OCR
Oxford Cambridge and RSA

GCE

Physics A

H156/02: Depth in physics

AS Level

Mark Scheme for June 2022

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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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.

PREPARATION FOR MARKING ON-SCREEN

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM assessor Online Training* and the *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the Instructions for On-Screen Marking and 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 and the **required number** of standardisation responses.

MARKING INSTRUCTIONS – FOR MARKING ON-SCREEN AND FOR PAPER BASED 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% deadlines. If you experience problems, you must contact your Team Leader 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.

   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. On each blank page the icon BP must be inserted to confirm that the page has been checked. For additional objects (if present), a tick must be inserted on each page to confirm that it has been checked.
Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there.

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).

   The hash key (#) on your keyboard will enter NR.
   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question)
   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 scoris messaging system, or e-mail.

9. **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 **8**.

10. Here are the subject specific instructions for this question paper.

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

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.

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.

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.

A marks These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

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 Additional Guidance.

11. Annotations available in RM Assessor

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.**
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

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

Question			Answer	Marks	Guidance
1	(a)		Use a micrometer / caliper (to measure the diameter of the ball)	B1	**Ignore** radius
			Repeat readings in different directions and average	B1	**Allow** places / points / positions for directions AW
			r = (mean) diameter ÷ 2	B1	
	(b)		$\rho = \frac{169 - 96}{87}$ or $\frac{73}{87}$	C1	**Ignore** power of tens
			$\rho = \frac{0.169 - 0.096}{87 \times 10^{-6}}$ or $\frac{0.073}{87 \times 10^{-6}}$	M1	**Note** power of tens must be seen for both mass and volume
			ρ (= 839) = 840 (kg m^{-3})	A0	
	(c)		volume = $\frac{4\pi(8.1\times10^{-3})^3}{3}$ or 2.226 × 10^{-6} (m^3) OR 840 × 9.81 × candidate's volume	C1	**Ignore** power of tens
			840 × 9.81 × 2.226 × 10^{-6} or 0.0183	M1	
			0.018 (N)	A0	
	(d)	(i)	Terminal velocity is when the velocity is constant	B1	**Allow** acceleration is zero for velocity is constant
			(Terminal) velocity is determined from the gradient	B1	
			when graph is a straight line / constant gradient OR evidence of calculation of gradient of straight section	B1	Check read-offs are appropriate.

Question			Answer	Marks	Guidance
		(ii)	Tangent drawn at t = 0.2 s extends at least two large squares (0.2 s) in the x-direction 1.2 (m s^{-1})	**M1** **A1**	 **Allow** 1.10 (m s^{-1}) to 1.30 (m s^{-1})
	(e)		$\eta = \frac{0.017 \times 9.81 - 0.018}{6\pi \times 8.1 \times 10^{-3} \times 1.8} \left(= \frac{0.14877}{6\pi \times 8.1 \times 10^{-3} \times 1.8}\right)$ 0.54 kg m^{-1} s^{-1} OR N s m^{-2} OR Pa s	**C1** **A1** **B1**	 **Allow** 0.55 **Note** for power of ten errors 607 or 0.607 or 5.4 × 10^{-4} scores one mark
			Total	**15**	

Question			Answer	Marks	Guidance
2			**Level 3 (5–6 marks)** Clear diagram and procedure and measurements including explanation of the use of one light gate **and** analysis including determination of *Q* and *R*. *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 procedure, some measurements and some analysis. OR Limited procedure, limited measurements and detailed analysis OR Detailed procedure, detailed measurements and limited analysis *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 procedure and limited measurements and 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 x 6**	**Indicative scientific points may include:** **Diagram and procedure** • labelled diagram including light gate positioned at P • card added to trolley to interrupt light beam • description of procedure • repeats experiment for each *M* • keep *d* constant • method to keep *d* constant, e.g. mark start position • method to stop trolley hitting pulley / load hitting floor e.g. cushion / sand bag • method to fix M to the trolley • use a release mechanism **Measurements** • use ruler to measure length of card / object interrupting light beam • use of balance to determine *M* • method to determine *W* • use of ruler to measure *d*. **Analysis** • v = length of card ÷ time • plot a graph of $1/v^2$ against *M* (or equivalent graph • gradient = $\frac{1}{2dW-Q}$ • *R* = *y*-intercept • $Q = 2dW - \frac{1}{\text{gradient}}$
			Total	**6**	

Question			Answer	Marks	Guidance
3	(a)		Sum of the forces / net / resultant force (in any direction) = 0 Sum of the moments / net / resultant moment (about any point) = 0 Sum of the forces <u>in any direction</u> = 0 <u>and</u> Sum of the moments /torques <u>about any point</u> = 0	M1 M1 A1	**Allow** (total) upward force = (total) downwards force **Allow** (total) clockwise moment = (total) anticlockwise moment **Allow** torque for moment
	(b)	(i)	Weight of M = 3.9 – (2.1 + 0.49) or 1.31 $M = \frac{1.31}{9.81}$ = 0.134 (kg) 0.13 (kg)	M1 M1 A0	**Allow** any rearrangement
		(ii)	1.3 × 0.1 OR 2.1 × 0.3 OR 0.49 × 0.38 $1.3 \times 0.1 + 2.1 \times 0.3 + 0.49 \times 0.38 = 0.9462$ d = 0.24 (m)	C1 C1 A1	**Allow ECF** from (b)(i) **Allow** 1.28 or 1.31 for 1.3 **Allow** 1.28 or 1.31 for 1.3; 0.9442 or 0.9472 for 0.9462
			Total	8	

Question			Answer	Marks	Guidance
4	(a)	(i)	$E_p(= 0.16 \times 9.81 \times 2.5) = 3.9$ (J)	A1	3.924
		(ii)	$v^2 = \frac{2\times3.9}{0.16}$ or 48.75 OR $v^2 = 2 \times 9.81 \times 2.5$ or 49.05 v = 7.0 (m s^{-1})	C1 A1	**Allow ECF** from (a)(i) **Allow** 1sf
	(b)	(i)	$R(= 12 \times 0.71) = 8.5(2)$ (m)	A1	
		(ii)	$E_k = \frac{1}{2} \times 0.16 \times 12^2$ or 11.5 OR $= \frac{1}{2} \times 0.16 \times 13.9^2$ or $\frac{1}{2} \times 0.16 \times 193$ E_k (= 11.5 + (a)(i) = 11.5 + 3.9) = 15(.4) (J)	C1 A1	**Allow** use of vertical v = 6.97 (calculated using $v = u+at$;) **Allow** 15.5 (J) **Allow ECF** from (a)(i)
		(iii)	$\theta\left(= \tan^{-1}\left(\frac{\text{(a)(ii)}}{12}\right) = \tan^{-1}\left(\frac{7}{12}\right)\right) = 30°$	A1	**Allow ECF** from (a)(ii) 30.256
			Total	7	

Question			Answer	Marks	Guidance
5	(a)		1.97×10^8 and 2.05×10^8	B1	in that order
	(b)		$\sin C = \frac{1}{1.52} = 0.658$ 41 (°)	C1 A1	 41.1395 or 41.3
	(c)		TIR shown at lower left-hand boundary with ray turned through 90° and horizontally to the lower right-hand boundary (by eye) TIR shown at lower right-hand boundary with ray returning vertically parallel to incident ray (exiting glass block) (by eye)	M1 A1	
	(d)	(i)	$\sin C = \frac{1.46}{1.52} = 0.961$ 74 (°)	C1 A1	 73.8
		(ii)	Ray bends away from the normal (by eye)	B1	**Note** no ECF from (d)(i)
			Total	8	

Question			Answer	Marks	Guidance
6	(a)		Any **three** from: • electrons have wave properties • (diffraction of electrons occurs when) the (de Broglie) wavelength is comparable / similar to the gap size • reason for the rings as opposed to linear pattern, e.g. graphite atoms are irregularly arranged or graphite is polycrystalline • electron's (kinetic) energy transferred to light when the electrons collide with the screen • bright rings indicate maxima and/or dark rings minima.	**B1 × 3**	**Do not allow** electrons become / are waves
	(b)		$p = \sqrt{2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times 1800}$ OR 5.24×10^{-46} OR $\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times 1800}}$ or 2.9×10^{-11} (m) 2.3×10^{-23} (kg m s^{-1})	**C1** **A1**	
			Total	**5**	

Question			Answer	Marks	Guidance
7	(a)	(i)	$I = \frac{1100 + 1700}{230}$ or $\frac{1100}{230}$ or 4.78 or $\frac{1700}{230}$ or 7.39	C1	
			12(.2) (A)	A1	
		(ii)	Cost (= 2.8 × 0.5 × 18) = 25 (p)	A1	**Allow** 25.2 (p)
	(b)		$A = \frac{48 \times 10^{-8} \times 11.8}{31}$ or 1.827×10^{-7}	C1	
			$d^2 = \frac{4 \times 1.827 \times 10^{-7}}{\pi}$ or 2.326×10^{-7}	C1	
			4.8×10^{-4} (m)	A1	**Allow** 5.82×10^{-8} (determines r^2) for 1 mark **Allow** 2.4×10^{-4} (determines r) for 2 marks
	(c)	(i)	Correct symbols circuit for components including <u>four</u> cells	B1	**Ignore** other circuit components (e.g. rheostat)
			Circuit diagram: ammeter connected in series with battery and ring A and voltmeter in parallel with ring A / battery.	B1	**Note** if variable resistor added to circuit then voltmeter must be in parallel with ring A.
		(ii)	$R\left(= \frac{6.2}{0.34}\right) = 18\ (\Omega)$	A1	**Allow** 18.2 (Ω)
		(iii)	$\frac{0.02}{0.34}(\times 100)$ or $\frac{0.2}{6.2}(\times 100)$	C1	**Allow** max/min methods, e.g. $\frac{6.4}{0.32}$ or $\frac{6.0}{0.36}$
			Percentage uncertainty (= 5.9 + 3.2) = 9.1 %	A1	**Allow** 9 (%) **Do not allow** bald 10(%)
		(iv)	When using the battery pack, current is lower than when connected to the mains ORA	B1	
			When using the battery pack the temperature of the wire / heating effect is lower ORA	B1	

Question			Answer	Marks	Guidance
		(v)	Any **two** from: Repeat experiment with a different number of cells / use a variable resistor Use more sensitive meter(s) or reading to greater precision Plot a graph of V against I	**1B1 × 2**	 **Allow** variable power supply **Do not allow** power supply greater than 12 V **Do not allow** more accurate meters / digital meters
			Total	**15**	

Question			Answer	Marks	Guidance
8			**Level 3 (5–6 marks)** Clear explanation of the maxima and minima **and** uses the results to determine the path difference leading to a value for wavelength. *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)** Clear explanation of maxima and minima **and** some attempt to use the results to determine the path difference leading to a value for wavelength. OR some explanation of maxima and minima **and** uses the results to determine the path difference leading to a value for wavelength. *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 explanation of maxima and minima OR some attempt to use the results to determine the path difference leading to a value for wavelength. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	**B1 x 6**	***Indicative scientific points may include:*** ***Explanation of maxima and minima*** • Two (or more) waves meet at D • Superposition • Displacements added • Minima not zero since path is longer via the reflector • Coherence: constant phase difference due to same source • Changing *y* changes the path difference • Discussion of path difference for maximum and minimum • Discussion of phase difference of maxima and minima • When path difference changes by $\lambda/2$ then maxima changes to minima or minima changes to maxima ***Determination of path difference and wavelength*** • Use of Pythagoras to determine path length • Attempt to find a path difference • Path difference repeated • Path differences 1.4, 2.8, 4.2, 5.6 (cm) • Wavelength = 2.8 cm
			Total	**6**	

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