Examiners' Report
Principal Examiner Feedback

January 2021

Pearson Edexcel International Advanced Level
In Physics (WPH16) Paper 1
Practical Skills in Physics II

Introduction

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 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, along with Appendix 10 in the specification.

In this specification, it is expected that students will carry out a range of core practical experiments as 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, both of which are defined in Appendix 10. 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.

The paper for January 2021 covered the same skills as in previous series and was therefore comparable overall in terms of demand. In addition, it appeared that whilst a number of students were well prepared for this examination, some were not capable of the basic skills expected of an A level student.

Question 1

This question was set in the context of using a ball on a U-shaped track to investigate oscillations and was therefore related to Core Practical 16.

Part (a) required students to describe the basic techniques used to measure the time period of the oscillations. There appeared to be some misinterpretation of the term "accurate" in this context as some students suggested using a datalogger or video camera rather than describe appropriate techniques. Although these were not given credit directly if the student described suitable techniques for using them, they could score marks. Students most often stated that a repeat measurement should be taken, but sometimes failed to state that a mean should be calculated. Similarly, many mentioned timing multiple oscillations, but did not go further to state dividing by the number of oscillations. A good number also described using a timing marker, but there were a few that were unclear about where the marker should be placed. Those that suggested using a timing marker at the extremes of the oscillation had not considered that the oscillations would be damped. As a departure from the previous specification, allowing the oscillations to settle was accepted as this is an appropriate technique to use. Occasionally, students suggested measuring mass or calculating the period from the simple pendulum formula.

In part (b) students had to describe how to measure the distance between the vertical parts of the track accurately. Again, appropriate techniques were expected here rather than choosing an appropriate instrument. Many students did realise that a metre rule would need to be placed horizontally using an appropriate method, for example by using set squares. There were a number that stated they should avoid parallax error but did not describe how. Some students had clearly missed the idea of a "single measure" as they described taking a repeat measurement. Occasionally students discussed measuring time or counting oscillations.

Part (c) involved using the data to confirm whether the data was consistent with a predicted formula. Whilst a good number did what was expected and used the formula to predict a constant for all three sets of data, the main error was not comparing the calculated constants in their conclusion or not stating a conclusion at all, however the inclusion of a conclusion was seen more frequently than in previous series. In addition, as this was a "show that" question students must show their working and use an appropriate number of significant figures. There were a few students that used alternative methods which were also given credit. Occasionally students tried to use the formula for a simple pendulum, which was not appropriate in this case but could still gain credit.

Question 2

This question assessed planning skills within the context of determining the total capacitance of two capacitors in series. Although this used the techniques directly associated with Core Practical 11 many students seemed unfamiliar with it.

In part (a) students had to draw a circuit diagram that would charge and discharge the capacitors. Many good circuits were seen with some ingenious use of switches. On occasion there were additional components in the circuit, for example a voltmeter, but these were ignored provided the circuit would give valid data. Some common errors included not using standard symbols for capacitors, using capacitors in parallel or just using one capacitor. There were also a small but surprising number of students who did not know the symbol for a d.c. power supply. A number of students also drew a single series circuit therefore the capacitors would not be able to discharge.

Part (b) required students to state a safety precaution. There were some valid suggestions here including references to the polarity of the capacitors and use of a low potential difference. However, there were a good number that made inappropriate or trivial suggestions, such as wearing gloves, water, components getting hot etc.

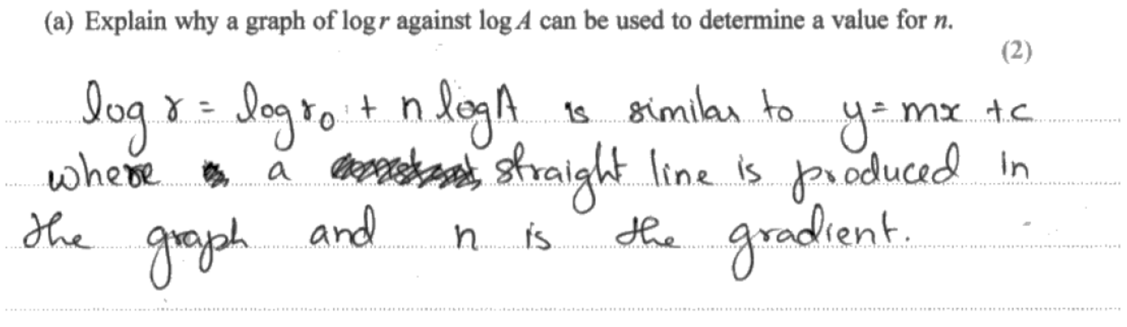
In part (c) students had to describe a method for determining an accurate value for the total capacitance of the capacitors. Although there were some students that knew the associated core practical well, it was clear that many did not. It should be noted that marks were not awarded for linking ideas, but students often suffered as their use of language was imprecise or their descriptions became muddled making their intentions unclear. In addition, those that used bullet points generally wrote a clearer answer. There were several methods that could be used, either using a discharge graph or timing until the current reached either half or 37% of the initial value. For those that identified the logarithmic graph, it was common to see the "–" missing from the gradient. There were also candidates that appeared to mix methods. Some candidates did not make the connection that this was related to the investigation already described in the question and discussed measuring potential difference. These candidates were not disadvantaged by discussing this, but those that wanted to measure charge generally did not score well. There were a number that tried to use $Q = CV$ and calculate $Q = It$ without realising that the current would need to be constant. However, those that discussed constant current charging were given credit as this is a valid method although not on the specification.

Finally, part (d) asked students to suggest why a data logger would improve the investigation. As is usual with questions regarding data loggers students talk in general terms rather than relate it to the context of the experiment. Many students stated a reduction in reaction time; however this is not an acceptable answer as the measurements are anticipated. Students should realise that it is difficult to measure two values simultaneously. Many students also stated that the data logger can take many measurements without referring to a specific time period. Again, it is the sampling rate which is important in experiments where values are changing rapidly.

Question 3

This question involved the analysis of a power formula, in this case the relationship between the radius of the nucleus and nucleon number.

Part (a) required students to explain why plotting a log-log graph can be used to determine a value for the index. This is a familiar style of question which students often recognised but a number made the errors that are seen, and are commented on, in each series. The vast majority of students expanded the formula correctly however it was the explanation where the errors occurred. The most frequent error was that the order of the expanded formula did not match $y = mx + c$, as shown in the example below.


(a) Explain why a graph of $\log r$ against $\log A$ can be used to determine a value for n.

(2)

$\log r = \log r_0 + n \log A$ is similar to $y = mx + c$ where a straight line is produced in the graph and n is the gradient.

Here the student should have written $y = c + mx$ or defined each of the terms used. A second error was not stating that n is the gradient of this graph. Occasionally, students did not relate the expanded formula to $y = mx + c$ at all.

Part (b)(i) assessed the students' ability to process data and plot the correct graph. This is a question that appears in every paper therefore there is plenty of opportunity to practise this skill and to consult the associated mark scheme and Examiner's Reports to correct common errors. However, many students still find this problematic. Fortunately, students had taken notice of the instruction not to convert the radius to metres as this would lead to negative numbers. Indeed, there is usually no need to convert to SI units as the gradient has the same value.

A good student should be able to access most of the marks but only a handful of graphs scoring full marks were seen. Many students processed the data correctly although there were some occasional errors in rounding. The number of significant figures given should be sufficient to plot a graph on standard graph paper. For logarithms, the first figure is not significant, hence students should ideally give a four-figure number, for example 0.182, although if the range is larger three-figures may be sufficient. The most common error here was the inconsistent use of decimal places, often switching from three to two as in the following example.

Isotope	***A***	***r* / fm**	log r	log A
H-2	2	1.54	0.188	0.301
He-4	4	1.92	0.283	0.602
Be-9	9	2.47	0.393	0.954
C-12	12	2.72	0.435	1.08
O-16	16	3.00	0.477	1.20
Mg-24	24	3.42	0.534	1.38

The most common error in the graph was not labelling the *y*-axis in the correct form, i.e. log *r* or log *r* / fm rather than log (*r* / fm). Occasionally, ln values were calculated, which is acceptable, but the labels were still given as log. Some students reversed the graph axes which led to issues with the gradient calculation. 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 should also be encouraged to label every major axis line, i.e. every 10 squares, with appropriate numbers. 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.

Most students plotted the graph using neat crosses (× or +) and the use of these rather than dots should be encouraged. If a dot extends over half a small square, then this is not considered to be accurate plotting, and occasionally larger blobs were seen. Occasionally lines looked disjointed, perhaps a result of using a ruler that was too small or realising that the *y* intercept would be needed and extending the line afterwards. Lines that were too thick also did not gain this mark. It is recommended that students use a 30 cm ruler in this examination. Finally, students should not force a line through the origin or simply join the first and last points without judging the scatter of the points as this often does not result in a good best fit line.

In part (b)(ii) the students had to use their graph to determine a value of *n*. It is expected that the gradient of the graph should be calculated, which the majority did well particularly those that labelled this on the graph. The triangle used should cover at least half of the plotted points and most did so. The main reasons for students not gaining full marks were using too few or too many significant figures, or including a unit which suggests that students do not understand that a logarithm is dimensionless. Occasionally students gave the final answer as a fraction rather than a decimal which is not usually acceptable, did not show a calculation, or made errors in reading from the graph. Those that used scales of 0.25, 0.3 or 0.4 or other awkward scales were often only successful when sensible values were used. Some students used the values from the data in the table, which is acceptable provided the points are on the best fit line.

Finally, the students had to calculate a value for r_0 and state the mathematical relationship. Most students were successful at calculating r_0 but there were errors in reading the *y* intercept, for example giving a value of 0.9 instead of 0.09. Some students then went on to convert this from a natural log rather than a log to base ten. Occasionally students thought the *y* intercept was the value of r_0. Other methods that used the formula with data and the calculated value of *n* were accepted however the data used had to lie on the best fit line to gain full credit.

Question 4

This question focused on the analysis of uncertainties in the familiar context of a density measurement for a cylindrical container.

In comparison to previous specification, this question was worth more marks as it contained more analysis. It should be noted that students must show clear working for this question as marks are awarded for the method, and the methods used follow those set out in Appendix 10 of the specification.

Part (a) allowed the students to demonstrate their understanding of how the percentage uncertainty is affected by different ways of conducting a measurement. In this case, students had to compare a direct measurement of the diameter using a metre rule with measuring the circumference using a piece of string. Although most students understood that this was based on the size of the measurement there were some that were distracted by the nature of the string used or by a potential method used. It should also be noted that the use of the term “precision” now no longer applies to describing the smallest interval of an instrument. This term was often seen and not given any credit.

In part (b)(i) students had to explain two techniques that should be used to determine the thickness of the string accurately. Whilst many students described at least one suitable technique, a good portion of these did not explain why it is used in terms of random or systematic errors. This suggests that student misunderstood the meaning of the command word “explain”. Another common error here was not stating that the measurement should be repeated **in different places** or that a mean should be calculated.

The rest of the question focused on the analysis of the measurements. In part (b)(ii) the students had to calculate the mean thickness with its uncertainty. Whilst the vast majority calculated the mean correctly, as it is a simple calculation, too many significant figures caused many to lose the mark. It is expected that the number of significant figures used should match those of the measurement. The uncertainty calculation caused more problems as the calculation of the half range was expected. There were some that did not show this so could not be awarded the mark. In addition, some students stated the percentage uncertainty rather than uncertainty or wasted time in calculating the percentage uncertainty then converting it back again. A significant figure penalty was not applied on the uncertainty however it is good practice to use the same number of decimal places as given in the measurement.

In part (c)(i) the students had to calculate the circumference of the container using the quoted formula. This was a simple calculation which many managed well. Here, an answer given to three significant figures was accepted, but many used four. The number of significant figures should match the lowest used in the measurements. In addition, there were a number of students who failed to convert the thickness from mm to cm. In part (c)(ii) the students were asked to show that the uncertainty in the circumference was 0.2 cm. This involved adding the uncertainties as the measurements were subtracted, but a surprising number did not manage this either as they tried to combine percentage uncertainties, or they again failed to convert from mm to cm. As this was a “show that” there were some who lost the mark for showing too few significant figures. There were some that calculated a maximum or minimum value which were credited if done correctly.

In part (d) students had to calculate the volume of material using the formula. Again, students were able to use the formula correctly but then did not apply the correct number of significant figures, which in this case was three. Calculating the uncertainty caused more issues. The majority of students correctly combined the percentage uncertainties of the circumference and length, but then went on to add the percentage uncertainty in the internal volume which is incorrect as the internal volume was subtracted in the formula.

In part (e) students had to decide, using the densities of common materials given, whether the container would be safe to heat directly using a Bunsen burner. It was here that students who had done poorly in (d) often could achieve marks. It was interesting that students found various ways to answer this part of the question and the more successful methods involved calculating the limits of the measured density using either the percentage uncertainty or the maximum/minimum values. Out of these, using the percentage uncertainty was more reliable as some students using the maximum/minimum method did so incorrectly, i.e. by calculating the maximum value using both the maximum mass and maximum volume. 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. In particular, they should make measurements on simple objects using vernier calipers and micrometers 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.
- Be able to describe different measuring techniques in different contexts and explain the reason for using them in terms of errors.
- 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. Quantities derived from measurements should be quoted to the lowest used 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.
- Use a sharp pencil to plot data using neat crosses (× or +), and to draw best fit lines. Avoid plotting with circles.
- Use a 30 cm ruler to draw a best fit line. Avoid simply joining the first and last data points or forcing the line through the origin.
- 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 new IAL specification.
- Revise the content of WPH13 as this paper builds on the knowledge from AS.