Pearson Edexcel

Examiners' Report

Principal Examiner Feedback

October 2020

Pearson Edexcel Advanced Subsidiary GCE

In Physics (8PH0)

Paper 01: Core Physics I

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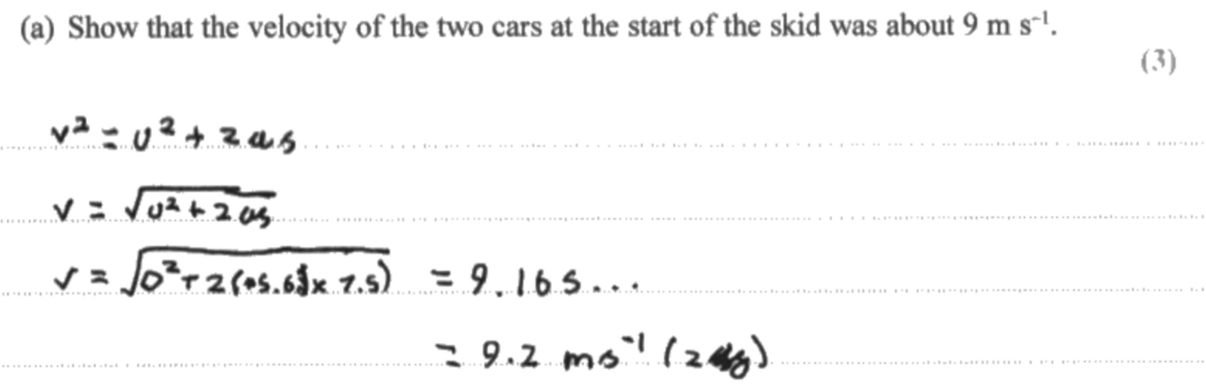
Introduction

This is the fifth time that the Pearson Edexcel AS paper 8PH0 01, Core Physics I, has been sat by students. Section A of the paper is worth 58 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 22 marks on this paper and examines material from the whole AS specification. It contains two questions worth 10 and 12 marks including a data analysis question based on determining the wavelength of laser light passed through a diffraction grating. This is a core practical and so it should be familiar to students from their AS course. The second question in section B is a synoptic question based on the motion of a shuttlecock and testing the candidates understanding of both projectile motion and the effects of air resistance on flight. This paper enabled students of all abilities to apply their knowledge to a variety of styles of examination questions. Many students showed a good progression from GCSE to AS level, with prior knowledge extended and new concepts taught and understood well. The calculation questions were generally answered well by many students, although the need for ratios and interpretation of unfamiliar units in question 13d challenged a great many candidates. In the open response and the extended writing questions, students that 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 and poor use of subject specific language. Question 14b involved a description of a graph from an electrical investigation. Candidates found it hard to describe the shapes shown on the graph, and to relate these to the circuit using correct terminology. Question 12 involved writing a method for an electrical practical. Although it was not a core practical, it is a practical that would commonly be carried out by students in the course of their studies both at GCSE and AS Level, yet many students seemed unaware of the need for a water bath to control the temperature of the thermistor. However, learners from across the ability range managed to score some marks within these questions.

Question 9(a)

It was expected that candidates would answer this using an equation of motion. However, as the mass was included to enable candidates to complete part (b), this opened up another route through the calculation using energy considerations. Most candidates that attempted this calculation completed it successfully.



(a) Show that the velocity of the two cars at the start of the skid was about 9 m s^{-1}.

(3)

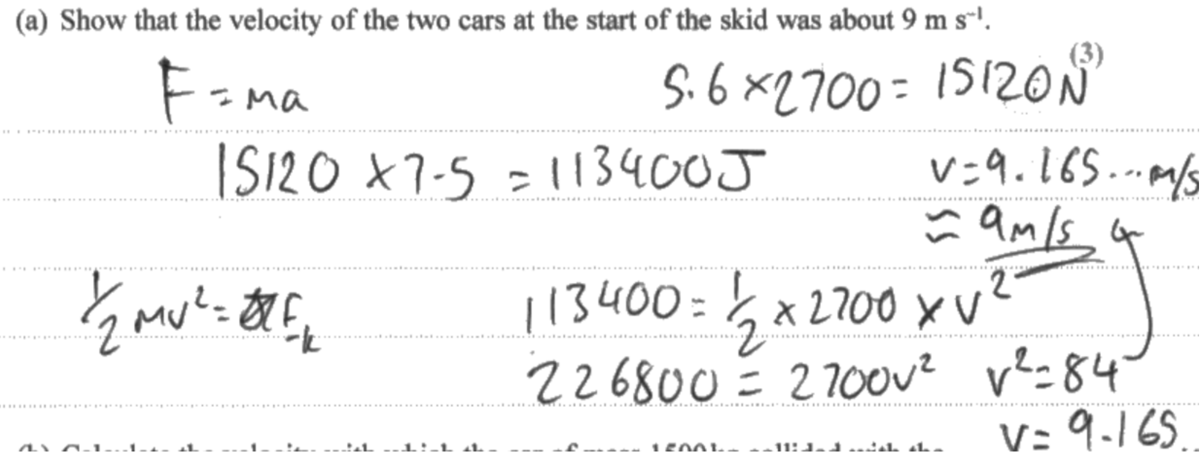
$v^2 = u^2 + 2as$

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

$v = \sqrt{0^2 + 2(5.6 \times 7.5)} = 9.165...$

$\approx 9.2\ ms^{-1}$ (2sf)

This candidate has completed the calculation successfully using an equation of motion.



(a) Show that the velocity of the two cars at the start of the skid was about 9 m s^{-1}.

(3)

$F = ma$ $\quad 5.6 \times 2700 = 15120N$

$15120 \times 7.5 = 113400J$ $\quad v = 9.165...m/s$

$\approx 9m/s$

$\frac{1}{2}mv^2 = E_k$ $\quad 113400 = \frac{1}{2} \times 2700 \times v^2$

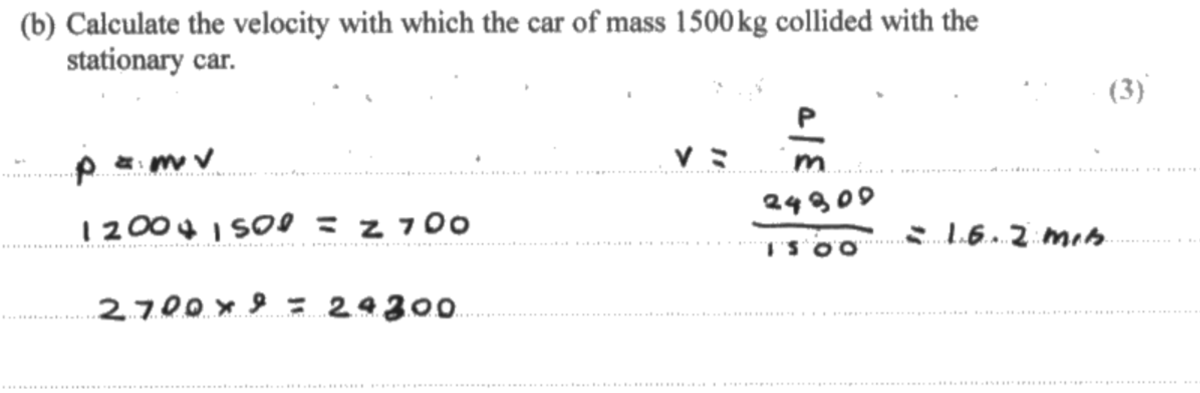
$226800 = 2700v^2$ $\quad v^2 = 84$

$v = 9.165..$

This candidate has chosen to use energy considerations to answer the question. It leads to a correct answer, but the use of three different equations leaves the candidate with more opportunities for error.

Question 9(b)

Here, conservation of momentum should be applied using either the value of 9 ms[-1] or the candidates own value.



(b) Calculate the velocity with which the car of mass 1500 kg collided with the stationary car.

(3)

p = mv

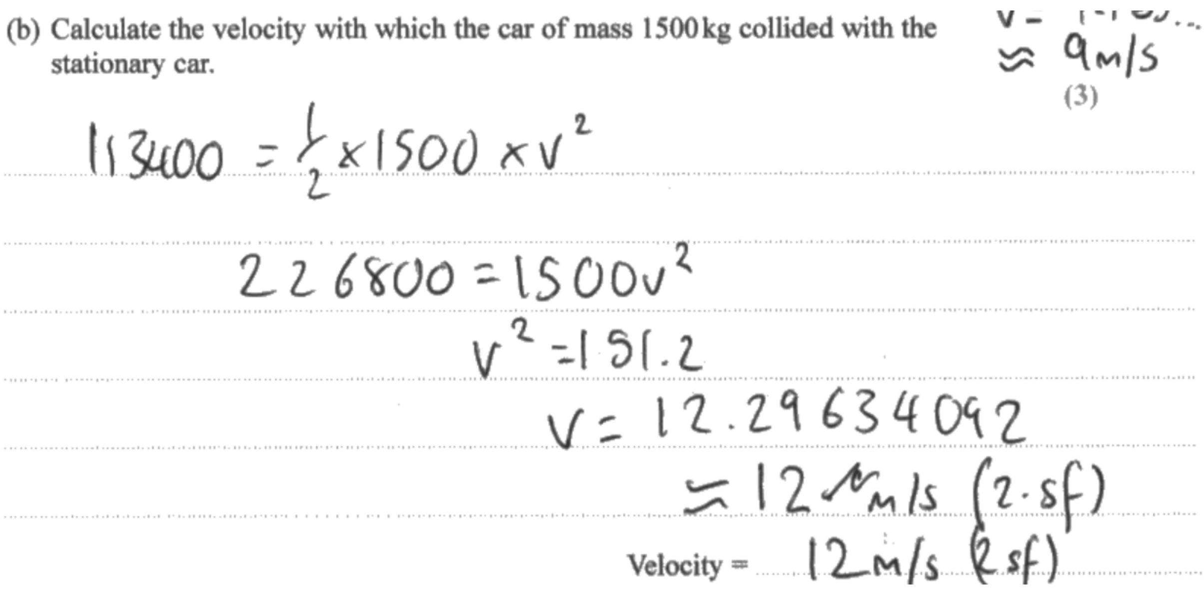
1200 + 1500 = 2700

2700 × 9 = 24300

v = P / m

24300 / 1500 = 16.2 m/s

This candidate has completed the calculation correctly.



(b) Calculate the velocity with which the car of mass 1500 kg collided with the stationary car.

(3)

113400 = 1/2 × 1500 × v²

226800 = 1500v²

v² = 151.2

v = 12.29634092

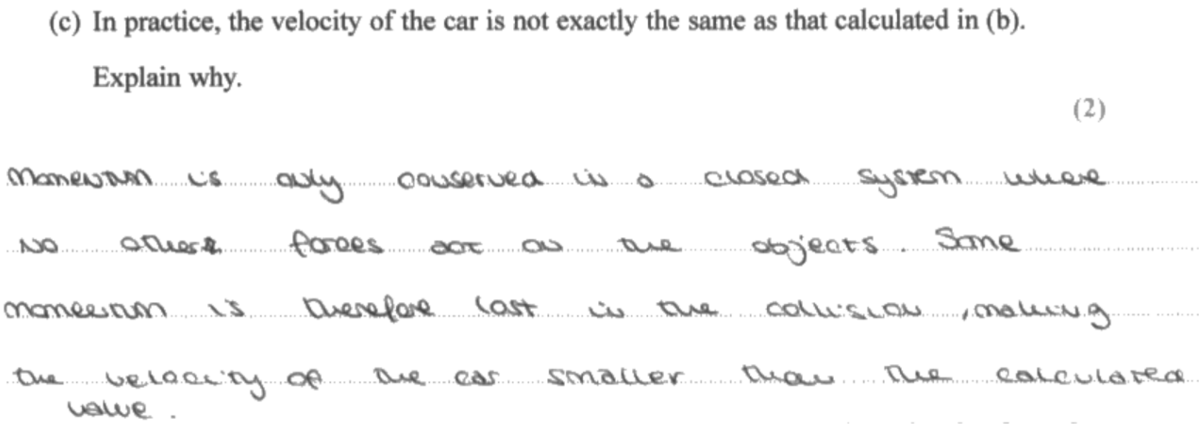
≈ 12 m/s (2.sf)

Velocity = 12 m/s (2 sf)

This candidate has tried to apply conservation of kinetic energy instead of momentum, assuming that the collision is elastic. A collision in which the two objects stay together is never elastic.

Question 9(c)

This question tests the candidates understanding of the conditions necessary for the application of momentum conservation. Most candidates recognised that friction played a part in the velocity difference, but very few related this to momentum, most choosing to discuss loss of energy from the system.

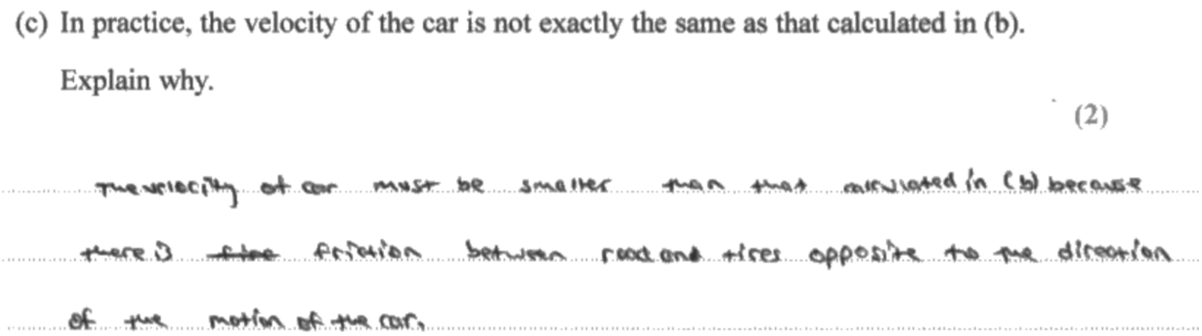

(c) In practice, the velocity of the car is not exactly the same as that calculated in (b).

Explain why.

(2)

Momentum is only conserved in a closed system where no other forces act on the objects. Some momentum is therefore lost in the collision, making the velocity of the car smaller than the calculated value.

This candidate has realised that momentum is only conserved if there are no external forces but has failed to relate this to the context of the question by stating the force involved here.


(c) In practice, the velocity of the car is not exactly the same as that calculated in (b).

Explain why.

(2)

The velocity of car must be smaller than that calculated in (b) because there is ~~the~~ friction between road and tires opposite to the direction of the motion of the car.

This was a typical response focussing on the frictional force but failing to relate it to the conservation of momentum.

Question 10(a)

This was asking for a definition of 'in equilibrium'. Most students referred either to the forces, or the moments, not both, and those that referred to moments often used the context of the question in their explanation therefore missing out the 'sum of' part of the definition.

(a) State what is meant by 'in equilibrium'.

(2)

Equilibrium is when Sum of clockwise moments = Sum of anticlockwise moments. There is no force or movement in any direction.

This candidate explained the mark point about moments well, but needed the word 'resultant' when writing about force to gain the other mark.

(a) State what is meant by 'in equilibrium'.

(2)

when the forces are balanced and there is no resultant force acting on the object.

This achieved the forces mark point, but there was no mention of moments at all.

Question 10(b)(i)

Candidates were expected to show that the clockwise and anticlockwise moments were the same. Most worked out both moments but not all concluded that they were equal.

(b) (i) The owl has a mass $2M$ and the crow has a mass M. Show that the perch will balance when suspended as shown from position X.

(1)

owl: $2M_g \times x = 2M_g x$

crow: $M_g \times (2x) = 2Mx_g \quad 2Mx_g = 2Mx_g$

This candidate worked out both clockwise and anticlockwise moments, then at the end of the second line equated them to one another which was a minimum requirement to get the mark.

(b) (i) The owl has a mass $2M$ and the crow has a mass M. Show that the perch will balance when suspended as shown from position X.

(1)

distance from X

moment crow = M × 2 = 2M

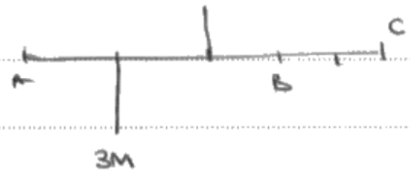
moment owl = 2M × 1 = 2M = moment crow.

This candidate has also calculated clockwise and anticlockwise moments but has failed to comment on the fact that they are the same, or to equate them to each other.

Question 10(b)(ii)

The question hinges on candidates realising that the weight of the 3M mass from the lower perch all acts through the point where it is attached to the top perch. Candidates that still tried to treat the birds on the lower perch as separate weights normally got confused, often giving the owl a moment for instance, when it is in fact under the pivot for the upper perch and has no moment about it.

(3)



M = F × d.

Σ clockwise = Σ anticlockwise.

A × 2x + 3M × x = B × x + M × 3x

A2x + ~~3Mx~~ = ~~3Mx~~ + Bx   A = crow

A × 2x = B × x   B = owl

A × ~~x~~ 2 = B

A = B/2

(Total for Question 10 = 6 marks)

This candidate clearly realises that the weight of the 3M mass acts through the point where it connects to the upper perch and therefore it’s able to successfully take moments and come to a correct conclusion.

As shown in the diagram on the previous page, ~~the perch~~ first perch (the on with the crow on the left, and owl on the right) is at equilibrium. the weight of this perch is 3mg.

$(2 \times x m) + (3mg \times 1) = (1 \times y m) + (3 \times m)$ $\quad 2x = y$

$2xm + 3mg = ym + 3m$ $\quad x = 1, \; y = 2$

$2xm = ym$

(Total for Question 10 = 6 marks)

This answer again takes moments correctly but fails to relate the outcome to the type of bird in each position.

Question 11(a)

This question explored the candidate understanding of how to use spreadsheets to model circuit behaviour. Many candidates did not appreciate what was happening here, and instead treated this as a table of experimental results and therefore improvements such as 'repeat and mean' were often seen in part (c).

(a) Show how the value in B2 is calculated. (1)

$B2 = \frac{1.5}{A2+3} \qquad \frac{1.5}{3+0.5} = 0.428 \approx 0.43$

This candidate has obviously created formulae in spreadsheets before as shown by his use of the cell reference 'A2'. He has used then used the correct numbers to show how the value in B2 was calculated.

(a) Show how the value in B2 is calculated. (1)

$P = I^2R \qquad I = \sqrt[2]{\frac{P}{R}} = \sqrt[2]{\frac{0.09}{0.5}} = 0.424\ldots \approx 0.43$

This candidate has not understood how the data has been generated and has worked backwards by using the value of the power.

(a) Show how the value in B2 is calculated. (1)

$\frac{1.5}{3.5} = 0.4285... = 0.43$ A

This candidate understands the calculation necessary to calculate the current but has failed to show where the 3.5 has come from.

Question 11(b)

(b) Show how the value in C5 is calculated. (1)

$P = I^2 \times R$

$0.3^2 \times 2.0 = 0.18$

This shows clearly how the power was calculated. It was not necessary to include a cell reference in the formula. No unit is given, but as this was given in the table, it is not necessary to get the mark.

Question 11(c)

This question required candidates to critically examine data in order to improve it. Most candidates were able to say that smaller intervals were necessary, but few added the detail of the range where this was needed giving the impression that they were simply repeating something they had learned rather than applying it to the context of the data they were given.

(c) The student concluded that the power dissipated by the resistor is a maximum when R is between 2.5 Ω and 3.5 Ω.

Explain how this spreadsheet could be improved so that this maximum can be located more precisely. (2)

The student could measure at smaller intervals ~~in~~ between 2.5 → 3.5 Ω eg. every 0.1 Ω, to precisely locate the maximum. They could also take multiple readings and calculate a mean.

The candidate has realised that more readings are needed in the area of the peak and has scored both marks. However, the comment about taking extra readings and calculating a mean shows that the candidate has not fully understood that this is a computer modelling exercise.

(c) The student concluded that the power dissipated by the resistor is a maximum when R is between 2.5 Ω and 3.5 Ω.

Explain how this spreadsheet could be improved so that this maximum can be located more precisely.

(2)

More data could be provided to ensure that the results were not anomalous and that the lowering after row 8 was consistent.

‘More data’ is encouraging but the candidate does not explain whether this is in the form of smaller intervals, or a greater range. A greater range would not provide more data in the area of the peak and therefore this was not awarded any marks.

Question 12(a)

In candidates answers to this question it was very obvious whether they had encountered a practical similar to this before. Missing out the use of a water bath cost candidates several marks as they were not thinking of the correct practical and therefore were unlikely to gain marks 5 and 6, as well as losing 2 and 3.

(a) Write a set of instructions that the student could follow and include one safety precaution.

(6)

~~For~~ For a negative temperature coefficient the resistance decreases as temperature increases. If the student uses a battery connected in series with a thermistor ~~along with a~~ and ammeter, along with a voltmeter in parallel to thermistor. This will allow the the resistance to be calculated. Then have a beaker with hot water and a thermometer in the beaker to measure the temperature. Then place the thermistor in the hot water enough that is submerged under the surface of the water. Then as the temperature ~~increases~~ decreases measure the voltage and current at 5°C intervals until the temperature remains constant. Then using the values calculate the resistance with voltage over current, to get the resistance at that specific temperature. Then plot a graph of temperature against resistance to visually see the relationship. When conducting the experiment clear a drop zone and use goggles and gloves just in case of the hot water spilling.

This candidate has gained all of the marks except for the last mark point. They have used an ammeter/voltmeter circuit to calculate the resistance of the thermistor which is perfectly valid.

(a) Write a set of instructions that the student could follow and include one safety precaution.

(6)

First the student needs to make a circuit that includes a cell, a thermistor, a Ammeter and a voltmeter. Then you set up the ~~sa~~ circuit where the cell, thermistor and ammeter are in series and the voltmeter parallel to the thermistor. Now to test the NTC thermistor you can use a heater or lamp or an area where you can change the temperature Acealy. So you can control the temperature and write down the results from the ammeter and voltmeter at different temperatures and then work out the resistance using $R = \frac{V}{I}$. You need to be careful when changing the temperature, wear gloves so you don't get burnt.

This candidate only scores mark point 1. Although the candidate is aware that the temperature of the thermistor needs to be changed and the resistance recorded, a waterbath has not been used so there is no way of regulating or measuring the termperature of the thermistor.

Question 12(b)

Most candidates were able to offer some useful suggestions here. As there were three possible mark points that could be mentioned to gain a maximum of two marks, most candidates scored well.

Give two modifications to the experimental procedure that could improve these results.

(2)

Start from a lower temperature and use a smaller interval

This candidate has gained mark points 1 and 2.

Give two modifications to the experimental procedure that could improve these results.

(2)

repeat the experiment mutiples times and take the average

measure at smaller intervales of temprature

This candidate has gained mark points 1 and 3.

Question 12(c)

This question tested the knowledge of semiconductors. Many candidates spoke of movement of electrons from the valance band to the conduction band but did not relate this to the charge carrier density and therefore the current. Few candidates scored mark point one, although many candidates discussed the electrons gaining energy. Few candidates backed up their arguments by using equations and therefore missed out on mark points 3 and 4.

(c) Explain, in terms of particle behaviour, why the resistance of the thermistor decreases as temperature increases.

(4)

The thermistor is made of a semiconductor. ~~As the temperature increases, the electrons in the semiconductor move from the~~ when the temperature is low, the semiconductor has a low number of charge carriers (electrons). When the temperature is increased, electrons move from the valence band to conduction band this means more charge carriers are available and as $I = nAvq$ this means current increases. As $R = \frac{V}{I}$ as current increases and p.d remains the same, resistance decreases.

(Total for Question 12 = 12 marks)

This response gains 3 marks, losing only mark point 1. The candidate has explained clearly the link between more charge carriers and the decrease in R using equations to justify their argument.

When the temperature increases, the atoms in the thermistor gain energy. This causes them to vibrate and become 'excited'*. As a result, if the atoms gain enough energy, they will emit electrons. Electrons are charge carriers and the more electrons are emitted, the easier it will be for the charge to flow. This decreases the resistance of the thermistor as the temperature increases.

* more vibrations means more ~~successful~~ successful collisions.

This candidate scored the first mark point. The use of the word ‘emit’ when discussing the release of electrons was not ideal however, and there is no justification of the link between ‘more electrons’ and ‘decreases the resistance’.

Question 13(a)

There were many hints given in the value here that showed that it could not be an efficiency, both in the magnitude of the value and the units. Most candidates were able to state one of them, as in the two examples below.

(a) State why the ‘efficiency’ given on the website cannot be a value of efficiency as defined in physics.

(1)

efficiency is between 1 and 0

(a) State why the ‘efficiency’ given on the website cannot be a value of efficiency as defined in physics.

(1)

Efficiency does not have any units as its a ~~ratio~~ ratio of energy/power output to energy/power (total) input.

Question 13(b)

Most candidates were able to relate power, energy and time with the correct equation, although a few just quoted SI units and did not make the link to kWh clearly.

(b) Explain why the kilowatt-hour (kWh) is a unit of energy.

(2)

$\text{Power} = \frac{\text{Energy}}{\text{Time}}$ ∴ Power × Time = Energy

KW × h = Energy

Kw is 1000W which is a measure of Power

h is 3600s which is a measure of time

This candidate has given the equation and clearly identified kW and h as units of power and time respectively, gaining both marks.

(b) Explain why the kilowatt-hour (kWh) is a unit of energy. kWh = $\frac{1000}{3600}$ (2)

This is because it measures the amount of Power used as time passes by. Based on the equation E = P x t.

This candidate knows the correct equation here gaining mark point 1. There is an attempt to convert units in the top right corner, but the candidate is unable to link the equation clearly to the units used.

Question 13(c)

Candidates are familiar with the efficiency equation and how to use it. Many gave their answers as both a number and a percentage, but a few gave only a percentage. This was allowed, but it is better to give efficiency as a unitless number, and it is not necessary to convert this to a percentage as well. Some candidates were a little overwhelmed by the amount of data given and could not pick out the correct data from which to find the input energy for the battery.

(c) Calculate the efficiency of the battery. (3)

3.6 x 7 = 25.2 KWh

$\frac{22}{25.2}$ = 0.87

Efficiency = 0.87

This candidate has used the correct data clearly to calculate a correct value for efficiency.

(c) Calculate the efficiency of the battery.

(3)

7hrs × 3600 = 25200 seconds

25200 × 3600 = 90,720,000 J

22 × 3600 × 1000 = 79,200,000

$\frac{79,200,000}{90,720,000}$ = 0.873015873 ≃ 0.87 (2sf)

Efficiency = 0.87 (2.sf)

This candidate has gained all three marks but has spent unnecessary time on the calculation as they have converted both energy values in kWh to J. A better understanding of the ratio would have saved the candidate time.

Question 13(d)

Candidates chose to calculate this in many ways. In essence, they needed to compare either the ranges or the costs fairly.

Show that the electric car is cheaper to run.

cost of 1 litre of petrol = £1.20

cost of 1 kWh of electricity = 13 p

(2)

Petrol -> To go 21km = £1.20

Electric -> To go 21km = ~~[crossed out]~~ $\frac{195}{1000}$ × 21

= 4.095

= (4.095)(0.13)

= £0.53

The electric car costs £0.67 less to run per km than a petrol car.

This candidate calculated the cost for the electric car using the 'efficiency' value given in the data. They then compared the cost correctly for a range of 21km.

(d) A comparable petrol car has a petrol consumption of 21 km / litre.

Show that the electric car is cheaper to run.

cost of 1 litre of petrol = £1.20

cost of 1 kWh of electricity = 13 p

(2)

~~21 × 129 = 2709~~ $\frac{129}{21} = 6.14$ l.

cost = 1.20 × 6.14 = £7.37

~~cost~~ $\frac{129}{195} = 0.66$ $\frac{195}{129} = 1.51$ kWh

cost = 0.13 × 0.66 = cost = 0.13 × 1.51 = 0.1963

= 20 p.

20p < £7.37

This candidate aims to find the cost for comparable ranges of 129km but makes a mistake when calculating the cost for the electric car. The candidate is still awarded mark point 2, however.

Question 13(e)

Candidates on the whole did not score well here. Most did not take into the account the gases emitted by some power stations which are generating the electricity needed for the electric car. It was common to see answers such as 'no CO_2 emissions' instead of LESS CO_2 emissions. It was also common to see candidates referring to 'fumes' and 'doesn't burn fossil fuels' which were not worthy of credit.

(e) Give one environmental advantage of an electric car.

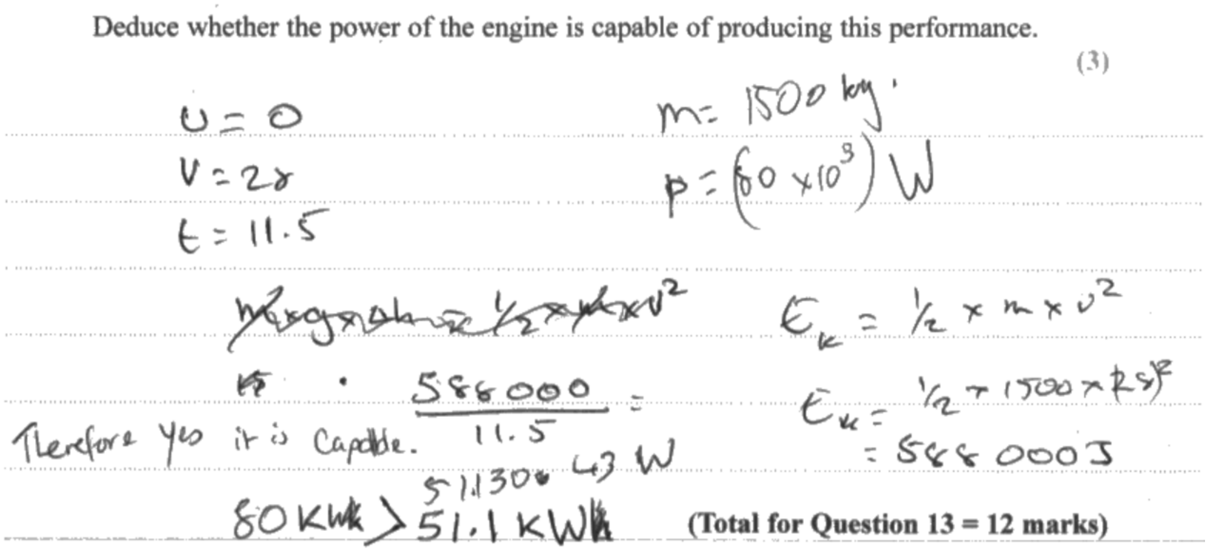
(1)

It does not burn fossil fuels which keeps the atmosphere ~~of~~ cleaner

This candidate has not taken into account the method by which the electrical energy for the car was generated in the power station.

Question 13(f)

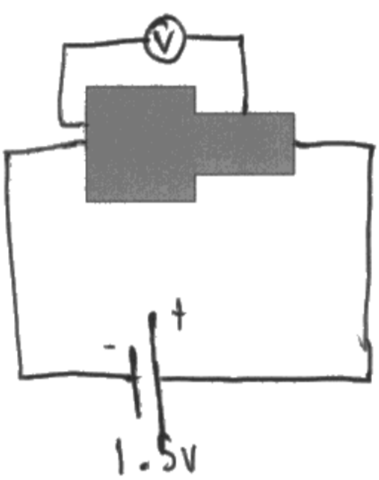
The easiest way through this calculation was equating work done and kinetic energy and the candidates that used this route through were normally successful. Others used equations of motion to find a, then found F and used W=Fs. This also works but a higher percentage of the candidates that used this route made errors.



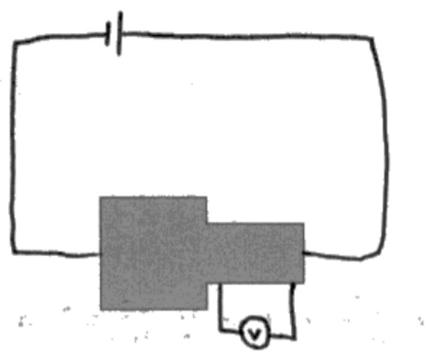
This candidate has used the energy route through this question and has completed a successful calculation. They have then compared the two powers and come to a correct conclusion.

Question 14(a)

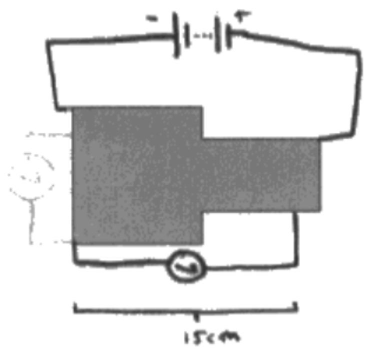
A surprising number of candidates in this question did not appear to know the polarity of a cell correctly. Credit was not given for labelling a cell with + and – if they were applied to the wrong ends of the cell. Most candidates were able to put the voltmeter in parallel though not always connected across the right section of the paper.



This candidate scores both marks.



This candidate scores mark point 1 but does not have the voltmeter correctly connected.



This candidate scores mark point 3 for the voltmeter connection, but loses mark point 1 as the cell symbol polarity does not agree with the + and – labels. The cell should have been drawn the opposite way around.

Question 14(b)

There were many points that could have been referred to by candidates to score marks here, but the trick was to link their statements to the relevant equation. Those that managed this scored much more highly than those that did not.

Explain the shape of this graph. (6)

The graph crosses through the origin because at 0 distance, there is zero current, so no potential. Then, as the end of the voltmeter was dragged across, the voltage increased, because as length increases, resistance increases ~~[illegible]~~ ($R = \frac{\rho L}{A}$), therefore, the voltage also increases ($V = IR$). The potential increases at a steady rate until 10 cm. After 10 cm, the area ~~[illegible]~~ of the carbon paper decreases from 160 cm^2 to 80 cm^2, so as area decreases, the resistance increases even more ($R = \frac{\rho L}{A}$). The area ~~of~~ has halved, so resistance doubled. As a result, the voltage increases even more, which causes the gradient of this graph to increase.

This response scores 4 marks. The candidate has linked the resistance equation to the potential changing ‘at a steady rate’, as well as mentioning that at 0cm the potential is 0V.

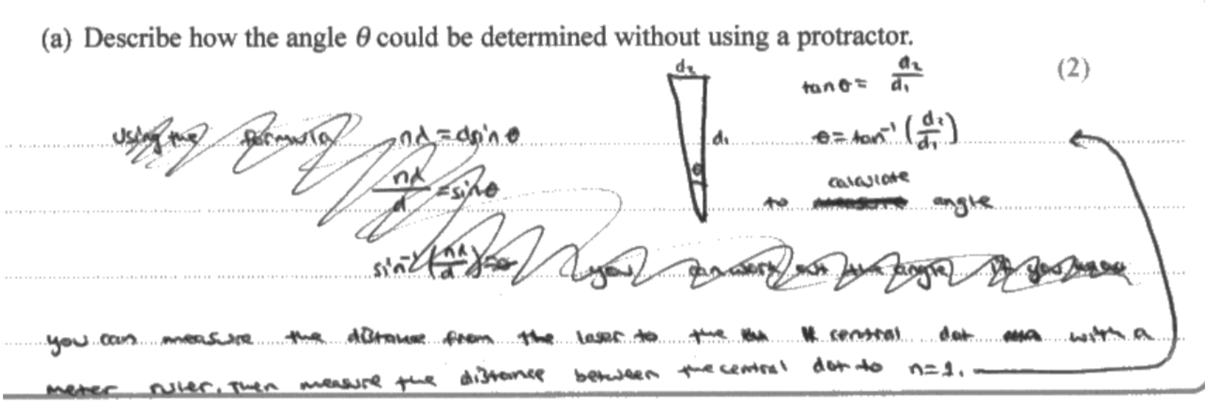
Explain the shape of this graph. (6)

The p.d. of the cell increases ~~uniformly~~ uniformly from 0 cm to 10 cm from the 16 cm end.
It then increases uniformly ~~m~~ with a larger gradient from 10 cm to 20 cm.
This is because as the length increases, the resistance increases as the charge carriers (carrying current) have a greater distance to travel. This therefore reduces the current of the circuit and increases the voltage across it.

The candidate gives a good explanation of the pd increasing linearly for each part of the paper (apart from referring to it as the cell pd!) but fails to link it to a relevant equation. In Physics answers it is always a good idea to back up statements with an equation wherever possible.

Question 15(a)

This question tests knowledge of a required practical. Most candidates assumed that the equation nλ=dsinθ would be used. More careful reading of the question would have told them that the purpose of the experiment was to find λ and therefore this was not a good place to start. Of the few students who realised it was a matter of measurement and trigonometry, most scored at least one mark, with common mistakes including describing the measurements but not the calculation or putting the measurements incorrectly into a trigonometrical equation.


(a) Describe how the angle θ could be determined without using a protractor.

(2)

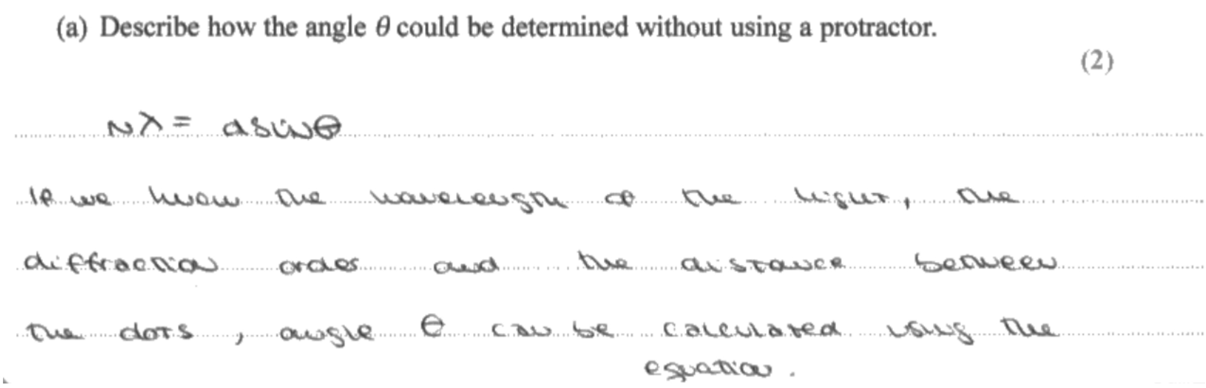
$\tan\theta = \frac{d_2}{d_1}$

$\theta = \tan^{-1}\left(\frac{d_2}{d_1}\right)$

to calculate angle

you can measure the distance from the laser to the central dot with a meter ruler, then measure the distance between the central dot to n=1.

This candidate scored both marks.


(a) Describe how the angle θ could be determined without using a protractor.

(2)

$n\lambda = d\sin\theta$

If we know the wavelength of the light, the diffraction order and the distance between the dots, angle θ can be calculated using the equation.

This candidate tried to apply the equation for a diffraction grating despite not knowing the wavelength.

(a) Describe how the angle θ could be determined without using a protractor.

(2)

By measuring the distance between the central dot and the desired light ray dot, as well as the distance from the diffraction grating to the screen. these values can then be used with trigonometry to find the angles

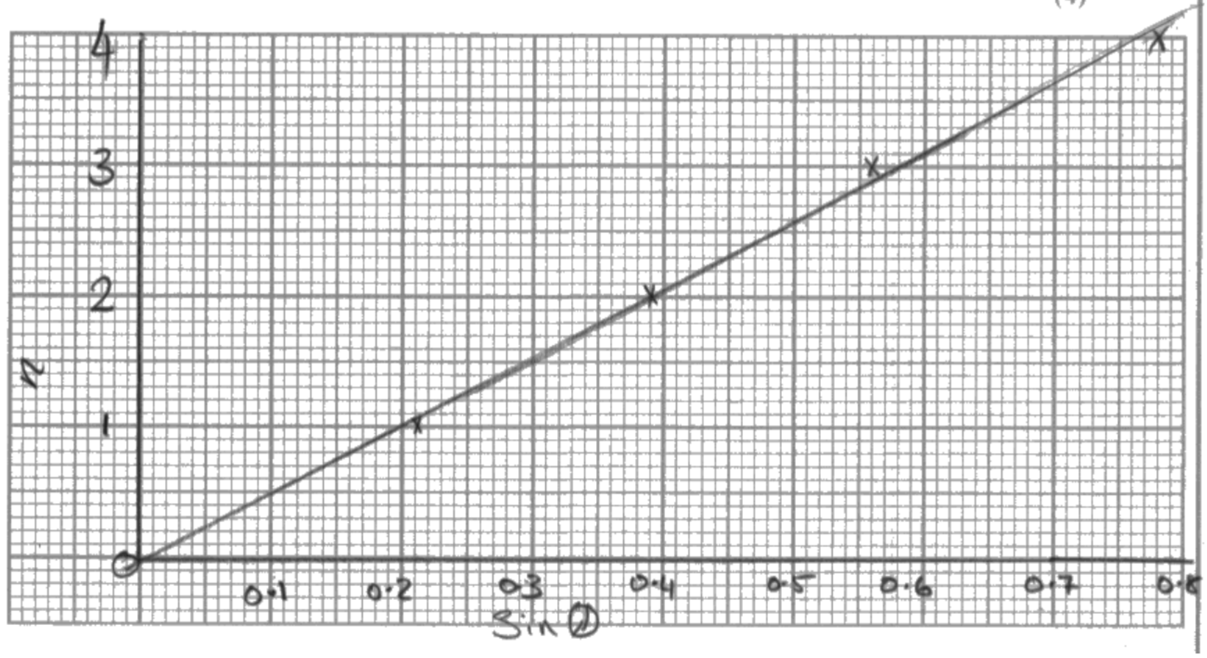
This candidate started well, scoring mark point 1, however the phrase ‘used with trigonometry’ would always be too vague for mark point 2. If a calculation needs to be used as part of a descriptive answer, always give the equation to be used.

Question 15(b)

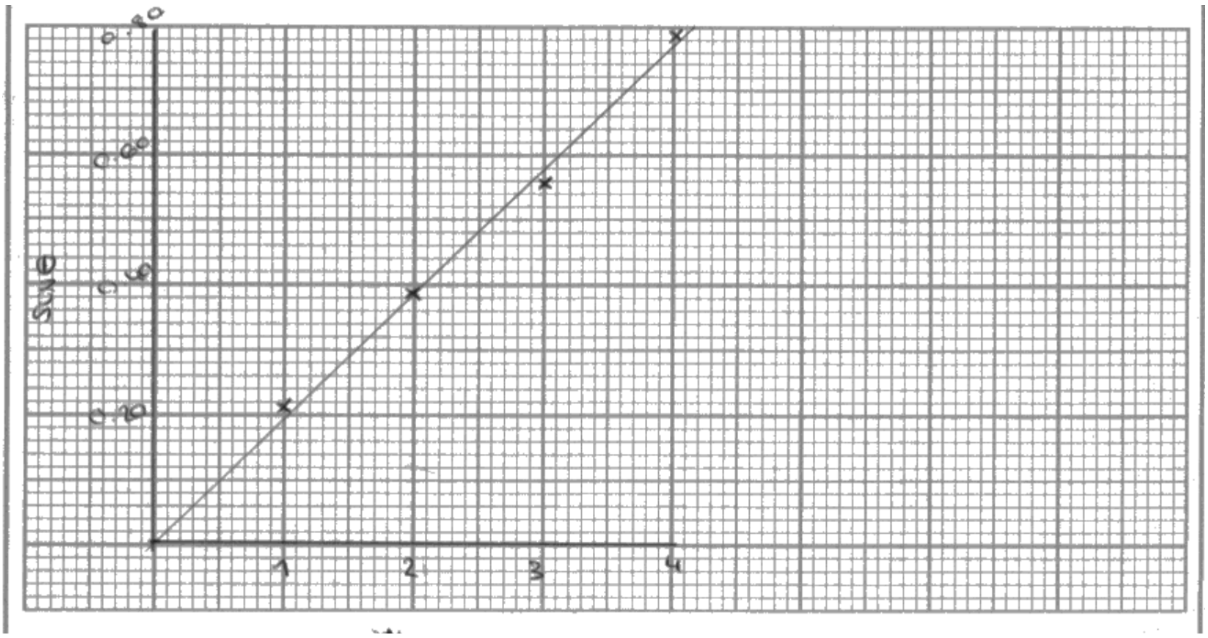
This was a straightforward graph to plot. Most candidates were able to label axes and plot points correctly, however many candidates switched the axes. ‘n’ should have been on the y axis. The best fit line should be drawn with a sharp pencil as the best fit line mark is forfeited if the line is too thick or bent. Whether ‘n; or ‘sinθ’ was plotted on the x axis the scale should have taken up more than half of the available grid.

(b) Plot a graph of n against $\sin\theta$ on the grid below.

(4)



This candidate has plotted the axes the correct way around and has chosen an x axis scale that uses the grid available.



This candidate has drawn the axes the wrong way around and has not used half of the available grid in the x direction. However, the points are correct as is the best fit line.

Question 15(c)

Very few candidates successfully found the wavelength. Some used a set of data from the table to input into the equation and many were unable to calculate 'd' from the lines per millimetre. Of those that calculated a gradient, some were unable to then equate this to d/λ.

Determine the wavelength of the laser light.

(4)

$n\lambda = d \sin\theta$

$y = mx + c$

$n\lambda = d \sin\theta$

$x_1 \quad y_1 \qquad\qquad x_2 \quad y_2$

$(0.2, 1) \qquad\qquad (0.6, 3.1)$

$\frac{3.1 - 1}{0.6 - 0.2} = 5.25$ = gradient

$\lambda \times 300 = 5.25 \sin\theta + c$ $\qquad$ $mm^{-1} \times 10^{6}$

$\frac{5.25 \times \sin(0.5) + 2.6}{300}$ $\qquad$ $= 8819.(4 s.f.$

Wavelength = $8.81 \times 10^{-3}\ mm^{-1}$

This candidate found a correct gradient but was unable to calculate d correctly, or use the gradient correctly to find λ. Many candidates were confused by the ‘sinθ’ and seemed reluctant to equate the gradient directly to d/λ.

(c) The diffraction grating has 300 lines mm^{-1}.

Determine the wavelength of the laser light.

(4)

$n\lambda = d\sin\theta \qquad d = \frac{1\times10^{-3}}{300}$

$\lambda = \frac{d\sin\theta}{n} \qquad = 3.33\times10^{-6}$

$\lambda = \frac{(3.33\times10^{-6})(0.21)}{1}$

$= 7\times10^{-7}\,m$

This candidate correctly calculated d, but simply used a data set from the table to do the calculation of λ instead of calculating the gradient.

Question 16(a)(i)

Candidates mostly understood that this question was simply a matter of using u=s/t, but often used language that was too vague to allow the awarding of mark point 1 as it was not clear that the vertical displacement was being measured. Very few candidates referred to the time interval being 0.1s. Some candidates tried to apply projectile principles here and discussed measuring gradients and resolving. They had not grasped that the readings for the vertical motion could be taken directly from the graph as it was plotted to scale.

(i) Explain how the velocities have been calculated from the successive vertical positions of the shuttlecock.

(2)

velocity = distance / time → vertical displacement / time.

This candidate has been clear about using the vertical displacement but has not given 0.1s for the time.

(i) Explain how the velocities have been calculated from the successive vertical positions of the shuttlecock.

(2)

[illegible] Using $s = \frac{d}{t}$ as the distance is known as well as the regular time interval of 0.1s.

'the distance is known' does not make it clear that the vertical displacement is needed here, but the candidate is awarded mark point 2 for recognising that the time interval of 0.1s must be used.

Question 16(a)(ii)

The velocity is plotted at the mid-range as each is calculated as a mean across the time interval. Most candidates did not realise this and instead spoke of uncertainty in the reading, possibly picking up on the word 'mid-range' used in the question and relating that to the 'half range' used to calculate uncertainty.

(ii) State why these velocities have been plotted at the mid-range of the time interval.

(1)

because the average velocity was calculated

This candidate has realised that a mean has been calculated and that this was the relevant point here.

Question 16(a)(iii)

In this part of the question it was hoped that candidates would be aware that the horizontal motion of a projectile moving freely under gravity is constant, and that the vertical motion has constant acceleration and would therefore be able to use evidence from the two graphs to compare the motion of the shuttlecock with the motion that would be expected for a projectile moving freely under gravity. Most candidate were able to give at least one description of projectile motion although candidates were on the whole less able to give evidence to explain why the motion of the shuttlecock did not follow the same rules.

(iii) State, with a reason, two pieces of evidence from the graphs that show that the shuttlecock does **not** follow the motion of a projectile moving freely under gravity.

(3)

The gradient for the velocity-time graph is not constant ~~straight~~ so the shuttlecock does not accelerate due to gravity. The time intervals are ~~[illegible]~~ closer together on the 1st graph as the shuttlecock falls so it does not follow projectile motion under gravity. The time intervals should have been more spread out

This candidate has realised that the v-t graph should have a constant gradient for projectile motion and that this is a difference for the shuttlecock. The candidate then goes on to discuss decreasing time intervals which is incorrect Physics. The time intervals stay constant, but the change in horizontal position between successive time intervals is smaller as the horizontal velocity decreases instead of staying constant.

(iii) State, with a reason, two pieces of evidence from the graphs that show that the shuttlecock does **not** follow the motion of a projectile moving freely under gravity.

(3)

One reason is it does not follow a uniform parabolic curve, acceleration/deceleration is not equal to 9.81/-9.81.

This candidate has noted two relevant pieces of evidence.

(iii) State, with a reason, two pieces of evidence from the graphs that show that the shuttlecock does **not** follow the motion of a projectile moving freely under gravity.

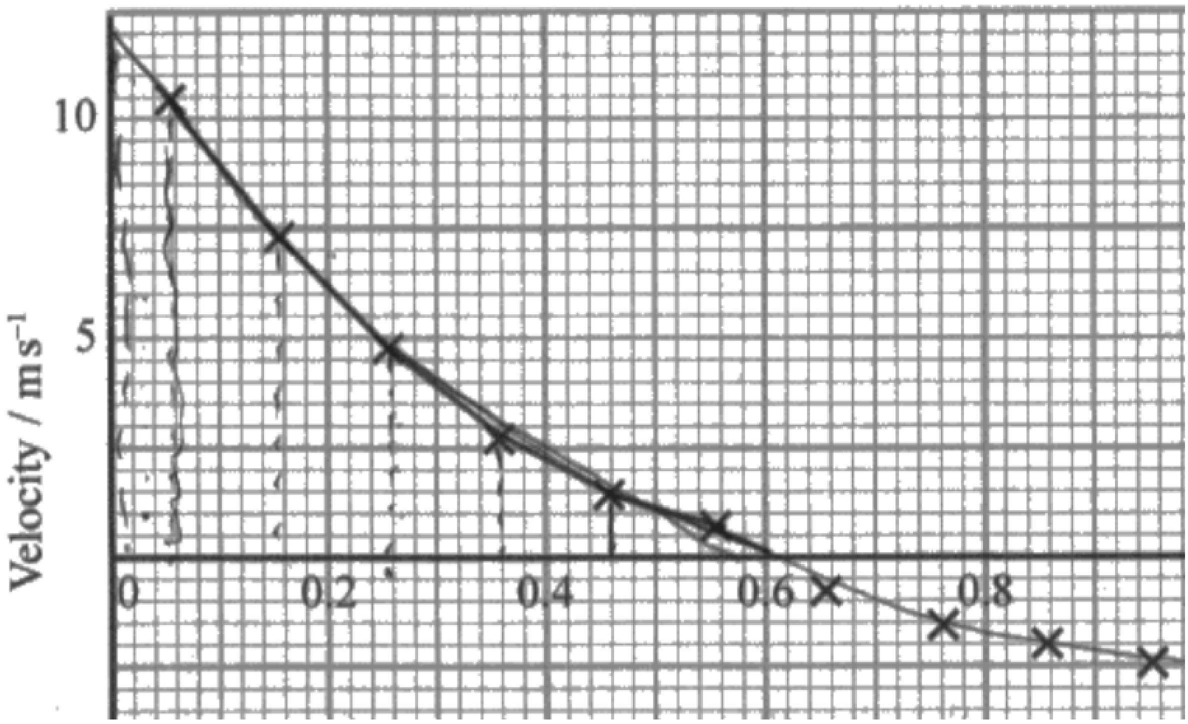
(3)

Horizontal component of velocity is not constant

This candidate has noted that the horizontal component of the velocity is not constant and therefore must have noted that the horizontal distance between the points decreases. If the candidate had given the evidence as well as the conclusion, this would have been awarded a higher mark.

Question 16(a)(iv)

This question required candidates to find area under the v-t graph. Most candidates were focussed on the mathematics of projectiles and tried to use equations of motion failing to recognise that the acceleration was not uniform.



$\frac{1}{2}(12+7.5) \times 0.15 = 1.4625$

$\frac{1}{2}(7.5+4.75) \times 0.08 = 0.49$

$\frac{1}{2} \times 4.75 \times 0.37 = 0.87875$

$1.4625 + 0.49 + 0.87875 = 2.83125\text{ m}$

$\approx 3\text{ m}$

This candidate has clearly found the area under the graph be dividing it into trapeziums. When attempting to answer a calculation like this, candidates should always mark up the graph to show how they carried out their calculation.

(iv) Show, using the velocity-time graph, that the maximum height gained by the shuttlecock is about 3 m.

(3)

$S = \left(\frac{U+V}{2}\right)t$

$S = \left(\frac{10-2.6}{2}\right) \times 1.34 = 4.96\,m$

This candidate has not realised that the area under the graph is key, instead applying an equation of motion. This will lead to an incorrect answer as the equations of motion can only be used for motion with a constant acceleration. This is not the case here.

Question 16(b)

Most candidates realised that the feathers produced a high drag force on the shuttlecock, though few mentioned air flow or surface area. Commonly, students then concluded that the shuttlecock therefore decelerated, without considering the separate effects on the horizontal and vertical motion. In fact, at the beginning as the shuttlecock travels upwards it would be decelerating anyway due to gravity, as any other projectile would, and the shuttlecock does accelerate vertically downwards immediately after the highest point even with the effect of the drag included, as the downward velocity increases. However, it does not accelerate at ‘g’ either on the way up or on the way down, and this is due to the effect of the drag force.

Explain how the feathers affect the motion of the shuttlecock along its path.

(3)

The feather increas the the shuttles surface area meaning there is a greater drag force acting on it meaning there is a continuous deceleration after being hit by a racket

This candidate response refers to the surface area for mark point 1 and notes the higher drag force for mark point 2. There is no detail about the effect on the motion however, so mark point 3 cannot be awarded.

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