Examiners' Report
June 2013

GCE Physics 6PH01 01

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Introduction

This is the tenth time that unit 1 of the specification has been examined. The assessment structure of the paper is the same as that of other units in the specification. Section A of the paper contains 10 multiple choice questions while section B contains questions of increasing length and usually of increasing demand. This paper examines both the mechanics and materials component of the course providing a transition for candidates between GCSE and A2. Although there is no overlap with the other units, the skills and concepts covered, especially in the mechanics topic are used as a basis for the teaching of circular motion, momentum and simple harmonic motion in units 4 and 5.

This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. Although many candidates showed a good progression from GCSE to AS level, the wording and context of some questions proved to be more challenging and some candidates missed out on marks as they had misunderstood the question. The physics seen in such cases indicated a good level of knowledge but not always an equivalent level of understanding of the concept and the question. However, candidates from across all ability ranges always managed to score some marks within these questions.

Calculations were answered well but were differentiated across the ability ranges due to the selection of the correct values to be substituted into the formulae. Where a response required more than one step within a calculation, the final mark was not commonly seen as candidates did not always select or calculate the correct value to be used. The calculations were therefore found to be more challenging than in previous papers, as they required a greater understanding of the question being asked so that the correct data could be selected. Units were used correctly across the paper.

In section B, there were fewer questions than in previous exams of the style that required candidates to define quantities and list properties and more that required careful reading of the question in order to select the correct method needed to answer the question. Question 11 illustrated this with many candidates using Stokes' law to show that the unit of viscosity is the Pa s or kg m^{-1} s^{-2} but few realised that the question was asking for an equivalence of these units and that starting to use Stokes' Law was deviating them from proving this relationship. Question 15 (d) also demonstrated candidates with a sound knowledge of the Physics in the specification missing the point of the question. The stem of the question refers to the same force being applied but many responses seen referred to more force being applied to obtain the same extension and hence more work would have been done. Correct physics but these are not the conditions described on the paper and so would not score any marks.

Question 13 required the candidates to compare the emissions emitted by the car when travelling the same distance at the two speeds. Some candidates compared a ten minute journey at both speeds and were still able to score 3 out of 4 marks in (b)(i). The most common marks awarded were 1 and 2 but there was an equal spread across the other marks awarded which demonstrates a spread of marks appropriate to all abilities. Weaker candidates missed that the emissions were in kg km^{-1} and found a difference between the (emission x speed) or (emission x time). More able candidates managed to find a distance but did not always calculate a difference at the two speeds. This question proved to be an example of some straightforward physics being embedded in a challenging context where the majority of candidates scored marks for their working with 87% of candidates managing to score at least 1 mark.

Although free body diagrams usually score very well across all ability ranges, the accelerometer referred to in question 17 proved to be challenging to all candidates, many diagrams seen contained drag as well as force of the car or even the resultant. Candidates again found constructing a vector diagram challenging. There was a definite improvement over the paper sat In January 2013 but good candidates that had managed to construct a triangle of forces often had the resultant in the wrong direction. Very few attempts were seen at a parallelogram of forces.

Finally, question 18 required some analysis of the graphs of the two bouncing balls. The vast majority of candidates know that a gradient had to be found of the tangent to score both marks. Although a tangent was requested not all responses included them. The values used for a candidate's gradient from the graph were check by all examiners and the level of accuracy often lost the second mark. The tangents were often accurately drawn but the precision of reading from the graph let the candidates down. Further on in the question 18, part (d) the candidates were required to describe the notion of the ball. This style of question is not common and the vast majority of responses seen did not refer to the time at which the various aspects of the ball's journey took place and so responses seen were very basic and just referred to accelerating and bouncing. Candidates, through practice of past papers, should have the experience that the standard of the last few marks on the paper are often higher than the earlier marks and so there will be more detailed and challenging requirement to core the marks.

Section A

The multiple choice questions were answered well with a mean score of 6.9. Candidates at the A grade boundary tended to score 9 or 10 whilst E grade candidates scored at least 7 marks. Question 3 proved to be challenging to all candidates with only 50 % of A grade and 32 % of E grade candidates answering it correctly. Questions 4,6,7 and 9 were differentiated across the ability ranges. The remaining questions were answered well by all candidates with very little variation between A grade an E grade candidates.

Question number	Subject	Percentage of candidates who answered correctly	Most common incorrect response
1	Vector and scalar quantities	81	A
2	Calculation of strain	86	A and D
3	Derived SI quantities	40	D
4	Velocity-time graphs for a projectile	63	B
5	Stress-strain graphs	89	D
6	Upthrust	64	A
7	Resolving forces	52	D
8	Plastic deformation	95	A
9	GPE to KE transfer of energy	55	C
10	Newton's first and third laws	69	B

Question 1

The **not** in the stem of the question, although in bold, was missed by those candidates not scoring the mark. As the first response contained a vector and a scalar quantity, response A was incorrectly selected by most not scoring the mark. Hence a good reason to check through all responses, even the multiple choice ones, if there is time at the end of the paper.

Question 2

Answered well but the incorrect responses indicated that some candidates believed the strain to be either extension/new length or new length /original length. This formula is given at the back of the paper.

Question 3

The “quantity” mentioned in the question was missed by the vast majority of candidates as they opted for a derived SI unit. SI units are commonly referred to in text books and in examinations so, probably due to reading at speed, the subtle mention of a quantity was missed. As was seen in part B, candidates with a sound knowledge of the subject are missing out on marks by not taking enough care to read the question thoroughly.

Question 4

Candidates are generally not confident with their understanding of the direction of vectors when using SUVAT equations or looking at displacement, velocity or acceleration time graphs. In addition to this the constant speed of an object when travelling horizontally is often forgotten. Here the candidate had confused the displacement-time graph with the velocity time graph and many selected B.

Question 5

This was answered well by most candidates with the majority of incorrect responses assuming that material Y is hard and not ductile. The gradient of the graph is an indicator of the hardness of the material even though when discussing hardness we are only looking the surface of the material rather than as a whole. Given that we are comparing two materials in this question, the one with the lower gradient could therefore not be called hard.

Question 6

This question required candidates to recall that the upthrust is equal to the weight of water displaced. To calculate the weight from a density $V\rho g$ needs to be used and was given. The candidates just had to remember that it is the weight of the water and not the sphere that was required here. Given that this concept is generally well understood, there must have been an element of speed that contributed to incorrect response selection here.

Question 7

As was demonstrated in question 14, the use of trigonometry to resolve a vector quantity into a horizontal or vertical component is variable. Given that 41% of E grade and just 70% of A grade candidates answered correctly this indicates that this applies to all ability groups. Although D was the most common incorrect answer, A and B were not far behind indicating that some candidates struggled with the idea that there were three tension components equal to the weight.

Question 8

Question 8 was answered well by all candidates and involved the recall of (a partial) definition of malleable, a concept that was also examined in January 2013.

Question 9

Potentially a straightforward concept examining the transfer of GPE to KE. Answered by 43% of E grade students and and 77% of A, the most common incorrect response of C indicated that candidates were using equations of motion incorrectly rather than an energy transfer. Even if an equation of motion had been used, the correct answer could have still been obtained had the correct vertical height been used.

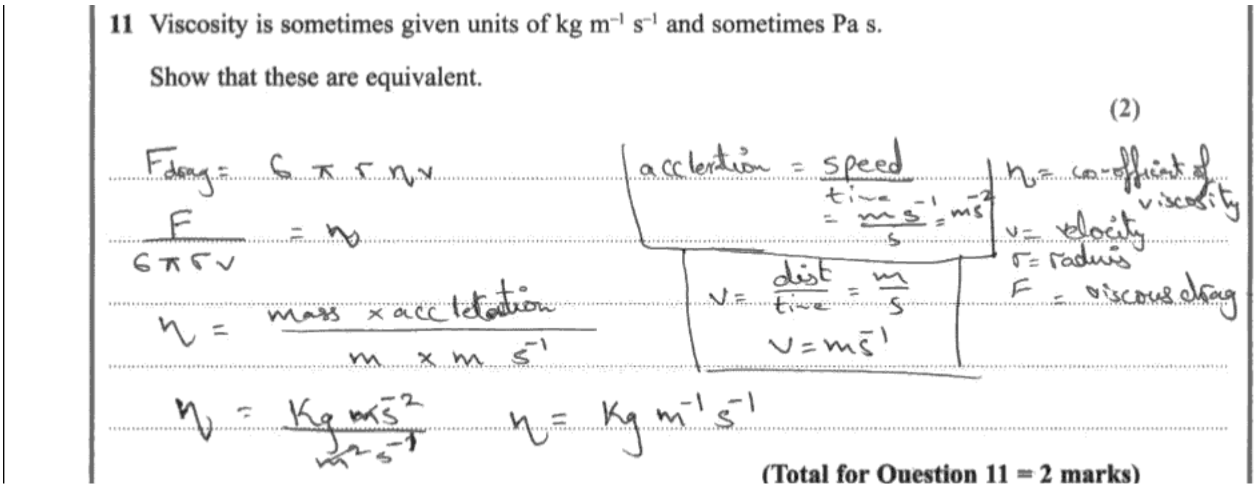
Question 10

A difficult question which was answered well by candidates of all abilities. It would have been expected that a higher proportion of more able students would have scored better with this item and the most common incorrect response just indicated that the two pairs of forces involved were the wrong way round. Candidates usually find describing the forces associated with first law and third law pairs challenging but can usually identify the correct forces for each law so again, speed may have been an issue.

Question 11

As mentioned in the introduction, many candidates chose to prove that viscosity can either be measured in Pa s or in kg m^{-1} s^{-1} using Stokes' law and did not see the need to show their equivalence as the question had requested, hence scoring 0 marks. Some candidates managed to score 1 out of the 2 marks by identifying that N = kg m s^{-2} or that Pa = N m^{-2} but candidates that generally worked in Pa and hence quoted F/A managed to score both marks. Method marks were sometime difficult to award due to candidates working using a combination of units and symbols. All the working here, as the equivalence of two units was required, should have been in terms of units.

A fair bit of working backwards was observed with some candidates using the end point of kg m^{-1} s^{-1} and trying to show that Pa = kg $m^{-1}s^{-2}$. This did not earn any marks as they had not explained why that was equivalent to Pa.



11 Viscosity is sometimes given units of kg m^{-1} s^{-1} and sometimes Pa s.

Show that these are equivalent.

(2)

$F_{drag} = 6\pi r \eta v$

$\frac{F}{6\pi r v} = \eta$

$\eta = \frac{\text{mass} \times \text{acceleration}}{m \times m\,s^{-1}}$

$\eta = \frac{kg\,m\,s^{-2}}{m^2\,s^{-1}}$ $\eta = kg\,m^{-1}\,s^{-1}$

acceleration = $\frac{\text{speed}}{\text{time}}$ = $\frac{m\,s^{-1}}{s}$ = $m\,s^{-2}$

$v = \frac{\text{dist}}{\text{time}} = \frac{m}{s}$

$v = m\,s^{-1}$

η = co-efficient of viscosity

v = velocity

r = radius

F = viscous drag

(Total for Question 11 = 2 marks)

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Examiner Comments

In general, candidates that used Stokes' law to show that the unit of viscosity is either kg m^{-1} s^{-1} or Pa s did not tend to score any marks as they were not addressing the question being asked.

This candidate has correctly proven the units for viscosity but none of the steps given would be able to lead to an equivalence of the units, just an equivalence of viscosity and the unit.

ResultsPlus

Examiner Tip

Read the question carefully so that important words are not missed out and you give the answer that the examiner is expecting and not an answer for a question that has not been asked.

11 Viscosity is sometimes given units of kg m^{-1} s^{-1} and sometimes Pa s.

Show that these are equivalent.

(2)

$$Pa\,s = \frac{N\,s}{m^2} = \frac{kg\,m\,s^{-2} \times s}{m^2} = kg\,m^{-1}\,s^{-1}$$

$\therefore Pa\,s = kg\,m^{-1}\,s^{-1}$

(Total for Question 11 = 2 marks)

$v = \frac{kg}{ms}$

$= \frac{kg}{}$

$=$

$F = 6\pi\eta r v$

$\eta = \frac{F}{6\pi r v}$

$= \frac{N}{m \times m s^{-1}}$

$= \frac{kg\,m\,s^{-2}}{m^2\,s^{-1}}$

$Pa\,s = \frac{N}{m^2}$

$= N\,m^{-2}$

$= \frac{kg\,m\,s^{-1}}{m^{-2}}$

ResultsPlus
Examiner Comments

A good response scoring both marks. All lines of working have been in terms of units and not symbols or symbols and units. A straightforward substitution of Pa = N/m^2 into Pa s has lead to showing that Pa s = kg m^{-1} s^{-1}.

ResultsPlus
Examiner Tip

When working with units keep your answer solely in terms of units and likewise for quantities, do not bring in units. Mixing units and symbols when proving relationships will not score any marks.

Question 12 (a)

As seen with the January 2013 paper, many candidates are not accurately able to define certain terms that are in italics in the specification. The proportion of candidates that could successfully define the centre of gravity had increased since January but only 25 % of candidates scored this mark. If the definition was not known candidates either attempted complicated explanations or used mass and gravity in place of weight. Some candidates omitted to mention that it was a point and just gave a statement such as 'where the weight acts' which again implies the need for some standard accurate definitions to be learnt as part of the course.

12 (a) State what is meant by centre of gravity.

(1)

The point on a free body diagram where all forces are thought to be centred.

ResultsPlus
Examiner Comments

Scores 0 but a typical response.

ResultsPlus
Examiner Tip

The centre of gravity is the point:

at which the weight of an object can be assumed to act,

or

at which all the weight is centred upon,

or

that can be used to represent the whole weight.

Another typical answer.

12 (a) State what is meant by centre of gravity.

(1)

The pivote point on an object whore the gravity acts.

ResultsPlus
Examiner Comments

When referring to forces, gravity is insufficient and cannot be used in place of weight or gravitational force. Gravity is the effect of a gravitational field of a massive object on any body near its surface. Therefore the term alone does not imply a force and 'force of' etc. must be added. Force of gravity or gravitational force/pull are taken to be equivalent to weight.

Question 12 (b)

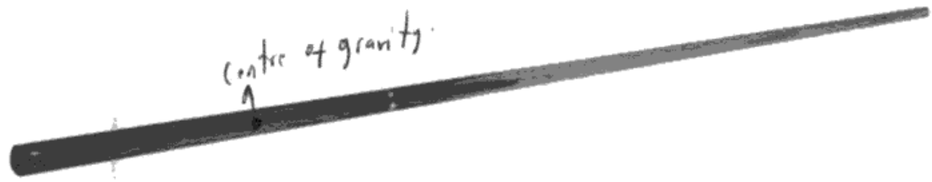
The majority of candidates managed to score at least one mark, usually for identifying the correct position of the centre of gravity of the snooker cue.

(i) Some markings were very small and candidates should be encouraged to make annotations to diagrams much clearer. A small proportion of candidates did not realise that, as it is a non-uniform body, the centre of gravity would not be in the centre but about a third of the way along from the left side.

(ii) The question asked for a simple method such as balancing the cue at that point on your finger to see if it would balance would have sufficed. Some candidates were not quite specific enough and just mentioned balancing without stating on what it would be balancing while other candidates referred to balancing on it on such a wide object that it would have not have given a precise enough position.

Some candidates tried to describe the method for finding the centre of gravity of an irregular 2-d object by suspending the cue from its end multiple times. This method was not appropriate here and did not score the mark. It was a one mark question so little detail was required.

(b) The picture shows a snooker cue. It is made from wood of uniform density and takes the form of a rod with decreasing diameter towards one end.



(i) On the picture, mark the position of the centre of gravity of the snooker cue.

(1)

(ii) State a simple method to test if this is the correct position.

(1)

place the point on your finger, if it balances, this is the correct position.

ResultsPlus
Examiner Comments

A good response scoring all the marks. (i) the centre of mass is just under a third of the way along the rod and is in the centre of the acceptable range for the position. The position has been clearly labelled. (ii) A simple but correct method described involving a small pivot (finger) and a reference to balancing.

This scored (i)0 and (ii) 0.

The position of the centre of gravity is out of range and the plumb line method is not appropriate for the snooker cue.

(i) On the picture, mark the position of the centre of gravity of the snooker cue.

(1)

(ii) State a simple method to test if this is the correct position.

(1)

use a plumb line to check its centre of gravity. and hang the plumb line with the snooker cue.

(Total for Question 12 = 3 marks)

Examiner Comments

Most correct responses used a method of balancing on a small pivot. Candidates could have also described suspending the rod horizontally at the centre of gravity using a thin string or thread to find the position of the centre of gravity.

Examiner Tip

The plumb line method is an accurate way of finding the centre of gravity of a 2-dimentional object as its position is always directly below the point of suspension. For 3-dimentional objects a method involving balancing will give the most accurate position.

Question 13 (a)

This question was answered well by the vast majority of candidates. Marks were generally not awarded if the candidate had not quoted the final answer to more than 2 SF to give evidence that the quantity of 18 m s^{-1} had actually been calculated. Other candidates did not always show all the stages involved in the unit conversion. This was a very straightforward question but candidates were required to write down a clear explanation to score the mark.

13 Queues of cars often form behind cyclists on narrow, rural roads.

Sometimes cars that would normally travel at 65 km $hour^{-1}$ may be limited to about 20 km $hour^{-1}$ by a cyclist.

(a) Show that 65 km $hour^{-1}$ is about 18 m s^{-1}.

(1)

$\frac{65 \times 1000 m}{3600 s} = 18.1 ms^{-1}$.

ResultsPlus
Examiner Comments

Scores 1 mark.

Working written out and answer quoted to 3 SF.

13 Queues of cars often form behind cyclists on narrow, rural roads.

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(a) Show that 65 km $hour^{-1}$ is about 18 m s^{-1}.

(1)

65000m or 65km per hour / 60 mins 3600secs $\frac{65000}{60}$ = per min = $\frac{1083m}{60}$ = per sec = 18 m s^{-1}

ResultsPlus
Examiner Comments

Answer just quoted to 2 SF so there is no evidence that the value that the candidate was asked to prove has been calculated.

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Examiner Tip

If you are asked to 'show' a given value then you must quote your answer to at least 1 more SF than the value is quoted to. This shows the examiner that your method has been tried out and gives the correct value.

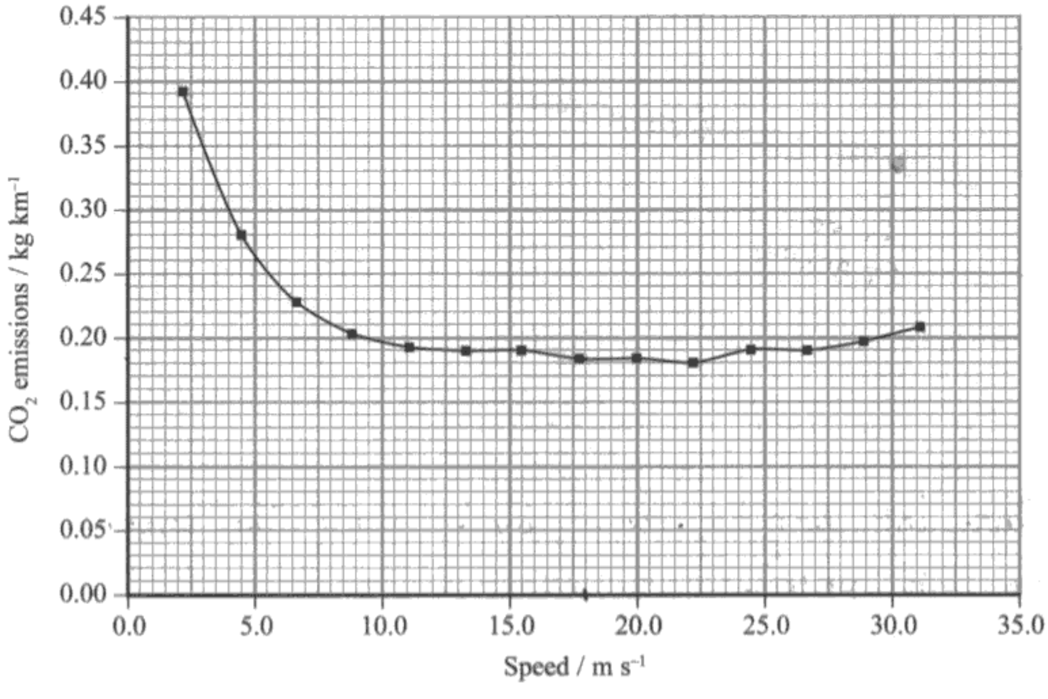
Question 13 (b)

Candidates were required to read emissions for two different speeds from the graph and then use these emissions to calculate the extra CO_2 emitted by the 3 cars due to travelling at the lower speed. The emissions were given in kg km^{-1} so the candidates had to calculate the distance that would have been covered had the cars been travelling at 5 m s^{-1} and then compare the emissions emitted over the same distance had the cars been travelling at the greater speed of 18 ms^{-1}.

The majority of candidates managed to score at least 1 mark with almost an even distribution for the remaining marks awarded. Although some candidates compared two journeys of equal time (10 minutes) rather than equal distance(3 km), such responses could still score the three method marks out of the four that were available.

The use of the units of the emissions proved to be challenging to most candidates. Many candidates did calculate a distance and then realised that they had to multiply the emission by a distance but many candidates multiplied by time or nothing at all. Unnecessary conversions of ms^{-1} to km h^{-1} were also seen and 20 km h^{-1} quoted in the stem of the question was also used. The scaling of the emissions for the three cars was nearly always successfully carried out but it was not always easy to tell whether a '3 x emission' was due to the number of cars (1 mark) or the distance travelled (3 marks) highlighting the need for candidates to show all working even if the question is not a 'show that' style of question.

13 (b)(ii) was marked in line with the candidates response to part (b)(i) so a sensible statement linking the given value of 0.54 kg of CO_2 to the calculated value from (i) was credited. General comments about the environment and the effect of CO_2 on the environmnt were seen and generally quantitative comparisons were more successful at scoring the marks.



During a 10 minute journey a cyclist, travelling at 5 m s^{-1}, has an average of three cars queuing behind him. The cars would otherwise be travelling at 18 m s^{-1}. The cars emit more carbon dioxide because they are travelling slowly.

(i) Calculate the extra carbon dioxide emitted by the 3 cars due to travelling at this reduced speed for 10 minutes.

(4)

Normal ~~Extra~~ Emitted Carbon dioxide = $(3 \times 0.183) \times (10 \times 60)$

$= 0.549 \times 600$

$=$ ~~9.15×10~~ 329.4 kg km⁻¹

~~Extra Carbon dioxide = 32 329.4 (3x~~

Extra Carbon dioxide = $((3 \times 0.26) \times (10 \times 60)) - 329.4$

$= (0.78 \times 600) - 329.4$

$= 468 - 329.4 = 138.6$ kg km⁻¹

Extra carbon dioxide emitted = 138.6 kg km⁻¹

(ii) If the cyclist had made the same journey in his car at 18 m s⁻¹, his car would have emitted 0.54 kg of carbon dioxide. Comment on the significance of this.

(1)

The significance is that the cycle doesnot emit carbon dioxide and hence, this helps ~~t~~ reduce the effects of global warming.

ResultsPlus
Examiner Comments

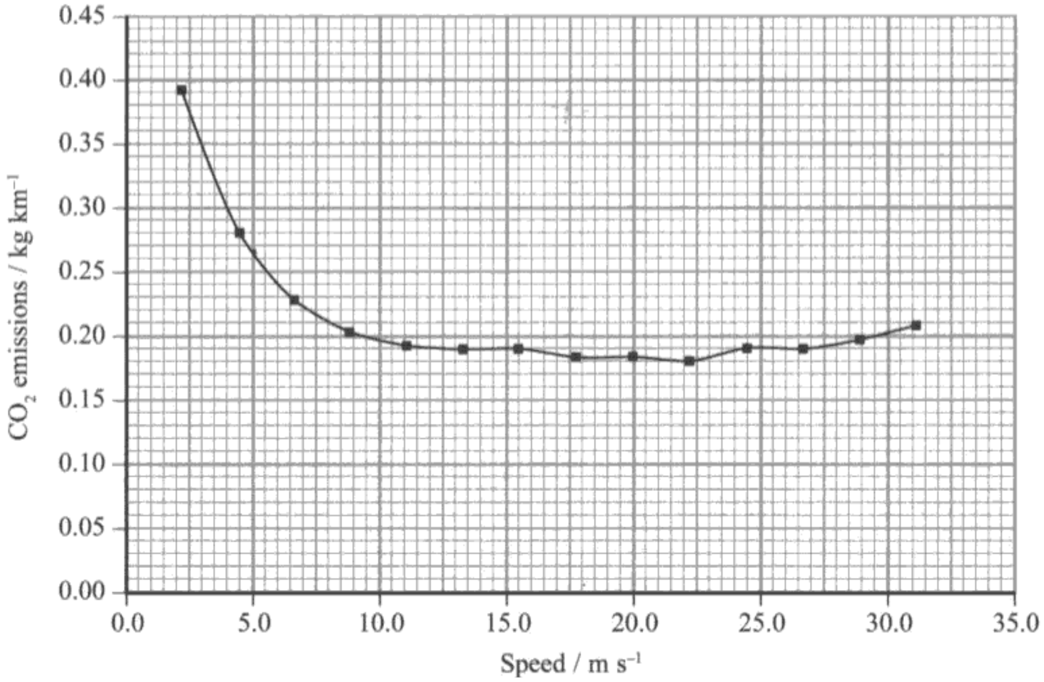
This response scored (i) 1 and (ii) 0 marks.

(i) The candidate has not appreciated the significance of the units and has multiplied the emissions by a time before subtracting them to find a distance. Therefore the third marking point only for a difference in emissions could be awarded.

(ii) A general statement about the cycle not emitting any CO_2 failed to compare the calculated and given values of CO_2 emission and so could not be awarded a mark.

ResultsPlus
Examiner Tip

When taking readings from a graph check that the units of the quantity is the same unit that you would expect to give your answer in. The emissions on the vertical axis are measured in kg km^{-1}. To obtain a value for the CO_2 emissions in this question in kg you had to multiply the emission by the distance (in km).



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(i) Calculate the extra carbon dioxide emitted by the 3 cars due to travelling at this reduced speed for 10 minutes.

(4)

0.265 Kg Km^{-1} 5 ms^{-1} = 18 Km $hour^{-1}$

18 ÷ 6 = 3

10 mins = 3Km

0.265 x 3 = 0.795 KgKm^{-1} for 1 Car

0.795 x 3 = 2.385 Kg Km^{-1} for 3 Cars

0.181 x 3 x 3 = 1.629

2.385 − 1.629 = 0.756

Extra carbon dioxide emitted = 0.756 Kg

(ii) If the cyclist had made the same journey in his car at 18 m s^{-1}, his car would have emitted 0.54 kg of carbon dioxide. Comment on the significance of this.

(1)

This means that although he didnt emit any CO_2 by cycling he caused other people to emit more. if he had driven it would of ment less CO_2 emitted by all of them together.

(Total for Question 13 = 6 marks)

ResultsPlus
Examiner Comments

A correct response scoring (i)4 and (ii)1.

(i) The candidate read an emision at 5 ms^{-1} from the graph. They then:

- calculated the distance travelled in 10 minutes (3km)
- multiplied the emission by the distance travelled to find the emission in kg (0.795 kg)
- multiplied by 3 as there were 3 cars (2.385 kg)
- repeated these calculations in 1 step for the emission at 18 m s^{-1} (1.629 kg)
- subtracted the two total emissions at these speeds to obtain 0.756 kg.

(ii) A correct statement '.... that by cycling he caused other people to emit more CO_2....' comparing the value calculated in (i) i.e. had he been cycling to the value quoted in (ii) for using his car.

Question 14 (a)

A straightforward calculation requiring a substitution into an equation(s) of motion to calculate the height the ball was dropped from. Most candidates chose to use the most direct method by substituting into $s = ut + 1/2at^2$ obtaining a distance of 7.4 m. Hence proving that the astronaut would have to be over 7 m tall for the ball to take 3 s to land.

Some candidates chose to work this through in reverse using a distance of 7 m to show that it would take 2.9 s to reach the ground. This scored both marks. However, reverse calculations in 'show that' style questions worth 3 marks can usually only obtain 2 marks so this method is not always the highest scoring one to use.

14 The gravitational field strength on the Moon is about 1/6 of the gravitational field strength on the Earth.

(a) On the Moon, an astronaut dropped a golf ball. He later wrote "When I dropped the ball, it took about three seconds to land."

Show that the astronaut would need to be over 7 m tall for the ball to take 3 s to land.

(2)

$s = ut + \frac{1}{2}gt^2 = 0 + \frac{1}{2} \times \frac{9.81}{6} \times 3^2 = 7m$ [shown]

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Examiner Comments

Just 1 mark awarded for the substitution into the correct equation of motion.

The final answer was not quoted to at least 2 SF to show that the final answer had been calculated.

14 The gravitational field strength on the Moon is about 1/6 of the gravitational field strength on the Earth.

(a) On the Moon, an astronaut dropped a golf ball. He later wrote "When I dropped the ball, it took about three seconds to land."

Show that the astronaut would need to be over 7 m tall for the ball to take 3 s to land.

(2)

$\frac{1}{6} \times 9.81 = 1.635 Nm^{-1}$

$1.635 = a$ $u = 0$ $t = 3$ $s = υ$

$s = ut + \frac{1}{2}at^2$ $s = \frac{1}{2} \times 1.635 \times 3^2$

$s = 0.8175 \times 9 = 7.3575 m$

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Examiner Comments

A good response scoring both marks.

Question 14 (b)

This was an accessible question that was attempted well by many candidates with most managing to score at least 1 mark. The most common mark awarded was 6 and then 1 mark with an equal spread of candidates earning 2,3,4,5 or 0 marks.

Candidates that did not manage to score full marks often just scored method marks for substitution in to the correct equation of motion in (i) and (ii). The difficulty encountered for some was the correct resolving of the given launch velocity to its vertical and horizontal components. Use of 18sin34 for the horizontal and 18cos34 for the vertical were frequently seen which restricted the candidates in both parts to just obtaining the two middle use of marks. Many candidates often just substituted in 18 m s^{-1} without trying to resolve it into the correct components.

Candidates that were not consistent with the direction of their initial velocity and acceleration were not awarded the last mark for part (i) which accounts for the candidates scoring 5 marks for both parts of this question. However, some candidates demonstrated a confident understanding of projectiles and used the total displacement for the journey to calculate the time of flight in one step or (without stating) assumed that the time for the downwards journey was equal to the upwards time and so used v = 18sin34 and u = 0.

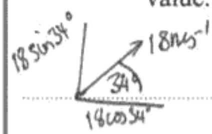
A number of more able candidates used the range equation to answer 14(b)(ii) and full credit was given for a correct answer.

(b) The astronaut hit the ball with a golf club. He wrote "The ball, which would have gone thirty to forty yards on the Earth, went over two hundred yards. The ball stayed up in the black sky for almost thirty seconds."

Assume an initial velocity of 18 m s^{-1} at 34° to the horizontal.

(i) Show that the astronaut's suggested time of flight of 30 s is over twice the actual value.

(3)



↑ $v = 0 = u + at = 18\sin 34° + (-1.635)t$

$t = 6.1563$ seconds

Time of flight $= 2t = 2 \times 6.1563$

$= 12.31$ seconds

$\frac{30}{2} = 15$ seconds $12.31 < 15$ seconds

$24.62 < 30$ seconds

(ii) Show that the value given for the initial velocity leads to a value for the horizontal distance travelled by the ball in agreement with his stated value.

200 yards = 183 m

(3)

$t = 12.31 \longrightarrow s = ut + \frac{1}{2}at^2$

$= 18\cos 34° (12.31) + \frac{1}{2}(0)$

$= 183.7\,m$

$\approx 183\,m = 200$ yards

ResultsPlus

Examiner Comments

A good response scoring full marks.

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Examiner Tip

(b)(ii) the candidate has quoted s = ut + 1/2at^2 and has correctly substituted in 0 for the acceleration. Remember that for projectiles there is no horizontal force acting so (and we usually take air resistance to be negligible) only v= ut needs to be used for horizontal motion.

This response scored (i)2 (ii)0.

(b) The astronaut hit the ball with a golf club. He wrote "The ball, which would have gone thirty to forty yards on the Earth, went over two hundred yards. The ball stayed up in the black sky for almost thirty seconds."

Assume an initial velocity of 18 m s^{-1} at 34° to the horizontal.

(i) Show that the astronaut's suggested time of flight of 30 s is over twice the actual value.

(3)

v = u + at

0 = 18 sin 34 + 1.635 × x

0 = 10.07 + 1.635x

x = 10.07 / 1.635

x = 6.16

6.16 × 2

= 12.32 s

(ii) Show that the value given for the initial velocity leads to a value for the horizontal distance travelled by the ball in agreement with his stated value.

200 yards = 183 m

(3)

s = ut

= 18 × 12.32

= 221.76 m

200 yard = 183 m

x = 221.76 m

= 242.36 yards

ResultsPlus

Examiner Comments

(i) The correct vertical component of the initial velocity has been found but the candidate has made both the direction of both the initial velocity (up) and the acceleration(down) acting on the ball the same. Responses where the u and v were not consistent with the sign for g could only obtain a maximum of 2 marks.

(ii) No horizontal component for the initial velocity has been calculated so just the second marking point for substitution into a suitable equation of motion.

ResultsPlus

Examiner Tip

Remember to consider the direction of the quantities that you are substituting into an equation of motion. It does not matter which direction you take to be positive but you must make sure that quantities moving or acting in the opposite direction are negative.

Remember that, although an object thrown upwards is moving up, the acceleration acting on it is acting down hence it is slowing down and g should be negative if you make u,v,s positive.

Question 14 (c)

The candidates were required to describe how a lower gravitational field strength and no atmosphere contributed to an increase in range. About a third of candidates managed to score one mark for this item, mainly for identifying that the time of flight would be longer. This question differentiated well and the idea that there was a lower acceleration was seen however, this mark would have been awarded more frequently had candidates selected an appropriate term to describe the lower acceleration. Responses such as 'slower acceleration' were seen and did not score the mark.

Reference to the lack of atmosphere and air resistance were commonly seen but the question required a link between the given physical factor and the increased range. Hence responses including ' there is no air resistance' did not score. In addition, references to 'less air resistance' were seen, often accompanied by a correct description on the effect this would have on the motion of the ball, again scoring no marks as it is quite clear in the question that there is no atmosphere and not less of an atmosphere.

A good attempt scoring 2 marks.

*(c) A projectile would have a greater range on the Moon than the Earth because of the lower gravitational field strength and because of the lack of an atmosphere.

Explain how each of these factors would increase the range of the projectile.

(3)

- Lower gravitational feild reduces acceleration of vertical motion of prodectile hence it would take longer time to strike the ground increasing the range.
- Lack of atmosphere means no air resistance for the horizontal motion of the prodectile hence it would travel longer distance or increase range of projectile

ResultsPlus
Examiner Comments

lines 1/2: reduces the acceleration

line 3: longer time.

No air resistance has been mentioned but it has not been linked to how it will make the range greater.

ResultsPlus
Examiner Tip

A statement such as 'there is air resistance' or as in this case 'there is no air resistance' will not score any marks. A question has usually been asked as to why a value has increased or decreased so you will need to explain how the air resistance does or does not affect the motion of the object.

This response scored no marks but the candidate clearly had understood the question and could have scored 2 of the 3 marks if the candidate had been a little bit more precise in their descriptions.

*(c) A projectile would have a greater range on the Moon than the Earth because of the lower gravitational field strength and because of the lack of an atmosphere.

Explain how each of these factors would increase the range of the projectile.

(3)

Lower gravitational field strength cause the vertical component to be lower then o Earth thus it travel less vertically then it ~~on~~ Earth. Lack of atmosphere decreases the drag force of the ball. ~~The~~ Thus it travels with greater velocity. Since no air resistance the vertical & horizontal velocity are les effected.

(Total for Question 14 = 11 marks)

ResultsPlus

Examiner Comments

Line 2: '.....vertical component to be lower.....'. This just needed a mention of the acceleration

Line 4: '....decreases the drag force of the ball. Thus it travels with a greater velocity'. Firstly, on the ball would have been correct. An explanation as to why it has a greater velocity i.e. no deceleration or reduction of speed etc was also required form the third marking point.

ResultsPlus

Examiner Tip

Always add a quantity to the term component. In this question it was the component of acceleration that was missing.

Forces act on objects so in this question the drag force acted on the ball. The answer that the candidates gave implies that the ball is causing the drag. Check your work to make sure that little points like this have not been missed.

Question 15 (a)

It is a common misconception, seen in many previous papers, by some candidates that a straight line section on a force-extension graph indicates that the material obeys Hooke's law. Hence this question refers to a student making this incorrect assumption. With less than a fifth of all candidates scoring full marks and fewer scoring 1 mark this seems to be a point worth making. Although some candidates had the right idea that before AB, the graph it is not a straight line, this did not necessarily mean all the way back to the origin. Therefore a reference to the origin or a description of the origin was required as part of the explanation.

The relationship between force and extension in Hooke's law is one of direct proportion, as opposed to a linear relationship of the form y = mx + c. Many candidates did not distinguish between these relationships when discussing Hooke's Law and do not realise the significance of the origin. This is a point worth emphasising when teaching this law.

(a) The student notices that her graph is a straight line between A and B and concludes that the device obeys Hooke's law.

Comment on this conclusion.

(2)

A straight line would obey Hooke's law as the gradient should be constant. So at point A - B, it obeys Hooke's law. But it only obey's hook'e's law in the region from A to B!

ResultsPlus

Examiner Comments

To avoid incorrect physics leading to a correct statement that the device did not Hooke's law, the second marking point was made conditional on the candidate obtaining the first marking point. This was the only conditional mark on the paper.

This response scored 0 as the candidate has the incorrect conclusion and has not made a reference to the origin.

ResultsPlus

Examiner Tip

To obey Hooke's law the force must be directly proportional to the extension and so there must be a straight line passing through the origin to be correct. A straight line in a later section of the graph would just give a linear relationship e.g. y = mx + c and this would not pass through (0,0).

This response scored both marks.

(a) The student notices that her graph is a straight line between A and B and concludes that the device obeys Hooke's law.

Comment on this conclusion.

(2)

This is incorrect, Hooke's law requires proportionality between force and extension until the limit of proportionality is crossed. Therefore, it should (but does not) cross the origin.

ResultsPlus

Examiner Comments

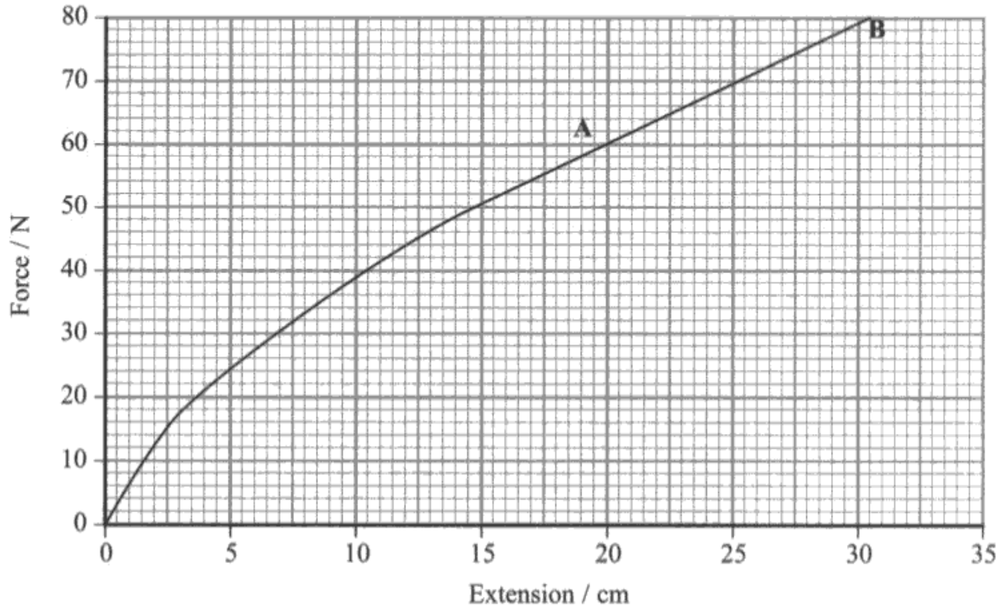
The 'it' in line 3 was assumed to refer to the section AB and so a correct reference was made to 'AB not passing through the origin' and that the device does not obey Hooke's law.

Question 15 (b) (i)

The majority of candidates managed to score at least 1 mark, mainly for suggesting that the area under the graph would give an estimate of the work done in extending the device. Given that this was a two mark question many candidates then failed to add any additional detail that would enable a value of the work done to be calculated from the area under the graph which was the main emphasis of the question. The most popular correct method to find the area was counting squares with very few responses seen with references to the trapezium rule or more simple methods of approximating the area under the graph to a series of triangles and rectangles.

Incorrect responses usually involved references to Work done = force x distance or 1/2 x F x Δx. Some candidates assumed that using the graph required taking a gradient and so did not score any marks.

This response scored both marks. A very detailed method for the 2nd marking point has been described giving the breakdown of the area under the graph into a trapezium and a region where squares would be counted.



(b) (i) Describe how the student could use the graph to obtain an estimate of the total work done.

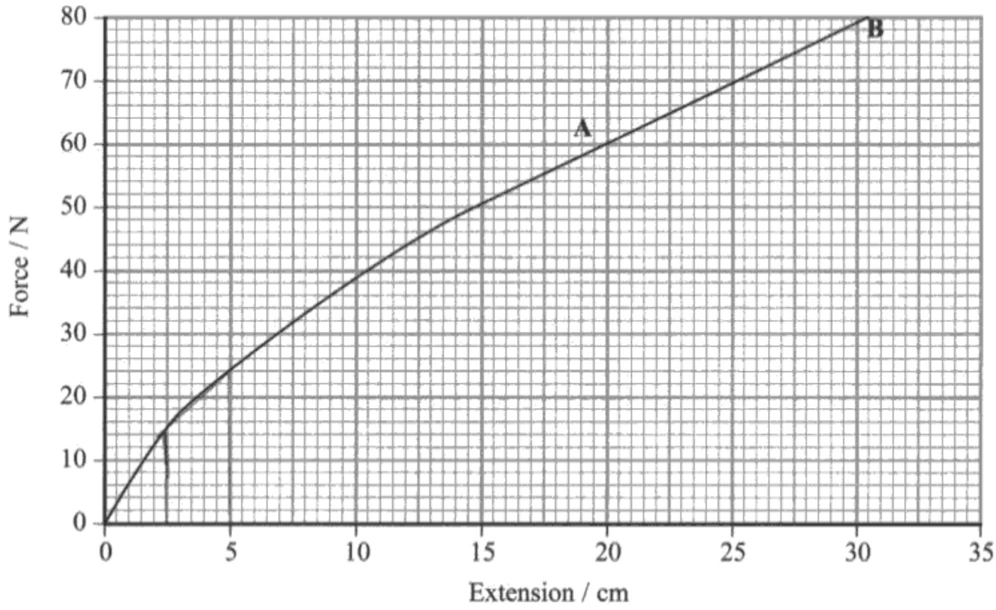
(2)

Work done can be found by calculating the area of force - extension graph. Total area = Area under AB (area of trapezium) + area under the rest of the curve which can be calculating by counting squares (or using trapezium rule)

ResultsPlus

Examiner Comments

Although it was not required, few candidates were seen to go into any detail beyond counting squares and further information should be included in such responses as to what to do with the number of squares such as finding the area of a square and then multiply this by the area of each square.



(b) (i) Describe how the student could use the graph to obtain an estimate of the total work done.

(2)

By ~~Measuring~~ finding the area underneath the graph from the start point to breaking point.

ResultsPlus
Examiner Comments

A typical response scoring just the first marking point for the idea that the work done is equivalent to the area under the graph.

ResultsPlus
Examiner Tip

If a question asks for a method to be described then some of the steps from that method will be required, even if it just for 1 mark. In this response the candidates has just stated the name of the method without providing any further detail.

Question 15 (b) (ii)

This sub-question leads on from 16(b)(i) which should have given a clue to the direction the answer should take, i.e. a reference to the area under the graph. The better responses included reference to the rectangles going above the line but were often not followed by a correct reference to the force changing.

Candidates found this question to be very challenging, often giving tangled answers around the cumulative nature of the data. The vast majority of candidates did not realise that the work done had been calculated by finding the area of a rectangle created by the additional extension produced by adding the additional mass. The majority of incorrect responses discussed that the work done should 1/2 FΔx and not Force x distance.

This candidate scored 1 mark for realising that it is the force component when calculating the work done that is the reason for the over estimation. However, they have not correctly described why the force is incorrect and so just scored the first marking point.

Explain why this spreadsheet results in an over-estimate for the total work done.

(2)

It is using the total stretching force, rather than the change in stretching force which matches the change in extension.

ResultsPlus
Examiner Comments

The work done was calculated by effectively dividing the force-extension graph up into rectangles and then finding the area of each rectangle

i.e. base (change in extension) x height (applied force).

By looking at the table you can see the values used for each rectangle and by drawing them onto the graph you would see that the force used each time is the total and not the average (i.e. initial + final)/2 for each rectangle.

Explain why this spreadsheet results in an over-estimate for the total work done.

(2)

It is Calculating the work done after every 10N is added and once it has stopped extending ~~off~~ as if it is an instantaneous change when its gradual so it has a gradient therefore its an overestimation

ResultsPlus

Examiner Comments

This candidate scored both marks. They realised that it is an over estimation of the force and then explained correctly that the force is not just added instantaneously but is added gradually i.e. constantly changing.

Question 15 (c)

Over half the candidates managed to score full marks with the majority of the remaining candidates scoring 1 or 2 marks.

Nearly all responses saw a correct calculation of the energy transferred to mechanical work. Most candidates then attempted to find either the number of stretches or the number of minutes involved by using total energy divided by the energy per stretch or by a time. Not all candidates did this in one step and weaker candidates were seen to divide the total energy by one of the quantities given, mainly the energy per stretch, without fully understanding the final quantity to be calculated and therefore only scoring 2 marks.

The final answers were quoted in a variety of units and the majority of candidates managed, although unnecessary, to change the final time to hours or seconds.

A correct answer with a unit error scoring just 2 marks.

(c) The student eats a packet of crisps and then uses the exercise device. The energy content in a packet of crisps is 540 kJ. During exercise this energy is converted and 25% of it is transferred to mechanical work.

The student extends the device fully 15 times in 1 minute. An accurate value for the work done in fully extending the device is 14.7 J.

Calculate the time it would take the student, working at this rate, to transfer 25% of the energy from the crisps to mechanical work.

(3)

$\frac{x}{540\times10^{+3}} \times 100 = 25\%$

$x = 135\times10^{3}$ J

~~$\frac{135\times10^{3}}{9183.6}$~~ $\frac{135\times10^{3}}{14.7} = 9183.6$

$\frac{9183.6}{15} = \frac{612.2}{60} = 10.2$

Time = 10.2 mints

ResultsPlus
Examiner Comments

The candidate has set out their work clearly although from line 3 onwards they have not written that they are calculating the number of stretches initially as a total then per minute an then per hour. An example of an unnecessary time conversion at the end of the calculation which consequentially then had an incorrect unit for time.

ResultsPlus
Examiner Tip

When working through a logical series of steps which requires common sense as oppose to a substitution into a given formula still describe your steps. In this case line 3 should be 'number of stretches' and line 4 should be 'time taken'.

Calculate the time it would take the student, working at this rate, to transfer 25% of the energy from the crisps to mechanical work.

(3)

14.7 x 15 = 220.5 → 220.5 joules expended in one minute

25% of 540kj = 135kj or 135000 J joules

60 ÷ 15 = 4 - 4 seconds to perform one extension

135000j ÷ 220.5j = 612 J → 612 mins to burn energy, or 10.2 hours

Time = 612 mins / 10.2 hrs

ResultsPlus

Examiner Comments

A correct response scoring all 3 marks.

All stages of working have been described.

Question 15 (d)

Many candidates demonstrated a good knowledge and understanding of this specification however they did not always answer the question being asked which specifically referred to the same maximum force. Most candidates assumed that the same extension would be required so a greater force should be applied.

Candidates that referred to a smaller extension often failed to score the second mark as they quoted out F x Δx. To gain any marks for a correctly quoted formulae in terms of symbols then all terms must be defined or the equation written out using the quantities rather than their symbols.

References to displacement and distance in place of extension were common and were not credited.

(d) Explain whether more or less work would be done applying the same maximum total stretching force to a similar exercise device with rubber cords of twice the cross-sectional area.

(2)

Less: ~~ki~~ if the same force was applied then the extension of each ~~rub~~ cord would be less so the work done would also be less.

ResultsPlus
Examiner Comments

A good response describing the smaller extension for the same force resulting in less work being done.

This response scored 1 mark for less extension with the same force.

(d) Explain whether more or less work would be done applying the same maximum total stretching force to a similar exercise device with rubber cords of twice the cross-sectional area.

(2)

more work would be done because if you apply the same force to a larger cross sectional area you would get less extension. meaning you would need a larger fore therefore creating more work.

ResultsPlus
Examiner Comments

The candidate has assumed that extension needs to be the same so loses out on the second marking point as they go on to discuss a greater force.

As these are independent marking points the first statement for same force and less extension can be credited.

Question 16 (a) (iii)

This question required candidates to state why the power was a minimum. The examiner required more than just a reference to friction therefore most candidates did not manage to score a mark here.

The carriage would require additional power if some of the energy supplied to it had been transferred elsewhere. Therefore a reason would need to include a reference to energy or power as well as friction.

Many candidates referred to energy being 'lost' and these responses were not credited. Air resistance was accepted in place of or in addition to friction when discussing the reason for requiring additional energy etc.

This response scored no marks.

(iii) Suggest why the power in (ii) is a minimum value.

(1)

Because some energy might have been dissipated therefore its not a 100% power input.

ResultsPlus

Examiner Comments

No explanation given as to why the energy was dissipated so no mark.

This response scored no marks.

(iii) Suggest why the power in (ii) is a minimum value.

(1)

No account of frictional forces.

ResultsPlus

Examiner Comments

The candidate is correct in that the frictional forces were not taken into account but they have not explained why there would need to be additional power.

ResultsPlus

Examiner Tip

This question is about power or energy so the answer to this part should also be in terms of those quantities. Remember to keep your answer in the context of the question being asked.

Question 16 (a) (i)-(ii)

Part (a)(i) was answered well with nearly every candidate managing to calculate the acceleration using v = u + at and score at least 1 mark. The most common error was quoting the units of acceleration as m s^{-1}.

Part (a)(ii) was answered in a variety of ways, calculation of the kinetic energy and then the power was the most straightforward method and hence the most successful method.

Many candidates chose to use P= Fv and, although it is not in the specification, full marks could still be awarded. However, many candidates failed to realise that the average velocity was required and not the maximum velocity which had been quoted in the question. Use of the maximum velocity could still score 2 out of the 3 marks with a correct value of force.

The third way to calculate the power involved effectively calculating the gain in GPE or, as it is quoted in the mark scheme the work done on the carriage to raise it to the top of the first slope. To gain the first mark, a height had to be calculated using equations of motion, then a force using F = ma, then use of work done = force x distance. Finally the candidate had to use power = energy /time to obtain the final answer. This explains why a method using KE/ time was the most successful route to scoring 3 marks.

Besides use of the maximum velocity in place of an average, common errors included use of 'g' instead of the calculated velocity from (i). As was seen in part (b) many candidates thought that there was a vertical force applied to launch the Stealth up the slope and did not grasp the process involved here of the carriage being accelerated horizontally and then decelerated as it moves up the slope due to its weight. This misunderstanding could have led to these incorrect substitutions of 'g' for the acceleration for some candidates.

This response scored (i) 2 and (ii) 1 marks.

16 The 'Stealth' roller coaster at the Thorpe Park theme park is advertised as reaching 135 km $hour^{-1}$ from rest in 2.3 seconds.

Most roller coasters are driven slowly up to the top of a slope at the start of the ride. However the carriages on 'Stealth' are initially accelerated horizontally from rest at ground level by a hydraulic launch system, before rising to the top of the first slope.

(a) (i) Calculate the average acceleration of the carriages.

135 km $hour^{-1}$ = 37.5 m s^{-1}

(2)

t = 2.3 s   v = 37.5 $a = \frac{v-u}{t}$

a = 37.5 / 2.3 s

= 16.3 ms^{-2}

Average acceleration = 16.3 ms^{-2}

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

$P = E/t$

$F = ma = 10000 \times 16.3 = 163000$ N

~~163000/2.3~~

$P = 163000/2.3 = 70869.6$ W

$= 70.9$ kW

Minimum average power = 70.9 kW

ResultsPlus

Examiner Comments

The candidate has correctly used F = ma to calculate the force but, although they have quoted P = E/t, they have effectively used P = F/t and this scores 0 marks.

No distance was given and as it was not obvious that a distance needed to be found then the candidate reached a 'dead' end' and so just divided the 2 quantities they had. This was a common error.

ResultsPlus

Examiner Tip

This was a 3 mark question. As one mark would have been for use of power = energy/time and one mark for calculation of the final answer there are a lot of stages required for the third mark if a more complicated route is used. As we would not expect you to have to use 3 formulae for 1 mark then try to see if there is a more direct route using the variables that you have been given or have already calculated in the question.

A good response scoring (i)2 and (ii)3.

16 The 'Stealth' roller coaster at the Thorpe Park theme park is advertised as reaching 135 km hour^{-1} from rest in 2.3 seconds.

Most roller coasters are driven slowly up to the top of a slope at the start of the ride. However the carriages on 'Stealth' are initially accelerated horizontally from rest at ground level by a hydraulic launch system, before rising to the top of the first slope.

(a) (i) Calculate the average acceleration of the carriages.

135 km hour^{-1} = 37.5 m s^{-1}

(2)

$a = \frac{v-u}{t} = \frac{37.5 - 0}{2.3} = 16.3 \text{ ms}^{-2}$

Average acceleration = 16.3 ms^{-2}

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

$v^2 = u^2 + 2as$ $F = ma$ $P = \frac{43.125 \times 163040}{2.3}$

$(37.5)^2 = 2 \times 16.304 \times s$ $F = 10000 \times 16.304$

$s = 43.125$ $= 163040.$ $P = 3057$ kW

Minimum average power = 3057 kw.

ResultsPlus

Examiner Comments

The candidate has set out their answer well and opted to work out the distance and force and then use power = (force x distance)/time in one step.

All stages were clearly set out and explained.

Full marks (i)2 and (iii) 3 awarded.

(a) (i) Calculate the average acceleration of the carriages.

135 km hour^{-1} = 37.5 m s^{-1}

$v = u + at$

(2)

$a = \frac{v-u}{t}$ $\frac{37.5 - 0}{2.3} = a$

$a = 16.3 ms^{-2}$

Average acceleration = $16.3 ms^{-2}$

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

$\frac{\text{energy transfer}}{\text{time}} = \text{Power}$

$\frac{\text{Kinetic energy}}{\text{time}} = \text{power}$ (energy → $\frac{1}{2}mv^2$)

$\frac{(0.5) \times (10,000) \times (37.5^2)}{2.3} = \text{Power}$

Power = 3057065W ≈

Minimum average power = 3057×10^3 W

ResultsPlus

Examiner Comments

The candidate has managed to do all the calculations in one line demonstrating the simplicity of this method, unfortunately it was not commonly seen.

Question 16 (b)

This question was answered more successfully by the more able candidates as many were confused about the exact mechanism for getting the carriage to the top of the slope.

The introduction to the question on the previous page did explain that the carriages are accelerated horizontally and then they move up the slope. Unfortunately, a sizeable proportion of candidates assumed that there was a vertical force acting on the carriages. Hence, explanations referring to a discussion of a resultant force involving the launching force or the weight is greater than the launching force is it is pulled down were seen.

The idea that the same acceleration or maximum velocity was required to get the carriage to the top was described well by many when seen but as mentioned below, was usually accompanied by a reference to the forces and not the energy involved.

Appreciation that more energy was required to prevent roll back was uncommon . This was a separate item to part (a)(iii) but many candidates seemed to link the two issue involved of minimum power and not reaching the top by discussing power rather than energy for the majority of their responses. Few candidates managed to discuss both forces and energy, so it was common to award 1 or 2 marks with less than 2% managing to mention all three points and score the maximum of 3 marks.

This response scored 2 marks.

*(b) The force required to launch 'Stealth' is not always the same. The ride is monitored and the data from preceding launches is used to calculate the required force.

If the mass of the passengers for a particular ride is significantly more than for preceding launches, this can lead to 'rollback'. This is when the carriages do not quite reach the top of the first slope and return backwards to the start.

Explain why 'rollback' would occur in this situation.

(3)

because the force required to launch stealth has been calculated from the previous mass which is lighter, therefore the new heavier mass won't recieve enough force to reach the speed needed as it is heavier than the force is calculated for

ResultsPlus
Examiner Comments

The first 2 lines of the response are a repeat of the stem of the question but below this they have the idea that the force is not enough (first marking point) to reach the speed needed. This is not a direct statement that the same speed is required but it is implied and would have been awarded the second marking point.

No references to energy were made at all.

There is no eneagh kinetic energy ~~to~~ to be transfured all of the kinetic energy is tranfared to Potintial energy before it reachs the top.

ResultsPlus
Examiner Comments

Just 1 mark here for the 3rd marking point that there is insufficient energy.

This candidate scored 0 as they have assumed that the force applied is acting vertically and this is not the force that is insufficient.

Reference to overcoming gravity or weight demonstrated a lack of understanding of the physics involved and did not score at all.

As there is more weight of parsangers when the roller coaster reaches the top its velocity becomes zero and since gravity is working on it, ~~it~~ it The roller coaster will not have enough force to overcome the gravity thus ~~causing~~ cawsing a rollback.

ResultsPlus
Examiner Comments

How the Stealth works

The carriage was launched horizontally and accelerated along a flat track at a constant speed. Once it had reached it's top speed of 135 km h^{-1}, before beginning to rise, it travelled at a constant velocity momentarily. Once the track began to have a vertical component, a downwards acceleration due to the weight of the carriage began to slow down the carriage. If the mass is small enough, the carriage will have sufficient acceleration and hence maximum velocity to not slow down to 0 before it has reached the top.

Why rollback occurs

A greater mass would result in a lower acceleration for the same launching force. A lower acceleration would result in a lower maximum velocity on the horizontal part of the slope. Therefore there would be less KE to transfer to GPE and so the height reached would be less and the carriage would not reach the top as it reaches a speed of 0 before the top and would 'rollback'.

Question 16 (c)

There was an equal split between those candidates scoring 1 and those scoring 2 marks with this question with very few not managing to score any marks here.

A good understanding was demonstrated for this question although not all candidates realised that a comment linking the lower viscosity to the greater acceleration was required. Therefore whilst most responses seen described a lower viscosity, not all mentioned that this would reduce the frictional or drag forces acting on the carriage.

Both marks scored.

(c) Suggest why roller coasters may have a greater acceleration when the lubricating oil between the moving parts has had time to warm up.

(2)

Increasing the temperature of the lubricating oil decreases its viscosity and the oil would be thinner ~~decreasing~~ reducing the friction (resistive force) and causing more forward net force, and more acceleration

ResultsPlus
Examiner Comments

Clear statements mentioning a decrease in viscosity and a decrease in friction have been included.

Just 1 mark awarded for the reduction on friction between the moving parts.

(c) Suggest why roller coasters may have a greater acceleration when the lubricating oil between the moving parts has had time to warm up.

(2)

Warmed up lubricants ~~ma causes least frictional force to~~ reduces friction between moving parts. So less work is done against friction and thus less energy is lost while making the roller coaster accelerate.

ResultsPlus
Examiner Comments

The candidate has not explained why the warmer oil has reduced the friction i.e. lower viscosity.

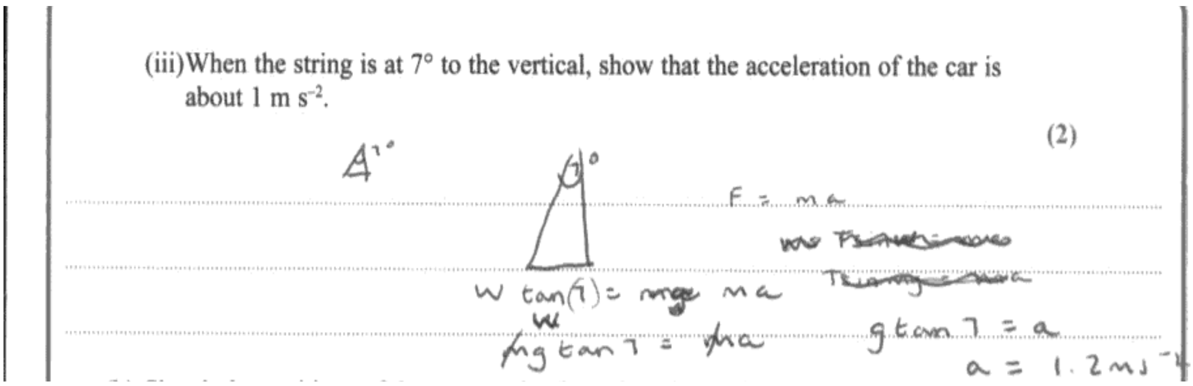
Question 17 (a) (iii)

The majority of candidates realised that a component of tension had to be calculated to enable evaluation of the car's acceleration. Unfortunately, most candidates failed to realise that both the vertical and horizontal components needed to be determined to eliminate the mass and tension which had not been given. For 1 mark a few steps were required to reach the conclusion that ma/mg = tanθ but few responses were seen where candidates had tried to resolve in both directions.

'gsin7' was the most common response and due to the small proportion of candidates obtaining 2 or even 1 mark here, it could be said that this was really only attainable by candidates at the higher end of the A grade ability range.

The trigonometry involved in this question was more challenging than that found in question 14(b) however, looking at the responses from candidates of both items, it is clear that there is a lack of confidence and knowledge in using trigonometry at all within this subject. An area which should be addressed in future teaching.

This response scored both of the marks.



(iii) When the string is at 7° to the vertical, show that the acceleration of the car is about 1 m s^{-2}.

(2)

F = ma

W tan(7) = ma

mg tan 7 = ma

g tan 7 = a

a = 1.2 ms^{-2}

ResultsPlus

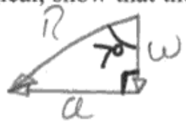
Examiner Comments

A slightly less conventional but straightforward method, the candidate has added the accelerating force of ma into their triangle of forces acting on the mass.

Using tanθ = opposite/adjacent = ma/mg leads to a = gtanθ and the candidate then calculated the correct acceleration of 1.2 ms^{-2} .

This response scored 0.

(iii) When the string is at 7° to the vertical, show that the acceleration of the car is about 1 m s^{-2}.



(2)

S^{O}H C^{A}H T^{O}A

$\sin 7 = \frac{a}{R}$

$a = R\sin 7 = 10\sin 7 = 1.22\ ms^{-2}$

ResultsPlus
Examiner Comments

The candidate has drawn a triangle from which to base their trig using both forces and acceleration. They then use a value of g= 10. No correct answer could be obtained from this working.

ResultsPlus
Examiner Tip

As the tension and the mass had not been given, you had to resolve both vertically and horizontally to cancel out the unknown quantities:

$T\sin\theta = ma$

$T\cos\theta = mg$

Dividing one by the other will give $\tan\theta = a/g$ so a can now be calculated as g and θ are known.

Question 17 (a) (i)-(ii)

17(a)(i) The question asks candidates to complete a free body force diagram for the accelerometer as the car starts moving. The weight and the tension were usually correctly drawn. However, most candidates included additional forces. Drag, air resistance, force from car acceleration, resultant and lift were seen. Some drew in the vertical and horizontal components of tension as well as showing the tension itself. As marks were deducted for additional forces from any marks awarded for correct forces, few candidates scored more than 1 mark.

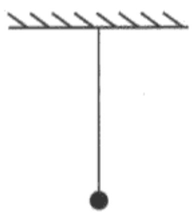
17(a)(ii) The construction of a vector diagram using the correct forces was required in this question. There was no error carried forward available for additional or incorrect forces from part (i) and many candidates tried to incorporate their 3 or more forces from part (i) into their vector diagram in part (ii). Hence only a few managed to score 1 or 2 marks in this part as a poor score in (i) made this part almost inaccessible.

The first marking point was for drawing the weight and tension in a correct vector diagram. The second marking point was for a labelled resultant in the correct direction. There was a disproportionate number of candidates who had scored 2 marks in part (i) going on to score no marks in part (ii). Candidates who had scored the first mark often lost the second mark as the resultant was in the wrong direction. The frequency of this error highlights the gap in many candidates' knowledge of how to construct a correct vector diagram, particularly the concept of 'tip-to-tail' when drawing a closed triangle of vectors. Many candidates did not appear to know how to construct a vector diagram at all, often leaving this blank. Only a handful of correct parallelogram diagrams were seen.

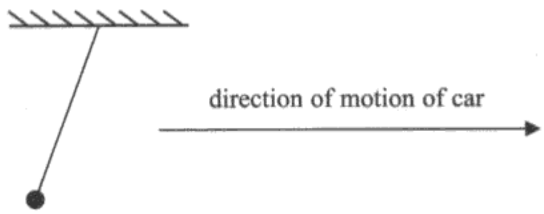
This response scored (i) 0 and (ii) 0.

17 Many hand held devices such as smartphones and tablet computers contain accelerometers. These allow changes in orientation of the device to be tracked.

A student models a simple accelerometer by attaching a small mass on a string to the roof of a car.

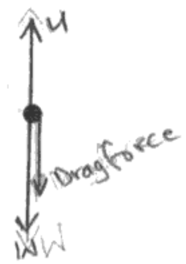


When the car starts moving, the string is seen to change position as shown below.



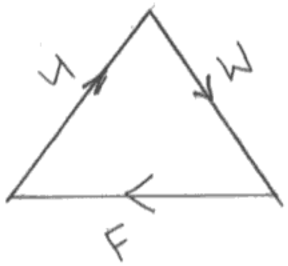
(a) (i) Complete a free body force diagram for the mass when the car starts moving.

(2)



(ii) Draw a vector diagram, in the space below, to show how the resultant force on the mass is produced.

(2)

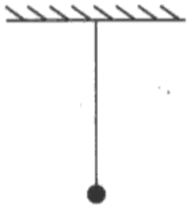


ResultsPlus

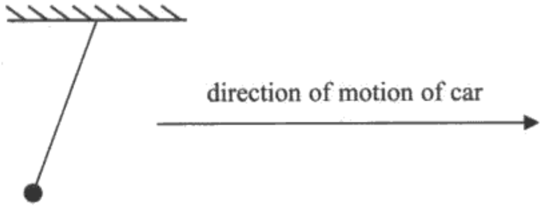
Examiner Comments

(i) The candidate has labelled weight correctly but also added in a downwards drag force which would imply that the object is moving upwards. So 1 correct - 1 incorrect force would give 0. Assuming that 'U' is upthrust, no penalty would have been made for this force and, as upthrust was taken to be neutral and was ignored as it is negligible.

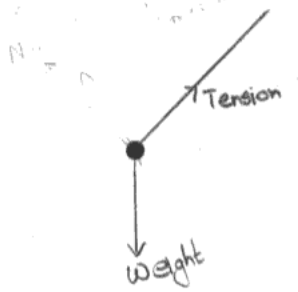
(ii) The candidate has constructed a triangle using the 3 forces given in part (i) but this is not a vector diagram so no credit could be given.



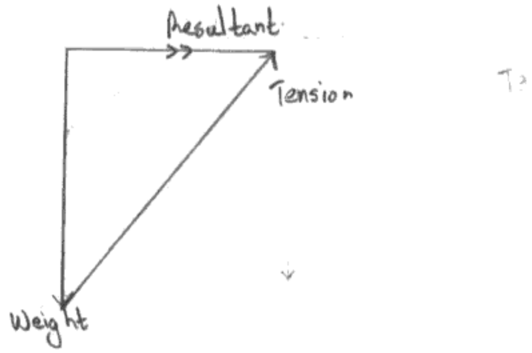
When the car starts moving, the string is seen to change position as shown below.



(a) (i) Complete a free body force diagram for the mass when the car starts moving. **(2)**



(ii) Draw a vector diagram, in the space below, to show how the resultant force on the mass is produced. **(2)**



ResultsPlus

Examiner Comments

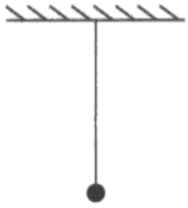
A good response scoring (i)2 and (ii)2 marks.

ResultsPlus

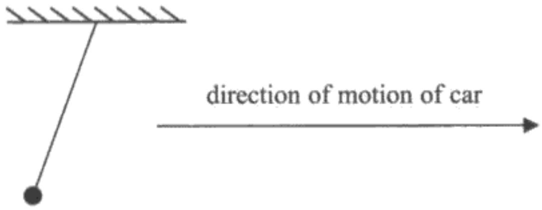
Examiner Tip

When transferring forces from a free-body diagram to be used in a vector diagram, make sure that the tip of one arrow (weight) touches the tail of the other (tension). The resultant is effectively the shortest route from the tail of the first arrow to the tip of the second and, as you can see in this diagram it goes from left to right.

This response scored (i)1 and (ii)1.

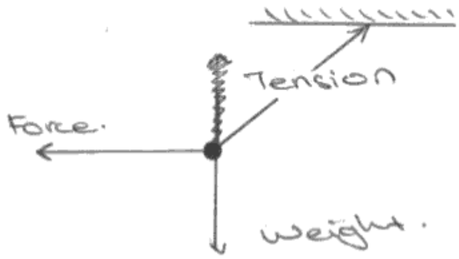


When the car starts moving, the string is seen to change position as shown below.



(a) (i) Complete a free body force diagram for the mass when the car starts moving.

(2)



(ii) Draw a vector diagram, in the space below, to show how the resultant force on the mass is produced.

(2)

ResultsPlus
Examiner Comments

(i) 2 correct forces = 2 marks. However there is an additional force of weight so (2-1) 1 mark awarded.

(ii) Weight and tension in the correct position in the triangle so 1 mark. No resultant labelled in the correct direction, force in the opposite direction has been labelled in place of resultant so just 1 mark.

Question 17 (b)

Candidates demonstrated a good understanding of the physics involved with these items. The majority of responses were well drawn but some freehand drawings were untidy, casting doubt as to whether the candidates were trying to illustrate a vertical string in (i).

The second diagram requiring the position under a greater acceleration was the most accurate and the most common error in (iii) was to draw the string to the left as in part (i). This illustrated that some candidates did bot realise that the direction of the force causing the deceleration is opposite to one causing the acceleration in (i).

All 3 marks awarded for this response.

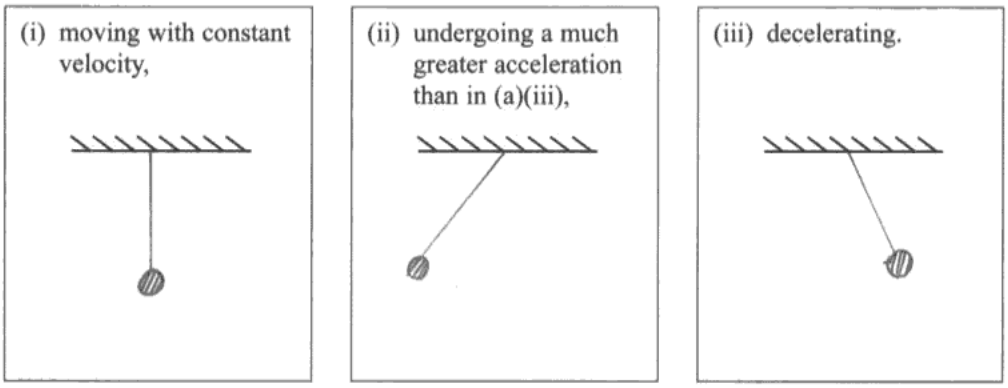
(b) Sketch the positions of the mass and string when the car is moving in the same direction and is:

(i) moving with constant velocity,

(ii) undergoing a much greater acceleration than in (a)(iii),

(iii) decelerating.

(3)

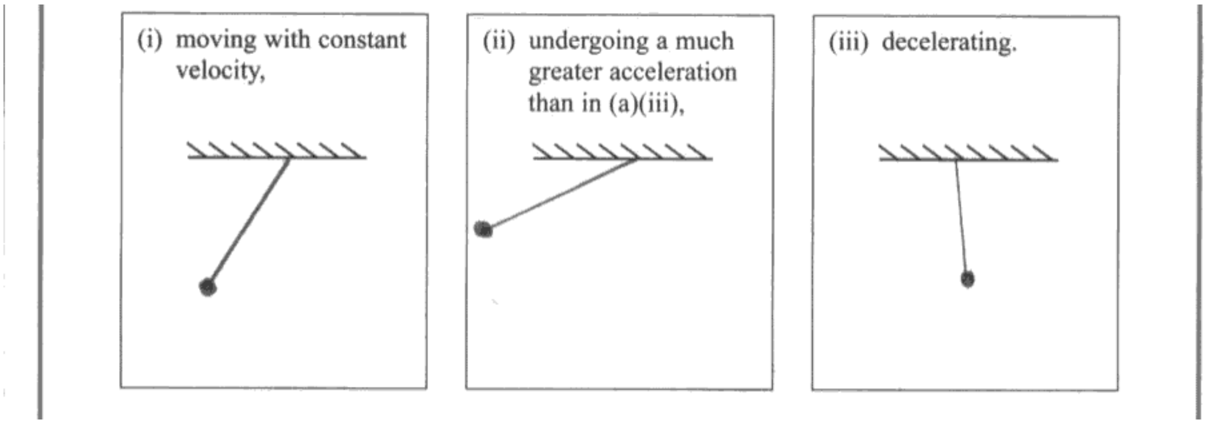


ResultsPlus

Examiner Comments

Clear lines drawn for the string using a ruler so that there is no ambiguity as to the angle of the string.

Just 1 mark awarded for (ii).



ResultsPlus
Examiner Comments

(i) indicates that the car is accelerating and it should be at constant velocity and (iii) has the car at a constant velocity whilst it should be decelerating.

Question 17 (c)

Nearly half of all candidates managed to explain, albeit poorly, that there must always be a vertical force due to weight as a reason for the string never being completely horizontal. Most candidates were not as successful in describing that this would create a vertical component of the tension. Some were close to this by referring to a vertical component but did not mention that it would be of the tension. Others just said that ' there would be nothing to balance the weight'.

Very few candidates answered in terms of infinite acceleration and those that did often failed to mention the angle, referring to weight instead.

> (c) Explain why the string would **not** become horizontal, however great the acceleration.
> (2)
>
> because there is always a weight acting down upon it so there will always be a vorticle component to the tension. also the ball would hit the car roof

ResultsPlus
Examiner Comments

A good response scoring both marks.

This response gained just 1 mark for a reference to weight always acting vertically.

The candidate did not comment on the other vertical force acting on the string i.e. the tension so no further marks scored.

> There will always be a downward component of weight acting on the ball, no matter at what acceleration the car travels. W = mg mass and g constant

ResultsPlus
Examiner Comments

Horizontally there is an unbalanced force when accelerating equal to ma (ma = tsinθ).

Vertically the forces are balanced so weight - tension = 0 therefore both of these forces need to be mentioned.

Question 17 (d)

The independence of components at right angles is taught and hence understood by many candidates. However, candidates find applying this as a concept to contexts given very challenging. Therefore very few responses seen actually gave a statement that the 3 accelerometers will read 3 independent quantities as they are perpendicular to one another.

Candidates were given an alternative to this as stating that motion in the x,y,z planes etc implies that they are at 90° to each other and hence independent of one another. Lots of references were seen to just 3-d and this was not thought to be sufficient as an explanation of the independent planes of motion.

Lots of candidates misunderstood the meaning of 'arranged at right angles' and though this to mean right angles in the same plane, sometimes accompanied by a diagram illustrating this. Many incorrect responses included references to accuracy, to taking averages or to tracking acceleration in all directions.

This response scored no marks.

(d) Suggest why many devices contain 3 accelerometers, arranged at right angles to each other.

(1)

~~To react to motion from 3-dimension~~ To react to 3-dimensional motion, helping to react to the slightest change of motion in all possible directions.

ResultsPlus
Examiner Comments

3-dimensional is insufficient for the mark as the planes needed naming to imply that they are perpendicular so no marks awarded.

This response scored 1 mark.

(d) Suggest why many devices contain 3 accelerometers, arranged at right angles to each other.

(1)

so they can gauge the Objects orientation in 3D space (x, Y, Z) axis

ResultsPlus

Examiner Comments

The three planes have been named: X,Y,Z axis so scores the mark.

Question 18 (a)

Most candidates made a correct sensible statement giving the evidence from the graph that the ball does not reach terminal velocity. The most common response was that that the graph is not horizontal or that the ball does not travel at a constant velocity indicating that the concept of terminal velocity is well understood.

Vague answers were more often than not the main cause for not awarding the mark such as 'no straight line' or 'graph not constant'.

(a) State how the graphs show that neither ball reaches terminal velocity.

no flat horizontal lines

ResultsPlus
Examiner Comments

This response scored 1 mark as either flat or horizontal would have been acceptable.

(a) State how the graphs show that neither ball reaches terminal velocity.

(1)

Neither graph has a line that is parallel to the time axis (constant velocity).

ResultsPlus
Examiner Comments

Again, this is a good response that would get the mark.

Question 18 (b)

This question differentiated well across all ability ranges with all candidates of E grade ability or above managing to score at least 1 mark and the majority of A grade candidates scoring 6 or more.

(i) Most candidates managed to draw a tangent but not everyone could take accurate readings from the tangent to find the correct gradient and hence the acceleration. Even if the answer was within the range given in the mark scheme, all values were checked by examiners against the drawn gradient and could only score the second mark if the values were read accurately from the graph. A considerable number of candidates drew long tangents but chose to draw very small triangles from which to calculate the gradient, sometime causing their values to fall out of the acceptable answer range.

Less able candidates did not use the tangent and just divided the velocity by the time

at t= 0.60 s.

(ii) This question was answered well using either the given value of 7 m s^{-2} or the calculated acceleration from part (i). Some candidates chose to use g for the acceleration.

(iii) Many candidates realised that a weight needed to be calculated and scored the first mark but not all realised that this had to be subtracted from the resultant force. The four question parts that made up (b) were all interlinked with parts (i), (ii) and (iii) leading on from one another. Students, from exam question practice should realise that a previous answer is usually required in subsequent parts. Hence less able candidates tended to just score 1 mark for this item and the more able candidates managed to score 2.

(iv) Candidates did not score very well for this item mainly as they had to use a correct velocity, either 5.2 m s^{-1} taken at 0.60 s or the maximum of 6.6 m s^{-1} in the equation for Stokes' law. For many the scale for the velocity axis caused the problem and the value at the maximum or 0.60 s was misread. Some marks were lost due to not converting the radius of the hollow ball to m.

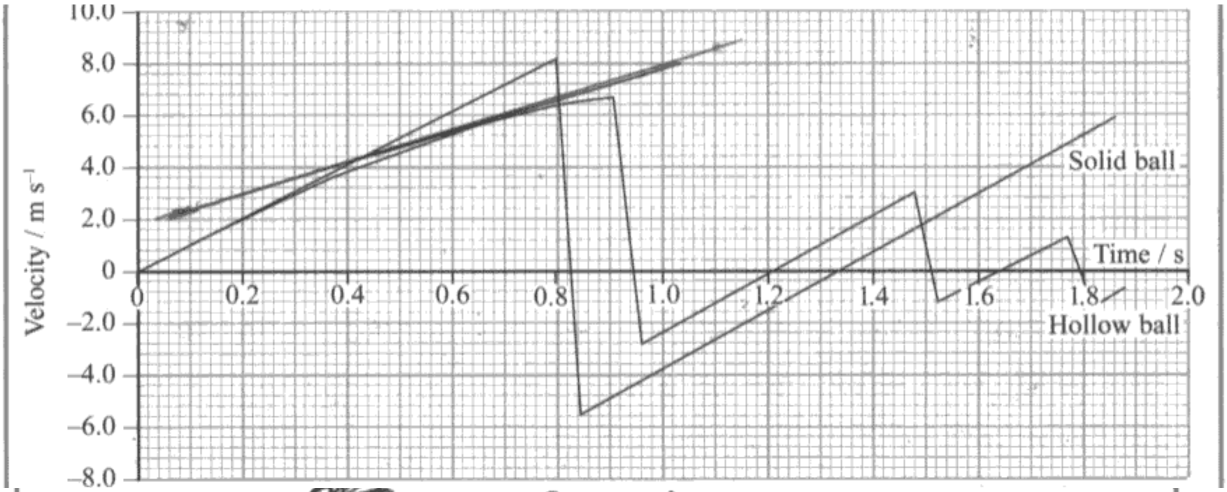
This candidate scored:

(i)1

(ii)2

(iii)0

(iv)2.



$\frac{8.4-2}{1.1-0.2} = \frac{6.4}{0.9} = 7.11\ ms^{-2}$

(ii) Show that the resultant force on the hollow ball at t = 0.60 s is about 0.02 N.

mass of hollow ball = 2.4 g

(2)

$F = ma$

$= 2.4 \times 10^{-3} \times 7.11$

$= 0.017$ aprox 0.02

(iii) Show that the drag force on the hollow ball at t = 0.60 s is about 0.01 N. You may neglect upthrust.

(2)

weight − drag = 0.017

drag = weight − 0.017

= 0.026 − 0.017

= 0.009N, about 0.01N

(iv) Demonstrate that the Stokes' law force is **not** sufficient to produce this drag force.

radius of hollow ball = 2.0 cm

viscosity of air = 1.8×10^{-5} Pa s

(2)

$f = 6\pi\eta rv$

$= 6\pi \times 1.8 \times 10^{-5} \times 0.02 \times 5.2$

$= 3.53 \times 10^{-5} = 0.0000353$

ResultsPlus

Examiner Comments

(i) The tangent is not steep enough and does not appear to have been drawn at 0.60 s. The candidate managed to calculate a value in range because they misread the time from the graph. Therefore just 1 mark awarded for use of the gradient.

(ii) Calculated value from (i) used in F= ma correctly so 2 marks. No unit penalty as this is a 'show that' style of question and the unit has already been given in the question. It should have still been included with the answer though.

(iii) No working out for weight and the candidate has 0.020 so the final answer has not been calculated and no marks awarded. It looks as though the candidate originally had 0.023 down for the weight (it should be 0.0235 N) but this would have given a drag of 0.006 N which perhaps the candidate did not think was close enough to 0.01 N.

(iv) a correct value for velocity used with the radius in cm so both marks awarded.

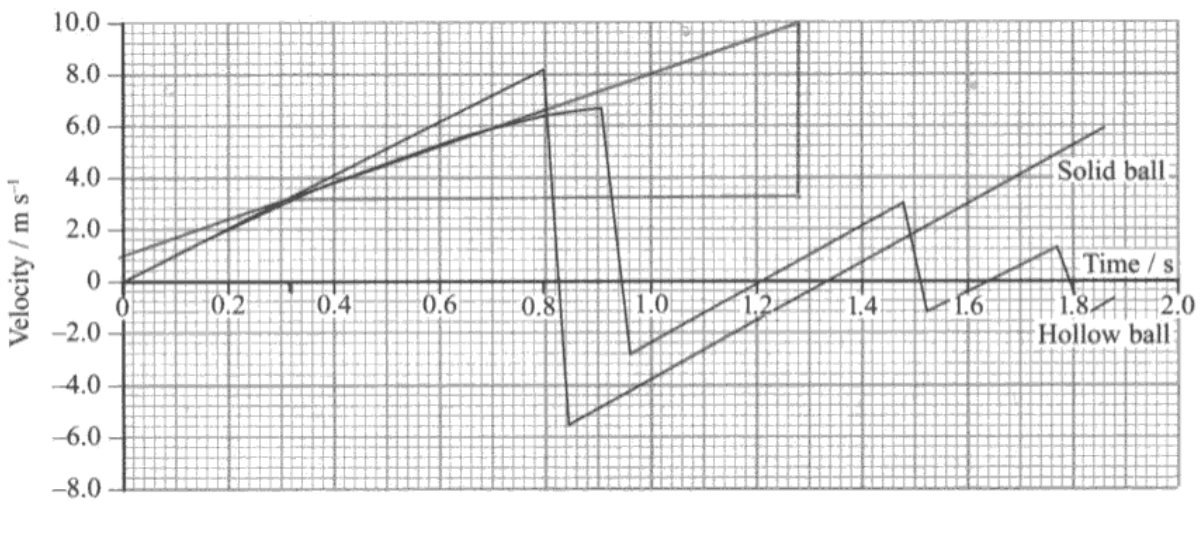
ResultsPlus

Examiner Tip

Make sure that you have a lot of practice reading from different scales also that you do not misread any graphs in the exam. Each 2mm square here represented 0.4 m s^{-1} but many candidates took it to represent 0.2 m s^{-1}.

This candidate in part (ii) has also written out a word equation describing the forces acting on the sphere. A diagram could have also been drawn just to mark sure that you have the correct direction of the forces. The maths involved with such a question is relatively straightforward, appreciating what goes on in terms of forces to reach the resultant force is more challenging and can be where some candidates go wrong.

An excellent response scoring full marks.



$a = m = \frac{\Delta y}{\Delta x}$ $\Delta y = 6.8 \text{ ms}^{-1}$

$\Delta x =$ ~~1.28 0.32 =~~

$1.28 - 0.32 = 0.96$. $a = \frac{6.8}{0.96} = 7.08 \text{ ms}^{-2}$

(ii) Show that the resultant force on the hollow ball at $t = 0.60$ s is about 0.02 N.

mass of hollow ball = 2.4 g

(2)

$F = ma$. $m = 2.4\text{g} = 0.0024\text{kg}$.

$F = (0.0024)(7.08)$

$= 0.017\text{N}$.

(iii) Show that the drag force on the hollow ball at $t = 0.60$ s is about 0.01 N. You may neglect upthrust.

(2)

W = drag.

~~24~~ $(0.0024)(9.81) = 0.0235$.

$0.0235 - 0.017 =$ ~~0.00656~~

0.0065N.

(iv) Demonstrate that the Stokes' law force is **not** sufficient to produce this drag force.

radius of hollow ball = 2.0 cm

viscosity of air = 1.8×10^{-5} Pa s

(2)

~~F = 6πηrv~~ $F = 6\pi\eta rv$

$F = 6\pi(1.8\times10^{-5})(0.02)(5.2)$

$F = 3.53\times10^{-5}$ N.

ResultsPlus

Examiner Comments

(i) The candidate has drawn an accurate tangent and a large triangle. They have read accurate values from the graph and calculated the correct gradient.

(ii) Calculated acceleration from (i) used correctly in F = ma to find the resultant force.

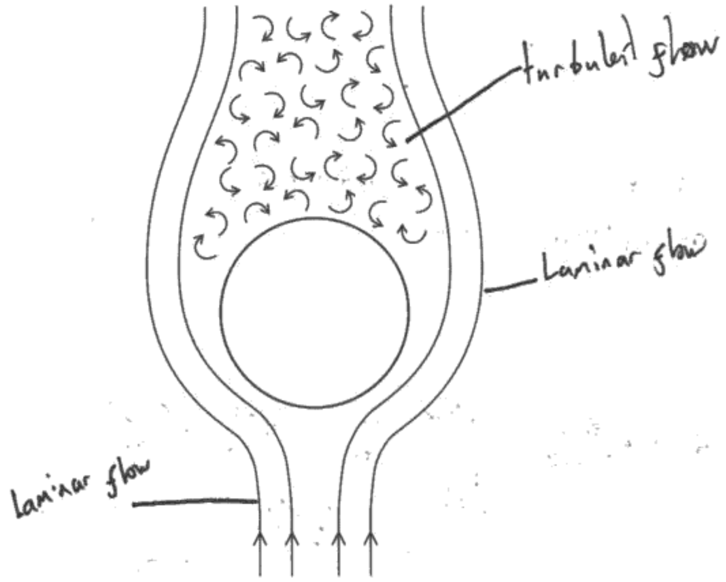
(iii) Weight calculated and shown and then the resultant force is subtracted from it to find the drag.

(iv) Correct velocity used in the formula for Stokes' Law to obtain the correct force.

Question 18 (c) (i)

This question was answered vey well and has been asked many times in the past. Most marks lost were just due to ambiguous labelling, especially if a label for turbulent flow was written next to the parallel lines at the top of the diagram.

(c) The diagram shows the air flow around the hollow ball as it falls.

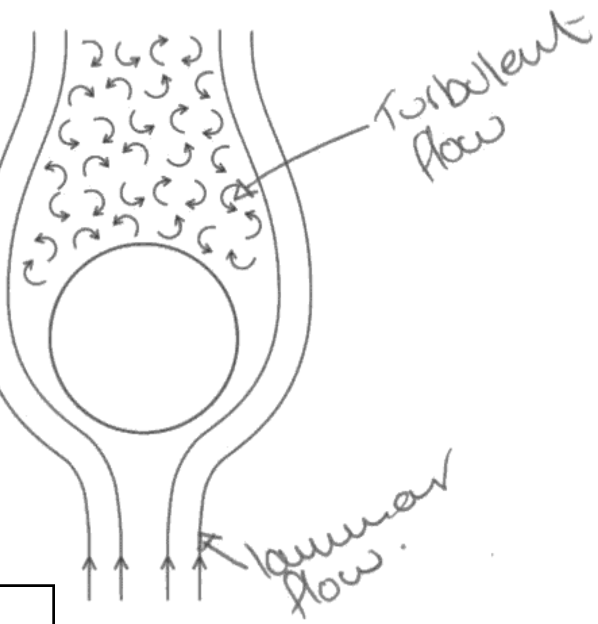


(i) Add labels to show laminar flow and turbulent flow.

(1)

ResultsPlus
Examiner Comments

Clearly labelled regions of turbulent and laminar flow scoring the mark.



ResultsPlus
Examiner Comments

Another example scoring the mark.

Question 18 (c) (ii)

This question was attempted by most candidates, successfully by about half of them. It tests specification point 20, Stokes' law and its conditions i.e. laminar flow at slow speeds for small, smooth spheres. Therefore once a candidate had realised what the question was asking it was just a matter of recall.

The most common incorrect response was just a reference that Stokes' law does not take into account the drag or that the ball is hollow. The most common correct response was that the air flow around the ball is turbulent, perhaps more of a guess than remembering the conditions for the law to apply but good candidates did answer in terms of Stokes' law.

(ii) Suggest why the drag is much greater than the Stokes' law force.

(1)

~~atstm~~ stokess law does not take into account turbulant flow.

ResultsPlus

Examiner Comments

A correct response scoring the mark.

This response scored the mark.

(ii) Suggest why the drag is much greater than the Stokes' law force.

(1)

Stoke's equation is only valid when objects are moving at relatively lower speeds. The air turbulence becomes so much more at high speeds that stoke's equation becomes invalid.

ResultsPlus

Examiner Comments

A good answer explaining why the prescence of turbulence prevents this from being a Stokes' law force.

ResultsPlus

Examiner Tip

The drag force acting on an object can be calculated using Stokes' law if:

The air flow around the ball is only laminar

The ball is moving slowly

The ball is smooth

The ball has a small surface area.

Question 18 (d)

This question was attempted by most candidates but the answers seen did not reflect the candidate's abilities. Less able candidates just managed to describe the stages of the balls bounces, perhaps scoring 1 mark for falling at a constant acceleration or bouncing at 0.8 s. More common were descriptions of the graph rather than describing the motion. More able candidates tended to use the time of the changes of direction in addition to any references to acceleration.

Although for most candidates, the full answer space was used, the lack of detail around the description of an event (i.e. a bounce) or a quantity (e.g. acceleration) prevented many candidates from scoring.

The marking points given in the scheme were aimed at crediting sensible comments about key features in the motion of the ball. However, as mentioned above the lack of detail held many candidates back. Going through the mark scheme point by point the following points were observed.

- Reference to the ball accelerating initially was not quantified by mentioning that the acceleration was constant.
- Failure to give the time of the first bounce.
- Very few candidates identified the different speeds before and after the bounce. The max speed before the bounce was often mentioned but with no additional information.
- Only a small number of candidates identified that the maximum height was reached at 1.3 s
- Given that the gradients of the lines are the same it was very surprising that virtually no candidates picked up on this as comments comparing the 2 accelerations were rare.

Candidates continue to have difficulty interpreting velocity-time graphs in unstructured questions. This was the last question on the paper and although it should have challenged most candidates it was expected that it would differentiate across all abilities and not just be accessible to those of C grade and above.

This response scored 0.

(d) Without further calculation, use the graph to describe the motion of the solid ball.

(3)

When dropped both balls accelerate to wards the floor, when they hit the floor there velocity is vastly decreased and absorbed before bouncing back up, the solid ball bounces just once, however the hollow ball bounces 3 times.

ResultsPlus
Examiner Comments

A general description of the balls motion without any reference to time or a detailed reference to acceleration.

ResultsPlus
Examiner Tip

When asked to describe key features of a graph refer to the points at which these features happen. In this case it is time.

Also look at the gradients and what they signify, here it was constant acceleration both times (between 0 and 0.8 s and between 0.84s and 1.86 s) and the same acceleration before and after the bounce.

(d) Without further calculation, use the graph to describe the motion of the solid ball.

(3)

The ball is dropping from t = 0 to t = 0.8, and then it bounces and travels upwards to ≈ 0.9, during the time it is dropping, it falls at a constant speed, meaning ~~it~~ that it is accelerating constantly and so must have vertical motion.

ResultsPlus
Examiner Comments

One mark was awarded for identifying that the ball bounces at 0.8 s.

The candidate went on to discuss constant speed and accelerating constantly which contradict one another and so no further marks were awarded.

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 greater understanding of the context and question being asked would have helped many candidates. A sound knowledge of the subject was evident for many but the responses seen did not reflect this as the specific question was not always answered as intended.

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 are not missed. Remember to check these responses if there is time at the end of the paper in case careless mistakes have been made.
- Constructing vector diagrams to enable the magnitude and direction of the resultant to be identified or measured.
- Accurate definitions of all terms given in italics in the specification.
- For every example given using vector quantities make sure that you have identified the direction to be taken as positive and remember to make all quantities acting or travelling in the opposite direction negative on graphs and in calculations.
- Practice resolving components into their horizontal and vertical components for a variety of contexts.
- Make answers relevant to the question. E.g. if a question refers to keeping the force constant then do not discuss an increasing force.

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