Examiners' Report
June 2014

IAL Physics WPH01 01

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Introduction

This is the second time that the Edexcel International A level in Physics has been sat by candidates. The specification examined and assessment structure of the paper is the same as that of 6PH01 paper. Section A of the paper contains 10 multiple choice questions while section B contains questions of increasing length and usually of increasing demand. This paper examines both the mechanics and materials component of the course providing a transition for candidates between GCSE and A2. Although there is no overlap with the other units, the skills and concepts covered, especially in the mechanics topic are used as a basis for the teaching of circular motion, momentum and simple harmonic motion in units 4 and 5.

This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. Many candidates showed a good progression from GCSE to AS level, with prior knowledge extended and new concepts taught and understood well. Some questions were not answered as well as would have been expected by many candidates. It was evident that some candidates did not fully understand the exact question being asked so the physics applied and subsequent explanations did not always supply sufficient and relevant detail.

However, candidates from across all ability ranges always managed to score some marks within these questions.

Calculations were answered well but were differentiated across the ability ranges. Questions 13 and 14 required use of trigonometry where less able candidates did not always select the correct trig function leading to an incorrect vector component being calculated.

Question 17(c) required the use of the gradient of the stress-strain graph to calculate the Young modulus. The vast majority of the candidates applied the correct method but not all gave a final answer of the correct order,but often forgetting the factor of 10^{6} from the stress. In addition to this, the unit of Pa or N m^{-2} was often omitted. Although the concept of Mach numbers would not have been familiar most candidates, the use of ratios in question 18(c) did appear to be challenging for some which was mirrored in similar questions on other papers.

In general, time was not an issue at all with this paper with the vast majority of candidates completing all questions on the paper. Less able candidates did tend to leave out some items, particularly those which required descriptive responses. Power of 10 errors and unit errors were common, and the quality of writing for some candidates made some responses difficult to decipher.

Section A - Multiple choice items

For the majority of candidates, their performance in the multiple choice items correlated well with their performance in section B.

Questions 5, 6 8 and 10 proved to be challenging for all candidates while questions 1, 2 and 7 were not always answered correctly by the weakest candidates.

Question	**Topic**	**% correct**	**Common wrong answer**
1	Vector and scalar quantities	90	A
2	Velocity-time and acceleration-time graphs	80	C
3	Viscosity	94	C
4	Viscosity and temperature	91	A and B
5	Energy stored in a spring	42	D
6	Kinetic energy	47	B and D
7	Spring constant definition	70	C
8	Direction of vector quantities	61	A and B
9	Use of $v^2 = u^2 + 2as$	89	A
10	Vector diagrams	55	A

Question 1

There is no evident reason for choosing response A, the most common incorrect response, besides rushing into this section without reading the stem properly where the definition of all the given physical quantities are defined. Even without the given definitions, these are all symbols used in the formulae sheet so there should have been no confusion as to *m* standing for mass and being a scalar quantity.

Question 2

This response was answered very well however it did prove to be challenging for less able candidates. As no particular context was described, the question required the candidates to be able to match the correct acceleration-time graph to the velocity-time graph. The most common incorrect response of C indicates that these candidates did not appreciate that an object moving at constant velocity would have no acceleration, which is of some concern at this level.

Question 3

Answered very well by almost all candidates. Incorrect responses were most likely due to reading the stem of the question too quickly and missing 'lowest'. It would be good practice to underline any adjectives within the command sentence so that careless mistakes are avoided.

Question 4

Again answered well, but this did confuse some candidates due to the amount of reading for each response.

Question 5

The most popular incorrect response of D, as well as the lack of any working out seen on the scripts, implies that many candidates did not spend the time required on this, more challenging question. Ideally, candidates would use Hooke's law to realise that double the spring constant would give half the extension and then use $E = ½ F r x$ to deduce that half the energy would be stored.

Question 6

As seen with question 18(c), the use of ratios seems to trip up candidates of all abilities. While all candidates should be able to successfully substitute into an equation for kinetic energy, here they were required, after reading a fairly long introduction to re-arrange the equation for kinetic energy and use a ratio. No working out was required but the two step process involved confused some, with just under half answering correctly. The two common incorrect responses indicate a weakness with some candidates in manipulating equations and correct use of ratios.

Question 7

The correct response of A is just a straightforward definition of *k*, the spring constant. Candidates that would have learnt this should have not found it necessary to read on further once the correct definition in A was spotted. The other responses were slightly longer than is sometimes seen as distractors in section A, and this could have incorrectly directed candidates towards the incorrect response of C in particular.

Question 8

With calculation questions using the suvat equations, the direction of acceleration is often forgotten or sometimes even fiddled without full understanding. With this in mind question 8 set out to examine the candidates' understanding of vector direction for a simple projectile. The direction of either was not defined but a knowledge that the direction of the resultant force is downwards should have led candidates to the direction of the consequent acceleration and, given that the ball is moving upwards, its velocity is in that direction.

Question 9

This was answered well with a high percentage of responses being correct, indicating that candidates are good at selecting and using equations of motion.

Question 10

This question was found to be the most challenging for all candidates. The construction of vector diagrams is an area of the specification that most candidates appear to have very little experience and understanding of. In this case we just wanted the direction of the resultant force. The simplest method is to extend the original diagram into a parallelogram to identify the direction and approximate magnitude of the resultant force. As is often seen with vector forces, it was not always the more able candidates answering this correctly. This indicates that is often due to the amount of time a centre has spent teaching and consolidating this subject, rather than ability, that produces good answers.

Question 11

Part (a)

Candidates could usually identify that the plastic deformation was required to create the permanent deformation that results in the folding of the rock. However, not all candidates realised that the forces involved here were under compression and instead assumed they were under tension and stating that the property was ductile or ductile and malleable. Some candidates then went on to list additional forces that could be used to describe the sandstone, such as 'strong', but these were not the property that allow it to fold, negating the mark that could have been awarded for identifying malleable. Misinterpretation of the question was quite common with answers that concentrated on the fault rather than the fold leading to responses that related to brittle.

Part (b)

This was less well answered with candidates struggling to see that the material could show elastic deformation as well as the plastic discussed in part (a). Most properties seemed to be given as an explanation with plastic behaviour probably being the most common along with descriptions of absorption rather than transmission of energy. Candidates whogained the mark for elastic behaviour usually gained the second mark for a correct definition of it.

(a) This was a very good response scoring both marks, the candidate even refers to plastic deformation under compression.

(b) An example of a response where the candidate has discussed the mechanisms of the waves travelling through the rock but has not linked this to the property of the wave that it allows the vibrations to pass through the rock. No marks scored.

(a) State and explain the properties of the sandstone that allow it to fold.

(2)

Sandstone is malleable and therefore it folds. Malleable materials such as sandstone have the ability to be beaten in various shapes (pressure causes folds) and have a large plastic deformation under compressive forces (in this case, the pressure)

(b) State and explain the properties of the sandstone that allow it to carry seismic waves.

(2)

As sandstone is a solid and the molecules are close together, the seismic waves can pass causing molecules to vibrate (earthquake)

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Examiner Comments

Although not stated within the question, the subtle difference between part (a) and part (b) is that the larger compressive forces cause the rock to fold but the smaller forces both under tension and compression as the molecules vibrate require elastic behaviour. Although waves are taught in the WPH02 specification the only prior knowledge required was that waves are due to vibrations. This should have led to the idea that an oscillation within a material requires the molecules to go back to their original position or length when the force is removed i.e. elastic behaviour.

This response scored (a) 1 mark and (b) 2 marks.

(a) State and explain the properties of the sandstone that allow it to fold.

(2)

The sandstone is tough; it ~~deforms~~ absorbs large amounts of energy by deforming plastically under compressive stress.

(b) State and explain the properties of the sandstone that allow it to carry seismic waves.

(2)

Sandstone behaves elastically, it absorbs energy by deforming ~~plas~~ elasitically and releases the energy by returning to its original shape; this transfer of energy carries seismic waves.

(Total for Question 11 = 4 marks)

ResultsPlus
Examiner Comments

(a) All references to tough were treated as neutral as it was felt they did not contradict the correct property and just added detail to the plastic behaviour of the rock. However this candidate has gone on to describe correctly that the deformation would be plastic. Again a good reference to compressive seen. Question 17 required candidates to distinguish between tensile and compressive forces, a task many candidates did not do, so it is encouraging to see the consideration of the context described here.

(b) The candidate correctly identified the plastic behaviour and the idea that it will not deform permanently. The reference to absorbing and then releasing energy so that the transfer of energy continues through the material demonstrates an excellent understanding of the context.

ResultsPlus
Examiner Tip

When forces are applied across a material and you are asked to describe the effect read the question carefully and use any diagrams or photographs to help you identify the nature of the force. This will then help you to work out which physical property you need to select to describe the context of the question.

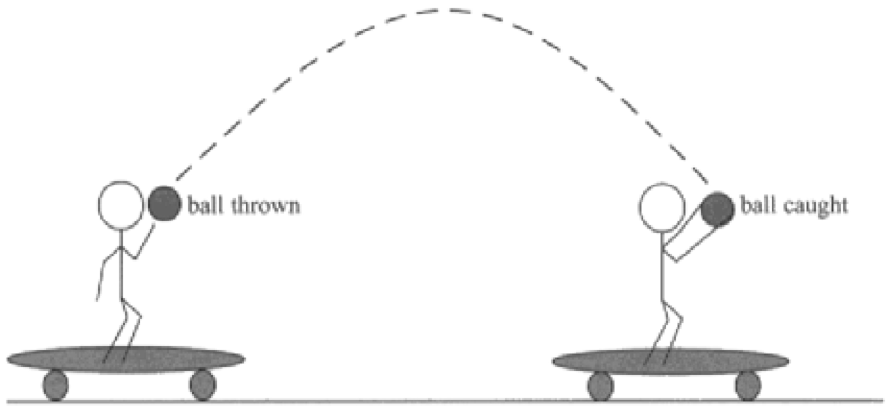
Question 12

Explanation style questions where the candidates are asked to use their knowledge of Physics to explain an observation or event are not always answered well. The candidates sitting this paper grasped the concept of the question and mainly applied the correct and relevant physics well. Not only did the candidates have to cover a description of the vertical forces or acceleration but they also had to compare the motion of the ball and skateboarder. Although responses seen were well structured and relevant and 57% of candidates scored at least 1 mark, only 8 % of candidates scored 3 or 4 marks as responses from many of the more able candidates were often not quite precise enough to fully describe a marking point.

Marks were lost where candidates had only discussed one part of the required answer, usually the vertical motion of the ball and usually in too much detail without moving on to discuss any further aspects of the ball or skateboarder's motion. In addition to this some candidates had the right concepts but did not express them in enough detail to gain any credit such as 'the horizontal velocity of the ball after it was thrown is constant', would not have scored any marks as they have not explained why it is constant (i.e. no horizontal acceleration) or compared it to the velocity of the skateboarder. Weaker candidates seemed to describe in detail the parabolic path without addressing the question asked. A number of candidates believed the ball was thrown at an angle to create the parabolic trajectory, while others introduced a second skateboarder to catch the ball.

The last marking point, a conclusion and statement as to why the ball was caught. Both a reference to distance and time of the ball and skateboarder was required but was the least frequently awarded mark. Candidates found it difficult to express and combine all their ideas clearly.

This was a good, well-structured response that scored all 4 marks.



Explain why the ball can be caught even though it was thrown vertically upwards and the skateboarder is moving horizontally. Ignore the effect of air resistance.

(4)

→ Not only skateboarder but also the ball is moving horizontally and the speed of ball equals to speed of skateboarder.
→ When the skateboarder throws the ball upward, the ball due to its inertia also ~~keeps~~ travel in a horizontal direction.
→ This is because there is no force acting on ball to oppose it's horizontal motion and according to Newton first law body ~~or~~ moving will keep on moving with constant velocity unless Resultant force acts on it. → So the ball follows a projectile path as it has both horizontal and vertical component of velocity. Ball and skakeboarder travels same distance in same time as both has same horizontal velocity as vertical velocity of ball do not effect it's horizontal velocity.

(Total for Question 12 = 4 marks)

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Examiner Comments

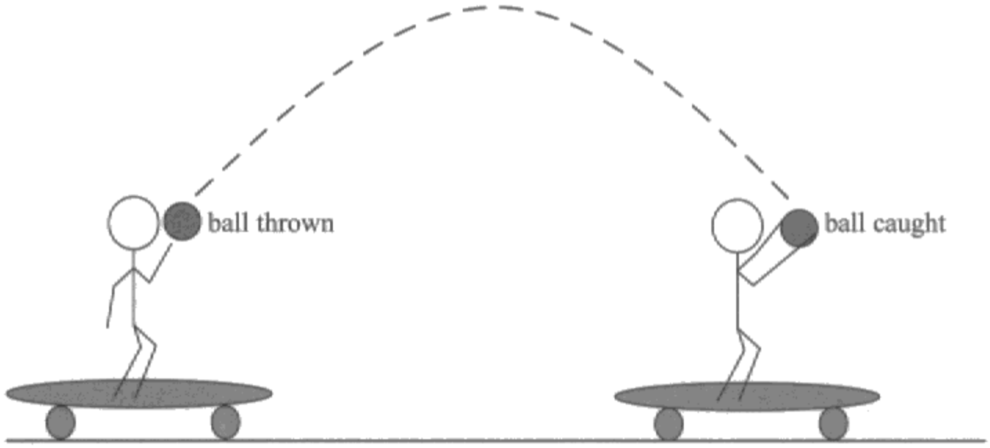
Lines 1-3 contain the second marking point that the ball and skateboarder are travelling at the same speed.

Lines 7-8 contain the third marking point that there is no horizontal force.

Lines 13 and 14 contain the idea that the ball and the skateboarder are at the same position at the same time for the 4th marking point.

Lines 14 and 15 describe the independence of the vertical and horizontal motion for the first marking point.

This response scored no marks.



Explain why the ball can be caught even though it was thrown vertically upwards and the skateboarder is moving horizontally. Ignore the effect of air resistance.

(4)

The ball can be caught even though it was thrown vertically upwards because the ball was projected while moving horizontally therefore the angle of projection is not exatly vertically upwards and also there is a force to the direction in which the skateboarder is moving, therefore ~~the~~ the ball could be caught ~~eventhough~~ whilst still moving horizontally.

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Examiner Comments

The candidate assumed that the parabolic path is due to the ball being thrown at an angle with a horizontal force.

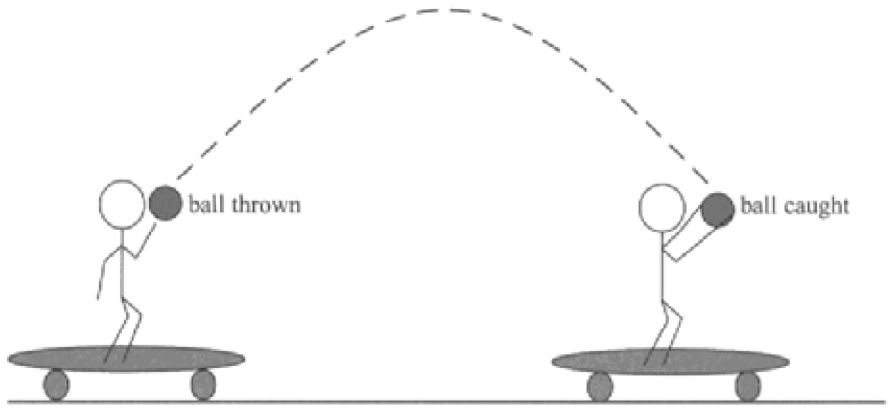
ResultsPlus

Examiner Tip

You would be told in the stem of a question if a projectile has been thrown at an angle.

In this case the path is parabolic because the ball is already travelling at a constant horizontal velocity before it was thrown.

A very clear response scoring all 3 marks for their explanation of the ball's motion.



Explain why the ball can be caught even though it was thrown vertically upwards and the skateboarder is moving horizontally. Ignore the effect of air resistance.

(4)

The ball has an initial horizontal velocity which is the same as the skateboarder's horizontal velocity. When the ball is projected upwards, it accelerates in vertical ~~downward~~ direction due to its weight. There is no resultant ~~R~~ horizontal force, so there is no ~~a~~ horizontal acceleration of the ball. The ball travels at a constant horizontal velocity. Since both the skateboarder and the ball has same horizontal velocity, the range or horizontal displacement of the ball is equal to the displacement of the skateboarder, at the same time, so the ball can be caught.

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Examiner Comments

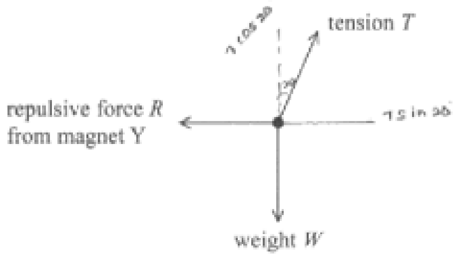
The only point missed was that the vertical and horizontal components of the velocity are independent of each other (first marking point). This is an assumption that has to be made in order to make the assumption about the displacement of the ball being the same as that of the skateboarder, which gives the 4th marking point.

Question 13

The majority of candidates could successfully apply trigonometry to calculate the required forces. Less able candidates had more difficulty using trigonometry with incorrect expressions such as $T = mg\cos 20^\circ$, $T = mg/\sin 20^\circ$ and $T = mg$ seen for the tension in (a) and $R = T\tan 20^\circ$ and $R = T\tan 20^\circ$ were also seen for the magnitude of R in part (b). Some candidates were careless with their rounding, truncating rather than rounding their answer, especially in (a). The answer should have been 0.16 N (from 0.156594) but many just quoted 0.15 N, losing the third mark in that item.

Most candidates realised in part (c) that the magnitudes were the same due to Newton's third law, although not all candidates stated the magnitude, preferring instead to state that they are the same which was not enough for the mark. Some candidates justified the magnitude of the forces with the idea of identical magnets, often after describing the correct reason of N3 and this then negated the mark.

This response scored (a) 2 (b) 3 (c) 2



(a) Show that T is about 0.2 N.

mass of bar magnet = 0.015 kg

(3)

$T\cos 20 = mg$

$T\cos 20 = 0.015 \times 9.81$

$T = \dfrac{0.015 \times 9.81}{\cos 20}$

$= 0.15\text{ N}$

$\approx 0.2\text{ N}$

(b) Calculate the magnitude of R.

(3)

$R = T\sin 20$

$= 0.15\sin 20$

$= 0.05\text{ N}$

$R =$ 0.05N.

(c) State the magnitude of the repulsive force that magnet X exerts on magnet Y and justify your answer.

(2)

0.05N, because Newtons third law pair. ~~The force exerted on X~~ When the body X exerted a force on body Y it will exert an identical force (same type, same magnitude) force on body X. both will act on opposite direction and different bodies.

(Total for Question 13 = 8 marks)

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Examiner Comments

(a) Correct method but the final quoted answer was truncated and not rounded to 0.16 N therefore no final answer mark. The final answer of 0.2 N was the show that value and we always require an answer to at least one more significant figure than the given 'show that' value.

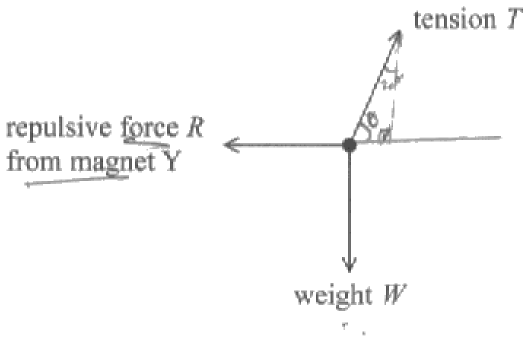
(b) Using the candidate's incorrect value of 0.15 N from part (a) 0.05N was the correct answer for part (b).

(c) Correct magnitude of 0.05 N quoted using the candidate's calculated value from part (b) with a correct explanation of Newton's third law.

ResultsPlus
Examiner Tip

Do not just truncate (chop off the final numbers) when reading from your calculator, round up or down to at least one more significant figure than the value you have been asked to show.

This response scored (a) 3, (b) 3 and (c) 1 mark.



(a) Show that T is about 0.2 N.

mass of bar magnet = 0.015 kg

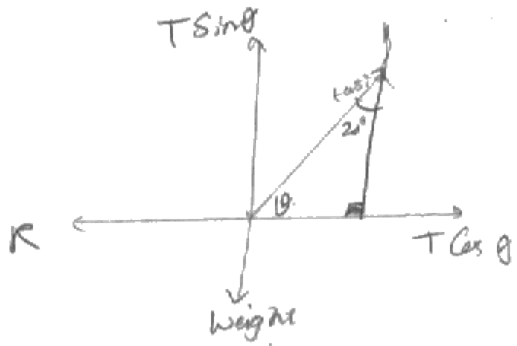
(3)

$\theta = 180 - 90 - 20 = 70°$

$T \sin\theta = \text{Weight}$

$\frac{T \sin 70}{\sin 70} = \frac{0.015 \times 9.81}{\sin 70}$

$T = 0.15659 \text{ N} \simeq 0.160 \text{ N}$



(b) Calculate the magnitude of R.

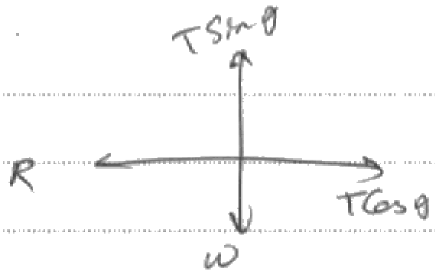
(3)

R = T Cos θ

R = 0.160 X Cos 70

R = 0.0547 N

R ≃ 0.055 N



R = 0.055N

(c) State the magnitude of the repulsive force that magnet X exerts on magnet Y and justify your answer.

(2)

the repulsive force will also be equal to 0.055N as the angle between the thred and point (p) is the same so same Tension and same (θ)

(Total for Question 13 = 8 marks)

ResultsPlus
Examiner Comments

The candidate unusually chose to use the angle of 70° between *R* and the *T* to calculate successfully the values of *R* and *T* in parts (a) and (b).

In (c) the correct magnitude was given of the force but the explanation was insufficient to score the second mark.

Question 14 (a)

Most candidates understood why the child on the walkway would not appear to move. The language used was not always precise enough to score both of the marks, often interchanging between forces and velocity. The first mark for stating or describing the resultant velocity was commonly awarded but candidates often missed out on the second mark because they did not say what would happen to the child or described what the child would have to do to reach the start, i.e. accelerate.

The idea of relative velocity is not specifically referred to in the specification and this question could have been awarded full marks without it. However, some candidates did pick up on the idea that it was the position relative to the ground or a stationary observer that needed to be considered.

This response scored no marks.

Explain why the child will not reach the start of the walkway.

(2)

This is because the child is moving at the opposite direction of the walkway. The child will move slower than 1.9 m s^{-1} as ~~force of~~ walkway exerts opposite force on the child. If the child wants to reach earlier he needs to increase speed to counter the resistance and frictional force of walkway

ResultsPlus
Examiner Comments

The first sentence described the idea of the walkway and child moving in opposite directions but there is no reference to the speeds being the same. Rather than describe the relative position of the child, this candidate discussed what the child would have to do in order to reach the start of the walkway and did not answer the question.

ResultsPlus
Examiner Tip

It sounds obvious but read the question thoroughly. Once you have finished your answer then read through the question again and then read through your response to make sure you have actually answered the question being asked. In this case the question was not, 'What would the child have to do to reach the start of the walkway?'.

This response scored both marks.

Explain why the child will not reach the start of the walkway.

(2)

The walkway and child are travelling at the same speed but in opposite directions. ~~Because~~ Velocity ~~has~~ is a vector value with direction and magnitude considered therefore the child can be regarded as having a velocity of −1.9 ms⁻¹ and the walkway having a velocity of +1.9 ms⁻¹. ~~These~~ Therefore the ~~ve~~ total resultant velocity is 0 (+1.9 ms⁻¹ + (−1.9 ms⁻¹)) so the child's displacement will also be 0. (he will not move)

. velocities cancel out.

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Examiner Comments

The candidates has stated that the resultant velocity would be zero as well as showing this numerically; both methods would score the first marking point alone.

The candidate then state that the child's displacement will be 0 which covers the second marking point.

This candidates has clearly identified that this question is about vector quantities and direction. With the exception of the reference to speed in the first line, all other quantities mentioned are vector quantities. As they have always used quantities that are vector and relevant to the context of the question, there were no ambiguous explanations in their answer and so both marks were awarded.

ResultsPlus

Examiner Tip

Make sure that you only refer to physics that is relevant to the question being asked. In this question it would be to make sure that only vector quantities are discussed, the question gives you the velocities, and so a good answer would be in terms of velocity and displacement.

Question 14 (b)

(b)(i) This section was a good discriminator. It was generally answered very well especially as three stages were involved to obtain the final answer. Less able candidates substituting into v = s/t to get the distance travelled along the slope of 47.5 m. The weight was usually found correctly but the weaker candidates did not attempt to use trigonometry to calculate the component of the weight along the slope or to calculate the vertical height of the slope. A second mark was often scored by these candidates for use of work done = force x distance.

The more able candidates often scored all 4 marks using a variety of correct methods to calculate the work done, most commonly seen was the use of the component of weight along the slope x distance along the slope.

(b)(ii) The most common problem with this question was that some candidates did not realise that the work done using the stairs was the same as the work done when using the ramp. Those who realised this, usually scored both marks for dividing their work done from part (i) or the show that value of 5 kJ by the time of 12 s. Other candidates attempted, usually incorrectly to calculate a new component of weight parallel to the stairs, using 45° and then used the same distance along the ramp as calculated in part (i). As the first mark was for the candidate realising that both work done valued would be the same, no marks could be salvaged from such methods.

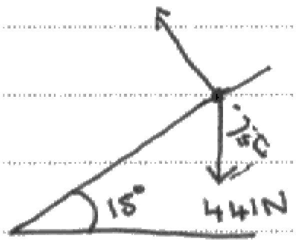
A good response scoring (i) 4 and (ii) 2 marks.

Show that the work done by the child is about 5 kJ.

mass of child = 45 kg

(4)

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



Distance = $(1.9 \times 25) = 47.5$ m

F = 114.14N

$\sin 15 = \frac{F}{441}$

$WD = F \times d = 114.14 \times 47.5 = 5421.65$ ≈ 5kJ

(ii) On another occasion, the child uses the staircase to reach the next floor in 12 s.

Calculate the power developed by the child as she uses the staircase.

(2)

WD = 5421.65   t = 12

$P = \frac{WD}{t} = \frac{5421.6}{12} = 451.8$ W

Power developed = ~~450W~~ 452W

(Total for Question 14 = 8 marks)

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Examiner Comments

(i) This candidate has calculated the component of weight acting along the slope and then used work done = force x distance with the calculated value of distance to obtain the correct work done (with a unit).

(ii) The calculated value from part (i) has been divided by the time of 12 s to calculate the power correctly.

A good response scoring (i) 4 and (ii) 2 marks.

Show that the work done by the child is about 5 kJ.

mass of child = 45 kg

(4)

~~(↑) vertical component~~

~~= 1.9 sin 15 = 0.492 ms⁻¹~~

~~K.E = ½ mv²~~

~~= ½ × 45 × (1.9 sin 15)²~~

s = u t

= 1.9 × sin 15 × 25

= 12.29 m

W.D = mgh

= 45 × 9.81 × 1.9 × sin 15 × 25

= 5427 J

≈ 5 kJ

(ii) On another occasion, the child uses the staircase to reach the next floor in 12 s.

Calculate the power developed by the child as she uses the staircase.

(2)

$\frac{5427}{12}$

= 452.25 J s⁻¹

Power developed = 452.25 W

(Total for Question 14 = 8 marks)

ResultsPlus

Examiner Comments

(i) This candidate chose to calculate the work done against gravity i.e. the GPE (as opposed to the identical work done along the slope). Trigonometry was successfully used to calculate the vertical height and then GPE = mgh was used to obtain the correct energy.

(ii) The value calculated in part (i) was used to calculate the power and a final answer given with a correct unit, so 2 marks were awarded.

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Examiner Tip

The work done on an object to raise it a certain height is the same, regardless of the route to get it there (assuming frictional forces are ignored). In this question the student could calculate the work done to walk along the slope (F x d) or the gain in GPE (mgh) which is the work done against gravity in climbing to that height. They are the same, it is just it could take longer to walk along the slope as the distance is greater (less power developed). See question 11 WPH01_01 January 2014.

Question 15 (a) (i)

This question described an experiment that may have been carried out in some centres. For candidates that had not seen the experiment before, a long description of the method was given in the stem of the question. For all candidates, including those who may have used this equipment before, an understanding of the transferral of the masses from the hanger to the trolley was required but not seen in most responses.

Part (a) asked the candidates how the student carrying out the practical would be able to obtain a value for the accelerating force from the data obtained in the experiment. F = ma was a common but incorrect response, with the candidates not realising that the falling masses provided the force to make the trolley accelerate and hence the weight of the hanging masses was the accelerating force.

This scored 0 marks.

(a) (i) State how the student obtained a value for the accelerating force *F*.

(1)

F = ma.

ResultsPlus
Examiner Comments

The candidate has been asked to show how the force can be calculated. The accelerating force is the weight, mg.

This response scored the mark.

(a) (i) State how the student obtained a value for the accelerating force *F*.

(1)

F = m x g

ResultsPlus
Examiner Comments

Not much more than the previous example but a correct statement of F = mg given.

Question 15 (a) (ii)

The question required the candidates to describe a method that was relevant to this experiment and used the measured variables that had been described in the introduction to the question. Just 44 % of candidates scored at least 1 mark, with only the best candidates managing to score the second mark and remembering to take into account that the trolley started from rest.

Methods that required the light gates to measure initial and final velocity were not valid. In addition to this, methods that described obtaining a table of results for s and t and then plotting a graph were also not valid as the weight of the hanging masses was the only independent variable described in the question, it did not mention anywhere changing the distance *s*.

Candidates that attempted to describe the second method rarely managed to score both marks as they did not always appreciate that the final velocity is double the average velocity.

This response scored 0.

(ii) Explain how the student should calculate a value for the acceleration *a* of the trolley using *t*.

(2)

He should calculate initial velocity at first light gate. $u = \frac{\text{length of trolley}}{t_1}$. Then calculate final velocity at light gate 2, $v = \frac{\text{length of trolley}}{t_2}$.

The acceleration would be given by the equation: $a = \frac{v-u}{t_3}$. t_3 is the time taken for the trolley to travel distance s.

ResultsPlus

Examiner Comments

This was not the method described at the beginning of the question. The question clearly states that the light gates are being used as a timer to measure the time taken to travel the fixed distance '*s*'.

ResultsPlus

Examiner Tip

Read the method correctly and make sure that you understand what the light gates are being used for, i.e. to record a short time as an object passes through them or to record the time taken for an object to travel a fixed distance, as was the case here.

A good response scoring both marks.

(ii) Explain how the student should calculate a value for the acceleration a of the trolley using t.

(2)

using the formula: $s = \cancel{ut}^{0} + \frac{1}{2}at^2$ and since $u = 0$

rearrange to get $a = \frac{2s}{t^2}$

where s = distance between lightgates

t = time between lightgates.

ResultsPlus

Examiner Comments

Correct equation of motion identified and the candidate has indicated that with u = 0, the acceleration is equal to $2s/t^2$. A rearrangement was not required but most that were attempted were correct, and demonstrated a good understanding of the method.

ResultsPlus

Examiner Tip

If you are going to re-arrange an equation as part of your response, make sure that you include the original formula of the equation before it has been rearranged in case you make a mistake when rearranging.

Question 15 (a) (iii)

Few candidates managed to make their response specific enough to the experiment in the question with most answers in general terms such as 'to make it a fair test' or 'so that force is proportional to acceleration'. The answer required a reference to this experiment in that we were investigating the relationship between force and acceleration and changing the mass would also change the acceleration which is not what was being investigated. Reference to both objects being accelerated were rare and again, not always making the point clearly enough to score the mark.

A good response scoring the mark.

(iii) Transferring a mass m from the hanging masses and adding it to the trolley means that the total mass being accelerated each time remains constant.

State why the total mass being accelerated should remain constant.

(1)

So that an change in acceleration is due to the force added not change in mass $F \propto a$. $m = constant$.

ResultsPlus
Examiner Comments

The candidate has implied that the change in acceleration in this experiment should be due to the change in force and not the acceleration.

This response scored the mark.

(iii) Transferring a mass m from the hanging masses and adding it to the trolley means that the total mass being accelerated each time remains constant.

State why the total mass being accelerated should remain constant.

(1)

Because mass is controlled varible, if we change the mass we cannot find out ~~the~~ the relationship between force and acceleration.

ResultsPlus
Examiner Comments

Another correct response in terms of the described experiment.

Question 15 (b)

A full understanding of the experiment was not required for this question and many candidates demonstrated a basic understanding of $F = ma$ and directly proportional relationships, as the vast majority of responses in part (i) had a straight line through the origin.

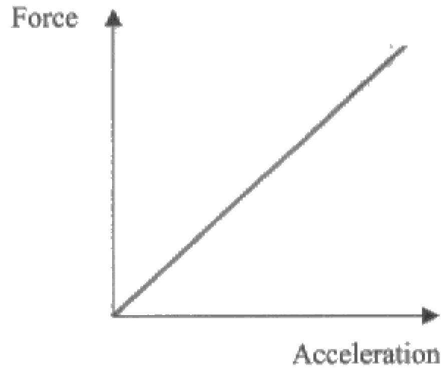
Most candidates who scored the mark in part (ii) did so by stating that the gradient was equal to the mass. Those who attempted to describe which objects it represented the mass of often lost the mark, as they failed to appreciate that it was the total mass being accelerated. Therefore responses such as 'mass of trolley' or 'mass of hanging masses' were incorrect where as a general 'mass' was not contradictory and weaker candidates often scored the mark over more able candidates more by luck than understanding.

(i)1 mark and (ii) 1 mark.

(b) (i) A graph is plotted of accelerating force against acceleration.

Sketch the graph you would expect the student to obtain.

(1)



(ii) State what quantity is represented by the gradient of the graph.

(1)

the total mass being accelerated

ResultsPlus
Examiner Comments

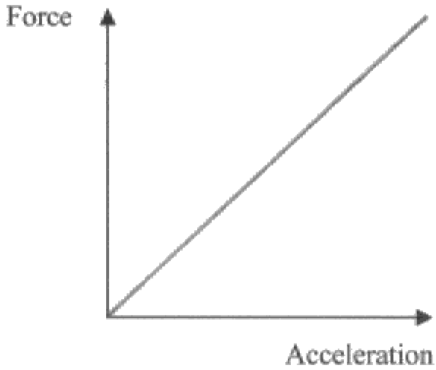
A perfect answer with this candidate clearly understanding that both objects are being accelerated by the same accelerating force.

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

(b) (i) A graph is plotted of accelerating force against acceleration.

Sketch the graph you would expect the student to obtain.

(1)



(ii) State what quantity is represented by the gradient of the graph.

(1)

Mass of the trolley

ResultsPlus

Examiner Comments

The candidates has failed to appreciate that the weight of the hanging masses is making both the hanging masses and the trolley accelerate.

Question 15 (c)

Questions similar to that asked in part (c) have been asked many times before on the home 6PH01 paper. Candidates only had to state two disadvantages without any explanation as to how they would have effected the final results or as to why they occur. This was therefore a well answered question with most candidates opting for human reaction time and then either a reference to parallax or zero error. Some candidates lost the mark as they failed to mention time, so 'human error' and 'human reaction' were not sufficient to score the mark.

This response scored 1 mark.

(c) The time t could have been measured using a stopwatch.

Suggest **two** disadvantages of using a stopwatch rather than light gates and a timer to measure t.

(2)

- In a Stop watch . reaction times can cause mistakes.
- When using a stopwatch humans have to calculate time.

(Total for Question 15 = 8 marks)

ResultsPlus
Examiner Comments

This response includes a correct reference to the reaction time.

It was quite common to see statements about the light gates enabling graphs to be plotted or calculation to be carried out automatically. These statements may be true but the question only asked for the advantage of light gates to measure *t* and not about the advantages in general.

This response scored both marks.

(c) The time *t* could have been measured using a stopwatch.

Suggest **two** disadvantages of using a stopwatch rather than light gates and a timer to measure *t*.

(2)

Using stopwatch can exposed to random error due human reaction time. 0.01 s, and exposed to pallax. error during taking the time. We have to ~~do the~~ do the graph manually compared to light gate.

(Total for Question 15 = 8 marks)

ResultsPlus

Examiner Comments

The candidate has made two correct statements about the reaction time and the parallax error.

The statement about the graph is not relevant to the question as they were only asked about obtaining the time and not to comment on any part of the method beyond that.

Question 16 (a) (i-iii)

(a)(i) Most candidates successfully used the expression density = mass/volume to obtain the correct answer of 1.06 x 10^6 kg s^{-1}. Some candidates truncated their answer rather than rounding it correctly. Although the required answer had to round to two sf to 1.1, many responses were seen with a final quoted answer of 1.05 x 10^6. Although these would have still been awarded both marks, poor rounding and quoting of final answers to too few significant figures, was common on this paper. The data in this question is given to three and four significant figures so candidates should be encouraged to work to and give their answers (accurately) to the same number of significant figures as that given in the least accurate data, i.e. to 3 s.f. in this question.

(a)(ii) This question was answered correctly by the vast majority of candidates. Some candidates did not quote their final answer to 2 sf, opting to go straight from the substitution into mgh to 2 GW. This lead examiners to believe that perhaps, as seen on other papers this summer, that the candidates did not know that giga represents 10^9.

A few candidates failed to use GPE = *mgh* and instead assumed the water was falling freely and used $v^2 = u^2 + 2as$ to obtain a final velocity and then used $P = Fv$ with the weight/second to calculate a mass. This method scored no marks.

(a)(iii) Most candidates were able to correctly use the efficiency conversion to calculate 80% of either the calculated power from part (ii) or 80% of the 'show that 'value of 2 GW. Most could then correctly convert the power to an energy, calculating the energy produced in a year. Some strange and careless time conversions were used, mainly using 360 days in a year or including an additional x 60. The unit watt, instead of Joules, was fairly common.

A significant number of candidates that scored full marks in part (i) and (ii) did not score more than 1 or 2 in part (iii) due to incomplete calculations, missing units or power of 10 errors in the calculation.

A good response scoring (i) 2, (ii)2 and (iii) 3 marks

The reservoir contains fresh water.

(a) The total flow rate across all the turbines is 1060 $m^3 s^{-1}$.

(i) Show that the mass of water entering the turbines each second is about 1×10^6 kg.

density of fresh water = 997 kg m^{-3}

(2)

1060 m^3 per second

mass per second = volume × density

= 1060 × 997

= $1.06 \times 10^6 \approx 1 \times 10^6$ kg

(ii) On average the water will drop through a height of 185 m.

Show that the total power of the falling water before entering the turbines is about 2 GW.

(2)

WD = mgh

= $1.06 \times 10^6 \times 9.81 \times 185 = 1.92 \times 10^9$ J

$P = \frac{WD}{t}$ t = 1 $P = \frac{1.92 \times 10^9}{1} = 1.92 \times 10^9$ W

1.92×10^9 W = 1.92GW ≈ 2GW

(iii) The turbines convert 80% of the power of the falling water into electrical power.

Calculate the amount of electrical energy the Hoover Dam produces each year.

(3)

~~1.926~~ $1.92 \times 10^9 \times 0.8 = 1.536 \times 10^9$ J

$(1.536 \times 10^9) \times (60 \times 60 \times 24 \times 365)$

$= 4.8 \times 10^{16}$ J

Electrical energy = 4.84×10^{16} J

ResultsPlus

Examiner Comments

A clear response with all working out shown and the correct units of Joules quoted in part (iii).

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

The reservoir contains fresh water.

(a) The total flow rate across all the turbines is 1060 $m^3 s^{-1}$.

(i) Show that the mass of water entering the turbines each second is about 1×10^6 kg.

density of fresh water = 997 kg m^{-3}

(2)

Volume = $1060 m^3 s^{-1} \times 1 s$
= $1060 m^3$
Mass = density × Volume
= 997×1060

Mass = 1.05×10^6 kg

(ii) On average the water will drop through a height of 185 m.

Show that the total power of the falling water before entering the turbines is about 2 GW.

(2)

Gravitional potential energy = mgh
= $1.05 \times 10^6 \times 9.81 \times 185$
= 1.91×10^9 J
Power = $\frac{\text{work}}{\text{time}}$ = 1.91×10^9 Watt = 1.91 GW

(iii) The turbines convert 80% of the power of the falling water into electrical power.

Calculate the amount of electrical energy the Hoover Dam produces each year.

(3)

$\frac{80}{100} \times 1.91 \times 10^9 = 1.53 \times 10^9$ Watt

Power = $\frac{\text{work}}{\text{time}}$

$1.53 \times 10^9 \times 3.11 \times 10^7$
= 4.76×10^{16} J

Electrical energy = 4.76×10^{16} J

ResultsPlus
Examiner Comments

(i) The candidate has correctly substituted into the equation but has truncated their final answer. We just required an answer that, when rounded to 2 sf, was equal to 1.1×10^6 . This candidate could still score 2 marks as 1.05 to 2 sf is 1.1.

(ii)Use of GPE with the division by 1 (not shown but assumed) to go from GPE to power.

(iii) Two marks awarded. The candidate has gone wrong when quoting the number of seconds in a year, it should be 3.15×10^6 but they quoted 3.11 and so the final answers gives an incorrect energy. The second marking point was still awarded as a time conversion had been attempted but an arithmetic or transferral error must have occurred.

ResultsPlus
Examiner Tip

Show all of your working, in this case the candidate should have written out all the steps they carried out to calculate the number of seconds in a year.
It makes checking your work at the end of the exam easier and often there are interim marks for substitutions into equations.

Question 16 (a) (iv)

If a candidate implies that energy has been lost or wasted they will not be awarded a mark due to incorrect physics. They should always explain that the energy has been transferred or dissipated and state how (as heat/thermal energy) or why (work done against friction). In this question we also accepted responses that did not specifically refer to a transfer of energy but were more specific about the cause of the transfer such as friction acts between the water and the turbine. Just as a bold answer of 'air resistance' in question 18 (b)(ii) would not be accepted, a reference to friction alone would not suffice here. Candidates should get into the habit of always describing which two bodies the friction is acting between.

A good answer scoring 1 mark.

(iv) Suggest why not all of the power from the falling water is converted into electrical power.

(1)

The water needs to stop if all is converted / Not all gpe is transferred into k.E / water is still flowing

ResultsPlus
Examiner Comments

Similar to the idea of the wind turbine seen in a previous 6PH01 paper, the idea that the water would still be moving once it has passed through the turbine demonstrates an excellent understanding of the context and is well deserved of the mark.

This scored no marks.

(iv) Suggest why not all of the power from the falling water is converted into electrical power.

(1)

Energy lose due to kinetic ~~transfer~~ of water trasfer to heat energy of moving parts.

ResultsPlus
Examiner Comments

This candidate clearly has the idea that the energy is transferred to other forms of energy. They have described and energy transfer and we can ignore the earlier reference to lost by assuming that they have now qualified that statement by explaining that the energy is transferred i.e. they have explained what they mean by 'lost'.

ResultsPlus
Examiner Tip

Never refer to energy as being lost or wasted. Describe the energy transfer by giving the mechanism of transfer such as heating or the form of energy that the energy is transferred as e.g. thermal or heat. Ideally you would also describe the body (e.g. surroundings, turbine blades) the energy has been transferred to.

Question 16 (b)

Candidates answered this well with most responses featuring some reference to flow rate or lower speed for the salt water. The exact choice of words meant that some responses fell short of the requirement of the mark scheme. Therefore responses such as less mass reaching the turbine was seen fairly often but did not score the mark as they did not say 'per second'. A reference to time was required because the same mass of salt water as fresh water would reach the turbines but would just take slightly longer. As mentioned in the introduction to this report, some candidates, who had a good understanding of the context and physics, lost marks for ambiguous responses.

Many responses failed to follow through the arguments to score a second mark.

This response was given 2 marks.

Explain, without further calculation, why the different viscosity of the water would cause the power output using salt water to be less than the power output using fresh water.

(2)

when viscosity is greater, this causes the fluid to flow at a lower velocity. This means the salt water will hit the turbines with less velocity so less turning of the turbines means less power output

(Total for Question 16 = 10 marks)

ResultsPlus
Examiner Comments

The candidate has described a lower viscosity and the turbines turning less. These are two linked points demonstrating an explanation for the lower power output. Ideally they would have described the lower rotation speed of the turbines a little better but the idea being described can be understood.

This response did not score any marks.

Explain, without further calculation, why the different viscosity of the water would cause the power output using salt water to be less than the power output using fresh water.

(2)

In fresh water less viscosity would mean easier flow of water and so will help generate turbines at a faster rate, in salt water there would be resistive forces at high viscosity.

(Total for Question 16 = 10 marks)

ResultsPlus

Examiner Comments

The candidate writing this response clearly understood why the power output with salt water would be lower. Unfortunately, none of the points were specific enough to be given a mark.

Water flows easier is not enough.

Generate turbines at a faster rate is not describing them turning.

The idea of resistive forces was examined in the previous part of the question, therefore to earn a mark here in terms of resistive force there had to be a comparison between the consequence of the greater resistive forces with salt water i.e. a reference to energy transferred and the reason e.g. greater frictional forces.

ResultsPlus

Examiner Tip

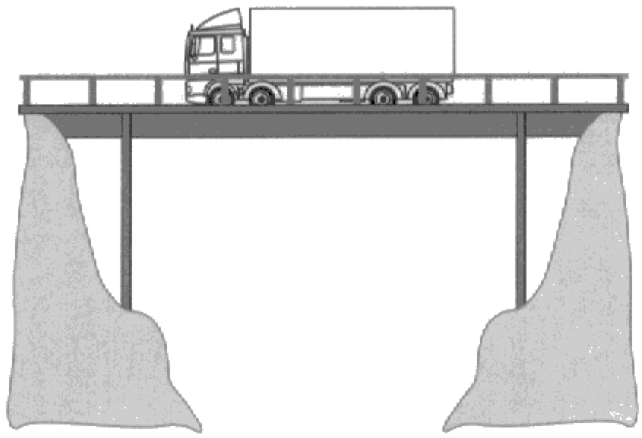
Never describe anything as 'easier', use the correct physics terminology. In this case what is meant by easier is 'flows at a greater velocity'.

Question 17 (a) (i)

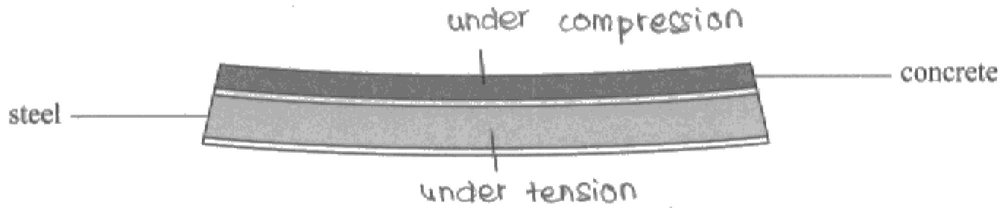
Some very vague labelling of tensile and compressive forces were seen here. We were not looking for a very precise positioning of labels, just an indication that anywhere on the steel was under tension and anywhere on the concrete was under compression. It was common to see compression labelled throughout the centre with tension labelled on both materials across the end.

2 marks were awarded.

17 A composite steel beam bridge is used across short spans.



A bridge beam consists of a base of steel with a layer of concrete on top. The diagram below shows how one of the beams will bend when a load is applied.



(a) (i) Label the diagram to show where the beam is under tension and under compression.

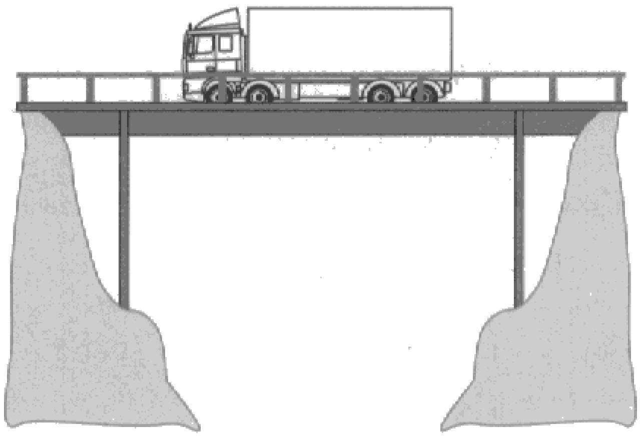
(2)

ResultsPlus
Examiner Comments

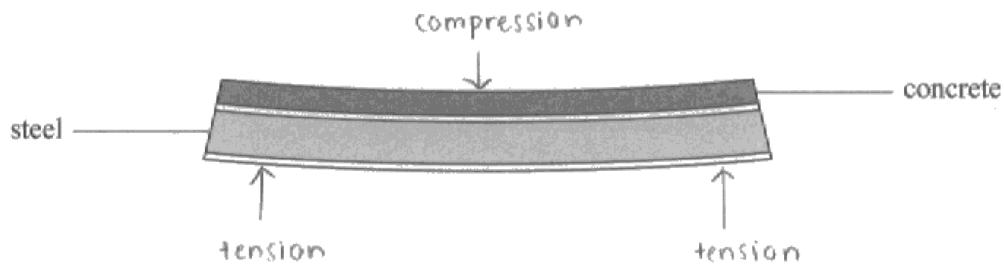
Both regions clearly labelled.

2 marks were awarded.

17 A composite steel beam bridge is used across short spans.



A bridge beam consists of a base of steel with a layer of concrete on top. The diagram below shows how one of the beams will bend when a load is applied.



(a) (i) Label the diagram to show where the beam is under tension and under compression.

(2)

ResultsPlus
Examiner Comments

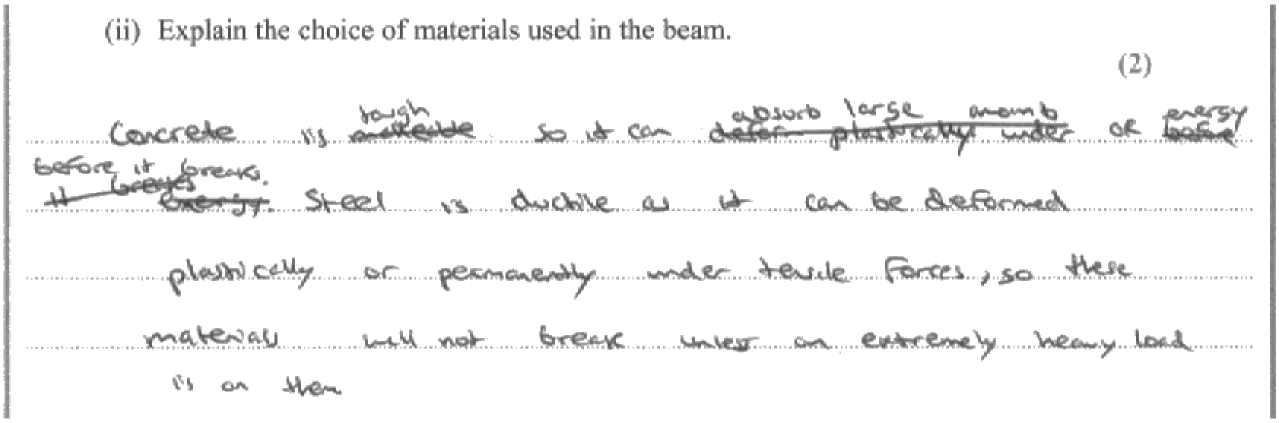
Another good response.

Question 17 (a) (ii)

Responses to this question were poor.

Many responses seen defined general in terms of strong, with few candidates identifying that the nature of the forces acting on each material were different. Steel having a high ultimate tensile stress was probably the most frequent response that scored a mark, most probably because candidates had learnt that by rote about steel. Correct explanations of the suitability of concrete were less common as it is a material less likely to be given as an example when teaching materials. However, no prior knowledge was required, as long as the candidate could identify that the concrete beam in part (i) was under compression, the rest could have been inferred i.e. in that it is strong under compression. References to strong were common. Some answers appeared incomplete in that the candidate identified that the concrete was under a compressive force and the steel under a tensile force but responses such as the steel has a high tensile stress with no reference to breaking would not have scored.

This response scored 1 mark for their description of ductile and steel.



(ii) Explain the choice of materials used in the beam.

(2)

Concrete is tough ~~malleable~~ so it can absorb large amount ~~defor plastically under~~ of energy ~~before~~ before it breaks. ~~It breaks energy.~~ Steel is ductile as it can be deformed plastically or permanently under tensile forces, so these materials will not break unless an extremely heavy load is on them

ResultsPlus
Examiner Comments

No mention at all has been made of the concrete but amongst all the irrelevant physics this candidate has given (which does not contradict any correct physics), there is a correct reference to tensile force and not breaking under a heavy load.

This response scored both marks.

(ii) Explain the choice of materials used in the beam.

~~(high UTS)~~ **(2)**

Steel is a very strong material and can withstand a lot of stress before breaking. Steel has a very high UTS and therefore is the perfect choice for tension. Concrete has a very high compressive strength, unlikely to crack or buckle under compressive loads.

ResultsPlus

Examiner Comments

A rare but excellent answer identifying that the choice of material is dependent on the high breaking strength under the appropriate compressive or tensile force.

ResultsPlus

Examiner Tip

When you are asked to describe the suitability of a material for an application, think about the most important property that the material must have. In the case of a road you would not want it break under the load created by traffic driving over it. Therefore the breaking strength is the main property to be considered.

As there were two materials used here and the previous question asked you to consider where the compressive and tensile forces acted, that should have been a clue as to the additional information required in the question.

Question 17 (b) (i)

This question required the candidates to state and define the property of concrete that causes it to break suddenly, without warning. The candidates were given the stress-strain graph for the concrete as well as the information given in the question; therefore this was answered very well.

As this question required a definition rather than an application of a property the mark scheme required a more rigorous response. Therefore candidates that did not refer to breaking in their response were not awarded the second mark.

2 marks awarded.

(i) State and define the property of concrete that causes it to break suddenly without warning.

(2)

Because brittle material.

It breaks with little or no plastic deformation.

ResultsPlus
Examiner Comments

Brittle has been identified and the candidate went on to explain that it will break with little or no plastic deformation.

This response scored 1 mark only.

(i) State and define the property of concrete that causes it to break suddenly without warning.

(2)

1. It is brittle.

2 It undergoes little or no plastic deformation.

ResultsPlus
Examiner Comments

The candidate had identified that concrete is brittle but the definition of brittle is missing a reference to breaking after little or no plastic deformation, so no second mark.

Question 17 (b) (ii)

This question required the candidates to apply their knowledge of the properties of materials to the bridge if the applied stress became too large and it would start to fail.

The first three marks required the candidates to describe the effect on steel if a large stress is applied and the final mark required a description of what you would see on the bridge. This item discriminated well with most candidates scoring at least one mark and the best often achieving all 4 marks for well-structured explanations.

The most common mark awarded was for identifying that the steel would undergo plastic deformation (MP3) followed by a (permanent) change in shape (MP4). The more able candidates manage to identify that this only occurred once the elastic limit had been exceeded with some candidates even identifying that this will be at the yield point. More through meticulousness than difficulty, only the best candidates identified that steel is ductile, usually giving them all 4 marks.

This response scored one mark.

(ii) Use the graph to explain why there would be visible signs that the steel part of the bridge was starting to fail if the applied stress were too large.

(4)

This is because the graph shows that after the elastic limit, when the amount of stress is decreased, there is an increase in the strain (change in length). This means that every time the force exerted per unit area would increase, the change in length over the original length would also increase. As there is change in length, the structure of the bringdge can also change and the bridge can break down. This is what the graph displays, indicating that if the force exerted increases (stress), the bridge will start to fail as the extensions of the bridge would increase, after a certain limit.

ResultsPlus
Examiner Comments

The candidate has correctly identified that if the applied stress is too large then the elastic limit will be exceeded. They then attempted to describe plastic behaviour but were not specific enough. Finally there was an attempt at describing the visible signs of failure but these were too general.

ResultsPlus
Examiner Tip

Learn the definitions of the properties of materials accurately as questions often just ask for a definition. In this question the candidates had to use the definition to describe what would happen to the bridge.

This response scored 3 marks.

(ii) Use the graph to explain why there would be visible signs that the steel part of the bridge was starting to fail if the applied stress were too large.

(4)

The Steel is a ductile material. It undergoes a very long range of plastic deformation before breaking. This plastic deformation can be easily seen and they will not put the load. They'll know if the load is too large due to the plastic deformation. In contrast, with concrete we don't know if it'll break since it's brittle. Steel undergoes much plastic deformation and there's enough time to remove the load before it breaks. When the load is removed the steel will not return to its original shape

ResultsPlus

Examiner Comments

The candidate has clearly identified that the steel is ductile and that it will exhibit a large amount of plastic deformation resulting in it not returning to its original shape. No reference was made to the elastic limit or yield point but this well structured answer scored 3 out of the 4 marks.

Question 17 (c) (i)

Although the vast majority of candidates used the gradient of the graph or pairs of points within the linear region, a far smaller proportion of candidates took notice of the units on the axis. Calculated answers often had a power of ten error or a missing unit.

The graph clearly passed through (0,0) but many candidates did not chose to use (0,0) as one of the points, often introducing additional errors when reading the co-ordinates from the graph.

This response scored 1 mark.

(i) Calculate the Young modulus of the steel.

(2)

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{150\ \text{Pa}}{8.5 \times 10^{-3}} = 17647.05$$

$$= 17600$$

Young modulus = 17600 Pa

ResultsPlus
Examiner Comments

The gradient of the graph within the liner region has been attempted however this candidate forgot to include the mega from MPa from the axis for stress, therefore creating an error of x 10^6 in their final answer. Therefore no final answer mark could be awarded.

ResultsPlus
Examiner Tip

Check the units on the axis for every graph, making sure that all prefixes are seen and then included in your calculations.

This response scored both marks.

(i) Calculate the Young modulus of the steel.

(2)

E = young's modulus = $\frac{\text{stress}}{\text{strain}}$ $E = \frac{152.5 \times 10^6 \text{ Pa}}{0.875 \times 10^{-3}}$

at P → limit of ~~proportionality~~ elasticity $E = 1.7 \times 10^{11}$ Pa.

Young modulus = 1.7×10^{11} Pa

ResultsPlus

Examiner Tip

A pair of points from within the linear region have been taken. All quantities included the correct scale factors read from the axes of the graph. The final answer is within the given range on the mark scheme with a unit, so both marks scored.

Question 17 (c) (ii)

This specification specifically makes a distinction between the elastic limit and yield point. This question was intended to examine the candidates' knowledge, not allowing any overlap between definitions. Questions which require these points to be identified or applied are usually more lenient in the language used but as this was clearly a definition item then clear and accurate explanations were required.

This response scored no marks.

State what is meant by elastic limit and yield point.

(2)

Elastic limit – is the point where an object will go back to its original shape. After this point it will no longer go back to its shape.

Yield point – The point at which after ~~plast~~ the material ~~g~~ undergoes plastic deformation.

(Total for Question 17 = 14 marks)

ResultsPlus
Examiner Comments

This response is very similar to many seen. The definition of the elastic limit is nearly correct but is missing a reference to the (deforming) force being removed.

The candidate has then confused the elastic limit with the yield point and has given a very good definition of the elastic limit. This would have scored the mark had it been identified as the correct explanation for elastic limit.

No mention at all to the 'yielding' that occurs at the yield point.

ResultsPlus
Examiner Tip

Please learn definitions accurately.

The elastic limit and the yield point are two separate points that can occur in the behaviour of some materials as the applied stress in increased. Although plastic behaviour continues beyond both points, it begins at the elastic limit and if sufficient stress is applied that a material will reach its yield point. At this point, the material will suddenly produce a great extension with little, or even no, additional applied stress.

A good response scoring both marks.

State what is meant by elastic limit and yield point.

(2)

Elastic limit is the point beyond which a material cannot retain its original dimensions, even after removal of the deforming force. (~~Beyond this point, (Stress is not~~)

Yield point is the point at which a material shows a ~~ø~~ large increase in strain for a small increase in stress.

(Total for Question 17 = 14 marks)

ResultsPlus

Examiner Comments

This candidates has written a clear and correct definition for both the elastic limit and the yield point.

We have asked for a limit and a point to be defined. Therefore it is expected that any response will refer to what happens at the end of the limit, i.e. from this point or up to this point. This is slightly more obvious and more commonly seen for yield point and most responses tend to start with 'This is the point at which...'. Responses starting with 'It is where......' are to be avoided, especially with elastic limit, as this really refers to a single point on a stress-strain graph.

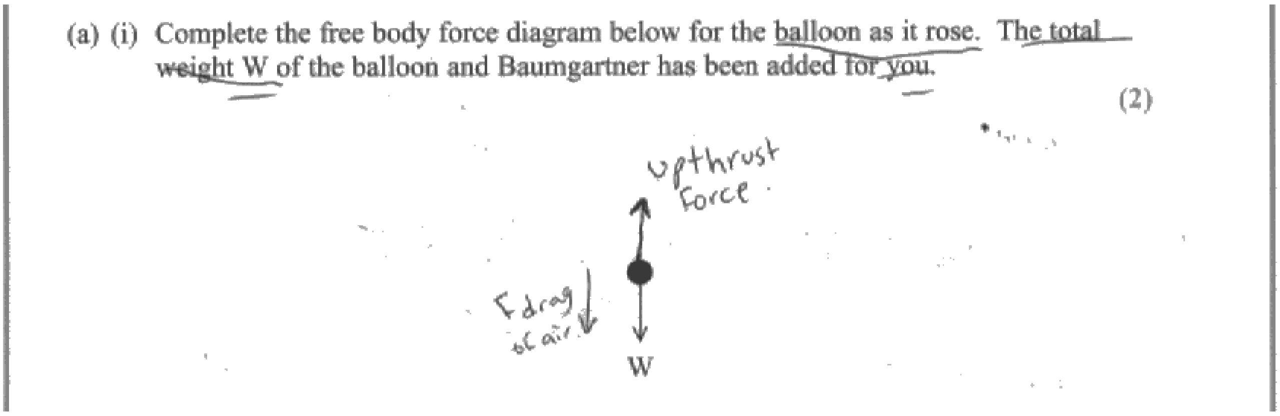
It is important to mention the 'increase' in stress when defining the yield point. Many candidates just refer to an applied stress producing a large extension. It is the use of 'no' or 'little' additional force that creates the large extension.

Question 18 (a) (i)

While most candidates remember to include the upthrust, many had clearly not read the question and not realised that the balloon was rising. A large proportion of responses therefore had the drag force in an upwards direction implying that the balloon was falling. We have only tended to examine objects moving upwards in the multiple choice items and have mainly asked questions involving falling items in the longer questions of section B. Candidates had clearly re-drawn free-body diagrams from completing such practice questions, rather than from reading the question and thinking about the context.

For the majority of responses, the labels used for the forces were appropriate but an undefined '*V*' for viscous drag was not acceptable. This could have been confused with viscosity which has been incorrectly used on such diagrams in the past. In addition to this an undefined '*F*' will not be acceptable as a label, as it could refer to any force.

This response scored one mark for the correct direction and labelling of the upthrust.


(a) (i) Complete the free body force diagram below for the balloon as it rose. The total weight W of the balloon and Baumgartner has been added for you.

(2)

ResultsPlus

Examiner Comments

The force for drag is correctly labelled and in the correct direction but due to its position, it does not appear to be acting on the balloon.

ResultsPlus

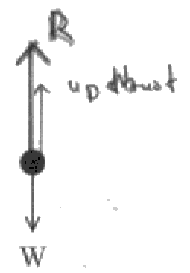
Examiner Tip

Free-body diagrams should show all the forces acting on a body with their correct directions. All lines with arrow heads must touch the dot to imply that the force is acting on the object the dot represents.

Just one mark awarded for upthrust.

(a) (i) Complete the free body force diagram below for the balloon as it rose. The total weight W of the balloon and Baumgartner has been added for you.

(2)



ResultsPlus

Examiner Comments

No drag drawn in or labelled. Some candidates do sometimes include a resultant force. Any arrows labelled 'resultant' or 'R' will be counted as additional forces and marks could be deducted if the candidates has already scored full marks for drawing and labelling the correct forces. In this case no marks were deducted as only one mark had been awarded.

ResultsPlus

Examiner Tip

Do not include resultant force arrows in free body diagrams. The resultant is not an additional force but the sum of all the forces acting on the object and should not be drawn in. For the balloon, the resultant force should have been zero anyway as it is moving at a constant velocity.

Question 18 (a) (ii)

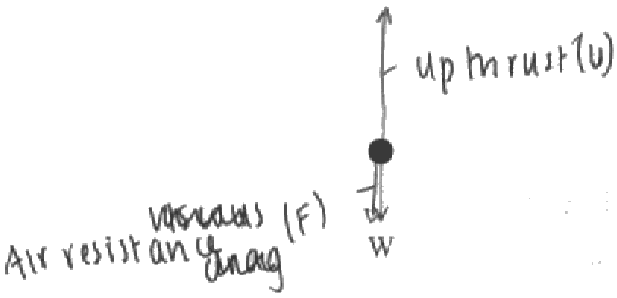
There was no ecf from part (i) for incorrect directions of forces from part (i) so although some candidates had written expressions consistent with their free body diagrams, no marks were awarded for incorrect statements of physics.

The stem of the question refers to the balloon rising, so the response required was expected to describe the motion during the constant velocity phase of its motion as this was for nearly 95 % of its journey time. Many candidates chose to use inequalities implying that there was a resultant force, often with the inequality the wrong way round implying that the balloon was accelerating. Such answers were not credited and only statements with no resultant force were accepted.

One mark awarded.

(a) (i) Complete the free body force diagram below for the balloon as it rose. The total weight W of the balloon and Baumgartner has been added for you.

(2)



(ii) Write an expression for the forces acting on the balloon as it rose.

(1)

U = F + W

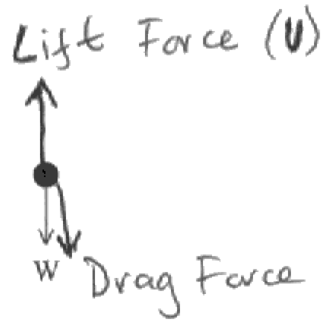
ResultsPlus
Examiner Comments

'F' was defined on the diagram giving a correct statement for the forces at constant velocity.

No marks awarded.

(a) (i) Complete the free body force diagram below for the balloon as it rose. The total weight W of the balloon and Baumgartner has been added for you.

(2)



(ii) Write an expression for the forces acting on the balloon as it rose.

(1)

Lift Force (upthrust) > Weight + Drag Force.

ResultsPlus

Examiner Comments

Using the candidates labels from part (i), this response described the object as accelerating and scored no marks.

Just to note that 'lift force' would not have been accepted in place of 'upthrust' in part (i).

The drag force is not as vertical as we would have liked but given that the label for weight is in the way, there was a greater tolerance on the direction of the vertical forces than usual.

Question 18 (a) (iii)

This question differentiated well across all abilities. The common error was due to not reading the question properly and assuming that this question was about the resultant force acting on the balloon as it rose, discussing the relative magnitudes of the upthrust and drag. These responses often went into detail about Newton's second law and Stoke's law, none of which were relevant to the main idea that the density of the air decreases as the balloon rises.

The most common responses seen involved the density of air decreasing so the upthrust would increase, scoring two marks. A smaller number of candidates identified that a greater volume of air would be displaced as it rose so the upthrust increases. Few candidates managed to include both of these ideas and only a small number of candidates included a conclusion comparing these two effects - the 5th marking point.

This response scored 2 marks.

Explain the changes in the upthrust as the balloon rose. Assume that the weight did not change.

(4)

- Upthrust increases at first.
- The envelope expanded and volume increases.
- Upthrust decreases then.
- The density of air decreases a lot.

ResultsPlus
Examiner Comments

The ideas that the density increases and the envelope expands are correct and were awarded 2 marks. As this response has been written using bullet points the statements about the upthrust are not linked to the correct even and are too ambiguous for the marks. In the order in which they have been written they seem to imply that the change in the upthrust causes the change in density and volume.

This response scored 2 marks.

Explain the changes in the upthrust as the balloon rose. Assume that the weight did not change.

(4)

At first, the upthrust was greater than the weight, which caused an unbalanced force and caused the capsule to accelerate upwards. When the capsule gained speed, the drag builds up and W+D equals upthrust, hence terminal velocity. When the system ascends, the air gets thinner and this means the density decreases, since upthrust is dependent on density, it decreases and the balloon slows down, so Drag reduces, the balloon comes to a standstill when the the upthrust is equal to the velocit.

ResultsPlus

Examiner Comments

Even though the graph of the balloon's ascent is primarily a straight line this candidate assumed it was accelerating. The earlier part of the response was treated as neutral because it did not contradict the description of the balloon at heights at which the change in upthrust is significant. The candidate eventually began to discuss a decrease in upthrust due to decreasing density, scoring 2 marks.

Question 18 (a) (iv)

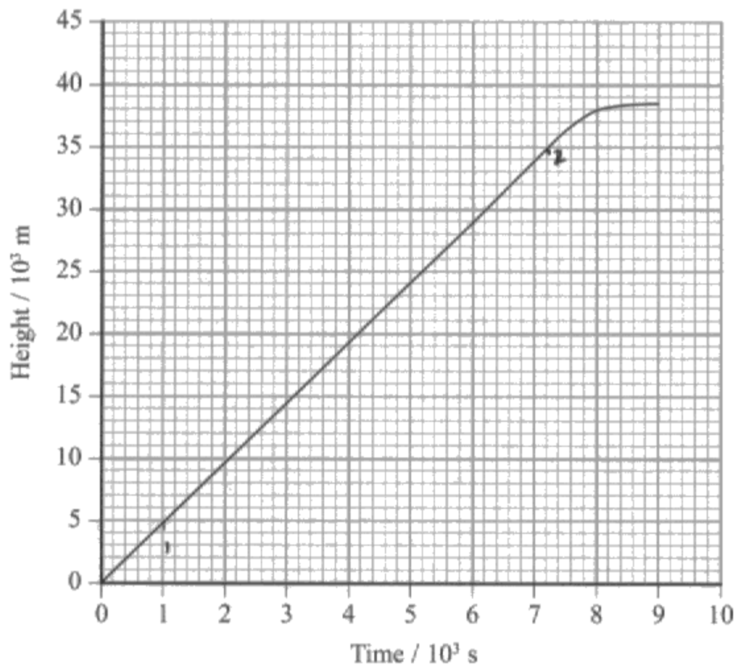
Candidates found the extraction and use of data from the graph to be straightforward with a high proportion getting 2 marks for this item. Some candidates chose a pair of values from the horizontal region of the graph, scoring one for use of speed = distance /time but producing an answer out of range so no scoring any further marks.

Errors occurred when candidates had omitted the power of ten in either the numerator or denominator of their expression. An answer to 2 significant figures was required as that eliminated ambiguous values taken from the decelerating or stationary part of the graph. A significant number of responses did not include a unit.

This response scored both marks.

The balloon rose to a height where the density of the air is less than 1/200 of its value at sea level. As the height increased the envelope expanded.

The graph below shows how the height of the balloon increased with time.



(iv) Use the graph to calculate the velocity of the balloon as it rose.

(2)

$m = \frac{h_2 - h_1}{t_2 - t_1} = \frac{35 - 5}{7.2 - 1} = 4.84\ ms^{-1}$

Velocity = $4.84\ ms^{-1}$

ResultsPlus
Examiner Comments

The candidate has calculated the gradient using most of the linear region to obtain an answer in range with a correct unit.

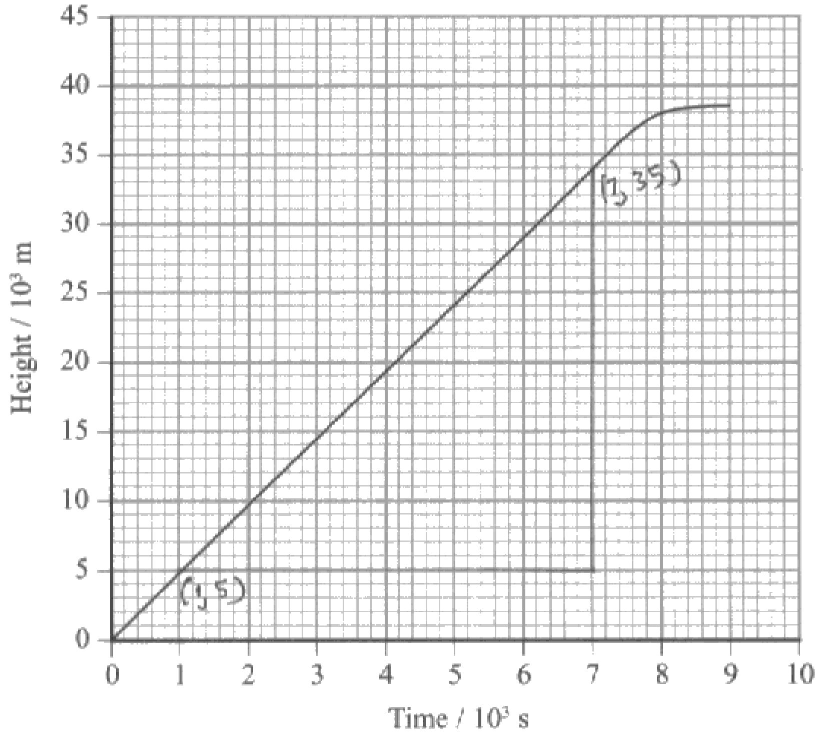
ResultsPlus
Examiner Tip

If taking a gradient from the graph use the largest triangle possible, extending the linear region of the line if necessary.

This response scored 1 mark only.

The balloon rose to a height where the density of the air is less than 1/200 of its value at sea level. As the height increased the envelope expanded.

The graph below shows how the height of the balloon increased with time.



(iv) Use the graph to calculate the velocity of the balloon as it rose.

(2)

(7, 35)
(1, 5)

$\frac{y_2 - y_1}{x_2 - x_1} = \frac{35 - 5}{7 - 1} = \frac{30}{6} = 5$

Velocity = 5 m s^{-1}

ResultsPlus
Examiner Comments

This candidate has only quoted their answer to 1 s.f. so could not be given a mark for their final answer.

Some less able candidates used (0,0) and (1,5) obtaining an answer of exactly 5 m s^{-1}, a response not deserved of both marks, hence the 2 sf stipulation.

Question 18 (b) (i)

This question was well answered by nearly all of the more able candidates.

Most responses seen used $v = u + at$ to obtain a correct answer of 491 m s^{-1}. Some candidates truncated their answer and quoted 490 rather than or 491 as their final answer and did not score a second mark. Incorrect responses tended to use a non-zero initial velocity either taken from earlier in the question or following an attempt at a calculation.

A correct response scoring both marks.

(i) Show that the theoretical speed he could have reached 50 seconds after stepping out of the capsule was about 500 m s^{-1}.

(2)

$v = u + at$

$v = 0 + 9.81 \times 50$

$v = 490.5$ m/s ≈ 500 m/s

ResultsPlus

Examiner Comments

The correct answer using $v = u + at$, with $u = 0$, has been calculated and included the correct unit.

This response scored 0 marks.

(i) Show that the theoretical speed he could have reached 50 seconds after stepping out of the capsule was about 500 m s^{-1}.

(2)

$H_{max} = 38.5 \times 10^3$ m

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

$-38.5 \times 10^3 = u(50) + \frac{1}{2}(-9.81)(50^2)$

$u = \frac{12262.46}{50} = 245$ ms^{-1}

ResultsPlus

Examiner Comments

The candidate has not understood the question and assumed it was asking for an initial rather than a maximum velocity. It appears as though they tried to calculate an initial velocity based on falling the total height of the drop in 50 s.

Question 18 (b) (ii)

As mentioned when discussing item 16(b)(iv), to state air resistance alone, without a reference to the body on which it is acting, would not score the mark. Air resistance was a very common response and given the number of time in the past questions have been asked about the effect of air resistance on projectiles, the poor performance of candidates in this item was disappointing.

For the candidates that scored the mark, the lack of consideration of air resistance when calculating the speed and, 'the air resistance was acting on him', were the most common responses.

Some candidates wrote down the difference between the two speeds without any additional comments while other common responses referred to energy being lost or wasted, again without any addition comments to explain why there was this 'loss' of energy. Very few candidates appreciated that he had reached his terminal velocity with even fewer candidates giving an answer in terms of the resultant force.

1 mark awarded.

Account for the difference between the theoretical speed and the actual speed.

(1)

~~5001-3800~~ Air resistance was acting on him.

ResultsPlus

Examiner Comments

Straight from the mark scheme, a good answer.

No marks awarded.

Account for the difference between the theoretical speed and the actual speed.

(1)

air resistance

ResultsPlus

Examiner Comments

Not much to see but as mentioned above this was a very common answer.

This question does ask for the candidates to account for the difference between the speeds. Just stating air resistance is not accounting for the difference, it is just stating a type of resistive force hence additional information/explanation is required for the mark.

Question 18 (c)

More able candidates had no problems creating and manipulating a ratio from the information given in the stem of the question. A significant number of weaker candidates had no idea how to approach this question and left it blank or just multiplied 380 by 1.2 (rather than divide by 1.2). Some candidates confused Mach 1.2 i.e. a ratio of 1.2:1 with a ratio of 1:2 and doubled the speed.

2 marks awarded.

(c) The Mach number is the ratio of the speed of an object to the speed of sound. The maximum speed reached by Baumgartner was 380 m s^{-1} at a height of 20 km above the Earth. This speed can be described as Mach 1.2.

Calculate the speed of sound in air at a height of 20 km.

(2)

1.2 → 380 ms^{-1} $= \frac{380}{1.2}$ ≐ 316.67

1.0 → x ?

Speed of sound = 316.7 ms^{-1}

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

ResultsPlus

Examiner Comments

Correct use of the ratio to give a correct answer with unit but units were not always remembered.

This response did not score any marks.

(c) The Mach number is the ratio of the speed of an object to the speed of sound. The maximum speed reached by Baumgartner was 380 m s⁻¹ at a height of 20 km above the Earth. This speed can be described as Mach 1.2.

Calculate the speed of sound in air at a height of 20 km.

(2)

$\frac{20\,000}{380} = 52.6\,s$

52.6 speed = $\frac{\text{distance}}{\text{time}}$

$= \frac{20\,000}{52.6} = 380$

380 : speed of sound = 1 : 1.2

380 × 1.2 = 456

Speed of sound = 456 ms^{-1}

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

ResultsPlus

Examiner Comments

A well set out answer but the candidate has misunderstood the definition of Mach and made it into a ratio the wrong way round which resulted in the speed being multiplied by the Mach number and not divided.

Paper Summary

This paper provided candidates with a wide range of contexts from which their knowledge and understanding of the physics contained within this unit could be tested.

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

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

- Slow down during the multiple choice items, so that key words in the command sentence responses are not missed.
- Remember to check responses if there is time at the end of the paper in case careless mistakes have been made, especially powers of 10 or missing units
- Revise accurate definitions of all terms given in italics in the specification
- If a series of events has to be described, do not spend all of your time describing one aspect e.g. just the vertical motion and then have no time left to describe the horizontal motion.
- Read the question and answer exactly what is being asked. Do not give the answer to a question you may have seen on a previous paper because perhaps different forces are involved.

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