Examiners' Report
Principal Examiner Feedback

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

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 scenario of this question has previously been seen in WPH12 papers. The key idea is a layer of graphite as the conductor in a resistivity experiment, with a rectangular cross-sectional area, rather than a wire with a circular cross-section.

Q1(a)(i) asks students to simply identify the resolution of a digital measuring device. This should be as simple as identifying the smallest increment the device can measure – 0.001 MΩ. However, nearly half of all responses scored 0 marks. The most common error was to state the uncertainty (half the resolution).

Since the answer could be given as 1000 Ω, another common error was not giving the unit for their answer.

Q1(a)(ii) asks students to determine the percentage uncertainty in the measurement shown. Over 2/3 of students completed this calculation, but only 44% were awarded both marks. For answers awarded 1 mark, this was for the use of the full resolution stated in Q1(a)(i), rather than uncertainty being half the resolution, as instructed in appendix 10 of the specification.

(a) (i) State the resolution of the ohmmeter.

(1)

$0.001\,M\Omega = 1000\,\Omega$

(ii) Determine the percentage uncertainty in the measurement of *R*.

(2)

$\frac{0.001 \times 10^6}{2} = 500$

$\frac{500}{0.289 \times 10^6} \times 100 = 0.173\% \simeq 0.17\%$

Percentage uncertainty = 0.17%

This example scored 1 mark for Q1(a)(i) and 2 marks for Q1(a)(ii).

(a) (i) State the resolution of the ohmmeter.

(1)

0·001 MΩ·

(ii) Determine the percentage uncertainty in the measurement of R.

(2)

$\left(\frac{\text{Resolution}}{\text{Actual}}\right) \times 100$ Absolute uncertainty.

$\frac{0{\cdot}001\,\cancel{M\Omega}}{0{\cdot}289\,\cancel{M\Omega}} \times 100$

$= 3{\cdot}460 \times 10^{-3}$

$= 0{\cdot}346\%$

Percentage uncertainty = 0·346%

However, in this example for Q1(a)(ii) the full resolution was used as the uncertainty. So, only 1 mark was awarded.

Question 1(b)

This practical scenario proved a challenge to many students. Most did link the question to $R = \rho l/A$, but had difficulty identifying how this applied.

In Q1(b)(i) it was common for l to described as the length of the shading, rather than the length of the graphite between the electrodes. It was also common for A to be the length × width of the graphite (the area of the upper surface). Many students missed the key fact that the resistivity of graphite ρ was known.

As such, scored full marks (less than 3%) and most scored 0 marks. Where marks were scored, it was for a description of measuring resistance *R* at different lengths, and then plotting a *R* against *l* graph.

For Q1(b)(ii), the error identified must be a systematic error, rather than a random error, and needed to be relevant to the method described in Q1(b)(i). Most students identified a random error – commonly parallax error when measuring length.

(b) The thickness of the graphite pencil shading can be determined from a known value for the resistivity of graphite. $R = \frac{\rho L}{A}$

(i) Describe how the student could determine an accurate value for the thickness of the graphite pencil shading. The method should use a suitable graph.

(4)

Measure the distance between the two electrode using a metre rule. Measure at eye level with metre rule to reduce parallax errors.

Measure ~~Record~~ the resistance for this distance / length of graphite. Vary the length between the electrodes, but make sure both electrodes are in contact with the graphite. Repeat measurements of resistance for different lengths between the electrodes. Repeat measurements of resistance for the same ~~to~~ distance between the electrodes and ~~take~~ calculate the mean value ~~resor~~ to get an average value for resistance for a specific length between the two electrode. Measure the width of the shading at several points along the shading using a metre rule and take an average. Plot a graph of resistance against distance between two electrodes / length. Calculate the gradient to get $\frac{\text{resistivity}}{\text{cross-sectional area}}$. ~~[illegible]~~ Do $\frac{\text{resistivity}}{\text{gradient}}$ to get cross-sectional area. Divide the cross-sectional area by the width to get the thickness of the shading ~~[illegible]~~, as per $R = \frac{\rho L}{A}$.

(ii) Identify a possible source of systematic error in your method.

(1)

Zero error on ammeter. Contact resistance between crocodile clips

This example is one of the few that scored full marks for Q1(b).

Question 2(a)

The whole of question 2 is introduced as an investigation of the interference of sound waves.

In the introduction Q2(a), it is made clear that the sound heard is loud and continuous. This implies that at the position of hearing, there is constructive interference with no variation in amplitude, meaning that the two waves are meeting in phase and that the phase relationship is constant.

As such, for Q2(a)(i) we needed students to state this, and we allowed several different ways to describe a constant phase relationship. Despite this, only 28% of students were awarded this mark.

(a) The student adjusted the signal generator output until he heard a loud, continuous sound from the loudspeakers.

(i) State a reason for connecting both loudspeakers to the same signal generator.

(1)

For the loudspeaker to produce waves that are coherent.

(a) The student adjusted the signal generator output until he heard a loud, continuous sound from the loudspeakers.

(i) State a reason for connecting both loudspeakers to the same signal generator.

(1)

So the loudspeaker have same frequency, amplitude and wavelength and two ~~[illegible]~~ Sound waves are in phase.

Both of the examples above were awarded the mark. The second example achieves the mark in two different ways.

For Q2(a)(ii) we asked students to identify a health and safety issue when using loud sounds in an investigation and to give a preventative measure. Students performed better here, with over 80% scoring at least 1 mark (for identifying the issue or suggesting a preventative measure) and over ½ were awarded both marks.

(ii) Identify a health and safety issue for the student and how it may be dealt with.

(2)

The sound of the loudspeakers could be too loud, harming the ears, therefore standing further away or ear protection could be used.

This example was awarded both marks, as there is a clear link between the loud sound and damage to ears, plus two methods of prevention.

(ii) Identify a health and safety issue for the student and how it may be dealt with.

(2)

The sound waves from the ~~spe~~ speakers could be too loud and so the student should use soundproof ~~sound~~ soundproof headsets

This example does not link the loud sound to damage to the ears/hearing, but does describe a prevention measure.

(ii) Identify a health and safety issue for the student and how it may be dealt with.

(2)

~~The~~ if exposed to loud sound for a long period of time, ~~the~~ it will be hazardous for students eardrums. & may cause hearing problems.

This final example links long periods of exposure to loud sounds with damage to the eardrums and hearing problems. But, does not outline how this can be prevented.

Question 2(b)(i) and (ii)

The investigation as outlined links back to skills students would have developed during core practicals 4 and 6. In core practical 4, students would have identified the difference between positions where 2 sound waves aligned and calculated a mean. In core practical 6, they would have identified positions on a screen where light underwent constructive interference (or maximum sound intensity in the scenario presented).

As such, for Q2(b)(i) students were expected to subtract the values shown to calculate the separation of the maxima, and then calculate the mean separation. Most (55%) completed this successfully, with some realising they could calcualte the mean *w* directly by dividing the difference between the first and last positions by 5.

However some (20%) only calculated 1 value, the *w* as marked on the diagram – this scored only 1 mark as no mean was calculated.

(i) Determine an accurate value for the separation *w* of the maxima.

(3)

· 0.85 − 0.22 = 0.63m
· 1.46 − 0.85 = 0.61m
· 2.09 − 1.46 = 0.63m
· 2.72 − 2.09 = 0.63m
· 3.33 − 2.72 = 0.61m

mean value o w

$\bar{w} = \frac{0.63 + 0.61 + 0.63 + 0.63 + 0.61}{5} = 0.622\text{m}$ to 2s.f.s

$w =$ 0.62m

This example shows a calculation of each separation then determined the mean of these values.

(i) Determine an accurate value for the separation *w* of the maxima.

(3)

$w = \frac{3.33 - 0.22}{5}$

$= 0.62\ \text{m}$

$w =$ 0.62 m

This example shows the direct approach. Both examples were awarded 3 marks.

In Q2(b)(ii) students were asked to complete a follow-up calculation, using a given equation and their value from Q2(b)(i). 41% of students completed the calculation correctly.

However, 48% scored only 1 mark. Many did not convert the various units provided, so ended up with a value that was several powers of 10 out. Alternatively, they did not round the answer to 2 significant figures (all values of *w*, *D* and *s* were given to 2 significant figures).

Determine the value of λ.

$D = 4.0\,\text{m}$
$s = 110\,\text{cm}$

(2)

$\bar{\omega} : \dfrac{\lambda D}{s}$

$0.62 : \dfrac{\lambda \cdot 4}{110 \cdot 10^{-2}} \iff \lambda : \dfrac{0.62 \cdot 110 \cdot 10^{-2}}{4} = \underline{0.171\,\text{m}}$

$\lambda =$ 0.171m

This example shows a correct calculation, but an incorrect rounding, so only 1 mark was awarded.

Determine the value of λ.

$D = 4.0\,\text{m}$
$s = 110\,\text{cm}$

(2)

$W = \dfrac{\lambda D}{s}$

$0.62 = \lambda \times 4 \div 1.1$

$\lambda = 0.17\,\text{m}$

$\lambda =$ 0.17 m

In this example, the answer is correctly rounded, so 2 marks were awarded.

Question 2(b)(iii)

This part of Q2 links to core practical 6, where students would expect a maximum at the midpoint, as at this position there would be zero path difference and the waves would meet and superpose in phase.

For a minimum to have occurred, the waves would need to superpose in antiphase, as destructive interference took place. Since the path difference is zero, the waves were emitted in antiphase, suggesting one speaker was wired in reverse.

Only 20% of students successfully made that link, with many (45%) scoring 0 marks. The remaining 35% scored 1 mark for identifying that destructive interference was taking place.

Suggest why there was actually a minimum intensity at this point.

(2)

Waves are in anti phase as ~~path difference~~

· They interfere & superpose destructively producing minim amplitude hence minimum intensity at this point.

In this example we can see a clear link between the waves being in antiphase and that they interfere destructively causing minimum amplitude. Both marks were awarded.

Suggest why there was actually a minimum intensity at this point.

(2)

-> Between maximas, therefore the waves at the specific point met out of phase, ~~ea~~ superposing and interfere destructively.

“Out of phase” is not specific enough – this could apply to any phase difference that was not in phase. However, there is an identification that this caused destructive interference, for 1 mark.

Question 2(c)

The question now combines skills from core practicals 4 and 6. In core practical 6, the separation of maxima is used to determine wavelength. In core practical 4, the separation of the measured positions gives wavelength directly. The oscilloscope is used to determine the frequency of the wave, so the speed of sound can be calculated.

In Q2(c)(i), students were asked to explain (not just identify) what other apparatus would be needed. In this case, students needed to realise a value for frequency is needed as wavelength was calculated in Q2(b)(ii). Once students had identified the need to determine the frequency, then they needed to state the apparatus that would allow this. Most referred to the oscilloscope method used in core practical 4, but we did allow for other approaches.

(i) To determine an accurate value for the speed of sound, the student would need to use other apparatus.

Explain what other apparatus the student would need.

(2)

Oscilloscope is needed since period can be found. As ~~period~~ frequency $= \frac{1}{\text{period}}$, frequency can be found. Then apply $v=f\lambda$ to find out speed of wave.

This example clearly identifies how frequency can be determined using an oscilloscope for 2 marks.

However, it was rare for students to make this link. 68% scored 0 marks. Most common amongst these were responses that described a speed = distance / time approach.

Explain what other apparatus the student would need.

(2)

A sound ~~[illegible]~~ & reciever as ~~you~~ they can measure the time taken for the sound to reach the reciever and a ruler to measure the distance between the speaker and reciever. $s = \frac{d}{t}$

In Q2(c)(ii) students are asked to explain how an increase in the speed of sound on a humid day would affect the value of *w* measured.

As this is an "explain" question, justification of their reasoning is required, in this case identifying factors that would not change (in this case *f*, *D* and *s* would all be constant). Half of the students did not make this link clear, with most of these simply stating the change to *w* with no justification.

(ii) On a humid day, the speed of sound in air increases.

Explain how an increase in the speed of sound would affect the value of *w* for this investigation.

(2)

As $v = f\lambda$, v increase, ~~λ remain~~ f remain unchanged, so λ increase, and $w = \frac{\lambda D}{s}$, D and s remaind unchanged, so w will increase.

This example gives a clear argument that the increase in speed will lead to an increase in wavelength and therefore an increase in *w*. It also justifies this argument by making clear *f*, *D* and *s* would all be constant. Full marks were awarded.

Explain how an increase in the speed of sound would affect the value of *w* for this investigation.

(2)

① The ~~speed~~ ~~inc~~ increasing of speed leads to larger wavelength if the frequency is constant.

② Larger wavelength leads to one larger w according to $w = \frac{\lambda D}{s}$. So the value of w increases.

This example does link the increase in speed to and increase in wavelength and *w*. But it is missing the justification that the other factors are all constant. The explanation is incomplete, so was awarded only 1 mark.

Question 3(a)(i)

This type of question has been commonly seen in WPH13 and WPH03 papers. A measuring instrument is appropriate if it can cope with the range of measurement values required and has a low percentage uncertainty. Which is why 55% of students scoring 0 was a surprise.

It is clear a metre rule would be appropriate for the range criteria, so to be awarded marks students needed to explain why the metre rule was appropriate in terms of percentage uncertainty.

Since the value given was 5.2 cm, students are made aware that the metre rule is marked in mm. As such, they should be able to state the uncertainty is 0.5 mm (or since it is possible a judgement is made at both ends of the spring, total uncertainty is 0.5 mm + 0.5 mm = 1 mm).

(a) The student used a metre rule to measure the unstretched length l_0 of the spring.

(i) The value of l_0 was 5.2 cm.

Explain why a metre rule is an appropriate instrument for this measurement.

(2)

because the resolusion is 1mm which it's ~~enough~~ accurate enough, % uncertainty - ~~1.92%~~ 0.96%

This example scored both marks. This was rarely seen, only 7% of responses scored 2 marks.

Although appendix 10 of the specification suggests percentage uncertainty below 5% would suggest a value that is accurate or repeatable, this is not a fixed figure and would depend on the practical scenario.

As this is an “explain” question, we did need some justification in the form of a calculated percentage uncertainty value, based on a stated uncertainty or resolution, but we did not require a specific comparison (eg to 5%.)

Question 3(a)(ii)

Students are very likely to have measured the length or the extension of a spring several times. However, 44% of responses scored 0.

Most did score at least 1 mark, but as this is a “describe” question, students needed to develop their answer, giving a clear account of the techniques. As such, only 18% scored full marks.

Most students focussed on parallax error in the length, so descriptions of taking measurements “at eye level” were common.

Describe **two** techniques the student should use to make this measurement as accurate as possible.

(2)

Make sure the ~~metr~~ metre ruler is perpendicular to the base using a set square. Make sure ~~the~~ the reading from the ~~the~~ metre ~~ruler~~ ruler is taken perpendicular to the eye level.

This response scored 2 marks, for a description of how to ensure the rule was vertical and a statement describing how to reduce parallax error.

Question 3(b)(i)

This is a typical question on WPH13. For the data provided, there is only one issue. For both W and l, the data is not recorded to the same number of decimal places as the resolution of the measuring devices. For both variables, the data is rounded to inconsistent decimal places.

As this is a common question, most students were well prepared and 67% were awarded the mark.

There remains a confusion between data recorded to consistent decimal places (measured data – recorded to the resolution of the measuring device) and to consistent significant figures (calculated data – recorded to the same/least number of significant figures as the original data). As such, we accepted inconsistent significant figures, but students should be made aware of the difference.

Question 3(b)(il)

This is a relatively straightforward question. The graph shows 4 plots on or very close to the line of best fit drawn and 1 plot about 1 cm away from the line.

Since students were asked to explain which value should be checked, we needed to see an identification of the 3rd plot (stated or marked on the graph) and the reason why that plot was chosen. Over ½ of responses scored both marks, with another 32% scoring 1 mark (for identifying the value but not explaining the reason that value was chosen).

Question 3(b)(iii)

This question tested a very basic skill, the ability to use a graph to interpolate a value. In this case, matching 8.4 cm on the x-axis to 0.24 N on the y-axis. A tolerance of ½ a square was applied. 22% of responses did not manage to do this successfully.

Question 3(c)

In Q3(c)(i), students were required to use the given data and a given equation to calculate the density of modelling clay. This was performed correctly by the vast majority of students (87%), with another 7% scoring 1 mark as no unit was given.

(i) Determine the density of the modelling clay.

$W_1 = 0.65\,N$
$F = 0.27\,N$
density of water = $1000\,kg\,m^{-3}$

(2)

$\frac{\text{density of modelling clay}}{1000 kg m^{-3}} = \frac{0.65N}{0.65N - 0.27N}$

density of modelling clay = $1710.53\ kg m^{-3}$

Density of modelling clay = $1710.53\ kg\,m^{-3}$

For Q3(c)(ii) students then needed to apply a 4% percentage uncertainty to their value, before comparing their range to the given density of polymer clay. This skill has been tested many times in previous WPH13 papers, and the evidence suggests students were well-prepared as 68% scored at least 1 mark, with 40% scoring both marks.

(ii) The student estimated the percentage uncertainty in his calculated value of the density of modelling clay to be 4%.

The density of polymer clay is $1760\,kg\,m^{-3}$.

Deduce whether the modelling clay could be made from polymer clay.

(2)

$1710.53 kg m^{-3} \times (1 + 4\%) = 1778.95 kg m^{-3}$
$1778.95 kg m^{-3} > 1760 kg m^{-3}$
So the modelling clay could be made from polymer clay.

The 28% that scored 1 mark was commonly due to applying the 4% to the density of polymer clay (1760 kg m^{-3}), so making the wrong range comparison.

Deduce whether the modelling clay could be made from polymer clay.

(2)

$1760\,(1-4\%) = 1689{,}6 < 1710{,}53$

So the modelling clay could be made from polymer clay

Rarer were students who calculated the correct range/limits and made the correct comparison (1778 kg m^{-3} > 1760 kg m^{-3}), but made the incorrect conclusion (that it could not be polymer clay)

Deduce whether the modelling clay could be made from polymer clay.

(2)

$\cancel{1760 \times 4\%} =$

$1710 \times (1+4\%) = 1778.4\ \mathrm{kgm^{-3}}$

$1778.4 > 1760$

So it couldn't be made from polymer clay.

Question 4(a)

Q4(a)(i) is a straightforward calculation of a mean. There are no values significantly distant from the others, with the range of values (3.51 to 3.61 s) being smaller than reaction time (approx 0.2 s). As such, students should have included all 4 values in their mean calculation.

Since all time values were recorded to 3 significant figures, the calculated mean should also be stated to 3 significant figures. 75% were awarded 2 marks with another 21% scoring 1 mark, for an answer not correctly rounded. There were some responses that were awarded 1 mark having incorrectly discounted one time as an anomaly (eg 3.61 s).

Q4(a)(ii) required students to follow the guidance given in appendix 10 to calculate the percentage uncertainty of a set of repeated measurements (uncertainty = half the range). Appendix 10 also allows for using the reading furthest from the mean, which gives the same answer for the data provided. 60% of students scored at least 1 mark, with over ½ scoring both marks. For students who incorrectly eliminated a value in Q4(a)(i), we applied error carried forward.

(i) Determine the mean value of time in s.

(2)

$$\frac{3.57 + 3.61 + 3.54 + 3.51}{4} = 3.56\ s$$

Mean value of time = 3.56 s

(ii) Determine the percentage uncertainty in the mean value of time.

(2)

$$\frac{3.61 - 3.51}{2} = 0.05$$

$$\%u = \frac{0.05}{3.56} \times 100\% = 1.4\%$$

Percentage uncertainty = 1.4%

This response scored full marks for both parts.

Question 4(b)

The introduction text in this question guided students to realise that reaction time was the issue, as with higher force the car would be faster, so time would be shorter. Answers that described how different apparatus could be used to eliminate reaction time were required.

As such, we expected a description of an automated timing system. Students should be aware of light gates and electronic timers from core practical 1, so a description of this approach was expected.

However, it is possible students taking the WPH13 examination had studied WPH14 and completed core practical 10. So, we also accepted the use of a video camera and motion tracking software or frame analysis to determine the time. However, a generic "camera" was not deemed sufficient unless it was made clear a video was recorded.

Most students (74%) scored at least 1 mark, but only 26% gave fully described answers.

Describe how different apparatus could be used to measure the time, so that the percentage uncertainty is reduced.

(2)

A light gate paired with a data logger could be used to measure the timing more ~~a~~ accurately, as well as recorde it precisely.

This response linked the use of light gates to the data logger for more accurate timing – 2 marks.

Describe how different apparatus could be used to measure the time, so that the percentage uncertainty is reduced.

(2)

Use a video camera to recorde to motion play it frame by frame to measure the time.

This response described analysing a video recording frame by frame to measure time – 2 marks.

Question 4(c)(i)

It is common to ask students to link variables in a given equation (in this case *t*) to values determined from a graph (the gradient or the *y*-axis intercept being the most common)

In this case, students needed to explain why *t* can be determined from the gradient, with the most common approach being to re-arrange the given equation and compare this to $y = mx + c$.

(i) Explain why a graph of F against v can be used to determine a value for t.

(2)

$Ft = Mv$

$F = \frac{Mv}{t}$

$F = \frac{M}{t} \cdot v$

~~is~~ which is similar with

$y = mx$

So ~~M~~ $\frac{M}{t}$ is the gradient of the graph since the mass of the toy car M is constant, so the vale for t can be measured.

66% of students scored at least 1 mark, with 33% awarded 2. This was lower than in many previous exam series, perhaps because this question was asked before the graph was plotted, so students had not linked the equation given to the gradient of the *F*-*v* graph.

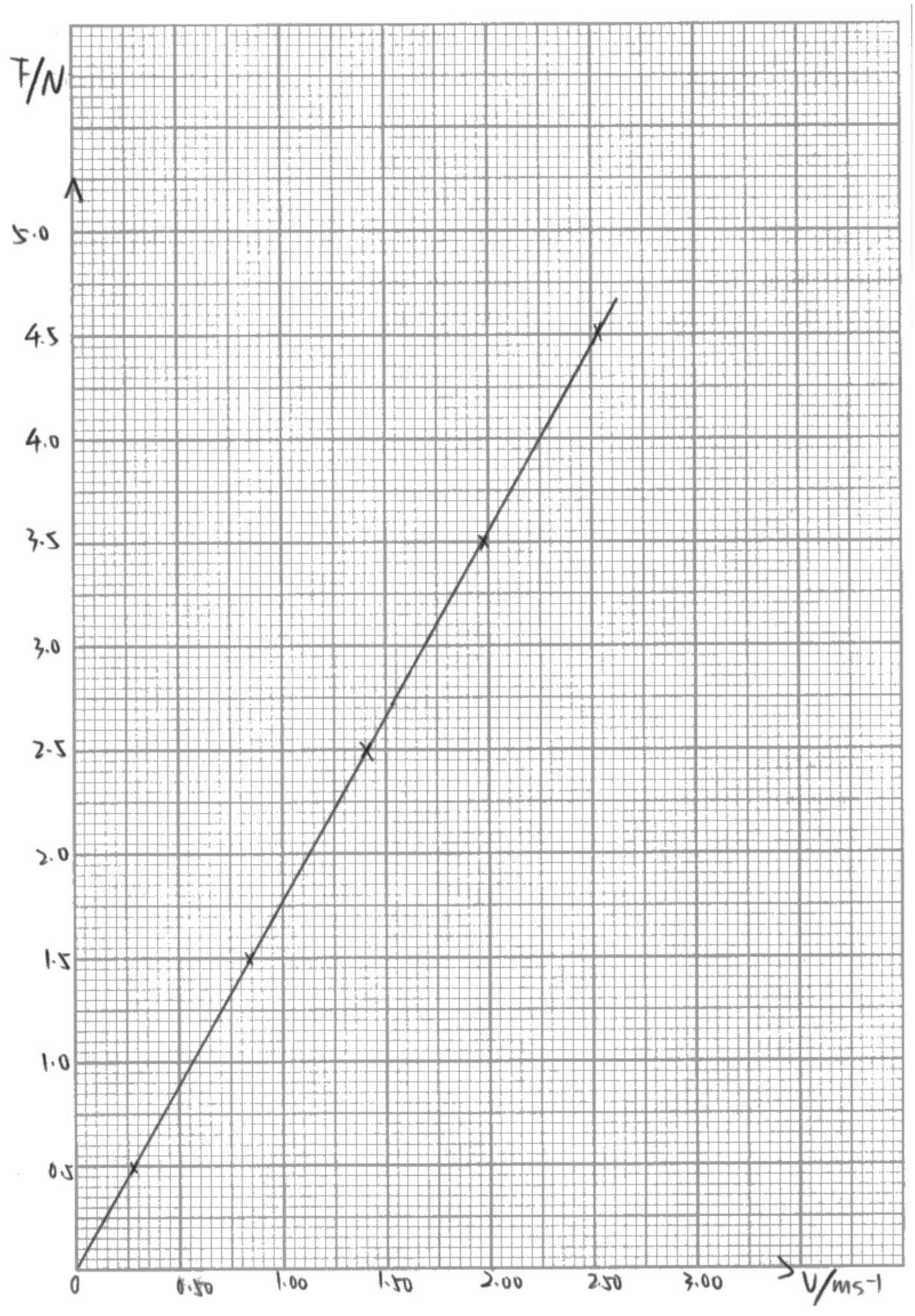
Question 4(c)(ii) and (iii)

Q4(c)(ii) required students to plot a graph of the given data.

Graphs remain a challenge to students, but this is one area where a little more time spent on practice would have a significant benefit (both in WPH13 and WPH16 in the future). There are 5 marks available for a graph on WPH13, so a well-drawn graph could increase student achievement by a grade.

The standard expectations of a well-drawn graph are:

- Labelled axes – the quantity **and** unit separated by a **/**
  eg *F* / N and *v* / m s^{-1} (both were given in the correct format in the results table.)
- 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 *x*-axis increments of 0.5 m s^{-1} every 2 cm and on the *y*-axis increments of 0.5 N every 2 cm
- Data points that are plotted accurately to **within 1 mm** (half a square) in both directions. This means large and 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 ×) 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.



This is an example of a well-drawn graph that was awarded all 5 marks.

The marks were awarded relatively evenly, with 22% scoring 5 marks and 28% scoring 2 marks (most often axis labels and line – due to inappropriate scale choice). Only 6% scored 0 marks, many of which were blank.

Q4(c)(iii) required students to calculate the gradient of their graph, and correctly use this gradient to determine the corresponding value of t, based on the equation provided in Q4(c)(i).

Since students were provided with an equation, some substituted a pair of F and v values from the graph. This was accepted if the student demonstrated that their graph supported this (eg the line of best fit was drawn through the origin).

Most were successful, with 41% scoring all 3 marks and another 20% scoring at least 2 marks (with final values being out of the accepted range).

(iii) Determine a value for t using the gradient of your graph.

$M = 0.125\,\text{kg}$

(3)

Gradient $= \dfrac{4.45 - 0}{2.50 - 0} = 1.78$

$t = \dfrac{0.125}{1.78} = 0.07025$

$t = 0.07025$

This is an example of a correct gradient calculation (using the graph in the example on the previous page), utilising almost the full length of the line (so certainly a large gradient "triangle") and giving a t value within the accepted range.