Examiners' Report
June 2015

GCE Physics 6PH01 01

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Introduction

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. Many candidates showed a good progression from GCSE to AS level, with prior knowledge extended and new concepts taught and understood well. Some questions were not answered as well as would have been expected by many candidates. While the contexts used in the examination were not any more challenging than in previous examination series, the consideration by candidates as to all the factors involved was not always thorough enough and answers given lacked the precision required to score the marks. However, candidates from across all ability ranges always managed to score some marks within these questions.

Calculations were answered well and were differentiated across the ability ranges. Questions 14(b)(ii), 15(a)(i) and 18(b)(i) required use of trigonometry. Whereas traditionally less successful candidates do not always select the correct trig function, the standard seen here was much better than in previous examinations. As would be expected the less successful candidates managed to score some, but not usually all, of the marks in the multiple stage calculations.

The most demanding question for all candidates was the open response question 17 that required not only a good understanding of the context of the question but a good understanding of Newton's Laws as well as the ability to express themselves precisely so that no contradicting or ambiguous statements were made. Only the more successful candidates scored full marks however all candidates had a fair attempt, with many managing to pick up some marks.

For the calculations the presentation was clear when the correct answer was obtained. There were still many instances of poor presentation, with missing subjects on the left hand side to an equation, missing equals signs and lines of working not strictly following on.

In general, time was not an issue at all with this paper with the vast majority of candidates completing all questions on the paper. Power of 10 errors and unit errors were common and the quality of writing for some candidates made some responses difficult to decipher.

Section A

Question 1

All four of the distractors had the weight and the tension identically placed. Therefore candidates had to only determine the correct position of the reaction force. There was almost an equal split between those that chose responses B and D. With those selecting B failing to spot that such a free-body diagram would result in a horizontal acceleration and those choosing D were confusing the third law pair created by the reaction force. It would almost be a worthwhile exercise to give these two incorrect distractors to a class and ask the students to explain why they are incorrect.

Question 2

This response required a precise definition of the centre of gravity. This should be a quick recall question however a significant proportion of students selected responses A and D, the common incorrect responses when a written definition has been asked for in previous examinations. The differences between candidates in their understanding of the importance of this point is significant and highlights the need for precise definitions to be taught for terms italicised in the specification.

Question 3

Due to the diverse range of incorrect responses given this question highlights both misreading the question and a weakness with some candidates in identifying correct directions of vector quantities. Whenever a question requires a substitution onto an equation of motion a significant proportion of candidates will use an incorrect direction, particularly that of the vertical acceleration. Therefore candidates choosing responses C and D had failed to realise that *g* always acts downwards and should therefore be negative. The candidates who had correctly identified the correct direction of *g* and selected response B missed the point that we were only looking for the speed, i.e. just a magnitude and that this was independent of the direction.

Question 4

Although this question was within the context of specification point 1 it required the candidates to use skills examined in assessment objective 3 (AO3) statement d, interpreting/evaluating results. There are at least 4 marks per paper allocated to examine this assessment objective so candidates should have this in mind at all times where the questions have a practical context.

Question 5

Experiments to measure *g* have appeared frequently in the past. Candidates who chose response A were not considering the 'by itself' statement given in the stem of the question. The only measurements taken in the experiment are the height and time taken to fall. Therefore, although this would be correct with additional data, with no means to measure the final velocity this would not be a complete method.

Question 6

This question was answered well by all candidates with the vast majority correctly linking 'panels' with malleable. Although it could be assumed that steel is 'strong' and one of the reason it is used in the manufacture of cars, it is not the reason that panels can be formed from the steel. Therefore candidates must look at the specific property for the function being described, i.e. production of panels when considering the relevant property of a material.

Question 7

Candidates are expected to explain the meaning of, use and calculate stress and strain. Multiplying these two quantities together to find the area under the graph would give an expression for the work done (as on the formulae sheet at the back of the paper) divided by the volume. The factor of half should have been considered when looking at the equation for work done and explains why this was mostly only answered correctly by candidates towards A grade.

Question 8

This question asked the candidates to consider the horizontal position of the box relative to the ground. Candidates were told that the air resistance was negligible which should have led to the conclusion that its position relative to the plane would not change, i.e. response D. Those who chose response A had overlooked the initial horizontal velocity the box would have if dropped from a moving plane.

Question 9

This question was intended to examine the candidate's understanding of work done. The stem of the question specified that the ramp was frictionless, therefore only the work done against the gravitational force was required. While few candidates selected response D, the common incorrect responses of A and B indicated that the vertical component of the force *F* was not considered by many.

Question 10

This question was answered well by most candidates. Again it highlighted the confusion with some candidates as to which direction to make the acceleration. In this case the acceleration of the ball is causing a decrease in velocity so should be negative at all times. Candidates who correctly identified the correct negative acceleration graph should have been able to make the easier choice of C rather than D. The ball is clearly slowing down which would be represented by a decreasing gradient on a displacement-time graph.

Question 11

This question, relating to a familiar domestic setting may have served as an initial confidence booster with most candidates making a correct connection between viscosity and temperature, scoring the first marking point. It lulled many candidates into using familiar, unscientific language when describing the effect of the lower viscosity on the spreading process with references to runny, thinner and flows more easily and some verbose discussion about easier spreading. Perhaps it is worth reminding students at this point that they are unlikely to get any marks for repeating the information given in the stem of the question. The idea of greater force required, or work done, picked out the candidates who were really using their physics.

Some candidates did refer to the rate of flow but this was not relevant to the context as the student referred to in the question was not waiting for the butter to spread itself and flow across the bread. Some candidates did not pay close attention to the number of marks available and failed to link the change in viscosity to a physics reason for the increased spreadability.

This response scored just the first marking point for the correct link between temperature and viscosity.

A student wants to spread butter on some bread.

Explain why it is easier to use butter at room temperature than straight from the fridge.

(2)

It is easier, because as temperature increases, viscosity will decrease. As the viscosity of ~~the~~ the butter decreases it will spread faster on the bread. Straight from the fridge the butter is more viscous compare to room temperature where the temperature has increased.

ResultsPlus
Examiner Comments

Besides the reference to 'spreading faster', no physical explanation as to why it would be easier to spread has been given so the second marking point could not be awarded.

ResultsPlus
Examiner Tip

Explain style questions are usually for a minimum of two marks. Therefore, as in this case, a general physics statement will need to be applied to the context for the second mark. Repeating information such as 'easier to spread' from the stem of the question is not adding anything to your explanation that isn't already known and will not gain any more marks.

A good response which scored both marks.

A student wants to spread butter on some bread.

Explain why it is easier to use butter at room temperature than straight from the fridge.

(2)

Because the viscosity decreases when temperature increases. Room temperature is warmer than straight from the fridge. Viscosity means less resistance from the butter, making it require less force to spread the butter (easier).

ResultsPlus

Examiner Comments

The candidate included the correct relationship between viscosity and temperature and then made the link between the correct physics and the context of the question, i.e. between viscosity and easier to spread by referring to requiring less force.

Question 12 (a)

Those who scored the mark had a clear understanding of the steepest part of the graph relating to the greatest velocity. Many candidates did not go beyond describing the graph by simply stating that the gradient of the graph was the greatest at t = 1.2 s or that the balloon was at the greatest height. Some candidates incorrectly referred to terminal velocity which is uncertain as the line does not look straight and does not answer the question.

A few candidates lost the mark by referring to a greater velocity whereas the question specifically wanted a link between the greatest energy transfer and a maximum velocity. Just referring to a greater speed could involve any instant in the motion of the balloon as it is accelerating.

References to greatest acceleration were not treated as neutral and demonstrated a misunderstanding by some candidates of displacement-time graphs. Also to mention here that, although it did not prevent candidates from obtaining the marks for correct physics, it would remove the ambiguity seen in some responses if terms such as 'greatest velocity' could be used rather than using everyday language such as 'going the fastest' or 'quickest'.

This response scored 0.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

It was travelling at higher velocity because balloon is accelerating downwards. (using $E_k = \frac{1}{2}mv^2$ a higher value of V results in a higher kinetic energy))

ResultsPlus
Examiner Comments

The candidate missed the key point in the question in that the maximum was being discussed rather than just an increasing energy or velocity.

ResultsPlus
Examiner Tip

Look for adjectives such as maximum or minimum within a question. The explanation of the conditions at these extreme points will require precise terms to be used. In this case the velocity is always increasing so mentioning a 'higher velocity' is not enough to answer the question.

This response scored 0 marks.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

$E = \frac{1}{2}mv^2$ The gradient of the graph (v) is steepest at 1.20 s

so $E \propto v^2$ ∴ energy transfer is greatest where the gradient is steepest.

ResultsPlus
Examiner Comments

The candidate repeated information given in the question by mentioning that the energy transfer was the greatest. The only explanation given was in terms of the shape of the graph and did not include any physics to help explain why the graph was steepest at this time.

A good response which scored the mark.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

The balloon was travelling at a greater velocity at this time than any other point, so the air resistance on the balloon will increase

ResultsPlus
Examiner Comments

Slightly wordier than many other correct responses but the candidate correctly described the velocity being 'greater at this time than any other time' scoring the mark. The reference to air resistance was treated as neutral because, although it was true, it was not relevant to the explanation as the velocity was still a maximum.

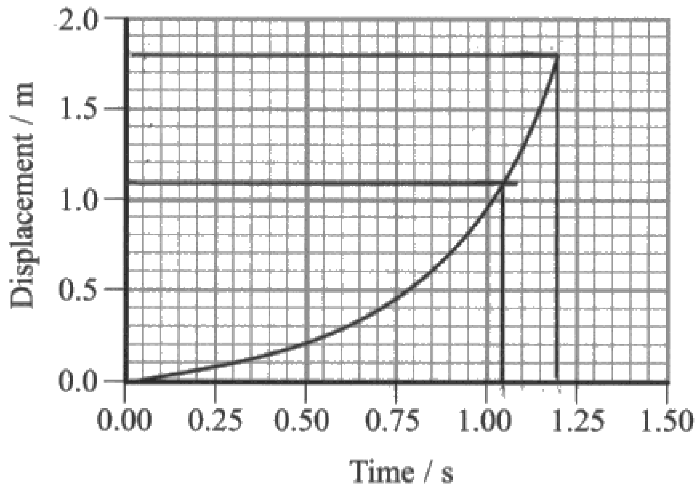
Question 12 (b)

This question was generally well answered with very few instances of candidates losing the first marking point by ignoring the question instruction to calculate the change in GPE. Considering the question made it clear that the candidates should use GPE to find out the value, a surprising number calculated the gradient of the graph and then substituted this into the kinetic energy equation, this usually resulted in only gaining the second marking point for use of the average rate of energy transfer. The majority of mistakes seen though were caused by misreading of the axes of the graph, usually preventing the candidate from scoring just the final mark for obtaining a value that was out of the given range. It was common to see two values of GPE calculated and subtracted rather than use the change in height. A correct equivalent method which involved extra work and more room for mistakes.

Quite a few candidates fell into the trap of calculating the energy difference between the two heights and then assuming that this was the answer, perhaps thinking that 0.027 was similar (ignoring the power of 10 difference) to the show that value of 0.2 W.

A good response which scored both marks.

12 A small, gas-filled balloon was dropped from a height. The displacement-time graph for the balloon is shown.



As the displacement of the balloon from its point of release increased, gravitational potential energy was transferred to kinetic energy and thermal energy.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

Because as time passes the balloon covers more displacement which means that it has higher (h) to use in the formula and gives a greater rate ($\frac{1}{2}mv^2 = mgh$)

(b) By calculating the change in gravitational potential energy of the balloon between 1.05 s and 1.20 s, show that the average rate at which the gravitational potential energy was transferred during this time interval was about 0.2 W.

mass of balloon and air = 0.004 kg

(3)

1.05s → 1.1m

1.20s → 1.8m

GPE at 1.05s ⇒ mgh = (0.004)(9.81)(1.1)

= 0.043

GPE at 1.20s ⇒ mgh = (0.004)(9.81)(1.8)

= 0.070

→ GPE(1.20) − GPE(1.05) =

= 0.070 − 0.043

= 0.027 J

so ⇒ $\frac{0.027}{1.20 - 1.05 \text{(time)}}$ = 0.18W

≈ 0.2W

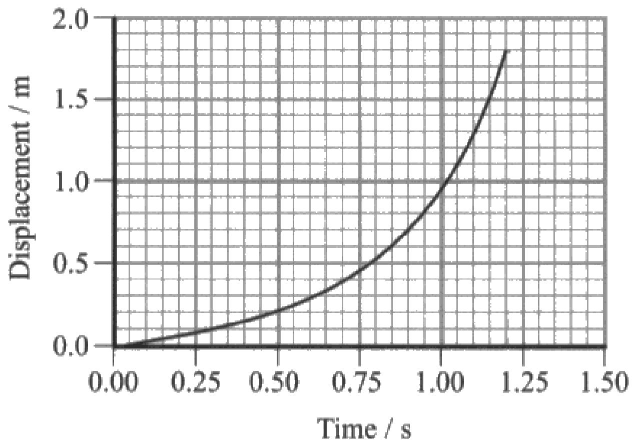
ResultsPlus

Examiner Comments

The candidate calculated the instantaneous GPE at the two given times and then subtracted them to obtain the change in GPE. They then correctly divided the change in GPE by the time taken for the change of 0.15 s to obtain a correct value to at least 1 more significant figure than the shown value of 0.2 W given in the question.

This response only scored the first mark for a calculation of the change in GPE of the balloon.

12 A small, gas-filled balloon was dropped from a height. The displacement-time graph for the balloon is shown.



As the displacement of the balloon from its point of release increased, gravitational potential energy was transferred to kinetic energy and thermal energy.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

The rate of energy transfer was greatest at 1.20s because.

(b) By calculating the change in gravitational potential energy of the balloon between 1.05 s and 1.20 s, show that the average rate at which the gravitational potential energy was transferred during this time interval was about 0.2 W.

mass of balloon and air = 0.004 kg

(3)

gpe = mgh

1.05s gpe = 0.004 x 9.81 x 1.1

= 0.04

1.20s gpe = 0.004 x 9.81 x 1.8

= 0.07

change = 0.07 − 0.04

= 0.03

ResultsPlus
Examiner Comments

No attempt was made to calculate the power or rate of energy transfer, it is almost as if the entire question had not been read before being answered.

ResultsPlus
Examiner Tip

Some questions require a two-step calculation and specifically state which two quantities are required. Underline the command parts of the question so that no steps are omitted. Here you would have to underline 'calculating (the change in gravitational potential energy)' and 'show that (the average rate at which the gravitational potential energy was transferred during this time interval was about 0.2 W)'.

Question 13 (a)

The question required the candidates to define work done using 'state what is meant by' an alternative command wording for this style of question. This question was poorly answered by the vast majority of candidates providing wordy explanations in terms of energy transfer, which it is, but that is not a definition. More successful candidates gave defined equations however most were without references to direction.

This response scored 0.

13 (a) State what is meant by work done.

(1)

Work done = Force x Distance

(The energy required to apply a force over a certain distance)

ResultsPlus
Examiner Comments

'Certain direction' is not specific enough. The direction must be stated to be in the same direction as the (applied) force.

ResultsPlus
Examiner Tip

When questions ask for a quantity to be 'stated' or 'defined' a description or explanation is not usually required. You will be expected to give a standard definition of the quantity, as you would find in a text book.

In the case of a quantity that is usually given by a formula, the formula can be written out with every term carefully defined, e.g. force x distance moved in the direction of the force.

A good response which scored 1 mark.

13 (a) State what is meant by work done.

(1)

$\Delta W = F \Delta s$ – work done is force applied (N) multiplied by displacement in the direction of the force (m)

ResultsPlus
Examiner Comments

The formula alone would not be enough for the mark because *F* and Δ*s* need defining. A clearly stated direction was given in this example.

Question 13 (b)

This question was generally answered well with many candidates achieving the correct answer, but by various routes. Candidates preferred using the $F = ma$ route to determine the acceleration and then using suitable equations of motion, usually $v^2 = u^2 + 2as$, to determine the distance as opposed to calculating the kinetic energy and equating this to the work done to obtain the distance.

The most common mistake was to subtract the two velocities first and then use the change in velocity in the equation for kinetic energy, such a response would only enable the candidate to score the first two marking points for the use of the equations. Some forgot to square the correct velocities when using them in the equation for the kinetic energy, thus preventing them from obtaining the use of mark for kinetic energy. Generally, many incorrect answers seemed to follow a fairly random method, i.e. a candidate doing any sort of calculation hoping to arrive at the correct answer without a clear direction through the calculations. This included assuming the car came to a stop and using $v = 0$, calculating only one value of KE or using g to calculate a force and sometimes subtracting the braking force from this value.

A good response which scored all 3 marks.

(b) A car of mass 1.5×10^3 kg is travelling on a country road towards a village at 55 miles per hour. The speed limit in the village is 30 miles per hour.

When the brakes are applied, there is a constant braking force of 3750 N.

Calculate the minimum distance before reaching the village that the driver should apply the brakes to avoid exceeding the speed limit.

55 miles per hour = 24.6 m s^{-1}

30 miles per hour = 13.4 m s^{-1}

(3)

$KE = \frac{1}{2}mv^2$ at 55 mph, $KE = \frac{1}{2} \times (1.5 \times 10^3) \times 24.6^2$

$= 453870$ N

at 30 mph, $KE = \frac{1}{2} \times (1.5 \times 10^3) \times 13.4^2$

$= 134670$

$453870 - 134670 = 319200$

$\frac{319200}{3750} = 85.12$ m

Minimum distance = 85.12 m

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Examiner Comments

The candidate worked out the kinetic energy of the car when travelling at both of the velocities. They then subtracted them to determine the change in kinetic energy due to braking and then equated this to the work done by the brakes on the car and divided by the force to give a correct distance of 85.1 m.

You can ignore the incorrect unit of N for the kinetic energy of the car at 55 mph. Although units can often help the examiners as to which quantities are being determined, usually when the candidate has incomplete working out, any penalties for missing or incorrect units would only be awarded in the final answer mark.

A good response again, this time using the alternative method, which scored all 3 marks.

(b) A car of mass 1.5×10^3 kg is travelling on a country road towards a village at 55 miles per hour. The speed limit in the village is 30 miles per hour.

When the brakes are applied, there is a constant braking force of 3750 N.

Calculate the minimum distance before reaching the village that the driver should apply the brakes to avoid exceeding the speed limit.

55 miles per hour = 24.6 m s^{-1}

30 miles per hour = 13.4 m s^{-1}

(3)

$F = ma$

$\frac{3750}{1.5 \times 10^3} = 2.5 ms^{-2}$

s? u 24.6 v 13.4 a −2.5

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

$179.56 = 605.16 + -5s$

Minimum distance = 85.1 m

ResultsPlus
Examiner Comments

The candidate used the more popular method of using the braking force to determine the produced deceleration of 2.5 m s^{-2}. They then used this correctly in the equation $v^2 = u^2 + 2as$ to calculate the distance over which the deceleration occurred.

The answer only required the magnitude of the distance so no penalties were given for incorrect or missing directions. However few candidates identified that the braking force and hence the subsequent deceleration should both be negative. In this case, probably on realising that 179.56 – 605.16 would give a negative value, the candidate has correctly substituted in a negative value of the acceleration so that the final calculated value for distance is positive.

ResultsPlus
Examiner Tip

Think about the directions of vector quantities when substituting them into equations. A correct direction demonstrates a better understanding of the physics to an examiner than just substituting the numbers into the equation. Even if a final answer has the correct magnitude the final answer mark may not always be given if directions have been missed out or 'fiddled' to get to the answer.

An incomplete response which scored just 1 mark.

(b) A car of mass 1.5×10^3 kg is travelling on a country road towards a village at 55 miles per hour. The speed limit in the village is 30 miles per hour.

When the brakes are applied, there is a constant braking force of 3750 N.

Calculate the minimum distance before reaching the village that the driver should apply the brakes to avoid exceeding the speed limit.

55 miles per hour = 24.6 m s^{-1} — mass = 1.5×10^3 kg

30 miles per hour = 13.4 m s^{-1} — Force = 3750 N

(3)

$\frac{1}{2}mv^2 = E_k$ — $F = ma$

$\frac{1}{2} \times (1.5 \times 10^3) \times 24.6^2 = 453870$ J — $\frac{3750}{1.5 \times 10^3} = 2.5$ m s^{-2}

$\frac{1}{2} \times (1.5 \times 10^3) \times 13.4^2 = 134670$ J

$v = \frac{s}{t}$

ResultsPlus
Examiner Comments

The candidate scored 1 mark only for either using the kinetic energy equation correctly or by the second method, use of $F = ma$.

ResultsPlus
Examiner Tip

Try to come back to incomplete answers.

It is clear in this case that the candidate did not know what to do with the two energies or the calculated acceleration. Perhaps after completing question 18(b)(i), at the end of the paper which used the equations of motion, the candidate could have attempted to use the calculated acceleration to find the distance.

Question 14 (a)

A large number of candidates scored all three marks for this item.

The command word of 'describe' led some candidates to try to explain why the statements were incorrect and answers solely in terms of vectors and scalars were treated as incomplete and did not score any marks. Responses that included references to vectors and scalars as well as correct descriptions about the statements were still able to score the marks.

The initial sentence in the question was intended to guide the candidates to the idea that the statements were incorrect based on the fact they would either be describing vector or scalar quantities so any descriptions should be based on picking out the flaws, i.e. describing any incorrect terms or missing words.

Statement 1

Several correct comments were often made, however candidates referring to 'it' made it unclear whether reference was being made to the mass or the weight. Sometimes the reader was expected to make their own deductions when candidates re-wrote the statement with the correction. Ideally the candidates should have stated the error before correcting it. This was the easiest of the three statements and if a mark was not awarded it was most likely due to an unclear answer rather than a lack of physics knowledge.

Statement 2

Given that direction is not usually considered when discussing the speed of light this statement seemed to cause the most confusion. Many candidates stated that light can travel in all directions or mentioned that you would need to see a reference to 'in a vacuum'.

Statement 3

This was answered very well and indicated that candidates, as they should be, are aware that a car that slows down should have a negative acceleration. Some candidates just replaced the word acceleration with deceleration and a few suggested using both deceleration and a negative value of acceleration, i.e. a double negative which lost them the mark.

A good answer which scored all 3 marks.

14 Physical quantities can be vectors or scalars.

(a) Describe what is wrong with each of the following statements.

(3)

A car has a mass of 10 000 N acting vertically downwards.

The unit for mass should be "kg" rather than "N". "N" is for force.

The velocity of light from the Sun is 3×10^8 m s^{-1}.

If any one wants to use velocity to replace, they have to state the direction as well, in this case, velocity should change to speed.

The car slowed down with an acceleration of 2.5 m s^{-2}.

Minus sign should be applied in front of $2.5 ms^{-2}$, due to the car is slowing down.

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Examiner Comments

The candidate identified and described clearly what was wrong with each of the three statements.

ResultsPlus
Examiner Tip

'Describe' as a command word in a question requires you to discuss, in terms of what is written on the page, the information given. You do not need to explain why the statement is wrong, just tell the examiner where it is wrong.

Another good response which scored all 3 marks.

14 Physical quantities can be vectors or scalars.

(a) Describe what is wrong with each of the following statements.

(3)

A car has a mass of 10 000 N acting vertically downwards.

"mass" should be changed to "weight"

The velocity of light from the Sun is 3×10^8 m s^{-1}.

"velocity" should be "speed"

The car slowed down with an acceleration of 2.5 m s^{-2}.

"acceleration" should be "deceleration"

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Examiner Comments

Rather than describe what was wrong with each statement, the candidate corrected each statement, this was an acceptable way to answer this question.

This response scored just 1 mark for the first statement.

14 Physical quantities can be vectors or scalars.

(a) Describe what is wrong with each of the following statements.

(3)

A car has a mass of 10 000 N acting vertically downwards.

Mass is a Scalar and so doesn't have a direction. weight is a vector of mass multiplied by acceleration due to gravity

The velocity of light from the Sun is 3×10^8 m s^{-1}.

The velocity isn't from an origin, it has no displacement value. velocity is a vector

The car slowed down with an acceleration of 2.5 m s^{-2}.

The car isn't slowed down with an acceleration, a force causes the mass to accelerate by 2.5 m s^{-2}

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Examiner Comments

The mark was awarded for statement 1 for the first sentence in identifying that a direction was not required for the mass.

No mark was awarded for the second statement as telling us that velocity was a vector quantity was not identifying what was wrong with the statement.

The third statement was not precise enough in describing what was wrong. '....isn't slowed down with an acceleration' is not telling us what was wrong in that it should be speeding up. The rest of the answer, although not incorrect, does not add anything further to the description.

Question 14 (b)

The vast majority of candidates managed to add together the two distances to score the mark. Candidates that were not awarded the mark had usually a missing or incorrect (usually m) unit. There was only one unit error for the whole of 14(b) so a second missing unit for the displacement in part (b)(ii) was not penalised. However the large number of unit errors in this question indicates a lack of focus on the question stem and context as well as the speed at which many candidates were clearly working through the earlier parts of Section B of the paper.

Most candidates could use Pythagoras successfully to obtain the magnitude of the displacement, however a complete correct statement of the direction was rarely seen with a significant proportion of candidates failing to realise that 'direction' means calculate an angle. Many candidates just quoted a direction of north east or gave an angle in the direction of north east, neither of which would have scored the last mark. A quoted direction along with an indication of an angle on a diagram enabled more candidates to be awarded the final mark however the final angle of 34° should have been quoted as E of N. The variation between candidates in their abilities to quote the direction of a vector correctly does highlight the need for a variety of contexts to be given to candidates when determining the resultants of vectors both by calculation and by drawing.

This response scored the first 3 marks.

(b) A car travels 45 km due north and then 30 km due east.

(i) Calculate the total distance travelled by the car.

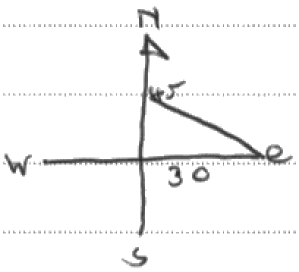
(1)

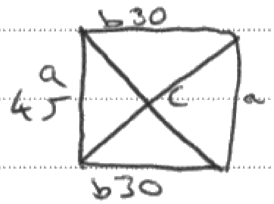
45 + 30 = 75

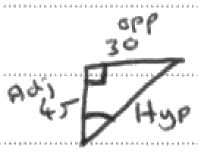
Total distance travelled = 75 km

(ii) Calculate the displacement of the car.

(3)







45 Tan(90)

$a^2 + b^2 = c^2$

$45^2 + 30^2 = c^2$ c = 54.083

Magnitude of displacement = 54.083 km

Direction = 54°

ResultsPlus
Examiner Comments

(i) Correct distance with unit given (1 mark)

(ii) Correct use of Pythagoras to obtain a correct distance with correct unit of 54.083 km. The direction of 54° has been calculated but the only angle indicated anywhere within the answer section is to the north and 54°should be to the east. Therefore the last mark for the direction could not be awarded.

ResultsPlus
Examiner Tip

When a question asks for a vector quantity, unless the question only asks for the magnitude, a direction will be required as well. Just calculating an angle using trigonometry is not enough, the direction must be with reference to a fixed direction such as east of north. In this question you could not just state 'from the north' as it could go anti-clockwise and be west of north. Make sure that the direction you state is clear and could not be confused with another fixed direction point.

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

(b) A car travels 45 km due north and then 30 km due east.

(i) Calculate the total distance travelled by the car. **(1)**

~~$\sqrt{45^2+30^2} = 54.08$~~

Total distance travelled = ~~54.08 km~~ 75 km

(ii) Calculate the displacement of the car. **(3)**

$\sqrt{45^2+30^2} = 54.08$ km

Magnitude of displacement = 54.08 km

Direction = 45° /NE

ResultsPlus

Examiner Comments

Again it was the direction that cost the candidate the final mark. In this case there was no attempt to calculate the direction with an approximate 45° or NE given. This was not precise enough and did not get the direction mark.

A good response which scored all 4 marks for part (b).

(b) A car travels 45 km due north and then 30 km due east.

(i) Calculate the total distance travelled by the car.

(1)

~~$s = \sqrt{45^2 + 30^2}$~~ ~~$s = 54.08326913$~~ $45 + 30 = 75$

Total distance travelled = ~~54 km~~ 75 km

(ii) Calculate the displacement of the car.

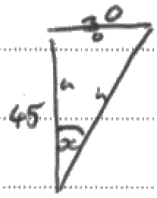
Sol Cah Toa

(3)

$s = \sqrt{45^2 + 30^2}$

$= 54.08326913$

km



$\tan^{-1}\left(\frac{30}{45}\right) = 33.69$

Magnitude of displacement = 54 km

Direction = 34° from north

ResultsPlus

Examiner Comments

(i) Correct distance with unit (1 mark).

(ii) Correct use of Pythagoras to obtain the correct distance of 54 km. The direction was calculated and, although 'from the north' was not quite enough for the mark, the candidate indicated on the diagram that it was from the north towards the east (drawn into their triangle) so that the final mark could be awarded.

Question 15 (a) (i)

Part (a)(i) required the candidates to use *W* = *mg* to calculate the weight, divide this by 4 and then to resolve to find the component of the weight along the legs. While most candidates managed to score at least one mark for one of these stages far fewer were able to carry out all three steps successfully to obtain the correct tension of 1.5×10^{-3} N.

The physics involved in this question was fairly straightforward however many candidates found the context to be more challenging, often missing key words in the stem of the question such as the correct number of legs to consider. Many candidates missed the key information given right at the beginning of the question (but still on the same page) that only four of the six legs were in contact with the twig therefore preventing them from scoring the third and final marks for this item. The most frequent number of marks awarded across the candidates of lower abilities was two, mainly from using an incorrect number of legs or from incorrect trigonometry. This did shift to a mode of 4 (only just though) for the more able candidates demonstrating that greater care needs to be taken when selecting information from the question and when using trigonometry to calculate the components of a force.

A correct response which scored all 4 marks.

(i) Calculate the tension in the lower section of each leg in contact with the twig assuming that these tensions are all equal.

mass of praying mantis = 5.4×10^{-4} kg

(4)

$W = mg$

$W = 5.4 \times 10^{-4} \times 9.81$

$W = 5.2974 \times 10^{-3}$ N

Weight shared by each leg $= \frac{W}{4}$

$= \frac{5.2974 \times 10^{-3}}{4}$

$= 1.32435 \times 10^{-3}$

Tension $= 1.32435 \times 10^{-3} = T \cos 30°$

$T = 1.5292 \times 10^{-3}$

$T = 1.53 \times 10^{-3}$

Tension = 1.53×10^{-3} N

ResultsPlus

Examiner Comments

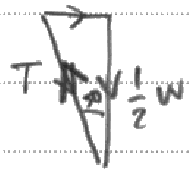
The candidate correctly used *W* = *mg* to find the weight of the praying mantis. They then divided by 4 and correctly used trigonometry to determine the component of the weight acting along each leg (top right of the response) giving a correct answer with unit.

This response scored just 2 marks.

(i) Calculate the tension in the lower section of each leg in contact with the twig assuming that these tensions are all equal.

mass of praying mantis = 5.4×10^{-4} kg

(4)



$\cos 30 = \frac{\frac{1}{2} w}{T}$

$T = \frac{\frac{1}{2} \times 5.4 \times 10^{-4} \times 9.81}{\cos 30} = 3.06 \times 10^{-3}$ N

Tension = 3.06×10^{-3} N

ResultsPlus
Examiner Comments

The candidate used *W* = *mg* but a factor of 1/2 can be seen as they have assumed that the weight only acts over two legs and not 4.

The candidate then divided by cos 30 to find the component of weight along each leg. Therefore only marking points 1 and 2 were awarded as the final answer was not correct.

Question 15 (a) (ii)

Very few responses scored the mark with this question because candidates did not discuss it in terms of components of the weight of the praying mantis. The marks awarded were only then to those at the top end of the ability range. The term component was required before the mark could be awarded and it was found that candidates that did not use the term component at all usually were going down the wrong route of discussing numbers of legs or distribution of forces. Some candidates came near to a correct statement by stating that the tension was at an angle but rarely went any further and into detail about components of weight.

Most responses discussed general ideas such as the centre of gravity not being at the midpoint or the weight/mass not being equally distributed between the legs. Other candidates seemed to think that there was some significance to the two legs that were not in contact with the twig and stated that the weight should be divided between all 6 legs while a smaller proportion of candidates discussed the reaction force from the twig.

1 mark was awarded for identifying that the tension would have a horizontal component as well.

(ii) A student suggests that the tension in each leg in contact with the twig is 25% of the weight of the praying mantis. State why this is **not** correct.

(1)

The vertical component of the tension in each leg is equal to 25% of the weight, but there is a horizontal component as well

ResultsPlus
Examiner Comments

This candidate had two correct statements that could have each scored the mark on their own.

'Vertical component of the tension equals 25% of the weight' or 'there is a horizontal component as well'.

ResultsPlus
Examiner Tip

When a vector quantity, in this case the weight, is resolved into a component, the other component (at 90° to the one you have calculated) is still there and may also have to be considered when describing the motion or as in this case the forces acting on the object.

This response scored no marks.

(ii) A student suggests that the tension in each leg in contact with the twig is 25% of the weight of the praying mantis. State why this is **not** correct.

(1)

Because the mass of mantis is not uniformly spread across its volume

ResultsPlus
Examiner Comments

The candidate has not considered the components of the weight and has gone down the route of describing an uneven distribution of the mass of the praying mantis.

Question 15 (b)

While most candidates had the right idea about tensile and compressive stress, a number discussed the magnitude rather than the type of stress and incorrectly thought that the stress in the legs would be larger when the praying mantis was on top of the twig compared to when it was below.

Some candidates referred to a compressive and tensile force but were credited because the question was examining the difference between compressive and tensile rather than the understanding of the term stress.

A good response which scored the mark.

(b) The praying mantis moves around the twig so that it is now standing upright and on top of the twig.

State the difference between the stress in the legs when the praying mantis is beneath the twig and when it is on top of the twig.

(1)

When it is above the twig, the stress in the ~~legs~~ leg is ~~tensile~~ compressive stress. When it is below the twig, the stress in the leg is tensile ~~stress~~ stress.

ResultsPlus
Examiner Comments

The candidate mentioned the nature of the stresses rather than make a comparison of their magnitudes when above and below the twig as required.

This response did not score the mark.

(b) The praying mantis moves around the twig so that it is now standing upright and on top of the twig.

State the difference between the stress in the legs when the praying mantis is beneath the twig and when it is on top of the twig.

(1)

$Stress = \frac{F}{A}$, so as the force increases, the stress increases. The Stress is larger when the mantis is on top of the twig, opposed to being beneath it.

ResultsPlus
Examiner Comments

The candidate incorrectly described the magnitude of the stress increasing when the praying mantis was on top of the twig.

ResultsPlus
Examiner Tip

The weight of the praying mantis does not change as it moves from being under the twig to being on top of the twig. Therefore the force causing the stress remains the same, it is now just acting downwards from the top of the body whereas before it was acting downwards, below the body, hence the change from tensile to a compressive stress.

Question 16 (a) (i)

This question was answered well with most candidates stating a correct conclusion in that the wire obeys Hooke's Law. The statement 'in relation to this graph' in the stem of the question was missed by some with answers in terms of the force and not the mass. Some candidates could not articulate an alternative description for increases linearly and did not describe a relationship beyond stating that the graph had a constant gradient.

A good response which scored both marks.

(i) Initially the extension increased linearly.

State what is meant by 'increased linearly' in relation to this graph and what can be concluded about the wire from this observation.

(2)

The linear increase means that the extension and mass is proportional, as the mass increases. This shows that the material is following Hooke's law.

ResultsPlus

Examiner Comments

The candidate described the two variables on the graph and has mentioned both mass and extension and then made a correct conclusion, linking this to Hooke's Law.

ResultsPlus

Examiner Tip

If a question asks you to specifically refer to a graph you must not bring in any other variables, just describe or explain what is in front of you on the paper.

This response scored 1 mark for the correct reference to Hooke's Law.

(i) Initially the extension increased linearly.

State what is meant by 'increased linearly' in relation to this graph and what can be concluded about the wire from this observation.

(2)

'Increased linearly' is the straight line portion of the graph. In this section, the ~~Alo~~ wire stretches elastically as it obey's Hooke's law, as the extension is directly proportional to the force applied. The wire had not deformed past its elastic limit.

ResultsPlus

Examiner Comments

The candidate missed the key command in the stem of the question 'in relation to this graph' and recalled their knowledge rather than used the context as the question demands and described the relationship between force and not the mass and extension.

'Straight line' alone would not be sufficient for the first mark. It was an incomplete description of the shape of the graph. Given that the relationship between the variables in Hooke's law is one that is increasing, the statement given for the first marking point was intended to be the link between the shape of the graph and the conclusion made.

Question 16 (a) (ii)

This question was answered well with half of all candidates scoring all three marks and the vast majority attempting a calculation of the area below the correct region of the graph. This was not a straightforward use of $\frac{1}{2}F\Delta x$ question. Firstly the graph was that of applied mass and not weight so to obtain the final answer mark $W = mg$ should have been used at some stage within the calculation. No individual mark was given to the use of $W = mg$ as this had already been examined in the first marking point of 15(a)(i) so it was expected to have been used in order to produce the final correct answer.

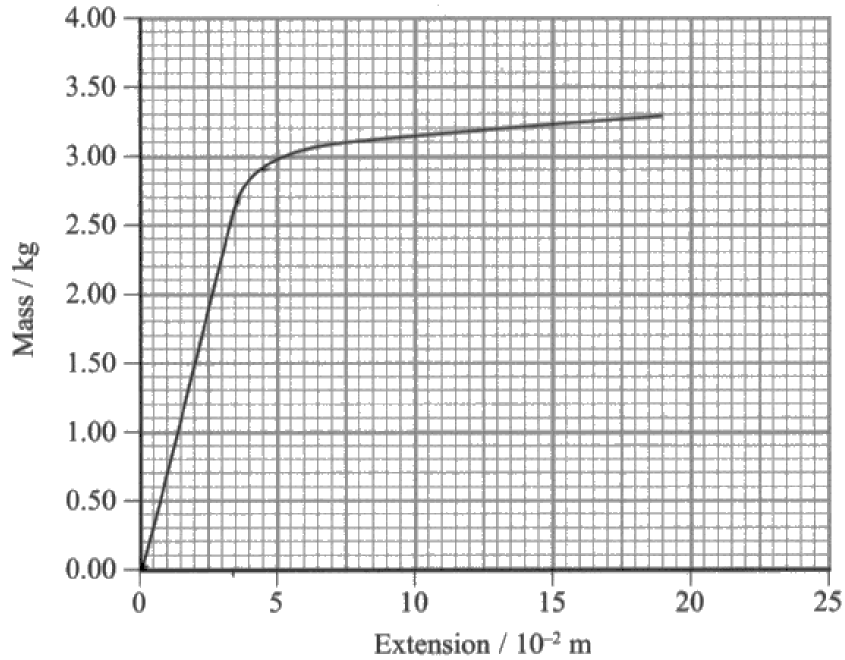
Candidates were also expected to identify the correct position of the limit of proportionality. The main source of errors with this question by far was the large numbers of power of ten errors when either reading the extension from the horizontal axes of the graph or from forgetting to multiply the mass by *g*. Although predominantly effecting middle ability candidates, some more able candidates also lost out on marks due to careless reading of powers of ten from the axis. An issue that appears every examination series.

A few candidates attempted to find the gradient while others used *F* x *d* with either the maximum mass/force or the mass/force at the limit of proportionality. As this is not the area under the graph it counted as using an incorrect formula and producing double the correct value for the maximum energy. Such methods only permitted candidates to score the second mark for identifying the correct position of the limit of proportionality.

Some candidates attempted to find the gradient of the linear region of the graph and then substitute this into $E = \frac{1}{2}k\Delta x^2$ which did not always manage to score all three marks due to rounding in the additional step creating a final answer slightly out of the acceptable range.

A good response which scored all 3 marks.

(a) The following mass-extension graph was obtained.



(ii) Use the graph to calculate the maximum energy that the wire could store while behaving linearly.

(3)

$E = \frac{1}{2}Fe$ $\quad W = mg$

$2.7 \times 9.81 = 26.487$ N

$\frac{1}{2} \times 26.487 \times (3.5 \times 10^{-2}) = 0.46$ J

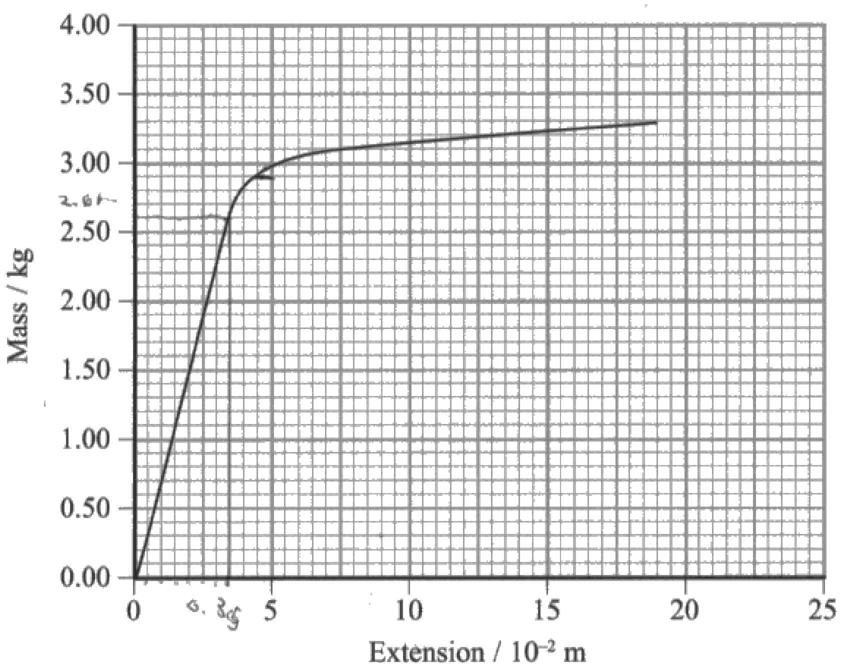
Maximum energy = 0.46 J

ResultsPlus
Examiner Comments

The candidate correctly identified the applied mass at the limit of proportionality and then used this in the equation *W* = *mg* to calculate the applied force at this point. They then used the equation ½FΔx to calculate the value for the maximum energy.

This response scored 2 marks.

(a) The following mass-extension graph was obtained.



(ii) Use the graph to calculate the maximum energy that the wire could store while behaving linearly.

(3)

$\frac{1}{2} f \times \Delta x$ $\quad x = 0.35$ m

$\frac{1}{2} \times 25.506 \times 0.35$ $\quad m = 2.6$ kg $\quad f = m \times g$

$= 4.46355$ $\quad 2.6 \times 9.81 = 25.506$ N

$= 4.46$ J

Maximum energy = 4.46 J

ResultsPlus
Examiner Comments

The limit of proportionality was identified correctly to be at 2.6 kg and the subsequent applied force was calculated using $W = mg$. The candidate then read the extension at the limit of proportionality as 0.35 rather than the correct value of 0.035 or 3.5 x 10^{-2}. Therefore due to the power of ten error the final answer mark could not be awarded.

ResultsPlus
Examiner Tip

When reading from a graph check the labels on the axis to see if a scale has been used. Sometimes the scale will be in the form of a pre-fix of a unit or, as in this case, the scaling factor will have been included next to the unit.

Question 16 (a) (iii)

The vast majority of candidates who sat this paper were able to identify that the material would now be producing a plastic or permanent deformation, scoring the second marking point. A large number of responses contained multiple instances of the second marking point with some going overboard with additional information that was not relevant or describing the behaviour beyond this point, such as Hooke's Law was no longer valid, mass and extension were no longer proportional or the wire was ductile.

Few candidates thought to discuss the relative sizes between the applied force/mass and the subsequent extension. Although some attempts were seen that indicated consideration of the vast change in gradient on the graph beyond this point, these were usually not precise enough to score the first mark, 'extends faster' being an example of such a response.

This response scored 1 mark.

(iii) Describe the behaviour of the wire when the added mass was greater than 2.9 kg.

(2)

The material behaved plasmically, it extended more than expected, it doesn't obey Hookes law any more, and will not return back to it's original shape if the force was removed.

ResultsPlus
Examiner Comments

The candidate scored the second marking point only, for 'behaves plastically' and 'will not return back to its original shape'.

ResultsPlus
Examiner Tip

When looking at the graph the decrease in the gradient indicates that the material has yielded, i.e. exceeded its yield point. Although a consequence of this is that the material will now be permanently deformed the main implication is that the material will now exhibit plastic properties. This means that for a small increase in the applied force there will be a large increase in the extension.

A good response which scored both marks.

(iii) Describe the behaviour of the wire when the added mass was greater than 2.9 kg.

(2)

when the mass added was greater than ~~22~~ 2.9kg, the wire no longer obeyed hookes law as it surpassed the limit of proportionality and was plastically deformed, as shown by the large increase in extension for the low increase in mass.

ResultsPlus

Examiner Comments

The candidate clearly identified that there would be plastic deformation and then added the further explanation that there would be a large increase in extension for a low (small) increase in mass.

The additional information at the beginning, although true, did not add anything further to the explanation and so was treated as neutral and ignored.

Question 16 (b) (i)

This question was answered very well with the most common responses being longer or thinner with smaller cross sectional area seen, although less frequently. Some candidates often gave more than one alternative response, usually retaining the mark but sometimes including an incorrect suggestion such as shorter length making any correct suggestions void and losing the mark.

A few candidates stated the variable to be changed without stating the specific modification in how it would change. Therefore a response such as 'use a wire with a different value of *k*' would not have scored the mark.

This response scored 1 mark.

(b) The student modifies the investigation.

(i) Suggest **one** modification that would produce a greater extension for a given mass.

(1)

Increase the original length of the wire.

ResultsPlus

Examiner Comments

This was a straightforward response scoring the mark.

Another good response which scored 1 mark.

(b) The student modifies the investigation.

(i) Suggest **one** modification that would produce a greater extension for a given mass.

(1)

Reduce the cross-sectional area of the wire.

ResultsPlus

Examiner Comments

Reduce cross sectional area was an acceptable answer.

Just to note that a few candidates lost the mark through carelessness in mentioning the **surface** rather than the **cross sectional** area.

ResultsPlus

Examiner Tip

It is worth noting that you need to take care when using 'cross sectional' and 'surface' to make sure you have selected the intended term.

Question 16 (b) (ii)

Candidates were asked to describe two measuring techniques, ideally two measures they would have taken when completing this or a similar practical themselves, to ensure the accuracy of the measured extensions. This item was not answered well with half of all candidates failing to score any marks at all. Most suggestions would not have improved the accuracy of the experiment and would have made no difference to their measurements at all. The common standard response when the term accuracy is mentioned in a question of repeat (and average) was not relevant, neither was the suggestion to use a second person to take the measurements. The question only concerned with the accuracy of each individual measurement.

Many candidates discussed the precision suggesting using a meter rule with mm graduations. Another common suggestion was to use a vernier or micrometer to measure the diameter of the wire which was not the question asked as they were only asked to comment on the extension measurement. Others suggested using photography or video, usually to reduce parallax, without the consideration that the same parallax errors could still be present. One other incorrect suggestion commonly seen proposed weighing the masses on a balance to check their accuracy, again, not the measurement being asked about in the question. Some candidates suggested using light sensors but their exact use and role in taking the measurements of extension were usually not described and were not thought to be sufficient for the mark. If additional equipment is to be used to improve accuracy the candidate must describe rather than just state its use.

More successful responses scored a mark for reading at eye level however there was some variations in the description of this which, although it was clear what the candidate was describing, led to some ambiguity and the mark not being awarded. Therefore responses such as 'look directly at the scale' and 'look along/parallel to the scale' did not score the mark. Other good responses included use of a marker, description of a set square (and not just a statement of 'use a set square') and, although not very frequently, adding masses gently or waiting for the extension to finish.

This response scored 1 mark.

(ii) Suggest **two** measuring techniques that could be used to ensure the accuracy of the measured extensions.

(2)

1) Place a marker on the wire before ~~a~~ the loads are added, measure the distance. Then measure its distance post-load.

2) Use a recording camera to watch ~~to~~ the ruler, so that it reads the measurement from the same location each time

(Total for Question 16 = 10 marks)

ResultsPlus
Examiner Comments

One mark was awarded here for use of a (fiducial) marker on the wire.

The second suggestion of a recording camera was treated as neutral and ignored, however the candidate has clearly been trying to describe a method to avoid parallax albeit unsuccessfully. Although some experiments do lend themselves to the being filmed, usually as a timing method, candidates should be aware that due to the position of the camera relative to the scale, parallax errors may still be present.

This response did not score any marks.

(ii) Suggest **two** measuring techniques that could be used to ensure the accuracy of the measured extensions.

(2)

- Repeat again with ~~wire of exact dimensions~~ same ~~wire~~ type of wire with the same dimensions
- Use a video camera to record the rule next to the slotted masses

ResultsPlus
Examiner Comments

Repeating the experiment did not score the mark, this would have improved the reliability but not the accuracy of the individual measurement.

The second point is again heading towards reducing the parallax but has not been described clearly enough for the mark. The idea that the rule should be next to the masses is heading in the right direction but is an expected method rather than an additional measure to ensure accurate results. Placing the rule behind the wire or as near as possible to the wire shows examiners that the candidate has taken an additional step towards greater accuracy.

Just to include one response that did score both marks.

(ii) Suggest **two** measuring techniques that could be used to ensure the accuracy of the measured extensions.

(2)

marking the ~~[illegible]~~ wire with a white tab so you can tell exactly where to measure from. Also weight until both the tabs have stopped moving before taking the measurement.

ResultsPlus

Examiner Comments

The candidate scored the mark for describing the use of a marker (white tab) and the suggestion that you should wait for the wire to stop moving (assuming this means extending) before taking the measurement scored the second mark.

This was clearly a candidate who had carried out this or a similar experiment and made notes at the time of the additional steps taken to improve the accuracy of the measured extensions.

Question 17 (a)

Question 17 required a good understanding of Newton's laws and was less straightforward to explain than previous questions. The common misunderstanding was the one that most non-scientists would give, the man would fall over when the train accelerated because he was being pushed. However, candidates of all abilities were able to attempt this question with less able candidates usually only scoring a mark for a description of Newton's first law with the more able candidates heading towards, and sometimes successfully, applying Newton's laws to the context.

The first marking point that could be awarded was for a description of Newton's first law. Not all candidates were very precise in their statement of the law but the mark scheme was lenient on that. Too many candidates used the word 'external' over 'resultant' when describing this law and were not awarded the mark. Candidates should be aware that the law requires use of a 'resultant force' and not an 'external force'.

Many did say that the man would remain still while the train accelerated away beneath him, enabling the third marking point to be awarded. Only the more successful candidates identified that there were two systems of motion occurring and managed to separate out the forces acting on the top half from those acting on the lower half of his body. Therefore responses that considered the feet accelerating or having a resultant force were very good (and scored the second marking point) but unfortunately rare. Some candidates that managed to identify that the feet were significant in this question lost out on the mark by not specifically mentioning resultant (force) choosing to just state that there is a force on the feet. This could also imply the upwards reaction force on the feet and candidates must take extra care when more than one force acts on a body to specify which force.

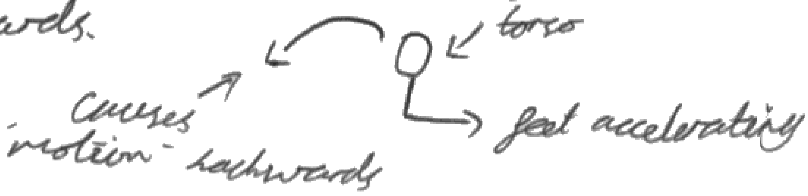
It is very common for candidates to slip back into everyday language and where a question specifically mentioned Newton's laws most points should lead to a statement about the **acceleration** or **resultant force** or both. Therefore comments such as 'the man will move' rather than specifically say 'accelerates' are not enough to imply that an acceleration is taking place and should be avoided.

This response scored all 3 marks.

Use Newton's first law of motion to explain why he falls backwards.

(3)

Newton's first law states that an object at rest or at a constant velocity will not accelerate unless a resultant force is applied to it. In this ~~same~~ case, there is a resultant force, and that's acting forwards. The carriage speeds up and his feet speed up too, as they're in contact with the carriage, however, his torso remains without a resultant force, and it does not accelerate. As his feet ~~move~~ accelerate forward, and his torso remains at a constant velocity, he falls backwards.



ResultsPlus
Examiner Comments

Marking point one was awarded for the description of Newton's first law in lines 1-4.

Marking point two was awarded for the candidate identifying in line 6 that the feet are accelerating 'feet speed up'.

This candidate clearly understood the context of the question and separated out the motion of the lower half of the body from that of the top half of the body. Marking point three was awarded for lines 8 and 9 where the candidate has said that the torso remains without a resultant force and does not accelerate. All descriptions were clear and the candidate then went on to describe again the feet accelerating and the torso falling back as it remains at a constant velocity.

This response scored 1 mark.

Use Newton's first law of motion to explain why he falls backwards.

(3)

Newton's first law states that if the forces acting on an object are in equilibrium (ie. no resultant force) then they will remain moving at a constant velocity. In this train, when ~~the train~~ it accelerates for a moment the man continues to move at his previous velocity but the train is now accelerating forwards, so the man's velocity is less relative to the train so he moves backwards because there is a resultant force acting on him in the opposite direction.

ResultsPlus

Examiner Comments

Marking point one was awarded for an adequate description of Newton's first law.

It looked as though the third marking point (1st alternative response) could be awarded for lines 5-7 in that the candidate described the motion of the man relative to the train and identified that the train would be accelerating but the man would continue to travel at his previous velocity. This was then contradicted by the candidate saying that there was a resultant force acting on the man. As the candidate did not specify as to whether they were talking about the top or the bottom half of the body it can only be assumed that they have effectively said that an object is moving at a constant velocity with a resultant force. Therefore, due to this contradiction, no further marks could be awarded.

Due to the candidate not specifying that the force referred to in Newton's first law was a resultant force they did not scored any marks for this response.

Use Newton's first law of motion to explain why he falls backwards.

(3)

Newtons first low states that an object at rest must have a force applied on it to move it away from constant speed. ~~as~~ And so the passenger falls back because he is suddenly getting a force acted on him and so he will fall back ~~until~~ until he gets accustomed to the direction of travel and acceleration.

ResultsPlus
Examiner Comments

Beyond the incomplete description of Newton's first law the candidate then made the common misconception that there would be a force pulling the man back, making him accelerate to the floor. A correct link between (resultant) force and acceleration however not applicable in this context.

ResultsPlus
Examiner Tip

Do not just refer to a force when using Newton's laws.

It is a resultant force that will cause an acceleration. Just mentioning 'force' could be referring to the normal contact force of the floor on the feet or the man's weight. In this question (and in part (b)) we were only interested in the horizontal forces acting on the man, particularly the resultant of the horizontal forces acting on the man so please be specific when using the term 'force'.

Question 17 (b)

This question discriminated well, with the majority of candidates scoring a maximum of two marks, usually in two bands between those middle ability or less able candidates that believed there was no resultant force and the more able candidates (probably A grade only) that identified there was now a resultant force and could explain why.

Most candidates achieved marking points one and two, although sometimes not very clearly, for use of Newton's third law in identifying the forces between the man and the support. In a complete reversal of the physics seen in part (a) most candidates then thought that these forces 'cancelled out' and that there was no resultant force on the man and hence the man did not fall over. Many candidates therefore did not appreciate that the third law pair of forces act on different bodies. There was much confusion after this, often including snippets of correct physics which was unfortunately contradicted by earlier incorrect statements in many responses and could not score.

A small number of candidates lost out on some marks for correct physics and application to the context in marking points 2 and 4 as they did not state which law they were discussing. It was also found that the few who did score the third marking point for identifying that there was a resultant force on the man usually went on to score at least 4 marks on this question and occasionally if they remembered to compare the acceleration or velocity of the man and train (MP5) they could score all 5 marks.

This typical response scored the first two marking points only.

With reference to Newton's laws of motion, explain why holding on to a vertical support prevents the passenger falling backwards.

(5)

Newton's second law that Σ Force = mass × acceleration. Even though the train is accelerating, the person does not fall backwards as his resultant force is zero because he is holding on the ~~the~~ vertical support. Newton's third law states that to every force, there is an equal and opposite reaction force. So as the person is holding on to the support, the force of him falling backwards is balanced out by the force that he is holding onto the vertical support. The ~~forces~~ contact forces of the hand on the support is equal in magnitude and opposite directions of the contact force of support on the hand.

ResultsPlus
Examiner Comments

As mentioned previously just the first two marks for the last three lines where the candidate has identified the third law pair of forces and linked this (reading on from the section above) to the third law.

No further marks could be scored because the candidate assumed that the resultant force was zero.

This response scored two marks only (MP1 and MP2).

With reference to Newton's laws of motion, explain why holding on to a vertical support prevents the passenger falling backwards.

(5)

• when tram accelerates, the passenger experiences a resultant force backwards (Newton's 1st Law)
~~[illegible]~~ (he moves) → object will stay at rest / constant V if there is no resultant force.
• when he holds on to the support, as he begins to pull on it backwards, the support exerts an equal but opposite force on the man, pulling him forwards. (Newton's 3rd Law) (if object A exerts a force on object B, B responds with an equal + opposite force on A.)
• This means the forces cancel out and there is no resultant force, therefore due to Newton's 2nd Law (F=ma) there can be no acceleration for the man, (also as he is of constant mass.)

ResultsPlus
Examiner Comments

This answer started off very well with a description of a resultant force on the man (mp3). This was then followed by a clear explanation of the N3 forces between the man and the support in lines 4-7. The candidate then suddenly decided that there was not a resultant force after all because the N3 forces cancel out and the man was not accelerating.

Therefore the third mark has been contradicted and can no longer be awarded.

ResultsPlus
Examiner Tip

Please check through long explanations to make sure that you have not included any contradicting points.

The two forces involved in a Newton's third law pair act on different bodies so can never cancel out. When considering the resultant forces you should only be looking at the forces acting on the object, i.e. in this case one half of a N3 pair, the man.

An excellent, clearly written response which scored all 5 marks.

With reference to Newton's laws of motion, explain why holding on to a vertical support prevents the passenger falling backwards.

(5)

The first law now shows that because a force is applied to him he will accelerate with the train as ΣF ≠ 0. The passenger is pulled by the train whilst holding onto the rail, this resultant force allows him to accelerate at the same rate as the train. (So he doesn't fall back). Newtons Third law describes pairs of forces. As the train exerts a force on his arm, his arm also exerts a force on the train. These forces are equal in magnitude, the same type of force, opposite in direction AND ACT on DIFFERENT bodies. because ~~the~~ force forces act on different bodies there is a resultant force on the man ∴ he will accelerate with the train. This is a "third law pair". The Second law also states that the acceleration is ~~direction~~ directly proportional to the resultant force and that the acceleration acts in the same direction as the resultant force. (inversely prop to mass too!)

(Total for Question 17 = 8 marks)

ResultsPlus
Examiner Comments

Although on reading this response you will see a clear explanation of the motion of the man the breakdown of marks is as shown below:

Line 1 = MP5

Line 5 = MP3 for the idea that there is a resultant force acting on the man

Lines 7-9 = MP1 and MP2 for identifying the third law pair of forces and linking to N3.

Line 15 onwards = MP4 for linking the acceleration to N2.

Question 18 (a) (i)

This question showed an encouraging understanding of projectiles from most candidates. They either correctly concluded that the ball was kicked from a greater initial height or they interpreted the data to conclude that the ball must have landed on the ground before the goal.

Some less able candidates argued that the ball can't go below the ground which did not score the mark as they failed to link this to what must have happened such as bouncing, greater initial height etc. Answers describing that the ball did not reach the goal were also unsuccessful as the candidate had not told us why the ball hadn't reached the goal.

This response scored the mark.

(i) State the significance of the negative value of height for an angle of 10°.

(1)

It must mean that the ball made contact with the ground before it ~~reathet~~ reached the goal.

ResultsPlus

Examiner Comments

'Made contact with the ground' demonstrated an understanding of the significance of the negative height.

A good response which scored the mark.

(i) State the significance of the negative value of height for an angle of 10°.

(1)

The height is lower than that it was kicked at, at 10°.

ResultsPlus

Examiner Comments

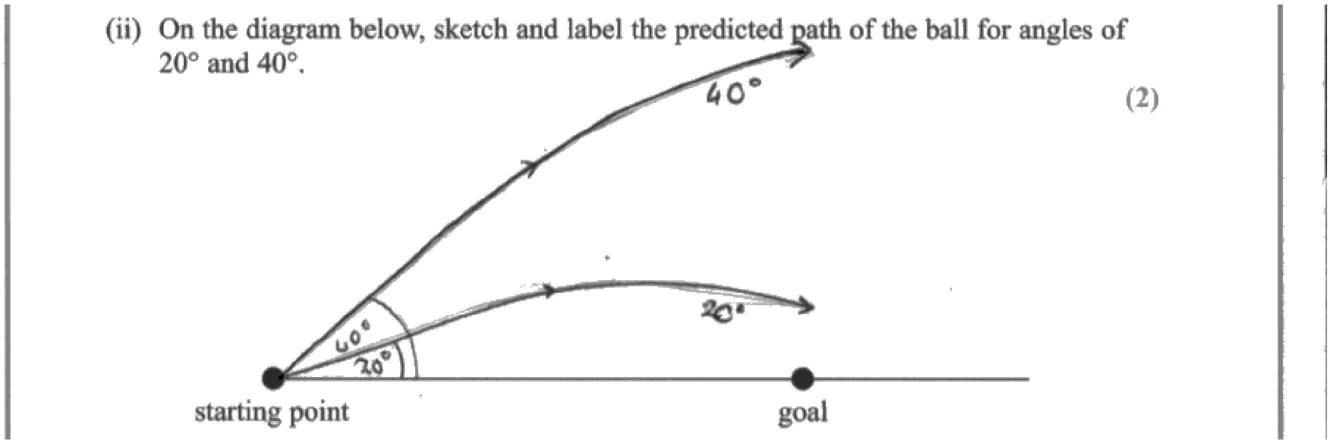
Although quite a few alternative responses could be given, this type of response where the candidate considered the initial height and the final height demonstrated a good understanding of the role of direction with vector quantities as well as the good understanding of the context of the question.

Question 18 (a) (ii)

With over half of all candidates scoring both marks, this question was answered well. While most candidates managed to score the first mark for drawing a parabolic curve, less able candidates tended to lose out on the second mark for failing to indicate that the range of the 40° trajectory would be greater than that of the 20°. Candidates did not have to draw the trajectories beyond the goal however it should have been clear that two ranges (had they been completed) were not the same. Ambiguous answers that looked as though both trajectories would end at the same point were not able to score the higher demand mark.

It can be difficult to draw a parabolic trajectory by eye and there was a large margin of tolerance accepted. However, many of the responses seen took little care to consider the key features of a trajectory such as the symmetry (assuming they are ignoring drag/spin) and the constantly decreasing then increasing gradient. Hence rulers should not have been used and the maxima should not be horizontal.

A good response which scored both marks.



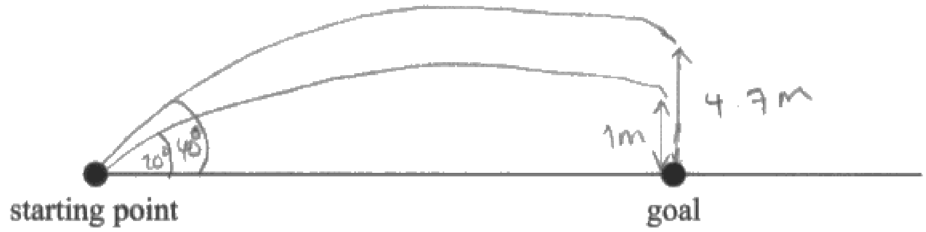
ResultsPlus
Examiner Comments

The candidate had two correctly drawn trajectories and had considered the relative positions of the ball at the goal depending on the initial angle.

A rather poorly drawn but typical response that (just about) managed to score the first mark for the shape of the trajectory.

(ii) On the diagram below, sketch and label the predicted path of the ball for angles of 20° and 40°.

(2)



ResultsPlus

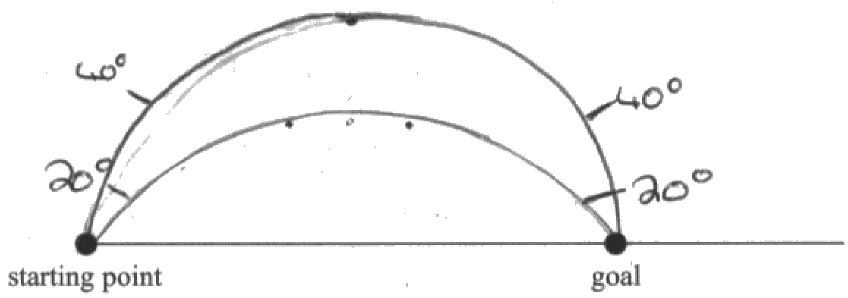
Examiner Comments

As a guide examiners looked for the position of the maxima to decide whether the range of the 40° would be greater than that of the 20° initial angle trajectory. It was unclear from the candidate's drawing if the two paths would have different ranges and as it looked as though the maxima are in the same place and the ranges would be the same. Therefore a second mark could not be awarded.

1 mark scored for the shape of the trajectory.

(ii) On the diagram below, sketch and label the predicted path of the ball for angles of 20° and 40°.

(2)



ResultsPlus

Examiner Comments

The candidate drew the same range for both trajectories. The second marking point was examining the knowledge that different initial angles would create different maximum heights and hence ranges with the requirement that both trajectories were correct to at least the goal.

Question 18 (b) (i)

This question was answered well by candidates and discriminated well across all ability groups with the vast majority of candidates scoring. Candidates approached this question methodically demonstrating good teaching and preparation.

Most candidates managed to calculate the horizontal and vertical components of the initial velocity with many going on to calculate the time to travel the horizontal distance of 11m. At this point some candidates became side-tracked and started to calculate the maximum height assuming that this was the height of the ball at the goal. However some marks could often be salvaged for earlier work, usually just marks 1 and 3, for the components of the initial velocity.

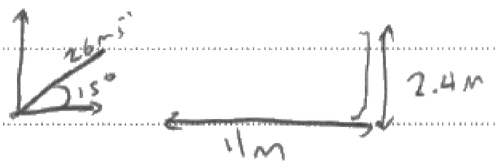
Candidates usually selected the correct formula of $s = ut + ½at^2$ to determine the height however a negative value of g had to be substituted to be awarded this mark. Few arithmetic errors were seen and most candidates who obtained a correct value of 2.01 m as the maximum height then realised they had to add the radius or diameter in order to make a sensible conclusion as to whether the goal would be scored. A bold statement that the goal would or would not be scored was not sufficient and required some comparison, however small, e.g. (2.01 + 0.22 =) 2.23< 2.4 m to be made.

Candidates who had an incorrect height though arithmetic errors, use of a positive value of *g* or had determined the maximum height were still able to access the last mark for marking a comparison between the height calculated and the height of the goal, a skill which required some interpretation of the context and worth examining.

This response scored 4 marks.

By means of a calculation, determine whether or not the ball will pass into the goal. You may ignore the effects of air resistance.

(6)



$26 \times \cos 15 = 25.11\ \text{m s}^{-1}$ = h. component of v.

$\frac{11}{25.11} = 0.438$ seconds

$26 \times \sin 15 = 6.73\ \text{m s}^{-1}$

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

$s = (6.73 \times 0.438) + (0.5 \times 9.81 \times (0.438)^2) = 3.89\ \text{m}$

$3.89 - 0.22 = 3.67\ \text{m}$

$3.67 > 2.4\ \text{m}$ so ∴ the ball won't go into the goal.

ResultsPlus

Examiner Comments

This candidate scored the first 3 marks for correctly calculating the initial horizontal velocity (25.11 m s^{-1}), the time to the goal (0.438 s) and the initial vertical velocity (6.73 m s^{-1}). Although the correct equation of motion was selected the candidate failed to use the correct direction for the acceleration and substituted in a positive value of *g* creating a height at the goal of 3.89 m. This prevented the candidate from scoring marking points 4 and 5 however they then made a sensible conclusion and comparison based on their calculated height and could score the last marking point for a comparison between their calculated height to that of the goal.

ResultsPlus

Examiner Tip

For projectiles moving upwards, if you take the upwards velocity and displacement to be positive then the acceleration will be negative. The force causing the acceleration is gravity which acts downwards and causes a negative acceleration, i.e. a deceleration.

A good response which scored all 5 marks.

By means of a calculation, determine whether or not the ball will pass into the goal. You may ignore the effects of air resistance.

(6)

Horizontal velocity = 26 cos 15 = 25.1 ms^{-1}

$u = 25.1$ $s = 11$ $a = 0$ $t = ?$

$s = ut + \frac{1}{2}at^2$ $11 = 25.1t + 0t^2$

$t = 11/25.1 = 0.438$ s for ball to reach goal

vertical velocity = 26 sin 15 = 6.73 ms^{-1}

$u = 6.73$ $a = -9.8$ $t = 0.438$ $s = ?$

$s = ut + \frac{1}{2}at^2$ $s = 6.73 \times 0.439 + \frac{1}{2} -9.81 \times 0.438^2$

$s = 2.01$ m

ball's height will be 2.01 m when it reaches the goal, so it will pass into the goal.

ResultsPlus

Examiner Comments

This response completed all the necessary stages to obtain a correct value for the height of the ball at the goal of 2.01 m.

The candidate did not manage to score the last mark because they did not justify their final statement by adding on the diameter or radius of the football.

ResultsPlus

Examiner Tip

If you are asked to make a judgement in a question a bold 'yes' or 'no' will not suffice. You will need to use the value calculated to explain your decision even if it is as simple as adding on a value or comparing your value to one given in the question.

Question 18 (b) (ii)

The majority of candidates who sat this paper scored at least one mark for this question. This was usually for the second marking point where a correct comment usually described a decreased range or maximum height.

This was a two mark response and required an explanation so one mark was available for the direct effect on the motion, i.e. deceleration, decreased range, etc. and the second mark required an explanation, i.e. a link between the stated air resistance and the deceleration. Candidates tended to describe all the effects on the motion without supplying an explanation. Therefore the first mark for describing the negative effect of the air resistance i.e. **negative** direction, work done **against,** etc. was not awarded very frequently.

As seen in previous examinations most candidates who tried to describe the change to the velocity of the projectile due to the air resistance failed to grasp the concept that the force was not instantaneous but was acting all of the time so its effect would be continuous and there would be a deceleration. Responses that just described a lower speed/velocity were not specific enough and only those describing a deceleration or decreasing speed could score the second mark for this.

Just to note that a common misconception that became apparent was that many candidates believed there to be a horizontal force making the ball accelerate. This led to responses describing a decreasing acceleration due to the air resistance rather than just a deceleration.

This response scored 2 marks.

(ii) Air resistance would cause an additional force on the ball.

Explain the effect this would have on the ball's motion.

(2)

air resistance acuse a drag force on the ball which reduces the distance the ball coul travel. ~~due to~~ due to work done against frictional forces. ~~therefore~~ the motion of the ball is less as it travel less horizontal distance and vertical distance.

ResultsPlus
Examiner Comments

The candidate correctly explained that because work was done against the air resistance the effect would be a reduced horizontal distance (range) and maximum height.

ResultsPlus
Examiner Tip

If a question asks you to explain an effect you will not only have to state the effect but will also have to use your knowledge of physics to support this.

In this question there were a few effects that you could have described however the reason for all of them happening was the same, the air resistance acted against the motion or work was done against air resistance. You could have even discussed this in terms of resultant force in that there would now be a resultant force horizontally that was **backwards** or **negative** or the **negative** resultant force vertically was greater (up to the maximum).

Just 1 mark was awarded for this response.

(ii) Air resistance would cause an additional force on the ball.

Explain the effect this would have on the ball's motion.

(2)

It would slow down the ball's horizontal speed, so in fact the ball would decelerate.

ResultsPlus

Examiner Comments

This response scored the mark for the horizontal deceleration.

The comment regarding the horizontal speed was very common and insufficient for the mark as the speed wasn't just slowed down implying it jumped to a lower value, it was constantly slowing down.

Question 19 (a) (i)

Most candidates (82%) were able to correctly draw and label upthrust, drag and weight appropriately.

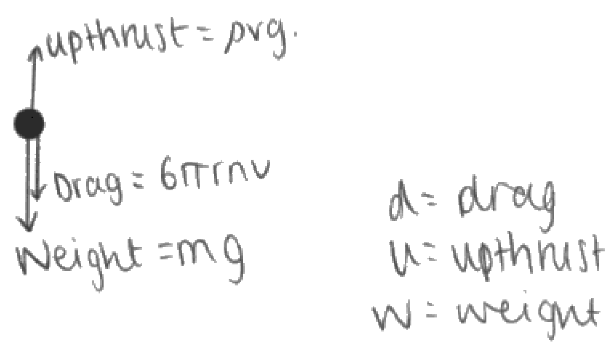
A few candidates did not start their arrows at the dot and lost out on the marks through carelessness rather than lack of knowledge. The forces in a free-body diagram must be straight lines (drawn with a rule) originating from the dot.

Some candidates, probably from confusing this question with previous questions and experiments with small balls falling in fluids, drew the drag force as upwards.

A good response which scored all 3 marks.

(a) (i) Complete the free-body force diagram for a bubble as it rises through the liquid.

(3)



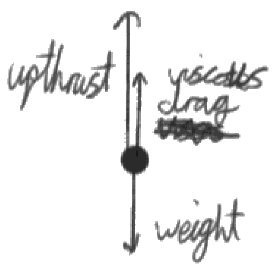
ResultsPlus
Examiner Comments

By eye, the lines are all vertical and the labels with correct labels.

This response was awarded 2 marks.

(a) (i) Complete the free-body force diagram for a bubble as it rises through the liquid.

(3)



ResultsPlus
Examiner Comments

The drag force was incorrectly drawn as upwards rather than downwards.

Question 19 (a) (ii)

The idea that the upthrust would increase for larger bubbles generally got a mark but the fact that the drag increases as well was less well understood.

Quite a few candidates didn't really think that any other force needed to be mentioned beyond the upthrust but some managed to pick up the third mark by mentioning greater terminal velocity or greater resultant force. Those who made the comparison between the drag and the upthrust were often awarded all 3 marks for just one sentence demonstrating a good understanding of the concept, e.g. 'the increase in upthrust is greater than the increase in drag'.

Non-scoring responses included 'reached terminal velocity quicker' which would not be the case for the larger bubbles.

This response scored 2 marks, marking points 1 and 3.

*(ii) It is observed that larger bubbles reach the top of the column of liquid in less time than smaller bubbles.

By considering the forces acting on a bubble as it rises, explain this observation.

(3)

$F = 6\pi\eta r v$

Larger bubbles have greater cross-sectional areas which means that the upthrust is greater for larger bubbles than smaller bubbles. With a greater upthrust ~~> weight +~~ ~~d~~ in comparison to the weight plus the drag the bubbles rises up faster. There is a greater resultant upward force on larger bubbles.

ResultsPlus

Examiner Comments

The candidate correctly identified that the upthrust would increase. We were not expecting, for this mark, an explanation as to why the upthrust increased so ignored the candidate's incorrect attempt at an explanation.

The candidate did not mention that the drag increasing but commented on a greater resultant force, scoring the third mark as well.

This response scored all 3 marks.

*(ii) It is observed that larger bubbles reach the top of the column of liquid in less time than smaller bubbles.

By considering the forces acting on a bubble as it rises, explain this observation.

(3)

Larger bubbles displace more liquid. As upthrust equals the weight of the liquid displaced, the larger bubbles experience greater upthrust. The larger bubbles do experience greater viscous drag but this is not enough to cancel out the force from upthrust. Therefore the bubbles have a greater resultant force acting on them which means they experience greater acceleration and rise in less time

ResultsPlus

Examiner Comments

Marking points 1 and 2 were awarded for identifying that there would be a greater upthrust and drag force. The final mark was then awarded for a greater resultant force.

The statement in line 5 comparing the two forces would not have been sufficient for a comparison mark. They were comparing the forces acting on one bubble, i.e. effectively saying that there was a resultant force, rather than the difference between the increase in the forces on both bubbles.

Question 19 (b) (i)

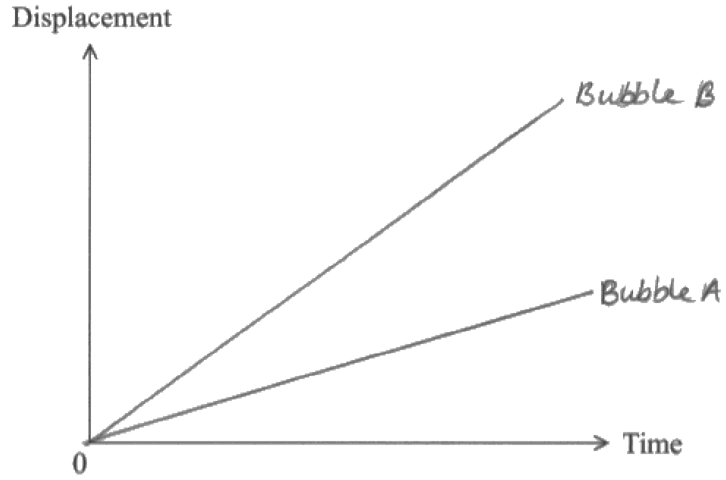
It should have been clear from the photographs that the bubbles were rising at an approximately constant speed however a large number drew very curved graphs.

One mark was awarded to candidates that had identified that the initial gradient of A, the smaller bubble, should be lower than that for B indicating a lower terminal velocity for the smaller bubble. The mark was awarded independently of the shape of the graph so the candidates who had drawn curves of increasing or decreasing gradient could still be credited for the correct physics of representing two velocities on a displacement-time graph.

This response was awarded 2 marks.

(i) Sketch on the axes below two labelled lines to show how the displacements of the smaller bubble A and the larger bubble B vary with time over the four images.

(2)



ResultsPlus
Examiner Comments

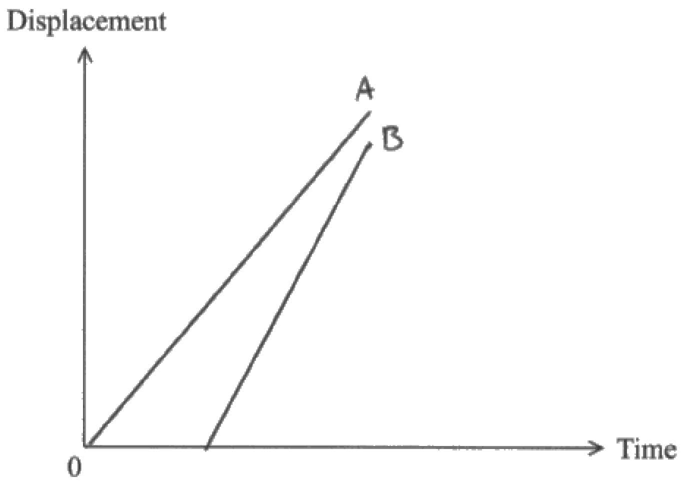
The candidate realised that the smaller bubble would be travelling at a lower velocity than the larger bubble and so drew the smaller bubble with a lower gradient, starting from $t = 0$.

The candidate also realised that the bubbles were moving at a constant (terminal) velocity and so correctly represented the motion as a straight line on the displacement-time graph.

This response was awarded 1 mark.

(i) Sketch on the axes below two labelled lines to show how the displacements of the smaller bubble A and the larger bubble B vary with time over the four images.

(2)



ResultsPlus
Examiner Comments

t = 0 was the same for both bubbles. They were in the same image therefore they should have both started from t = 0, a requirement for the first marking point.

This candidate scored just the second mark for the gradient of A being lower than the gradient of B.

Question 19 (b) (ii)

With nearly half of all candidates scoring all 4 marks, this question was answered well and was a good discriminator.

The most common measurement was 0.5 cm with most candidates managing to obtain a reading in range. Some candidates forgot to scale the photographs and the factor of 12 was missing. The most common mistake seen was a power of ten error created by those who forgot to convert cm from the measurement to m when quoting the final velocity in m s^{-1}.

Some candidates chose to ignore the instruction that the measurements should be taken from photographs 2 - 3 and chose instead to find the total distance travelled over all four photographs. These candidates usually went on to score all 4 marks as the appropriate time of 0.99 s was used.

A good response which scored all 4 marks

(ii) The photographs are at a scale of 1 to 12. By using measurements from the photographs, calculate the speed of bubble B between photographs 2 and 3.

(4)

change = 45mm − 40mm = 5mm

scale 5x12 = 60 mm = 0.06m

0.33 s

$\frac{0.06}{0.33}$ = 0.18 m s^{-1}

Speed of bubble B = 0.18 m s^{-1}

ResultsPlus
Examiner Comments

- The candidate measured the distance moved from the images as 5 mm (MP1)
- This was then multiplied by 12 to find the actual distance travelled between the images (MP2)
- The distance in mm was then converted to a distance in m.
- The candidate then used speed = distance/time (MP3) to calculate a correct value for the velocity of the bubble with a correct unit (MP4)

ResultsPlus
Examiner Tip

Take care when quoting the final units of a question to make sure that this is consistent with all of the values you have used within the question.

In this example the candidate converted the distance in mm to one in m so the final speed could be quoted in m s^{-1}.

This response scored just 1 mark.

(ii) The photographs are at a scale of 1 to 12. By using measurements from the photographs, calculate the speed of bubble B between photographs 2 and 3.

(4)

t = 0.33s 3.6cm in 2 4cm in 3

4cm − 3.6cm = 0.4cm

t = 0.33

D = S × T

S = D / T

$\frac{0.4}{100} = \frac{4 \times 10^{-3}}{0.33} = S$

$s = 0.012\,ms^{-1}$

Speed of bubble B = $0.012\,ms^{-1}$

ResultsPlus

Examiner Comments

- The measurement taken from the photograph was 0.4 cm which was out of the acceptable range for the first marking point.
- The candidate converted the distance to m but did not apply the scale and the factor of 12 was not been used.
- The candidate used the equation speed = distance/time correctly and was awarded the third marking point only.
- The final answer was incorrect and out of range so no further marks could be awarded.

Question 19 (c) (i)

This question was intended to be a straightforward recall of knowledge required for specification point 20, Stokes' Law. It highlighted the variation between candidates in their understanding of the correct conditions to be able to apply the law.

Many candidates omitted the 'small' with spheres or assumed that the spheres had to be moving at a terminal velocity.

The most common mark to award was the second marking point for a description of the radius or shape changing as the bubble rose.

The most common response seen that did not score referred to the viscosity (or sometimes other quantities from $6\pi r\eta v$) not being known showing no knowledge of the conditions required to apply the law beyond interpreting the equation at the back of the paper.

This response scored 2 marks.

(c) A student wishes to determine the total drag force acting on a bubble.

(i) Explain why it might not be possible to use Stokes' law to calculate the drag force acting on a bubble.

(2)

The Stoke's law equation can only be calculated for small round objects. The bubbles might be too big. Also it would be hard to calculate their diameter as it is always changing shape as it moves up the tube.

ResultsPlus
Examiner Comments

One mark was awarded for identifying that the law can only be applied to 'small round objects'.

A second mark was given for 'changing shape'.

The comments about the difficulties measuring the diameter suggest that this candidate may have confused the question. The candidate would have just spent a significant amount of time taking measurements from the photographs in part (b)(ii) so it should have been evident that any measurement of the diameter could be taken from the photographs.

This response did not score any marks.

(c) A student wishes to determine the total drag force acting on a bubble.

(i) Explain why it might not be possible to use Stokes' law to calculate the drag force acting on a bubble.
(2)

It may not be perfectly spherical, therefore the radius would be incorrect. ~~Or~~ Also, it may never reach terminal velocity as it's so light weight, therefore V would be incorrect.

$6\pi r v \eta = f$

ResultsPlus
Examiner Comments

The candidate has correctly identified that the object needed to be spherical but omitted the key point that it needed to be small as well.

The comment referring to the terminal velocity was incorrect so no marks were awarded.

ResultsPlus
Examiner Tip

Stokes' Law was used to determine the drag force acting on a small sphere moving through a fluid. In order to apply this law certain conditions must be met such as there must only be laminar (or no turbulent flow) and the object must be a small sphere and the object must be moving with a low speed.

The law applies if the object is moving at a constant speed or still accelerating to reach its terminal/constant speed.

Question 19 (c) (ii)

This question was attempted by most candidates with many of those at E grade or above scoring at least 1 mark, usually for the measurement of the diameter or radius. With only the most able candidates scoring 3 or 4 marks (11.5 %).

More students opted for the Stoke's Law method than the resultant forces method but usually only scored 1 mark for the measurement of the diameter or radius as candidates did not usually explain how to calculate the terminal velocity. Quite a few candidates mentioned that the viscosity of the fluid would need to be known.

With the resultant forces method a surprising large number of candidates referred to measuring the radius to get the volume without referring to the equation for the volume. The question asked how the measurement 'could be used to determine the drag force' so no assumptions should have been made and a detailed explanation was required. A second mark was frequently awarded to the more able candidates for stating the equation for the resultant force (drag = upthrust - weight) but as mentioned above the lack of detail in how to obtain these quantities prevented many from scoring the second and third marking points for $4/3\pi r^3$ and $V\rho g$.

This was a good response. Unfortunately the candidate forgot to include '*g*' in their explanation of the calculation of the upthrust and weight so the third marking point was not be awarded.

*(ii) Describe an additional measurement that would need to be taken from the photograph and how it could be used to determine the drag force, assuming that the bubble has reached its terminal velocity.

(4)

The radius of the bubble would be needed from the photograph assuming the ~~spheres~~ spheres are spherical. We know that $U = W + D$ at terminal velocity, so $\frac{4}{3}\pi r^3 \rho_{liquid} = \frac{4}{3}\pi r^3 \rho_{air} + 6\pi r v \eta$ so D or $6\pi r v \eta$, $D = \frac{4}{3}\pi r^3 (\rho_{liquid} - \rho_{air})$ (volume) thus we can find the drag force if we know the radius of the bubble as using it's volume. And we know the difference in densities from liquid to air.

(Total for Question 19 = 18 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

$F = 6\pi r v \eta$

$W = \frac{4}{3}\pi r^3 (\rho_{air})$

$U = \frac{4}{3}\pi r^3 (\rho_{liquid})$

ResultsPlus

Examiner Comments

- Marking point 1 for identifying that the only measurement would have to be the radius.
- Marking point 4 for $U = W + D$ (symbols were accepted for this mark but to achieve all 4 marks, as this was a QWC item, definitions were required)
- Marking point 3 for seeing $4/3\pi r^3$ appropriately described.
- No marking point 3 for $\rho V g$ to find the upthrust or weight of the bubble as the mass has not been multiplied by the *g* to give the weight or upthrust.

This response scored 1 mark.

*(ii) Describe an additional measurement that would need to be taken from the photograph and how it could be used to determine the drag force, assuming that the bubble has reached its terminal velocity.

(4)

we would need to measure the ~~radius~~ radius of the bubble from the photograph to be able to calculate drag ~~action~~ acting on the bubble.

We would ~~so~~ also need to know the density of the liquid and air in the bubble to work out upthrust and weight and ~~take them~~ ~~to~~ use these to calculate drag force by rearranging the equasion including these and stokes law.

(Total for Question 19 = 18 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

ResultsPlus

Examiner Comments

This scored 1 mark for 'measure the radius'.

The candidate then went on to describe all the additional information that would be required but not how to use it to determine the drag force. No further marks could be 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 language lacked precision and its ambiguity prevented some marks from being awarded.

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

- slow down during the multiple choice items so that key words in the command sentence responses are not missed
- remember to check responses if there is time at the end of the paper in case careless mistakes have been made, especially powers of 10 or missing units
- accurate definitions of all terms given in italics in the specification
- practice drawing parabolic paths for projectiles and always use a ruler for free-body diagrams
- do not confuse resultant with external force. An external force can contribute to a resultant force but there could be other forces acting on the system that would need to be considered as well
- make sure that you have thought about the direction of vector quantities before substituting them into equations of motion or representing them on graphs
- read the question and answer exactly what is being asked.

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