Examiners' Report
Principal Examiner Feedback

January 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.

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 that 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) and of practical keywords (such as reproducibility) proved a challenge to students.

Question 1 (a)

This question asked students to describe how to determine velocity using a light gate. This relates to Core Practical 1, where a light gate can be used to determine the final velocity of the falling object, using the length of the object and the time taken as it passes through the light gate, blocking the beam.

In this case, the length would be that of the card. There were was some confusion about the position of the light gate, leading to some students assuming this was the dashed line. For those students, we accepted the use of the length of the trolley. For both, students needed to include details of the calculation.

$$velocity = length\ of\ card/time\ taken$$

(a) The light gate was connected to a data logger. The data logger recorded the time taken for the card to pass through the light gate.

Describe how the student could determine the velocity v of the trolley as it passed through the light gate.

(2)

He could measure the length of the card with a metre ruler and calculate velocity by $\frac{\text{length of card}}{\text{time}}$. Ensure length of card is converted to m

This example scores 2 marks.

It was common for students to describe measuring the total distance travelled and $distance = average\ speed \times time\ taken$ to then determine the final speed.

(a) The light gate was connected to a data logger. The data logger recorded the time taken for the card to pass through the light gate.

Describe how the student could determine the velocity v of the trolley as it passed through the light gate.

(2)

Use meter rule to measure the the total distance from the top of ramp to the light gate. Use stop watch to count the time needed to travel. By $s = \frac{1}{2}(u+v)t$, initial velocity $= 0\ ms^{-1}$ and input the mean value which is taken average to calculate the velocity v.

This approach scored 0 marks, as the light gate was positioned after the end of the ramp.

Question 1 (b)(i) & (ii)

Part (i) asks students to perform a standard calculation of mean average and percentage uncertainty for a set of repeat readings. This is listed as a skill required at WPH13 (section 3.5 of the specification) and the method is outlined in Appendix 10 of the specification.

Most students correctly calculated the mean average. However, many did not round the percentage uncertainty to the correct number of significant figures. This question was one of the two places we assessed this skill, but students should be applying this to all calculations. There were no clear anomalies in this data, so all 4 measurements should be included.

Part (ii) uses the mean value from (i) to determine the acceleration. Most students correctly used$v^2 = u^2 + 2as$, scoring 2 marks. Some students attempted to calculate the time taken and then use $a = (v - u)/t$, which would work if the time was calculated using $s = \frac{(v+u)}{2}t$, so was also awarded 2 marks as a correct alternative.

But, in many examples, students incorrectly used $s = vt$, resulting in an incorrect answer from an incorrect method, scoring 0 marks.

(i) Calculate the mean value for v and the percentage uncertainty in v.

(3)

$\frac{2.07+1.84+1.91+2.1}{4}$ = mean v = 1.98 m/s

uncertainty is half range of results is $\frac{2.1-1.84}{2}$ = 0.13 $\frac{0.13}{1.98}$ ×100 = 6.6%

Mean v = 1.98 m s^{-1}

Percentage uncertainty in v = 6.6% %

(ii) The student measured the distance s that the trolley travelled on the ramp.

Determine the acceleration of the trolley on the ramp.

s = 1.50 m

(2)

s = 1.5 $\quad \frac{v^2-u^2}{2s} = \frac{1.98^2}{2\times1.5}$ = a = 1.31 m/s^2

u = 0

v = 1.98

a

t

Acceleration = 1.31 m s^{-2}

This example scored full marks.

Question 1 (b)(iii)

Appendix 10 of the specification describes reproducibility as "when similar results are obtained by students from different groups using different methods or apparatus"

In this question, students are told "A second student carried out the same experiment", which means they did not follow a different method or use different apparatus. So simply repeating this statement was enough to score the mark. Other acceptable alternatives were "the same equipment was used" or "they carried out the same method".

Very few students understood the meaning of this keyword. Most simply stated reasons why the results might not be the same, eg there was a random error.

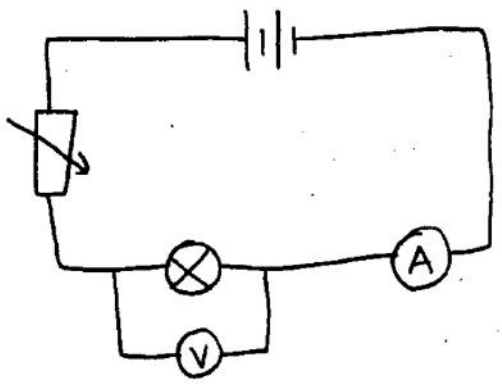
Question 2 (a)

This question asks students to draw a standard circuit, measuring the current in and potential difference across a filament bulb. However, as the introduction stated the power will be varied, some method of varying pd / current was also required.

(a) The student built a circuit to vary the power of the bulb. The student used an ammeter and voltmeter to determine the power of the bulb.

Draw a circuit diagram that the student could have used.

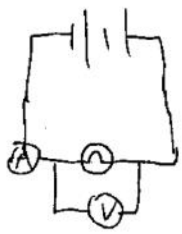
(2)



Most students answered this question well, as above, scoring both marks. Some students missed out the variable resistor (or variable power supply), scoring only 1 mark.

Draw a circuit diagram that the student could have used.

(2)



A small number of students missed out the bulb, so scored 0.

Question 2 (b)

This question followed on from (a), asking the student to describe how (eg the method) to obtain the data for a graph of the LDR resistance against the power of the bulb. As students were told the LDR resistance was measured by an ohmmeter, we did not reward this detail.

Most were awarded the first mark, for the calculation of power using $P = VI$.

Few considered the need for a range of at least 5 sets of data, so a graph could be plotted. Many did not describe how the set-up should be changed to gain these sets of data (eg gave only a generic "do this 5 times").

Few considered the last part of the question "Your description should include how to ensure that the data is accurate", most of those discussed repeating to calculate the mean but did not consider suitable control variables.

Describe how the student could have obtained the set of data required to plot the graph. Your description should include how to ensure that the data is accurate.

(4)

The student can vary the resistance of the circuit using the variable resistor. He can ~~calculate~~ record the current and voltage at each resistance. He should also use the ohmmeter to record resistance for LDR ~~at each~~. He should calculate power of the bulb using $P = IV$. He should calculate 3 values of P ~~and Resistance at each~~ by getting 3 values of current and voltage and taking a mean for P to reduce effects of random error. He should do the same for resistance of LDR. He should take at least 6 readings over a wide range of values for Power and resistance

This example includes the calculation of power using $P = VI$, the idea of using 3 values of current and voltage, to calculate the mean power, and the idea of taking at least 6 readings over a range of bulb power and resistance (which the start of the answer explains varies the voltage).

So, this example scored 3 marks. It was only missing the final mark, as it lacks a description of controlling background light or the distance from the bulb to the LDR.

Question 2 (c)

Students generally answered this well, with a variety of ways to describe the resistance of the connecting wires as negligible (eg too small, tiny).

(c) The LDR is connected to the ohmmeter using two connecting wires. The ohmmeter reading includes the resistance of the two connecting wires.

State why the student does not need to correct this reading.

(1)

Their resistance is very small ~~and~~ so the change in resistance is negligible and doesn't effect the reading of resistance of the ohmmeter

(Total for Question 2 = 7 marks)

Question 3 (a)

For this question, students were to describe how θ could be determined using a metre rule. Most students described the length measurements that were needed. But, many did not complete the description, ending with $\sin\theta = \frac{BC}{AB}$, so scoring only the first mark,
eg

(a) Describe how the student could determine θ using a metre rule.

(2)

Measure length from B to C and length of wire using metre rule. Use the equation $\sin\theta = \frac{\text{length of BC}}{\text{length of wire}}$

rather than showing the final step of $\theta = \sin^{-1}\left(\frac{BC}{AB}\right)$ (or the equivalent for the other trigonometric functions) for 2 marks.
eg

(a) Describe how the student could determine θ using a metre rule.

(2)

He could measure length of bracket (AC) with a metre rule. He could measure distance from hinge to wall (BC) also with metre rule. ~~Calculate~~ Repeat ~~twice~~ three ~~times~~ more and calulate a mean for each

$\theta = \tan^{-1}\left(\frac{BC}{AC}\right)$

Question 3 (b)

This question was generally answered poorly. Students often did not name suitable equipment (eg set square, protractor) or did not describe how the equipment was to be used (eg identified where to place the equipment).

This is an example of a good answer.

(b) Describe how the student could check that the bracket was horizontal.

(1)

He could use a set square and check if ~~a~~ BC and AC are at 90°. If not bracket isn't horizontal

Question 3 (c)

This type of question regularly occurs on WPH13 papers. Here we awarded 3 marks, for 3 clear issues with the data. As such, most students scored at least 2 marks. However, there are still many students who are too vague, eg giving a generic "inconsistent significant figures" which could be comparing *x* and mean *F*, rather than a much clearer statement "inconsistent s.f. for mean F".

Another common response was "no repeats". In this situation, we know repeat measurements have been taken for *F*, so here we were looking for "repeats were not recorded". However, unless students contradicted themselves (eg no repeats or mean), we took "no repeats" to mean no repeats shown.

In this example we awarded 1 mark for "no repeat readings", but the statement about inconsistent decimal places was not linked to specific data.

Criticise the recording of these results.

(3)

Inconsistent number of ~~de~~ ~~sigmys~~ decimal places

No repeat readings.

The measured x is not in S.I unit

Question 3 (d)(i)

In the question introduction, students were shown a straight line graph and given an equation that was formatted to match $y = mx + c$.

Most students realised the *y*-axis intercept = $\frac{W}{2\sin\theta}$, so found the calculation straightforward, scoring 3 marks.

Determine a value for *W* using the graph.

$\theta = 42°$

(3)

$\frac{W}{2\sin\theta}$ = y-intercept = 0.8

$W = 0.8 \times 2 \times \sin 42$

$= 1.07$

W = 1.07 N

Some students attempted to use 2 data points, to derive simultaneous equations to solve for *W*. This method would work, but often led to errors in the calculation.

Many attempted to substitute only 1 data point into the equation, which then required values of *m* and *l* which are not provided. This approach proved unsuccessful.

Question 3 (d)(ii)

Here students were asked to evaluate, or "come to a supported judgement". In this case, a judgement of accuracy required some evidence of the difference between the value of *g* given in the question and the standard value of *g* given in the datasheet.

Evaluate the student's conclusion.

(2)

The student's value is accurate as g has a value of $9.81\ m/s^2$. ~~Hence~~ As the percentage difference in value of g is small (1.73%) ~~high~~, the value is accurate and hence the conclusion is correct.

This example scored 2 marks, for calculating the percentage difference and then making a judgement supported by that percentage difference.

Question 4 (a)(i)

Plotting of graphs using provided or calculated data is a common requirement of WPH13.

As *w* was given to 2 significant figures, 1/*w* should also be rounded to 2 significant figures.

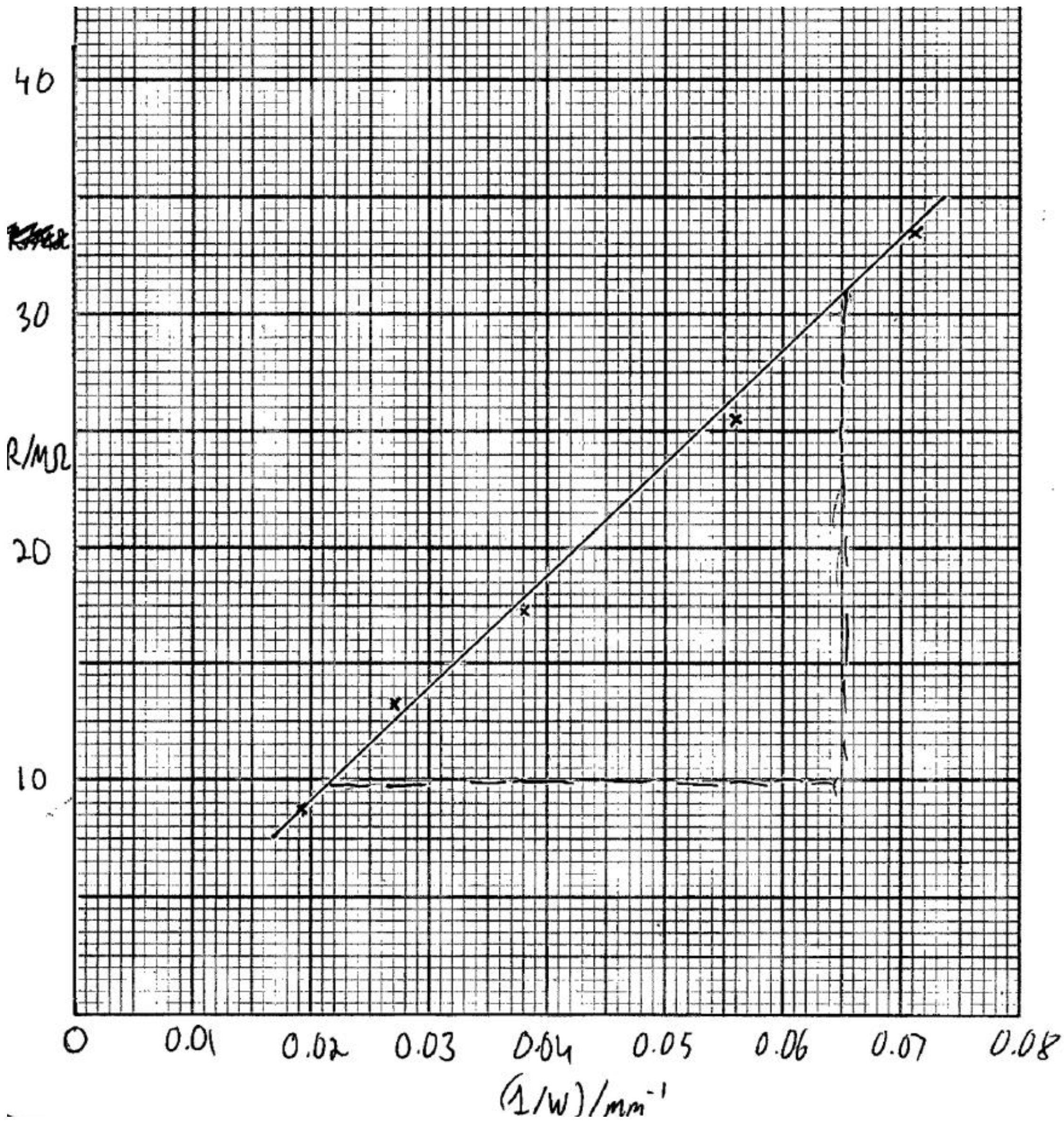
The unit of 1/*w* should also be m^{-1} or mm^{-1} if not converted at this stage. This unit was assessed on the graph axes.

As in earlier series for this paper the same common mistakes were seen.

- Missing/incorrect units for axis labels – axes need complete labels, with units given **using a forward slash symbol**, eg *R* / MΩ.
- Unusual scale choices – scales should be a factor of 1, 2 or 5 on the 2 cm lines.
  This mark also requires that the chosen scale allows **all** points to be plotted, spreads plotted points over more than half available graph paper in each direction and is not an awkward scale e.g. multiples of 3, 7 etc.
- Inaccurate plotting – plots should be small and neat, so plotting can be checked and shown to be **within 1 mm** of the correct position.
  It is still common to see large dots (almost the size of a 2 mm square) as plots.
  For WPH13, there are 2 marks available for plotting.
- Unbalanced/uneven lines of best fit. It was common for lines to be forced through the origin, rather than follow the direction of the plotted data.

(a) The table shows the student's measurements.

w/mm	*R*/MΩ	(1/w)/mm^{-1}
14	33.6	0.071
18	26.1	0.056
26	17.2	0.038
37	13.3	0.027
53	8.7	0.019



This example gives

- Correctly rounded calculated values – 1 mark
- Both axes correctly labelled – 1 mark
- *y*-axis scale of 5 and *x*-axis scale of 0.01 every 2 cm – 1 mark
- the 4th plot is (0.56, 25.5) so 2 mm out on the *y*-axis, but the rest are ok – 1 mark
- an unbalanced line (the top 3 points are all below the line) – 0 mark

As such, this example scored 4 marks out of 6.

Question 4 (a)(ii)

In 4(a)(i) students were given the equation linking resistance *R* to width *w*. From this, the student can determine that the gradient of an *R* against 1/*w* graph can be used to determine the thickness.

$$gradient = {}^{\rho l}/_{t}$$

Using the gradient (or intercept) of a graph is a skill regularly assessed by WPH13 papers, so students should be well-practised in using a large range (large triangle) covering over half their drawn line of best fit when calculating the gradient.

As lines of best fit vary slightly, there is an allowed range in the final value of thickness, and a unit is required.

(ii) Determine t using data from the graph.

$\rho = 4.0 \times 10^3\ \Omega\,\mathrm{m}$
$L = 10.0\,\mathrm{cm}$

(3)

$$\frac{\rho l}{t} = \text{gradient} = \frac{(31-10)\times 10^6}{(0.065-0.022)\times 10^3} = 488000 = \frac{\rho l}{t}$$

$$t = \cancel{488000}\ \frac{4\times 10^3 \times 0.1}{488000}$$

$$\cancel{= 8.2\times 10^{-3}}$$

$$= 8.2\times 10^{-4}\,\mathrm{m} = 0.82\,\mathrm{mm}$$

This example scored full marks.

Question 4 (b)(i)

There were two aspects to the method described in the question introduction. The equipment used was a micrometer and the slices were stacked (which made the thickness larger).

For full marks, students were expected to explain the effect on uncertainty for each aspect.

Very few considered both, but it was common for students to explain that stacking the slices made the measured thickness larger, so the percentage uncertainty would be smaller.

(i) Explain why this method gives a value for t with low uncertainty.

(2)

The value measured using the micrometer is higher as there are several slides stacked. ~~So, the~~ As the resolution of the device is same, percentage uncertainity reduces, giving a ~~ma~~ less uncertain value of t.

This example scored 1 mark. This answer mentions the resolution of the device but does not identify this as high resolution (so low uncertainty). However, it does link a "higher" value measured to reduced percentage uncertainty.

Question 4 (b)(ii)

Using the uncertainty in one value to deduce whether another value is consistent (eg within the range of uncertainty) is a common practical skill. Many students did not complete the second part of the answer, comparing the value from 4(a)(ii) to the range calculated to support their deduction.

This is an example of a good answer, scoring 2 marks.

(ii) The value of t obtained using this method was 0.80 mm with an uncertainty of 2%.

Deduce whether this value is consistent with the value of t obtained from the graph.

(2)

$0.80 \times \frac{2}{100}$

$= 0.016$

range = 0.816 to 0.784

since 0.875 does not lie within the range it is not consistent.

Question 5 (a)(i)

This question tested recall of how to use a CRO and interpret the screen to make measurements, a skill developed in core practical 4.

Most students understood that the time per division setting was the time for the 1 cm square on the screen image, and identified there was 7.2 divisions between peaks, so found the calculation relatively straightforward for full marks.

(a) (i) Determine the speed of sound in air.

distance between microphones = 1.25 m

(4)

7·2 divisions between peaks.

So, difference in time $= 7\cdot2 \times 0\cdot5 \times 10^{-3}$ s

$= 3\cdot6 \times 10^{-3}$ s

Speed $= \dfrac{1\cdot25}{3\cdot6 \times 10^{-3}} = 347$ m/s

Speed of sound = 347 m s^{-1}

Some students incorrectly stated the number of divisions between the peaks was 7. This gave a value outside the range (357 m s^{-1}), so these students only scored 2 marks.

There were some students, who did remember the time setting on a CRO are fixed values, who interpreted the dial to be set to 0.4 ms. Correct calculations based on this were credited.

Question 5 (a)(ii)

Most students realised that the CRO was being used to measure time, so calculated the time taken for the sound based on the new speed. This was then used to justify (give evidence to support) the teacher's statement that the CRO setting of 20μs was incorrect.

Justify the teacher's comment.

The piece of wood is made of oak. The speed of sound in oak is approximately 4000 m s^{-1}.

(3)

Difference in time would be = $\frac{1.25}{4000}$ s

$= 3.125 \times 10^{-4}$ s = 0.3125 ms

= 312.5 μs

Only 8 divisions are there on the trace. So, using a 20 μs setting, a maximum of 160 μs can be measured within the same trace while the time taken is larger. Hence, a larger time base should be set as per the teacher.

This example scored 3 marks.

Three different approaches could provide evidence to support the statement that the time setting was incorrect. Students could calculate the maximum time that could be shown across 8 divisions, they could calculate the number of divisions that would be needed to show the time, or they could calculate the actual time/division that would show the two peaks on a screen of 8 divisions.

Some students made the incorrect assumption that the results shown on the previous page were still correct for the new material and settings, and calculated the speed these results suggested. This approach was incorrect and was not credited.

Question 5 (b)

Most students misinterpreted "sound lasting a longer time" to be the time between peaks would be longer (so percentage uncertainty would decrease).

Very few correctly linked the width of the peak to the duration of the sound and even fewer students then linked that to the uncertainty in identifying the time for each peak.

(b) The student tried the same experiment using a rubber hammer. The rubber hammer compressed as it hit the wood making a sound that lasted for a longer time.

Explain the effect that using the rubber hammer had on the accuracy of the time determined.

(2)

The accuracy reduces as the exact time at which there is a peak cannot be determined accurately.

This example scored 1 mark but did not explain why the "time at which there is a peak" was not accurate.

Question 5 (c)

Most students found this question clear and easy. We expected students to calculate the percentage uncertainty in Young Modulus and compare that to the 3% uncertainty in density.

Young modulus E of oak = 11.2 GPa ± 0.5 GPa
Density ρ of oak = 650 kg m^{-3} with an uncertainty of 3%

Assess which of these values was the more significant source of uncertainty in the value of the speed of sound.

(2)

% uncertainity in $E = \frac{0.5}{11.2} \times 100 = 4.46\%$

As % uncertainity in Young Modulus is greater than that of density, Young modulus is more significant source of uncertainity.

(Total for Question 5 = 11 marks)

Some students calculated the range for each value and compared this, but that does not give evidence for which quantity affected the uncertainty of speed of sound the most.