GCE

Physics B

H557/03: Practical skills in physics

A Level

Mark Scheme for June 2024

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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:

    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.

11. **Abbreviations**

Abbreviation	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)		use water or oil in the hole. ✓	1	**ALLOW** any liquid or gel. **DO NOT ALLOW** heat conducting material. **IGNORE** any reference to insulating the block.
	(b)	(i)	Vertical error bars ± 1.0 °C drawn on all plots. ✓	1	There must be at least 7 error bars of correct length for the mark to be awarded
		(ii)	(Any) straight line drawn through the error bars ✓ Steepest <u>and</u> shallowest straight lines drawn within error bars. ✓	2	At least one line drawn <u>within</u> all the error bars for the first mark point. Least steep pass through (10,35) to (2,23) Steepest pass through (8,33) to (0,19) Within a small square. Lines must go across the whole grid. **IGNORE** minor feathering but do not allow if lines drawn are wider than half a small square. **ALLOW** ecf from incorrectly drawn error bars. If candidate's error bars are such that it is impossible to get a line which passes through all the bars, then award **ONE** mark for an appropriate line drawn which could reasonably be either the steepest or shallowest line or the line of best fit.

<table>
<tr>
<td></td>
<td></td>
<td>(iii)</td>
<td>Use of 2 pairs of coordinates on a line substituted into $\frac{\Delta y}{\Delta x}$ for one line with Δx ≥ 5 mins or 300 s ✓

Conversion of rate to °C s^{-1} (dividing gradient value by 60 OR multiplying x-coordinate value by 60) ✓

Calculation of mean gradient from 2 correctly calculated gradients = 0.027 °C s^{-1} (OR 1.6 °C min^{-1})✓

Calculation of spread or uncertainty ✓
½(max - min) OR (max - mean) OR (mean - min)

Calculation of percentage uncertainty (spread÷mean gradient value)×100 with consistent units ✓</td>
<td>5</td>
<td>Read offs correct to (half a) small square from candidate’s line.
<table>
<tr><td>RANGE</td><td>°C/min</td><td>°C s^{-1}</td></tr>
<tr><td>Steepest</td><td>1.75 ± 0.05</td><td>0.0292 ± 0.0008</td></tr>
<tr><td>Shallowest</td><td>1.50 ± 0.05</td><td>0.0250 ± 0.0008</td></tr>
<tr><td>Mean</td><td>1.63 ± 0.05</td><td>0.0272 ± 0.0008</td></tr>
</table>
ALLOW 0.028 ≥ rate ≥ 0.026
(1.56 ≥ rate ≥ 1.68)

If a candidate has only drawn one line or only calculated one gradient, they could get a max of 2 marks here – method for calculating gradient and conversion.

If candidate uses range (max – min) instead of half range, they can get ONE mark for converting that to percentage uncertainty correctly.

Working must be shown for both the marks for uncertainty calculation.
.</td>
</tr>
<tr>
<td></td>
<td>(c)</td>
<td>(i)</td>
<td>$E = mc\Delta\theta$ <u>and</u> $P=E/t$ ✓

Substitute E into power equation to give $P = \frac{mc\Delta\theta}{t}$
OR substitute $\Delta\theta = \frac{E}{mc}$ into gradient = $\frac{\Delta\theta}{\Delta t}$
(and rearrange for $\frac{\Delta\theta}{t} = \frac{P}{mc}$) ✓</td>
<td>2</td>
<td>This is a ‘show-that’ question, so both these relationships need to be clearly stated (any subject) for the first marking point.</td>
</tr>
</table>

		(ii)	Calculation of power $P = IV$ = 3.76 x 9.6 (= 36) ✓ Substitution and calculation of $\boldsymbol{c} = \frac{\boldsymbol{P}}{\boldsymbol{mass} \times \boldsymbol{gradient}}$ ✓ (mass = 1) **EITHER** % method to find uncertainty: Add % uncertainties of all variables ✓ Calculation of absolute uncertainty of c ✓ *[multiplying %uncert by c]* **OR** Max/min method: Calculation of max value and/or min value ✓ Absolute uncertainty (= ½(max-min) OR = max-mean OR = mean – min) ✓	4	**EXPECT** $c \approx$ 1300 J kg^{-1} K^{-1} if candidate has correctly found gradient of line. **ALLOW** ecf of candidate's value of gradient from part (b)(iii). % uncertainties: **Mass: 0.01/100 = 1%** Power: 2.9% **OR** pd: 2% <u>and</u> current: 0.9% Gradient: candidate's value from (b)(i) Expect total %uncert of 11%. Expect values in region of 1340 ± 150 J kg^{-1} K^{-1}. Min value of *c* using max value of mass (1.01 kg), max value of candidate's gradient and min value of Power (35 W) [V_{min} = 9.4 V and I_{min} =3.7 A] Max value of *c* using min value of mass (0.99 kg), min value of candidate's gradient and max value of Power (37 W)) [V_{max} = 9.8 V and I_{max} =3.8 A] Omission or incorrect calculation of uncertainty in mass – MAX 1 mark out of 2 for uncertainty.

	(d)		Calculated value higher than textbook value ORA ✓ Any **ONE** of: The power / energy from the heater is not all used to heat the Al block some power / energy wasted block is not insulated ✓	2	**IGNORE** discussion of uncertainties in measured values or miscalculations.

Question			Answer	Mark	Guidance
2	(a)		Conductance = current ÷ pd = $7.5\times10^{-3} \div 0.65$ = **$0.0115\ \Omega^{-1}$** OR $1.15\times10^{-2}\ \Omega^{-1}$ ✓ **EITHER** Max/min method ✓ [Max = 11.9 and/or min = 11.1 Absolute uncert = ½(max-min) OR max – mean OR mean – max] **OR** % uncertainty method ✓ [%U in current (0.267%) + %U in p.d. (3.08%) to give total %U (3.34%). 3.34% of 11.5] **= ± 0.4×10^{-3}** ✓	3	**ALLOW** answer given to 2sf: 0.012. IF there is a POT error in the calculation of conductance, **ALLOW** uncertainty calculated consistently (eg final value 12 ± 0.4 Ω^{-1} will gain 2 marks with POT.) If conductance has been calculated incorrectly method of finding uncertainty must be consistent with calculation. $(12 \pm 0.4) \times 10^{-3}\ \Omega^{-1}$ $0.012 \pm 0.0004\ \Omega^{-1}$
	(b)		Vary potential difference (and measure pd and current) ✓ Use small increments OR more reading of pd around the threshold value. ✓ (Once threshold is reached) there could be a very high current so resistor is needed to protect circuit. ✓	3	**IGNORE** use of datalogger.

	(c)		Correct shape graph drawn: Current increases <u>sharply</u> at (a threshold) positive V ✓ Low negative current for negative V ✓	2	Line climbs over a smaller range of V than it was remaining at (or near) zero. **ALLOW** zero current for negative V, **IGNORE** increase of negative current beyond reverse breakdown voltage as long as magnitude of reverse breakdown voltage significantly larger than positive threshold voltage. See APPENDIX for additional guidance.
	(d)		Change in current very small below threshold voltage ✓ so very precise ammeter or very low range ammeter used. ✓ **OR** voltmeter with increased precision✓ (needed) either side of threshold pd. ✓ **OR** use of sensors/meters connected to a datalogger so that more readings can be taken ✓ graph generated automatically ✓	2	**ALLOW** use more precise or more sensitive meter (without detail) for 1 mark.

Question			Answer	Mark	Guidance
3	(a)		$\frac{1}{u}$ column: -8.70, -6.49 ✓ $\frac{1}{v}$ column: 2.54, 4.08 ✓	2	Expect both values of $\frac{1}{u}$ to be negative. Expect all values to be given to 3sf, if not, then **[1]** max.
	(b)		Appropriate scales and axis labels ✓ Points plotted correctly (± small square) ✓ Appropriate line of best fit drawn (with acceptable balance of plotted points either side of line) ✓	3	Candidates were told to go -12 on x-axis and +12 on y-axis so expect: axes scales of 1 cm: 1 m^{-1} and 2 cm: 1 m^{-1} respectively. Do not award axes mark if: • more than 4cm between scale markings, • awkward scales (eg 1:3 or worse), • small scales (0 – 12 scales crammed into half the graph grid or less). • Negative x-axis in positive direction. • Axes are not labelled correctly 1/u (x axis) and 1/v (y-axis). Ignore units. **ALLOW** bottom plot at (-9.4, 1.4) as well as (-9.5, 1.4) Plotted points should not be 'blobs' with diameter > half a small square. Do not award line mark if: • Line is kinked or thicker than half a small square. • Line does not span all plotted points ($\Delta x \geq 6$) Line should cross y-axis between 9.5 and 11, and should cross x-axis between -10 and -11 but drawn line does not have to extend to axes for this mark to be awarded.

Question			Answer	Mark	Guidance
	(c)		Use either $\lvert$x-intercept$\rvert = \frac{1}{f}$ **OR** the y-intercept $= \frac{1}{f}$ **OR** use coordinates of a point on the line substituted into equation $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ to find $\frac{1}{f}$ ✓ Find the mean of two values to give final answer ✓ Find the reciprocal (of the mean of the) candidate's value (obtained from a valid method) of $\frac{1}{f}$ ✓ [Expected final answer $0.094 \leq f \leq 0.102$]	3	Read offs correct to ± small square from candidate's line. **DO NOT ALLOW** data point from the table unless it falls on the line (± small square). If a candidate only uses one intercept or one pair of coordinates MAX 2 marks. If candidate finds equation of line using two pairs of coordinates award up to 3 marks: Check gradient method and read-offs $\Delta(1/v)$ must be at least 3 m^{-1} [1] Check coordinates used to substitute to find intercept.[1] Final mark for reciprocal of intercept.[1]

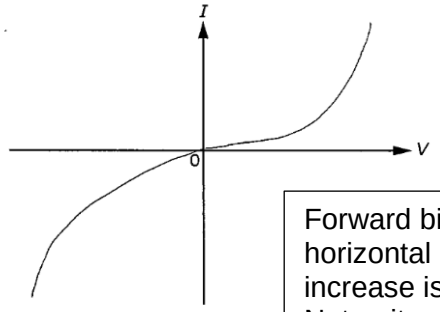
3	**(d)**		**Level 3 (5-6 marks)** ✓✓ Detailed discussion of difficulties finding both image distance and object distance such as a detailed explanation about why eg monochromatic light would improve the outcome. *There is a well-developed line of re* *reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.* **Level 2 (3-4 marks)** ✓✓ Some discussion of uncertainties and limitations such as some explanation about eg why monochromatic light would improve the outcome. *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)** ✓✓ Identification of uncertaint(ies) and limitation(s) and/or suggested improvement(s) which may or may not refer to monochromatic light. *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.*	6	**Indicative scientific points may include:** • Uncertainties and limitations: ○ Difficult to locate centre line of lens so both *u* and *v* will be uncertain. ○ Filament lamp is a 3-D object so difficult to determine where to measure *u* from. ○ Difficult to identify clear image so *v* difficult to measure ○ Depth of field issues 2-D image of 3-D object. ○ Filament may not be lined up with the centre of the lens ○ Screen could be tilted. ○ Appreciation that **t**he precision of length measurements are insignificant in comparison ot other uncertainties. • Improvements ○ Use a darkened room to make the image clearer ○ Use an illuminated slide as the object so it is easier to determine where to measure *u* from. ○ Means of ensuring lens and screen are parallel to one another. • Monochromatic light: ○ Chromatic aberration occurs with white light ○ Different wavelengths/frequencies will be refracted by different amounts by the lens. ○ Blue light refracts more than red. ○ More difficult to identify sharp clear image with white light.

Question			Answer	Mark	Guidance
4	(a)		Conservation of momentum idea used or clearly stated.✓ (570 x 6,000)/4.8x10^{9} = 7.1x10^{-4} ms^{-1}✓ Sensible assumption stated: ✓ For example (list is not exhaustive): • All linear momentum transferred to linear momentum of Dimorphos. • No rotation of Dimorphos • Calculated velocity is relative velocity or change of velocity. • Dimorphos remains intact • Whole of DART becomes embedded	3	**IGNORE** Conservation of energy Dimorphus stationary before collision
	(b)		Clear reference to ratio of masses of DART and Dimorphos (8.4 x 10^{6}) OR Small rider in region 18 μg or large rider in the region of 1.3 x 10^{6} kg, ✓ hence impractical.✓	2	NOT difference in mass, must refer to ratio or proportion Candidates could gain mark by referring to the ratio of the velocities being measured. Second mark is dependent on some statement about masses.

	(c)	**(i)**	v = 0.9 ms^{-1}✓	1	**ALLOW** 0.91 ≥ v ≥ 0.90 ms^{-1}
		(ii)	**EITHER** Use of $m \times \frac{\Delta v}{\Delta t} = F$ ✓ F = 0.15×(0.9 - 0.8) / 1✓ = 0.015 (N) ✓ **OR** Distance travelled by rider found to be 0.85m ✓ ΔKE of rider = 0.5 × 0.150 × (0.9^2 -0.8^2) ✓ $F = \Delta KE \div 0.85$ = 0.015 (N) ✓	3	**ALLOW** 0.0165 ≥ F ≥ 0.015 ms^{-1} **IGNORE** sign of final answer.
		(iii)	0.15 × 0.9 = 0.15 × (-0.23) + 0.25v✓ v = 0.68 ms^{-1} AND hence smaller (than velocity in c(i))✓	2	Negative recoil velocity only. Use of positive recoil velocity gives value v = 0.402 ms^{-1}. This gets zero marks. No marks without correct calculation.
	(d)		Decreasing negative gradient **OR** decreasing deceleration **OR** velocity decreasing with decreasing rate of change ✓ Resistive force decreases as velocity decreases (hence gradient decreases) ✓	2	**IGNORE** exponential Explanation must link to description of graph.

	(e)		**Level 3 (5-6 marks)** ✓✓ A workable plan explaining how to use the apparatus to obtain sensible data and an explanation of how to use the data obtained to prove or disprove the relationship. *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)** ✓✓ Limited description of a valid method of measuring velocity and drag force using the apparatus. Limited explanation of how to analyse 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)** ✓✓ Recognition that the two variables to measure are velocity and drag force with an idea of measurement. *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.*	6	**Indicative scientific points may include:** • Independent variable – speed or velocity ○ Relative velocity between air and sail ○ Method of propulsion of rider ▪ Using pulley and weights ▪ Using fan ○ Measuring (relative) velocity ▪ Ultrasonic range finder to measure speed of rider ▪ Anemometer to measure wind speed • Dependent variable – drag force ○ Equilibrium between force on sail from fan and weights on pulley ○ Using velocity-time graph of rider. ▪ Finding acceleration/deceleration of rider from v-t graph at different velocities ▪ Calculating net force = mass x acceleration ▪ Finding drag force = net force – driving force. ○ The driving force will be equal to the weight and hence constant. • Other practical issues: ○ Control variables to be kept constant ▪ Sail area ▪ Mass of rider ○ Air track must be level. ○ May not be completely frictionless. ○ Idea of collisions is a bit of a distractor, so maybe best to ignore collisions. • Determine relationship ○ Plot graph of v^2 against drag force or acceleration. ○ Calculate $\frac{Drag\ force}{v^2}$ (or equivalent) to check it is constant. ○ Should be a straight line if they are proportional. ○ If there is a relationship between drag force and velocity it shouldn't matter if the rider is accelerating or decelerating.

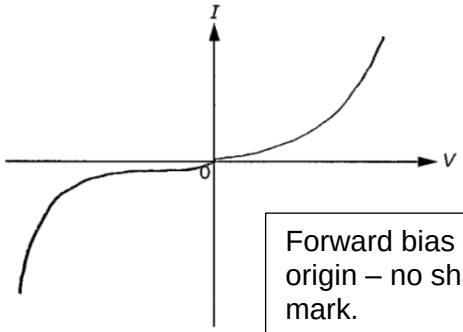
APPENDIX Additional guidance for Q2(c)



Forward bias – initially not horizontal enough so the sudden increase is not obvious enough. Not quite good enough.

Negative bias – incorrect so no mark

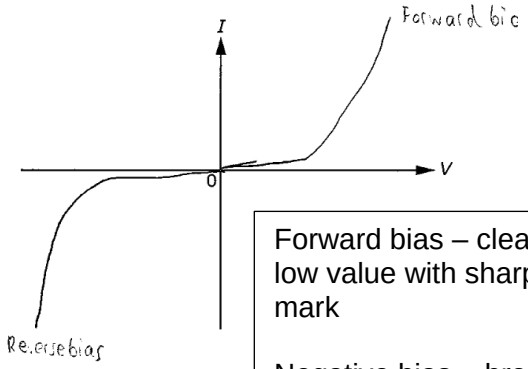
ZERO marks



Forward bias – smooth curve from origin – no sharp increase. No mark.

Negative bias – right sort of shape but no sense of scale so breakdown voltage is too small compared to positive V. no mark

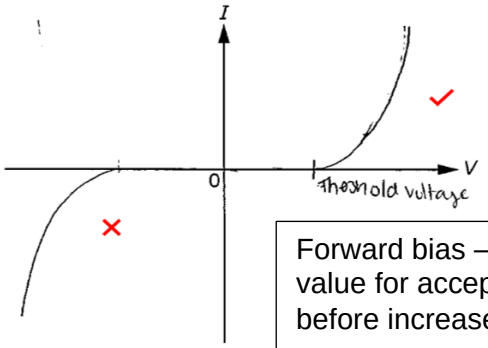
ZERO marks.



Forward bias – clearly almost horizontal low value with sharp increase. Gets the mark

Negative bias – breakdown too close to origin

1 mark



Forward bias – almost horizontal low value for acceptable (ratio of) ΔV before increase. Gets the mark.

Negative bias – Allowing zero current in negative bias but breakdown too close to origin

1 mark

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