



Pearson
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Examiners' Report
Principal Examiner Feedback

October 2024

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

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October 2024

Publications Code WPH16_01_2410_ER

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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 Unit 6 and 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.

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, 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 2024 covered the same skills as in previous series and was therefore similar in demand.

Question 1

This question was set in the context of investigating the characteristics of a diode at varying temperatures. This investigation shares many features with Core Practical 12: Thermistor.

In part (a) candidates had to **identify one** health and safety issue for the investigation **and** how it should be dealt with. At this level, safety precautions should be **specific** to the investigation being described. In addition, general comments such as students being “hurt” are not accepted. Most candidates focused on the risks associated with heating. The most common errors were referring to gloves or safety gloves, rather than insulated or heat-resistant gloves, or using tongs to move the hotplate or thermometer. Students also needed to refer to the hotplate or water being hot. Some candidates discussed electrical safety but sometimes these were just general comments. A number referred to using a low p.d. which was not accepted as the circuit contained a diode which generally operates at a few volts. A few candidates tried describing the potential instability of the beaker but did not comment on what would cause this.

In part (b) candidates had to **explain** why a variable resistor was included in the circuit. This question was not answered well. Most candidates assumed this was included to limit the current despite a fixed resistor being included in the circuit, or to control the current which was being investigated. Very few candidates realised that the aim of the variable resistor in this circuit was to keep the p.d. across the diode constant. Those that did rarely explained why the p.d. may vary adequately enough.

Part (c) involved evaluating the data recorded by the student. In part (i) candidates had to **explain** whether the unit for current given in the table was correct for the

data shown. Many students correctly calculated either a current, p.d. or resistance, but the comparison was often not clear enough, with most simply stating that the units for current should be in mA without any reference to the values in the table. A significant number of candidates calculated the ratio of the values in the table rather than addressing the question asked, presumably as they are used to using such a technique to determine whether there is a proportional relationship between data.

Finally, in part (ii) candidates had to **give two** reasons why the data could not be used to **test the prediction**. Many discussed inconsistent decimal places, lack of repeats or inconsistent intervals which did not address the question. Most candidates did refer to not enough readings being present to draw a graph, but occasionally answers appeared to be confused with repeating to calculate a mean. Few candidates referred to the range of data, and those that did often did not refer to temperature.

Question 2

This question assessed planning skills within the context of investigating the free oscillations of a mass-spring system. Parts of this question contained the techniques found in Core Practical 16: Oscillations.

Part (a) involved determining the time period of the oscillations. In part (i) candidates had to **determine** a mean value of the time period from the set of data. Note that candidates are not expected to identify and remove “anomalous” data. The most common error was giving the answer for $5T$ rather than T however unit errors were rare. At A2 level, candidates are expected to give the correct value of the mean to the **same number of decimal places as the data**. Some candidates gave too many decimal places.

Part (a)(ii) involved calculating the percentage uncertainty in the mean value. The candidates **must show** the calculation for the first mark, and this is awarded for calculating the **correct half range or furthest from the mean**. Occasionally, candidates used what appeared to be a resolution, which is not accepted. The final mark was for the correct percentage uncertainty given to one or two significant figures. Often candidates gave three or more significant figures.

Part (a)(iii) was familiar question in which candidates had to **describe three other techniques** to determine the time period of the oscillation. In general, candidates did not score as well on this question as in previous series as many reiterated the question, i.e. timing multiple oscillations and repeating to calculate a mean. Some candidates included additional apparatus, such as using a video camera, which was not accepted as the question referred to **techniques not modifications**. Many candidates chose to use a timing marker. Candidates should get into the habit of stating **where** it should be placed, i.e. at the centre of the oscillation. Some candidates stated the **reason** for using one, for example to mark the start and end of the oscillation, which was not required for a **describe** question. Many candidates described starting the stopwatch after several oscillations, but it was rare to see any reference to the initial displacement being small or checking that the oscillations were vertical, although occasionally candidates referred to keeping the initial displacement constant which was not accepted.

Part (b) was the familiar planning question based on the damped oscillation of the spring. Candidates should be aiming to **devise** a method for the investigation described in the question that could be followed by a competent physicist. Many candidates answered this question well as the mark scheme for this type of the question follows a similar structure in each series. Although marks were not awarded for linking ideas, candidates using vague language or not describing a method logically can lead to marks not being awarded. The best answers were structured and concise, leading to a method that could be followed easily. In

addition, candidates should devise a method which **relates to the formula given in the question**. Those candidates that started by analysing the formula often scored well.

The first two marks were for describing how to **measure the amplitude** of the oscillation. Many candidates referred to the placement or reading of a metre rule without **explicitly** stating that the metre rule was being used to measure the amplitude of the oscillation. Candidates at this level are expected to link the variable being measured with the instrument, e.g. measure amplitude with a metre rule, then discuss associated techniques. It was clear that some candidates had not read the question sufficiently as they but focused on the length or extension of the spring. A few candidates referred to motion sensors, but these were rarely described adequately enough to score many marks. As is usual with techniques associated with a metre rule, there were some candidates that mixed up perpendicular with parallel, used perpendicular without reference to an object, or used "straight" to mean "vertical".

The third mark was for **linking the two variables given in the formula**. Many candidates misunderstood the question as they tried to measure amplitude as a function of time. This was surprising as time did not appear in the formula. Those that started with the formula tended to be clearer with this. Candidates should routinely identify the dependent and independent variables in a formula and link them together in a sentence, for example, measure the dependent variable (amplitude) at different values of the independent variable (number of oscillations).

The final three marks were for obtaining **sufficient and valid data to determine the time taken for the amplitude to halve**. For the fourth mark, some candidates were too vague in their descriptions as it was unclear whether they

were repeating the measurement five times to calculate a mean or measuring at five **different** values to plot a graph. Another common error included stating “many values” instead of stating how many. Candidates most often scored the mark for stating the graph to plot, however some candidates did not use the natural log, for example $\log A$ against n . The final mark was for how to analyse the graph to obtain the time for the amplitude to halve. Some candidates appeared to have the right idea, but did not express it sufficiently to be awarded the mark. The more successful candidates realised that they simply had to read of the graph the value of n when the amplitude had halved, but some candidates did not link this directly to the graph or they used half the log value rather than log of half the amplitude. Some candidates expressed this in terms of half-life, which is a different experiment. Some candidates tried to use the formula, but often did not link the value of λ to the gradient. Occasionally, candidates described how to obtain the value of n but then did not multiply by the time period T . Some candidates tried to measure the time taken to reach n , but this was not accepted as n may not be a whole number.

Question 3

This question involved plotting and analysing the graph of the luminosity and mass data for main sequence stars. A question involving a graph appears in each series therefore there are plenty of opportunities to practise this skill and consult Examiner’s Reports to correct common errors.

In part (a) candidates had to **explain** how a graph of $\log L$ against $\log \frac{M}{M_{\odot}}$ could be used to determine the value of r given the relationship $L = L_{\odot} \left(\frac{M}{M_{\odot}} \right)^r$. This type of question should be very familiar however there may a slightly different emphasis that candidates should be aware of. 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 such as this or an exponential function. However, some candidates did not complete this successfully. For the second mark candidates must compare their log expansion with $y = mx + c$, which is standard for this type of question. The comparison must be **explicit**, i.e. the order of the log expansion **must match** the order of terms of the equation of a straight line. It should be noted that where two forms of the expansion are given, it is usually the final one that is used as the comparison. In some cases, candidates used arrows and missed out the + and = which was not credited. Candidates then had to identify the gradient correctly as r . Some referred to “ m ” or relied on a loop or arrow rather than state “the gradient is”. As this is an “explain” question, this must be explicit.

Part (b)(i) assessed the candidates’ ability to process data and plot the graph of $\log L$ against $\log \frac{M}{M_0}$, and there was a marked improvement in graph drawing this series. The mark scheme follows the same format for each series. The first two marks were for **processing the data correctly**. It is expected that candidates use base 10 logarithms, however as the logarithms for both variables are required other bases were accepted. On rare occasions, candidates gave one set of values to base 10 and used natural logs for the other set of values. To gain these marks, the values must be **correct** and given to a **consistent number of decimal places** sufficient to plot a graph accurately on standard graph paper. For logarithms candidates should give **three decimal places** although two can be accepted if it is valid for the graph. The most common errors here were truncating rather than rounding, using an inconsistent number of decimal places in processed data, or using too many or too few decimal places. Candidates were instructed not to convert the values to W . Although the values were accepted, candidates often used only one decimal place which was insufficient.

The third mark was for **placing the axes the correct way around and labelling with the correct quantity and unit**. Some candidates reversed the axes, i.e.,

they plotted $\log \frac{M}{M_{\odot}}$ against $\log L$. 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 error 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. $\log (L / 10^{35} \text{ W})$. Some candidates converted their L values but then incorrectly labelled the axis by including the factor of 10^{35} . A few candidates applied a factor of 10^{35} or another power of 10 to $\frac{M}{M_{\odot}}$. Some candidates placed their axes on the left of the grid instead of at $\log \frac{M}{M_{\odot}}$ equal to zero which was accepted but often lead to mistakes later in the question.

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 note that, although the graph paper given in the question paper is a standard size, the graph does not have to fill the grid and using the grid in landscape is unnecessary. Candidates at this level should also realise that **scales based on 3, 4 (including 0.25) or 7 are awkward and not accepted**. Candidates should also label every major axis line, i.e. every 10 small squares, with appropriate numbers, so that examiners can easily see the scale used. A minority of candidates tried to use the values of logarithms as their scales.

The fifth mark is for **accurate plotting**. Candidates should use **neat crosses** (\times or $+$) rather than dots when plotting points. Candidates were not awarded this mark if they used large dots that extended over a small square or used an awkward scale. The values of 4.49 for $\log L$ and -0.03 for $\log \frac{M}{M_{\odot}}$ were most commonly mis-plotted, however candidates should check a plot if it lies far from the best fit line.

The final mark is for drawing a **reasonable best-fit line** and was awarded most often. When drawing a best-fit line, candidates will often join the first and last points instead of judging the scatter of the data points. Candidates should ensure there are plots on both sides of the line and that the line cannot be rotated. Other errors include the line being too thick, i.e. over half a small square, discontinuous, or containing a clear bend. Candidates should use a single piece, 30 cm ruler for this examination.

In part (b)(ii) candidates were asked to **determine** the value of r from the gradient of the graph. There were several common errors seen. The first mark is for using a **large triangle which covers at least half of the plotted points** to calculate the gradient. Unusually, some candidates inverted their 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 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 **mark these as a triangle on the graph**. Those that drew the triangle on the graph tended to make fewer mistakes and those that used awkward scales were often only successful when sensible values were used. Some candidates included a factor of 10^{35} which led to an incorrect value for r . The final mark could be awarded from an incorrect gradient, but often candidates used too many or too few significant figures.

In part (b)(iii) candidates had to determine a value for the constant L_{\odot} . Most scored at least one mark. Many read the value of $\log L_{\odot}$ correctly from the graph, or correctly calculated the value using the calculated gradient and a set of data points lying on the best-fit line. It was here that those candidates who placed their y axis on the left of the page made a mistake in determining the y intercept as they extrapolated the line to the axis drawn. In addition, some stated that this was the value of L_{\odot} . Many scored the second mark by converting the log value, but some candidates used the incorrect antilog function. Some candidates used the original

formula, which was accepted provided the values used were taken from a point lying on the best-fit line. The final mark was for the correct value given to two or three significant figures with the unit. The most common errors were not including the factor of 10^{35} . or a unit.

Part (b)(iv) involved determining the luminosity of a star with a mass of $33M_{\odot}$. This was a relatively straightforward calculation using the values of r and L_{\odot} calculated previously. However, some candidates included an additional factor of 10^{35} when their value of L_{\odot} did not include one. Other errors included using the factor of 33 in the denominator, too many or too few significant figures and omitting units.

Question 4

This question involved making measurements on a wooden metre rule. The analysis of uncertainties is common to all past papers therefore candidates should 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.

In part (a) candidates had to **explain** a technique to determine the width of the metre rule using **digital calipers**. The first mark was for **stating** the technique and the second was for **explaining** the technique **in terms of errors**. A few candidates described another method, e.g. stacking several together, which is not a technique for using digital calipers. As this is A2 level, more detail is required for this question compared to AS level, such as checking **and** correcting for zero error. Candidates also need to think about the object being measured. Many candidates used the word "orientations" which should only be used for a diameter of an object with a uniform cross-sectional area, such as a wire or sphere and so was not

accepted. Although phonetic spellings are accepted, candidates must be careful not to use a different word, such as “systemic” or “system” for “systematic”.

Part (b) involved an investigation to determine the Young modulus of the wood by measuring the oscillations of a mass attached to the end of the metre rule. Candidates were given the formula for the Young modulus in terms of the time period and the properties of the metre rule.

In part (b)(i) candidates had to **explain** how increasing the length of the oscillating rule would affect the percentage uncertainty in the time period. The most common error was to only discuss D and never mention time. Many candidates fell into this trap and gave effectively perfect answers but not about time. Some candidates decided that increasing D would decrease T and proceeded along that line of logic, usually getting zero marks. Some candidates did not mention D or T so could not score many marks. The second mark was omitted most as candidates did not discuss the uncertainty in the measurement of time.

In part (b)(ii) they were asked to **show that** the Young modulus was about 14 GPa. For a **show that** question, all working must be shown, and candidates should give their final answer to at least one more significant figure than the value. It should be noted that a sensible number of significant figures is expected in a practical paper, so the mark may not be awarded if there are too many. Candidates often substituted the values correctly, but the most common error was incorrect powers of 10. Either these were completely missing or candidates attempted to convert the length to mm to match the other two measurements. Some candidates did not convert the mass to kg or tried to convert values after the calculation. Some candidates appeared not to know what the power of ten equivalent of Giga is. Candidates should check the units for the final value and convert measurements

before performing the calculation. A few candidates rounded measurements before the calculation, which was not credited.

In part (b)(iii) they were asked to **show that** the percentage uncertainty in the value of the Young modulus was about 5%. Candidates used two methods of solving this, either by combining percentage uncertainties or by using the maximum and minimum method. Those that used the maximum and minimum method were often less successful as they used maximum/maximum and minimum/minimum. Other errors included not calculating the half range or rounding values too early. Those that combined percentage uncertainties often scored well. Occasionally, candidates added the absolute uncertainties which was not credited as the method is invalid.

Finally, in part (b)(iv) candidates were given the Young modulus of beech wood and had to **deduce whether** the metre rule could be made from beech wood. This is a standard type of question used in every series and was performed well by most candidates, but there were a few that did not attempt this or just made a vague statement with no calculation. It is expected that candidates **use the percentage uncertainty to calculate limits**, but the most common error here was calculating the limits of the Young modulus of beech wood rather than the calculated Young modulus. The final mark was for a correct conclusion with a comparison. As in previous series, the main error with the conclusion was not explicitly making a comparison between relevant values.

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 candidate performance on this paper.

- Be able to describe how to measure lengths, angles, force, mass, time, potential difference, current, pressure and temperature using the most appropriate apparatus and techniques.
- Refer to random or systematic errors when explaining techniques.
- Practice the process of planning an experiment to obtain sufficient and valid data using the formula given.
- Show working in all calculations and include a unit. Check the number of decimal places or significant figures needed for different calculations.
- Choose graph scales that are sensible, i.e. the value of a small square is 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, e.g. 0.25, 3, 4 or 7.
- Plot data using neat crosses (\times or $+$) and check any points that lie far from the best-fit line. Circle any points that are not being used to judge the best-fit line.
- Use a one piece, 30 cm ruler to draw a straight best fit line. Ensure there are data points on both sides of the line, and the line cannot be rotated.
- Draw a large triangle that covers at least half of the plotted data 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.

