Examiners' Report
Principal Examiner Feedback

October 2019

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

Introduction

This is the second time the Pearson Edexcel International AS-level paper WPH13, Practical Skills in Physics I, has been sat by students. The paper is worth 50 marks and consists of five questions, enabling students of all abilities to apply their knowledge and skills to a variety of styles of question.

Each question tests knowledge, understanding and skills students developed while completing practical investigations during their Unit 1 and 2 studies.

As student understanding of the 8 core practical tasks will be assessed by the WPH11 and WPH12 papers, the practical contexts met in the WPH13 paper may be less familiar.

These practical tasks described will be related to content taught for WPH11 and WPH12. However, the focus of WPH13 is assessment of the practical skills the students have developed, as applied to the physics context described in the question.

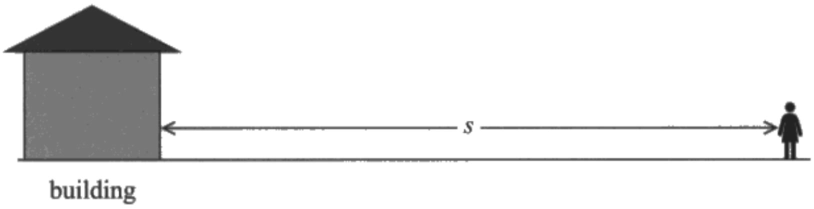
There will be questions that are familiar for students who had studied previous series' WPH03 papers, but there are some questions where performances would suggest that they were unfamiliar with the practical skills.

At all ability levels, there were some questions where students answered with generic and pre-learned responses, rather than being specific to the particular scenario as described in the question.

Understanding of keywords (such as resolution) and command words (such as describe and explain) proved a challenge to students at the lower end of the ability range.

Question 1 (a)

1 A teacher demonstrated echolocation to her students. The teacher made a loud sound and an echo returned from a distant building as shown in the diagram.



The teacher and five students stood a distance s from the building. Each student measured the time t between hearing the sound and hearing the echo.

(a) State one source of uncertainty in the values of t measured by the students.

(1)

the reaction time with the stopwatch since value of t is very small therefore uncertainty is large

The typical response students gave referred to reaction time – scoring 1 mark.
Responses that did not receive credit tended to refer to the distance *s* rather than the time.

Question 1 (b)(i)

This question proved a challenge to students taking the examination. The question stated that both the "teacher" and "student" suggestions were reasonable and to explain why this is so.

There was an assumption made by many, that a value that is not in agreement with other values (the term "not concordant" was seen often) is automatically an anomalous result and should be discarded. In this question, students were led to challenge this assumption by explaining the "student" view.

However, the majority of the answers focused on one aspect only, that the 0.75 value was far from the others.

Although students sitting the exam were not expected to remember a typical a value for reaction time, Q1(a) responses indicate these students are well aware of the relative size of reaction time compared to these values, but few considered this when explaining the "student" view in the question.

Example 1:

(b) The table shows the values recorded by the five students.

Student	1	2	3	4	5
t/s	0.88	0.87	0.91	0.75	0.88

The students suggested that they should include in their calculations all the values of t.
The teacher suggested the value recorded by student 4 should be discarded.

(i) Explain why both of these suggestions are reasonable.

(4)

Since student 4 has a large ~~time~~ gap ~~bet~~compared to other results it ~~be~~can be considered an anomaly & discarded

Since it ~~is~~ the different isn't that it can ~~co~~be counted to get better value for avg

In this example, the "student" suggestion that all values should be included was barely considered. It was awarded 1 mark, for the idea that student 4's result had a large gap compared to the other results. However, there was no explanation of this. The idea that including all 5 values would give a "better average" was common.

Example 2:

(i) Explain why both of these suggestions are reasonable.

(4)

By the students way of thinking the mean would be 0.86 ± 0.115 (±13%) which has not a so large uncertainty that it could be used * ~~but~~. The teacher's way will have a mean value of 0.89 ± 0.025 (± 2%) which has a much smaller uncertainty and it will give more accurate results. However in both cases the value won't ~~have~~ give a huge uncertainty and the error won't be huge so both are reasonable

Also a difference of 0.15 can be explained by reaction time

This second example scored 3 marks.

There is a clear explanation of the "student" view, calculating the uncertainty of all 5 values and comparing that 0.11s to a reaction time of 0.1s.
There is then a comparison to the range of the 4 values the "teacher" suggested using.
However, the justification for excluding student 4's result was not clear.

Question 1 (b)(ii)-(iv)

These calculations followed on from Q1(b)(i) – so either method of calculation (using or discarding student 4's value) were rewarded equally.

(b)(ii)

The calculation of the mean was generally performed well.
Occasional calculation errors occurred, as the values given were to 2 significant figures the final mean should have also been given rounded to 2 s.f.
However, the most common reason the second mark was not awarded was failing to include the unit.

(b)(iii)

As the question included a table of repeated values, with different values, the expected method for answering Q1(b)(iii) is that shown in the specification, in appendix 10.
e.g.

- Use of half the range to give the uncertainty.
- The difference between the mean and the value furthest from the mean

The example calculation in the mark scheme was for students who followed the "teacher" method from (b)(i) – however, all correct calculations for the percentage uncertainty in the mean calculated in (b)(ii) were rewarded.

(b)(iv)

The question clearly asked for the maximum distance to the wall of the building, calculated using the maximum time (which could be 0.91 s from the table, but could also be calculated using the percentage uncertainty calculated in (b)(iii).
However, some students calculated the mean distance while others calculated the total distance travelled by the sound, forgetting to divide that by 2.

Example 1:

(ii) Calculate the mean value for t.

(2)

Mean value $= \frac{0.88+0.87+0.91+0.88}{4} = 0.885 \simeq 0.89\ s$

Mean $t =$ $0.89 s$

(iii) Calculate the percentage uncertainty in t.

(2)

Uncertainty $= \frac{0.91-0.87}{2} = 0.02\ s$

percentage uncertainty $= \frac{0.02}{0.89} \times 100 \simeq 2.25\%$

Percentage uncertainty in $t =$ 2.25%

(iv) The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$.

Calculate the maximum value of s from the students' values.

(4)

$S = \frac{1}{2}vt = \frac{1}{2} \times 330 \times 0.91 = 150.15\ m$

Maximum $s =$ $150.15\ m$

This is a good example of an answer scoring the full 2, 2 and 4 marks. It is well organised, with clear calculations. The rounding of final answers is correct for (b)(ii). Fortunately for this student, the exam tested understanding of significant figures on part (ii) only.

Example 2:

(ii) Calculate the mean value for t.

(2)

$(0.88+0.87+0.91+0.88) \div 4 = 0.89$ s

Mean t = 0.89 s

(iii) Calculate the percentage uncertainty in t.

(2)

uncertainty = $0.1 \div 2 = 0.05$ s

percentage uncertainty = $0.05 \div 0.89 \times 100\% = 5.62\%$

Percentage uncertainty in t = 5.62%

(iv) The speed of sound in air is 330 m s^{-1}.

Calculate the maximum value of s from the students' values.

(4)

$s = vt$ · displacement are proportional to the time.

the maximum time ~~cause~~ compared with maximum displacement.

$t = 0.89 + 0.05 = 0.94$ s.

$s = vt = 330 \times 0.94 = 310.2$ m

Maximum s = 310.2 m

In this example, (b)(ii) was calculated using the values from students 1, 2, 3 and 5. It was correctly rounded to 2 s.f. and the correct unit was given – so the full 2 marks were awarded.

However, for (b)(iii) the incorrect method to calculate uncertainty was used. Uncertainty being half the resolution of the device is the method used for a **single** value or repeats that give the **same** value each time. As such, (b)(iii) scored 0 marks.

For (b)(iv), there is a correct use of s = v and this is used with a **maximum** value of time. However, the factor of 2 is missed, so the value calculated is the total distance the sound travelled not the distance to the wall of the building.

Question 2(a)

It is clear students are well practised in converting an equation into a linear form ($y = mx + c$) for analysis using a graphical method. Unfortunately, this is the approach a large number of the students followed.

This methodology would have been useful if the question had asked them for a method to determine v or g. Complex description of how to measure v using light gate were seen. However, this was irrelevant.

The students were told that horizontal distance d was measured for different launch angles θ. So repeating this idea was not credited. However, as students were to describe the experimental method, identifying the equipment used to make these measurements was rewarded. In many cases this was the only mark awarded.

Some students refered to repeating the measurements to calculate a mean, which was rewarded if it was clear d was the measurement being repeated.

However, the detemination of most students to generate a linear graph, plotting a d against $\sin 2\theta$ graph to find a maximum of $\sin 2\theta$ from which to calcualate θ demonstrated a misundertanding of the equation and the sin function itself (as $\sin 2\theta$ would always have a maximum value of 1 and θ a value of 45°).

(a) Describe an experimental method to determine the value of θ at which d is a maximum.
(4)

*Use a range of θ from 0° to 90° at ~~intervals~~ relatively wide intervals. (e.g: use θ=0°, 15°, 30°, 45°, 60°, 75° and 90°).

~~*Plot a graph of d against~~

*Launch a certain ball and measure the distance d using a meter ruler.

*Repeat several times for each θ and calculate the mean value of d each time.

*Plot a graph of d against θ. Find the range in which the contains maximum. ~~is in~~

*Use more ~~x~~ angles within that range (e.g: 30° ~ 60°) at shorter intervals and repeat for each θ as the previous procedure.

*Plot more precisely in the selected range and find the value of θ at which d is a maximum.

This example was awarded 4 marks.
The equipment for measuring d is given, repeating to give a mean value of d is described.
This example uses a graph of d against θ to find the maximum d and the corresponding θ value.
The rarely seen idea, that of using a smaller interval of angle around the maximum can also be seen.

Question 2(b)

The responses to this question suggest many students do not understand the difference between the command words 'state' (recall one or more pieces of information) and 'suggest' (use your knowledge and understanding in an unfamiliar context). Though projectile motion is not unfamiliar, this particular laboratory practical may be.

Many answers simply stated factors, such as "air resistance not considered" or "parallax error". These ideas were not used to suggest a reason why the distance was smaller at 45˚ (or why the angle needed to be less than 45˚ to reach maximum distance)

These examples show answers with two clear and distinct reasons why the distance measured is not at maximum at 45˚.

Example 1:

(b) The equation predicts that when θ is 45°, d is a maximum.

From the student's measurements, d was a maximum when θ was less than 45°.

Suggest two reasons why.

(2)

• Effect of air resistance may have reduced vertical velocity

• The student may have measured 'd' inaccurately ~~reasong being~~ which allowed parallex error.

Example 2:

(b) The equation predicts that when θ is 45°, d is a maximum.

From the student's measurements, d was a maximum when θ was less than 45°.

Suggest two reasons why.

(2)

Air resistance. Work is done againt the resistance so less velocity.

Parallax error when measuring the angle.

Question 3(a)

This question was one where students generally did not consider the context described in the question.

Many gave a generic, pre-learned answer, rather than use the idea of suspending the rod using a thread.

Example 1:

3 A student was given a thin aluminium rod of length 30 cm.

(a) The rod appeared to have a uniform diameter.

Explain how the student could confirm that the rod had a uniform diameter, by suspending it from a thread.

(2)

Student should use micrometer to measure the diameter of aluminium rod in different ~~[illegible]~~ position. and find the mean of the diameter compare with ~~those~~ other readings.

This answer has not considered the context described in the question and has only given the "default" answer seen many times in the past. As this does not answer the question asked, it scored 0 marks.

Example 2:

3 A student was given a thin aluminium rod of length 30 cm.

(a) The rod appeared to have a uniform diameter.

Explain how the student could confirm that the rod had a uniform diameter, by suspending it from a thread.

(2)

The student can suspend the ~~[illegible]~~ rod at it's middle (by measuring at the 15cm mark). If the rod remains level, it means that it has uniform diametre because anticlockwise moments = clockwise moments hence it's in equilibrium. It means that the centre of mass is in the middle of the rod.

This student has answered the question asked. The answer explains with clear physics ideas why suspending the rod at it's middle and it being horizontally balanced, will demonstrate it is uniform.

Question 3(b)(i)-(ii)

Although this would not be the most straight-forward method to determine the p.d. across the full 30 cm length of the rod, it is the method the student is following in the question.

In the context of this question, the student has decided after making three measurements to extrapolate the line to give the value of p.d. to be used in the final calculation.

(b)(i)

The idea that p.d. across a length of conducting rod is directly proportional to the length of the rod should have been familiar to students from WPH12.

As such, a straight line of best fit should have been drawn, terminating between 0.40 and 0.45 V. There were a significant number of students who drew a curved line, terminating between 0.25 and 0.30 V.

The three data points plotted suggest some systematic error occurred, as the line of best fit misses the origin. However, students who assumed the line should pass through the origin would still achieve a V value within range if the line of best fit drawn was balanced.

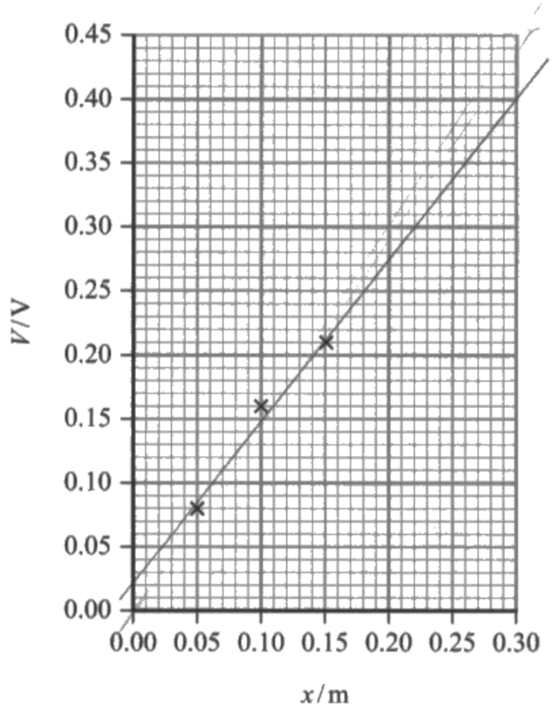
(b)(ii)

This part of the question assessed students in their ability to perform calculations using data derived from a practical, in this case the exptrapolated p.d. from (b)(i).

Although many students were successful, a large number correctly calculated the p.d. of the 0.2 Ω resistor but failed to add the two p.d.s together to give the terminal p.d.

Example 1:

The student plotted the values on a graph.



(i) Determine the value of V when x is 30 cm.

(1)

V = 0.40 V

(ii) The student measured the resistance of the full length of the rod using an ohmmeter.

The resistance was 70 mΩ.

Determine the terminal p.d. of the cell.

(2)

$R = \frac{V}{I}$

$\cancel{0.2}$ $70 \times 10^{-3} = \frac{0.40}{I}$

~~$I = 5.71A$~~ ~~$1.48A$~~

$I = \frac{40}{7}$ A

~~$R = \frac{V}{I}$~~

~~$70 \times 10^{-3} = \frac{V}{}$~~

~~voltage~~ p.d. in resistor

$0.2 = \frac{V}{\frac{40}{7}}$

$V = \frac{8}{7}$ V

~~$R = \frac{V}{I}$~~

~~70×10^{-3}~~

Terminal p.d. $= \frac{8}{7} + 0.40$

$= 1.54$ V

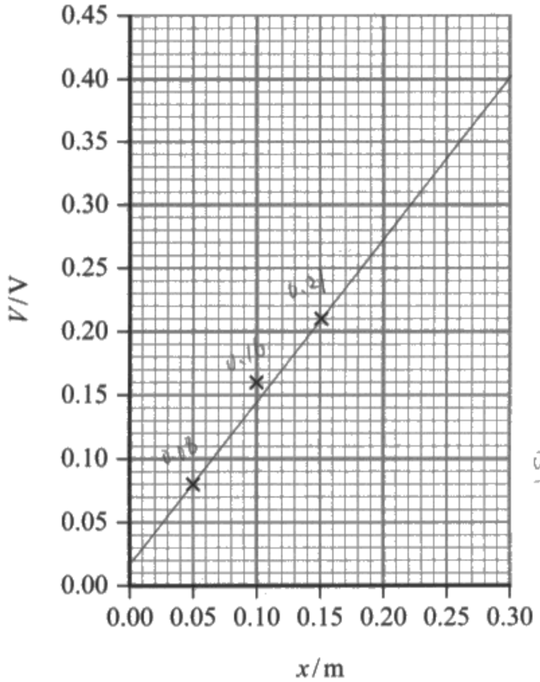
Terminal p.d. = 1.54 V

In this example we can see a straight line of best fit, that gives a value within range.

This value is then used correctly in the calculation. So this example scored 1 and 2 marks.

Example 2:

The student plotted the values on a graph.



$\frac{0.21 - 0.08}{0.15 - 0.05} =$

(i) Determine the value of V when x is 30 cm.

(1)

$V =$ 0.39 V

R V 30cm →

(ii) The student measured the resistance of the full length of the rod using an ohmmeter.

The resistance was 70 mΩ.

$7\times10^{-6}\,V = 0.078$
10^{-6}

Determine the terminal p.d. of the cell.

(2)

$\frac{70\times10^{-6}}{0.3}$ ± $\cancel{R_t = R_1 + R_2 = 70\times10^{-6} + 0.2 = 0.2\,\Omega}$

$\frac{70\times10^{-6}}{0.39} = \frac{0.2}{V}$

$V =$

Terminal p.d. = ...

In this example, we can see a good line of best fit which gives 0.40 V at 30 cm. However, the student has recorded the value of 0.39 V, which is out of range.

The calculation is started correctly. If evaluated, this would have given the p.d. of the 0.2 Ω resistor. If this was then added to the 0.39 V of the 30 cm rod, the terminal p.d. would have been calculated correctly.

Alternatively, if the total load resistance of the circuit (0.27 Ω) had been substituted, the V calculated would have been the terminal p.d. So this response scored 0 and 1 mark.

Question 3(c)

The question asked students to explain the reason taking further readings would improve the accuracy of the calculated terminal p.d. As the terminal p.d. value was determined using the result of an extrapolated line of best fit, this line of best fit forms the basis of the answer. A more accurate line of best fit would lead to a more accurate p.d. for the 30 cm rod, which was used for the calculation of the terminal p.d.

Many students referred in general terms to making the graph more accurate, or "better", without linking this to the line of best fit. Most focussed on the idea of taking repeat readings, discarding anomalies and taking the mean, which could make a single p.d. reading more accurate. Without linking more accurate p.d. values to the idea of a more accurate line of best fit, this was insufficient to explain why the terminal p.d. would be more accurate.

Example 1:

(c) The student measured only three values of V and x.

Explain why taking further readings could improve the accuracy of his value for the terminal p.d. of the cell.

(2)

If he takes more readings he can plot them on his graph making the line of best fit more accurate. This makes it easier to identify anomalies.

This example clearly states the line of best would be more accurate. However, it does not link this to a more accurate p.d. for the rod.

Example 2

(c) The student measured only three values of V and x.

Explain why taking further readings could improve the accuracy of his value for the terminal p.d. of the cell.

(2)

Taking further readings can reduce random error, and the best-fit line of the graph will be more accurate, ~~&~~ so the line will show a more accurate p.d. across the rod of full length.

In this example, both ideas can be seen. The line of best will be more accurate, leading to a more accurate p.d. for the full length of the rod.

Question 4(a)

The command word "determine" required an answer with quantative element, calculations using the data provided. In this case, the calculations were required to support the student's decision regarding whether *k* was a constant.

The students were provided with the data and the equation. To determine whether *k* was a constant would require at least 2 calculated values of *k*. The values of *k* calculated were with 3% of each other, so students could conclude that *k* was a constant.

However, some students chose a sequence of calculations that demonstrated *k* increased slightly with angle. The conclusion mark was awarded based on a statement consistent the values the students calculated, so it was possible for students to conclude that *k* was not a constant and be awarded full marks.

(a) Determine whether these results support the statement that *k* is a constant.

(3)

$8 = k \times 125 \times 0.1 \rightarrow k = 0.64$

$11 = k \times 170 \times 0.1 \rightarrow k = \cancel{0.647}\ 0.65$

$14 = k \times 215 \times 0.1 \rightarrow k = 0.65$

$16 = k \times 250 \times 0.1 \rightarrow k = 0.64$

$19 = k \times 290 \times 0.1 \rightarrow k = 0.66$

As the values of k varied between 0.64 to 0.66, which only have a small variance, so the results support the statment of k is a constant.

Many students calculated all 5 values of *k*, as in this example which scored full marks.

As the question stated the depth of the solution was a constant 10 cm, it was possible to demonstrate *k* was a constant by demonstrating the ratio of angle and concentration was constant, rather than calculating *k*.

Question 4(b)

The context for this question is that the angle of rotation depends on the concentration of the solution. So any change to the concentration of the solution, caused by the equipment, would have an effect on the angle of rotation. Answers that considered this idea were not common.

Many answers focussed on the light, rather than the heat, produced by a more powerful bulb. Amongst the students who did relate their answers to heating effects, many referred to the heating of the bulb or tube, but not specifically the sucrose solution.

(b) Explain why the polarimeter light source should have a low power.

(3)

As sucrose solution is a mixture of water and sucrose, the light source will poovid high amount of heat during high power. As the heat supplied may evapourate the solution and chaye the concentration, the source should have a low power to prevent evapouration happe

In this example, there is a clear link between the heat supplied to the solution and evaporation, which changes the concentration of the solution.

Question 4(c)

This style of question has been seen on WPH03 and WPH13 in the past, so students were well prepared to treat the equation given as that of a straight line. As in the past, a clear link between the equation given and the equation of a straight line was expected.

Many students demonstrate a misconception, that as depth was a constant (10 cm) it was not required for plotting the graph or the calculation of *k* using the gradient.

(c) Describe a graphical method the student could have used to determine *k*.

(3)

angle = k (0.1m) (concentration)

by comparing To y = mx + c

c = 0 and m = 0.1 k

draw a graph with y axis the ∠ of rotation and ~~x~~ axis the concentration. The gradient = 0.1 k and ~~k~~

k = gradient × 10

This example shows a clear comparison between the equation given and $y = mx + c$, including the value 0.1 m for the depth. There is a clear description of the graph to be plotted and a method to calculate *k*.

Question 5(a)

The introduction to this question refers to the metal surface in the apparatus. The metal surface is labelled as part of the apparatus on the left in the photograph above. The question then leads students to understand that this particular metal can be used with visible light, rather than the light with a higher photon energy required by other metals. Students were asked to explain, rather than state, an advantage of this apparatus.

However, it was very common to see answers that were stating advantages of the digital voltmeter. Many of these were correct advantages of a digital voltmeter. Unfortuntately, that was not the apparatus referred to in the question.

(a) The metal surface in this apparatus can be used to determine the Planck constant with visible light. Other metals require higher photon energies.

Explain an advantage of using this apparatus.

(2)

Using higher energy EM radiation such as gamma rays are dangerous as they are ionizing radiation. Using visible light is much safer as it has less energy.

In this example, there is a clear link between higher photon energies and the danger of gamma radiation, with a comparison that visible light would be safer to use.

It was not expected that students would limit their answers to ultraviolet light, but and electromagnetic radiation named must be one with a higher photon energy than visisble light.

Question 5(b)

This question assessed students mathematical ability, carrying out a simple calculation. It was expected that students would calculate an value in Joules, however student who have studied WPH12 would be aware of the electron-volt, so an answer of 1.58 eV would be awarded full marks.

Question 5(c)(i)-(ii)

(c)(i)

Students who were fully prepared would expect a question requiring them to plot a graph, as this question has appeared regularly in both WPH03 and WPH13 papers.

However, the same issues as seen in past exam series arose.

- Axis labels with missing or incorrect units
- Scales that do increase in factors of 1, 2 or 5 on the 2 cm lines and the plots that cover less than half the area

- Plots that were more than 2 mm away from the correct position, or plots that were themselves over 2 mm wide so accuracy could not be checked
- Lines of best fit that were not straight or were not balanced (simimilar number and distance of plots above and below the line)

(c)(ii)

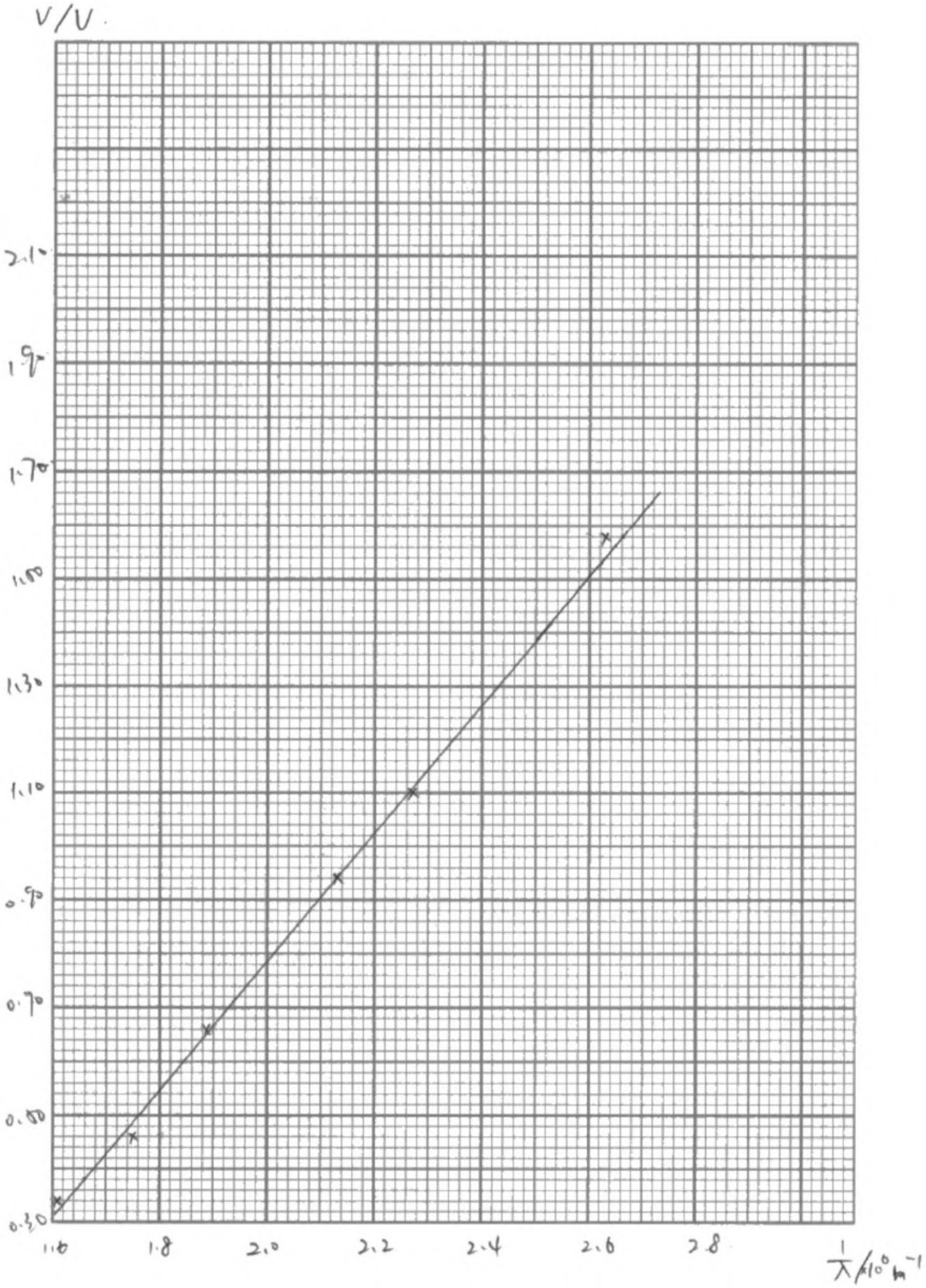
When calculating a gradient, students are expected to use pairs of values from the line, with a range covering over half the line drawn. This can be shown as a triangle on the graph. Values from the table can be used, but only if the plot of those values falls on the line of best fit.

For this question, the gradient calculated was to be used in the equation given.

As the resulting constant *h* is found in the list of data, formulae and relationships, an answer of 6.63×10^{-34} J s would only be awarded the third mark if that answer matched the calculation shown in the students work.

It was common to see incorrect powers of 10 in the calculation, following from (c)(i). These answers could still be awarded the first 2 marks, but the final answer would not be within range. As students are aware *h* should be $\times\ 10^{-34}$, it was common to see a unit conversion factors applied. Benefit of doubt was given, unless it was clear this was done purely to make the final answer $\times\ 10^{-34}$.

Example 1:



This graph is fully labelled, with units for both axes. The scales go up by 0.2 every 2 cm and the plotted area is over half of each axis. The 2 pairs of plots checked were found to be correctly plotted and the line is reasonably balanced. So this graph scored 6 marks.

(ii) Determine the Planck constant using your graph and the equation

$$h = \frac{\text{gradient} \times e}{c}$$

(3)

$\text{gradiant} = \frac{\Delta y}{\Delta x} = \frac{1.08 - 0.38}{(2.66 - 1.66)\times 10^{6}} = 1.20 \times 10^{-6}\ \text{Vm}$

$h = \frac{1.20\times 10^{-6} \times 1.6\times 10^{-19}}{3\times 10^{8}} = 6.4 \times 10^{-34}\ \text{Js.}$

Planck constant = 6.4×10^{-34} J s.

The gradient calculation used values from 1.66 to 2.66 on the *x*-axis – so covering over half the line drawn. This gradient was then correctly substituted, along with values of *e* and *c* into the equation given. The final value was within the accepted range and a unit was given, so scoring full marks.

Question 5(d)

The question asked students to suggest modifications which would improve the accuracy of their value of *h* from this experment. So, answers that discussed replacing the apparatus in this experiment were not relevant to this question.

In the introduction to the question, it was explained that p.d. was increased until the reading on the ammeter fell to zero. As the ammeter was not shown in the photograph, answers that referred to a more sensitive ammeter were rewarded.

It was common to see answers state “repeat the experiment and calculate the mean”. However, this would not be a modification as that has already taken place and was clearly stated in the introduction to part (c).

Most students identified completing the experiment in a darkened room as a modification. As the filter is placed above the metal surface, depending on how this is arranged. Students may consider the filter to be held several cm above the apparatus, eg in a ray box, rather than placed on its surface, so this is a reasonable suggestion and was rewarded.

As the value of *h* is determined from the gradient of the line of best fit, suggestions that could result in a more values to plot or a more accurate line of best fit were also rewarded.

Example 1

(d) Suggest two modifications that would improve the accuracy of the value of the Planck constant determined from this experiment.

(2)

Repeating experiment at wider range of wavelength and voltage. ~~This will~~. Then find its mean values.

~~Make~~ ~~P~~ Do experiment in dark place to prevent interference of metal surface with other lights. Make sure filter and metal surface is close so all light enters with same wavelength.

Although reference is made to repeating, in this instance it was linked to a wider range of wavelengths. Reference is also made to working in a dark place, so this example scored 2 marks.

Example 2:

(d) Suggest two modifications that would improve the accuracy of the value of the Planck constant determined from this experiment.

(2)

- Use a wider range of values ~~[illegible]~~
- Repeat readings & calculate a ~~average~~ mean value for each ~~[illegible]~~ to get more precise values and obtain a more acurate result for Planck's constant

Although there is a reference to a wider range, this example is not clear that refers to a wider range of wavelengths. The second modification restates what has already been outlined in the question, the measurements were repeated and a mean value of V was calculated.

Paper Summary

This paper provided students with a range of practical contexts from which their knowledge, understanding and skills developed within this unit could be tested.

A sound knowledge of the subject was evident for many, but some responses seen did not reflect this, with answers that did not match the question, or the context being assessed.

Based on their performance on this paper, candidates are offered the following advice:

- Ensure answers are specific to the context of the question, rather than generic statements supplied as a list of answers based on a previous mark scheme.
- When plotting graphs, your plots must use at least 50 % of the graph paper in either direction so make sure your scale is large enough. Lines of best fit should be continuous and thin.
- Avoid unusual scale divisions (power-of-10 multiples of 1, 2 and 5 per 2 cm are the standard) and start scales at a suitable value, it is not always necessary or useful to start a scale at 0 if this makes the plotted region small.
- When using a graph to determine a gradient, the points taken for the gradient must actually sit on your line of best fit. If a plotted point does not sit on the line of best fit, then it should not be one of the points you use for the gradient.
- Review appendix 10 of the specification, particularly the keywords listed in the glossary and the methods for calculating uncertainty.