Examiners' Report
June 2016

IAL Physics 1 WPH01 01

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Introduction

This unit is designed to test how well candidates 'understand and apply their knowledge of physics in the areas of mechanics and properties of matter. Their knowledge of physics is basic to all the questions on the paper, but is specifically tested, for instance, in questions asking for definitions of terms (such as the meaning of yield point in question 12), and those asking for straightforward statements (such as the meaning of laminar flow in question 19).

Their understanding of the subject is tested in a large proportion of this AS paper, for instance in questions requiring them to select the right equation to use in a calculation, in questions requiring them to understand what a law of physics means (such as Newton's laws in question 18), and in many other questions where their knowledge needs to be used rather than just stated. The candidates' ability to apply their knowledge is tested in about 50% of the marks on this paper, in questions requiring calculations, and in questions requiring them to explain how physics is applied to situations that will probably not have been taught directly (such as a car's suspension system in question 14 and a rowing boat in question 16).

The questions on this particular paper were mostly context based, with few that were straightforward recall. The candidates responded well to this style of question, and were able to demonstrate their ability in the subject through their answers to questions set in approximately real situations (like the bouncing ball of question 17) rather than in the abstract (e.g. "a body falls to the ground"). It was good to see that, on the whole, the candidates were very well able to apply the physics they had learnt to these real situations even though they had not studied them directly.

It should be noted that there will always be some questions where the quality of the candidates' written communication is being assessed. Examples in this paper are question 16b (the force of a hammock on the supports) and 18a (about Newton's laws), and these questions are marked with an asterisk (*) in the question paper. For these questions, in addition to the correct physics requirement, the examiner looks for clear and logical arguments written in reasonable English. While clarity of the argument is always important, the candidates should pay particular attention to it here, avoiding, for instance, answers that are almost totally mathematical in content.

In general, while the candidates need to express themselves clearly in their responses, poor English will not be penalised unless such use of language makes the answer ambiguous. However, particularly for the questions described in the paragraph above, a clear and logical response is required, and the candidate needs to consider and understand his or her response before launching into the answer. For instance, in question 16b, start by asking just why the supporting poles are liable to fall inwards. Too often we see a number of disconnected statements in the response, which, although they might well score some marks, do not fully explain the question as it is set.

For this paper we were expecting all numerical answers to be quoted to at least two significant figures, and the candidates were penalised if their answers were not accurate to that level. Ideally, the candidates' working should be done to a higher precision and then rounded to the number of significant figures justified by the data in the question, although, in this paper, we always accepted two figures.

Section A

Question	Subject	% correct	Correct response	Most common alternative
1	Units	70	B	C or D
2	Power and energy	69	B	A
3	F-e graph and elastic limit	94	C	Not significant
4	F-e graph and energy	70	A	C
5	Distance-time graph	82	D	B
6	Vestor addition	37	D	C
7	KE and GPE	75	B	D
8	Vectors	69	A	B
9	Equations of motion	51	D	B
10	F-ma	58	D	B

As intended, the multiple choice section scored quite highly, with an average of about 69%, but not so highly that they failed to discriminate between the candidates. A-grade candidates were typically scoring 81% and above. Each question is worth just one mark, so the students should be discouraged from spending too much time on any one question in this section.

Q1 was a straightforward question asking for the base units of the joule. Although most gave the correct answer, some gave the units of force or momentum. The candidates need not be afraid to do a bit of rough working in the space beside the answers, which will be ignored by the examiners in this section.

Q2 was an energy calculation. The most common mistake was to assume 60 seconds in an hour. Another regular error was to give the answer in kJ.

Q4 concerned the area under a force-extension graph. The great majority of candidates knew that the energy stored was the area under the graph, but a few ignored, or did not notice, the 10^{-3} on the extension axis.

Q6 was the least well answered question in this section. The question concerned the vector addition of two tensions, and there seemed to be confusion about whether the forces were acting on the picture or the hook, and whether it was the determination of the resultant force or three forces in equilibrium. The question clearly says it is about the forces on the hook, the resultant of which must be downwards, and only one of the given answers had a downward resultant.

Q8 concerned the vector nature of velocity, and was reasonably well answered. The main difficulty was deciding whether a change from 20 to −40 was +60 or −60.

Q9 discriminated well, with 51% giving the correct response, and the C+ candidates being the ones who responded correctly. The lower ability candidates either lost the factor of 2 (due to the ball rising and then falling) or put that factor in as ½ rather than 2.

Q10, about the acceleration of a ball on the Moon, was also answered less well. It was generally recognised that the weight would be lower on the Moon than on the Earth, but only the higher ability candidates could relate that to the acceleration of the ball upwards when the spring was released.

Question 11

It is usual for the first question in Section B to be short and straightforward, as in this case. However, the question will still be marked to a full A-level standard and so, in this case, an understanding of the equation for stress is required and those who quote the radius as their answer rather than the diameter that the question asks for will be quite heavily penalised, in this case by 2 marks.

The first example below is a response that gained all three marks. We were looking for an understanding of how the equation for stress should be used, with appropriate values substituted into the equation. Then the equation for cross-sectional area had to be used, together with a recognition that the diameter is twice the radius. It was surprising how many candidates did not use the correct equation for cross-sectional area (area of a circle). Most candidates did remember to convert MPa to Pa.

11 A crane supports a load of 950 N with a steel cable. If the breaking stress of steel is 500 MPa, calculate the smallest diameter cable that can be used.

(3)

$\text{Stress} = \dfrac{\text{Force}}{\text{area}}$ $\quad\quad$ $\text{area} = \left(\dfrac{\text{diameter}}{2}\right)^2 \pi$

$\dfrac{950}{500 \times 10^6} = 1.9 \times 10^{-6}\ \text{m}^2$

$1.9 \times 10^{-6} = \left(\dfrac{d}{2}\right)^2 \pi$

$6.048 \times 10^{-7} = \left(\dfrac{d}{2}\right)^2$

$7.78 \times 10^{-4} = \dfrac{d}{2}$

$d = 0.001553633$

Smallest diameter of cable = 0.0016 m

ResultsPlus
Examiner Comments

Here the equation for stress is clearly stated, as is the equation for the area in terms of the diameter. Stress is substituted in Pa and the calculation correctly worked through and clearly laid out.

The answer has been worked out to more significant figures than required and then rounded for the final answer – always good practice to avoid rounding errors during a calculation.

ResultsPlus
Examiner Tip

State the equations being used before using them.

Work to more significant figures that required for the answer.

The following responses show two common but incorrect answers.

11 A crane supports a load of 950 N with a steel cable. If the breaking stress of steel is 500 MPa, calculate the smallest diameter cable that can be used.

(3)

$\text{Stress} = \frac{F}{A}$

$500\times10^{6} = \frac{950}{\pi r^2}$

$r = \sqrt{\frac{950}{500\times10^{6}\times\pi}} = 0.0007 \quad \times 2$

Smallest diameter of cable = 0.0015 m.

ResultsPlus
Examiner Comments

This is an example of a response that has achieved all the physics marks, but has incorrectly rounded the value of radius part way through the calculation, leading to an incorrect answer.

11 A crane supports a load of 950 N with a steel cable. If the breaking stress of steel is 500 MPa, calculate the smallest diameter cable that can be used.

(3)

$\text{Stress} = \frac{\text{force}}{\text{area}}$ $\quad 500\times10^{6} = \frac{950}{A}$ $\quad \pi r^2 = 1.9\times10^{-6}$

$A = 1.9\times10^{-6}$ $\quad r = 7.78\times10$

Smallest diameter of cable = 7.78×10^{-4} m

ResultsPlus
Examiner Comments

This response scored 1 mark out of 3 for the very simple error of not calculating the diameter, which is what the question asked for. "Diameter" is stated both in the question and on the answer line.

Other candidates calculated the area, but gave that as their answer, also scoring 1 mark only.

ResultsPlus
Examiner Tip

Read the question carefully.

Question 12

This question concerns the definition of the yield point, but the candidates were asked to look at what a student might have said and criticise it. They did find this a difficult question and although most were able to state what the yield point was, they generally could not say why the student was wrong. In face, many took up the wrong statement and just developed it when trying to describe the yield point, a procedure likely to fail as there was more than a single error in the statement. We were expecting the candidate to identify what was wrong with the student's statement for the first mark and also to give a correct description of the yield point for the second mark.

The response below is an example of one which gained both marks. It illustrates perhaps the best way to approach this type of question, which is to give the correct definition first and then explain why the student's definition was wrong.

We allowed either of two possible definitions of yield point:

- the onset of plastic deformation
- the point at which a small or zero change of stress gives rise to a large change of extension

When stating how the student was wrong, the candidate could say either:

- The stress at which there is a large extension could be anywhere in the plastic region.
- The student should have said "a change" of stress and extension.

12 A student was asked to define the yield point of a material. The student said 'the stress at which there is a large extension.'

Explain why the student's definition is incorrect.

(2)

The yield point is at which there's a large increase in strain ~~to~~ ~~at~~ for a very small ~~stress~~ increase in stress. The stress has a small increase which is lost in the student's definition, not just "the stress" and not nost "extension" but "increase in extension".

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Examiner Comments

This candidate has correctly given the meaning of the yield point and given the critical difference between that and the student's definition.

ResultsPlus
Examiner Tip

Definitions do need to be learnt.

These are a few responses which scored fewer than full marks.

12 A student was asked to define the yield point of a material. The student said 'the stress at which there is a large extension.'

Explain why the student's definition is incorrect.

(2)

The yield point is the point at which even if there is a small change or no change in stress, there is a large change in strain i.e. extension. The change in strain is much greater than stress. The student does not mention this and the definition provided can be applied to any load.

ResultsPlus
Examiner Comments

A good definition of yield point, but it is not clear what the student said wrongly. "The student does not mention this" is too vague.

12 A student was asked to define the yield point of a material. The student said 'the stress at which there is a large extension.'

Explain why the student's definition is incorrect.

(2)

Yield point is the point beyond which plastic deformation occurs, at that point the material ~~[illegible]~~ is on the brink of plastic deformation. A small change in stress causes a larger change in strain/extension. There is no linear relationship at/beyond the yield point.

ResultsPlus
Examiner Comments

This response is very clear about what the yield point is, but has not explained why the student's definition is incorrect, which is what the question asked.

ResultsPlus
Examiner Tip

A good physics response does not necessarily get all the marks if some aspect of the question is not answered.

12 A student was asked to define the yield point of a material. The student said 'the stress at which there is a large extension.'

Explain why the student's definition is incorrect.

(2)

It is wrong because yeild point is where ~~the~~ a ~~force~~ small stress is applied results in a large strain not extension.
~~Or you could~~ Strain = extension (change in length) / initial length

ResultsPlus

Examiner Comments

This response did not score either mark. It was a popular response to say that the student should be referring to strain rather than extension, whereas either can in fact be used.

Question 13 (a)

Question 13 tested the candidates' knowledge of properties of materials, and used the Olympic torch in the London arena as the context. The candidates had to apply their knowledge of the material properties to the way two different metals were used in the torch. It is important that candidates, as well as understanding what words like strong, brittle, tough etc mean, should be able to explain why such properties are important in particular situations.

13a asked why copper was a suitable material to make the petals, and a photograph of a petal was included showing how it is manufactured. To get the two marks, the candidate had to:

- State the property as "malleable".
- Explain that it is to enable the copper to be bent or beaten into shape.

The first response below shows the kind of response we were looking for.

(a) Explain why copper was a suitable material from which to make the petals.

(2)

It is malleable, ~~so~~ and so can be ~~hammered into~~ deformed plastically by hammering into specific shapes.

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Examiner Comments

The answer is concise and keeps to the point. This candidate knows what property is required and goes straight to the point.

ResultsPlus

Examiner Tip

Try to keep the answer concise.

These responses indicate some of the ways candidates lost marks.

(a) Explain why copper was a suitable material from which to make the petals.

(2)

copper is a very malleable material therefore it can be ~~st~~ hammered into thin sheets

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Examiner Comments

This candidate has the correct property, so gained 1 mark, but goes back a stage to say how the sheet of copper may have been produced. It is not acceptable for the 2nd mark because the question and the photograph show how the petal is being formed from the copper sheet, so we required them to say how the petal shape was formed. "Hammered into sheets" may well be a definition of malleable that the candidate had seen, but was not relevant to this question.

ResultsPlus
Examiner Tip

Beware of repeating a known form of words.

(a) Explain why copper was a suitable material from which to make the petals.

(2)

Copper is a tough material which is malleable; this means that it can undergo considerable plastic deformation under compressive stress. This property makes it suitable to be shaped into petals sheets.

ResultsPlus
Examiner Comments

This candidate has given two possible answers, "tough" and "malleable". Copper is both of these, but toughness is not relevant to this situation, and so the response is considered as giving the examiner a choice of answers, which is not acceptable. It therefore loses the mark.

There are other properties which might be considered as relevant, such as a high melting point. Although this was not the required answer, the stating of such properties did not prevent the correct "malleable" scoring the mark.

ResultsPlus
Examiner Tip

Try not to give the examiner a choice of answers.

Question 13 (b)

13b asks why steel is a suitable material for the stem. As the stems are under considerable bending stress when they are used, the response the examiners looked for was that steel is stiff, or has a high Young modulus. Any mention of steel being strong was ignored as it is relevant but not the most important property. Many candidates presented the examiner with a list of properties, such as "stiff and ductile", which as explained earlier, does not score the mark. The marks were for:

- The property being stiff, or high Young modulus
- The reason that the stem must not bend or deform.

If neither mark was scored, then the candidate could get a single mark for saying clearly that the steel is strong.

(b) Explain why steel was a suitable material from which to make the stems.

(2)

Steel is a stiff material, which has a high yang modulus. So it will not deform easily, ~~as~~ as we need a lot of stress to make a change in strain. It will support the petals with no ~~problem~~ problem.

(Total for Question 13 = 4 marks)

ResultsPlus
Examiner Comments

This clear response scores both marks, giving a full explanation of the choice of "stiff".

(b) Explain why steel was a suitable material from which to make the stems.

(2)

Steel is strong, As it has high ultimate tensile stress. So it can support the petals.

ResultsPlus
Examiner Comments

We allowed the maximum of one mark here for steel being strong. The statement that it needs to support the petals is insufficient, but had the candidate added "without bending" it would be correct.

(b) Explain why steel was a suitable material from which to make the stems.

(2)

ductile : steels can be pulled into wires, which show a large plastic deformation under tension.

ResultsPlus

Examiner Comments

It was a very common mistake to consider that the stems were made in the same way as wires would be, and so the steel had to be ductile.

(b) Explain why steel was a suitable material from which to make the stems.

(2)

Steel is a hard material, resistant to scratching. It is also a very stiff material, and will hold the copper petal up.

ResultsPlus

Examiner Comments

If giving more that one property, be sure that they are all relevant. In this case, we could not think why a hard material was needed, so the mark was lost even though the correct property was also given.

ResultsPlus

Examiner Tip

It is often helpful to give extra information, but if doing so be sure that it is correct and does not negate your answer.

Question 14 (a) (i)

This question concerned the function of the springs in a car's suspension system. In practice, a suspension system is more complex than shown here, with the addition of dampers, but the candidate here had to focus on the reason for having the spring and its properties. The introduction to the question explains why a spring is needed, so that when a car's wheel goes over a bump, the spring compresses and then expands again rather than having the car body move up and down. It was important for the candidate to have read and understood the introduction carefully to be able to fully respond to the questions that followed.

14ai required the candidate to make two points, one about the spring and the second about the effect on the car or its occupants.

- There will be less compression of the spring – many failed to gain this mark by making a much less specific statement about the spring being harder to compress.
- The car will bump up and down more, or words giving that meaning. Most candidates explained this well.

The first two samples here gained full marks. While the explanations are not perfect, the candidates clearly understood the situation well and have applied their knowledge of physics correctly.

(i) Suggest what the effect would be of using springs with a greater value k when driving on a bumpy road.

(2)

If it has greater stiffness there will be less compression for the force applied so the driver will feel the bumps more. The body of the car would move more, If its a lower stiffness the body wouldn't move up and down so much.

ResultsPlus
Examiner Comments

"Less compression" gains the first mark, and either "feel the bumps" or the implication that the car would move up and down more gets the second mark.

(i) Suggest what the effect would be of using springs with a greater value *k* when driving on a bumpy road.

(2)

The young modulus of the spring is more, thus the body of the car won't ~~be~~ stay at same level and the car will bump more, as there will be less compression.

ResultsPlus

Examiner Comments

"Less compression" gets the first mark, and "the car won't stay at the same level" gets the second. Young modulus does not apply to a spring, but that statement by the candidate was considered not important by the examiner.

The responses below gained one or zero marks, but were common ways in which candidates failed to get the full credit.

(i) Suggest what the effect would be of using springs with a greater value *k* when driving on a bumpy road.

(2)

A higher k value means a greater spring constant. Therefore the spring is ~~much more~~ stiffer and therefore more force is required to compress the spring. This results in a less comfortable, more bumpy ride as the springs dont absorb the forces easily when driving over bumps, hence body imbalance.

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Examiner Comments

This candidate says that more force is required to compress the spring, which is true but is only part of the reason for the bumpy ride. The candidate should have gone on to say that because more force is required to compress the spring, it will have less compression as the wheel goes over the bump. The "less compression" is the key here.

The second mark was scored for the "bumpy ride".

(i) Suggest what the effect would be of using springs with a greater value k when driving on a bumpy road.

(2)

If the stiffness is greater, the force required to compress the spring is greater. This would ~~take~~ require more work to be done, ~~be~~ as there would be greater frictional forces. More energy is therefore required by the car.

ResultsPlus
Examiner Comments

It was quite common to answer in terms of energy, but it does not help for this question. Neither mark was scored in this response.

ResultsPlus
Examiner Tip

Not every problem can be explained in terms of energy.

(i) Suggest what the effect would be of using springs with a greater value k when driving on a bumpy road.

(2)

- If they have a greater stiffness constant, there would be less compression
- The body of the car would not be maintained at the same level, it would be higher.

ResultsPlus
Examiner Comments

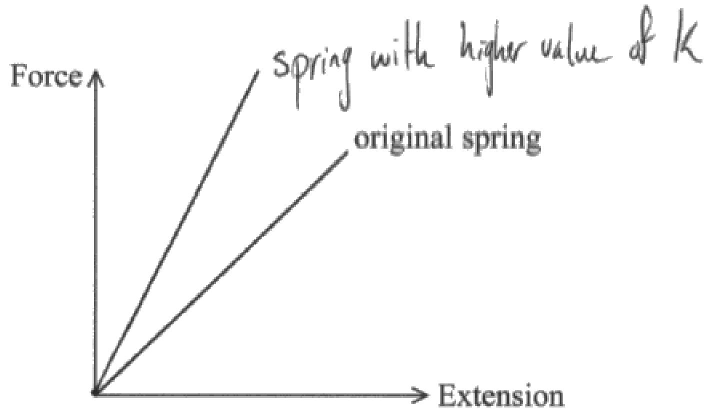
We saw this response a few times. If the spring were stiffer, and had the same original length, then the height of the car above the road would be greater, as stated here. However, that is not relevant to driving on the bumpy road.

Question 14 (a) (ii)

The force extension graph for the spring with height *k* was well answered for a single mark. A correct response would be a straight line of greater gradient passing through the origin.

(ii) Add an appropriate line to the force-extension graph for the new spring with a higher value of *k*.

(1)



ResultsPlus
Examiner Comments

This is the response we expected. A freehand straight line was allowed, but unless a ruler was used it was sometimes difficult to tell that the candidate meant the line to be straight.

ResultsPlus
Examiner Tip

Use a ruler to draw straight lines.

Question 14 (b)

This was a straightforward calculation using the equation $F = k\,\Delta x$. The candidates were expected to

- Substitute suitable values into the above equation
- Calculate the extension
- Calculate the k value with the appropriate unit.

Most candidates performed well on this item, but mistakes were to substitute the length rather than the extension, and to use a force of 4.07 N leading to a power of ten error.

(b) A spring used in the front suspension of a car has an initial length of 0.316 m and a new length of 0.205 m when under a load of 4.07 kN.

Calculate the spring constant of the spring.

(3)

Compresson ~~extension~~ $\Delta x = (0.316 - 0.205)\,m$

$= 0.111\,m$

$F = kx$

$k = \frac{F}{x} = \frac{4.07 \times 10^3}{0.111} = 36667\ N\,m^{-1}$

$\approx 3.7 \times 10^4\ N\,m^{-1}$

Spring constant = $3.7 \times 10^4\ N\,m^{-1}$

ResultsPlus

Examiner Comments

This is a well presented response. The candidate has calculated the compression, substituted into the equation, calculated the answer correctly, rounded to a suitable number of significant figures, and given the unit. In this item, 3 significant figures would have been better than two as all the data in the question was to 3 s.f.

ResultsPlus

Examiner Tip

A well laid out answer such as this one is more likely to get most of the credit should an arithmetic error cause the answer to be incorrect.

Here are two incorrect responses that were sometimes seen.

(b) A spring used in the front suspension of a car has an initial length of 0.316 m and a new length of 0.205 m when under a load of 4.07 kN.

Calculate the spring constant of the spring.

(3)

$F = K\Delta x \qquad 0.316 - 0.205$

$4.07 \times 10^3 = K(~~0.205 - 0.316~~)$

$4.07 \times 10^3 = K\, 0.111$

$3.6 \times 10^4\ Nm^{-1}$

Spring constant = ~~3.6~~ ~~36,66~~ $3.6 \times 10^4\ Nm^{-1}$

ResultsPlus
Examiner Comments

This response looks correct initially, but the final rounding of the answer is incorrect. 3.667 has been truncated to 3.6 rather than rounded to 3.7.

(b) A spring used in the front suspension of a car has an initial length of 0.316 m and a new length of 0.205 m when under a load of 4.07 kN.

Calculate the spring constant of the spring.

(3)

~~extension~~ change in lenght = −0.111

Force = 4.07 × 1000 = 4070 N

$k = \frac{4070\ N}{-0.111} = -36666.7$

Spring constant = $-36666.7\ Nm^{-1}$

ResultsPlus
Examiner Comments

We are happy to accept the negative change in length, but the candidate should know that the value of *k* is always positive.

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Examiner Tip

Always check that a numerical answer is sensible.

Question 15

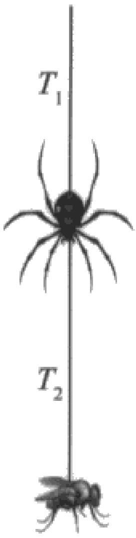
This is a question on forces and acceleration, set in a context that the candidate is unlikely to have studied directly. It therefore gives the candidate the opportunity to demonstrate their ability to apply the physics they know in a new situation. The question was not straightforward, as there were three forces acting on the spider and two on the fly, and the two force systems were inter-related. However, in part (a), the candidates were only required to deal with a single system at a time which should be uncomplicated. The great majority achieved most of the marks for part (a). For part (b) the whole spider-fly system is involved, which the candidates did find a lot more challenging and few achieved the full 3 marks.

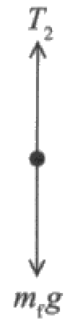
15 (a) (i)

We would like to see a single arrow vertically upwards labelled T_1 and two arrows vertically downwards labelled T_2 and $m_s g$. We were happy to accept $m_f g$ or weight of fly for T_2. We also accepted a single line down with two arrowheads, labelled as already stated, or a single arrow down labelled $T_2 + m_s g$. We did not accept a diagram with more than 3 forces on, possibly the weight of the fly as well as $T_{2.}$

15 A spider of mass m_s is hanging from a thread of spider silk. A fly of mass m_f is hanging from another thread of silk below the stationary spider.

The magnitudes of the tensions in each thread of silk are T_1 and T_2 as shown in the diagram. The free-body force diagram for the fly is also shown.

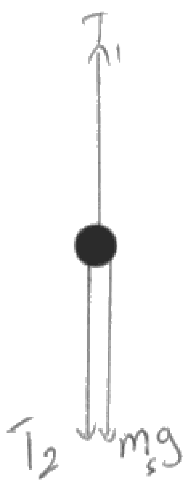




Free-body force diagram for the fly

(a) (i) Complete the free-body force diagram below for the spider.

(3)



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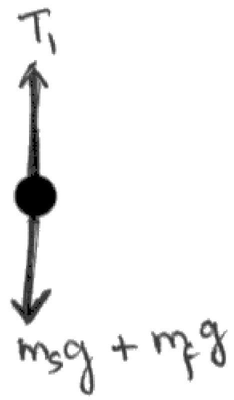
Examiner Comments

This is the ideal response, showing and labelling the three forces.

(a) (i) Complete the free-body force diagram below for the spider.

(3)

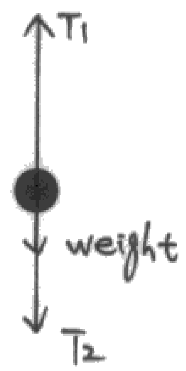


ResultsPlus
Examiner Comments

This diagram is less good, as it only includes a single arrow, but it was quite common and was allowed for all 3 marks.

(a) (i) Complete the free-body force diagram below for the spider.

(3)



ResultsPlus
Examiner Comments

This response gained 2 marks. We accepted the two down arrows on a single line, but there are two weights involved in the question and so the label was insufficient. Weight of spider, or $W_{s,}$ would have been accepted.

ResultsPlus
Examiner Tip

A free body force diagram needs labelling carefully.

15 (a) (ii)

The candidate is asked to write down two force equations, for the spider and for the fly. The question has said that for this section the spider is stationary, so the equations will be balanced. Unlike part (i) the candidate is expected to use the symbols given at the start of the question. The candidate will write down two equations and should make it clear which equation applies to the spider and which to the fly.

(ii) Write equations for the forces acting on the spider and for the forces acting on the fly.
(2)

Forces acting on spider :

$$T_1 = m_s g + T_2$$

Forces acting on fly :

$$T_2 = m_f g$$

ResultsPlus
Examiner Comments

This is an ideal response, including all the elements noted above.

15 (b)

A much smaller proportion of candidates obtained the full 3 marks for this part of the question. The spider and fly are now accelerating together under a resultant force equal to their combined weight minus the upward tension. The accelerating mass is the sum of the two. It was very common for candidates to ignore either the weight or the tension. Some attempted to use the equations they had given in part (a) (ii), but they were for a stationary system, which is now accelerating. The examples below show a correct response, and two common mistakes.

(b) The spider produces more silk, so the length of the thread of silk above the spider increases. The spider and the fly both accelerate towards the ground.

Assuming that the mass of the silk is negligible, calculate their acceleration.

$m_s = 6.5 \times 10^{-4}$ kg

$m_f = 8.0 \times 10^{-5}$ kg

$T_1 = 1.9 \times 10^{-3}$ N

(3)

$\Sigma F = ma$

$(m_s g + m_f g) - T_1 = (m_s + m_f)\, a$

$(6.5\times10^{-4})(9.8) + (8\times10^{-5})(9.8) - 1.9\times10^{-3} = (6.5\times10^{-4} + 8\times10^{-5})\, a$

$6.37\times10^{-3} + 7.84\times10^{-4} - 1.9\times10^{-3} = 7.3\times10^{-4}\, a$

$a = \dfrac{5.254\times10^{-3}}{7.3\times10^{-4}} = 7.2\ \text{ms}^{-2}$

Acceleration = $7.2\ \text{ms}^{-2}$

ResultsPlus

Examiner Comments

This fully correct response is also very clearly laid out. Starting with the equation to be used ($\Sigma F=ma$), the total force is equated to the total mass multiplied by the acceleration. The calculation is worked through and the answer given with the right unit.

(b) The spider produces more silk, so the length of the thread of silk above the spider increases. The spider and the fly both accelerate towards the ground.

Assuming that the mass of the silk is negligible, calculate their acceleration.

$m_s = 6.5 \times 10^{-4}$ kg

$m_f = 8.0 \times 10^{-5}$ kg

$T_1 = 1.9 \times 10^{-3}$ N

(3)

$F = ma$

$m_s g + m_f g = m_f + m_s \times a$.

$6.5 \times 10^{-4} \times 9.81 + 8 \times 10^{-5} \times 9.81 = (6.5 \times 10^{-4} + 8 \times 10^{-5}) \times a$

$7.16 \times 10^{-3} = 7.3 \times 10^{-4} \times a$

$a = \underline{9.81}$

Acceleration = $9.81\ \text{ms}^{-2}$

ResultsPlus

Examiner Comments

This common error ignores the effect of the upper tension T_1 on the acceleration. As the weight is then the only force acting, it is not unexpected that they fall with acceleration of g. The response scored 1 mark for using $F=ma$.

ResultsPlus

Examiner Tip

Since the spider and fly are not free falling, it should be clear that this answer is incorrect.

(b) The spider produces more silk, so the length of the thread of silk above the spider increases. The spider and the fly both accelerate towards the ground.

Assuming that the mass of the silk is negligible, calculate their acceleration.

$m_s = 6.5 \times 10^{-4}$ kg

$m_f = 8.0 \times 10^{-5}$ kg

$T_1 = 1.9 \times 10^{-3}$ N

(3)

$F = ma$

$1.9 \times 10^{-3} = (6.5 \times 10^{-4} + 8.0 \times 10^{-5})(a)$

$1.9 \times 10^{-3} = 7.3 \times 10^{-4} a$

$a = \frac{1.9 \times 10^{-3}}{7.3 \times 10^{-4}}$

$a = 2.60 \text{ ms}^{-2}$

Acceleration = 2.60 ms^{-2}

ResultsPlus
Examiner Comments

This was another common mistake, where the only force acting was assumed to be the tension. Again, it scored 1 mark.

Question 16 (a)

Question 16 as a whole was about resolving forces in the vertical and horizontal directions. The context was that of a person in a hammock and the relevant force was the tension in the supporting ropes, the hammock being hung between two vertical poles. Although the context was one that the candidates would be unlikely to have met during their physics course, it was straightforward, easily understood and the diagram given in the question showed clearly how the hammock was suspended, with the relevant tension and angle.

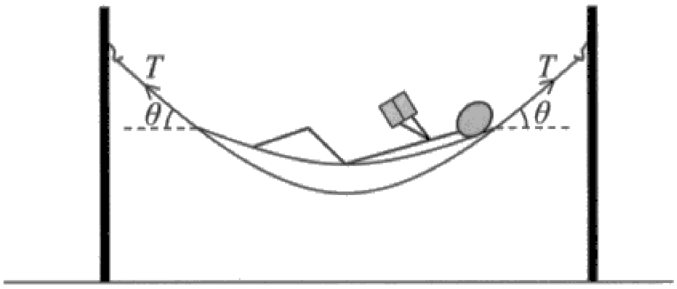
Part (a) was well answered, as expected, with many candidates gaining the full 3 marks. It required them to calculate the tension in the supporting ropes, given the mass and the angle of those ropes. They were required to:

- Calculate the weight from the mass.
- Divide that by sin40°.
- Calculate the answer.

The most likely mistakes were to ignore the mass of the ropes, so taking the mass to be 80 kg, or to be confused about the trigonometry required.

The following example gained full marks and was how we would like to see the response laid out.

16 A hammock is suspended between two rigid poles. Both ropes supporting the hammock are at an angle of θ to the horizontal as shown.



(a) When a man of mass 80 kg lies in the hammock, θ is 40°.

Show that the tension T in each of the hammock's supporting ropes is about 650 N.

mass of hammock and ropes = 4 kg

(3)

$W = 2T \sin \theta$

$84 \times 9.81 = 2 \times T \times \sin 40$

$\frac{84 \times 9.81}{2 \times \sin 40} = T$

$T = 640.989$

$T = 641$ N

ResultsPlus
Examiner Comments

The candidate has:

- stated the equation to be used
- shown how the weight is calculated (this is often done as a separate calculation).
- used the correct trigonometry – it is probably easier to state it this way as $T\sin\Theta$ rather than as $W/\sin\Theta$.
- quoted the answer to a sensible number of significant figures.

The following are two examples of candidates who did not gain the full 3 marks.

(a) When a man of mass 80 kg lies in the hammock, θ is 40°.

Show that the tension T in each of the hammock's supporting ropes is about 650 N.

mass of hammock and ropes = 4 kg

(3)

~~2T8sin40~~ $2T \sin\theta = mg$

$2T \sin 40 = 80 \times 9.81$

$T = \dfrac{80 \times 9.81}{2 \times \sin 40}$

$T = 610\text{N}$

ResultsPlus

Examiner Comments

This candidate has forgotten to include the mass of the rope and so gets the wrong answer. However, as the response clearly shows the weight being calculated from the mass and the correct trigonometry being used, it was awarded 2 of the marks.

ResultsPlus

Examiner Tip

A simple error might not cause the loss of many marks if the calculation is clearly laid out.

(a) When a man of mass 80 kg lies in the hammock, θ is 40°.

Show that the tension T in each of the hammock's supporting ropes is about 650 N.

mass of hammock and ropes = 4 kg

(3)

$80\text{kg} \times 9.81\text{ms}^{-2} = 784.8\text{N}$ $784.8 + 39.24 = 824.04\text{N}$

$4 \times 9.81 = 39.24\text{ N}$

~~Tsin40~~ $824.04\text{N} \times \cos 40 = 631\text{N}$

ResultsPlus

Examiner Comments

This response is an example of confusion in the trigonometry required. There was a surprising amount of confusion whether to use cosine or sine, and whether to divide or multiply. The correct calculation is to divide by sin θ , but this candidate has multiplied by cos θ. Deciding on the right trigonometry can be difficult, and a good way of doing that is to sketch a separate triangle or add to the diagram to ensure the correct choice.

As this was considered to be an error of physics, it only gained 1 mark.

ResultsPlus

Examiner Tip

If uncertain about the trigonometry, sketch a separate triangle with force and angle marked.

Question 16 (b)

The candidates found this part of the question much harder, with very few achieving the full 5 marks. However, the actual marking points lost varied considerably, with all the marking points individually being regularly scored. The question expected a written explanation, rather than a calculation, which is emphasised by the fact that it is a QWC question. Those few who just used sample calculations could not achieve more than 3 marks. The question is about why the poles have a tendency to fall inwards and why the force causing this is reduced if the value of θ is increased. The candidate is told to consider the vertical and horizontal components of the tension, which should be taken as a strong hint that this is the way to approach the question. It was marked as follows:

- The response must make it clear it is the horizontal component of the tension that is causing the poles to fall inwards. This might not be explicitly stated, but has to be clear. Many candidates thought it was the vertical component, as that drove the poles further into the ground.
- State that the tension is $T_v/\sin\theta$.
- Understand that the vertical component does not change, or that it is equal to 1/2 the weight.
- State that the horizontal component of the tension is $T\cos\theta$.
- The final mark is for either saying T decreases or that T_h decreases as θ increases.

Many candidates only got half way with this, either saying that since the vertical component was constant the tension would decrease, or assuming that the tension was constant and so the horizontal component would decrease.

There are two examples below of good responses that gained most of the marks.

*(b) The force of the supporting ropes could cause the poles to fall inwards.

By considering the vertical and horizontal components of the tension in one of the supporting ropes, explain why a larger value of θ creates a smaller force on the poles supporting the hammock.

(5)

The vertical component of the tension is $T\sin\theta$, The horizontal component of the tension is $T\cos\theta$. The larger the θ, the larger the $T\sin\theta$, so only requires a smaller force T to make ~~the~~ the equilibrium, according to the equation $2T\sin\theta = mg$. Since the weight of the man and hammock is constant.

ResultsPlus

Examiner Comments

This response, which was given 4 marks, has expressions for the horizontal and vertical components of the tension. The last two lines make it clear that the vertical component is equal to ½ weight, and so is constant, and the third line states that the tension reduces. The response does not say that it is the horizontal component that is important, nor does it show that this component reduces.

*(b) The force of the supporting ropes could cause the poles to fall inwards.

By considering the vertical and horizontal components of the tension in one of the supporting ropes, explain why a larger value of θ creates a smaller force on the poles supporting the hammock.

(5)

- As weight increases, θ will increase.
- This will cause the vertical component of tension to increase as vertical component = $T\sin\theta$
- However, the horizontal component of tension will decrease as horizontal component = $T\cos\theta$ (greater θ, smaller $\cos\theta$)
- Because only the horizontal component of force can cause it to move inwards, this means that a decreasing force in horizontal direction will cause a smaller force on the poles.
- vertical component will only push towards the ground.

ResultsPlus
Examiner Comments

This response also gained 4 marks. The relationships of horizontal and vertical components to the tension are stated, and it is explained why the horizontal component will decrease as the angle increases. It also explains clearly, in the latter part, that it is the horizontal component that causes the poles to move inwards. However, the fact that the vertical component does not change is not mentioned, as in fact it seems to be implied that the weight is increasing.

Take The vertical component, and if you were to increase The angle and make it 50°, Then The total tension would decrease because $T = \frac{784.8}{\sin 50}$ gives 1024 N which means That each pole would be subjected to 512N of Tension which is much less Than The 641N due to The 40° Angle.

ResultsPlus

Examiner Comments

This response gained 1 mark for saying that the tension would decrease. It was a common response to attempt to put in a value for θ other than 40° and try to compare the force with that obtained previously. This approach rarely worked well, and a calculation of this kind would not get the full credit as we required a written response.

ResultsPlus

Examiner Tip

If the question has an asterisk (*) against it means we are also testing the "quality of written communication", and so a purely mathematical response will not get full credit.

Increasing the value of θ gives a greater vertical component and a smaller horizontal component, so as the ~~4~~ horizontal component is smaller, it is less likely for the poles to fall inwards as there is a smaller horizontal force exerted on them. A greater vertical component just pushes the poles into the ground. ~~and~~

~~will~~

ResultsPlus

Examiner Comments

This response gained 2 of the 5 marks, but illustrates clearly a common misunderstanding about the forces. The candidate clearly suggests that it is the horizontal component that is the important one, and states that this component becomes less as the angle is increased. Those are the 2 marks. However, the assumption is that the tension in the ropes does not change as the angle changes. This is a straightforward assumption, with no physical basis, and therefore leads to errors such as that the vertical component increases. As the equations used have not been given, this candidate is fortunate to gain the 2 marks.

ResultsPlus

Examiner Tip

Think carefully about the physical basis of assumptions made.

Question 17 (a)

The question involved taking readings from a multiflash photograph, and using them to calculate (i) the height of the first bounce, and (ii) the horizontal velocity. The great majority of the candidates understood the photograph and the timings involved, and were able to take some appropriate readings from it. However, they found it much harder to complete the calculations involved using the readings taken.

Part (i) was very well answered. In order to find the distance fallen, they had to use the equation $s=\frac{1}{2}gt^2$. The reading required from the photograph was the number of time intervals between the balls marked X and Y, which should be 6, but many candidates included the balls at the two ends and so counted 7, which would lose 2 marks.

Part (ii) gained far fewer marks. In this case the candidate had to:

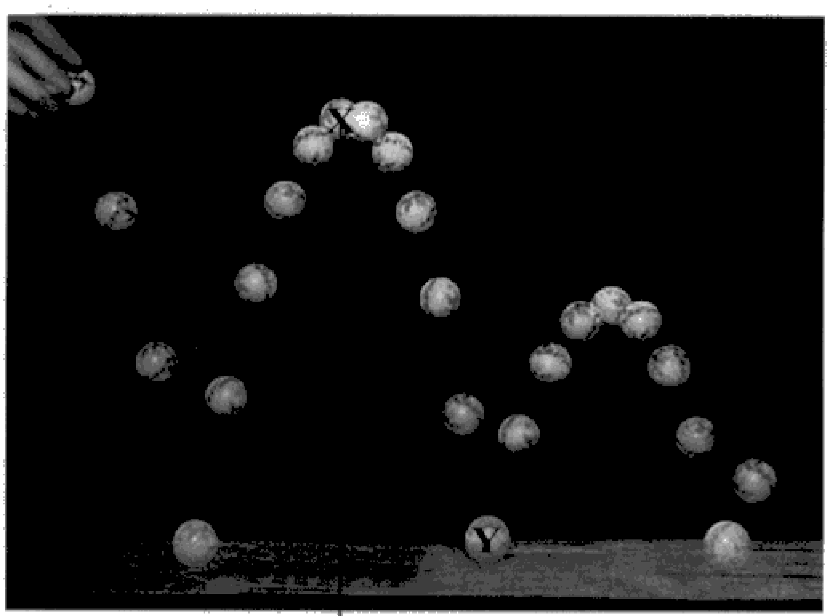
- Take a horizontal and vertical measurement from the photograph.
- Know the actual vertical distance from the calculation in (i) and determine a scale to enable the horizontal distance to be calculated.
- Calculate the speed = distance/time.
- State the answer, with its unit. This has a large acceptable range to allow for the many possible distances that could be taken from the photograph.

Many candidates lost marks through careless measuring of the distances on the photograph (we were expecting the measurement to ±1mm), or through not realising that a scale was needed and just using the distance on the photograph.

17 (a) (i)

The first two responses below gained all 3 marks.

17 The photograph shows a sequence of images of a bouncing ball. 20 images were taken per second.



(a) (i) Show that the distance the ball fell between point X and point Y is about 0.4 m.

(3)

6 images · $\frac{1}{20} \times 6$ $s = 0.44$ m

~~20~~ ✱
~~6~~
~~60000~~

$= 0.3$ s

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

$s =$ ~~ut~~ $\frac{1}{2} \times 9.81 \times 0.3^2$

ResultsPlus
Examiner Comments

The candidate has counted the 6 images at 1/20th second each giving 0.3 s. The correct equation of motion is used giving a correct distance of 0.44 s. The working is clearly laid out, so if any mistake were to be made, credit could be given for the correct parts.

(a) (i) Show that the distance the ball fell between point X and point Y is about 0.4 m.

(3)

$t = 0.3$, $a = 9.81$, $u = 0$, $v = ?$, $s = ?$

$v = u + at$ $\quad v = 9.81 \times 0.3 = 2.94\ ms$

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

$(2.94)^2 = 0 + 2(9.81)(s)$ $\quad s = 0.44\ m \simeq 0.4\ m$

ResultsPlus
Examiner Comments

This response also gained 3 marks, and shows that there are other ways in which the equations of motion can be correctly used.

(a) (i) Show that the distance the ball fell between point X and point Y is about 0.4 m.

(3)

$t = 6 \cdot \frac{1}{19} s = \frac{6}{19} s$

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

$= \frac{1}{2} \cdot 9.81 \times (\frac{6}{19})^2$

$\approx 0.49\ m$

ResultsPlus
Examiner Comments

This response gained 1 mark. This mistake was noted fairly regularly. The candidate has thought that if 20 images were taken per second, then there will only be 19 time periods. This is probably from previous experience with ticker timers where there is confusion about counting dots or spaces, but it is clearly an error of physics and so has a 2 mark penalty.

17 (a) (ii)

The response below gained all 4 marks.

(ii) Use measurements from the photograph to calculate the horizontal velocity of the ball.

(4)

X to Y vertical distance = 5.65 cm → 0.44 m

$1\text{ cm} \rightarrow \frac{0.44}{5.65}\text{ m}$

3.9 cm horizontal $= 3.9 \times \frac{0.44}{5.65}$ m, in $11 \times \frac{1}{20}$ s

$d = 3.9 \times \frac{0.44}{5.65}$ m, $t = \frac{11}{20}$ s

$s = \frac{d}{t} = \frac{\left(3.9 \times \frac{0.44}{5.65}\right)}{\left(\frac{11}{20}\right)} = 0.55\text{ ms}^{-1}$ (2 sf)

Horizontal velocity = 0.55 ms^{-1}

ResultsPlus
Examiner Comments

This candidate has measured the vertical distance accurately, and then used that, together with the actual vertical distance calculated in part (i), to determine the scale factor. Horizontally, any pair of ball positions can be used, but this candidate has used the best two, which are either end of the first bounce. This gives two ball positions on the same level, so the measurement is much simpler. The first to the third bounce would be an equally good choice. The commonly chosen X to Y is less good, as it is shorter, and the levels are very different.

The following responses illustrate some common errors that reduced the marks.

distance = 2 cm

velocity / speed $= \frac{0.02}{0.3}$

$=$ ~~6.67~~ 0.067 m/s

Horizontal velocity = 0.067

ResultsPlus
Examiner Comments

This response gained 2 marks.

There are two problems:

- No scale has been used, so the distance and hence the velocity, are too small.
- The horizontal distance from X to Y has been measured. That makes the time the same as in part (i), which simplifies the calculation, but as the two ball positions are on such different levels, errors of measurement are likely. In fact, in this case, the 2 cm is correct.

ResultsPlus
Examiner Tip

Any picture or photograph is unlikely to be actual size.

~~v =~~ From ~~calculate~~ measurement, the horizontal ~~veloci~~ distance is 9 cm.

so $v = \frac{s}{t} = \frac{0.09\text{m}}{\frac{23}{20}} = 0.078 \text{ ms}^{-1}$ (2 s.f)

Horizontal velocity = 0.078 ms^{-1}

ResultsPlus

Examiner Comments

This response again scored 2 marks, because there is no scale used.

The candidate here has measured the maximum distance from the first to the last ball. It should be 9.1 cm and we accepted 9.0 cm so this gained that mark. It is not always the case that the largest distance is the most accurate, and many tried this measurement but lost the mark because it was difficult to measure the horizontal distance accurately when the ball positions were on different levels. An error of ± 1mm was allowed.

ResultsPlus

Examiner Tip

When taking measurement from a picture, accuracy is important.

(a) (i) Show that the distance the ball fell between point X and point Y is about 0.4 m.

(3)

t = 0.3, a = 9.81, u = 0, v = ?, s = ?

v = u + at   v = 9.81 × 0.3 = 2.94 m s

v² = u² + 2as

(2.94)² = 0 + 2(9.81)(s)   s = 0.44 m ≃ 0.4 m

(ii) Use measurements from the photograph to calculate the horizontal velocity of the ball.

(4)

Sx = u × t

Uy = 2.94 ms

u cos 15 = 2.94

u = 3.04

u sin 15 = 3.04 sin 15 =

Horizontal velocity = 0.788 m s⁻

ResultsPlus
Examiner Comments

Finally, this example of an a(ii) response shows an alternative way of solving the problem, which was rarely seen and was not in the mark scheme, but shows that we are ready to give full credit for correct physics.

This candidate has measured the angle to the vertical of the path of the ball at the bounce. Then using the vertical velocity of the ball, $v_y = gt = 2.94$ m s^{-1} (calculated in part ai) found the actual velocity and hence the horizontal velocity which is the answer required. There is now no need for a scale. Unfortunately, this candidate measured 15°, whereas the angle should be 11° and so the answer is incorrect.

Question 17 (b)

This question is about what happens at the bounce, because it asks about the positions of the ball "a short time" before and after the bounce. Many candidates mistakenly thought it referred to the height of the bounce decreasing, and so discussed the transfer of gravitational potential energy. The candidates were expected to say:

- During the bounce, energy is transferred to thermal energy.
- Therefore the velocity after the bounce is less than before.

However, while many made the first point, few made the second. It was common to see energy being transferred to sound, which, while true, is very minor compared to the thermal energy. Many discussed friction, which was not given credit as this question is not about what happens as the ball is falling. Many were content with the simple statement that "energy is lost", gaining no credit – we want to know where the energy is transferred. "Lost to the surroundings" was also considered too vague.

The response below gained the full 2 marks.

(b) The vertical position of the ball a short time before a bounce was always higher than the vertical position the same time after a bounce.

Explain the difference in height of the ball before and after each bounce.

(2)

When ball bounces, energy ~~to~~ dissipates as heat ~~out~~ therefore some energy is lost, so the ball will bounce up with less speed as it has less energy so it will reach a lower ~~height~~ ~~height~~ hight at the ~~same~~ same time

ResultsPlus
Examiner Comments

The candidate has said that at the bounce, energy dissipates as heat. "Dissipates" is fine here for transfers, and for this question we allowed "heat" for thermal energy. "Energy lost" is also explained.

The candidate then says the speed is less and explains why that affects the height.

This candidate clearly understands the physics involved in the bounce.

ResultsPlus
Examiner Tip

Be careful in choosing the correct words to use.

Some energy ~~to~~ is transferred to the ground when it touches the ground.

ResultsPlus
Examiner Comments

This response scored zero marks. The response is vague. It does not tell us the form of the energy transferred to the ground, nor does it attempt to explain why that affects the height.

Some energy is lost due to friction (work done against friction)
Air resistance acting on the ball.

ResultsPlus
Examiner Comments

This very common form of response is probably drawing on previous questions about falling objects, or objects moving through the air. Because the question is about the height just before and just after the bounce, the effect of air resistance is very small.

ResultsPlus
Examiner Tip

"Air resistance" is often a correct answer to a question, but not always.

Question 17 (c)

For (c) (i) we expected the four positions of the ball to be in a single vertical line, and at the same height as the balls in the picture. They could be drawn to one side of the four balls on the question paper. On the whole, candidates obtained the 2 marks available for this part, the main problem being careless drawing.

For part (c) (ii) the two points below had to be explained.

- There is no horizontal displacement, or the fall is vertical, because there is no horizontal velocity.
- The vertical positions are the same because they have the same vertical acceleration.

The first point was much more commonly made than the second, as the candidates rarely linked the vertical positions to having the same acceleration.

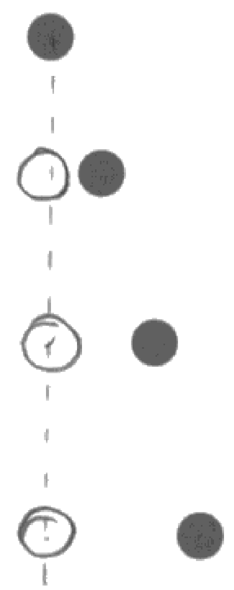
This response gained all the marks in both parts of the question.

(c) The ball was released with a small horizontal velocity.

(i) The position of the ball in the first 4 images is shown below.

Draw in the first 4 positions of the ball had it been released with no horizontal velocity.

(2)



(ii) Explain why you have drawn the ball in these positions.

(2)

As the ball has no horizontal velocity it would not have any horizontal displacement. The vertical heights at each ~~image are~~ consequetive ~~image~~ position is the same as both situations have the same vertical acceleration.

ResultsPlus
Examiner Comments

The candidate has drawn the ball positions clearly in a vertical line, and at the same height as those on the question paper. It is perfectly in order to draw in construction lines where that would help, as here in the vertical direction.

The two marking points required for part (ii) are clearly made.

ResultsPlus
Examiner Tip

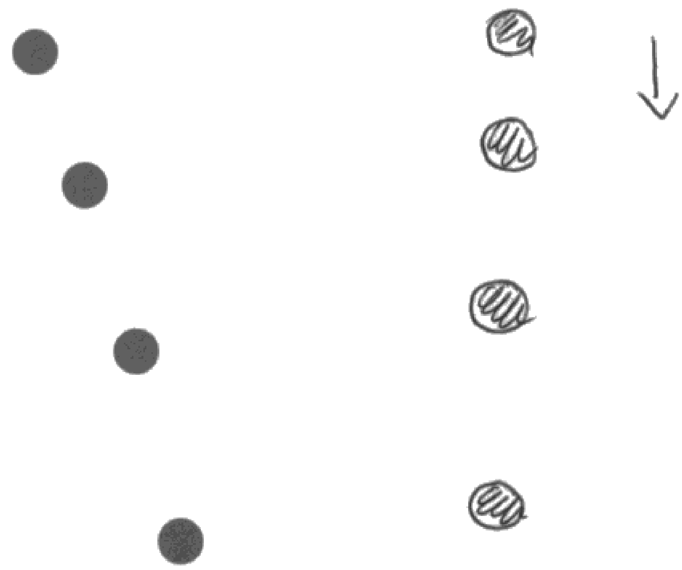
Construction lines can help.

(c) The ball was released with a small horizontal velocity.

(i) The position of the ball in the first 4 images is shown below.

Draw in the first 4 positions of the ball had it been released with no horizontal velocity.

(2)



(ii) Explain why you have drawn the ball in these positions.

(2)

I drew it in This position as the only component acting is The vertical velocity so it would fall straight down since There is no horizontal direction

ResultsPlus
Examiner Comments

The drawing here for part (i) is careless, with the ball positions only just being acceptable as vertically above each other, and clearly not drawn at the same height.

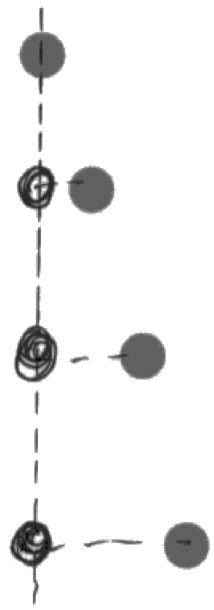
For part (ii) the response might just gain the first marking point, but the wording is very unclear. What does the candidate mean by "there is no horizontal direction"? The probable meaning is no horizontal displacement, but that is not clear.

(c) The ball was released with a small horizontal velocity.

(i) The position of the ball in the first 4 images is shown below.

Draw in the first 4 positions of the ball had it been released with no horizontal velocity.

(2)



(ii) Explain why you have drawn the ball in these positions.

(2)

Because no horizontal velocity, due to Newton's first law, the ball will move at constant speed.

ResultsPlus
Examiner Comments

This was a good response for part (i) but the candidate is very confused in part (ii). A simple re-reading of the response would probably spot the error.

ResultsPlus
Examiner Tip

Read through the response you have given.

Question 18 (a)

The whole question concerns a rower in a racing boat. The situation will have been familiar to the candidates, and so the context should be readily understood. However, it is unlikely that they will have studied the physics of rowing a boat, which is actually quite complex, and so they are being tested here on their ability to apply the physics they know to this context.

Part (a) concerns the application of Newton's laws of motion. The candidates need to know the statements of the three laws, although actual statements are not required here and no credit is given for the statement alone. The laws must be applied to the forces acting as the boat begins to move. This was a question where candidates demonstrated that they could define Newton's laws but could not apply them to the situation described in the question. The marks were for:

- The fact that the oar exerts a force on the water. Many said incorrectly that the rower exerted the force on the water. Although the rower might be where the force originates, the driving force is between the oar and the water.
- By Newton 3, the water exerts a force in the opposite direction. Many candidates went into detail about body A and body B etc, but did not relate that to the boat. Although the force is also equal, we did not look for that in this case. For the first mark, we were clear the force had to be between the oar and the water, but for this mark we accepted other objects, such as the force of the water on the boat.
- This produced a resultant force. Many here stated an external force, which lost the mark. There is some confusion between "resultant" and "external" as they both appear in different laws, but their meaning is quite different.
- By Newton 1 or 2, there is an acceleration. Many candidates forgot to relate the acceleration to Newton's laws.

The first two examples here show good responses that earned all 4 marks.

*(a) At the start of the race the boat is stationary.

Using Newton's laws of motion, explain why the boat begins to move through the water as the rower applies a force.

(4)

at the start the boat is stationary because there is no resultant force acting on the boat so according to newtons first law of motion. It will remain stationary. when the rower applied the force on the ~~fea~~ oar. The oar applies a force on the water. According to newtons third law a ~~for~~ the water will apply a same type and magnitude of force on the oar but in opposite direction. There will be a resultant force on the boat in the difection of travel. So according to newtons second law the boat will accelerate in the direction the resultant force acts.

ResultsPlus
Examiner Comments

The first three lines of this response are unnecessary, as the question did not ask why the boat remained stationary initially. However, the four marking points described above are clearly there, with extra detail included which mighthave been required on another marking scheme.

ResultsPlus
Examiner Tip

Try to avoid unnecessary statements, but give as much detail as you can.

~~Rowes~~ Oar exerts a force on the water.
Wate exerst equal and opposite force on the oar (Newton's 3rd law)
There is a net force on the oar so according to Newton's 1st low if there is a net force it will aeeeleate

ResultsPlus
Examiner Comments

This good response gives the same four points but in a very succinct fashion. The response is clear and to the point. "Net force" is accepted for "resultant force".

The following responses were awarded less than the full 4 marks.

Due to Newton's first law, the object will ~~remain~~ not move or move in a constant speed when there is no resultant force acts on it.
Due to Newton's third law, when object A exerts a force on object ~~be~~ B, object B will also acts a same magnitude ~~ab~~ and opposite force on A.
When the rower applies a force, there is a resultant force acts on the boat and it creates an acceleration, ~~so the boat~~ because the water also exerts a force on the boat. So the boat starts to move when there is an unbalanced force acts on it and starts to have an acceleration.

ResultsPlus
Examiner Comments

In this response, the first half consists of statements of Newton's laws, which gain no credit as they are not applied to the context in question. There are two general statements about "objects". When the candidate gets to the actual context, the laws stated are not actually applied, so this response gains very little credit.

ResultsPlus
Examiner Tip

If the question asks for Newton's laws to be stated, then do so, but understand that using the laws is not the same thing.

Due to Newton's third law, when ~~wat~~ rower applies a force to water, water will give a same size force to boat in the opposite direction. Due to Newton's second Law, as there's a resultant force applies on the boat, F=ma, the boat begins to accelerate, so it begins to move.

ResultsPlus
Examiner Comments

This response gained 3 marks. The candidate makes the very common mistake of saying that the rower applies the force to the water.

Newton's first law states that an object at rest will ~~rema~~ continue in the state of rest unless and until an exernal force is applied to it. ~~We~~ At first the boat was stationary or at rest. But as the rower applies a force, which is ~~a~~ the external force stated in newton's first law, the boat begins to move.

ResultsPlus
Examiner Comments

This response is an example of the use of the idea of an "external force". There are lots of external forces acting on the boat, but the motion depends on whether they add up to zero, or give a resultant.

Question 18 (b)

This question gave a graph of the force on the boat plotted against time for a single stroke of the oars. It then asked the candidate to calculate first the work done on the boat, and then the average power developed.

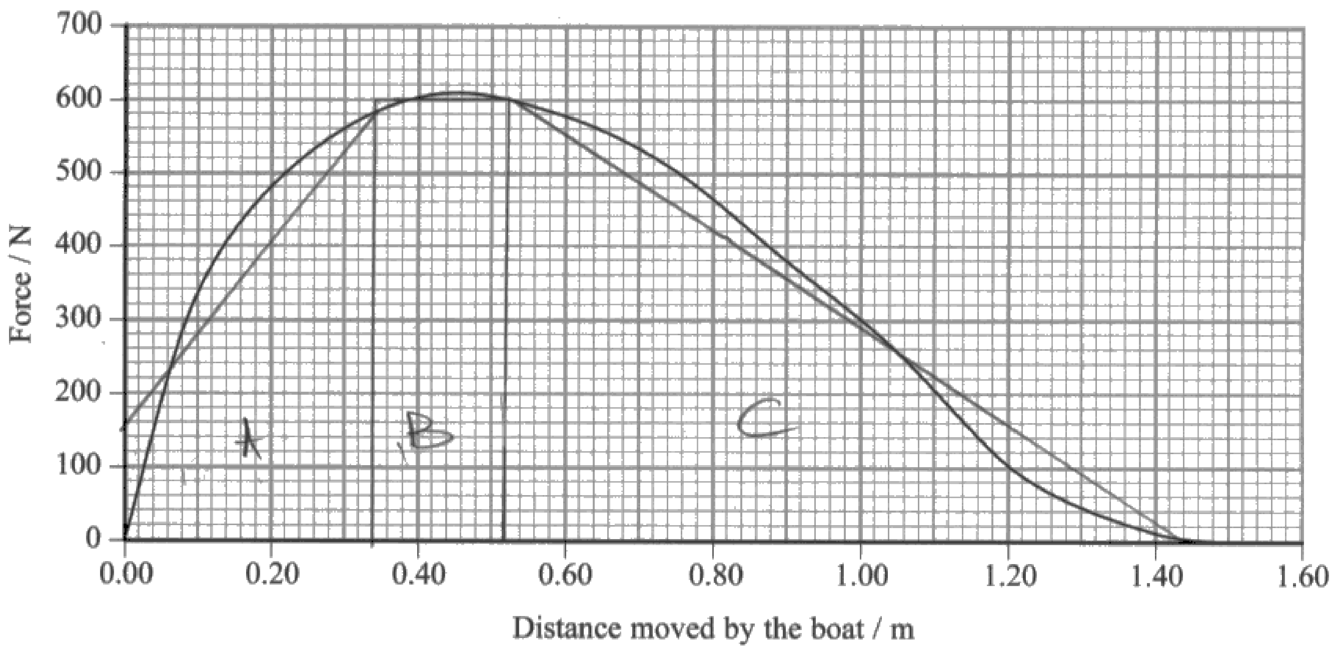
18 (b) (i)

Part (i) involved calculating the work done during a single stroke of the oars. The marks were for:

- Understanding that the work done is the area under the graph.
- Calculating the work done with a wide tolerance.
- Accurately calculating the work done.

The vast majority of candidates realised that the area under the graph had to be calculated, and they demonstrated a number of ways of doing that, from drawing on one large triangle, to counting all the small squares. The latter would be more likely to score the third mark for accuracy.

(b) The graph shows how the force applied to the boat varies with the distance moved by the boat during one complete stroke.



(i) Use the graph to show that the work done on the boat during one stroke is about 500 J.

(3)

Work done = area under the graph.

area of ⏢ A = $\frac{1}{2}(b+a)h = \frac{1}{2}(150+600)\times 0{\cdot}34 = 127{\cdot}5$ Nm

area of □ B = $l \times b = (0{\cdot}52 - 0{\cdot}34)\times 600 = 108$ Nm

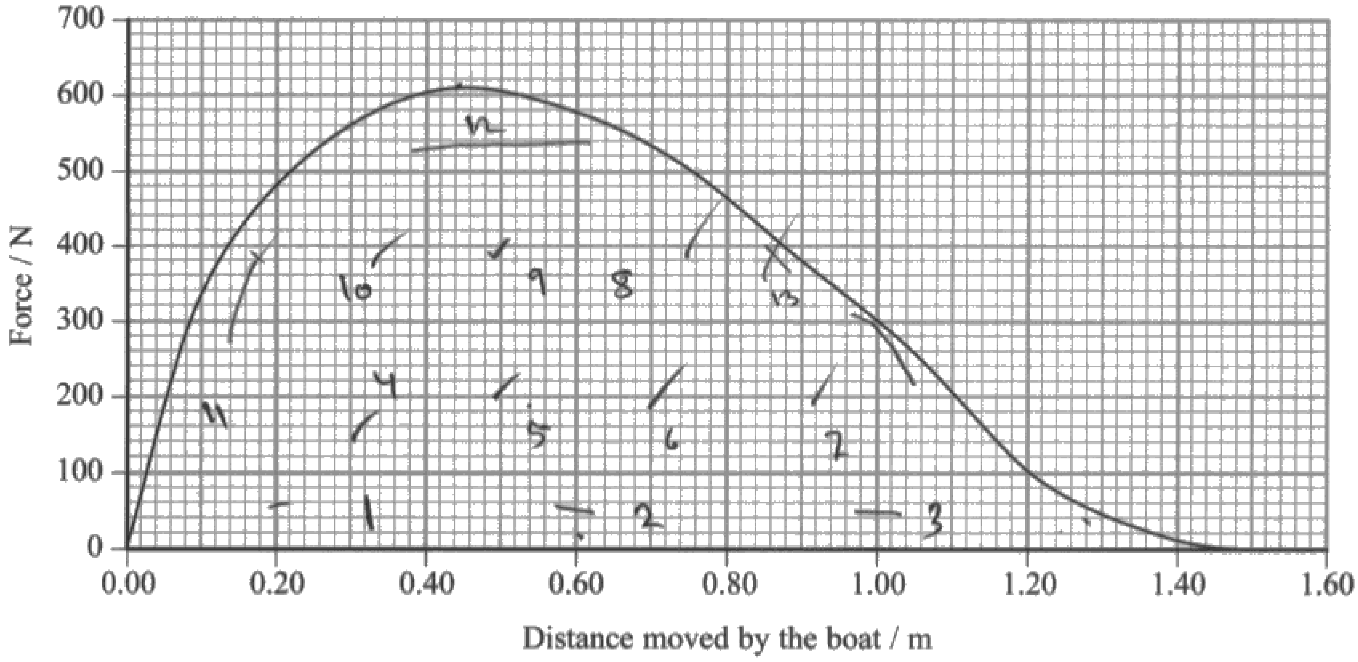
area of △ C = $\frac{b \times h}{2} = 600 \times \frac{(1{\cdot}44 - 0{\cdot}52)}{2} = 276$ Nm

total work done = $108 + 276 + 127{\cdot}5 = 512$ J

ResultsPlus
Examiner Comments

This candidate has divided the area into three sections and correctly calculated the area of each one. The answer is very close to the correct answer of 520 J. This type of method is much quicker than counting all the squares, and is probably less likely to lead to errors in the counting.

(b) The graph shows how the force applied to the boat varies with the distance moved by the boat during one complete stroke.



(i) Use the graph to show that the work done on the boat during one stroke is about 500 J.
(3)

No. of boxes = 13

∴ (area of 1 box) = 200 × 0.2 = 40

∴ 40 × 13 = 520 J

ResultsPlus
Examiner Comments

This candidate has counted the number of squares and multiplied by the work represented by each square. Again, the answer is very close to the true value.

18 (b) (ii)

The candidates now had to calculate the average power, either using the work done as calculated in part (i) or using the "show that" value (500 J) given in part (i). They had to:

- Indicate that power is work / time
- Calculate the time for one stroke
- Calculate the power.

The majority of the mistakes were in dealing with the 24 strokes per minute. They could either divide the work done by the time per stroke, or multiply by the frequency, but often they mixed these incorrectly.

(ii) Hence calculate the average power developed.

average stroke rate = 24 strokes per minute

(3)

Power = $\frac{\text{work done}}{\text{time}}$. $\frac{480 \times 24}{60}$

Average power = 192 W

ResultsPlus
Examiner Comments

This is a fully correct response, using the value of work done calculated in part (i). The candidate has multiplied the work done by the number of strokes to give the work done per minute, and then divided by 60 to give the power.

$P = \frac{W}{t} = \frac{530}{0.4} = 1325$ W

$\frac{24}{60} = 0.4$

Average power = 1325 W

ResultsPlus
Examiner Comments

This response is an example of the confusion between the stroke time and the stroke rate. This candidate has calculated the stroke rate (0.4 per second), but then divided the work done by that value assuming it was the time.

Question 18 (c)

The candidates were asked to explain why the work done by the rower was greater than the gain in kinetic energy by the rower and boat together. The question was relatively poorly answered. Discussion of the variation of the force, and the exhausted state of the rower were common. Again, many were content to just mention energy loss, which was insufficient for a mark. Many did mention friction with the water, but few described the kinetic energy given to the water. For the two marks they were expected to mention:

- The friction with the water
- The turbulence or kinetic energy of the water.

It is, of course, the drag with the water that causes the turbulence, but we did not mind whether they discussed the turbulence caused by the movement of the boat, or that caused by the movement of the oars.

(c) The work done by the rower is greater than the kinetic energy gained by the rower and the boat.

Suggest **two** reasons why.

(2)

This is because not all K.E. is transferred to the boat. There is (drag) friction between the boat and water. Also some energy is lost as water's K.E (water is also moving)

ResultsPlus

Examiner Comments

This good response gained both marks. The candidate notes the friction with the water, and also that some of the energy is transferred to kinetic energy of the water.

(c) The work done by the rower is greater than the kinetic energy gained by the rower and the boat.

Suggest **two** reasons why.

(2)

This is because not all K.E. is transferred to the boat. There is (drag) friction between the boat and water. Also some ~~er~~ energy is lost as water's K.E (water is also moving)

ResultsPlus

Examiner Comments

This response gains the mark for work done against friction. However, it is a very common response in all questions of this kind, to respond with a statement such as "some energy is lost to the surroundings", sometimes including "as thermal energy" as here. It is only rarely that such a response gets credit because at this level we need the candidate to demonstrate a greater understanding of how that happens.

ResultsPlus

Examiner Tip

Beware of the trivial response "energy is lost to the surroundings".

Some of the energy is lost as friction between ~~[illegible]~~ boat and water.
Some of the energy is lost as kinetic energy in water as waves are formed.

ResultsPlus

Examiner Comments

This response is an example of careless wording making it difficult to award marks. Energy should not be said to be lost, as it is always transferred somewhere. However, we might allow the word to be used if the meaning is clear and it is not the most important point we are looking for. In this response, the energy cannot be "lost" as friction, rather it is the friction that causes the transfer of the energy.

The kinetic energy in the waves formed by the boat is a good point, and would score the mark.

ResultsPlus

Examiner Tip

Take care with the wording of the response.

Question 18 (d)

The candidate was asked to suggest why the rower and the boat would gain different kinetic energies. The answer was very straightforward, but it was surprising how few candidates gave the answer that the masses of the rower and boat were different. There were suggestions that the forces on the rower and the boat were different, that there was more energy loss from one than the other, even that the rower became exhausted. Few seemed to grasp the fact that the rower and the boat must be travelling at the same speed.

(d) Suggest why the rower and the boat gain different amounts of kinetic energy during each stroke.

(1)

· The rower and the boat have different masses.

ResultsPlus
Examiner Comments

This response gives the basic fact we were looking for.

ResultsPlus
Examiner Tip

There is only 1 mark available, so the answer is going to be very simple.

(d) Suggest why the rower and the boat gain different amounts of kinetic energy during each stroke.

(1)

Because the kinetic energy ~~is depen~~ is equat with $\frac{1}{2}$·mass· velocity^2. So, the rower and boat have different mass, but same velocity. As a result, the kinetic energy is different.

(Total for Question 18 = 13 marks)

ResultsPlus
Examiner Comments

This response also gets the mark, but gives a more detailed explanation, showing the physics behind the statement in the previous example.

(d) Suggest why the rower and the boat gain different amounts of kinetic energy during each stroke.

(1)

Some of the energy was wasted in the form of heat and sound

ResultsPlus
Examiner Comments

This response shows the common fall-back response from a weaker candidate who has not really understood the physics.

ResultsPlus
Examiner Tip

Note that this response does not explain the question anyway.

(d) Suggest why the rower and the boat gain different amounts of kinetic energy during each stroke.

(1)

The rower may become tired over time causing a decrease in KE ~~p~~ during each stroke.

ResultsPlus
Examiner Comments

Another rather confused, but typical response.

Question 19 (a)

For part (i), the candidates had to state the meaning of laminar flow. Part (ii) asked for the conditions required for laminar flow. Although most obtained the single mark for part (i), the majority also attempted to describe laminar flow when answering part (ii), instead of giving the conditions required (see some examples below). The conditions expected for part (ii) were any two from:

- A small object
- A smooth surface
- A low velocity.

19 Stokes' law can be used to calculate the resistive force F acting on an object as it moves through a fluid.

The equation for Stokes' law is

$$F = 6\pi\eta rv$$

(a) Stokes' law is only valid if the flow around the object is laminar.

(i) State what is meant by laminar flow.

(1)

~~Laminar flow is when for at any point of~~

Laminar flow is when the velocity of the fluid at any point is constant.

(ii) State the conditions required for the flow around the object to be laminar.

(2)

- moves with a slow velocity

- The object has to have a smooth round surface.

ResultsPlus

Examiner Comments

This is an example of a good response that gains the mark for part (i) and gives two correct conditions for part (ii).

19 Stokes' law can be used to calculate the resistive force F acting on an object as it moves through a fluid.

The equation for Stokes' law is

$$F = 6\pi\eta rv$$

(a) Stokes' law is only valid if the flow around the object is laminar.

(i) State what is meant by laminar flow.

(1)

Laminar flow : Fluid flow ~~is~~ in layers. There's no sudden change of direction or speed of the flow. The velocity at a given point doesn't change. There are no eddies.

(ii) State the conditions required for the flow around the object to be laminar.

(2)

The flow is laminar so the condition of air is similar and not chaotic. The drag ~~and upthrust~~ doesn't change. ~~If~~ the turbulent flow may gives extra force to stop the object ~~fall~~ moving. Hence the result won't be accurate.

ResultsPlus
Examiner Comments

For part (i) this candidate has given four correct descriptions of laminar flow, any one of which would gain the mark. The response in part (ii) however, gains no marks.

ResultsPlus
Examiner Tip

It is fine to give the four possible responses in part (i) as long as they are all correct. However, if one were incorrect, then it would be considered to be giving the examiner a choice, and so would not gain the mark.

19 Stokes' law can be used to calculate the resistive force F acting on an object as it moves through a fluid.

The equation for Stokes' law is

$$F = 6\pi\eta rv$$

(a) Stokes' law is only valid if the flow around the object is laminar.

(i) State what is meant by laminar flow.

(1)

Fluid flow in each layer with no abrupt change in velocity.

(ii) State the conditions required for the flow around the object to be laminar.

(2)

There are no random change in velocity ~~&~~ of the flow.
The flow should have higher viscosity.
Have no eddies.

ResultsPlus
Examiner Comments

Part (i) gains the mark, but part (ii) is more about what laminar flow is than the conditions required, so no marks.

19 Stokes' law can be used to calculate the resistive force F acting on an object as it moves through a fluid.

The equation for Stokes' law is

$$F = 6\pi\eta rv$$

(a) Stokes' law is only valid if the flow around the object is laminar.

(i) State what is meant by laminar flow.

(1)

Streamlines / parallel flow lines

Steady flow with no eddies / obstruction.

(ii) State the conditions required for the flow around the object to be laminar.

(2)

flow lines should be parallel / streamlines

with no eddies.

ResultsPlus
Examiner Comments

Another typical response. It gains the mark for part (i) but part (ii) again describes what laminar flow is, so no mark.

ResultsPlus
Examiner Tip

Most candidates did not answer the question set in part (ii). Think just what the question is asking.

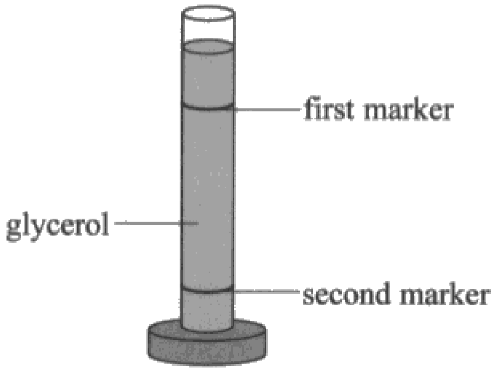
Question 19 (b) (i)

The two other quantities that need to be measured are:

- The distance between the markers on the measuring cylinder.
- The diameter of the ball bearing.

The candidate needs to think in terms of the experiment given, read the description carefully and actually imagine carrying it out. Instead of the distance between the markers, many candidates wrote the height of the measuring cylinder. Instead of the diameter of the ball bearing, many wrote the radius, thinking that the radius could be measured directly. Many suggested that the time of fall could be measured, even though that had been stated in the question as already noted. Sometimes all the quantities in the equation were listed. Note that a statement of the two quantities is all that is required.

(b) A student carried out an experiment to determine the viscosity of glycerol using the apparatus shown.



A ball bearing was released at the top of a measuring cylinder containing glycerol.
A stopwatch was used to measure the time taken to fall between the markers.
This was repeated for ball bearings of different sizes.

The following equation was used to calculate the viscosity η.

$$\frac{4\pi r^3}{3}\rho_b g - \frac{4\pi r^3}{3}\rho_g g = 6\pi r \eta v$$

r = radius of ball bearing
ρ_b = density of ball bearing
ρ_g = density of glycerol
v = terminal velocity

(i) The density of the glycerol and the ball bearing are known.

State **two** other quantities the student would have to measure directly to calculate the viscosity.

(2)

• the diameter of the ball

• the distance between the two markers.

ResultsPlus

Examiner Comments

These two statements are all that are needed to gain the two marks. The response is absolutely clear and straight to the point.

(2)

measure the ~~xx~~ diameter of the ball bearings and obtain the radius
measure the distance between markers and use the time measured to
obtain the velocity.

ResultsPlus
Examiner Comments

This response also gives the two correct answers but also goes on to explain how they are used. To do this is fine as long as the candidate has the time.

(2)

the time taken for the ball bearing to
fall and the distance through which it falls.
and the radius of the ball.

ResultsPlus
Examiner Comments

This candidate gives three possible answers, all of which are incorrect.

The time taken is a quantity already given in the question, so is not an "other quantity".

The distance through which the ball falls is imprecise – it must be between the markers.

The radius cannot be measured directly, and the question asks for quantities that have to be measured.

ResultsPlus
Examiner Tip

Be precise in your answers.

Question 19 (b) (ii)

The question asks what is represented by the first term on the left hand side of the equation. The candidate can either understand that there are the three forces acting on the ball bearing, the weight, upthrust and drag, and note which is which in the full equation, or just work through the term given, as volume × density × *g*. Although most candidates answered this part correctly, there were still a number of errors, giving answers such as volume of the ball or mass of the ball.

(ii) State the quantity that is represented by the term $\frac{4\pi r^3}{3}\rho_b g$.

(1)

It's the weight of the ball bearing

ResultsPlus
Examiner Comments

This response is the straightforward answer we expected.

(ii) State the quantity that is represented by the term $\frac{4\pi r^3}{3}\rho_b g$.

(1)

Upthrust on ball bearing.

ResultsPlus
Examiner Comments

This candidate has confused the density of the ball bearing with the density of the glycerol, an occurrence that was more common in part (iii).

(ii) State the quantity that is represented by the term $\frac{4\pi r^3}{3}\rho_b g$.

(1)

Weight

ResultsPlus
Examiner Comments

This occasional response did not gain the mark because there are too many possible weights. It could be the weight of the glycerol or the weight of the liquid displaced, as well as the weight of the ball. The examiner cannot tell whether the candidate knows which weight it is.

ResultsPlus
Examiner Tip

Ensure your answer is complete and unambiguous.

Question 19 (b) (iii)

The candidate is asked what the second term in the equation represents. There are two possible answers:

- The upthrust on the ball bearing.
- The weight of the glycerol displaced.

Either of these was allowed for the mark.

(iii) State the quantity that is represented by the term $\frac{4\pi r^3}{3}\rho_g g$.

(1)

It is the weight of the glycerol displaced which is the upthrust.

ResultsPlus
Examiner Comments

This very good response gives both the possible answers, although the mark would be gained for either of them.

It represents the weight of the glycerol

ResultsPlus
Examiner Comments

This is an example of an incomplete response because the candidate could mean it is the weight of all the glycerol. If the candidate responds with the weight of glycerol, it must be clear that it is the displaced glycerol.

ResultsPlus
Examiner Tip

Again, ensure your answer is full and unambiguous.

Question 19 (b) (iv)

The candidates were asked to describe how to use the results obtained in the experiment to determine the viscosity of glycerol, by means of a graphical method. It must be noted that the "results obtained", as given in the question, are the time taken to fall between the markers and the different sizes of the ball bearings. A very wide range of marks was obtained, many scoring zero and others the full 4 marks, with all the values in between. Most candidates understood the need to obtain a straight line graph, and were able to do so, although in many cases, the plotted variables were complex. A lot of marks were lost because key instructions were missing, such as "measure the gradient". The 4 marks were awarded as follows:

- Calculate the velocity of the ball bearing. Many missed this point, assuming that it had already been done.
- Plot the velocity against $(\text{radius})^2$. Many suggested far more complex axes – see some examples below. Complex axes did not score this mark.
- Determine the gradient. This had to be stated and not just implied, as it is an essential part of the procedure.
- State how to calculate the viscosity from the gradient.

A wide range of approaches was seen, but unfortunately some failed to realise that plotting v against r would result in a curved graph. Any graph that would be a curve could not score any of the 3 graph marks. Many students were aware of the need to calculate the terminal velocity, but went into great depth about it, some suggesting that a distance-time graph could be plotted to do so. It was very common for highly complex axes to be plotted, such as weight of ball minus the upthrust against $6\pi r$, giving a gradient of viscosity. Such responses were denied the plot mark but could score the other three.

(iv) Describe how the results obtained and a graphical method can be used to determine a value for the viscosity of the glycerol.

(4)

~~ß~~ The velocity will be calculated by ~~firs~~

~~ß~~ dividing the distance between the markers and the time between them ~~with~~ the radius is then calculated using a micrometer

velocity against (radius)² graph will be plot

The gradient will then be calculated

the viscosity is calculated by using

$$\text{gradient} = \frac{2g(\rho_s - \rho_g)}{9\eta}$$

$$\eta = \frac{2g(\rho_s - \rho_g)}{9\,\text{gradient}}$$

ResultsPlus

Examiner Comments

This is an ideal response, scoring all 4 marks. The candidate calculates the velocity, states the correct axes, states that the gradient is calculated, and gives the equation to find the viscosity from the gradient. This candidate has thought through the method before writing it down, so that the response is clear and direct.

ResultsPlus

Examiner Tip

When writing out an experimental method, make sure each step is clearly noted.

(iv) Describe how the results obtained and a graphical method can be used to determine a value for the viscosity of the glycerol.

(4)

$$\frac{4}{3}\pi r^2 \rho_b g - \frac{4}{3}\pi r^2 \rho_g g = 6\pi r \eta v$$

$$\frac{4}{3} r^2 g(\rho_b - \rho_g) = 6\eta v$$

$$v = \frac{2r^2 g(\rho_b - \rho_g)}{9\eta}$$

$$v = \left(\frac{2g(\rho_b - \rho_g)}{9\eta}\right) r^2$$

$$y = mx$$

taking terminal velocity as y and radius^2 as x plot a graph of V against r^2 which will be a straight line through origin Calculate the gradient which is equal to $\frac{2}{9\eta} g(\rho_b - \rho_g)$ as you know ρ_b and ρ_g you can calculate η which is the viscosity of glycerol

ResultsPlus
Examiner Comments

This response scores 3 marks, another good answer. The candidate this time shows clearly how the equation has been rearranged to give the variables to be plotted. However, there is no statement that the velocity has to be calculated first, so only scores 3 marks.

(iv) Describe how the results obtained and a graphical method can be used to determine a value for the viscosity of the glycerol.

(4)

velocity is found by = distance / time

radius found using metre rule

to find viscosity plot a graph of (weight of ball – weight of liquid displaced) on y axis and 6πrv on the x axis, the gradient of graph is viscosity

ResultsPlus

Examiner Comments

This response scored 2 marks, for calculating the velocity, and for stating how to determine the viscosity from the gradient. The axes chosen will give a straight line graph, but are complex and require a lot of calculation for each point. The plot mark was therefore not given. Unfortunately, the candidate did not tell us to measure the gradient.

ResultsPlus

Examiner Tip

Make sure each step of the method is clearly given.

(iv) Describe how the results obtained and a graphical method can be used to determine a value for the viscosity of the glycerol.

(4)

~~The~~ $F = \frac{4\pi r^3}{3} \rho_b g - \frac{4\pi r^3}{3} \rho_g g$

The force can be calculde ~~by cal~~ by using the above formula, and the ball could be dropped at different height between the first and second marker, and the velocity could have been calculated, by dividing the height by the time it take to fall through that heigh.

A graph of F against the terminal velocity could be plotted.

$F = 6\pi r \eta v$

$y = m . x$

The gradient of the graph = $6\pi r \eta$, and by diving the measured diameter of the ball by two the radius ~~of~~ can be found.

$\therefore \eta = \frac{m(\text{gradient})}{6\pi r}$

ResultsPlus Examiner Comments

This response scores a single mark only for calculating the velocity. At first sight, the axes chosen look satisfactory, if complex, but when it comes to the gradient it is clear that the value includes the variable *r* and so these axes would not give a straight line. It is therefore not possible to determine a gradient and none of the 3 graph marks can be scored. Had the X-axis been *rv* then more credit could have been given.

ResultsPlus Examiner Tip

Beware of gradients including a variable when looking for a straight line.

Question 19 (c)

The candidates were asked to explain how a low temperature would affect the supply of glycerol to a waste system. The 2 marks were awarded for:

- The viscosity is high at low temperature.
- The flow rate is reduces.

Note that this is about the flow of glycerol, not of the waste water or of the nitrogen, both of which are mentioned in the question. A few thought that the viscosity dropped as temperature fell, but the great majority scored the first point. Many did not score the second point because they discussed the effect on the waste water or the nitrogen removal.

(c) Glycerol can be pumped into waste systems to remove nitrogen during the treatment of waste water.

Explain the effect that low temperatures could have on the supply of glycerol to a waste system.

(2)

At low temperature the viscosity of the glycerol will be higher. This will reduce the rate of flow of glycerol.

ResultsPlus
Examiner Comments

This response scored both of the 2 marks. It is a clear and succinct answer.

(2)

1) viscosity of glycerol will ~~___~~ be greater
2) The flow rate of waste water will be smaller, as the flow rate of a fluid is inversely proportional to the viscosity. 3) Nitrogen will be removed.

ResultsPlus
Examiner Comments

This response scored 1 mark, for the viscosity being greater. However, the candidate then goes on to discuss the waste water and the nitrogen, as was done by many others also.

ResultsPlus
Examiner Tip

The question is about the supply of glycerol. Make sure that is the question you respond to.

(2)

It is going to take a very long time as the viscosity of glycerol will be thicker and will flow slower

ResultsPlus
Examiner Comments

This response scored 1 mark, for the slower flow of glycerol. "Thicker" is not a good scientific description of the viscosity, and it does not indicate whether the viscosity is higher or lower.

Paper Summary

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

- A number of times on this paper, some candidates tended not to answer the question as it was set. Read the question carefully, so that you are as clear as possible about what is required.
- When responding to a question, try not to give the examiner a choice of answers. If any are wrong, you will not gain the credit.
- Be accurate when taking measurements from pictures.
- Show all working in calculations, and beware of incorrect rounding of the answer.

Grade Boundaries

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

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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