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January 2013

GCE Physics 6PH08 01

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Introduction

The paper, for the International Alternative to Internal Assessment, is written to assess the skills associated with practical work in physics. It addresses skills associated with planning, data analysis and evaluation. Set in a wide variety of contexts, the questions will be more accessible to those candidates who have carried out a range of practicals in the laboratory.

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 UK centres and the mark scheme for each paper is designed to reflect the demands made on home candidates in their coursework for unit 6PH06. 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 - this is usually one mentioned in the specification - and analyse some data from an unfamiliar context; a plan at this level will consist of a number of stages.

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. Centres will find that the criteria for assessing the practical coursework for home centres provide a valuable framework for teaching practical work in preparation for this unit.

Question 1

This question asked the candidates to explain aspects of the technique for measuring length. The choice of apparatus was given, a metre rule (note the spelling) and candidates were asked to explain this choice. As for mark P5 on the coursework criteria for home centres, candidates were expected to discuss percentage uncertainty. The metre rule introduced an uncertainty of at least 1 mm due to its precision and since the measurement was about 300 mm the percentage uncertainty was about 0.3, this made the rule a good instrument to use.

The number of significant figures is of little use when choosing an instrument: it is the precision that is important. *Accuracy* is how close the reading is to the true value and this will depend almost entirely on how the instrument is used - an instrument itself does not have an accuracy.

Using the apparatus was best done by repeating measurements for a mean but sensible use of a set square was also credited. Here, a sketch diagram would have helped considerably to explain the perpendicular nature of the measurement.

This candidate gives a large amount of information. There will only be 3 SF if the measurement is above 100 mm but they mention low percentage uncertainty in context and so receive the mark. It would have been better if they had showed the calculation deriving 0.3%.

Answer ALL questions in the spaces provided.

1 A student is asked to determine the density of a metal in the form of a thin sheet.

The sheet is a square of approximately 300 mm × 300 mm and has a thickness of about 0.01 mm.

(a) (i) Explain why a metre rule is suitable to measure the length of each side of the sheet.

(1)

metre rule has precision of 1 mm. will ~~give~~ record value to 3 significant figures with low percentage uncertainty.

(ii) Describe how the student should use this rule to make the measurements as accurate as possible.

(1)

Take repeat measurements and obtain an average.

Read scale at eye level.

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Examiner Comments

Reading a scale at eye level is unlikely to be awarded a mark – it is difficult to see how else a scale might be read.

0 marks.

ResultsPlus
Examiner Tip

Calculate the likely percentage uncertainty introduced due to the precision of the instrument.

Here (1mm/300mm) x 100% = 0.3%

Here the candidate addresses the question but not in the right way.

Answer ALL questions in the spaces provided.

1 A student is asked to determine the density of a metal in the form of a thin sheet.

The sheet is a square of approximately 300 mm × 300 mm and has a thickness of about 0.01 mm.

(a) (i) Explain why a metre rule is suitable to measure the length of each side of the sheet.

(1)

Because the smallest unit of a metre rule is 1 mm.

(ii) Describe how the student should use this rule to make the measurements as accurate as possible.

(1)

Make sure his eye is parallel to the reading to avoid parallex error.

ResultsPlus
Examiner Comments

The smallest measuring unit is correctly identified as 1 mm, which is the precision of the rule but the candidate does not explain why 1 mm is sufficient.

To avoid parallax the line of sight should be perpendicular to the scale: this can be a valid technique but should be used with care. Here, there is no distance between the object, the aluminium sheet, and the scale, so there can be no parallax.

0 marks.

The use of a set square requires careful explanation.

Answer ALL questions in the spaces provided.

1 A student is asked to determine the density of a metal in the form of a thin sheet.

The sheet is a square of approximately 300 mm × 300 mm and has a thickness of about 0.01 mm.

(a) (i) Explain why a metre rule is suitable to measure the length of each side of the sheet.

(1)

Because the metre rule can measure up to 0.01 mm

(ii) Describe how the student should use this rule to make the measurements as accurate as possible.

(1)

Use the rule with a set square.

ResultsPlus

Examiner Comments

The examiner cannot infer how the set square will be used and the candidate must make this clear.

0 marks.

ResultsPlus

Examiner Tip

Always draw a diagram if it will help to explain a technique.

Use a pencil and ruler and have an eraser ready.

It should not be a small diagram.

Question 1 (b) (i)

The candidates were expected to discuss how to make a measurement that was smaller than the precision of the instrument. Here, the technique was to measure a number of thicknesses at the same time; a similar technique is to measure 10 periods of an oscillating pendulum. In measuring a number of thicknesses (or periods), you automatically find a mean thickness (or time). You should also repeat your reading, in order to check that you are reading the right thing and to find a mean for your own measurement. It is important to distinguish between the two ideas.

This question did not score very highly.

Descriptions must be precise and clear.

An error is a mistake and not part of a measurement, which will have an uncertainty. Techniques should aim to reduce the percentage uncertainty: if a measurement has an error it should be repeated.

(b) In order to determine the thickness, the student is told to fold the sheet in half five times.

(i) Explain why this technique would make the value for the thickness of the sheet more precise.

(2)

The thickness of one single sheet is too small. There may not be suitable apparatus. Folding increases the total thickness measured hence reduces the percentage error. Also, suitable apparatus is enabled to be used, as the folded sheet is like a thread.

ResultsPlus
Examiner Comments

Here the term 'percentage error' is used, which negates the good work done by discussing the effect of folding. Apparatus described as 'suitable' will get no credit: candidates are expected to suggest apparatus that is suitable to the task.

0 marks.

Overall thickness would increase ~~by five times~~.
So percentage uncertainty would decrease while measuring the width when ~~tow~~ folded five times as
% ΔU = $\frac{\Delta U}{U}$ x100%. So it gives more precise reading

ResultsPlus

Examiner Comments

Here, the candidate correctly identifies the reducing percentage uncertainty and comes close to the second mark. They would have received this by saying that the precision of the instrument remains the same but since the thickness increases the percentage, uncertainty is less.

1 mark.

The use of technical terms is important but they must be at an appropriate level and used to describe techniques appropriate to a level.

as the sheet is thin, it would be quite tough to get the measurment, but once fold in half five times, the thickness increases giving more accurate result and making easy to obtain it.

ResultsPlus
Examiner Comments

'Tough' has a particular meaning in physics and is not used appropriately here. The thickness is described as increasing but without any definite purpose, since accuracy is determined by how the micrometer will be used.

0 marks.

ResultsPlus
Examiner Tip

Use technical terms appropriate to an A level student.

Question 1 (b) (ii)

Most candidates scored this mark by saying 'micrometer (screw gauge)'. The measurement is required to a precision of 0.01 mm so digital calipers were also allowed.

Question 1 (c)

This question was about manipulating data and drawing a conclusion. It was answered well by most candidates and scores were very high.

Common errors included:

1. Multiplying by 32. Since this was a 'show that' question, candidates were expected to do the same as they do for the theory papers and quote their answer to one significant figure more than was in the question. Examiners are seldom misled by the candidate who writes down a wrong calculation and a 'correct' answer.
2. Using the range or half the range of the repeated readings was acceptable when calculating the uncertainty in a measurement, but candidates were expected to do the same throughout a calculation. Some candidates used the precision of the instrument and failed to get any marks.
3. 2 or 3 significant figures was suggested by the data and candidates who used any more lost this mark.
4. Most candidates correctly calculated the percentage difference but many failed to make the comparison with the percentage uncertainty calculated in (ii). Using the percentage uncertainty to calculate the upper bound of their measurement was also accepted for the first mark, but candidates were expected to state that this was less than the accepted value for the density and hence the material was unlikely to be aluminium. A number expected the examiner to draw this conclusion and lost the mark.

The work is well laid out.

(i) The folded sheet is 32 times thicker than a single sheet.

Use these measurements to show that the volume of the sheet is about 1.0×10^{-6} m^3.

(2)

Ans: Volume = Area × height

$= (301 \times 10^{-3})(300 \times 10^{-3}) \times \left(\frac{0.369 \times 10^{-3}}{32}\right)$

$= 1.04 \times 10^{-6}$ m^3

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

(2)

Ans: % uncertainty in length = $\frac{8}{301} \times 100 = 2.66$ %

% " " breadth = $\frac{6}{300} \times 100 = 2$ %

% " " height = $\frac{0.023}{0.369} \times 100 \times \frac{1}{32}$ ~~6.23~~ % = 0.19 %

% uncertainty in volume = ~~10.89~~ 4.85 %

Percentage uncertainty = 4.85 %

(iii) The student measures the mass of the sheet as 2.49 g with negligible uncertainty.

Calculate the density of the metal.

(1)

Ans: Density = $\frac{\text{mass}}{\text{volume}} = \frac{2.49 \times 10^{-3}}{1.04 \times 10^{-6}} = 2394$ kg/m^3

Density = 2400 (2 s.f.) kg m^{-3}

(iv) A website gives a value for the density of aluminium as 2750 kg m^{-3}.

Use your calculations to determine whether the sheet might be made from aluminium.

(2)

Ans: No, because density values are not too similar even when taking into consideration the percentage uncertainty of volume.

(Total for Question 1 = 12 marks)

ResultsPlus
Examiner Comments

The calculation is clearly correct.

The percentage uncertainty in the thickness has been divided by 32. The percentage uncertainty is the same for the calculated value as it is for the measurement itself - here 6.23%. The candidate uses the whole range for the uncertainty calculation, which is acceptable.

The density calculation is shown to 2 SF, which is acceptable.

No hard data is used in making the comparison and so the conclusion cannot be worth a mark.

4 marks.

ResultsPlus
Examiner Tip

Always lay out your work so that it is easy to follow.

This candidate has not quite mastered the work at this level.

(i) The folded sheet is 32 times thicker than a single sheet.

Use these measurements to show that the volume of the sheet is about 1.0×10^{-6} m³.

(2)

~~V = l×B×h~~ ~~V = l×B×h~~ ~~V = (0.369×32)×0.31×0.3~~

~~V = 0.369~~ $V = (0.369 \times 32) \times 0.31 \times 0.3 \times (1 \times 10^{-3})$

$\therefore V = 1.066 \times 10^{-6}\ m^3$

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

(2)

% uncertainity of L = $\frac{1}{301} \times 100 = 0.33$

% uncertainity of B = $\frac{1}{300} \times 100 = 0.33$

% uncertainity of thickness = $\frac{0.005}{0.369} \times 100 = 1.36$

% uncertainity of volume = $0.33 + 0.33 + 1.36 = 2.02$

Percentage uncertainty = 2.02 %

ResultsPlus

Examiner Comments

This candidate has multiplied by 32 instead of dividing and then 'fiddled' the powers of ten to arrive at an answer that is beguilingly close.

They have used the precision of the instrument in calculating the percentage uncertainties, but they have added three values so they receive the second mark.

2 marks.

ResultsPlus

Examiner Tip

Always use half the range of readings when calculating percentage uncertainties - unless this is smaller than the precision of the instrument.

This is a good candidate who has managed to lose a couple of marks.

(i) The folded sheet is 32 times thicker than a single sheet.

Use these measurements to show that the volume of the sheet is about 1.0×10^{-6} m³.

(2)

Volume = length × width × thickness

$= (301 \times 10^{-3}) \times (300 \times 10^{-3}) \times \left(\frac{0.369 \times 10^{-3}}{32}\right)$

$= 1.0 \times 10^{-6}$ m³.

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

(2)

%ΔV = %Δl + %Δw + %ΔT.

$= \frac{(305 - 297) \div 2}{301} + \frac{(303 - 297) \div 2}{300} + \frac{(0.379 - 0.356) \div 2}{0.369}$

$= 0.013 + 0.01 + 0.03$

$= 0.05\%$

Percentage uncertainty = 0.05 %

(iii) The student measures the mass of the sheet as 2.49 g with negligible uncertainty.

Calculate the density of the metal.

(1)

Density $= \frac{\text{mass}}{\text{volume}} = \frac{2.49 \times 10^{-3}}{1.0 \times 10^{-6}} = 2490$ kgm⁻³.

Density = 2490 kg m⁻³

(iv) A website gives a value for the density of aluminium as 2750 kg m⁻³.

Use your calculations to determine whether the sheet might be made from aluminium.

(2)

% Difference $= \frac{2750 - 2490}{2750} \times 100 = 9.45\%$

As % ~~uncertainty~~ difference is greater then % uncertainty is metal is not aluminium.

(Total for Question 1 = 12 marks)

ResultsPlus

Examiner Comments

The 'show that' answer cannot be awarded the second mark because it should be to 3 SF.

The candidate seems to have missed the point of percentage calculations.

5 marks.

ResultsPlus

Examiner Tip

Make sure your answer fits the question

Question 2 (a)-(e)

This question asks candidates to improve the plan for a practical to measure the time constant of a capacitor resistor combination. Planning is an activity that usually scores poorly and capacitance is a topic that often causes candidates difficulty.

Although the marks were well spread out at the lower end of the range, very few candidates scored high marks on this question. Candidates will find this type of question much more straightforward if they have carried out this sort of practical in the laboratory.

The question expects candidates to justify the choice of apparatus, discuss the method and precautions and explain how the data collected can be used. This is, again, along the lines of the criteria for the coursework for home centres.

This is a good candidate who has laid out their answer clearly so that their work is easy to follow.

(a) the initial current and the range he should set on the multimeter, (2)

(b) the expected value for the time constant and for how long he should take readings of the current, (2)

(c) a reason why this stopwatch is suitable, (1)

(d) a technique he should use to ensure his readings are as accurate as possible and one safety precaution that might be necessary, (2)

(e) an explanation of why a graph of ln I against t would give a straight line and how he should find a value for the time constant from the graph. (2)

~~7~~ a. $I = \frac{V}{R} = \frac{6}{47\times10^3} = 1.277\times10^{-4}$ (A).

The range he should set is 0 – 15 mA.

b. $\tau = RC$

$= 470\times10^{-6} \times 47\times10^3$

$= 22.09$ (s).

He should take readings every 10 seconds.

c. uncertainty is significantly lower than the percision 0.01.

~~So~~ Time constant is alot larger than percision.

d. ~~So~~ Film the process to ensure all readings are taken ~~in~~ on time. Eye level with the readings. Repeat the experiment and get average reasult of I on each time.

~~We~~ wear safty glasses and insulate gloves.

e. $I = I_0 e^{-\frac{t}{RC}}$

$\ln I = \ln I_0 - \frac{t}{RC}$

$\ln I = \ln I_0 - t \cdot \frac{1}{RC}$ because I_0, R, C are constants,

$y = mx + c$ is a straight line,

$\ln I = -\frac{1}{RC} \cdot t + \ln I_0$ is a straight line.

$-\frac{1}{RC}$ is the gradient of the line, $\frac{1}{RC}$ is ~~m~~ −1 × gradient

time constant $\frac{1}{RC} = -\frac{\Delta \ln I}{\Delta t}$

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Examiner Comments

The initial current is calculated correctly and an appropriate range is given. Many candidates had difficulty with the idea of the range of a meter. The mark was awarded to candidates who chose any value above their calculated value - as here. Familiarity with a multimeter used as an ammeter is a vital part of a candidate's knowledge but was found missing in very many cases.

The time constant is calculated correctly but many candidates described how frequently readings should be taken, such as every 10 seconds, as here. This is not what the question asks. Readings should be taken for a time of between one and two minutes in order to give sufficient time for the current to decay but without taking a lot of readings of a very small current. The idea of measuring a decaying current was poorly understood and would probably improve with practical experience.

There is confusion about the idea of high precision. It is a good idea to talk about the actual time, rather than rely on the word 'precision' alone. For a stopwatch the precision is 0.01 s, which is less than human reaction time so the stopwatch is suitable for use in this method. It is not clear what this candidate means about uncertainty.

'Repeat for a mean' is not a measuring technique but rather part of the method and so did not get a mark. This candidate has a lot of ideas but fails to apply them to this method and so scores zero. They should describe what is to be filmed; 'eye level with readings' means nothing by itself but a diagram showing how the position of the eye improves the reading might be worth the mark.

Similarly a hazard should be identified and a suitable precaution described. Wearing safety glasses or gloves for work with a 6 V electrical circuit is really a bit unnecessary; better is to describe why the experiment is safe. Any precaution must address a specified hazard. The proper use of the equipment is one such precaution. An experiment that destroys the apparatus is no good so, here, the polarity of the capacitor should be checked when connecting up the circuit and its working voltage should be more than the 6 V supply.

A large number of candidates compared the log equation with $y = mx + c$ but did not say that the value of RC was a constant and **hence** the gradient was constant and the line a straight one. A number of candidates ignored the fact that the line has a negative gradient and lost the second mark. This candidate scores both these marks.

4 marks.

This candidate starts off with a) as if to follow the question but soon moves away from answering it and falls into general comments that are not helpful.

(a) the initial current and the range he should set on the multimeter, **(2)**

(b) the expected value for the time constant and for how long he should take readings of the current, **(2)**

(c) a reason why this stopwatch is suitable, **(1)**

(d) a technique he should use to ensure his readings are as accurate as possible and one safety precaution that might be necessary, **(2)**

(e) an explanation of why a graph of ln I against t would give a straight line and how he should find a value for the time constant from the graph. **(2)**

a) Initial current of the circuit is calculated using $I = V/R$ where $V = 6V$ and $R = 47k\Omega$. The multimeter used should have a rang of 0 - 200 mA.

Time constant is the time taken for current to be 37% of its initial current. As the switch is moved from X to Y and circuit is allowed to discharge current at intervals of 50s is recorded upto 3 minutes.

A stopwatch is used to measure time as its precision is less than human reaction time which is 0.1s.

Repeated readings are taken. He should make sure that the capacitor is connected properly to the circuit, the positive terminal to the positive of the circuit and negative terminal to the negative of the circuit.

A graph of ln I against t is plotted.

$I = I_0 e^{-t/RC}$

$\ln I = \ln I_0 e^{-t/RC}$

$\ln I = \frac{-t}{RC} + \ln I_0$

$\ln I = \left(\frac{-1}{RC}\right)t + \ln I_0$

$y = m x + c$

It can be compared to a straight line equation whose gradient $= -1/RC$

$RC = \frac{-1}{\text{gradient}}$

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Examiner Comments

The candidate has probably calculated the initial current but has not written it down. The question does not ask how they would do this but asks them to give the value; the idea of a range for the meter is correct but does not get a mark because there is no value for the initial current given.

The explanation of time constant is not asked for, the value for it is expected. The candidate might have done this calculation but readings every 50 s for 180 s will give too few values and most of the decay will have happened by the first reading. The candidate clearly knows the physics but has not applied their knowledge to the question and so gets no marks for (b).

The precision of the stopwatch is quoted in the question and here the correct comparison with human reaction time gets the mark.

Repeat readings are not part of the technique to make each reading accurate. Placing the stopwatch and multimeter close to each other, or using the lap-timer facility, will make an improvement. The comment about the apparatus is worth a mark.

Comparison with the equation of a straight line is only valid if the gradient is correctly shown as constant. This must be stated explicitly, rather than allowing the examiner to make an inference. The minus sign in the time constant-gradient equation was often missing, although not in this example.

3 marks.

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Examiner Tip

Lay out your answer in sections that follow the question.

Make sure you answer the question that is asked.

The answers here are rooted in theory but not properly applied to the question asked.

(a) the initial current and the range he should set on the multimeter, **(2)**

(b) the expected value for the time constant and for how long he should take readings of the current, **(2)**

(c) a reason why this stopwatch is suitable, **(1)**

(d) a technique he should use to ensure his readings are as accurate as possible and one safety precaution that might be necessary, **(2)**

(e) an explanation of why a graph of ln I against t would give a straight line and how he should find a value for the time constant from the graph. **(2)**

(a) Find the initial current before move the switch to position Y, by using a multimeter. Range of current that should set on ammeter is 0.01 mA. The initial current is $I = \frac{6}{47k} = 0.13$ mA.

(b) According to formula $t = RC$, find time constant by multiply value of R (47kΩ) and value of C (470 μF). $t = 47k \times 470\mu = 22.09$ s. The time should be taken must greater than time constant, t (22.09 s).
Find at least 6 reading of time taken and find the average value.

(c) Measure a time taken by using a stopwatch. Stopwatch is used because it can measure up to 0.01s. Precision of a stopwatch is less than reaction time.

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Examiner Comments

This candidate gets the initial current right but the precision of the meter will not give very good readings and it is the range that is needed.

The time constant calculation is correct but the description of what is to be measured is confused. More than the time constant is what is needed and at least 6 values to plot a graph but what is to be averaged? Is it the 6 values or should, unstated, repeats be taken?

The stopwatch is appropriate but this candidate describes the precision as less where other candidates describe it as more. Quoting the precision as a time clears up this confusion.

5 marks.

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Examiner Tip

Doing this experiment as a practical exercise will improve your mark.

Question 2 (f)

This question tests the candidates' familiarity with practical technique and electrical circuit design. Some candidates simply exchanged the resistor and capacitor as if the current had to pass through the resistor before reaching the capacitor and once this restriction was removed, current would reach the capacitor unimpeded. This showed a very incomplete understanding of electricity theory.

Many candidates mentioned discharging or 'reaching a steady current' and so missed the first mark. The circuit design was very poorly answered, with candidates finding real difficulty in establishing anything that would work as required.

There is a need to use technical language clearly and correctly.

(i) Comment on why this wait is necessary.

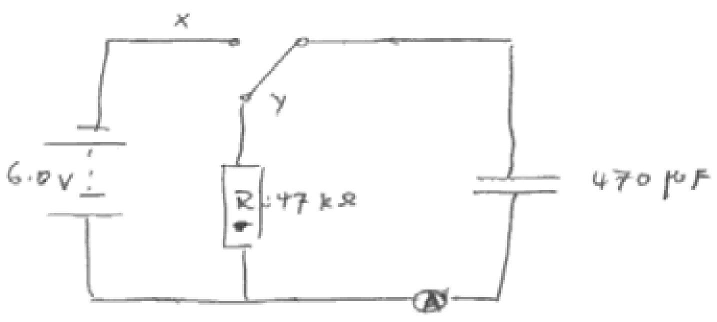
(1)

~~To make sure the capacitor is completely charged.~~

because of the resistor, series with capacitor.

(ii) Draw below a different arrangement of the circuit components so that there is no time delay.

(1)



(Total for Question 2 = 11 marks)

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Examiner Comments

The candidate clearly knows that with the components in series there will be a delay but fails to communicate that.

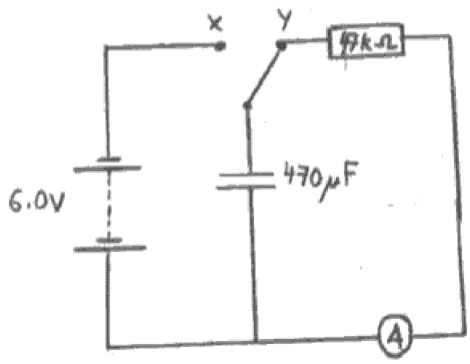
The circuit is ideal and the diagram is large.

1 mark.

Labelling the diagram is vital.

(ii) Draw below a different arrangement of the circuit components so that there is no time delay.

(1)



(Total for Question 2 = 11 marks)

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Examiner Comments

The candidate has changed the orientation of the switch but because this is labelled correctly the circuit is clearly correct.

1 mark.

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Examiner Tip

Make any diagram you draw large and clear. Use a ruler.

This diagram is ambiguous.

(i) Comment on why this wait is necessary.

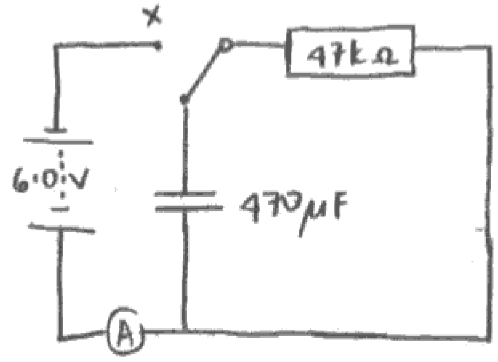
(1)

~~To ensure the capacitor is fully charged.~~

To allow the capacitor to be fully charged.

(ii) Draw below a different arrangement of the circuit components so that there is no time delay.

(1)



(Total for Question 2 = 11 marks)

ResultsPlus
Examiner Comments

The candidate understands that the capacitor needs to be fully charged - very clear.

The switch has been left as it was - probably - and so the capacitor will not charge up. The ammeter is wrong as well.

1 mark.

Question 3ai-iii

This section was answered very well. The only common errors were to quote the answer in (i) to more than 3 significant figures and in (ii) to forget to multiply the percentage uncertainty in the temperature by 4, thus arriving at an answer of 11% which was awarded one mark only.

Some candidates did not use the accepted value as the denominator when calculating the percentage difference. The mean value is only used when finding the percentage difference between two measurements of the same thing.

This candidate is familiar with the ideas but does not apply them correctly.

3 A student carries out an experiment on the Stefan-Boltzmann law.

$$L = \sigma T^4 A$$

She uses the filament of a light bulb as a model for a black body radiator.

(a) She obtains the following results.

$L = 23.5$ W ± 2% $T = 2400$ K ± 4%

The student estimates the surface area of the filament A to be 2.0×10^{-5} m^2 ± 5%.

(i) Use her results to calculate an experimental value for the Stefan-Boltzmann constant σ.

(1)

$L = \sigma T^4 A \quad \sigma = \frac{L}{T^4 A} = \frac{23.5}{2400^4 \times 2.0\times10^{-5}}$

Experimental value of σ = 3.5×10^{-8} W m^{-2} K^{-4}

(ii) Estimate the percentage uncertainty in the experimental value of σ.

(2)

% uncertainty = 2% + 4% + 5%

Percentage uncertainty = 11%

(iii) Calculate the percentage difference between the experimental value of σ and the accepted value, $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}.

(1)

% diff = $\frac{3.5\times10^{-8}}{5.67\times10^{-8}} \times 100$ = 61%

Percentage difference = 61%

ResultsPlus
Examiner Comments

2 significant figures for the value in (i) is fine but the percentage uncertainty does not take account of the fourth power of the temperature. If the candidate had quoted the percentage difference as 39% following this calculation, they would have received the mark.

2 marks.

Setting out your answer clearly is likely to help you to get the right result.

(iii) Calculate the percentage difference between the experimental value of σ and the accepted value, $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}. **(1)**

$$\frac{5.67 \times 10^{-8} - 3.54 \times 10^{-8}}{5.67 \times 10^{-8}} \times 100\%$$

$$\frac{2.13 \times 10^{-8}}{5.67 \times 10^{-8}} \times 100\%$$

37.566%

Percentage difference = 37.57%

ResultsPlus

Examiner Comments

This is clear and the candidate can check much of their calculation by looking again at what they have written.

They are unlikely to make a mistake with the powers of ten.

4 marks.

Question 3aiv

The percentage difference (%D) from part (iii) is to be compared with the percentage uncertainty (%U) from (ii). The %D is larger than %U, so the candidate should conclude that the experimental result is not reliable. About half of the candidates did this.

(iv) Use these percentages to comment on the reliability of the experimental value for σ.

(1)

38% > 28%   D% > U%

so the experimental value is not reliable.

ResultsPlus

Examiner Comments

This candidate makes it very clear.

1 mark.

(iv) Use these percentages to comment on the reliability of the experimental value for σ.

(1)

The percentage difference is over 10% so the experimental value for σ is not valid.

ResultsPlus

Examiner Comments

The percentage difference by itself has little meaning and the figure of 10% here is also not very meaningful.

0 marks.

Question 3 (b) (i)

This question deals with using logarithms to plot data as a straight line graph.

(b) The Stefan-Boltzmann law can be written as

$$\ln L = 4\ln T + \ln \sigma A$$

The student obtains a range of values for L and T and plots a graph of $\ln L$ against $\ln T$.

(i) Explain clearly how she could use this graph to obtain a value for σ.

(2)

She will ~~B~~get $\ln \sigma A$ from the graph as the y-intercep.

$\ln \sigma A =$ y intercept

~~ln A ln σ~~ $\cdot \sigma A = e^{\text{y-intercept}}$

$\sigma = \dfrac{e^{\text{y intercept}}}{A}$

(ii) She realises that she cannot control the temperature of the room

ResultsPlus

Examiner Comments

The right answer, shown clearly.

2 marks.

ResultsPlus

Examiner Tip

It is a help to the examiners if the writing is clear of the following question. Using the space on the right inside the box is preferable.

(i) Explain clearly how she could use this graph to obtain a value for σ.

(2)

$\ln L = 4 \ln T + \ln \sigma A$

$Y = m x + c$

The intercept of y-axis is the $\ln \sigma A$ which is the constant c. As the surface area is known then the value of σ can be calculated.

(ii) She realises that she cannot control the temperature of the room

ResultsPlus

Examiner Comments

The instruction to 'explain clearly' means that this candidate only gets one mark because they have not shown explicitly how to find the constant σ.

1 mark.

Candidates are expected to be familiar with the workings of logarithms and their use in plotting graphs.

(i) Explain clearly how she could use this graph to obtain a value for σ.

(2)

In this equation Ln σA is the positive y-intercept. So by using the graph value of a y-intercept can be found. Then by removing Ln and dividing the ~~y-it~~ y-intercept by the area a value of σ can be found.

(ii) She realises that she cannot control the temperature of the room

ResultsPlus

Examiner Comments

This candidate gets a mark for identifying the intercept as the important term.

1 mark.

Question 3 (b) (ii)

It was important for the candidates to describe the temperature of the bulb as very **much** greater than that of the room.

Some candidates thought that since the temperature did affect the outcome, they were being asked how to minimise that effect.

Controlling room temperature is a precaution often given by candidates. It is a good idea to measure it before and after the experimental work to see if it has changed and, if so, by how much. They can then consider if it has had any effect. Usually, any change will be very small.

(ii) She realises that she cannot control the temperature of the room.

Suggest why this will have little effect on the result of the experiment.

(1)

As the temperature is 2400, the fluctuation temperature of room is only about 1 to 2K, which % uncertainty $(\frac{1}{2400} \times 100\%) \times 4$ is only 0.16% which can be ignored. The ~~temperature is to power 4 which the~~ temperature fluctuation has negligible effect on the total value calculated.

(Total for Question 3 = 8 marks)

ResultsPlus

Examiner Comments

This candidate makes the point very clearly.

1 mark.

Question 4

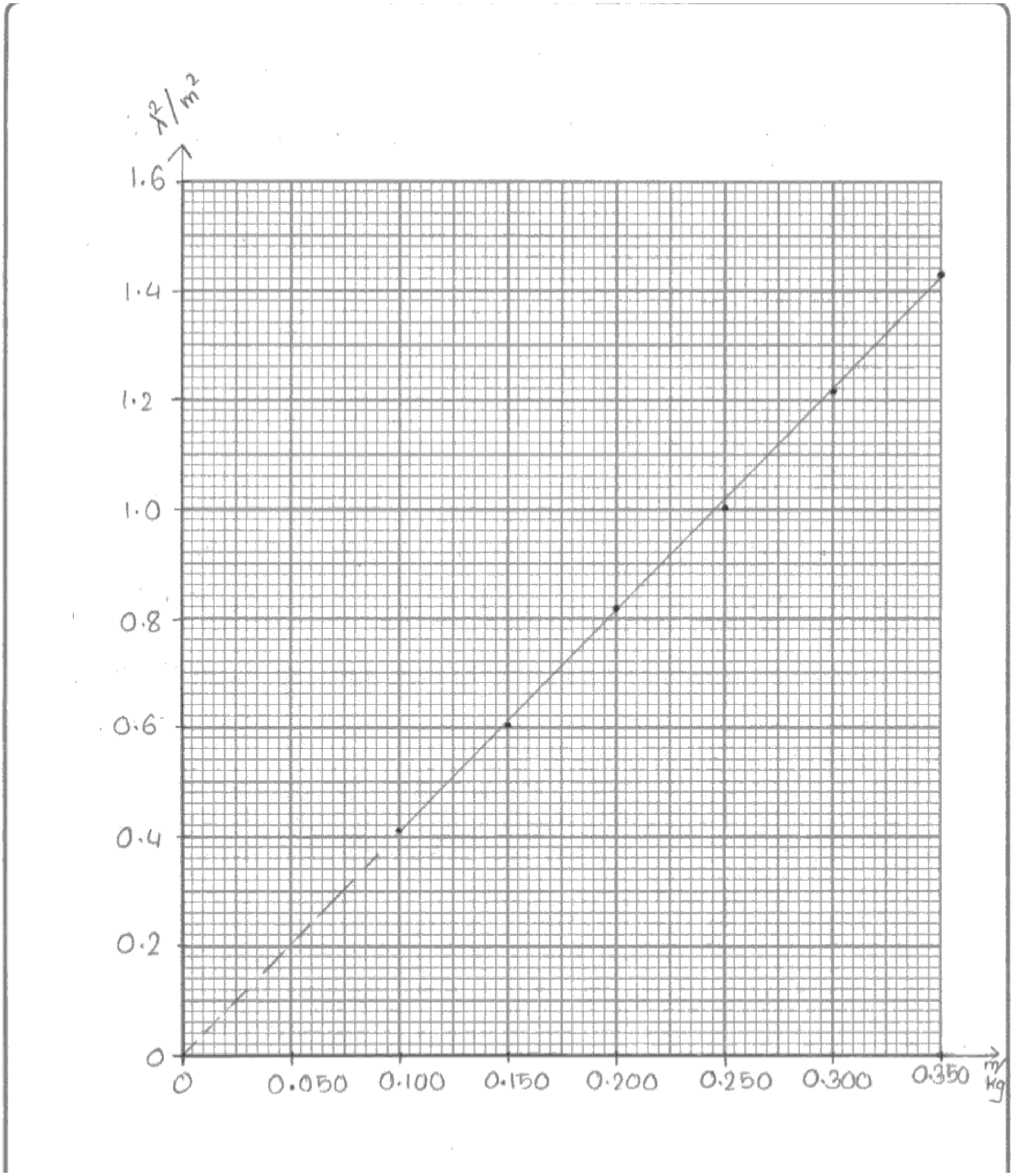
The only planning element of this question was the decision about which graph to plot. Most candidates found this straightforward. The graph plotting remains a good discriminator at this level and examiners expect a really high standard to achieve all the marks.

a) A few candidates mistakenly thought that the third column in the table was for dividing the second column value by that in the first and then squaring the resulting number. Otherwise, the table was completed correctly by most candidates, who seemed to understand the correct use of significant figures. The points on the graph were very close to the straight line of best fit (LoBF) but the 1.024 coordinate was often wrong. The LoBF rightly passes very close to the origin but it should not be forced through it and joining the top plot to the bottom produced the wrong line. A number of candidates confused the scale by using a false origin. It is seldom necessary to have the point (0,0) in the bottom left hand corner of the graph - it is more important to spread out the plots using a convenient scale.

b) Three significant figures is usually correct for graph work, including gradients, as here. Triangles should be as large as possible to minimise the uncertainty in the gradient calculation. It is permissible for them to extend to the edge of the grid, thus making two of the coordinates easy to read.

c) A rather easy end to the paper but many candidates lost a mark due to their units in the final answer.

The candidate makes their intentions very clear



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

(2)

$k = \text{gradient} = \dfrac{1.430 - 0.411}{0.350 - 0.100} = 4.076\ m^2\ kg^{-1}$

$k = 4.076\ m^2 kg^{-1}$

ResultsPlus

Examiner Comments

This is a clear graph but the *m* = 0.25 kg point is plotted too low - not at 1.024 m^2. The gradient calculation uses the top and bottom plots; this is bad practice and the candidate should use two points completely on the line but here the plots used are just close enough for their use to be allowed. The gradient calculation is to 4 SF, which loses a mark.

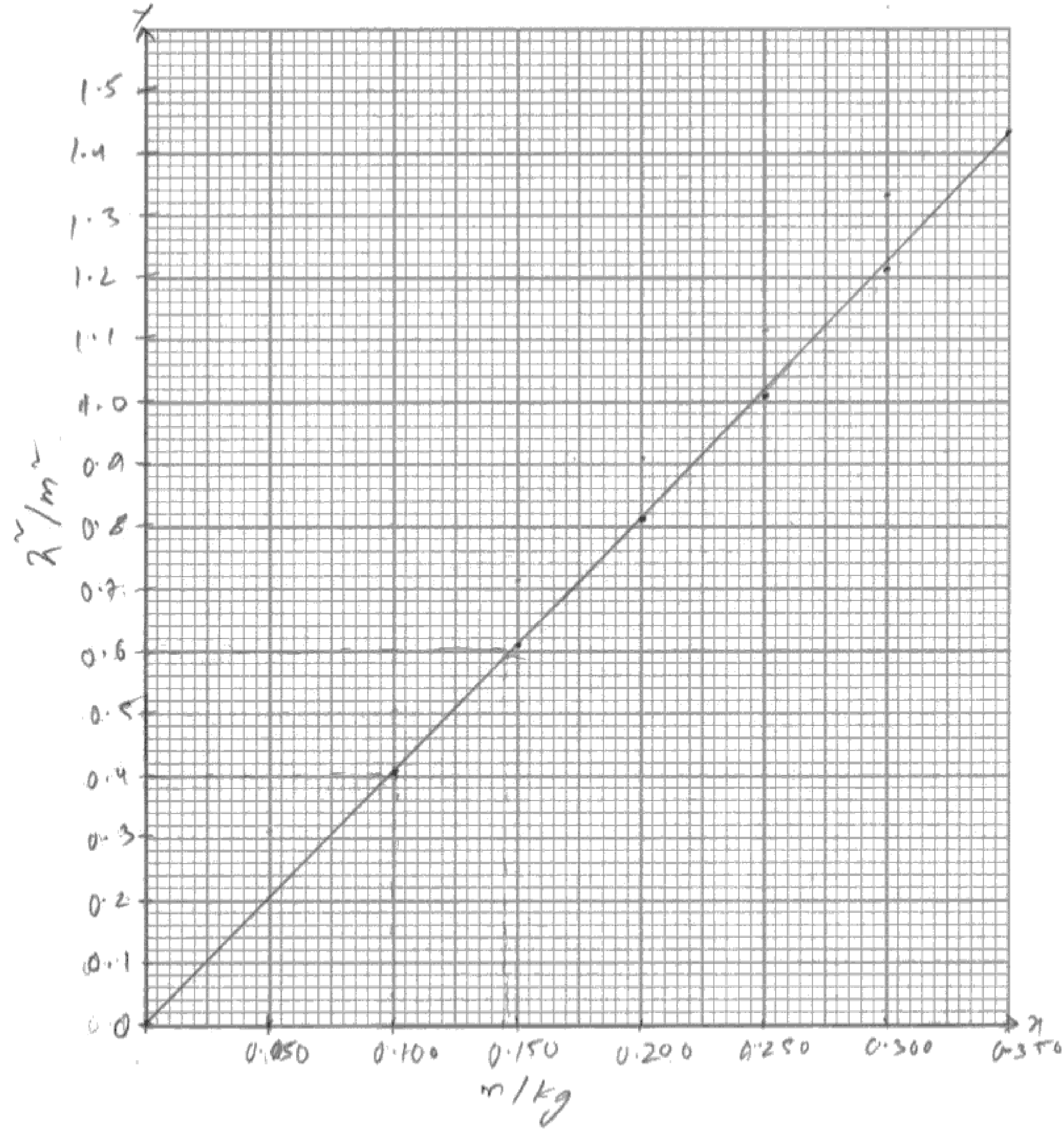
7 marks.

ResultsPlus

Examiner Tip

Check all your plots before you draw your line of best fit.

There are always rather unfortunate ways to lose a mark



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

(2)

~~$K = \frac{0.4m^2}{0.1 kg} = 4m^2kg^{-1}$~~ $K = \frac{0.6m^2}{0.13kg} = 4.6 m^2 k^{-1}$

$k =$ ~~$4m^2kg^{-1}$~~ $4.6 m^2 kg^{-1}$

(c) It is suggested that

$$k = \frac{g}{f^2\mu}$$

where $g = 9.81$ N kg^{-1}, frequency $f = 50.0$ Hz and μ = the mass per unit length of the wire.

Use your value for the gradient to calculate a value for μ.

(3)

$K = \frac{g}{f^2 M}$

$= f^2 M = \frac{g}{k}$

$M = \frac{g}{kf^2}$

$= \frac{9.81}{4.6 \times 50^2} = 8.53 \times 10^{-4}$

$\mu = 8.53 \times 10^{-4}$

ResultsPlus

Examiner Comments

This candidate loses a mark for the same mis-plot at *m* - 0.25 kg but here the LoBF has no plots above it and so is not really the best fit.

The gradient calculation uses a point not far enough away from the origin - their other point - and is mis-read; they also use 2 SF for their answer, losing both marks.

They score 2 of the 3 in (c) as an error carried forward because *their* calculation is correct but they omit a unit.

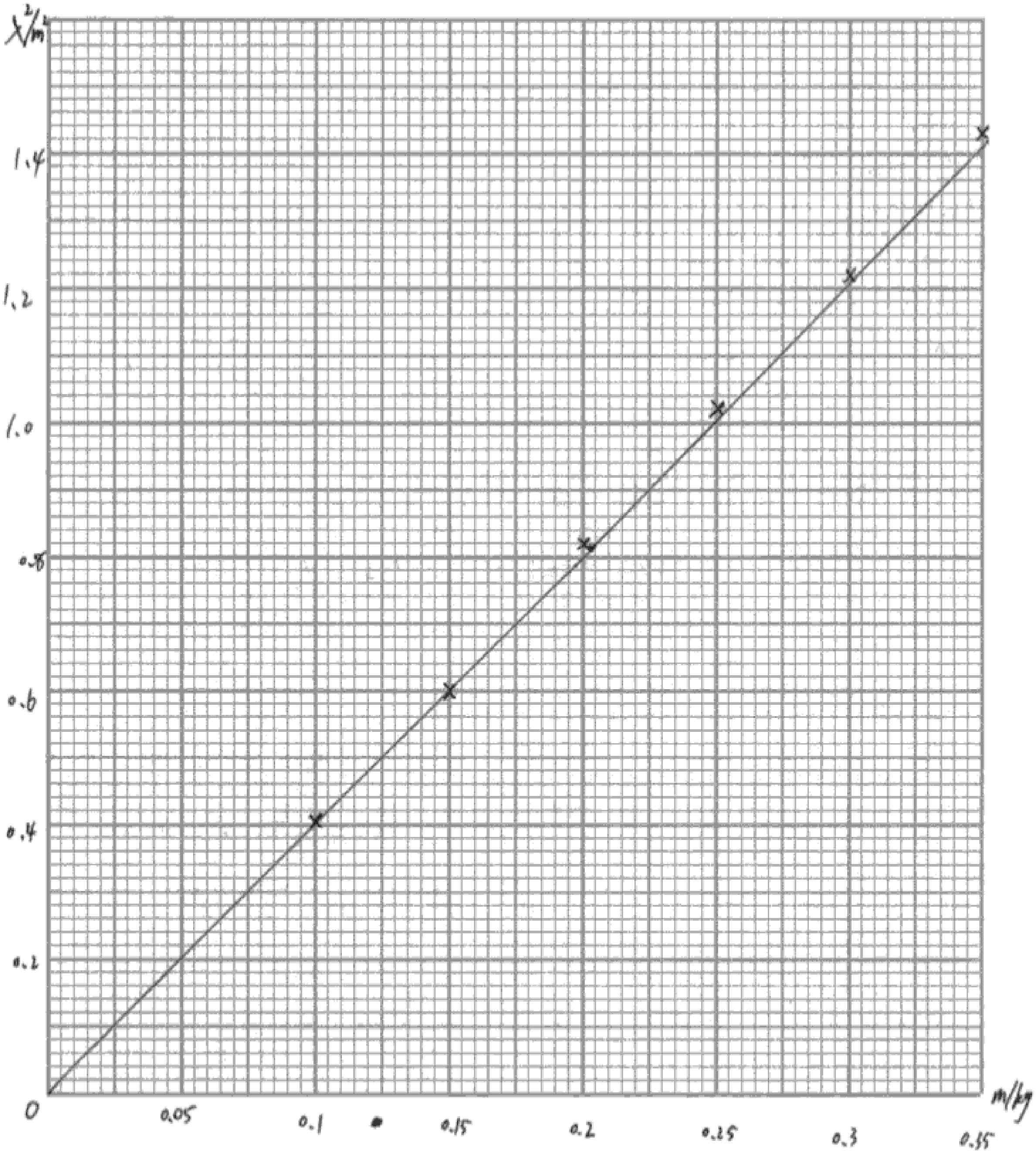
4 marks.

ResultsPlus

Examiner Tip

Check your units in your final answer.

All aspects of graph work are expected to be of high quality.



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

(2)

$k \approx \frac{1.43 - 0.411}{0.35 - 0.1} \approx 4.08$

$k =$ 4.08

(c) It is suggested that

$$k = \frac{g}{f^2 \mu}$$

where $g = 9.81\ \text{N kg}^{-1}$, frequency $f = 50.0$ Hz and μ = the mass per unit length of the wire.

Use your value for the gradient to calculate a value for μ.

(3)

$k = \frac{g}{f^2 \mu} \Rightarrow \mu = \frac{k f^2}{g}$

$\mu = \frac{4.08 \times (50)^2}{9.81} \approx 1040$ kg/m

$\mu =$ ....

ResultsPlus

Examiner Comments

This candidate has drawn their LoBF well below the upper plots, perhaps because they have forced it through the origin.

They have used the coordinates of the top and bottom plot in their gradient calculation, despite the fact that the LoBF does not pass through them. This will not find the gradient of the LoBF.

They have made mistakes in their final calculation and quoted their answer to 4 SF, so no marks for (c).

This candidate has drawn their LoBF well below the upper plots, perhaps because they have forced it through the origin.

They have used the coordinates of the top and bottom plot in their gradient calculation, despite the fact that the LoBF does not pass through them. This will not find the gradient of the LoBF.

They have made mistakes in their final calculation and quoted their answer to 4 SF, so no marks for (c).

4 marks.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice.

- Candidates will improve their overall marks by carrying out practical work in laboratories
- Planning skills are always assessed and candidates will do better if their answers follow the pattern of the question - this is always a low-scoring part of the paper
- Candidates should practise their data-handling skills for questions requiring graph-plotting. They are expected to be familiar with the variety of mathematical functions needed to obtain a straight line
- Capacitance is a topic that candidates always find hard but is inexpensive to do practically in a lab
- Diagrams will usually help in many of the answers required: such diagrams should be large and fully labelled

Each of the marks on the paper was awarded to some candidates and not awarded to others, so that the paper discriminated well and produced a good range of marks.

It is recommended that teachers familiarise themselves with the demand at this level by looking at the coursework support material available on the Edexcel website GCE Physics pages.

It will be helpful for candidates to look at past papers and their mark schemes as part of their exam preparation. These are also available on the website.

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

Grade Boundaries

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

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