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Examiners' Report
Principal Examiner Feedback

January 2018

Pearson Edexcel International Advanced Level

Physics (WPH06)

Unit 6: Experimental Physics

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General Introduction

The IAL paper WPH06 is called Experimental Physics and 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 A2 Physics learners 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.

The paper for January 2018 was in a similar format as previous series and with much the same skills content. This paper focused more on standard laboratory techniques set within experiments which the learners should have carried out as part of their studies. Hence learners who do little practical work will find this paper more difficult. In the forthcoming new specification, it is expected that learners carry out a range experiments as the skills and techniques learned will be examined in different contexts.

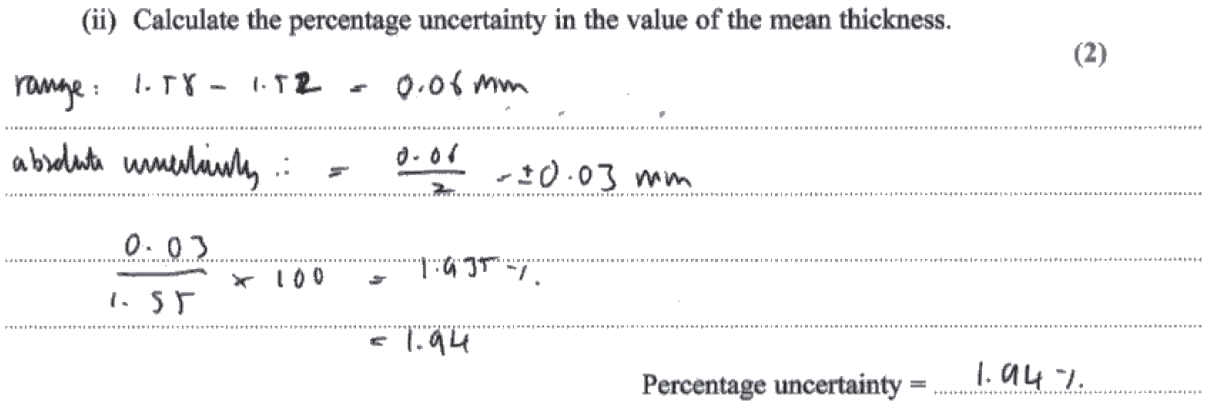
The mean mark was slightly higher than in previous series suggesting that this paper was as accessible. In particular, this paper used contexts that should have been familiar to most learners which was evident by the lack of blank spaces. However, there was a small but significant proportion of learners who appeared to be unprepared for this examination since there were some poor responses to standard questions.

Question 1:

As in previous series, this question assessed the learners' ability to calculate and use uncertainties at the level expected of an A2 candidate. This question concerned determining a value of the density of steel using measurements of the diameter and thickness of a metal disc. The learners were expected to use a calculated percentage uncertainty to judge whether the disc could be made of carbon steel.

(a) The learners had to explain the reason for repeating the measurement of the diameter to calculate a mean value. The only function of this is to reduce the effect of random errors and centres should ensure that learners are aware if this. Many learners related this to the disc itself by discussing the irregularity of the diameter which is the source of random error and gained credit. In some cases, learners referred to the thickness which was not required by the question. In addition, there were references to spotting anomalies, reducing percentage uncertainty and increasing accuracy which were not credited.

(b) Of the question invited the learners to calculate the mean thickness and calculate its percentage uncertainty from a range of measurements. Whilst most learners had little difficulty in calculating the mean there were a significant number of learners that used the resolution of the instrument to calculate the percentage uncertainty. This is only acceptable for a single measurement not a range of measurements and a good example is shown below. learners that used the full range of values were given credit on this occasion but in future series only the half range will be accepted.


(ii) Calculate the percentage uncertainty in the value of the mean thickness.

(2)

range: 1.58 − 1.52 = 0.06 mm

absolute uncertainty: = $\frac{0.06}{2}$ = ±0.03 mm

$\frac{0.03}{1.55}$ × 100 = 1.935 %

= 1.94

Percentage uncertainty = 1.94 %

(c) learners had to calculate the volume of the disc and its percentage uncertainty. learners should be made aware that they need to be able to recall formula to calculate the volume of simple geometric shapes since there were instances where learners used an incorrect formula. On the whole, most learners were successful in this but often did not gain full marks as the answer was given to too many significant figures. In a practical paper they should be using the number of significant figures consistent with the measurements which in this case was three. There were also some issues with unit conversions, particularly at the lower end of the grade range.

In the second part the learners had to calculate the percentage uncertainty in this value. It should be noted that learners are credited for the method they use, hence a full calculation should be shown such as in the following example.

(ii) Calculate the percentage uncertainty in the mean value for the volume of the disc.

(3)

% U d = $\frac{0.1}{35.2}$ × 100 = 0.28 %

% U th. = 3.87 %

% U V = 3.87 % + 2 × 0.28 % = 4.43 %

Percentage uncertainty = 4.43 %

Most learners achieved the first marking point however many did not double this value further on in the calculation so could not gain further credit. In addition, there were a number that decided to halve the percentage uncertainty in the diameter to get the percentage uncertainty in the radius. These learners clearly confused the idea that although the absolute uncertainty will halve the percentage uncertainty will remain constant. Centres should note that in future series it is expected that percentage uncertainties are quoted to one significant figure less that that of the measurements.

(d) The learners had to calculate the density of steel which posed little difficulty for the majority of learners but often they did not round to three significant figures as indicated by the data. As with the volume there were errors in unit conversion particularly at lower grades.

The final part of the question asked for the comparison which many learners did well since this type of question has appeared in many series. Here they should be using their percentage uncertainty to reach a valid conclusion and must show clear working. The accepted method, as shown in the example, is to calculate the upper and/or lower limit using the percentage uncertainty and commenting on whether the accepted value falls within the range.

(e) There are different types of steel. The density of carbon steel is 7860 kg m^{-3}.

Determine whether the disc could be made from carbon steel.

(2)

$7929 \times \frac{4.44}{100} = 352$, $7929 - 352 = 7577$

$7577 < 7860$ kgm^{-3}, so 7860 kgm^{-3} is in the range of possible values of r for the disc in the experiment. So the disc has been made from carbon steel.

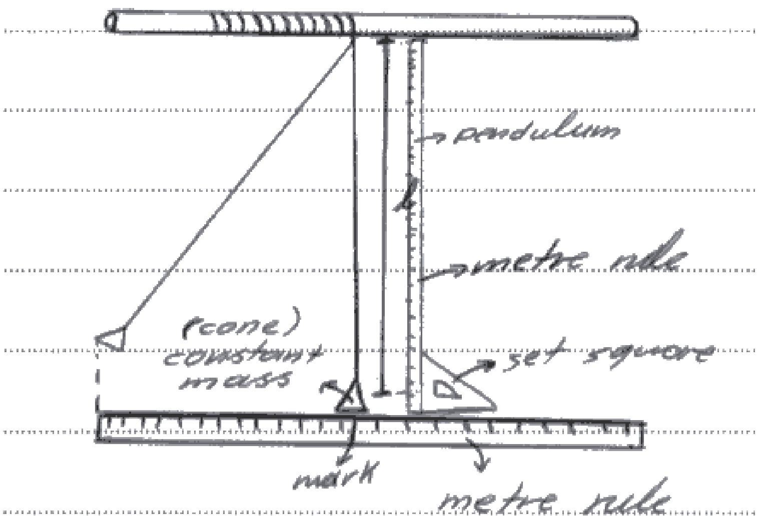
Answers based on the percentage difference were also accepted however learners made more computational errors here, in particular they did not use the accepted value in the denominator or used a mean value. On occasion the calculation as written was incorrect, possibly as a result of leaving a value in the calculator from the previous part. learners should ensure that they write down the numbers they use in the calculation. Another common mistake in this part is not to make a valid comment, often relating the percentage difference to a mythical 5 or 10% rather than the percentage uncertainty they have calculated.

Question 2:

This question focussed on planning a standard experiment to determine a value for *g* using a simple pendulum. It was clear that many learners had not carried out this experiment.

(a) Asked for a definition of the term "precision" given the context of the stopwatch. This was poorly answered even by learners at the top of the grade range. Many simply reiterated the stem of the question by substituting another word for precision, for example, measures to the nearest 0.01 s, rather than relate their answer to a scale. Also, many answers related to significant fissures or decimal places which is not specific enough. Occasionally learners referred to the spread of data which was incorrect in this context. Centres should be aware that in the new specification this will be replaced by the term "resolution" when referring to instruments and precision will only refer to the spread of data.

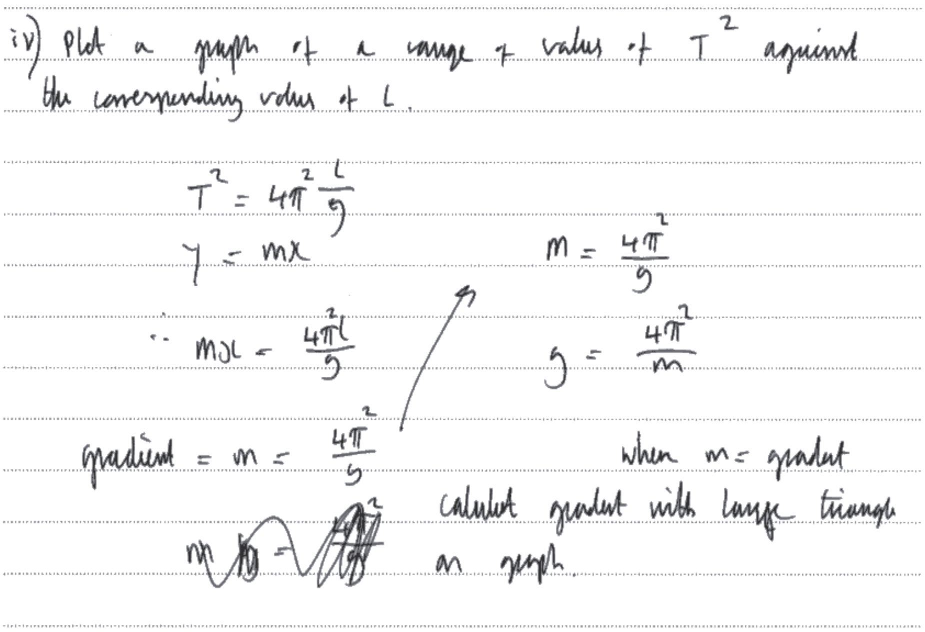
(b) Tested the learners' planning skills in a longer written answer. Although many learners followed the structure suggested by the question those that did not could still gain full credit. It was evident that many learners had not performed this experiment. In general, the diagrams were poor and an acceptable diagram is shown below.



In many cases the length was not indicated at all or the length did not extend to the centre of the bob so appeared only to measure the length of the string. Some learners did not provide a fixed support for the pendulum and left it hanging in mid-air. There were some attempts at a three-dimensional drawing which made it difficult to tell where a timing marker had been placed. A minority of learners appeared to misread the question and present a diagram involving a mass on a spring.

Many learners scored the mark for identifying the main source of uncertainty with just a bald statement of reaction time. It would be better if learners related this to the experiment as this leads into the need for specific timing techniques. The techniques involving measurement of time period is a common question therefore most learners did well in this part. Most learners gained the mark for repeating the measurements and calculating the mean. Some learners were not clear enough in their description of multiple oscillations, usually stating that they would find a mean without saying how, i.e. by dividing by the number of oscillations. In addition, many learners stated they would use a marker without being specific about where it would be placed, i.e. at the equilibrium position or the centre of the oscillation, however this mark was sometimes awarded where the marker was clearly indicated in the diagram, as in the above example. On occasion learners went on to state that they would start timing when the pendulum was released which contradicted the use of the marker, hence the mark was then lost. The final mark for allowing oscillations to settle or use a small angle was rarely given.

Finally, learners had to state the graph they would plot and how it would be used to determine *g*. At this level, it is expected that learners understand that they should plot the independent variable on the *x*-axis and the dependent on the *y*-axis, hence graphs of *l* against T^2 were not credited. learners that sketched the correct graph were given credit. Most learners scored the first mark and then went on to state how the value of *g* related to the gradient however only a very small number stated that the gradient should be calculated to determine the value for *g*. learners need to be aware that they should provide a set of instructions on how a graph is to be used not just describe it. The following example shows an acceptable answer in which the candidate has also identified the equation of a straight line which was not necessary.


iv) Plot a graph of a range of values of T^2 against the corresponding values of L.

$T^2 = 4\pi^2 \frac{L}{g}$

$y = mx$

$m = \frac{4\pi^2}{g}$

$\therefore mx = \frac{4\pi^2 l}{g}$

$g = \frac{4\pi^2}{m}$

gradient $= m = \frac{4\pi^2}{g}$

when m = gradient

calculate gradient with large triangle on graph.

Question 3:

(a) This question was based on an experiment involving measuring the intensity of light emitted from a light source with distance. Most learners scored the mark in part (a) however some learners misunderstood the question and stated other variables, such as using the same potential difference across the bulb and using the same bulb.

(b) This is a common question involving justifying the use of an instrument, in this case using a metre rule to measure distance. Most learners realised they had to state the resolution of the rule and scored the first mark. Many went on to calculate a percentage uncertainty and realised that using the 5 cm measurement would give the largest percentage uncertainty. There were a number that misunderstood this and used either the 80 cm measurement only or a mean value. Another common error was not to make a comment about the percentage uncertainty. Since this is an explanation type question a comment is expected as in the example below.

Explain, with the aid of a calculation, why a metre rule is a suitable instrument to measure the distance.

(2)

Because the precision of a meter rule is ±0.1 cm. So the percentage uncertainty will be very small. For example, the maximum percentage uncertainty is $\%U = \frac{0.1}{5} \times 100 = 2.0\%$ and the minimum percentage uncertainty is $\%U = \frac{0.1}{80} \times 100 = 0.13\%$. So the measure of the distances will be absolutely precise.

Finally, the learners were given data and had to explain whether the data was consistent with the given relationship. This was a different style of question compared to previous series however the vast majority of learners coped well and scored all the marks. There were some learners who employed a slightly different method by calculating *k* from the first set of data then using it to calculate *I* in the other two sets as a comparison. This was given full credit. The most common errors occurred in not using all three sets of data to form their conclusion or not realising that the differences in *k* values were acceptable in a practical context. In addition, some learners just reiterated the question rather than relate the consistency to the calculated values. The final mark could be gained in a number of ways, an example of which is shown below.

Explain whether these values are consistent with the equation. Your answer should include calculations.

(3)

$I = kd^{-2} \Rightarrow k = Id^2$

$k = 800(0.10)^2 = 8.00$

$k = 350(0.15)^2 = 7.88$

$k = 130(0.25)^2 = 8.13$

so value are indeed consistent since

$k = 8.00 \pm 0.125$ so small uncertainty

Question 4:

This is the data handling question that requires learners to process data and plot a graph to determine a constant. In this question learners were presented with the context of liquid flowing out of a burette with measurements of the volume of liquid remaining over time.

(a) This part asked for the property of the liquid that determines its flow rate. The vast majority of learners correctly identified viscosity, and there was some leniency shown in the spelling of this term. learners that were unsuccessful often referred to density, pressure or temperature. In addition, learners that gave more than one answer were not given credit since the question clearly states only one mark is available hence only one answer is required.

(b) learners had to suggest a reason for starting the investigation with the liquid level above the zero mark. It was clear that most learners did not imagine carrying out this experiment and what the difficulties might be. Here they should have contemplated issues such as errors involved in the tap not being fully open when timing starts or the difficulty of doing two things at once. In addition, there were some learners that referred to a standard technique in chemistry in which the capillary below the tap being full before taking readings which was not enough to gain the mark. learners that just stated reaction time were not given credit.

(c) This part is another standard question used in previous papers where they have to explain why the graph should produce a straight line. Here learners were more successful in understanding what they had to do. In the majority of cases the logarithmic expansion was done correctly however there were occasions where the comparison to the equation of a straight line was written such that the order of the terms did not correspond with the expanded equation. An example of this is given below.

Explain why a graph of $\ln V$ against t should be a straight line.

(2)

$\ln V = \ln V_0 - bt$ is similar to $y = mx + c$

This is a straight line with gradient = $-b$

The second mark asked for the gradient to be specified, which many learners did, however they also had so state that it was negative. As the question stated that *b* 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, learners should be responding with sentences rather than just using mathematical symbols. A good response to this question is shown in the following example.

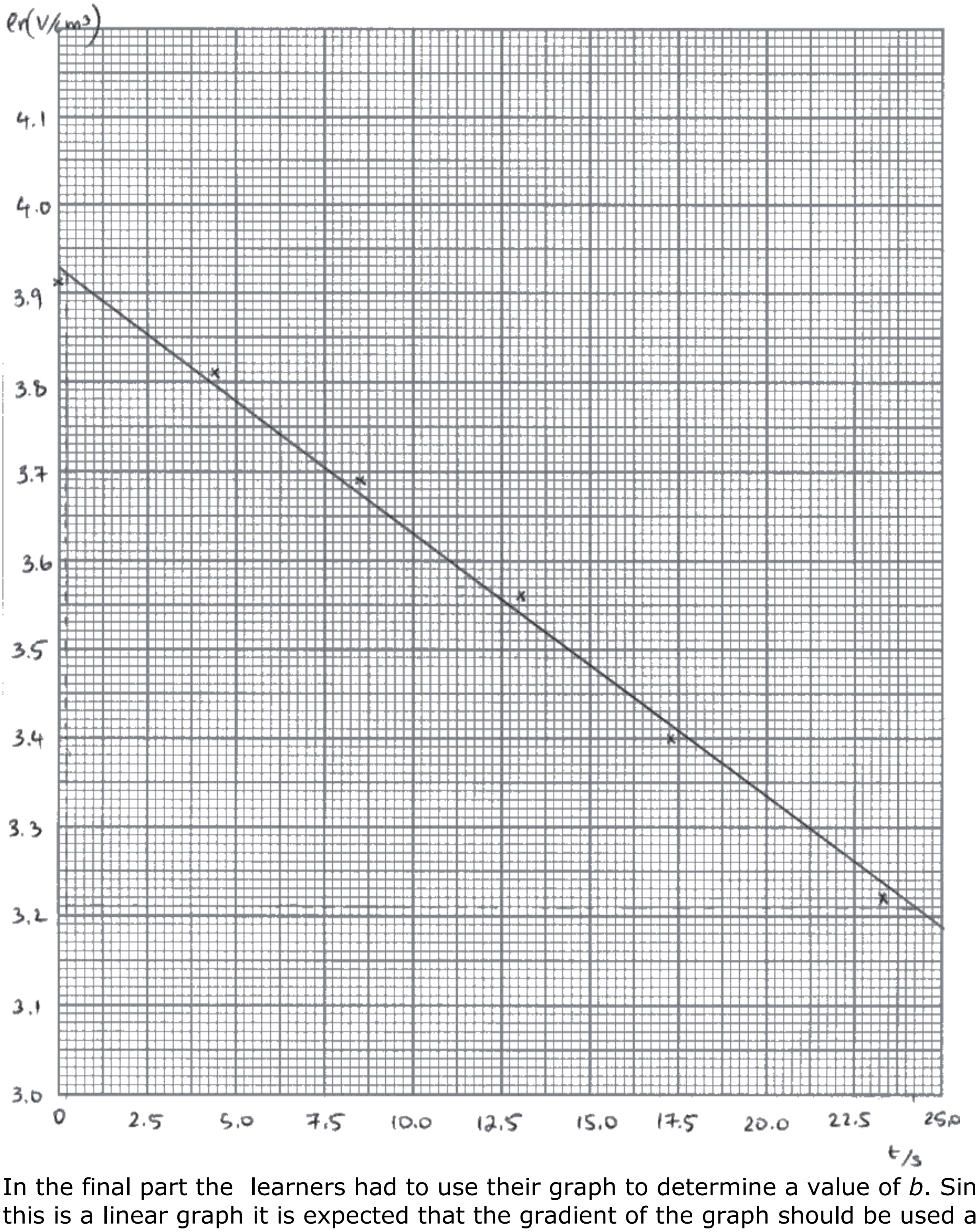
Explain why a graph of $\ln V$ against t should be a straight line.

(2)

$V = V_0 e^{-bt} \Rightarrow \ln V = \ln V_0 - bt$ where this equation is of the form $y = c + mx$. Where $\ln V_0$ and b are constants, $-b$ rerpresents the gradient and $\ln V_0$ represents the y-intercept of the graph.

(d) Finally, this part assesses the learners' ability to process data and plot the correct graph. A good candidate should be able to access the majority of the marks here. The majority of learners processed the data to the correct number of significant figures, i.e. three although four is acceptable for a logarithmic function. The most common error in the graph was not labelling the *y*-axis in the correct form, i.e. ln(V / cm^3). At this level the learners 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. learners 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. A significant number of learners presented *x* scales in 4s and occasionally *y* scales in 0.15 which are both not accepted. learners should realise that it is acceptable to use the graph paper in landscape if that gives more sensible scales which very few did. In addition, the graph paper given in the question paper is a standard size and the graph may not necessarily fill the grid.

Most learners were able to plot the graph accurately using neat crosses or small dots within a circle. If a dot extends over half a small square then this is not considered to be accurate plotting so learners should be encouraged to use crosses. Best fit lines were generally good since there was little scatter in the points, however it is expected that there should be an even number of points either side of the best fit line. Still a number of learners feel they should use the data point on the y-axis or join the first and last data points. 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.
An example of a good graph is shown below. There were some learners who plotted a *V*-*t* graph which could only gain the plots and best fit line marks. Furthermore, there were a few learners that appeared to plot some seemingly random numbers hence could not be awarded any marks.



In the final part the learners had to use their graph to determine a value of *b*. 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 learners are awarded marks for their ability to use the graph they have drawn. It is expected that learners at this level should use a large triangle automatically and to show clear working as marks are awarded for the method used. A well laid out answer is shown on the following page.

(ii) Determine a value for the constant *b*.

(3)

$\frac{3.9 - 3.445}{0.8 - 16} = -0.0299\ s^{-1}$

$b = -m$

$b = 0.0299\ s^{-1}$

$b =$ $0.0299\ s^{-1}$

There were many cases where the candidate had misread from the graph or used data points from the table which did not lie on the best fit line. The final answer should have been given to three significant figures, which most managed, however a number of learners did not give a unit. In addition, the learners had to realise that *b* is a positive number despite the gradient being negative.

Some learners that used two pairs of points from the line, particularly the value of the *y* intercept, which were substituted back into the equation to find *b*. Although this was an acceptable method in this case, this did have the disadvantage that it is more difficult to ascertain the correct units to use for *b*.

Summary

learners can improve their chances of gaining a good mark on this paper by routinely carrying out and planning practical activities for themselves using a wide variety of techniques. In particular they should make measurements on simple objects using vernier scales, and complete experiments involving electrical circuits, heating, timing and mechanical oscillations. These can be simple experiments that do not require expensive, specialist equipment and suggested practical activities are given in the specification.

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.
- If a question asks for an explanation or is a planning question, use sentences in a reasoned order.
- Where a calculation is used in an explanation complete the answer with a written conclusion based on the results of the calculation.
- If a rounded answer is written down in a subsequent calculation ensure that this is the number used in the calculation.
- Show working in all calculations as many questions rely on answers from another part in the question, or marks are awarded for the method used.
- Be consistent with the use of significant figures.
- Choose graph scales that are sensible, i.e. 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 and grids can be used in landscape if that gives a more sensible scale.
- Practise drawing diagrams that are fully labelled and two dimensional.
- Learn standard measuring techniques and the reason they are used.
- Learn the definitions of the terms used in practical work. These are given in Appendix 10 of the new IAL specification.

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