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June 2025

Int Advanced Level Physics WPH13 01

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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 candidates of all abilities to apply their knowledge and skills to a variety of styles of question.

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

There were questions that are familiar to candidates who have revised using the earlier series of WPH03 and WPH13 papers, but some performances would suggest some candidates were unfamiliar with the practical skills outlined in the specification for Unit 3.

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

Successful candidates could:

- use the resolution of a measurement, or the range of repeated measurements to determine the percentage uncertainty.
- describe measuring techniques that would improve accuracy
- outline a method to describe how to measure data for unusual practical scenarios
- carry out calculations and round the answer to a suitable number of significant figures

Less successful candidates:

- forgot to include units with numerical answers
- plotted graphs using scales with unsuitable increments, or were too small to be useful
- did not use specific key terms when describing errors (eg random error, systematic error)
- did not name equipment when describing a method.

A candidate's understanding of the 8 core practical tasks is assessed by the WPH11 and WPH12 papers. As such, the practical contexts met in the WPH13 paper may be less familiar, but will have similarities to the practical investigations candidates would 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 candidates have developed, during the completion of the required core practical tasks and any other experiments, as applied to the physics context described in the question.

Candidates who do little practical work will find this paper more difficult as many questions rely on applying their learning to unfamiliar experiments.

Question 1(a)

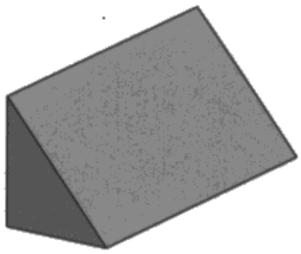
This question tested a candidate's ability to determine the percentage uncertainty in measurements for a single reading, using half the resolution of the instrument.

The display shows a value of 135 g, without a decimal point. As such, the resolution of the device was 1g.

When calculating the percentage uncertainty in 1(a)(ii), candidates were expected to halve their answer from 1(a)(i) and use the value shown.

Some candidates converted both values to kg, which was unnecessary but was credited if done correctly.

1 A student made measurements on the solid metal prism shown.



(a) The student used a balance to determine the mass of the metal prism.

The reading on the balance is shown below.

0135 g

(i) State the resolution of the balance.

(1)

~~0·0001g~~ 1g

(ii) Determine the percentage uncertainty in this reading.

(2)

Uncertainty = $\pm \frac{1}{2}$

% uncertainty = $\frac{0'5}{135} \times 100$

= 0'37%

Percentage uncertainty = 0'37%

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Examiner Comments

Fortunately, the candidate changed the answer for 1(a)(i); it was common for candidates to state standard resolutions for balances they may have used in centres (eg 0.1g or 0.0001 kg). This was correctly halved and used with the given value to determine percentage uncertainty. This example scored full marks.

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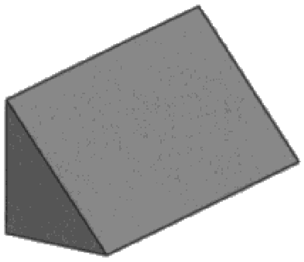
Examiner Tip

Make sure to focus answers on the scenario of the question, not just what you have memorised from practical work in class.

1 A student made measurements on the solid metal prism shown.



(a) The student used a balance to determine the mass of the metal prism.

The reading on the balance is shown below.

0.135 g

(i) State the resolution of the balance.

(1)

~~0.~~ 0.001g

(ii) Determine the percentage uncertainty in this reading.

(2)

$\% = \dfrac{\frac{\cancel{0.000}\ 0.001}{2}}{0.135} \times 100$

$= 0.3703\%$

Percentage uncertainty = 0.37 %

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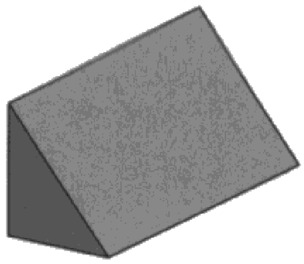
Examiner Comments

This was a common error, where a candidate has: assumed a decimal place is between 0 and 1 on the display (eg 0.135 g) converted to kg, but given the wrong unit. So, this example scored 0 for 1(a)(i). However, this was correctly halved and used with the given value (with the same conversion error) to determine percentage uncertainty. This example scored full marks for 1(a)(ii).

1 A student made measurements on the solid metal prism shown.



(a) The student used a balance to determine the mass of the metal prism.

The reading on the balance is shown below.

0135 g

(i) State the resolution of the balance.

(1)

~~0.0001g~~ 0.1g

(ii) Determine the percentage uncertainty in this reading.

(2)

% uncertainty = $\dfrac{\left(\dfrac{0.\cancel{000}1}{2}\right)}{\cancel{0.}0135} \times 100$

$= 0.037\%$

Percentage uncertainty = 0.037%

ResultsPlus
Examiner Comments

In this case, the candidate has given an incorrect resolution for the reading shown. However, error carried forward was applied, so full marks were awarded for 1(a)(ii).

Question 1(b)i

Candidates are assessed on their ability to "describe how to measure relevant variables using the most appropriate instrument and correct measuring techniques".

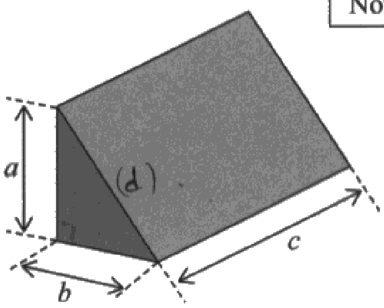
One standard technique is to repeat measurements across different positions, which would also include different orientations if the object were round, like a sphere (as in Core Practical 2) or a wire (as in Core Practical 7). In this case, it would not be sensible for measurements to be taken in different orientations, so such answers were not accepted.

As the candidates were told the measurements were to be taken using vernier calipers, they should know that these should be checked for zero error before taking any measurement.

As this question asked candidates to explain the technique, they were required to identify the error that would be eliminated/reduced by the technique described.

(b) The student used vernier calipers to determine the lengths a, b and c.

Not to scale



(i) Explain one technique he should use to determine accurate values for these lengths.

(2)

- Check for zero error in vernier caliper to prevent systematic error, by calibrating beforehead
- Repeat measurements from different positions ~~to~~ and find mean to eliminate random error.

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Examiner Comments

This candidate explained two techniques. Both techniques were correct (and both appeared on the mark scheme). Full marks were awarded.

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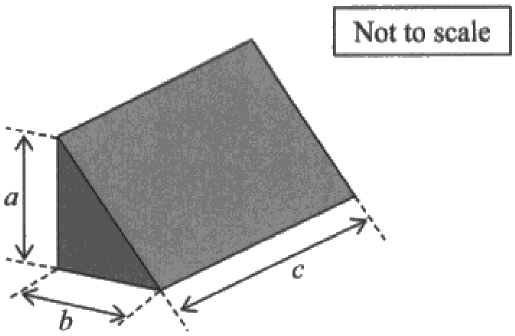
Examiner Tip

Avoid lists of answers. For this question candidates were asked to explain one technique. If a candidate offers more than one suggestion, they may contradict themselves for the same marking point. Generally if two answers are given for a marking point - the rule is right + wrong = wrong.

(b) The student used vernier calipers to determine the lengths a, b and c.



(i) Explain one technique he should use to determine accurate values for these lengths.

(2)

He should take several measurements and obtain the mean value to reduce random error brought by deformation or such.

This example came very close to two marks, but the candidate did not specify that the "several measurements" were to be taken in different places, so was not awarded the first mark.

Question 1(b)ii

Most candidates took the same approach, having realised the end of the prism was a right-angled triangle. These candidates described Pythagoras' theorem in some form, which would only apply if the angle was 90˚.

There is a length *c* on the diagram, but we allowed some benefit of doubt when candidates referred to _a_2 + _b_2 = _c_2.

There were some candidates who applied their advanced level Mathematics skills and described the use of the cosine rule, as this would give the unknown angle, so this was credited. However, other students referred to sine and tangent trigonometric functions, which would be used to calculate the other two angles of a right-angled triangle.

(ii) The student checked that the angle between the side of length *a* and the side of length *b* was a right angle. He did not have a set square or an instrument to measure the angle directly.

Describe how he could use one other measurement and a calculation to check this angle.

(2)

The student could measure the other side of the triangle, the hypotenuse of the cross-section and use pythagorean theorum to see ~~is~~ if $a^2 + b^2$ = hypotenuse^2 and if it is true, he can determine length a and b are 90° ~~90°t~~ to each other.

ResultsPlus
Examiner Comments

This is a good example of the first approach - using Pythagoras' theorem to prove the angle was 90˚. This scored full marks.

(ii) The student checked that the angle between the side of length a and the side of length b was a right angle. He did not have a set square or an instrument to measure the angle directly.

Describe how he could use one other measurement and a calculation to check this angle.

(2)

The student must have the lengths for a, b, and ~~the diagonal formula~~ ~~l~~.
~~Now, by using the trigonometric formula~~ the diagonal length
: ~~Cost~~ connecting a, b, let ~~co~~ name this as l. Now, let
name the angle between length a and b be θ. Lastly, by using
trigonometric formula: $\cos\theta = \frac{a^2+b^2-l^2}{2 \cdot a \cdot b}$; the angle of θ could be
obtained. If 90° is obtained, the angle between length a and b
must ~~be~~ ~~are~~ form a reight angle.
The student can also use the pythagoras theorem. ~~to determine~~
~~If~~ If the sum square of a and b is the squared value
of the ~~stan~~ diagonal length between a and ~~b~~ i.e. l.
∴ $a^2+b^2=l^2$; the student can be ensured that the angle between
a ~~&~~ b ie. θ is 90 - so is a right angle.

ResultsPlus Examiner Comments

This candidate chose the more difficult approach, but successfully described how to apply the cosine rule to determine the angle θ, and compared it to 90˚. This also scored full marks.

Question 1(b)iii-iv

Candidates are assessed on their ability to "perform calculations, using the correct number of significant figures" and to "discuss uncertainties quantitatively".

In 1(b)(iii), candidates were required to use given data to determine the density of metal. This also required them to recognise the shape shown in the diagram.

As all the values provided were to 3 significant figures, their final answer should also be rounded to 3 significant figures.

For 1(b)(iv), candidates were expected to apply a 0.9% uncertainty to **their** calculated value to determine the range of uncertainty, then use this range to decide whether the metal was or was not copper.

If candidates applied 0.9% to the **given** value, they were not awarded the first mark.

(iii) Determine the density, in $g\,cm^{-3}$, of the metal.

$a = 25.3\,mm$
$b = 24.9\,mm$
$c = 49.6\,mm$
mass of prism = 135 g

(3)

$V = \frac{1}{2} \times 2.53 \times 2.49 \times 4.96 = 15.6\,cm^3$

$\rho = \frac{m}{V} = \frac{135}{15.6} = 8.64\,g\,cm^{-3}$

Density = 8.64 $g\,cm^{-3}$

(iv) The percentage uncertainty in this calculated value of the density of the metal is 0.9%.

The accepted value for the density of copper is $8.94\,g\,cm^{-3}$.

Deduce whether the prism could be made of copper.

(2)

$8.64 \times 0.9\% = 0.07776\,g\,cm^{-3}$

$8.64 + 0.07776 = 8.72\,g\,cm^{-3}$

$8.72\,g\,cm^{-3} < 8.94\,g\,cm^{-3}$

So the prism could not be made of copper.

ResultsPlus
Examiner Comments

In this example, in 1(b)(iii) we see a correct volume calculation, leading to a correct density value. It is also rounded correctly to 3 s.f. In 1(b)(iv) we see a correct calculation of the range of uncertainty and a conclusion supported by a comparison.

ResultsPlus
Examiner Tip

Whenever a question uses the command word "deduce" - remember the 3Cs. Calculation Comparison Conclusion. NOTE - when calculating the range of uncertainty, it is not always necessary to calculate both ends of the range. In this case, 8.94 g cm - 3 is higher than 8.64 g cm - 3, so the upper end of the range is the most relevant to the comparison.

(iii) Determine the density, in $g\,cm^{-3}$, of the metal.

$a = 25.3\,mm$
$b = 24.9\,mm$
$c = 49.6\,mm$
mass of prism = 135 g

(3)

$a = 25.3mm = 2.53cm$, $b = 24.9mm = 2.49cm$, $C = 49.6mm = 4.96cm$

$V = 2.53 \times 2.49 \times 4.96 = 31.25cm^3$

$\rho = \frac{m}{V} = \frac{135g}{31.25cm^3} = 4.32\,g/cm^3$

Density = 4.32 $g\,cm^{-3}$

(iv) The percentage uncertainty in this calculated value of the density of the metal is 0.9%.

The accepted value for the density of copper is $8.94\,g\,cm^{-3}$.

Deduce whether the prism could be made of copper.

(2)

$4.32 \times (1+0.9\%) = 4.71\,g\,cm^{-3}$

$4.71 < 8.94$

So ~~no~~ it don't could be made of copper.

ResultsPlus
Examiner Comments

This candidate calculated the volume of a cuboid, not of the triangular prism shown. So they were only awarded the second mark for 1(b)(iii). However, error carried forward applied to 1(b)(iv) - so both marks were awarded.

Question 2(a)

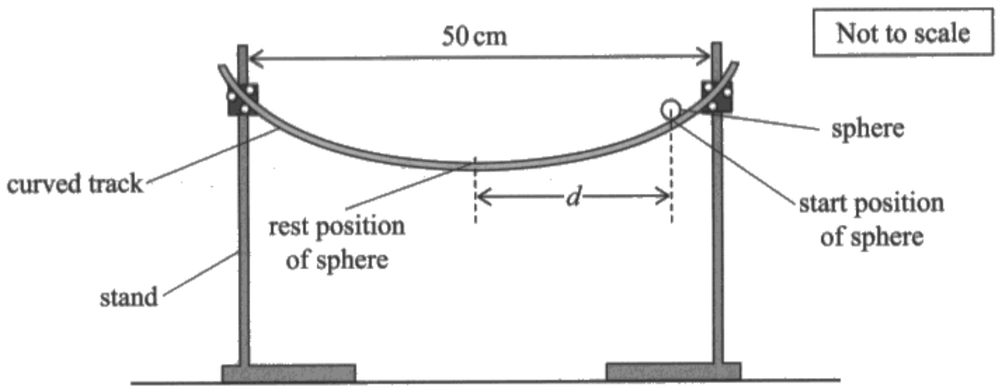
In this question, candidates are assessed on their ability to "describe how to measure relevant variables using the most appropriate instrument and correct measuring techniques" and to "comment on how the experiment may be improved, possibly by using additional apparatus".

In many practicals candidates will have completed, the measurement of a length would usually be along a straight object. In this case, the object was a curved track, so some "standard" responses, such as "take measurements at eye-level" were not relevant. We needed to see how they would accurately measure a point that could not be closely aligned with the metre rule, as the a horizontal metre rule could only align with one of either the start position or the rest position.

Some responses were too vague, eg "make sure the ruler is horizontal" and even if set squares were mentioned, answers were often unclear how the set square was used to ensure the metre rule was horizontal.

As such, it meant that many candidates only scored one or two marks (usually the first and third marking points).

2 A student investigated the motion of a small sphere on a curved track using the apparatus shown.



(a) The student marked the track at the rest position of the sphere.

The student then marked the track at the start position of the sphere.

She used a metre rule to measure the horizontal distance d between the two marks on the track.

Describe an accurate method to measure a single value of d.

(3)

Place metre rule as close to the track as possible.

use set square to ensure metre rule is horizontal.

Do not move the track & stand.

Read measurements at eye level perpendicular to scale using set square.

Ensure zero mark is on rest position to minimize ~~zero~~ error & systematic error.

use another ruler ~~a~~ or set square to align scale with start & rest ~~two~~ position. to reduce parallax error

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Examiner Comments

See below.

ResultsPlus
Examiner Tip

The first marking point can be seen clearly in the candidate's first sentence. However, their second sentence is not clear enough for marking point 2 - a set square must be set against something vertical to make sure the metre rule is horizontal. "Read the measurements at eye-level" would not have been enough for the fourth marking point, but the addition of the set square added the necessary detail, particularly when combined with the final sentence. Finally, the third marking point could be awarded for the description of aligning zero with the rest position. So, this response scored 3 marks.

Question 2(b)

In this question, candidates were assessed on their ability to "perform calculations, using the correct number of significant figures" and to "determine the percentage uncertainty in measurements for multiple readings using the half range".

In 2(b)(i) there was no clear anomalous value in the data provided. Candidates were expected to include all four values.

As all values were rounded to 3 significant figures, the candidate's final answer should also be rounded to 3 s.f.

For 2(b)(ii), candidates should calculate half the range (largest value – smallest value) to determine the percentage uncertainty in the mean.

(b) The student placed the sphere at the start position on the track.

The student released the sphere. She used a stopwatch to measure the time t for the sphere to come to rest at the rest position.

The student repeated the measurement several times and recorded the following data.

t/s	5.23	5.89	5.66	5.01

(i) Determine the mean value of t.

$$\frac{5.01+5.23+5.66+5.89}{4}$$ **(2)**

$= 5.45$

Mean value of t = 5.455

(ii) Determine the percentage uncertainty in the mean value of t. **(2)**

$$\frac{\frac{5.89-5.01}{2}}{5.45} \times 100$$

$= 8.1\%$

Percentage uncertainty = 8.1%

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Examiner Comments

For 2(b)(i) we see a correctly calculated mean value, using all four data values. Then in 2(b)(ii) the range had been calculated and halved, leading to a correct percentage uncertainty. Full marks.

ResultsPlus
Examiner Tip

Remember to give the unit for any value, even if calculating the mean.

(b) The student placed the sphere at the start position on the track.

The student released the sphere. She used a stopwatch to measure the time t for the sphere to come to rest at the rest position.

The student repeated the measurement several times and recorded the following data.

t / s	5.23	5.89	5.66	5.01

(i) Determine the mean value of t.

(2)

Mean value $= \dfrac{5.23 + 5.89 + 5.66 \cancel{+ 5.01}}{\cancel{4}\ 3} = \cancel{5.45sec}\ \cancel{5.45sec}\ 5.59sec$

Mean value of t = ~~5.45sec~~ 5.59sec

(ii) Determine the percentage uncertainty in the mean value of t

(2)

~~Percentage uncertainity = $\frac{0.\dots (0.1\dots)}{\dots}$ ×100~~

Estimated uncertainity $= \dfrac{max-min}{2} = \dfrac{5.89 - 5.23}{2} = \cancel{0.44sec}\ 0.33sec$

Percentage uncertainity Percentage uncertainity $= \dfrac{0.33}{5.59} \times 100 = 5.9\%$

~~$\frac{0.44}{5.45} \times 100 = 8\%$~~

Percentage uncertainty = ~~8.1%~~ 5.9%

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Examiner Comments

In this example, the candidate has assumed 5.01 s was an anomalous result, so did not include it in the mean calculation (crossed it out). However, they did calculate a mean, so were awarded the first mark point in 2(b)(i). Applying error carried forward, for both the mean value and the range, both marks were awarded for 2(b)(ii)

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Examiner Tip

Do not assume there must be an anomaly in repeated data.

Question 2(c)

In this question, candidates were assessed on their ability to "comment on the number of readings taken, the range of measurements taken and on significant figures" for the recording of the data as shown.

This question appears regularly on WPH13 (and WPH16), with similar marking points each time, but with some adaptation for the particular scenario.

One common response which is often worthy of credit is "no evidence of repeats". However, candidates have just been shown evidence of repeats of time measurement in 2(b), so this was not accepted; however if their answer suggested that the repeat readings were not shown in this table, we did credit this.

Many candidates did identify 82 s as an anomaly. However, most did not criticise the recording of 82 s (eg they did not identify the missing decimal place).

(c) The student investigated how varying the distance d affected the mean time t.

She recorded the following data.

d / cm	Mean t / s
12	3.6
14.5	5.12
17	82
19.5	12.66

The student used the data to plot a graph.

Criticise the data recorded by the student.

(3)

The value of d and t ~~each~~ is not the same decimal places. 4 values are not enough to plot a accurate graph. The value of t at 17 cm is ~~not~~ ~~shouldn't~~ not following the ~~trend~~ trend and should be 8.2 s instead of 82 s.

ResultsPlus Examiner Comments

All three marking points are clear to see (in mark scheme order).

ResultsPlus Examiner Tip

When discussing measurement data, the values should be recorded to the same resolution as the measuring device. In this case, a metre rule has a resolution of 1 mm. So, the d values should be recorded to 0.1 cm. So, for d, we expect values with 1 decimal place. When carrying out a calculation (in this case, calculating the mean), final values should be rounded to the same significant figures as the data. The time values in 2(b) are recorded to 2 decimal places (3 s.f.) so the mean t should be rounded to 3 s.f.

(c) The student investigated how varying the distance d affected the mean time t.

She recorded the following data.

d / cm	Mean t / s
12	3.6
14.5	5.12
17	82
19.5	12.66

The student used the data to plot a graph.

Criticise the data recorded by the student.

(3)

Inconsistent number of significant figures for Mean t/s, there is no evidence of repeated measurements and there is an anomalous value for the Mean t/s.

ResultsPlus
Examiner Comments

This response scored only 1 mark - the first marking point. In other series, saying "no evidence of repeats" might have been accepted, but in this case there is evidence the student in the question has carried out repeats. They have not "shown" the repeats in this table. Finally, stating "there is an anomalous value" is too simple a statement at Advanced Level.

Question 2(d)

Candidates are required to "comment on how the experiment may be improved, possibly by using additional apparatus" and to "suggest realistic modifications to reduce errors and improve the experiment".

In this question, it was suggested that a video camera should be used. Candidates were asked to explain how this could improve the measurement of time.

Since a video played at normal speed would not make any difference to reaction time or accuracy, the second marking point was dependent on students describing a method of viewing the video at a slower speed (eg in slow motion or frame-by-frame).

Candidates may have used similar slow-motion video techniques in class (eg during Core Practical 2), while those who discussed "frame-by-frame" are more likely to be older students retaking WPH13 (who have carried out Core Practical 10). Either description was credited for the first marking point.

(d) The student suggested using a video camera to record the motion of the sphere.

Explain how using a video recording could improve the measurement of t.

(2)

· Video camera could be used to watch in slow motion, ~~and~~ so less percentage uncertainty.

· No ~~parallax error~~ human reaction time as in the stopwatch, so more accurate reading of t.

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Examiner Comments

Here we can see the first marking point, along with both versions of the second marking point. So, this example scored full marks.

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Examiner Tip

Note - human reaction time is acceptable, but a generic "human error" would not be.

(d) The student suggested using a video camera to record the motion of the sphere.

Explain how using a video recording could improve the measurement of t.

(2)

It's more convenient because by using a video recording we can view it in slow motion, and get precise value for t.

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The first marking point can be seen clearly, "view it in slow motion". However, the key term "precise" does not mean more accurate.

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Examiner Tip

Candidates should ensure they study the glossary in Appendix 10 of the specification. Accuracy - A measurement result is considered accurate if it is judged to be close to the true value. It is a quality denoting the closeness of agreement between measurement and true value. Precision - A quality denoting the closeness of agreement (consistency) between values obtained by repeated measurement. A measurement is precise if the values 'cluster' closely together.

Question 3(a)i

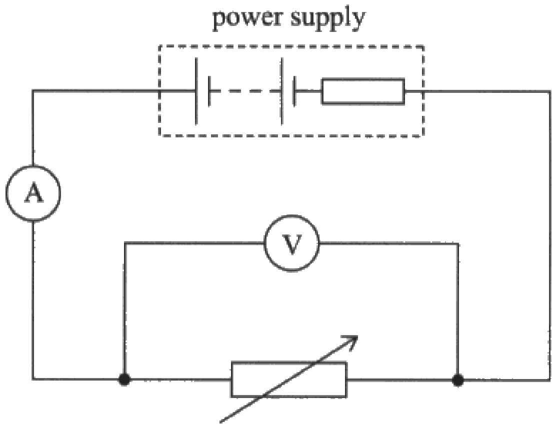
Questions often test a candidate's ability to "identify health and safety issues and discuss how these may be dealt with" in both familiar and unfamiliar situations.

During Core Practical 8, candidates may have been advised to ensure the variable resistor was at maximum resistance initially, to ensure the current (and any heating effects) were at a minimum.

The circuit shown in the question is very similar, but for a power supply rather than a single cell.

Although the question clearly stated "**max***imum* resistance", it was common for candidates to be less specific (eg lower current, limited current).

3 A student investigated the power output of a power supply using the circuit shown.



The power supply has an internal resistance.

(a) Before switching on the power supply, the student used an ohmmeter to check that the variable resistor was set to the maximum resistance.

He then measured corresponding values of current and potential difference for a range of resistances.

(i) Explain why starting from the maximum resistance is safer than starting from the minimum resistance.

(2)

Starting from the maximum resistance limit the current as $V = IR$ $R = \frac{V}{I}$, so therefore the component would not be damaged or overheated when suddenly applying high current

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Examiner Comments

The idea that the maximum resistance would "limit the current" is too vague. Any resistance would limit current for a given potential difference. However, this candidate did state why it would be safer.

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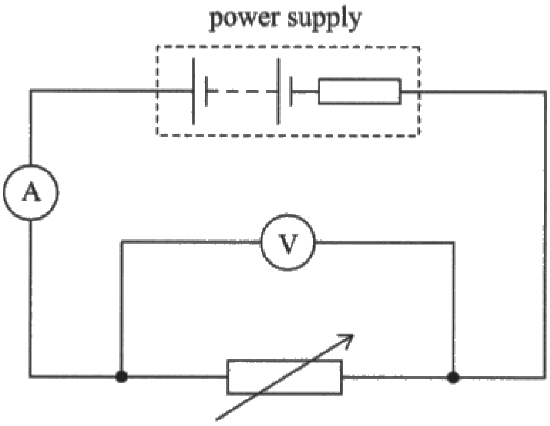
Examiner Tip

When answering, make sure to match the type of comparison words used in the question, eg Comparing upper and lower limits - use "st" words (most/least/biggest/smallest) or "um" words (maximum/minimum). Comparing changes - use "er" words (larger/smaller/higher/lower)

3 A student investigated the power output of a power supply using the circuit shown.



The power supply has an internal resistance.

(a) Before switching on the power supply, the student used an ohmmeter to check that the va~~riable resistor~~ was set to the maximum resistance.

He then measured corresponding values of current and potential difference for a range of resistances.

(i) Explain why starting from the maximum resistance is safer than starting from the minimum resistance.

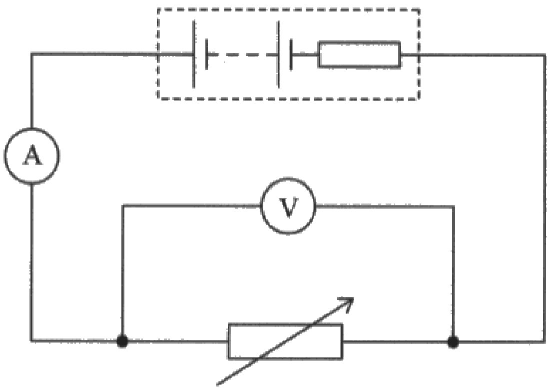
(2)

Maximum lesistance so that current is at minimum.
If current is to larger. the circuit will heat up and burn
the wire or other cells.

ResultsPlus
Examiner Comments

In this example, the candidate has matched the comparison words - maximum and minimum - so scores the first mark. The safety issue stated was less clear, but sufficient - "burn the wire or other cells" was accepted as "damaging the components".

3 A student investigated the power output of a power supply using the circuit shown.



The power supply has an internal resistance.

(a) Before switching on the power supply, the student used an ohmmeter to check that the variable resistor was set to the maximum resistance.

He then measured corresponding values of current and potential difference for a range of resistances.

(i) Explain why starting from the maximum resistance is safer than starting from the minimum resistance.

(2)

As resistance is maximum, the current is minimum therefore it is ~~more~~ safer as there is less risk of equipment overheating

ResultsPlus
Examiner Comments

This example was much clearer, with both mark points seen as written in the mark scheme.

Question 3(a)ii

Candidates should be able to "discuss whether repeat readings are appropriate".

Repeat readings are not always appropriate, many candidates think that repeat readings will reduce all errors and lead to more accurate data.

Repeat readings are appropriate when errors are random, as they give the opportunity to calculate a mean (and recheck/remove anomalies). For a systematic error, the repeat readings are likely to have the same error.

For this question, there was an argument to be made for both options.

(ii) Explain whether repeat readings are appropriate for this investigation.

(2)

~~the~~ Yes, they are appropiate because you can spot out an anolymous ~~anolymous~~ value, ~~you~~ ~~can average~~ and ~~anolymous~~

• You can average and calculate a mean value.

ResultsPlus
Examiner Comments

This example argues that repeats are appropriate as they allow you to "spot anomalous values".

(ii) Explain whether repeat readings are appropriate for this investigation.

(2)

~~Repeat readings are not appropriate as the voltmeter, ammeter and ohmeter are unvariable do not vary once after the resistance is set~~

They are not appropriate, as the voltmeter, ammeter, and ohmeter do not vary, after the resistance of the variable resistor is set.

ResultsPlus
Examiner Comments

This example argues that repeat readings are not appropriate, as the readings of the "voltmeter... and ammeter do not vary, after the... variable resistor is set."

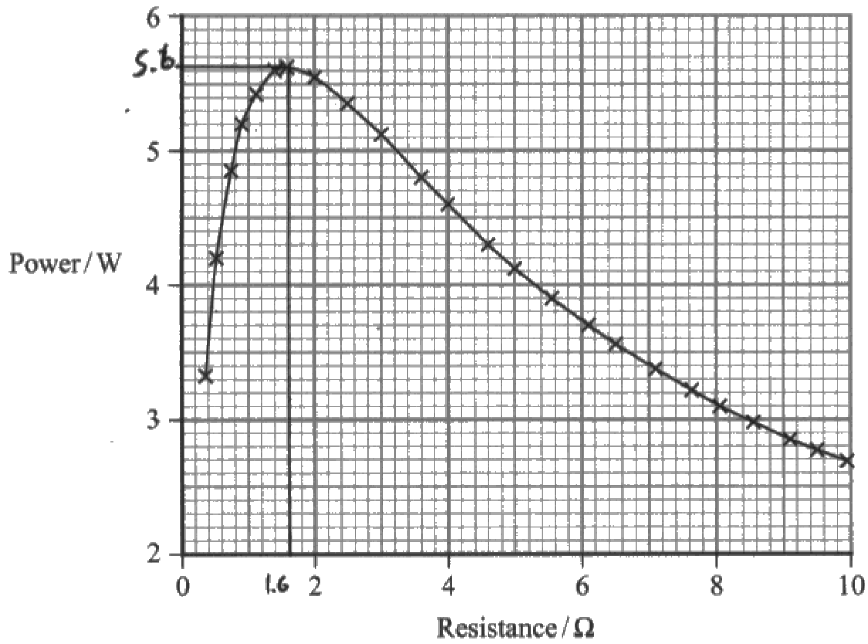
Question 3(b)

When the command word "determine" is used, candidates should use the data given, but may also need to identify any other data needed. In this case, data from the graph.

Here candidates needed to "determine a constant with the aid of a graph", the resistance at maximum power (the peak of the graph), and use those resistance and power values to "perform calculations" while using "the correct units throughout".

Most candidates scored full marks, though some chose points from the ends of the line (maximum and minimum resistance). These candidates usually scored 2 marks, from 3(b)(ii).

(b) The student used his results to plot a graph of the power output of the power supply against the resistance of the variable resistor, as shown.



The power output is at its maximum value when the resistance of the variable resistor is equal to the internal resistance of the power supply.

(i) Determine the internal resistance of the power supply.

(1)

Internal resistance = 1.6Ω

(ii) Determine the output potential difference of the power supply when the power output is a maximum.

(2)

~~V=~~ $P = \frac{V^2}{R}$ $P \cdot R = V^2$ $\sqrt{P \cdot R} = V$

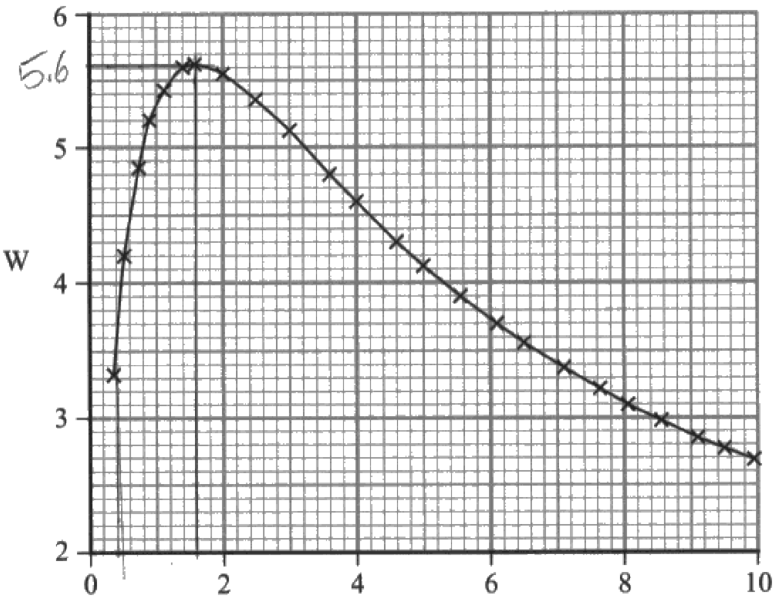
$V = \sqrt{5.6 \cdot 1.6} = 2.99V$

Output potential difference = ~~2.99~~ 2.99V

![ResultsPlus Examiner Comments]

This example scored full marks, with answers and calculations as written in the mark scheme.

(b) The student used his results to plot a graph of the power output of the power supply against the resistance of the variable resistor, as shown.



The power output is at its maximum value when the resistance of the variable resistor is equal to the internal resistance of the power supply.

(i) Determine the internal resistance of the power supply.

(1)

Internal resistance = 0.4 Ω

(ii) Determine the output potential difference of the power supply when the power output is a maximum.

(2)

$P = \frac{V^2}{R}$ $\quad 5.6 = \frac{V^2}{1.6}$ $\quad V^2 = 8.96$ $\quad V = 2.99$ ✓

≈ 3 ✓

Output potential difference = 3 V

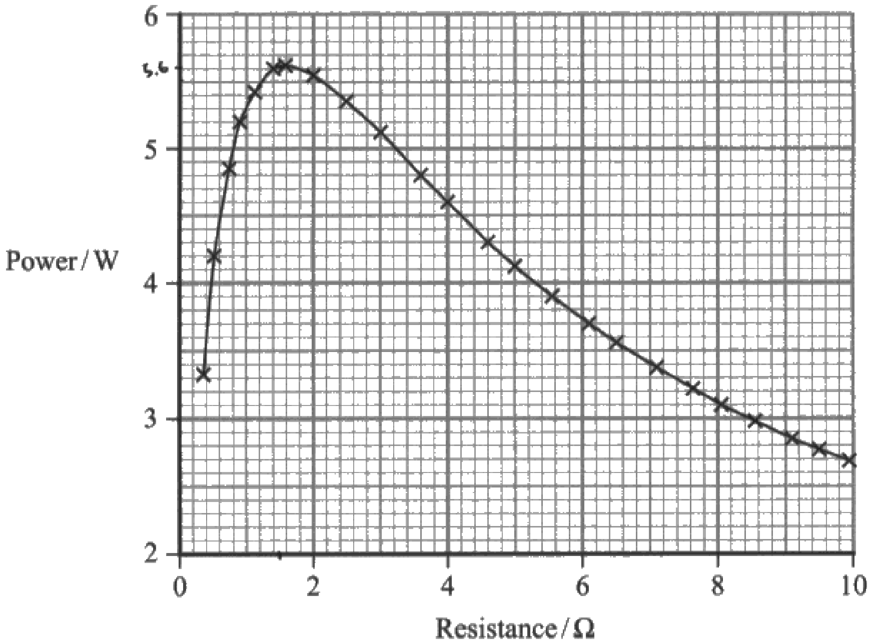
ResultsPlus
Examiner Comments

See below.

ResultsPlus
Examiner Tip

This candidate misinterpreted the sentence which explains that when the circuit resistance equals the internal resistance, power is at its maximum value. The minimum resistance was chosen (0.4 Ω) in 3(b)(i). However, for 3(b)(ii), they had correctly understood that power output was at maximum, so selected the appropriate data point on the graph and completed the calculation correctly - scoring both marks.

(b) The student used his results to plot a graph of the power output of the power supply against the resistance of the variable resistor, as shown.



The power output is at its maximum value when the resistance of the variable resistor is equal to the internal resistance of the power supply.

(i) Determine the internal resistance of the power supply.

(1)

Internal resistance = 1.45 Ω

(ii) Determine the output potential difference of the power supply when the power output is a maximum.

(2)

$P = \frac{V^2}{R}$

$5.6\text{ W} = \frac{V^2}{1.45}$ → $V = \sqrt{5.6 \times 1.45} = 2.85\text{V}$

Output potential difference = 2.85V

ResultsPlus
Examiner Comments

See below.

ResultsPlus
Examiner Tip

For 3(b)(i), the value chosen for the internal resistance was more than half a square (1 mm) from the peak value. With each small square being 0.2 Ω, the range of resistances accepted was set at 1.5 to 1.6 Ω. However, error carried forward was applied, so full marks were awarded in 3(b)(ii).

Question 3(c)

This is the type of question candidates find the most difficult to answer, where they are asked to "comment on the implications of physics and its context", so was targeted at a high demand level.

The introduction to the question points out that when the aerial and transmitter resistances are equal, the power output is at maximum, but efficiency is at 50%.

Candidates were asked to give a positive implication (advantage) and a negative implication (disadvantage). However, most candidates did little more than repeat the information given (eg stated that "50% of the power is wasted" or "it can cover a large area"). To be credited, a candidate's answer needed to go beyond just restating the information to outline their advantage/disadvantage.

So, most students did not score a mark, though high-performing students did manage to score 2 marks.

(c) When the power output is at its maximum value, the overall efficiency is 50%.

Radio transmitters are used to transmit radio waves over a large area.

The aerial connected to the radio transmitter has an equivalent resistance equal to the internal resistance of the transmitter.

Suggest one advantage and one disadvantage of making the resistances equal for a radio transmitter.

(2)

Advantage: The radio transmitter would have the maximum power output, so the aerial would also have the maximum power, producing the strongest radio waves over the area (signal would be clear;

Disadvantage: The efficiency is only 50%, which is low, so would waste half of the power into heat lost to the sorroundings.

(Total for Question 3 = 9 marks)

ResultsPlus
Examiner Comments

This candidate has identified that maximum output power on the transmitter would lead the strongest radio waves. They have also linked 50% efficiency to the idea that half of the power would be converted to "heat lost to the surroundings", scoring full marks.

(c) When the power output is at its maximum value, the overall efficiency is 50%.

Radio transmitters are used to transmit radio waves over a large area.

The aerial connected to the radio transmitter has an equivalent resistance equal to the internal resistance of the transmitter.

Suggest one advantage and one disadvantage of making the resistances equal for a radio transmitter.

(2)

maximum power produced $P = \frac{I}{A}$, power is proportional to Intensity, maximum intensity of radio waves produced.

lower efficiency, 50% of energy is converted to heat which can ~~damage~~ result in damages.

(Total for Question 3 = 9 marks)

ResultsPlus
Examiner Comments

This candidate has identified that maximum output power on the transmitter would lead the maximum intensity radio waves. They have also linked 50% efficiency to the idea that 50% of the power/energy would be converted to "heat", scoring full marks.

ResultsPlus
Examiner Tip

Some questions are written to challenge candidates at the higher grade range. However, these questions can be accessed by all. But there are no marks for repeating information we gave; candidates need to add to this, or combine different pieces of information, to tell us something new.

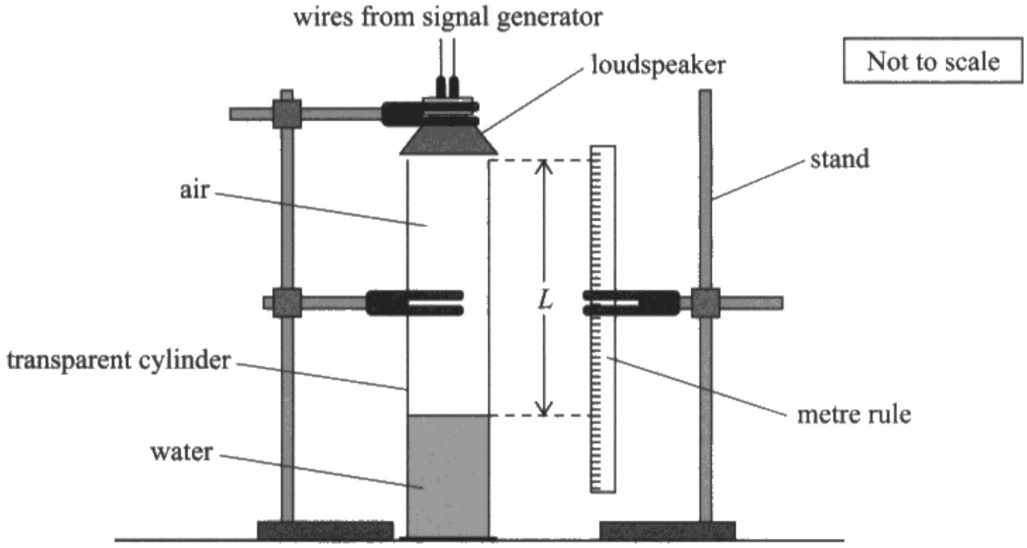
Question 4(a)

During the practical work, candidates have considered how to "identify possible sources of uncertainty and/or systematic error and explain how these may be reduced or eliminated".

In this scenario, students were asked how to reduce a source of uncertainty when using the equipment as set up in the diagram.

Some students focused on "zero error" and described a need to align the zero of the metre rule with the water level. However, without considering the two options given in the mark scheme, moving the metre rule close to the cylinder and ensuring it was vertical, then aligning the zero, would make little difference to the uncertainty in *L*.

4 A student determined the speed of sound in air using the apparatus shown.



(a) The student used the metre rule to determine the distance *L* between the level of the water and the top of the transparent cylinder.

Explain how to reduce a source of uncertainty in the measurement of *L*.

(2)

Fix the ruler as close as possible to the cylinder making sure it is perpendicular to the ground and measure at eye level to avoid parallax error.

ResultsPlus
Examiner Comments

This is an example of the first option on the mark scheme, putting the ruler as close as possible and measuring at "eye level" (which is accepted to mean perpendicular to the metre rule). It also links this method to a reduction in parallax error. Note, the section about "making sure it is perpendicular to the ground" was not sufficient, as it did not state how (eg set square, plumb line).

ResultsPlus
Examiner Tip

When discussing errors or uncertainties, always include the name of the specific error or source of uncertainty.

Question 4(b)

In this question, candidates needed to "comment on how the experiment may be improved, possibly by using additional apparatus". Completion of two of the Core Practicals will have given candidates examples of types of technique that could be used.

The first option given in the mark scheme relates to Core Practical 5, where candidates would identify a maximum (in that case the maximum amplitude of the standing wave on a string) from higher frequencies and from lower frequencies.

Although this was expected to be the most common approach, most candidates went with the second option, which relates to Core Practical 4, where a microphone and CRO were used to visualise a sound wave.

A third option was added, as some candidates focused their answer on how to determine how loud the sound was, so suggested the use of some form of sound level meter.

(b) The student connected the loudspeaker to a signal generator. She set the frequency f of the signal generator to its lowest value.

The student gradually increased f until a standing wave was produced in the transparent cylinder. The sound from the cylinder was loudest at this value of f.

Explain a technique the student could use to determine, as accurately as possible, when a standing wave is produced in the cylinder.

loudest sound = standing wave ~~So~~ has been formed, therefore **(2)**

Connect a microphoe close to the sound to a oscilloscope to track the loudest sound. Amplitude is the highest seen on oscilloscopes screen mark down that value. Repeat and average this experiment. Or use special equipment to reord ~~(to)~~ sound and mark ~~(when)~~ frequency when apparatus marks loudest sound. (~~As sound wave has~~)

ResultsPlus
Examiner Comments

This example shows option 2, with a clear link between the use of a microphone and an oscilloscope, and the identification that the loudest sound has the highest amplitude.

(b) The student connected the loudspeaker to a signal generator. She set the frequency *f* of the signal generator to its lowest value.

The student gradually increased *f* until a standing wave was produced in the transparent cylinder. The sound from the cylinder was loudest at this value of *f*.

Explain a technique the student could use to determine, as accurately as possible, when a standing wave is produced in the cylinder.

(2)

(measures sound in dB)

Use a sound metre / placed over the loudspeaker to measure the sound intensity, then increase the frequency until a maximum value of sound intensity has been reached, then, take repeat measurements & find an ~~average~~ average value for the frequency.

ResultsPlus
Examiner Comments

In this example, we see option 3, with a sound meter (measuring sound in dB) used to measure sound intensity, and looking to see the maximum value of sound intensity.

Question 4(c)i

Candidates are expected to be able to "discuss how the data collected will be used", which in this case required them to explain how a graph can be used to determine the speed of sound *v*.

This format of question is commonly seen on WPH13 papers, and WPH03 before it, so candidates are generally well practised.

In some series, the equation given needs to be rearranged into $y = mx + c$ format, which adds demand to the question. However, in this paper the equation is given in the required format, so candidates only needed to compare to $y = mx + c$ and explain how the gradient can be used to determine *v*.

(c) The student recorded the value of f for the first loud sound. She continued to increase f and recorded the next five values of f that also produced a loud sound.

She gave each of these recorded values a number n. For the lowest frequency $n = 1$ and for the highest frequency $n = 6$.

The student suggested that the relationship between f and n is given by the formula

$$f = \left(\frac{v}{2L}\right)n + k$$

where
v is the speed of sound in air
k is a constant.

(i) Explain how a graph of f against n can be used to determine the value of v.

(2)

A graph of $f = \frac{v}{2L}n + K$ where f is y-axis and n is x-axis will give us a gradient of $\frac{v}{2L}$ because of $y = mx + c$. We can the multiply the gradient by 2L to find speed of sound in air.

ResultsPlus
Examiner Comments

In this example, we can see a good comparison between the equation and y = mx + c for the first mark. This is followed by a correct description of how to use the gradient to determine v. So, both marks were awarded.

ResultsPlus
Examiner Tip

There are many different ways to describe the equation of a line used. y = mx + c y = k x + a y = a x + b. As such, it is important to link the appropriate quantity to the feature on the graph, eg m = v /2 L would not be sufficient for the second mark point without a statement that m is the gradient.

(c) The student recorded the value of f for the first loud sound. She continued to increase f and recorded the next five values of f that also produced a loud sound.

She gave each of these recorded values a number n. For the lowest frequency $n = 1$ and for the highest frequency $n = 6$.

The student suggested that the relationship between f and n is given by the formula

$$f = \left(\frac{v}{2L}\right)n + k$$

where
v is the speed of sound in air
k is a constant.

(i) Explain how a graph of f against n can be used to determine the value of v.

(2)

The gradient of the graph is $\frac{v}{2L}$. If you multiply gradient by 2L you obtain the value of v

ResultsPlus
Examiner Comments

In this example, we do not see a comparison between the equation and $y = mx + c$ for the first mark. There is a correct description of how to use the gradient to determine v, which is an independent mark, so was awarded.

Question 4(c)ii-iv

A candidate's ability to "plot results on a graph using an appropriate scale", to "determine the relationship between two variables or determine a constant with the aid of a graph" and to comment on the relationship obtained from the graph" are vital skills.

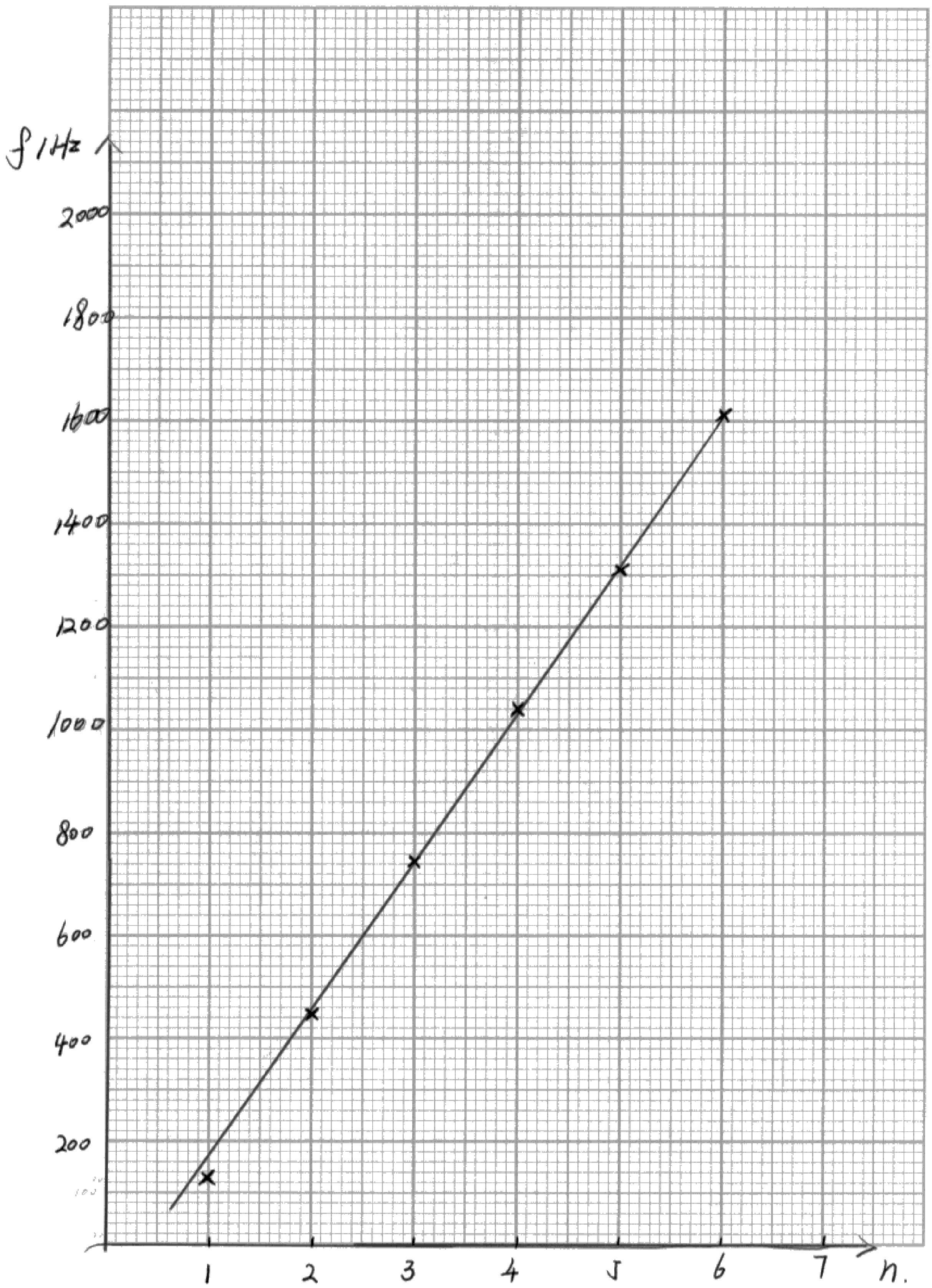
Three of the twenty-four points in the WPH13 specification are related to graphs, so the questions on graphs contribute a significant percentage of the total mark for WPH13.

As such, candidates who score highly are practised at accurately plotting graphs, determining gradients (and occasionally intercepts) and understanding what the gradient or intercept means in relation to the scenario.

The plotting of graphs has improved with very few graphs showing excessively large plots (eg the type you would see as default from a spreadsheet application), however there is a significant number of candidates who are proving very difficult to use scales (in an attempt to use the whole page).

Note - the general requirements are;

- Labelled axes, using a solidus to separate the quantity and unit, eg f / Hz
- A scale that has sensible increments (there are 10 small squares every 2 cm, so we use a scale that is sensibly divisible by 10, eg a power of 10 of 1, 2 or 5) choosing the increment that allows the graph to be plotted across more than half the available paper in each axis.
- Plots that are accurate to 1 mm, so half a small square, and are small/neat enough for such accuracy to be checked.
- A line of best fit that is a single straight line, is balanced, and follows the pattern of the plots.


f / Hz
2000
1800
1600
1400
1200
1000
800
600
400
200
1
2
3
4
5
6
7
n.

(iii) Determine the value of v from the graph.

$L = 0.595\,\text{m}$

(4)

when $n = 1$: $128 = \left(\frac{v}{2\times0.595}\right)\times 1 + k$ ① $\rightarrow 128 = \frac{v}{1.19} + k$

when $n = 6$: $1608 = \left(\frac{v}{2\times0.595}\right)\times 6 + k$ ② $\rightarrow 1608 = \frac{6v}{1.19} + k$

$\begin{cases} 128 = \frac{v}{1.19} + k & ③ \\ 1608 = \frac{6v}{1.19} + k & ④ \end{cases}$ $\therefore k = -168.$

④ − ③ : $1608 - 128 = \frac{6v}{1.19} - \frac{v}{1.19}$

$1480 = \frac{5v}{1.19}$

$\therefore v \approx 1480 \div \frac{5}{1.19} \approx 352.24\ \text{ms}^{-1}$ $v =$ $352.24\ \text{ms}^{-1}$

(iv) The student suggested that the magnitude of k is half the magnitude of the gradient.

Determine whether her suggestion could be correct.

(2)

The student's suggestion is incorrect.
The gradient's magnitude is 296, the k's magnitude is ~~[illegible]~~ 168. half of ~~[illegible]~~ gradient's magnitude is 149. 149 is not equal to 168.
So it's incorrect.

(Total for Question 4 = 17 marks)

ResultsPlus

Examiner Comments

This response is an example of the highest quality. For 4(c)(iii) we awarded this candidate 4 out of 5 marks. We can see: both axes correctly labelled with the required format for units (f/Hz) sensible scale increments every 2 cm (200 on the y -axis and 1 on the x -axis) small, neat and accurate plotting of the given data. Only the line of best fit raised questions, with the first two plots below the line suggesting the line should be slightly steeper to correctly follow the pattern of the data. In 4(c)(iv) this candidate took an unusual approach. Rather than use the standard approach (calculate the gradient and then determine v) they took the data back to the given equation and solved simultaneous equations. As mathematically this is the same as calculating the gradient (taking two data points, subtracting and dividing) and then substituting into part of the equation (gradient = v /2 L), it was accepted as equivalent to the first two marking points. After this, the mark scheme can be applied and the final two marks awarded. For 4(c)(iv) we can see a comparison between the k value (most candidates needed to calculate this, as their graph did not show the negative part of the y -axis) and half the gradient.

ResultsPlus

Examiner Tip

Most IAL Physics papers allocate 1 minute of time per mark, then add time for checking, eg WPH11 is 90 minutes for 80 marks. WPH14 is 105 minutes for 90 marks. Both WPH13 and WPH16 allow considerably more time (80 minutes for 50 marks), as both include plotting and analysing a graph, which is worth a considerable percentage of the total mark (26% for this paper). As such, candidates might consider starting to answer their WPH13 or WPH16 paper with the graph question, as we often see rushed graphs and incomplete answers.

Paper 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'.
- Be able to describe how to measure lengths, angles, force, time, potential difference and current using appropriate apparatus and techniques.
- Refer to random or systematic errors when explaining techniques.
- Practise writing experimental methods including identifying safety issues specific to that experiment.
- Show working in all calculations and give answers using appropriate significant figures and a unit.
- Choose graph scales that are sensible, ie the value of the smallest 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, eg 0.25, 3, 4 or 7.
- Plot data using neat crosses (× or +), and re-check any points that lie far from the best-fit line.
- Use a one-piece, 30 cm ruler to draw straight best-fit lines. Ensure there are data points on both sides of the line, and the line cannot be rotated. Using a pencil will allow for the line to be changed if needed.
- Draw a large triangle that covers at least **half** of the plotted data using sensible points. Drawing the triangle on the graph often avoids mistakes in data extraction.
- Learn the definitions of the terms used in practical work and standard techniques for analysing uncertainties at AS level. These are given in Unit 3 and Appendix 10 of the IAL specification.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link: https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

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