Pearson Edexcel

Examiners' Report

Principal Examiner Feedback

October 2018

Pearson Edexcel

International Advanced Level

In Physics (WPH06)

Paper 01 Experimental Physics

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General

The IAL paper WPH06 is called Experimental Physics and assesses the skills associated with practical work in Physics. In particular it addresses the skills of planning, data analysis and evaluation which are equivalent to those that A Level Physics learners in the UK are now assessed on within written examinations.

This document should be read in conjunction with the question paper and the mark scheme which are available at the Pearson Qualifications website.

The paper for November 2018 was in a similar format as previous series and with much the same skills content. This paper focused more on standard laboratory techniques set within experiments which the learners should have carried out as part of their studies. In the forthcoming new specification, it is expected that learners carry out a range experiments as the skills and techniques learned will be examined in different contexts. Hence learners who do little practical work will find this paper more difficult.

Although the mean mark was lower than the previous November series a good proportion of learners still gained high marks. However, there was a significant proportion of learners who appeared to be unprepared for this examination since there were some poor responses to standard questions and a number of blank spaces.

Generally, the learners often misunderstood the command words in the question. For example, where the learners were asked to explain they often described. In addition, some learners gave a list where they were asked for one description was asked for, and answers to calculations did not match the calculation as written. However, many learners presented answers that included logical and well-presented calculations clearly showing the methodology expected at this level.

Q01

As in previous series, this question assessed the learners' ability to handle uncertainties at the level expected of an A2 learner. This question concerned determining a value of the acceleration due to gravity *g* from a rolling marble experiment. The computations in this question were relatively straightforward however there were a surprising number of learners that made fundamental mistakes.

Part (a) of the question invited the learners to calculate the mean value of time from a set measurements along with its percentage uncertainty. Although this was a simple calculation, learners particularly at the lower end of the grade range either omitted a unit or gave the answer to too many significant figures. In addition, some learners assumed that the value of 2.29 s was anomalous which, given the context of the experiment, was not. Since a set of data had been presented the learners should be using the half-range in the set of measurements in order to calculate the percentage uncertainty not the resolution of the instrument. Note that calculations using the whole range were accepted on this occasion however this will not be accepted in the new specification. Although most were able to use the half range in the calculation of the percentage uncertainty there were a number that simply used the first and last measurements in the table. The example below shows a learner that had used too many significant figures in part (i) but went on to achieve both marks in part (ii).

(a) (i) Calculate the mean value for t.

(1)

mean = $\frac{2.37 + 2.33 + 2.36 + 2.29 + 2.32}{5} = 2.334\,s$

t = 2.334 s

(ii) Calculate the percentage uncertainty in t.

(2)

$\frac{1}{2}$ range = $\frac{2.37 - 2.29}{2} = 0.04\,s.$

$\%U = \frac{0.04}{2.334} \times 100\% = 1.70\%.$

Percentage uncertainty in t = 1.7%.

Part (b) contained the arithmetic aspects of the question alongside an explanation surrounding the use of uncertainties. The first part asked for an explanation for why the uncertainty of the change in height was recorded as 0.2 cm. This part was aimed at the higher end of the grade range, therefore most found this challenging. Most learners gave the resolution correctly although the term itself was rarely used. It should be noted that the term precision will not be accepted for resolution in the new specification. A number used or implied doubling the absolute uncertainty. Whilst in this case the value was the same they missed the point that absolute uncertainties are summed when variables are added or subtracted. Others also seemed confused by the set square. It appeared that they assumed both the ruler and the set square were used to measure rather than the set square used to ensure the ruler was perpendicular to the base surface. The following example shows a clearly reasoned answer which scored full marks.

(b) (i) The student measured the vertical heights of the start line and finish line from the bench. He used a metre rule and a set square each time.

He recorded the change in height Δh as 3.4 cm ± 0.2 cm.

precision

Explain why the uncertainty is stated as ± 0.2 cm.

(2)

the ~~resolution~~ of a metre rule is 0.1 cm.

h_1 = the vertical heights of the start line. uncertainty for $h_1 = \pm 0.1\,cm = U_{h_1}$

h_2 = the vertical heights of the finish line uncertainty for $h_2 = \pm 0.1\,cm = U_{h_2}$

$\Delta h = h_1 - h_2$, therefore uncertainty for $\Delta h = U_{h_1} + U_{h_2} = \pm 0.2\,cm$

The second part asked for a value for *g* to be calculated from the formula. Although most coped well with this there were some missing units or unit conversion errors. In the third part the learners had to calculate the percentage uncertainty in this value and it was here that the final percentage uncertainty should be given to 1 or 2 significant figures. It should be noted that learners are credited for the method they use, hence a full calculation should be shown such as in the following example. Unfortunately, this learner gave too many significant figures for the final percentage uncertainty hence scored the methodology marks only. On occasion learners either doubled the incorrect percentage uncertainties or did not double any at all.

(ii) t is given by the equation

$$t^2 = \frac{14s^2}{5g\Delta h}$$

where s is the distance travelled by the marble.

Calculate a value for g.

$s = 0.800\,\text{m} \pm 0.001\,\text{m}$

(1)

$g = \frac{14s^2}{5t^2\Delta h} = \frac{14 \times (0.800)^2}{5 \times 2.334^2 \times (3.4 \times 10^{-2})} = 9.68\ \text{m/s}^2$

$g = 9.68\ \text{m/s}^2$

(iii) Calculate the percentage uncertainty in the value for g.

(3)

$\%U$ in $s = \frac{0.001}{0.800} \times 100\% = 0.125\% \Rightarrow \%U$ in $s^2 = 2 \times 0.125\% = 0.25\%$.

$\%U$ in $t = 1.7\% \Rightarrow \%U$ in $t^2 = 2 \times 1.7\% = 3.4\%$.

$\%U$ in $\Delta h = \frac{0.2}{3.4} \times 100\% = 5.9\%$.

$\%U$ in $g = 0.25\% + 3.4\% + 5.9\% = 9.55\%$.

Percentage uncertainty in g = 9.55%

In the next part the learners had to comment on their calculated value of *g*. Here the learner should be using their calculated percentage uncertainty in order to compare their calculated value with the accepted value. The accepted method is to calculate the upper and/or lower limit using the percentage uncertainty and comment on whether the accepted value falls within the range, however most learners opted to determine the percentage difference value and then correctly compare that with percentage uncertainty. The vast majority of these correctly used 9.81 ms^{-2} as the denominator but then some learners compared the percentage uncertainty or percentage difference value to 5% which was not accepted.

In part (c) learners had to discuss whether using light gates would improve the accuracy of this value. Here the command word "Discuss" implies that both a positive and negative comment should be given but most of the learners only considered how light gates could improve the experiment. Whilst the majority of learners noted that the reaction time would be eliminated, or words to that effect, a number of those did not link this to the percentage uncertainty being reduced. A typical response scoring one mark is shown below. The vast majority did not consider the difficulties in using light gates with small objects or that the percentage uncertainty in t was low compared to that in Δh so the improvement would be small.

(c) The student suggested modifying the experiment to use a set of light gates to measure the time the marble took to roll to the finish line.

Discuss whether this modification would improve the accuracy of the value of g.

(2)

Use stopwatch will have random error, e.g. human's reaction time. When using a set of light gates, the random error can be almostly reduced.

So. this modification would improve the accuracy of the value of g.

Q02

This question focussed on measuring techniques set within the context of a standard experiment to investigate the absorption of gamma rays using lead sheets. It was clear that many learners had not carried out this experiment.

Part (a) was a typical question related to justifying the use of an instrument for a particular measurement but with a slightly different wording. A surprising number did not achieve any marks for this question despite being on most past papers in various contexts. Here the learners had to realise that a micrometer screw gauge was the instrument that should be used to measure a thickness of approximately 1 mm. Most learners achieved this however the most common mistake was to use a resolution of 0.1 mm instead of 0.01 mm or state that vernier calipers should be used with a resolution of 0.01 mm, which is incorrect. Digital vernier calipers with this resolution were accepted. It should be noted here that other words used to describe resolution were accepted apart from accuracy, however in the new specification only resolution will be credited. The second mark was given for using the resolution to calculate an expected percentage uncertainty which the majority could do, but then make a comment that it was small which was often omitted. The following example shows a learner that made this mistake hence scored only 1 mark.

(a) Explain the measuring instrument the student should use to measure the thickness of each lead sheet.

(2)

use micrometer with precision 0.01 mm

$\%U = 100\% \times \frac{0.01\ mm}{1\ mm} = 1\%$

Part (b) tested the learners' ability to identify the control variable in the experiment. Most learners were able to do so but often missed the mark by stating the distance between the source and the counter rather than the Geiger-Muller tube. There were a number of learners that stated other potential variables, such as temperature, time and background radiation, which did not score the mark.

In part (c) the learners had to consider how to ensure that the recorded count rate was accurate. It was rare to see learners gain both marks here. Often, they did not specify that background count rate should be subtracted from the measured count rate just that a background count should be measured. Most learners suggested repeating the measurement to find the mean which was credited although it was rare to see using a longer time period which is a valid technique. Other techniques were often seen, such as checking for zero error, which suggested that the learner had not read the question properly. The following learner did score both marks.

(c) Describe how the student should make sure that the recorded count rate is accurate.

(2)

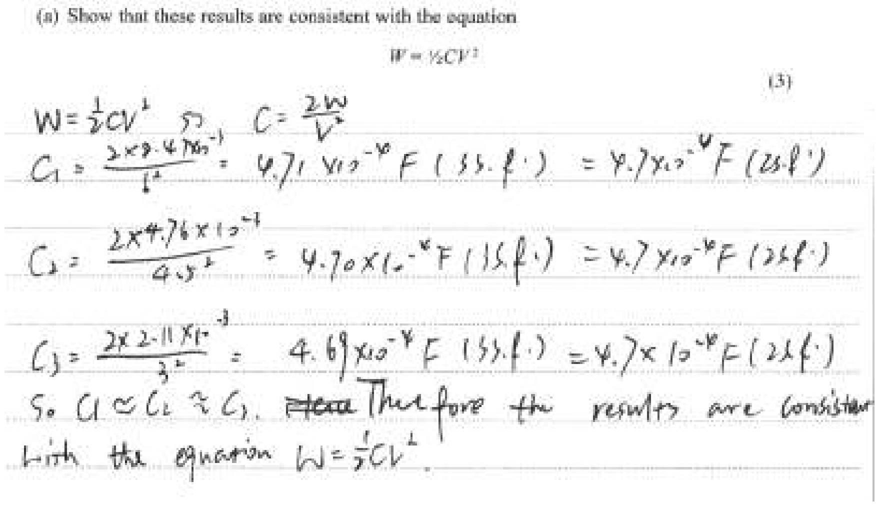
The student should first measure the background ~~count~~ Count rate before ~~two~~ other measurements ~~to~~ to avoid its influence. Then the students should take many measurements ~~a~~ each with ~~the~~ same ~~absop~~ absorption time ~~and~~ and ~~a~~ take the mean value. Finally he ~~sh~~ or she should subtract the mean value by the background rate.

In part (d) learners had to list one safety precaution and it was here that many listed several, again suggesting that the question had not been read properly. When using radioactive sources, learners should be considering distance, time and shielding only. Learners were not penalised for providing multiple correct answers but those that suggested wearing protective clothing, gloves or goggles were penalised.

Q03

This question was based on an experiment to measure the energy stored in a capacitor and a subsequent discharge experiment to determine the resistance of a voltmeter.

In part (a) the learners had to show that the results obtained for the energy stored were consistent with the equation. As it is a show that question it is expected that the learners show a full calculation and make a suitable comment based on their values. Many learners tackled this in the manner shown in the example below which scored full marks.


(a) Show that these results are consistent with the equation

$W = \frac{1}{2}CV^2$

(3)

$W = \frac{1}{2}CV^2$ so $C = \frac{2W}{V^2}$

$C_1 = \frac{2 \times 2.36 \times 10^{-4}}{1^2} = 4.71 \times 10^{-4}$ F (3 s.f.) $= 4.7 \times 10^{-4}$ F (2 s.f.)

$C_2 = \frac{2 \times 4.76 \times 10^{-3}}{4.5^2} = 4.70 \times 10^{-4}$ F (3 s.f.) $= 4.7 \times 10^{-4}$ F (2 s.f.)

$C_3 = \frac{2 \times 2.11 \times 10^{-3}}{3^2} = 4.69 \times 10^{-4}$ F (3 s.f.) $= 4.7 \times 10^{-4}$ F (2 s.f.)

So $C_1 \simeq C_2 \approx C_3$. ~~Hence~~ Therefore the results are consistent with the equation $W = \frac{1}{2}CV^2$.

The most common issues seen were not calculating the values correctly, not calculating three values or not making a valid comment. Other methods were also seen which were given credit, such as calculating a value for *C* using one set of measurements then using this to predict the values of *W*.

In the part (b) of the question the learners were presented with a discharge graph from which they were to calculate the resistance of the voltmeter. The first aspect of this part asked for a definition of the time constant which was poorly done by most learners. Many learners then went on to calculate the resistance correctly, usually by reading off the time constant from the graph or the time for the potential difference to halve. Occasionally learners used the incorrect formula, for example, they used the time constant in the half-life equation or vice versa. There were a significant number of learners that did not know how to tackle this part of the question, suggesting that they had not used a discharge graph before. The example below shows a learner that used an alternative method which still scored full marks.

(ii) Determine a value for the resistance R of the voltmeter. (2)

$V = V_0 e^{-\frac{t}{RC}}$

$V_0 = 6V$ according graph

$t = 50s$ $V = 3.5V$

$3.5V = 6V\ e^{-\frac{50s}{RC}}$

$-\frac{50s}{RC} = \ln\left(\frac{3.5V}{6V}\right)$

$C = (4.71\times10^{-4} + 4.7\times10^{-4} + 4.64\times10^{-4})\ \frac{1}{3}\ J\cdot V^{-2}$

$C = 4.7\times10^{-4}\ J\cdot V^{-2}$

$R = \frac{-50s}{C\times\ln\left(\frac{3.5V}{6V}\right)}$

$R = 1.97\times10^{5}\ \Omega$

$R =$ $1.97\times10^{5}\ \Omega$

Q04

This is the data handling question that requires learners to process data and plot a graph to determine a constant. In this question learners were presented with the measurements of time period from an oscillating metre rule from which they were to determine the relationship between the time period and the mass attached to the end of the rule. Although this is a not standard experiment, it is based on the measurement of oscillations so should have posed little difficulty.

Part (a) focused on explaining the measuring techniques specific to this experiment. Although many learners understood that they had to explain why a technique should be used there were a significant number that just reiterated the information in the question. It was rare to see all three marks awarded here as the use of a fiducial marker was not understood, often learners quoting that it is used to count oscillations rather than mark the position of the beginning and end of an oscillation. Learners that were credited for this mark often expressed this in a variety of ways. The marks for use of multiple oscillations and repeating and calculating a mean were often given as these are standard techniques although learners were not credited for spotting anomalies. The following example shows a learner that made these common errors.

Explain how this method would ensure that the time period T is as accurate as possible.

(3)

(i) Place a marker at the equilibrium to ensure the ~~make~~ marker can record the total number of period of oscillations.

(ii). measure time for 10 oscillations to take a longer time to decrease the percentage uncertainty due to $\%U = \frac{\Delta t}{t} \times 100\%$

(iii) repeat and get mean to ~~reduce~~ identify anomalies

There were some learners that had given good answers but unfortunately had not directly linked the reason to the technique, therefore could not score marks.

Part (b) is another standard question where they have to explain the graph to be drawn. Here learners were more successful in understanding what they had to do although there were a significant number that did poorly. Where the logarithmic expansion was done correctly learners may have lost the mark when the comparison was written in an order such that the terms did not correspond with the expansion. In addition, there were some learners that did not write in the operators. The second mark asked for the gradient to be specified, which many learners did. A response to this question that did not score marks is shown in the example.

(b) The time period T is related to the mass M by the equation

$$T = qM^r$$

where q and r are constants.

Explain why plotting log T against log M should produce a straight line graph.

(2)

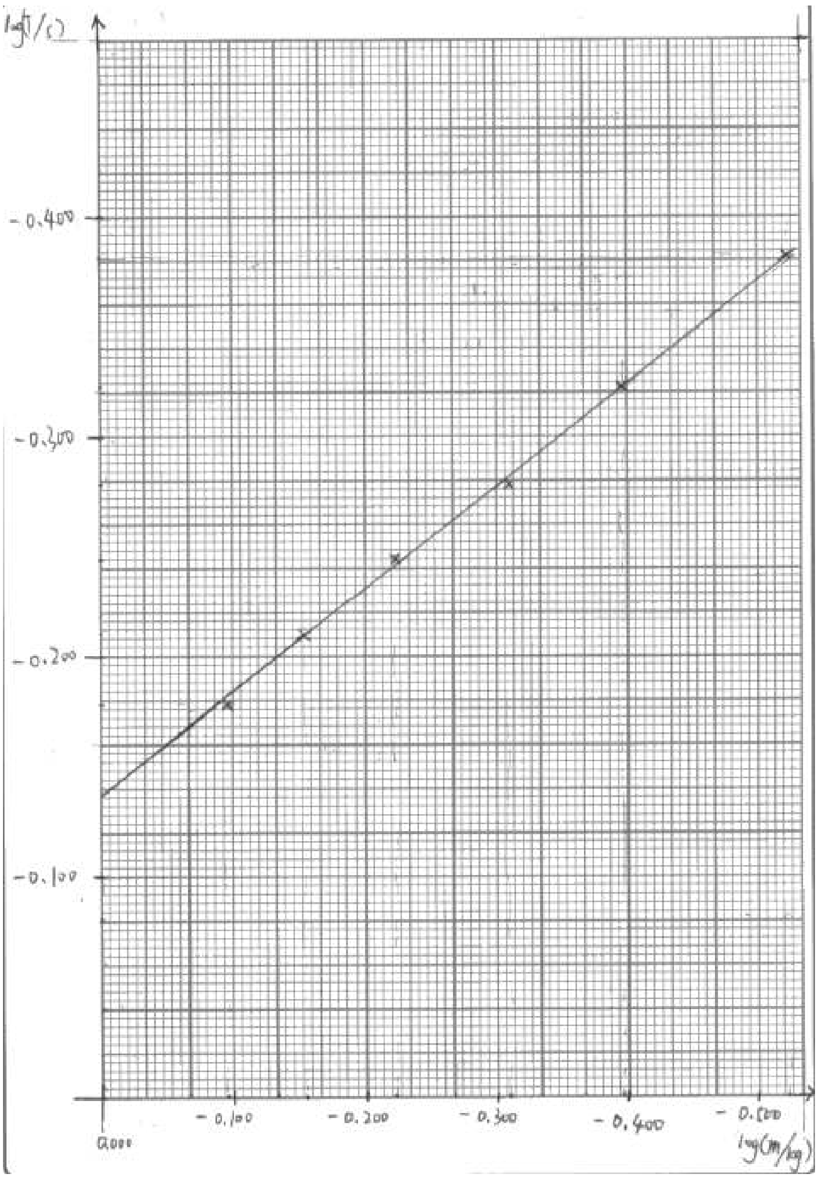
$\log T = \log q + \log M^r = \log q + r \log M$.

So it has the pattern with the equation of straight lines: $y=ax+b$. where a, b are constants. q is constant so log q is constant. r is also constant so it would ~~produce~~ produce a straight line graph.

Finally part (c) assesses the learners' ability to process data and plot the correct graph. A good learner should be able to access the majority of the marks here however many learners found plotting a graph using negative numbers challenging and tried many methods to try and avoid doing so. It was pleasing that the majority of learners could process the data to the correct number of significant figures and some learners chose to use the natural log rather than log to base 10. On rare occasions other bases were used however provided learners clearly label the table as such then this is acceptable. In addition, if a learner multiplies by factors of 10 to ensure that the log values are positive, then this is also acceptable provided the learner has clearly labelled the table as such. On occasion the negative sign was missed off the values.

Plotting the graph did cause a number of issues and it is clear that learners need more exposure to plotting negative numbers. The most common error in the graph was not labelling the axes in the correct form, i.e. log(T / s), or labelling the axes such that the negative numbers increased in the positive direction as shown in the example below. At this level the learners should be able to choose a scale such that the plotted points occupy over half the grid in both directions and is easy to read, i.e. in 1, 2 or 5 and their multiples of 10. Many learners opted for scales based on 4, e.g. 0.25 or 0.04, which are unacceptable, or used a strange scale to ensure the entire grid was used. Again this is shown in the example below. Learners should also be aware that landscape graphs are acceptable and the log values were best plotted in landscape, which was rarely seen.

In general, if the scale was sensible then learners were able to plot the graph accurately however learners must be encouraged to use neat crosses rather than dots. The best fit lines were generally good since there was little scatter, however it is expected that there should be an even number of points either side of the best fit line and, in this case, it should be extended to the *y*-axis as shown in the example below.



In the final part the learners had to use their graph to determine values of *r* and *q* to determine the relationship between *T* and *M*. Since this is a linear graph it is expected that the gradient of the graph should be used as it is this skill that is being assessed. It is also expected that learners at this level should automatically use a large triangle. Some learners did get into difficulty with the negative numbers in the calculation. There were some learners that used two pairs of points from the line to substitute back into the equation to find *r*. This is an acceptable method provided the points lie on the best fit line and are suitably far apart. It was also expected that the value for *q* would be determined from the *y* intercept. Those that had not used a scale that allowed them to do so still gained credit by using their value for the gradient and the co-ordinates of a point on the best fit line to substitute back into the formula. Some learners that had placed the *y* axis on the wrong side of the page generally did not achieve this mark and some learners did not find the antilog of their value. The final mark was for using these values to state the mathematical relationship and it was clear that many learners did not understand what this meant as they wrote a sentence rather than a mathematical expression. In addition, there were a number of learners that omitted this part. The following example shows a learner achieving full marks.

(ii) Determine the constants q and r and hence state the mathematical relationship between T and M.

(4)

$\text{gradient} = \frac{0,381 - 0,138}{0,523 - 0} = 0,46$

$\text{gradient} = r \Rightarrow r = 0,46.$

$y\text{-intercept} = -0,138 = \log q \Rightarrow q = 10^{-0,138} = 0,73$

$\Rightarrow T = 0,73 \times M^{0,46}$

Summary

Learners can improve their chances of gaining a good mark on this paper by routinely carrying out and planning practical activities for themselves using a wide variety of techniques. In particular they should make measurements on simple objects using vernier scales, and complete experiments involving electrical circuits, timing and mechanical oscillations. These can be simple experiments that do not require expensive, specialist equipment and suggested practical activities are given in the specification.

In addition, the following advice should help to improve the performance on this paper.

- Understand the command words in the question, in particular the difference between describe and explain.
- Use the number of marks given in a question as an indication of the number of answers required or if a number of answers is specified only give that number of answers.
- If a question asks for an explanation use sentences in a reasoned order.
- Where a calculation is used in an explanation complete the answer with a written conclusion based on the results of the calculation.
- If a rounded answer is written down in a subsequent calculation ensure that this is the number used in the calculation.
- Show working in all calculations as many questions rely on answers from another part in the question, or marks are awarded for the method used.
- Be consistent with the use of significant figures.
- Choose graph scales that are sensible, i.e. 1, 2 or 5 and their powers of ten only so that at least half the page is used. It is not necessary to use the entire grid and grids can be used in landscape if that gives a more sensible scale.
- Learn standard measuring techniques and the reason they are used.
- Learn the definitions of the terms used in practical work. These are given in Appendix 10 of the new IAL specification.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

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