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Examiners' Report
June 2018

IAL Physics WPH03 01

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Introduction

This paper is designed to test students' knowledge and understanding of practical skills. Although the majority of students showed good knowledge and understanding, there were some weaknesses in understanding some experimental procedures. It is important in the context of practical work that appropriate numbers of significant figures are used in answers. Some answers lost marks because scientific terms were not used correctly or because examiners had difficulty in understanding imprecise and confused explanations. As ever, it is important that candidates read the beginning of the questions carefully in order to identify the context.

This report should be read together with the published paper and mark scheme available on the Edexcel website.

The majority of students scored highly on Section A. An explanation of the distractors is included in the mark scheme.

Question 6

Students generally showed good calculating skill, but many were let down by presentation, for instance by choosing an inappropriate number of significant figures for their answers.

Question 6 (a)

Most students completed this task well, quoting the correct limits of the range. Unfortunately those who chose to give the range as a difference usually offered the truncated value of 0.01 (mm).

Question 6 (b)

Again most students calculated the percentage uncertainty correctly, but most gave their value to an inappropriate number of significant figures.

Question 6 (c)

The uncertainty in measurement was generally calculated correctly, but many values were given to three or more significant figures or lacked the correct unit.

6 An experiment report states that the mean diameter of a nylon thread is 0.150 mm ± 0.005 mm.

(a) State the range of the measurements.

(1)

0.145 mm — 0.155 mm

(b) Calculate the percentage uncertainty in the measurement of the diameter.

(1)

$P.U = \frac{0.005}{0.150} \times 100\ \% = 3.3\ \%$

Percentage uncertainty = 3.3 %

(c) The report states that the mean diameter of a human hair was measured as 0.075 mm with a percentage uncertainty of 5%.

Calculate the uncertainty in the measurement of the diameter of the hair.

(1)

$\frac{x}{0.075} \times 100\ \% = 5\ \% \Rightarrow \frac{x}{0.075} = \frac{5}{100} \Rightarrow x = \frac{0.075 \times 5}{100}$ = ~~3.75×10⁻³ m~~

$= 3.75 \times 10^{-3}$ mm

Uncertainty = 0.004 mm

ResultsPlus
Examiner Comments

This was a good answer which gained full marks.
The answer shows all working clearly.

ResultsPlus
Examiner Tip

Think carefully about significant figures.

6 An experiment report states that the mean diameter of a nylon thread is 0.150 mm ± 0.005 mm.

(a) State the range of the measurements.

(1)

0·145 mm to 0·155 mm

(b) Calculate the percentage uncertainty in the measurement of the diameter.

(1)

~~0·05~~ $\frac{0\cdot005 \times 2}{0\cdot150} \times 100 = 6\cdot666666667\%$

~~= 6·67 %~~ = 7%

~~= 6.~~

Percentage uncertainty = 7%

ResultsPlus
Examiner Comments

This candidate has used the full range for part (b). Either full or half range is acceptable.

ResultsPlus
Examiner Tip

Rounding to one significant figure in part (b) is good practice in this question.

Question 7

Most students gave full responses and aimed to cover all the required elements of the plan. There were some very good responses from well-prepared students who were clearly familiar with this method. Some students ignored the advice that both density values were already known and their plans concentrated heavily on methods to measure density. Some students described an experiment which had no relation to the experiment required but which may have appeared on previous examination papers.

Question 7 (a)

The diagrams seen generally indicated the correct set up, but many omitted to show the start and finish markers. Some students chose to show correctly placed light gates as a good alternative to markers. A few start markers or light gates were placed at the surface of the liquid, allowing no distance for the sphere to reach terminal velocity.

Question 7 (b)

The apparatus was correctly listed in most cases. The most common omission was an instrument to measure the diameter of the spheres. A few students suggested using vernier callipers to measure the diameter which was not accepted.

Question 7 (c)

Most students identified diameter, distance and time as the variables. However, fewer mentioned that the distance and time applied specifically to the period when the sphere was travelling at terminal velocity, or between appropriate markers.

Question 7 (d)

Quantity and instrument were usually correctly matched and the majority of students gained two marks here. The other two marks proved more difficult to achieve. There were some responses giving proper linkage between precision of instrument, expected values and % uncertainty, but when this explanation was attempted it usually failed through lack of a realistic estimate of the size of the expected measurement. Many explanations merely asserted that the instrument chosen would give a low percentage uncertainty.

Question 7 (e)

This was well answered with the vast majority of students correctly identifying both independent and dependent variables. A few confused responses suggested density, mass or temperature as variables in this experiment.

Question 7 (f)

This question elicited some good responses, with students identifying an appropriate quantity for which to repeat readings and adding a useful comment. A large number of weaker responses did not identify any specific quantity or simply suggested repeating the whole experiment.

Question 7 (g)

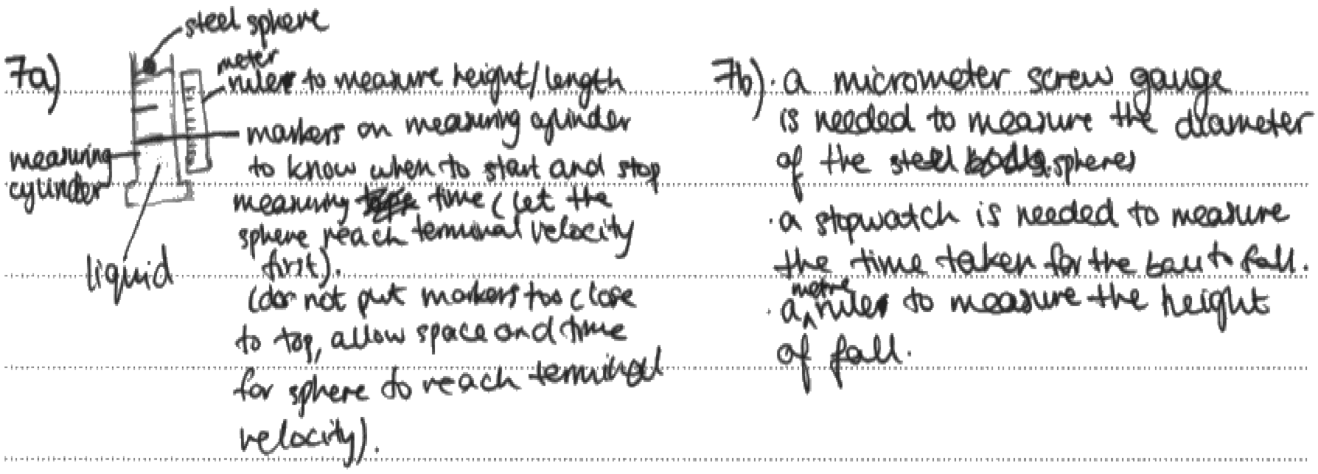
Few students clarified that calculations for velocity or radius should be done for each sphere rather than just for one. Most were able to explain that a v against r^2 graph should be used and sketch its shape. Fewer were able to link the gradient of the graph with the determination of the viscosity.

Question 7 (h)

Zero error was often identified but occasionally in connection with an inappropriate instrument. Parallax error was also given, although it was occasionally associated with the instrument rather than with the measurement. A few responses included the idea that the sphere might not have reached terminal velocity, but there was no clarification as to the relevance of this to the point at which the timing started. Vague responses about 'human error' or 'systematic error' received no credit.

Question 7 (i)

Some students simply described it as a low-risk experiment without commenting on the implications of that. Better responses included the use of goggles to avoid possible splashes into the eyes, preparations to minimise slip hazards after possible spillages and the use of gloves by those with allergies to oil. It was felt that the spheres used in this experiment would be far too small to cause injury by falling on to the feet of the experimenter.


7a)
steel sphere
meter ruler to measure height/length
markers on measuring cylinder to know when to start and stop measuring time (let the sphere reach terminal velocity first).
(do not put markers too close to top, allow space and time for sphere to reach terminal velocity).
measuring cylinder
liquid

7b) · a micrometer screw gauge is needed to measure the diameter of the steel spheres
· a stopwatch is needed to measure the time taken for the ball to fall.
· a metre ruler to measure the height of fall.

7c) · time taken for the ball to fall at terminal velocity
· height/distance the ball falls at terminal velocity
· diameter of the steel balls

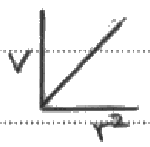
7d) · use a micrometer screw gauge to measure the diameter of the balls because a micrometer screw gauge has an uncertainty/precision of 0.01mm and the diameter will probably be a few millimeters so the percentage uncertainty will be low and almost insignificant. For example, if the diameter is 10mm, the percentage uncertainty would be 0.1%, which is very small (almost insignificant).

· use a metre rule to measure the distance/height because it will be around 15cm and a ruler has a precision/uncertainty of 1mm, which is very small and almost insignificant. For example, if the height is 15cm, the percentage uncertainty would be 0.67% which is very small (almost insignificant).

7e) Independant variable: radius of the steel spheres
Dependant variable: time taken for steel sphere to fall.

7f) Repeat readings for the diameter at different positions around the sphere and take an average – this value will be more accurate and reliable and it will help spot anomalies.

7g) Measure the time taken and diameter for at least five spheres and make sure to measure time taken and height only between the 2 markers to ensure the sphere is falling at terminal velocity. Use $v = \frac{s}{t}$ to obtain all the v values from the different times and the distance. Divide the diameter of the sphere by 2 to get its radius (r). Plot a graph of v on the y-axis against r^2 on the x-axis – it should be a straight line through the origin:



$$v = r^2\left(\frac{2(\rho_s - \rho_L)g}{9\eta}\right)$$

determine the gradient of the graph, this is equal to $\frac{2(\rho_s - \rho_L)g}{9\eta}$.

To get the viscosity, divide $2(\rho_s - \rho_L)g$ by the calculated gradient and divide the answer by 9. This will leave you with the value of viscosity of the liquid.

7h) · reaction time error when measuring time
· parallax error when measuring height.
· zero error in the micrometer or ruler
(diameter) (height).

7i) very low risk experiment – nothing dangerous as steel spheres are not heavy. Wear protective, closed shoes in case steel sphere drops on foot.

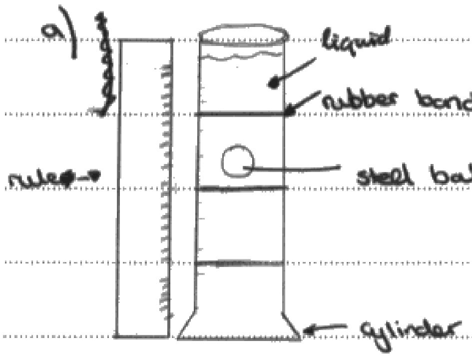
ResultsPlus
Examiner Comments

This was a good answer which gained all marks except for part (i). The diagram would have been improved by using a ruler.

ResultsPlus
Examiner Tip

Draw diagrams with a ruler.

a)



b) stopwatch, set square, micrometer

c) Distance travelled, time taken, diameter of sphere

i) This is a low risk experiment ~~so~~ but standard laboratory procedures should still be followed.

ResultsPlus
Examiner Comments

This is a good answer to parts (a) and (i). The student has used a ruler for the diagram and explained why this is a low risk experiment.

Question 8 (a)

Most of the responses seen were worth full marks, with many students making at least two valid criticisms of the data. Students mentioned the small range, the lack of repetition, the shortage of data pairs and the inconsistent use of significant figures in roughly equal measure. Interestingly, only a few students were able to relate their criticism to the particular experiment by pointing out that it would be better to measure more than a single oscillation.

(a) Criticise these results.

(2)

First, there are too few values recorded for l (only five).

Also, there are no repeat readings for each length.

ResultsPlus
Examiner Comments

A good answer. The student has realised that only two criticisms are needed for full marks.

ResultsPlus
Examiner Tip

Check the marks and make sure you make a matching number of points.

(a) Criticise these results.

(2)

① Too few results. (at least 6 groups).

② Inconsistent significant figures.

③ The range of l is too small.

④ No repetition.

ResultsPlus
Examiner Comments

This also gained full marks. It would have improved the answer if an example of the inconsistent figures had been given.

ResultsPlus
Examiner Tip

It is a good idea to say which measurement has inconsistent figures.

Question 8 (b)

Many students scored one mark here, by correctly squaring both sides of the equation and then relating their result directly to $y = mx$ (or to $y = mx + c$). Fewer were able to identify the constant factor or the zero value of the intercept. The most common error was to forget the 2π when squaring the right hand side of the equation.

A number of students did not fit their answer into the space provided. The lines allowed are a guide to the length of the answer expected.

(b) Explain why a graph of T^2 on the y-axis against l on the x-axis should be a straight line through the origin.

(2)

Rearrange into $T^2 = 4\pi^2 \cdot \frac{l}{g} = l \cdot \frac{4\pi^2}{g} = \frac{4\pi^2}{g} \cdot l$. Cf $y = mx + c$, where m is $\frac{4\pi^2}{g}$ (a constant) and c is 0. $y = mx + 0$ is a straight line trough the origin, so $T^2 = \frac{4\pi^2}{g} \cdot l$ is one too!

ResultsPlus
Examiner Comments

A good answer gaining both marks. The student has squared the equation correctly.

ResultsPlus
Examiner Tip

Remember to say that terms are constants.

(b) Explain why a graph of T^2 on the y-axis against l on the x-axis should be a straight line through the origin.

(2)

$T = 2\pi\sqrt{\frac{L}{g}}$, $T^2 = (2\pi)^2 \frac{L}{g}$, $T^2 = 4\pi^2 \frac{L}{g}$, $T^2 = \frac{L}{g} \times 4\pi^2$

$T^2 = L \times \frac{4\pi^2}{g}$ $\quad$ $c = \varnothing$ (y-intercept $\varnothing$ so goes through origin)

($y = (x \times m) + c$) $\quad$ gradient $= \frac{4\pi^2}{g}$, $4\pi^2$ is known value (constant)

g is constant

so, straight line

ResultsPlus
Examiner Comments

Another good answer. This too scores full marks.

ResultsPlus
Examiner Tip

Try to keep your answer within the lines provided.

Question 8 (c) - (d)

Many students had prepared well for this part of the paper. They showed good skills both when drawing their graph and when calculating. Several students presented their answers inappropriately, omitting an essential unit or quoting values to an inappropriately large number of significant figures.

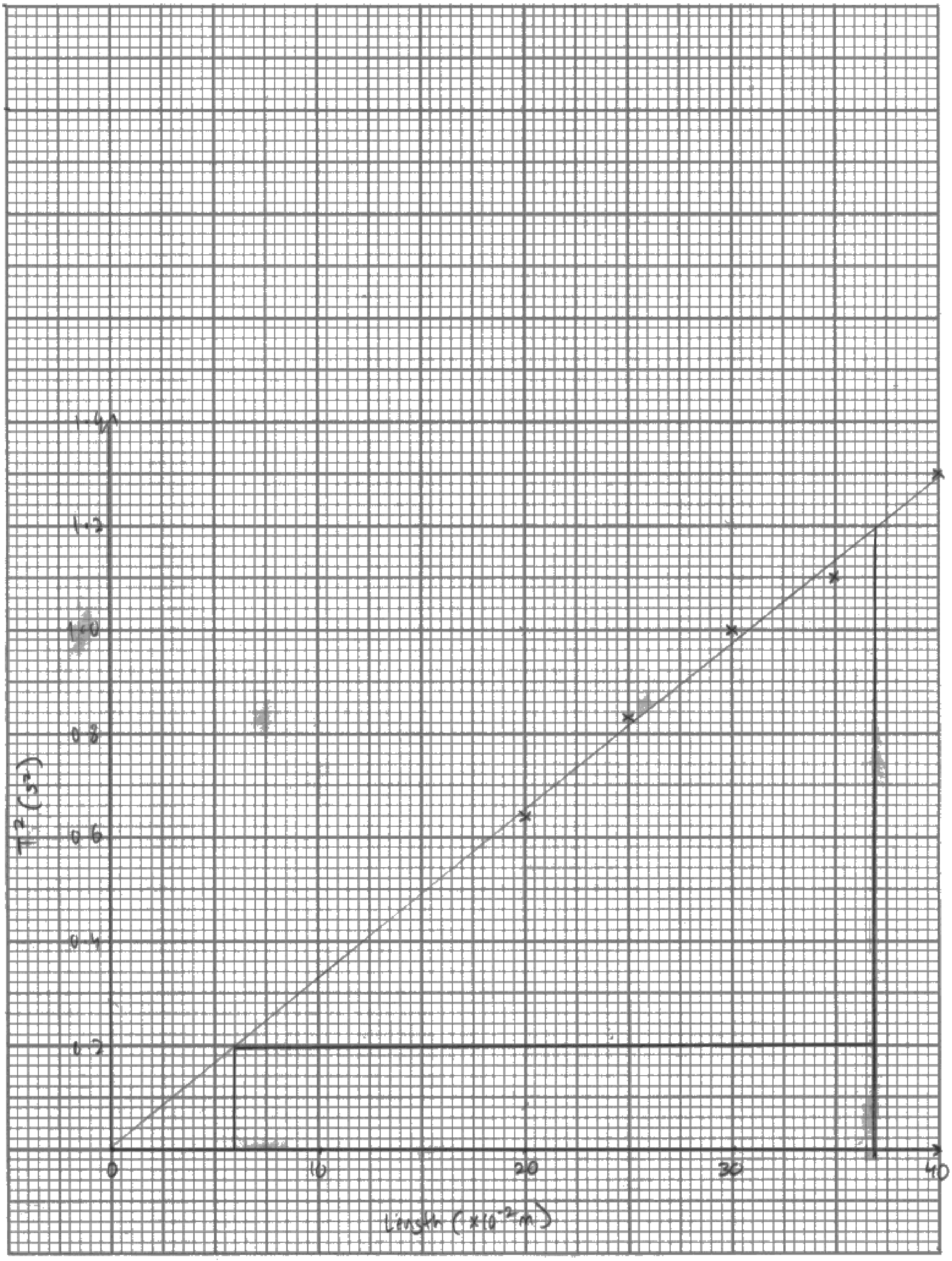
Question 8 (c)(i)

The majority of the students drew good graphs, choosing sensible scales for properly labelled axes and plotting their points accurately before drawing an acceptable line of best fit. Some students chose inappropriate scales in an attempt to make fuller use of the grid provided. This frequently resulted in plotting errors - probably caused by unusual scale factors. Some of the better graphs were drawn on truncated scales, but sometimes this resulted in a line spoiled by an attempt to force it through a false origin.

Question 8 (c)(ii) Most students used a large triangle, as required, to calculate the gradient of their line. Some slipped up when converting the length from centimetres to metres and gave a gradient value that was incorrect by a factor of 100.

Question 8 (c)(iii) Most students calculated a suitable value for g and their responses usually showed an appropriate number of significant figures. A significant minority omitted to include an acceptable unit at this stage.

Question 8 (d) Many students could perform this calculation properly. A correctly processed answer was accepted even if it was based on an erroneous value from part (c)(iii). A very large number of responses included values given to more than two significant figures.



1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
10
20
30
40
T² (s²)
Length (×10⁻² m)

(ii) Determine the gradient of the graph.

(2)

$m = \frac{\Delta y}{\Delta x} = \frac{1.2 - 0.2 \ s^2}{37 - 6 \ \times 10^{-2} m} = \frac{1}{31}$

$= 0.0322580645161...$

$= 0.0323 \ s^2 / \times 10^{-2} m$

$= 3.23 \ s^2/m$

Gradient = 3.23 s^2/m ~~0.0323~~

(iii) Use your value of the gradient to calculate a value for *g*.

(2)

$\frac{4\pi^2}{g} = \frac{1.0 \ s^2}{0.37_m - 0.06_m} = \frac{1.0 \ s^2}{0.31 m}$

$g = \frac{4\pi^2}{1.0 s^2 / 0.31 m} = 12.23830946 \ ms^{-2}$

$= 12.2 \ ms^{-2}$ (3.s.f)

$= 12 \ ms^{-2}$ (2.s.f)

g = 12.2 ms^{-2}

(d) Calculate the percentage difference between the value for *g* calculated in (c)(iii) and the accepted value for *g*.

$g = 9.81 \ ms^{-2}$

(2)

% difference = ~~original~~ $\frac{\text{difference}}{\text{original}} \times 100$

$= \frac{12.2 ms^{-2} - 9.81 ms^{-2}}{9.81 ms^{-2}} \times 100 = 24.75340935 \%$

$= 24.8\%$ (3.s.f)

Percentage difference = 24.8%

ResultsPlus
Examiner Comments

This was a good answer although only one mark was awarded for Q8 (c)(iii). A sensible scale was chosen and points are clearly drawn.

In Q8 (c)(iii) a mark was lost as the answer was written to three significant figures.

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Examiner Tip

Use scales which are multiples or sub-multiples of 1, 3 or 5.

Think carefully about significant figures.

Paper Summary

This paper provided students with a wide range of contexts from which their knowledge and understanding of the physics contained within this specification could be tested.

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

- All diagrams should be drawn with a ruler and it is important to use the correct symbols for electrical components.
- Familiarity with the SI system and the plotting and use of graphs using scales which are multiple or sub multiples of 1, 2 and 5 should be reinforced.
- Students should make sure they understand the term ‘experimental techniques’.
- Answers may be written using bullet points.
- Assertions should always be supported with reasons.
- In the planning questions it is useful to consider whether a reader could carry out the experiment completely from the instructions given in the answer.

Grade Boundaries

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