Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

January 2022

Pearson Edexcel International Advanced Level
In Physics (WPH16) Paper 1
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 students 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 students will carry out a range of Core Practical experiments. The skills and techniques learned will be examined in this paper but not the Core Practical experiments themselves. Students 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. Students 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 students to form conclusions. These are given in Appendix 9 of the specification, and centres should make sure that students understand what the command words mean.

The paper for January 2022 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 expansion of a sample of air at different temperatures. This experiment is a suitable method for studying gas laws, and the techniques for heating and temperature measurement are used in Core Practical 12: Calibrating a thermistor.

In part **(a)** students were asked to suggest a reason why the end of the capillary tube was left open. Students should have realised that in an experiment where the temperature and volume of a gas vary, the pressure should remain constant. As a control variable was not specifically asked for, sensible suggestions based on expansion were credited.

Part **(b)** involved identifying and explaining a hazard present in the method. Many students appeared to focus on either the boiling water or the sulfuric acid instead of the method used. As this is an explain question, students should be prepared to give reasons to support their statement. In this context, they should be thinking about what may happen if the temperature suddenly increased and why.

In part **(c)(i)** students were presented with a method and asked to state two techniques that should be used when measuring temperature accurately. As is often the case with this type of question, students mostly focused on avoiding parallax and repeating the measurement. In a heating experiment such as this, the most significant source of error is the thermometer being at a different temperature to the sample of air, therefore students should be thinking about ways to reduce this effect. In addition, some students gave answers relating to insulation, which is a modification rather than a technique.

Finally, in part **(c)(ii)** students were asked whether the recorded measurements would lead to an accurate value of absolute zero. Although many students were able to criticise the data adequately, few related this to the graph. In some cases, students tried to answer this mathematically by analysing the data itself, e.g. by trying to find a constant of proportionality. This suggests that students did not read the question carefully enough and relied on learning from past papers.

Question 2

This question assessed planning skills within the context of investigating the acceleration of a magnet falling inside a copper tube. This experiment uses the techniques found in the AS Core Practical 1: Determine the acceleration of a freely falling object applied to a Lenz's law demonstration, which is an A2 context.

Part **(a)** was the familiar planning question using another new command word, Devise. Students should be aiming to write a method for the investigation described in the question that could be followed by a competent physicist. Although marks were not awarded for linking ideas, students often suffered as their use of language was imprecise or their descriptions became muddled making their intentions unclear. The best answers were well 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 four marks were dedicated to how to collect the relevant measurements, identifying appropriate instruments and measurement techniques. Some students focused on the time measurement and omitted the length measurement. Although the use of a stopwatch was the most common method for timing, there were answers related to light gates. For this, students had to be very clear where the light gates were placed. In addition, some did not specify that the light gates would be used to measure time. Some students described using a light gate to measure velocity directly. Again, they had to be clear how this would be achieved, that the length of the magnet would need to be measured. The most common reason for not gaining the "repeating and calculating a mean" mark was that students did not make it clear enough that this related to the times for an individual tube. Only the more able students thought about ensuring the copper tube was vertical or how to release the magnet.

The final two marks are for understanding how to use a graphical method. Although some students stated that different lengths of tube should be used, they did not specify how many values. It is expected that a minimum of 5 sets of readings should be taken for a graph. The final mark is for stating which graph to plot and describe how to use the graph to check the prediction. As this is based on an AS experiment the students were expected to find the relevant formula themselves. A surprising number tried to use velocity-time graphs which would not be feasible using a simple timing method. In addition, they were often let down by the concept of **checking** that it is a straight line or has a constant gradient. It appeared that many assumed that the prediction was valid therefore the graph "will be" a straight line rather than "should be" a straight line.

In part **(b)** students had to explain a possible source of error in the experiment. Several possible answers were expected here, but the majority focused on reaction time. As this was an explain question, the idea of reaction time should have been related to the context of the experiment. Only the most able students considered the effect of the source of error on the measurements. Centres should encourage students to think about the experiment they have planned and then identify possible sources of error and what effect they would have on the experiment.

Question 3

This question involved measuring the half-life of a radioactive isotope and uses the techniques covered in Core Practical 15: Investigate the absorption of gamma radiation by lead.

Part **(a)** asked the students to state two precautions that should be taken when using a radioactive source. This is a standard safety procedure which students should learn. There were still several students quoting the use of personal protective equipment, which is not accepted. In addition, many students gave more than two answers. Unfortunately, marks cannot be awarded where the examiner must choose between a right and wrong answer, therefore students should be encouraged to check the number of answers matches that given in the question.

In part **(b)** students had to explain why a background count rate should be measured. Again, this is a standard technique and, as this is an explain question, students should give a reason. The reason should be based on the idea that this is a systematic error as it adds a constant or predicable amount to the count rate. Often, students stated that background adds the count rate but were not explicit enough to gain the mark.

In part **(c)** students had to explain how a value for the decay constant can be determined from the graph. This is a standard question used in most series, although the emphasis may vary slightly. For this question students had to identify that the decay constant is determined from the negative gradient. Often, where this mark was not scored it was because the student omitted the negative sign. The second mark was for the reason, which is where students should compare the log expansion to the straight-line formula. The most common mistake here was order of the expansion not matching the order of the formula.

Part **(d)(i)** assessed the students' ability to process data and plot the correct graph. This type of question that appears in every paper with a common mark scheme, therefore there is plenty of opportunity to practise this skill and consult Examiner's Reports to correct common errors. A good student should be able to access most of the marks and most students should score some marks.

The first mark is for processing the data correctly and was awarded most often. The number of significant figures given should be sufficient to plot a graph on standard graph paper. For logarithms students should give a minimum of two decimal places although three is accepted. Some students converted their count rates to hours^{-1}, which was unnecessary and sometimes lead to students giving answers to one decimal place.

The second mark is for placing the axes the correct way around and labelling with the correct quantity. 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 (C / s^{1}). Occasionally, the time axis was labelled t (hours) which is inconsistent with the log format.

The third mark is for choosing an appropriate scale. At this level, the students 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**. Students 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, and a landscape graph can be used if it produces a more appropriate fit. Students at this level should also realise that scales do not have to start from zero and scales based on 3, 4 (including 0.25) or 7 are not accepted. Students should also be encouraged to label every major axis line, i.e., every 10 squares, with appropriate numbers.

The fourth mark is for accurate plotting. Although there was improvement with this skill compared to other series, students that were not awarded this mark either used large blobs extending over half a square or used an awkward scale. Students should be encouraged to use neat crosses ($\times$ or +) rather than dots when plotting points. Mis-plots were rarely seen but students should check a plot if it lies far from the best fit line.

The final mark is for the best-fit line. Only the best candidates appreciated that the measurements were for **two** isotopes decaying, one of which had a short half-life therefore the line should be straight after at least five half-lives. Some students that drew a straight best-fit line appeared to include the value at 2 hours so unfortunately did not gain credit. Most students drew a curved best-fit line for the whole graph. For log plots, students should be encouraged to look at the plotted data to find a region where a straight best-fit line can be drawn.

In part **(d)(ii)** students were asked to determine a value for the decay constant. As this question is in the same part as the graph, the graph should be used, i.e., by calculating a gradient. Using the formula for a straight line is also an acceptable method. There were several errors seen in this part. Some students confused isotope X with isotope Y and used the value of 30 minutes. Another error was students using the first and last points, therefore trying to calculate the gradient of a curve, or calculated the gradient between the first two points. Some students found a gradient then did further processing, often using the 30-minute value. Some students calculated gradients from tangents, which was given some credit. It was pleasing to see that the vast majority used a large triangle, and those that extrapolated the graph did this well. However, too many students are relying on using the data from the table which is only acceptable if the data points lie **exactly** on the best fit line. Students 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 marking these on the graph, as in the example above. Those that used awkward scales were often only successful when sensible values were used.

Finally, in part **(d)(iii)** students had to use their value for the decay constant to determine the half-life. Most students accessed these marks, but some used an incorrect number of significant figures. In addition, there were some unit errors and some conversion errors.

Question 4

This question involved determining a value for *g* from the time taken for a hollow cylinder to roll down a ramp. This is a simple experiment that could be used to help students appreciate the uncertainties involved in timing. In addition, the analysis of uncertainties is common to all past papers therefore students should be encouraged to analyse uncertainties on a regular basis. Students should read Appendix 10 of the specification and include all working as marks are awarded for the method.

Part **(a)** focused on the measurement of the height of the start line above the bench. Part **(i)** involved describing two techniques to measure the height. For this type of question students should concentrate on describing **what they should do** when taking a single measurement. Although many stated that they would check that the metre rule was vertical, the mark was often missed by not stating how. In addition, students simply stated "use a set square" without describing how it would be used. Although many stated that they would reduce parallax error, sometimes this was poorly worded, e.g., by using parallel instead of perpendicular. Students should be encouraged give a reference point when using the words parallel and perpendicular, e.g., "perpendicular **to** the bench".

In part **(a)(ii)** the students had to explain why the uncertainty in the **difference** between the heights was recorded as 1 mm. The most common error was a simple statement such as "the resolution is 1 mm", indicating that the students had not realised that there were two measurements involved. The first mark was for stating what the uncertainty in a single measurement is in this context. Many simply stated that the uncertainty would be 0.5 mm without relating it to the resolution of the metre rule. In addition, many students used the word "precision" to mean resolution, which is not acceptable in this specification. Precision has a different meaning which is given in Appendix 10. The second mark was for explaining how to calculate the uncertainty when two variables are subtracted. In this series, it was expected that a clear calculation should be given.

Part **(b)** focused on the measurement of time. In part (b)(i) the students had to calculate the mean diameter with its uncertainty. This is a relatively simple calculation, and most students performed this well, however there were a number that missed out the value of 2.10 s. This suggests that students do not appreciate the uncertainty involved in timing the movement of an object. Common errors included using too many decimal places in the mean value, not showing how they arrived at the value of the uncertainty, and missing units. Occasionally, students calculated a percentage uncertainty, which was not asked for in the question.

In part **(b)(ii)** students were asked to explain how reducing the height of the start line might improve the measurements of time. In general, students did well and focused mainly on reducing the percentage uncertainty. Occasionally students stated that the uncertainty in time would be reduced, without referring to percentage. Some students gave explanations as to why the time would increase, which was not necessary in this question.

In part **(c)** students had to compare the accuracy and precision of the data collected by two different students using the same apparatus. This is a new style of question using the definitions of accuracy and precision as set out in Appendix 10. The most common error here was confusing the definitions accuracy and precision. Students that set out their answer to compare each definition separately often did better. Most students compared the ranges for each data set, and some related this to the precision. As the mean values were the same, percentage uncertainties were also accepted. Accuracy was more of an issue. Only the most able students realised that this was related to their mean values. Whilst they could state that the level of accuracy would be the same it was rare to see a statement stating how accurate the means were as the means could not be compared to a true value.

In part **(d)** the student had determine a value for *g* and discuss the accuracy of the value. Most students performed the calculation correctly in part **(d)(i)**, although rounding and unit errors were seen. Occasionally students did not use SI units, which then made the rest of the question more difficult. It was pleasing to see most students combine the uncertainties correctly in part **(d)(ii)**. The main errors here were not using the powers correctly, including the value of 4 or using absolute rather than percentage uncertainties. Students should show their working here as their final value may differ slightly owing to different levels of rounding. Students are also encouraged not to use answers left in a calculator but give the answer to the calculation as written. Occasionally, students chose to use a maximum or minimum method. Although this is acceptable this is more prone to calculation errors.

Finally, in part **(d)(ii)** students had to comment on the accuracy of their value. Again, most students either calculate limits or used the percentage difference method. Calculating limits usually results in fewer errors. Some students who made errors calculating the percentage difference usually gave the measured value in the denominator rather than the quoted value. In addition, a mean value should not be used. As in previous series, the main error with the conclusion was not explicitly making a comparison between values.

Summary

Students will be more successful if they routinely carry out and plan practical activities for themselves using a wide variety of techniques. These can be simple experiments that do not require expensive, specialist equipment. They should make measurements on simple objects using Vernier callipers and micrometre 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.
- Be consistent with the use of significant figures. Quantities derived from measurements should not contain more significant figures than the data and percentage uncertainties should be given to at least one fewer significant figure than the derived quantity.
- 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. Grids can be used in landscape if that gives a more sensible scale.
- Plot data using neat crosses ($\times$ or +), and to draw best fit lines. Avoid simply joining the first and last data points without judging the spread of data.
- 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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