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June 2025

Int Advanced Level Physics WPH16 01

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June 2025

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Introduction

The IAL paper WPH16 Practical Skills in Physics II assesses the skills associated with practical work in Physics and builds on the skills learned in the IAL paper WPH13. This paper assesses the skills of planning, data analysis and evaluation which are equivalent to those that A level Physics candidates in the UK are assessed on within written examinations. This document should be read in conjunction with the question paper and the mark scheme which are available at the Pearson Qualifications website, along with Unit 6 and Appendix 10 in the specification.

In this specification, it is expected that candidates will carry out a range of Core Practical experiments. The skills and techniques learned from carrying out these experiments will be examined in this paper, but the Core Practical experiments themselves are not assessed. Candidates who do little practical work will find this paper more difficult as many questions rely on applying the learning to novel as well as other standard experiments.

Candidates are expected to know and use terminology appropriately, and use standard techniques associated with analysing uncertainties. These can be found in Appendix 10 of the specification. In addition, command words may be used to challenge the candidates to form conclusions. These are given in Appendix 9 of the specification, and centres should make sure that candidates understand what the command words mean.

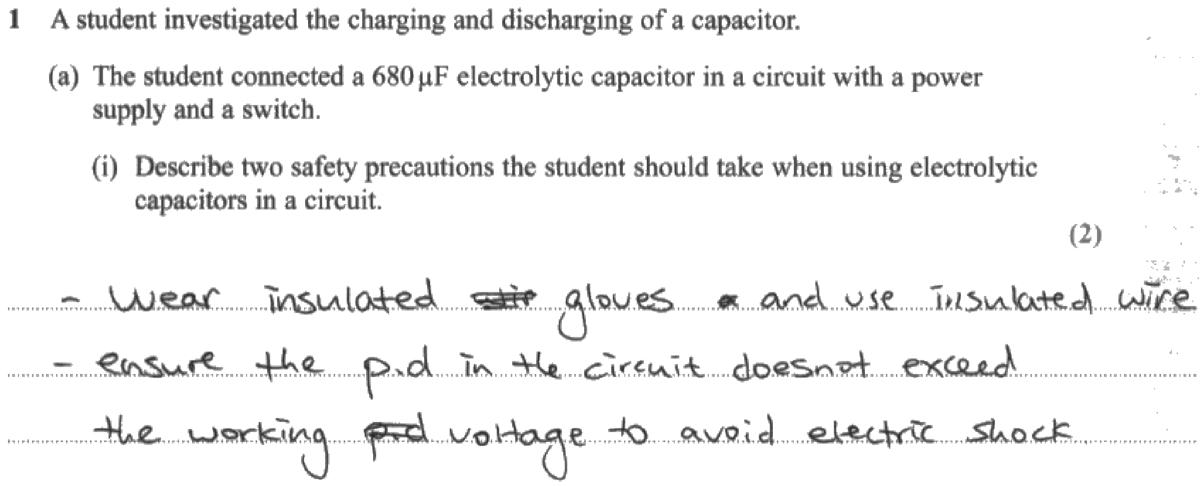
Candidates should be encouraged to work with mark schemes in preparation for their examination. However, it is important that they understand that mark schemes do not provide model answers to questions. Mark schemes are written for examiners and so sometimes refer to what examiners expect to see rather than giving a complete answer.

The paper for June 2025 covered the same skills as in previous series and was therefore similar in demand.

Question 1(a)i

Q01 was based on charging and discharging an electrolytic capacitor. Discharging capacitors is found in Core Practical 11: Capacitor Discharge. The investigation, however, varied slightly to the core practical.

In part (a)(i) candidates had to **state two** safety precautions when using electrolytic capacitors. Safety precautions should be **specific** to the investigation being described. This question was answered more clearly than in previous series, but some candidates still stated general precautions for connecting circuits. Some candidates stated that the capacitor had to be discharged but this is the purpose of the investigation, so more detail was required before handling the capacitor.



1 A student investigated the charging and discharging of a capacitor.

(a) The student connected a 680 μF electrolytic capacitor in a circuit with a power supply and a switch.

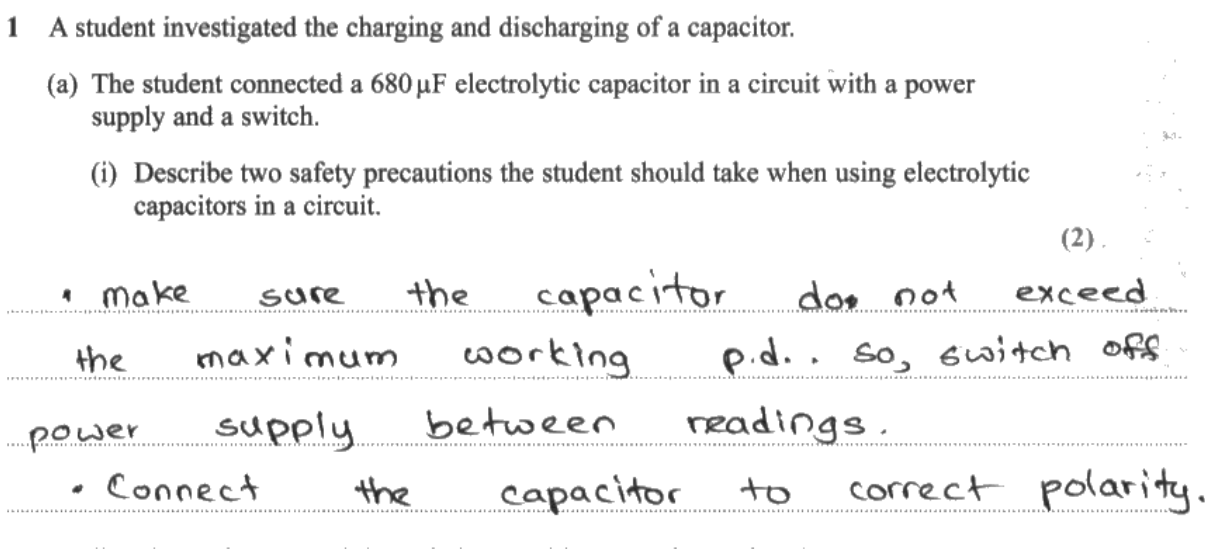
(i) Describe two safety precautions the student should take when using electrolytic capacitors in a circuit.

(2)

- Wear insulated ~~stir~~ gloves and use insulated wire
- ensure the p.d in the circuit doesnot exceed the working ~~pd~~ voltage to avoid electric shock

ResultsPlus Examiner Comments

Although the candidate has only given two potential safety precautions, line 1 is irrelevant to this investigation. It is not necessary to use insulated gloves in an electrical context. Insulated wires are usually used in any electrical investigation.



1 A student investigated the charging and discharging of a capacitor.

(a) The student connected a 680 µF electrolytic capacitor in a circuit with a power supply and a switch.

(i) Describe two safety precautions the student should take when using electrolytic capacitors in a circuit.

(2)

- make sure the capacitor do not exceed the maximum working p.d.. so, switch off power supply between readings.
- Connect the capacitor to correct polarity.

ResultsPlus Examiner Comments

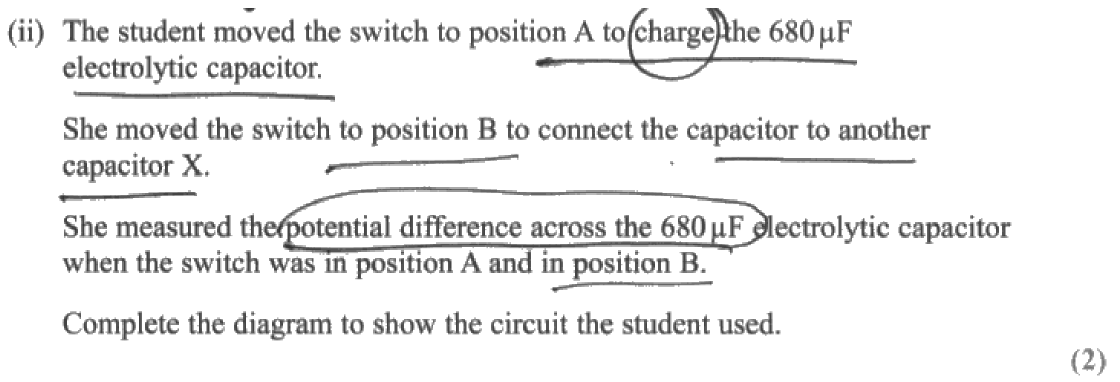
Two relevant safety precautions for using electrolytic capacitors listed.

ResultsPlus Examiner Tip

Ensure safety precautions relate to the investigation.

Question 1(a)ii

In part (ii) candidates had to **complete** the circuit diagram for the investigation. This was generally done well although it was clear that some candidates had not read the information as general discharge circuits were drawn. Some candidates decided that two voltmeters were needed, which was not accepted. It was also clear that some candidates did not understand the symbol for a double-throw switch.



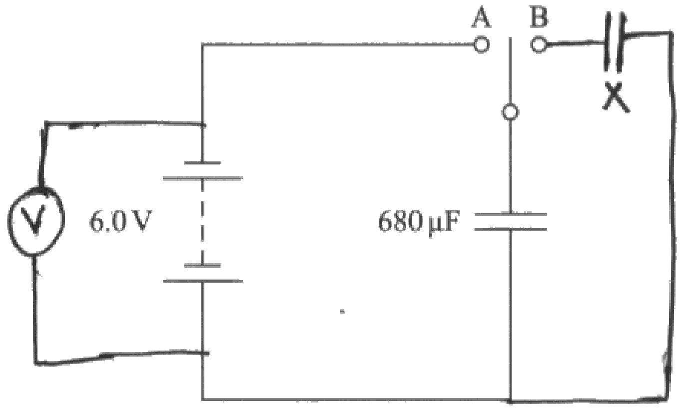
(ii) The student moved the switch to position A to charge the 680 µF electrolytic capacitor.

She moved the switch to position B to connect the capacitor to another capacitor X.

She measured the potential difference across the 680 µF electrolytic capacitor when the switch was in position A and in position B.

Complete the diagram to show the circuit the student used.

(2)



ResultsPlus
Examiner Comments

The voltmeter is not in the correct place as it would only ever show the potential difference across the power supply.

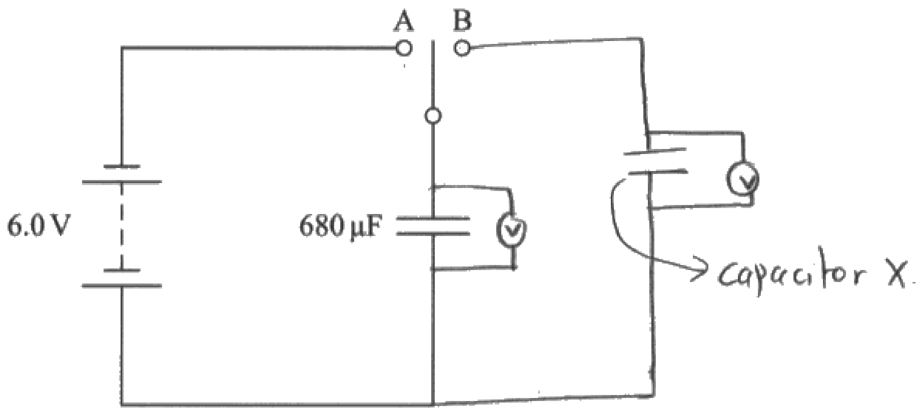
(ii) The student moved the switch to position A to charge the 680 µF electrolytic capacitor.

She moved the switch to position B to connect the capacitor to another capacitor X.

She measured the potential difference across the 680 µF electrolytic capacitor when the switch was in position A and in position B.

Complete the diagram to show the circuit the student used.

(2)



ResultsPlus
Examiner Comments

This candidate gave two voltmeters which was not accepted as one was correct for this investigation and one was incorrect.

ResultsPlus
Examiner Tip

Read the description of the investigation carefully and only include components needed for the measurements stated.

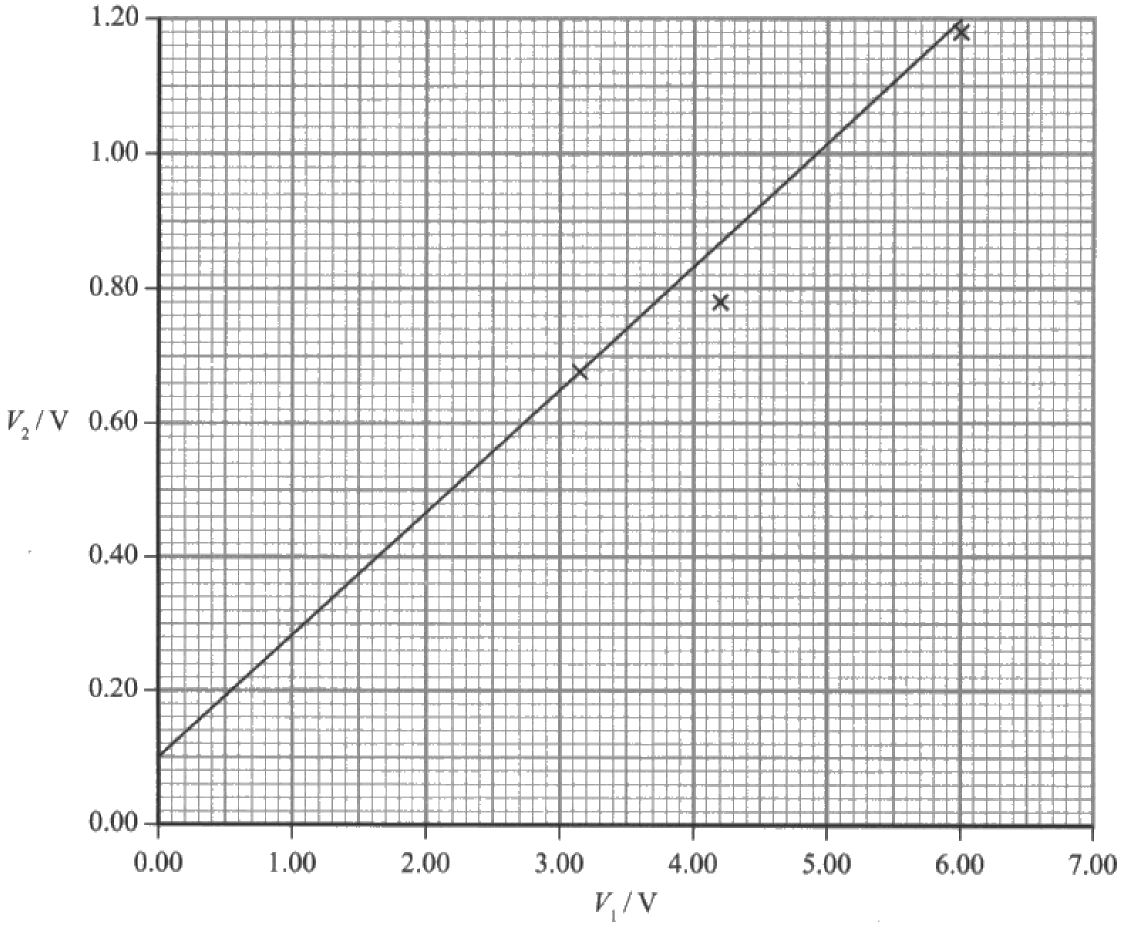
Question 1(b)

In part (b) candidates had to **criticise** the **graph**. It was clear that some candidates just wrote down everything they could remember about criticising rather than relate their comments to the graph. Whilst some candidates stated that the best fit line was not accurate they should have discussed the spread of data around the best fit line that was drawn. Some candidates referred to an anomaly or outlier which was not accepted as there was not enough data to make that judgement. Comments referring to the origin were not accepted as no formula had been given.

(b) The student charged the 680 μF capacitor to different potential differences, V_1.

For each value of potential difference V_1, she connected the 680 μF capacitor to capacitor X. The final value of the potential difference across the 680 μF capacitor was V_2.

She recorded the corresponding values of V_1 and V_2 and plotted the graph below.



Criticise the student's graph.

(3)

There are only 3 sets of data, must be atleast 5, so line of best fit inaccurate. Not sufficient data available to show if the graph is a line or a curve. Range of data too small.

Sets of data are taken ~~at~~ for inconsistent ~~values~~ intervals of V.

ResultsPlus
Examiner Comments

This candidate criticises the shape of the best-fit line.

ResultsPlus
Examiner Tip

When criticising best-fit lines, look at both the spread of data about the line and whether there is sufficient data to judge the shape of the line.

Question 2(a)

Q02 assessed planning skills based on investigating how the pressure of a fixed volume of gas varied with temperature to estimate a value for absolute zero. The techniques for heating can be found in Core Practical 12: Calibrating a Thermistor.

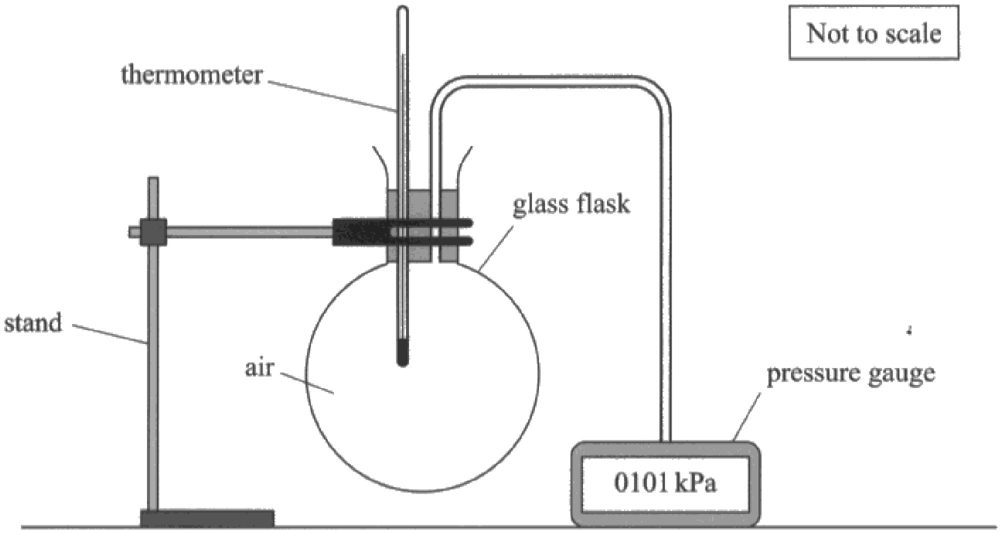
Part (a) was the familiar planning question. Candidates should be aiming to write a method for the investigation described in the question that could be followed by a competent physicist. Many candidates answered this question well as the mark scheme for this type of the question follows a similar structure in each series. Although marks were not awarded for linking ideas, candidates using vague language or not describing a method logically can lead to marks not being awarded. The best answers were structured and concise, leading to a method that could be followed easily. Some candidates wasted time and space by referring to gas laws, a volume measurement, or safety which were unnecessary. Candidates should also check the number of marks being awarded as many responses went beyond the lines given.

The first two marks were for describing how to vary the temperature of the gas between 0°C and 100°C. Most candidates described how to heat the air, but many forgot they had to somehow cool it to 0°C using a realistic method. Common errors included not referring to a specific type of heating apparatus found in a laboratory, for example an electric heater was not accepted.

The third mark was achievable in several ways, either for stating a relevant technique to ensure thermal equilibrium or for measuring temperature. Many candidates stated viewing the thermometer scale perpendicularly or heating the air gradually. Some referred to stirring the air, which is not appropriate.

The final three marks were for obtaining **sufficient and valid data** to determine a value for absolute zero. Candidates most often scored the mark for measuring the pressure at a particular temperature. Some candidates included a time measurement which was irrelevant and sometimes led to unclear descriptions. For the fifth mark, candidates should be stating how many **different** temperatures to use. Some candidates stated that they would take five sets of measurements to calculate a mean which does not score the mark. Most candidates stated which graph to plot, but there was some confusion at which intercept the value of absolute zero would be given.

2 A student investigated how the pressure of a fixed volume of air varied with temperature using the apparatus shown.



(a) The student used temperatures ranging from 0 °C to 100 °C.

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Devise a method the student could use to estimate a value for absolute zero.

Your method should include any additional apparatus and the use of a suitable graph.

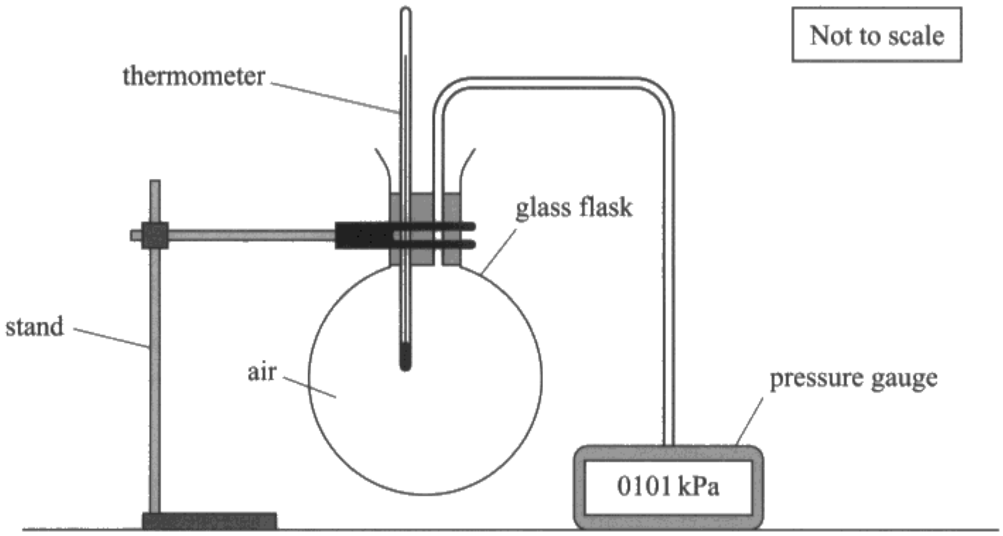
(6)

To reach a temperature~~s~~ of 0°c put the glass flask in a ice bath and then to slowly heat it up, place a bunsen ~~burner~~ burner underneath it. ~~fa~~ Every 5°c or 10°c ~~wee~~ take ~~a~~ the reading of the pressure gauge and plot the values in a table. Make sure to be eye level with the thermometer to remove parallax error. Repeat and average to get ~~precise~~ Precise values of pressure. Finally using your results table plot a graph of pressure against temperature and use the formula $\frac{P_1}{T_1} = \frac{P_2}{T_2}$. Make sure the volume of air is always constant.

ResultsPlus
Examiner Comments

A method that is set out clearly in a logical way. All marking points are there except this candidate does not state correctly how to determine absolute zero from the graph.

2 A student investigated how the pressure of a fixed volume of air varied with temperature using the apparatus shown.



(a) The student used temperatures ranging from 0 °C to 100 °C.

Devise a method the student could use to estimate a value for absolute zero.

Your method should include any additional apparatus and the use of a suitable graph.

(6)

use a ~~[illegible]~~ thermometer to measure the temperature (vary temperature)

Measure the volume of air (initially)

Measure the sets of values for the pressure and temperature

At least have 5 sets of Values to be able to plot a graph

Determine the number of the melucules of the air in the glass flask (By measuring the mass using an appropriate apparatus)

$PV = NKT$ since V constant, N constant and K is also a constant so the ~~pressure - temperature graph would~~

$\frac{PV}{N} = kT$ PV -N graph would give a straight line /constant gradient.

ResultsPlus
Examiner Comments

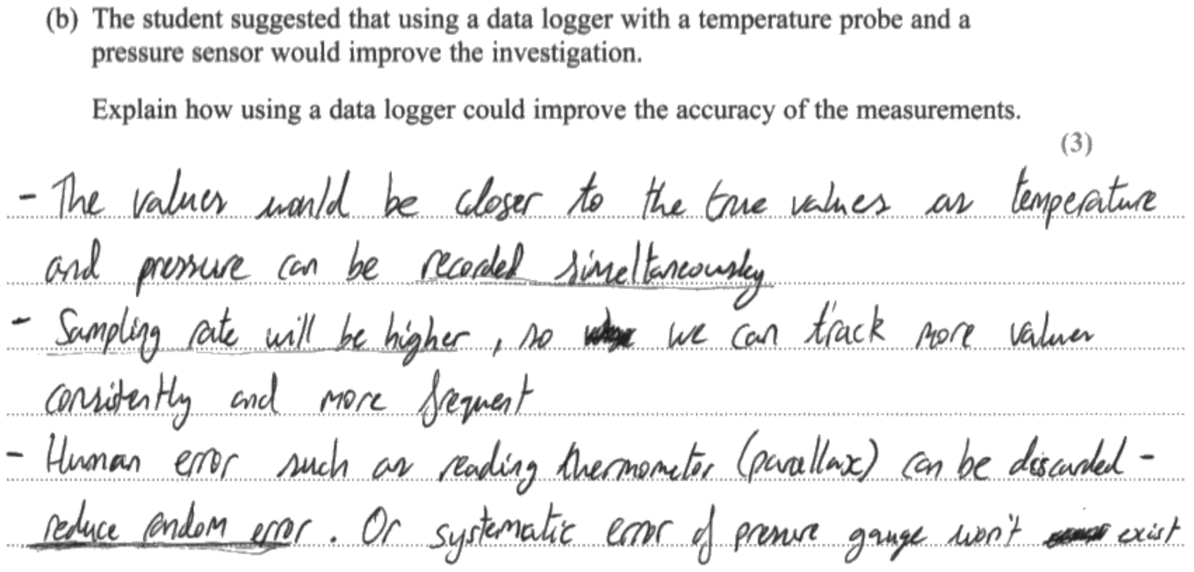
This candidate only scored the marks for stating which measurements to make and how many different sets of readings would be needed. There was no attempt at heating or cooling the air nor any associated technique. The graph does not relate pressure and temperature as these are the only two variables that are changing in this investigation.

ResultsPlus
Examiner Tip

Start with the variables being investigated or the graph that should be plotted.

Question 2(b)

In part (b) candidates were asked to **explain** why a data logger connected to a temperature probe and pressure sensor would **improve the accuracy of the measurements**. Candidates gave a range of answers that either did not relate this to the investigation. This question focused on the **accuracy of the measurements**, ie how the sensors and data logger can obtain measurements as close as possible to the true value. Most candidates gave the idea of simultaneous measurements, although there were some that gave simultaneous measurements of temperature and time rather than temperature and pressure. Some candidates did suggest that parallax error could be reduced but did not refer to where parallax error could arise. Very few candidates gave the third marking point.



(b) The student suggested that using a data logger with a temperature probe and a pressure sensor would improve the investigation.

Explain how using a data logger could improve the accuracy of the measurements.

(3)

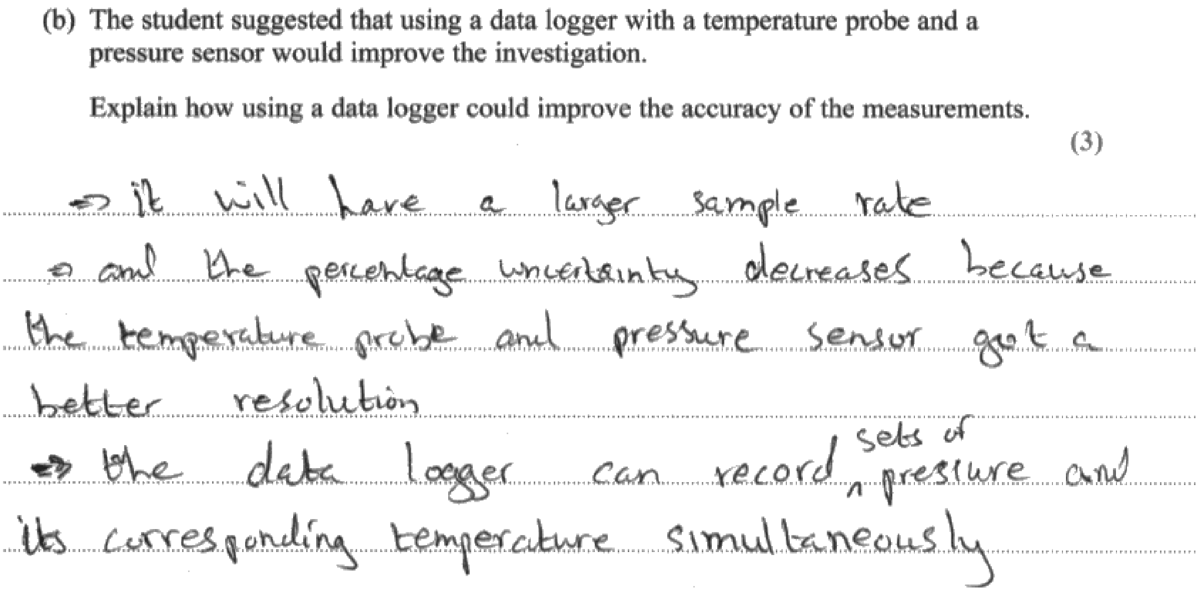
- The values would be closer to the true values as temperature and pressure can be recorded simultaneously
- Sampling rate will be higher, so we can track more values consistently and more frequent
- Human error such as reading thermometer (parallax) can be discarded - reduce random error. Or systematic error of pressure gauge won't exist

ResultsPlus
Examiner Comments

A very unusual answer that scores full marks.

ResultsPlus
Examiner Tip

Understand what is meant by accuracy.


(b) The student suggested that using a data logger with a temperature probe and a pressure sensor would improve the investigation.

Explain how using a data logger could improve the accuracy of the measurements.

(3)

⇒ it will have a larger sample rate

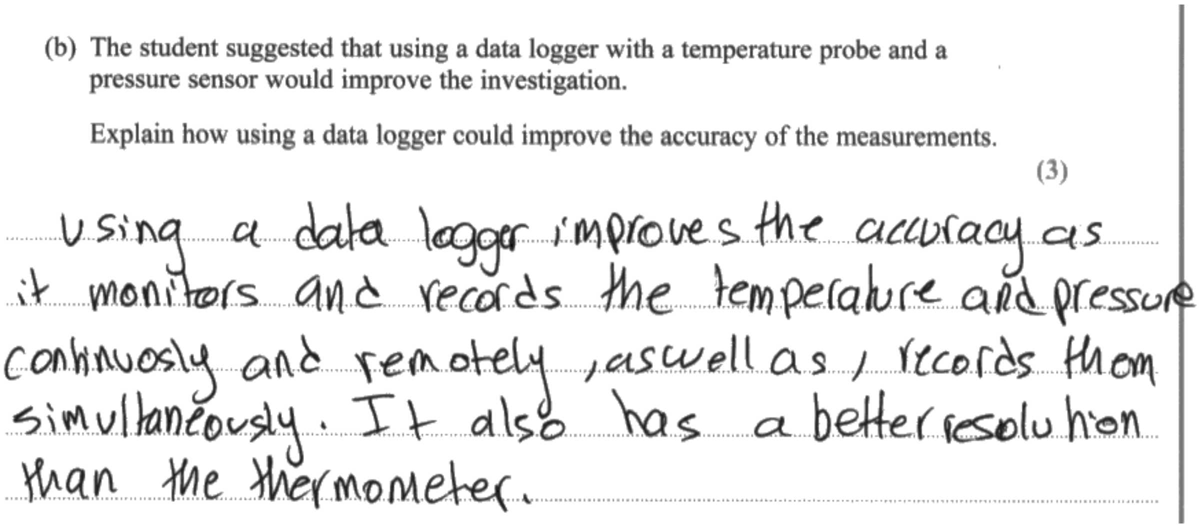
⇒ and the percentage uncertainty decreases because the temperature probe and pressure sensor got a better resolution

⇒ the data logger can record sets of pressure and its corresponding temperature simultaneously

ResultsPlus

Examiner Comments

A typical answer that lists properties that are irrelevant to the investigation or the idea of accuracy.


(b) The student suggested that using a data logger with a temperature probe and a pressure sensor would improve the investigation.

Explain how using a data logger could improve the accuracy of the measurements.

(3)

Using a data logger improves the accuracy as it monitors and records the temperature and pressure continuosly and remotely, aswell as, records them simultaneously. It also has a better resolution than the thermometer.

ResultsPlus

Examiner Comments

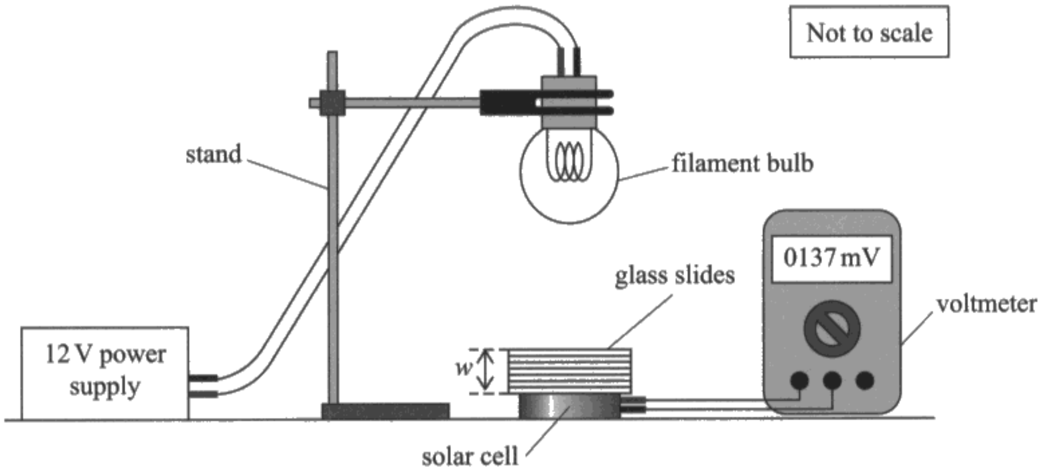
Another that lists irrelevant properties. Unfortunately, this candidate did not relate resolution to the temperature probe so could not be awarded a mark.

Question 3(a)

Q3 involved plotting and analysing the graph for an investigation into the absorption of light by glass. A question involving a graph appears in each series, therefore there are plenty of opportunities to practise this skill and consult Examiners' Reports to correct common errors.

In part (a) candidates had to **explain** why a micrometer screw gauge is a suitable instrument to measure a thickness of 1.21mm. The first mark was for stating the **resolution** of a standard micrometer screw gauge, ie 0.01mm. Some candidates used 0.1mm or 0.001mm despite the thickness being given to two decimal places. Some did not include a unit. As this is an **explain** question this could not be inferred from a calculation, other terms are accepted for resolution however **precision** and **accuracy** are not accepted. In addition, some candidates confused resolution with uncertainty. It is expected that the uncertainty in a **single** measurement is **half** the resolution. This was also a common error in the calculation of the percentage uncertainty in the second mark. Most candidates did calculate this correctly; however they then did not make a suitable statement.

3 A student investigated the absorption of light by glass using the apparatus shown.



The student varied the thickness *w* of glass by placing glass slides on the solar cell.

0.01 res.
0.005 unc.

$\frac{0.005\times100}{1.21}$

(a) The student used a micrometer screw gauge to measure the thickness of one glass slide. She recorded a single measurement as 1.21 mm.

Explain why a micrometer screw gauge was an appropriate instrument to use for this measurement.

Your answer should include a calculation.

(2)

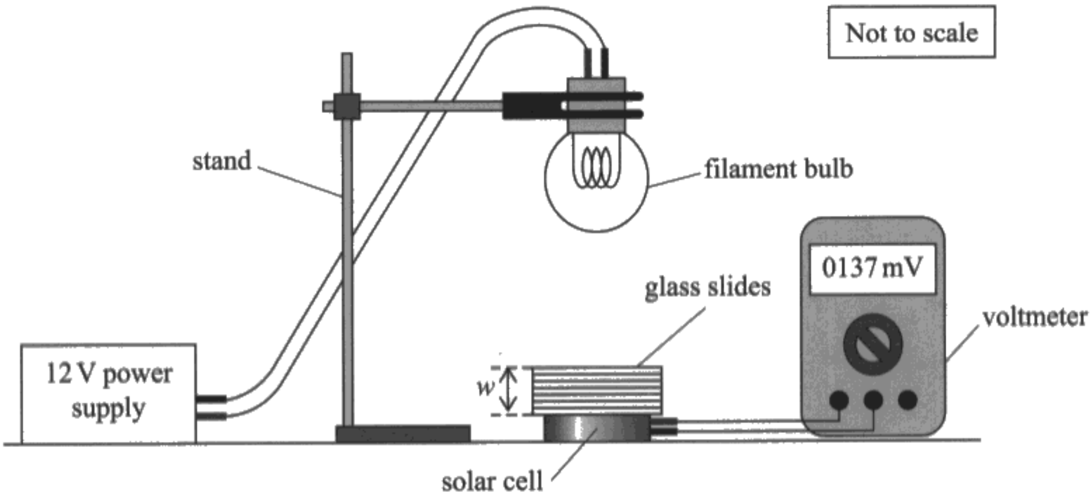
The micrometer has a resolution of 0.01mm and an uncertainty of 0.005mm.

$\frac{0.005\times100}{1.21} = 0.41\%$ percentage uncertainty which is low and will provide accurate measurements

ResultsPlus
Examiner Comments

An excellent answer that scores full marks.

3 A student investigated the absorption of light by glass using the apparatus shown.



The student varied the thickness *w* of glass by placing glass slides on the solar cell.

(a) The student used a micrometer screw gauge to measure the thickness of one glass slide. She recorded a single measurement as 1.21 mm.

Explain why a micrometer screw gauge was an appropriate instrument to use for this measurement.

Your answer should include a calculation.

0.01 mm

(2)

$\frac{0.01}{2} = 0.005$ $\frac{0.005}{1.21} \times 100 = 0.4\%$

So percentage uncertainty is low.

ResultsPlus Examiner Comments

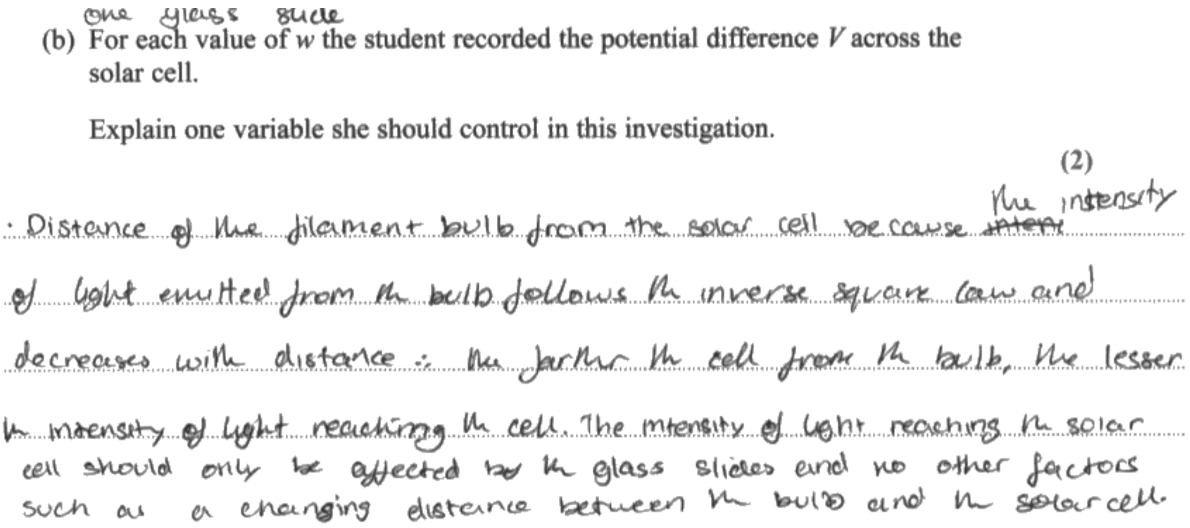
This candidate has not stated what the resolution or uncertainty is so could only score the final mark.

ResultsPlus Examiner Tip

Explicitly state what the resolution is with units.

Question 3(b)

In part (b) candidates had to **explain** a variable that should be controlled in the investigation. This was not answered as well as expected as many referred to parts of the apparatus, such as the power supply or the type of glass. Some candidates were able to state a control variable but were less successful in the explanation. The most common error was referring to the light intensity remaining constant rather than using physics to explain the effect of the variable on light intensity.



one glass slide

(b) For each value of w the student recorded the potential difference V across the solar cell.

Explain one variable she should control in this investigation.

(2)

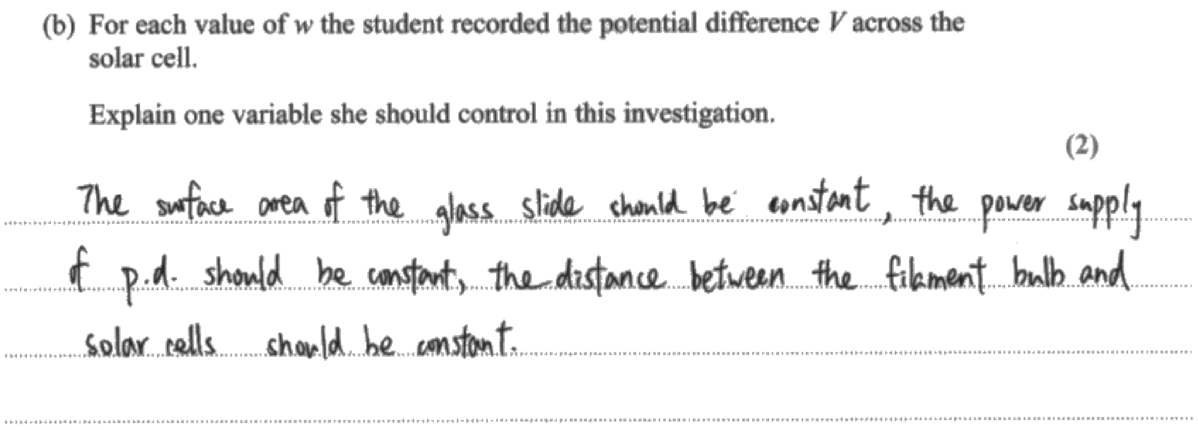
· Distance of the filament bulb from the solar cell because ~~intens~~ the intensity of light emitted from the bulb follows the inverse square law and decreases with distance ∴ the farther the cell from the bulb, the lesser the intensity of light reaching the cell. The intensity of light reaching the solar cell should only be affected by the glass slides and no other factors such as a changing distance between the bulb and the solar cell.

ResultsPlus
Examiner Comments

A clear two mark answer in which the candidate uses knowledge of physics to explain the effect of a variable.

ResultsPlus
Examiner Tip

Use physics concepts in explanations.



(b) For each value of *w* the student recorded the potential difference *V* across the solar cell.

Explain one variable she should control in this investigation.

(2)

The surface area of the glass slide should be constant, the power supply of p.d. should be constant, the distance between the filament bulb and solar cells should be constant.

ResultsPlus
Examiner Comments

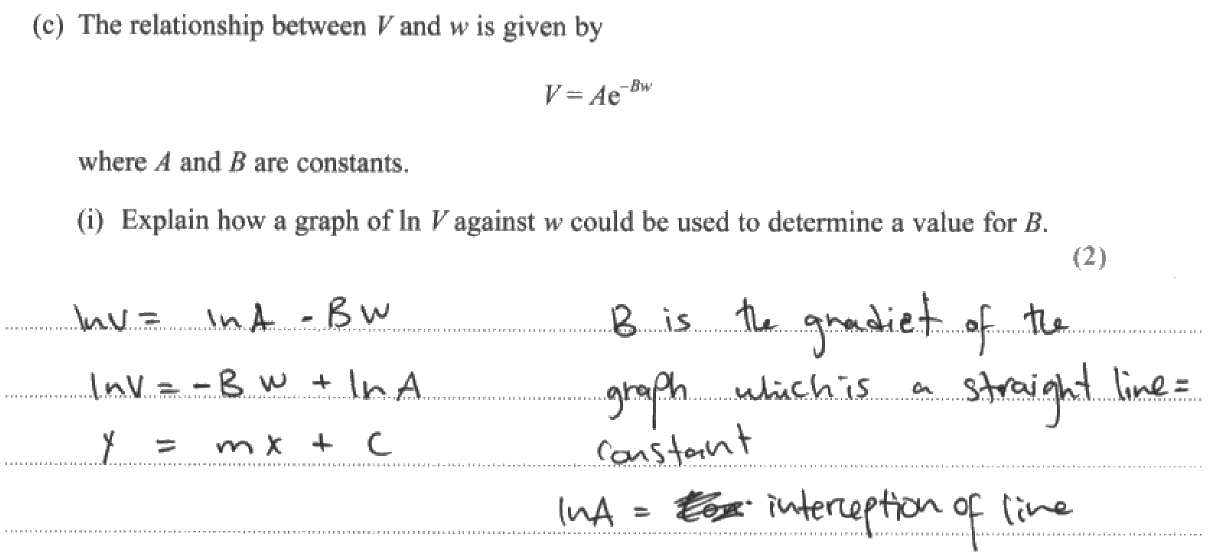
This candidate gave too many potential control variables, some of which relate to the apparatus itself. There is no attempt to explain any of them.

ResultsPlus
Examiner Tip

Check the command sentence for the number of answers expected and if it is a 'describe' or an 'explain' question.

Question 3(c)i

In part (c)(i) candidates had to **explain** how a graph of ln *V* against *w* could be used to determine the value of *B* given the relationship . The first mark was for performing a correct log expansion of the given formula. There are only two forms this can take, either a power law or an exponential function, however some candidates did not complete this successfully. For the second mark candidates must compare their log expansion with $y = mx + c$. The comparison must be **explicit**, ie the order of the log expansion must match the order of terms of the equation of a straight line. Occasionally candidates missed out the + and = which were not credited. Candidates then had to identify the gradient correctly as −*B*. Some referred to "*m*" or relied on a loop or arrow rather than state "the gradient is". As this is an "explain" question, this must be explicit. Some candidates omitted the minus sign.



(c) The relationship between V and w is given by

$$V = Ae^{-Bw}$$

where A and B are constants.

(i) Explain how a graph of ln V against w could be used to determine a value for B.

(2)

$\ln V = \ln A - Bw$

$\ln V = -Bw + \ln A$

$y = mx + c$

B is the gradiet of the graph which is a straight line = constant

$\ln A$ = ~~[illegible]~~ interception of line

ResultsPlus
Examiner Comments

The order matches but unfortunately the minus sign is missing.

(c) The relationship between V and w is given by

$$V = Ae^{-Bw}$$

where A and B are constants.

(i) Explain how a graph of ln V against w could be used to determine a value for B.

(2)

$\ln V = \ln A - Bw$, which is in the form $y = mx + c$, So the line of best fit would be a straight line, with gradient $= -B$

ResultsPlus
Examiner Comments

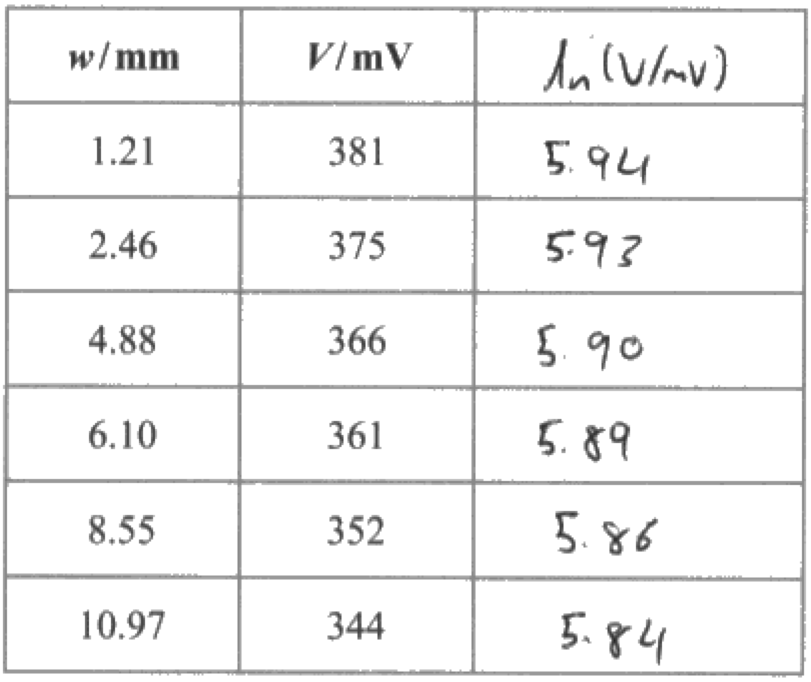
The order of the expansion does not match the order of equation of a straight line.

ResultsPlus
Examiner Tip

Write the equation of a straight line beneath the log expansion to ensure the order matches.

Question 3(c)ii-iv

Part (c)(ii) assessed the candidates' ability to process data and plot the graph of ln *V* against _w. The mark scheme always follows the same format. The first mark was for processing the data correctly. It is expected that candidates use natural logs for this type of expression. The values must be **correct** and given to a **consistent** number of decimal places sufficient to plot a graph accurately on standard graph paper. For logarithms candidates should give **three** decimal places although **two** can be accepted if it is valid for the graph. The most common errors were truncating rather than rounding, using an inconsistent number of decimal places in processed data, or using too many decimal places. Some candidates converted the values to volts which made plotting the graph more difficult. It is generally unnecessary to convert units in this question.



w/mm	V/mV	ln (V/mV)
1.21	381	5.94
2.46	375	5.93
4.88	366	5.90
6.10	361	5.89
8.55	352	5.86
10.97	344	5.84

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Examiner Comments

This candidate gave two decimal places, which was just fine for this graph. Note that the candidate included a table heading using the correct format. Although this is not credited here, it helps candidates to transfer it correctly to the graph.

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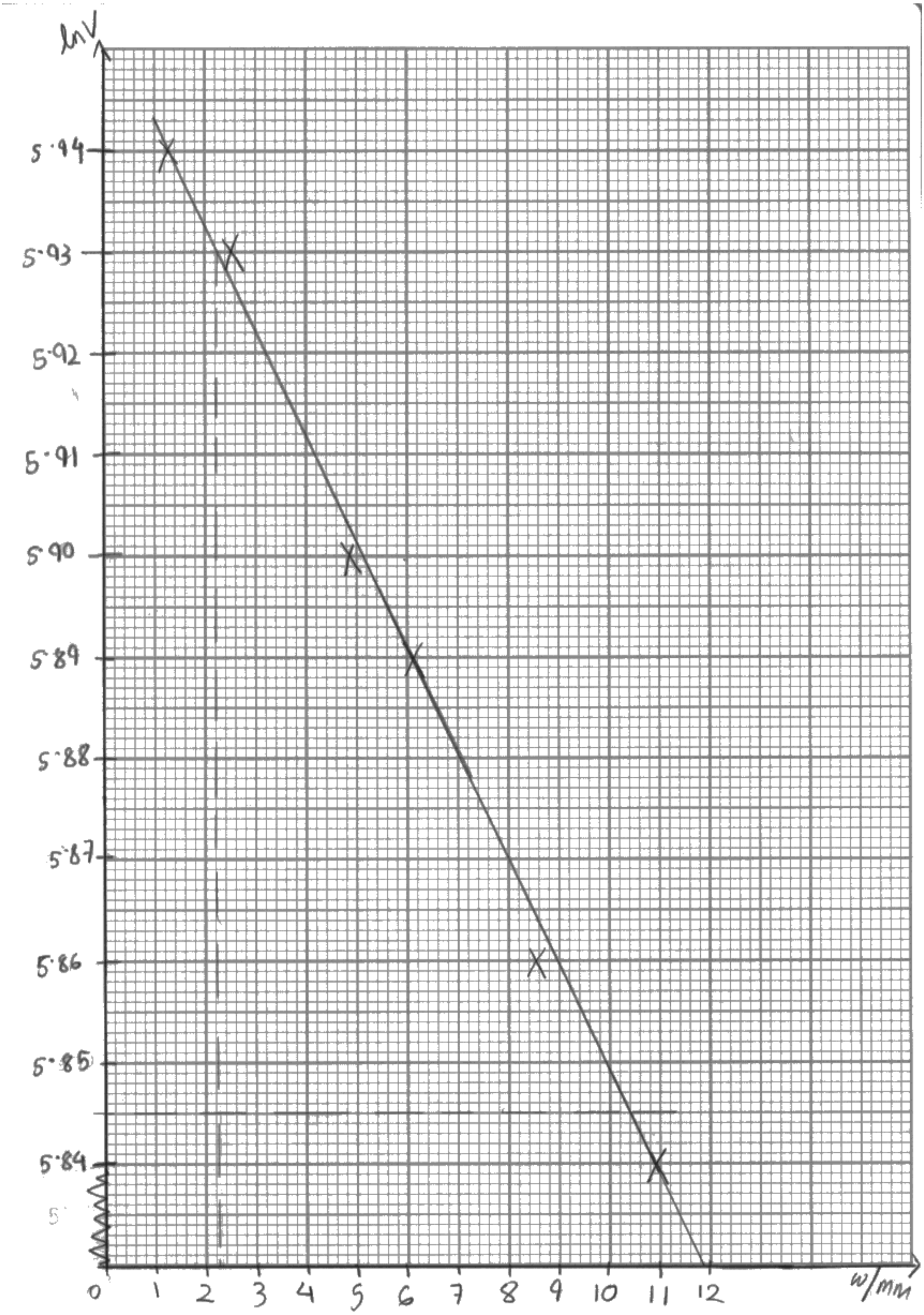
Examiner Tip

Use two or three decimal places consistently for log values.

The second mark was for placing the axes the correct way round, and labelling the axes following the correct convention. Some candidates reversed the axes, ie they plotted *w* against ln *V*, even though the question is always written in the form "plot *y* against *x*". This also often lead to mistakes in later parts. The most common error is not using the correct format for labelling a log axis, either by missing out the brackets or units or both. The correct form is log (quantity/unit), eg ln (*V* / mV). Some candidates converted their *V* values; however some then did not use the correct unit in the axis label.

The third mark was for choosing an appropriate scale. Candidates should choose the scale using **values of 1, 2, 5 and their multiples of 10** such that **all** the plotted points occupy **over half the grid in both directions**. Although the graph paper given in the question paper is a standard size, the graph does not have to fill the grid and using landscape-size paper is generally unnecessary. Scales do not have to start from zero and scales based on 3, 4 (including 0.25) or 7 are awkward and not accepted. Every major axis line, ie every 10 small squares, should be labelled with appropriate numbers so that examiners can easily see the scale used. A minority of candidates tried to use the values of logarithms or *w* as their scales.



lnV
5·94
5·93
5·92
5·91
5·90
5·89
5·88
5·87
5·86
5·85
5·84
0
1
2
3
4
5
6
7
8
9
10
11
12
w/mm

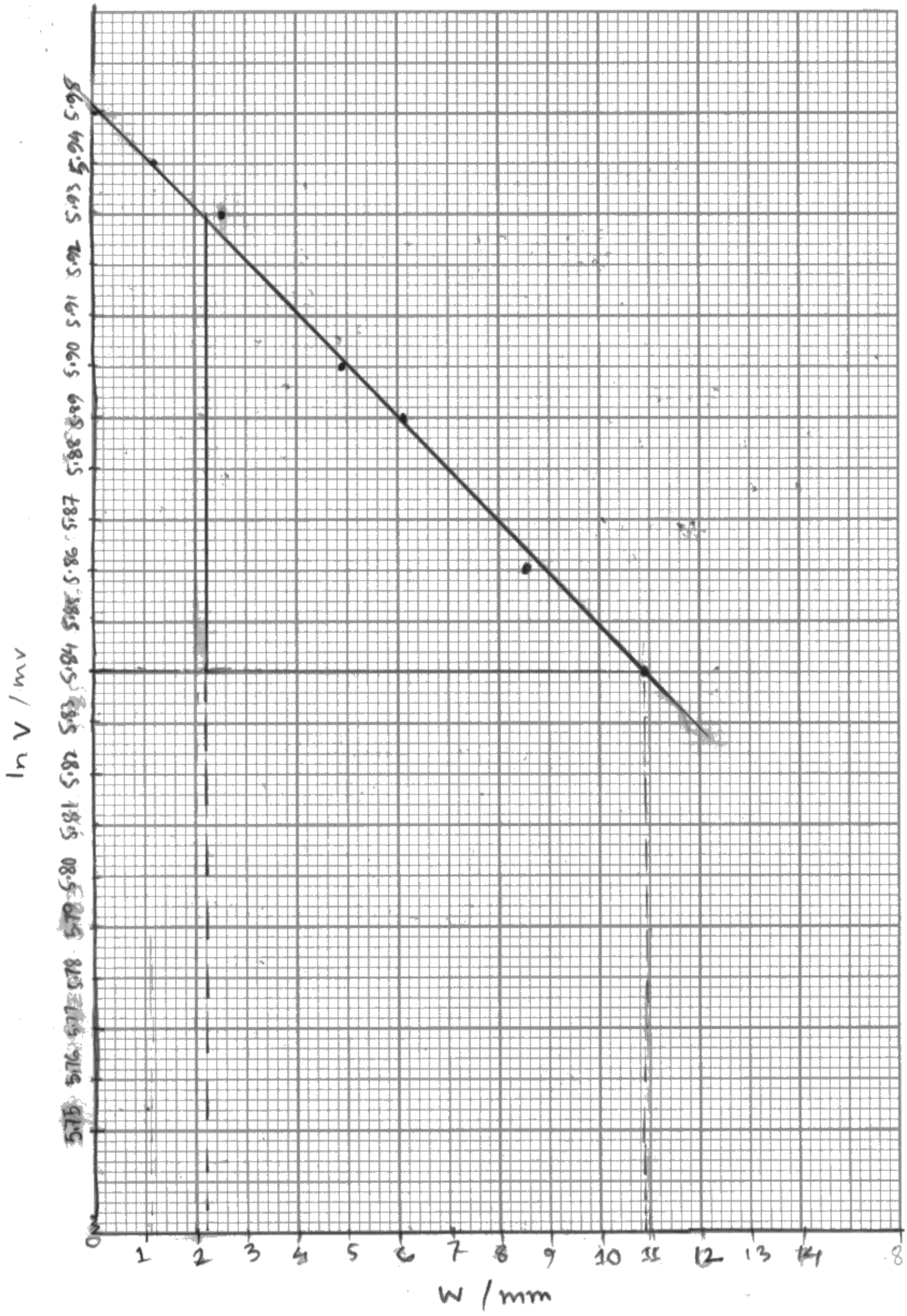
ResultsPlus
Examiner Comments

This candidate did not label the y axis with units. The scales were sensible and allowed the plots to spread over half the page in both directions.

ResultsPlus
Examiner Tip

Label a log axis using the format log(quantity/unit).

The fourth mark is for accurate plotting. Candidates should use **neat crosses** (´ or +) rather than dots when plotting points as the mark is not awarded if the dots cover a small square or there is an awkward scale.


ln V / mV
5.95
5.94
5.93
5.92
5.91
5.90
5.89
5.88
5.87
5.86
5.85
5.84
5.83
5.82
5.81
5.80
5.79
5.78
5.77
5.76
5.75
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
W / mm

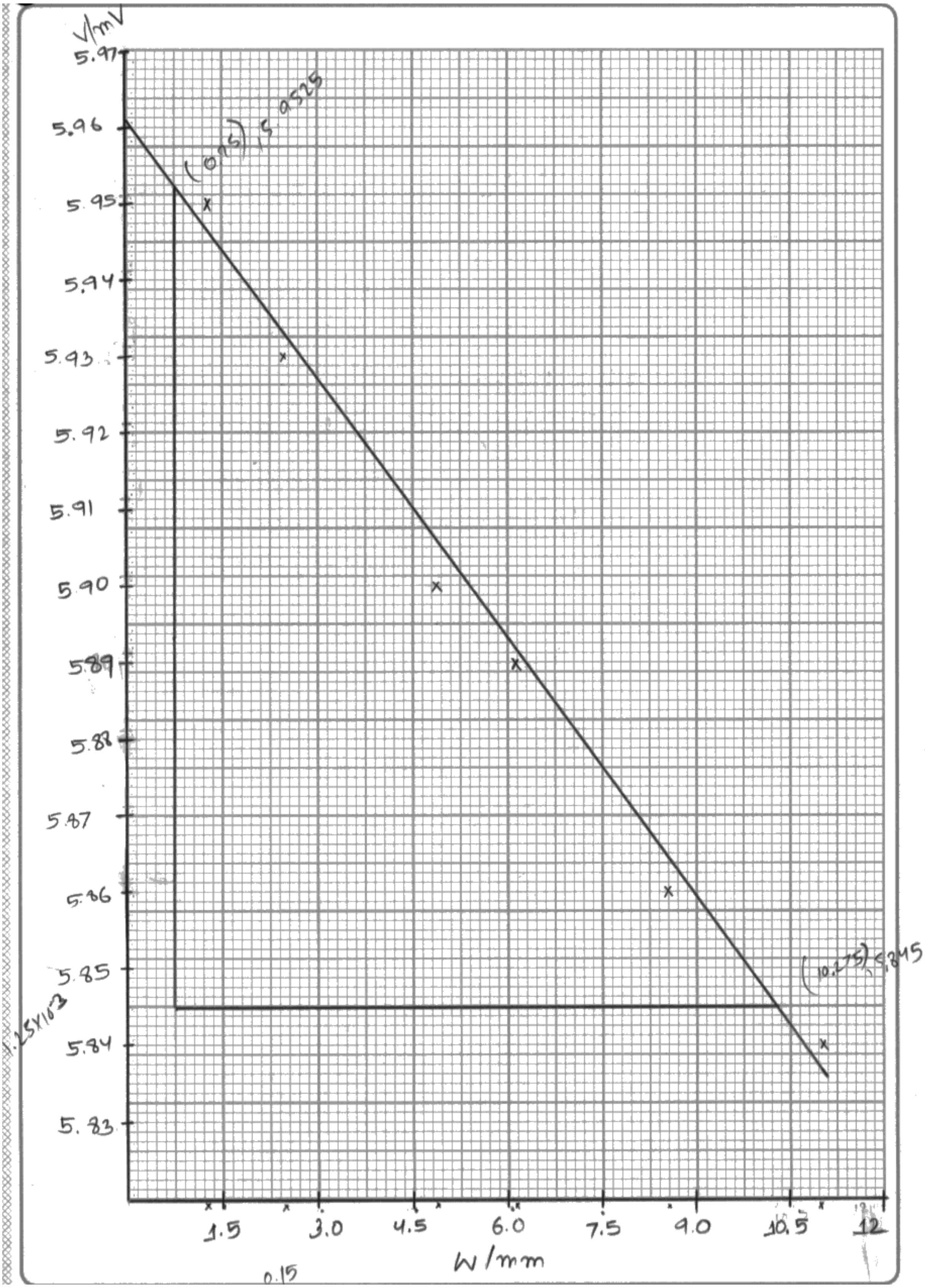
ResultsPlus
Examiner Comments

This candidate had forgotten the brackets in the y axis label. The y scale was also too small. This candidate also used dots that were judged to be just ok, but any bigger would have resulted in no plot mark. The best-fit line is reasonable enough. Note that this candidate had also drawn a large triangle on the graph which resulted in a correct gradient calculation.

ResultsPlus
Examiner Tip

Use neat crosses (+ or ×) when plotting points.

The final mark is for drawing a reasonable best-fit line. Candidates should not just join the first and last points without judging the scatter of the data points. There should be plots on both sides of the line and the line should not be rotated. Other errors include the line being too thick, ie over half a small square, discontinuous, or containing a clear bend. Candidates should use a single piece, 30 cm ruler for this examination and extend their line to cover the page.


V/mV
5.97
5.96
5.95
5.94
5.93
5.92
5.91
5.90
5.89
5.88
5.87
5.86
5.85
5.84
5.83
(0.75), 5.9525
(10.275), 5.845
1.25x10^-3
1.5
3.0
4.5
6.0
7.5
9.0
10.5
12
W/mm
0.15

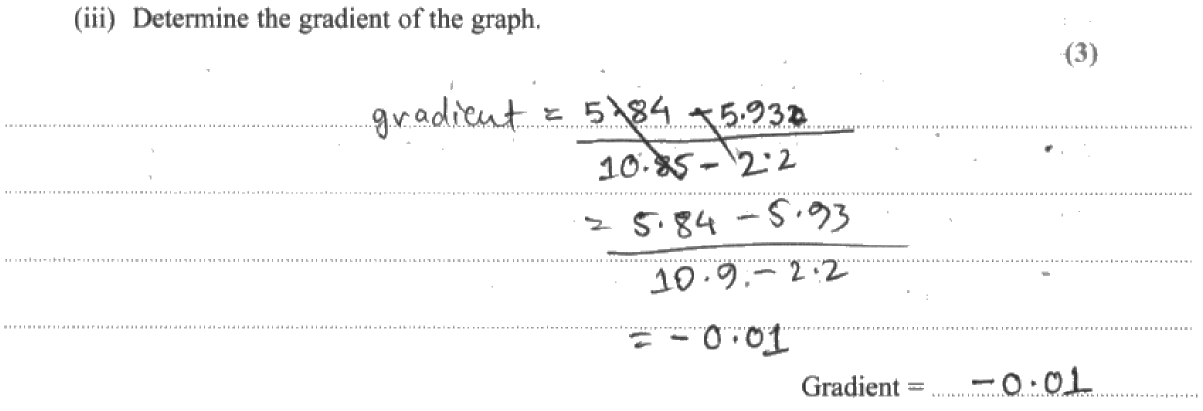
ResultsPlus
Examiner Comments

Unfortunately, this candidate only scored the mark for the table values. The y axis label is wrong and the x scale is in 1.5 which is awkward so the plot mark was also not awarded. The best-fit line was not considered reasonable for the data plotted. However, they had used a large triangle for the gradient calculation and drawn this on the graph using sensible values.

ResultsPlus
Examiner Tip

Use scales in 1, 2, 5 and multiples of 10 only.

In part (c)(iii) candidates were asked to determine the gradient of the graph. There were several common errors seen. The first mark is for using a **large triangle** taking up at least half of the plotted line to calculate the gradient of the graph. Occasionally candidates inverted their gradient. Many candidates used the first and last points, or other data points from the table. This is only acceptable if the data points lie **exactly** on the best fit line. Candidates should find places where the best-fit line crosses an intersection of the grid lines near the top and bottom of the best-fit line and **to mark these as a triangle on the graph**. Those that used awkward scales were often only successful when sensible values were used. The final mark could be awarded from an incorrect gradient, but often candidates used too many or too few significant figures or forgot the minus sign. <<<



(iii) Determine the gradient of the graph.

(3)

~~gradient = $\frac{5.84 - 5.932}{10.85 - 2.2}$~~

$= \frac{5.84 - 5.93}{10.9 - 2.2}$

$= -0.01$

Gradient = −0.01

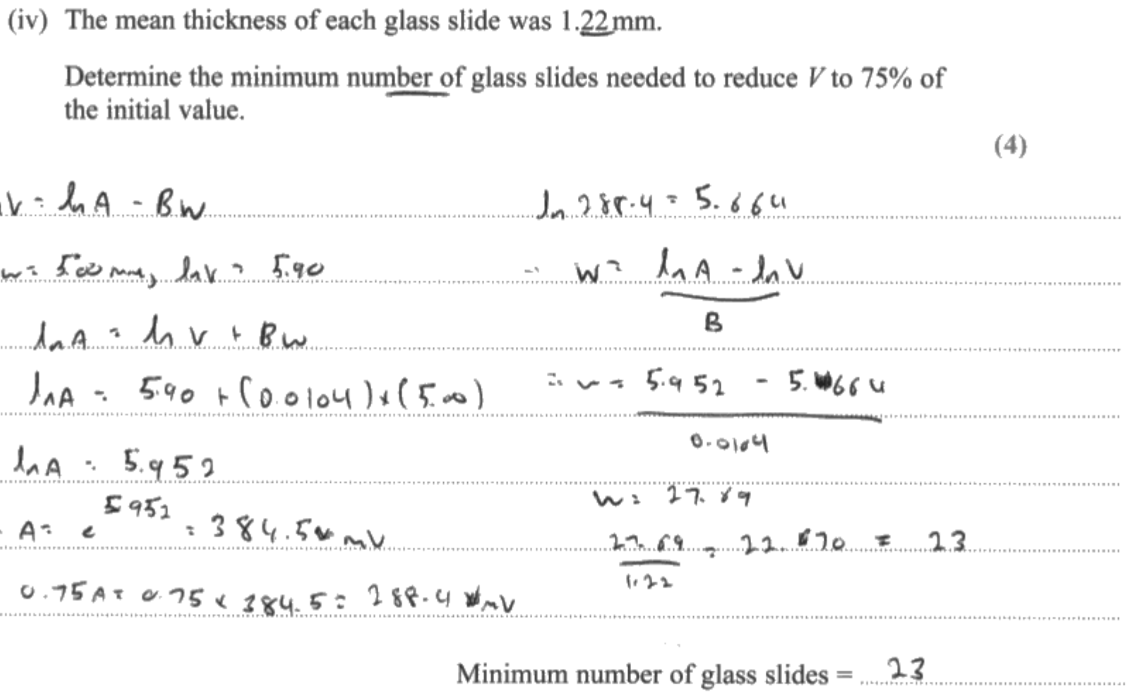
ResultsPlus
Examiner Comments

This candidate had used a large triangle with points from the line. The actual value from the calculation is −0.0103 so it is within the acceptable range, however the final value is given to one significant figure which is not appropriate.

ResultsPlus
Examiner Tip

Use two or three significant figures for values derived from gradients or y intercepts.

In part (b)(iv) candidates had to determine the minimum number of slides to reduce the intensity by 75%. The most successful candidates realised all they had to do was use ln(0.75) = $-Bw$ with their value of the gradient. Many candidates tried using 75% of the first value in the table or determined the value of A. These were acceptable methods, however many made the mistake of taking 75% of the log values rather than 75% of the actual values. Some candidates also calculated the logarithm of the log values which resulted in a value quite similar to that expected. Many candidates that attempted this did divide by the thickness of a slide, but some missed the final mark by rounding their final value down rather than up.



(iv) The mean thickness of each glass slide was 1.22 mm.

Determine the minimum number of glass slides needed to reduce V to 75% of the initial value.

(4)

$\ln V = \ln A - Bw$

at $w = 5.00$ mm, $\ln V = 5.90$

$\therefore \ln A = \ln V + Bw$

$\therefore \ln A = 5.90 + (0.0104) \times (5.00)$

$\therefore \ln A = 5.952$

$\therefore A = e^{5.952} = 384.5$ mV

$\therefore 0.75A = 0.75 \times 384.5 = 288.4$ mV

$\ln 288.4 = 5.664$

$\therefore w = \dfrac{\ln A - \ln V}{B}$

$\therefore w = \dfrac{5.952 - 5.664}{0.0104}$

$w = 27.89$

$\dfrac{27.69}{1.22} = 22.870 = 23$

Minimum number of glass slides = 23

ResultsPlus
Examiner Comments

This candidate made extra work for themselves by calculating the value of the y intercept. The rest of the calculation is easy to follow and the final value is rounded up.

ResultsPlus
Examiner Tip

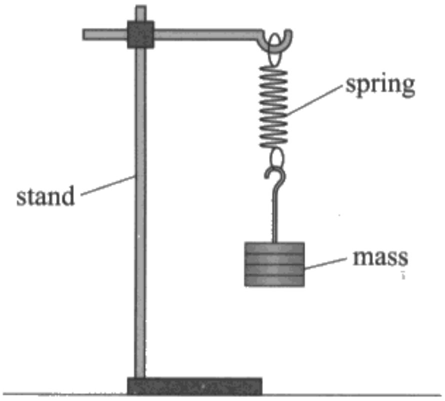
Show your working in a clear logical sequence.

Question 4(a)i

Q04 involved making measurements on a spring with their associated uncertainties. The analysis of uncertainties is common to all past papers therefore candidates should analyse uncertainties on a regular basis, either whilst making measurements or using past papers. Candidates should read Appendix 10 of the specification and **include all working** as marks are awarded for the method.

Part (a) involved the measurement of time period. In part (i) candidates had to **explain** why timing oscillations improves the measurement of time period. Most candidates had the idea that timing multiple oscillations increases the time, but some were not awarded the mark as they referred to *T* or time period which does not increase. Some candidates did refer to the uncertainty being constant and most stated that the percentage uncertainty would decrease.

4 A student investigated the properties of a spring using the apparatus shown.



(a) The student determined the time period T of the oscillations of the mass-spring system.

The student displaced the mass downwards. He released the mass so that the mass oscillated vertically. He used a stopwatch to measure the time for multiple oscillations.

(i) Explain why timing multiple oscillations improves the measurement of T.

(3)

The mass ~~moves~~ oscillates quickly, and it is difficult to judge when a complete oscillation has been done, so timing a single oscillation is difficult and increases the % U. The uncertainty in stopwatch remains constant, so value of T increases, for which the % U in T decreases, when timing multiple oscillations

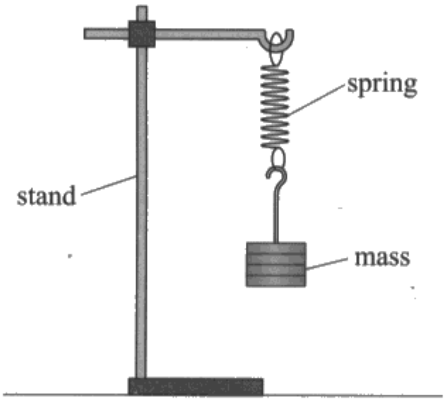
ResultsPlus
Examiner Comments

This candidate has included additional information which is almost contradictory. However, this candidate does not score full marks as they state that T increases rather than the time.

ResultsPlus
Examiner Tip

Understand why different techniques either improve accuracy or reduce percentage uncertainty.

4 A student investigated the properties of a spring using the apparatus shown.



(a) The student determined the time period T of the oscillations of the mass-spring system.

The student displaced the mass downwards. He released the mass so that the mass oscillated vertically. He used a stopwatch to measure the time for multiple oscillations.

(i) Explain why timing multiple oscillations improves the measurement of T.

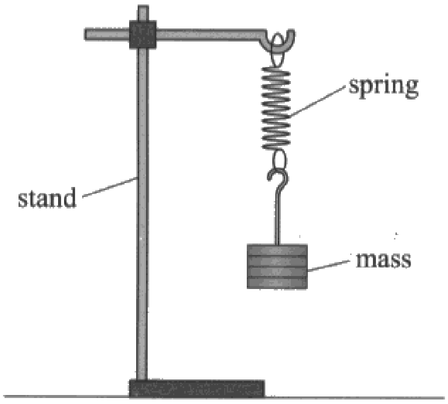
(3)

It increases the time recorded on stopwatch for ~~uncerta~~ a multiple ossilation, absolute uncertainity for stopwatch remains same, so percentage uncertainity for the measured time decrease. The time can then be divided with number of ossilations to find time period, T.

ResultsPlus
Examiner Comments

A full answer scoring all marks.

4 A student investigated the properties of a spring using the apparatus shown.



(a) The student determined the time period *T* of the oscillations of the mass-spring system.

The student displaced the mass downwards. He released the mass so that the mass oscillated vertically. He used a stopwatch to measure the time for multiple oscillations.

(i) Explain why timing multiple oscillations improves the measurement of *T*.

(3)

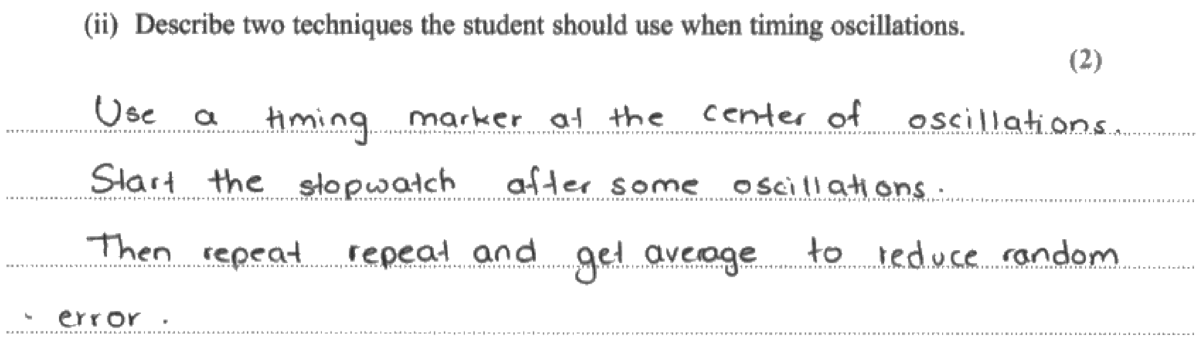
timing multiple oscillations at the same ~~#~~ time decreases the percentage uncertainity as ~~as~~ smaller uncertainity in a greater number. So, the value will be ~~for~~ more accurate & closer to the true value.

ResultsPlus
Examiner Comments

This candidate has the correct improvement but the reasoning is not described well enough. "A greater number" could refer to the oscillations or the time, so was not accepted.

Question 4(a)ii

In part (ii) candidates had to **describe** two other techniques when timing oscillations. Candidates scored well on this question. The most common error seen was referring to using a timing marker to see where an oscillation starts and ends or not stating where it should be placed. Most referred to allowing the oscillations to settle before starting to time.



(ii) Describe two techniques the student should use when timing oscillations.

(2)

Use a timing marker at the center of oscillations.

Start the stopwatch after some oscillations.

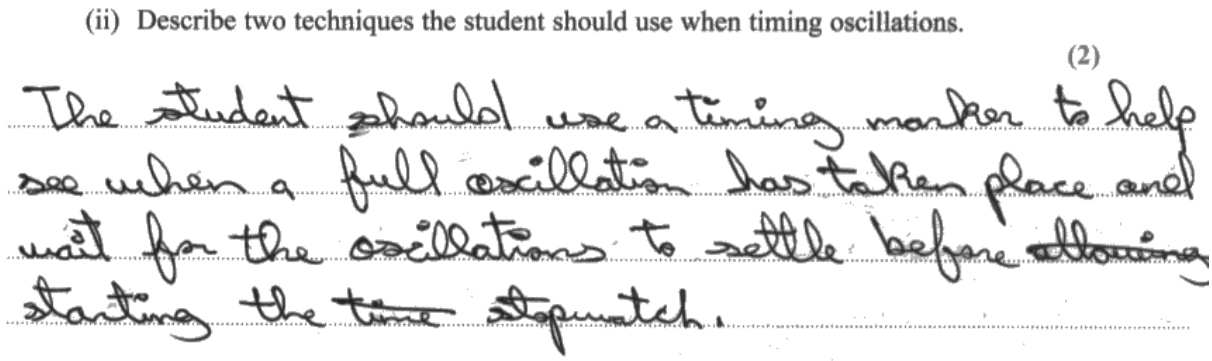
Then repeat repeat and get average to reduce random error.

ResultsPlus Examiner Comments

This candidate described three possible techniques, not two. The comment regarding repeating was ignored on this occasion.

ResultsPlus Examiner Tip

Use the number of marks to determine how many different points to discuss.



(ii) Describe two techniques the student should use when timing oscillations.

(2)

The student should use a timing marker to help see when a full oscillation has taken place and wait for the oscillations to settle before ~~allowing~~ starting the ~~time~~ stopwatch.

ResultsPlus Examiner Comments

This candidate made the error of not stating where the timing marker should be placed.

ResultsPlus
Examiner Tip

Ensure you know all techniques for timing oscillations.

Question 4(a)iii-iv

Part (iii) involved calculating a mean from a set of data. Note that candidates are not expected to identify and remove “anomalous” data. At A2 level, candidates are expected to give the correct value of the mean to the **same number of decimal places as the data**. Some candidates gave too many decimal places, did not give a unit or did not divide by 10.

Part (iv) involved a calculation of the percentage uncertainty in the mean value. The candidates **must show** the calculation for the first mark, and this is awarded for calculating the **correct half range or furthest from the mean**. The final mark was for the correct percentage uncertainty given to one or two significant figures, which was awarded more often in this series.

(iii) The student recorded the following results.

10*T*/s	6.88	6.93	6.84	6.96

Calculate the mean value of *T*.

(2)

$$T = \frac{6.88 + 6.93 + 6.84 + 6.96}{4 \times 10} = 0.690 \text{ s}$$

Mean value of $T =$ 0.690 s

(iv) Determine the percentage uncertainty in the mean value of *T*.

(2)

half range $= \frac{6.96 - 6.84}{2}$

uncertainty $=$ 0.06

% uncertainty $= \frac{0.06}{0.690} \times 100$

$= 8.695\ \%$

$= 8.70\ \%$

Percentage uncertainty = 8.70 %

ResultsPlus
Examiner Comments

This candidate had given a correct mean T but has used too many decimal places - the number of decimal places must match the original data. The percentage uncertainty is too large as the candidate calculated the half range for the 10 T values but used the mean T in the calculation.

ResultsPlus
Examiner Tip

Mean values must be recorded to the same number of decimal places as the data.

(iii) The student recorded the following results.

10T/s	6.88	6.93	6.84	6.96

Calculate the mean value of T.

(2)

$\frac{6.88 + 6.93 + 6.84 + 6.96}{4} = 6.9025$

Mean value of T = 6.90

(iv) Determine the percentage uncertainty in the mean value of T.

(2)

$\frac{6.96 - 6.84}{2} = 0.06$ $\frac{0.06}{6.9} \times 100$

$= 0.869$

Percentage uncertainty = 0.87 %

ResultsPlus
Examiner Comments

This candidate forgot to divide by 10 and also omitted the unit. The percentage uncertainty is correct and given to an appropriate number of significant figures.

ResultsPlus
Examiner Tip

Include units on all calculations.

$U = \frac{1}{2} \times r$

$\frac{1}{2} \times$ range

(iii) The student recorded the following results.

10*T*/s	6.88	6.93	6.84	6.96

Calculate the mean value of *T*.

(2)

$$\frac{6.88 + 6.93 + 6.84 + 6.96}{4}$$

$= 6.90$

Mean value of *T* = 6.90 8

(iv) Determine the percentage uncertainty in the mean value of *T*.

(2)

$$\%U = \cancel{6.90}\ \frac{\overset{0.02}{\cancel{2\times(6.96-6.84)}}}{6.90} \times 100\%$$

~~=0.010348~~

0.~~28%~~

= ~~3.48%~~

$U = \frac{1}{2} \times 6.96 - 6.86$

$= 0.02$

$= 0.2898$

Percentage uncertainty = 0.28% ~~3.48%~~ ~~0.034~~

ResultsPlus
Examiner Comments

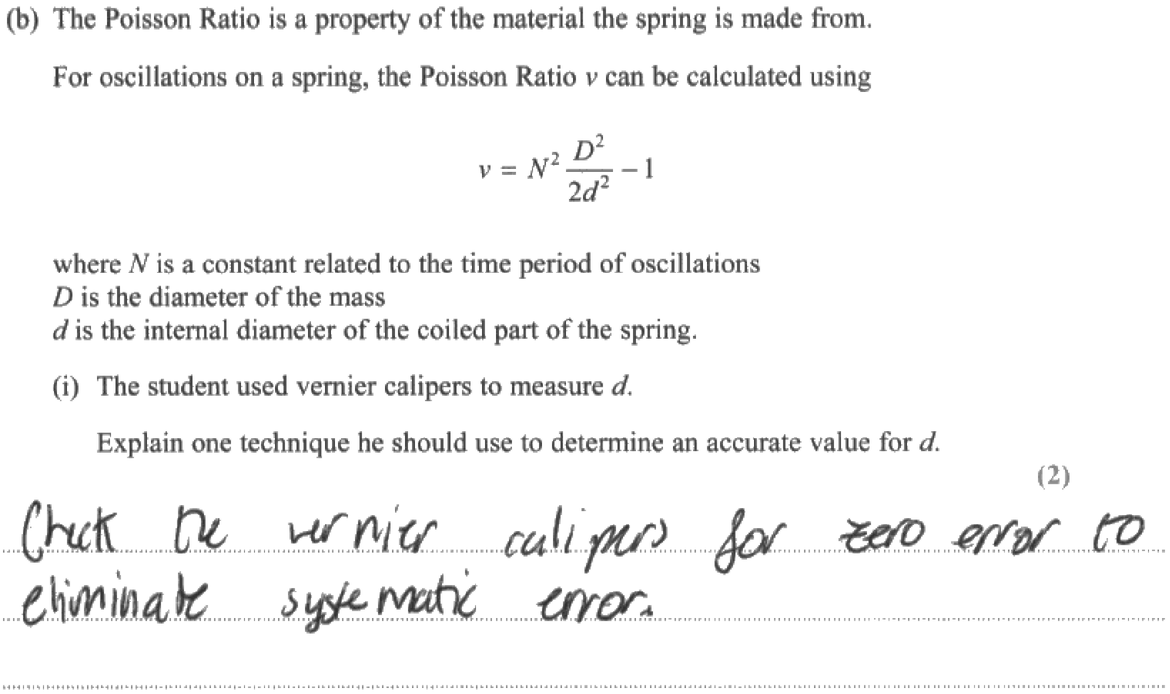
This candidate forgot to divide by 10 for the mean value. The half range calculation is incorrect as they have used a value not in the table.

ResultsPlus
Examiner Tip

For a half range calculation, the values must be consistent with the values used to calculate the mean.

Question 4(b)i

Part (b) involved deducing whether the spring was made from steel using a defined property of the material. In part (i) candidates had to **explain** a technique to determine the internal diameter of the spring using vernier callipers. The first mark was for stating the technique and the second was for explaining the technique in terms of errors. A few candidates described another instrument which is not a technique. As this is A2 level, more detail is required for this question compared to AS level, such as **where** they are going to repeat the measurement of the diameter, or checking **and** correcting for zero error. Candidates should be aware that random error cannot be eliminated or avoided, but systematic error can. Although phonetic spellings are accepted, candidates must be careful not to use a different word, such as "system" or "systemic" for "systematic".



(b) The Poisson Ratio is a property of the material the spring is made from.

For oscillations on a spring, the Poisson Ratio v can be calculated using

$$v = N^2 \frac{D^2}{2d^2} - 1$$

where N is a constant related to the time period of oscillations
D is the diameter of the mass
d is the internal diameter of the coiled part of the spring.

(i) The student used vernier calipers to measure d.

Explain one technique he should use to determine an accurate value for d.

(2)

Check the vernier calipers for zero error to eliminate systematic error.

ResultsPlus
Examiner Comments

This candidate scored the compensation mark. The technique is not detailed enough at this level, but has been linked to the correct type of error.

ResultsPlus
Examiner Tip

Check techniques include enough detail.

(b) The Poisson Ratio is a property of the material the spring is made from.

For oscillations on a spring, the Poisson Ratio v can be calculated using

$$v = N^2 \frac{D^2}{2d^2} - 1$$

where N is a constant related to the time period of oscillations
D is the diameter of the mass
d is the internal diameter of the coiled part of the spring.

(i) The student used vernier calipers to measure d.

Explain one technique he should use to determine an accurate value for d.

(2)

Measure the internal diameter at several places and ~~calu~~ calculate the mean.

ResultsPlus
Examiner Comments

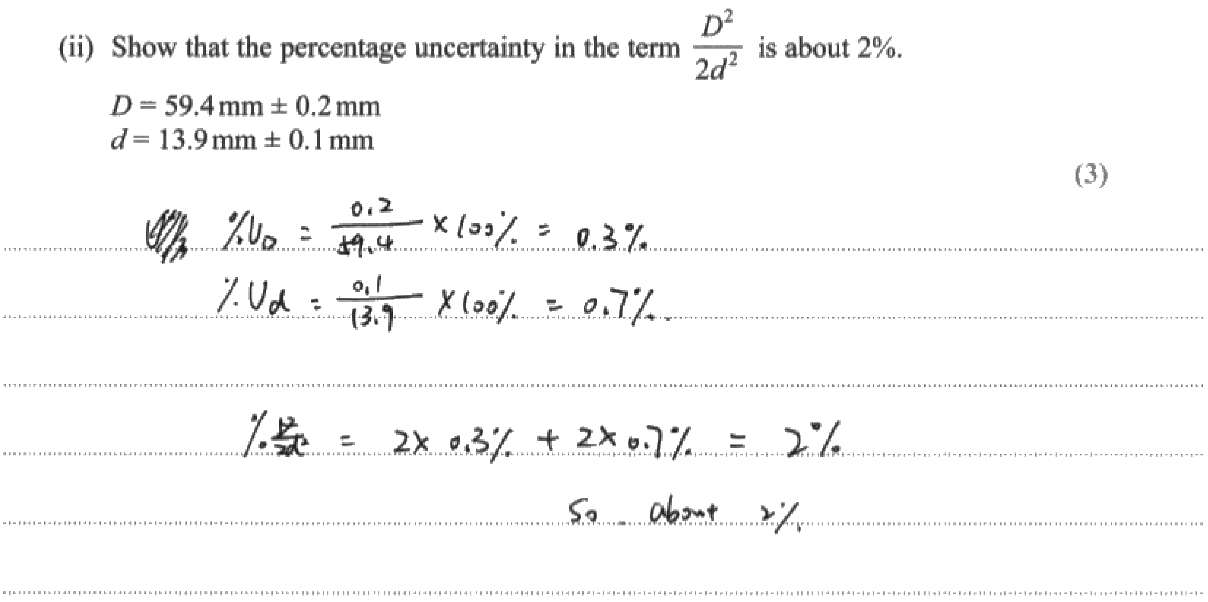
The technique here is detailed enough for this level. However the technique has not been explained at all.

ResultsPlus
Examiner Tip

Check you know the difference between 'describe' and 'explain'.

Question 4(b)ii

In part (b)(ii) candidates were asked to **show that** the percentage uncertainty in term stated was about 2%. Candidates used two methods of solving this, either by combining percentage uncertainties, or by using the maximum and minimum method. The combining uncertainties method was more successful, but a few candidates chose to round their values to one significant figure too early so could not be awarded the final mark. Some candidates appeared not to know how to combine percentage uncertainties when variables are raised to a power as only one was doubled or they were squared. The maximum and minimum method was less successful as they divided two maximum values or two minimum values. Some did not score full marks as a half range was not calculated or the values were rounded too early. Occasionally, candidates added the absolute uncertainties and randomly doubled some which is not a valid method. Again, the number of significant figures is important in a practical paper, particularly for uncertainties, and only two or three significant figures were expected.



(ii) Show that the percentage uncertainty in the term $\frac{D^2}{2d^2}$ is about 2%.

$D = 59.4\,\text{mm} \pm 0.2\,\text{mm}$
$d = 13.9\,\text{mm} \pm 0.1\,\text{mm}$

(3)

$\%U_D = \frac{0.2}{59.4} \times 100\% = 0.3\%$

$\%U_d = \frac{0.1}{13.9} \times 100\% = 0.7\%$

$\%\frac{D^2}{2d^2} = 2\times 0.3\% + 2\times 0.7\% = 2\%$

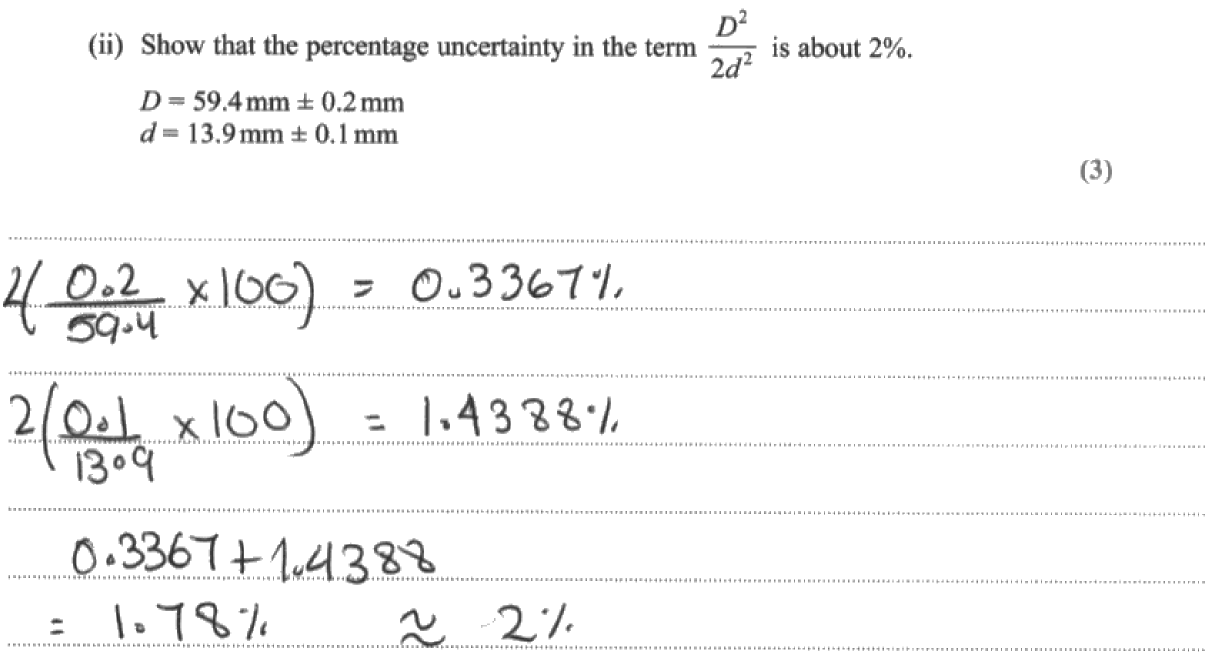
So about 2%

ResultsPlus
Examiner Comments

This candidate rounded their intermediate values to one significant figure which meant the final mark could not be awarded. This would be acceptable in a "calculate" question, but this is a "show that" question so the values should be given to at least one more significant figure than the "show that" value.

ResultsPlus
Examiner Tip

Use at least one more significant figure in "show that" questions on all values.



(ii) Show that the percentage uncertainty in the term $\frac{D^2}{2d^2}$ is about 2%.

$D = 59.4\,\text{mm} \pm 0.2\,\text{mm}$
$d = 13.9\,\text{mm} \pm 0.1\,\text{mm}$

(3)

$2\left(\frac{0.2}{59.4} \times 100\right) = 0.3367\%$

$2\left(\frac{0.1}{13.9} \times 100\right) = 1.4388\%$

$0.3367 + 1.4388$

$= 1.78\% \quad \approx 2\%$

ResultsPlus
Examiner Comments

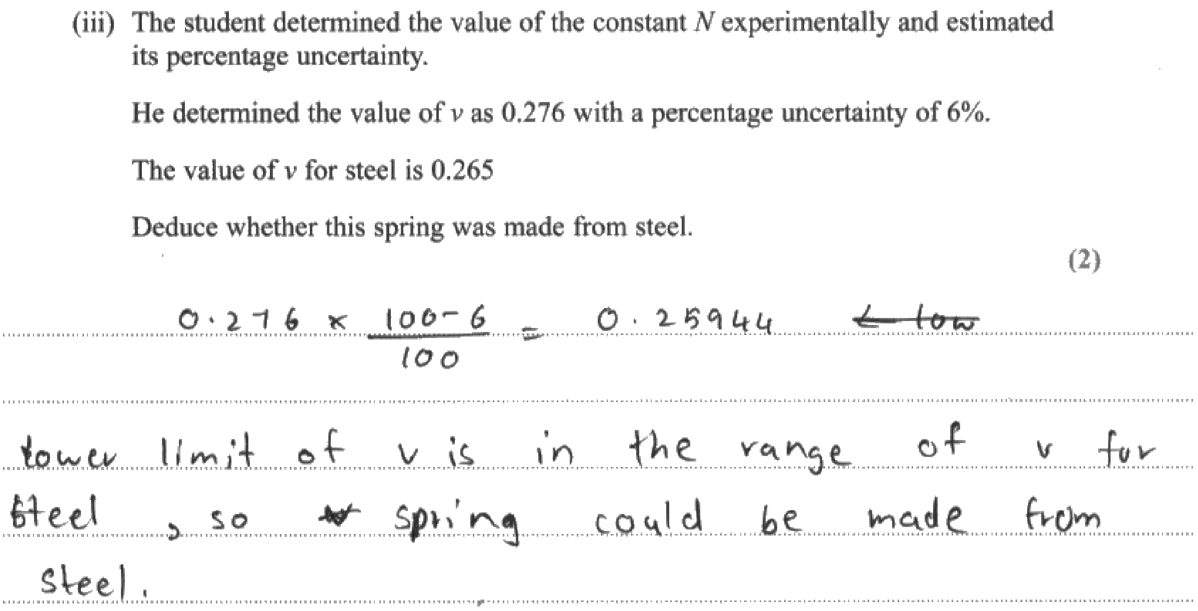
This candidate had intended on doubling both percentage uncertainties, but clearly made an arithmetic error. Both processing marks could be awarded as the working is clear despite the final answer being incorrect.

ResultsPlus
Examiner Tip

Show working in all calculations.

Question 4(b)iii

Finally, in part (iii) candidates were given a value for steel and had to **deduce whether** the spring could be made from steel. This is a standard type of question used in every series and was performed well by most candidates, but there were a few that did not attempt this or just made a vague statement with no calculation. Candidates should use the percentage uncertainty to calculate limits, but the most common error here was calculating the limits of the stated value rather than the calculated value. The final mark was for a correct conclusion. As in previous series, the main error with the conclusion was **not explicitly making a comparison** between relevant values as two values were given in the question.



(iii) The student determined the value of the constant *N* experimentally and estimated its percentage uncertainty.

He determined the value of v as 0.276 with a percentage uncertainty of 6%.

The value of v for steel is 0.265

Deduce whether this spring was made from steel.

(2)

$0{\cdot}276 \times \frac{100-6}{100} = 0{\cdot}25944$ ~~← low~~

lower limit of v is in the range of v for steel, so ~~a~~ spring could be made from steel.

ResultsPlus
Examiner Comments

This candidate had calculated a correct lower limit although it is not labelled as such. The conclusion does not include an explicit comparison between this value and 0.265. This candidate also refers to a range when a range was not calculated, but the range is for the value of steel which is incorrect.

ResultsPlus
Examiner Tip

Clearly state the value being compared to in conclusions.

(iii) The student determined the value of the constant *N* experimentally and estimated its percentage uncertainty.

He determined the value of *v* as 0.276 with a percentage uncertainty of 6%.

The value of *v* for steel is 0.265

Deduce whether this spring was made from steel.

(2)

$$\% \text{ difference} = \frac{0.276-0.265}{0.265} = 4.2\%$$

$\% \text{ d} > \% \text{unc.}$

∴ the spring ~~is~~ was not made from steel.

ResultsPlus
Examiner Comments

This candidate chose the percentage difference method with the correct value in the denominator, ie the "true" value. The conclusion is incorrect and 6% is not stated.

Paper Summary

Candidates will be more successful if they routinely carry out and plan practical activities for themselves using a wide variety of techniques. These can be simple experiments that do not require expensive, specialist equipment. They should make measurements on simple objects using vernier callipers and micrometer screw gauges and complete all the Core Practical experiments given in the specification.

In addition, the following advice should help to improve candidate performance on this paper.

- Be able to describe how to measure lengths, angles, force, mass, time, potential difference, current, pressure and temperature using the most appropriate apparatus and techniques.
- Refer to random or systematic errors when explaining techniques.
- Practice the process of planning an experiment to obtain sufficient and valid data.
- Show working in all calculations and include a unit.
- Check the number of decimal places or significant figures needed for different calculations.
- Choose graph scales that are sensible, ie the value of a small square is 1, 2 or 5 and their powers of ten only, so that at least half the page is used. It is not necessary to use the entire grid if this results in an awkward scale, eg 0.25, 3, 4 or 7.
- Plot data using neat crosses (´ or +), and check any points that lie far from the best-fit line.
- Use a one piece, 30 cm ruler to draw a straight best-fit line that covers the page. Ensure there are data points on both sides of the line, and the line cannot be rotated.
- Draw a large triangle that covers at least half of the best-fit line using sensible points. Labelling the triangle often avoids mistakes in data extraction.
- Learn the definitions of the terms used in practical work, in particular precision and accuracy, and standard techniques for analysing uncertainties. These are given in Appendix 10 of the IAL specification.
- Revise the content of WPH13 as this paper builds on the knowledge from AS.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link: https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

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