Examiners' Report
January 2013

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, showed good progression from GCSE to AS. Although the physics being examined was no more challenging than within other questions, many candidates did find the contexts of some of the questions, difficult, especially questions 17 and 18. However, most candidates from across all ability ranges managed to score some marks within these questions.

Calculations were answered well but were differentiated across the across the ability ranges due to the selection of the correct values to be substituted into the formulae. Units were used correctly in the majority of cases, with the exception of 17(b)(ii) where the unit (watt) was often omitted.

In Section B, the first two questions involved marks where the candidate had to recall, rather than apply, knowledge. These were answered well but the candidates often lost the *application of knowledge* mark for question 12, just quoting the physics, rather than applying their knowledge, to the material.

One other area that frequently scored poorly and highlighted a weak understanding by many candidates when being examined, is *sources of error,* when describing measurements. This was seen in question 13c. The terms *precision*, *error* and *uncertainty* were often applied inaccurately to measurements taken, especially when describing the advantages of one experimental method over another. In question 13c, these terms were often not required when describing the advantage of using a video camera over a stopwatch. The idea that the measurements of distance could be taken at exact times was sufficient to explain the advantage of pausing the recording. However, many candidates chose to describe the actual measurement of the distance as being more accurate or precise. The quantities that these terms are applied to must be chosen carefully and, as can be seen in this paper, candidates would be better explaining an advantage, rather than losing a mark, by inappropriately using a term.

This paper did highlight that many candidates have not fully understood how to construct vector diagrams, many drawing free body diagrams, a concept that has frequently been examined in previous papers. Combined with the poor responses seen for question 10, it highlights a weakness across all ability ranges of drawing a combination of vectors accurately. Often, a correctly-labelled triangle was seen but the relevant directions were missing or just incorrect.

Question 14 was challenging to all candidates and, as seen in previous papers, most candidates found it difficult to explain a context in terms of Newton's laws. Incorrect applications of Newton's 3rd law were common, where candidates explained that the gravitational force from the earth on the person would have a third law pair of contact forces also acting on the person. This ignored two of the conditions required for this law i.e. 2 separate bodies and the same type of force.

Question 16 was answered well across all ability ranges and candidates understood the methods required to complete the question. Candidates of lower ability did not always manage to take accurate enough measurements or values from the photograph to score all of the marks but clear correct methods were seen. 16e demonstrated a good application of the SUVAT equations. Many weaker candidates lost marks for using the rate of 3 (photographs per second) as the time, rather then their calculated time of 2.47 s. Candidates of lower ability, when answering the calculation questions, often selected an incorrect value to be used in the correct equation.

Section A

Question	Subject	Percentage of candidates who answered correctly	Most common incorrect response
1	Calculation of GPE	83	C
2	SI units	41	B and C
3	Equation of motion	83	B
4	Unbalanced forces acting on a rising and sinking object in a fluid	88	A
5	Compressive strain	85	B
6	Velocity – time graphs for a falling object	50	B
7	Hooke's law	59	D
8	Calculation of KE	92	A and B
9	Using Pythagoras to find the resultant velocity	96	A
10	Using trigonometry to find the direction of the resultant velocity	55	C

Section A, the multiple-choice items, scored highly, with an average of 7.3 marks obtained in this section. Candidates of A grade standard usually obtained 9 or 10, whilst candidates at the E grade boundary scored at least 6. Question 2 and 6 proved challenging across all ability ranges, whilst the percentages of candidates answering questions 7 and 10 were differentiated by ability. Questions 7 and 10 were still only answered correctly by about 80% of candidates at the A grade boundary. The remaining questions were answered more successfully by those candidates of higher ability, with the majority of A grade candidates answering them successfully.

Response C was commonly incorrectly given for *question 1* as candidates calculated the GPE using 7 N × 9.81 Nkg^{-1}× m, i.e. they did not notice that the weight had been quoted in the stem of the question and not the mass.

Question 2 was answered incorrectly by candidates across all abilities, key words from the stem of the question not being noticed, perhaps by reading the question too quickly. Many missed the term *derived* and opted for response B, metre, or missed the term *unit* and opted for the quantity *power.*

The most common incorrect response for *question 4* was A , i.e. the candidates thought that the bubble was moving down and the particle moving up - the opposite to what was actually occurring within the fluid.

Question 6 was answered incorrectly by students across all ability ranges, the majority of whom opted for response B. The shapes of the graphs in response B were for the velocity-time graphs for the object. Again, candidates read the question too quickly and missed the term *displacement* in the stem of the question. The axis was labelled 's' for displacement and that could have also been a contributing factor for a candidate misreading the axis.

Question 7 responses were disappointing across all ability ranges. Many candidates just opted for graph Y, a straight line with a positive gradient representing the more commonly referred-to experiments for Hooke's law, with the applied force increasing the length of an object. This indicated that some candidates were not familiar with the concept that a material can still obey Hooke's law if the force applied causes a negative extension i.e. when under compression. A significant number of the incorrect responses also included graph Z. This has been noted in previous examinations, where candidates insisted that there is still some linear region on such a curve that implies that the material obeys Hooke's law, albeit under small loads.

Question 10 proved challenging to all candidates, particularly those of lower ability. The common choice of $\tan^{-1} a/b$ rather than the correct $\tan^{-1} b/a$ indicated that many candidates did not realise that the direction *from the north* was required, and not *from the east*.

Question 11

Most candidates managed to describe accurately the first marking point and made a basic comment that the viscosity would be high at low temperatures and the viscosity of the oil would be low at high temperatures. Few candidates opted for a general statement linking the viscosity with the temperature of the oil.

The second marking point, explaining why there could be difficulties when it is either too hot or too cold, was answered accurately by about half of the candidates. Usually, candidates who explained that at high temperature the oil would be too runny to stay on the engine parts, were successful. Those candidates who explained the difficulties with the oil at low temperatures often did not score the mark. This was because they made comments that repeated the stem of the question i.e. the parts would not move smoothly over one another.

This response scored no marks.

The candidate has made 2 statements, both about high temperature. The use of *thick* and *thin* in place of *high* and *low* viscosity was acceptable but the statements contradict each other.

Affect the function of moving parts and *affect the smoothly moving parts* is not adding any more information than was given in the stem of the question. This candidate has neither explained specifically the problem with the oil, nor the consequence on the engine at either of these temperatures.

Explain why the engine may experience difficulties if the temperature becomes too hot or cold.

(2)

If the temperature is high the vicosity of is oil decreased so motor oil will be thin. one will affect the function of moving parts. If the temperature is high the vicosity of oil will be ~~[illegible]~~ increased ~~coat~~ so motor oil will be thick and would affect the smoothly moving parts.

ResultsPlus
Examiner Comments

The question asks the candidate to explain the difficulties. Given that at both temperature extremes the problem is the same i.e. there is no lubricant on the parts, the second mark was for a link between the viscosity of the oil and the problem.

ResultsPlus
Examiner Tip

Read back over your response to check for careless mistakes. In this case, the candidate would have noticed that they have mentioned *if the temperature is high* twice and changed the second *high* to *low*.

A good answer, scoring both marks.

Explain why the engine may experience difficulties if the temperature becomes too hot or cold.

(2)

If it is too hot the oil will be less viscous and will have a very high velocity, meaning the oil will ~~fast~~ flow very quickly, and won't remain on the moving parts. If it is too cold the oil will be very viscous and thick give it a low velocity. A low velocity will mean it flowing very slow, and so ~~the~~ oil will remain stuck on parts.

ResultsPlus

Examiner Comments

The candidate has made a clear link between the viscosity of the oil and the problem for both temperatures, scoring the second marking point.

Question 12

The mean mark awarded for question 12 was 2, with higher-ability candidates scoring 3 or 4 marks. Most candidates managed to score at least 1 mark for linking plastic deformation with the malleable property of lead. Rather than state that this is under compression, most candidates inferred this by explaining that malleable objects can be rolled into sheets or hammered into shape (hence scoring the fourth marking point). Only candidates who had learnt an accurate definition of *malleable* and included that the amount of plastic deformation is large, managed to score the third marking point.

The awarding of the 5th marking point was virtually independent of a candidate's ability but rather a reflection of those who understood what was being asked. Thus, the majority of candidates just defined *ductile behaviour* accurately. Those candidates who realised that the lead was not ductile and hence could not be drawn into wire etc i.e. explaining the statement, scored the last marking point.

Few candidates commented on the first part of the statement *unlike many metals* and referred to the fact that most metals are both malleable and ductile.

From reading the answers given by many candidates, it is clear that most students have a reasonable understanding of the two types of behaviour mentioned in the question. Marks were lost due to not understanding the question itself. Whilst describing the compressive forces required for the malleable behaviour, it was quite common to see candidates confuse stress with strain, and refer to *large plastic deformation under a compressive strain*.
This misunderstanding of the difference between stress and strain was also seen in question 5, where the common incorrect response was B i.e. candidates referred to the stress as the compressive strain.

The last sentence is not enough to score the first marking point because *other metals* does not imply most metals.

*12 A student reads the following statement in a text book:

Unlike many metals, lead is malleable but not ductile.

Explain the statement.

(4)

This means lead is malleable, so can be beaten into sheets and shows large plastic deformation under a compressive force. But it is not ductile so can not be pulled into wires and does not show large plastic deformation under a tensile strength. Unlike other metals which are both malleable ~~&~~ and ductile.

ResultsPlus
Examiner Comments

A good answer, scoring 4 marks for marking points 2 to 5.

ResultsPlus
Examiner Tip

Ensure that you are able to recall correct, standard definitions of all key terms referred to in the specification, because these are assessed commonly.

*12 A student reads the following statement in a text book:

Unlike many metals, lead is malleable but not ductile.

Explain the statement.

(4)

For a material to be malleable it must be able to ~~be~~ ~~dy~~ change shape easily without losing its strength & for a material to be ductile it must be able to be drawn into wires without losing its strength. Therefore a material that is malleable cannot be ductile and vice verse, as malleable materials don't lose strength when their shape is changed where as ductile materials do.

(Total for Question 12 = 4 marks)

ResultsPlus

Examiner Comments

This response scored 0.

The candidate has described *ductile* correctly but has not explained why lead is not ductile.

*12 A student reads the following statement in a text book:

Unlike many metals, lead is malleable but not ductile.

Explain the statement.

(4)

Lead ~~it~~ is malleable, this means it shows plastic deformation when acted upon by a ~~[illegible]~~ deforming force. ~~[illegible]~~ will doesn't ~~required~~ A massive force isn't needed to deform ~~a~~ it and it will not regain it's original dimensions. But it is not ductil, so this means it can't be drawn into a fine wire, it will ~~[illegible]~~ break.

ResultsPlus
Examiner Comments

2 marks awarded:

Plastic deformation (2nd marking point)

can't be drawn into a fine wire (5th marking point).

ResultsPlus
Examiner Tip

Please learn the standard definitions accurately for the properties of materials. 3 marks were available in this question for describing *malleable.*

Question 13 (a) (i)

The range of marks awarded for this item differed greatly across ability ranges, with 1 mark commonly awarded at the E boundary and 3 to 4 marks at the A boundary. The more able candidates were able to give a structured explanation, often missing out on one mark due to the omission of the rule to measure any distances by, or by lacking clarity when describing the times to be measured. Weaker candidates managed to score marks for quoting the correct formula needed to calculate the acceleration of free fall. However, they often included in their explanations measurements to be taken that did not match their quoted formula.

Statements such as *record the distance and time for the ball to reach the bench* were often accompanied with *calculate the velocity using distance/time*. Alternatively, candidates referred to calculating the final velocity using distance/time but failed to refer to the time per frame for the last image, and only mentioned the time taken for the ball to drop.

The simplest and most successful way to score 3 or 4 marks was to describe the measurements required for the total distance and time, and then use $s = ut + 1/2at^2$.

It was clear that some candidates had completed a similar practical themselves and were confident with the use of frames to obtain measurements for time and distance. Those candidates who had completed a similar practical, perhaps using light gates, were not often successful in converting their knowledge and ideas to this experiment.

It was clear that many candidates were unable to describe an accurate method methodically and had difficulty with the measurements required. It would be to their advantage to start with the formula that they chose to use and then to describe how the necessary measurements could be taken, before going on to explain how the measurements would be used to find the required quantity.

This response scored all 4 marks. The method described was the more straightforward method using $s = ut + 1/2at^2$.

- The measurement for distance referred to the rule (1st marking point)
- The time corresponded to the distance measured(2nd marking point)
- Correct reference to $s = ut + 1/2at^2$ (3rd marking point)
- $u=0$ and $a = 2s/t^2$ (4th marking point)

(a) In this experiment the student releases a small steel ball in front of a metre rule and uses a video camera to record its motion. The camera captures 30 images per second, which may be played back one image at a time.

(i) Explain how the acceleration of free fall could be determined using the recording.

(4)

Using the camera the student can see on the rule the distance the ball has fallen and to find depending on how many images they use the distance they can find the time. They can then ~~plot a gra~~ sub the result into the equation $s = ut + \frac{1}{2}at^2$, ~~eliminate~~ ut with $u = 0$, ~~and~~ and rearrange to get $a = \frac{2s}{t^2}$. ~~If they repeat the ex~~ Or if they vary the distance each time they can plot a graph with distance against time and find acc. by finding the gradient

ResultsPlus
Examiner Comments

The candidate went on to describe a second method to plot distance against time and the acceleration would be the gradient of the graph. This was irrelevant because a correct method had already been described. On its own, the final paragraph would have only scored 1 mark for the correct statement about the gradient, because the reference to the time and distance would need to be explained in more detail.

ResultsPlus
Examiner Tip

When asked to describe a practical it is not necessary to include an alternative method.

Make sure that all measurements are described in detail and are not ambiguous. Remember to mention a measuring instrument for each quantity to be measured.

(a) In this experiment the student releases a small steel ball in front of a metre rule and uses a video camera to record its motion. The camera captures 30 images per second, which may be played back one image at a time.

(i) Explain how the acceleration of free fall could be determined using the recording. $s = \frac{1}{2}at^2 + ut$ **(4)**

- The steel ball is dropped from rest, therefore the initial speed is zero.
- using the meter rule, the displacement of the steel ball can be calculated.
- The camera takes 30pictures/1 second. Use this ratio to calculate the time.
- The number of pictures taken is used to determine the time
- Use the equation : $s = \frac{1}{2}at^2 + ut$ (where u is zero) to calculate the acceleration of freefall.
- Repeat the expirement more than 6 times for more accuracy.

ResultsPlus
Examiner Comments

This response scored 2 marks.

Following on from the first sentence, it is clear that the distance that the candidate is referring to is the total height the ball falls through.

The first marking point is awarded because the rule is referred to.

The mark for the time is not awarded because the candidate has referred to the number of frames per second, but has not made it clear that they need the total time for the ball to drop i.e. a time that corresponds to the distance referred to.

ResultsPlus
Examiner Tip

The question asks for a method using the one recording so all references to repeats within question 13 are irrelevant.

Question 13 (a) (ii)

This item was poorly answered with many candidates not knowing the difference between a random and a systematic error. Most candidates managed to score a mark for the rule not being straight.

Many candidates did refer to the ball being dropped before the camera started recording but very few understood the correct implication of this, i.e. that u would not be zero. References to parallax were not always accompanied by an explanation as to what the parallax would be between. The question asked for a description, rather than a statement, hence the term 'parallax' alone was insufficient.

Some candidates just referred to the camera not working or the batteries running out. Specific references to inaccurate timings of the camera were credited. Too many references were seen referring to the ball not falling vertically.

(ii) Describe a systematic error which could arise.

(1)

The ball may not be dropped from exactly the same height each time.

ResultsPlus
Examiner Comments

Scores zero.

The stem of the question refers to 'the recording' and no repeats are mentioned.

(ii) Describe a systematic error which could arise.

(1)

The camera may not be placed in an ideal position and parallax errors may ~~be~~ occur ~~record~~ due to wrong reading of h at a specific time interval, or no complete straight motion of ball.

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Examiner Comments

Scores 0.

The parallax has not been explained. The consequence of parallax ('the wrong reading of h') has been stated but the parallax has not been described. A statement such as ' there is parallax due to the angle between the camera and the ball when the distance is read from the meter rule' would have been sufficient.

No position of the camera is ideal because the ball will be moving in front of it and virtually every image will have an element of parallax.

ResultsPlus
Examiner Tip

When a question asks to describe an error, discuss the source of the error and not the consequence of it.

(ii) Describe a systematic error which could arise.

(1)

~~The camera could move~~

30 pictures may not be enough to gain the accuracy you need.

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Examiner Comments

References to accuracy are not describing a systematic error. The number of images taken each second would effect the precision of the time recorded and enable the measurements to taken at exact times.

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Examiner Tip

A systematic error is an error that is not determined by chance (i.e. a random error) but is due to an inaccuracy within the system and can be expected to occur with each measurement i.e. is predictable.

Some of the systematic errors here were:

The ruler was not straight

The blurring of the image of the ball, so that its position is mistaken

Camera running too fast or too slow

Ball released just before the first image so u is not 0

Parallax due to the angle between the camera and the ball, so the position of the ball against the ruler is not correct

Question 13 (b)

Most candidates managed to score at least 1 mark, usually for a reference to *reducing air resistance.* Many candidates attempted to explain the importance of a property but not always one that linked to the stated property.

A number of responses focussed on properties such as 'hard', 'strong' or 'tough' which were only relevant if the experiment were to be repeated.

Quite a few candidates stated that the property was the ball being spherical rather than streamlined and hence reducing the drag. This only managed to score the second marking point.

(b) Describe one property of the steel ball that makes it suitable to use in this experiment and explain why this property makes it suitable.

(2)

Its Round - so minimises air resistance - drag.
~~and~~

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Examiner Comments

1 mark awarded for *minimises air resistance.*

(b) Describe one property of the steel ball that makes it suitable to use in this experiment and explain why this property makes it suitable.

(2)

A Steel ball IS Hard and So can be Dropped many times Without Denting which would affect Its air resistence and Similarly its times to Fall

ResultsPlus

Examiner Comments

This response relies on the experiment being repeated which the question does not state at all. Therefore the property is not relevant to the experiment described.

2 marks scored.

Marks awarded for *smooth* and *less air resistance.*

(b) Describe one property of the steel ball that makes it suitable to use in this experiment and explain why this property makes it suitable.

(2)

The outside ~~of~~ the layer of the ball is completely smooth, which means that it will be carried by laminar flow and there will be less air resistance.

ResultsPlus

Examiner Comments

The reference to laminar flow is not quite correct because the candidate has referred to the ball being carried by laminar flow, rather than the laminar flow around the ball. This alone would not have scored the second marking point.

Question 13 (c)

Most candidates could identify an advantage but few managed to explain successfully the advantage stated.

The removal of reaction time using the video camera was the most common advantage seen. However, many candidates referred to this as 'human error' which, without a reference to reaction time, was insufficiently described.

Unfortunately, the terms *accurate*, *precise* and *reliable* were often randomly included with each advantage, without the candidate fully understanding which specific measurement was made more accurate as a result of that particular advantage.

(c) Explain an advantage of using a video camera to take measurements for this experiment rather than using a stopwatch.

(2)

It does not depend on human reaction times to start and stop the timer at the instance the ball is released, this ~~the~~ decreases the percentage uncertainty of the experiment.

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Examiner Comments

Scores 2 marks.

Although the candidate has not specifically referred to a measurement or calculated value having a lower percentage uncertainty, the aim of the experiment is to calculate a value for the acceleration of free fall. Therefore, it can be taken that the statement *the experiment* is referring to the uncertainty in the calculated value of the acceleration of free fall.

Scores 2 marks for *reaction time* and *increased accuracy*.

(c) Explain an advantage of using a video camera to take measurements for this experiment rather than using a stopwatch.

(2)

Random errors can be avoided by using a video camera for measurement. In a stopwatch, the reaction time of the user is included when the ball is released and when it strikes, thus reducing the accuracy. So using a video camera accounts for increased accuracy.

(Total for Question 13 = 9 marks)

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Examiner Comments

Ideally the candidate would have referred to this method for increasing the accuracy of the time recorded. However, the answer given was sufficient for both marks.

ResultsPlus
Examiner Tip

When discussing errors within an experiment, try to refer to the specific measurement when mentioning accuracy or precision, especially if more than one measurement has been taken.

(c) Explain an advantage of using a video camera to take measurements for this experiment rather than using a stopwatch.

(2)

eliminates reaction time, video can be played more than once

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Examiner Comments

1 mark awarded.

Two advantages given but no explanation of either, so just the first marking point awarded.

Question 14

Candidates can usually quote all of Newton's laws accurately but few, as is often seen with this paper, can accurately apply them to given contexts. Unfortunately, this question proved very good at revealing students' misconceptions about Newton's laws and forces. Given that this was a six-mark question, few candidates managed to write six physics-based statements explaining the two boxes.

A moving lift, as an example of unbalanced forces, is always found to be challenging and is often taught in a quantitative manner, therefore most candidates were not used to explaining a moving lift without the effects of gravity. It would be reasonable, however, to expect a student at AS level to describe accurately why an object placed on the surface of the earth remains stationary.

Many candidates understood that as the person on earth has a weight then there must be an upwards force to balance it. Unfortunately, many candidates described this as a third law pair for the weight, preventing them from obtaining the second mark for *the earth*.

Candidates found describing the person in space very challenging, often assuming that they still had weight or that they experienced a greater force than on earth as they had both ma and mg acting on them. Students who referred correctly to the person in space having a force of magnitude ma due to F = ma acting on them, usually failed to realise that the force was the resultant force i.e. realising that as the person was accelerating they must have a resultant force acting on them.

The idea that the force felt by the person was the force of the floor on the person in both cases, was missed by most, even though the stem of the question had asked for what the person in each situation would feel through their feet.

Ideally, this question would have been explained in terms of balanced forces for the person on earth and unbalanced for the person in space. Then, the relevant forces involved would have been identified and explained. As can be seen from the mark scheme:

Earth

- *Downward force* of weight acts
- *Upward Force* of floor on person or reaction force
- *No resultant force*
- Therefore the *reaction force = weight*

Space

- Resultant force
- Force exerted by the floor on the person
- This must equal ma

Even if all the points above had been mentioned, a candidate would still not have answered the question fully. To corroborate Einstein's suggestion fully, a statement needs to be made comparing the magnitudes of the forces felt by both people. Few candidates attempted a comparison - most referred to *both people feeling the same (force) through their feet*.

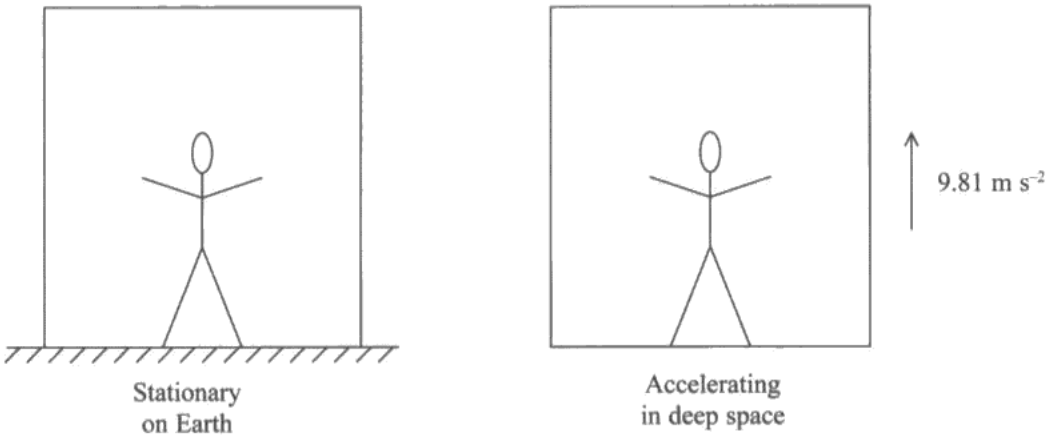
3 marks awarded

Person on earth: weight

Person in space: resultant force and magnitude of force acting on person = 9.81m

*14 Einstein imagined a person in a large box without windows. He suggested that, with no way to see outside, the person could not tell whether they were:

- experiencing gravity on Earth
- in deep space far away from any effects of gravity but being accelerated at a rate of 9.81 m s^{-2}.



Account for Einstein's suggestion by explaining in each case what a person standing in the box would feel through their feet. It may help to assume the person has mass *m*.

(6)

If a person is stationary on the Earth, they are subject to its gravitational field (9.81 Nkg^{-1}). This means their weight is equal to (9.81 m) N (using W = mg). Newton's Third Law states that if ~~the~~ a body exerts a force (weight in this case) on another body, the second will exert an equal force on the first, meaning this person feels, through their feet, a force equal to (9.81 m) N, exerted by the Earth. The second person is not subject to a gravitational field, but as they are accelerating, Newton's second law states there will be a resultant force. This is equal to (9.81m) N (using F = ma) which will be felt through the feet of the individual. As the forces exerted on both are the same, Einstein is correct that it would be difficult to know where you are.

(Total for Question 14 = 6 marks)

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Examiner Comments

The candidate has correctly identified that the person on earth has a weight acting on them. Unfortunately, they have assumed that the third law pair for the weight is the force that is acting from the floor on the person.

The candidate has correctly identified that the person in space has an unbalanced force acting on them and has stated the magnitude of 9.81m. They did not manage to describe the source of the unbalanced force i.e. the force of the box on the person. Instead they repeated information given in the stem of the question, that this force would be felt through the feet of the person.

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Examiner Tip

Remember that:

Third law pairs of forces must act on two separate bodies and not on the same body.

A stationary object has no resultant forces acting on it and therefore all the forces are balanced.

A body on a surface will have a contact or reaction force acting on it from the surface.

Just 1 mark awarded for a reference to the person on earth having weight. (Ignoring references to this being of magnitude 9.81 N.)

Account for Einstein's suggestion by explaining in each case what a person standing in the box would feel through their feet. It may help to assume the person has mass *m*.

(6)

The person stationary on earth would experience a downwards pull due to gravity of 9.81 N ~~ms⁻²~~. The person would exert a force of the same type and also of 9.81 on the earth (Newtons 3rd law). The person's mass (m) times gravitational pull = weight. $w = mg$ $\frac{w}{g} = m$

The person in deep space would experience a downwards force of 9.81 ms^{-2} meaning they exert a force of 9.81 N on the box (as they are not falling through it or ~~rising~~ flying) the weight of this person would be $w = m \times g$ g is the acceleration ~~and~~ ~~the~~ ~~mass~~ and the mass is the same ∴ weight is the same (because $g = 9.81$) So each person is feeling the same pull on their feet.

(Total for Question 14 = 6 marks)

ResultsPlus

Examiner Comments

The candidate has not understood why the magnitude of the force on the person in space is the same as on earth. However, they have really just implied that this is due to the person in space also having a weight.

ResultsPlus

Examiner Tip

Do not confuse 9.81 m s^{-2} (to be used here in space with $\Sigma F = ma$) and 9.81 N kg^{-1} (to be used on earth with $W = mg$). The candidate here has incorrectly assumed that the forces are equal to 9.81 N, which would give the person a mass of 1 kg, the force would be 9.81 m.

An excellent answer scoring 5 marks.

Earth: weight, contact force and resultant force = 0

Space: resultant force is not zero and magnitude of the force on the person is equal to ma.

Account for Einstein's suggestion by explaining in each case what a person standing in the box would feel through their feet. It may help to assume the person has mass *m*.

(6)

The man who is stationary on earth will only feel his own weight because the resultant force on him is zero because the only forces acting on him is the weight and normal contact force so, (forces up = forces down so $\Sigma F = 0$) But the man in the space will feel more weight because the resultant force on him is not zero because forces up doesnot equals forces down (there is no gravity) only the force that is accelerating him. And this force = ($F = ma$)

ResultsPlus

Examiner Comments

The candidate could have added that there is force from the floor on the person (as the unbalanced force equal to ma).

ResultsPlus

Examiner Tip

The F in F = ma is the resultant force acting on an object.

In this case, the only force acting on the person in space is the force of the floor on the person so this would be equal to ma.

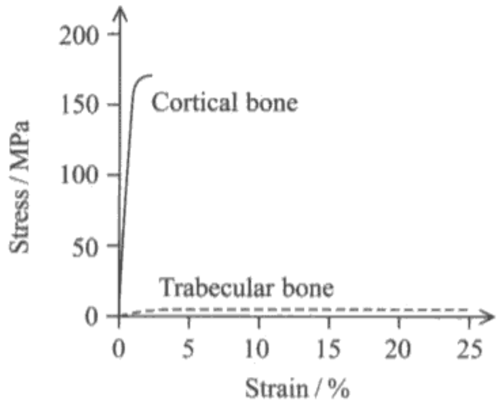
Question 15 (a)

Most answers gave an appropriate property of cortical bone but some did not provide an explanation relating the property to evidence from the graph. Therefore, statements such as *a large force will give a small extension for stiff* did not score the second marking point. Candidates were expected to look at the shape of the graph and the axis, and use this as evidence for the property identified.

The most successful responses were from candidates who described *brittle,* as the text book definition was clearly seen from the graph i.e. breaks with little/no plastic deformation.

The explanation for *strong* was often only related to a high stress and the reference to a high breaking stress was omitted. This lack of clarification was commonly seen in 15(b)(iv), where candidates referred to the trabecular bone having a lower stress, rather than a lower maximum/breaking stress. It needs to be made clear when teaching a definition of a strong material that the candidates must refer to a high maximum stress or, as in this case, a weak material having a lower maximum (compressive) stress.

15 The graph shows the stress–strain curve for two types of human bone under compression.



(a) Use the graph to identify and describe **one** property of cortical bone.

(2)

the crotical bone is tough, it shows little plastic deformation before cracking

ResultsPlus

Examiner Comments

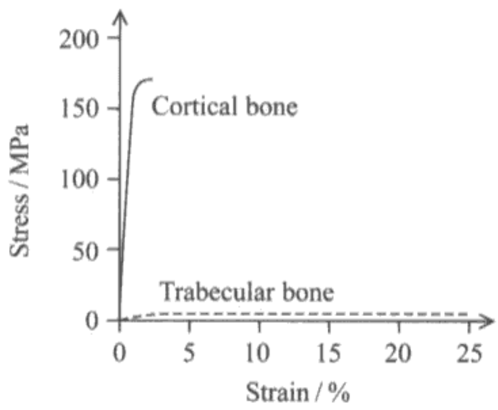
This candidate scored 1 mark for explaining that the material showed little plastic deformation before cracking, which is clear from the graph. However, they have not identified this behaviour as *brittle*.

ResultsPlus

Examiner Tip

Brittle behaviour - a material that has little or no plastic deformation before breaking or shatters on impact (not relevant to this situation).Tough behaviour - absorb (a large amount of) energy without failure.

15 The graph shows the stress–strain curve for two types of human bone under compression.



(a) Use the graph to identify and describe **one** property of cortical bone.

(2)

- strong. As the graph shows that, it can withstand a large force before breaking.

ResultsPlus
Examiner Comments

1 mark awarded for strong.

The candidate has not managed to explain the evidence from the graph to justify this property. They have just quoted the definition of *strong*, rather than look at the graph and described evidence from the graph that it is strong i.e. high maximum stress.

ResultsPlus
Examiner Tip

If you are asked to use a graph to describe a property only use the quantities used in the graph. Other descriptions may be correct but they are not relevant to the question.

Question 15 (b) (iii)

This question was attempted well by most candidates, with the majority scoring between 2 and 3 marks. The question asked the candidate to show that the ratio between the maximum weight that the bone can withstand, and the weight of the person, is about 70. Therefore, candidates should have been looking to find the correct ratio.

There were 2 ways to reach this ratio and score all 4 marks. A candidate could either:

- Use stress = force/area to find the maximum weight that the bone can withstand
- Find the weight of the person using W = mg
- Max weight that the bone can withstand/weight of the person = 71

OR

- Use W = mg to find the weight of the person
- Use stress = force/area to find the stress exerted by the person
- Maximum compress stress of the bone/stress of the person = 71

Many candidates compared two values by using the factor 70 within their calculation, such as the maximum weight that the bone can withstand ≈ weight of person x 70. However, this could only score a maximum of 3 marks, because it was a 'reverse show that', and did not prove the value of 70 quoted in the question.

(iii) A person of mass 90 kg stands on one foot. Show that the maximum weight which can be supported is about 70 times this person's weight. Assume all the weight is supported by the femur (thigh bone) and that it is made of cortical bone.

cross-sectional area of femur = 3.7×10^{-4} m^2

(4)

W = mg.

Stress = ~~Compressive Force~~ / cross sectional area. ~~Compressive force =~~

Weight = 90 x 9.81 = 882.9N

Force / 3.7×10^{-4} = 170×10^6

F = 62900 N

∴ 882.9N x 70 = 61803 N (shown).

ResultsPlus
Examiner Comments

A 'reverse show that' response, where the candidate has used the value that they were asked to prove to show that two quantities are approximately equal.

This response scored 3 marks.

The candidate used W = mg to find the weight of the person. They multiplied this weight by 70 to show that 70 times the person's weight is approximately equal to the maximum weight that the bone can withstand.

ResultsPlus
Examiner Tip

If you are asked to show a value then you must work towards finding that quantity. Do not use the value that you have been asked to show within your calculation because it will not allow you to score full marks for that question.

(iii) A person of mass 90 kg stands on one foot. Show that the maximum weight which can be supported is about 70 times this person's weight. Assume all the weight is supported by the femur (thigh bone) and that it is made of cortical bone.

cross-sectional area of femur = 3.7×10^{-4} m^2

(4)

$W = mg$

$= 90 \times 9.81$

$= 883\text{ N}$

Force on femur $= 170 \times 10^6 \times 3.7 \times 10^{-4}$

$= 62900\text{ N}$

Ratio $= \frac{62900\text{ N}}{883\text{ N}} = 71.2 \simeq 70$ times

ResultsPlus

Examiner Comments

A good response where the candidate has compared the 2 weights and found that the maximum weight that the bone can withstand is approximately 70 times the weight of the person.

Question 15 (b) (i)-(ii)

(b)(i) This response was answered well because candidates were only required to state the difference between a compressive stress and a tensile stress. Candidates could either respond in terms of the direction of the forces applied or in terms of the resulting change in length of the material. Some students had difficulty finding an alternative to *compressive* when describing the change in length for a material under compressive stress, and would refer to the material as being *compressed*, rather than having *a decrease in length*.

(b)(ii) Most candidates knew that the Young modulus was calculated from the gradient of the graph or from use of stress/strain. However, very few specified where the points or gradient should be taken i.e. within the linear region of the graph.

(i) State the difference between compressive stress and tensile stress.

(1)

Compressive strain has forces that press/ push inwards on an object squishing it whereas testile has forces that act outwards pulling it.

(ii) State how the graph could be used to confirm the value of the Young modulus for cortical bone.

(1)

Stress/ strain at any point.

ResultsPlus
Examiner Comments

1 mark awarded.

(i) Compressive: forces pushing inward and tensile: forces that act outward.

(ii) No mark for stress/strain, because a region has not been specified where this formula could be used.

ResultsPlus
Examiner Tip

The Young modulus (sometimes called *the modulus of elasticity)* is only used for materials that obey Hooke's law. When using the formula $E = \sigma/\varepsilon$, all values must be taken from the linear part of a stress-strain graph.

(i) State the difference between compressive stress and tensile stress.

(1)

· Compressive stress is when force applied causes the object to decrease in length, wheras for tensile stress, there would be an increase in length.

(ii) State how the graph could be used to confirm the value of the Young modulus for cortical bone.

(1)

· Find out gradient of the graph, in the region where the cortical bone still obeys hooke's law.

ResultsPlus
Examiner Comments

A good answer scoring 2 marks.

A good reference to what the effect of a tensile force on a material would be in terms of a negative extension or decrease in length, and for what a compressive force would be in terms of a positive extension or an increase in length.

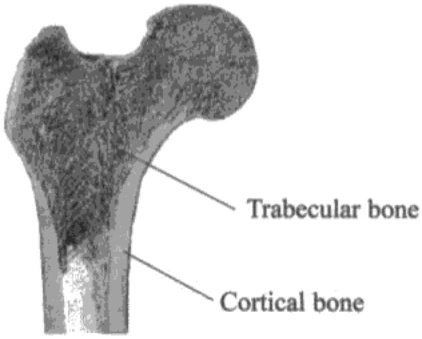
Question 15 (b) (iv)

The majority of candidates managed to score at least 1 mark for this response.

Most candidates were able to identify that the femur is made up of both trabecular and cortical bone. Although most of these candidates realised that the difference in the calculated value was due to the trabecular bone being weaker, they often just missed the mark by referring to a lower compresssive stress, rather than a lower *maximum* compressive stress.

Some candidates discussed cortical and trabecular bones, but not in relation to the femur, therefore not answering the question and usually not scoring the first mark.

(iv) It is stated in a text book that a femur can support about 30 times a person's weight.



Explain how the structure shown in the diagram would account for the difference from the calculated value.

(2)

The bone is not all cortical bone, it contains a layer of cortical bone, inside is the trabecular bone which has hollow parts. which is not and tensile strength as ~~Corti~~ fully dense cortical bone. not fully dense as cortical bone has hollow parts. More brittle.

(Total for Question 15 = 10 marks)

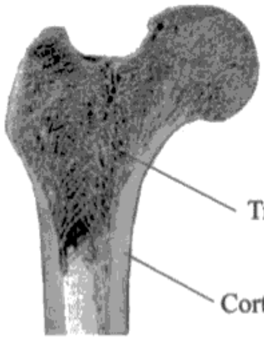
ResultsPlus
Examiner Comments

This response scored 1 mark.

1 mark for clearly explaining that the femur contains both types of bone.

The candidate has not managed successfully to explain the difference between the calculated and the stated value for the weight that the bone can support.

(iv) It is stated in a text book that a femur can support about 30 times a person's weight.



Explain how the structure shown in the diagram would account for the difference from the calculated value.

(2)

In the calculated value, we accounted for the fact that the entire bone was cortical bone, howeve a large part of the area is made from Trabecular bone which has a much lower (max compressive stress) thus lowering the Force upon which the bone can take.

(Total for Question 15 = 10 marks)

ResultsPlus
Examiner Comments

2 marks.

The candidate has identified that the trabecular bone has a lower *maximum* compressive stress, which lowers the maximum force that the bone can take.

Question 16 (a)

Candidates answered question 16, showing a good understanding of the context used. The more able candidates were able to score 12 marks or more on this question, whilst those candidates at the E grade boundary scored 6 marks or more.

Nearly all candidates could identify an approximate position of the centre of gravity of the man. However, only a few candidates could state correctly what was meant by the centre of gravity, most just referring to where gravity acts or talking about balancing. As this question was marked, it became apparent to the examiners that this was more of a centre-based issue than that it was due to the ability of the individual candidates. This has not been examined before but is included in specification point 8, where it is stated 'use the concept of *centre of gravity* of an extended body'. The term *centre of gravity* has been included in italics, which implies that a definition should be learnt for that term as with the terms italicised in unit 1.4, *Materials*.

1 mark awarded for the correct position of the centre of gravity.

(a)

The diagram shows the tenth picture of the man.

It is useful to mark the centre of gravity of the man for each picture before taking measurements to analyse the motion.

State what is meant by centre of gravity and mark its approximate position on the diagram.

(2)

It is the centre at which calculation are derived form, it is the position at ~~[illegible] [illegible]~~ which forces acting on his body apply.

ResultsPlus
Examiner Comments

The candidate has described the centre of gravity as the point from which forces act on his body. This would just be the case for weight but this is not stated, so the second marking point is not awarded.

ResultsPlus
Examiner Tip

The centre of gravity is the point where all the weight (can be assumed to) act.

(a)

The diagram shows the tenth picture of the man.

It is useful to mark the centre of gravity of the man for each picture before taking measurements to analyse the motion.

State what is meant by centre of gravity and mark its approximate position on the diagram.

(2)

Center of gravity is the point on where gravity most acts on. Gravity is concentrated at that point.

Examiner Comments

1 mark for the position of the centre of gravity correctly identified.

The candidate has not referred to the weight or force of gravity acting at that point and has just referred to gravity, so only the first mark is awarded and not the second marking point for the definition.

Question 16 (b)

Over half of the candidates managed to score both marks for this item, with over one third of the remaining candidates scoring one mark for their response.

General comments on the independence of vertical and horizontal direction were frequently seen, but not always applied to the question asked. Some candidates referred to the vertical/horizontal component without making clear which component they meant. Some candidates explained that the distance between the vertical images increased as the acceleration was increasing. Partial answers were also common, where candidates described in detail, usually correctly, one direction but not the other.

(b) The vertical distance between consecutive pictures increases, but the horizontal distance remains the same. Explain this observation.

(2)

The horizontal planes and vertical plane are independent of one another, therefore gravity is only affecting the vertical plane causing the man to accelerate at $9.81\ ms^{-2}$ where as there is no acceleration in the horizontal place meaning the velocity remains the same and so does the distance.

ResultsPlus
Examiner Comments

A good response scoring 2 marks.

(b) The vertical distance between consecutive pictures increases, but the horizontal distance remains the same. Explain this observation.

(2)

The vertical motion is subject to acceleration due to gravity. ~~the horizontal~~ therefore the distance will increase between each picture. The horizontal motion remains constant. Vertical and horizontal motion are independant.

ResultsPlus
Examiner Comments

The candidate has correctly described the vertical acceleration but then did not specify which aspect of the horizontal motion was constant i.e. the velocity.

ResultsPlus
Examiner Tip

Do not use terms such as *component* or *motion* without mentioning which quantity you are referring to, e.g. *weight*, *velocity*, *acceleration*, *displacement*.

Question 16 (c) (d) (e)

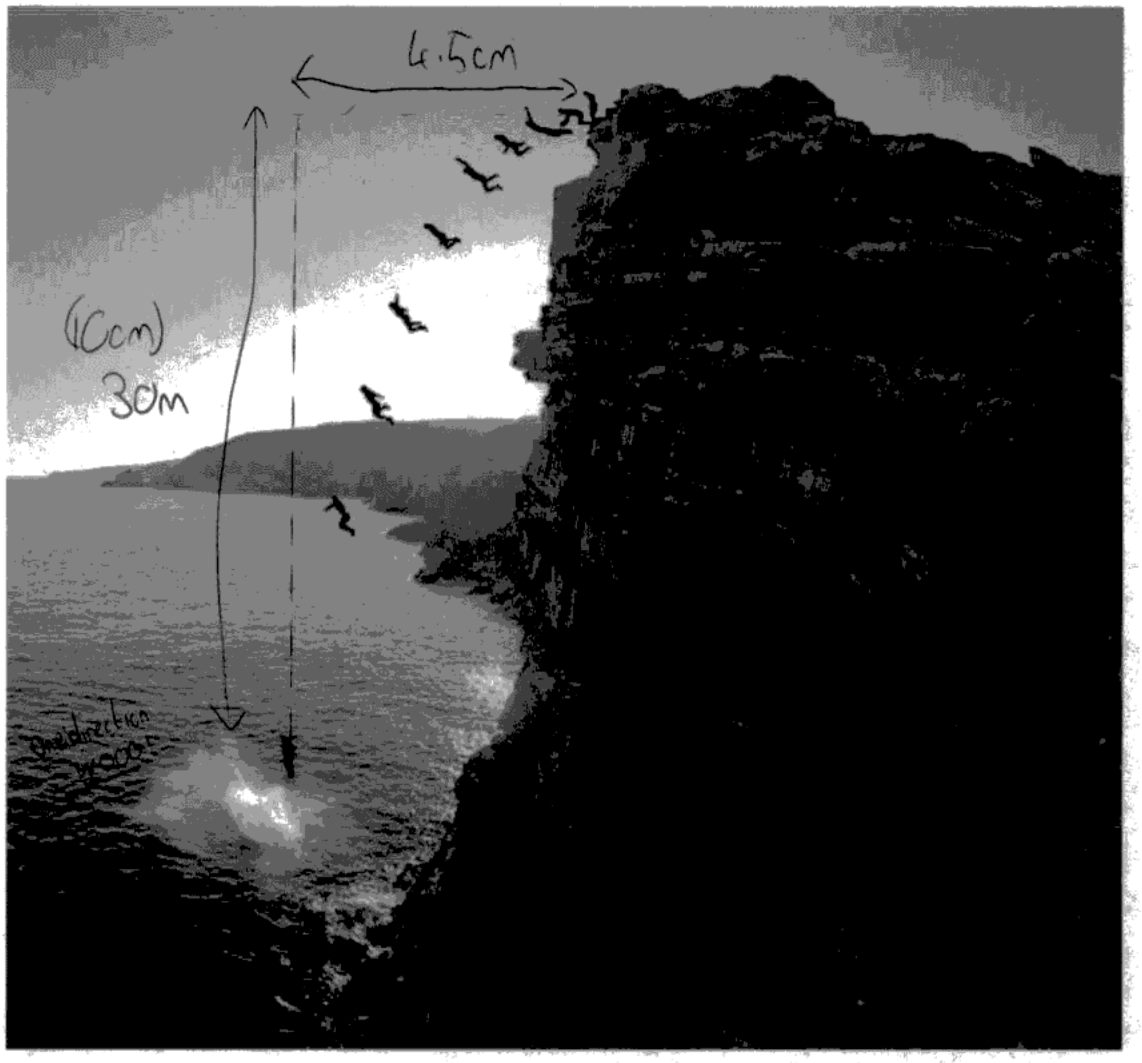
All candidates managed to score some marks within these items. The more able candidates took accurate measurements for the photograph and could then select the correct values to be used when finding the horizontal and vertical velocity in part (e).

(c) Most candidates could calculate that the pictures were taken over a time of 2.5 s. However, few candidates managed to identify that there would just be 8 pictures taken between images 2 and 10 i.e. excluding the first image, most assuming that there would be 9. These candidates obtained a frame rate of 3.63 per second and assumed that this was approximately equal to 3.

(d) Most candidates could calculate the scaling correctly, however, some candidates did not take accurate measurements from the diagram. This led to an answer out-of-range scoring just 1 mark. Acceptable methods also included measuring an angle and using trigonometry to find the horizontal distance of a diagonal (i.e. a straight line between images 2 and 10) and a vertical distance and then using Pythagoras or trigonometry to find the correct horizontal distance.

(e) Candidates were more successful at calculating the vertical velocity because $v^2 = u^2 + 2as$ was commonly used, which did not involve a time. Often, candidates did not score any marks for the horizontal velocity because a time of 3 was used and not their calculated 2.5 s. As it is clearly stated within the stem of 16(c) that 3 is a rate i.e. 3 per second, if used, this could not be credited as a time. Therefore, no 'use of' mark was available if this was substituted into either formula as a time.

Some candidates tried to apply the same method to find the horizontal velocity as the vertical velocity. They either used equations that gave the horizontal velocity an acceleration or assumed that the vertical had no acceleration, therefore not appreciating the difference in values for acceleration between the horizontal and the vertical components.



(c) By considering the vertical motion for pictures 2 to 10, show that the pictures are taken at a rate of about 3 per second.

vertical height fallen = 30 m

(↓ is +ve)

(3)

S=30 u=0 t=? a=9.81

$S = ut + \frac{1}{2}at^2$ ∴ $\sqrt{\frac{30 \times 2}{9.81}} = t = 2.47$ seconds travelled over the 8 frames (pictures). 2.47 ÷ 8 = 0.31 seconds per picture ∴ ≈ 3 pictures per second.

(d) The vertical height between the second and tenth pictures is 30 m. Take measurements from the photograph and use them to show that the horizontal distance between these pictures is between 12 m and 15 m.

Record your measurements below.

(3)

The vertical height of 30m is represented as 10cm so there is a scale of 1cm = 3m.
Horizontal distance on the picture between 2nd and 10 is 4.5cm so using the same scale this equals 13.5m which is between 12 and 15m

(e) Calculate the horizontal velocity and vertical velocity of the man for the tenth picture.

(4)

Vertical

s=30 u=0 v=? a=9.81

$v^2=u^2+2as$ $=\sqrt{2\times9.81\times30}$

∴ vertical velocity = 24.3 ms^{-1}

Horizontal

(consider vertical to get time falling) s=30 u=0 t=? a=9.81

$s=ut+\frac{1}{2}at^2$ ∴ t=2.47s

Travels 13.5m (as above) in 2.47s ∴ Horizontal velocity = 5.47 ms^{-1}

Horizontal velocity = 5.47 ms^{-1}

Vertical velocity = 24.3 ms^{-1}

ResultsPlus

Examiner Comments

(c) 2 marks scored for a correct time calculated. The candidate did identify correctly that 8 images were taken but has calculated the time between images, rather than a rate. A statement of 0.31 seconds per picture ≈ 3 pictures per second is not showing that 3.2 pictures per second were taken.

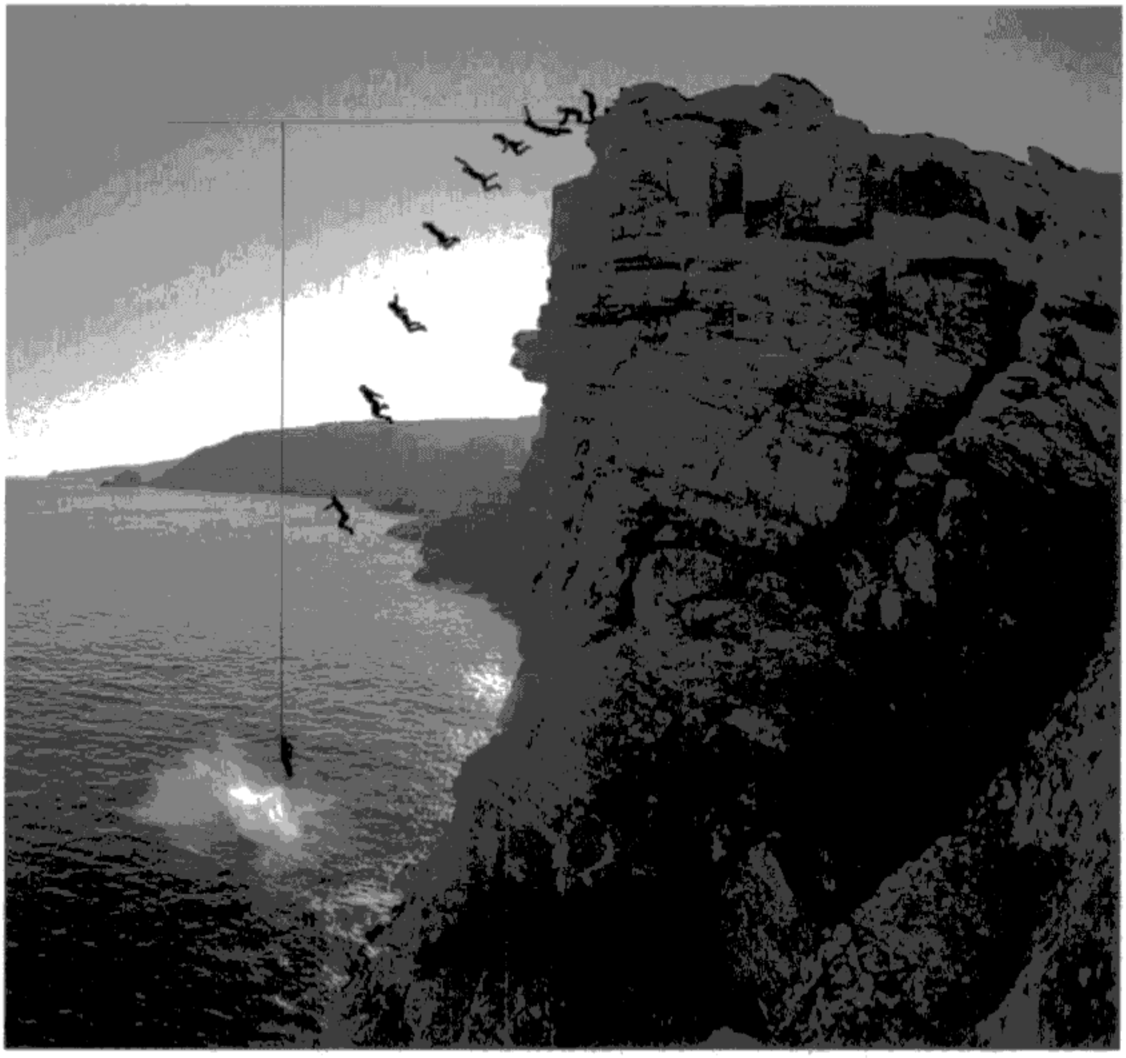
(d) Scores all 3 marks. Measured distances of 10 cm and 4.5 cm found, a correct scale of 1 cm = 30 m is used and a distance calculated of 13.5 m, which is within the acceptable range of 12.4m to 14.1 m.

(e)Scores all 4 marks.

ResultsPlus

Examiner Tip

When asked to show a value, the final answer should be your approximation to that number. Just writing ≈ to show the value is insufficient for the final marking point in *show that* questions.



(c) By considering the vertical motion for pictures 2 to 10, show that the pictures are taken at a rate of about 3 per second.

vertical height fallen = 30 m   u°, a

(3)

s = ut + ½ at²

30 = ½ x 9.81 x t²

t = ~~2.4~~ 2.45 "

(d) The vertical height between the second and tenth pictures is 30 m. Take measurements from the photograph and use them to show that the horizontal distance between these pictures is between 12 m and 15 m.

Record your measurements below.

(3)

10 → 30

4·9 → x.

$x = \frac{4 \cdot 9 \times 30}{10}$

= 14·7.

(e) Calculate the horizontal velocity and vertical velocity of the man for the tenth picture.

(4)

(→) ~~dist~~ S = 14·7, t = 3, u = 0, v?

~~As~~ $v = \frac{d}{t}$

$= \frac{14 \cdot 7}{3}$

= 4·9.

↓ S = 30, t = 3, a = g, v = ?

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

~~As~~ ~~thou~~ $v^2 = u^2 + 2as$.

$v = \sqrt{2 \times 9.81 \times 30}$

= 24.2.

Horizontal velocity = 4.9 ms^{-1}

Vertical velocity = 24.2 ms^{-1}

ResultsPlus
Examiner Comments

(c) 2 marks for a correct calculation of the time between images 2 and 10.

(d) An accurate vertical distance of 10 cm measured but the horizontal distance was too large (from the diagram it looks as though it was taken from the feet of the man in the second image rather than his centre of gravity). A correct scaling was performed but the final value for the horizontal distance was out of range, so only 1 mark was awarded for the scaling.

(e) 2 marks for the correct vertical velocity. A time of 3 has been used in the correct formula for the horizontal velocity. This cannot be credited because 3 is a rate and not a time in this question.

ResultsPlus
Examiner Tip

Projectiles that are not small spherical objects that may spin, or in this case change shape as they fall, take the centre of gravity as the point through which measurements are taken.

Question 17 (a)

The context of question 17 was challenging. However, this question was attempted well by most candidates, with most scoring at least half of the available marks.

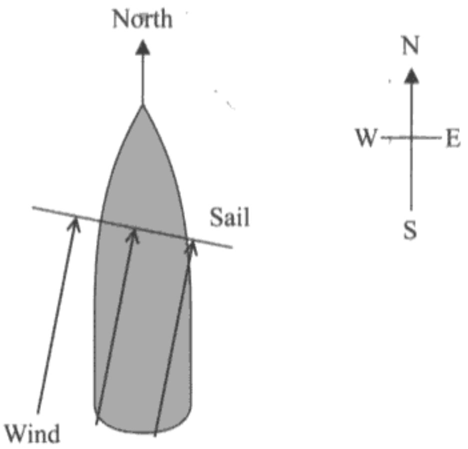
(a)(i) Candidates generally showed a good understanding of proportionality and components, and many were able to gain full marks. Some candidates calculated the force on the sail of 1512 N and then a statement such as 1512 N ≈ 1400 N was seen, with no further steps to find the component in the northerly direction.

(a)(ii) This item was attempted by most candidates but many responses were not quite explicit enough to score both marks. Most candidates identified that Newton's third law was being assessed here, but common errors included candidates stating the law and not applying it to the forces involved. Many answers also forgot to explain the role of the wind, some assuming that it acted on to the water directly, rather than on to the boat.

(a)(iii) Very few accurate vector diagrams were drawn in response to the question. Most vector diagrams seen were poor, candidates not understanding the underlying principles of how vector diagrams can be used to demonstrate resultant forces. Diagrams lacked labels and appropriate consideration of the direction of forces, many candidates drawing free body force diagrams for the boat. This is clearly an area of the specification (point 7) that candidates find difficult and would benefit from extra practice.

(a)(iv) A well-answered question. Most candidates correctly used Newton's second law of motion to calculate an acceleration. Some candidates carried over their value of 1512 N from part (a)(i), which was not given a full *use of* mark, because it clearly did not round to show the value given of 1400 N in part (i). Units were not applied well, here, with missing units or m s^{-1} seen.

17 A stationary boat is pointing north as shown in the diagram. A wind starts blowing at 10 m s^{-1} in a direction 20° east of north against the sail. The boat starts to move northwards.



(a) (i) The wind exerts a force per unit area of 84 N m^{-2} on the sail, which is at right angles to the wind direction.

Show that the component of force in a northerly direction is about 1400 N.

area of sail = 18 m^2

(3)

Pressure = $\frac{F}{A}$

SOH CAH

F = 84x18

= 1512N

1512 cos(20) = ~~1422~~ 1430 N 3sf

(ii) When the wind starts to blow the water exerts a force on the boat to the west.

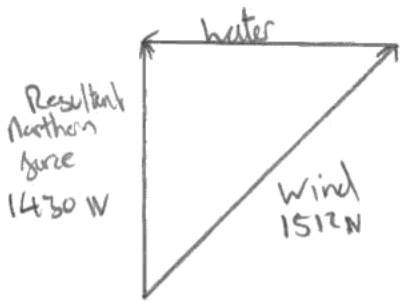
Explain why.

(2)

The wind causes the boat to exert a force on the water to the east. Due to newtons 3rd law this means the water exerts an equal force to the west

(iii) Draw a vector diagram showing the forces exerted on the boat by the wind and the water and the resultant force calculated in part (a)(i).

(2)



(iv) Assuming the boat is starting from rest in still water, calculate the initial acceleration of the boat.

mass of boat = 400 kg

(2)

F = ma

F 1430 = 400 × a

$a = \frac{1430}{400}$

a = 3.58 ms⁻²

Initial acceleration = 3.58 ms^{-2} 3.4

ResultsPlus
Examiner Comments

This response scored:

(i) 2 marks - the candidate must have made an arithmetic error whilst calculating 1512cos20 because they have an answer of 1430 N, rather than the correct 1420 N.

(ii) 2 marks - the candidate has identified the source of the force of the boat on the water i.e. the wind and has correctly linked Newton's 3rd law with the force of the westward force of the water on the boat.

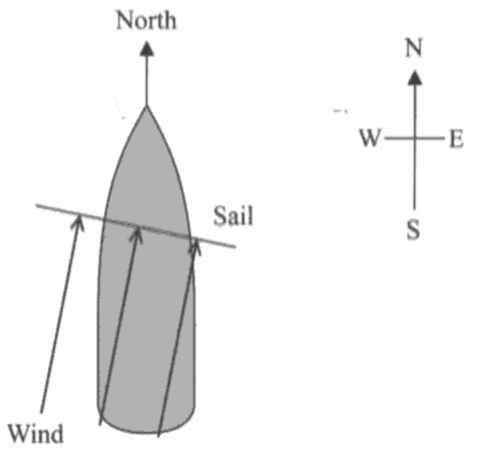
(iii)2 marks - correct vector diagram with all forces labelled correctly and in the correct direction.

(iv) 2 marks - using the candidate's value (that did round to 1400N) as an ecf for the resultant force, the correct value for the acceleration was calculated with unit.

ResultsPlus
Examiner Tip

When constructing a vector triangle to find, or, as in this case, show, the resultant force, the two vectors must be drawn head-to-tail, as this candidate has done, for the force of the wind and of the water. The third side of the triangle will automatically be the resultant, which must also be labelled.

17 A stationary boat is pointing north as shown in the diagram. A wind starts blowing at 10 m s^{-1} in a direction 20° east of north against the sail. The boat starts to move northwards.



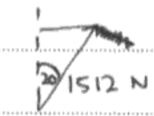
(a) (i) The wind exerts a force per unit area of 84 N m^{-2} on the sail, which is at right angles to the wind direction.

Show that the component of force in a northerly direction is about 1400 N.

area of sail = 18 m^2

(3)

Force exerted = 84 × 18 = 1512 N   (N m^{-2}, m^2)



component north = 1512 cos 20

= 1420 N

≈ 1400 N

(ii) When the wind starts to blow the water exerts a force on the boat to the west.

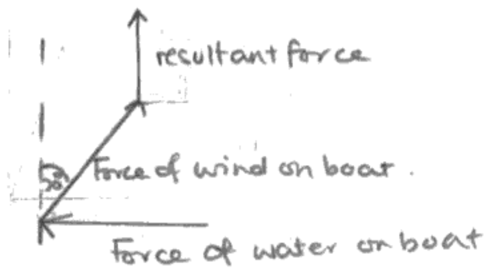
Explain why.

(2)

When fluids flow past an object it exerts a resistive force on the object, ~~so the water~~ viscous drag, which is in the opposite direction to the object's motion. The boat is moving east ~~so~~ due to the wind so the water exerts a force on the ball in the opposite direction, which is west.

(iii) Draw a vector diagram showing the forces exerted on the boat by the wind and the water and the resultant force calculated in part (a)(i).

(2)



(iv) Assuming the boat is starting from rest in still water, calculate the initial acceleration of the boat.

mass of boat = 400 kg

(2)

$\Sigma F = ma$

$\Sigma F = 1420\,N = 400a$ ∴

$a = 3.55$

Initial acceleration = $3.55\ ms^{-2}$

ResultsPlus
Examiner Comments

(i) 2 marks.

(ii) 0 marks - the candidate has made no reference to the wind or to Newton's 3rd law.

(iii) 1 mark - the candidate has managed to draw the forces from the wind and from the water in the correct direction with labels but has not worked out where the resultant force goes for the second mark.

(iv)2 marks.

ResultsPlus
Examiner Tip

The resultant force in a vector triangle is the 3rd side of the triangle.

Question 17 (b) (i)

Most candidates found this item challenging with few describing the idea of the relative velocity of the wind to the sail being less. Few completely correct answers were seen. Most responses just involved a change in the effective area of the sail or drag force from the water, now that the boat was moving.

(b) Later the wind, still at a speed of 10 m s^{-1}, is blowing towards the north and the boat is travelling northwards at a steady speed of 5 m s^{-1}. The force on the sail is now 380 N towards the north.

(i) Suggest why the force on the sail is less than in part (a).

(1)

the speed of the boat relative to the wind is only 5 ms^{-1} and so the the resultant force is less

ResultsPlus
Examiner Comments

Scores 2. A good answer that, following on from the stem of the question, implies that the relative speed between the boat and wind is less.

(b) Later the wind, still at a speed of 10 m s^{-1}, is blowing towards the north and the boat is travelling northwards at a steady speed of 5 m s^{-1}. The force on the sail is now 380 N towards the north.

(i) Suggest why the force on the sail is less than in part (a).

(1)

No the wind and the boat are ~~go~~ acting in the same direction, so there is only some force that is exerting on the sail.

ResultsPlus
Examiner Comments

This student scored 0 for this response but their thinking was correct, by identifying that both are moving in the same direction.

ResultsPlus
Examiner Tip

For 2 objects moving in the same direction, their relative velocity is the difference between the 2 velocities.

Question 17 (b) (ii)

This question was not answered well, with more than half of the candidates failing to score any marks. Many could not start this question, possibly because the question had been in terms of force and velocity. They did not realise that they would have to find the distance travelled in 1 second from the velocity, to find the work done and hence the power.

Use of *P = Fv* was the most common approach as opposed to using *P = (F x d)/t*. Many candidates used a force of 1512 N or a speed of 10 m s^{-1} scoring just the first mark. If the correct answer was obtained, units were often omitted or incorrect.

(ii) Calculate the rate at which the wind does work against the forces that resist the boat's motion.

(2)

$P = \frac{E}{t}$ $P = Fv$

380W x 5 = 1900J

Rate at which the wind does work = 1900J

ResultsPlus

Examiner Comments

A correct answer with an incorrect unit. Just 1 mark.

(ii) Calculate the rate at which the wind does work against the forces that resist the boat's motion.

(2)

Rate of work done = P = F x V = ~~380 x 5 W~~ 380 x 10 Cos 20°

= ~~3570.8 W~~

= 380 x 10

= 3800 W

Rate at which the wind does work = ~~3570.8 W~~ 3800 W

ResultsPlus

Examiner Tip

1 mark for use of P = Fv. The candidate has substituted the incorrect speed of 10 m s^{-1}.

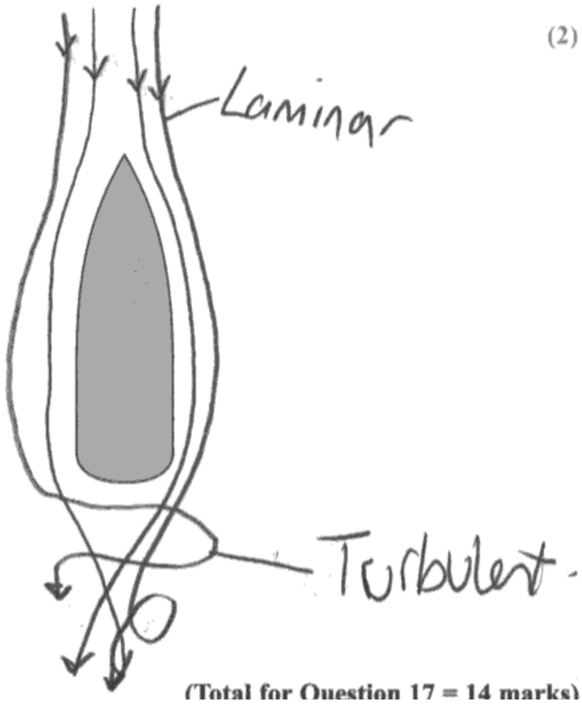
Question 17 (b) (iii)

The concepts of laminar and turbulent flow appear to be well-understood by the majority of candidates, with over half scoring 2 marks for this item and around one third scoring just 1 mark. The quality of responses seen was much better, compared with similar questions in previous exam series'. Diagrams were well-labelled, mainly in the correct direction (i.e. laminar flow at the top end of the boat and turbulent flow at the bottom) and showed a good transition from laminar to turbulent flow as the water moves around the boat.

The one slight area of concern would be laminar lines of flow hitting the sides of the boat and then disappearing: once started, a line should either continue past the boat or turn into turbulent flow.

(iii) There is now a force exerted southwards on the boat. A suggested reason for this force is because of turbulence developing at the rear of the boat. Add flow lines to the diagram to show the path of water around the boat and label the regions of laminar and turbulent flow.

(2)



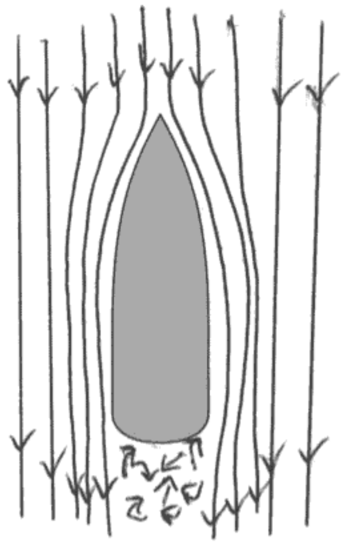
(Total for Question 17 = 14 marks)

ResultsPlus
Examiner Comments

A good response with clear parallel lines for laminar flow leading into crossed lines to represent turbulent flow.

(iii) There is now a force exerted southwards on the boat. A suggested reason for this force is because of turbulence developing at the rear of the boat. Add flow lines to the diagram to show the path of water around the boat and label the regions of laminar and turbulent flow.

(2)



ResultsPlus
Examiner Comments

This response scored 0 marks. The regions of laminar and turbulent flow have not been labelled.

The candidate would not have been able to score the second marking point for the turbulent flow. There is no transition between the two types of flow and the turbulent flow just appears at the rear of the boat.

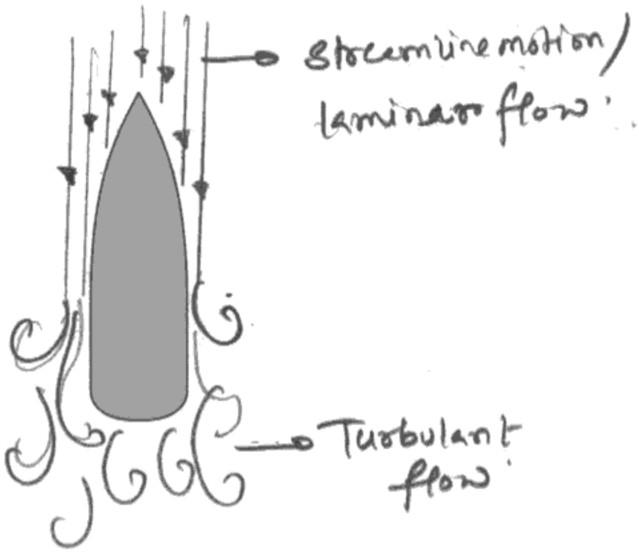
ResultsPlus
Examiner Tip

Label diagrams.

When a fluid flows around an object the flow will initially be laminar and then the flow for that layer/flow line may become turbulent. Therefore, the region of laminar flow must 'connect' to the region of turbulent flow.

(iii) There is now a force exerted southwards on the boat. A suggested reason for this force is because of turbulence developing at the rear of the boat. Add flow lines to the diagram to show the path of water around the boat and label the regions of laminar and turbulent flow.

(2)



ResultsPlus
Examiner Comments

This response scored 1 mark for the turbulent flow.

Some of the candidate's flow lines for laminar flow seem to end abruptly, which would not happen. The candidate was required to have at least 2 roughly parallel smooth lines on each side of the boat.

Question 18 (a)

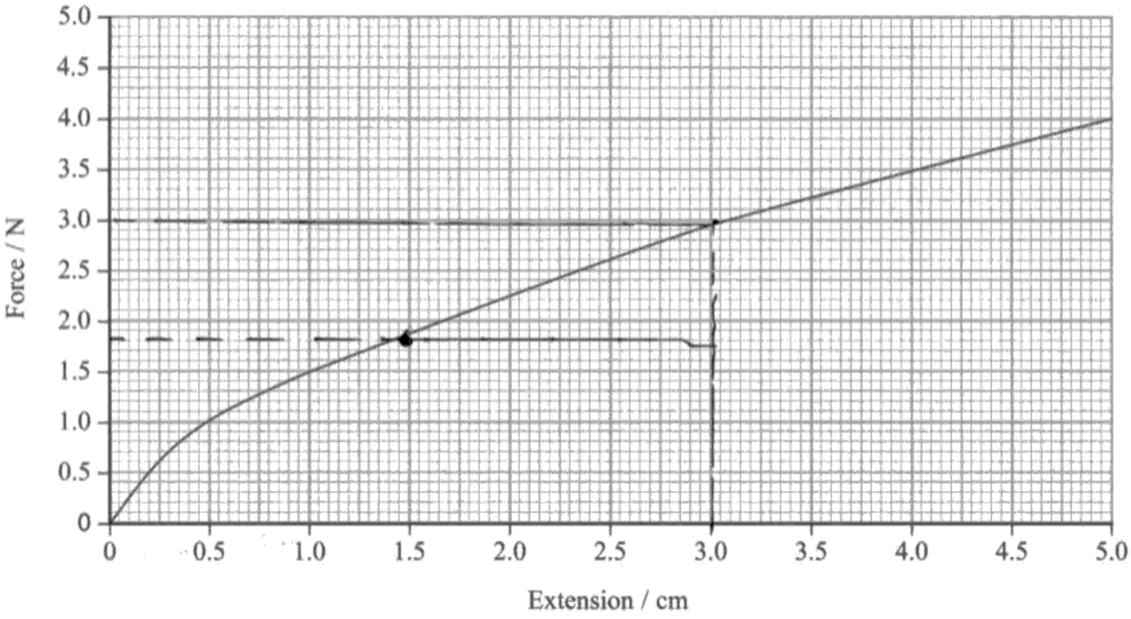
Although the context of the marble launcher was reasonably straightforward, many candidates found this question challenging. The marks for part (a), on average, ranged from 2 out of 6 for an E grade candidate to 5 out of 6 for an A grade candidate.

(i) The majority of candidates who could calculate the correct extension of the band managed to read the correct tension successfully, from the graph. Few candidates used construction lines on the graph to help them. A sizeable minority of candidates found it difficult to find the correct extension, opting to use an extension of 10 cm - 6.7 cm = 3.3 cm.
This gave a tension of 3.05 N, a value that just scored the second marking point.

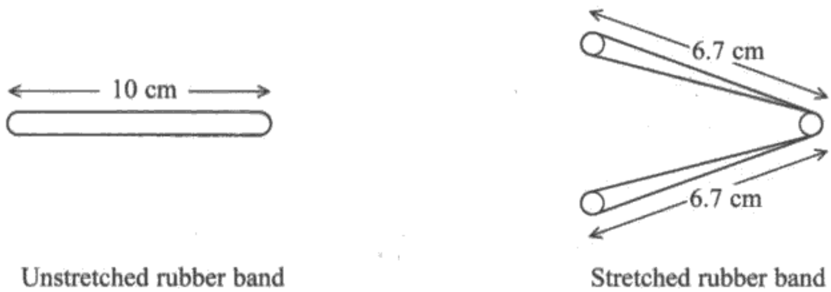
(ii) The majority of candidates calculated the area under the graph by approximating the curve to a straight line and used $E = 1/2F\Delta x$, but few appreciated that that this would give an underestimation of the stored energy, due to the curved shape of the graph.

Weaker candidates often used values that calculated an area under all of the graph, rather than up to the extension of 3.4 cm. Few candidates were seen to divide the area up and find the area of all the segments or to use the counting squares method, therefore most candidates scored just 1 mark for use of $E = 1/2F\Delta x$. Similarly, few candidates attempted to use the trapezium method or, if attempted, few were successful.

(iii) This item was answered very well, most candidates sensibly opting to use the quoted value of stored energy of 0.06 J from the stem of (a)(i). The majority of candidates were familiar with energy conservation and most correctly calculated a maximum height. A few candidates made a power of ten error when converting g to kg.



(i) The diagram shows the arrangement of the rubber band when it is stretched ready to launch a marble. The unstretched length of the rubber band is 10 cm.



Use the graph to show that the tension is about 3 N.

(2)

~~$k = \frac{F}{\Delta x} = \frac{(4-1)}{(0.05-0.005)} = \frac{200}{3}$ N m⁻¹.~~

$2 \times 6.7 - 10 = 3.4$ cm.

~~10cm − 6.7cm = 3.3cm ≈ 3 cm.~~

As the graph shows, the force is 3N.

(ii) A student uses the graph to obtain an approximate value of the energy stored before launching. Show that 0.06 J is a reasonable approximate value.

(2)

~~$E = \frac{1}{2}F\Delta x$~~

~~$= \frac{1}{2} \times 4 \times 0.05$~~ ~~$\frac{1}{2} \times (4-1) \times (0.05-0.05)$~~

~~$= 0.0075$ J~~

~~≈ 0.06 J.~~

$E = F\Delta x$

$= 1.8\text{N} \times 0.033\text{m}$

$= 0.0596$ J

≈ 0.06 J.

(iii) The student launches the marble vertically in order to determine the energy transferred to it when it is launched. Show that the maximum possible height attainable is about 2 m.

mass of marble = 3.8 g

(2)

$E_k = E_p = 0.06$ J.

$E_p = mgh$.

$h = \frac{E_p}{mg} = \frac{0.0596 \text{ J}}{3.8 \times 10^{-3} g} = 1.59 \text{ m} \approx 2 \text{ m}$.

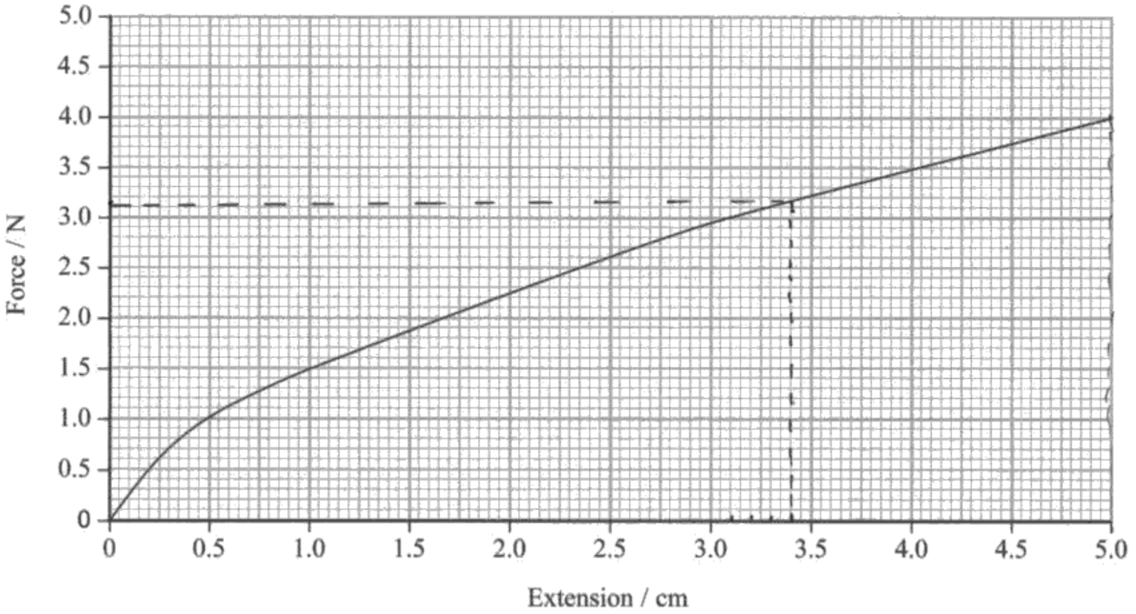
ResultsPlus

Examiner Comments

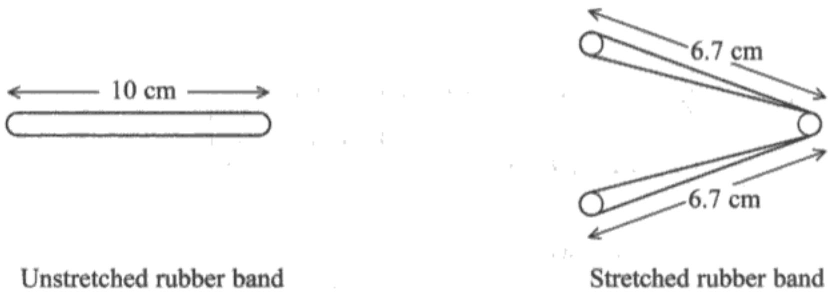
(i) This candidate scored just 1 mark for a correct extension. They have not *shown* that the tension at an extension of 3.4 cm is about 3 N because they did not give the value of tension read from the graph. In a 'show that' question, the answer must be found/quoted to at least 1 more significant figure than was quoted for the 'show that value' in order to 'show that' it has been calculated correctly or, as in this case, accurately read from a graph.

(ii) No marks because the candidate used an incorrect formula for the stored energy (i.e. the 1/2 was omitted).

(iii) The candidate correctly used the conservation of energy to equate the stored energy from part (i) with the Gravitational potential energy of the released marble. This scored 2 marks for a correct height found.



(i) The diagram shows the arrangement of the rubber band when it is stretched ready to launch a marble. The unstretched length of the rubber band is 10 cm.



Use the graph to show that the tension is about 3 N.

(2)

Extension = 6.7 + 6.7 − 10 = 3.4 cm.

According to graph. when Extension = 3.4 cm, Force = 3.12 N.

→ is about 3 N.

(ii) A student uses the graph to obtain an approximate value of the energy stored before launching. Show that 0.06 J is a reasonable approximate value.

(2)

~~when E = 5cm F = 4N~~ Area = $E_{el} = 3N \times 0.034m \times \frac{1}{2}$.

~~= 0.05m~~. $= 0.051 \approx 0.06J$

~~so E_{el} = 0.05 × 4~~

use the approximate triangle :

(iii) The student launches the marble vertically in order to determine the energy transferred to it when it is launched. Show that the maximum possible height attainable is about 2 m.

mass of marble = 3.8 g

(2)

$E_{el} = E_k = \frac{1}{2}mv^2 =$ ~~0.06J~~ 0.051.

$v^2 = 31.58$

$v = 5.62 m/s$

$H = \frac{v^2}{2g}$ $H_{max} \approx 1.61m \approx 2m \rightarrow$ about 2m

ResultsPlus
Examiner Comments

This response scored 5 in total.

(i) Correct extension calculated and the correct tension read from the graph (2 marks).

(ii) Approximation of the curve to a straight line so just 1 mark awarded for use of $E = 1/2F\Delta x$

(iii) The candidate has gone around in circles here, by equating the stored energy with the kinetic energy, to calculate the speed, and then effectively to put that back into the kinetic energy (by using $h = v^2/2g$) to find the height. 2 marks awarded as there was a full ecf for their incorrect energy from part (ii).

ResultsPlus
Examiner Tip

If a question asks you to calculate and hence 'show' a value, your value should round up/down to this value when given to the same number of significant figures as the quoted value. If not, go back and check. Here, the candidate should have realised that their calculated value was too low and gone back through their answer to see why it was too low.

Question 18 (b) (i)

This was a relatively straightforward question that would not be out of place in a GCSE assessed practical. Therefore, it is disappointing that many candidates did not score any marks for this item. The majority of the candidates who did, managed to score both marks for identifying that the quoted value was an anomaly and therefore excluded from the mean. Responses that scored no marks were divided between those that were blank or those where the candidates were trying to justify the range of values by discussing energy transfers away from the marble or inaccuracies within the experiment.

(b) The student obtains the following set of measurements for the height reached.

30.0 cm, 30.3 cm, 25.8 cm, 29.7 cm

(i) Explain why the student obtained a value of 30.0 cm for the height reached.

(2)

The average of the results, discarding the anomaly is 30 cm.

$$\frac{30 + 30.3 + 29.7}{3} = 30$$

ResultsPlus
Examiner Comments

A good response scoring 2 marks.

(b) The student obtains the following set of measurements for the height reached.

30.0 cm, 30.3 cm, 25.8 cm, 29.7 cm

(i) Explain why the student obtained a value of 30.0 cm for the height reached.

(2)

Because the student would use one significant figure for the average results, and the results above are all 30.0 to one significant figure.

ResultsPlus
Examiner Comments

This response scored zero because the student just assumed that all values are quoted to 1 significant figure.

Question 18 (b) (ii)

Very few of the candidates that sat this paper managed to identify that the block itself would accelerate and hence require some of the stored energy. However, many candidates analysed the situation correctly and gave sensible explanations as to the fate of the energy originally stored in the band.

Weaker candidates explained this with references to energy being lost to heat, or energy lost as friction, or just bald statements such as *because of air resistance*. Use of the term *lost* with the form of energy did not score and candidates had to be precise when describing energy transfers away from the system, or the reason for the energy transfers. *Not all the KE transferred to GPE* was also seen commonly, which was not a sufficient explanation as to why the ball reached a much lower height than predicted.

(ii) Explain why the height reached is so much less than 2 m.

(2)

Some energy is lost as sound and heat, in addition to general friction and air resistance.

ResultsPlus
Examiner Comments

This student has given every possible reason in their response, rather than trying to describe accurately one energy transfer away from the marble.

Scores 0.

ResultsPlus
Examiner Tip

Do not refer to energy as being lost. If there has been an energy-transfer away from the moving object limiting the height it reaches or the distance it travels, then describe to what and to where the energy has been transferred.

If there have been frictional forces such as air resistance, then describe what the forces are acting on or between. A much better response in such questions would be to explain that work has been done to overcome air resistance (acting on the marble).

(ii) Explain why the height reached is so much less than 2 m.

(2)

The height reached is so much less than 2m because not all of the energy goes into the marble to make it move. Some was used moving the band and the block and some was used in sound and heat energy

ResultsPlus

Examiner Comments

This response scored 2 marks because the candidate identified that the block would move as well, and therefore some of the (stored) energy went to the block instead of the marble.

Question 18 (b) (iii)

This question required the candidates to suggest a realistic modification to the equipment that would allow the marble to reach a greater height. Many candidates realised that the best way would be to obtain more elastic potential energy in the band, but not all (only about one third) could suggest a practical way of doing this.

Responses such as *use a longer rubber band* and *pull back the band further* were not realistic, given the equipment as it stood and therefore failed to score the mark. Some ideas were not expressed with sufficient precision: *a larger elastic band* could imply a longer one or a thicker one.

Quite a few responses were seen where the candidate suggested using the marble launcher at an angle of 45°. This could be a good exercise in itself – to use the data within this question to show the difference that this would make to the height reached by the marble.

(iii) Suggest how the marble launcher could be adapted so that the height reached by the marble could be increased.

(1)

The block of wood could be sanded or lubricated to reduce friction when firing. A shorter band or stiffer band could be used to increase elastic strain energy stored when stretched.

ResultsPlus
Examiner Comments

This candidate has clearly understood the question and has suggested 4 suitable adaptations to the equipment to enable the marble to reach a greater height. 1 mark.

(iii) Suggest how the marble launcher could be adapted so that the height reached by the marble could be increased.

(1)

The block of wood could be sanded or lubricated to reduce friction when firing. A shorter band or stiffer band could be used to increase elastic strain energy stored when stretched.

ResultsPlus
Examiner Comments

1 mark for *shorter elastic band*.

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.

Some candidates did have difficulty working through the paper in the allocated time, leaving some items blank towards the end of the paper. To practise better exam technique, candidates should be encouraged to work at approximately a minute a mark, which would then leave 10 minutes at the end to go through the paper.

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

- Constructing vector diagrams to enable the magnitude and direction of the resultant to be identified or measured
- Accurate definitions of all terms given in italics in the specification
- Resultant forces and Newton's second law
- Describing experiments in a methodical sequence, and making sure all quantities to be measured are described accurately, with correct references to the equipment used
- Make answers relevant to the question. E.g. if an experiment is to be carried out only once, it is not necessary to discuss repeats etc

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