Examiners' Report
Principal Examiner Feedback

October 2023

Pearson Edexcel International Advanced Level In Physics (WPH16)
Paper 01: Practical Skills in Physics II

General

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 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.

It should be noted that, whilst much of the specification is equivalent to the previous specification, there are some notable differences. 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, new command words may be used which 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.

The paper for October 2023 covered the same skills as in previous series and was therefore comparable overall in terms of demand.

Question 1

This question was set in the context of investigating the force on a current-carrying wire. Electrical measurements can be found in several AS and A2 core practicals, in particular Core Practical 2: Electrical Resistivity.

In part (a) candidates had to describe a safety issue and how it should be dealt with. Although this question was aimed at the lower end of the grade scale, very few candidates scored both marks and many descriptions were too vague. Some candidates focused on the mechanical risks by referring to instability of the wooden blocks rather than the electrical or thermal risks of the experiment. It is expected at this level that candidates identify a potential risk and a suitable precaution that goes beyond simply "not touching the wire".

In part (b) candidates had to complete the circuit diagram for this investigation. It is expected that candidates use standard electrical symbols and produce a circuit that would work. Too often, candidates used incorrect symbols, such as two circles or a labelled box for a d.c. power supply, or a thermistor for a variable resistor. Occasionally, there were circuits that would not work, for example as there was a short circuit or a voltmeter added in series. The most common error here was not including a means to vary the current in the circuit.

Finally, in part (c) candidates were presented with a graph of the readings taken by the student along with an expected relationship between the variables. Candidates then had to explain why the graph shown may not support the given relationship. Although candidates were given some direction in referring to the readings, many did not do so. Candidates should have referred to the number and range of readings taken, and why they were insufficient in supporting the relationship. Some candidates wasted time by calculating a constant of proportionality, but some were given credit in forming a valid conclusion based on their working.

Question 2

This question assessed planning skills within the context of investigating the oscillations of a long simple pendulum. The techniques used in this practical are directly related to Core Practical 16: Oscillations.

In part (a) candidates had to **show that** the relationship between time period *T* and the distance *h* from the floor could be written as $T^2 = \frac{4\pi^2 H}{g} - \frac{4\pi^2 h}{g}$. It is expected that candidates show a step-by-step process starting with the initial formula. Those that started with the general formula for a simple pendulum with *l* then being substituted for *H*–*h* often scored both marks. Those that scored no marks often tried to use two formulae for the simple pendulum. In this situation, the formula $T = 2\pi\sqrt{\frac{h}{g}}$ alone makes no physical sense. Occasionally, candidates would make algebraic errors, such as not squaring the factor of 2π.

Part (b) was the familiar planning question based on using the formula in part (a). Candidates should be aiming to write a method that could be followed by a competent physicist to obtain reliable, valid and sufficient data. Although marks were not awarded for linking ideas, candidates often used vague language, or their descriptions did not follow logically. The best answers were structured and concise, leading to a method that could be followed easily. This question was answered well overall suggesting that candidates had encountered experiments using oscillations.

The mark scheme for this type of the question can vary owing to the context of the experiment however they all follow a similar structure. The first two marks were for identifying a suitable measuring instrument to measure *h* and a technique to use the instrument accurately. Some candidates suggested that a metre rule could be used to measure *H,* the height of the room, directly which was not the purpose of the experiment. Better candidates often gave several techniques to measure *h* accurately.

The second two marks were for describing how to obtain an accurate time period. Most candidates should be able to achieve at least one of these marks. As is usual, candidates recite "repeat and take a mean" without any thought as to how this should be done in the context of the investigation, therefore were not credited if it was unclear.

The final two marks were for describing how to obtain sufficient data to plot a graph. Despite the question guiding candidates to use a suitable graph, some candidates described a simple calculation using the formula which was not credited. In addition, candidates that were unclear as to whether they were obtaining five sets of data at the same h or for five different values of h did not score the mark. The final mark was for stating which graph to plot to determine H. Again, some candidates missed this mark by not realising that H should be determined using the y-intercept of the graph, as often they stated the gradient.

In part (b) candidates had to explain how using a video recording may improve the method. The performance on this question was higher than usual owing to the command word. As is usual for this type of question, candidates made general remarks about reaction time without relating it to the investigation which was not credited. Most candidates who scored a mark described how to use the video recording, for example by slowing it down. It was more unusual to see candidates describing that it would be difficult to judge when a complete oscillation accurately.

Question 3

This question involved plotting and analysing the graph for the variation of atmospheric pressure with height above sea level. This relationship is of the form of an exponential decay which appears in experiments such as in Core Practical 11: Capacitor Decay. A question involving a graph appears in each series with a common mark scheme. Therefore, there are plenty of opportunities to practise this skill and consult Examiner's Reports to correct common errors. A good candidate should be able to access most of the marks and most candidates should score some marks.

In part (a) candidates had to explain how a graph of ln P against h can be used to determine the value of the constant b. This type of question should be very familiar as it appears in most papers. 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. The second mark required candidates to compare their log expansion with $y = mx + c$, which is standard for this type of question, **and** state the gradient is $-b$. The most common error here was not writing this in the same order as the log expansion. It should be noted that where two forms of the expansion are given, it is the final one that is used as the comparison. In some cases, candidates wrote $y = c - mx$ or missed out the operators, both of which were not credited. Some candidates missed the – sign, and some referred to "m" rather than state "the gradient is".

Part (b)(i) assessed the candidates' ability to process data and plot the graph of ln P against h. The first mark was for processing the data correctly and was awarded most often. As the relationship was an exponential only the use of natural logs was accepted for this mark. Occasionally, candidates gave the values for ln h. In addition, some candidates converted the values of P from kPa to Pa which is unnecessary. Often, converting the units makes the graph more difficult to draw and can lead to errors. The number of decimal places given should be sufficient to plot a graph accurately on standard graph paper. For logarithms candidates should give a minimum of two decimal places although three is accepted. The most common errors here were truncating rather than rounding and using an inconsistent number of decimal places in processed data.

The second mark was for placing the axes the correct way around and labelling with the correct quantity using the correct convention. Some candidates inverted the axes, i.e., they plotted h against $\ln P$. Candidates should note that the question is always written in the form "plot y against x". This also often lead to mistakes in later parts. The most common mistake 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), e.g. ln (P / kPa). Those that used logarithms given in a different base did not score this mark.

The third mark was for choosing an appropriate scale. 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 **all** the plotted points occupy **over half the grid in both directions**. 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. Candidates at this level should also realise that scales do not have to start from zero. The most common error was using a y-scale starting from 0 and going up in 0.5. Scales based on 3, 4 (including 0.25) or 7 are awkward and not accepted, and x-scales of 400 were quite common. Occasionally, candidates appeared to use scales based on subtracting the highest and lowest values and dividing by the number of squares available, or simply labelled the axes with the data values. Neither is an acceptable method. Candidates should also be encouraged to label every major axis line, i.e. every 10 small squares, with appropriate numbers so that examiners can easily see the scale used. This often leads to fewer plotting errors.

The fourth mark was for accurate plotting. Candidates should be encouraged to use neat crosses (× or +) rather than dots when plotting points. Candidates were not awarded this mark if they used large dots that extended over a square or used an awkward scale. Mis-plots were more common as candidates found using a scale of 500 more difficult, however candidates should be encouraged to check a plot if it lies far from the best fit line.

The final mark was for the best-fit line. This mark was awarded often as the data used did not produce a significant scatter. Often candidates will join the first and last points without judging the scatter of the data points around the line which can lead to errors. Where candidates were not awarded this mark it was either because the line was too thick, i.e. over half a small square, or was not continuous or clearly bent. Candidates should be encouraged to use a 30 cm rule for this examination, and to circle any points they have not used to judge their best-fit line.

In part (b)(ii) candidates were asked to determine the gradient of the graph. There were several common errors seen. The first mark was for using a large triangle, i.e. at least half the plotted points in the *x* direction, to calculate the 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 be encouraged to 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 second mark was for a value in the range stated. The most common error here was using a factor of 10^3 as candidates assumed that this was needed as the units of pressure were given as kPa. Candidates should know that log values are pure numbers therefore a conversion is incorrect. 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. Although a unit for a gradient is not expected, those that stated m^{-1} were credited, however those that stated kPa m^{-1} were not credited.

In part (b)(iii) candidates were given a formula using the gradient of the graph to determine the mass of an air molecule. Most candidates scored well on this part. The most common error here was using too many significant figures, using an additional factor of 10^3, or using incorrect or no units.

Finally in part (b)(iv) candidates had to determine the value of P at 414 m **below** sea level. Candidates approached this in a variety of ways. Those that realised that this required determining a value of P_0 often scored well. Some candidates simply stated a value for P_0, often around 100 kPa, and this was not credited as a full calculation is expected. The most common error in the calculation was using 414 m and not –414 m. Occasionally, candidates forgot to use the – sign for the gradient. Those that thought they could simply interpolate from the graph did not score marks.

Question 4

This question involved measuring dimensions of a rubber band and rubber bung. This involved the the techniques when using a micrometer screw gauge which candidates encounter in several AS core practicals. In addition, the analysis of uncertainties is common to all past papers therefore candidates should be encouraged to 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)(i) was a familiar question in which candidates had to **explain one technique** when using a micrometer screw gauge to measure the thickness of the rubber band. As is usual in this type of question, many candidates only described the technique but did not link them to a particular type of error, or gave two techniques instead of the one the question asked for. It is also expected that candidates give enough detail in relation to the context of the experiment for each technique. Therefore, for a repeated measurement it is expected that the candidate describes where or how to take the repeated measurement. Often, candidates stated “at different orientations” without realising the rubber band had a rectangular cross-section which would not be valid. Only a few candidates realised that the rubber band would be compressed so the ratchet should be used. It is expected that candidates state that a zero-error must be corrected for not just checked. The second mark was for linking the technique to its type of error. Candidates who attempted this did it well, although it should be noted that a random error can only be reduced not eliminated or avoided. Phonetic spellings for “systematic” are accepted but the word “systemic” has a different meaning and is not accepted.

Part (a)(ii) involved calculating a mean and percentage uncertainty from a set of data. The first mark was for the correct value of the mean given to the **same number of decimal places as the measurements**. Many candidates gave too many decimal places. The second two marks were for the percentage uncertainty calculation. The candidates **must show** the calculation for the second mark, and this is awarded for calculating the **half range or furthest from the mean**. Some candidates calculated the uncertainty not the percentage uncertainty. The final mark was for the correct percentage uncertainty given to one significant figure less that the measurements.

In part (a)(iv) candidates had to explain the effect of folding the rubber band on the percentage uncertainty. Although many stated that the measurement would be larger, those that did not score marks were not explicit in stating that the uncertainty or resolution would be constant. This could not be implied from a single calculation as an explanation was required. It should be noted that some candidates are still using the term "precision" for resolution, which is not accepted in this specification.

Part (a)(v) was problematic for candidates but was aimed at the higher grades. Candidates were asked to suggest why the volume calculated from the formula may not be accurate. Often candidates focused on the measuring techniques which a competent physicist should be using, or the resolution of the instruments. Occasionally, candidates disputed the formula with no justification. Those that scored a mark often identified that there would be an error in the measurement of the length owing to the shape of the rubber band at the ends. Very few recognised that the rubber band needed to be taut to measure the length or could be more easily compressed when measuring the width.

In part (b) candidates were given the dimensions of a rubber bung and a formula for calculating the average cross-sectional area. In part (i) they were asked to **show that** the uncertainty in D^2 was about 0.07 cm^2. As in all "show that" calculations **all working must be shown**, and an answer that looks correct but is arrived at using the wrong method is not credited. In addition, the correct number of significant figures must be used for this paper, so in "show that" questions **only one additional significant figure** is credited. There were two methods that could be used for this part, either using the percentage uncertainty or calculating the half range of the maximum and minimum values, and both proved straightforward. The most common errors was giving too many significant figures.

In part (b)(ii) they were asked to **show that** the uncertainty in the average cross-sectional area was about 0.05 cm^2. Again, candidates used two methods of solving this, either by combining absolute uncertainties, or by using the maximum and minimum method. Those that combined the percentage uncertainties in the values often scored no marks as this is an invalid method. Those that chose to combine the absolute uncertainties usually scored well as the factor of $\frac{\pi}{12}$ was included. The maximum and minimum method also scored well in this case as the formula did not include a ratio of variables.

In part (c) candidates were given data for the densities of the rubber band and rubber bung determined by the student with the corresponding percentage uncertainties. Candidates then had to deduce whether the two objects were made from the same type of rubber. Candidates **must show their working** as marks are awarded for the method. As there was no “true” value of density to compare to, the percentage difference method could not be used. As is usual for this type of question, the final mark was for a correct conclusion based on their calculation. As in previous series, the main error with the conclusion was not explicitly making a comparison between the values of the upper limit for the rubber band and the lower limit for the rubber bung.

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 calipers and micrometer screw gauges and complete all the Core Practical experiments given in the specification.

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

- Learn what is expected from different command words, in particular the difference between describe and explain.
- Use the number of marks available to judge the number of separate points required in the answer.
- Be able to describe different measuring techniques in different contexts and explain the reason for using them.
- Show working in all calculations.
- 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 if this results in an awkward scale, i,e. in 3, 4 or 7.
- Plot data using neat crosses (× or +), and to draw best fit lines with a 30 cm ruler. Avoid simply joining the first and last data points without judging the scatter of data around the best-fit 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 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.