Examiners' Report
Principal Examiner Feedback

October 2022

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.

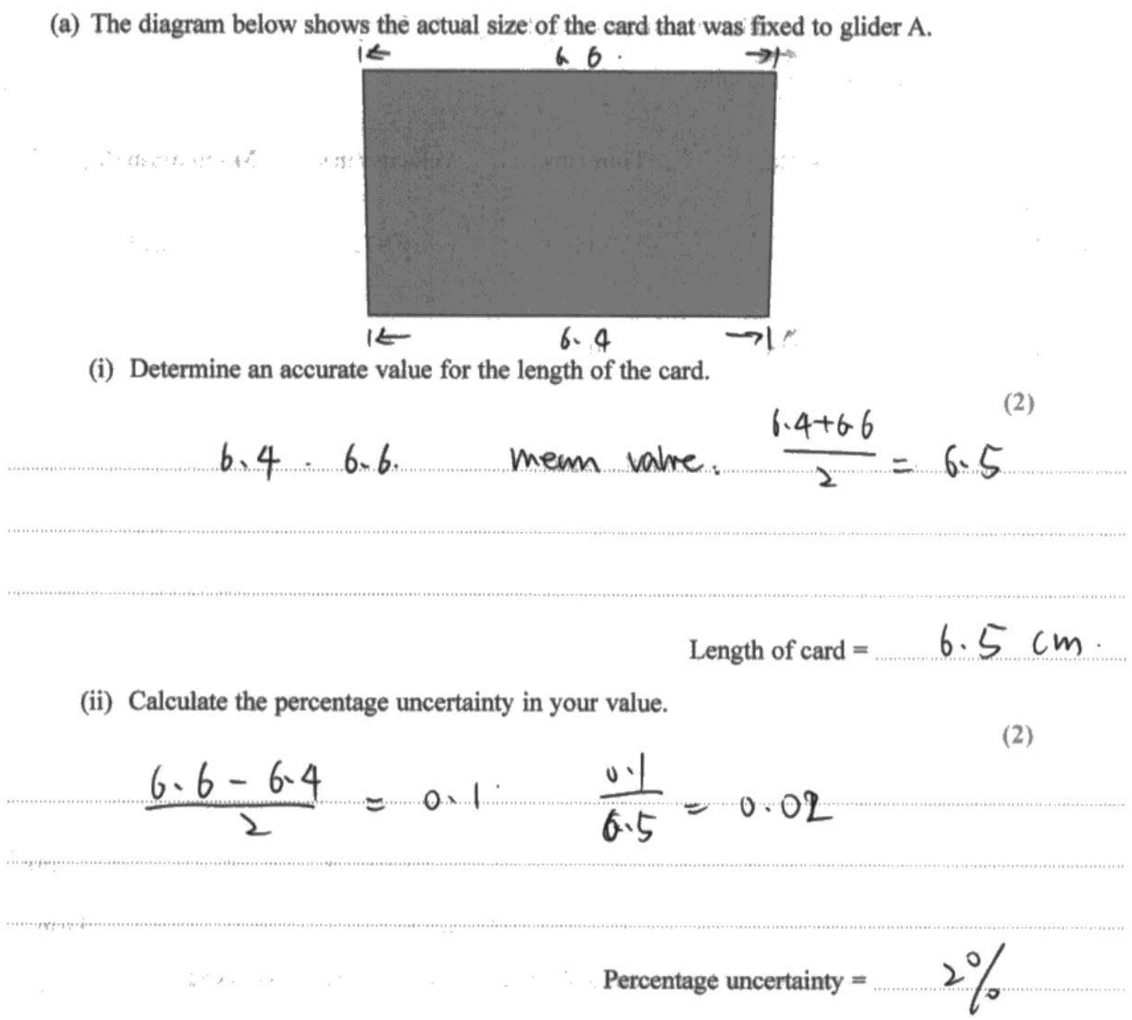
At all ability levels, there were some questions which students answered with generic and pre-learned responses, rather than being specific to the particular scenario as described in the question. Additionally, understanding the meaning of the standard command words (such as evaluate and determine) proved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

Question 1(a)

This question tested the student's ability to measure accurately and calculate a percentage uncertainty for their measurement.

The diagram shows a noticeably non-rectangular shape, suggesting to students that they should take measurements in multiple positions – a skill students would have developed during practical work for WPH11 and WPH12. However, students could also have taken a single measurement across the centre of the card. This means there are different methods to calculate the percentage uncertainty in (a)(ii), which were marked in accordance with the measuring technique shown in (a)(i).

Most students were awarded 2 marks for (a)(ii), but it was common to see only a single measurement (top or bottom) for (a)(i). The example below was awarded 2 marks for (a)(i) and 2 marks for (a)(ii) as the correct calculation method was used for calculating percentage uncertainty in repeated measurements.



(a) The diagram below shows the actual size of the card that was fixed to glider A.

6.6

6.4

(i) Determine an accurate value for the length of the card.

(2)

6.4 6.6 mean value. $\frac{6.4+6.6}{2} = 6.5$

Length of card = 6.5 cm

(ii) Calculate the percentage uncertainty in your value.

(2)

$\frac{6.6 - 6.4}{2} = 0.1 \quad \frac{0.1}{6.5} = 0.02$

Percentage uncertainty = 2%

Question 1(b)

This question asks students to process the data recorded by the light gates and timers, following an inelastic collision of the two gliders on the air track.

For (b)(i), most students correctly used the time and card length to calculate the velocity of the combined gliders as they passed through the second light gate, and then calculated the momentum of the combined gliders.

As students were presented with data recorded to 3 significant figures, students were expected to round their answers to 3 significant figures. Over 50% of students managed to perform both calculations correctly and to round their answers to 3 significant figures.

For (b)(ii), the command word used is determine. This means the answer must contain an element that is quantitive. In this case, a simple statement that momentum was/was not conserved was not enough, there needed to be a quantitative justification of this view for full credit to be awarded.

The example below was awarded 4 marks for (a)(i) and 2 marks for (a)(ii).

(i) Calculate the values missing from the table.

(4)

10.5 cm = 0.105 m

$V = \frac{s}{t} = \frac{0.105\text{m}}{205\times10^{-3}\text{s}} = 0.512$ m/s

$P = mV = 0.274 \times 0.512 = 0.140$ kgm/s

Velocity = 0.512 m s^{-1}

Momentum = 0.140 kg m s^{-1}

(ii) Determine whether the student's values show that momentum was conserved in this collision.

(2)

$\frac{0.143-0.140}{0.143} \times 100\% = 2.1\%$

Yes it is, because the different of two momentums is very small.

Question 1(c)

This question tested the student's ability to apply their understanding of uncertainty to a specific situation. The command word "discuss" required students to identify the issue that was being assessed (the effect on the uncertainty in momentum values), explore the aspect and investigate using reasoning.

Students generally exhibited the misconception that repeating an experiment will always reduce uncertainty, nearly 50% of students took this approach. This demonstrated a misunderstanding between the definitions of uncertainty and accuracy, treating them as the same concept.

In the scenario presented to students, it is unlikely the starting conditions of the experiment will be the same each time, leading to increased uncertainty as there would be a range of time values recorded. As uncertainty in repeated values is estimated to be half the range, repeating the experiment would likely lead to a larger uncertainty in time (and therefore velocity and momentum).

Most students scored some marks, with higher performing students achieving at least 2 marks.

This example gives a well-reasoned argument that explores the 3 key aspects:

- Force is unlikely to be the same each repeat, it is applied by hand
- Different forces would cause different accelerations, velocities, and times recorded by the light gate and timer
- The range of times/velocities would increase the uncertainty in time/velocity and therefore momentum

(c) In the experiment, the student applied a small force with her hand to start glider A moving.

The student repeated the experiment and calculated the mean values of the time taken to pass through each light gate.

Discuss how this affected the uncertainty in the calculated values of momentum.

(3)

- force applied by the hand varies each time
- ~~Thus~~ this leads to uncertainty in initial velocity of glider A this will result in increase in uncertainty in values ~~of~~ of momentum.

Question 1(d)

This question asks students to explain, meaning the answer must include some reasoning or justification. Although the question was written in terms of explaining the advantage of using the light gates and data logger, students could answer by discussing the comparable disadvantage of the stopwatch.

This was answered well by students. Over ¾ of students scored at least one mark, with ¼ being awarded both marks. The example below was awarded 2 marks.

(d) Another student used a stopwatch to measure the time taken for the gliders to travel a known distance.

Explain the advantage of using light gates and a data logger, instead of using a stopwatch.

(2)

There is no reaction time for light gates and data logger, so the uncertainty is lower for using light gates and a data logger

Question 2(a)

This question asked students to justify the conclusion that the resistivity of the salt solution would decrease as the mass of salt dissolved was increased. This means students needed to give evidence to support the statement.

Many students saw *R* and ρ, and attempted to approach the question by considering $R = \rho l/A$.

But, this only repeats the information described in the question.

After measuring the resistance *R* of the salt solution with the ohmmeter, she calculated the resistivity ρ of the salt solution.

It does not allow students to the other information provided, the fact that salt ions are charge carriers. The question links resistivity to resistance, and the mass of salt ions to charge carriers (and hence current), so students were strongly directed towards the evidence required.

This question was targeted to a high demand level, as 3 separate physics concepts needed to be combined. However, most students scored at least 1 mark, with 35% scoring at least 2 marks.

Below is a well-argued response that scored all 3 marks.

After measuring the resistance *R* of the salt solution with the ohmmeter, she calculated the resistivity ρ of the salt solution.

(a) When salt dissolves in water, the salt breaks down into ions. The salt ions are charge carriers.

The student predicted that the resistivity of the salt solution would decrease as *m* increased.

Justify her prediction.

(3)

If more salt was added there would be more charge carriers in the same volume of water, ~~so when the carriers flow they will collide more often increasing~~ the $I = nqva$. Increasing the number of charge carriers would increase the current. Therefore the resistance and resistivity will decrease.

Question 2(b)

Q2(b)(i) highlighted a weakness in the mathematics of many students.

The graph presented demonstrated a linear relationship between the inverse of resistivity and the mass of salt.

The stated conclusion students were asked to explain was that “resistivity... is inversely proportional to the mass”. So, to explain this successfully, students needed to demonstrate that this graph shows that $1/\rho$ was directly proportional to *m*.

How a proportional relationship appears on the graph was largely lacking in student answers.

Many gave vague descriptions of positive correlations. Some correctly identified the line was straight but missed the key detail that a proportional relationship would give a straight line passing through the origin.

The third mark was dependent on identifying **both** aspects of a proportional relationship. As such, the most commonly awarded mark was 1.

We did see straight lines drawn through the origin on the graph. But, as this question asked students to explain, this did not receive credit unless used to justify a statement that 1/ρ was directly proportional to m.

For Q2(b)(ii), the question tested a similar concept as the more usual “Critise the recording of these results” question we see in Q4(a). In this case, the data was presented on a graph, but students should still be considering the number and range of data points recorded when plotting a graph.

The example below scored full marks for both sections.

(i) The student wrote the following conclusion.

The resistivity of the salt solution is inversely proportional to the mass of salt dissolved in the sample.

Explain how the graph supports the student's conclusion.

(3)

According to graph there is ~~straight~~ straight line through the ~~origin~~ origin so $\frac{1}{\rho}$ is directly proportional to m. Which means $m \propto \frac{1}{\rho}$, so ~~resisti~~ resistivity of salt solution is ~~~~ inversely proportional to mass. As mass increases resistivity decreases.

(ii) Give two reasons why the graph may not support the student's conclusion.

(2)

The student took too ~~f~~ few readings. Should have taken at least six readings. ~~to~~ And ~~should be~~ did not take readings starting from zero mass ~~Should~~ so the line of ~~bestf~~ bestfit cannot be drawn accurately.

Question 3(a)

Q3(a)(i) proved a challenge to many students. As they were asked to “describe” the measurement of u and v, which were identified on the diagram, we needed to see more detail than “use a metre rule to measure *u* and *v*” – which was a common answer amongst students at the lower end of the performance scale.

We identified three plausible methods that could be used, each needing 2 measurements to be clearly described (eg using a ruler to measure the distance to the filament and from the paper), and 1 additional process that would be required (e.g., subtracting the two distances).

It was surprising how many students assumed *u* and *v* were velocities, having missed the labels and their descriptions on the previous page. However, nearly 60% of students scored at least 1 mark, but less than 20% scored all three.

It was common for students to give an answer to Q3(a)(ii) whilst describing the method in Q3(a)(i) – as such, we marked (a)(i) and (ii) as a single answer.

Most students were well versed in dealing with practical uncertainty, with 70% scoring at least 1 mark, and 40% scoring full marks. The example below was awarded full marks for both sections.

(a) (i) Describe a method to measure *u* and *v*.

(3)

u and v can be measured using a meter ruler with the zero line being atop the paper. V is measured from zero the value corresponding with the top of the glass container. u is measured from zero to the filament bulb deducting v. To avoid parallax error a set square should be used to take the correct reading

(ii) Identify a possible source of uncertainty in the measurement of *u*, and how it can be dealt with.

(2)

u is determined by deducting v from the total measure which can lead to uncertainity. To minimize the uncertainity u should be taken multiple times and an average value calculated.

Question 3(b)

The overall concept of question 3 is a practical that is likely unfamiliar to students. However, WPH13 expects students to apply the practical skills they have developed to both familiar and unfamiliar situations.

In Q3(b), students were asked to perform calculations, using data and equations provided to them.

This tested their ability to perform a calculation and give the answer using the correct number of significant figures. The only additional information required was the refractive index of air, which students should recall is 1 having studied refraction in WPH12 and used the refractive index of air in calculations.

Most students (nearly 100%) completed the calculation correctly for Q3(b)(i), but 12% did not round their answer correctly.

Q3(b)(ii) proved more challenging, with 19% failing to score any marks. But 61% did remember the refractive index of air is 1 and completed the calculation successfully to score 3 marks.

The example below was awarded full marks.

(i) For a lens, P can be calculated using

$$P = \frac{1}{u} + \frac{1}{v}$$

Calculate the value missing from the table.

(2)

Here, $P = \frac{1}{0.615} + \frac{1}{0.374} = 4.29 \approx 4.30$

So, the missing value is 4.30.

$P =$ 4.30 D

(ii) When surrounded by air, the power of a lens this shape can be calculated using the equation

$$P = \frac{n_{lens} - n_{air}}{n_{air}}\left(\frac{1}{r}\right)$$

where r is the radius of the curve that forms the lens
n_{air} is the refractive index of air
n_{lens} is the refractive index of the liquid.

Determine the value of n_{lens} when $r = 0.070$ m.

(3)

mean for power = (4.28 + 4.31 + 4.30)/3 = 4.30 D.

$n_{air} = 1$. So, $P = \frac{n_{lens} - n_{air}}{n_{air}} \left(\frac{1}{r}\right)$

or, $4.30 = \frac{n_{lens} - 1}{0.070}$.

$\therefore n_{lens} - 1 = 0.30$

$\therefore n_{lens} = 1.30$

$n_{lens} =$ 1.30

(Total for Question 3 = 10 marks)

Question 4(a)

This type of question appears regularly in WPH13 exam papers.

As the data recorded are **measured** values, they should all be recorded to the same number of decimal places (eg the resolution of the measuring device).

Nearly 70% of students scored at least 1 mark, but many were too vague and did not identify *d* as the quantity when identifying inconsistent decimal places to be an issue.

This example is clear, so scored 2 marks.

(a) Criticise the recording of these results.

(2)

• incosistent number of significant figures on second collum called << d / m >> and on first collum << f / N >>

• no evidence of reapeat and average

This example to too vague, so scored 0 marks.

(a) Criticise the recording of these results.

(2)

The results may not give accurate readings, the result have different values of significant figures.

Question 4(b)

Graphs remain a challenge to students, but this is one area where a little more time spent in the exam 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 expectations of a well-drawn graph are:

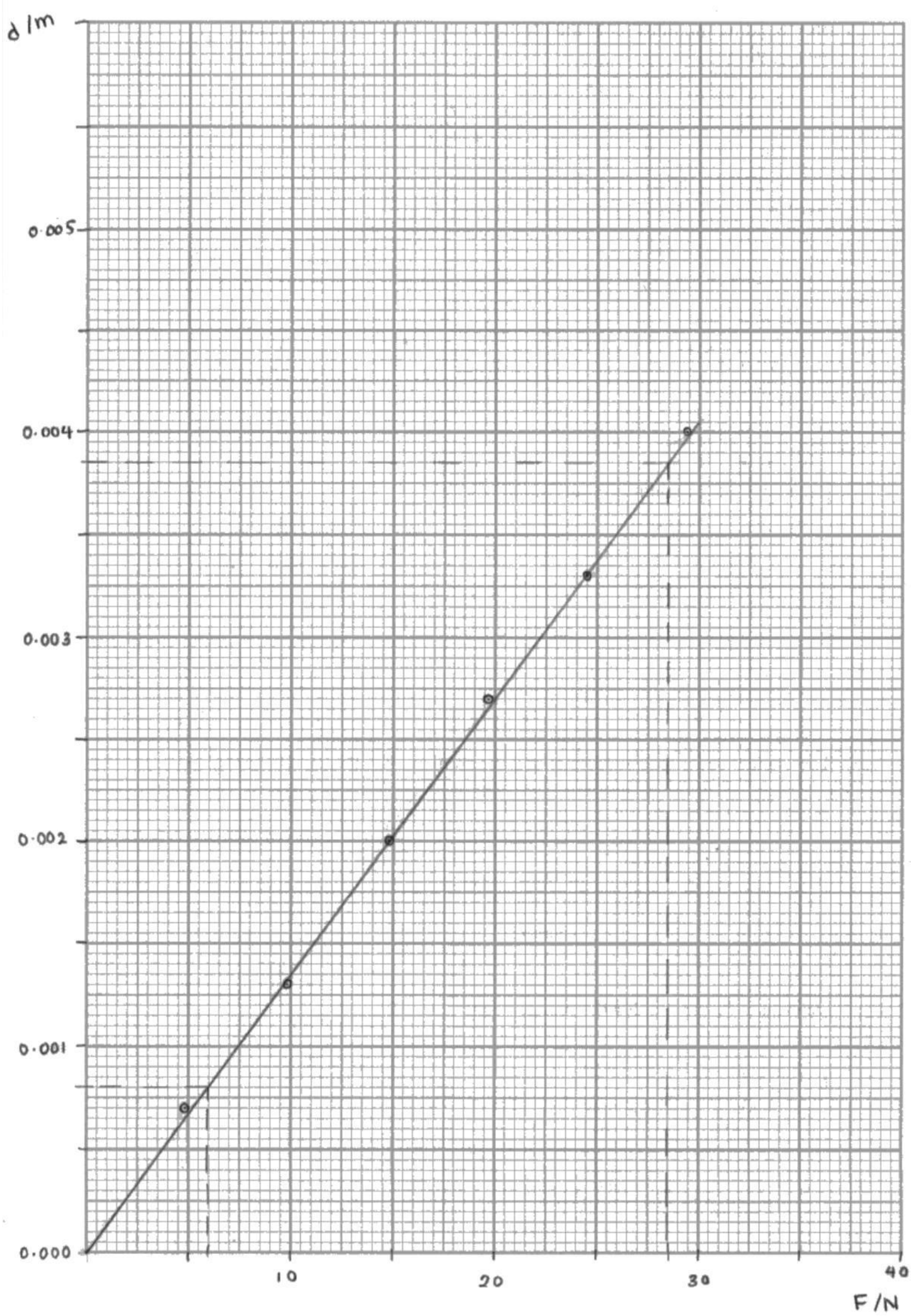
- Labelled axes – the quantity **and** unit separated by a ***/***
  eg *d* / m and *F* / N
- Scales chosen that maximise the size of the used portion of the graph, while still being an easily interpreted scale. The graph paper provided is divided into 10 small squares every 2 cm, so we expect a scale 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 5 N every 2 cm and on the *y*-axis increments of 0.005 m every 2 cm
  NOTE – a scale that is difficult to interpret may also mean plots **cannot** be checked – reducing the mark awarded by 3.
- 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.
- A well-balanced line of best fit that follows closely the trend of the plots. This includes any incorrect plots students may have assumed was an anomaly if the plot has not been marked as an anomaly.

The marks for the graph were spread evenly.

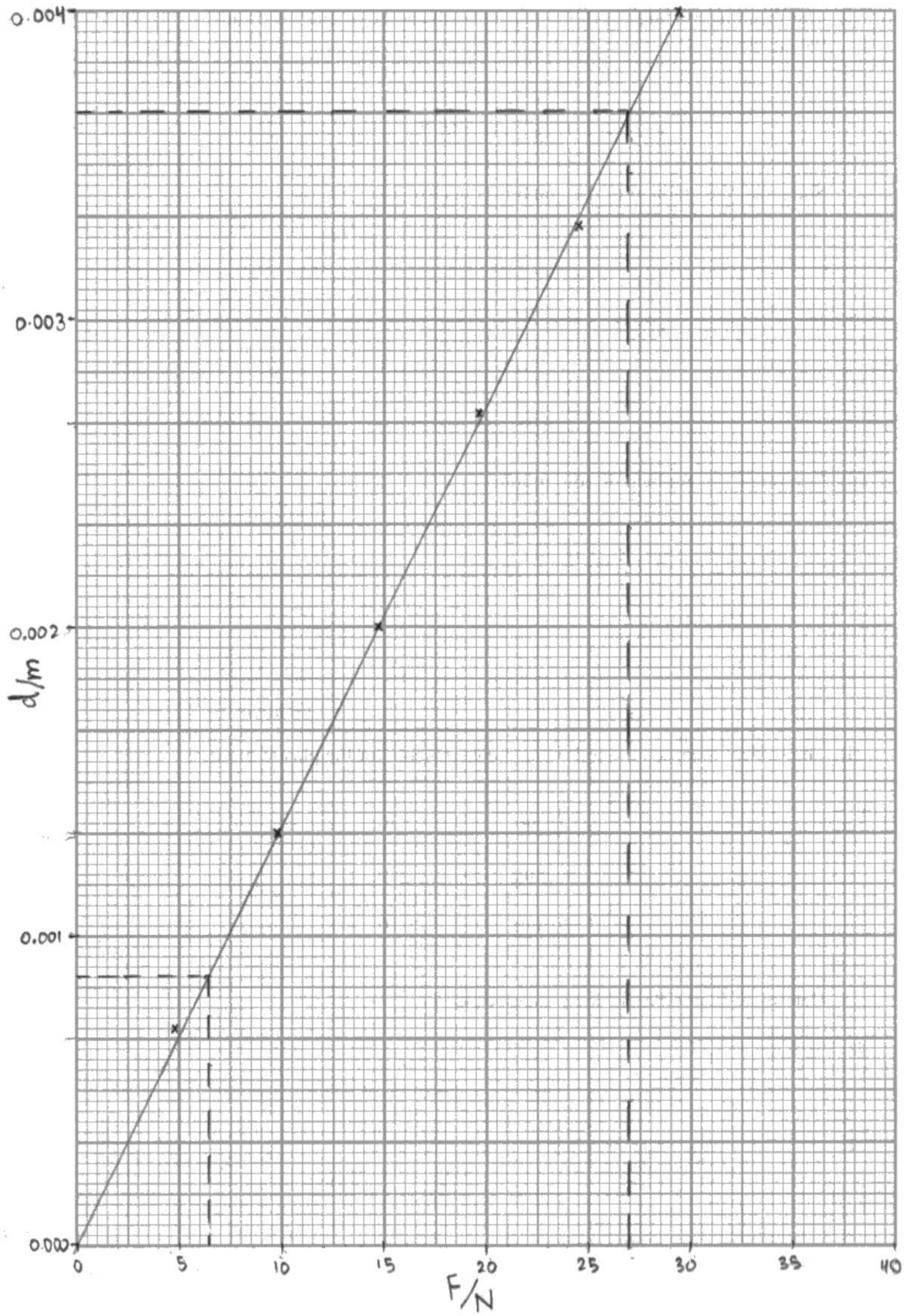
Just under 7% did not score any marks, but these were largely blank graphs where students ran out of time.

This means 93% of students scored at least 1 mark, 17% earned full marks, with 42% scoring 3 or more marks.

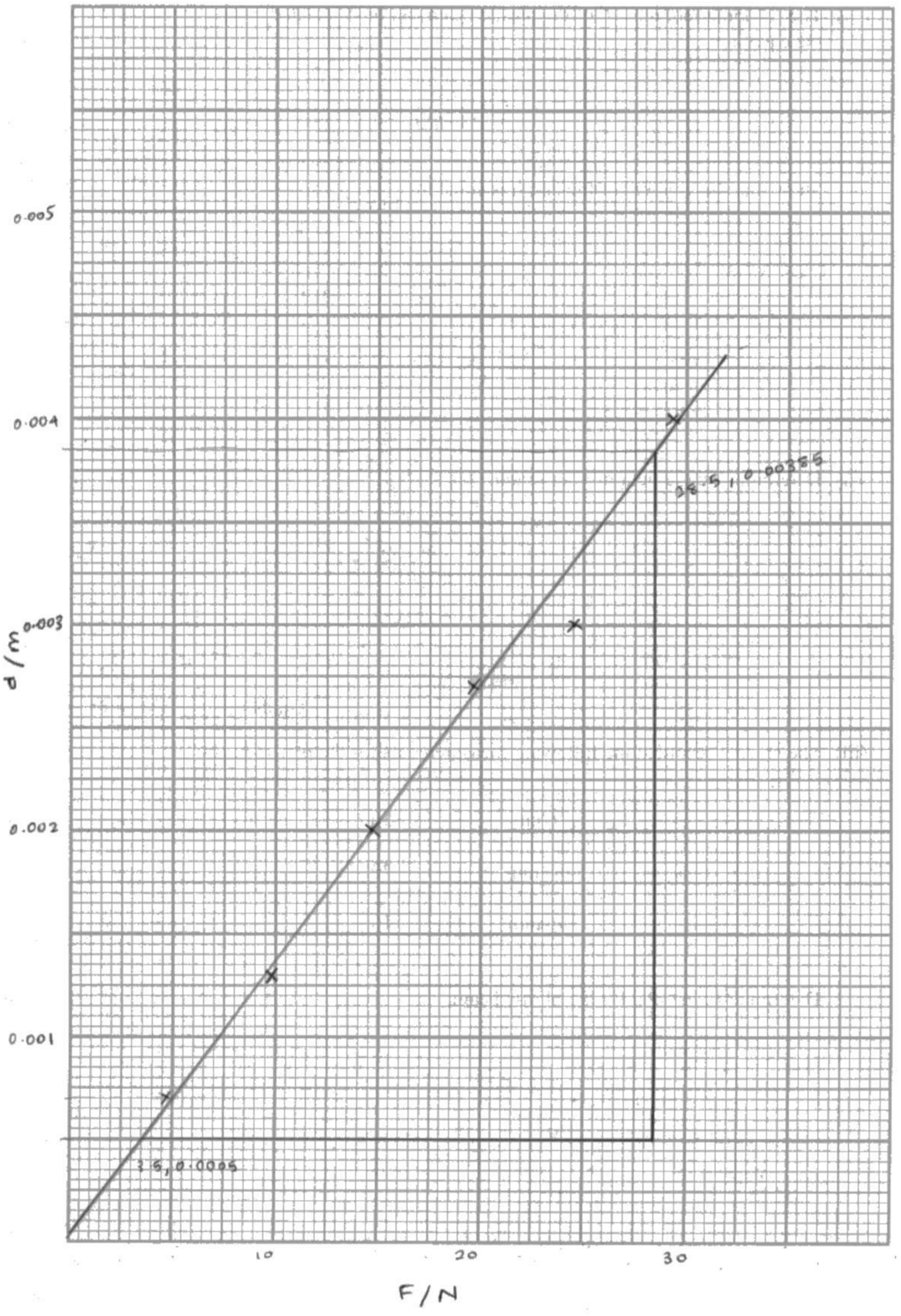
This graph was awarded all 5 marks. Note, the plots are marked as ⊙, which is hard to make out, but we can identify the centre of the plot.



This graph looks good at first glance, however the *y*-axis scale is unsuitable. The scale increases by 0.0003333... m every 2 cm (0.001 m every 6 cm). This means every 1 mm on the scale (plot accuracy required) is 0.00001666 m, too unsuitable for checking accuracy. As such, only the first and last marking points were awarded.



This graph does have labels and a suitable scale on both axes. The plots a small and clear, but there is an error in one plot. This plot has not been identified as an anomaly, so the student should have considered the impact of this plot when balancing the line of best fit. So, this graph scored 3 marks.



Question 4(c)

Q4(c) tests the student's ability to analyse a graph.

In (c)(i), students are asked to show (by rearrangement and comparison) that the gradient is equal to the given formula.

Most students scored full marks. But, despite this style question being common in WPH13 exam papers, many students (18%) did not make a comparison between the rearranged equation and gradient, and some skipped steps in the re-arrangement (or made mistakes), so did not clearly "show" the link.

For (c)(ii), students then use the standard mathematical process to determine the gradient of their graph. Again, most (45%) scored full marks, but 27% only scored 1 mark, as the choice of data points used in the gradient calculation were too close together. We expect the separation of the data points to be over half the length of the line of best fit (see the example graphs shown for Q4(b))

Finally, in (c)(iii) students were expected to combine their gradient and the gradient formula stated in (c)(i), although we did credit students who used the equations and data from their graph. In both cases, it was common to see *l*, *w*, and *h* substituted without conversion to m. It was also common to see incorrect conversions of Pa to GPa. As such, 37% of students scored 0 marks, but 27% scored full marks.

The example below scored full marks for each section.

(c) (i) The 'bending modulus' E of the plastic beam can be calculated using the equation

$$E = \frac{l^3F}{4wh^3d}$$

Show that the gradient of the graph is equal to $\frac{l^3}{4wh^3E}$

(2)

$E = \frac{l^3 F}{4wh^3d}$ ~~E~~ $4wh^3dE = l^3F$

~~$E = \frac{l^3}{4wh^3d} \times F$~~ $d = \frac{l^3}{4wh^3E} \times F$

~~$y = m \; x$~~ $y = m \; x$

~~$m = \frac{l^3}{4wh^3d}$~~ $m = \frac{l^3}{4wh^3E}$

(ii) Determine the gradient of your graph.

(28.5, 0.00385) (6, 0.0008)

(2)

$m = \frac{0.00385 - 0.0008}{28.5 - 6} = \frac{0.00305}{22.5} = 1.36 \times 10^{-4}$ ~~$N m^{-1}$~~ $m N^{-1}$

Gradient = 1.36×10^{-4} $m N^{-1}$

(iii) The student recorded the following measurements for the plastic beam.

l/cm	30
w/mm	20
h/mm	10

Determine E, in GPa, for the plastic beam.

(2)

$m = \frac{l^3}{4wh^3E}$ $\frac{(30 \times 10^{-2})^3}{4 \times (20 \times 10^{-3})^3 \times (10 \times 10^{-3})^3 \times E} = 1.36 \times 10^{-4}$

$E = 2.48 \times 10^9$ Pa

$= 2.48$ GPa

$E =$ ~~2.48~~ 2.5 GPa

Question 4(d)

This question required students to combine two ideas.

The first, based on the equation provided on the previous page, was that if *h* was smaller, then *d* would be larger (for any given force *F*, as *E* is constant).

The second required students to recall that a larger measured value, has a smaller **percentage** uncertainty (assuming the same measuring device was used).

Both marking points can be seen in this example.

> **(d)** The student's teacher suggested that using a plastic beam with a smaller value of *h* would improve the measurement of *d*.
>
> Justify the teacher's statement.
>
> **(2)**
>
> Correct, smaller h, The greater The value of d, since uncertainty is the same and mean value is greater precentage uncertainty would decrease

Most students 67%) scored at least the first marking point, but only 16% related this to percentage uncertainty. Most only referred to uncertainty, but the uncertainty of a single measurement is half the measuring device resolution, which would be the same.

Question 4(e)

This question was written to target 1 low-demand mark and 1 high-demand mark.

The key difference between this question and similar questions in the past was that students were not asked to identify and "solve" a safety issue. They were asked to explain (in terms of physics concepts) why using glass would cause a safety issue.

There are two concepts, linked to the Materials topic studied as part of WPH11, that apply.

- Glass is more brittle, therefore likely to break rather than deform (physics explanation).
- The broken glass could then cause cuts or enter the eye (safety issue).

or

- Glass is stiffer, therefore required a larger force to produce a similar d (physics explanation).
- A larger force would require a larger mass, which could fall and injure feet/legs (safety issue)

Most students considered the first version, but only 8% of responses included the physics explanation. 45% of responses described a relevant safety issue. But 47% of responses were too vague, with statements such as "the glass could break and injure someone" being common.

The example below scored 2 marks.

(e) The student suggested repeating the investigation using a glass rod instead of a plastic beam.

Explain a safety issue that would be caused by using a glass rod.

(2)

Plastic beams are more elastic ~~and~~ Glass however is more brittle and fragile than ~~g~~ plastic and sharp piecies of glass can chatter everywheme when glass is broken. fragmented piceses of glass can be on the floor causing cuts on legs or even get into eyes which could result in an eye injury.

(Total for Question 4 = 17 marks)