 =) 60°	M1	**Allow** 59.8° (use of 30.2°) **Allow** ECF from (b)(iii)
			$C = \sin^{-1}\left(\frac{1}{1.52}\right) = 41(°)$	M1	
			$i > C$	A1	**Allow** 60(°)> 41(°) Do not allow 49.9 > 41
5	(b)	(v)	Mirror image about vertical plane at Q by eye to where ray leaves the block and bends away from the normal	B1	**Ignore** other lines (since could be due to answering (ii)
			Total	13	

Question			Answer	Mark	Guidance
6	(a)		4 (ms) OR 0.004 (s) 250 (Hz)	C1 A1	 **Allow** one mark for 0.25 (Hz) to any power of ten
6	(b)		One node drawn at closed end and one antinode drawn at open end N and A correctly labelled	B1 B1	
6	(c)		(3×250=) 750 (Hz)	B1	**Allow ECF** from (a) **Not** ECF from (b)
			Total	5	

Question			Answer	Mark	Guidance
7	(a)	(i)	Since the current is zero, the (terminal) p.d. / voltmeter reading is the e.m.f.	B1	no p.d. across *r* as $I = 0$
	(a)	(ii)	$\frac{4.57-4.50}{0.018} = 3.8888$ ... OR $\frac{0.07}{0.018} = 3.8888$ (3.9 Ω)	M1 A0	**Allow** 4.57 = 4.50 + 18 × 10^{-3} × *r* and 3.88… **Allow** 4.57 = 18 × 10^{-3} × 250+ 18 × 10^{-3} × *r* and 3.88…
		(iii)	$\frac{1}{R} = \frac{1}{300} + \frac{1}{300}$ and $\frac{1}{R} = \frac{1}{300} + \frac{1}{300} + \frac{1}{300}$ 150 + 100 = 250 Ω OR $R = \frac{4.5(\text{V})}{18(\text{mA})}$ or $\frac{4.5}{0.018}$ = 250 Ω	M1	$R = \frac{300}{2} + \frac{300}{3}$ **Allow** $R = \frac{4.57(\text{V})}{18(\text{mA})} - 3.9$
7	(b)	(i)	($0.018^2 \times 3.9 \times 300 = 0.379$) 0.38 (J)	A1	($0.018 \times 0.07 \times 300 = 0.378$)
7	(b)	(ii)	0.018 × 300 OR 5.4 (C) OR $Q = \frac{0.38}{0.07} = 5.43$ $\left(N = \frac{5.43}{1.60 \times 10^{-19}} =\right) 3.4 \times 10^{19}$	C1 A1	**Allow ecf** from (b)(i) For use of 24 J (calculating energy in circuit) $Q = \frac{24}{4.5} =$ 5.33 which gives 3.3×10^{19}
7	(b)	(iii)	I_X = 0.009 A **and** I_Y = 0.006 A 1.5	C1 A1	**Allow** use of total current through 1st parallel combination = total current through second parallel combination and $I_X = I / 2$ **and** $I_Y = I / 3$ **Allow** $\frac{3}{2}$, 3: 2
7	(c)	(i)	decreases	B1	
7	(c)	(ii)	increases	B1	
			Total	11	

Question			Answer	Mark	Guidance
8*			**Level 3 (5–6 marks)** Clear description of experiment and observations **and** detailed comparison of de Broglie wavelengths *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some description of experiment **and** observations **and** some comparison of de Broglie wavelengths **or** Limited description of experiment and observations **and** detailed comparison of de Broglie wavelengths **or** Clear description of experiment and observations **and** limited comparison of de Broglie wavelengths *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description of experiment and observations **or** Attempt at calculating the de Broglie wavelength of the car *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	**B1× 6**	Use level of response annotations in RM Assessor **Indicative scientific points may include:** **Description of experiment and observations** • Electrons accelerated by a (high) p.d. • In a vacuum • Electrons fired at a (graphite) target • Rings observed • Diagram showing rings (or apparatus set-up) • Due to diffraction between spacing of atoms • So wavelength ≈ spacing of atoms • Increase in accelerating p.d. decreases spacing of rings • Multiple layers of (graphite) atoms means diffraction occurs in all directions • Since diffraction occurs in all directions, rings are observed • Avoid touching the terminals / use insulated connections **Comparison of the Broglie wavelengths** • λ electrons in the experiment ≈10^{-10} m • $\lambda = \frac{h}{p}$ • Estimate of mass of car: 500 kg to 3000 kg • Speed of car: 30.5 or 30.6 (279/9) m s^{-1} • λ car ≈ 7 ×10^{-39} m to 4 ×10^{-38} m • λ electrons >> λ car.

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