Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

October 2020

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

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Introduction

The Pearson Edexcel International AS-level paper WPH13, Practical Skills in Physics I is worth 50 marks and consists of four questions, which enabling 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 in 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, as applied to the physics context described in the question.

There will be questions that are familiar for students who have revised using the earlier series of WPH03 and WPH13 papers, but some performances would suggest they 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 justify and criticise) proved a challenge to students at the lower end of the ability range.

Question 1 (a)

This question assesses the ability of students to choose appropriate apparatus when planning an experiment. Students are introduced to a standard experiment investigating the viscosity of a liquid by timing the flow through a funnel.

For both parts, the command word "state" indicates a recall of a piece of information.

(a) (i) State a piece of apparatus the student could use to vary the temperature of the oil.

(1)

Water bath with a Bunsen flame underneath to provide heat/ ice water bath.

This is an example of a student answer that exceeds the requirement of the command word "state". Although there is a list, both the hot water and ice water bath are acceptable, so this response scored 1 mark.

(ii) State a piece of apparatus the student could use to measure the time taken for the oil to flow through the funnel.

(1)

stopwatch

This is an example of a more typical response to a "state" command word. A single word answer, that identifies a suitable piece of apparatus. This response scored 1 mark.

However, many students gave answers that did not describe a specific piece of apparatus but named a general type of apparatus. These responses were considered too vague at this level.

(ii) State a piece of apparatus the student could use to measure the time taken for the oil to flow through the funnel.

(1)

timer.

A timer could include any time measuring device, such as a sand clock (egg timer). Similarly, for 1(a)(i) a heater could describe any source of thermal energy, such as a candle.

For 1(a)(i) it was common to see responses stating apparatus to measure temperature, rather than to vary it.

(a) (i) State a piece of apparatus the student could use to vary the temperature of the oil. **(1)**

temperature ~~therom~~ thermometer

As such, fewer students scored the mark for 1(a)(i), though both parts were answered well by the vast majority of students.

Question 1 (b)

The command word “justify” required students to give evidence to support the choice of the digital thermometer.

One approach students could use is to consider the resolution of the devices and justify the choice by comparing the percentage uncertainty of the two thermometers.

(b) The two thermometers shown below are available.

liquid-in-glass thermometer

digital thermometer

He chooses to use the digital thermometer.

Justify his choice.

(2)

He is right. The digital thermometer has a precision to 0.1°C while liquid-in-glass thermometer's presision is to only 1°C. So the percentage uncertainty is reduced and no parallax when reading. ~~So~~ So it is more accurate. Random error is also reduced.

This response includes both versions of the first mark, by considering the resolution of the two thermometers and identifying the impact of parallax error. This gives the evidence to support the justification that percentage uncertainty is reduced. So, this response scored 2 marks.

It was common for students to score 1 mark, as most students did not fully justify the choice so were awarded only the first mark.

Justify his choice.

(2)

By using a digital thermometer he ensures that the measurement is in the ~~highe~~ highest resolution (0.1°C) rather than (1°C)

This response scores the first mark only, as this evidence is not linked to the justification that the digital thermometer has a lower percentage uncertainty.

Question 1 (c)

The identification of a control variable was problematic for many students. It was clear many did not understand the term control variable, as a large proportion described controlling the temperature, which 1(a)(i) indicates is being varied.

However, if a student did describe how an incorrect control variable can be controlled (eg outlined the apparatus and method), it was still possible to award the mark for 1(c)(ii).

(c) (i) Identify one control variable in this investigation. (1)

Temperature. (independent variable)

(ii) Describe how this variable can be controlled. (1)

We can heat the oil with a Bunsen Burner or cool it by allowing it some time to cool (decrease temperature)

Check temperature using a thermometer.

This response is an example where 1(c)(i) is not awarded the mark, but 1(c)(ii) can be awarded the mark.

(c) (i) Identify one control variable in this investigation. (1)

~~The diameter of the funnel~~

The mass of the oil.

(ii) Describe how this variable can be controlled. (1)

Measure the mass of oil using a top pan balance and use the same mass each time.

This response gives an acceptable control variable (having replaced a previous answer) and the apparatus and method to control it, so this response scored the mark for each part.

Many students suggested apparatus, rather than a variable. It was deemed unlikely a student at this level would be changing apparatus mid experiment, so was not credited for 1(a)(i). However, the mark for 1(c)(ii) could still be awarded if the method of control was suitably described.

Question 1 (d)(i)

This question uses the command word "state" as students should be able to recall that a rate is generally a quantity divided by time. Eg an electrical current is the rate of flow of charge, calculated by the amount of charge flow divided by the time taken.

In this case, the rate of flow of oil can be calculated by dividing a suitable description of an amount of oil (eg volume or mass) divided by time.

> (d) The student initially measures the time from starting to pour the oil into the funnel to the last drop of oil falling from the funnel.
>
> (i) State how the rate of flow of the oil should be calculated.
>
> (1)
>
> Volume of oil in the measuring cylinder divided by time taken to fall.

This response scored the mark for a clear statement. Many students gave similar answers in the form of an equation.

However, it was common for students to describe how to take the measurements needed to calculate the rate of flow, rather than state the calculation itself.

> (d) The student initially measures the time from starting to pour the oil into the funnel to the last drop of oil falling from the funnel.
>
> (i) State how the rate of flow of the oil should be calculated.
>
> (1)
>
> with measuring the time and .record the oil falling down to the empty cylinder with the measured liter.

This response was not awarded the mark, as there is no calculation given.

Question 1 (d)(ii)

It was clear many students were well versed in the details of core practical 2, as these students described that experiment.

(ii) Describe how the same apparatus could be used to calculate a more accurate value for the rate of flow of the oil.

(2)

mark the measuring cylinder with rubber bands on different distances and drop a ball through the oil and measure the time by ~~measuring cylinder~~ stop watch.

Unfortunately, this is not the same apparatus. There is no ball, so these responses could not be awarded marks.

However, some students adapted their understanding of core practical 2 and applied it to the experiment described in this question.

(ii) Describe how the same apparatus could be used to calculate a more accurate value for the rate of flow of the oil.

(2)

label 2 points, and then find volume of oil between them.
Find the time for oil to fill between those 2 points
then use the equation $v = \frac{d}{t}$ to find the speed, where d is the volume
repeat and take average

Here, the use of labelled 2 points and the time between them is correctly linked to volume rather than distance (the student clarifies by stating d is the volume). This response scored both marks.

Many student's responses focused only on repeating the experiment. As the experiment was to be repeated at varying temperature, such responses needed to make clear that these repeats were occurring for the same temperature of oil and a mean is calculated, to be awarded a mark.

(ii) Describe how the same apparatus could be used to calculate a more accurate value for the rate of flow of the oil.

(2)

Repeat the experiment at the same temperature for a few times to record several sets of time for the oil to completely fall into the cylinder, then take the average of the time, to reduce the percentage uncertainty in the rate of flow of oil.

Question 2 (a) & (b)

This question considered a light-emitting diode (LED). Students were expected to combine several ideas covered during the study of WPH12 and apply them to an unusual context.

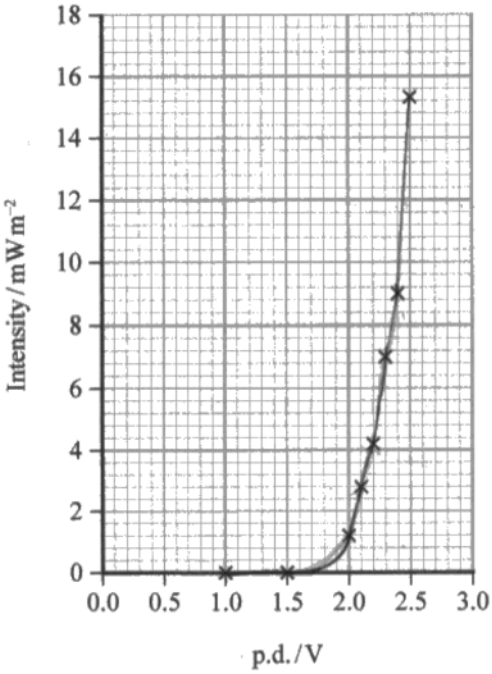
In these parts of the question, students needed to draw a line of best fit on to the given graph, then the value of potential difference at which the LED starts to conduct to calculate the minimum energy transferred to the conduction electrons.

2(a) proved to be a challenge. Most candidates understood that current (rate of flow of electrons) and intensity (rate of emission of photons) were proportional, so the line of best fit would have the same shape as the classic I-V graph for a diode. But it was common to see a straight line of best fit applied, in some cases only considering the plots on the right or a curve that treated the last plot as an anomaly.

2(b) allowed for error carried forward, eg for 2(b)(i) if the value matched the point where the student's line touched the p.d./V axis, the mark was awarded.
For 2(b)(ii) a correct calculation using this value would score at least 1 mark, with 2 marks for an answer within an accepted range. It was common to see a p.d. of 2.0V used. As this p.d. is a plot on the graph that is conducting, this p.d. gives values that are out of range. Similarly for 1.5V, this p.d. gives 0 intensity is not the point at this the LED starts to conduct.

2 A student investigated how the intensity of light emitted by a light emitting diode (LED) varied with the potential difference (p.d.) applied across the LED. She measured the intensity of the light using a lightmeter which was shielded from external light sources.

She plotted her results on a graph as shown.



(a) Add a line of best fit to the graph.

(1)

(b) (i) Give the value of the p.d. at which the LED starts to conduct.

(1)

1.75 V

(ii) Calculate the minimum energy that must be transferred to an electron in the LED for light to be emitted.

(2)

W = V × Q

= 1.75 V × 1.6 × 10^{-19} C

≈ 2.8 × 10^{-19} J

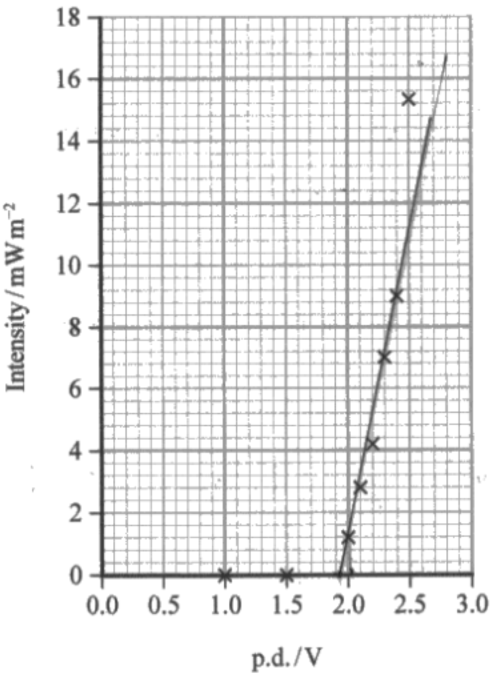
Minimum electron energy = 2.8 × 10^{-19} J

This first example scored full marks for 2(a), as there is a curved line of best fit that matches the plots given.

For 2(b) the value of p.d. stated matches the line the student drew, and the subsequent calculation uses this p.d. correctly to calculate an energy value that was within the accepted range, scoring 2 marks.

2 A student investigated how the intensity of light emitted by a light emitting diode (LED) varied with the potential difference (p.d.) applied across the LED. She measured the intensity of the light using a lightmeter which was shielded from external light sources.

She plotted her results on a graph as shown.



(a) Add a line of best fit to the graph. (1)

(b) (i) Give the value of the p.d. at which the LED starts to conduct. (1)

1.9

(ii) Calculate the minimum energy that must be transferred to an electron in the LED for light to be emitted. (2)

$W = VQ$

$= (1.9 \times 1.6 \times 10^{-19})$

$= 3.04 \times 10^{-19}$ J

Minimum electron energy = 3.04×10^{-19} J

This second example demonstrated a student who did not score the mark for 2(a).

But, for 2(b) the value of p.d. stated matches the line the student drew, and the subsequent calculation uses this p.d. correctly to calculate an energy value that was within the accepted range.
So both marks were awarded.

Question 2 (c)

This question asks students to consider given data to complete the next step of the analysis, to demonstrate the ability to use an LED to determine a value for the Planck constant h.
Again, students were asked to use three parts of WPH12 knowledge (*W*=*QV*, *v*=*fλ* and *E*=*hf*) applied to a practical context that is likely new to many of them.

Most students performed the calculation well, though it was common to see incorrect powers of 10 in the final answer or final answers with incorrect or missing units.

(c) Light is emitted when the electron releases energy as a photon.

The student tested a second LED which emitted light of wavelength 625 nm.

From her results she determined the minimum electron energy to be 3.1×10^{-19} J.

Calculate the value of the Planck constant from this data. **(3)**

$E = hf$ $\quad$ speed of light → $v = f\lambda$

$E = h \times \frac{c}{\lambda}$ $\quad$ $f = \frac{v}{\lambda}$

$3.1 \times 10^{-19} = h \times \frac{3 \times 10^{8}}{625 \times 10^{-9}}$ $\quad$ $h = 6.458 \times 10^{-34}$

$= 6.5 \times 10^{-34}$ Js

The Planck constant = 6.5×10^{-34} Js

This example scored 3 marks.

For students, there remains confusion between the different aspects of the Particle Nature of Light, with some applying the photoelectric effect equation and others the de Broglie equation.

Question 2 (d)

This question asks students to consider how the uncertainty in wavelength/frequency of light that is not monochromatic would affect the value calculated in 2(c).

This proved a challenge for most students, who did not link the idea of monochromatic light having a single wavelength to the idea of light that is not monochromatic having a range of wavelengths. Of the students that did, few fully explained the effect on the value of the Planck constant.

(d) The LED does not produce monochromatic light.

Explain how this would affect the value of the Planck constant calculated.

(3)

- there would be a range of values for planck constant.
- Different colours produced, have different wavelength.
- Therefore different range of frequencies.

$e = hf \therefore h = \frac{e}{f}$

$\therefore$ as f varies h also varies ; f ↑ h ↓, f ↓ h ↑ (inversely proportional)

This example successfully links the ideas of a range of frequency leading to there being a range of values for the Planck constant, so scored 3 marks.

(d) The LED does not produce monochromatic light.

Explain how this would affect the value of the Planck constant calculated.

(3)

Different colours of the light have different wavelengths. Higher the wavelength, higher the value of planck constant calculated. Lower the wavelength, lower value of planck constant calculated.

In this example, the first 2 marking points are clear. The idea of there being different wavelengths and how a higher/lower wavelength would affect the value of the Planck constant.

But the answer does not go beyond the detail given in the second marking point on the mark scheme, so scored only 2 marks.

Question 2 (e)

This part of question 2 asks students to evaluate the experiment as described, by suggesting and explaining a realistic modification to the method to reduce uncertainty. As the minimum p.d. is determined from the graph, the explained method needed to include the use of the line of best fit on the graph. It was this second marking point that was often missed.

Many student responses were too simplistic, eg repeat measurements and average. As the point of the minimum p.d. lies on the curved line between 2 plots, simply repeating the same values would not alone be enough to reduce the uncertainty of that curved line.

(e) The accuracy of the value of the Planck constant calculated depends on the minimum p.d. determined from the graph.

Explain how the student could reduce the uncertainty in her value of the minimum p.d.

(2)

• Around the minimum p.d., take small increments in p.d so that the best fit line is more accurate.

• This decreases percentage uncertainty of the minimum p.d. More points should be plotted on the graph around the minimum p.d.

(Total for Question 2 = 12 marks)

This response clearly outlines the additional data points to be measured and how that affects the line of best fit, so scored 2 marks.

(e) The accuracy of the value of the Planck constant calculated depends on the minimum p.d. determined from the graph.

Explain how the student could reduce the uncertainty in her value of the minimum p.d.

(2)

Measure the intensity at more p.d, especially from 1.5V to 2.0V. And plot the graph of Intensity against p.d again and find the minimum p.d.

(Total for Question 2 = 12 marks)

This response does outline the additional data to be collected. But it does not explain how replotting the graph would reduce the uncertainty in the minimum p.d. value, so scored only 1 mark.

Question 3 (a)

Question 3 explores the semiconductor nature of a solar panel, considering the effect of temperature would have on the power output.

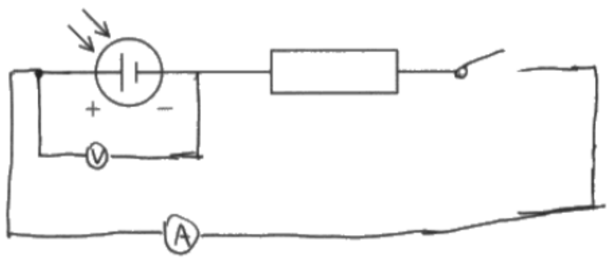
Students were not expected to recall details about semiconductors or solar panels, however, they were expected to be able to apply WPH11 and WPH12 knowledge to the context described.

3(a) asked students to complete the circuit diagram, to allow measurements that could be used to determine the power output. From WPH12, students should know P=VI, so the circuit required an ammeter and voltmeter correctly positioned to measure the current and p.d. of the solar cell drawn.

Some candidates added additional circuit components, marks could still be awarded if these components did not prevent the ammeter or voltmeter measuring the current and p.d. of the solar cell itself. Most candidates drew acceptable circuits.

(a) Complete the diagram to show a circuit that would allow him to determine the power output of the solar cell.

(2)



This example clearly shows an ammeter in series with the solar cell and a voltmeter in parallel with the solar cell so scores 2 marks.

Question 3 (b)

This question was often misinterpreted. Students were asked to describe how to ensure intensity remained constant.

Many students interpreted the question to be what measurements would you need to take to check intensity remained constant. Others gave responses that were too simplistic, eg “use the same light source”.

(b) Describe how the student could ensure that the intensity of light incident on the solar cell remained constant.

(2)

Use the same light source and ensure its relative position to the cell is ~~the~~ same, i.e. rays of incidence should be from the same ~~place~~ distance and incident at the same angle. Shield the cell from external light sources.

This response does include “use the same light source” but expands upon this, cleary describing 2 methods to ensure intensity remained constant. So this response scored 2 marks.

(b) Describe how the student could ensure that the intensity of light incident on the solar cell remained constant.

(2)

Shield the appratus from external light, use a flash light at right angles to the solar cell and keep the distance from the cell constant.

This example also describes 2 methods to ensure the light intensity remained constant, so also scored 2 marks.

Question 3 (c)

Students were asked to state a method that could be used to increase the temperature of the solar cell. It was expected that such methods would be safe for the student in the question.

Although it was common to see suitable apparatus stated, many responses did not outline how that apparatus was to be used.

(c) State a method the student could use to increase the temperature of the solar cell.

(1)

Put the solar cell in beaker with water, and use bunsen burner to increase temperature.

This response outlines a suitable safe method, so scores the mark.

It was common to see students stating the use of a thermostat, suggesting a misunderstanding of the term “thermostatically controlled” with regards to a water bath, for example.

Question 3 (d) & (e)

These two-part questions formed a linked calculation.

Part (d) being a calculation using the equation $P=VI$ from WPH12.

The vast majority of students completed this calculation correctly though, as, with other calculation questions, some values had incorrect powers of 10 while others had missing or incorrect units.

Part (e) required students to combine the value from part (d) with along with a calculation of the input power from the light source, using $I = P/A$, which should be familiar from WPH12 studies. These two values were then substituted into the efficiency equation from WPH11.

Again, most students completed this calculation correctly. Students were rewarded for the correct use of an incorrect answer given in 3(d).

(d) At room temperature, the student measured a potential difference of 2.74 V and a current of 45 mA for the solar cell.

Calculate the power output of the solar cell.

(2)

p.d = 2.74 $I = 45 \times 10^{-3}$

$2.74 \times 45 \times 10^{-3} = 0.123$

Power output = 0.123 W

(e) He measured the intensity of the light incident on the solar cell to be 200 W m^{-2}.

Calculate the efficiency of the solar cell at room temperature.

dimensions of solar cell = 60 mm × 60 mm

(3)

$I = 200 \text{ W m}^{-2}$

$I = \frac{P}{A}$ $A = 0.06 \times 0.06 = 3.6 \times 10^{-3}$ m

P = 0.72 W

$\frac{0.123}{0.72}$ ~~×100~~ =

Efficiency = 0.17

In this example, both calculations are carried out correctly. Clear working is shown. The final value for efficiency is not converted to a %, so the lack of unit is correct. So this response scores 2 and 3 marks.

(d) At room temperature, the student measured a potential difference of 2.74 V and a current of 45 mA for the solar cell.

Calculate the power output of the solar cell.

(2)

$P = 2.74 \cdot 45 \cdot 10^{-6} = 1.237 \cdot 10^{-4}$

Power output = $1.2 \cdot 10^{-4}$ W

(e) He measured the intensity of the light incident on the solar cell to be 200 W m^{-2}.

Calculate the efficiency of the solar cell at room temperature.

dimensions of solar cell = 60 mm × 60 mm

(3)

$I = \frac{P}{A} \Rightarrow 200 = \frac{P}{60 \cdot 10^{-3} \cdot 60 \cdot 10^{-3}} \Rightarrow P = 0.72$ W

efficiency $= \frac{\text{output}}{\text{input}} = \frac{1.2 \cdot 10^{-4}}{0.72} = 1.67 \cdot 10^{-4}$

Efficiency = $1.67 \cdot 10^{-6}$

This response is an example of a power of 10 error for 3(d), so this part scores only 1 mark.

There is a correct calculation of input power and the correct use of the value from 3(d) in the efficiency calculation. However, there is a discrepancy in the powers of 10 for the final answer.
As the difference is a factor of 100, it could not be assumed to be a transcription error, eg where 10^{-4} is rewritten as 10^{4}, or 10^{19} is rewritten as 10^{9}. So 3(e) was awarded 2 marks in this case.

Question 3 (f)(i)

Criticism of a set of results is a common question for WPH13, so candidates generally perform well here.

As in earlier series of WPH13, criticisms of data should be linked to the quantity. The table shows a mix of the number of decimal places, temperature showing no decimals, *V* giving 2 decimals and *I* being inconsistent between 0 and 1 decimals. So an answer "inconsistent decimal places" should be linked to current values.

As a general point, **measurements** should have a number of **decimal places** consistent with the measuring device. **Calculated values** should have a number of **significant figures** consistent with the initial data. However, for this question, we did accept "inconsistent number of significant figures" as an alternative at this question demand level.

(f) The student made measurements of the potential difference *V* and current *I* for the solar cell over a range of temperatures.

His results are recorded in the table.

Temperature / °C	*V* / V	*I* / mA
15	2.76	45.8
20	2.62	47
30	2.46	48
50	2.05	51.5

(i) Criticise these results.

(2)

- only 4 set of temperalture
- Small range
- insufficient significant figures of current.

This response gives 3 clear criticisms. They do not contradict, so both marks could be awarded.

Question 3 (f)(ii)

Using a graph to determine a relationship between two variables is a key skill for students.
In 3(f) students are introduced to data for temperature, potential difference and current.

For 3(f)(ii), students were asked to describe a graphical method that could be used to determine a relationship between power output and temperature increase.

(ii) Over the range of temperatures shown, the relationship between the power output of the solar cell and its temperature is linear.

Describe how the student could use a graphical method to determine the change in power output for each 1 °C of temperature increase.

(3)

For the range of temperatures, the corresponding power outputs should be calculated and the values should be plotted on a power output vs. temperature graph. By calculating the gradient of the linear graph, the change in power output for each 1 °C of temperature increase can be calculated.

(Total for Question 3 = 15 marks)

This example gives all 3 marking points.

There were two common issues in the students' responses.
Many descriptions did not include details for how the values of power were to be calculated.
Another common issue related to the use of the gradient, particularly when students described a graph with power on the *x*-axis (and temperature on the *y*-axis).

(ii) Over the range of temperatures shown, the relationship between the power output of the solar cell and its temperature is linear.

Describe how the student could use a graphical method to determine the change in power output for each 1 °C of temperature increase.

(3)

The student should draw the graph for Power (x) against temperature (y axis). The graph shows a straight line that represents linear relationship. The gradient gives the Intensity.

(Total for Question 3 = 15 marks)

This example shows both of the common issues. A suitable graph is described, but no details are given for the calculation of the power values. For a graph, it is accepted convention to plot *y* against *x*. However, in this case, the student has clearly stated the axes for each variable. However, the gradient statement is incorrect. So this example scores only 1 mark, for identifying a suitable graph.

Question 4 (a)

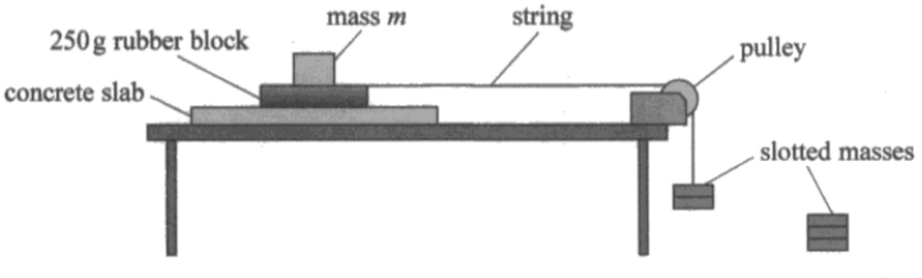
The practical scenario as described in question 4 may be unfamiliar. The equation is not one required for WPH11 (although A-Level Maths students will likely be aware of this equation).

However, students may have measured friction by pulling a sample using a newton meter. It is likely students have investigated *F=ma* using slotted masses pulling a string over a pulley to provide a horizontal force or standing waves where the slotted masses provide the tension in the vibrating string. It is also likely students have measured stiffness or Young's modulus using slotted masses, with a wire passing over a pulley.

So the idea of adding slotted masses and calculating the force using *W=mg* is something students will have met during WPH11 and WPH12 studies.

However, many students focus on the equation given, rather than the situation shown in the diagram. So, many responses discussed using *W=mg* with the mass on top of the rubber block, along with the unknown μ value.

A student investigated this relationship for a rubber block on a concrete surface. She set up the apparatus as shown in the diagram.



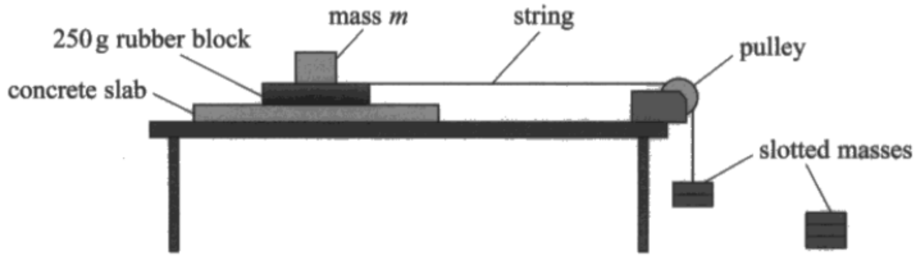
(a) Describe how the student can determine F for the situation shown. (W=mg)

(2)

Add masses until sliding starts to occur. The weight of the masses at which sliding begins will be equal to the maximum frictional force.

This response clearly describes adding slotted masses until the rubber block starts to slide and correctly describes how the force is then calculated, so scores 2 marks.

A student investigated this relationship for a rubber block on a concrete surface. She set up the apparatus as shown in the diagram.



(a) Describe how the student can determine F for the situation shown.

(2)

F= mg

As the slotted masses are added string is pulled downward

This example describes adding slotted masses and how the force is calculated. But, it does not describe the situation where *F* is the maximum value, so scores only the second marking point.

Question 4 (b)(i)

Most students could describe how the *N* values were calculated using the mass *m* and the mass of the rubber block (250g), along with *N=W=mg*.

m / g	*N* / N	*F* / N
0	2.45	1.4
200	4.41	2.5
400	6.38	4.0
600	8.34	4.6
800	10.3	5.8

(i) Explain how the values of *N* are calculated.

(2)

The mass m and the mass of rubber block are added and then multiplied by 9.81 to get the value of N.

This example explains using sentences but scores 2 marks.

m / g	*N* / N	*F* / N
0	2.45	1.4
200	4.41	2.5
400	6.38	4.0
600	8.34	4.6
800	10.3	5.8

(i) Explain how the values of *N* are calculated.

(2)

N = Weight of rubber + weight of m.

2.45 + (m x 9.81)

⇒ where m is in Kg (g ÷ 100 = Kg)

This example explains using equations but again scores 2 marks.

It was common for responses to identify combining the masses, but missed the step of calculating the force (weight) of the combined mass or confusing the terms mass and weight.

(i) Explain how the values of *N* are calculated.

(2)

The values of N are determined as the sum of the weights of the rubber block and the mass on the concrete slab.

Question 4 (b)(ii) & (c)

The plotting of given data and the calculation of a gradient using the graph plotted are skills regularly tested by WPH13 papers.

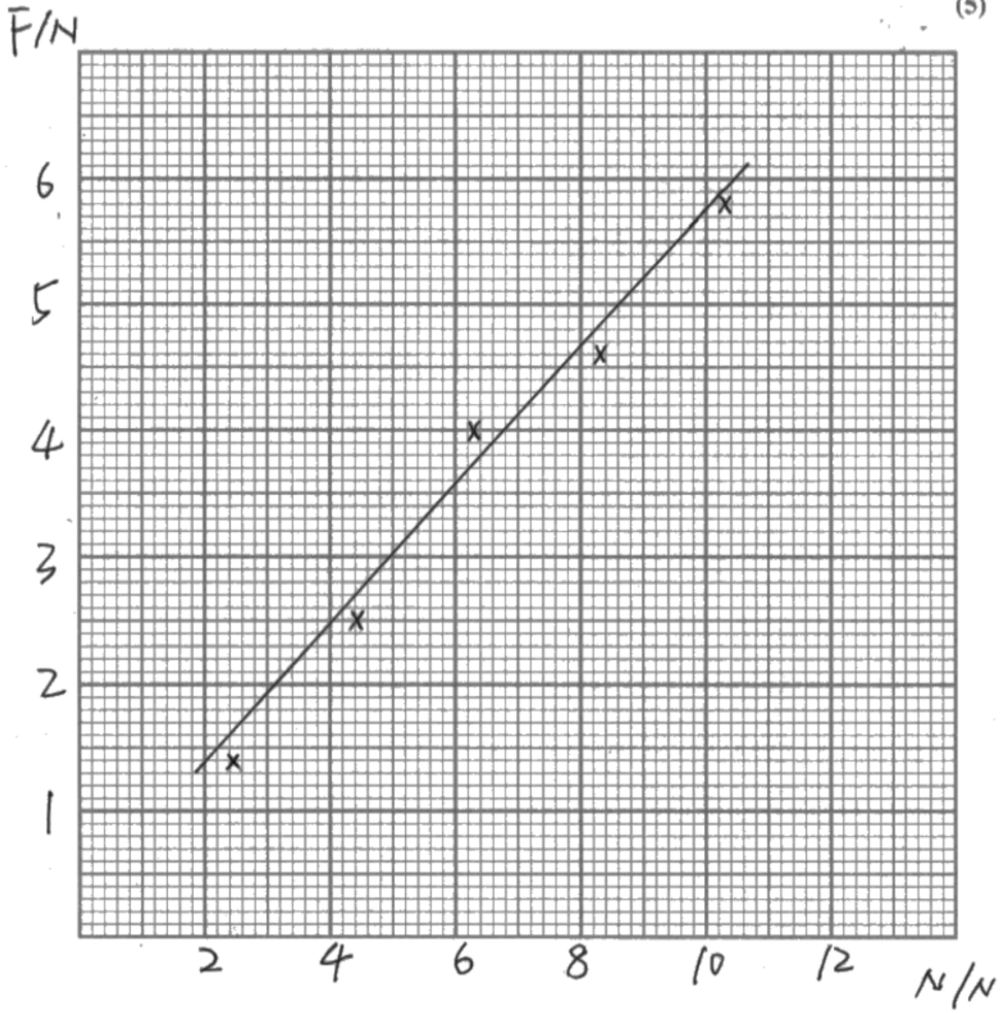
4(b)(ii) As in earlier series for this paper (and WPH03 papers from the earlier qualification) the same common mistakes were seen.

- Missing units for axis labels – axes need complete labels, with unit given using a forward slash symbol, eg temperature / ˚C.
- Unusual scale choices – scales should be a factor of 1, 2 or 5 on the 2 cm lines. Difficult scales can lead to inaccurate plotting.
  In some cases, this can mean plots cannot be checked for accuracy
- Inaccurate plotting – plots should be small and neat, so plotting can be checked and shown to be within 1 mm of the correct position.
  For WPH13, there are 2 marks available for plotting.
- Unbalanced/uneven lines of best fit – for this paper, many lines of best fit ignored the middle point (so were too low) or were forces through the origin (so the line was drawn below the first 2 points)

4(c) Most students could calculate a gradient, though many still use a range of values (eg a gradient triangle) that covers less than half the line drawn. Some students used values from the table, which is only credited if those plots are on the line of best fit.

(ii) Plot a graph of *E* on the *y*-axis against *N* on the *x*-axis using the grid below.

(5)



(c) Determine a value for μ.

(3)

$\mu = \frac{\Delta F}{\Delta N} = \frac{5.2 - 1.5\,N}{9 - 2.2\,N} = 0.54$

$F = \mu N$. compare to $y = mx$

$y = F$ $x = N$. μ is constant

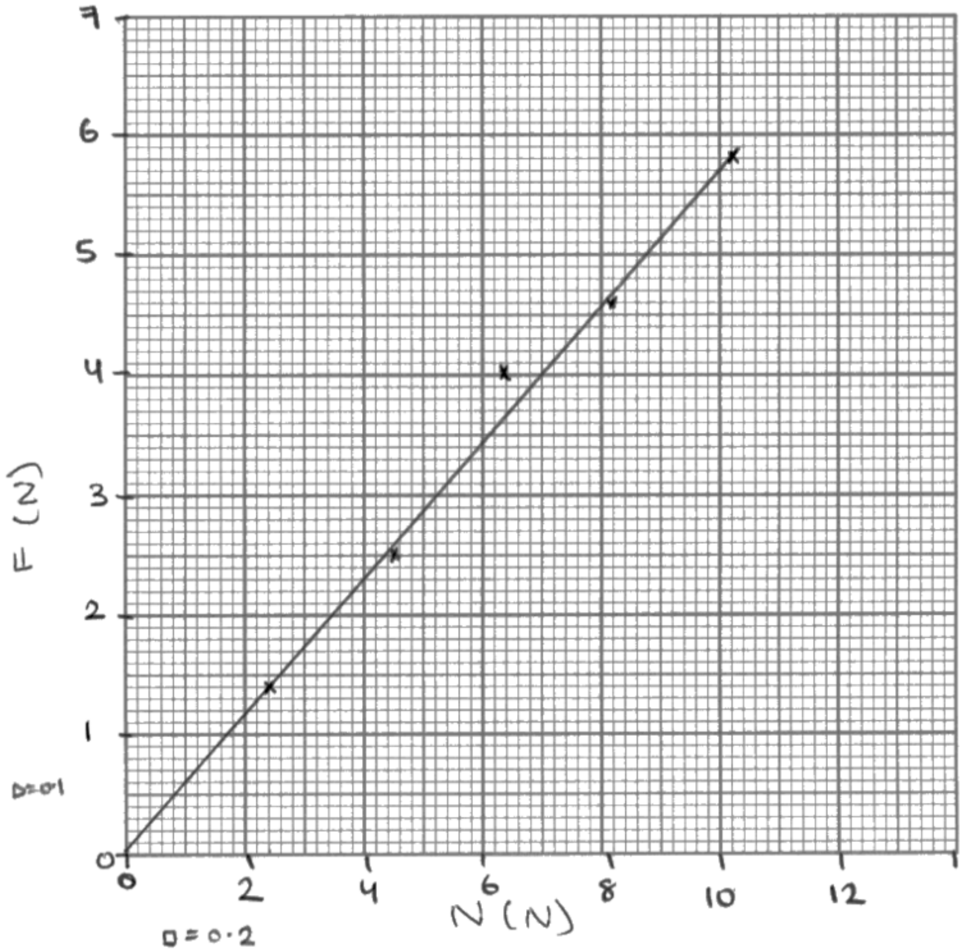
μ is the gradient.

$\mu =$ 0.54

This is an example showing the standard expected, scoring 5 for 4(b)(ii) and 3 for 4(c).

(ii) Plot a graph of F on the y-axis against N on the x-axis using the grid below.

(5)



(c) Determine a value for μ.

(3)

μ = F/N μ = gradient

gradient = F/N = 5·8/10·3 = 0·56 N/N

no units

μ = 0·56

In this example, you can see the common issue with the axis label units given in brackets.

There is also an inaccurate plot (the 4th point – plotted at (8.2,4.6) which is more than 1 mm out).

The line is lower than expected but is acceptable as it passes above points 1, 2, 4 and 5, and attempts to balance these with point 3.

So the graph scores 3 marks for 4(b)(ii) (1 for the scales, 1 for the plots, 1 for the line). A correct calculation of the gradient, giving a value within the accepted range, means a score of 3 for 4(c).

Question 4 (d)

This final part of question 4 assesses a student's ability to suggest the implications of physics (eg benefits) in a social (safety) context. This is a high level of demand, so it is not surprising that many students found this question difficult. The test outlined in the question was to determine the maximum value of friction, so student responses needed to discuss reasons why a tyre manufacturer would need to determine maximum friction a tyre could provide and a reason why these tests were necessary.

For the first mark, students needed to give some indication that the manufacturer must ensure the maximum friction was high enough, either for the different samples of rubber or for different road surface conditions. For the second mark, there needed to be a safety reason for the requirement that the friction needed to be high enough. The examples below all scored 2 marks.

(d) A tyre manufacturer carries out similar tests on samples of the rubber used for tyres.

Suggest why these tests are necessary.

(2)

To ensure the maximum friction is large enough for the tyres so that the car is unlikely to slip ~~away~~ when ~~ust~~ driving at a high speed.

(d) A tyre manufacturer carries out similar tests on samples of the rubber used for tyres.

Suggest why these tests are necessary.

(2)

Tyres should have a good grip on the road while moving, for this the tyre should have more friction acting on it, if the friction is not sufficient the tyres would skid and cause accidents, therefore the ~~manfu~~ manufacture should test the sample of rubbers used in tyres to have a bigger μ value so that F increases.

(d) A tyre manufacturer carries out similar tests on samples of the rubber used for tyres.

Suggest why these tests are necessary.

(2)

The tests are important as they make sure they tyres have enough friction to prevent the car from skidding on the road to make them safer.

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.

Sound knowledge of the subject was evident for many, but some responses seen did not reflect this. Some answers did not match the question, or the context being assessed. For example, when asked to criticise a table of results, some students outlined a conclusion or describe the pattern.

Based on their performance on this paper, students 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 describing a method, the answer should include the measuring apparatus and how it is to be used, not just the variables being **measured**.
- When plotting graphs, **plots** must be clear (eg small × drawn with a sharp pencil,) so that the accuracy of plotting can be checked. Plots should be added in pencil, so mistakes can be removed. Large circular marks that fill a 2 mm square cannot be checked for accuracy, so plotting marks cannot be awarded.
- Straight lines of best fit should be continuous (so should not change direction), with a balance of plots above and below the line, and the line should be **thin.** (eg the line of best fit should be a single line, drawn with a sharp pencil and with a ruler long enough to draw a single line).
- When using a graph to determine a gradient, the values used for the calculation of the gradient must sit on the line of best fit. If a plotted data point does not sit on the line of best fit, then it should not be one of the points of data used for the gradient.
- Review **appendices 9** of the specification, particularly the command words used to identify the task students need to complete to answer the question.

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