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Examiners' Report
June 2019

IAL Physics WPH06 01

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Introduction

WPH06 Experimental Physics assesses the skills associated with practical work in physics. In particular it addresses the skills of planning, data analysis and evaluation which are equivalent to those that A Level physics candidates in the UK are now 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.

Candidates who do little practical work will find this paper more difficult as many questions rely on candidates being able to apply their knowledge of practical techniques to novel as well as standard experiments. In the forthcoming new specification, it is expected that candidates will carry out a range of experiments as the skills and techniques learned will be examined in different contexts.

The paper for June 2019 covered the same skills as in previous series however there were questions that were more open-ended and unstructured. This resulted in a mean mark that was lower than in June 2018; however, centres should note that these types of questions will appear in the new specification. In addition, it appeared that whilst a good number of candidates were well prepared for this examination, a significant number were not capable of the basic skills expected of an A Level candidate.

Question 1 (a) (i)

As in previous series, this question assessed the candidates' ability to calculate and use uncertainties at the level expected of an A2 candidate. This question was set in a more familiar context concerning the measurement of the time period of a pendulum.

Part (a)(i) asked for a reason why a small displacement should be used and should have elicited answers based around the conditions required for simple harmonic motion. Often this type of question is testing the Physics behind a practical technique and is aimed at the lower end of the grade scale. However, this was surprisingly poorly answered by the vast majority of candidates.

Question 1 (a) (ii)

In part (a)(ii) the candidates were asked to explain the reason for using a timing marker at the centre of the oscillation. Again, this was poorly answered by the majority of candidates who mainly described the techniques for measuring oscillations, rather than considering the technique being asked about. This also suggested that candidates did not understand the difference between describe and explain, or simply recalled the mark scheme for previous questions regarding oscillations. Only the more able candidates realised that they were being asked to explain why the timing marker should be at the centre of the oscillation rather than elsewhere. In many cases they were able to access one of the marks, most often for stating that the velocity is highest or realising that the amplitude would change as a result of damping. The two following examples show a common "describe" response and a rare example of a candidate scoring both marks.

(ii) The student used a pin as a timing marker.

Explain how placing the pin at the centre of oscillation would lead to a more accurate value for $10T$.

(2)

Hence the center of the motion (the equillibrium) can be found, where it can be used to count the ~~no~~ no. of oscillations, by counting the no. of times the bob, passes infront of the pin, and dividing that value by two.

ResultsPlus
Examiner Comments

This example is typical of a candidate that has described how the timing marker is used rather than explained why it should be used at the centre of the oscillation. This type of response scored no marks.

ResultsPlus
Examiner Tip

When asked to explain a method, think of reasons why it is used in the way described in the question.

(ii) The student used a pin as a timing marker.

Explain how placing the pin at the centre of oscillation would lead to a more accurate value for $10T$.

(2)

The pin is the equilibrium position of the ball Hence it has to pass through this point even, amplitude is less. Whereas if marker was at maximum point, the ball might not have reach after few oscillation This will prevent random error in calculating Time period

ResultsPlus
Examiner Comments

This candidate had clearly thought about why the centre of the oscillation is used and given two valid points, hence scores both marks.

ResultsPlus
Examiner Tip

Always check the number of marks available as this will relate to the number of separate points you need to make.

Question 1 (b) (c)

Part (b) involved calculating the mean value of 10T, and hence T, from a set of measurements followed by its percentage uncertainty. It appeared that there were a number of candidates who either could not calculate a mean or assumed that there was an anomalous result. Given that this involves timing manually, this spread of measurements would be acceptable. Candidates were, however, given credit elsewhere if an incorrect value was used. In addition, it was expected that the numbers of significant figures used should be consistent. It was pleasing that more candidates were using the half range of data to calculate the percentage uncertainty rather than the full range, although candidates were given some credit for using the full range. Centres should note that only the half range will be accepted in the new specification. In addition, only a very small number used the resolution of the stopwatch or a value which appeared to be equivalent to a reaction time, which was not credited. Mistakes in calculation were rare although there were instances of a power of 10 error, caused either by using the value of T or further dividing by 10 to mirror the previous calculation. It is expected that the uncertainty should be stated to at least one fewer significant figures than the data, which a large number of candidates did. However, answers to three significant figures were accepted on this occasion.

Part (c) introduced the idea of the ratio of the values of T^2 for two pendula, one with twice the length of the other. In part (i) candidates had to show that the ratio should be equal to 2. Many candidates scored full marks here, the majority using an algebraic method which was clearly laid out. Those who failed to score with this method often forgot to square the value of π or use a value of 4. The majority of candidates who scored one mark here did so for correctly squaring the formula given but then did not go on to consider the ratio of values.

The final part of the question, part (c)(ii), required the candidates to determine whether the measured ratio was indeed 2 once given a value for the time period of a pendulum twice as long. This was a less structured question than in previous series and candidates found different, albeit valid, methods which were all credited provided their argument was clear. In previous series this question would have been split into two parts, firstly calculating a final percentage uncertainty then comparing to a final value. Weaker candidates often failed to realise that uncertainties should be used at all and just calculated the ratio and compared it to 2, hence this part of the question discriminated particularly well. Stronger candidates were able to cope with this question and often produced well-structured answers. Centres should encourage candidates to show calculations clearly as marks are awarded for the method being used.

It was expected that the candidates would calculate a percentage uncertainty for the ratio then use it to calculate the upper and lower limits for comparison. A number of candidates used the absolute uncertainties to calculate the upper and lower limits, which was also valid, however some candidates who tried this lost marks by using the incorrect combination of maximum and minimum values or by only using the maximum or minimum in one value.

Centres should note that the percentage difference method was accepted on this occasion and is only valid when comparing a measured value to an accepted or theoretical value, in this case for comparing the ratio to 2. There were a number of candidates who tried to use this method for comparing other values, such as a predicted length, the two time periods or the percentage uncertainties.

(ii) The student determines T for the longer pendulum as 1.461 ± 0.011 s.

Determine whether her results support her prediction.

(4)

shorter: $\frac{0.83}{100} \times 1.02 = 8.466 \times 10^{-3}$ $1.02 \pm 8.466 \times 10^{-3}$

max T = $1.02 + 8.466 \times 10^{-3} = 1.028466$

min T = $1.02 - 8.466 \times 10^{-3} = 1.011533203$

longer: min T = $1.461 - 0.011 = 1.450$

max T = $1.461 + 0.011 = 1.472$

$\frac{\max T_d^2}{\min T_s^2} = \frac{1.472^2}{1.012^2}$ $\frac{\min T_d^2}{\max T_s^2} = \frac{1.450^2}{1.028^2}$

$= 2.12$ ← both approximately 2 therefore prediction is supported → $= 1.99$

ResultsPlus Examiner Comments

This is a good example of how to use the absolute uncertainties to calculate the range of possible values. The calculation is very clear and this would achieve the three method marks.

ResultsPlus Examiner Tip

Ensure your calculations are set out clearly so that the examiner can follow your line of reasoning.

Question 2 (a)

This question focused on planning an investigation to verify the relationship between the e.m.f. induced in a secondary coil and the distance between the primary and secondary coil. Although this was an unusual context, the majority of candidates were able to access some marks. As is usual with this type of unstructured planning question, there was good discrimination between the more able and weaker candidates.

Part (a) assessed the physics behind the practical and was often not answered well. The issue may have been language, but answers were often very unclear as to what causes what in a logical order. Although a minority of candidates could confidently use terms such as "flux linkage" and "cutting", these were, more often than not, not included in a coherent description. In addition, only a small number of responses referred to a varying or changing magnetic field being a result of the alternating current. Many candidates also stated Faraday's Law but did not link this to the question being asked.

Question 2 (b)

In part (b) candidates had to plan the investigation and, on the whole, they followed the order given in the question. The circuit diagram was relatively simple but a surprisingly large number of candidates did not gain credit as they used the symbol for a cell or battery for the a.c. power supply. Some candidates also included a voltmeter with the primary coil which meant that they were in danger of a contradiction when describing the measurements. The majority of candidates did describe the measurements required well and the minimum expected would be a statement of the variable and the instrument to be used. In the majority of cases, the distance measurement was correctly described, hence it was rare to see candidates not scoring at all. The most common mistake was in the description of the induced e.m.f. measurement. Many did not specify a voltmeter on the secondary coil and there were instances when this measurement was not mentioned at all, as in the example below.

The analysis part of the investigation was well answered as most could understand how to relate the formula to that of the equation of a straight line, and how to use this to obtain a value for the constant. There were a number of ways this could be achieved and, provided the graph was valid, credit was given. The most common errors here were to state a graph of V against I or V against d^3. The final part of the question was usually only answered well by the more able candidates. It is a difficult skill to judge a major source of uncertainty in an unfamiliar practical but some candidates who stated the distance measurement did not give quite enough detail to gain the mark. It is expected that there is an appreciation of why this is a major source of uncertainty which, in this case, is mainly the result of alignment issues. However, candidates who understood that the percentage uncertainty would be tripled as the distance is cubed gained credit.

The student investigates how V varies with d.

Write a plan to determine k using a graphical method.

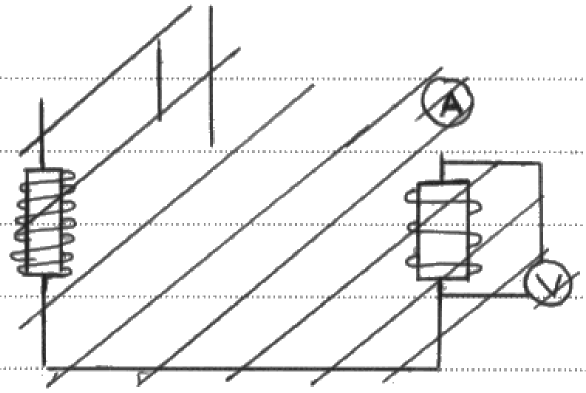
Your plan should include:

(i) a circuit diagram to show how the primary coil should be connected with any additional components required, **(1)**

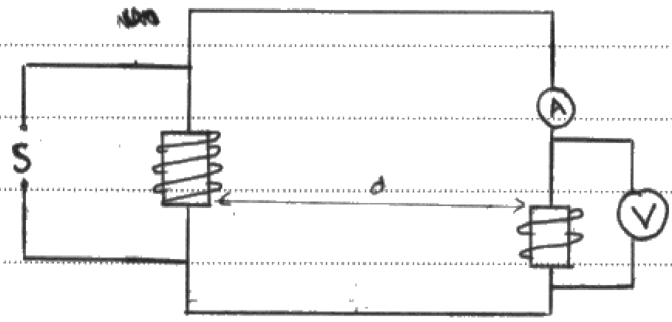
(ii) the measurements to be made with any additional apparatus required, **(3)**

(iii) the graph to be plotted and how it would be used to determine k, **(2)**

(iv) a statement of a significant source of uncertainty. **(1)**



(i)

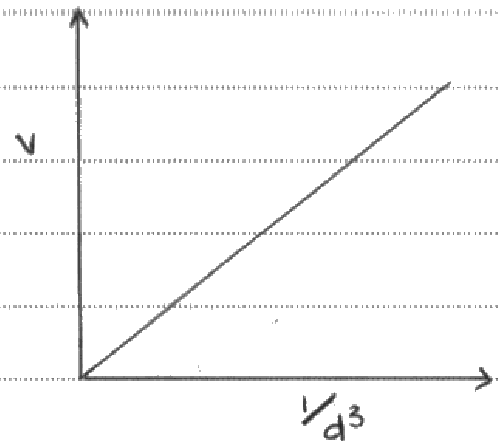


(ii) ~~voltage and coi~~ voltage and current.

distance between the primary and secondary coil.

The number of turns on the primary coil.

(iii) $V = kNI \times \frac{1}{d^3}$ where kNI is a constant and kNI = gradient.



kNI = gradient.

$k = \frac{\text{gradient}}{NI}$.

iv) zero error on the voltmeter.

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Examiner Comments

In this example, the candidate appears to believe that the coils need to be connected together, hence does not get the diagram mark although a correct symbol was used for the a.c. supply. There is no mention of a metre rule for the distance measurement, nor is the measurement of induced e.m.f., however the number of coils is stated which gains credit. The graph is valid with a correct corresponding gradient hence both marks were awarded here but the source of uncertainty was not awarded. Overall this response gains three marks.

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Examiner Tip

Remember to state the measuring instrument for each variable to be measured.

Question 3 (a)

This question was based on measurements of the intensity of the radiation emitted by the star Betelgeuse at different wavelengths.

Part (a) involved fitting a best fit line to the data which should have produced a curve with a clear peak. This was done well by the majority of candidates and there were very few responses with major deviations or peaks that were too broad. In addition, there were few instances where candidates tried to use a straight line. In general, candidates extrapolated the value of the peak wavelength accurately and were able to use the correct formula to calculate the value of T. Although unit errors were quite rare, those losing a mark did so by quoting the value to too many significant figures. Candidates should have realised that the data was given to three significant figures. Only the weakest candidates did not use the correct formula.

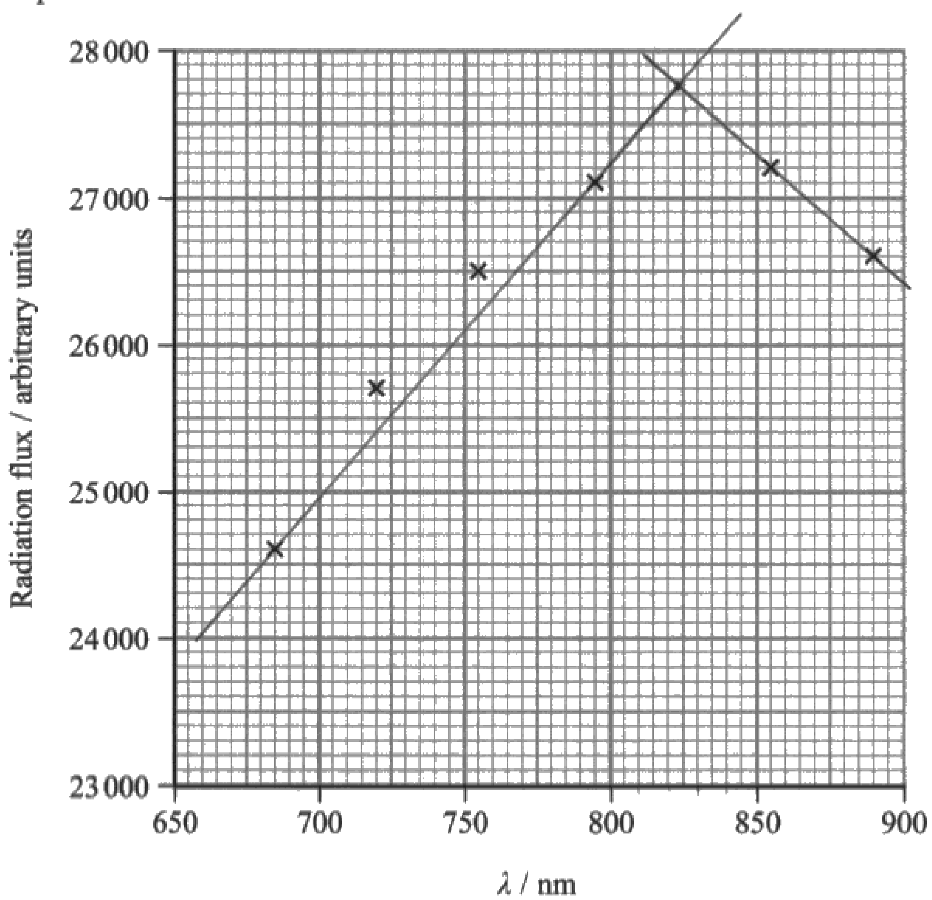
3 The surface temperature T of a star can be estimated by determining the wavelength λ_{max} at which peak power emission occurs from the star.

A student astronomer observed the red giant Betelgeuse.

He measured the radiation flux at six wavelengths and obtained the following results.

Radiation flux / arbitrary units	λ / nm
24600	685
25700	720
26500	755
27100	795
27200	855
26600	890

The data was plotted as shown.



(a) (i) Draw a line of best fit to show where the radiation flux is a maximum.

(2)

(ii) Estimate λ_{max}.

(1)

λ_{max} = 824 nm

(iii) Calculate a value for T.

(2)

$\lambda_m T = 2.898 \times 10^{-3}$ mK

$T = \frac{2.898 \times 10^{-3}}{824 \times 10^{-9}} = 3516.9$ K

T = 3517 K

ResultsPlus
Examiner Comments

An unusual response where the candidate has not realised that the data shows a curve, which scores no marks for the graph. However, the value of the intersection was used in parts (ii) and (iii) hence scored two marks in total.

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Examiner Tip

Best fit lines can also be curves.

Question 3 (b)

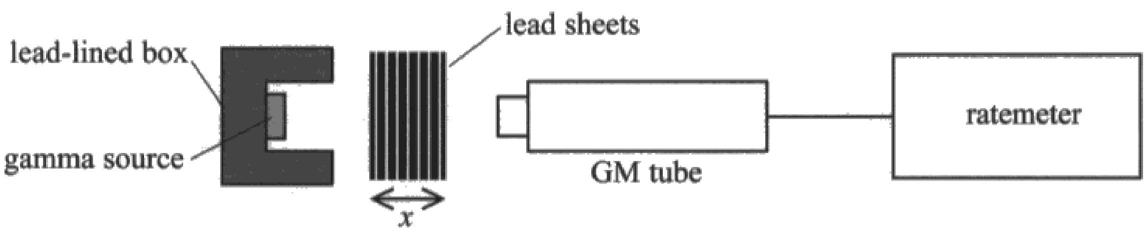
Part (b) assessed the candidates' ability to relate the data given to the accuracy of the value for λ_{max}. A number of candidates tried to give "astronomical" answers such as discussing Doppler shift or dust in the atmosphere rather than relating this to the data presented. Very few candidates were able to relate the shape of the graph to the uncertainty in the maximum value, although many cited the lack of readings around the peak as well as commenting on the apparent lack of repetition of measurements.

Question 4 (a)

This is the data handling question that requires candidates to process data and plot a graph to determine a constant. In this question candidates were presented with the absorption of gamma rays in lead, which is a standard practical in the new specification.

Part (a) involved explaining why background radiation can be corrected for and was not answered well by the majority of candidates. Similar to Q01(a)(ii) candidates often described how this could be achieved rather than explaining why, suggesting that the candidates did not understand the difference between describe and explain, unlike in the examples below. In addition, some candidates also described where background radiation originates from or stated that background is always present.

4 A student investigated the absorption of gamma radiation by lead, using the apparatus shown.



(a) She recorded and corrected for the background count rate.

Explain why it is possible to correct for background count rate.

(2)

It is a source of systematic error, as background count rate, recorded away from other radiation sources, is a constant value.

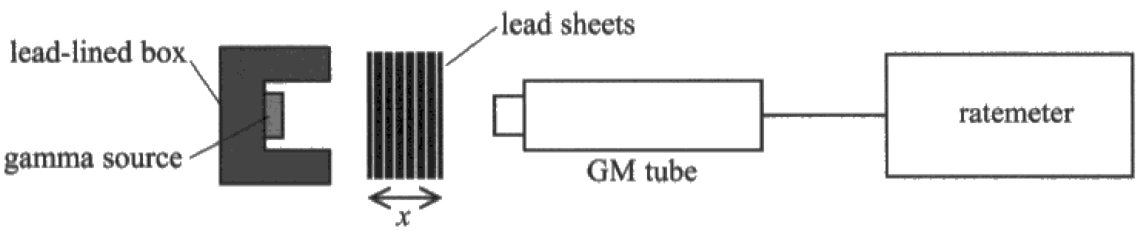
ResultsPlus
Examiner Comments

This clearly scores both marks. This candidate has underlined the "why" in the question which can help focus the answer towards an explanation rather than a description. This answer could have started with the word "because" and still made sense, therefore it is an explanation.

ResultsPlus Examiner Tip

Underline the command word in the question and understand what you it is telling you to do.

4 A student investigated the absorption of gamma radiation by lead, using the apparatus shown.



(a) She recorded and corrected for the background count rate.

Explain why it is possible to correct for background count rate.

(2)

Because the background count rate ~~will~~ also affect for the measurement. Therefore the background count rate must be deducted. Measured countrate − ~~8~~ background countrate ~~Me~~ Otherwise the percentage uncertainity will be high.

ResultsPlus Examiner Comments

Although this candidate does appear to explain with the use of "because", unfortunately there is no indication that the measurements will be affected by the same or a predicted amount.

ResultsPlus Examiner Tip

Check that you understand how certain experimental techniques reduce the effects of systematic or random errors.

Question 4 (b)

Part (b) is another standard question used in previous papers where candidates have to explain why the graph should produce a straight line. Here candidates were more successful in understanding what they had to do. In the majority of cases the logarithmic expansion was done correctly, hence gaining the first mark. For the second mark the expanded formula must be compared to the equation of a straight line. However, there were occasions where the order of the terms did not correspond with the expanded formula, as in the example below. In some instances, the equation of the straight line was not written out in full which is illustrated in the final example.

The second mark also required the gradient to be specified as well as being negative. As the question stated that μ is a constant, it was not necessary to state that the gradient was constant although it is good practice to state this. As this question asked for an explanation, candidates should be responding with sentences rather than just using mathematical symbols.

(b) The student recorded the corrected count rate C with different thicknesses of lead sheets.

The relationship between C and the total thickness x of the lead sheets is

$$C = C_0 e^{-\mu x}$$

where C_0 is the count rate without any lead sheets and μ is a constant.

Explain why plotting a graph of $\ln C$ against x will produce a straight line.

(2)

$\ln C = \ln C_0 - \mu x$, Comparing to $y = mx + c$, $m = -\mu$ and since μ is a constant gradient is a constant hence a straight line.

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Examiner Comments

This is an example where the candidate has not written the terms in the correct order. Here the expanded formula is in the form *y=c+mx*, hence this only scores one mark.

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Examiner Tip

Check the order of the terms match.

(b) The student recorded the corrected count rate C with different thicknesses of lead sheets.

The relationship between C and the total thickness x of the lead sheets is

$$C = C_0 e^{-\mu x}$$

where C_0 is the count rate without any lead sheets and μ is a constant.

Explain why plotting a graph of $\ln C$ against x will produce a straight line.

(2)

$\ln \frac{C}{C_0} = -\mu x$ $\quad \ln C - \ln C_0 = -\mu x$

$\ln C = -\mu x + \ln C_0$

$\uparrow \quad = \quad \uparrow\uparrow \quad \uparrow$

$y \quad mx \quad c$

It will produce a straight ~~line~~ line with a negative gradient of y-intercept $\ln C_0$.

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Examiner Comments

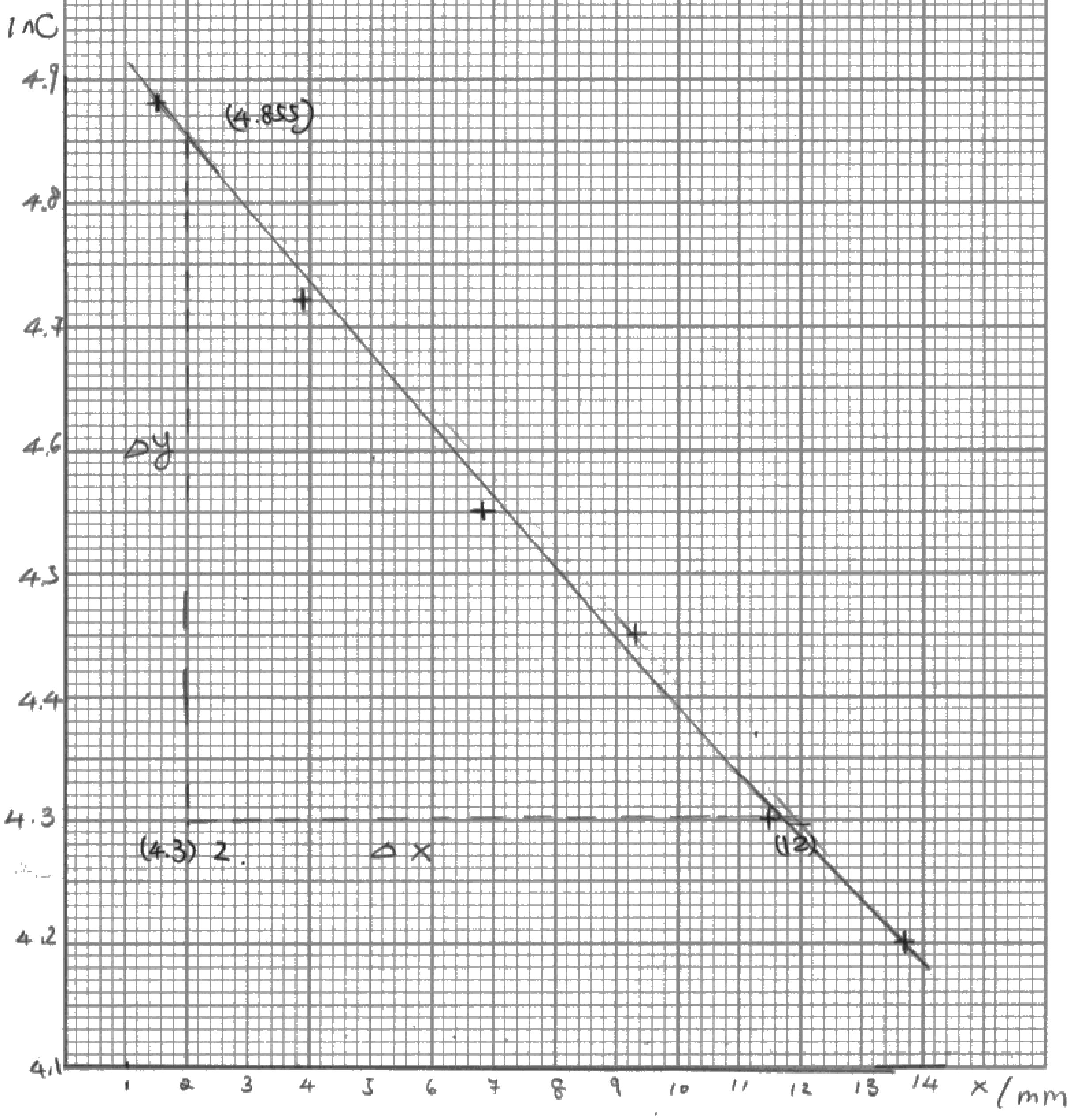
The equation of the straight line must be written out in full, including the operators. In this case the "+" is missing, therefore this will only score one mark.

Question 4 (c)

Finally, part (c) assessed the candidates' ability to process data and plot the correct graph. A higher ability candidate should be able to access the majority of the marks here and many good graphs were seen. The majority of candidates processed the data to three significant figures although there were some occasional errors in rounding, presumably as a result of rounding to four significant figures then rounding that value to three significant figures. There were fewer candidates that plotted seemingly random numbers compared to previous series. The most common error in the graph was not labelling the *y*-axis in the correct form, ie ln(C / s^{-1}). Some candidates chose to convert the thickness into metres, which was unnecessary and produced negative values which candidates often find harder to plot. At this level the candidates should be able to choose the most suitable scale in values of 1, 2, 5 and their multiples of 10 such that the plotted points occupy over half the grid in both directions. Candidates that started the *y*-axis from zero did not gain this mark. Scales based on 3, 4 or 7 are not accepted and often lead to plotting errors. Candidates should realise that although the graph paper given in the question paper is a standard size the graph does not have to fill the grid.

Most candidates were able to plot the graph accurately using neat crosses (x or +). If a dot extends over half a small square then this is not considered to be accurate plotting so candidates should be encouraged to use crosses. Best fit lines were generally good however it is expected that there should be an even number of points either side of the best fit line. Candidates that joined the first and last points could not gain this mark as there would have been too many points below the line. In addition, some lines looked disjointed or did not extend across all data points, perhaps a result of using a ruler that is too small, or were too thick hence could not gain this mark.

In the final part the candidates had to use their graph to determine a value of μ. Since this is a linear graph it is expected that the gradient of the graph should be used as it is this skill that is being assessed. It should be noted that candidates are awarded marks for their ability to use the graph they have drawn. It is expected that candidates at this level should use a large triangle automatically and to show clear working as marks are awarded for the method used. There were some cases where the candidate had misread from the graph, forgotten that the line did not start from 0,0 or used data points from the table which did not lie on the best fit line. Candidates who label the triangle on the graph are often more successful in the calculation. The final answer should have been given to three significant figures, which most managed, however only the better candidates gave a correct unit.


ln C
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
(4.855)
Δy
(4.3) 2
Δx
(12)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
x / mm

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Examiner Comments

In this graph, the *y*-axis label is not in the correct format and the best fit line is incorrect as there are three points below the line and only one above. The ln values were correct as are the scales and plotting, hence this graph scores three marks.

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Examiner Tip

Check that the best fit line has an even number of points above and below the line. Joining up the first and last points is not always a good strategy.

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 and suggested practical activities are given in the specification. In particular they should make measurements on simple objects using vernier scales, and complete experiments involving electrical circuits, heating, timing and mechanical oscillations.

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

- Use the number of marks given in a question as an indication of the number of answers required.
- Learn what is expected from different command words, in particular the difference between describe and explain. In addition, use of determine and deduce require a calculation.
- Show working in all calculations as many questions rely on answers from another part of the question, or marks are awarded for the method used.
- Be consistent with the use of significant figures, in particular that quantities derived from measurements should not contain more significant figures than the data and uncertainties should be given to at least one fewer significant figure than the derived quantity.
- Choose graph scales that are sensible, ie 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 and grids can be used in landscape if that gives a more sensible scale.
- Use a sharp pencil to plot data using neat crosses (x or +), and to draw best fit lines.
- Avoid simply joining the first and last data points without checking that the spread of data is even above and below the line.
- Draw a large triangle on graphs using sensible points. Labelling the triangle often avoids mistakes in data extraction.
- Learn the definitions of the terms used in practical work. These are given in Appendix 10 of the new IAL specification.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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