Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

October 2023

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH13)
Paper 01: Practical Skills in Physics I

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Introduction

The Pearson Edexcel International AS-level paper WPH13, Practical Skills in Physics I is worth 50 marks and consists of four questions, which enable students of all abilities to apply their knowledge and skills to a variety of styles of question.

Each question assesses the student's knowledge and understanding of the skills developed while completing practical investigations.

A student's understanding of the 8 core practical tasks will be assessed by the WPH11 and WPH12 papers. As such, the practical contexts met in the WPH13 paper may be less familiar but are similar to practical investigations students may complete during their AS Physics studies. The scenarios outlined will be related to content taught during the study of WPH11 and WPH12.

However, the focus of WPH13 is the assessment of the practical skills the students have developed, during the completion of the required core practical tasks and other experiments, as applied to the physics context described in the question.

There will be questions that are familiar to students who have revised using the earlier series of WPH03 and WPH13 papers, but some performances would suggest some students were unfamiliar with the practical skills outlined in the specification for Unit 3. A particular issue commonly seen related to the uncertainty in measured data and the calculation of percentage uncertainty.

At all ability levels, there were some questions which students answered with generic and pre-learned responses, rather than being specific to the particular scenario as described in the question. Additionally, understanding the meaning of the standard command words (such as evaluate and determine) proved a challenge to students at the lower end of the ability range.

Question 1(a)

The measurements provided in the table are recorded to a resolution of 0.1 mm. As such, students were expected to identify a measuring instrument that has a resolution of at least 0.1 mm, such as a vernier caliper, digital caliper or a micrometer screw gauge.

It was common to see a ruler or meter rule suggested, but neither had the required resolution.

It was also common to see a list of suggestions. In such cases, we did not ignore incorrect suggestions that would not have the required resolution.

Question 1(b)

It was common for students to explain “how” they knew the uncertainty in mean with was larger (wider range in width values), rather than suggest “why” it was larger.

As such, we were looking for a reason for, or a cause of, the larger uncertainty. This could be the identification of a particular anomalous measurement, or the cause of the larger variation, eg a damaged cube.

Question 1(c)

The method students are expected to follow when calculating the percentage uncertainty in the mean value of a set of repeated measurements is described in appendix 10 of the specification.

The mean value is given in the table, but it was common to see students calculating a new mean which included this 4^{th} value – indicating students had misinterpreted the table and treated the 4^{th} value as the final repeated measurement.

If a student followed the correct procedure, but for the wrong set of data (e.g. width or height), we awarded 1 mark.

Question 1(d)(i)

The instruction to “show that” the density is about 8800 kg m^{-3} required students to clearly show the conversions from g to kg and mm to m. Otherwise, the final answer given did not match the value and units required.

It was common to see a final density value in g mm^{-3} that was then "shown" to be 8800 kg m^{-3} with no further steps to demonstrate the conversion of units. These responses were awarded 2 marks for the use of the volume and density equations.

Question 1(d)(ii)

The question states the 2% uncertainty estimate is in the value of density the student in the question calculated. As such, the application of the 2% uncertainty to the values in the table is not relevant and was not credited.

Since 1(d)(i) gave a "show that" value, we did award the application of 2% uncertainty to either the student's answer in 1(d)(i) or 8800 kg m^{-3}.

The command word "deduce" requires students to draw a conclusion from the information provided, so for full marks a reasoned conclusion was required. A simple statement that the metal was copper without any attempt to use the information was not credited.

Question 2(a)

Core practical 7 requires students to make measurements of resistance and length for a wire, to allow them to determine the resistivity of the wire material. This involves the use of a metre rule to measure the length of the wire and often a multimeter set to be an ohmmeter. Although this model train circuit is a different context, the practical skills required are the same, so many students could describe how to measure the values of x and R.

The metre rule is not mentioned in the question, so there was a mark awarded for naming this device, plus a second mark for describing how to ensure x was measured accurately. As the ohmmeter was named in the question, there was no credit for identifying this as the measurement device. The marks were for describing how to use this accurately. The second mark, understanding that there would be contact resistance, was rarely seen in 2(a), but was often a suggestion for 2(b).

Some students ignored the ohmmeter and described an alternative approach using a voltmeter and ammeter set-up. This was ignored.

Question 2(b)

Students were required to apply their knowledge of the proportional relationship between the resistance and length of a wire, so a resistance against length graph would normally pass through (0,0), whilst recognising the connected length of the moveable copper wire remained at 5 cm as x varied. The length of the connecting leads also remained constant as x varied.

So, students who identified that the resistance measured when $x = 0$ would be the resistance of 5 cm of the moveable rod or the connecting leads received credit.

It was common to see "zero error" stated without any further information. Since zero error in the metre rule was unlikely to be the cause (the graph indicates this would be about 2.5 cm), students needed to link zero error to the ohmmeter.

It was also common to see "the copper rods have resistance". This statement was judged to be too vague, as when $x = 0$ the resistance of the two 30 cm copper rods was not relevant.

Question 2(c)

Students will be aware of the equation $R=\rho l/A$ and to clarify the circuit, students were told that $l = 2x + 0.050$ m and that the diameter of the rods was 3.0 mm. To complete the calculation, students were required to select a pair of R and x values from the graph.

Most students scored 3 marks. The most common error seen was a failure to correctly convert units, eg mΩ to Ω, or mm to m, leading to a value with an incorrect power of 10.

Question 2(d)

This question was a challenge to most students, having a high demand level due to the logical thinking required. Many students were awarded 1 mark, for identifying that as the track wore down the resistance of the track would increase.

The difficulty came when concluding how this would affect the estimated position, with many students making the incorrect assumption that as R decreases, l decreases so the estimated position is closer than the actual position. This assumption comes from the application of $R=\rho l/A$.

However, the system estimates the position based on the measured resistance. So, students needed to refer to the graph which shows that a higher resistance would suggest a larger x, the estimated position would be further than the actual position.

Question 3(a)

In this question, the measuring devices required were identified, so the marks awarded were for describing how the measurements could be made accurately.

Depth *d* was vertical, so a description of how to ensure the metre rule was vertical was expected, but rarely seen. As the tray may not have been level, a measurement of *d* in multiple places and a mean *d* calculated would also be expected. Although many students mentioned repeating the measurement of *d*, most of these were missing the required additional details.

Speed *v* required a time measurement and a calculation of speed. The tray length (40.0 cm) was given, but being a short distance the time measurement would be small. So credit was given for descriptions of time measured over multiple lengths of the tray, or for repeated measurements of time and a calculation of the mean speed or mean time.

For the final marking point, it was common to see $v = s/t$ stated, but without details described (eg the specific distance and time) this was not sufficient for a description of how do determine *v*.

A lack of details in the description lead to many students scoring only 1 or 2 marks out of 4, with some generic answers scoring 0.

Question 3(b)(i)

This style of question has appeared regularly on WPH13 (and WPH03) papers, so most students scored both marks. The most common approach was to compare $v^2 = kd$ with $y = mx$.

However, as this equation describes a line without a *y*-axis intercept, and the graph was not defined, a description of an appropriate graph (e.g. v^2 against *d*) and equivalent use of the gradient to determine *k* was also worth credit.

Question 3(b)(ii)

Criticism of the recording of results is also a common question type for this paper. For this series, only 1 mark was available. Most students were awarded this mark.

Many of those not awarded the mark lacked detail, e.g. students identified that the results were not recorded to the same number of decimal places. However, that would only be relevant for results measured using the same device (eg *d*).

Similarly, identifying results were not recorded to the same number of significant figures would only be relevant for calculated data (eg *k*)

Question 3(b)(iii)

The command word "discuss" asks students to investigate a situation by reasoning or argument. Students were instructed to include calculations in the answer. As such, were expected to perform calculations using the *k* values given in the table and the *g* value given in the data list.

Many students were awarded the first mark, for calculating the mean of the *k* values. But, for most students, their comparison of mean *k* with 9.81 N kg^{-1} lacked vigour, with many simply stating that 9.71 is similar to 9.81.

Question 4(a)(i)

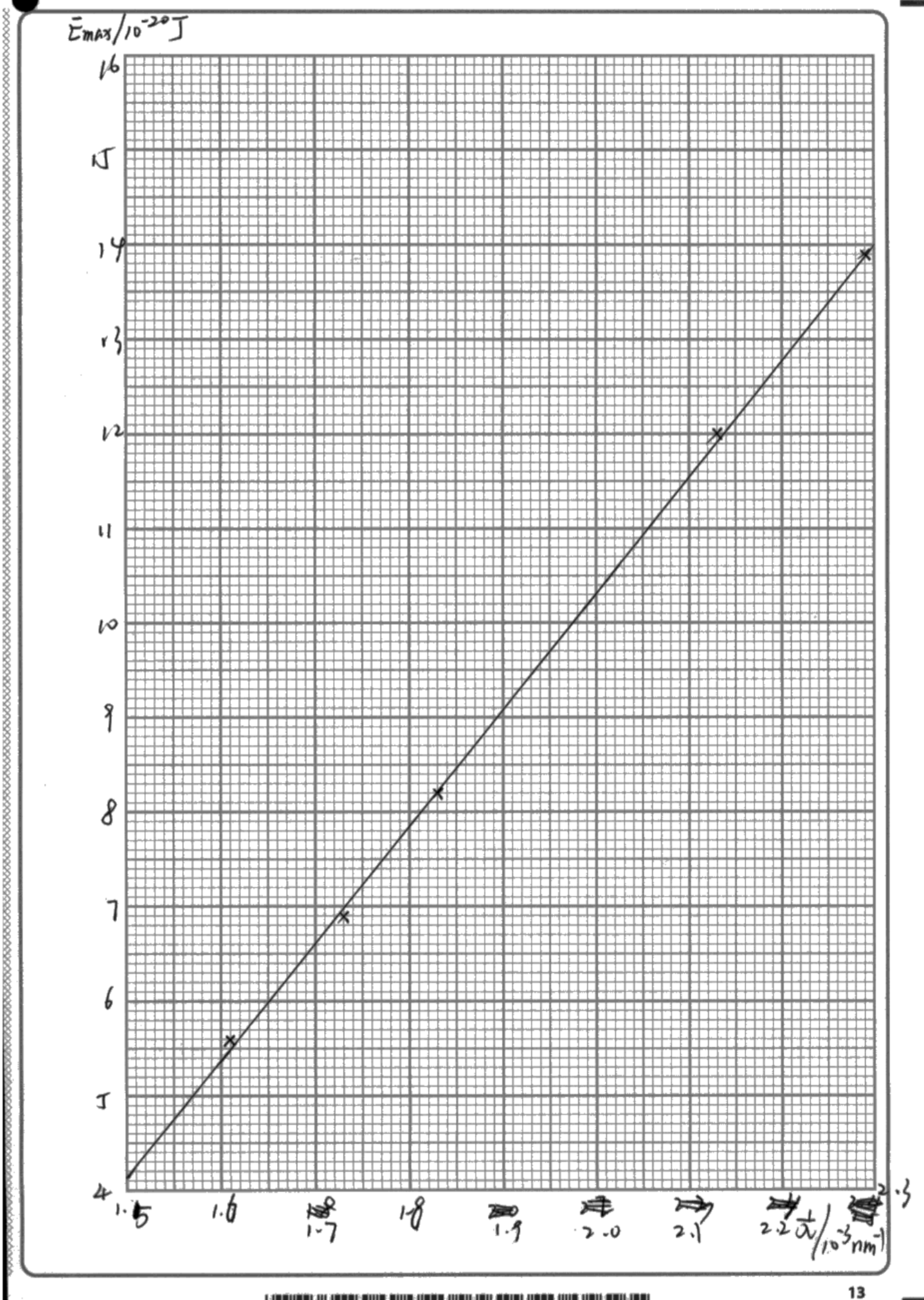
Graphs remain a challenge to students, but this is one area where a little more time spent on practice would have a significant benefit. In addition to the mark for processing data, there are 5 marks available for plotting a graph on WPH13, so a well-drawn graph could increase a student's achievement by a grade.

The standard expectations of a well-drawn graph are:

- Labelled axes – the quantity **and** unit separated by a **/**
  eg E_{max} / 10^{-20} J and 1 / λ / 10^{6} m^{-1}
- Scales chosen that maximise the size of the used portion of the graph, while still being an easily interpreted scale. The graph paper provided is divided into 10 small squares every 2 cm, so we expect a scale with increments **on the 2 cm** lines that go up in **1, 2 or 5** if we ignore powers of 10.
  eg on the *y*-axis increments of 1×10^{-20} J every 2 cm and on the *x*-axis increments of 1×10^{6} m^{-1} every 2 cm
- Data points that are plotted accurately to **within 1 mm** (half a square) in both directions. This means large or unclear plots cannot be checked for accuracy. (eg students should be advised that **large bullet-point style plots** will not be credited.) Small neat plots (eg $\times$) are expected.
  NOTE – a scale that is difficult to interpret may also mean plots **cannot** be checked for accuracy – reducing the mark awarded by 3. (eg scales of 0.25 or 0.3 every 2 cm)
- A well-balanced line of best fit that follows closely the trend of the plots. This includes any incorrect plot students may have assumed was an anomaly, if that plot has not been marked as an anomaly to be disregarded.

The example graph on the next page meets all the expected standards, with the *x*-axis unit left in nm^{-1}, so this student was awarded all 6 marks.

Note - the conversion of the *x*-axis to m^{-1} is not required at this stage, as the conversion to standard units is assessed via the *h* value calculated in 4(a)(iii).


Emax/10^-20 J
16
15
14
13
12
11
10
9
8
7
6
5
4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
1/λ /10^-3 nm^-1

Question 4(a)(ii)

Comparing a given equation to $y = mx + c$ and identifying the gradient or y-axis intercept is a commonly tested skill.

Unlike question 3(b)(i), this equation does not describe a directly proportional relationship. As such, the most appropriate strategy is for students to re-arrange the given equation to $y = mx + c$ format, matching the y-axis and x-axis quantities of the graph with y and x in the equation. Doing so would allow students to demonstrate the link between m and hc.

Since this is a "show that" question, students needed to demonstrate clearly the steps that lead up to the relationship shown. Many students did not separate hc from $1/\lambda$, so did not demonstrate this link clearly enough.

It is not enough to simply re-arrange the given link to state hc = gradient unless the students have demonstrated why hc is equal to the gradient, so the second mark can only be awarded if the first mark has been awarded. So, many students scored 0.

Question 4(a)(iii)

In question 4(a)(ii) students were told that h is equal to the gradient of the graph divided by the speed of light in a vacuum. Most students correctly used their graph to determine a gradient and calculated a value of h. However, many of these students gave a final value with the incorrect powers of 10, having forgotten to convert nm^{-1} to m^{-1} on the x-axis. So, many students were awarded 3 out of 4 marks.

Most students scored 2 marks, with many of those incorrectly calculating the gradient (either using data from the table that did not match the line of best fit drawn or using a data range that covered less than half the range of the line of best fit).

Question 4(a)(iv)

When calculating the percentage difference between a calculated value and the accepted value (as on the list of data), the accepted value should be used as the denominator. The use of the incorrect denominator was the main reason most students scored 0 marks.

Where students did use the correct denominator, mathematical errors often lead to incorrect answers (even when “error carried forward” was applied to incorrect values of *h* from 4(a)(iii)

Question 4(b)

Being the final question, many responses were blank or limited. However, it was also clear many students did not understand the difference between sources of random error and systematic error.

The most common source of random error seen was background light, but since the intensity of background light would not affect the E_{max} of the photoelectrons, students needed to link background light to wavelength to be awarded the mark. However, it was common to award a mark for controlling/blocking background light (eg working in a dark room)

The most common source of systematic error seen was zero error. However, this needed to be linked to a relevant measuring device (eg the voltmeter or ammeter). The solution was often vague (eg check the ammeter/voltmeter) without explaining when (eg before connected or with no light shining)

It was common to see sources of error suggested in the wrong category. In those cases, we awarded marks for a suitable modification but did not credit the incorrect source of the error.

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