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June 2013

GCE Physics 6PH08 01

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Introduction

The paper 6PH08 is the International Alternative to Internal Assessment unit 6PH06. It assesses the skills associated with practical work in physics and addresses the skills of planning, data analysis and evaluation. Set in a wide variety of contexts the questions will be more accessible to those candidates who have, themselves, carried out a range of practicals in the laboratory and a plan at this level will consist of several stages. There are questions concerning choice of apparatus, and the use of that apparatus, that will be immediately familiar to those with the practice behind them.

The title of the paper, Experimental Physics, is the same as that for unit 6PH06 for home centres and the mark scheme for each paper is designed to reflect the demands made on home candidates in their coursework. In this way all candidates face the same test at A2.

The style of the paper is that there are four questions that combine to test the range of practical skills from the beginning of the experiment to the end. So the first question will usually address the selection and use of measuring instruments, the middle two questions will ask the candidate to plan an experiment and analyse some data from another; the plan is usually one mentioned in the specification but the analysis from an unfamiliar context. The final question asks the candidate to consider a practical situation that they might have seen in the laboratory and to answer questions on how such a practical might be carried out; there will normally be some data to analyse by drawing a graph.

Uncertainty in measurement and its effect on a conclusion are ideas that run through the paper and can occur in a variety of ways; numerical work is expected to show an awareness of the role of significant figures and physical units. Candidates are expected to be familiar with standard practice in an A level physics laboratory; there are examples in the specification.

Question 1 (a) (i)

This question asks the candidate to estimate the uncertainty introduced into a measurement by the choice of measuring instrument; this will be due to the precision of the instrument and the percentage uncertainty depends on the likely size of the measurement. Here the uncertainty in the callipers is 0.1 mm if they have a vernier scale and 0.01 mm was also allowed since this is the precision of digital callipers.

This is a good clear answer that is correct.

(a) (i) She uses vernier callipers to measure the diameter of coin X.

Show that the percentage uncertainty for this measurement is less than 1%.

(1)

precision of vernier callipers is 0.1 mm, ~~Percentage uncer~~

Percentage uncertainty = $\frac{0.1}{25}$ × 100% = 0.4%

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Examiner Comments

Since the question asks the candidate to show that the percentage uncertainty is less than a certain value it is not necessary to include that value in the answer.

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Examiner Tip

Always show your numerical working, even when it is relatively easy.

Most candidates avoided mistakes like this and scored the mark.

(a) (i) She uses vernier callipers to measure the diameter of coin X.

Show that the percentage uncertainty for this measurement is less than 1%.

(1)

Uncertainty in Vernier callipers = 0.01 cm = 1×10^{-3} mm

% uncertainty = $\frac{\text{Uncertainty}}{\text{Value}}$ × 100 = $\frac{1 \times 10^{-3}\text{mm}}{25}$ × 100 = 4×10^{-3} %

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Examiner Comments

Here the candidate knows about uncertainty but gets confused about units.

It is always worth checking your numerical working if your answer seems unusually large or small, as here.

Question 1 (a) (ii)

This question is about the technique required in using the selected instrument. Checking for zero error is probably the easiest answer here yet many candidates scored the mark by discussing how to measure in different places although the language needed to be quite precise here. Some candidates wanted to measure across a number of coins but the question says there are only two, different, coins. Parallax is not a problem in reading callipers.

This sort of response is often seen but it never scores the mark. 'Eye level' is too vague. If parallax is indeed a problem then 'making sure my eye is lined up with the scale' is quite a good response but the best is to draw a sketch diagram. This always scores the mark if correctly done.

(ii) Apart from repeating her readings, state one precaution she could take to ensure each measurement is as accurate as possible.

(1)

Take readings at eye level to avoid parallax error

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Examiner Comments

This is not the way to describe the method used to address this problem; neither is parallax a problem here.

(ii) Apart from repeating her readings, state one precaution she could take to ensure each measurement is as accurate as possible.

(1)

• Take reading of the Diameter from both Sides of the Coin  ; and ensure to not overtighten the vernier Calliper.

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Examiner Comments

This is a nice clear answer.

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Examiner Tip

It is always a good idea to include a diagram in your answer where you think it will save you some words.

Here it is the right size, not too small, and clearly illustrates the answer. The examiner is in no doubt what the candidate means.

(ii) Apart from repeating her readings, state one precaution she could take to ensure each measurement is as accurate as possible. (1)

Ensure that zero error for the vernier callipers are accounted for.

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Examiner Comments

Another clear response.

Question 1 (a) (iii)

This question about measuring the thickness was answered well by most candidates but some read the question as measuring the diameter or decided to use a micrometer - this is not what the question says.

Many candidates responded correctly with the standard answer that measuring at different points allows anomalies to be discarded when finding the mean value. A mean is needed because the thickness varies.

(iii) The student measures the thickness of coin X using a micrometer screw gauge. She takes measurements at different points on the coin.

Explain why this would make the mean value for the thickness more accurate. (1)

thickness of coin X is different at each ~~dir~~ different points.

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Examiner Comments

A good simple response.

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Examiner Tip

Written answers do not need to be long neither are there any marks for use of language so bullet points are a good way to present your answer.

(iii) The student measures the thickness of coin X using a micrometer screw gauge. She takes measurements at different points on the coin.

Explain why this would make the mean value for the thickness more accurate.

(1)

An average value is found excluding any anomalous readings

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Examiner Comments

This scores the mark.

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Examiner Tip

Repeating words from the question might help the sense of the answer - as here - but do not score marks by themselves. So here using the word 'average' helps express the meaning but does not contribute to the score.

Question 1 (b) (c) (d)

This section gives the candidate the measurements and asks them to process this information and reach a conclusion about the two coins based on the uncertainties in the measurements.

Generally this question was done well and candidates seem well rehearsed in calculating and then using uncertainties.

Quite a few candidates had difficulty in calculating the volume of the coin so it is worth drawing attention to Appendix 12 of the specification where the mathematical requirements are laid out and volume of a cylinder is mentioned there. It is possible candidates did not think of a coin as cylindrical.

This sort of question always expects the candidates to get the significant figures correct. There should be the same number of significant figures in the answer as there is in the data. Candidates frequently lost marks in this question by quoting too many significant figures.

The use of units must be consistent although not necessarily SI, correct equivalents are accepted.

This response scores full marks. The work is neatly laid out and therefore easy to follow and it shows the candidate thinking about the problem in a logical fashion.

(b) She records the following values for coin X:

diameter/mm 25.9, 25.9, 25.9

thickness/mm 1.80, 1.84, 1.82

(i) Use these measurements to calculate the mean value for the volume of coin X.

(2)

mean diameter = 25.9mm

mean thickness = $\frac{1.8 + 1.84 + 1.82}{3}$ = 1.82mm

volume = cross-sectional area x thickness

= $\pi r^2 \times h$

= $\pi \left(\frac{25.9}{2}\right)^2 \times 1.82$ ≐ 958.87mm^3 = 0.959cm^3

Mean value for the volume of coin X = 0.959cm^3

(ii) Use the measurements to estimate the percentage uncertainty in the volume.

(3)

percentage uncertainty for diameter = 0.4%

percentage uncertainty for thickness = $\frac{1.84 - 1.82}{1.82} \times 100\% = 1.1\%$

total percentage uncertainty = 2(0.4) + 1.1 = 1.9%

Percentage uncertainty = 1.9%

(c) She measures the mass of coin X as 7.08 g with negligible uncertainty.

Calculate the density of coin X.

(2)

density = $\frac{\text{mass}}{\text{volume}} = \frac{7.08}{0.959} = 7.38\ g/cm^3$

Density of coin X = $7.38\ g/cm^3$

(d) The student makes the same measurements for coin Y. The value of the density for coin Y is 6900 kg m^{-3}. The percentage uncertainties in the measurements are the same for both coins.

Use these measurements to decide if the coins are made from the same material.

(2)

lower range for density of X = 7380 x (100 - 1.9)% = 7239.78 kg/m³

upper range for density of Y = 6900 x (100 + 1.9)% = 7031.1 kg/m³

∴ There is quite a large difference between the possible values for the ~~density~~ densities, they do not seem to be made of the same material.

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Examiner Comments

(b) (i) The means are shown and the formula used is written out. Some candidates did not round off to 3 SF thus losing a mark but any correct unit is acceptable so the answer here could be in mm^3 or cm^3 or even m^3.

(b) (ii) The uncertainty in the diameter is not zero. If all the measurements are the same then the uncertainty is the precision of the instrument, here 0.1 mm. Candidates were awarded the mark for working this out using 25.9 mm or simply quoting their answer from part (a). When calculating the percentage uncertainty for the thickness either the whole range or half the range (as here) of the readings should be used. A good number of candidates doubled the percentage uncertainty in diameter since this is raised to the power 2 in the calculation.

(c) The candidates scored the mark if they divided the mass by their value for the volume from b(i). Again, any correct unit is acceptable but only 3 SF is correct.

(d) All candidates moved back to SI units here but only the best candidates realised the point that both values are experimental so the percentage difference must be compared with twice the percentage uncertainty to conclude whether both coins are of the same material. Alternatively the extreme values of the ranges of the two quantities can be calculated, as here, when the comparison shows that they do not overlap.

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Examiner Tip

Always write down the formula you are using. It is a good idea to rearrange it as necessary before substituting the numbers.

Question 2

This question asks the candidate to plan an experiment about mechanical energy transfer. It is hoped that the candidates have seen such an experiment and perhaps performed it for themselves.

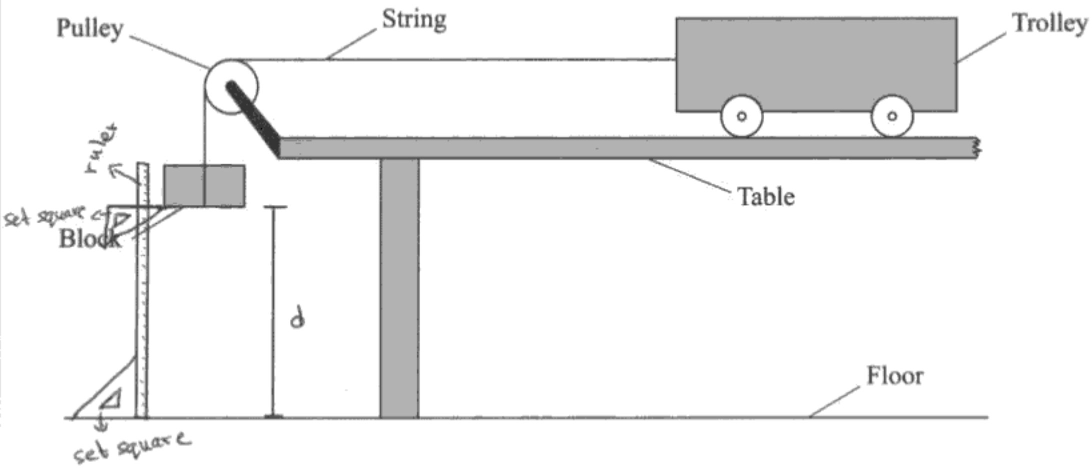
This question is a very good example of how to use a diagram as part of your answer. Those who did not show on the diagram how *d* might be measured rarely scored more than one of the two marks.

When commenting on safety the risks might be to people or to apparatus, in all cases the hazard should be identified and a suitable precaution mentioned. The risk will not be a major one in most school laboratory experiments but neither should a trivial one be considered. If there is no real risk then the reason why there is no hazard should be explained.

Planning forms a significant part of the assessment and attention is drawn to the criteria for unit 6PH06 listed in the specification. The marks for questions such as this one follow the criteria quite closely.

These responses score all the early marks but the candidate could improve the quality of the responses to make sure of the score. The last two are rather weak.

2 A student is asked to carry out an experiment about the energy transferred when a trolley is pulled across a table. The apparatus is set up as shown.



As the block falls it loses gravitational potential energy and the trolley and block together gain kinetic energy. The student is asked to find out what fraction of the gravitational potential energy becomes kinetic energy.

The student writes an outline plan for an experiment and produces a table.

1. *Measure the mass M of the trolley and the mass m of the falling block and set up the apparatus as shown.*
2. *Pull back the trolley so that the block is close to the pulley and release the trolley.*
3. *Measure the distance d fallen by the block.*
4. *Measure the time t it takes to fall.*
5. *The final velocity is given by* $v = \frac{2d}{t}$.
6. *Calculate the gravitational potential energy lost and the kinetic energy gained.*
7. *Divide the kinetic energy by the gravitational potential energy. This is the fraction required.*

Quantity to be measured	Measuring instrument	Precision of measuring instrument
Masses, M and m	Balance	At least 0.1 g
Distance, d	Metre rule	At least 1mm
Time, t	Stopwatch	At least 0.01s

Add more detail to improve this plan. You should do the following:

(a) complete the table,
(3)

(b) add a line to the diagram to show the distance *d*,
(1)

(c) describe how you would measure *d* accurately (you may add more to the diagram if you wish),
(2)

(d) describe how you would make each measurement of *t* accurate,
(1)

(e) comment on any safety aspect of this experiment.
(1)

c) Use set square and a ruler, in order to be sure that ruler is perpendicular to the bench, and use another set square to find d.

d) Be at eye level with the block

e) Make sure that string is new, and not corrupted anywhere because it may break

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Examiner Comments

(a) Most candidates clearly understand precision and most answers that mentioned weighing in some way were allowed, only 'scale' was not. It should be noted that a precision of 1 mm is different from a precision of 1.0 mm; the former is correct here.
(b) The height that the mass falls through is to be marked. Some candidates made estimates along the string; since the question is about gravitational potential energy these were marked as incorrect.

(c) Those candidates who added to the diagram usually scored both marks. The rule must be drawn close to the block; it should be no further away than is shown here. The lower set square, to ensure a vertical rule, gets the second mark. The upper set square is poorly used and this is not worth a mark; in order to ensure a horizontal alignment the vertical edge of the set square should be aligned with the edge of the rule. The written response adds nothing to the information shown by the additions to the diagram.

This would be a good question in which to draw an eye placed parallel to the lower edge of the block looking across the bottom to avoid parallax. A dotted horizontal line from eye to block makes the point.

(d) This is a disappointing response using the term 'eye level'. It is a good idea to listen to when the block hits the floor. Quite a number of candidates repeated their readings but several repeats were needed for a mean.

(e) New string is not really a precaution, it is better to say what you might do to avoid injury if the string breaks. A hazard and consequent precaution are expected.

Question 3 (a)

This question required careful thought since it asks what happens as the resonant frequency is approached. The only answer acceptable was that the amplitude increased.

(a) State what you would observe as *f* gets close to the resonant frequency.

(1)

The amplitude of the oscillations would get larger and larger.

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Examiner Comments

Here the correct answer is given.

(a) State what you would observe as *f* gets close to the resonant frequency.

(1)

The spring vibrates faster with greater amplitude.

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Examiner Comments

"Faster" is not a helpful term. The frequency is increasing so the mass is being driven faster, no matter what happens to the amplitude. The candidate gets the mark for mentioning that.

(a) State what you would observe as *f* gets close to the resonant frequency.

(1)

The oscillations of the spring will be at its maximum, so the mass will oscillate at it's maximum.

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Examiner Comments

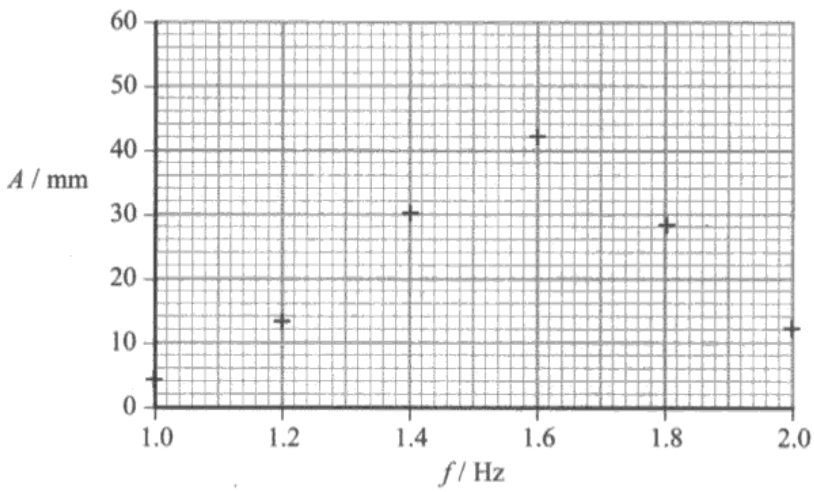
This response is admirably clear but does not answer the question asked.

Question 3 (b)

There was quite a lot to do for the first mark; candidates were expected to draw a curve showing the line of best fit and then read off the maximum to 3 SF. They were then asked to comment on the data and the method.

This question requires a nonlinear curve to be drawn; this is a skill expected at this level, though candidates seemed unfamiliar with the idea. Similarly it is clear in this graph that a value of 1.6 Hz is rather vague.

(b) As f is varied, the amplitude of oscillation A of the mass is recorded. The results are shown on the graph.



(i) Use the graph to estimate the resonant frequency.

(1)

Resonant frequency = 1.6 Hz

(ii) Describe how you would improve the experiment to obtain a more accurate value for the resonant frequency.

(2)

Repeat the ~~ex~~ experiment and take average.

more ~~or~~ frequencies used in the interval of the resonant frequency (iii)Suggest why it would be better to use an ultrasound position sensor and data logger to record the position of the mass.

(1)

more accurate readings

graph plotted instantly

no human error

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Examiner Comments

(i) The candidate quotes the maximum using 2 SF and without drawing a line of best fit.

(ii) The candidate asks for more frequencies but is vague about the values to be used.

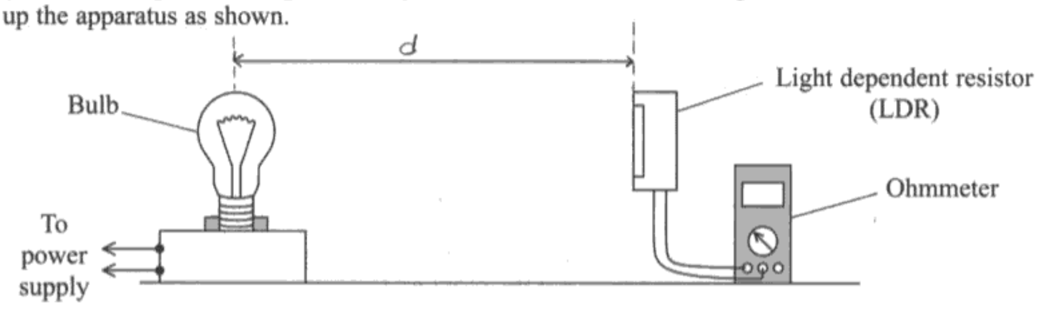
(iii) The mark is awarded for the accuracy. The data logger is in fact only measuring one of the variables. It can plot a graph of position against time so accurate measurements of amplitude and frequency can be made but the resonance curve cannot be drawn. Many candidates mentioned this but it is not worth the mark.

Question 4 (a)

The envelope has no bearing on the emission of the light and so the distance must be measured to some part of the filament.

Dimension lines and a double-headed arrow clearly labelled *d* were not commonly seen but many candidates scored the mark.

4 A physicist investigates how light intensity varies with distance from a light bulb. He sets up the apparatus as shown.



(a) Mark on the diagram the exact distance *d* he should measure.

(1)

(b) State why the resistance *R* of the LDR will increase as it gets further away from the

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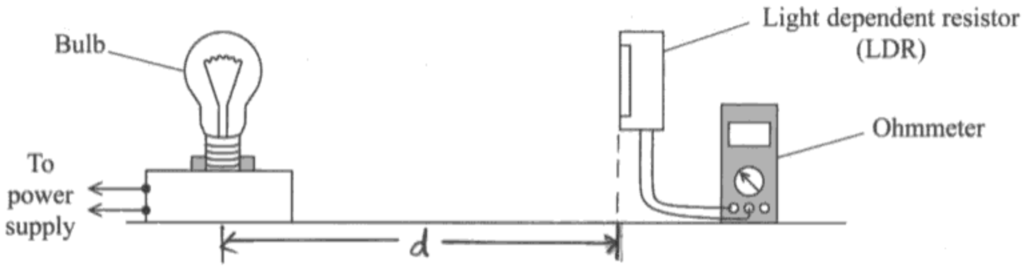
This is the best sort of response.

4 A physicist investigates how light intensity varies with distance from a light bulb. He sets up the apparatus as shown.



(a) Mark on the diagram the exact distance d he should measure.

(1)

(b) State why the resistance R of the LDR will increase as it gets further away from the

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Examiner Comments

This too is perfectly acceptable and shows how dimension lines can be used to reduce clutter.

Question 4 (b)

This is another question requiring a precise answer. It is not enough to say that there is less light: rather candidates at A2 level are expected to talk about light intensity.

(b) State why the resistance R of the LDR will increase as it gets further away from the bulb.

(1)

when the light is further, less current passes through it. According to V=IR, resistance increases.

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Examiner Comments

The candidate understands that lesser light intensity reduces the number of available charge carriers but has not related that to the question which asks about resistance. Ohm's law is not appropriate here.

(b) State why the resistance R of the LDR will increase as it gets further away from the bulb.

(1)

Further away from the bulb light intensity is smaller as $L \propto \frac{1}{d^2}$ and the current through the LDR would reduce so Resistance increases. LDR is not a ohmic conductor.

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Examiner Comments

The cause and effect are slightly confused in that the resistance increase causes the reduction in current rather than the other way round. But the mark is awarded for the underlying cause, the reduction in light intensity.

(b) State why the resistance R of the LDR will increase as it gets further away from the bulb.

$R \propto \frac{1}{LI} \propto d$

(1)

The resistance of the LDR is inversly proportional to light intensity and light intensity is inversly proportional to distance from bulb

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Examiner Comments

This is a neat way of expressing the answer. The words are unnecessary.

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Examiner Tip

Use mathematics in your answer whenever you think it will help.

Question 4 (c)

The idea of control variables is not really a difficult one but here it needs applying to the experiment. Since it is light intensity that is being measured, indirectly, then this must be controlled. Many candidates thought that the power supply might vary yet few mentioned a voltmeter and ammeter to check. In fact what is needed is to control other sources of light, from the sun and even other lamps. Nearly all candidates getting this came up with suitable control measures.

(c) State the most important quantity to control to ensure a fair test and explain how the physicist might control it.

(2)

don't let any other lightsource be in the room or make sure all other light sources are constant, Cover the windows and turn of all other lights. Use a dark room used for developing photographs

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Examiner Comments

A very clear response.

(c) State the most important quantity to control to ensure a fair test and explain how the physicist might control it.

(2)

The light intensity of the room the experiment is ~~bein~~ ~~being~~ being done in has to be constant. This can be done by performing experiment in dark room.

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Examiner Comments

A slightly simpler version of the previous answers but all that is needed.

(c) State the most important quantity to control to ensure a fair test and explain how the physicist might control it.

(2)

The current ~~and~~ in the bulb.

* By connecting a variable resistor to the circuit so that current and voltage both are controlled.

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Examiner Comments

This control is not suitable since nothing is measured. There is no reason the power supply should vary unless it says so in the question.

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Examiner Tip

Answer only what the question asks for, do not invent other conditions.

(c) State the most important quantity to control to ensure a fair test and explain how the physicist might control it.

(2)

He should ensure that the only source of light being detected by the LDR is that from the bulb used in the experiment.

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Examiner Comments

A rare example scoring only one mark as there is no control measure suggested.

Question 4 (d)

A regular question which very many candidates get correct.

(d) The relationship between R and d is given by

$$R = k\,d^p$$

where k and p are constants.

Explain why a graph of ln R against ln d will give a straight line.

(2)

$R = kd^p$ m, gradient = p where p = constant

ln R = ln k + p ln d y-intercept = ln k where k is constant

hence ln R = p ln d + ln k so the graph will be a straight line as

compare with y = m x + c gradient is constant.

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Examiner Comments

A clear answer that makes explicit the link with y = mx + c.
Also clear is that *p* is the gradient.

Explain why a graph of ln R against ln d will give a straight line.

(2)

$R = k d^P$ LnR = P ln d + Ln k. ~~which is~~

compare with y = ax + b. there will be a straight

line

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Examiner Comments

Here, the link to the gradient is left too vague and so the second mark is not awarded.

Question 4 (e) (f)

This is the question that always causes the most difficulty. To improve, candidates should practise plotting graphs of complex relationships requiring logarithms but also the simple skill of fitting the data to the size of grid provided. If the choice of scale is complex the candidate usually makes a mistake plotting a point or reading wrongly the values for a gradient calculation.

Here the range of gradients for the lines of best fit was quite large but many candidates did not get the Best Fit Line mark, often because they drew it through the point on the axis.

For part (f) candidates are asked to use their graph to find values for gradient and intercept. If candidates cannot be seen taking measurements from the graph then they cannot be awarded the mark.

It is expected that candidates will use 3 significant figures (3 SF) for graphical work. Data to be plotted should be tabulated to at least 3 SF and gradient calculations should be measured from the graph to 3 SF and the final value quoted to 3 SF.

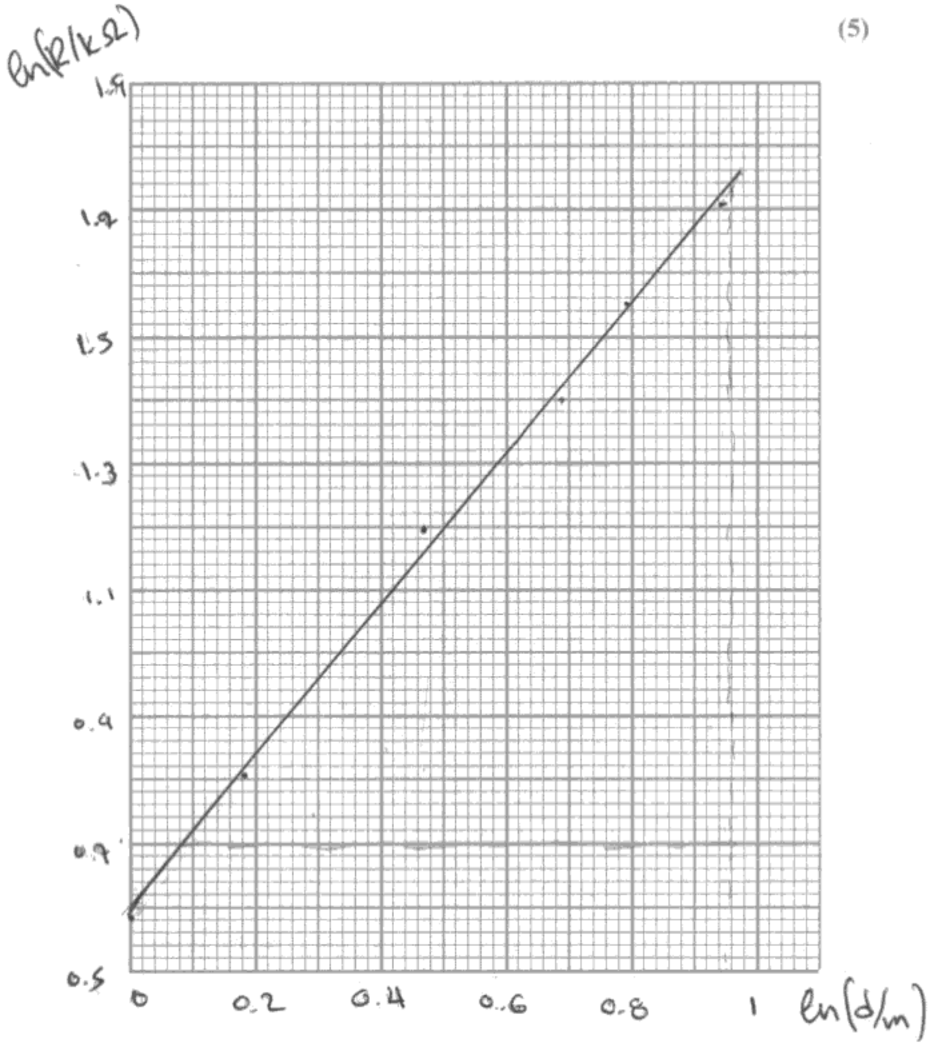
This is a good candidate who has scored full marks.

(e) He measures R for different values of d and records the following results.

d/m	R/kΩ	ln(d/m)	ln(R/kΩ)
1.00	1.79	0	0.582
1.20	2.24	0.182	0.806
1.60	3.32	0.470	1.200
2.00	4.04	0.693	1.396
2.20	4.70	0.788	1.548
2.60	5.50	0.956	1.705

Plot a graph of ln R against ln d. Use the column(s) provided to show any processed data.

(5)



(f) (i) Use your graph to find a value for p.

(2)

p = gradient = $\frac{1.74 - 0.70}{0.96 - 0.08}$ = 1.18

p = 1.18

(ii) Use your graph to find a value for *k*.

(2)

ln k = y-intercept = ~~[crossed out]~~ c (y = mx + c)

⇒ k = e^c = $e^{0.59}$ = 1.80

k = ~~[crossed out]~~ ~~[crossed out]~~ 1.8

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 40 MARKS

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Examiner Comments

The data table is clear. It is acceptable that one column goes to 4 SF since it starts at 3 SF and the last significant figure can just be used to make a difference in the plotting. The plots should be crosses rather than dots as these can disappear under the line of best fit. The line drawn is thin and straight and treats the plots well.

Marking a triangle on the grid helps you get the gradient measurements correct and the value here is right in the middle of the range.

The intercept on the ln *R* axis has been measured and the anit-log found correctly. Candidates whose line of best fit passed through the plot at 0.58 and quoted 1.79 as the value for *k* got no credit as they had not used their graph as asked.

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Examiner Tip

Show as much working as possible to help the examiner award you the marks.

This candidate is nearly as good but makes a few mistakes that could easily have been avoided.

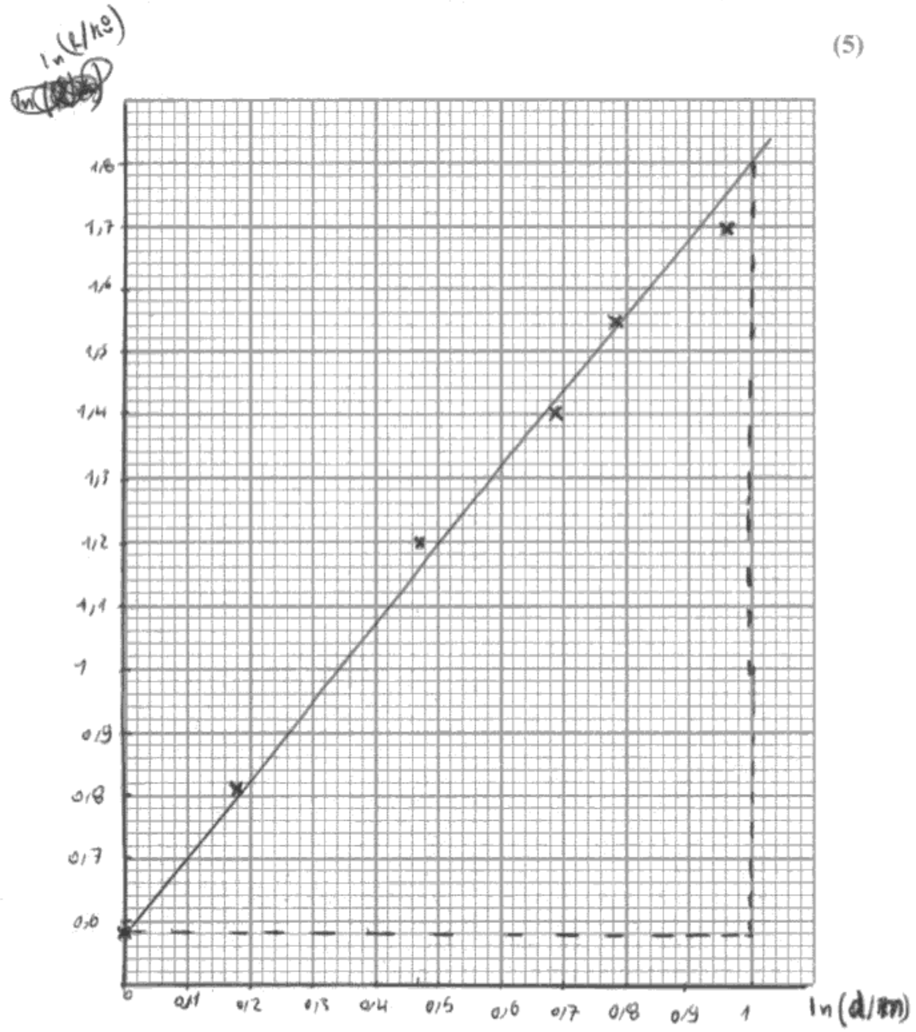
(e) He measures R for different values of d and records the following results.

ln R = ln a + p ln d

d/m	R/kΩ	ln(d/m)	ln(R/kΩ)
1.00	1.79	0	0,58
1.20	2.24	0,18	0,81
1.60	3.32	0,47	1,20
2.00	4.04	0,69	1,40
2.20	4.70	0,79	1,55
2.60	5.50	0,96	1,70

Plot a graph of ln R against ln d. Use the column(s) provided to show any processed data.

(5)



(f) (i) Use your graph to find a value for p.

(2)

gradient = $\frac{1.8 - 0.58}{1}$ = 1.22 m/kΩ

p = 1.22 m/kΩ

(ii) Use your graph to find a value for *k*.

(2)

ln k = the initial value of ln R

k = 1.79 kΩ

k = 1.7 kΩ

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 40 MARKS

ResultsPlus

Examiner Comments

Only 2 SF have been used for the data and this makes the graph look rather different as well as losing a mark.

The line of best fit only just scores a mark as it has two plots above and two below, as required, but it would be better drawn meeting the axis above the 0.58 plot.

The gradient calculation is very clearly shown using a large triangle. The gradient of a log-log graph though has no units as it represents the index *p* which cannot have a unit.

This candidate has simply quoted the table value with almost no explanation and has not used the graph. So the score is zero.

Paper Summary

The examiner reports are written to provide guidance for teachers and candidates. There was evidence that the reports from previous series had been used in preparation, which is good practice.

Candidates should pay more attention to diagrams and lines of best fit on graphs - visual communication. Diagrams should have any measured length shown with dimension lines and rulers should be close to the length they are being used to measure.

Candidates should take care when using significant figures (SF). 3 SF are expected for graph work, plotting and gradient measurement and calculation.

When a graph is non-linear candidates find great difficulty drawing the line of best fit and using it to reach a conclusion.

There can be no substitute for carrying out practical work in the laboratory and discovering how enjoyable it can be to successfully record and analyse some real physics.

Grade Boundaries

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

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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