OCR
Oxford Cambridge and RSA

GCE

Physics A

H156/02: Depth in physics

AS Level

Mark Scheme for June 2023

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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 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 2 and 7.

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)	(i)	$\left(\frac{(-)18}{2.7} =\right)$ (-) 6.7 (m s^{-2})	A1	**Ignore** sign
1	(a)	(ii)	(1200 × 6.7 =) 8000 (N)	B1	**ALLOW ECF** from **(a)(i)** **IGNORE** "-"
1	(a)	(iii)	$d = 18\times0.7+\frac{1}{2}\times18\times2.7$ OR $d = (3.4+0.7)\times\frac{1}{2}\times18$ 37 (m)	C1 A1	**ALLOW ECF** from **(a)(i)** **ALLOW** $d = 18\times0.7+18\times2.7-\frac{1}{2}\times6.7\times2.7^2$ 36.9 **ALLOW** one mark for $\left(\frac{1}{2}\times18\times2.7 =\right) 24(.3)$ (m)
1	(a)	(iv)	8000 × 24(.3) OR 8000 × $\frac{1}{2}\times18\times2.7$ 190 000 (J)	C1 A1	**ALLOW ECF** from **(a)(i)** and **(ii)** and **(iii)** **ALLOW** $\frac{1}{2}\times1200\times18^2$ **ALLOW** 194 000 / 200 000 (J) **ALLOW** one mark for $(8000\times37 =)\ 296000$ (J)
1	(b)		Horizontal line starting at 9 m s^{-1} Horizontal line from (0, 9) to (0.7, 9) <u>and</u> a straight line from (0.7, 9) to between (2.0, 0) and 2.1, 0)	C1 A1	 **Note** calculation gives 2.05 s
1	(c)	(i)	Horizontal line / section would be longer (and no change to sloping line)	B1	**IGNORE** idea of a tired driver applying a different braking force **IGNORE** thinking time / distance
1	(c)	(ii)	Sloping line / section would be steeper (and no change to horizontal line)	B1	**ALLOW** (magnitude of) gradient is greater **IGNORE** gradient is lower **IGNORE** braking time / distance
			Total	10	

Question			Answer	Mark	Guidance
2*			**Level 3 (5–6 marks)** Clear description of method including a diagram **and** clear explanation as to how the data can be analysed to determine *K* *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 **and** some analysis of data **or** Clear description of method including a diagram but limited analysis **or** Limited description but explanation as to how the data can be analysed to determine *K* *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 **or** Limited analysis *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 method** • Diagram showing liquid in a container • Marks added to side of container • Use of stopwatch to measure time *t* for fall • Repeat measurements of *t* and average *t* • Repeat for different *d* • Measure *d* with a micrometer / calipers • Repeat measurements of *d* in different directions • Method to determine density of balls • Method to determine density of liquid • Method of ensuring *v* is terminal velocity • Method to remove balls from cylinder • Container in a tray / supported • Use of a tall container **Analysis of data** • *v* = distance / time • density = mass / volume • volume of ball = $\frac{4\pi r^3}{3}$ • Plot graph of *v* against d^2 • If relationship is correct, graph should be a straight line passing through the origin • $K = \frac{(\rho-\sigma)g}{18\times\text{gradient}}$

Question			Answer	Mark	Guidance
			Total	**6**	

Question			Answer	Mark	Guidance
3	(a)		22.3 cos 84 (= 2.33) 2.33	M1 A0	**ALLOW** 22.3 sin 6
3	(b)		$v_v{}^2 = 2.33^2 + 2 \times 9.81 \times 2.4$ $v_v = \sqrt{52.517}$ OR 7.247 7.25	M1 M1 A0	**ALLOW ECF** from (a)
3	(c)		u_h =22.3 sin 84 = 22.2 $v = \sqrt{22.2^2 + 7.25^2} = 23.35$ $\left(= \frac{1}{2} \times 0.210 \times 23.35^2\right) = 57.2$ (J) OR Change in potential energy = 0.210 × 9.81× 2.40 = 4.94 Initial kinetic energy = $\frac{1}{2} \times 0.21 \times 22.3^2$ OR 52.2 (J) (4.94 + 52.2 =) 57.1 (J)	C1 C1 A1 C1 C1 A1	**ALLOW** v^2 = 545 **ALLOW** 57.2 (J)
3	(d)		(change of) Momentum = mass × (change of) velocity As velocity increases, the momentum increases OR force = rate of change of momentum gravitational force acts on the ball and increases momentum OR Momentum is a vector quantity, change in direction means that the momentum changes.	M1 A1 M1 A1 M1 A1	**ALLOW** changes for increases
			Total	8	

Question			Answer	Mark	Guidance
4	(a)	(i)	callipers	B1	
4	(a)	(ii)	32.7 ± 0.2 (mm)	B1	
4	(a)	(iii)	18×0.0327 $(\frac{18 \times 0.0327}{9.81} =)$ 0.060 (2sf)	C1 A1	**ALLOW ECF** from **(a)(ii)** **ALLOW** 36 × 0.01635 (alternative method; 1 spring) **Note** Answer must be 2 sf **ALLOW** one mark for 0.06 (1sf) **ALLOW** one mark for 60 (power of ten error)
4	(a)	(iv)	$W = \frac{1}{2} \times 18 \times 0.0327^2$ 9.6×10^{-3} (J)	C1 A1	**ALLOW ECF** from **(a)(ii)** and **(iii)** for POT and/or *k* E.g. For x = 32.7: 9.6×10^3 (J) For k = 36 N m^{-1}: 19.2×10^{-3} (J) For x = 32.7 and k = 36 N m^{-1}: 19.2×10^3(J)
4	(b)	(i)	Evidence that gradient = $\frac{AE}{L}$ $A = \frac{1600 \times 4.4}{120 \times 10^9}$ 5.9×10^{-8} (m^2)	C1 C1 A1	e.g. $F = \frac{AE}{L}x$ **ALLOW** *F* and *x* correctly read from linear section and substituted into *A =FL/Ex* **Note** 5.9×10^n scores two marks
4	(b)	(ii)	Area under graph = energy Evidence of <u>area</u> under graph determined, e.g. Counting squares (1cm^3 = 1.25×10^{-4} J and number of squares counted squares) OR Adding/subtracting shapes in the non-linear part 4.0×10^{-3} (J) to 4.4×10^{-3} (J)	C1 M1 A1	 **IGNORE** sf

Question			Answer	Mark	Guidance
			Total	**12**	

Question			Answer	Mark	Guidance
5	(a)	(i)	Transverse because the oscillations / vibrations are at right angles / perpendicular to the direction of travel / energy transfer	B1	**ALLOW** oscillations / vibrations vertical and direction of travel is horizontal
	(a)	(ii)	Plane polarised because the oscillations / vibrations are all in the vertical / (only) one plane / direction	B1	
5	(b)		2.5 (Hz)	B1	
5	(c)	(i)	Path difference = (20.2 – 12.2 =) 8.0 cm Path difference = $\left(\frac{8.0}{3.2} =\right) 2.5\ (\lambda)$ Destructive interference	C1 M1 A1	
5	(c)	(ii)	Path difference = (19.7 – 12.5 =) 7.2 cm Path difference = $\left(\frac{7.2}{3.2} =\right) 2.25\ (\lambda)$ $\frac{\pi}{2}$ (rad)	C1 C1 A1	**ALLOW** 1.6 (rad) OR $\frac{9\pi}{2}$ OR 14 (rad)
			Total	9	

Question			Answer	Mark	Guidance
6	(a)		(filament) lamp	B1	
6	(b)		**E**	B1	**ALLOW** 0 – 20 V, ± 0.01 V
6	(c)	(i)	Current in Z = 180 mA $\frac{4.8}{0.220-0.180} = \frac{4.8}{0.040}$ 120 (Ω)	C1 M1 A0	May be on graph **ALLOW** calculation of resistance of parallel network (21.8 Ω) and resistance of lamp (26.7 Ω) substituted into parallel resistors formula 119 Ω
6	(c)	(ii)	(*E* =) 5.72 (V) $\frac{5.72 - 4.80}{0.220}$ (*r* =) 4.2 (Ω)	B1 C1 A1	 4.18
6	(d)		Current / ammeter reading increases (since) total / overall resistance of the circuit decreases (Larger current means) Ir or lost volts is greater / greater proportion of V across the *r* So voltmeter reading decreases	B1 B1 M1 A1	 **IGNORE** *R* decreases (repeats question)
			Total	11	

Question			Answer	Mark	Guidance
7*			**Level 3 (5–6 marks)** Clear description of method to determine *f* **and** graph analysed to determine *v* and the percentage uncertainty in *v* *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 determine *f* **and** some analysis of data to determine *v* or the percentage uncertainty in *v* **or** Limited description of method to determine *f* **and** graph analysed to determine *v* and an attempt to determine the percentage uncertainty in *v* **or** Clear description of method to determine *f* **and** limited analysis of graph *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 determine *f* **or** Limited analysis to determine *v*	**B1× 6**	Use level of response annotations in RM Assessor **Indicative scientific points may include:** **Description of method** • Adjust frequency until maximum amplitude observed / heard • Start from a low frequency • Since fundamental frequency is the lowest resonance • Measure period of wave on oscilloscope • Period = timebase x horizontal distance • $f = 1/T$ • read frequency from signal generator. **Analysis of data** • Gradient = $-\frac{4}{v}$ • Determines gradient of line (-0.012 Hz^{-1} m^{-1}) • Determines *v* (330 to 344 m s^{-1}) • Correct power of ten and unit • Draws worst acceptable line • Determines gradient of worst acceptable line • Calculates absolute uncertainty in gradient • Determines percentage uncertainty in gradient • Percentage uncertainty in gradient = percentage uncertainty in *v*

Question			Answer	Mark	Guidance
			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.*		
			Total	**6**	

Question			Answer	Mark	Guidance
8	(a)	(i)	Any one from: • The energy from photons is absorbed by (photo)electrons • The energy of a photon is greater than the work function	B1	
8	(a)	(ii)	The minimum frequency of the incident radiation needed to emit a (photo)electron	B1	**ALLOW** The minimum frequency of the incident radiation needed to overcome the work function
8	(b)	(i)	$1.9 \times 1.60 \times 10^{-19}$ or 3.04×10^{-19} $(3.0 \times 10^{-19}$ J)	M1 A0	
8	(b)	(ii)	$f = 990\ (\text{THz}) + \frac{3.0\times10^{-19}}{6.63\times10^{-34}}\ (= 1450\ (\text{THz}))$ $\lambda = \frac{3.0 \times 10^{8}}{1450 \times 10^{12}}$ $\lambda = 2.1 \times 10^{-7}$ (m) OR Energy of photon = $6.56 \times 10^{-19} + 3.0 \times 10^{-19}$ (J) $\lambda = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{9.56 \times 10^{-19}}$ $\lambda = 2.1 \times 10^{-7}$ (m)	C1 C1 A1 C1 C1 A1	**Allow** alternative methods **Note** 2.1×10^{n} scores two marks **Note** 6.6×10^{-7} scores zero (omits work function) **Note** 3.0×10^{-7} scores zero (omits energy of electrons) **Note** 2.1×10^{n} scores two marks
8	(c)	(i)	no change / stays the same	B1	

Question			Answer	Mark	Guidance
8	(c)	(ii)	doubles	B1	
			Total	**8**	

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