Examiners' Report
June 2015

IAL Physics WPH01 01

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Introduction

The specification examined and assessment structure of the WPH01 paper is the same as that of the 6PH01 paper for UK candidates. 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.

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 with some candidates finding the contexts finding too unfamiliar. In such questions, although it was clear that the concepts being examined were known to some degree, the candidates could not express their ideas sufficiently to answer the question being asked. This was particularly true for most candidates for question 19 and less so for 15(a) and 17(b)(i). However, candidates from across all ability ranges always managed to score some marks within these questions.

With the exception of 19(b)(ii) the mathematical skills seen were to a very high standard, however there was a significant lack of consideration to the direction of vector quantities and to the selection of the correct variables to substitute into the equations of motion. In general, a lack of meticulousness when answering quantitative questions, through haste rather than lack of understanding, lost good candidates marks with only the best scoring fully on most of the calculations.

Time was not an issue at all with this paper, with the vast majority of candidates completing all questions on the paper scoring consistently throughout the paper, in particular question 18 which was answered well by most candidates.

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. The multiple choice questions were answered well with a mean score of 7.6. Candidates at the A grade boundary tended to score a minimum of 8 whilst E grade candidates scored at least 6 marks.

Questions 4 and 9 proved to be challenging for all candidates while questions 1 and 3 in particular were found to be more demanding by the weakest candidates The remaining questions were answered well by all candidates with very little variation between A grade an E grade candidates.

Question	**Topics**	**% Correct**	**Common Wrong answer**
1	Velocity-time graphs	70	C
2	Vectors and scalars	94	A
3	Extension of a spring	75	B
4	Energy-time graph for a bouncing ball	25	B,D
5	Hooke’s Law	83	D
6	Properties of materials	87	B
7	GPE and power	93	D
8	Equations of motion	85	D
9	Work done	60	B
10	Viscosity	92	A

Question 1

A straight-forward question to begin the paper with. Given that the most popular incorrect response was C this indicates that some candidates read through the text of the question too quickly, missing the key statement that the acceleration was non-zero. This was true across all abilities and not just at the lower end.

Question 3

This question required the candidates to compare the four arrangements of springs to deduce the combination that would give the greatest extension. By identifying the relative force acting on each spring it could be deduced that C would give the greatest extension due to both springs having the same load mg acting on them. Those that chose B did not realise that the load would be halved for two springs in parallel hence the extension would be halved.

Question 4

This question required the candidates to consider the total energy of the ball. Few correctly selected C. The correct graph C has the decrease in the total energy of the ball as it bounces which would be due to heating.

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 a candidate's 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

The candidates were expected to consider the work done on the swimmer by the water to stop them completely i.e. $mgh = \frac{1}{2}mv^2 = Fd$. A majority of candidates correctly chose B, the speed of the swimmer, a quantity that would determine the kinetic energy of the swimmer on impact with the water and hence affect the work done by the water on the swimmer.

Question 11

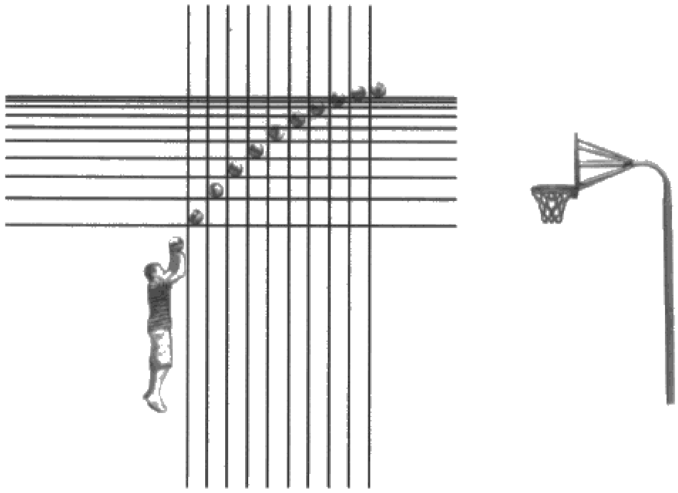
This question was generally answered well. Some weaker candidates assumed that the horizontal lines indicated changes to the horizontal motion with the same error for the vertical lines.

Candidates seemed to find it easier to explain the reason for the vertical lines being equally spaced i.e. constant velocity compared to the situation in (b), although many responses in this second part failed through a lack of direction being mentioned. Some candidates, clearly knowing the physics, did not score due to a lack of precison in their language when describing the motion, in particular in (b) where answers such as 'the speed decreases with height' were not specific enough.

This reponse scored 1,1.

11 A basketball is thrown towards a basket. The position of the ball at equal time intervals is shown in the photograph.

Vertical and horizontal lines have been added to the photograph to help identify the ball's horizontal and vertical position.



Suggest a reason for each of the following observations:

(a) the vertical lines are evenly spaced,

(1)

There is no force opposing the horizontal motion of ball so travels at a constant speed

(b) the horizontal lines become closer together.

(1)

Vertically ~~for~~ downward force, weight, acts on ball causing it's speed to decrease

ResultsPlus
Examiner Comments

(a) The mark was awarded for identifying that there is no horizontal (resultant) force.

(b) The candidate has described the vertical speed decreasing to get the mark. The references to weight and force are not quite enough on their own to score the mark because in the vertical direction the idea of a negative or downwards resultant force was required.

ResultsPlus
Examiner Tip

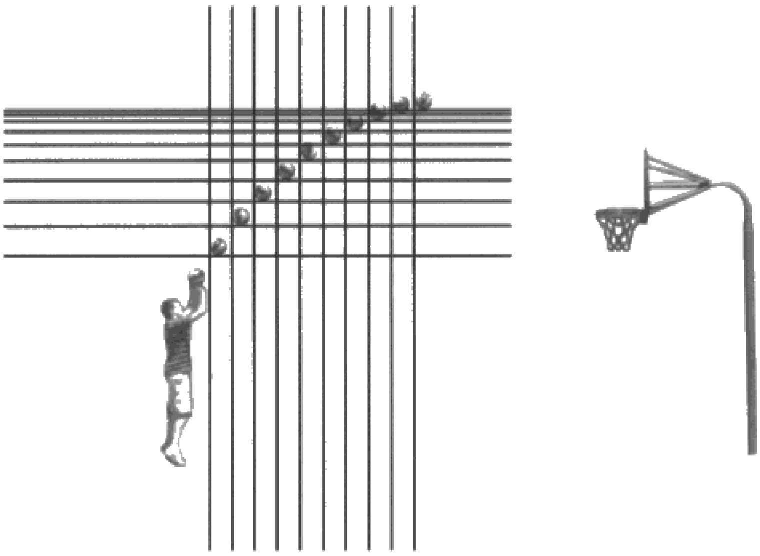
When referring to forces to make it clear that you are referring the resultant or a specific force.

In this example there is already weight acting vertically downwards as well as the smaller force of air resistance (also downwards while the ball travels upwards) but it is the resultant force that acts downwards (against the direction of motion) creating a negative acceleration or deceleration.

This response scored 0,1.

11 A basketball is thrown towards a basket. The position of the ball at equal time intervals is shown in the photograph.

Vertical and horizontal lines have been added to the photograph to help identify the ball's horizontal and vertical position.



Suggest a reason for each of the following observations:

(a) the vertical lines are evenly spaced,

(1)

This is because they represent the horizontal movement/ positions of the ball. The horizontal component is constant per time period.

(b) the horizontal lines become closer together.

(1)

This is because they represent the vertical movement/ positions of the ball. This is affected by acceleration due to gravity downwards, hence the ball is slowing down (decelerating) per time period.

(Total for Question 11 = 2 marks)

ResultsPlus
Examiner Comments

(a) The candidate has not specified which aspect of the horizontal motion is constant per time period i.e. the displacement/distance, so does not score the mark.

(b) Downwards acceleration (due to gravity) or deceleration can both score the mark and there is no doubt that the candidate is discussing the vertical motion as they linked the horizontal lines to the vertical motion in their first sentence.

Question 12 (a)

The most frequently awarded mark for this item was 1 with only the best students picking up a second mark for the correct direction for the vertical acceleration.

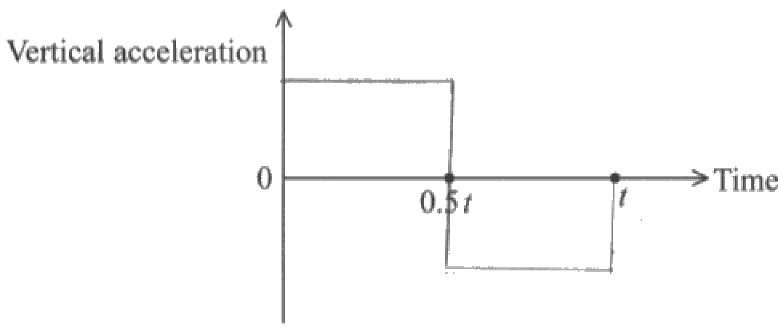
A wide variety of responses were seen for this question. Most common was a horizontal line changing direction at 0.5*t* suggesting that students thought that acceleration changed direction at the highest point. Even candidates that had a single horizontal line were evenly split between those who correctly drew a negative acceleration and those with an incorrect constant positive acceleration.

Diagonal lines were also fairly common suggesting that candidates thought they were drawing a velocity-time graph with curved lines suggesting a displacement-time graph.

This response scored 1 mark.

(a) On the axes below, sketch the corresponding graph of vertical acceleration against time for the motion of the cricket ball.

(2)



ResultsPlus
Examiner Comments

This was the most common response seen and scored 1 mark for the horizontal line i.e. a constant value of acceleration (ignoring the direction).

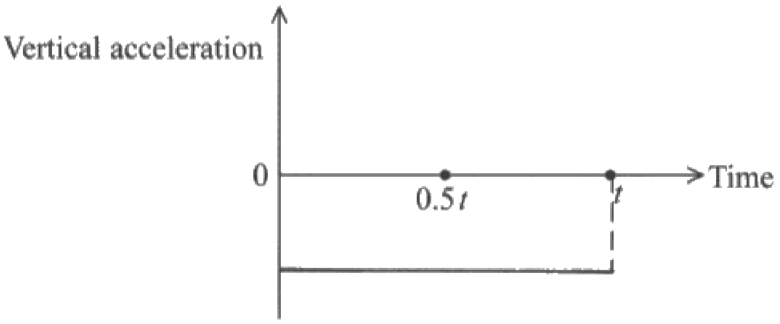
ResultsPlus
Examiner Tip

The downwards gravitational force causing the (negative) acceleration is constant and will be the same regardless of the direction of motion of the ball. Therefore the direction of the acceleration will be the same throughout the ball's motion, i.e. a constant negative value.

A good response scoring both the marks.

(a) On the axes below, sketch the corresponding graph of vertical acceleration against time for the motion of the cricket ball.

(2)



ResultsPlus

Examiner Comments

The graph shows a constant negative value for the acceleration ending at time *t*, when it is caught.

Question 12 (b)

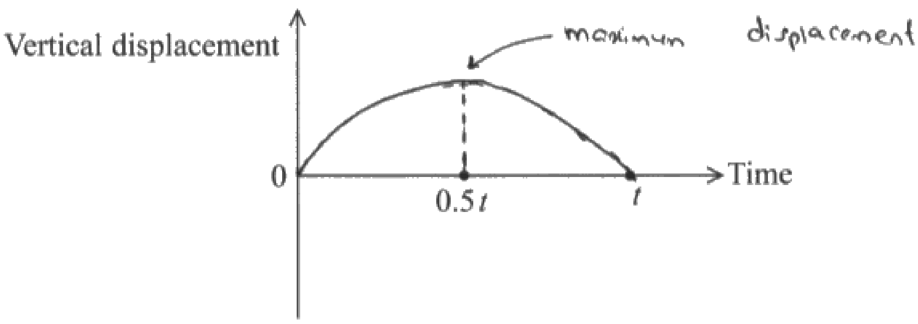
Across all abilities this question was not well answered. Candidates were expected to draw a parabolic curve ending at time *t* with a peak at 0.5*t*.

Candidates that drew the correct shape curve tended to score both marks placing the maximum and end points correctly. The most common response (awarded one mark) was a triangular shaped graph with a peak at 0.5*t*. A common incorrect response was one which included a horizonal line, symmetrical parabolas or upside down parabolas.

This response scored both marks.

(b) On the axes below, sketch the corresponding graph of vertical displacement against time for the motion of the cricket ball.

(2)



(Total for Question 12 = 4 marks)

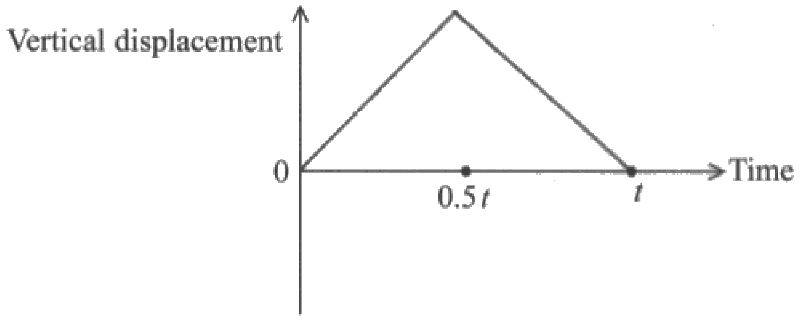
ResultsPlus
Examiner Comments

This was not the most precise curve but the shape was considered to be parabolic so this could get MP1. The maximum value was at 0.5*t* and it ended at time *t* when the ball was caught scoring MP2 as well.

1 mark scored.

(b) On the axes below, sketch the corresponding graph of vertical displacement against time for the motion of the cricket ball.

(2)



(Total for Question 12 = 4 marks)

ResultsPlus
Examiner Comments

This graph was very common and only scored the second marking point for a maximum at 0.5*t* and for ending at *t*.

ResultsPlus
Examiner Tip

The displacement-time graph for an accelerating object is not a straight line, that would be for an object travelling at a constant velocity.

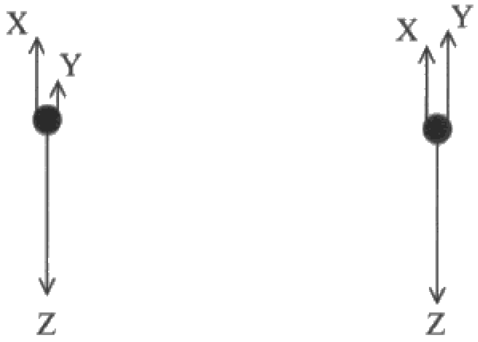
Question 13 (a)

This question was answered very well by most candidates. Candidates just below E grade did not always get drag and upthrust the right way round, failing to realise that the upthrust would stay the same and the drag would increase with velocity.

The labelling of the forces was usually correct. However some candidates lost marks due to poor labelling using terms such as resistance, viscosity and gravity.

3 marks.

13 A small steel ball is released at the surface of some oil of known viscosity and begins to sink. The diagrams show the forces acting on the ball shortly after its release and when it has reached terminal velocity.



Steel ball shortly after release

Steel ball at terminal velocity

(a) Identify forces X, Y and Z.

(3)

X is upthrust

Y is viscous drag

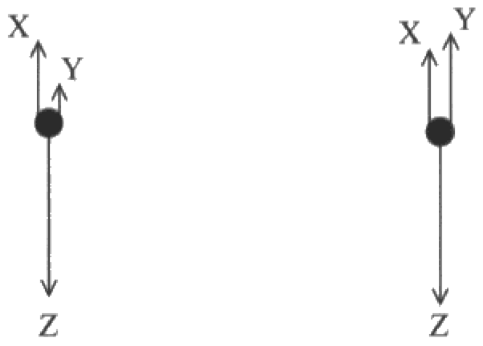
Z is weight

ResultsPlus
Examiner Comments

A perfect answer, all responses fitting the mark scheme exactly.

No marks scored.

13 A small steel ball is released at the surface of some oil of known viscosity and begins to sink. The diagrams show the forces acting on the ball shortly after its release and when it has reached terminal velocity.



Steel ball shortly after release

Steel ball at terminal velocity

(a) Identify forces X, Y and Z.

(3)

X is ~~thrust~~ resistance

Y is vicosity

Z is gravity

ResultsPlus
Examiner Comments

It was unusual for candidates to have three incorrect labels but this shows that not all candidates are confident in their labelling of common forces.

ResultsPlus
Examiner Tip

At this level the downwards force due to gravity must be called 'weight' or 'gravitational force'. 'Gravity' alone is insufficient.

'Viscosity' is not the name of a force; viscous drag, viscous force, fluid resistance, friction or drag could have all been used here. Not air resistance because the object is falling through oil and not air.

Question 13 (b)

Most candidates scored one mark.

One mark was available for candidates stating radius and (terminal) velocity. However most candidates seemed to confuse the concepts of 'measure' and 'calculate'.

A good response scoring both marks.

(b) A student uses Stokes' law to calculate force Y.

State the measurements the student should make to calculate force Y acting on the ball when it is moving at terminal velocity.

(2)

$F = 6\pi r \eta v$

Student should ~~ee~~ measure:

- diameter of the ball to calculate radius of ball ($r = \frac{d}{2}$)
- time taken for ball to fall ~~a measured~~ distance between 2 markers
- distance between 2 markers

(Total for Question 13 = 5 marks)

ResultsPlus

Examiner Comments

The candidate clearly has appreciated the difference betwen 'measure' and 'calculate' and has employed correct references to both the diameter (measure) and radius (calculate).

They have gone on to describe the measurements required to determine the (terminal) velocity with simple statements describing the measuring of the time to fall and the corresponding measured distance.

1 mark only, for identifying the two quantities that need to be calculated rather than measured.

(b) A student uses Stokes' law to calculate force Y.

State the measurements the student should make to calculate force Y acting on the ball when it is moving at terminal velocity.

(2)

Radius of the steel ball and ~~the~~ its terminal velocity.

ResultsPlus
Examiner Comments

Mark awarded for identifying the two quantities that need to be calculated rather than measured.

ResultsPlus
Examiner Tip

When a question asks for the measurements to be stated then you need only state the quantites that will be measured directly.

The radius cannot be measured directly using the Vernier calipers. You would measure the diameter and then halve it to obtain the radius.

Equally, the velocity of a small ball could not be measured directly. You would time how long it takes to fall a measured distance.

(b) A student uses Stokes' law to calculate force Y.

State the measurements the student should make to calculate force Y acting on the ball when it is moving at terminal velocity.

(2)

$F = 6\pi \cdot \eta \cdot r \cdot v$

- the student must measure the distance travelled by the ball. (r)
- the student has to measure η for the liquid (oil) it was placed in.

ResultsPlus
Examiner Comments

No mention of time or diameter so no marks

Question 14 (a)

This question was answered well and the majority of candidates knew the correct definitions for elastic and plastic deformation. Whilst most candidates scored all 3 marks, weaker candidates, notably those just below grade E grade, dropped a mark for not mentioning the condition that the applied force has to be removed before observing elastic or plastic deformation.

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

14 (a) A force is applied across the ends of a sample of wire. For small forces the deformation of the wire is elastic and for large forces the deformation is plastic.

Explain what is meant by the terms

(3)

elastic deformation It means that the object can ~~be~~ regain its original shape and length after being stretched or compressed.

plastic deformation It means that ~~a~~ the object can't regain its original shape and length after being stretched or compressed.

ResultsPlus

Examiner Comments

'After being stretched' was not sufficient for 'after the removal of the force', so only the first two marks could be awarded.

All three marks awarded.

14 (a) A force is applied across the ends of a sample of wire. For small forces the deformation of the wire is elastic and for large forces the deformation is plastic.

Explain what is meant by the terms

(3)

elastic deformation: It is when ~~the~~ an object that is deformed returns to it's original dimensions once the applied force is removed.

plastic deformation: It is when ~~the~~ an object that is deformed does not return to it's original dimensions once the force applied is removed

ResultsPlus

Examiner Comments

Correct explanations for elastic and plastic deformation. The candidate has mentioned that the applied force has to be removed in order to see these deformations.

Question 14 (b) (i)

There was little variation in the marks awarded for this question between different ability groups. The majority of candidates managed to score 1 mark for an initial positive straight line followed by an attempt at a plastic region.

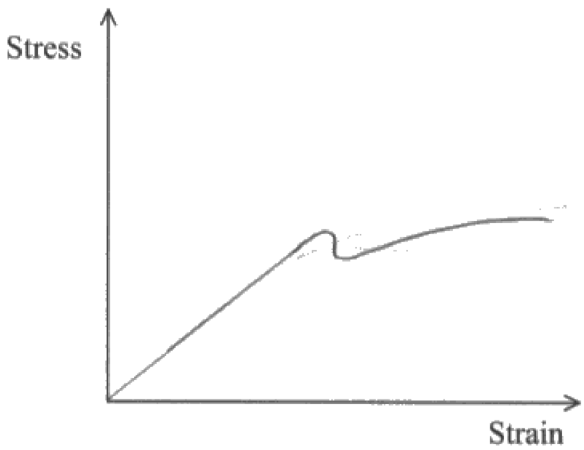
The second marking point required more detail and the emphaisis was on the plastic behaviour of the copper. Therefore examiners were looking for a significant amount of plastic behaviour to be shown on the graph. This required a continuous, negative gradient and a comparison to the linear (Hooke's Law) region which would be far smaller for a ductile material.

The most common failiure to achieve the second marking point was the size of the region with the negative gradient, no negative gradient at all (the graph just levelling out to a horizontal line), the insertion of various kinks (as you would see on the graph for steel) or sudden changes in the gradient towards the end of the graph.

This response scored one mark for the initial positive straight line.

(i) On the axes below, sketch the stress-strain graph for copper.

(2)



ResultsPlus
Examiner Comments

The candidate has drawn the stress - strain graph for steel so a second mark could not be awarded.

ResultsPlus
Examiner Tip

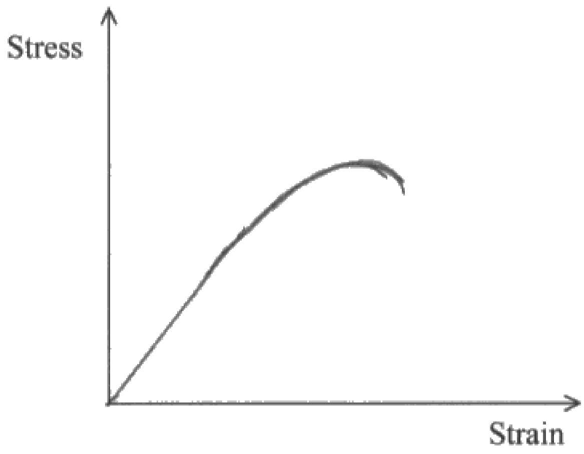
Be aware that stress-strain graphs for ductile materials are not all the same shape. While they will all have a large plastic region, the linear regions will vary.

When a load is applied to a steel wire, once it has reached its yield point, there will be a sudden but small decrease in the stress before the stress starts to increase again. This is due to the cross-sectional area decreasing.

(b) Copper is a ductile material. This makes copper suitable for the production of wires.

(i) On the axes below, sketch the stress-strain graph for copper.

(2)



ResultsPlus

Examiner Comments

The basic shape of the graph is correct; however the candidate has a very small plastic region in comparison to its linear region. Therefore the graph does not have enough of a plastic region to show that it is ductile.

Just one mark for the initial positive straight line (with some attempt at a plastic region).

Question 14 (b) (ii)

This question was generally well answered with most correct answers referring to a large plastic region.

Whereas most candidates realised that the plastic region was significant, many did not indicate that this region was large, as should have been indicated on the graph in (b)(i).

Some candidates lost out on the mark by discussing the elastic as well as the plastic region. In this case, although there is a region of elastic behaviour, that is not the property which makes it suitable for the production of copper wires.

(ii) With reference to your graph, state why copper is a suitable material for the production of wires.

(1)

~~Due to~~ Copper can undergo large plastic deformation (beyond the elastic limit) when subjected to tensile stress without breaking, the graph shows it can undergo a lot of plastic deformation without breaking as it extends way past the elastic limit.

(Total for Question 14 = 6 marks)

ResultsPlus
Examiner Comments

'Large plastic deformation' is described, so this response scored the mark.

(ii) With reference to your graph, state why copper is a suitable material for the production of wires.

(1)

Copper can be easily stretched into wires as it is ductile, this is because there is less stress needed to extend it.

(Total for Question 14 = 6 marks)

ResultsPlus
Examiner Comments

Unfortunately, although the candidate has explained why copper can be made into wires i.e. it is ductile, they have not made reference to their graph. A comment based on the large plastic region or even the large region with the negative gradient was required.

ResultsPlus
Examiner Tip

If the question specifically asks you to refer to a graph you will need to describe which feature of the graph provides the best evidence, in this case, for the copper being made into wires.

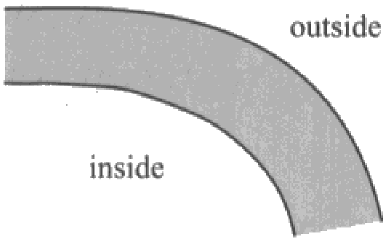
Question 15 (a)

Most candidates missed the point of the question, by not associating greater frictional forces with the shallower moving water.

Many candidates cited increased turbulent flow on the inside of the bend without providing an explanation for the turbulence.

This response scored the mark.

(a) At a bend, the water on the inside of the bend is shallower than the water on the outside of the bend.



Suggest why the speed of the water is lower at the inside of the bend than at the outside of the bend.

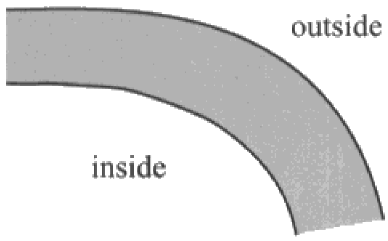
(1)

~~Energy of water The velocity Force is bein work is being done~~ The water inside of the bend is shallower, thus more energy is ~~required~~ dissapiated to turn, as viscous drag is higher.

ResultsPlus
Examiner Comments

The candidate has correctly made the connection between the depth of the water and the drag force, including a link to the energy transfers too.

(a) At a bend, the water on the inside of the bend is shallower than the water on the outside of the bend.



Suggest why the speed of the water is lower at the inside of the bend than at the outside of the bend.

(1)

~~Because~~ Because ~~to~~ the water at the inside of the bend is laminal flow

the water at the outside of the bend is turbulent flow.

ResultsPlus
Examiner Comments

No reason has been suggested as to why there would be turbulent flow on the inside so this answer is not sufficient for the mark.

In practice there would be both laminar and turbulent flow at both bends and candidates should have made a comparative comment rather than a definitive statement i.e. there would be more turbulent flow so the frictional force is greater.

Question 15 (b)

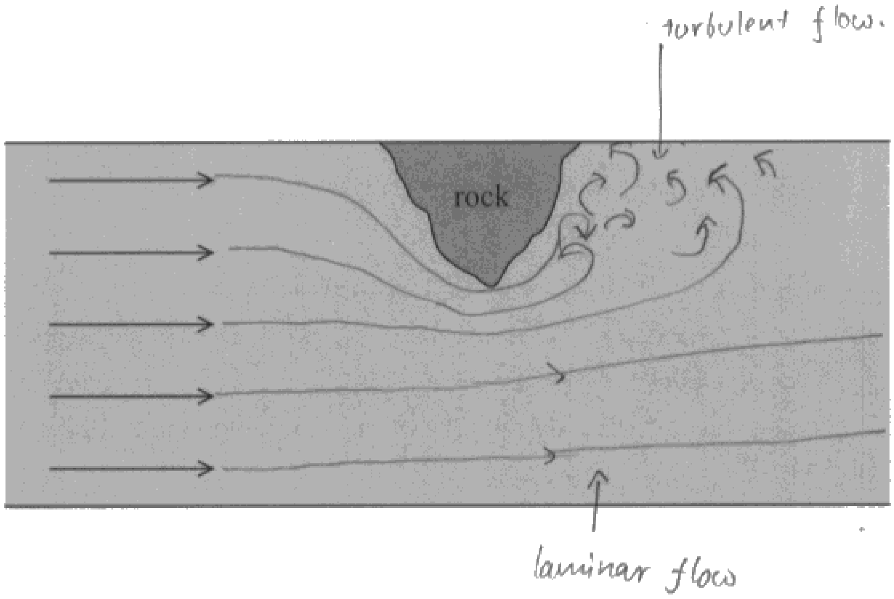
This question was answered well with some excellent diagrams seen. However many good diagrams lost marks because the candidates had not included labels as requested in the question.

Most candidates scored one mark, with clear, labelled, drawn regions of laminar and turbulent flow. Incorrect diagrams tended to lose out on the first mark for starting the region of turbulent flow before the water had reached the rock.

Too many candidates 'abandoned' the flow lines at the wrong point. The knowledge required is to show the path of the flow lines around an obstacle as the flow turns from laminar to turbulent. Flow lines should not stop abruptly.

(b) On a straight section of the river, the water becomes very turbulent around a large rock. Complete and label the diagram below to show the flow of the water around the rock.

(2)



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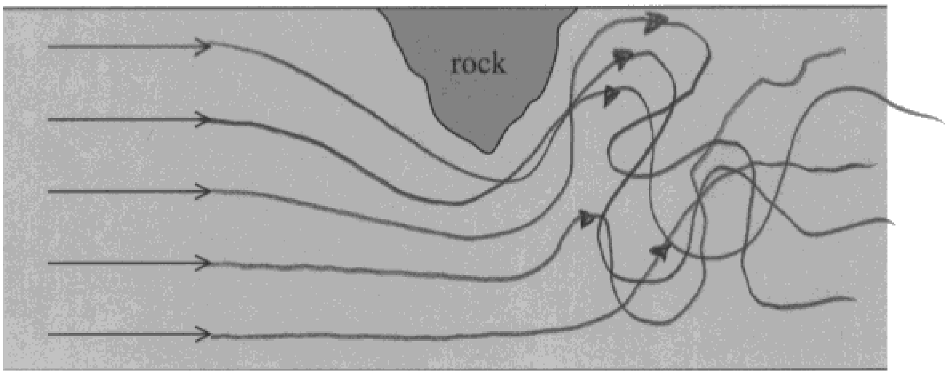
Examiner Comments

This response showed a correct transition from laminar to turbulent flow as the water passed the rock.

Both regions have been correctly labelled so this response scored 2 marks.

(b) On a straight section of the river, the water becomes very turbulent around a large rock. Complete and label the diagram below to show the flow of the water around the rock.

(2)



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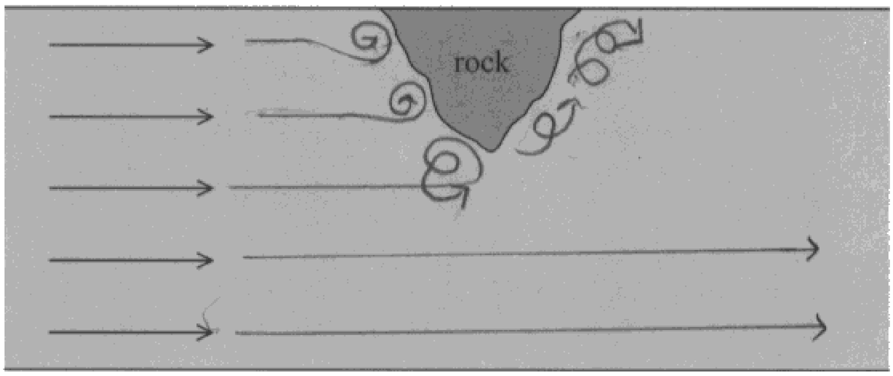
Examiner Comments

A very good diagram showing correctly drawn regions of laminar and turbulent flow (marking point 1 awarded). No labels have been given so a second mark can't be awarded.

(b) On a straight section of the river, the water becomes very turbulent around a large rock. Complete and label the diagram below to show the flow of the water around the rock.

(2)



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Examiner Comments

Turbulent flow started too early and no labels given so this response did not get any marks.

Candidates were not penalised for starting their own flow lines. The 5 arrowed lines have been drawn in to help candidates and it is expected, in this style of question, that the candidates will continue on the from the given lines rather than start their own.

Can candidates also please be discouraged from representing flow lines as dashed lines. Flow lines are continuous and should be represented as such.

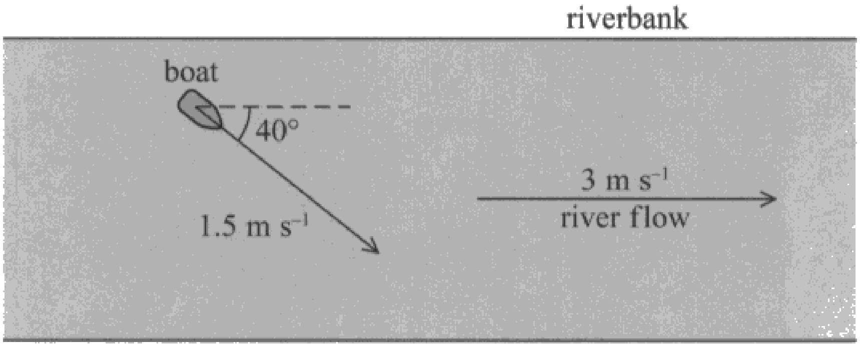
Question 15 (c)

Method marks were available and a significant proportion of candidates picked up marks for correct scaling and constructed vector diagrams even if their answer was out of range. However, attempts at drawing vector diagrams were generally poor, often without scaling or labels, with many candidates not drawing the original two vectors in the correct configuration (i.e. not tip to tail) leading to the wrong resultant being drawn.

Some candidates chose to determine the magnitude of the velocity by calculation and used the cosine rule while others resolved the (paddling) speed of the boat into its components, then used Pythagoras to determine the resultant. Such efforts were not answering the question, in that they were not using the diagram.

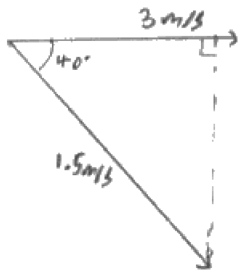
This response scored 1 mark only.

(c) The river is flowing at a speed of 3 m s^{-1}. A boat is pointed at an angle of 40° to the riverbank and paddled at a speed of 1.5 m s^{-1}, as shown in the diagram.



In the space below, draw a vector diagram to scale and use it to determine the magnitude of the actual velocity of the boat.

(3)



~~$(1.5)^2 = \text{Actual velocity}^2 + (3)^2$~~

$\Rightarrow$ Act vel. $= 3^2 + 1.5^2 - 2 \times 3 \times 1.5 \times \cos 40°$

$= 4.35$ m/s

Magnitude of actual velocity = 4.35 m/s

ResultsPlus
Examiner Comments

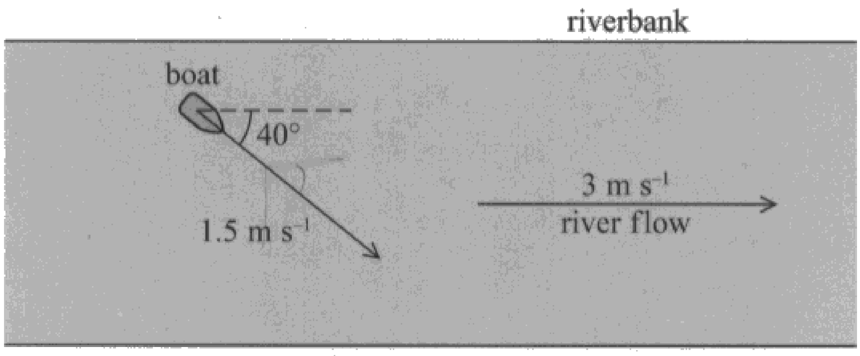
This candidate did not know how to construct a vector diagram. However, they did know the cosine rule so managed to score 1 mark for the correct magnitude. No further marks could be awarded as they had not used the diagram when determining the velocity.

ResultsPlus
Examiner Tip

If a question asks a candidate to draw a diagram and then complete another task, some of the marks for the question will actually be for construction of the diagram. If they are asked to use the diagram, they will be expected to reach the final answer using that diagram and not by some other method.

Three marks were awarded for this response.

(c) The river is flowing at a speed of 3 m s^{-1}. A boat is pointed at an angle of 40° to the riverbank and paddled at a speed of 1.5 m s^{-1}, as shown in the diagram.

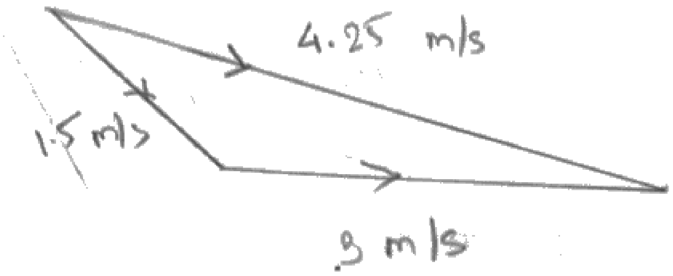


In the space below, draw a vector diagram to scale and use it to determine the magnitude of the actual velocity of the boat.

(3)

Ratio of speed between boat and river

= 1.5 : 3 = 1 : 2 1 m/s = 2 cm



72 cm — 1 m/s

8.5 —

Magnitude of actual velocity = 4.25 m/s

ResultsPlus
Examiner Comments

A correctly constructed vector diagram, to scale, leading to an answer in range (with the unit). The direction of the 3 m s^{-1} velocity vector is slightly out but the final answer is within range so this small lack of precision was allowed.

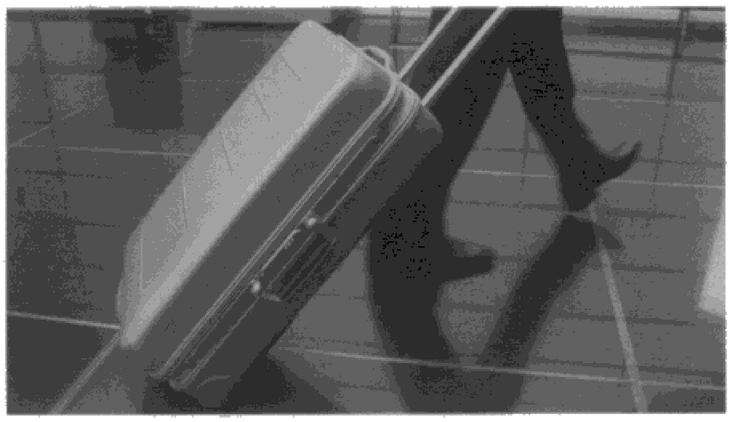
Question 16 (a) (i-iii)

These questions were probably the most well answered on the entire paper with very few marks being dropped, usually in (ii), across the entire cohort.

Most candidates identified the correct component in (i) and (iii). A mark was occasionally lost in part (ii) when the candidate selected 80 N rather than their answer to part (i) to use in the equation $\Delta W = F\Delta s$. One mark was awarded for use of the equation.

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

16 A passenger in an airport pulls a suitcase at a constant speed with a force of 80 N at an angle of 65° to the horizontal.



(a) (i) Show that the horizontal component of the applied force is about 30 N.

(2)

80 cos 65

= 33.8 N

(ii) Hence calculate the work done on the suitcase in pulling it a distance of 320 m.

(2)

W = fd

= ~~38 80 30~~ 33.8 x 320

= 10816 J.

Work done = 10816 J.

(iii) Show that the vertical component of the applied force is about 70 N.

(2)

80 sin 65

= 72.5 N.

ResultsPlus
Examiner Comments

This was a well-set-out answer with the correct units for the work done in part (ii).

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

16 A passenger in an airport pulls a suitcase at a constant speed with a force of 80 N at an angle of 65° to the horizontal.

(a) (i) Show that the horizontal component of the applied force is about 30 N.

(2)

Horizonal component of the applied fore = ~~80 × sin 65~~ 80 × Cos 65

= 33.8 N

≃ 30 N (shown)

(ii) Hence calculate the work done on the suitcase in pulling it a distance of 320 m.

(2)

Work done = 80N × 320

= 25600 Nm

Work done = 25600 Nm

(iii) Show that the vertical component of the applied force is about 70 N.

(2)

Vertical component of the applied force = 80 × Sin 65

= 72.5

≃ 70 N (shown)

ResultsPlus

Examiner Comments

(ii) The candidate has not used the component of the applied force in the direction of motion, i.e. the answer to part (i) of 33.58 N, to calculate the work done but has used the total applied force of 80 N.

Just one mark awarded for this item for use of the equation $\Delta W = F\Delta s$.

Question 16 (a) (iv)

This question was answered well, with candidates demonstrating a good understanding of how to apply the' work done' equation. The majority of candidates successfully managed to get across the idea that there was no vertical displacement.

Most of the marks lost were due to a lack of precison with language rather than a lack of knowledge, e.g. answers that merely stated that the resultant force was 0 without referring to direction.

1 mark.

(iv) State why no work is done in a vertical direction even though there is a component of the applied force in the vertical direction.

(1)

No vertical motion, no acceleration, the object is at rest vertically and ∴ no resultant force vertically.

ResultsPlus
Examiner Comments

The candidate has a clear understanding of the context in which the question is asked.

Another example of a response scoring 1 mark.

(iv) State why no work is done in a vertical direction even though there is a component of the applied force in the vertical direction.

(1)

Because the displacement of the suitcase is in the horizontal direction only.

ResultsPlus
Examiner Comments

This time the candidate has answered in terms of the horizontal displacement but it can be inferred that there would therefore be no vertical displacement.

Question 16 (b)

This question gave candidates the opportunity to demonstrate their knowledge and understanding of components of forces. It was answered and discriminated well with most of the more able candidates able to score 3 marks and the weaker candidates generally picking up one or two marks.

Candidates were only able to discuss the horizontal component of force with few realising the implications of an increase in the applied force to the vertical components and the vertical resultant force.

Most candidates approached this by first stating that a decrease in the angle would increase the horizontal component of the force. They then usually stated to increase the applied force as well. Few thought to consider the vertical forces and did not state that it was nescessary to keep the resultant vertical force the same, i.e. zero.

This response scores three marks.

*(b) Explain how the magnitude and angle of the applied force must change in order to make the suitcase accelerate horizontally.

(4)

The force applied must be greater for the suitcase to accelerate. The angle must be smaller. For smaller angles cos θ value is higher. Hence the horizontal component increases. so the suitcase will accelerate.

Greater the force applied the faster it is pulled. Hence high magnitude will accelerate the suitcase

ResultsPlus

Examiner Comments

The candidate has identified that both increasing the applied force and reducing the angle will increase the horizontal component of the applied force.

The vertical forces must still add up to 0 as there is no vertical acceleration which should have been mentioned for the fourth mark (MP2).

A rare but correct response scoring all 4 marks.

*(b) Explain how the magnitude and angle of the applied force must change in order to make the suitcase accelerate horizontally.

(4)

The magnitude of the force must increase and the angle of the applied force must decrease to increase the Horizontal component resolved force and to maintain the vertical component resolved force equal to weight of the suitcase. when decreasing the angle most of the Resolved force is resolved Horizontally so the Horizontal force will increase, increasing the Horizontal acceleration by $\Sigma F = m.a$ but the vertical force component will decrease so extra Force need to be inputed by the

(Total for Question 16 = 11 marks)

Passenger to the suitcase to maintain its vertical position off the ground by making the vertical component equals to weight.

ResultsPlus

Examiner Comments

The candidate has correctly described increasing the applied force and a reduction in the angle to increase the horizontal force.

No mention has been made as to the reaction force but they have the right idea that the vertical forces must remain the same.

Question 17 (a)

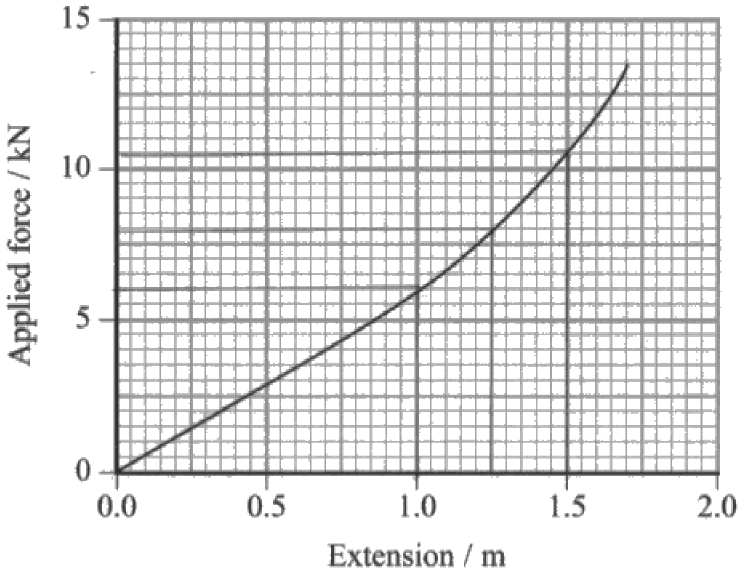
This question proved challenging for a number of candidates. While most candidates knew that they had to find the area under the graph to determine the work done, few managed the precison to obtain all 3 marks.

A common aproach was to use $\Delta W = F\Delta d$, which scored 0. The majority of candidates used $E_{el} = ½F\Delta x$, but this effectively simplified the area to a triangle and gave answers out of range and could only score a maximum of one mark. Candidates who chose to count squares to find the area under the graph often produced an answer out of range due to only counting cm rather than mm squares around the region where the graph began to curve, therefore only scoring 2 marks. Generally there seemed to be some reluctance to use this method. The most successful candidates tended to be those who divided the area into smaller sections which generally produced answers in range.

This question seemed to generate a large number of power of 10 errors by candidates who had missed the prefix of 'k' for the applied force, creating answers a power of 10^3 out.

A very thorough answer scoring all 3 marks.

17 (a) The force-extension graph obtained when stretching a nylon rope is shown below.



Use the graph to determine the work done in extending the rope by 1.5 m.

(3)

Area under the graph =

$= \left(\frac{1}{2} \times 1{\cdot}0 \times 6 \times 1000\right) + \left(\frac{1}{2} \times 0{\cdot}25 \left[(6 \times 1000) + (8 \times 1000)\right]\right)$

$+ \left(\frac{1}{2} \times 0{\cdot}25 \left[(8 \times 1000) + (10{\cdot}5 \times 1000)\right]\right) = 7062{\cdot}5$

Work done = 7062·5 J

ResultsPlus

Examiner Comments

The candidate has divided the region below the graph into a triangle and two trapesiums. They then used E_{el} = ½$F\Delta x$ to determine the area under the linear part of the graph, as well using the trapesium rule to determine the area of the trapesium from 1.00 m to 1.25 m, and the area of the trapesium from 1.25 m to 1.50 m.

With correct use of the 'kilo' prefix this gave an area of 7062.5 J, a value in the middle of the given range. This was very similar to the example on the mark sheme that used mm squares to determine the work done proving this was a very precise method.

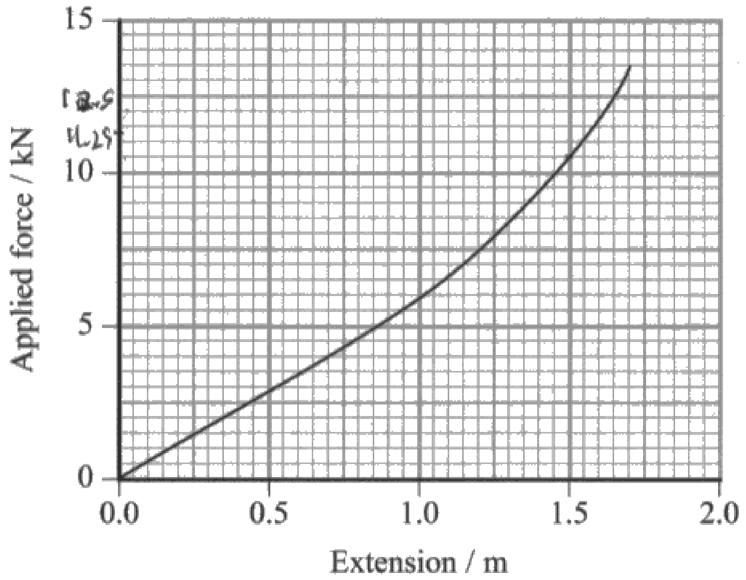
ResultsPlus

Examiner Tip

Unless the graph is a straight line throughout the region for which the candidate has to determine the work done, using E_{el} = ½$F\Delta x$ will not enable the candidate to score full marks. The best method to use is to divide the area under the graph into a series of shapes and then use E_{el} = ½$F\Delta x$ where possible, and then use the trapesium rule or counting squares method to determine the rest of the area under the graph.

This response scored 0.

17 (a) The force-extension graph obtained when stretching a nylon rope is shown below.



Use the graph to determine the work done in extending the rope by 1.5 m.

(3)

~~tess~~ $w = f \times d$

$W = 0.0105 \times 1.5$

$W = 0.01575$ J

$W = 15.75 \times 10^{-3}$ J

Work done = ~~6~~ 15.75×10^{-3} J

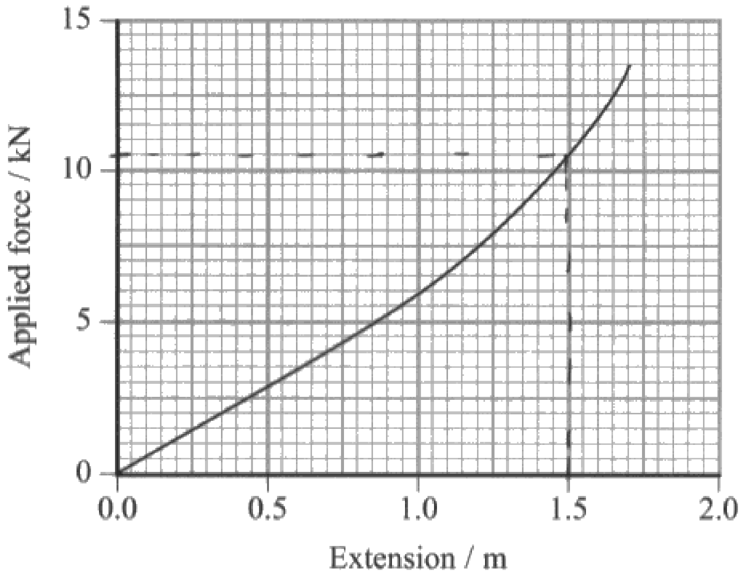
ResultsPlus

Examiner Comments

The candidate has used Work done = force x distance which is not the correct formula and does not take into account the increasing force.

Just 1 mark awarded.

17 (a) The force-extension graph obtained when stretching a nylon rope is shown below.



Use the graph to determine the work done in extending the rope by 1.5 m.

(3)

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

$E = \frac{1}{2}(10{,}000)(1.5) = 7500\ J$

Work done = 7500 J

ResultsPlus

Examiner Comments

$E_{el} = \frac{1}{2}F\Delta x$ was used producing an answer of 7500 J which is out of range as it is too high. It doen't take into account the slighly concave nature of the curve and this small region should have been subtracted from this value.

Question 17 (b) (i)

Although most responses demonstrated insight into the problem, many did not describe the physics in sufficient detail, tending to say the strap would come back to its original length pulling the car with it. This repeated part of the question, and therefore did not score. Other candidates said that a force was acting on the strap, but did not mention where the force came from.

Many responses switched between explanations in terms of forces and energy. If a candidate wants to construct a force argument they should restrict themselves to only speaking about forces.

Many missed the clue about the car 'beginning to move' and would therefore need a resultant force to produce the acceleration.

A common approach was to state that the elastic or potential energy was stored in the strap which, when released, returned to its original length. This did not score any marks because the specific energy transfer, or a reference to the work done by the strap, was required. Most candidates who scored marks favoured method 1, choosing to answer in terms of forces rather than energy.

This response scored 2 marks.

*(i) Explain why, even if the towing car had then stopped, the trapped car would still begin to move. (2)

kinetic energy of towing car stored as elastic potential energy of strap.
when ~~nylon~~ towing car is moving, nylon ~~string~~ strap extends/ stretches storing elastic energy in it. when towing car stops the stored elastic energy in ~~strip~~ strap is converted to kinetic energy of trapped vehicle. So it ~~bin~~ trapped vehicle begin to move.

ResultsPlus
Examiner Comments

Using method 2 the candidate has correctly described the energy transfers from the towing car to the strap and then from the strap to the trapped car.

0 marks scored.

*(i) Explain why, even if the towing car had then stopped, the trapped car would still begin to move.

(2)

Because the nylon ~~rope~~ strap behaves elastically and tries to change back to its original shape resulting a pull at trapped car.

ResultsPlus
Examiner Comments

This response has not added anything besides describing the strap going back to its original length. This is not an answer in terms of energy or force so is insufficient. Line 4 of the stem of the question refers to the strap pulling the trapped car free so the reference here again is insufficient and should have said that the 'strap applies a force on the trapped car'.

1 mark scored.

*(i) Explain why, even if the towing car had then stopped, the trapped car would still begin to move.

(2)

Because there is still tension on the nylon strap which pulls the trapped car until it becomes quite slack again.

ResultsPlus
Examiner Comments

Method 1, first marking point was awarded for 'tension in the strap'.

Nothing of merit beyond that as a reference to work, acceleration or resultant force was needed to make the link between the force on the strap and the acceleratAion of the trapped car.

Question 17 (b) (ii)

Candidates who divided 25 by 0.02 to obtain the correct answer of 1250 did not score any marks. The marks were awarded for using the correct physics to justify this ratio and a ratio with no justification was not demonstrating any knowledge at all.

Those candidates who used $E_{el} = ½F\Delta x$ did not always justify their value for the extension, preventing them from scoring the first mark. However, these candidates, on making a substitution into the correct equation followed by the correct ratio, scored the last 2 marks.

Candidates that chose to use ½ x stress x strain were able to score all 3 marks. They justified the stresses cancelling out by stating or showing that the forces and the cross-sectional areas would be the same.

Some candidates confused the E of Young's modulus for energy and tried to do a proof in terms of Young's modulus, scoring 0.

No marks scored.

(ii) The nylon strap used for kinetic towing typically has a breaking strain of 25%. Steel cables, often used for towing cars along roads, typically have a breaking strain of 0.02%.

It can be assumed that the nylon strap and the steel cable both obey Hooke's law. Show that, for the same pulling force and just before breaking, a nylon strap can store over 1000 times more energy than a steel cable of identical initial length and cross sectional area.

(3)

$\frac{25\%}{0.02\%} = 1250\%$

→ 1250 times more energy.

ResultsPlus

Examiner Comments

This type of response was very common and has not shown how to get to 1250. The candidates had to justify their use of 25/0.02

This response scored all 3 marks.

(ii) The nylon strap used for kinetic towing typically has a breaking strain of 25%. Steel cables, often used for towing cars along roads, typically have a breaking strain of 0.02%.

It can be assumed that the nylon strap and the steel cable both obey Hooke's law. Show that, for the same pulling force and just before breaking, a nylon strap can store over 1000 times more energy than a steel cable of identical initial length and cross sectional area.

(3)

nylon — steel

$x \times 100 = 25$ $\qquad$ $y \times 100 = 0.02$

$x = 0.25 \therefore \Delta x = 0.25l$ $\qquad$ $y = 0.0002$ $\qquad$ $\Delta x = 0.0002l$

$W = \frac{1}{2}F \times \Delta x$ $= \dfrac{\frac{1}{2} \times F \times 0.25l}{\frac{1}{2} \times F \times 0.0002l}$

$\dfrac{0.25}{0.0002} = 1250$

$= 1250 > 100$ times

ResultsPlus Examiner Comments

The candidate (although they have not specifically stated this) made the original length of each wire *l* and then used the stress equation to obtain an expression for the extension (stress x *l*). This consideration of the extension and length is enough to score MP1.

They have then used the appropriate extension in the formula for the elastic strain energy $E_{el} = \frac{1}{2}F\Delta x$, keeping the force applied to each wire as *F*. As they have the same pulling force this is correct and the ratio of the two expressions scored (MP2).

Finally, the F, ½ and *l* terms cancel as they are the same for both wires leaving the ratio of 0.25/0.02 which gives the correct answer of 1250 (MP3).

Question 17 (b) (iii)

While a small proportion of candidates across all abilities managed to score this mark, many stated relevant physics but were not quite precise enough to be successful. Responses such as 'steel cannot store a lot of energy' were not applying the physics to the context of the question in that they had to suggest why steel was not suitable for this method of towing. Hence responses were required to identify that the energy stored by the steel was too small or insufficient or a lot less than the energy stored in the nylon strap.

Incorrect responses commonly did not refer to the energy stored, such as 'steel is too stiff/ brittle' or had incorrect references to the breaking strain.

This response scored 0 marks.

(iii) Suggest why steel cables are **not** suitable for kinetic towing of cars.

(1)

Steel cables will break ~~under~~ under large amounts of force.

ResultsPlus
Examiner Comments

An answer in terms of breaking force had to get across the idea that a sudden large force rather than just a large force would break the steel.

This response scored the mark.

(iii) Suggest why steel cables are **not** suitable for kinetic towing of cars.

(1)

Because the ~~kin~~ elastic strain ~~&~~ energy it can stored is too small. So it will be difficult to use it to drag cars

ResultsPlus
Examiner Comments

Correct description of the stored energy being too small for the kinetic towing of cars.

Question 18 (a-d)

18(a) This part of the quesion was answered very well with virtually all candidates reading the reaction force correctly from the graph and then going on to use $W = mg$ successfully. The odd mark dropped here was usually due to a rounding error.

18(b)(i) Unfortunately most candidates did not get this mark and answers seen rarely got across the idea of the point being an 'assumption', the most common incorrect response being 'the point where the weight acts from.'

Common responses included 'weight acts through this point' and 'gravity/weight acts in all directions from this point' with a good number of responses mentioning mass instead of weight.

18(b)(ii) This part of question 18 was left out by some candidates, but answers seen generally demonstrated a good understanding of the graph and the question set. Unfortunately a lack of detail when referring to forces caused some candidates to miss out on marks because candidates had to be quite clear as to whether they were referring to the reaction force or the resultant force. References to 'force' were insufficient. A small number cited Newton's laws without applying them to the athlete jumping.

18(c) This question was answered well. However, many candidates focused solely on Newton's third law, usually scoring the first marking point without carrying on to make the link with the resultant force and then the acceleration due to N1/2.

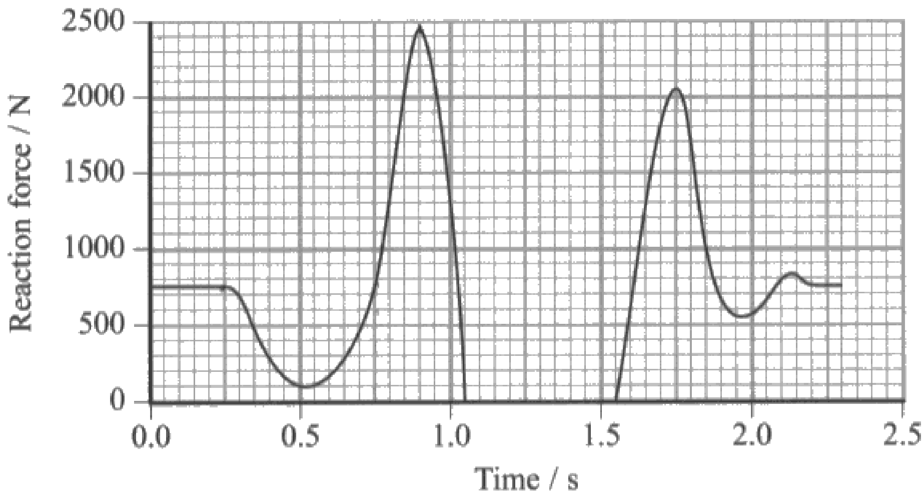
18(d) Most candidates managed to pick up at least a mark here, usually just the second marking point, usually for use of $F = ma$. Few candidates understood that resultant forces cause acceleration, in line with the successful proportion in part (c), and did not attempt to calculate one before using $F = ma$.

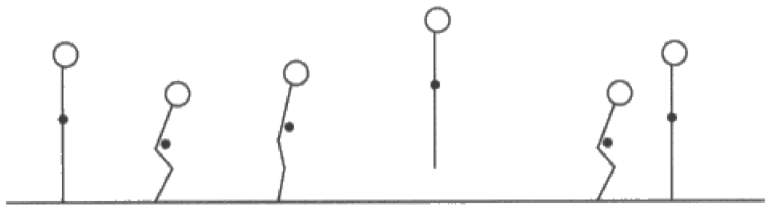
This response scored:

- (a) 2 marks
- (b)(i) 0 marks
- (b)(ii) 2 marks
- (c) 3 marks
- (d) 3 marks

18 An athlete bends his knees and then springs up into a vertical jump. The graph below shows how the reaction force from the ground on the athlete varies with time.

The diagram below the graph shows the position of the athlete at the corresponding times as he completes his jump.





(a) Show that the mass of the athlete is about 80 kg.

(2)

From the graph we know: the force when athlete stand ~~on~~ ground is 750N which is the weight.

$W = mg \quad m = \frac{W}{g} = \frac{750N}{9.81} = 76.5 \text{ kg}$

(b) The small dot on each diagram of the athlete represents his centre of gravity.

(i) State what is meant by centre of gravity.

(1)

The ~~sig~~ single point where all forces acts on.

(ii) Between 0.25 s and 0.75 s the athlete bends his knees. As a result of this, his centre of gravity moves lower.

Explain how the graph shows that an acceleration is produced as the athlete bends his knees.

(2)

The force from the ground is lower than his weight. Therefore there is an unbalanced force which can cause an acceleration.

*(c) In order to jump, the athlete pushes down on the ground between 0.75 s and 1.05 s.

With reference to Newton's laws, explain why the athlete must push down on the ground.

(3)

From neton's third law we know, when athlete exerts a downward force on the ground the ground will exerts a upward force one the athlete with the same type and magenitude. ~~and~~

The ~~ath~~ athlete ~~go thaw~~ has a big upward force. Resultant force is upward. From Newton's first law we know he will accelerate upward and move up.

(d) The maximum reaction force was reached at $t = 0.9$ s. Calculate the acceleration of the athlete at this point.

(3)

Force ~~at~~ $t = 0.9$ s is 2450 N.

Resultant force = 2450N − 750 N = 1700 N

$F = ma \quad a = \frac{F}{m} = \frac{1700\,N}{76.5\,kg} = 22.2\,m/s^2$

Acceleration = $22.2\,m/s^2$

ResultsPlus
Examiner Comments

This was a good response and demonstrates how even the candidates scoring the highest grades did not always know a correct and complete definition of the centre of gravity, referring to 'force' rather than 'weight'.

All other parts were correct with the clear response to part (c), demonstrating a good understanding of Newton's laws.

ResultsPlus
Examiner Tip

The term 'centre of gravity' is crucial to this question.

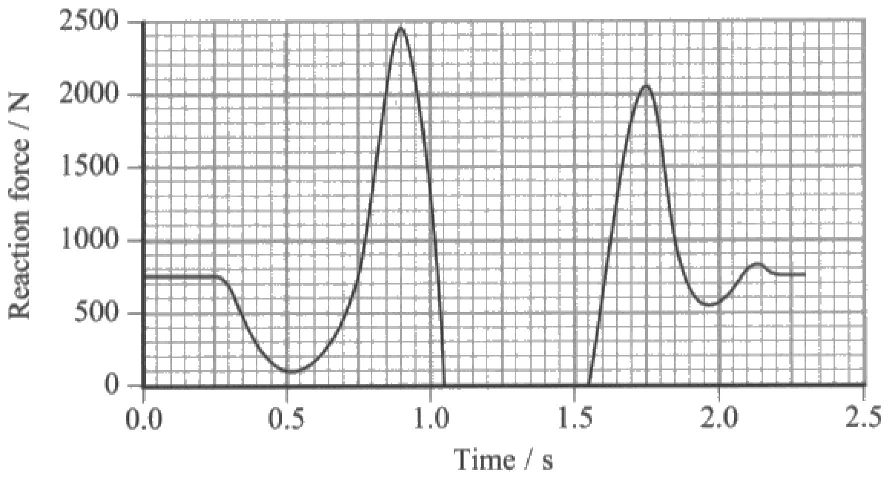
For an object to accelerate there must be a resultant force. If more than once force is acting on the object/person then the candidate will be required to calculate the resultant force in order to determine the acceleration that it causes.

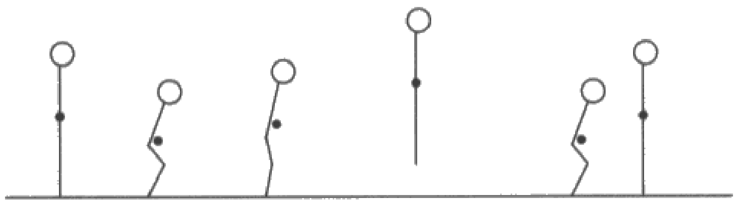
This response was very common and scored the mean mark of 5 for all parts a-d:

- (a) 2 marks
- (b)(i) 0 marks
- (b)(ii)1 mark
- (c) 1 mark
- (d) 1 mark

18 An athlete bends his knees and then springs up into a vertical jump. The graph below shows how the reaction force from the ground on the athlete varies with time.

The diagram below the graph shows the position of the athlete at the corresponding times as he completes his jump.





(a) Show that the mass of the athlete is about 80 kg.

(2)

F = mg

750 = m x 9.81

m = 750 / 9.81

m = 76 kg

(b) The small dot on each diagram of the athlete represents his centre of gravity.

(i) State what is meant by centre of gravity.

(1)

It is the point at which the Earth's gravitational force acts on.

(ii) Between 0.25 s and 0.75 s the athlete bends his knees. As a result of this, his centre of gravity moves lower.

Explain how the graph shows that an acceleration is produced as the athlete bends his knees.

(2)

There is a sudden decrease in the reaction force from 0.25s to 0.5s and then a gradual increase in the reaction force ~~to~~ from 0.5s to 0.7s.

*(c) In order to jump, the athlete pushes down on the ground between 0.75 s and 1.05 s.

With reference to Newton's laws, explain why the athlete must push down on the ground.

(3)

~~In Newton's first third law it states that for every action there is an equal and opposite reac~~ In Newton's first law it states that a body continues to rest or moves in uniform velocity in a straight line ~~unles~~ until a net external force acts on it. So when the athlete pushes down on the ground another force acts on him making him able to jump. In Newton's second law states ~~the~~ ~~f~~ acceleration ~~of the~~ is independent of the mass of an object but is directly proportional to it's force applied. So when the athlete pushes on the ground he's applying a force which will help him to jump higher with a high acceleration.

(d) The maximum reaction force was reached at $t = 0.9$ s. Calculate the acceleration of the athlete at this point.

(3)

F = 2450 N ~~a =~~ F = ma

2450 = 76 × a

$a = \frac{2450}{76}$

$a = 32.2\ ms^{-2}$

Acceleration = $32.2\ ms^{-2}$

ResultsPlus
Examiner Comments

Again there was no mention of 'assumed' for the centre of gravity definition in part (b)(i).

In part (b)(ii) the candidate has only described the changes to the reaction force and has not made the link between the change in reaction force to the acceleraion i.e. no mention has been made of the resultant force.

In part (c) only the third mark could be awarded for the link between N2 and acceleration. No mention has been made as to N3 and the force of the floor on the man, neither was there a mention of the reaction force that would have caused the acceleration.

In part (d) again there was no consideration as to the resultant force and the candidate launched staight into using

$F = ma$ using the reaction force rather than the (reaction force − weight).

Therefore three question parts all affected by the lack of consideration of the resultant force and 5 marks lost in total.

Question 18 (e)

It was extremely rare to award all 4 marks for these calculations. Whilst the vast majority of candiates could select the correct equation of motion to use in each question part, the selection of the correct values to substitute into each equation proved to be more challenging. Only the top candidates selected the correct time (0.25 s) and acceleration (g) and used them with correct consideration for direction in the appropriate formulae.

Firstly, the selection of the correct time to use. The athlete was in the air for 0.50 s, therefore the time to the maximum height was 0.25 s, and all calculations should have taken this into account. Secondly, the only force acting on the athlete once airborne (assuming air resistance to be negligible) was weight. Therefore the only acceleration is a downwards one equal to g. The vast majority of candidates assumed that the athlete was launched with the acceleration calculated in part (d).

Candidates who generally used $mgh = \frac{1}{2}mv^2$ in part (ii) scored both marks (with an ecf for the incorrect height from part (i)). Just to note here that in part (d)(i) candidates that used their values of acceleration from part (d) with the incorrect time of 0.5 s generally had a maximum height of over 3 m. This should have alerted the candidates to go back through their work to find the source(s) of such an error.

(i) 2 and (ii) 2 scored here.

(e) The athlete was in the air for 0.50 s.

(i) Calculate the height jumped by the athlete.

(2)

$v=0$. $s = vt - \frac{1}{2}at^2$

$a=-9.81$ $s = -\frac{1}{2}(-9.81)(0.25)^2$

$t=0.25$ $= 0.307\text{ m (3sf)}$

$s?$

Height = 0.307 m

(ii) Calculate the speed of the athlete on leaving the ground.

(2)

$v=0$. $v = u + at$

$a=-9.81$ $0 = u - 9.81(0.25)$

$t=0.25$ $u = 9.81 \times 0.25$

$u?$ $= 2.45\text{ m/s (3sf)}$

Speed = 2.45 m/s

ResultsPlus
Examiner Comments

(i) The candidate has correctly selected to use the time of 0.25 s with the acceleration of −9.81 m s^{-2} in the equation of $s = vt - \frac{1}{2}at^2$. This equation is perfectly acceptable as an alternative to the given equation of $s = ut + \frac{1}{2}at^2$ for calculation of the maximum height and is the same equation with $(v - at)$ substituted in for u (from $v = u + at$).

(ii) Correct equation of motion selected with the correct time of 0.25 s and acceleration of $-g$. Few candidates remembered to make the acceleration negative.

A more typical response scoring (i) 1 and (ii) 1.

(e) The athlete was in the air for 0.50 s.

(i) Calculate the height jumped by the athlete.

(2)

~~$v^2 = a$~~ $S = \frac{1}{2} \times 22.4 \times (0.50)^2$

$= 2.8\ m$

Height = 2.8 m

(ii) Calculate the speed of the athlete on leaving the ground.

(2)

Speed: $V = \sqrt{2 \times 22.4 \times 2.8}$

$= 11.2\ m/s$

Speed = 11.2 m/s

ResultsPlus

Examiner Comments

(i) The candidate has done their calculation based on the downwards motion taking *u* to be 0 and the acceleration to be positive. However they have used their acceleration from part (d) with the incorrect time of 0.50 s so can only score 1 mark for use of the correct equation of motion.

(ii) Not much working has been shown but this candidate has used $mgh = \frac{1}{2}mv^2$, using their value for the height from part (i), they have however used the acceleration from part (d) rather than 9.81 m s^{-2} so can only score MP1.

Question 19 (a) (i)

The context of question 19 generally was found to be challenging for many candidates. While some marks were picked up in the question by most candidates it was not answered well across the whole ability range.

While many could resolve a force into its components, very few could articulate this and the explanations seen for part (a)(i) reinforced this. The better candidates tended to score one mark for a description of the force or acceleration acting on the object in diagram 2. Few could explain the resultant force acting on the object in diagram 1 was just the component of weight, with many either incorrectly discussing vertical and horizontal components or failing to realise that an expression for the force or acceleration would be a good way to start their explanation. 'Weight in diagram 1 is acting at an angle' was too basic and not specific enough to contribute to the explanation as to why the object takes longer in diagam 1 to travel the distance *s*.

Those candidates who answered in terms of energy and distance were more successful, but even they tended to score only the second mark.

A response scoring all 3 marks.

(i) Assuming that the frictional forces between the plane and the object are negligible, explain why the object in diagram 1 takes longer to travel distance *s* than the object in diagram 2.

(3)

For diagram 2, all the weight is contributed to acceleration. But for diagram 1, weight x sinθ is contributed to acceleration. since, weight x sinθ is smaller than the weight. The acceleration in diagram 1 is smaller, hence it needs more time to travel s. According to F=ma.

ResultsPlus
Examiner Comments

The candidate has not specifically said resultant force is equal to these quantities but it is clear that they are desribing a resultant force, so weight and weightsinθ are sufficient for the first two marks. The candidate has then compared the magnitudes of these two forces and then made the link to acceleration, thereby scoring the third mark.

This response scored 0.

(i) Assuming that the frictional forces between the plane and the object are negligible, explain why the object in diagram 1 takes longer to travel distance *s* than the object in diagram 2.

(3)

In diagram 1, there are 2 components involved, the horizontal component is independant of the vertical component, the vertical component is affected by acceleration due to gravity, and the vertical distance travelled by the object is less therefore taking less time, whereas in diagram 2, the vertical distance travelled is more therefore taking more time

ResultsPlus

Examiner Comments

Nothing of merit here. Quite a few candidates went down the route of discussing the independence of horizontal and vertical motion which was not relevant in this question. The candidate has then made the mistake of assuming that the distance travelled in diagram 2 is greater when the distance is the same.

Question 19 (a) (ii)

This question demonstrated that weaker candidates find it difficult to resolve vertical forces parallel and perpendicular to a slope. The resolving required in question 16a to the horizontal and vertical was answered correctly by most.

Unit errors also appeared a few times with this item.

(ii) Calculate the acceleration of the object in diagram 1 when $\theta = 35°$.

(2)

9.81 sin 35

= 5.63 ms^{-2}.

Acceleration = 5.63 ms^{-2}.

ResultsPlus

Examiner Comments

2 marks for the correct answer with the correct unit of m s^{-2}.

This response scored 0.

(ii) Calculate the acceleration of the object in diagram 1 when $\theta = 35°$.

(2)

~~u cos 35.~~ S = u cos 35.

~~Acceleration = Change in velocity / time~~ ~~S=C~~

~~= u cos 35 / time~~ Acceleration = 9.81 cos 35

= 8.03 ms^{-2}

Acceleration = 8.03 ms^{-2}

ResultsPlus

Examiner Comments

The incorrect trig function has been selected. No method marks can be given so this scored no marks.

Question 19 (b) (i)

The vast majority of candidates scoring an E grade or above managed to score at least 1 mark for a straight line or curve increasing with distance (from the origin). The question should have been guiding candidates towards the idea that there is an acceleration in diagram 1 which many candidates described correctly in part (a)(i) and calculated in part (a)(ii). However, few considered this when deciding on the shape of their graphs in part (b)(i).

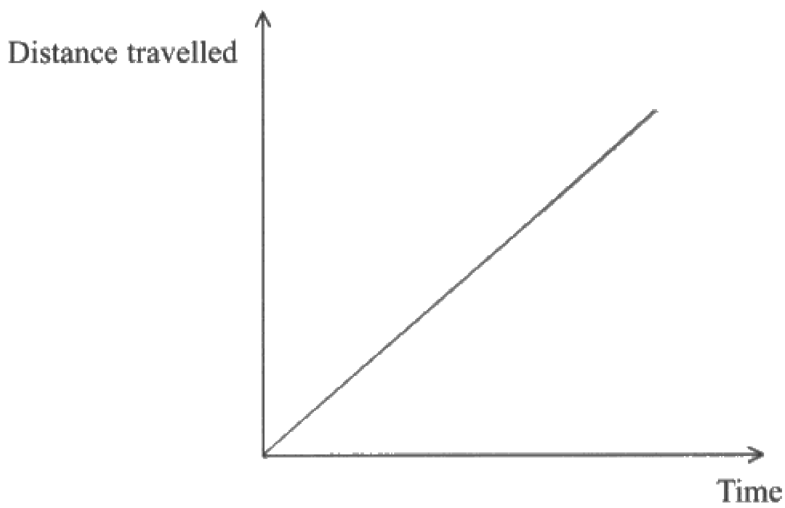
Few realised the squared relationship between distance travelled and time i.e. the same relationship as for a projectile just with a smaller constant value of *a* because it is a smooth plane so frictional forces can be ignored.

Quite a few candidates drew a straight line, obviously not understanding that an acceleration was present. Many times the gradient was seen to decrease towards the end.

1 mark only.

(i) On the axes below, sketch the distance-time graph that would be expected from these readings.

(2)



ResultsPlus
Examiner Comments

Straight line increasing from origin so only the first mark was awarded.

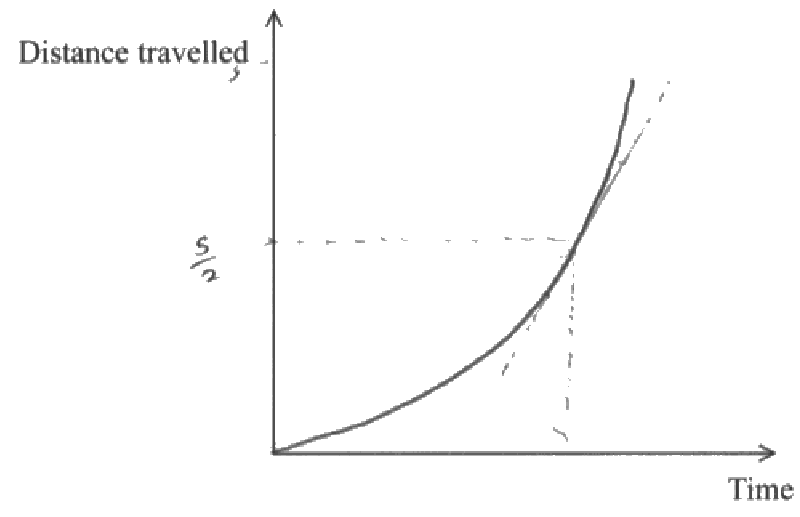
ResultsPlus
Examiner Tip

The object is accelerating down the slope, although the acceleration would be less than for diagram 2. Question 19(a)(ii) asks for the acceleration to be calculated. Therefore this question required candidates to sketch a displacement-time graph for an object moving at a constant positive acceleration from rest, ie. a curve with an increasing gradient ($s = \frac{1}{2}at^2$).

Correct response scoring 2 marks.

(i) On the axes below, sketch the distance-time graph that would be expected from these readings.

(2)



(ii) Write an expression for the time taken, in terms of t, for the ball to roll a distance $\frac{s}{2}$

ResultsPlus
Examiner Comments

The graph drawn increases from the origin and has a curve of increasing gradient.

Question 19 (b) (ii)

This question was very poorly answered.

The question required the candidates to derive an expression in terms of *t*, the time taken to travel a distance *s*, an expression for the time to travel a distance s/2. Therefore the first stage was to obtain an expression for *s* in terms of *t* and then to progress to an expression of s/2 in terms of the original time *t*:

- $s = ½at^2$ (when travelling a distance s)
- $s/2 = ½at_1^2$ (when travelling a distance s/2, t_1 is the time taken to travel $s/2$)
- $(½at^2)/2 = ½at_1^2$ (substituting in for *s* as the expression needs to be in terms of *t* and not *s*)

Cancelling out the 1/2*a* terms on each sides leaves

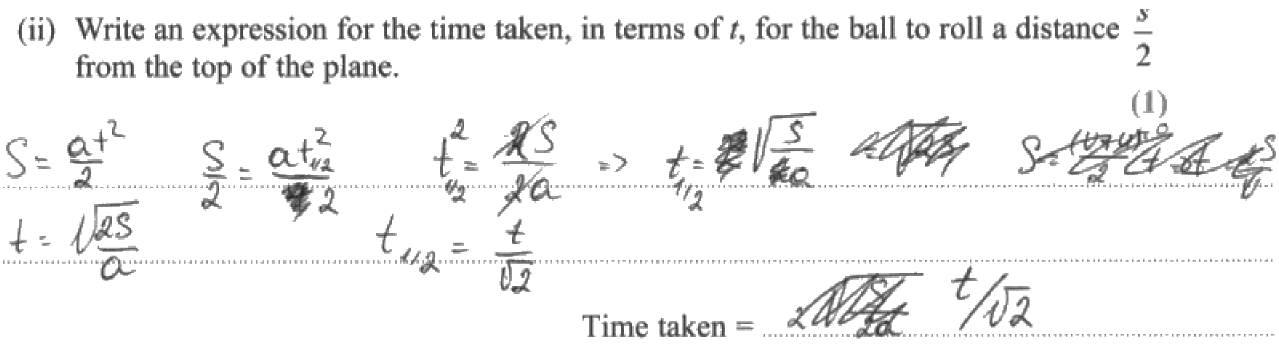
$t^2/2 = t_1^2$

$t_1^2 = t^2/2$

$t_1 = \sqrt{(t^2/2)}$

t_1 **$= t/\sqrt{2}$**

An excellent response.


(ii) Write an expression for the time taken, in terms of *t*, for the ball to roll a distance $\frac{s}{2}$ from the top of the plane.

(1)

$S = \frac{at^2}{2}$ $\quad \frac{S}{2} = \frac{at_{1/2}^2}{2}$ $\quad t_{1/2}^2 = \frac{S}{a}$ $\Rightarrow t_{1/2} = \sqrt{\frac{S}{a}}$

$t = \sqrt{\frac{2S}{a}}$ $\quad t_{1/2} = \frac{t}{\sqrt{2}}$

Time taken = $t/\sqrt{2}$

ResultsPlus
Examiner Comments

This was only for 1 mark so no working was required. The candidate has correctly derived the expression for the time in terms of *t*.

This started off well but scored 0.

(ii) Write an expression for the time taken, in terms of t, for the ball to roll a distance $\frac{s}{2}$ from the top of the plane.

(1)

$\frac{s}{2} = 0t + \frac{1}{2}(9.81)t^2$ $4.905t^2 = \frac{s}{2}$

$9.81t^2 = s.$ $t = \sqrt{\frac{s}{9.81}}$

Time taken = $\sqrt{s/9.81}$

ResultsPlus

Examiner Comments

The candidate has managed to get an expression for the new time in terms of the distance *s* but has not tried to substitute for *s* so that the final expression is in terms of *t*. Had this question been worth more marks this initial step would have been credited but only 1 mark was available so no method marks could be awarded.

Question 19 (c)

This experiment was intended to examine candidates' understanding of the terms 'reliable' and 'precise' and their ability to apply their understanding to the context of Galileo's experiment. Candidates realised where the faults of Galilieo's experiment originated but did not appear to have a good working knowledge of the ways errors are defined. Many were not clear of the meanings of the words 'reliable' and 'precise' and even when these terms were mentioned they were not always correlated to the required reason. Most usually insisted on using the term 'inaccurate' (some the term 'precise') in place of 'reliable.'

Many candidates identified the variable heart rate but did not connect this to reliability or repeatability. Many also identified that measurements to the nearest second would limit this experiment but usually failed to mention precision.

This response scored 0.

(c) Galileo repeated his measurements many times and obtained similar results on each occasion. He did not have a stopwatch and had to measure times using his pulse. A human pulse is about one beat per second.

Comment on Galileo's method.

(2)

Galileo used his pulse ~~so that~~ which might have some error as his pulse might beat different at different times but if his pulses are the same in each measurements then the time would be appropriate to measure

ResultsPlus
Examiner Comments

The candidate has understood that the pulse would vary but has not linked this to the results obtained, i.e. that they would vary every time or be 'unreliable.'

Just mentioning variation within one set of data was not enough for this first marking point. If the candidate did not mention the term 'reliable' or 'unreliable' they had to describe very clearly that the results (not an individual reading) would vary every time.

1 mark scored.

(c) Galileo repeated his measurements many times and obtained similar results on each occasion. He did not have a stopwatch and had to measure times using his pulse. A human pulse is about one beat per second.

Comment on Galileo's method.

(2)

Its not a very ~~its~~ reliable method as the heart beat of the human is not always same, the heart beat may increase as he was excited or scared effecting his pulse.

ResultsPlus

Examiner Comments

The candidate has mentioned reliability and linked this to the variation in the heart rate to score the first marking point.

Question 19 (d)

This question required the candidates to list the equipment needed to enable a value for *g* to be calculated. Most candidates knew that a time and a distance were required. However, many gave a detailed explanation of the method, often forgetting to mention the apparatus needed.

Most candidates scored one mark, with a significant proportion remembering to mention both pieces of apparatus, thereby scoring a second mark.

Light gates were the most frequently mentioned piece of apparatus to use as a timer, but some candidates failed to mention what they should be connected to in order to obtain a time. Some candidates mentioned stopwatches which were not credited because the question clearly mentioned the use of ICT, and so the chosen method for measurements should have involved use of ICT even if in the form of a timer in a circuit, for example.

This response scored both marks.

(d) Today, the acceleration of free fall can be found accurately by dropping a metal ball vertically and using ICT to collect data.

Suggest the apparatus required to take the measurements needed to calculate a value for the acceleration of free fall. $a = \frac{v-u}{t}$

(2)

Distance travelled can be measured using a ruler. ~~Time is measured using a light gate~~. Time could be measured using a camera which takes 3 pictures per second and the time could be calculated by counting the frames. The camera, ~~$a = \frac{v-u}{t}$~~, has to be ~~at a~~ vertical so there is no error. Speed could be then calculated using ~~each~~ either a data logger ~~or the equation~~ connected to a computer.

ResultsPlus

Examiner Comments

The ruler and camera method is sufficient to enable the distance and the time to be measured. The additional comment at the end regarding the use of a data logger is incomplete

This response scored 1 mark.

(d) Today, the acceleration of free fall can be found accurately by dropping a metal ball vertically and using ICT to collect data.

Suggest the apparatus required to take the measurements needed to calculate a value for the acceleration of free fall.

(2)

- Light gates to measure the time taken between two points.
- Meter rule to measure distance.
- ~~Beam balance to get the mass of the~~ Newton meter to get the weight of the object.
- Can calculate acceleration using $a = \frac{F}{m}$.

ResultsPlus
Examiner Comments

Just 1 mark for the ruler. The light gates on their own would not give a measurement of the time, they would need to be connected to a computer or data logger or timer so the second mark could not be awarded.

This detailed response scored just 1 mark.

(d) Today, the acceleration of free fall can be found accurately by dropping a metal ball vertically and using ICT to collect data.

Suggest the apparatus required to take the measurements needed to calculate a value for the acceleration of free fall.

(2)

Apparatus -
* A steel ball
* Electromagnet to hold the ball.
* A circuit with a trapdoor and stopwatch connected

* The ~~~~ ~~that take~~ distance s should be measured from the bottom of the ball, to the trap door.
* The time taken to travel this distance should be measured.
* A graph of s vs t^2 should be plotted.
* the inverse of the gradient will be the acceleration (g).

ResultsPlus
Examiner Comments

The trap door method was seen fairly frequently and described well, the minimum candidates were required to mention was an electromagnet, a trap door and some sort of timer placed in the circuit.

Although this candidate has almost described the entire experiment (although they have not described which variables would change each time and *g* would be equal to half the gradient and not the inverse of the gradient) they have forgotten to include the ruler that would be measuring the distance travelled by the ball each time. Just the second marking point awarded.

Paper Summary

Based on their performance on this paper, candidates should:

- slow down during the multiple choice items so that key words in the command sentence responses are not missed,
- ensure accurate definitions of all terms given in italics in the specification are employed,
- not spend all of their time describing one aspect of the question only,
- make sure that they have thought about the direction of the velocity and the acceleration of the object before substituting values into the correct equation of motion or drawing the correct graph.

A rare but correct response scoring all 4 marks.

The candidate has correctly described increasing the appplied force and a reduction in the angle to increase the horizontal force.

No mention has been made as to the reaction force but they have the right idea that the vertical forces must remain the same.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

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