OCR
Oxford Cambridge and RSA

GCE

Physics B

H157/02: Physics in depth

AS Level

Mark Scheme for June 2023

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.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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 3 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 3 and mark the practice responses ("scripts") and the STM standardisation responses

   YOU MUST MARK 6 PRACTICE AND 8 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 3 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 3 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. 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).

8. The RM Assessor 3 **comments box** is used by your team leader to explain the marking of the 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 3 messaging system, or e-mail.

9. Annotations available in RM Assessor 3:

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
	Correct response
AE	Arithmetic error
	Wrong physics or equation

10. 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
(1)	Separates marking points
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
(1)m	a method mark, awarded if a correct method is used
(1)e	an evaluation mark, awarded for correct substitution and evaluation

11. All question parts bearing mark totals > 1 should be annotated with ticks in the body of the text to show where marks have been awarded.
Ticks must NOT be used in 6(a) or 8(d) — these should be annotated with X, L1, L2, L3 only for marks 0 to 6.
Allow responses that round correctly to the responses given in the markscheme unless stated otherwise.

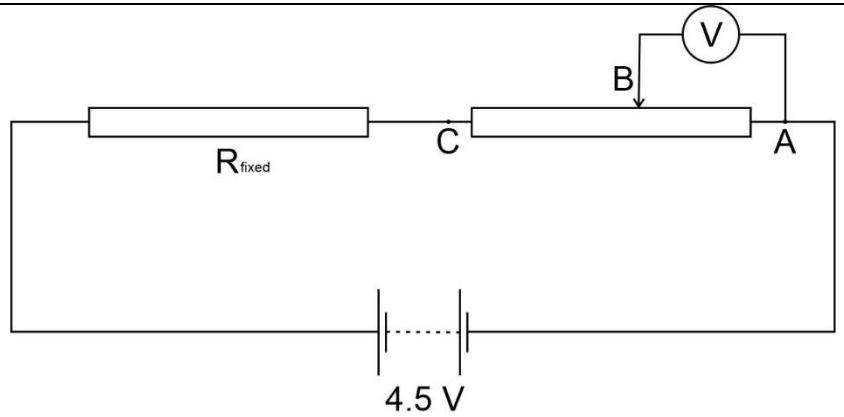
Question			Answer	Marks	Guidance
Section A					
1	**(a)**		u_H = 7.8 / 7.83 (m s^{-1}) (1) u_V = 12/ 11.6 (m s^{-1}) (1)	**2**	If sin and cos reversed so u_H = 12 (m s^{-1}) AND u_V = 7.8 (m s^{-1}) award (1) total
	(b)		$v_V^2 = 0 = u_V^2 + 2as_V = (11.6 \text{ m s}^{-1})^2 + 2(-g)\, s_V$ $s_V = (11.6 \text{ m s}^{-1})^2 / (2 \times 9.81 \text{ m s}^{-2})$ = 6.8 / 6.85 / 6.9 m(1) height = s_V + 1.7 m = 8.5 / 8.55/ 8.6 (m) (1)	**2**	Other approaches possible. Ignore excessive s.f. Unrounded u_V gives 6.86 m, u_V = 12 m s^{-1} gives 7.34 m Allow ecf from (a)
	(c)		$v_V - u_V = gt \Rightarrow t = (0 - 11.6 \text{ m s}^{-1})/(-9.81 \text{ m s}^{-2})$ = 1.18 s (1) $s_H = u_H t$ = 7.83 m s^{-1} × 1.18 s = 9.24 m = 9.2 m (1)	**2**	Unrounded u_H, u_V give 9.26 m Using 7.34 gives 8.66 and scores 2
			Total	**6**	
2	**(a)**		$f = c/\lambda$ = 3.0× 10^8 m s^{-1}/470 × 10^{-9} m = 6.38 × 10^{14} Hz (1) Work done = $E = hf$ = 6.63 × 10^{-34} J s × 6.38 × 10^{14} Hz = 4.23 × 10^{-19} J (1)	**2**	Correct substitution into hc/λ scores 1st mark. hc/λ
	(b)		$V = W/Q$ = 4.23 × 10^{-19} J/1.60 × 10^{-19} C = 2.64 V (1) 2.60 V <u>will not supply electron with enough energy</u> for the emission to occur. (1)	**2**	ORA via 2.60 V × 1.60 × 10^{-19} C = 4.16 × 10^{-19} J (1) which is less than 4.23 × 10^{-19} J.(1)
	(c)		30 mA $\Rightarrow$ 30 × 10^{-3} C s^{-1}/1.60 × 10^{-19} C electron^{-1} = 1.875 × 10^{17} electrons s^{-1} (1) Number of photons/second = (93/100)× 1.875 × 10^{17} = 1.74 × 10^{17} s^{-1} (1)	**2**	If correct alternative method used, correct substitution scores 1 mark.
			Total	**6**	
3	**(a)**		$p_{total} = p_{A\ before}$ = 0.160 kg × 1.5 m s^{-1} = 0.24 N s (1) 0.24 N s = $p_{A\ after} + p_{B\ after}$ = 0.160 kg × 0.4 m s^{-1} + $p_{B\ after}$ $p_{B\ after}$ = 0.24 N s - 0.064 N s = 0.176 N s (1) $v_{B\ after}$ = 0.176 N s/0.120 kg = 1.5 (1.47) m s^{-1} (1)	**3**	Can be done in terms of acceleration & Newton III: a_A = (0.4 m s^{-1} - 1.5 m s^{-1})/0.2 s = - 5.5 m s^{-2} (1) F_A = 0.160 kg × - 5.5 m s^{-2} = -0.88 N = -F_B (1) a_B = 0.88 N/0.120 kg = 7.33 m s^{-2} $v_{B\ after} = a_B\, \Delta t$ = 7.33 m s^{-2} × 0.2 s = 1.47 m s^{-1} (1)
	(b)		$F = \Delta p/\Delta t = p_{B\ after}$/0.2 s =- 0.176 N/0.2 s = 0.88 N (1)	**1**	If method above used, can quote F from (a) for the mark
			Total	**4**	

Question			Answer	Marks	Guidance
4	(a)	(i)	Any 2 from: zero order = no path difference (therefore) all wavelengths meet in phase (so) what you see is a combination of all the wavelengths present in the light path difference for maxima for higher orders wavelength dependent At zero order constructive superposition	2	Allow no diffraction at zero order (1) (So) colour seen is the sum of all the wavelengths emitted by the tube (1) Any reference to refraction scores zero.
	(a)	(ii)	Blue light has a shorter wavelength than red light (so from $n\lambda = d \sin\theta$, smaller $\lambda \Rightarrow$ (smaller sin $\theta \Rightarrow$) smaller θ) (1)	1	
	(b)		Make a valid measurement (eg Measure θ between a blue line and the 0 order) (1) detail, e.g. mark apparent position and use trig to deduce θ /use protractor to determine θ (1) use $n\lambda = d \sin(\theta)$ to find λ (1)	3	Measure or find θ *(or a length* to allow θ to be calculated) Use of ruler is sufficient practical detail for 2nd mark Seen or described.
			Total	6	
5	(a)		$A = \pi r^2 = (0.508/2 \times 10^{-3}\text{ m} \times \pi)^2 = 2.03 \times 10^{-7}\text{ m}^2$ *OR* $R = \rho L/A \Rightarrow L = RA/\rho$ (1) $= 15\ \Omega \times 2.03 \times 10^{-7}\text{ m}^2 / 1.10 \times 10^{-6}\ \Omega\text{ m}$ $= 2.76$ m (1)	2	Allow 2 (1sf)
	(b)		Max. proportional uncertainty = 0.1/15 (= 6.67×10^{-3}) (1) $L \propto R$ $\Delta L = 6.67 \times 10^{-3} \times 2.76\text{ m} = 0.018$ m (1)	2	Or 0.02 m
			Total	4	
			Section A total	26	

Question			Answer	Marks	Guidance
			Section B		
6	(a)		**(Level 3) (5 – 6 marks)** Identifies places where the materials are under tension and where under compression, possibly annotated on the diagram. Considers the cost of materials used and the need for safety and stability. *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)** Accurately discusses behaviour of steel and concrete under (tensile) stress but may not clearly identify which parts of the bridge are under tension and which under compression. No discussion of cost of materials or of stability. *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)** Makes generalised comments about steel and concrete under stress but does not relate them to the bridge structure.. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant* **(0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	**[6]**	**Indicative scientific points may include:** **Tensile and compressive stress** • Tough, elastic materials have similar behaviour under tension and compression • Brittle materials are strong under compression and weak under tension … • … due to crack propagation • Brittle failure could cause the structure to collapse. • Bridge hangers (and suspension cables, and deck) are under tension • Bridge towers are under compression **Relevant properties of steel** • Strong, • Tough. • Relatively expensive • Needs to be cast to fit **Relevant properties of concrete** • Strong under compression, weak under tension • Brittle under tension • Can be poured into moulds in situ • Can be reinforced by e.g. steel bars • Relatively cheap **Use the L1, L2, L3 annotations in Assessor; do not use ticks.**

Question	Answer	Marks	Answer	Question	Guidance
	(b)	**(i)**	Weight per hanger $F = mg/500$ $= 1.4 \times 10^8$ kg $\times$ 9.81 N kg^{-1}/500 $= 2.75 \times 10^6$ N (1) (Cross-section area of a hanger, $A = \pi(0.32\text{ m}/2)^2$ $= 0.0804\text{ m}^2$) $\sigma = F/A = 2.75 \times 10^6$ N/0.0804 m^2 $= 3.42 \times 10^7$ Pa (1) $\sigma/\sigma_{yield} = 3.42 \times 10^7$ Pa/2.7×10^9 Pa $= 0.0127 = 1.27\%$ (which <2%) (1)	**3**	Can be done in terms of total σ and total A In this case first marking point is for total weight (1.375×10^6 N). (2nd marking point for stress calculated correctly) 3rd mark can also be scored by comparison of the correct stress value with correct calculation of 2% of yield stress.
	(b)	**(ii)**	Additional weight = 2700 m $\times$ 6000 kg m^{-1} $\times$ g = 1.59×10^8 N (1) Total weight per hanger = $2.75 \times 10^6 + 1.59 \times 10^8/500$ N $= 3.07 \times 10^6$ N $\sigma_{max} = 3.07 \times 10^6$ N/0.0804 m^2 $= 3.82 \times 10^7$ Pa (1) ratio $\sigma_{max}/\sigma = 3.82 \times 10^7$ Pa/3.42×10^7 Pa = 1.117 2 s.f. is appropriate, as in raw data, so ratio = 1.1 (1)	**3**	Alternative method 1 using total weight: 1st mark is for additional weight calculated correctly. 2nd mark is for (original weight + additional weight) calculated correctly. Correct calculation of ratio to 2 s.f. scores 3 marks. Alternative method 2 using mass: 1st mark is for additional mass calculated correctly. 2nd mark is for (original mass + additional mass) calculated correctly. Correct calculation of ratio to 2 s.f. scores 3 marks.
	(b)	**(iii)**	Any two points from: Some lorries may be very heavily loaded (1) Traffic may stop on bridge and tail back, getting closer and so exceeding the max number per metre allowed at that point (1) Wind loading may introduce additional force on hangers(1)	**2**	Allow any reasonable factor Allow degradation with time but not damage. Not “wear”
			Total	**14**	

Question			Answer	Marks	Guidance
7	(a)	(i)	11 T = 23.7 ms ⇒ T = 2.15 × 10^{-3} s (1) f_{mean} =1/T = 465 Hz (1) ΔT = ± 0.1 ms T_{max} = 23.8 ms/11 = 2.163 × 10^{-3} s (1) f_{min} = 1/2.163 × 10^{-3} s = 462 Hz $\Delta f = f_{mean} - f_{min}$ = (465-462) Hz = 3 Hz $f \pm \Delta f$ = 465 ± 3 Hz (1)	4	allow 450 – 480. Allow 0.05 ms to 0.2 ms. Ecf own T throughout. Needs f rounded to precision of Δf Δf allow 2, 3 or 4 Hz. Maximum 2 marks unless > 9T First mark for correct reading of period. 2nd mark for calculating f correctly in Hz using their period.
	(a)	(ii)	Single frequency is a sine wave whereas this has repeating irregularities/harmonics present (1) The irregularities fluctuate at a greater frequency than the frequency of repeat of the pattern (1)	2	Allow “multiple peaks at different heights” but not just “multiple peaks” Allow any sensible clear comparison of Fig. 7.1 & sinusoid
	(b)	(i)	3-bit encoding ⇒2^3 = 8 different levels (i.e. one each mV) (1) At each sampling time, value recorded is the level nearest <u>below</u> the true value (1) 3 in binary is 0 1 1 (1)	3	
	(b)	(ii)	The curve has been smoothed AW /there are only 8 distinct levels (1) will have different harmonics/constituent frequencies from the original signal / high frequency sounds may be missed (1)	2	Not “sample every 0.5s” Not noise Allow “loss of detail”. Allow “less defined”.
	(c)		number of samples = 99 s/0.25×10^{-3} s = 396 000 (1) (size = 396 000 samples × 3 bits $sample^{-1}$ = 1 188 000 bits) number of bytes = 1 188 000 bits/8 = 148 500 (1)	2	Ignore POT error for 1st mark (eg 99/0.25)
	(d)		Time between samples = 1/44100 Hz = 2.27 × 10^{-5} s Number of samples in 1 minute 39 s = 99 s/2.27 × 10^{-5} s = 4.37 × 10^6 (1) No of bits in stereo recording = 2 × 8 × 4.37 × 10^6 = 6.99 × 10^7 bits download time = 6.99 × 10^7 bits/65 × 10^6 bits s^{-1} = 1.07 s (1)	2	Award 1 mark for t=0.54
			Total	**15**	
			Section B total	**29**	

Question			Answer	Marks	Guidance
Section C					
8	**(a)**	**(i)**	 Diagram as shown = 2 marks R and potentiometer in series with battery = 1 mark	**2**	Allow omission of “4.5 V” label and “Rfixed” label Allow A and C reversed. Must use a recognisable circuit symbol for potentiometer (not a sketch).
	(a)	**(ii)**	Any two points from: The voltmeter (is in parallel with potentiometer section AB and) would draw a significant current from the battery (1) the actual resistance between A and B is a parallel combination (1) The response of the potentiometer is not linear with position, (which would make use of the sensor complicated) (1)	**2**	Not “path of least resistance”.
	(b)	**(i)**	The trend is better shown with more values at low d / d – V_{AB} relationship is non-linear (1) V_{AB} changes more rapidly for small d than for large d **OR** Although Δd is non-linear between adjacent readings, ΔV_{AB} is relatively constant between adjacent readings. (1)	**2**	Allow this would provide excess data.
	(b)	**(ii)**	(Fractional uncertainties in d are typically 0.5 mm/15 cm ≈ 1/300 but) The voltmeter has a higher resolution, (even rounded to the nearest 10 mV), than the ruler.	**1**	e.g. ruler uncertainty = 0.5 mm/150 mm = 1/300 whereas voltmeter uncertainty, when rounded, is 10 mV/3.5 V = 1/350. Going to the nearest 1 mV would make the reading too precise.
	(c)		Points plotted correctly with uncertainties Δd the same as the other points (¼ mm) (1) Smooth curve drawn through all uncertainty bars (1)	**2**	Point (0,0) may have no uncertainty bar; allow omission of (0.0)

Question	Answer	Marks	Guidance
(d)	**(Level 3) (5 – 6 marks)** Recognises that the difference in the circuits lies in the value of the fixed resistor used and that the repeat used a higher value of R_{fixed}. May consider sensitivity of the sensor circuit in each case and recognise the variation in the repeat data is more uniform. May explain that a uniform variation of V_{AB} with d will result in more consistency in identifying the position d. *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)** Describes differences between the sets of results. Provides justification and some additional detail. Recognizes the two circuits used were different but did not ascribe this to the fixed resistor. *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)** Describes differences between the sets of results. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant* **(0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	**[6]**	**Indicative scientific points may include:** **Comparing the two circuits** • Greater range of p.d.s in the repeat • In first set, V_{AB} changes rapidly near d = 0 and then more slowly near d = 50 mm • V_{AB} changes more uniformly in the repeat set **Analysis of the data** • Sensitivity = dV/dd = gradient of the graph • Hard to resolve small movements at large d in first set • When V_{AB} is 2.25 V (½ E) then R_{fixed} = resistance of segment **AB** of the potentiometer • For the first set of data, R_{fixed} = about 9 mm of the potentiometer making R_{fixed} = (9/50) × 10 kΩ = 1800Ω • For the repeat set of data, R_{fixed} = a bit under 30 mm of the potentiometer making R_{fixed} = (29/50) × 10 kΩ = 5800Ω **Evaluation** • A linear response of V_{AB} with d in the repeat is better than the very non-linear of the original • The higher value of R_{fixed} produced better results **Use the L1, L2, L3 annotations in Assessor; do not use ticks.**
	Section C Total	**15**	

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on

01223 553998

Alternatively, you can email us on

support@ocr.org.uk

For more information visit

ocr.org.uk/qualifications/resource-finder

ocr.org.uk

Twitter/ocrexams

/ocrexams

/company/ocr

/ocrexams

CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT

OCR is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

OCR operates academic and vocational qualifications regulated by Ofqual, Qualifications Wales and CCEA as listed in their qualifications registers including A Levels, GCSEs, Cambridge Technicals and Cambridge Nationals.

OCR provides resources to help you deliver our qualifications. These resources do not represent any particular teaching method we expect you to use. We update our resources regularly and aim to make sure content is accurate but please check the OCR website so that you have the most up-to-date version. OCR cannot be held responsible for any errors or omissions in these resources.

Though we make every effort to check our resources, there may be contradictions between published support and the specification, so it is important that you always use information in the latest specification. We indicate any specification changes within the document itself, change the version number and provide a summary of the changes. If you do notice a discrepancy between the specification and a resource, please contact us.

Whether you already offer OCR qualifications, are new to OCR or are thinking about switching, you can request more information using our Expression of Interest form.

Please get in touch if you want to discuss the accessibility of resources we offer to support you in delivering our qualifications.