



GCE

Physics B

H157/02: Physics in depth

AS Level

Mark Scheme for June 2024

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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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).

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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

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11. Annotations

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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 <u>numerical answers only</u> , 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.

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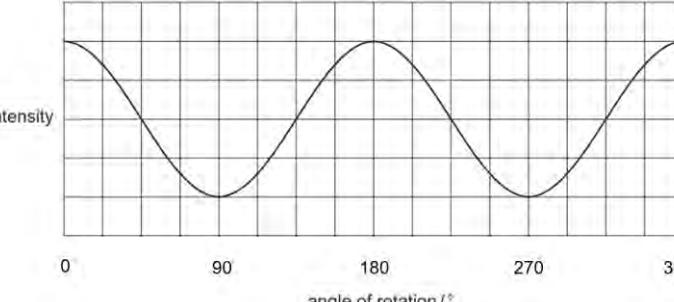
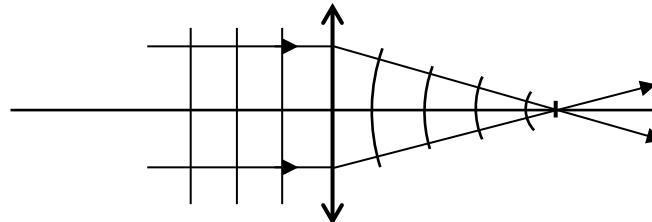
Annotation		Meaning
XP	Wrong physics or equation	Used in <u>numerical answers only</u> , unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer.
^	Omission	Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough).

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
Reject	Answers which are not worthy of credit
Not	Answers which are not worthy of credit
Ignore	Statements which are irrelevant
Allow	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject Specific Marking Instructions**LEVELS OF RESPONSE TARGETING AO1 AND AO2**

Where a mark scheme targets marks at AO1 and AO2, there is no requirement for a response to be awarded in the same level for AO1 as for AO2, so for example a response could be awarded Level 3 for AO1 and Level 2 for AO2.

Question			Answer	Mark	Guidance
1	(a)	(i)		1	Scale marking of (at least) 90, 180, 270 and 360 shown at correct places – within $\frac{1}{2}$ square. Allow 0° for 360 on final line Any further labels must be correct (1 square = 22.5°) Condone missing zero. Do not accept radian as measure unless the axis label is changed.
1	(a)	(ii)	Light waves are <u>transverse</u> .	1	Allow 'oscillations/vibrations are perpendicular / at 90° to the direction of the wave/energy transfer' or acceptable description of transverse wave
1	(b)		 Rays pass through principal focus within 1mm Wave-fronts between lens and principal focus curve inwards with consistent curvature, centred on principal focus / at 90° to rays by eye.	1 1 1	Ignore any rays/wave-fronts after principal focus Rays must be continuous from those before lens and up to the principal focus. At least 3 wave-fronts required. Equal, consistent separation judged by eye.
				Total	4

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Question		Answer	Mark	Guidance
2	(a)	$hc/e = V\lambda$ giving $h = (1.60 \times 10^{-19} \times 1.9 \times 565 \times 10^{-9}) / 3.0 \times 10^8$ $= 5.73 \times 10^{-34}$ (Js)	1 1	Substitution mark Correct answer gains both marks. 3sf max.
2	(b)	Repeat using LEDs of different colours Plot graph of threshold voltage against frequency Allows weighted mean / reduces random error / identifies anomalies OR Connect a (sensitive) ammeter in series with the LED The p.d. at which the current becomes non-zero is more detectable than the point at which the led begins to glow <u>So</u> , this will give a more accurate value for threshold voltage OR Carry out in darkened room As this allows the turn on point for the LED to be seen more easily <u>So</u> , this will give a more accurate value for threshold voltage	1 1 1 (1) (1) (1) (1) (1) (1)	Allow 1/wavelength for frequency Allow 3 rd mark for identifies anomalies if referring to repeats using the same (colour) LED Allow any method for seeing the trun on point for the LED
			Total	5

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Question		Answer	Mark	Guidance
3	(a)	<p>The ball travels the same distance <u>horizontally</u> in the 1st and 2nd seconds / the <u>horizontal</u> (component of the) velocity does not change over the 1st second.</p> <p>If air resistance was acting then the horizontal distance/velocity would be less</p>	1	
			1	Allow The <u>vertical</u> (component of the) velocity after the first second is about 10 ms ⁻¹ (consistent with acceleration of 10 ms ⁻²) as an alternative for the second marking point
3	(b)	<p>Horizontal component = 1 large square</p> <p>Vertical component = 3.9 large squares</p> <p>Resultant = 20(.2) (ms⁻¹)</p>	1 1 1	<p>Must be exact by eye</p> <p>Allow 3.8 – 4.0</p> <p>Allow by calculation or scale drawing. Allow in range 19-21 ms⁻¹ Tolerance of ½ small square accuracy with scale drawing. Allow ecf from diagram</p>
			Total	5

Question		Answer	Mark	Guidance
4	(a)	<p>Calculation of weight = $50 \times 9.81 = 490$ / 491 N</p> <p>Calculation of component of weight = $491 \times \sin(23.6) = 197$ N</p>	1 1	<p>Alternative method: Either: $mgh = 50 \times 9.81 \times 2 = 981$ J OR $\frac{1}{2}mv^2 = 400$ J</p> <p>Work done (against friction) = $mgh - \frac{1}{2}mv^2 = 981 + 400 = 581$ (J)</p>

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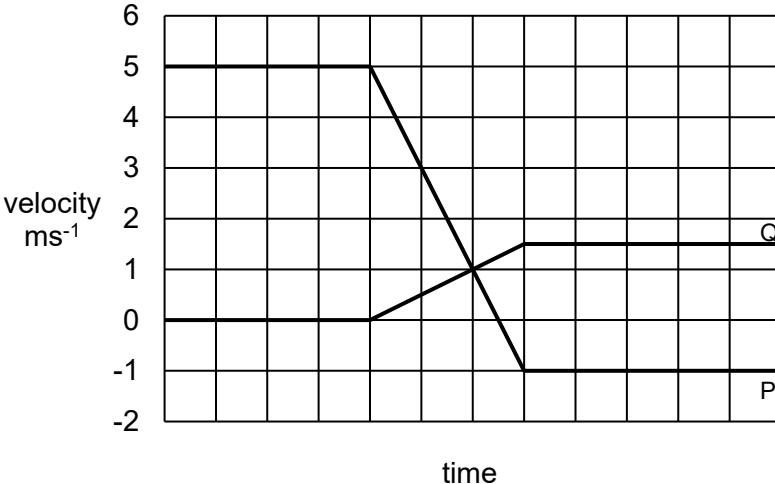
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Question		Answer	Mark	Guidance
		Acceleration = $v^2/2s = 4^2/10 = 1.6 \text{ ms}^{-2}$ $F_{\text{res}} = ma = 490 \sin 23.6 - F_{\text{fric}} = 50 \times 1.6$ giving $F_{\text{fric}} = 116 \text{ N}$	1 1	($W = Fs = 581 = F \times 5$) $F = (581/5) = 116 \text{ (N)}$ Expect at least 3sf
4	(b)	Average speed = $4.0 / 2 = 2.0 \text{ ms}^{-1}$ $P (= Fv) = 116 \times 2$ = 232 (W) OR Time = $2s/v = 10/4 = 2.5$ Power = work done / time taken = $581/2.5$ = 232 (W)	1 1 1 (1) (1) (1)	Allow $120 \times 2 = 240 \text{ (W)}$
			Total	7

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Question		Answer	Mark	Guidance
5	(a)	<p>Δp is the <u>change</u> in momentum, Δt is the time taken (for the change)</p> <p>$F = \frac{\Delta p}{\Delta t}$ and $\Delta p = m(v - u)$ so $F = \frac{m(v-u)}{\Delta t}$ so $F = ma$ as $a = \frac{(v-u)}{\Delta t}$</p>	1	
5	(b)	 <p>Velocity for Q = 0 before collision and constant (positive) value after, with straight line during collision</p> <p>Velocity for Q = 1.5 ms⁻¹ after collision.</p>	1	
			Total	4

Question		Answer	Mark	Additional Guidance
6	(a)	$(c_{air} / c_{glass} = \sin i / \sin r \text{ giving } c_{glass} = 3.00 \times 10^8 \times \sin(27) / \sin(40))$ $= 2.1(2) \times 10^8 \text{ (ms}^{-1}\text{)}$ $(\lambda_{air} / \lambda_{glass} = c_{air} / c_{glass} \text{ giving } \lambda_{glass} = 650 \times 10^{-9} \times 2.1 \times 10^8 / 3.00 \times 10^8)$ $= 460 \text{ (nm)}$	1 1	Allow ecf from incorrect speed of light in glass
6	(b)	<p>(At least 3) wave-fronts on each, emerging curved and have the same wavelength as the incident waves</p> <p>The wave-fronts in the lower diagram clearly more curved / circular than the first</p>	1	Judge wavelength by eye. Curvature to be in correct direction. Expect all wavefronts drawn to be equally separated Allow straight lines for first diagram Allow straight lines with curving at edges for the first diagram Ignore wavefronts past the principal focus
6	(c)	<p>(i)</p> <p>Dist between consecutive maxima = $1.25 \times 10^{-2} / 2 = 6.25 \times 10^{-3} \text{ (m)}$</p> <p>Angle of first order $\theta = \tan^{-1}(6.25 \times 10^{-3} / 2.5) = 0.143^\circ$</p> <p>$n\lambda = d \sin \theta \rightarrow \lambda = (0.2 \times 10^{-3} \times \sin(0.143)) = 4.99 \times 10^{-7} = 500 \text{ (nm)}$</p> <p>OR</p> <p>Angle of second order $\theta = \tan^{-1}(1.25 \times 10^{-2} / 2.5) = 0.286^\circ$</p>	1 1 1 (1)	Allow in cm Correct answer gains three marks

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Question		Answer	Mark	Additional Guidance
		$n\lambda = d \sin \theta \rightarrow \lambda = (0.2 \times 10^{-3} \times \sin (0.286)) / 2$ $= 500(\text{nm})$ <p>OR</p> $\text{Dist between consecutive maxima} = 1.25 \times 10^{-2} / 2 = 6.25 \times 10^{-3} (\text{m})$ $\lambda = xd/D = 6.25 \times 10^{-3} \times 0.2 \times 10^{-3} / 2.5 = 5 \times 10^{-7}$ $= 500 (\text{nm})$	(1) (1) (1) (1) (1)	
6	(c)	(ii) Any two from: <ul style="list-style-type: none"> Central maximum white Other maxima (continuous) spectrum Red light diffracted most, violet diffracted least Overlapping of orders of spectrum 	2	Allow description of colours in terms of angles (e.g. red at largest angle)

<p>6</p> <p>(c)</p> <p>(iii)</p> <p>Expect explanation to refer to Fig 6.3, but don't penalise general statements referring to maxima and minima rather than specific locations on Fig 6.3</p> <p>(Level 3) (5 – 6 marks)</p> <p>The formation of the interference pattern is clearly explained using both models and differences between them are described.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>(Level 2) (3 – 4 marks)</p> <p>The formation of the interference pattern is explained using both models, but key elements are missing from both explanations.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>(Level 1) (1 – 2 marks)</p> <p>The formation of the interference pattern is explained using one of the models.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant</i></p> <p>(0 marks)</p> <p>Insufficient or irrelevant science. Answer not worthy of credit.</p>	<p>6</p> <p>The wave model</p> <ul style="list-style-type: none"> • The light from the two slits is coherent (the waves have a fixed phase difference) • Waves passing through the slits diffract • And superpose / interfere • At Q the path difference between the waves from the two slits is half of one wavelength ($S_2Q - S_1Q = \lambda/2$) • At Q the waves from S_1 and S_2 are in antiphase (180° or π radians out of phase) • Destructive interference takes place at Q so intensity is minimum / low at Q • At R the path difference between the waves from the two slits is one wavelength ($(S_2R - S_1R = \lambda)$) • At R the waves are in phase • Constructive interference takes place at R so intensity is maximum / high at R <p>The photon model</p> <ul style="list-style-type: none"> • All of the possible pathways between the slits and Q and / or R have to be taken into account • Each photon has its own phasor arrow at Q and / or R • The probability of a photon arriving at Q and / or R is determined by combining the phasors for all possible paths • Probability of a photon arriving is proportional to the length of the resultant phasor arrow
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					<ul style="list-style-type: none">Intensity at a point is proportional to the probability of a photon arriving at that pointThe probability of a photon arriving at Q is low / amplitude of resultant phasor is low at QThe probability of a photon arriving at R is high / amplitude of resultant phasor is large at R
				Total	15

Question		Answer	Mark	Guidance
7	(a)	(i)		<p>NOTE: The equation for the curve is $v = 3.2 - 3.2e^{-3t}$ and the equation for the tangent is $v = 2.891t + 1.08$</p> <p>Mark each point independently</p> <p>1 Must be at $0.40s \pm 1$ small square horizontally</p> <p>1 Judge accuracy by extension of tangent to y-axis gives intercept between 1.0 and 1.2</p> <p>1 Expect Δv to be > 2.0</p> <p>Allow 2sf evaluation (2.8 to 3.1 ms^{-2})</p>
7	(a)	(ii)	1	<p>2nd curve above the first with the same general shape, extending to 0.50s</p> <p>Expect: similar initial gradient, 2nd curve always above original curve, continually decreasing gradient</p> <p>Explanation:</p>

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Question		Answer	Mark	Guidance
		<ul style="list-style-type: none"> (Adding mass gives) resultant downward force is greater; and so it reaches a higher speed before air resistance balances the weight 	1 1	Allow greater weight downward Allow idea of cone hitting the ground earlier due to greater speed for 2 nd mark only
7	(b)	(i) At terminal velocity $a = 0$ $k = 9.8/9.5^2 = 0.11$	1 1	This must be stated or clearly implied Substitution and evaluation to at least 2dp Allow $0 = 9.8 - k(9.5)^2 = 0.11$ for both marks
7	(b)	(ii) $9.416 \text{ (ms}^{-2}\text{)}$	1	4sf answer only Allow in table or on the line Take answer on line as final answer
7	(b)	(iii)1 $v_{\text{new}} = v_{\text{previous}} + (a_{\text{previous}} \times \Delta t)$	1	v_{new} must be subject
7	(b)	(iii)2 $= C_2 + (B_2 \times 0.10)$	1	Allow (A3-A2) for 0.10 or equivalent
7	(b)	(iii)3 $2.930 \text{ (ms}^{-1}\text{)}$	1	Allow 2.93
7	(b)	(iv) Advantage – the changing acceleration would make it difficult to calculate velocity using other mathematical methods (algebra and / or calculus). Improvement – make the time increments smaller	1 1	Allow Advantage – using a computer spreadsheet allows a large number of calculations to be carried out quickly. Allow Advantage – easy to change parameters of problem to test different theories
			Total	15

SECTION C

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Question		Answer	Mark	Guidance
8	(a)	<p>Component of weight down slope = $0.50 \times 9.81 \times \sin 8^\circ$ $= 0.68 \text{ (N)}$</p> <p>(As there is no acceleration) this is the value of the frictional force on the trolley</p>	1 1 1	This is used to overcome friction
8	(b)	<p>Average time = $(2.06 + 1.74 + 1.78) / 3 = 1.86 \text{ (s)}$</p> <p>Acceleration ($= 2s/t^2$) = $(2 \times 1) / 1.86^2$ $= 0.578 \text{ (ms}^{-2}\text{)}$</p> <p>Uncertainty in t = half range = $(2.06 - 1.74)/2 = 0.16$ <u>and</u> percentage uncertainty in t = $(0.16 / 1.86) \times 100 = 8.6\%$</p> <p>percentage uncertainty in a = $(2 \times \text{percentage uncertainty in } t) = 2 \times 8.6 = 17.2\% \text{ and}$ absolute uncertainty in a = $(17.2/100) \times 0.578 = 0.099 \text{ (ms}^{-2}\text{)}$</p>	1 1 1 1 1 1	<p>Expect to be filled into table, but allow in answer space if clear</p> <p>Allow ecf from average time as long as $0.53 < a < 0.68$ Allow any alternative method</p> <p>Correct value of acceleration implies correct average time for first mark</p> <p>Allow method using fractional uncertainties Allow ecf throughout but penalise incorrect physics</p> <p>Alternative: calculate max and min values of acceleration as 0.661 m s^{-2} and 0.471 ms^{-2} giving uncertainty = $\pm 0.095 \text{ (ms}^{-2}\text{)}$</p> <p>Allow reasonable range of values of uncertainties for different methods and rounding at intermediate stages</p>
8	(b)	(ii) Point and error bar plotted correctly	1	Ecf from (b) (i) but cannot be awarded if point or error bar lies outside of scale of axes

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8	(b)	(iii)	<p>(Level 3) (5 – 6 marks) A line of best fit is drawn and its equation is determined. A clear evaluation is seen and an appropriate comment on whether the results support Newton's 2nd law is made. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>(Level 2) (3 – 4 marks) The line of best fit is drawn and its equation is determined. The y-intercept and / or the gradient is used to comment on whether the results support Newton's 2nd law. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>(Level 1) (1 – 2 marks) The line of best fit is drawn and a comment about how it could be used to determine if acceleration is proportional to 1/mass. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant</i></p> <p>(0 marks) Insufficient or irrelevant science. Answer not worthy of credit.</p>	6	<p>Relationship between acceleration and 1/mass Line of best fit (The line should pass through or close to (1.00, 0.433) and have a reasonable scatter of the other points) Gradient between 0.525 and 0.400 Equation determined - expect equation to be similar to $a = 0.47(1/m) - 0.037$</p> <p>Comment on whether results support Newton's 2nd law Newton's 2nd law should be a straight line through the origin / directly proportional y-intercept should be zero Compares their line with Newton's 2nd law line e.g line is straight / y-intercept is not zero Addresses issue of y-intercept - uses uncertainty in the acceleration to conclude whether the calculated value of the y-intercept is effectively zero.</p> <p>Additional possibilities: Gradient should be equal to force provided by falling mass ($0.05 \times 9.8 = 0.49$) Compares gradient of worst line to best line Systematic error (e.g. incorrect friction compensation) leading to systematic error could explain non-zero intercept</p>
			Total	15	

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