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Examiners' Report
June 2012

GCE Physics 6PH01 01

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Introduction

This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. The knowledge of candidates, with respect to starting the course did show good progression from GCSE to the end of the AS stage. The candidates' ability to apply their knowledge successfully to contexts given was of a good standard but often they did not score as highly as would be expected, especially for the higher ability candidates when the contexts were more challenging. This was very evident in questions 14(c), 17(c) and 18(b)(vi).

Calculations were answered well across the ability ranges. There was a good use of units and formulae that were given to the candidates and were manipulated and used well. Across all ability ranges, there was a great improvement in the correct use of direction with vector quantities.

Weaker candidates often misread values from graphs as well as apply the wrong method once the data was obtained. This was seen with questions 14(b) and 18(b(iv) and it would be an idea to go through, as part of a revision task, all the typical graphs that a candidate would have seen during the teaching of the unit and practice methods required for obtaining physical quantities using the gradient or area. One other point that was common across most ability ranges was the application of F= ma and F= 6πrηv. The majority of candidates can select and use the correct formula but only a few seemed to be able to understand that when more than one force is involved, a resultant force is required. This was evident in questions 17(b)(ii) and 18(b)(ii) where the candidates were required to identify that there is a resultant force, calculate it's value and then use the formulae.

In section B the first few questions required candidates to apply their knowledge and definitions of physical quantities and properties to a given context. Whilst most candidates were able to quote definitions and laws, and score some marks, candidates across all ability ranges found it difficult to apply the piece of Physics that had been quoted. This was true for questions 11 to 14(a)

Section A

Multiple choice question	Subject	Percentage of candidates who answered correctly	Most common incorrect response
1	Base units	82	C
2	Velocity-time graphs	87	D
3	Calculation of tensile strain	61	A
4	Identification of scalar and vector quantities	79	C
5	Properties of materials	99	D
6	Calculation of KE	90	A
7	Resolving a vector quantity into its components	57	C then A
8	Relationship between GPE and KE of a falling object	54	D
9	Calculation of power	92	A
10	Identification of key points on a stress- strain graph	64	D then B

The multiple choice items scored highly with an average of 7.7 marks obtained in this section. Question 8 was the only question that was found challenging across all ability groups. Questions 3 and 7 were found to be more challenging due to their mathematical nature and in question 10 candidates confused the ultimate tensile strength with the maximum tensile stress.

Question 3 did require the candidate to conclude that double the length would give double the extension or to equate equations for the strain or Young modulus for both wires to give a value of $2\Delta x$. Given the most common incorrect answer seen, it would appear that some candidates assumed that doubling the length had the same effect as applying the same force to 2 parallel strings of the original length.

Question 4 did not require any knowledge of vectors beyond being able to identify scalar and vector quantities. This specification point (5) could be introduced independently very early on in the course, to allow it to be reinforced as the quantities are taught during the year.

Question 6 required use of KE = ½ mv2 .The most common incorrect response was due to candidates forgetting to square the velocity which should not be happening at this level of Physics.

Question 7 covered a concept many students, especially those not taking A level maths find challenging: to be able to resolve a vector quantity into components parallel (in this case) and perpendicular to a slope. The only other use of angles was in question 16(a)(iii) and if the candidates had drawn out a correct triangle of the forces involved this was seen to be a much easier and hence more successful task. Given that in the past candidates have not only been asked to resolve forces on a slope but to then use the components of their forces to find other quantities such as acceleration, this is an area of the curriculum that they would benefit from doing extra practice.

Question 8 was found difficult by candidates across all abilities. Candidates realised that there is a reduction in GPE but concluded that as the object is accelerating the graph must be a curve. Hence response D was the most popular. This question required either an application of the conservation of energy or the relevant equation of motion (v2= u2 + 2as) to show that v2µ -s to give a straight line.

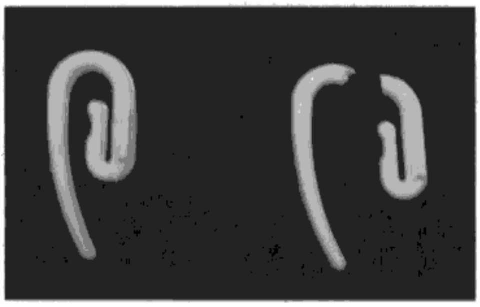
Question 10 as mentioned above was mainly answered incorrectly due to confusion between the terms ‘ultimate tensile strength’ and ‘maximum tensile stress’, indicating candidates rushing at this point rather than a lack of knowledge.

Question 11

This question required the candidates to explain plastic behaviour and then state and explain the type of behaviour that the hook exhibited. Although the context of the question is a curtain hook, text book definitions would have earned the candidate 3 marks with a further mark for identifying the hook was brittle. Many candidates did not attempt to explain plastic behaviour at all. References to permanent deformation were often incomplete with candidates failing to mention that this would only happen only once the force had been removed. Most common mark scored was 2, usually for identifying brittle and then an explanation of brittle or a reference to plastic behaviour and permanent deformation. This question has highlighted the need for complete definitions to be covered as part of the curriculum, as well as an understanding of the concepts.

*11 A student is taking down some curtains and notices that several of the curtain hooks snap when they are bent.

The photograph shows an unsnapped hook and a snapped hook.



The student thinks that it is odd that the material the hooks are made from is referred to as plastic when the hooks don't show plastic behaviour.

The student finds the following list of terms used to describe materials.

Brittle   ~~Ductile~~   ~~Hard~~   ~~Malleable~~   ~~Tough~~

Only one of these terms describes the behaviour of the hooks.

Explain what is meant by 'the hooks don't show plastic behaviour' and state and explain the term from the list that correctly describes the behaviour.

(4)

The hooks don't show plastic behaviour because plastic behaviour is when a ~~material~~ force is exerted on a material, then that material change shape due to plastic deformation and remain in that shape when the force is removed. The hooks ~~3~~ snap and so therefore cannot withstand the force, meaning the hooks display a brittle quality as they crack easily and do not deform plastically.

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Examiner Comments

This response scores 3 marks, a correct explanation of plastic deformation and brittle identified. No explanation of brittle.

ResultsPlus
Examiner Tip

Go through the specification and make sure that you know complete and accurate definitions for all the terms that have been written in italics.

Explain what is meant by 'the hooks don't show plastic behaviour' and state and explain the term from the list that correctly describes the behaviour.

(4)

Plastic behaviour is where materials permanently deforms or changes shape when a force is applied, it does not return to its original shape, even after the load is removed, it is plastically deformed. However, the hook does not undergo plastic deformation, it is brittle. Brittle material are those that break without plastic deformation when an impact force is applied.

ResultsPlus
Examiner Comments

This response scores all 4 marks. They correctly described plastic behaviour and then identified the behaviour as brittle with an explanation of brittle. The reference to impact force at the end was ignored as it is not incorrect but is just not relevant to the force used to break the hook in this case.

Question 12

This question scored highly as candidates found the context more accessible than previous questions on Newton's 3rd law. Candidates were required to quote the law and then explain how this context provided evidence that the 2 forces involved were a 3rd law pair.

Most candidates could attempt a fairly accurate version of Newton's 3rd law. Those writing the minimum of 'for every action there is an equal and opposite reaction' often scoring better than those who chose to describe the forces in more detail. This was mainly due to the omission of the direction or stating that the forces act in different, rather than opposite directions.

Many candidates were able to process the information and describe how it related to the third law, the most common omissions being that the forces act on different bodies and are the same type of force. As is usually found with questions on Newton's Laws some candidates did repeat the stem of the question, rather than pull out the required information to demonstrate how these forces were a third law pair.

Some candidates did lose marks because they assumed that as the forces are equal in magnitude and opposite in direction then the resultant force would be 0 with the forces in equilibrium. This demonstrates the poor understanding of some candidates for the requirement of the forces to be acting on separate bodies.

A good response scoring all 5 marks.

12 A student entering a physics classroom sees the following sentences on the board. These sentences are being used as examples in an explanation of Newton's third law.

The car tyre exerts a frictional contact force of 300 N backwards on the road.

The road exerts a frictional contact force of 300 N forwards on the car tyre.

State Newton's third law.

Explain how the sentences provide a good example of a Newton's third law pair.

(5)

~~- The forces are the same type - frictional contact force~~

Newton's third law is when body A exerts a force of body B and body B exerts an equal and opposite force on body A. These sentances ~~are~~ are an example of Newton's third law because: the ~~f~~ exerted forces are the same type - frictional contact force. The forces are of the same magnitude, 300N and act in opposite directions to eachother. The forces act on seperate bodies (car + road), on the same line of action.

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Examiner Comments

An accurate statement on the third law followed by the conditions required for the forces to be a third law pair. Each condition has been linked to the relevant part of the statement. Marks would have been awarded for either the conditions or the correct parts of the statement identified and this candidate has described both.

This response would score 3 marks. The candidate has tried to rewrite the statements explaining the similarities and differences between the 2 forces but they have really just repeated the stem of the question which would not gain any marks alone.

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>
> *The road exerts a frictional contact force of 300 N forwards on the car tyre.*

State Newton's third law.

Explain how the sentences provide a good example of a Newton's third law pair.

(5)

Newton's third law: If body A exerts a force on body B, body B exerts an equal but opposite force on body A.

The sentences provide a good example of Newton's third law pair as the second sentence states that the road exerts an equal force on the car tyre ~~white~~ ~~the~~ forward, while the car tyre was exerting a backward frictional force of 300N on the road. In the two sentences body B (road) exerts an equal but opposite force on body A (car tyre).

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Examiner Comments

Due to the final sentence, some of the conditions have been identified so marks were awarded for, in addition to one for the statement of the law, identifying that there are 2 bodies and the forces are equal (the magnitude was implied in their rewriting of the stem of the question). No mark for identifying that the forces act in opposite direction as we needed to see the word 'direction' with opposite and lines 4 to 6 are a repeat of the stem of the question.

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Examiner Tip

Try to avoid rewriting information given to you in the stem of the question. It will not be awarded any marks as it is not answering the question.

Question 13

This question gave the candidates a statement with three pieces of information:

If you hold an apple it is about a *newton*

If you raise it through 1 m that's about a *joule*

If you do it in one second that's about a *watt*

The candidates were then told to **explain** and **justify** the statements given the mass of the apple.

The candidates were required to **explain** each statement by either identifying or defining the physical quantity that the unit was a measure of and then **justify** each statement by calculating and showing that the values given in the statement are correct.

This question was attempted well by most candidates. The first mark explaining that the apple is one newton, was found to be the most challenging by candidates as many either forgot to mention it at all or quoted $F = ma$ which is not a definition of weight or a method to calculate it. Other candidates were seen to use g = 10 ms^{-2} as they did not see this question as a 'show that' type of question and were trying to get values identical to those in the statement. Use of g=10 ms^{-2} will always be penalised by 1 mark in all Physics papers.

A well set out and complete answer scoring all 6 marks.

13 Metrology is the science of measurement and World Metrology Day is May 20th. In 2010, the day was used to celebrate the 50th anniversary of the SI system.

A metrologist from the National Physical Laboratory said on a radio programme that the SI system uses units that everyone can understand. He stated the following example.

"If you hold an apple in your hand it's about a *newton*, if you raise it through one metre that's about a *joule* and if you do it in one second that's about a *watt*."

Assuming that the apple has a mass of 100 g, explain and justify the statements made about the three words in italics.

(6)

The newton is a unit of force: $W = mg$. The weight of the apple should then be $W = 0.1 \times 9.81 = 0.981$, which is about a newton.

The joule is the unit of energy / workdone : $work = f \times s$. The work done in raising it through one metre, should then be $work = 0.981 \times 1 = 0.981$ J, which is again about one joule.

The watt is a unit of power : $power = \frac{work\ done}{time}$.

The power required to do it in one second would be $p = \frac{0.981}{1} = 0.981$ W, which is ~~about~~ also about one watt.

ResultsPlus

Examiner Comments

The structure of this answer shows that the candidate has followed the prompts in the stem of the question and identified that each of the words in italics needs to be explained and justified.

A well set out answer explaining each part of the statement in order. This response scored 5 marks.

The first marking point was not awarded as the candidate has 'defined' weight as F=ma. However, a correct weight was found of 0.981 N so the second and subsequent marks were awarded.

The 5th marking point requiring the definition of power or the identification of the watt as the unit of power was given even though the candidate has used W and T for work done and time. W was defined earlier on in the response and as T could not be anything other than time in the context of this question, it was given the benefit of the doubt and the mark awarded.

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Assuming that the apple has a mass of 100 g, explain and justify the statements made about the three words in italics.

(6)

Apple ~~W~~ $F = ma$

$9.81 \times 0.1\,\text{kg} = 0.981\,\text{N}$

using the statement we can assume that the apple is about 1 Newton, 0.981 N is roughly 1 N.

$W = F\Delta s$ $\quad 0.981\,\text{N} \times 1\,\text{m}$

$= 0.981\,\text{J}$

this is roughly 1 Joule.

Power $= \frac{W}{T}$ $\quad \frac{0.981\,\text{J}}{1\,\text{s}} = 0.981\,\text{W}$

this is roughly 1 Watt

(Total for Question 13 = 6 marks)

ResultsPlus

Examiner Comments

There has been some confusion between *F= ma* and *F =mg* here, a point that perhaps needs extra clarification when teaching specification points 9 and 10.

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Examiner Tip

When using g in equations, always use 9.81 ms^{-2} and not 10 ms^{-2}. A mark will be deducted if you substitute the wrong value.

Remember the difference between *F=mg*, the force acting on an object due to the gravitational pull of e.g. the earth and *F = ma*, the (resultant) force acting on an object causing it to have an acceleration, a.

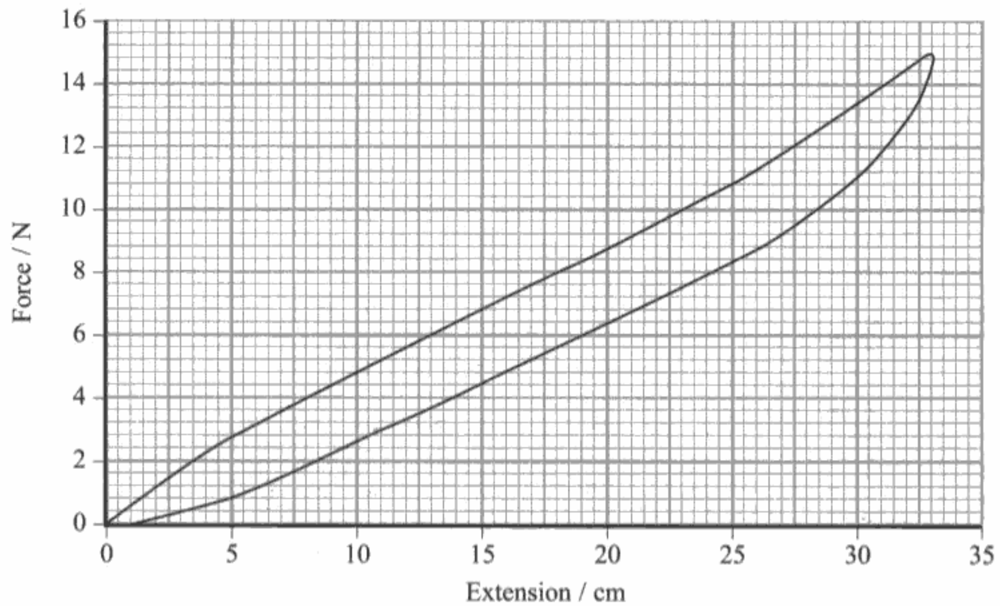
Question 14 (a)

The graph given in this question demonstrated how the extension of the elastic waistband from a pair of trousers varied with the forces acting on it for loading and unloading. A very small portion of the curve initially was a straight line and then the gradient increased.

Candidates were require to decide whether the elastic waistband followed Hooke's Law and then justify their decision i.e. make a correct reference to the shape of the graph.

This question was answered poorly with most candidates just scoring 1 mark for giving the conditions needed for Hooke's law i.e. to obey Hooke's law force is proportional to extension. Some candidates believed the entire line to be straight or 'almost straight' and therefore the graph did obey Hooke's Law, others thought that as the main section of the graph is straight then it obeyed the law. Other incorrect responses saw candidates refer to the elastic's limit of proportionality and elastic limit.

14 A student investigates the effect of varying the stretching force applied to the elastic waistband of some trousers.



The graph produced by the student shows the stretching force against extension for the elastic waistband. The top line was recorded as the force increased and the lower line as the force decreased.

(a) Explain whether the elastic waistband obeys Hooke's law.

(2)

No, it doesn't obeys Hooke's law because force is not directly proportional to the extension.

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Examiner Comments

One mark awarded for correctly identifying the conditions required for a material to obey Hooke's Law. Although the candidate has correctly said that the two quantities are not directly proportional to one another, they were required to describe which aspect of the graph this was seen from i.e. that the graph was not a straight line.

ResultsPlus
Examiner Tip

When a graph has been given and you have used it to help you answer the question, give the data or information from the graph that you have used to come to your conclusion. In this case you were looking at the gradient to decide whether or not these quantities were proportional. A reference to the graph passing through the origin should also be made when deciding whether or not a material obeys Hooke's Law although it was not required in this case.

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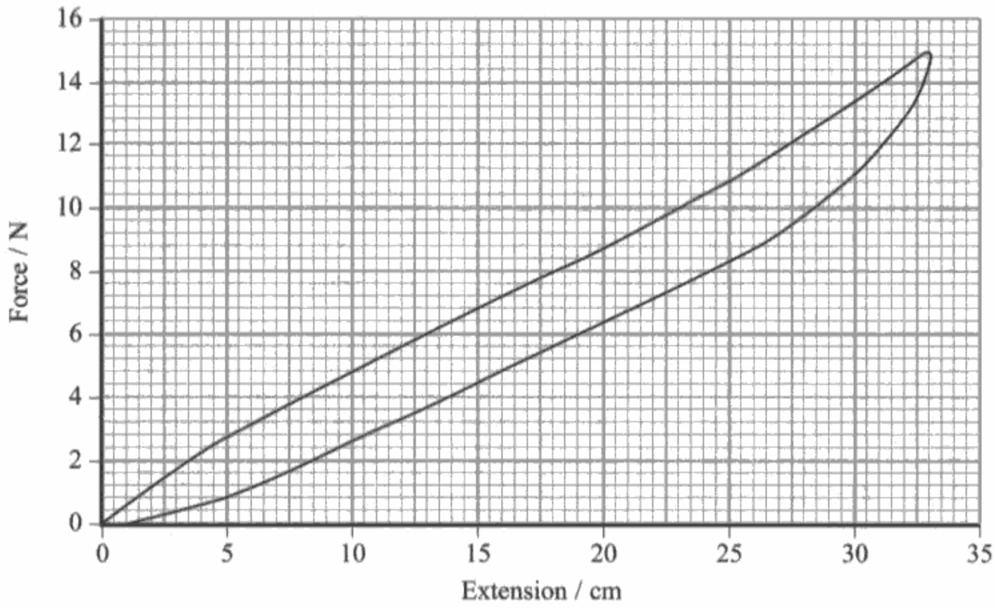

The graph produced by the student shows the stretching force against extension for the elastic waistband. The top line was recorded as the force increased and the lower line as the force decreased.

(a) Explain whether the elastic waistband obeys Hooke's law.

(2)

The elastic waistband does indeed obey Hooke's law as it's ~~whi~~ within the limit of ~~proportional~~ proportionality and does not exceed it's elastic limit.

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Examiner Comments

This response scored 0 as they have not identified the conditions needed to obey Hooke's Law and made a correct reference to the line not being straight.

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Examiner Tip

The conditions needed for a material to obey Hooke's law are that the force needs to be directly proportional to extension and, for a graph like this of force against extension, it needs to pass through the origin and be a straight line.

Question 14 (b)

The candidates were required to show that the work done was less than 3J. An area under all of the loading graph needed to be taken.

Many candidates, across all abilities incorrectly chose to use work done = force x distance. Other incorrect responses were due to misreading the extension from the graph due to its scaling or just finding the area under a shorter length of the graph. The majority of candidates did not score any marks with this question and only those candidates of higher ability managed to score 2 marks. Very few candidates scored just 1 mark due to so many trying to use force x distance.

(b) Show that, in this investigation, the work done on the elastic waistband in stretching it is less than 3 J.

(2)

$E_{el} = \frac{1}{2} F \Delta x$ $\quad \Delta x = 33 \text{cm}$ $\quad f = 15 \text{N}$

$= 0.33 \text{m}$

$\frac{1}{2}(15)(0.33) = 2.475 \text{J} < 3 \text{J}$

ResultsPlus
Examiner Comments

A correct answer (within range) scoring the full 2 marks.

(b) Show that, in this investigation, the work done on the elastic waistband in stretching it is less than 3 J.

(2)

work done = Area under graph

$= (14.8 \text{N} \cdot \frac{36}{100} \text{m}) : 2$

$= 2.66 \text{J}$

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Examiner Comments

This response scored just 1 mark for 'use of area under the graph'. The candidate has misread the scale which has 2 x 1mm squares to 1 cm, rather than 1 x 1 mm square and has an incorrect maximum extension.

ResultsPlus
Examiner Tip

Be careful when taking values from a graph. Do not assume that 1 square is 1 cm or 1 unit etc. Double check the scaling that has been used.

(b) Show that, in this investigation, the work done on the elastic waistband in stretching it is less than 3 J.

(2)

Work done = Force x distance = ~~[crossed out]~~ = (13 ÷ 100) x 6 = 0.78 J.

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Examiner Comments

The most common type of response seen:

use of force x distance

This scored 0 marks.

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Examiner Tip

To find the work done when stretching a material it is the area under a force-extension graph (not the area under a force-length graph). This is the same as using the formula:

work done in stretching elastic or elastic potential energy stored= 1/2 F Dx.

Question 14 (c)

This question was found to be challenging for candidates across all abilities. Very few candidates understood that the elastic would be under tension and therefore applying a force to the waist (and hence the waist gives the elastic a force to hold up the trousers). The majority of candidates realised that the elastic would be trying to return to its original length but then failed to explain how they would be kept in place, many just effectively repeating the stem of the question i.e. 'this holds them in place'.

(c) Suggest how the elastic properties of the waistband help in keeping the trousers in place.

(2)

when the trousers are put on the elastic waistband is stretched so that it is wider than the girth of the waist. Due to the waistband being elastic when it is released the waistband will snap back to the exact waist girth thus preventing it from falling off.

ResultsPlus
Examiner Comments

Very common answer scoring just 1 mark.

The candidate has realised that the elastic will try to reduce in length but there has been no reference to any forces.

(c) Suggest how the elastic properties of the waistband help in keeping the trousers in place.

(2)

- It retains its original shape while being stretched.
- The waistband will constantly act to close the gap and return to its original shape.
- Force from the waistband always acts on the body.

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Examiner Comments

Two marks, one for the waistband returning to its original shape and a second mark for the idea that the waistband would be applying a force.

Question 14 (d)

This question required the candidates to explain why the decreasing force line on the graph was lower than the line for increasing. Very few candidates managed to score 2 marks on this question and less than half of the candidates managed to score 1 mark.

Many candidates knew that the areas under the graphs represented energy but often lost the mark for saying that energy was lost rather than transferred or dissipated. Even though this was a 2 mark question most candidates just launched into describing the energy without linking the difference in the heights of the 2 lines to work done or area under the graphs and hence missing out on the first marking point.

Specification point 22 does imply that candidates should have seen a variety of stress-strain graphs, including rubber and, as referred to in specification point 27, candidates should know that the area under a force-extension graph corresponds to energy.

Specification point 22:

Obtain and draw force–extension, force–compression, and tensile/compressive stress-strain graphs. Identify the limit of proportionality, elastic limit and yield point.

Obtain graphs for, example, copper wire, nylon and rubber.

Some candidates however, did recognise this graph as being due to the hysteresis of the elastic but then failed to refer to the energy transfer as a result of it.

(d) The line for the decreasing force is lower than the line for the increasing force.

Explain the significance of this.

(2)

Less energy is needed for the band to return to its original position. The difference in the middle of two all lines is the energy transferred to the internal energy of the waistband, making it warmer.

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Examiner Comments

This response scored 1 mark. The candidate just missed out on the first marking point as they just referred to the difference between the 2 lines rather than the area between them.

They then scored a mark for the correct transfer of energy.

(d) The line for the decreasing force is lower than the line for the increasing force.

Explain the significance of this.

(2)

- Some energy is lost to heat energy when unloading.
- When loading potential energy is converted to kinetic energy.

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Examiner Comments

This response scored 0 marks as although the candidates realised that the difference in height was due to an energy transfer, the term 'lost' was used. No reference made at all linking the given graph to area or energy.

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Examiner Tip

If you are given a graph to refer to then make sure that you refer to it, in this case, the difference between the 2 lines and then think about what this difference could correspond to, before discussing physical quantities i.e. forces and in this case energy.

(d) The line for the decreasing force is lower than the line for the increasing force.

Explain the significance of this.

(2)

The line for increasing force is higher because there is a great of amount of force needed to strech the waistbelt a little, but there is lower amount of force needed to reform back the waistbelt into its original shape or lenght. Thus the line for decreasing force is lower than the increasing force.

(Total for Question 14 = 8 marks)

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Examiner Comments

This response scored 0 marks. There is no reference to energy at all, just the magnitudes of force involved.

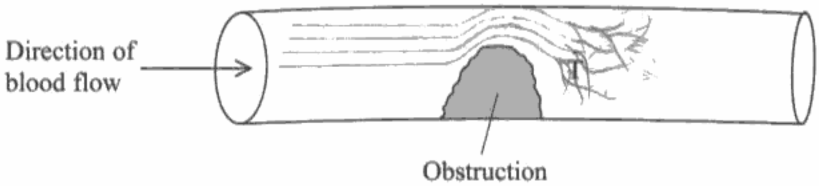
Question 15 (a) (i)

The candidates were required to add flowlines to the diagram to show laminar flow changing into turbulent flow. Candidates can mostly draw the 2 types of flow independently but they found drawing the transition between the 2 types of flow challenging, many not attempting it at all. Many candidates drew laminar flow on the left of the obstruction and turbulent flow on the right, leaving a large gap between the 2. Responses where candidates had not made a reasonable attempt to show the transition could only obtain a maximum of 1 mark.

Candidates seem to have become more conservative when drawing their turbulent flow and some candidates did not score the 'turbulent' mark because the flow did not contain flow lines crossing or a change in direction greater than 90^{o}. Candidates would benefit from a task where they have to draw the transitions from one type of flow to another around a variety of shapes of objects as well as drawing laminar flow around more streamlined objects.

15 Blood clots can lead to heart attacks. Blood flow through arteries is normally laminar, but an obstruction may cause the blood flow to become turbulent. This can lead to the formation of blood clots.

(a) The diagram shows an artery containing an obstruction.



After passing the obstruction the laminar flow becomes turbulent in the area marked T.

(i) Add flow lines to the diagram to show laminar flow changing to turbulent flow after passing the obstruction.

(2)

ResultsPlus
Examiner Comments

This response scored both marks, the laminar flow went around the obstacle well and there is some transition to the turbulent flow. The turbulent flow is not very conventional but the lines of flow are crossing so is sufficient.

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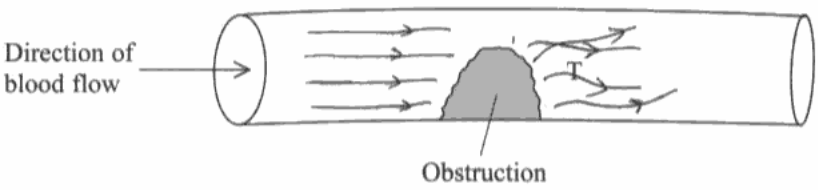

After passing the obstruction the laminar flow becomes turbulent in the area marked T.

(i) Add flow lines to the diagram to show laminar flow changing to turbulent flow after passing the obstruction.

(2)

ResultsPlus

Examiner Comments

Just 1 mark maximum awarded for the 2 lines crossing for the turbulent flow (as mentioned earlier, a rather conservative attempt at turbulent flow) and the parallel flow lines for laminar as no attempt was made at a transition between the laminar and turbulent regions.

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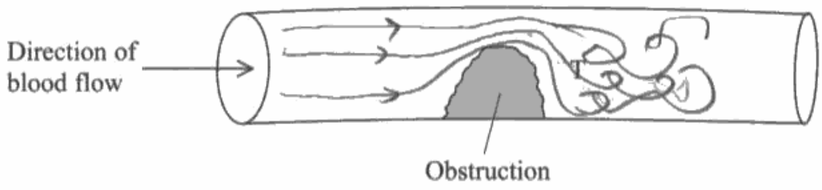
Examiner Tip

The question has specifically asked for flow lines to be added to show the **change** from laminar to turbulent. There would not be a region where the flow stops as in this diagram so the flow should be continuous.

15 Blood clots can lead to heart attacks. Blood flow through arteries is normally laminar, but an obstruction may cause the blood flow to become turbulent. This can lead to the formation of blood clots.

(a) The diagram shows an artery containing an obstruction.



After passing the obstruction the laminar flow becomes turbulent in the area marked T.

(i) Add flow lines to the diagram to show laminar flow changing to turbulent flow after passing the obstruction.

(2)

ResultsPlus
Examiner Comments

Two marks, a much better attempt at turbulent flow and the candidate has drawn the turbulent flow into the region T and not earlier. A good response.

Question 15 (a) (ii)

Candidates were asked to explain the meaning of laminar and turbulent flow. There are many ways to describe each type of flow and, rather than concentrate on describing one method correctly, many candidates, as usual tried to mix and match between the alternatives, failing to be accurate enough with any of the descriptions used and missing out on marks.

The alternatives are given as there are many ways of describing both laminar and turbulent flow. Although candidates must be aware of all the characteristics of each type of flow only one is required when answering questions where it is clear that there is just 1 mark per flow type.

(ii) Explain what is meant by laminar flow and turbulent flow.

(2)

Laminar flow

Also known as streamline flow which occurs at a low velocity and steady or ~~slow~~ ~~movement~~ displacement

Turbulent flow

Also known as ~~turbulent~~ (chaotic) flow is a flow which occurs at high velocity, flow of a fluid is not steady and displacement is very high.

ResultsPlus

Examiner Comments

One mark was awarded for 'streamline flow' but as can be seen the candidates also attempted to describe the velocity. No marks for the description of the turbulent flow, as chaotic is not specific enough.

This response scored 2 marks.

(ii) Explain what is meant by laminar flow and turbulent flow.

(2)

Laminar flow

* ~~When~~ It's a stream line flow, ~~where~~ there is no abrupt change in speed or direction no eddies, regular flow.

Turbulent flow

It's an abrupt change in direction or speed, irregular chaotic fluid flow which causes eddies.

ResultsPlus

Examiner Comments

Laminar: both streamline flow and no abrupt change in speed or direction would get the mark.

We do not accept 'no eddies' for an explanation of laminar flow and 'regular flow' would need more information to describe it.

Turbulent: abrupt changes in direction or speed and eddies would both score the mark.

ResultsPlus

Examiner Tip

Learn one definition of laminar and one of turbulent flow very well and make sure that you understand the other ways to describe flow in case they are more relevant to a context that you are given and can help with an explanation.

Question 15 (b) (i)

This question was answered very well with most candidates scoring the mark. Marks lost were due to candidates referring to an increase in blood flow rather than an increase in the velocity or rate of blood flow or candidates stating that both increased.

(b) In one experiment on blood flow, the viscosity of the blood and the velocity of blood flow were measured.

(i) Describe how you would expect the velocity of blood flow to vary with the viscosity.

(1)

When the viscosity of the blood increases the velocity decreases. When the viscosity of blood decreases the velocity increases.

(ii) Suggest and explain how a rise in the temperature of the blood would affect the

ResultsPlus

Examiner Comments

A good answer, scoring the mark. The candidate has given explanations for both the viscosity increasing as well as decreasing.

(b) In one experiment on blood flow, the viscosity of the blood and the velocity of blood flow were measured.

(i) Describe how you would expect the velocity of blood flow to vary with the viscosity.

(1)

If there is greater viscosity blood flow would be less. If there is lower viscosity blood flow would be more.

(ii) Suggest and explain how a rise in the temperature of the blood would affect the

ResultsPlus

Examiner Comments

Unfortunately this scored 0 due to the lack of clarity of the term 'flow'.

Question 15 (b) (ii)

This question was answered very well by the majority of candidates. Nearly all the candidates explained that the viscosity decreased and so the velocity increased. Similar questions in previous sessions have often seen candidates giving the observation with no explanation.

(ii) Suggest and explain how a rise in the temperature of the blood would affect the velocity of flow.

(2)

As temperature increases the blood will become less viscous, because temperature and viscosity are inversely proportional. So as it becomes less viscous the velocity of blood flow will increase.

ResultsPlus
Examiner Comments

A good answer scoring both marks.

(ii) Suggest and explain how a rise in the temperature of the blood would affect the velocity of flow.

(2)

Temperature is directly proportional to viscosity. If viscosity increase ~~to~~ then to flow the blood velocity of flow will also increase. ~~Therefore~~

ResultsPlus
Examiner Comments

This candidate has correctly concluded that the velocity of the blood would increase and could score 1 mark. However, they have not understood the reason for the increase in velocity and have incorrectly made the temperature proportional to the viscosity.

Question 16 (a)

This projectile question discriminated well between candidates of lower and higher abilities.

The weaker candidates could usually manage to answer parts a (i) and a (ii) but were usually unsuccessful in scoring any marks in part b (iii).

For a (ii) candidates were required to show that the initial vertical velocity was 4 ms-1. At least half of candidates that managed to score the full 2 marks used s = ut + 1/2at2 (with s=0 and t = 0.88 s) whilst others used v = u +at. Many candidates were careless with the direction of the acceleration, g, and often only obtained the final answer by either assuming they were finding the final velocity, v or ignoring the negative sign that appeared with their answer.

E.g. v = u + at

v = 0 + (9.81 x 0.44)

v = 4.32 ms-1

Where this was clearly evident, even though the correct answer of about 4 m s-1 may have been found, a mark was deducted. Some candidates using s = ut + 1/2 at2 used the horizontal distance of 1.88 m for the total vertical displacement of the rocket. This type of error, i.e. substituting in horizontal components in place of vertical ones does not even allow the candidates to get a use of mark and such responses score 0. Some candidates lost marks by using the total time of flight in v = u + at rather than the time to get to v = 0 i.e. the max height.

Candidates always find projectile motion questions challenging and do not break the journey down into manageable sections for both the horizontal and vertical components, enabling the selection of the correct data to be substituted much easier and more accurate. Very few candidates were seen to list values for u,v,a,t, etc for horizontal and vertical motion, most just quoting a formula and substituting straight in.

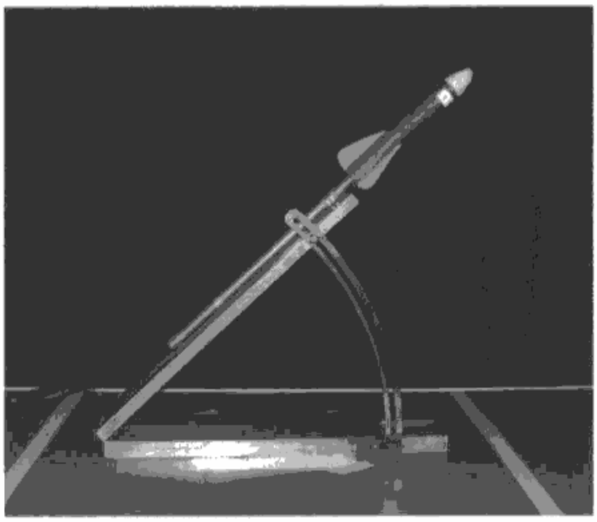
For a (iii) most candidates that attempted this question were able to score at least 2 marks, usually for the magnitude of velocity of the rocket. Often candidates that attempted to find the direction used the vertical and horizontal velocities the wrong way round and found the angle to the vertical by accident. Where candidates had drawn a triangle and labelled in the velocities a 'use of ' mark could be awarded for use of a trig function to find the direction. Therefore it is to be encouraged, that a small sketch of the vectors involved is drawn with values to be used to help the candidate select the correct values and effectively show their working out.

Candidates could select from their calculated values or the 'show that' values given in the question. The majority seemed to opt for the easier 1 sf values of 2 ms-1 and 4 ms-1 given in the question. Where a candidate has found a value that is not very near the show that value and would not round to that value if it were to be given to 1 sf, then it would not be allowed as an error carried forward in part (iii).

For example if a candidate found the vertical velocity to be 2.2 ms-1, then tried to substitute it into part (iii) as their vertical velocity (e.g. v2 = 2.22 + 2 2, v = 2.97 ms-1), then the candidates would only be able to get the use of mark. The same is true for values used to find the direction. If a candidate's value found is therefore not near enough to the value in the question then they should be encouraged to use the value in the question for subsequent calculations.

This response scored 2 marks for 16 (a)(i), 0 marks for 16 (a)(ii) and 4 marks for 16 (a)(iii).

16 The photograph shows an arrangement used to launch a light, foam rocket at a school science competition.



The rocket is launched at the level of one end of a long table and lands at the other end at the same level. The students measure the horizontal distance travelled by the rocket and the time of flight.

(a) The rocket travels 1.88 m in a time of 0.88 s.

(i) Show that the horizontal component of the initial velocity of the rocket is about 2 m s^{-1}.

(2)

Horizontal component of intial velocity $= \frac{1.88\text{m}}{0.88\text{s}}$

$= 2.14 \text{ms}^{-1}$

$= 2 \text{ms}^{-1}$ (1 s.f.) (This is because the horizontal component of velocity is constant throughout the time of flight.

(ii) Show that the vertical component of the initial velocity of the rocket is about 4 m s^{-1}.

(2)

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

$1.88 = u(0.88) + \frac{1}{2}(-9.81)(0.88)^2$

$0.88u = 5.678$

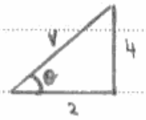
(iii) Calculate the initial velocity of the rocket.

(4)

Let initial velocity be v.

Horizontal component: $v \cos \theta = 2 ms^{-1}$

Vertical component: $v \sin \theta = 4 ms^{-1}$



$\therefore \tan \theta = \frac{4}{2}$

$\theta = 63.43°$

$v \cos \theta = 2$

$v = \frac{2}{\cos 63.43}$

$= 4.47 ms^{-1}$

Magnitude of initial velocity = $4.47 ms^{-1}$

Angle to the horizontal of the initial velocity = $63.4°$

ResultsPlus

Examiner Comments

Marks were lost in part (ii) as the candidate had substituted in the total horizontal displacement rather than the total vertical displacement of 0.This candidate had realised that the acceleration was negative but unfortunately, due to the confusion of the vertical and horizontal components scored 0.

ResultsPlus

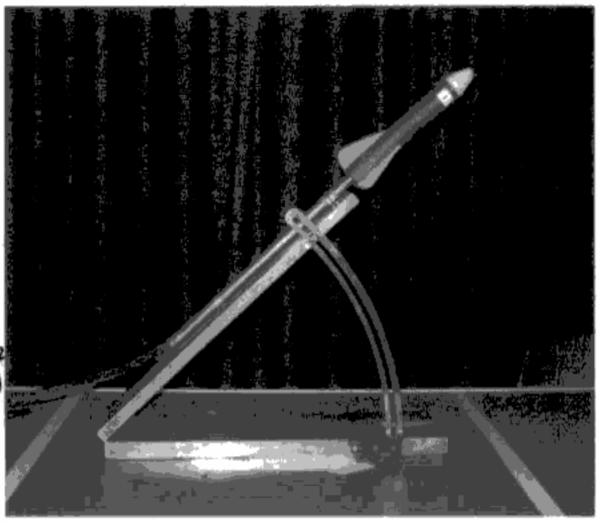
Examiner Tip

If a question involves both horizontal and vertical components then make sure you do not confuse them, either list them in columns or underline etc. the text to separate the data into the components.

This candidate has drawn out a triangle to represent the vertical and horizontal velocities to help them with part (iii), these diagrams will be looked at as part of the working out if an error has been made and, apart from helping you to answer the question correctly, they could help you to earn method marks.

This response scored 2 marks for 16 (a)(i), 0 marks for 16 (a)(ii) and 0 marks for 16 (a)(iii).

16 The photograph shows an arrangement used to launch a light, foam rocket at a school science competition.



* a i) $s = ut + \frac{1}{2}at^2$

$1.88\,m = u(0.88) + \frac{1}{2} \times 0 \times (0.88)^2$

$1.88 = u\,0.88$

$\frac{1.88}{0.88} = u$ $\quad u = 2.1\,ms^{-1} \approx 2.0\,ms^{-1}$

The rocket is launched at the level of one end of a long table and lands at the other end at the same level. The students measure the horizontal distance travelled by the rocket and the time of flight.

(a) The rocket travels 1.88 m in a time of 0.88 s.

(i) Show that the horizontal component of the initial velocity of the rocket is about 2 m s^{-1}.

~~$s = ut + \frac{1}{2}at^2$~~ $a = 0$ ~~$s = 1.88\,m = u(0.88\,s)$~~

(2)

* see asterisk above

~~$s = 1.88\,m$ $t = 0.88$ $s = ut + \frac{1}{2}at^2$~~

~~$1.88 = u(0.88) + \frac{1}{2} \times (-9.81) \times (0.88)^2$~~

~~$1.88 = 0.88u - 3.798$~~

~~$1.88 + 3.78 = 0.88u$~~ ~~5.66~~

(ii) Show that the vertical component of the initial velocity of the rocket is about 4 m s^{-1}.

(2)

$s = ut + \frac{1}{2}at^2$ $\quad \approx 4$

$1.88\,m = u(0.88) + \frac{1}{2} \times 9.81 \times (0.88)^2$

$1.88 = u\,0.88 + 3.798$

~~$3.588 + 3.79$~~

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

~~$0 = u^2 + 2 \times 9.8 \times 1.88$~~

~~$u^2 = 36.8$~~

(iii) Calculate the initial velocity of the rocket.

(4)

u = ?

t = 1.76 s

S = 3.76m ~~1.88×2~~ 1.88

a = 9.8

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

$3.76 = u \times 1.88 + \frac{1}{2} \times 9.8 \times 1.88^2$

$3.76 = u\,1.88 + 17.318$

$3.76 - 17.318 = u\,1.88$

$-13.55 = u\,1.88$

$u = \frac{-13.55}{1.88} = -7.21$

$\frac{3.76}{7.21} = \cos\theta \quad \theta = 58.5°$

$F\cos\theta = 7.21$

$(3.76)\cos\theta = 7.21$

$\cos\theta = \frac{7.21}{3.76}$

Magnitude of initial velocity = 7.21 ms^{-1}

Angle to the horizontal of the initial velocity = 58.5°

(b) The students obtained their data by filming the flight. When they checked the

ResultsPlus

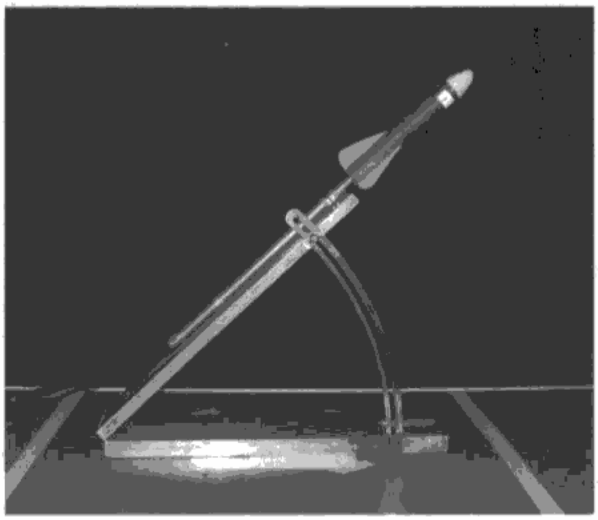
Examiner Comments

The 2 marks were lost in part (ii) as the horizontal displacement was used in place of the vertical displacement of 0.

Marks were lost in part (iii) as the candidate attempted to use equations of motion rather than pythagoras to find the resultant velocity. The direction was calculated using the horizontal displacement (doubled) and the incorrect resultant velocity so no marks at all could be awarded.

This response scored 2 marks for 16 (a)(i), 2 marks for 16 (a)(ii) and 2 marks for 16 (a)(iii).

16 The photograph shows an arrangement used to launch a light, foam rocket at a school science competition.



The rocket is launched at the level of one end of a long table and lands at the other end at the same level. The students measure the horizontal distance travelled by the rocket and the time of flight.

(a) The rocket travels 1.88 m in a time of 0.88 s.

(i) Show that the horizontal component of the initial velocity of the rocket is about 2 m s^{-1}.

(2)

$s = 1.88$ $\quad t = 0.88$

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

$s = ut + 0$

$1.88 = u \times 0.88$ $\quad$ ~~$u = 1.88 \times 0.88$~~

$u = \frac{1.88}{0.88}$

$u = 2.14 \text{ ms}^{-1}$

(ii) Show that the vertical component of the initial velocity of the rocket is about 4 m s^{-1}.

(2)

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

$s = 0 \quad a = -9.81 \text{ ms}^{-1}$

$0 = u(0.88) + \frac{1}{2} \times (-9.81) \times (0.88)^2$

$0 = u(0.88) - 3.798$

$u = \frac{3.798}{0.88}$

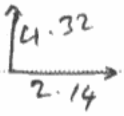
$u = 4.316$

~~$u = 4.32 \text{ ms}^{-1}$~~

$u = 4.32 \text{ ms}^{-1}$

(iii) Calculate the initial velocity of the rocket.

(4)



initial velocity $= \sqrt{(4.32)^2 + (2.14)^2}$

$= \sqrt{18.66 + 4.58}$

$= \sqrt{23.24}$

$= 4.82\ ms^{-1}$

$\tan \theta = \frac{2.14}{4.32}$

$\theta = \tan^{-1} \frac{2.14}{4.32}$

$\theta = 26.35$

$\theta = 26.4°$

Magnitude of initial velocity = $4.82\ ms^{-1}$

Angle to the horizontal of the initial velocity = $26.4°$

ResultsPlus

Examiner Comments

Part (iii) lost the final 2 marks for the direction because the candidate used the horizontal and vertical velocities the wrong way round and therefore found the angle to the vertical rather than the horizontal. Two arrows were labelled with the horizontal and vertical velocity correctly, the right way round but no angle was indicated or triangle completed so no method marks could be awarded.

Question 16 (b) (i)

Candidates were required to give a suggestion as to why the maximum height obtained was less than the calculated value. Besides a few references such as 'because gravity is acting', most candidates realised that air resistance was the cause. However, candidates were required to write more than just 'air resistance' such as *air resistance* was acting on the rocket or *'air resistance* was not taken into account or energy was transferred due to *air resistance*. Many candidates managed to earn this mark.

(b) The students obtained their data by filming the flight. When they checked the maximum height reached by the rocket they found it was less than the height predicted using this velocity.

(i) Suggest why the maximum height reached was less than predicted.

(1)

Due to ~~air~~ air resistance

ResultsPlus
Examiner Comments

This scored 0 because stating that there is air resistance is not providing a reason why the calculated value was too high or the actual value was too low. The candidate had to explain why the air resistance caused this e.g. it was not taken into account for the calculation of the maximum height.

(b) The students obtained their data by filming the flight. When they checked the maximum height reached by the rocket they found it was less than the height predicted using this velocity.

(i) Suggest why the maximum height reached was less than predicted.

(1)

Work is done against air resistance. So, the kinetic energy of the rocket is reduced. The ~~to~~ speed is reduced

ResultsPlus
Examiner Comments

Good answer scoring 1 mark.

(b) The students obtained their data by filming the flight. When they checked the maximum height reached by the rocket they found it was less than the height predicted using this velocity.

(i) Suggest why the maximum height reached was less than predicted.

(1)

This is because there are air resistance, which was neglected during the calculation of the predicting height.

ResultsPlus
Examiner Comments

Good answer scoring 1 mark.

Question 16 (b) (ii)

This question required candidates to give 2 advantages of filming the flight to obtain the data. Most candidates answered this well, the majority of which scored 1 mark.

Candidates often answered by saying that this method improved accuracy and reliability without explaining how. The most common correct responses seen were that it can be paused, watched frame by frame or in slow motion, replayed and removed errors due to human reaction time. Some candidates gave statements that it could reduce human error without referring to the type of error that it would remove.

Some confusion with this method was seen where candidates thought that replaying the recording was equivalent to taking repeat readings.

(ii) Give two advantages of filming the flight to obtain the data.

(2)

1 The human response time is neglected when measuring the time taken.

2 Parallax error is avoided when measuring the maximum height.

ResultsPlus

Examiner Comments

This response scores 1 mark for this method, neglecting human response time. No credit for parallax as this could still be there if the camera is not positioned at a height that is not near enough to the maximum height.

(ii) Give two advantages of filming the flight to obtain the data.

(2)

1 Can be watched multiple times / as much as user requires to.

2 Video can be slowed down and stopped to gather accurate readings.

ResultsPlus

Examiner Comments

2 marks awarded for watching multiple times and slowed down.

(ii) Give two advantages of filming the flight to obtain the data.

(2)

1 The time taken of the object at any point will be more accurate.

2 The displacement of the object for ~~vert~~ vertical and horizontal component will accurate. No parallax error.

ResultsPlus

Examiner Comments

This response scored 0. The candidate made references to accuracy without explaining why and to parallax which is incorrect.

ResultsPlus

Examiner Tip

When comparing experimental methods or equipment, statements referring to accuracy, errors and precision should all have explanations, explaining why that particular piece of equipment etc. makes it more accurate etc.

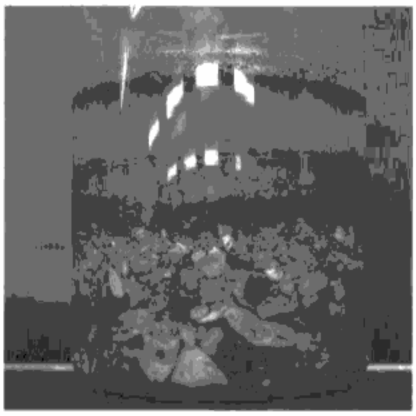
Question 17 (a)

Part (a)(i) required the candidates to label all 3 forces acting on a particle falling through water. Most candidates realised that as the particle is moving down, the drag should be upwards and remembered to include the upthrust. Most labels were accurate enough with very few incorrect references to gravity instead of weight. Marks seemed to be lost in general due to arrows curving or not touching the particle itself (a requirement for a free body diagram).

Part (ii) required the candidates to give a detailed explanation of the motion of the particle as it falls from rest through the fluid. This was a QWC question and any letters or symbols used should have been defined here or in part (i). The stem of the question should have helped candidates to structure their question rather than just launch into an explanation of the forces once the object is travelling at terminal velocity.

Most candidates realised that the resultant force is downwards or that the drag was 0 initially but many used up quite a few lines explaining how the forces acting on the particle initially were balanced and then rushed through the last 3 marking points, often missing critical points. Many candidates thought that the upthrust would increase as well, writing statements such as' as the velocity increases, the upthrust and drag increase as well'. Although such references to upthrust were ignored and a mark was still given for the drag increasing, there does seem to be some confusion here. The most common point to be omitted was that there is no acceleration when the particle is at terminal velocity.

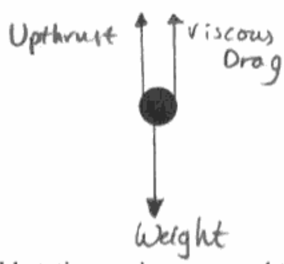
17 Soil is usually made up of a variety of particles of different sizes. The photograph shows what happens when soil is mixed up with water and the particles are allowed to settle.



(a) The dot below represents a particle of the soil falling through water.

(i) Add labelled arrows to show the three forces acting on the particle as it falls through the water.

(2)



*(ii) Explain why a particle held stationary in water and then released accelerates downwards at first but then reaches a steady downwards speed.

(4)

At first it's weight force is larger than upthrust and viscous drag as so there is a net force downwards, causing it to accelerate as F = ma. However, as it speeds up, the drag force increases and so it decellerates untill Weight Force = Upthrust + Drag, and there is a net force of 0 N. This is where it reaches it's terminal velocity as the forces are balanced so there can no longer be any acceleration.

(iii) Write an expression showing the relationship for these forces when the particle is falling at a steady speed.

(1)

Weight = Upthrust + Viscous Drag

ResultsPlus

Examiner Comments

A good response scoring maximum marks:

17(a)(i) 2 marks

17 (a) (ii) 4 marks

17 (a)(iii) 1 mark

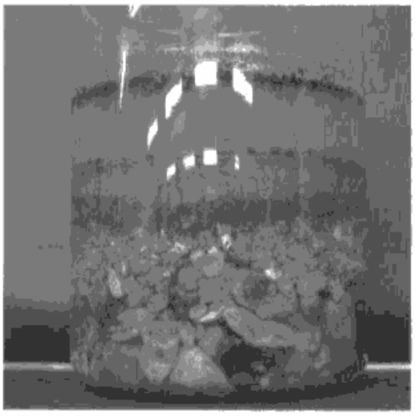
This response scored:

17(a)(i) 0 marks

17 (a) (ii) 0 marks

17 (a)(iii) 1 mark

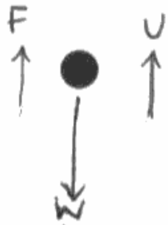
17 Soil is usually made up of a variety of particles of different sizes. The photograph shows what happens when soil is mixed up with water and the particles are allowed to settle.



(a) The dot below represents a particle of the soil falling through water.

(i) Add labelled arrows to show the three forces acting on the particle as it falls through the water.

(2)



*(ii) Explain why a particle held stationary in water and then released accelerates downwards at first but then reaches a steady downwards speed.

(4)

Weight of the particle accelerates it downwards at first, then the viscous drag and up thrust is ~~ag~~ acting against it resulting in the decrease in acceleration. This happens until $W = U + F$ meaning it has reached terminal velocity, Thus going down at a steady speed.

(iii) Write an expression showing the relationship for these forces when the particle is falling at a steady speed.

(1)

W = U + F

ResultsPlus

Examiner Comments

17(a)(i) The candidate has the correct forces and directions but has lost both marks as none of them are touching the particle.

17 (a)(ii) No references have been made to the initial motion of the particle or the increase in drag as it accelerates. The candidate has realised that the acceleration decreases but has not made the statement that it becomes 0. The candidate wrote the equation for the forces being balanced but there was no explanation of the equation such as 'the forces are balanced'. This is a QWC question and asked for an explanation hence the equation was insufficient. Therefore this response scored 0.

17 (a)(iii) 1 mark.

ResultsPlus

Examiner Tip

This candidate repeated too much of the question and added very little. The question asked for a description of the motion of the particle so for 4 marks you would expect to write at least 4 steps.

For example:

- Initially weight is greater than upthrust (so the particle accelerates)
- Drag increases (with speed)
- Eventually the forces become balanced
- Acceleration is now 0 (particle has reached terminal velocity)

Question 17 (b)

Candidates found these questions more challenging, the majority of the marks were scored for part (b)(i) with some method marks awarded for part (b)(ii), less than half of candidates scored all 5 marks.

Part (b)(i) required the candidates to find the upthrust. Most could use the formula density = mass/ volume but some lost the second mark because they had either substituted in the wrong density of they forgot to multiply their mass by 'g' to find the weight (often just changing the power of 10 of their mass to match the power for the upthrust).

For part (b)(ii) most candidates managed to score 1 mark for use of Stoke's law. However, very few realised that the force required was the resultant force and few 3 mark responses were seen. Only the most able candidates were able to score these last 2 marks. Some managed to successfully quote and use the equation $v = 2r2g(\rho1-\rho2)/9\eta$ to find the terminal velocity.

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

(b) A typical particle of sand in the sample has the following properties:

diameter = 1.6×10^{-3} m

volume = 2.1×10^{-9} m^3

density = 2.7×10^3 kg m^{-3}

weight = 5.7×10^{-5} N

(i) Show that the upthrust acting on the particle is about 2×10^{-5} N.

density of water = 1.0×10^3 kg m^{-3}

(2)

$U = \rho g V$

~~$U = (2.7\times10^3)(9.81)(2.1\times10^{-9})$~~

$U = (1.0\times10^3)(9.81)(2.1\times10^{-9})$

$U = 2.0601\times10^{-5}$ N $\simeq 2\times10^{-5}$ N

(ii) Calculate the steady downwards speed this particle would achieve if allowed to fall through water.

viscosity of water = 1.2×10^{-3} Pa s

(3)

$F = 6\pi\eta r v$

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

$v = \dfrac{2.0601\times10^{-5}}{6\pi(1.2\times10^{-3})(\frac{1.6\times10^{-3}}{2})}$

$v = 1.138$ m/s

$v = 1.14$ m/s (3sf)

Speed = 1.14 ms^{-1}

ResultsPlus

Examiner Comments

(b)(i) The candidate has worked out the weight of water displaced in 1 step using upthrust = ρgv.

(b)(ii) The candidate has substituted the upthrust as the force into Stoke's equation rather than the weight - upthrust. Just 1 mark for 'use of ' F = 6πrηv.

ResultsPlus

Examiner Tip

If more than 1 force has been mentioned in a question e.g. here you have found the upthrust and are given the weight of the particle, check to make sure whether they are all acting on the object. If so, any calculations involving the forces, to find out information about the motion of the particle (here it is the terminal velocity) will need you to use the **resultant** force.

This response scored 2 marks for (b)(i) and 3 marks for (b)(ii).

(b) A typical particle of sand in the sample has the following properties:

diameter = 1.6×10^{-3} m

volume = 2.1×10^{-9} m^3

density = 2.7×10^3 kg m^{-3}

weight = 5.7×10^{-5} N

(i) Show that the upthrust acting on the particle is about 2×10^{-5} N.

density of water = 1.0×10^3 kg m^{-3}

(2)

Upthrust = $\rho V g$ = $(1.0\times10^3 \text{ kgm}^{-3})(2.1\times10^{-9} \text{ m}^3)(9.81)$

= 2.0601×10^{-5} N

(ii) Calculate the steady downwards speed this particle would achieve if allowed to fall through water.

viscosity of water = 1.2×10^{-3} Pa s

(3)

viscous drag = weight - upthrust

= $(5.7\times10^{-5}$ N$)$ - $(2.0601\times10^{-5}$ N$)$ = ~~3.6399~~ 3.64×10^{-5} N

$3.64\times10^{-5} = 6\pi r \eta v = 6\pi(0.8\times10^{-3})(1.2\times10^{-3})v$

$v = \dfrac{3.64\times10^{-5}}{6\pi(0.8\times10^{-3})(1.2\times10^{-3})} = 2.0118$ ms^{-1}

= 2.01 ms^{-1}

Speed = 2.01 ms^{-1}

ResultsPlus

Examiner Comments

In part (ii) the candidate has found the resultant force first and then substituted it into Stoke's equation to find the correct value of 2.01 ms^{-1} for the terminal velocity.

Question 17 (c)

Candidates of all abilities found this question to be challenging, with very few candidates scoring all 3 marks.

Most could not appreciate that the reason the larger particles reached the bottom first was because they were accelerating for longer compared to the smaller particles or that they have a higher terminal velocity. Candidates were expected to reach this conclusion and then explain why, ideally making reference to the relationships between the drag and radius and the weight and radius cubed.

The most common mark awarded was for larger particles having a greater terminal velocity as they have a greater weight but very few attempted to back this up with mathematical relationships. Responses seen mainly discussed the larger particles accelerating faster, falling faster or reaching the bottom faster.

One mark awarded.

(c) The different types of particles in soil can be defined according to their diameters, as in the following table.

Soil particle	Particle diameter
clay	less than 0.002 mm
silt	0.002 mm – 0.05 mm
sand	0.05 mm – 2.00 mm
fine pebbles	2.00 mm – 5.00 mm
medium pebbles	5.00 mm – 20.00 mm
coarse pebbles	20.00 mm – 75.00 mm

The photograph shows that when soil is allowed to settle in water, the pebbles tend to be found towards the bottom, followed by sand, silt and clay in succession.

Explain why this happens. Assume that all particles have the same density.

(3)

The pebbles have wider diameters and therefore radii, so it takes more time for them to reach terminal velocity than the other objects so they accelerate for a longer period of time and reach the bottom first. As the diameter decreases so does the speed so the sand, silt and clay follow in the order of their diameters.

ResultsPlus

Examiner Comments

This candidate managed to score 1 mark for the idea that the pebbles take longer to reach their terminal velocity which is the same idea as the smaller particles reach their terminal velocity quicker, as on the mark scheme.

(c) The different types of particles in soil can be defined according to their diameters, as in the following table.

Soil particle	Particle diameter
clay	less than 0.002 mm
silt	0.002 mm – 0.05 mm
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The photograph shows that when soil is allowed to settle in water, the pebbles tend to be found towards the bottom, followed by sand, silt and clay in succession.

Explain why this happens. Assume that all particles have the same density.

(3)

As pebbles are larger they have more weight. So according to terminal velocity conditions, their terminal velocity is more than others. So reaches the bottom fast. Sand to clay has their ~~radius~~ diameter decreasing and weight also decreases. And velocity also decreases from sand to clay. And clay has the slowest velocity and finish on top of others.

ResultsPlus

Examiner Comments

This response scores 1 mark for the idea that the pebbles have a greater terminal velocity. Following this correct statement the candidate just put the particles in order of decreasing terminal velocity, not gaining any further marks.

Question 18

Parts of question 18 were answered well but some candidates left sections blank. Part (b)(vi) was found to be the most challenging for all candidates with only few candidates scoring at all.

(a) Most candidates were able to score both marks by finding the spring constant from the given weight and extension.

(b)(i) The majority of candidates that used F = kx managed to score both marks. Some candidates did try to use F=ma but mostly failed to use the correct acceleration of (9.81 + 0.4), just managing to score 1 mark for use of F= ma.

(b)(ii) This part asked for an explanation of how the average acceleration is calculated. A qualitative explanation would have sufficed but most candidates attempted this quantitatively. However, very few realised that it was the resultant force acting on the spring that caused acceleration of 0.4 ms-2 and most just tried to substitute the 4 N force of the spring on the mass obtaining an acceleration of 10 ms-2.

(b)(iii) Most candidates found this straightforward and were able to use v = u + at successfully and obtain 2 marks.

(b)(iv)Most candidates were able to draw the correct shape of the graph. Surprisingly it was quite common to see an incorrect maximum plotted (constant velocity section) even if the candidate had managed to calculate 0.8 m s-1 in part (iii). This was not penalised in this part but in part (v) if an distance of 4m was not obtained.

(b)(v) Most candidates managed to score at least 1 mark for attempting to find the area under all of their graph. The second mark was lost if candidates did not obtain a distance of 4 m, usually because of inaccurate graph drawing.

(b)(vi) Candidates found this question as challenging as question 17(c). Most just concluded that as the extension was decreasing as the lift travelled, then it must therefore be in an upwards direction. Candidates that did manage to state there must be a resultant force upwards usually did this more by luck, as often the rest of their explanation was either irrelevant or incorrect. Those candidates that did manage to spot that the extension initially is greater than when at rest could rarely go on to conclude that this was due to an upwards resultant force.

This is a typical well answered response of a high scoring candidate that manages to score:

18(a)2 marks

18(b)(i)2 marks

18(b)(ii)2 marks

18(b)(iii)2 marks

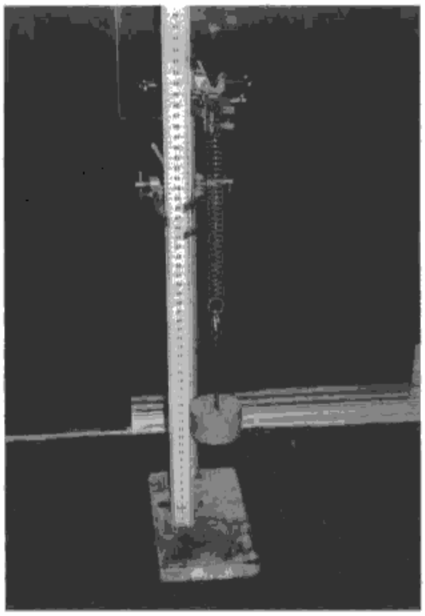
18(b)(iv)2 marks

18(b)(v)2 marks

18(b)(vi)0 marks

18 A student uses a mass hanging on a spring to investigate the motion of a lift travelling between two floors.

The photograph shows the apparatus used which is placed in the lift.



(a) The weight of the mass hanging on the spring is 3.90 N.

It produces an extension of 12.2 cm.

Show that the spring constant is about 30 N m^{-1}.

(2)

$F = kx$ $\qquad x = \frac{3.90}{0.0122}$

$kx = F$

$x = \frac{F}{k}$ $\qquad x = 31.97$ Nm^{-1}

(b) The lift takes 7.0 s to travel between floors, starting and ending at rest.

The student makes a video of the apparatus and constructs the following table from the observations made. The student notes three phases of the motion.

Phase of motion	**Duration of phase / s**	**Average extension of spring / cm**	**Average acceleration / m s^{-2}**
Start	2.0	12.7	0.4
Middle	3.0	12.2	0.0
End	2.0	11.7	–0.4

(i) Show that the spring exerts a force of about 4 N on the mass during the start phase.

(2)

$F = kx$

$= 31.97 \times \left(\frac{12.7}{100}\right)$

$= 4.06$ N

(ii) Show how the average acceleration during the start phase is calculated.

mass hanging on spring = 0.40 kg

(2)

$4.06 - 3.90 = 0.40a$

$\frac{4.06 - 3.90}{0.40} = a$

$a = 0.4$ ms^{-2}

(iii) Use the values in the table to calculate the speed at the end of the start phase.

(2)

$a = \frac{v-u}{t}$ $v = 0.4 \times 2$

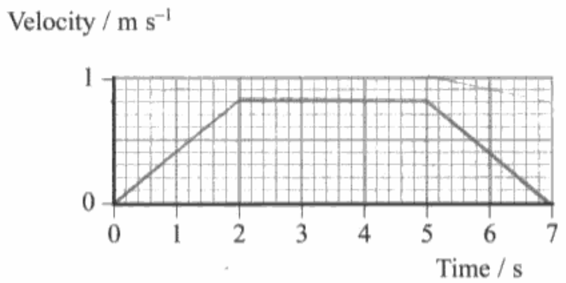
$a = \frac{v}{t}$ $= 0.8$ ms^{-1}

$v = at$

Speed = 0.8 ms^{-1}

(iv) Complete the graph to show the motion of the lift.

(2)



(v) Use your graph to find the distance travelled between the floors.

(2)

~~$\frac{1}{2}bh$~~ $= (0.8 \times 2) + (2.4)$

$= \frac{1}{2}bh$ $= l \times b$ $= 4$ m

$= \frac{1}{2} \times 2 \times 0.8$ $= 0.8 \times 3$

$= 0.8$ $= 2.4$

Distance = 4

(vi) Explain how the data for the average extension of the spring shows that the lift is moving upwards.

(2)

The extension is decreasing, because the force applied to it feels weightless ~~at~~ as it moves upwards.

ResultsPlus
Examiner Comments

Part (b)(vi): The candidate has confused this situation with the reduction in the reaction force as a lift moves downwards hence reducing the 'weight' that the person experiences.

This response scores:

18(a)2 marks

18(b)(i)2 marks

18(b)(ii)2 marks

18(b)(iii)2 marks

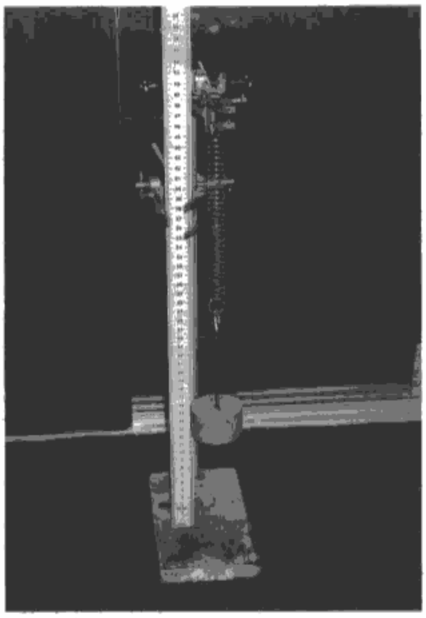
18(b)(iv)2 marks

18(b)(v)2 marks

18(b)(vi)2 marks

18 A student uses a mass hanging on a spring to investigate the motion of a lift travelling between two floors.

The photograph shows the apparatus used which is placed in the lift.



(a) The weight of the mass hanging on the spring is 3.90 N.

It produces an extension of 12.2 cm.

Show that the spring constant is about 30 N m^{-1}.

(2)

$F = k\Delta x$

$\Rightarrow k = \frac{3.90 \text{ N}}{(12.2 \times 10^{-2}) \text{ m}} = 31.97 \text{ N/m} \simeq 30 \text{ N/m}.$

So, spring constant = 31.97 N/m ≈ 30 N/m.

(b) The lift takes 7.0 s to travel between floors, starting and ending at rest.

The student makes a video of the apparatus and constructs the following table from the observations made. The student notes three phases of the motion.

Phase of motion	Duration of phase / s	Average extension of spring / cm	Average acceleration / m s^{-2}
Start	2.0	12.7	0.4
Middle	3.0	12.2	0.0
End	2.0	11.7	–0.4

(i) Show that the spring exerts a force of about 4 N on the mass during the start phase.

(2)

$F = k \times \Delta x$

$= 31.97 \times (12.7 \times 10^{-2})$

$= 4.06 N$

$= 4 N.$ so, force $= 4.06N \simeq 4N.$

(ii) Show how the average acceleration during the start phase is calculated.

mass hanging on spring = 0.40 kg

(2)

$F = ma$

$\Rightarrow (4.06 - 3.90) N = a \times 0.40$ kg.

$\therefore$ acceleration $= \frac{0.16}{0.40} = 0.4 m/s^2$.

(iii) Use the values in the table to calculate the speed at the end of the start phase.

(2)

$v = u + at$

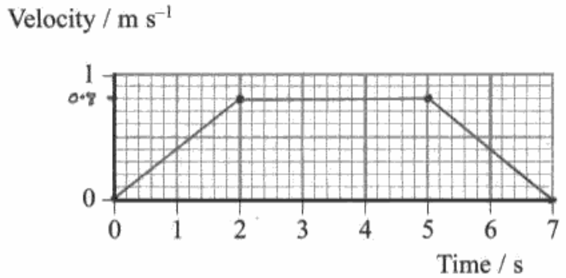
$\Rightarrow v = 0 + (0.4 m/s^2 \times 2)$

$\Rightarrow v = 0.8$ m/s.

Speed = 0.8 m/s

(iv) Complete the graph to show the motion of the lift.

(2)



(v) Use your graph to find the distance travelled between the floors.

(2)

distance = area under the graph

$= \frac{1}{2} \times h \times (a+b)$

$= \frac{1}{2} \times 0{\cdot}8 \times (7+3)$

= 4m

Distance = 4m.

(vi) Explain how the data for the average extension of the spring shows that the lift is moving upwards.

When the lift moves with a constant velocity the average extension is 12·2cm.

(2)

When the lift moves upwards and accelerates, resultant force acts upwards. The average extension of the string increases to 12·7 cm. This means that along with the lift, the spring also moves. But as a load is attached to it at the bottom, the upper part of the spring moves, showing an increase in extension.

(Total for Question 18 = 14 marks)

ResultsPlus
Examiner Comments

This candidate managed to score both marks in part (b)(vi) as they have concluded that the resultant force is upwards and have identified that the extension is more than when the lift is travelling at a constant velocity (this is as good as comparing it to the extension when stationary). The 2 points were not really linked together, which was not a requirement but would just show a greater understanding. However, this candidate has managed to obtain more information from the data than most and scored both marks.

Paper Summary

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

- Calculation of the resultant force when more than 1 force acts on an object.
- Accurate definitions of terms given in italics in the specification.
- Reading from graphs accurately and then knowing what the area under the graph represents.
- Remembering that acceleration and velocity are vector quantities and their direction should not be ignored when using suvat equations.
- Keeping horizontal and vertical components of projectiles separate and not mixing them up.

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