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Examiners' Report
Principal Examiner Feedback

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

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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 January 2024 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 forced oscillations of a mass-spring system. The techniques for timing oscillations are found in Core Practical 16: Oscillations.

In part (a) candidates had to describe how to determine an accurate value for the time period *T* of the oscillations. Although this is a standard question few candidates scored full marks. The question stated that a stopwatch was to be used to time the oscillations, but some candidates chose to describe a method using equipment such as a video camera or light gates. This type of response would be appropriate for a question based on improvements or modifications. In general, if a piece of equipment is stated in this type of question, candidates should focus on the techniques for using the equipment correctly not suggest something that may be more suitable. In general, candidates were able to identify thar multiple oscillations should be used, but often they did not describe how to obtain the value of *T*. Some candidates stated they would use a timing marker, then stated that they would start the stopwatch when the mass passed the marker and stop the stopwatch the next time the mass passed the marker. This would not give a value for *T*, so repeating this measurement was not credited. Some candidates also described varying the mass and drawing a graph, suggesting that they had not read the question properly.

In part (b) candidates were shown a graph of the amplitude of the oscillations at different frequencies near the resonant frequency. In part (i) candidates had to use the graph to determine the value of the resonant frequency. It was clear that some candidates had not studied resonance as the most common error was to use the frequency at the beginning of the curve. Other common errors included only using 2 significant figures when the graph could easily be read to 3 significant figures, and missing units. In part (ii) candidates had to determine the value of the mass using their value of the resonant frequency. Where candidates understood they had to use the formula for oscillations on a spring, they completed the calculation successfully. In general, candidates gave their values to an appropriate number of significant figures and included units. The most common error here was candidates using the value of the amplitude and equating $F = kx$ with $F = mg$. A small number of candidates used the maximum amplitude with the formula for simple harmonic motion to score full marks.

In part (iii) candidates had to explain why the value of the resonant frequency may not be accurate. As this was in the part of the question related to the graph, candidates should have evaluated the graph rather than focus on any issues relating to measuring the amplitude. Those that scored a mark often evaluated the best fit line. Many candidates stated that there were not enough points plotted, but this needed to be related to a specific area of the graph.

In part (c) candidates had to explain whether using a motion sensor and data logger may improve the experiment. As is usual with questions about the use of data loggers, candidates respond with a list of properties in the hope of stating the correct one. As a result, candidates often scored the mark relating to high sampling rates. As this was an explain question, candidates then had to explain the effect of a higher sampling rate on the measurements. Of those that attempted this, there were a number that appeared to focus on the timing aspect, for example, by stating a data logger would make it easier to judge the start and end of an oscillation. This suggests that candidates had not appreciated the context of the experiment. In addition, very few candidates realised that the data logger would improve the measurement of the amplitude of the oscillations.

Question 2

This question assessed planning skills within the context of investigating the cooling of oil. The techniques for heating and cooling experiments are used in Core Practical 12: Calibrate a Thermistor.

In part (a) candidates had to describe one 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. At this level, it is expected that candidates are more specific with identifying the hazards associated with an experiment, such as burns rather than just hurt, and can describe a suitable method to reduce the risk involved. In many cases, candidates simply stated gloves without being about the type, for example, heatproof or insulated gloves.

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. This can often lead to descriptions being too unclear to award marks. The best answers were structured and concise, leading to a method that could be followed easily.

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 mark was for identifying a suitable measuring instrument to measure time. Whilst it is preferable for candidates to identify the variables and state the measuring instrument for each one, this mark was often inferred from the description of the method. Simply stating “stopwatch” without any context was not credited.

The second mark was for stating a starting condition. This mark was not awarded often. In some cases, the candidates would state “measure the initial temperature” or “start the stopwatch” without putting the two together. Some candidates started the stopwatch at other times, such as when the hot plate was switched on, or when the thermometer was placed in the water.

The third mark was for describing an accurate technique for measuring temperature. The most important technique for this type of experiment is to ensure that the water was in thermal equilibrium. Many candidates realised that stirring the water would help to ensure the temperature measurement was accurate.

The fourth mark was for describing what measurements would be taken. In general, candidates described this well, however those that did not score this mark were not specific about taking a series of temperature measurements at specific times. This mark was awarded if the candidate described this in terms of heating the water rather than cooling the water.

The fifth mark was 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. For any heating or cooling experiment, a standard method involves taking many readings to reduce the effect of random error. In many cases, candidates stated only 5 sets of readings which is insufficient for this type of experiment. Repeating and calculating a mean is not appropriate for this type of experiment.

The final mark was for stating which graph to plot to test the validity of the relationship. Again, some candidates missed this mark by stating that the graph will be a straight line, or the gradient will be $-b$, instead of using the idea of checking the line is straight. The majority of candidates attempted this, and in a large number of cases, this was all that was written.

Question 3

This question involved plotting and analysing the graph for the relationship between the force between two bar magnets and their separation. 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 describe a method to measure a single value of the separation using a 30cm ruler. Some candidates recited the "repeat and calculate a mean" despite the question asking for a single value. Some candidates made a good attempt at describing how to obtain a value for the separation. There were also some good attempts at describing techniques, most commonly being perpendicular to the scale. Only some candidates realised they could place the ruler close to the magnets. Some candidates described placing the ruler next to the magnets, but this was only credited if the ruler was drawn on the diagram.

In part (b) candidates had to explain how a graph of log F against log x can be used to determine the value of the constant p. 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 p. 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 missed out the operators which is not credited. Some candidates referred to "m" rather than state "the gradient is".

Part (c)(i) assessed the candidates' ability to process data and plot the graph of log F against log x. The two marks was for processing the data correctly and was awarded most often. Some candidates converted the values of F from mN to N or the values of x from mm to m. This is unnecessary as converting the units often 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 three decimal places although two is accepted. The most common errors here were truncating rather than rounding and using an inconsistent number of decimal places in processed data. Occasionally, values were rounded twice making the final value incorrect.

The third 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 log *x* against log *F*. 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. Some candidates choose to plot the graph in landscape, but this is usually unnecessary. 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. log (*F* / mN). Those that used logarithms given in a different base often did not score this mark as "log" is conventionally to base 10 and "ln" is the natural log.

The fourth 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. Scales based on 3, 4 (including 0.25) or 7 are awkward and not accepted. 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 and will not score many marks. 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 fifth 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 less common in this series 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. Usually this will not produce a best fit line. Equally, candidates should be encouraged to check whether a line can be rotated, i.e. where the data points at the top are on one side of the line and the data points at the bottom are on the opposite side. 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 one-piece, 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 a result of candidates calculating dx/dy. 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.

Finally in part (b)(iii) candidates were asked to explain whether the **graph** supported the suggestion that the relationship between F and x was in the form of an inverse square law. This type of question has appeared before and it seems candidates do not focus on evaluating the **graph** but instead look back at the table of data. Those that calculated a constant from the data could only score the first marking point for identifying the form of an inverse square law.

Question 4

This question involved measuring dimensions of circular lens. This involved the the techniques when using a micrometer screw gauge or vernier calipers 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 vernier calipers to measure the diameter. 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, for example “at different orientations”. It is expected that candidates state that a zero-error must be corrected for and not just checked. This was awarded where a candidate described how to do this. 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” is not accepted.

Part (a)(ii) involved explaining an appropriate instrument to use to determine a single value of thickness. It is expected that a percentage uncertainty using the **half resolution** should be calculated. The final mark was awarded where the candidate stated the instrument with the corresponding resolution and commented on the percentage uncertainty. Candidates could compare the percentage uncertainty to another instrument, and were awarded this mark if the comment was correct for the percentage uncertainty using the full resolution. The most common error was omitting a comment, although language that was too ambiguous could lead to not scoring the mark.

In part (b) candidates were given the distances between the lens and a wire mesh and a screen, along with a formula to determine the focal length of the lens. They were asked to **show that** the uncertainty in the focal length was about 0.2 cm. 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. As is usual with uncertainties questions, candidates chose to use one of two methods, either combining percentage uncertainty or calculating the half range of the maximum and minimum values. In general, if the question asks for an uncertainty, then the maximum/minimum method is more straightforward. However, as the formula involved a fraction, some used all maximum or all minimum values, instead of a combination of maximum and minimum values. Unfortunately, this also meant that the candidates did not calculate a half range as subtracting their values was close to the final value. Those that chose to combine the percentage uncertainties often could not calculate the percentage uncertainty in $u + v$. The most common error was giving too many or too few significant figures in the final answer.

In part (c) candidates were given a formula to calculate the refractive index of the material used to make the lens along with some data. In part (i) the candidates had to determine the refractive index using the formula and most were successful in this. The most common errors here were not converting all values of length into a common unit or using too many significant figures. Occasionally, candidates added a unit, such as cm. In part (ii) they were asked to determine the percentage uncertainty in the refractive index. Again, candidates used one of the two methods of solving this. In general, if the question asks for a percentage uncertainty then combining the percentage uncertainties is more successful. The most common error for this approach was using too many significant figures as usually two are accepted for a percentage uncertainty. Those that chose to the maximum and minimum method also scored well in provided they hadn’t made the same error in part (b). The half range was expected for this calculation.

In part (iii) candidates were given the value for the refractive index of crown glass. Candidates then had to deduce whether the lens could be made from crown glass. Candidates **must show their working** as marks are awarded for the method. The recommended method is to calculate the limits using their percentage uncertainty. The percentage difference method can lead to errors, such as placing the “measured” value in the denominator rather than the “true” value. The final mark was for a correct conclusion based on their calculation, and the main error was not making an explicit comparison.

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.

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