OCR
Oxford Cambridge and RSA

GCE

Physics B

H557/03: Practical skills in physics

A 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 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. For answers marked by levels of response:
    a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
    b. **To determine the mark within the level**, consider the following

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

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	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**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Significant figure penalties

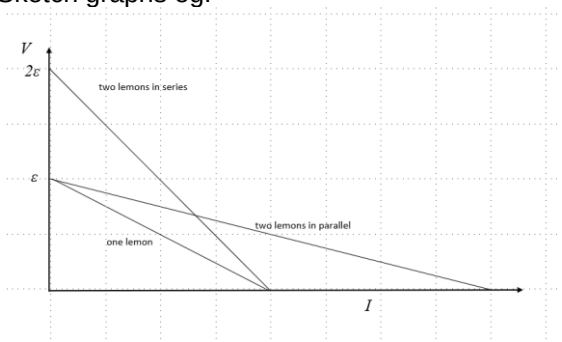
Significant figure penalties will be shown on the markscheme. There is a maximum of one significant figure penalty on each paper. Not all papers will include such penalties – this depends on the particular questions given in the paper. The question that attracts a significant figure penalty (if one do so) will be decided by the examiners at the standardisation meeting. You must not penalize such errors unless clearly stated in the markscheme.

Annotation on scripts

Each markworthy point should be registered with a tick – the total number of ticks on the paper should equal the number of marks awarded for non-LOR questions. Mark errors in physics with a cross and omissions with a carat. Centres and candidates who request scripts back find such annotations extremely useful.
LOR questions do NOT have ticks on the papers. These questions should only be annotated with L1, L2, L3.

Question			Answer-	Mark	Guidance
1	(a)	(i)	73.8 or 74 57.5 or 58 (μA) ✓	1	
1	(a)	(ii)	Both points plotted to within ½small square ✓ (74, 740) and (58, 765) Acceptable straight line of best fit drawn across all the plotted points. ✓	2	Plots must not be 'blobs' (diameter larger than half a small square) Line should cross the y-axis between 880 and 900, and cross the x-axis between 176 and 182. **ALLOW** ECF from a misplot. If the misplot is far from the line and identified as an anomaly it can be ignored, and the above tolerance still just about works. Otherwise, you will need to judge a reasonable balance of points either side of the line to award the mark. Do not allow kinked or hairy lines or lines wider than half a small square. The line must cover the width of the plots -ie from x = 40 to x = 164.
1	(a)	(iii)	Correct method to find gradient of line (ie $\Delta y/\Delta x$) ✓ Gradient must give a negative value. $\varepsilon = V + Ir$ rearranged to give $V = \varepsilon - Ir$, to show that gradient = -*r* ✓ internal resistance = - gradient value to correct POT (ie 2200 Ω)✓	3	**DO NOT ALLOW** positive gradient. **IGNORE** POT in gradient calculation Look for some working to obtain negative gradient value $2100 \leq -m \leq 2300$. eg; substituted coordinate values, points marked on the graph etc. **ALLOW** ecf from candidate's line. If no working to show that gradient or m = -r, do not award 2nd mark; max 2, for marks 1 and 3. **IGNORE** sign here but value must be to correct POT

Question			Answer-	Mark	Guidance
1	(a)	(iv)	**EITHER:** • Current from the lemon cells Is much too low (to light the lamp) OR current from lemon cells would be less than 1 mA. • Current required by lamp = 0.3 A **OR:** • Resistance of lamp = 5 Ω • Resistance of lamp is much smaller than internal resistance so most p.d. is across the lemon cells	2	Current from lemons could be calculated – either short circuit max current or current read from graph at 0.75V. This could be shown with a calculation of power from the lemon.

1	(b)		**Level 3 (5-6 marks)** ✓✓ Comprehensive description of the differences for one lemon and two lemons in both parallel and series including annotated sketch graphs and a clearly laid out derivation of the emf expression for lemons in parallel. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.* **Level 2 (3-4 marks)** ✓✓ Good attempt to describe the differences for one lemon and two lemons in both parallel and series, including sketch graphs. An attempt to derive the emf expression for the lemons in parallel. *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 qualitative description of the effect of putting two lemons in series with or without a sketch graph. Incorrect or omitted description of two lemons in parallel. *There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.* **0 marks** *No response or no response worthy of credit.*	6	**Indicative scientific points may include:** **2 lemons in series:** • Rearrange the expression to give: $V_l = 2\varepsilon - 2I_s r$ • Hence y-intercept = 2***ε*** • Gradient = -2*r* • Steeper line • x-intercept same as that of one lemon • Same current in both the lemon cells and the load. • Larger proportion of lost volts **2 lemons in parallel:** • Total internal resistance = $\frac{r}{2}$ • So $\varepsilon = V_L - I_p \frac{r}{2}$ • Rearrange to give: $V_L = \varepsilon - I_p \frac{r}{2}$ • Hence y-intercept = ***ε*** (same as for single lemon) • Gradient = $-\frac{r}{2}$ • Less steep line • x-intercept twice that of one lemon • Current in each lemon cell is half that in the load. • For the same load current the proportion of lost volts is less. Sketch graphs eg: 

Question			Answer	Mark	Guidance
2	(a)	(i)	= (1.42 + 1.44 + 1.48 +1.47 + 2(1.48) + 1.49 + 3(1.50) +1.51 + 2(1.52) + 1.53 +1.54) ÷ 15 = (22.36 ÷ 15 =) 1.49 (V)✓ Uncertainty = ½ range = ½ (1.54 -1.42) = 0.06 ✓	2	Answer given to at least 3sf. **DO NOT ALLOW** ignoring any values as outliers for the mean calculation. Uncertainty mark can be awarded if they consistently ignore 1.42 as an outlier. **ALLOW** uncertainty = mean – min = 0.07 **ALLOW** ecf from candidate's value of mean. If 2 (or more) values have been identified as outliers, no mark can be awarded.
		(ii)	cause of uncertainty for example: ✓ • ambient light level • difficult to determine when LED starts to glow suggested improvement for example: ✓ • take readings in the dark • shield the LED from ambient light • use an ammeter to detect when the current begins to increase rapidly	2	**ALLOW** use a light meter to judge consistently when it starts to glow.
2	(b)	(i)	Vertical error bars on all points ± 3 squares (± half a small square) ✓ Steepest worst fit line drawn ✓	2	**ALLOW** ecf from uncertainty value in (a)(i). Straight line drawn from bottom on lowest error bar to top of highest error bar (on their graph). Allow ± half a small square. If the error bars are so small that you can't get a worst line within them, the second mark cannot be awarded.

Question			Answer	Mark	Guidance
		(ii)	Correct method to find gradient of worst line using coordinates of two points on their line ✓ Absolute uncertainty = gradient - 8.90×10^{-7} Vm ✓	2	Expect a value $9.70\times10^{-7} \leq$ gradient $\leq 10.3\times10^{-7}$ **IGNORE** POT in gradient calculation for the first marking point] **ALLOW** ecf from candidate's line. Expect uncertainty to be between 0.8×10^{-7} to 1.4×10^{-7}. **IGNORE** any attempt to calculate the gradient of the printed line. **ALLOW** uncertainty to be given to 1(or more) sf.
2	**(c)**	**(i)**	Use of $E = \frac{hc}{\lambda}$ and $E = Ve$ ✓ Rearranging to show that $V = \frac{hc}{\lambda e}$ or $\frac{hc}{e}$ $(\frac{1}{\lambda})$; Gradient of line, $V\lambda = \frac{hc}{e}$; so $h = gradient \times \frac{e}{c}$ ✓	2	Recognising that the gradient = V/(1/λ) = Vλ without using the correct expressions for energy for one mark.
		(ii)	h = 4.7(5)$\times10^{-34}$ Js ✓ To find uncertainty **EITHER** Use gradient of worst fit line to find value of h_{max} ✓ and then calculate the difference. ✓ **OR** Find relative uncertainty in gradient value ✓ And apply this to value of h to find absolute uncert ✓	3	h_{max} = value of gradient from 2(b)(ii) multiplied by $\frac{e}{c}$ (eg. $10\times10^{-7} \times 5.3\times10^{-28} = 5.3\times10^{-34}$, and uncertainlty in h = $\pm0.6\times10^{-34}$) relative uncertainty = uncertainty value from 2(b)(ii) ÷ 8.9×10^{-7} (eg. $1.1\times10^{-7} \div 8.9\times10^{-7} = 0.124$, leading to abs uncertainty in h = $0.124 \times 4.7\times10^{-34} = \pm0.6\times10^{-34}$)

Question			Answer	Mark	Guidance
3	(a)		Circuit diagram showing capacitor charging circuit with power supply and a flying lead/two-way switch or 2 switches ✓ And a discharge part of circuit with resistance in series with capacitor (without the power supply in the discharge circuit) and a voltmeter in parallel across the capacitor ✓ Method – any 2 of: ✓✓ • charge capacitor (fully) from the power supply, swap to discharge circuit • record *V* and *t* at intervals as it discharges • start stopwatch when pd reaches a certain value eg 8.0 V • repeat readings	4	**DO NOT ALLOW** resistor in series with capacitor in charging circuit.
3	(b)	(i)	Values in table; 1.089, 0.683 ✓ **EITHER** calculation of at least 3 ratios of voltage **OR** calculation of at least 3 differences in lnV values. ✓ Comment on the difference or similarity of the calculated values (related to exponential decay). ✓	3	**ALLOW** at least 3 calculations of RC, or 1/RC. **DO NOT ALLOW** ratios of lnV values.
	(b)	(ii)	Average ratio calculated = $\frac{10}{RC}$, or average difference = t/RC; hence show that *RC* = 25s. ✓	1	**ALLOW** any value between 23 and 26 with some calculation from any values in the table. **ALLOW** time constant relates to 37% V_0 = 2.6V. This lies somewhere between 20s and 30s from data in table.

Question			Answer	Mark	Guidance
	(b)	**(iii)**	Capacitance = $\frac{\tau}{R}$ = 25 ÷ 4.7×10^{3} = 5.3×10^{-3} F ✓	1	ALLOW use of candidate's calculated value of CR in part (i) provided 10 < CR < 30.
	(c)	**(i)**	$V = V_0 e^{-5RC/RC}$ so $V = V_0 e^{-5}$ OR 6.74×10^{-3} V_0 ✓ Energy $= \frac{1}{2}CV^2$ OR Energy is proportional to V^2 ✓ $E = E_0 e^{-10}$ OR E = (6.74×10^{-3})^2 E_0 = 4.5×10^{-5} E_0 ✓	3	This is a 'show-that' question, so we need to see each step. **ALLOW** numerical working instead of algebraic. For example: Using C = 5.3×10^{-3} F and V_0 = 7 V; Calculation of $V_{5\tau}$ = 0.047 ✓ Calculation of energy value; E_0 = 0.13 J or $E_{5\tau}$ = 5.9×10^{-6} J ✓ Then calculate ratio of E/E_0 = 4.5×10^{-5} for third mark. ✓
		(ii)	To estimate when there is negligible energy/ charge/voltage left in the capacitor. ✓ **OR** To estimate when it is safe to handle ✓	1	**DO NOT ALLOW** (approximate) time for capacitor to fully discharge.

Question			Answer	Mark	Guidance
4	a	i	Flux linkage = *BAN*✓ = $5.0 \times 10^{-3} \times (\pi \times 0.02^2) \times 10 = 6.28 \text{ x } 10^{-5}$ OR $6.3 \text{ x } 10^{-5}$ ✓	2	This is a 'show-that' question, so we need to see the equation written down for the first marking point. Substitution and evaluation for second mark.
		ii	Any two from: ✓✓ • An emf is induced when the coil is cutting lines of flux or when there is a change of flux linkage OR emf is proportional to rate of change of flux (linkage). • rate of cutting lines of flux is maximum when the angle between the coil and the lines of flux is close to right angles / minimum when coil and lines of flux are parallel. • Direction (of induced emf) changes twice each rotation. • Flux cutting area varies sinusoidally (when coil is rotating at constant angular velocity)	2	**ALLOW** emf is proportional to $-\,{}^{d\phi}/_{dt}$ in symbol form for the first marking point. The following derivation would gain both marks. $\varepsilon = -\,{}^{d(BAN)}/_{dt} = -\,BN\,{}^{d(A\cos\omega t)}/_{dt} = -BN\,A\omega\,\sin\omega t$
		iii	T = 8 squares / 8 × 0.625 (= 5 s) ✓ Use of $\omega = 2\pi f$ and $f = \frac{1}{T}$ OR $\omega = \frac{2\pi}{T}$ ✓ $\omega = 2\pi \times 0.2$ OR $\omega = \frac{2\pi}{5}$ = 0.4π OR 1.26 (rad s^{-1}) ✓	3	If period is the incorrect number of squares, then 1 mark max (middle marking point) **ALLOW** answer in terms of π.
		iv	$\theta = \omega t$ ✓ Component of flux (perp with coil) $\varphi = BA\cos\theta$ ✓	2	
	b	i	All 3 peaks/troughs at 3 squares from centre line. ✓ Smooth sinusoidal line with same period and phase ✓	2	Drawn line should cross the middle axis at the same points as the printed line and be above (not touching) printed line at either side of the graph for this final mark to be awarded.

		ii	Evidence of gradient at 0.23s – either coordinates from line or a tangent drawn on graph grid. ✓ Calculation of gradient ✓ for example: $\varepsilon = -\frac{8--8}{0.17-0.29}$ (= 130) OR $\varepsilon = -\frac{14--14}{0.13-0.32}$ (= 150) Final value $1.2\times10^{-4} \leq \varepsilon \leq 1.6\times10^{-4}$ ✓	**3**	**ALLOW** use of peak-trough values from line eg (0.1, 12.5) to (0.37, -12.5) for first two marks. Ignore POT and sign for the first two marks. **IGNORE** sign of final answer but it must be to correct POT. **ALLOW** use of $\varepsilon_{max} = BAN\omega$ EITHER use ω calculated in part (a)(iii) ω = 1.26 rad s^{-1} OR find ω using the graph eg half T = 0.375 – 0.1 = 0.275; ω = 11 rad s^{-1}. ✓ EITHER substitute values of B and A given in part (a)(i) to give $\varepsilon_{max} = 5x10^{-3} \times \pi\ 0.02^2 \times 20 \times \omega$ OR use $N\Phi_{max} = 12.5\times10^{-6}$ from peak on graph ($\varepsilon_{max} = 12.5\times10^{-6} \times \omega$) ✓ Evaluation for final mark. ✓

		iii	**Level 3 (5-6 marks)** ✓✓ Calculation of max gradient, or stating time period, at equivalent points in successive cycle and finds ratios between them. States a conclusion consistent with their data. Clear working and explanation of method or test being carried out. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.* **Level 2 (3-4 marks)** ✓✓ An attempt to find max gradient, or time period, at equivalent points in successive cycles. Some working must be shown. Description of a suitable test to carry out using the data. *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)** ✓✓ Qualitative statement linking graph to emf falling each cycle and/or limited description about comparing emfs/gradients/time periods but no working shown, or incorrect working shown. *There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.* **0 marks** *No response or no response worthy of credit.*	**6**	**Indicative scientific points may include:** Qualitative statements: • Max gradient decreases each cycle. • Time period is increasing with each cycle. Description of test to carry out: • Find gradients of graph at same point in each cycle • Ratio of successive gradients should be equal (within experimental uncertainty) if peak emf reduces by the same fraction in each cycle. • Find successive time periods from graph • Ratio of successive time periods should be equal (within experimental uncertainty) if peak emf reduces by the same fraction in each cycle. • Calculations carried out as described. • Statement of conclusion consistent with their calculated values. Indicative values which might be calculated. Do not penalise POT error already penalised in 4bii, if consistent calculations are carried out.
			QUESTION TOTAL	**20**	

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.