AQA

A-LEVEL
Physics
7408/3A

PAPER 3 SECTION A

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the 'extra information' column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

'Ignore' or 'insufficient' is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

'Do **not** allow' means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word 'Show that…', the answer should be quoted to **one more** sf than the sf quoted in the question eg 'Show that X is equal to about 2.1 cm' – answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of 'Give your answer to an appropriate number of significant figures'.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of 'State an appropriate SI unit for your answer '. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 weber/metre^2 would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

Level of response mark schemes are broken down into three levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are two marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level. i.e. if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

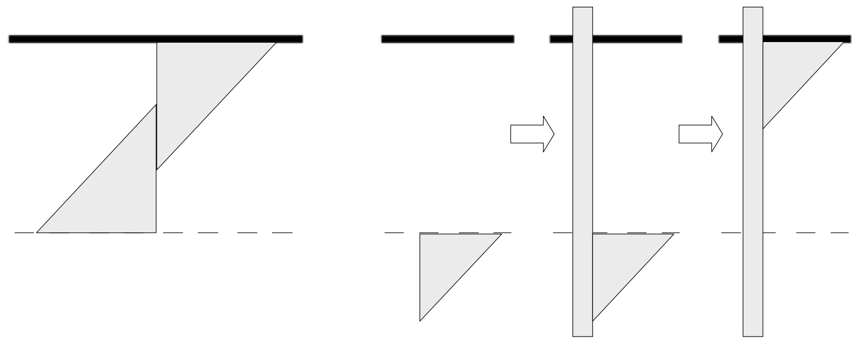
The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

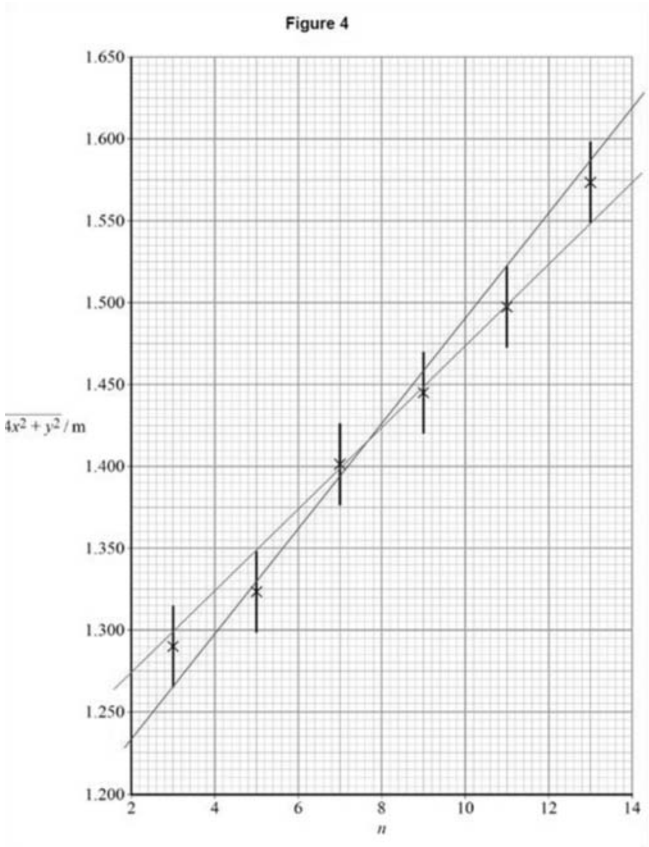
You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answer	Additional Comments/Guidance	Mark
01.1	180 degrees OR π radians ✓	accept ° for degrees condone ^{c} or 'rad' for radian reject 'half a cycle' treat 'π radians in phase' as talk out	1
01.2	(idea that) sets of combining waves do not have the same amplitude ✓	condone 'waves do not have same intensity' or 'same energy' or 'some energy is absorbed on reflection' or 'same power' or 'same strength' or idea that non point source or non point receiver would lead to imperfect cancellation condone the idea that the waves may not be monochromatic ignore 'some waves travel further' or 'waves do not perfectly cancel out' reject 'waves may not be 180° out of phase'	1

01.3	valid use of a set square or protractor against TR (to ensure perpendicular) $_1$✓ measure *x* at two <u>different</u> points [at each end of M] **<u>and</u>** adjust until [make sure] both <u>distances are the same</u> $_2$✓ OR use of set square to align M with the perpendicular line earns $_2$✓ if method used does not allow <u>continuous</u> variation in *x* then award maximum 1 mark OR align <u>graph paper</u> with TR $_1$✓ align M with grid lines on graph paper $_2$✓	both marks can be earned for suitable sketch showing a viable procedure involving one or more recognisable set squares or protractors; the sketch may also show a recognisable ruler, eg  allow use of scale on set square to measure the perpendicular distances don't penalise incorrect reference to the set square, eg as 'triangular ruler', as long as the sketch shows a recognisable set square	2

01.4	G_{max} line <u>ruled</u> through bottom of n = 3 error bar and through top of n = 11 error bar $_1$✓ G_{min} line <u>ruled</u> through top of n = 5 error bar and through bottom of n = 13 error bar $_2$✓ G_{max} and G_{min} calculated from valid y step divided by valid x step; <u>both</u> n steps ≥ 6 $_3$✓	allow 1 mm tolerance when judging intersection of gradient lines with error bars ignore any unit given with G_{max} or G_{min}; penalise power of ten error in 01.5  $_{12}$✓= 1 MAX if (either) line is thicker than half a grid square or of variable width or not continuous; expect G_{max} = 3.2(1) × 10^{-2} and G_{min} = 2.5 (2.49) × 10^{-2}	3

01.5	λ (from $\frac{G_{max}+G_{min}}{2}$) AND result in range 2.8(0) to 2.9(0) × 10^{-2} (m) $_1$✓$_2$✓ OR award one mark for 2.7(0) to 3.0(0) × 10^{-2} (m) $_{12}$✓	penalise 1 mark for a power of ten error reject 1 sf 3 × 10^{-2} (m) if a best fit line is drawn between the G_{max} and G_{min} lines and the gradient of this is calculated award 1 mark for λ in range 2.8(0) to 3.0(0) × 10^{-2}(m)	2
01.6	uncertainty in λ = $G_{max}-\lambda$ OR $\lambda - G_{min}$ OR $\left(\frac{G_{max}-G_{min}}{2}\right)$ $_1$✓ percentage uncertainty = (uncertainty/λ)×100 $_2$✓ result in range 11(.0) % to 14(.0) % $_3$✓	$_1$✓ can be earned by showing a valid uncertainty then dividing by λ ecf their λ, G_{max} and G_{min} for $_1$✓ and $_2$✓ allow λ found from best fit line accept $\left(\frac{G_{max}-\lambda}{\lambda}\right)\times 100$ or $\left(\frac{G_{max}-G_{min}}{G_{max}+G_{min}}\right)\times 100$ etc for $_{12}$✓✓ allow $\left(\frac{\Delta\lambda}{\lambda}\right)\times 100$ where $\Delta\lambda$ is any plausible uncertainty for $_2$✓ numerical answer without valid working can only earn $_3$✓	3

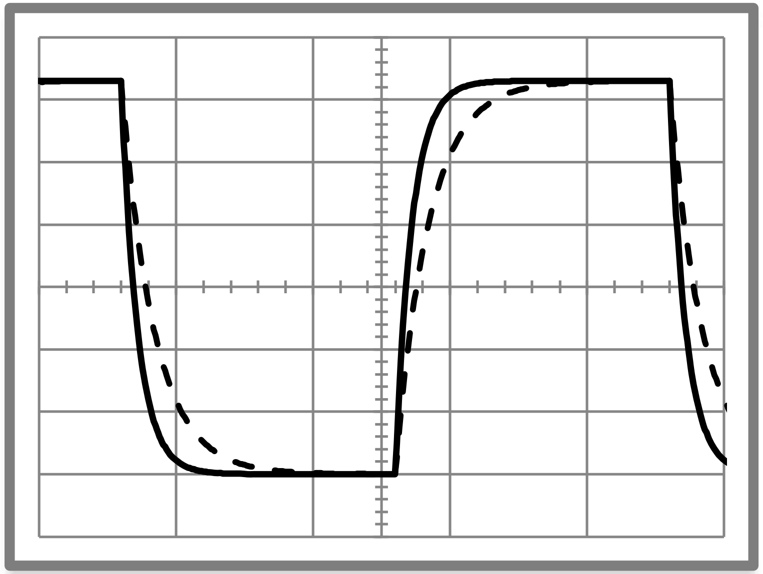
<table>
<tr><td>01.7</td><td>(states) <u>calculate</u> the (vertical) intercept $_1$✓
OR
outlines a valid calculation method to calculate y $_1$✓
determine the intercept for <u>both lines</u> and calculate average value $_2$✓
OR
determine the (vertical) intercept of the line of best fit (between G_{max} and G_{min}) $_2$✓</td><td>draw the line of best fit (between G_{max} and G_{min}); perform calculation to find intercept earns $_{12}$✓✓</td><td>2</td></tr>
<tr><td>01.8</td><td><table><tr><td>result</td><td>reduced</td><td>not affected</td><td>increased</td></tr><tr><td>G_{max}</td><td></td><td>✓</td><td></td></tr><tr><td>G_{min}</td><td>✓</td><td></td><td></td></tr><tr><td>λ</td><td>✓</td><td></td><td></td></tr><tr><td>y</td><td></td><td></td><td>✓</td></tr></table></td><td>general marker question
allow any distinguishing mark as long as only one per row
for ✓ and ✗ in same row ignore ✗
for ✓ and ✓ in same row give no mark
ignore any crossed-out response</td><td>4</td></tr>
</table>

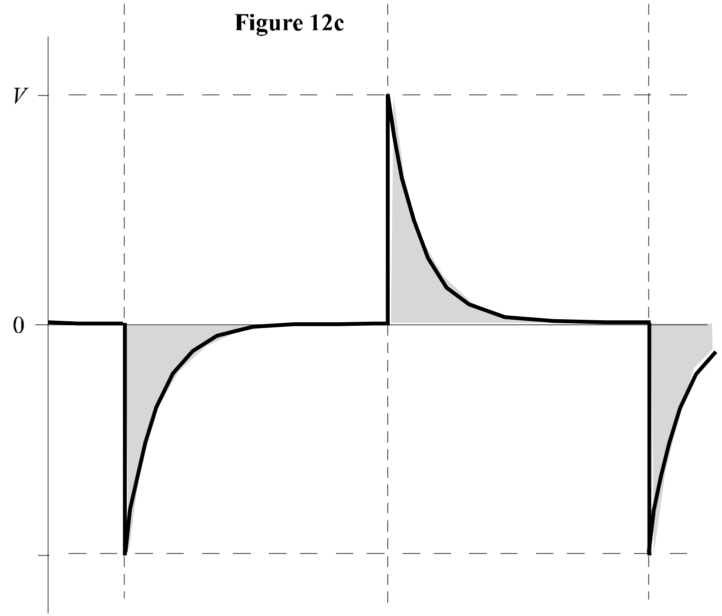
alternative approach: single best fit line drawn on **Figure 4**			
01.4	*G* calculated from *y* step divided by *x* step; *n* step ≥ 6 $_3$✓		MAX 1
01.5	λ in range 2.8(0) to 2.9(0) × 10^{-2} ✓		MAX 1
01.6	percentage uncertainty in λ = $\frac{\Delta\lambda}{\lambda}\times 100$ AND result in range 11(.0) % to 14(.0) % ✓		MAX 1
01.7	<u>calculate</u> intercept OR outlines a valid calculation method to find *y* ✓		MAX 1
01.8	as main scheme	no ecf possible	4
alternative approach: non-crossing lines for G_{max} and G_{min} on **Figure 4**: includes lines that meet but do not cross			
01.4	G_{max} and G_{min} calculated from *y* step divided by *x* step; both *n* steps ≥ 6 $_3$✓		MAX 1
01.5 to 01.8	as main scheme		11

Question	Answer	Additional Comments/Guidance	Mark
02.1	peak (to peak) voltage = 6.3(0) (V) ✓	accept any answer that rounds to 6.3 V do not allow power of ten errors, eg 0.0063 V	1
02.2	period = 8 divisions (= 8 × 0.5 × 10^{-3} (s)) = 4 ms $_1$✓ $\left(f = \frac{1}{T} = \frac{1}{0.004}\right)$ = 250 (Hz) $_2$✓	award both marks if 250 Hz seen accept 4.0(0) ms for $_1$✓ but reject 4.05, 3.95 etc ecf_2✓ for wrong period	2

02.3	any valid approach leading to *RC* in range 2.1×10^{-4} to 3.4×10^{-4} or 3×10^{-4} (s) OR their *T* in 02.2 × 0.069 ± 10 % 12✓✓ 1 mark can be awarded for use of any valid approach in which *RC* is seen with substitutions or with rearranged equations, eg $0.5 = 6.3e^{\frac{-6\times10^{-3}}{RC}}$ or $RC = \frac{-t}{\ln\left(\frac{V}{V_0}\right)}$ or $RC = \frac{t}{\ln\left(\frac{V_0}{V}\right)}$ OR $1.75\times10^{-4} = RC \times \ln 2$ OR $RC = \frac{t_{0.5}}{\ln(2)}$	valid approaches; reads off *t* when *C* starts to discharge and *t* at a lower value of *V*: rearranges $V = V_0 e^{\frac{-\Delta t}{RC}}$ to calculate *RC* for ecf 2✓ Δt used must correspond to interpretation of time base used in determining the frequency in 02.2; there is no ecf for misinterpretation of the voltage scale OR reads off *t* when *C* starts to charge and *t* at a higher value of *V*: rearranges $V = V_0\left(1 - e^{\frac{-\Delta t}{RC}}\right)$ to calculate *RC* etc OR determines half-life $t_{0.5}$ and finds *RC* from $\frac{t_{0.5}}{\ln(2)}$ for ecf 2✓ $t_{0.5}$ used must correspond to etc OR uses idea that during discharge *V* falls to $0.37V_0$ in one time constant: determines suitable *V* and reads off *RC* directly for ecf 2✓ time interval used must correspond to etc OR uses idea that during charging *V* rises to $0.63V_0$ in one time constant: determines suitable *V* and reads off *RC* directly reject idea that *V* falls to zero in 5*RC*	2

02.4	qualitative comment idea that the waveform will stretch horizontally $_1$✓ quantitative comment by a factor of $\left(\frac{0.5}{0.2}=\right)$ 2.5 $_2$✓ OR half a cycle now covers 10 (horizontal) divisions on the screen $_2$✓ (and also earns $_1$✓) (so the) resolution of the time axis has increased $_3$✓ (and also earns $_1$✓) measuring larger distance / across more divisions from the screen reduces (percentage) uncertainty in reading the time (constant / interval / half life) $_4$✓	for $_1$✓ look for reference to time axis or direction waveform is re-scaled accept 'graph is longer/stretched' or 'will not see whole cycle' or 'fewer cycles shown' or 'period takes more space' or 'distance being measured is larger' or 'time per division is less' or 'larger in *x* direction' or 'time is stretched' reject 'waveform becomes larger' or 'may not see whole cycle' or 'measuring larger time' for $_2$✓ there needs to be valid quantitative detail award $_{12}$✓✓ for 'half a cycle now fills the screen' or 'half a cycle is displayed' as these clearly recognise the stretching is along the time axis and 'half' is quantitative accept 'new distance (on screen corresponding to half life or time constant) is 2.5 × answer shown in working for 02.3' the candidate who realises that half a wave now covers the complete width of the screen cannot claim this is a disadvantage; they would still be able to bring either half cycle into view by using the X-shift and find *RC* for $_3$✓ uses technical language correctly ignore (but do not penalise) 'times are more precise' or 'more accurate' reject 'smaller resolution' or 'lower resolution' for $_4$✓ there needs to be a qualifying explanation for the comment about uncertainty reject 'advantage because the (time) scale is easier to read'	3 MAX

02.5	valid sketch on **Figure 11** showing discharge time to 0 V reduced and charging time to peak voltage reduced (see right) 1✓ connecting resistor in parallel with R halves [reduces by 50%] circuit [total] resistance [time constant] 2✓	 do not insist on seeing second discharge although if shown this must look correct	2

02.6	amendment to **Figure 12** showing waveform across R with approximately the correct shape, amplitude ± *V* and the correct phase correct waveform shown while signal generator output is low (0 V): only the complete negative half cycle needs to be shown but if second negative half cycle is included it must be correct $_1$✓ correct waveform shown while voltage across signal generator output is high; condone no signal or signal = 0 V before going to –*V* for the first time $_2$✓	Figure 12c  don't insist on seeing vertical lines	2
02.7	reduce the (sensitivity of) (Y-voltage)) gain $_1$✓ (change) to 2 V division^{-1} $_2$✓ (and earns $_1$✓) adjust the Y (vertical) shift $_3$✓	'make (Y-) gain smaller' or 'increase the volts per division' or 'reduce the Y-resolution' are acceptable substitutes for 'reduce the (Y-)gain' increase the (Y-) gain to 2 V division^{-1} $_2$✓ not $_1$✓ reduce the (Y-) gain to 0.5 V division^{-1} $_1$✓ not $_2$✓ ignore any comment about time base or 'X-gain' if all positive waveform is given for 02.6 allow sensible comment about triggering/stability control, eg waveform may not be stable $_1$✓; adjust triggering $_2$✓	2 MAX

Question	Answer	Additional Comments/Guidance	Mark
03.1	p_0 = 198.4 (cm) ✓	only acceptable answer	1
03.2	all x values correct and recorded to nearest mm ✓	n p/cm x/cm 0 198.4 174.6 2 157.0 133.2 4 125.4 101.6 6 101.3 77.5 9 75.4 51.6 13 53.8 30.0 allow ecf for $x = p - 23.8$ if $p_0 \neq 198.4$ penalise 2 sf x = 30 for n = 13	1

03.3	six values of ln(x/cm) recorded consistently ie all to (minimum) 2 dp; confirm that value of ln(x) for n = 6 corresponds to tabulated value of x [1]✓ vertical axis labelled ln(x/cm) ie bracket required; suitable vertical scale (points should cover at least half the grid with a frequency of not less than 5 cm) [2]✓ points plotted for n = 0, 2, 4, 6, 9 and 13; check n = 6 point is plotted within half a grid square of tabulated position; suitable continuous ruled line of negative gradient from n = 0 to (at least) n = 13 [3]✓	expected data: n p/cm x/cm ln(x/cm) 0 198.4 174.6 5.162 6 101.3 77.5 4.350 for n = 0, x = 0, ignore missing or incorrect ln(x) and ignore missing/wrongly-plotted point for [2]✓ vertical axis should be labelled ln(x/cm) (note that bracket is essential); expect vertical scale to start at 3 with major divisions of 0.2 for [3]✓ a suitable line must pass through all points if these have been correctly calculated; for any errant plotted points the line must be the best line in the opinion of the marker; line must not be thicker than half a grid square and width must not vary; points must not be thicker than half a grid square (reject any dots or blobs)	3

03.4	graph is <u>linear</u> and has <u>negative</u> gradient ✓	allow 'straight line' for 'linear'; statement must be confirmed by **Figure 18** allow 'negative slope' or 'slopes downwards' for 'negative gradient' no ecf for non-linear graph	1
03.5	gradient triangle for **Figure 16**; correct read offs (± 1 mm) for all points or for both steps in triangle $_1$✓ expected gradient result is –0.135 for gradient between –0.139 to –0.133 (allow this intermediate answer shown as a fraction) award two marks for minimum 3 sf *x* when *n* = 20 in range 11.2 to 12.2 (cm) $_{23}$✓✓ OR one mark for *x* when *n* = 20 in range 10.8 to 12.7 (cm) $_{23}$✓ OR (if gradient out of range) marker uses candidate's gradient (<u>which must be negative</u>) and (marker must read off) intercept on **Figure 16** to calculate *x* when *n* = 20 minimum 3 sf result in range ± 4% $_{23}$✓✓ OR 1 mark minimum 3 sf result in range ± 8% $_{23}$✓ (theoretical result for *x* when *n* = 20 is 11.7(3) cm)	for $_1$✓ allow 1 mark for sufficient evidence of working and a valid calculation of the gradient of a <u>linear</u> graph even if graph has a positive gradient for $_2$✓ and $_3$✓ give no credit if graph drawn has a positive gradient allow 1 mark for using a positive value for the (negative) gradient in the calculation for *x* when *n* = 20 (this leads to 2592 cm); result must be in range ± 4% $_{23}$✓ allow 'similar triangles' method; eg $\frac{5.16-3}{16}=\frac{5.16-\ln x_{20}}{20}$ $_1$✓ ln x_{20} = 2.46 $_2$✓; x_{20} = 11.7(0) cm $_3$✓ allow ecf *x* when *n* = 20 based on **Figure 16** if scales used enable value to be read directly using an extrapolated line; do not allow such working to extend beyond the grid into the margin $_1$✓; value in range 11.2 to 12.1 cm $_{23}$✓ = 1 MAX	3

03.6	valid procedure 1 described $_1$✓ explained $_2$✓; valid procedure 2 described $_3$✓ explained $_4$✓	explanation mark ($_2$✓) is only awarded when it is relevant to a correct procedure ($_1$✓); one procedure/explanation allowed per response no credit for conflicting statements or wrong physics any two from: repeat experiment and average calculated (*p*) $_1$✓ to reduce (impact of) random [human] error $_2$✓ and/or repeat readings to detect anomalies $_1$✓ <u>so these can be discarded</u> (before averaging) $_2$✓ and/or view air track at right angles [at eye level] $_1$✓ to reduce [eliminate] (impact of) parallax error $_2$✓ and/or repeat experiment with track direction reversed and average calculated (*p*) $_1$✓ to account for the effect of non-level bench $_2$✓ and/or use <u>video</u> (camera) technology [or a <u>motion sensor</u> linked to a <u>data logger</u> or <u>laser ranger</u>] to view [record] the position of the glider as it reaches the top of the track $_1$✓ to reduce (impact of) random [human] error [to identify and eliminate anomalous results] $_2$✓ reject any suggestion that involves changing the glider, its initial position on the track or the air track itself including the position of the scale	4