Examiners' Report
June 2017

GCE Physics 8PH0 01

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June 2017

Publications Code 8PH0_01_1706_ER

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Introduction

This is the second time that the Pearson Edexcel AS paper 8PH0-01, Core Physics I, has been sat by candidates. Section A of the paper is worth 60 marks and consists of 8 multiple choice questions followed by 6 questions of increasing length comprising of short open, open-response, calculation and extended writing style questions. Section A examines material from the topics 'Working as a Physicist', Mechanics and Electric Circuits. Section B is worth 24 marks on this paper and examines material from the whole AS specification. It contains two questions worth 10 and 14 marks including a data analysis question based on Hooke’s law. Although not a core practical it is a context that would be familiar to candidates from both their GCSE and their AS courses.

This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. Many candidates showed a good progression from GCSE to AS level, with prior knowledge extended and new concepts taught and understood well. Some candidates found the length of some of the calculations to be challenging, often missing out key steps preventing them from scoring more than one or two marks for the interim steps. Some questions were not answered as well as would have been expected by many candidates; this was particularly evident in the open response and the extended writing questions. Candidates who had a sound understanding of the physics involved did not always demonstrate this in their responses due to a lack of precision when applying their knowledge to the context, poor use of subject specific language and missing the point of the question due to being unfamiliar with the command terms. However, candidates from across all ability ranges always managed to score some marks within these questions.

For the calculations, the presentation was clear when the correct answer was obtained. There were still many instances of poor presentation, with missing subjects on the left hand side to an equation, missing equals signs and lines of working not strictly following on. This was particularly evident in Question 12(a) where the purpose of the question was to show how to set out work clearly in order to explain the method used.

In general, time was not an issue at all with this paper with the majority of candidates completing all questions on the paper. However, questions 16(b) and (c) appeared to be the ones where a few candidates experienced time constraints.

Section A - Multiple choice questions 1-8
'A grade' candidates tended to score a minimum of 6 out of the 8 whilst 'E grade' candidates scored, on average, 4 marks for these items. However, for many candidates the performance with these items was not indicative of their overall performance in the exam. This is usually due to a disproportionate amount of time spent on the multiple choice items, particularly for less able candidates, taking time away from the higher scoring questions later in the paper.

Question	Subject	Percentage of candidates who answered correctly	Most common incorrect response
1	Vector quantities	94	A and C
2	Acceleration-time graphs	67	B and D
3	Resultant force using a diagram	71	B
4	Use of the equation $Q = It$	87	C
5	Deriving the equation for combining resistances in series	66	C
6	Resolving a vector into its vertical component and use of equations of motion	42	A
7	Use of Ohm's law with resistors in series	81	C
8	Light dependent resistor and thermistor	56	C and D

Question 1

This was answered correctly by nearly all candidates. Any incorrect responses really were due to timing, an issue for some throughout all eight multiple choice items on what could be seen to be a relatively straightforward set of multiple choice items.

Question 2

Candidates are less familiar with acceleration-time graphs than other graphs representing motion. However, this question was relatively straightforward but did require the candidates to read through all the responses as both velocity-time and acceleration-time graphs were referred to.

Question 3

A common error with the movement of bubbles or objects through a fluid is to not take note of the direction of motion and place the drag force in the wrong direction. In this question while most candidates placed the drag as correctly acting downwards, the relative lengths of the arrowed lines were also of importance. The question referred to the bubble moving at a constant velocity so the total length of the downwards arrows should equal the length of the up thrust arrow to give a resultant force of zero.

Question 4

While nearly all candidates knew to use the equation $I = nqvA$, those who were working through the question a little too quickly missed the unit conversion, selecting 18 C rather than 1080 C.

Question 5

Derivations of the total resistance equation are one difference between the new AS specification and the legacy AS specification. The bringing together of the conservation of charge and energy for resistors in series and parallel is viewed by many candidates as a method that should be learnt by rote rather than through understanding. This question gave the candidates the steps involved but required them to identify which step used the conservation of charge. Step 4 used the conservation of charge; however, many candidates incorrectly chose step 3 and fewer chose step 1, the stages that are justified using the conservation of energy.

Question 6

The success in answering this question for most candidates was more down to reading the question correctly than application of Physics. Most could identify that this is just an application of $v = s/t$ with the horizontal component of the initial velocity. However, many missed that the direction of the initial velocity was given to the vertical rather than the more usual direction to the horizontal. Again, it was the speed with which the candidates answered that affected the outcome of the question.

Question 7

This question was answered well and candidates could answer by applying their knowledge of potential dividers, perhaps even from memory, or by using Ohm's law with the total resistance of resistors in series. Candidates consistently find using such a relationship difficult, partially due to the selection of the correct data to be used. This was seen as a more straightforward task by many, with a slip by some, in selecting response C incorrectly due to the incorrect resistance as the numerator of the equation.

Question 8

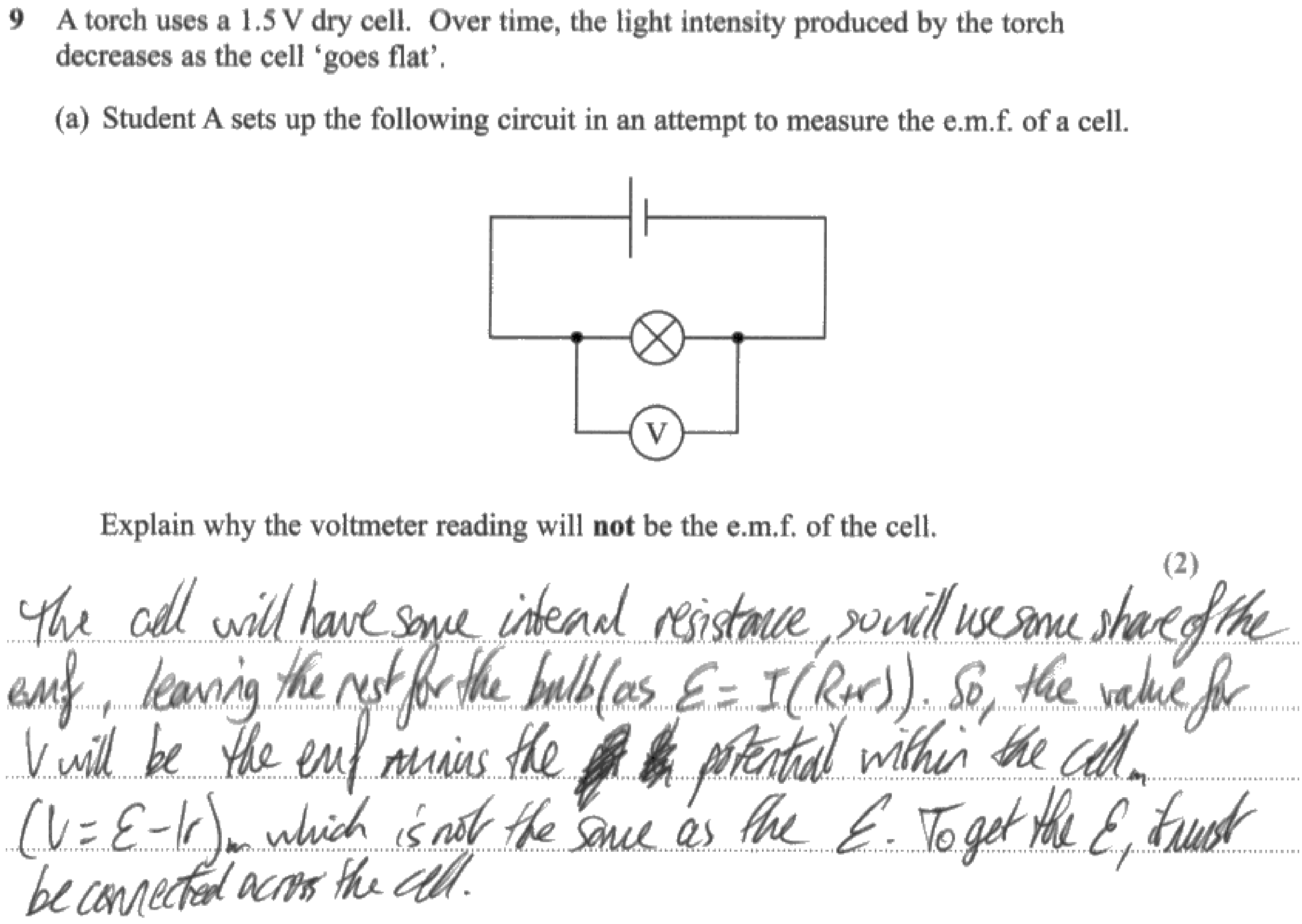
Again, this was answered well by most candidates. There was nothing here that was not covered at GCSE. The question only required candidates to work through the conditions for both resistors to produce the highest resistance. Candidates selecting an incorrect response either misread highest resistance and assumed highest current (or lowest resistance) or selected light and hot in error due to the speed of working through the question.

Question 9 (a)

In general, the understanding by the majority of candidates of the difference between e.m.f and potential difference is poor. While many can apply the equations for internal resistance, the significance of the potential difference across the components in a circuit not being equal to the e.m.f. is not understood by many. Many responses referred to the position of the voltmeter as being across the bulb rather than across the cell.

A large proportion of candidates did score a mark here but few could add to the idea of internal resistance, with 'lost volts' being the most common method to score a second mark. Some were not awarded the mark as they did not specifically refer to the cell, just stating internal resistance and/or 'lost volts' without identifying to which part of the circuit this applied.

This is a response that scored both marks.



9 A torch uses a 1.5 V dry cell. Over time, the light intensity produced by the torch decreases as the cell 'goes flat'.

(a) Student A sets up the following circuit in an attempt to measure the e.m.f. of a cell.

Explain why the voltmeter reading will **not** be the e.m.f. of the cell.

(2)

The cell will have some internal resistance, so will use some share of the emf, leaving the rest for the bulb (as $E = I(R+r)$). So, the value for V will be the emf minus the potential within the cell. ($V = E - Ir$), which is not the same as the E. To get the E, it must be connected across the cell.

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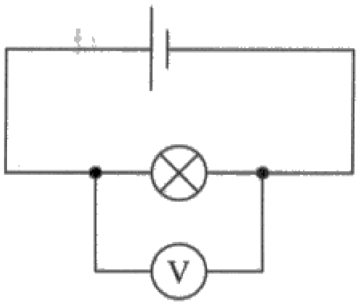
Examiner Comments

The candidate has understood the effect that the internal resistance has on the e.m.f. of the cell and hence the terminal potential difference of the cell and they described a potential difference across the 'internal resistance' of the cell. That alone would be sufficient but the candidate went on to refer to the equation e = $V + Ir$ which would also have scored MP2.

This is a typical response from a candidate that scored no marks.

9 A torch uses a 1.5 V dry cell. Over time, the light intensity produced by the torch decreases as the cell 'goes flat'.

(a) Student A sets up the following circuit in an attempt to measure the e.m.f. of a cell.



Explain why the voltmeter reading will **not** be the e.m.f. of the cell.

(2)

The voltmeter is connected across the lamp component and will therefore only measure voltage across that, given that voltage remains the same across parallel routes.

ResultsPlus
Examiner Comments

The voltmeter could have been positioned across either the bulb or the cell. The reading on the voltmeter would have been the same as it is dependent on the e.m.f., internal resistance of the cell (and the bulb) and not its position in a circuit with only one component.

ResultsPlus
Examiner Tip

The e.m.f. of a cell is not the same as the output potential difference from a cell (terminal potential difference). There will be a voltage drop (potential difference) across the internal resistor in the cell. In this case, as there is only one component, the output potential difference from the cell is the same as the potential difference across the bulb.

Question 9 (b)

Whilst there were many excellent answers a number of candidates were not aware that 'determine' as a command word requires a response which engages quantitatively with the question. This question required the candidates to use a series of calculations to provide evidence for a decision as to whether either of the students' statements was correct. There were two statements so each one needed addressing.

Many responses were entirely qualitative with no application of Physics and calculations; even if the candidate had ‘guessed’ correctly that both students were correct, without the evidence no credit could be given. The mark scheme refers to MP5 being conditional on MP4.

Those that answered the question quantitatively were required to select the relevant data to use in the equation for e.m.f. of the cell, i.e. e = $V + Ir$. The original data of the cell (1.63 V and 1.15 W) was there to be used for a comparison and not to be used in any equations. Although some credit could be given for use of incorrect data in the above equation, use of the Ohm’s law equation (MP2) was more rigid and had to be with the correct data to demonstrate an understanding of the context.

MP1 was for identifying that the e.m.f. of the cell after several weeks of use was 1.36 V. In the majority of responses seen, correct use of 1.36 V in a relevant equation was sufficient evidence for this. The candidates had to then use the terminal potential difference of 0.84 V to calculate the current in the circuit. From here they could then use the equation e= $V + Ir$ to calculate the internal resistance of the cell and hence compare this, and the e.m.f. of the cell, to the original values.

This response did not score any marks. No attempt was made by the candidate to use the data given for the cell and circuit and a response which was solely qualitative was given.

Determine whether either student is correct about the changes in the cell as it goes flat.

(5)

A battery has chemicals inside which react together to provide energy. That chemical energy is converted into electrical energy by the cell and thus we get voltage $\left(\frac{\text{energy}}{\text{charge}}\right)$. As time passes the chemicals in the battery get used up so less and less energy is produced by them thus ~~tes~~ there is less convertion of chemical energy to electrical thus the e.m.f of the battery decreases. So student A is correct. However as the voltage decreases ~~V=IR~~ because the chemicals get used up. They ~~might~~ might be providing ~~of the resist~~ less resistance for the electrons to pass through so student B is incorrect

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Examiner Comments

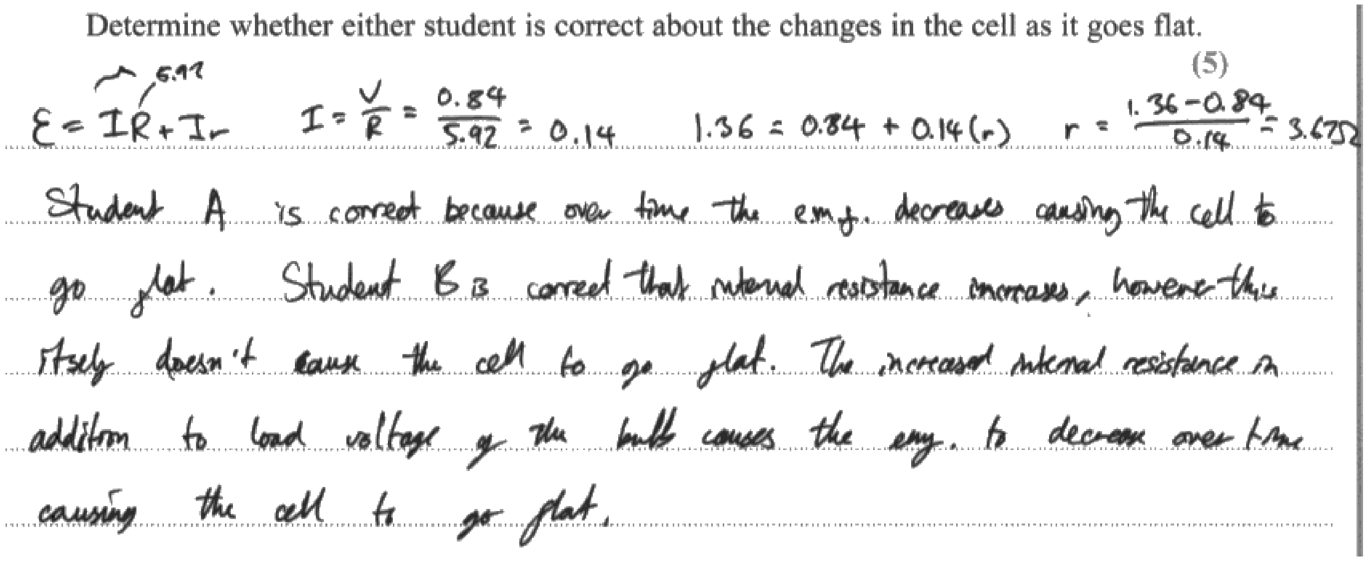
The candidate has correctly identified that the e.m.f. of the cell will decrease over time but incorrectly stated that the resistance increases.

ResultsPlus

Examiner Tip

If data is given in a question, particularly in digits rather than in words, then you are expected to use it as part of your answer. Determine means to calculate when it is used as a command word.

This response scored all 5 marks. Four of the five marks are in the top line of the response.



Determine whether either student is correct about the changes in the cell as it goes flat.

(5)

$\mathcal{E} = I\overset{5.92}{R} + Ir$ $\quad I = \frac{V}{R} = \frac{0.84}{5.92} = 0.14$ $\quad 1.36 = 0.84 + 0.14(r)$ $\quad r = \frac{1.36-0.84}{0.14} = 3.67\Omega$

Student A is correct because over time the e.m.f. decreases causing the cell to go flat. Student B is correct that internal resistance increases, however this itself doesn't cause the cell to go flat. The increased internal resistance in addition to load voltage of the bulb causes the e.m.f. to decrease over time causing the cell to go flat.

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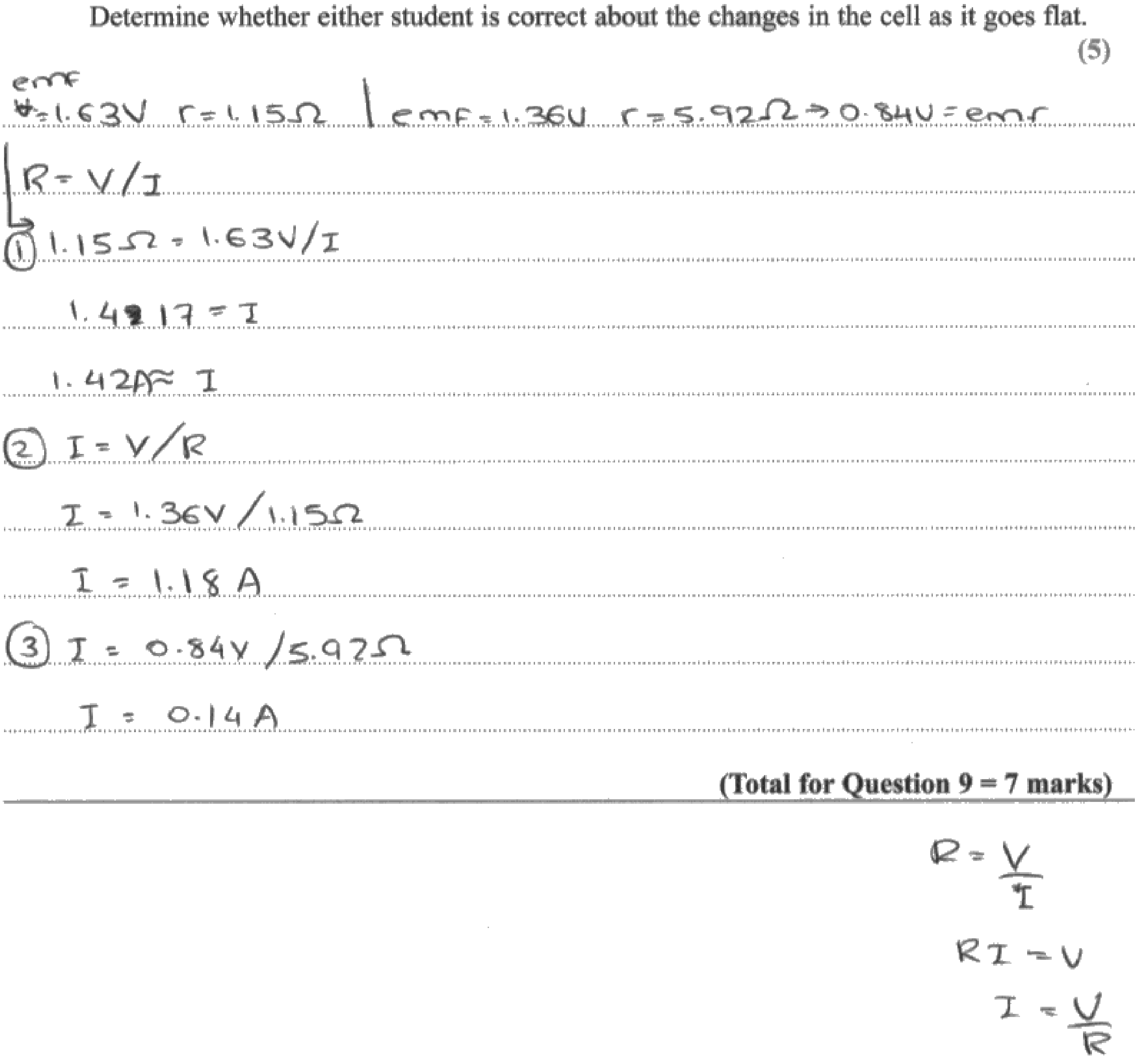
Examiner Comments

The candidate has correctly calculated the new internal resistance of the cell (3.67 Ω) and then made a conclusion below that the internal resistance has increased and the e.m.f. decreased as described by the students.

This response scored two marks.



Determine whether either student is correct about the changes in the cell as it goes flat.

(5)

~~V~~ emf = 1.63V r = 1.15Ω | emf = 1.36V r = 5.92Ω → 0.84V = emf

$R = V/I$

① $1.15\Omega = 1.63V/I$

$1.417 = I$

$1.42A \approx I$

② $I = V/R$

$I = 1.36V / 1.15\Omega$

$I = 1.18$ A

③ $I = 0.84V / 5.92\Omega$

$I = 0.14$ A

(Total for Question 9 = 7 marks)

$R = \frac{V}{I}$

$RI = V$

$I = \frac{V}{R}$

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Examiner Comments

The candidate knew that this question had to be approached quantitatively but did not appreciate the significance of the three voltages given and attempted to calculate three currents.

Therefore, although this question did not lead anywhere, credit was given for the candidate calculating the current in the circuit (equation three) and for identifying that the e.m.f. is 1.36 V (generously reading the statement on the right of the top line).

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Examiner Tip

The e.m.f. of a cell can only be measured directly when the cell does not form part of a complete circuit. When a voltmeter is placed directly across the cell (without a circuit), the reading on the voltmeter will be the e.m.f. of the cell. There will be no current through the cell as there is not a circuit.

You cannot use $V = IR$ with the e.m.f. and internal resistance of a cell as there will be no current through the cell in such a circuit.

When the cell is connected to a circuit, the e.m.f. is not the p.d. across the 'internal resistor' so use of any e.m.f. in $V = IR$ is inappropriate.

This is an example of a response scoring 4 marks.

Student B suggests it is because the internal resistance increases.

Determine whether either student is correct about the changes in the cell as it goes flat.

(5)

$1{\cdot}36 = IR + Ir$

$= 0{\cdot}84 + Ir$

$1{\cdot}36 - 0{\cdot}84 = \left(\frac{21}{148}\right) r$

$\frac{0.52}{21 \div 148} = r = 3{\cdot}66\,\Omega$

$I = \frac{0.84}{5{\cdot}92} = \frac{21}{148} = 0.142$

↑

Internal resistance HAS increased so B is correct.

ResultsPlus

Examiner Comments

All calculations were carried out correctly. The candidate only commented on one of the student's comments so the final mark for the conclusion could not be awarded.

Question 10 (a)

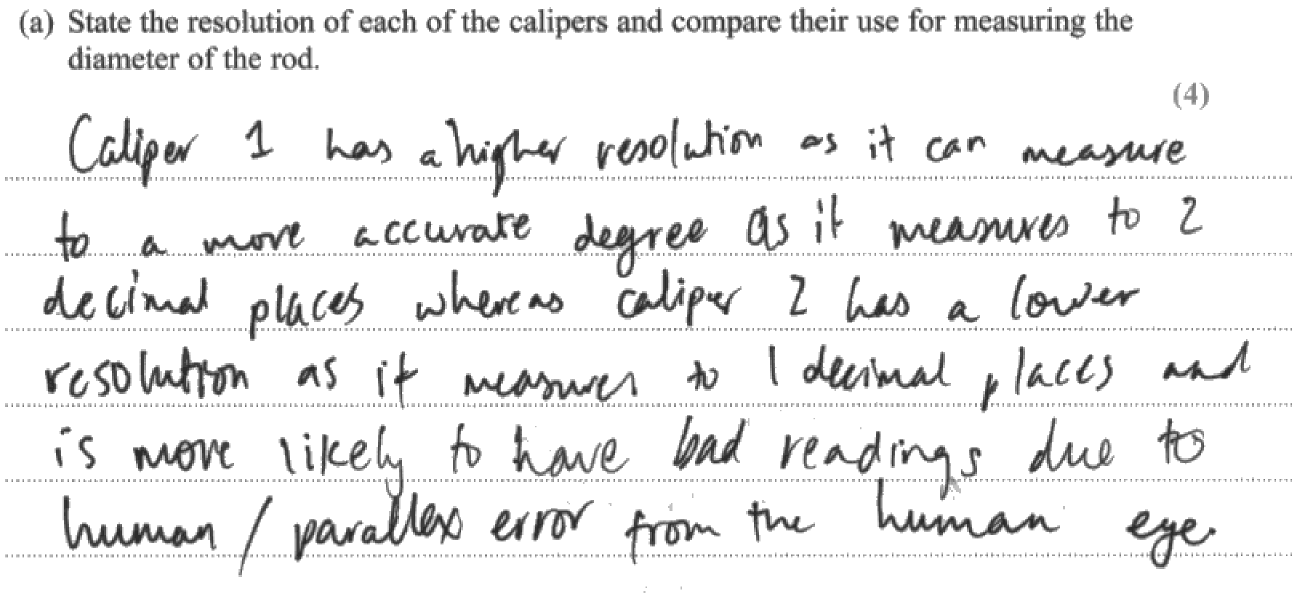
This question required a statement of the resolution of each caliper and then a comparison between them in the context of measuring the diameter of the rod. As seen with Question 9(b), the question was not explicit so candidates were not led directly to the answer and did not answer as well as expected.

The resolution is the smallest measuring interval and is a number based in the scale of the device. Many responses referred only to the number of decimal places while others assumed the resolution of Caliper 2 is 1 mm, perhaps from looking at the cm scale in the photograph. The only information required to answer this question was the statement of the diameter below each photograph.

The third marking point was for a comparison of techniques between the two calipers. Parallax etc. was accepted. A general term such as 'human error' was not accepted as there are many ways that humans could add to the uncertainty and more detail was required.

Many candidates identified that the greater resolution of Caliper 1 would lead to a smaller percentage uncertainty; however, many candidates just reeled off all the terms that are usually associated with measurement such as accurate and reliable in the hope that one of them was correct.

This response scored just 1 mark.



(a) State the resolution of each of the calipers and compare their use for measuring the diameter of the rod.

(4)

Caliper 1 has a higher resolution as it can measure to a more accurate degree as it measures to 2 decimal places whereas caliper 2 has a lower resolution as it measures to 1 decimal places and is more likely to have bad readings due to human / parallax error from the human eye.

ResultsPlus

Examiner Comments

Marking points 1 and 2 were not awarded as the resolution has not been stated. The resolution is an absolute value and the number of decimal places implies that there could be a range of values within the last figure.

Human error in line 6 was insufficient but parallax error added further detail and MP3 was awarded.

ResultsPlus

Examiner Tip

The resolution is the smallest value that can be read from the scale. It has a value (and a unit) and is not to be confused with precision or accuracy.

This response scored 0 marks.

(a) State the resolution of each of the calipers and compare their use for measuring the diameter of the rod.

(4)

The first caliper is a digital caliper, this makes it more accurate. The second caliper is ~~manual~~ analog, meaning that you have to read the measurement, it is not displayed numerically. The diameter of the rod should be measured using caliper 1, as it is digital and gives us 4 significant figures, it is more precise. Whereas caliper 2, ~~gives~~ only goes upto 3 significant figures.

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Examiner Comments

No attempt has been made here to state any resolution. The number of significant figures is not a statement of the resolution. The resolution of a measuring device is the same, regardless of the quantity being measured. The number of significant figures will also depend on the size of the object being measured as well as the person taking the reading's decision as to how many significant figures to quote the value to.

This response scored 2 marks.

(a) State the resolution of each of the calipers and compare their use for measuring the diameter of the rod.

(4)

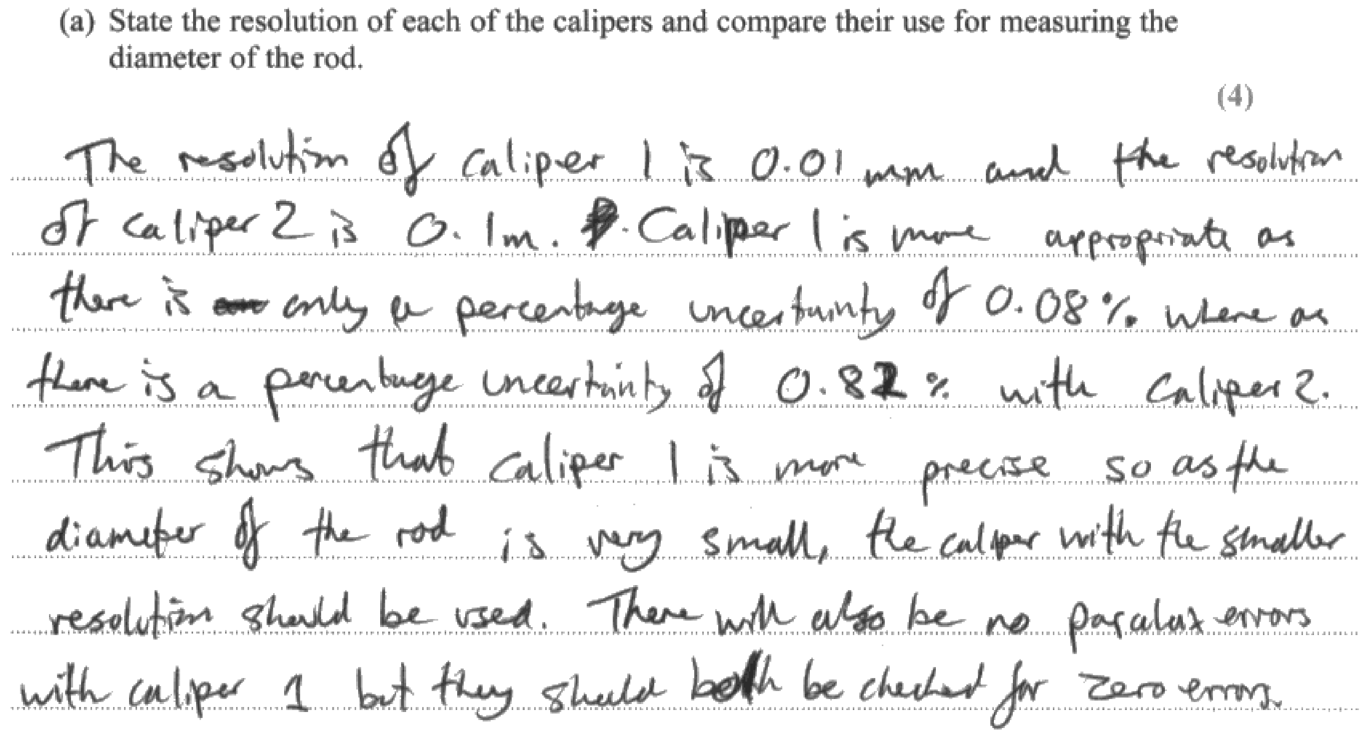
Caliper 1 measures to $\pm\ 0.01 \times 10^{-3}$ m, whilst caliper 2 measures to $\pm 0.1 \times 10^{-3}$ m. Caliper 1 is much better for measuring the diameter of the rod, as it not only has a higher resolution than caliper 2, it is also far easier to read than caliper 2.

ResultsPlus

Examiner Comments

There are two clear statements of the resolution. 'Easier' in line 5 is insufficient for MP3 as they have not explained why Caliper 1 is easier to use compared to Caliper 2.

This response scored all 4 marks.



(a) State the resolution of each of the calipers and compare their use for measuring the diameter of the rod.

(4)

The resolution of caliper 1 is 0.01 mm and the resolution of caliper 2 is 0.1m. Caliper 1 is more appropriate as there is ~~an~~ only a percentage uncertainty of 0.08% where as there is a percentage uncertainty of 0.82 % with caliper 2. This shows that caliper 1 is more precise so as the diameter of the rod is very small, the caliper with the smaller resolution should be used. There will also be no paralax errors with caliper 1 but they should both be checked for zero errors.

ResultsPlus
Examiner Comments

There are two statements of the resolution of each caliper.

A statement that there would not be parallax when using Caliper 1, i.e. the same as saying that Caliper 2 may have parallax errors, scored MP3.

Although not requested, the candidate has calculated the percentage uncertainty of each reading which was sufficient for MP4.

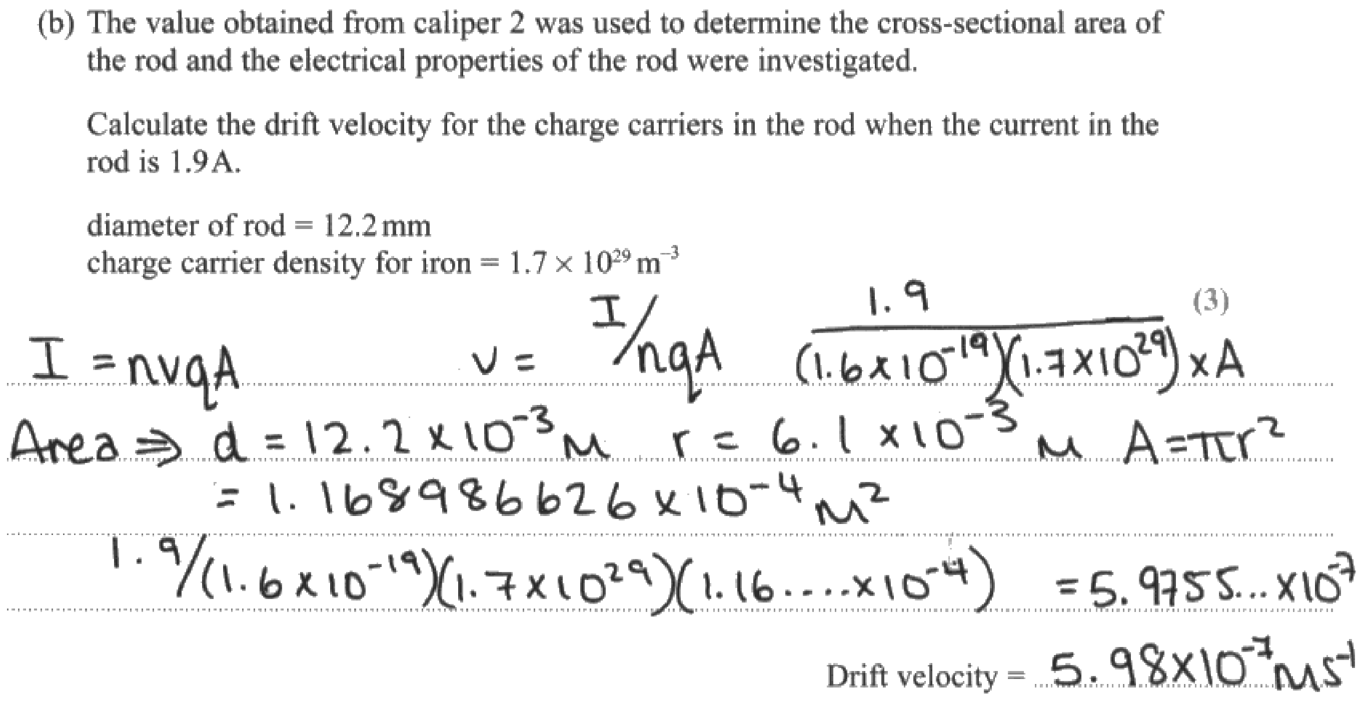
Question 10 (b)

This question should be a straightforward use of the formula $I = nqvA$ to determine the drift velocity of the charge carriers.

The calculations of the cross-sectional area of the wire proved challenging for some, especially for lower ability candidates, who often used the diameter in place of the radius. Many did not convert the given value for the diameter of the rod from mm to m.

Substitutions into the equation $I = nqvA$ often omitted the charge so at best the less able candidates scored 1 mark while only the most able managed to pull together all the components to score all 3 marks.

This response scored all 3 marks.



(b) The value obtained from caliper 2 was used to determine the cross-sectional area of the rod and the electrical properties of the rod were investigated.

Calculate the drift velocity for the charge carriers in the rod when the current in the rod is 1.9 A.

diameter of rod = 12.2 mm

charge carrier density for iron = $1.7 \times 10^{29}\ \mathrm{m}^{-3}$

(3)

$I = nvqA \qquad v = \frac{I}{nqA} \qquad \frac{1.9}{(1.6\times10^{-19})(1.7\times10^{29})\times A}$

Area ⇒ $d = 12.2\times10^{-3}\ \mathrm{m} \qquad r = 6.1\times10^{-3}\ \mathrm{m} \qquad A = \pi r^2$

$= 1.168986626\times10^{-4}\ \mathrm{m}^2$

$1.9/(1.6\times10^{-19})(1.7\times10^{29})(1.16\ldots\times10^{-4}) = 5.9755\ldots\times10^{-7}$

Drift velocity = $5.98\times10^{-7}\ \mathrm{ms}^{-1}$

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Examiner Comments

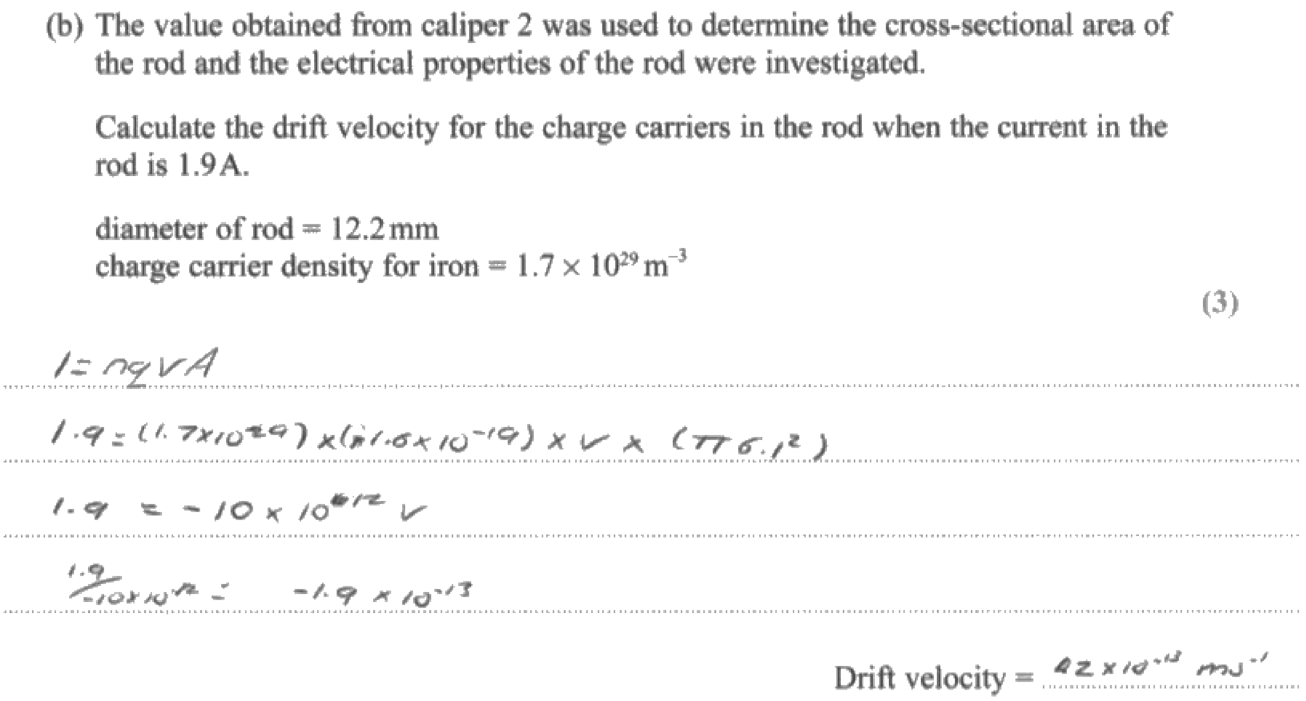
The diameter was converted into m and then halved to give the radius. A correct substitution into πr^2 gave a correct value for the cross-sectional area. All values were then correctly substituted into $I = nqvA$ to obtain a correct value for the drift velocity.

ResultsPlus

Examiner Tip

Be consistent with units. Make sure that any unit conversions are done as soon as you use a quantity in an equation.

This response scored 2 marks, the average for this question.



(b) The value obtained from caliper 2 was used to determine the cross-sectional area of the rod and the electrical properties of the rod were investigated.

Calculate the drift velocity for the charge carriers in the rod when the current in the rod is 1.9 A.

diameter of rod = 12.2 mm
charge carrier density for iron = $1.7 \times 10^{29}\ \text{m}^{-3}$

(3)

$I = nqvA$

$1.9 = (1.7 \times 10^{29}) \times (1.6 \times 10^{-19}) \times v \times (\pi 6.1^2)$

$1.9 = -10 \times 10^{12} v$

$\frac{1.9}{-10 \times 10^{12}} = \quad -1.9 \times 10^{-13}$

Drift velocity = 42×10^{-13} ms^{-1}

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Examiner Comments

MP1 and MP2 were awarded. MP1 was awarded for use of the area equation, even though there has been no conversion of the units from mm to m.

MP2 was awarded for all the variables successfully substituted into the equation $I = nqvA$.

No further marks could have been awarded but the candidate has also made an arithmetic error in determining their value of the drift velocity. They should have an answer of 5.97×10^{-13} m s^{-1}, i.e. a factor of 10^6 out due to the unit conversion error.

Question 11 (a) (b)

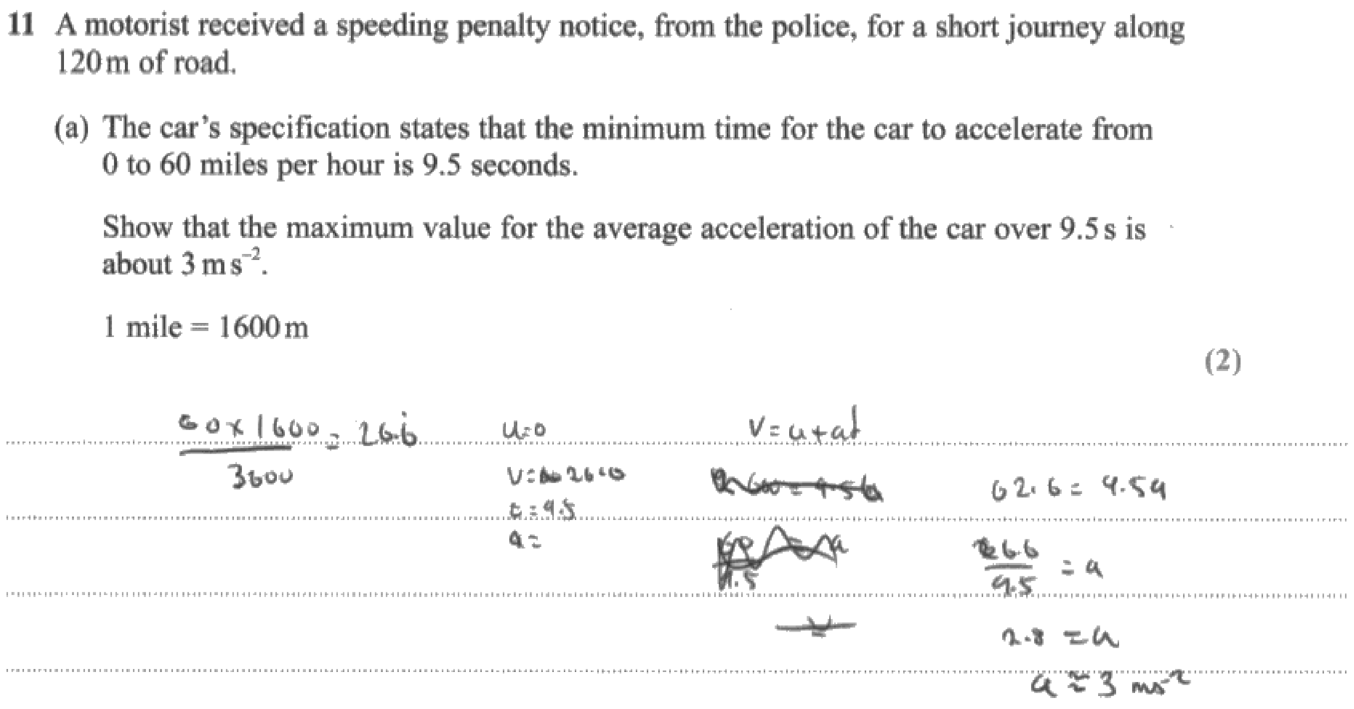
The context of this question required the candidates to sift through a large amount of information to select the correct method and data to use. The area of the specification covered is equations of motion, in one plane only, so a meticulous candidate spending the appropriate amount of time reading the question carefully would have no difficulty applying their knowledge successfully here.

(a) The information about the 120 m length of road applies to the car but not the maximum acceleration. To calculate the maximum acceleration the time and the maximum speed are the only pieces of information required. Candidates were required to convert the speed from miles per hour to m s^{-1}, a task most could do. They then had to select the correct equation, i.e. $v = u + at$, to determine the acceleration. Candidates tended to only go wrong if they attempted to use the total distance of the journey as part of their calculation.

(b) Candidates could either show that the maximum possible speed reached using the maximum acceleration over a 60 m stretch of road would be less than the police's recorded value of 20 m s^{-1} or show that, had they been going at 20 m s^{-1}, their acceleration would exceed the maximum acceleration of the car (from their calculation in (a)).

Most candidates went along the velocity route, often only dropping a mark due to a lack of a concluding statement. This was another 'determine' question and while most did attempt a calculation, not all realised that they had to make a 'decision' at the end as to whether the penalty notice should be challenged.

This response scored (a) 2 marks and (b) 2 marks.



11 A motorist received a speeding penalty notice, from the police, for a short journey along 120 m of road.

(a) The car's specification states that the minimum time for the car to accelerate from 0 to 60 miles per hour is 9.5 seconds.

Show that the maximum value for the average acceleration of the car over 9.5 s is about 3 m s^{-2}.

1 mile = 1600 m

(2)

$\frac{60 \times 1600}{3600} = 26.\dot{6}$

$u = 0$

$v = 26.6$

$t = 9.5$

$a =$

$v = u + at$

~~60 = 4.5a~~

$62.6 = 9.5a$

$\frac{26.6}{9.5} = a$

$2.8 = a$

$a \approx 3\ ms^{-2}$

(b) The police recorded a maximum speed for the car of 20 m s^{-1}.

The motorist knows that the speed at the start and at the end of the 120 m journey was zero.

Assume that the car had:

- constant positive acceleration, equal to the value in part (a), for the first 60 m of the journey
- constant negative acceleration of the same magnitude for the final 60 m of the journey.

Determine whether the motorist should challenge the penalty notice.

(3)

$s = 60$
$u = 0$
$v = ?$
$a = 3 ms^{-2}$

$u^2 = v^2 + 2as$
$= v^2 + 360$
$v = 18.97$

$s = 60$
$u = ?$
$v = 0$
$a = -3$

$u^2 = v^2 + 2as$
$= \sqrt{380}$

Yes he should challenge the penalty notice as his maximum speed was only ~~was~~ 18.97 ms^{-1}.

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Examiner Comments

(a) The candidate correctly converted the speed from miles per hour to m s^{-1}. Using $v = u + at$ with $u = 0$, a correct acceleration of 2.8 m s^{-2} was obtained.

(b) $v^2 = u^2 + 2as$ correctly used with $u = 0$ to obtain a correct possible maximum speed of the car of 18.97 m s^{-1}. The candidate has made a statement at the end; however, just a yes/no statement is not sufficient and a comparison to the police's recorded value of 20 m s^{-1} was required.

ResultsPlus
Examiner Tip

When a question asks for a decision to be made as to whether a student/statement is correct, if data is supplied, not only will a calculation have to be carried out, you will have to show how the value calculated was used to make that decision i.e. a comparison to another value.

This is a good response scoring full marks, (a) 2 marks and (b) 3 marks.

11 A motorist received a speeding penalty notice, from the police, for a short journey along 120 m of road.

(a) The car's specification states that the minimum time for the car to accelerate from 0 to 60 miles per hour is 9.5 seconds.

Show that the maximum value for the average acceleration of the car over 9.5 s is about 3 m s^{-2}.

1 mile = 1600 m

(2)

$t = 9.5s$ ~~s=120m~~

$u = 0.$

$v = \frac{60 \times 1600}{3600} = 26.\dot{6}$

$$\xrightarrow{} 26.\dot{6} - 0.$$

$$\text{Acceleration} = \frac{26.\dot{6}ms^{-1}}{9.5s} = 2.807 \approx 3ms^{-2}$$

time taken to accelerate

(b) The police recorded a maximum speed for the car of 20 m s^{-1}.

The motorist knows that the speed at the start and at the end of the 120 m journey was zero.

Assume that the car had:

- constant positive acceleration, equal to the value in part (a), for the first 60 m of the journey
- constant negative acceleration of the same magnitude for the final 60 m of the journey.

Determine whether the motorist should challenge the penalty notice.

(3)

On $s = 60m$ ~~60~~ $s = \frac{1}{2}ut + \frac{1}{2}at^2$

$a = 2.807ms^{-2}$ $60 = 0 + 1.4035t^2$

$v = ?$ $t^2 = 42.75$

$t = ?$ $t = \sqrt{42.75} = 6.538$

$u = 0.$ $0 + (2.807 \times 6.538) = \underline{18.352166}ms^{-1}$

Initial 60m ~~and final 60m~~ @ 2.807 ms^{-2} of acceleration does not exceed 19ms^{-1}; therefore the penalty should be challenged as the driver was not going ~~above~~ at 20ms^{-1}!

ResultsPlus

Examiner Comments

(a) Correct conversion and substitution into the relevant equation of motion to give an acceleration of 2.8 m s^{-2}.

(b) Correct maximum velocity calculated with a comparison to the speed the motorist was accused of driving at and a sensible statement e.g. 'penalty should be challenged', so MP3 awarded this time and full marks.

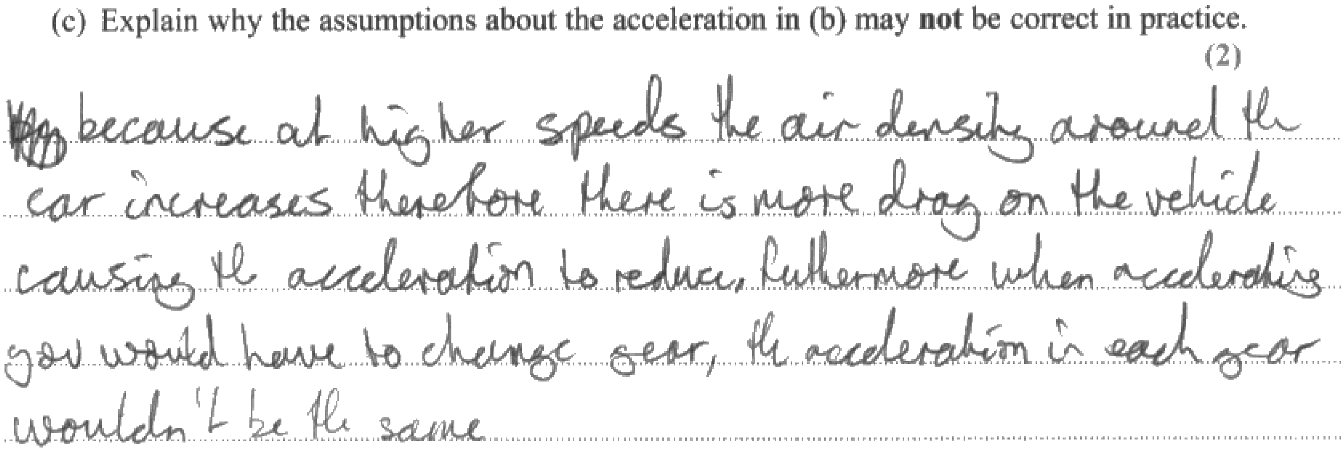
Question 11 (c)

Two assumptions were made therefore two explanations were required.

The first assumption was that the acceleration would be constant. This is the one that the candidates were most successful in attempting to explain. However, two points were required and most explanations just stopped at a reference to air resistance. A reference to both increasing air resistance at greater speeds and a decreasing acceleration were required.

The second assumption was more difficult to explain as it required the candidates to consider the acceleration and deceleration not being equal. Given the limit of the maximum acceleration of the car, if the car accelerates for a longer period, in order for the journey to still take place over 120m, the car would have to brake with a greater deceleration than in the initial context. No information was given as to whether the car could produce a greater deceleration than acceleration so, within the constraint of the other variables remaining constant; this would be the only option.

This response scored 1 mark.



(c) Explain why the assumptions about the acceleration in (b) may **not** be correct in practice.

(2)

because at higher speeds the air density around the car increases therefore there is more drag on the vehicle causing the acceleration to reduce, furthermore when accelerating you would have to change gear, the acceleration in each gear wouldn't be the same

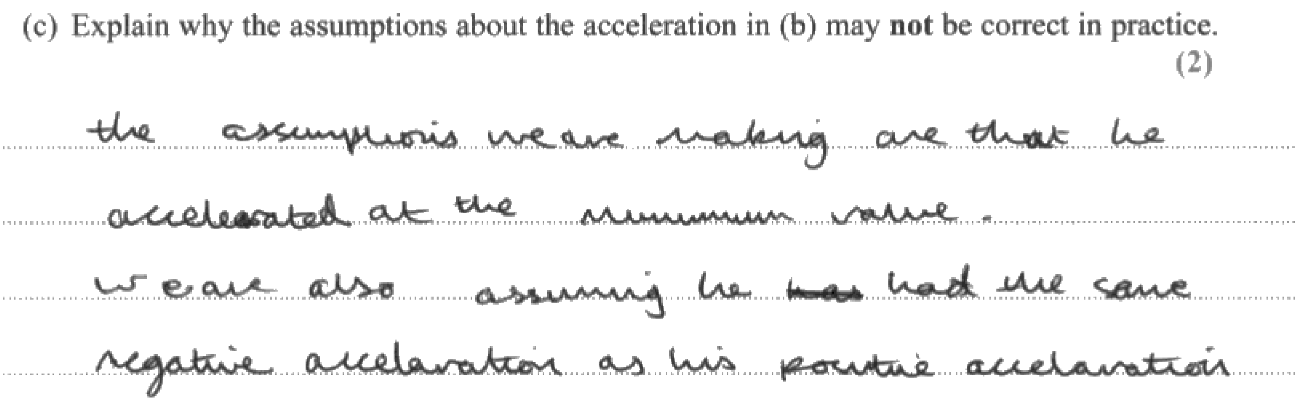
ResultsPlus

Examiner Comments

Ignoring the reference to air density at higher speeds, this candidate has covered MP1 from the mark scheme. Greater speeds, more drag and reduced acceleration.

No credit was given to changing gears when accelerating/decelerating and such statements were treated as neutral.

This response was more typical of the responses seen and scored 0.


(c) Explain why the assumptions about the acceleration in (b) may **not** be correct in practice.
(2)

the assumptions we are making are that he accelerated at the minimum value.
we are also assuming he ~~was~~ had the same negative accelaration as his positive accelaration

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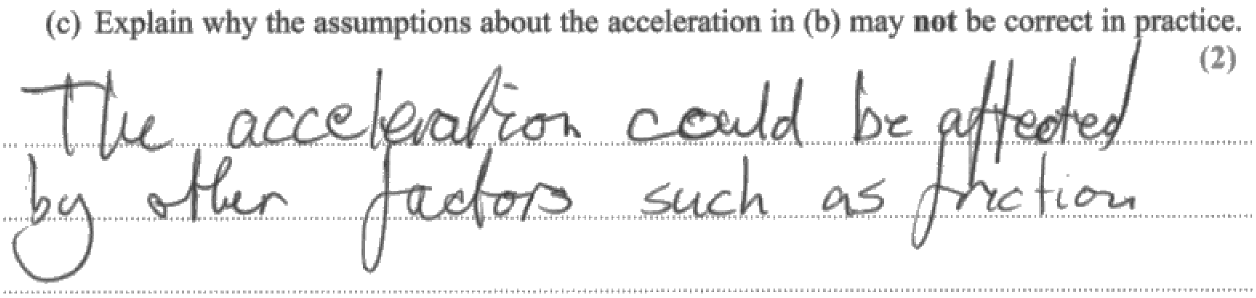
Examiner Comments

No additional physics added to the information given in the stem of the question so no marks.

This is an example of another response which scored 0 marks.


(c) Explain why the assumptions about the acceleration in (b) may **not** be correct in practice.
(2)

The acceleration could be affected by other factors such as friction

ResultsPlus
Examiner Comments

Air resistance or friction alone is insufficient.

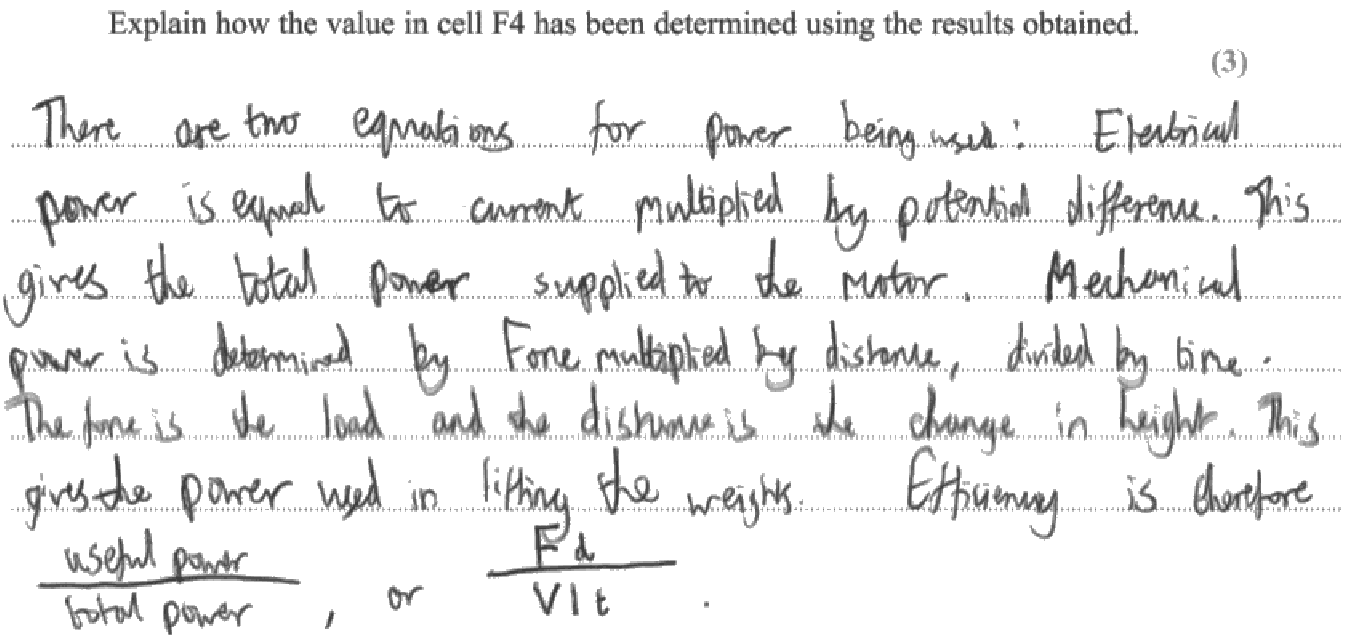
Question 12 (a)

This question asked candidates to explain how the efficiency was calculated for the motor when a load of 4.00 N was lifted. While most candidates could use the equations for electrical power and work done, fewer were able to set this out in a logical and coherent way and use the efficiency equation with two equivalent quantities i.e. power and power or energy and energy. Candidates are traditionally quite poor at setting out work in clear steps and identifying the quantities in the calculations. Often the working out constituted of substituted values, rarely equated to the quantity being determined.

Responses seen went from a straight calculation of the efficiency, which would have scored 0 marks, to detailed explanations, the best often being in prose rather than a series of incomplete steps.

Examiners were looking for clear steps and any calculated values or cells had to be explained (labelled) so power alone would not have sufficed; input power would need to be equated to *VIt*.

This response scored all 3 marks. The candidate has 'explained' rather than shown how a value is determined as the question demanded.



Explain how the value in cell F4 has been determined using the results obtained.

(3)

There are two equations for power being used: Electrical power is equal to current multiplied by potential difference. This gives the total power supplied to the motor. Mechanical power is determined by Force multiplied by distance, divided by time. The force is the load and the distance is the change in height. This gives the power used in lifting the weights. Efficiency is therefore

$$\frac{\text{useful power}}{\text{total power}} \;, \quad \text{or} \quad \frac{Fd}{VIt} \;.$$

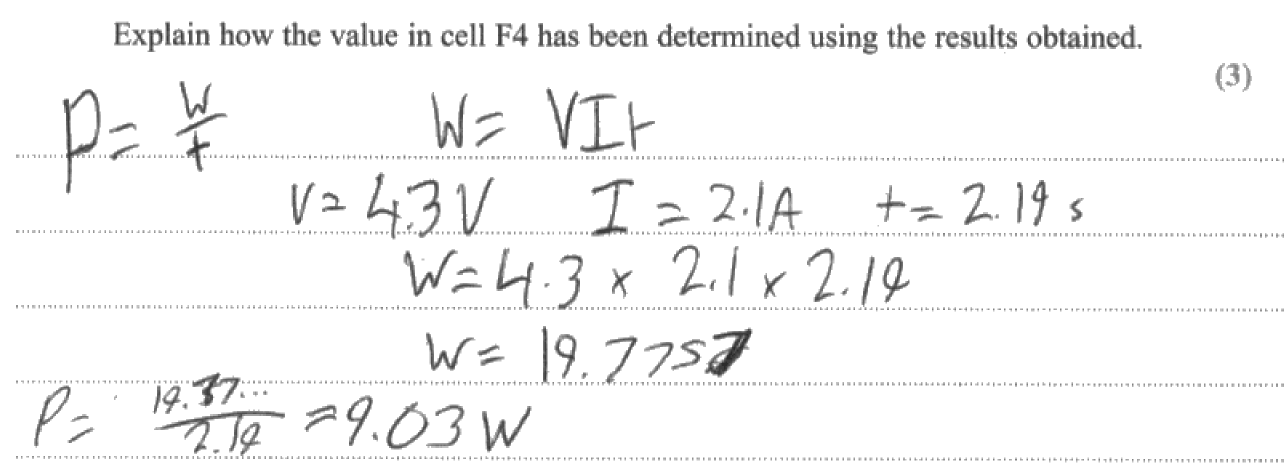
ResultsPlus
Examiner Comments

A description of how to calculate the electrical power and the mechanical power was given, followed by the equation for the efficiency. The right equation under the response gave the credit for MP3. The left ratio of useful power divided by total power was not defined so alone would not have scored the third mark.

ResultsPlus
Examiner Tip

This question demonstrates the need to set out work clearly and explain each step. You should always state which quantity is being calculated when quantities are substituted into an equation.

This response did not score any marks.


Explain how the value in cell F4 has been determined using the results obtained.

(3)

$P = \frac{W}{t}$ $W = VIt$

$V = 4.3V$ $I = 2.1A$ $t = 2.19\ s$

$W = 4.3 \times 2.1 \times 2.19$

$W = 19.7757$

$P = \frac{19.77...}{2.19} = 9.03\ W$

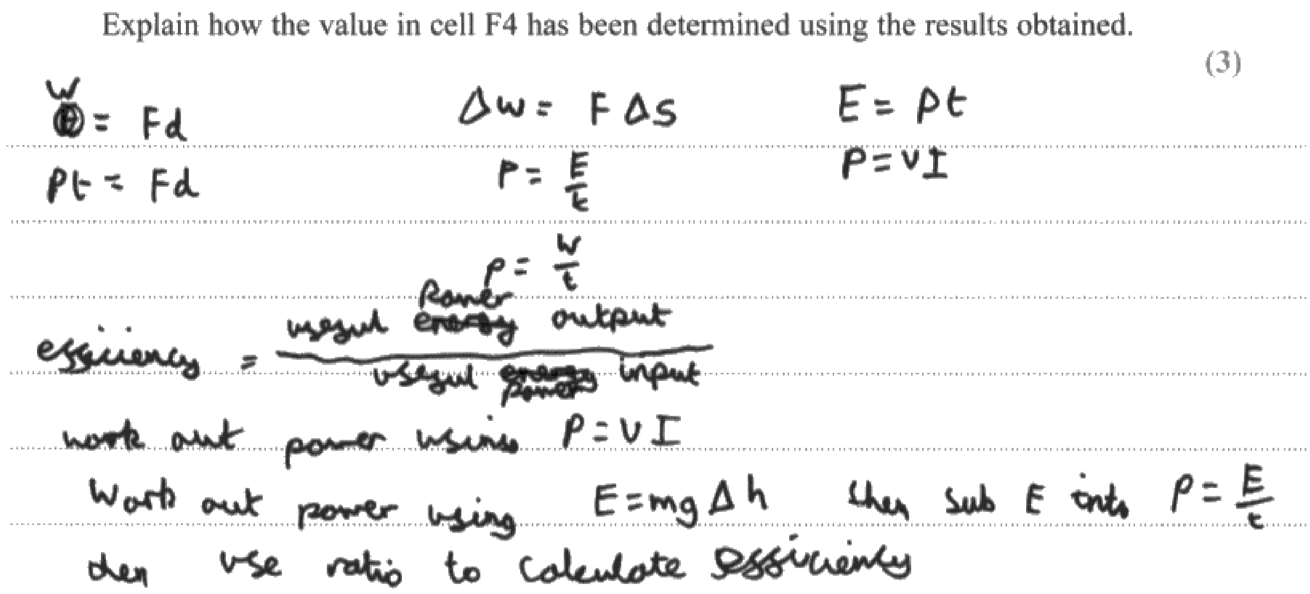
ResultsPlus

Examiner Comments

The candidate has correctly shown how to calculate the input energy to the motor but did not explain what quantity they were determining. A 'W' alone was insufficient for the 'label' as this is an explanation question.

No attempt was made to calculate the output energy or power or efficiency so no marks could be awarded.

This response scored 1 mark.



Explain how the value in cell F4 has been determined using the results obtained.

(3)

$\overset{W}{\cancel{D}} = Fd$ $\Delta W = F\Delta s$ $E = Pt$

$Pt = Fd$ $P = \frac{E}{t}$ $P = VI$

$P = \frac{W}{t}$

$\text{efficiency} = \frac{\text{useful } \cancel{\text{energy}} \text{ Power output}}{\text{useful } \cancel{\text{energy}} \text{ Power input}}$

work out power using $P = VI$

Work out power using $E = mg\Delta h$ then sub E into $P = \frac{E}{t}$

then use ratio to calculate efficiency

ResultsPlus

Examiner Comments

MP1 for the efficiency equation was the only mark awarded.
Two powers have been described but it has not been made clear which is the output power and which is the input power.

While the power = *VI* is correct, this should have been described as the input power. To calculate the power using *E* = *mg*Δ*h* and then divide by time does not match any information given in the table. The table only supplies the load and not the mass, so mgh is not an appropriate equation to use here. The correct initial equation for the output energy is written above, Δ*W* = *F*Δ*s*. However, there are so many equations on the first two lines, none of which have correct 'labels', no credit can be given.

Question 12 (b)

'Criticise' is a command term that is new to the AS specification. For the 6 available marks, 6 separate, independent points were expected. While the entire range of marking points were awarded over the entire cohort, few attempted to describe more than 2 or 3 of these points. Sometimes more points were attempted but they often lacked the precision required to describe the point successfully.

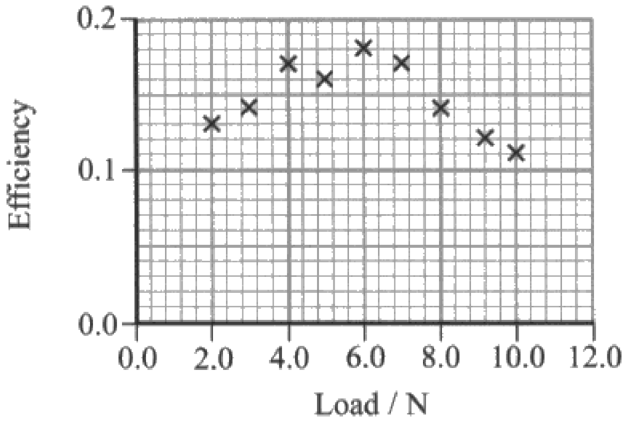
The question asked for the candidates to consider the investigation as well as the conclusion made by the student. Many candidates only commented on the graph, its shape and lack of a line of best fit rather than the experimental technique. This covered the data in the table as this led to the calculation of efficiency plotted on the graph.

Seven possible areas to be discussed were given although candidates, to score 5 marks, were only expected to describe five.

- Point 1: Few noted that the time was too short to be measured by a stopwatch, given the high uncertainty of a stop watch and the relatively short duration it took to raise each load.
- Point 2: Only the most able candidates looked at the number of variables involved. Primarily the variation in the input power i.e. current and pd and the additional problems this may entail.
- Point 3: Probably the most frequently awarded mark although some forgot to refer to a mean/average.
- Point 4: While some good statements about no repeats to check for anomalies were seen, the answer required the candidates to link back to the context and refer to the data and the possible anomaly at about 5 N.
- Point 5: Only the most able candidates started to think about the reliability of the data around the potential maximum with equal numbers describing smaller intervals of weight and more data points around 6 N.
- Point 6: Due to the potential dip in the graph at 5N, you can't be quite sure where the maximum is. Few candidates thought to mention this.
- Point 7: Spotted by many, the conclusion only describes the trend until the maximum and does not address the decrease in efficiency after the maximum.

This response scored 3 marks.

(b) The student uses the spreadsheet to plot a graph.



The student concludes that 'the efficiency of the motor increases with the weight of the load up to a maximum when the load is 6.00 N'.

Critcise the student's investigation ~~and~~ conclusion.

(5)

The result for 5 N of load appears to be an anomalie and could therefore have an actual value higher than that of the 6 N. Repeats should have been done (at least 5 times) to make anomalies clear and an average calculate. The lack of repeats reduces the accuracy, making it hard to ensure the conclusion is correct. The use of a stopwatch could introduce more error as random errors may occur due to the reaction time of the person using the stopwatch.

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Examiner Comments

Point 5 was awarded for lines 1-5 for identifying where the anomaly is and suggesting repeats.

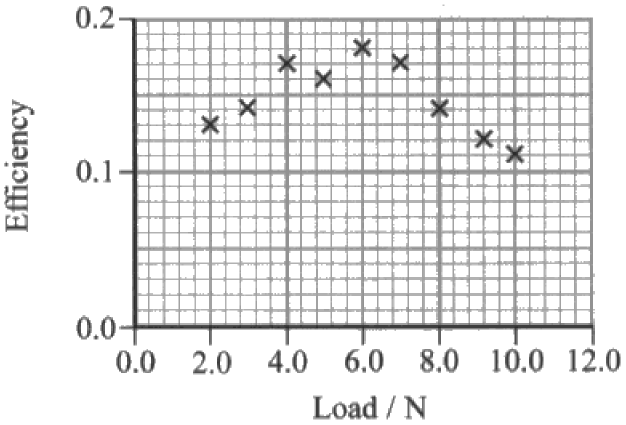
Point 3 was awarded for repeats and average (lines 3-6).

Point 1 was awarded for the reference to the reaction time for the stop watch (lines 7-10).

Although 5 marks were available to discuss 7 ideas, only 3 ideas were addressed here.

This response scored 1 mark.

(b) The student uses the spreadsheet to plot a graph.



The student concludes that 'the efficiency of the motor increases with the weight of the load up to a maximum when the load is 6.00 N'.

Critcise the student's investigation and conclusion.

(5)

That statement is true but ~~have~~ the investigation could have been more accurate as there is a human error by using a stop watch ~~especially as its quite~~ with reaction time to start and stop the stop watch. also instead of just using weights marked '1.00N' they should of measure the mass of added load and times that by gravity $(9.81 ms^{-2})$ to get a more accurate reading for the weight being added as they wont all be exactly 1.00N. In terms of the conclusion it is true but ~~she~~ they have ignored ~~4~~ of the readings ~~she~~ they got so should have mentioned that in their conclusion

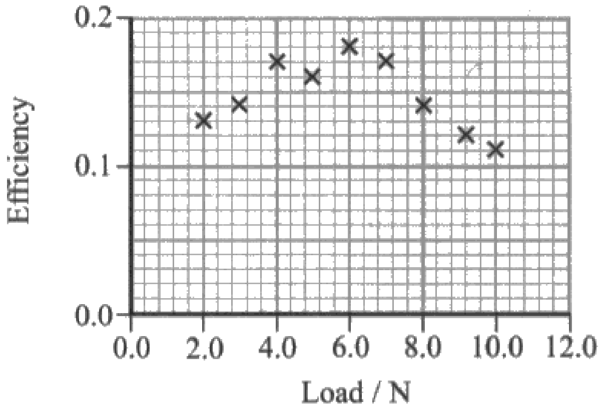
ResultsPlus

Examiner Comments

Point one was awarded for the reference to the stop watch and reaction time in lines 1-3. The candidate went on to discuss measuring the mass of each load and then calculating the weight so no further credit could be given.

This response scored 2 marks.

(b) The student uses the spreadsheet to plot a graph.



The student concludes that 'the efficiency of the motor increases with the weight of the load up to a maximum when the load is 6.00 N'.

Critcise the student's investigation and conclusion.

(5)

First of all, the weights should have been weighed using a balance, instead of relying on the label, so that the mass known is a more accurate precise measurement. Secondly, the student only did the experiment once. The student should have repeated it so there is a total of 3 sets of data to make it more reliable. Also, the student's conclusion is flawed. The general trend is an efficiency increase up until 6.00 N possibly, but there is an anomaly shown, which was not taken into account. Furthermore, the efficiency then decreases after more than 6.00 N is added. The student has not explained or referred to this in their conclusion. However it seems to be rather important information. Also, the maximum load may be anywhere between 6.00 N and 7.00 N, it just wasn't measured, so not taken into account.

Examiner Comments

This is another candidate discussing the values of the load. Even if these were slightly incorrect, the impact of this on the experiment has not been discussed. It is the technique and conclusion that are to be discussed.

Repeats were mentioned but no mention of anomalies or a mean so no credit could be given.

Point 7 was awarded for the decrease after 6.00 N in line 8.

Point 6 was awarded for the penultimate two lines for not knowing where, between 6.00 N and 7.00 N, the maximum lies.

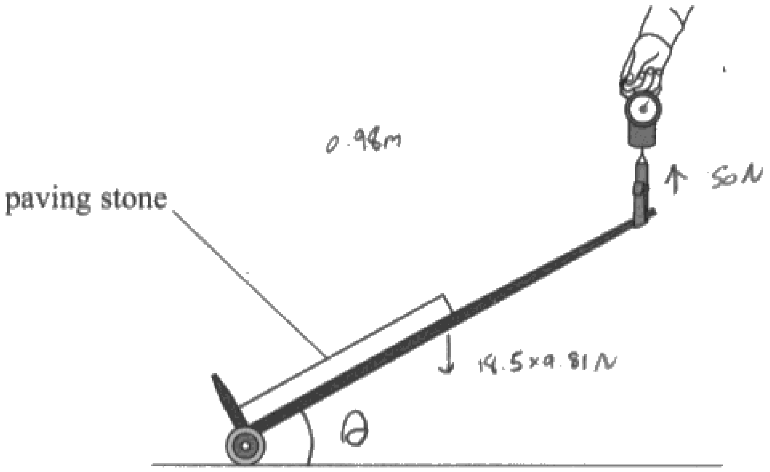
Question 13 (a)

The idea of the principle of moments is well understood by most candidates; however, the idea that a moment uses the perpendicular distance from the pivot was not well understood.

While just under half of candidates failed to score any marks, the majority of the remaining 50% only scored 2 marks. Only the top 6 % of candidates scored all 3 marks. This was entirely due to the use of any trigonometry and perpendicular distances when calculating individual moments. The system was symmetrical, in that both the force on the handle and the weight were both acting vertically. The *cosθ* terms cancelled out when the individual moments were equated, due to the principle of moments. No angle was given for the position of the trolley and this may have been the cause of this error as candidates may not have seen the need to use any trigonometry, even though it is very clear that the forces are not acting at 90° to the trolley.

This response scored all 3 marks.

13 A gardener used a trolley to move a paving stone.



A force meter was attached to the handle of the trolley.

The gardener recorded the following measurements when the trolley was at rest in the position shown in the diagram.

mass of trolley and paving stone = 18.5 kg

length of trolley = 97 cm

force on handle = 50 N

(a) Determine the distance of the centre of gravity of the loaded trolley from the wheels.

(3)

$\times \cos\theta$

↶moment = ↷moment ⇒ $50 \times 0.98 = 18.5 \times 9.81 \times d \times \cos\theta$

$\therefore d = \frac{50 \times 0.98 \times \cos\theta}{18.5 \times 9.81 \cancel{\times \cos\theta}} = \frac{50 \times 0.98}{18.5 \times 9.81} = 0.27m$ (3s.f.)

Distance = 0.27m

ResultsPlus

Examiner Comments

Although the use of cosθ appears to be a bit of an afterthought, the candidate had written correct expressions for the moments, about the wheels, of the weight and the force at the handle.

The two cosθ terms cancel enabling the unknown distance *d*, from the centre of gravity to the wheels (pivot) to be determined.

ResultsPlus

Examiner Tip

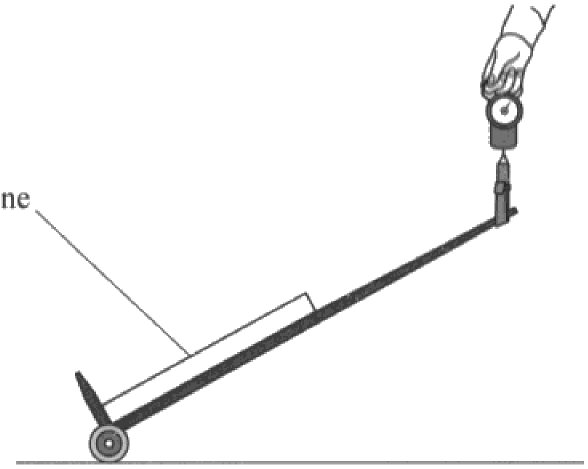
Moment = force x perpendicular distance of the force from the pivot.

In this case the only distances involved were the length of the trolley and the distance of the centre of gravity from the pivot. Both act along the slope of the trolley so are not perpendicular to the forces.

Practice moments questions where the force is not perpendicular to its direction from the pivot i.e. not basic see-saw or bridge style questions.

This response scored just 2 marks.

13 A gardener used a trolley to move a paving stone.



A force meter was attached to the handle of the trolley.

The gardener recorded the following measurements when the trolley was at rest in the position shown in the diagram.

mass of trolley and paving stone = 18.5 kg

length of trolley = 97 cm   0.97 m

force on handle = 50 N

(a) Determine the distance of the centre of gravity of the loaded trolley from the wheels.

(3)

Total clockwise moments = total anticlockwise moments

$0.97 \times 50 = (18.5 \times 9.81) \times D$

$D = \frac{0.97 \times 50}{(18.5 \times 9.81}$

$= 0.267239\ldots$

$= 0.27$ m (to 2sf)

Distance = 0.27 m (to 2sf)

ResultsPlus

Examiner Comments

This response looks very similar to the previous response; it is just missing the cosθ term in each moment.

This was still able to score 2 of the 3 marks. Examiners were unable to tell if this was an error of Physics or, the candidate just knowing these terms would cancel, omitted them from the start.

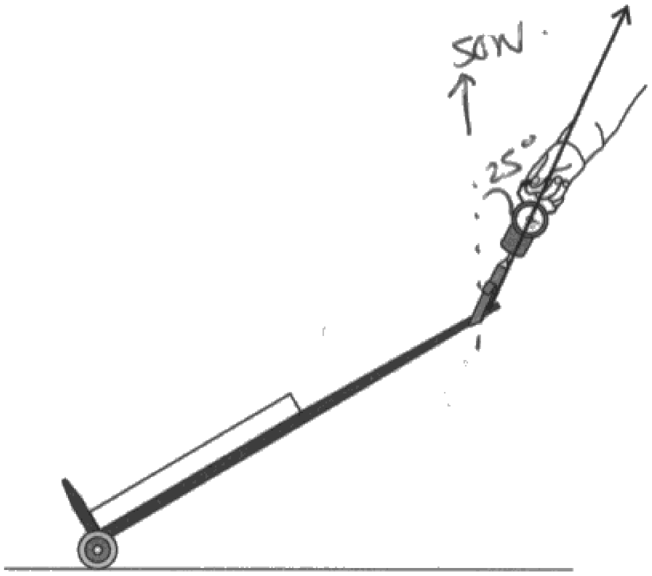
Question 13 (b)

(b)(i) The angles were given in this part of the question but it was not answered well by most candidates. Poor knowledge of trigonometry let most candidates down with the incorrect function used. This was most likely for the same reason as in multiple choice Question 6; the angle had been given to the vertical and not the horizontal which most candidates missed. However, the trigonometry in part (i) was more successfully applied than in part (ii).

(b)(ii) The most common mark to award here was just MP2, for use of $W = Fs$ and $P = W/t$, with the incorrect component of the applied force. Often, even if a candidate had calculated the correct magnitude of the applied force in part (i), few could correctly resolve this force to the horizontal, the direction of motion. Compared to the basketball post question on the 2016 paper, this was a simpler context, involving only two forces at a time and should have been more successfully answered, particularly by the top end of the cohort.

This response was one of the top 11% seen; it scored the maximum (i) 2 marks and (ii) 3 marks.

(b) The gardener then pulled the trolley and measured the applied force while the trolley was moving.

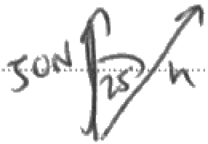


The direction of the applied force is 25° to the vertical, as shown by the arrow.

(i) Calculate the magnitude of the applied force.

Assume the magnitude of the vertical component of the force remains at 50 N.

(2)



$S\frac{O}{H}$ $\boxed{C\frac{A}{H}}$ $T\frac{O}{A}$

$\frac{50}{\cos(25)} = h$

$h = 55.17$ (4sf)

Magnitude of applied force = 55.~~17~~2 (3sf) N

(ii) The gardener continues to walk and pulls the trolley a distance of 15 m in a time of 4.2 s.

Calculate the power developed while pulling the trolley.

(3)

~~P=W×S~~. $P = \frac{W}{t} = \frac{F \times S}{t} = \frac{15m \times (55.2\sin(25))}{4.2}$

83.3~~(3~~ W

Power = 83.3W (3sf)

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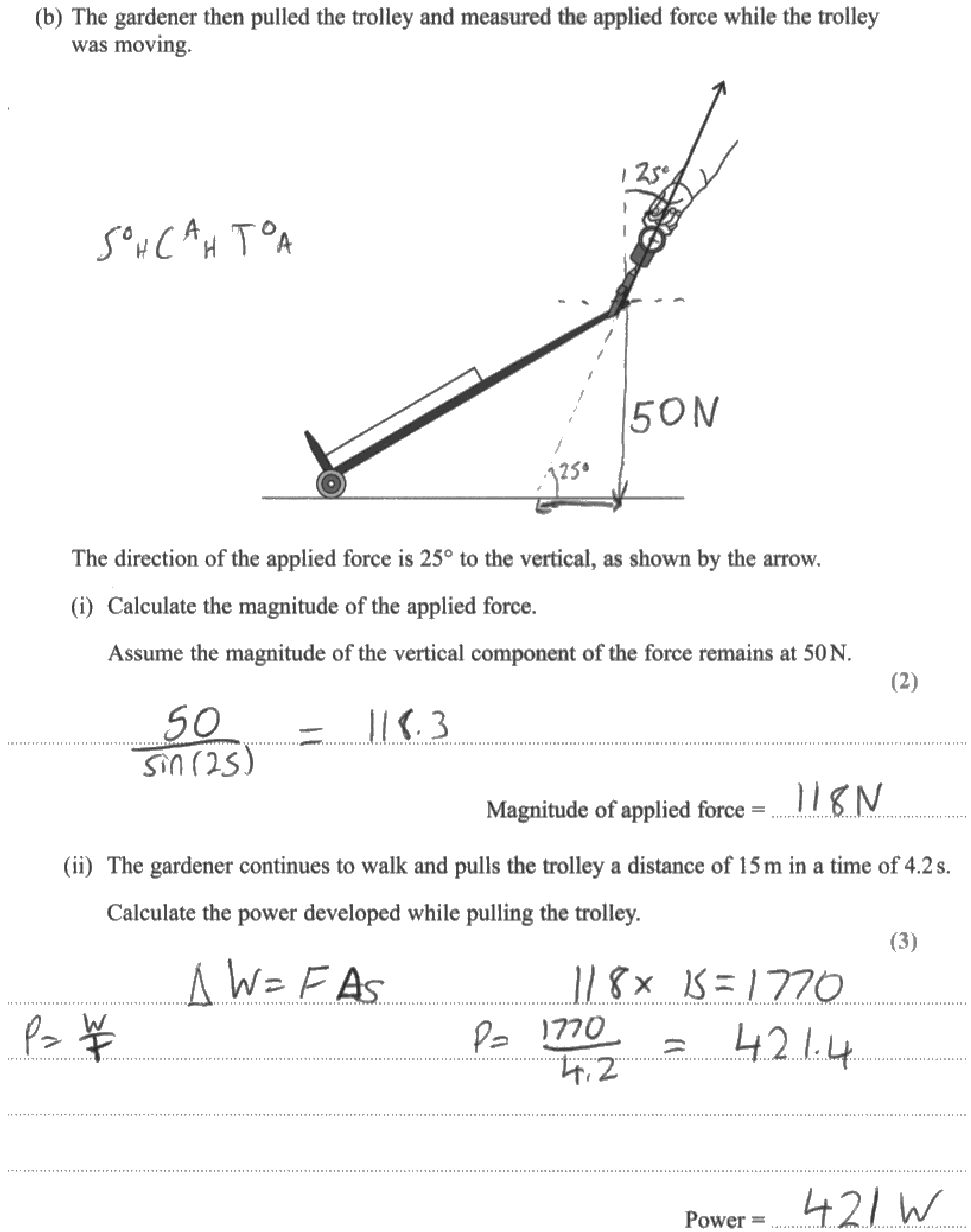
Examiner Comments

(i) Correct use of trigonometry to determine the magnitude of the applied force from its vertical component and direction to the vertical.

(ii) While most candidates managed to pick up a mark here for use of *W* = *Fs* and *P* = *W*/*t*, few were able to determine the horizontal component of the applied force. This was mostly an oversight rather than incorrect use of trigonometry; most responses used 55N from part (i), not realising that this was not in the direction of motion.

This was carried out in one step but there was correct use of the two formulae using the horizontal component of the applied force so all 3 marks were awarded.

This response scored 0, 1 mark and was typical of nearly a third of all responses.



(b) The gardener then pulled the trolley and measured the applied force while the trolley was moving.

The direction of the applied force is 25° to the vertical, as shown by the arrow.

(i) Calculate the magnitude of the applied force.

Assume the magnitude of the vertical component of the force remains at 50 N.

(2)

$\frac{50}{\sin(25)} = 118.3$

Magnitude of applied force = 118N

(ii) The gardener continues to walk and pulls the trolley a distance of 15 m in a time of 4.2 s.

Calculate the power developed while pulling the trolley.

(3)

$\Delta W = F\Delta s$ $\quad 118 \times 15 = 1770$

$P = \frac{W}{t}$ $\quad P = \frac{1770}{4.2} = 421.4$

Power = 421 W

ResultsPlus

Examiner Comments

(i) Incorrect trig function of sine and not cosine selected so no marks could be awarded.

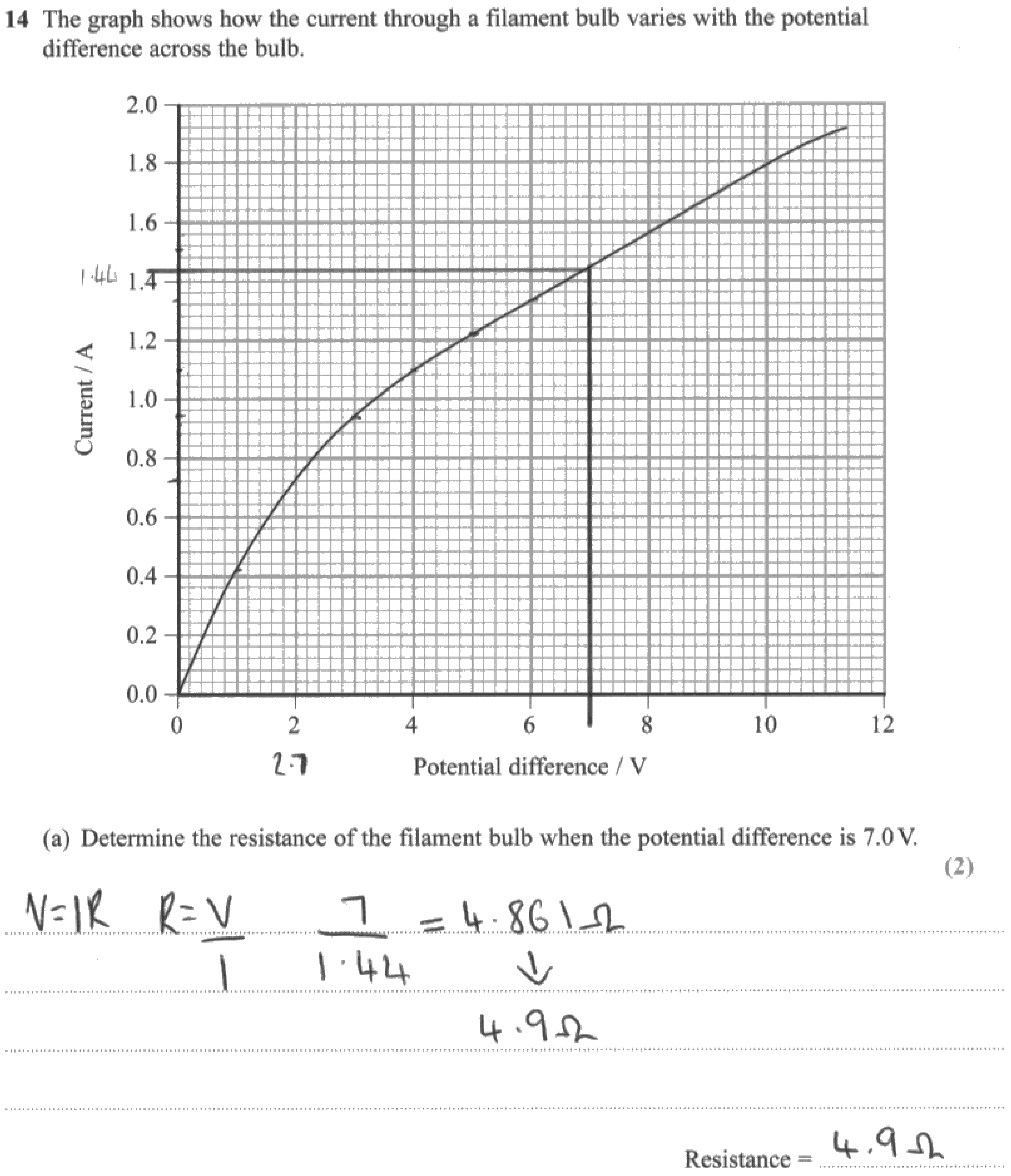
(ii) One mark only awarded for use of *W* = *Fs* and *P* = *W*/*t*. The applied force has not been resolved for the horizontal component so the force used in the equations is incorrect.

Question 14 (a) (b)

(a) This was mostly well answered with the odd candidate misreading the scale and obtaining an answer for the resistance at 7.0 V that was out of range. A few candidates attempted to calculate a gradient of the graph at 7.0 V which could not gain any marks.

(b) One mark was the most common to award here for a line or curve with a positive gradient. Few candidates thought to translate the information obtained in part (a) and mark on the axes the known resistance and PD of 4.9 W, 7.0 V. Those that did put any values on the axes usually omitted the units so no credit could be given. The aspect of the graph that was missed the most but demonstrated the best understanding of resistance was the non-zero origin. A resistor will still have a resistance even if there is no p.d. across it.

This response scored (a) 2 and (b) 3 marks. This was seen in less than 1% of the cohort.



14 The graph shows how the current through a filament bulb varies with the potential difference across the bulb.

(a) Determine the resistance of the filament bulb when the potential difference is 7.0 V.

(2)

$V=IR$ $R=\frac{V}{I}$ $\frac{7}{1.44}=4.861\Omega$

↓

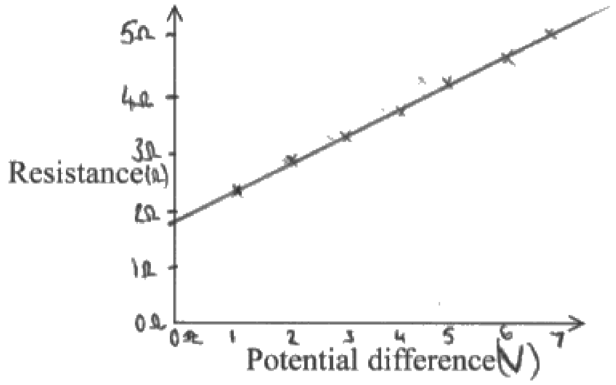
4.9Ω

Resistance = 4.9Ω

(b) Sketch a graph of resistance against potential difference for the filament bulb over the range 0 V to 7 V.

(3)

1V 2.3Ω
2V 2.7Ω
3V 3.2Ω
4V 3.6Ω
5V 4.1Ω
6V 4.5Ω
7V 4.9Ω



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Examiner Comments

(a) 4.86 Ω was the most common correct value seen for the resistance. The candidate has read the current and potential difference from the graph to within half of one of the 2mm squares each time to obtain an answer that rounded (to 2 sf) to 4.9 Ω.

(b) The graph demonstrates an increasing resistance with potential difference, passes through the known values of 7.00 V, 4.9 Ω (including units) and has a non-zero origin. Therefore all 3 marks awarded.

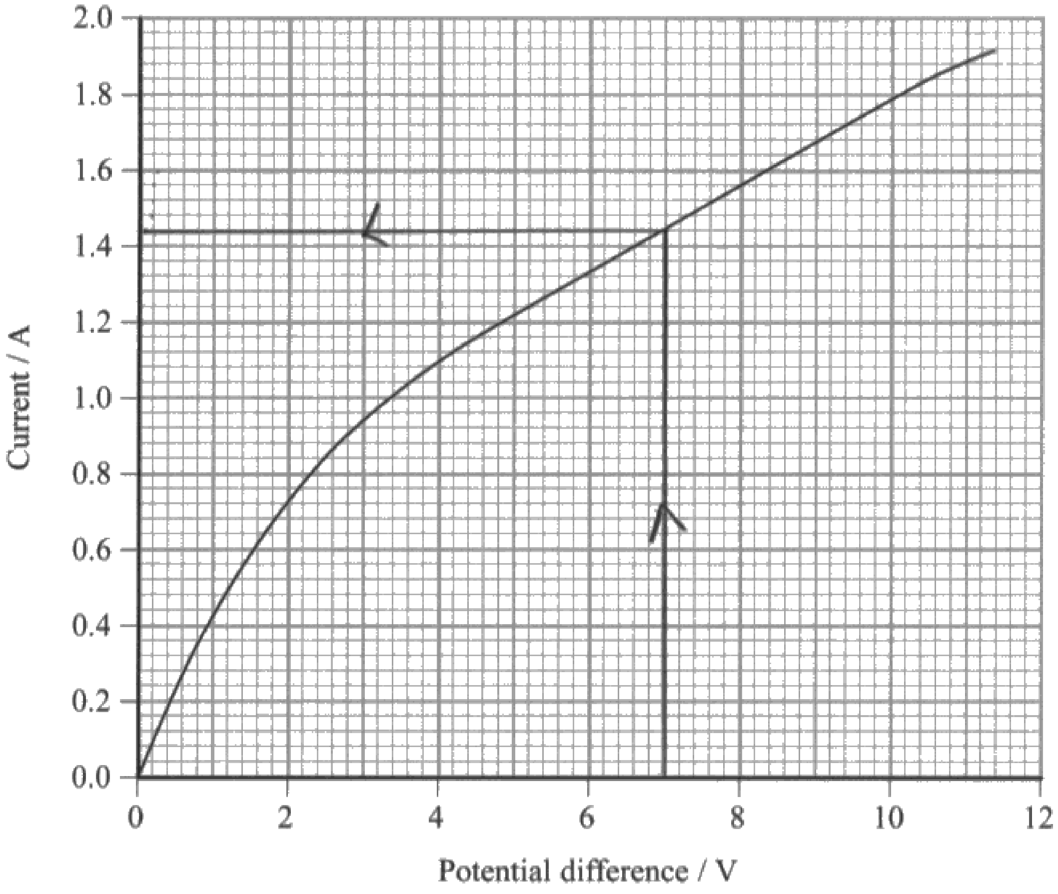
ResultsPlus

Examiner Tip

Even if the command term is to 'sketch' for a graph, if you know any values then these can still be added to the axes. Sketch just means that you are unable to plot every single point and examiners are looking for the shape as well as a few key features to be added to the graph.

This response scored (a) 2 marks and (b) 1 mark.

14 The graph shows how the current through a filament bulb varies with the potential difference across the bulb.



(a) Determine the resistance of the filament bulb when the potential difference is 7.0 V.

(2)

7V = 1·44A

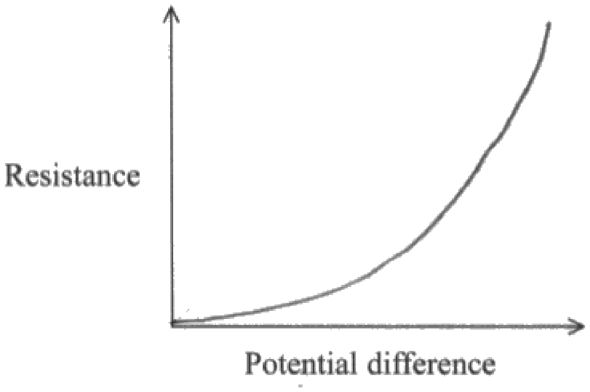
$R = \frac{V}{I} = \frac{7}{1 \cdot 44} = 4 \cdot 861\ldots$

$= 4 \cdot 9\ \Omega$ (2.sf)

Resistance = 4·9Ω

(b) Sketch a graph of resistance against potential difference for the filament bulb over the range 0 V to 7 V.

(3)



ResultsPlus

Examiner Comments

(a) 4.86 Ω obtained from the graph for the resistance so both marks awarded.

(b) Just 1 mark for the resistance increasing with the potential difference. No values marked onto the axes and the graph starts from the origin.

Candidates were not expected to consider the shape of the graph and straight lines or curves of increasing or decreasing gradient were acceptable for MP2, as long as the gradient was positive.

Question 14 (c)

This question was the indicative content question for the paper. Six indicative content points, based on the main points of Physics, were required to explain the variation of resistance with potential difference as set out in the mark scheme. Using the table in the mark scheme the marks awarded are based on the number of indicative content points made, up to a maximum of four marks. The remaining two marks are awarded for linkage. If a candidate gets 2 or 3 indicative points awarded and then links these together, then 1 linkage mark is available and for 4-6 indicative content points awarded, there are 2 linkage marks available.

The question specifically asked for an explanation in terms of particle behaviour which only middle ability candidates or better managed to do successfully. It was expected that references would be made to the lattice or ions as well as the (conduction/free) electrons or charge carriers. Less able candidates referred to atoms and particles, preventing them from being awarded some of the indicative content points.

While many candidates could quote from memory the explanation of the increase of resistance with temperature, few could correctly extend this to the increasing potential difference as the cause for the increase in energy. Even fewer could successfully score the last indicative marking point which explains the increase in gradient of a resistance – p.d. graph at higher values of p.d. Many started to explain a decrease in the drift velocity of the electrons (with increasing p.d.) and hence a decrease in current. The language to describe this, i.e. the increase in current was not in proportion to the p.d., was beyond most candidates.

The most common indicative content point awarded was for the idea of a heating effect (in the filament) though few, as mentioned above, could correctly explain the reason for this. From this point, it was common to see a short explanation in terms of increased vibrations of the lattice ions which, although not complete, was taken to mean increased amplitude of vibrations. From here some candidates continued with a discussion of increased collision rate between the ions and the electron. This question should have been answered in terms of increasing p.d. so at every stage, everything was increasing. Therefore, answers just referring to collisions without implying that there would be more collisions did not get awarded the indicative content point.

Up to now such explanations were not addressing the increased temperature of the filament. The first two indicative content points were for explaining this effect i.e. increased acceleration, velocity or energy of electrons so therefore there would be a greater energy transfer in collisions between electrons and ions and the temperature increases. This was the applied component of the answer that could not be learnt by rote and only the most able candidates thought to start their explanation at this point.

This response scored 1 mark.

The candidate has the right idea about the mechanism resulting in an increased resistance but the lack of detail and language prevents them from scoring more than 1 mark here. With the ideas understood two or three more indicative content points could have been awarded, increasing the mark to a maximum of 4 marks without adding much more Physics, had the ideas been expressed more precisely.

*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

As potential difference increases, so does current as they are directly proportional. An increase in current means and ~~increase~~ faster rate of overall movement of charge at a greater quantity. However, in terms of particle behaviour. As metals have a fixed lattice structure of atoms, an increase in the movement of the delocalised charge carries is going to result into more frequent vibrations within the atoms, resulting in a increase in heat and effectivly increasing resistance. Therefore, although increasing pd from the emf does provide a stronger push to the current, this in fact counteracts and results in increased R which therefore slowly decreaseds current.

ResultsPlus

Examiner Comments

Indicative Content (IC) point 1 required a link between increased p.d. and acceleration/velocity/energy of the electrons. This candidate in lines 1-3 discussed a faster rate of movement of charge; there is no reference to any of the above terms or charge carriers or electrons (so no IC point 1).

Line 8 again lacked the precise language to score IC point 5. Atoms and not ions have been referred to and it is the amplitude and not the frequency of the vibrations that increases (due to the greater transfer of energy from the collisions).

IC point 3 was awarded in line 9. This was thought to be the most straightforward point to award and as long as the examiner thought a heating effect was described, the point was awarded (regardless of the language).

The last 5 lines demonstrate the difficulty in expressing an increasing resistance with ratio of I/V decreasing. The current is not decreasing; it is just not increasing as much for the same increase in p.d. at higher values of the p.d.

This response scored 3 marks.

*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

* As the potential difference increases, ~~the~~ more current is driven through the filament bulb. This increases the frequency of the collisions between the electrons and the metal ions in the lattice. The energy transfered upon collision increases the amplitude of the ion vibration and so increases the temperature of the metal. This thus increases the frequency of collisions even more and so resistance increases dramatically. Thus the graph curves up.

* For small potential differences, the ~~p.~~ current is lower and so the number of collisions is less. Therefore resistance is less and the graph is a straight line.

(Total for Question 14 = 11 marks)

ResultsPlus

Examiner Comments

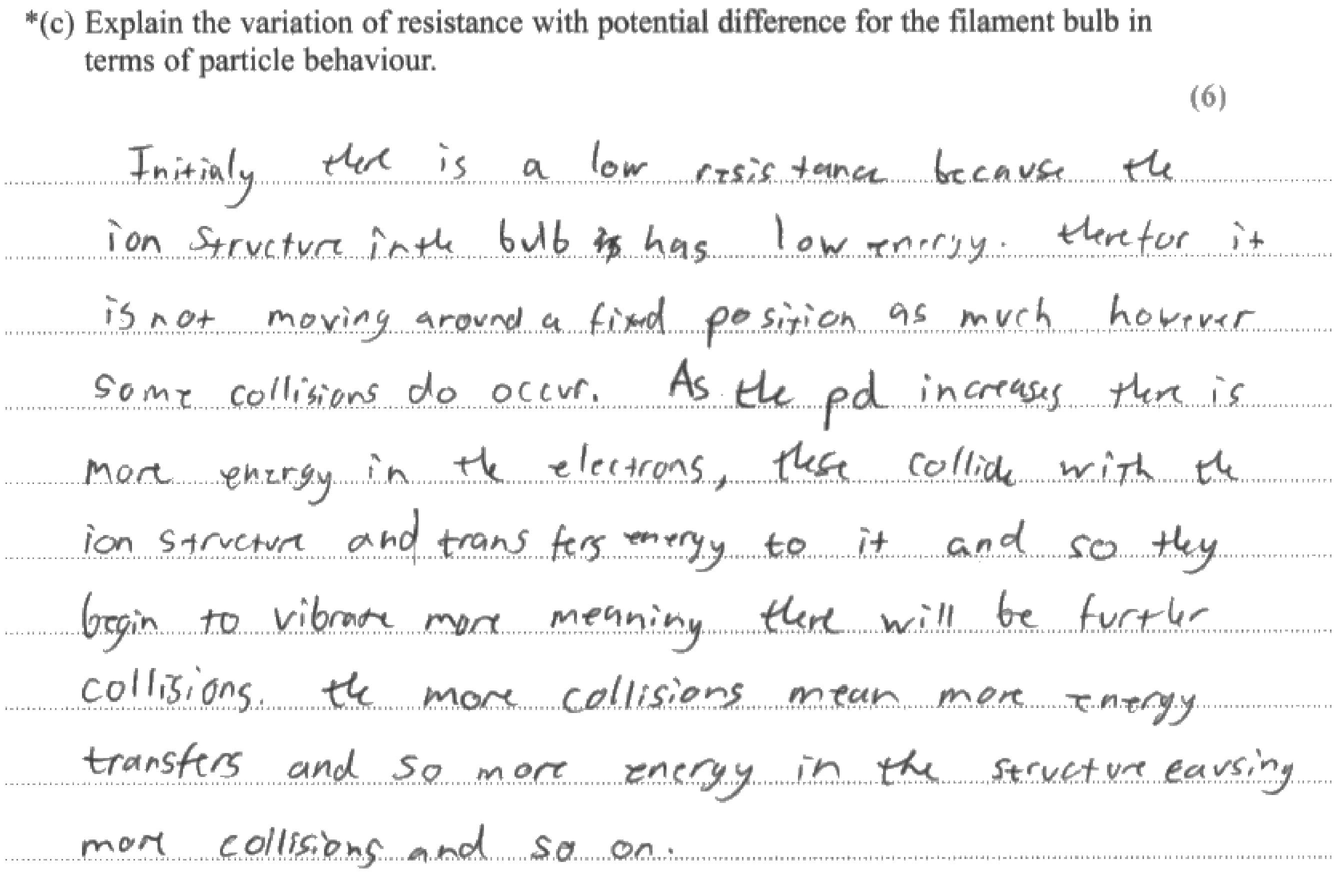
IC point 5 in lines 3-5 for more frequent collisions between electrons and lattice.

IC point 4 in line 6 for greater amplitude of vibration of the ions.

IC point 3 in lines 7/8 for increases the temperature of the metal.

So three linked indicative content points = 2 marks + 1 linkage mark = 3 marks.

This response also scored 3 marks.



*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

Initialy there is a low resistance because the ion Structure in the bulb ~~is~~ has low energy. therefor it is not moving around a fixed position as much however some collisions do occur. As the pd increases there is more energy in the electrons, these collide with the ion structure and transfers energy to it and so they begin to vibrate more meaning there will be further collisions. the more collisions mean more energy transfers and so more energy in the structure causing more collisions and so on.

ResultsPlus

Examiner Comments

IC point 1 for p.d. increases so electrons have more energy (lines 4-5).

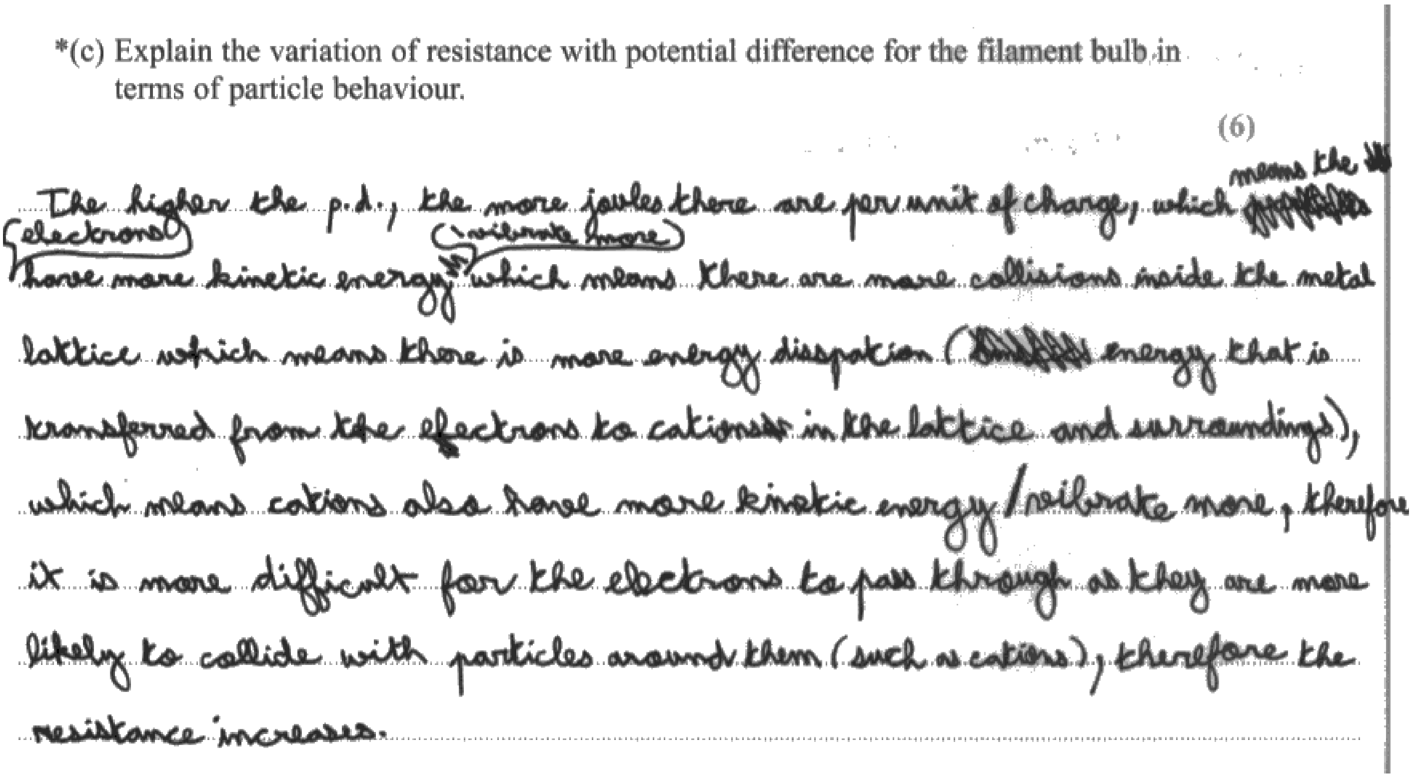
IC point 4 for ions vibrate more (lines 6-7).

IC point 5 for more collisions (between ions and electrons is implied) (line 8).

The candidate has the correct idea that energy is transferred in each collision but, due to the increased p.d., the energy transferred per collision is increased and the initial cause of the heating effect.

3 indicative content points = 2 marks + 1 linkage = 3 marks.

This response scored 5 marks.



*(c) Explain the variation of resistance with potential difference for the filament bulb in terms of particle behaviour.

(6)

The higher the p.d., the more joules there are per unit of charge, which means the
(electrons) (vibrate more)
have more kinetic energy* which means there are more collisions inside the metal
lattice which means there is more energy dissipation (energy that is
transferred from the electrons to cations in the lattice and surroundings),
which means cations also have more kinetic energy / vibrate more, therefore
it is more difficult for the electrons to pass through as they are more
likely to collide with particles around them (such as cations), therefore the
resistance increases.

ResultsPlus

Examiner Comments

Line 2: electrons have more kinetic energy (IC1).

Lines2/3: more collisions (between electrons and ions implied by reading further) (IC5).

Line 4: more energy transferred in collisions (IC2).

Line 5: (cat)ions vibrate more (IC4).

All 4 indicative content points are linked i.e. read on from one another so both linkage marks can be awarded.

4 indicative content points = 3 marks + 2 linkage marks = 5 marks total.

Question 15

The context of solar sails is most probably unfamiliar to most candidates; many candidates managed to successfully score marks, most commonly on the second half of the question that dealt with the photoelectric effect over the first half that covered the de Broglie equation. Only the most able candidates managed to pull together the two ideas and make a comparison of the two methods in part (c). However, 75 % of candidates scored at least 1 mark on this question and, with the exception of those scoring full marks, all other marks were equally distributed between the candidates so this question differentiated well across all abilities (of E grade and above).

(a) (i) Those candidates that did not appreciate that the wavelength had to be determined in order to use the de Broglie equation for the momentum of a photon tended to go down some incorrect routes that mainly involved trying to calculate the 'mass' of a photon to then obtain its momentum. Therefore, less able candidates tended to fair less well in this half of the question.

(a) (ii) Surprisingly few candidates managed to pick up a mark here. Candidates most commonly re-stated their answer to part (i), while others re-wrote it with a negative sign.

(b) (i) This multi-step calculation was answered less successfully than expected. The substitutions into the photoelectric equations were nearly always correct when attempted for the energy of the incident light and work function but not all managed to substitute for the kinetic energy, or used an incorrect mass. Those that did manage to substitute correctly sometimes went on to have difficulty to re-arrange the equation and make 'v' the subject of the equation. However, in such cases 2 of the 3 marks could still be scored.

(b) (ii) This calculation was often completed with success although quite a few candidates did not score the final mark due to a unit missing.

(c) As mentioned above, candidates found this to be challenging as many had just worked through the values involved in the question without much consideration of the context. In this final part of the question candidates were asked to explain if larger changes in momentum could be produced using laser light (i.e. the photoelectric effect) compared to reflected light from the sun. Many candidates attempted to explain why the statement was true as opposed to whether it was true. MP2 was the most frequently awarded marking point for identifying that the ejection of the photoelectron produced a larger change of momentum than for the reflection of the photon.

This response scored (a)(i) 2 marks, (a)(ii) 0 marks, (b)(i) 3 marks, (b)(ii) 2 marks and (c) 1 mark.

15 (a) Solar sails are a form of propulsion for spacecraft. The sail is made of a thin sheet of reflective material. When photons of light from the Sun reflect from the material a force is exerted on the sail. The photons reflect with a momentum equal to their initial momentum but in the opposite direction.

(i) Show that a single photon of frequency 1.5×10^{15} Hz has a momentum of about 3×10^{-27} N s.

(2)

$v = f\lambda$

$\lambda = \frac{v}{f} = \frac{(3 \times 10^{8})}{(1.5 \times 10^{15})} = 2 \times 10^{-7}$ m

$\lambda = \frac{h}{p}$

$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{2 \times 10^{-7}}$

$= 3.315 \times 10^{-27}$ Ns

(ii) Hence determine the momentum transferred to the solar sail by this photon.

(1)

Momentum transferred = -3.315×10^{-27} Ns

(b) An alternative method of producing a momentum change is being investigated. Researchers have suggested that 'larger changes in momentum could be produced by directing laser light at graphene oxide'. Electrons are emitted from the graphene oxide surface, resulting in a force being exerted on the graphene oxide in the opposite direction.

A researcher has suggested that one possible mechanism for the emission of the electrons is the photoelectric effect.

(i) Show that the maximum velocity for a photoelectron emitted after absorption of a photon of light of frequency 1.5×10^{15} Hz is about 8×10^{5} m s^{-1}.

work function of graphene oxide = 6.7×10^{-19} J

(3)

$\overset{E}{hf} = \phi + \frac{1}{2}mv^2$

$(6.63 \times 10^{-34}) \times (1.5 \times 10^{15}) = 6.7 \times 10^{-19} + \frac{1}{2} \times (9.11 \times 10^{-31}) v^2$

$-6.7 \times 10^{-19} = \frac{1}{2} \times (9.11 \times 10^{-31}) \times v^2$

$v = 844040.2548$ ms^{-1}

(ii) Hence calculate the momentum of the photoelectron.

(2)

$p = mv = (9.11 \times 10^{-31}) \times 844040.2548$

$= 7.6892... \times 10^{-25}$

Momentum of photoelectron = 7.68×10^{-25} kgms^{-1}

(c) Explain whether the suggestion in (b) that 'larger changes in momentum could be produced by directing laser light at graphene oxide' is true.

(2)

momentum of photoelectron emitted after absorption of a photon is higher than the momentum of a single photon, so suggestion is true

ResultsPlus

Examiner Comments

(a)(i) The wave equation was used to determine the wavelength of the light from the sun. The wavelength was then used in the de Broglie equation to calculate the momentum of the light. The final answer was quoted to at least one more significant figure than the 'show that' value giving 2 marks.

(a)(ii) As mentioned earlier, (ii) was not answered as well and this candidate has just placed a '−' in front of their momentum from part (i) which does not demonstrate the change in momentum, just the momentum after the reflection from the sail.

(b) (i) Correct substitution of all variables into the photoelectric equation and re-arranged successfully to give the velocity to at least 1 more significant figure than the 'show that' value of 8 x 10^5 m s^{-1}.

(b)(ii) $p = mv$ used successfully to give the correct momentum with unit, so 2 marks.

(c) MP2 awarded for a correct comparison of the change in momentum produced from a photoelectron and a single photon.

This response scored (a)(i) 2, (a)(ii) 1, (b)(i) 1, (b)(ii) 0 and (c) 0 marks.

15 (a) Solar sails are a form of propulsion for spacecraft. The sail is made of a thin sheet of reflective material. When photons of light from the Sun reflect from the material a force is exerted on the sail. The photons reflect with a momentum equal to their initial momentum but in the opposite direction.

(i) Show that a single photon of frequency 1.5×10^{15} Hz has a momentum of about 3×10^{-27} N s.

(2)

~~$f = 1.5 \times 10^{15}$ $V = f$~~ $3 \times 10^{8} = f\lambda \rightarrow \lambda = 2 \times 10^{-7}$

~~$p =$~~ mV $\lambda = \frac{h}{p} \rightarrow 2 \times 10^{-7} = 6.63 \times 10^{-34}$

$p = \frac{6.63 \times 10^{-34}}{2 \times 10^{-7}}$ $p = 3.315 \times 10^{-27}$

(ii) Hence determine the momentum transferred to the solar sail by this photon.

(1)

$3.315 \times 10^{-27} \times 2 = 6.63 \times 10^{-27}$

Momentum transferred = 6.63×10^{-27}

(b) An alternative method of producing a momentum change is being investigated. Researchers have suggested that 'larger changes in momentum could be produced by directing laser light at graphene oxide'. Electrons are emitted from the graphene oxide surface, resulting in a force being exerted on the graphene oxide in the opposite direction.

A researcher has suggested that one possible mechanism for the emission of the electrons is the photoelectric effect.

(i) Show that the maximum velocity for a photoelectron emitted after absorption of a photon of light of frequency 1.5×10^{15} Hz is about 8×10^{5} m s^{-1}.

work function of graphene oxide = 6.7×10^{-19} J

(3)

$hf = \phi + \frac{1}{2}mv^2$

$6.63 \times 10^{-34} \times 1.5 \times 10^{15} = 6.7 \times 10^{-19} +$ ~~$\frac{1}{2}(1.6 \times 10$~~ $\frac{1}{2}mv^2$

$1.484 \times 10^{-5} = \frac{1}{2}mv^2$

$v^2 = \frac{1.484 \times 10^{-5} \times 2}{1.6 \times 10^{-19}} = 1.855 \times 10^{14} \rightarrow V = 1.36 \times 10^{7}$

(ii) Hence calculate the momentum of the photoelectron.

(2)

$P = mV = 1.6 \times 10^{-19} \times 1.36 \times 10^{7} = 2.18 \times 10^{-12}$

Momentum of photoelectron = 2.18×10^{-12}

(c) Explain whether the suggestion in (b) that ‘larger changes in momentum could be produced by directing laser light at graphene oxide’ is true.

(2)

If the Light has a higher frequency, the Kineticenergy would be higher, therefor the Photelectron would travel faster. As the Photoelectron is travelling faster and has a Constant mass, the momentum must increase

ResultsPlus

Examiner Comments

(a)(i) Wavelength and then momentum correctly calculated and answered to more than 1 significant figure.

(a)(ii) Value for the momentum from part (a)(i) doubled to give the correct change in momentum so 1 mark.

(b)(i) Line 2 shows the energy of the incident light and the work function correctly substituted into the photoelectric equation. The equation has not been correctly re-arranged and the charge of an electron has been substituted in for its mass so no further credit.

(b)(ii) Again, the charge of the electron rather than its mass has been used in the momentum equation so no marks here.

(c) This is more of a 'why?' than a 'which?' explanation which did not score any marks.

Question 16 (a)

(a)(i) There was a fair amount of information candidates were expected to read before starting this question. Therefore, many candidates may not have spent sufficient time reading the command sentence for the plotting of the graph at the bottom of the page. Many graphs were plotted the wrong way around and some were plotted of plunger position rather than the compression.

Candidates were awarded MP1 if all of the compressions were correctly calculated. This was marked from the results table rather than from the graph.

Axes were generally well labelled with units; however, this mark (MP2) was not awarded if the graph was the wrong way around.

A correct scale had to be one that covered at least half of the graph paper, in both directions, and went up in sensible scales I, 2, 4 or 5 i.e. not 3 s. A scale that goes up in 3s would also not have been eligible to score the plotting mark due to difficulties checking the points.

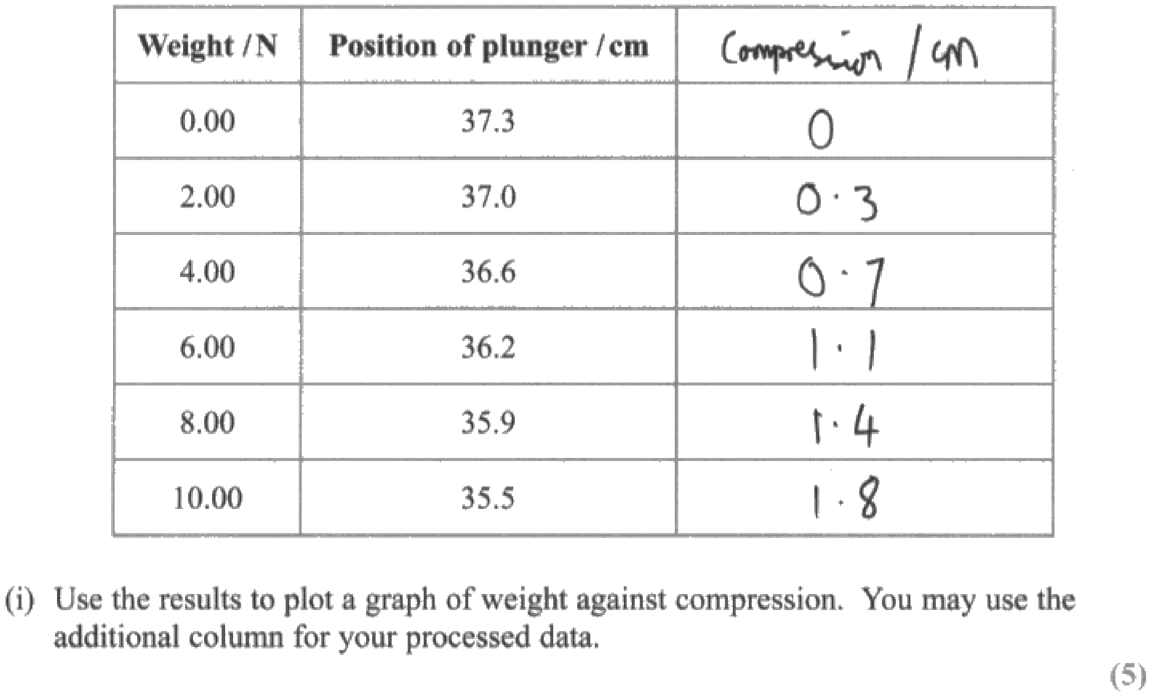
All plotting points were checked by examiners. It was expected that candidates would plot all the values from the table; therefore if a scale was too large to enable all points to be plotted MP3 and MP4 were not awarded. It was also expected that the point at (0 cm, 0.00 N) would be plotted. Plotted points must be drawn with a fine enough pen/ pencil so that the exact position of the point can be seen. A point that creates more than half a 2 mm square of ambiguity was counted as an incorrect plot. Lines of best fit must also be continuous (i.e. a long ruler and not a short ruler used), thin and clear.

MP5 was for the line of best fit and, in general, examiners were looking for an equal distribution of points either side of the line. As most graphs went through the origin, a distribution of the remaining 5 points 3 to 2, either side of the line, if sensibly placed, scored this mark.

(ii) Most candidates attempted to calculate a gradient. It was expected that a triangle at least half the length of the drawn line would be used. Therefore, candidates who only drew small triangles, even if their answer was in range, were unable to score MP3 and 4.

The question asked candidates to determine whether the student's conclusion was justified. Therefore, a calculation alone was not sufficient, candidates had to also comment as to whether Hooke's law was obeyed i.e. a straight line through the origin because force is proportional to extension or compression. Hence, while many candidates calculated a gradient, fewer addressed both aspects of the student's conclusion explaining the lower than expected marks from (a)(ii).

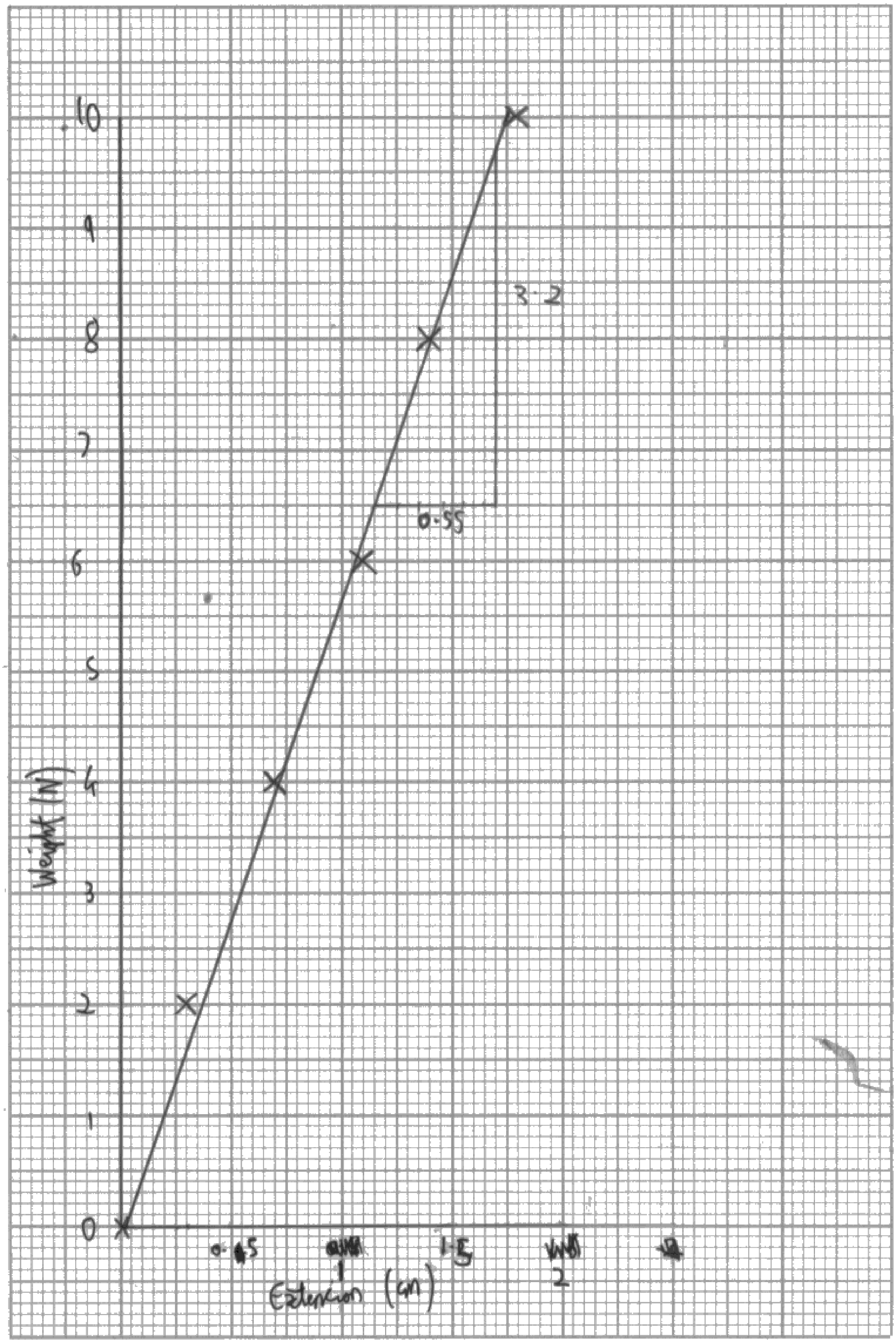
This response scored (a)(i) 4 marks and (a)(ii) 1 mark.



Weight / N	Position of plunger / cm	Compression / cm
0.00	37.3	0
2.00	37.0	0·3
4.00	36.6	0·7
6.00	36.2	1·1
8.00	35.9	1·4
10.00	35.5	1·8

(i) Use the results to plot a graph of weight against compression. You may use the additional column for your processed data.

(5)


10
9
8
7
6
5
4
3
2
1
0
Weight (N)
3·2
0·55
0·5
1
1·5
2
Extension (cm)

(ii) The student concluded that the spring obeys Hooke's law with a spring constant of about 600 N m^{-1}.

Determine whether the student's conclusion is justified.

(4)

Gradient of my line of best fit $= \frac{3.2}{0.55} \approx 5.81\ \text{Ncm}^{-1}$

$= 581.8\ \text{Nm}^{-1}$

Therefore the student's conclusion is justified as the graph has a straight line of best fit for a spring constant of 581.8 Nm^{-1} ≈ 600 Nm^{-1}

So obeys Hooke's Law as Force is proportional to extension

ResultsPlus
Examiner Comments

(a)(i) All compressions were calculated correctly, plotted correctly and the line of best fit was good enough. The graph was plotted the correct way round and the axes labelled correctly.

The only mark dropped was for the scaling as, given the size of the graph paper, the extension scale could have been doubled.

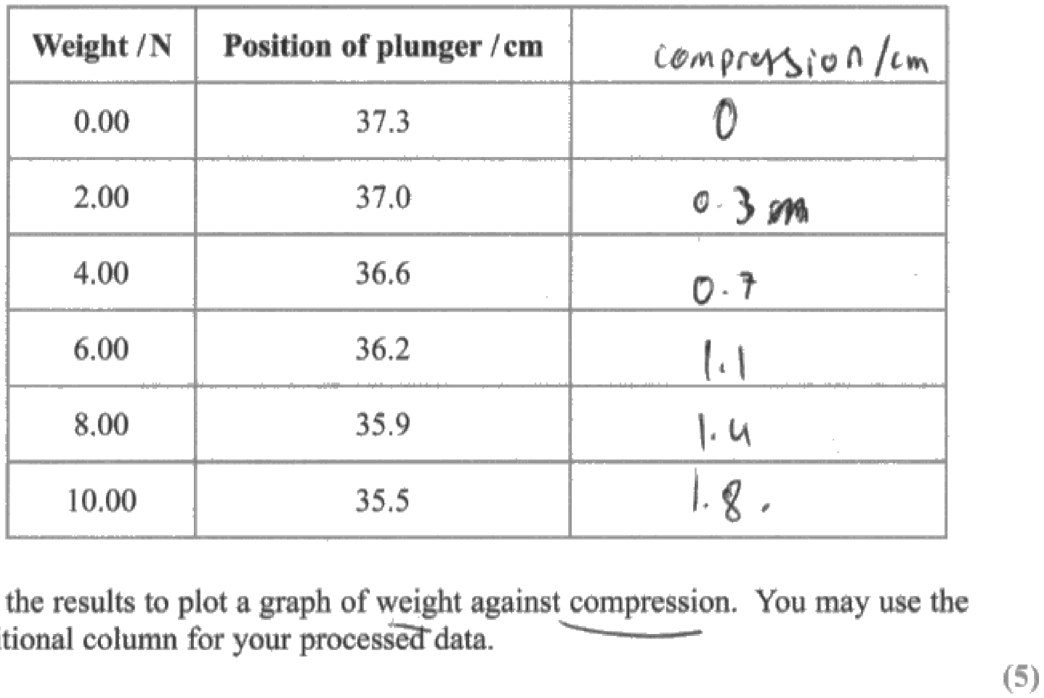
(a)(ii) 3.2/0.55 as a gradient does give a value in range; however, the triangle used to calculate the gradient was less than half the length of the line so no credit (MP3) could be given for the method. MP4 was conditional on MP3 and therefore could not be awarded here. The candidate has partially explained the conditions required for Hooke's law in that the force is proportional to the extension so MP2 was awarded.

ResultsPlus
Examiner Tip

Use all of the graph paper, drawing the axes along the edge of the grid so the maximum possible space can be used.

Always use at least half the length of the line of best fit when taking values from a graph to calculate a gradient.

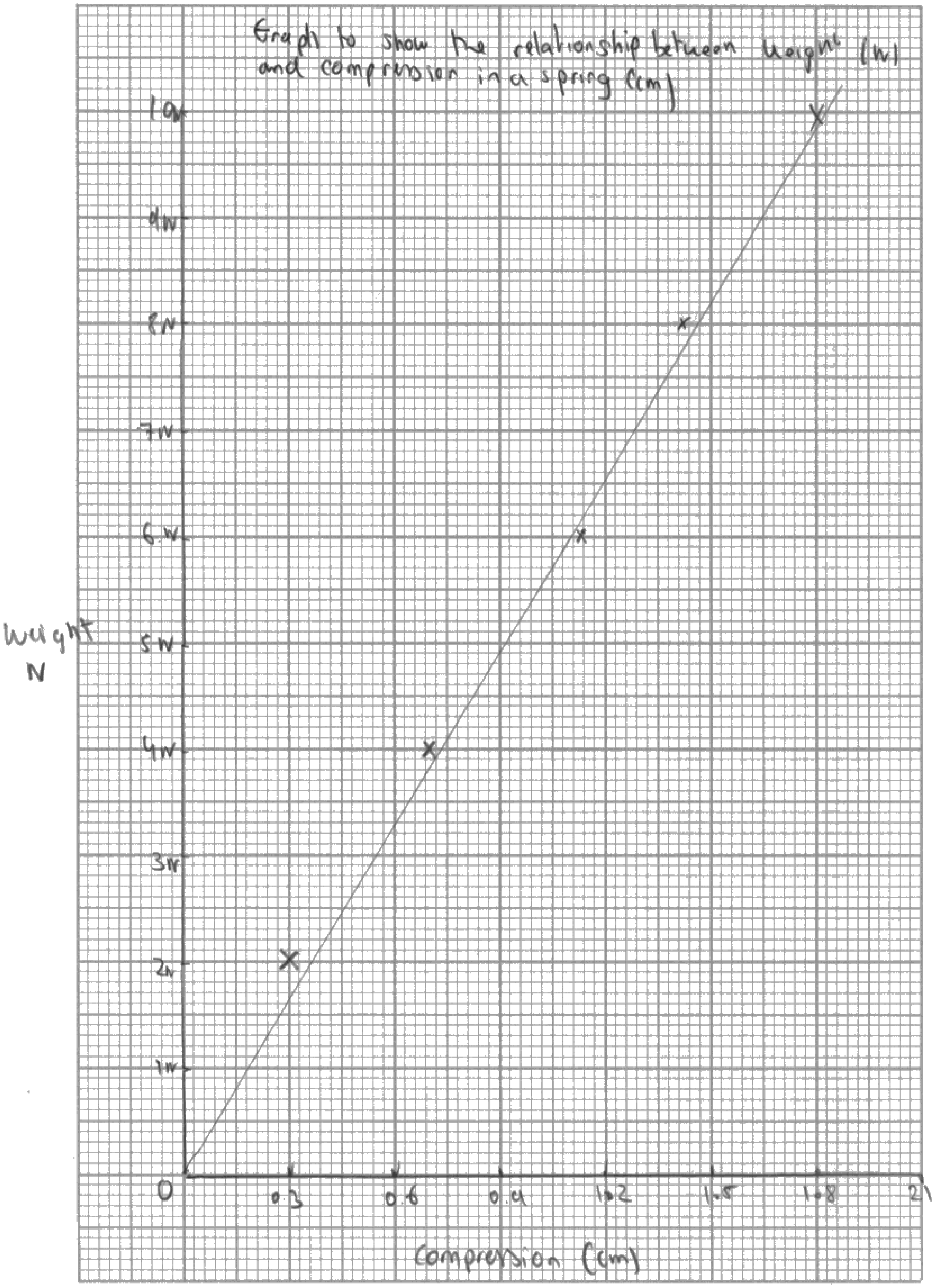
This question scored (a)(i) 2 marks and (a)(ii) 3 marks.



Weight / N	Position of plunger / cm	compression / cm
0.00	37.3	0
2.00	37.0	0.3 cm
4.00	36.6	0.7
6.00	36.2	1.1
8.00	35.9	1.4
10.00	35.5	1.8.

(i) Use the results to plot a graph of weight against compression. You may use the additional column for your processed data.

(5)


Graph to show the relationship between weight (N) and compression in a spring (cm)
10N
9N
8N
7N
6N
5N
4N
3N
2N
1N
0
Weight N
0.3
0.6
0.9
1.2
1.5
1.8
2.1
Compression (cm)

(ii) The student concluded that the spring obeys Hooke's law with a spring constant of about 600 N m^{-1}.

Determine whether the student's conclusion is justified.

(4)

The student conclusion is justified because Hook's law states that the force is proportional to ~~[illegible]~~ the extention

~~[illegible]~~

$F = k \Delta x$

$10 = k$ ~~[illegible]~~ 0.018

$k = \frac{10}{0.018}$

$k = 560$

$\simeq 600 \text{ Nm}^{-1}$

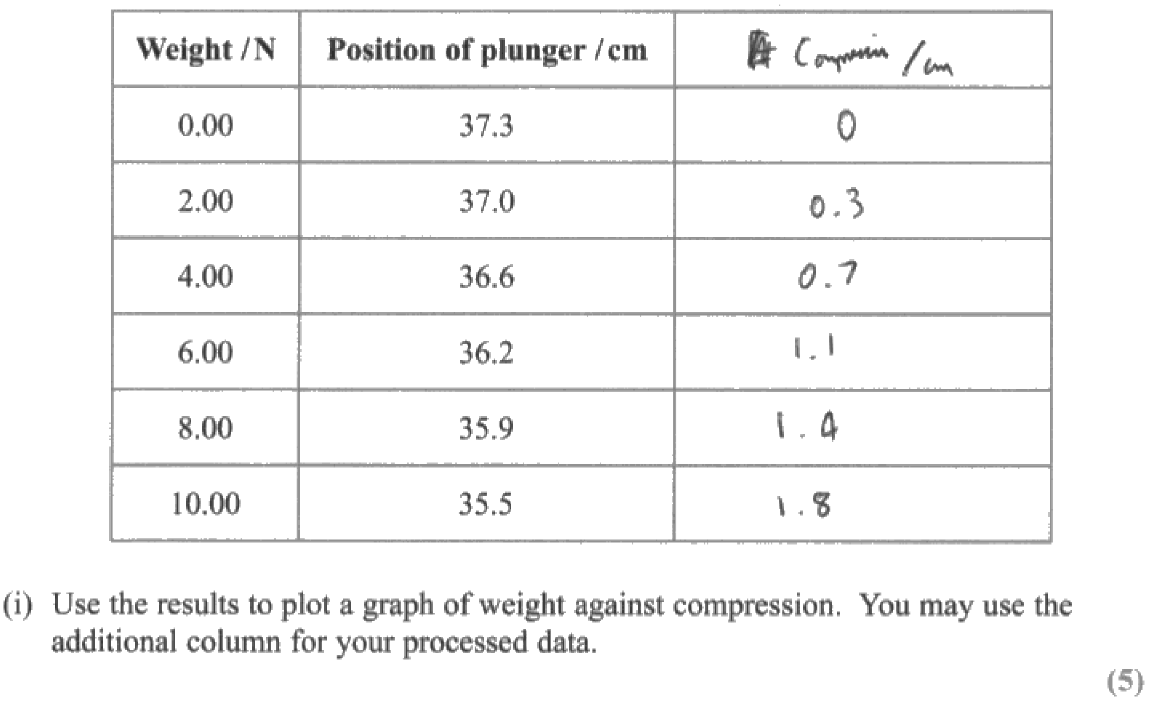
ResultsPlus

Examiner Comments

(a)(i) Although all the values in the table have been calculated correctly, the scaling on the compression axis goes up in threes therefore MP3 and 4 cannot be awarded.
The line of best fit has 4 points along one side and one point below so was not good enough for MP5. Therefore just MP1 for the calculated compressions and MP2 for the labelling of the axes could be awarded.

(a)(ii) The candidate has used the full length of the line to calculate their gradient and obtained a value in range so MP3 and 4 could be awarded for the spring constant. A statement that force is proportional to extension also gets MP2. So 3 marks maximum as there was no reference to a straight line passing through the origin (which would show that force is proportional to the extension).

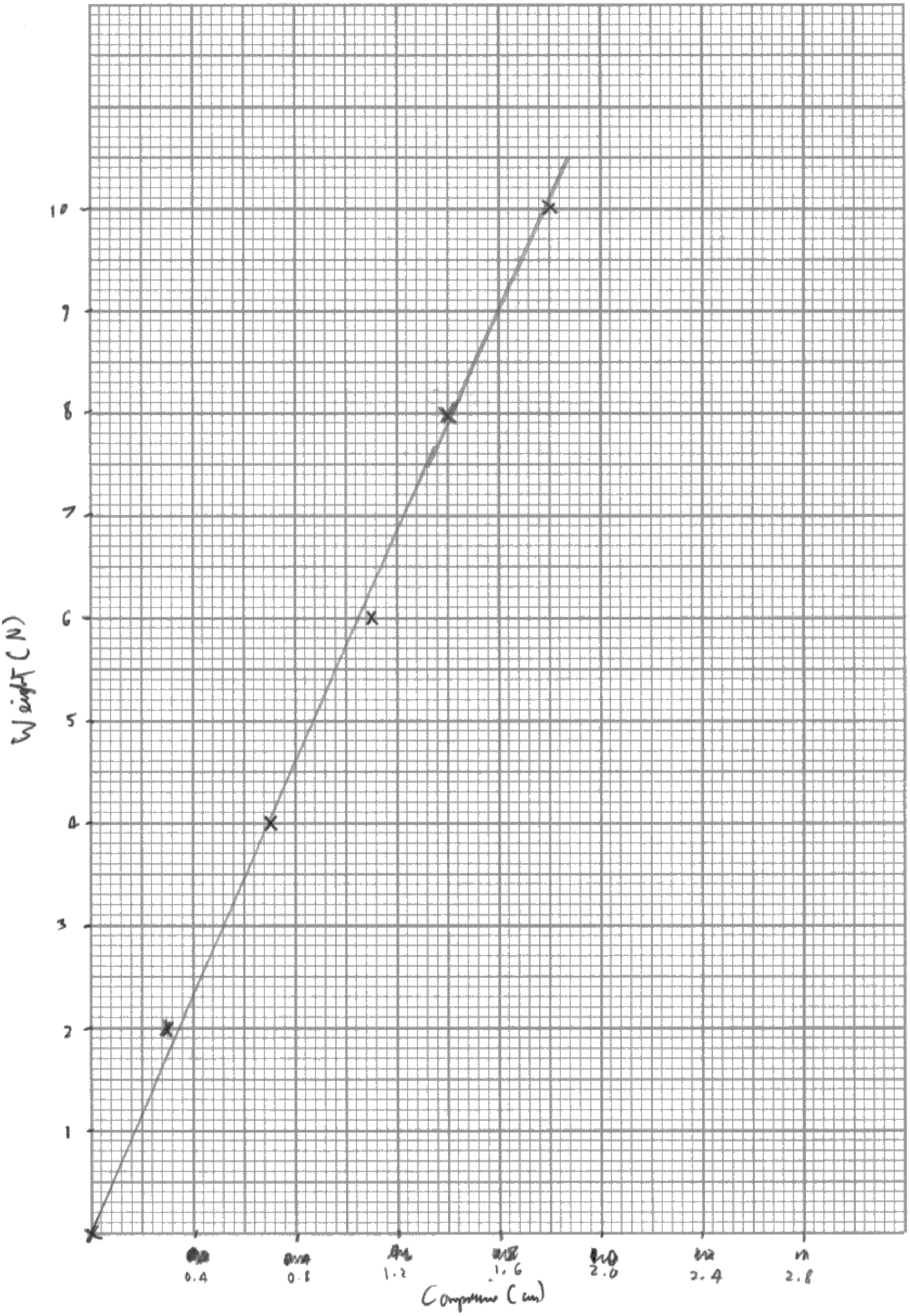
Finally, this example scored full marks. (i) 5 marks and (ii) 4 marks.



Weight / N	Position of plunger / cm	Compression /cm
0.00	37.3	0
2.00	37.0	0.3
4.00	36.6	0.7
6.00	36.2	1.1
8.00	35.9	1.4
10.00	35.5	1.8

(i) Use the results to plot a graph of weight against compression. You may use the additional column for your processed data.

(5)


Weight (N)
10
9
8
7
6
5
4
3
2
1
0.4
0.8
1.2
1.6
2.0
2.4
2.8
Compression (cm)

(ii) The student concluded that the spring obeys Hooke's law with a spring constant of about 600 N m^{-1}.

Determine whether the student's conclusion is justified.

(4)

The student's conclusion is justified as when the results are plotted, they show a linearly proportional relationship because they are joined by a best fit line that goes through the origin. This is in accordance to Hooke's law as force applied is proportional to the extension. The spring constant is equal to the gradient of the graph which is : [illegible] convert cm to m → 1.8cm = 0.018m ∴ gradient = $\frac{10}{0.018}$ = 555.5 Nm^{-1} which roughly round up to 600 Nm^{-1}

ResultsPlus

Examiner Comments

(a)(i) The scale isn't the easiest to follow but covers at least half of the graph paper. All plots are correct and the line of best fit is sufficient.

(a)(ii) This candidate has understood how to justify Hooke's law in stating the evidence, line through origin and conclusion i.e. force applied proportional to extension. The gradient uses all of the graph and obtains a value in range so all 4 marks awarded.

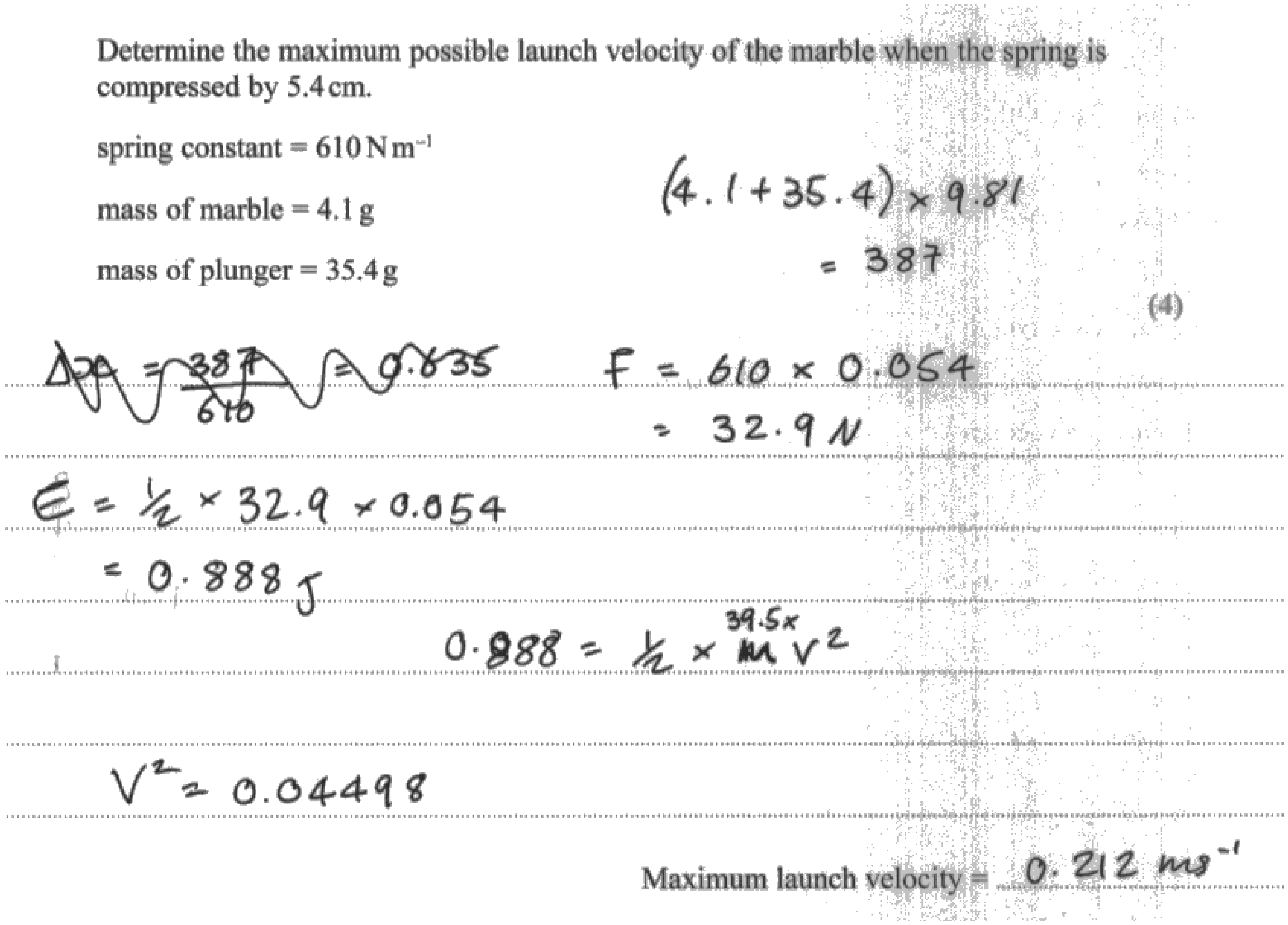
Question 16 (b)

This multi-step question required the candidates to determine the maximum launch velocity of the marble when the spring was compressed by 5.4 cm. The candidates had to first determine the force required to compress the spring by that amount and then calculate the elastic potential energy stored in the spring under that compression. Then equating the elastic potential energy to the kinetic energy of the spring-marble system, the launch velocity could be determined.

Nearly half of candidates did not score any marks at all and the majority of the remaining candidates only picked up one mark, usually for the calculation of the tension in the spring of 32.94 N. Some candidates omitted the ½ in D E_{el} = ½ F Dx and those that managed to equate the energy to ½ mv^2 often did not realise that both the mass and spring were accelerating and a combined mass was required.

Unsuccessful candidates attempted to use $F = ma$ to determine an acceleration and then equations of motion for the velocity. Timing appears to have been an issue for some candidates as this question, at the end of the paper, was left blank in some cases.

This response scored 3 marks.



Determine the maximum possible launch velocity of the marble when the spring is compressed by 5.4 cm.

spring constant = 610 N m^{-1}

mass of marble = 4.1 g

mass of plunger = 35.4 g

$(4.1 + 35.4) \times 9.81$

$= 387$

(4)

~~$\Delta x = \frac{387}{610} = 0.635$~~

$F = 610 \times 0.054$

$= 32.9\ N$

$E = \frac{1}{2} \times 32.9 \times 0.054$

$= 0.888\ J$

$0.888 = \frac{1}{2} \times \overset{39.5\times}{m} v^2$

$V^2 = 0.04498$

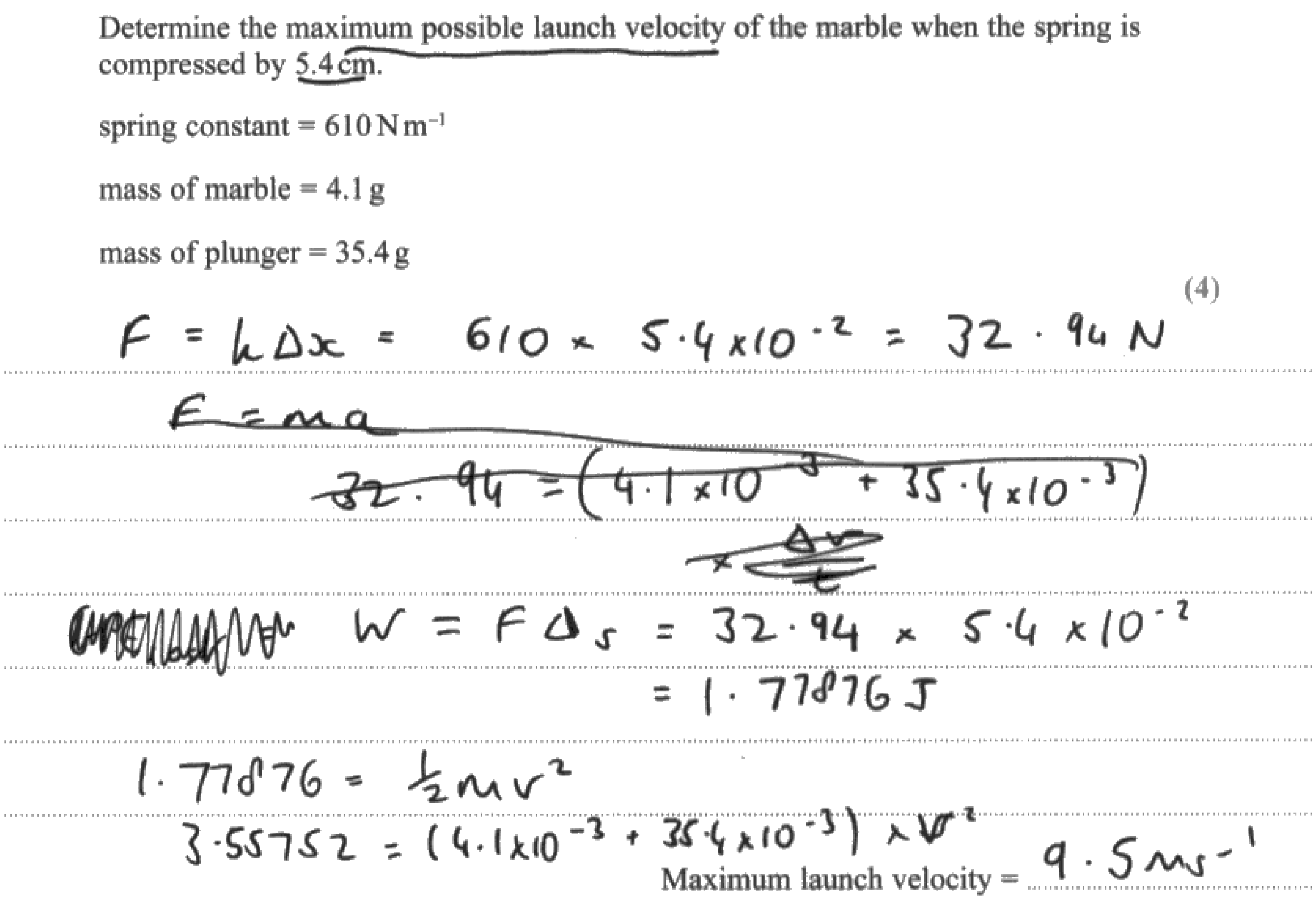
Maximum launch velocity = 0.212 ms^{-1}

ResultsPlus

Examiner Comments

MP1, 2 and 3 were awarded. The candidate had even used the total mass of the spring and marble. The only error was to not convert the mass into kg when used in ½mv^2, causing the final answer to be incorrect.

This response scored 2 marks.



Determine the maximum possible launch velocity of the marble when the spring is compressed by 5.4 cm.

spring constant = 610 N m^{-1}

mass of marble = 4.1 g

mass of plunger = 35.4 g

(4)

$F = k\Delta x = 610 \times 5.4 \times 10^{-2} = 32.94\ N$

~~$F = ma$~~

~~$32.94 = (4.1 \times 10^{-3} + 35.4 \times 10^{-3})$~~

~~$\times \frac{\Delta v}{t}$~~

$W = F\Delta s = 32.94 \times 5.4 \times 10^{-2}$

$= 1.77876\ J$

$1.77876 = \frac{1}{2}mv^2$

$3.55752 = (4.1 \times 10^{-3} + 35.4 \times 10^{-3}) \times v^2$

Maximum launch velocity = $9.5\ ms^{-1}$

ResultsPlus

Examiner Comments

MP1 and 3 were awarded. The ½ has been omitted from the equation for the energy stored in the spring; however, as this was clearly an attempt at an energy, this was allowed in the substitution into ½*mv*^{2} scoring MP3 as well.

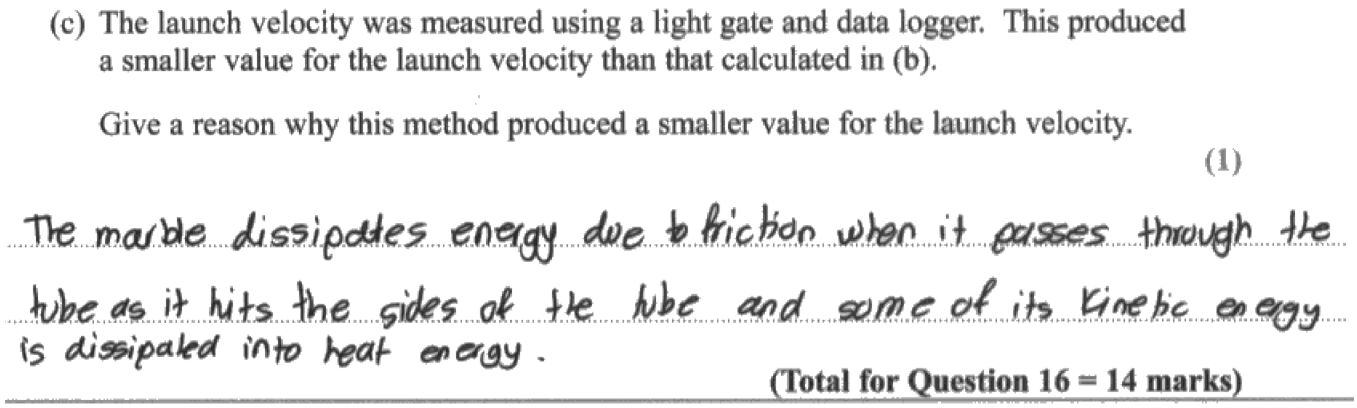
Question 16 (c)

The question asked why the calculated value of the maximum velocity in part (b) would be larger than the actual velocity of the marble when launched. Most candidates reverted to the standard answer in such questions of air resistance. Given that the marble and spring were still within the casing and tube during the process of the acceleration, air resistance would not have been a significant factor.

References to friction were not quite sufficient. Despite being similar to previous questions, some of which were on the previous specification, candidates find it difficult to discuss the idea that work is done against friction or that friction is acting between two objects, stating the objects.

A few candidates commented on the position of the light gate above the launch position. Hence a deceleration would have already occurred. Such responses were good, although rare.

This response scored the mark.



(c) The launch velocity was measured using a light gate and data logger. This produced a smaller value for the launch velocity than that calculated in (b).

Give a reason why this method produced a smaller value for the launch velocity.

(1)

The marble dissipates energy due to friction when it passes through the tube as it hits the sides of the tube and some of its kinetic energy is dissipated into heat energy.

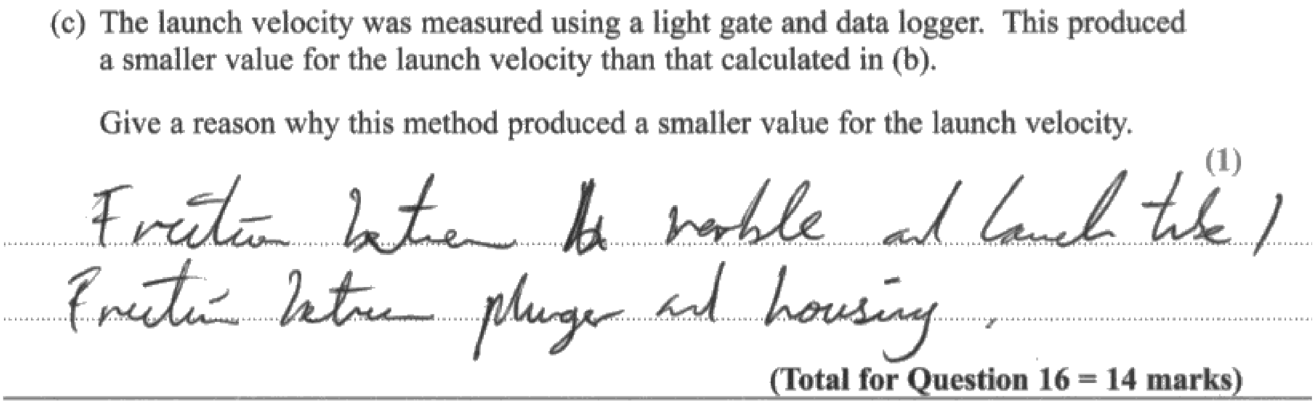
(Total for Question 16 = 14 marks)

ResultsPlus

Examiner Comments

Energy dissipated due to friction between the marble and the tube has been described which tells us the two objects the friction is acting between.

This is another good example that scored 1 mark.



(c) The launch velocity was measured using a light gate and data logger. This produced a smaller value for the launch velocity than that calculated in (b).

Give a reason why this method produced a smaller value for the launch velocity.

(1)

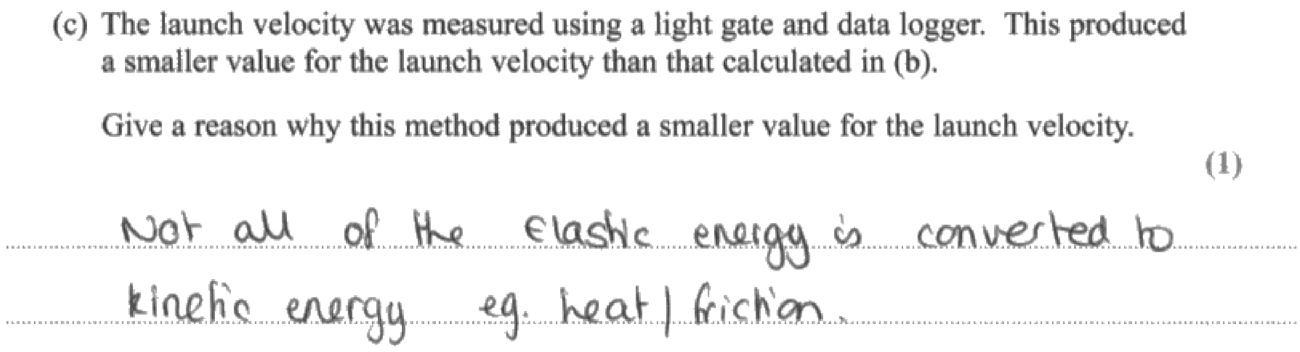
Friction between the marble and launch tube / Friction between plunger and housing.

(Total for Question 16 = 14 marks)

ResultsPlus
Examiner Comments

The candidate has described two different regions of friction and the components involved in each case i.e. marble and launch tube as well as plunger and housing have been described.

This final example did not score any marks.



(c) The launch velocity was measured using a light gate and data logger. This produced a smaller value for the launch velocity than that calculated in (b).

Give a reason why this method produced a smaller value for the launch velocity.

(1)

Not all of the elastic energy is converted to kinetic energy eg. heat | friction.

ResultsPlus
Examiner Comments

The candidate is correct in that not all the elastic potential energy is converted to kinetic energy but they have not explained why i.e. made a reference to friction or work done against friction. Therefore this was insufficient for the mark.

ResultsPlus
Examiner Tip

Friction must always act between two objects. When referring to frictional forces, state which objects are involved. A better answer would be to state that work is done against friction due to frictional forces between, as in this example, the marble and plunger.

Paper Summary

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

A sound knowledge of the subject was evident for many but the responses seen did not reflect this as the language lacked precision and its ambiguity prevented some marks from being awarded.

Based on their performance on this paper, some candidates could benefit from more teaching time and extra practice on the following concepts and skills:

- Slow down during the multiple choice items so that key words or directions in the command sentence responses are not missed.
- Make sure that you have taken note of the command term. If a question requires a ‘decision’ to be made then a statement at the end of the question as to your decision, along with the evidence that you have used to make that decision must be given.
- When plotting graphs read the question carefully to make sure that they are plotted the correct way around. Plot all points in the table, including 0,0.
- Read the questions thoroughly; if an angle has been given make sure you have noted whether it has been given to the vertical or horizontal.
- Practise questions using moments, particularly where the given distances from the pivot are not perpendicular to forces.
- Make sure when you answer questions that appear to be a standard explanation for a process, that you are applying physics to the context of the question and not just repeating a law or writing down the explanation from memory. Some conditions may have changed and you will need to explain them as well.

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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