Pearson Edexcel

Examiners' Report June 2018

IAL Physics WPH01 01

ResultsPlus

https://xtremepape.rs/

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk.

Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

ResultsPlus

Giving you insight to inform next steps

ResultsPlus is Pearson's free online service giving instant and detailed analysis of your students' exam results.

- See students' scores for every exam question.
- Understand how your students' performance compares with class and national averages.
- Identify potential topics, skills and types of question where students may need to develop their learning further.

For more information on ResultsPlus, or to log in, visit www.edexcel.com/resultsplus.
Your exams officer will be able to set up your ResultsPlus account in minutes via Edexcel Online.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk.

June 2018
Publications Code WPH01_01_1806_ER

All the material in this publication is copyright
© Pearson Education Ltd 2018

https://xtremepape.rs/

Introduction

The two areas of physics covered by Unit 1 are basic mechanics and properties of matter. The unit is designed to examine the students on these subject areas in three distinct and important ways:

- testing their knowledge as described in the specification
- their understanding of the physics involved
- their ability to apply that knowledge in numerical and unfamiliar contexts.

To give a few instances from this particular paper, Question 11 is a simple test of whether they can apply Stokes' law and carry out a straightforward calculation. Question 15(b) is a much more complex calculation, involving a projectile, having a number of perfectly good but alternative ways of reaching the answer, and so part of the test involves the student having to decide on a good approach to a solution. Question 16(b), on work and forces, presents the students with a familiar situation (pushing or pulling a trolley), but requires them to analyse it in a way they are unlikely to have done previously. Question 19 requires them to respond to both numerical and descriptive tests about a completely unfamiliar situation. Overall, the students found analysing a familiar context in a new way the most demanding.

This year, the students did, in general, respond to the question as asked, rather than answering a slightly different question as in previous papers. The responses to numerical questions were generally good, and in most cases the physics of such questions was understood and the right equation was correctly applied. There were some instances where this was not the case, as in 19(b), where in many cases Stokes' law was used in an attempt to determine the upthrust rather than using the weight of the displaced water, but generally the correct equations were used in this exam. When responding to a question involving a calculation, it is important that the examiner is able to follow the student's reasoning since most of the marks are awarded for the methods used in the calculation. Attention to the layout of the response is therefore necessary.

Once again, there was weakness in learning the correct definitions of the properties of materials (tough, strong, malleable, brittle etc), and the students could be clearer in their use of technical terms, such as the confusion of velocity with acceleration, and accuracy with precision.

It is also important that the students note the keyword of a question. "Describe" and "Explain" do not have the same meaning; explain requires reasoning as well as a description. "Criticise" would mean something else again. It would be worth learning the meaning of the possible keywords for these questions.

The standard of written English seen by the examiners in this paper was good, and caused little difficulty in the marking of the paper. Apart from the * questions, where the candidate's quality of written communication is being assessed along with the physics, lack of skill in written English is not penalised, as long as the response is clear and unambiguous.

https://xtremepape.rs/

Section A

Question	Subject	Correct response	Most common alternative
1	Vectors and scalars	D	A and C
2	Units	C	D (the unit for Pa)
3	Properties of materials	C	
4	Calculation of acceleration	C	
5	Gravitational potential energy	B	A
6	Energy stored in a spring	D	C
7	Displacement-time graph	C	A
8	Newton's first law	C	D
9	Newton's third law	A	C
10	Hooke's law	C	

As intended, the multiple choice section scored quite highly. 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.

Question 1 was surprisingly not answered as well as expected. Probably, many students thought that weight was a scalar quantity. Since the difference between vector and scalar quantities is rather important, perhaps more emphasis needs to be placed on its teaching throughout the curriculum.

Question 5 concerned the change of gravitational potential energy as three equal mass spheres are raised, so the greatest change of GPE is for the sphere raised by the greatest distance. Many students thought P would gain the greatest amount of GPE since the centre of mass is highest, but in fact P and Q are raised by the same distance.

Question 6 concerned the work done in extending a spring. The fact that the graph is plotted as extension against force, rather than the more usual force against extension, was not noted by most students. The work done for the graph in the question is the area to the left of the line. Almost half the students decided it was the area under the line, and many assumed it was $½F_1x_1$ i.e. the equation for the energy stored in an elastic spring, ignoring the graph.

Question 7 concerned the force required to cause a given displacement time graph for a moving object. The graph clearly indicates a decelerating object, so the force must be opposite to the direction of motion. Most students opted for an increasing or decreasing resultant force, which would, of course, have caused the object to increase its velocity and hence the gradient of the graph.

https://xtremepape.rs/

Question 11

(a) This straightforward calculation using Stokes' law was generally answered well. The resultant downward force of 1.0×10^{-5} N when the stone was stationary near the surface of the lake would be equal to the drag on the stone when it reached terminal velocity. There were 2 marks for the calculation:

Mark 1 was for correctly using the Stokes' law equation given in the list of data at the back of the exam paper.

Mark 2 was for a fully correct calculation, leading to the correct speed with a unit.

A common mistake was to substitute the diameter for the radius of the stone. Occasionally, where the number substituted for the radius was the fraction "1.1/2" rather than 0.55, there were mistakes made in dealing with the factor of 2 in the subsequent calculation.

(b) The students were expected to state a condition which would ensure that the stone obeyed Stokes' law, but not an assumption that had already been given in the question. Stating that the stone was small or travelling at low speed are correct requirements for Stokes' law, but in this case we know the size of the stone, and have calculated its speed, so these are not assumptions the student had to make. A good response, made by many students, was that the stone was spherical or had a smooth surface, or that the flow of the water around the stone was laminar.

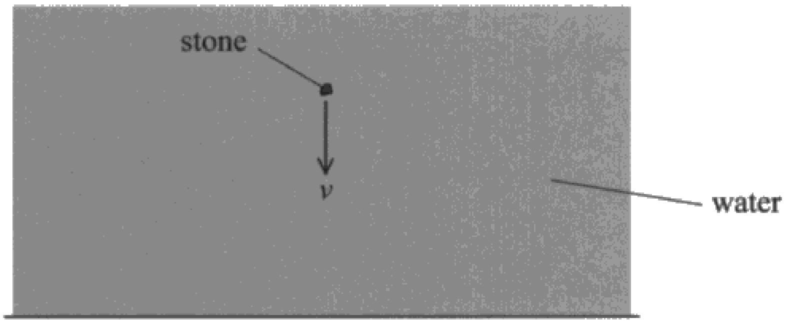
https://xtremepape.rs/

The first example below is a fully correct and well written response to both parts of the question.

SECTION B

Answer ALL questions in the spaces provided.

11 A small stone is released at the surface of a lake. Immediately after it is released the resultant downward force on the stone is 1.0×10^{-5} N. The stone initially accelerates through the water and then reaches a steady downwards speed v as shown.



(a) Calculate v.

(2)

diameter of stone = 1.1×10^{-3} m
viscosity of water = 9.0×10^{-4} Pa s

$F = 6\pi\eta rv$ $\quad 1\times10^{-5} = 6\pi \times 9\times10^{-4} \times \frac{1.1\times10^{-3}}{2} \times v$

$1\times10^{-5} = 9.33\times10^{-6}\, v$

$\frac{1\times10^{-5}}{9.33\times10^{-6}} = v = 1.07\ \text{ms}^{-1}$

$v =$ $1.07\ \text{ms}^{-1}$

(b) State **one** assumption made when calculating the answer to part (a).

(1)

The stone was perfectly spherical

(Total for Question 11 = 3 marks)

https://xtremepape.rs/

ResultsPlus
Examiner Comments

This student:

- Quotes the equation.
- Shows the equation with the values substituted.
- Does the calculation correctly.
- Quotes the answer with its unit.

ResultsPlus
Examiner Tip

You are less likely to make mistakes with a well ordered response.

This response scored 1 mark for part (a) and 1 for part (b).

(a) Calculate v.

(2)

diameter of stone = 1.1×10^{-3} m
viscosity of water = 9.0×10^{-4} Pa s

$F = 6\pi \mu r v$

$1.0 \times 10^{-5} = 6 \cdot \pi \cdot 9.0 \times 10^{-4} \cdot 1.1 \times 10^{-3} \cdot v$

$v = 0.53587...$

$v = 0.54\ ms^{-1}$

v = $0.54\ ms^{-1}$

(b) State **one** assumption made when calculating the answer to part (a).

(1)

The flow of fluid around the stone is laminar

The radius of the stone is constant.

(Total for Question 11 = 3 marks)

https://xtremepape.rs/

ResultsPlus
Examiner Comments

It was a common mistake to substitute the diameter for the radius. Diameter is often quoted because that is the quantity that would be measured, but it is usually the radius that is required for formulae.

ResultsPlus
Examiner Tip

Check whether radius or diameter is required.

(b) State **one** assumption made when calculating the answer to part (a).

(1)

assumed that upthrust is small so it is negligible.

ResultsPlus
Examiner Comments

Probably the most common mistake in 11(b) was to say either that the upthrust was negligible, or that there was no friction on the stone. The students often did not seem to realise that the calculation in part (a) used the viscous drag force, and that the upthrust was included in the resultant downward force given in the question.

This was a very common response, clearly not scoring the mark.

https://xtremepape.rs/

Question 12

This question involved a straightforward calculation concerning a boat heading across a river. However, unlike Question 11, it required a calculation of two or more stages, depending on the method chosen. The demand on the student's understanding of the physics involved was therefore higher than is the case where a single equation only is needed to achieve the solution. There were a number of possible methods that the student could use to determine the distance required:

- The time to cross the river could be calculated using the speed perpendicular to the banks, and then the speed parallel to the river would be multiplied by that time. This is the method we were expecting the students to use.

- Trigonometry could be used with the two speeds to calculate the angle at which the boat travels across the river, and then that angle, together with the width of the river would give the distance required.

- The overall speed of the boat could be determined by Pythagoras which, together with the time to cross, could lead to the distance required.

- There were other possible and correct methods also.

Those students who used the first method tended to make the fewest mistakes, and this was the most common method chosen. Where the combined speed was calculated, few managed to follow it through to the correct distance.

Sometimes slightly incorrect answers for the distance were found due to rounding of intermediate values during the calculation. The final value in any question should be rounded to an appropriate number of significant figures, but rounding of intermediate values could lead to an error in the final answer.

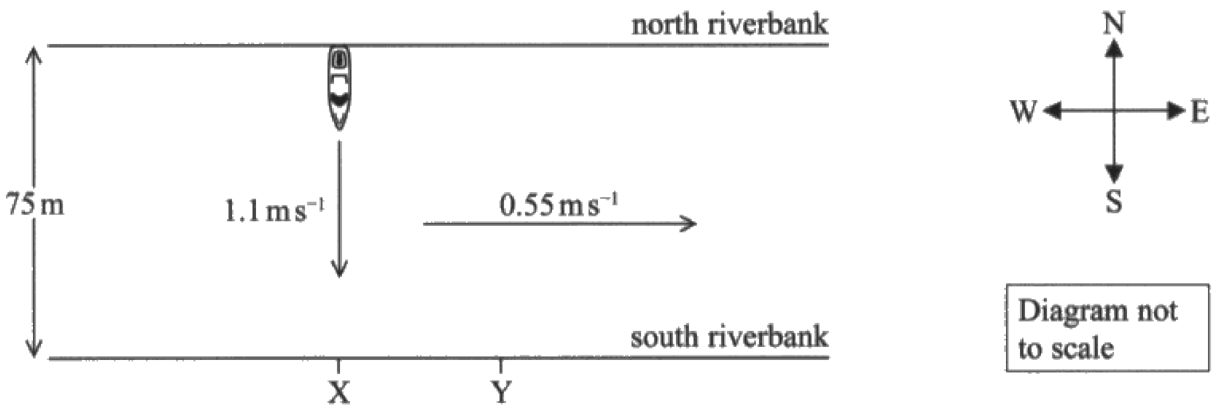
A significant number of responses treated the boat as a projectile, accelerating across the river at 9.81 m s^{-2}. That was a clear misunderstanding of the context of the question.

A few students took measurements from the diagram, even though it is clearly stated as not to scale. Others attempted to construct a scale diagram. In cases where the question asks for a scale diagram we would expect that form of response and would allow a reasonable range for the answer, but here such a method usually led to an answer outside the allowed range.

https://xtremepape.rs/

The first two examples below scored all 3 marks.

12 A boat heads across a river towards X at a speed of $1.1\,m\,s^{-1}$ as shown. The speed of the river from west to east is $0.55\,m\,s^{-1}$.



The boat reaches the south riverbank at Y.

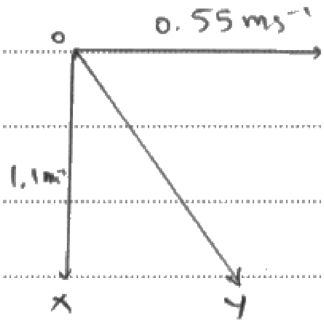
Determine the distance XY.

(3)

width of river = 75 m

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

$t = \frac{s}{v} = \frac{75}{1.1} = 68.2\ s$



$s = vt$

$= 0.55 \times 68.2$

$= 37.5\ m$

~~$XY^2 = 75^2 + 37.5^2$~~

~~$XY = 83.9\ m$~~

$XY = 37.5$

XY = 37.5 m

(Total for Question 12 = 3 marks)

https://xtremepape.rs/

ResultsPlus
Examiner Comments

This is the most straightforward method, and the student has shown the working well.

Velocities: $\arctan\left(\frac{0.55}{1.1}\right) = \theta$

$\theta = 26.6°$

Displacements: $\tan\theta = \frac{XY}{75}$

$XY = 75 \tan 26.6$

$XY = 37.5\text{ m}$

XY = 38 m

ResultsPlus
Examiner Comments

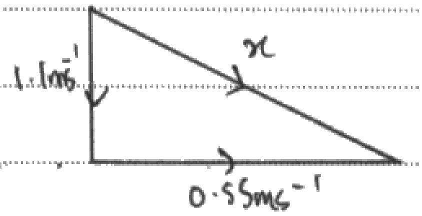
This method, using trigonometry, is also straightforward and is well explained.

This response scored 2 marks.

The method used is correct. The overall speed has been calculated, as has the time to cross. The diagonal distance is then found and Pythagoras is used to determine the distance along the river.

https://xtremepape.rs/

time taken to travel to X $= \frac{75}{1.1} = 68.181\,s$



$x^2 = 0.55^2 + 1.1^2$

$x = \sqrt{1.512}$

$= 1.22\ ms^{-1}$

distance to Y

$= 1.22 \times 68.181$

$= 83.180m$

distance between XY

$= \sqrt{83.180^2 - 75^2}$

$= \sqrt{1294.048}$

$= 35.972m$

$= 36m$ (2sf)

XY = 36m

ResultsPlus
Examiner Comments

This is a complex method involving a four step calculation, and most students who use this method do not achieve full marks. This response has all four steps correct, but has incorrectly rounded the value of x to 1.22 rather than 1.23 part way through the calculation, giving rise to an error in the final answer.

ResultsPlus
Examiner Tip

Always try to use the most straightforward method.

https://xtremepape.rs/

Question 13 (a)

The question was not answered as well as had been expected. As the ball bearing rolled across the bench towards the magnet, it would decelerate due to the frictional forces acting on it. However, as it approached the magnet, the magnetic force of attraction would increase, equalling the frictional force at 0.3s and then causing an acceleration at an increasing rate. Very few students explained the graph fully, but the mark scheme did not demand that. The marks were for:

Mark 1 for saying that the ball bearing initially decelerates and then accelerates.

Mark 2 for the explanation that the initial change occurred due to friction.

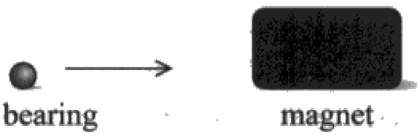
Mark 3 for the explanation that the acceleration near the magnet was due to the force from the magnet.

The first mark is for a description of what is happening, but we were expecting the technical terms decelerate and accelerate to be used, not just that the velocity is decreasing and increasing. This mark was usually achieved. The other marks are for an explanation, and it should be noted that the command word in the question is "explain", so a reason for the shape of the graph was expected. Few students gave a reason for the initial deceleration of the ball.

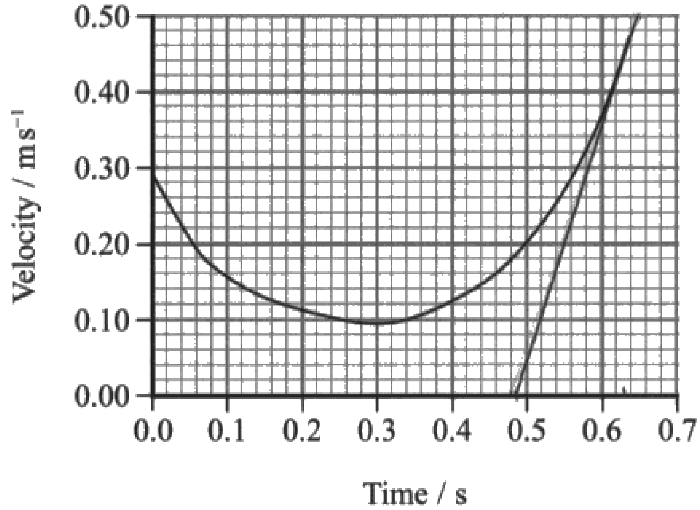
https://xtremepape.rs/

The first example below shows a response that gained all 3 marks. The others show responses that could not be given all the marks.

13 A ball bearing moves across a horizontal bench towards a magnet as shown.



The velocity-time graph for the horizontal motion of the ball bearing up to the point of contact with the magnet is shown.



(a) Explain the shape of the graph.

(3)

The ball decelerates at first, because of the friction of the ~~table~~ bench is larger than the attraction of the magnet, but after 0.3s the attraction of the magnet becomes stronger than the friction of the table, because the ball bearing is closer. Now that the resultant force is positive, using F=ma, the ball accelerates towards magnet. The rate of acceleration also increases as the resultant F increases. ~~because the resultant~~

https://xtremepape.rs/

ResultsPlus
Examiner Comments

In this excellent response, the student understands well what is happening and the underlying cause. The first mark is given for the description (decelerates then accelerates), and the other marks also for the explanations. This response goes beyond the mark scheme and also explains why the rate of acceleration increases - the curved line. On a tougher mark scheme, that might have been required.

ResultsPlus
Examiner Tip

The clarity of the expression here makes the response easy to understand.

0.07

(a) Explain the shape of the graph.

(3)

~~The~~ During the first 0.2 seconds the ball is ~~decre~~ non-uniformly decelerating. Then remain ~~so~~ steady ~~at 0.~~ between 0.2 to 0.4 seconds. Then it accelerate non-uniformly to reach the maximum ~~accelerat~~ velocity of 0.47 m/s.

ResultsPlus
Examiner Comments

This response gains the mark for describing what is happening, but there is no attempt at an explanation.

https://xtremepape.rs/

ResultsPlus
Examiner Tip

Differentiate between the keywords "describe" and "explain". If asked to explain, you need to give reasons for what is happening.

(a) Explain the shape of the graph.

(3)

At the first, the ball bearing moves across ~~the~~ a horizontal bench and the velocity decrease ~~when~~, ~~after 0.3s~~; so from 0.0s to 0.3s, the ~~graph~~ graph shows that the velocity is decreasing, after 0.3s, the ~~magnetic field of~~ the magnet attract the ball bearing which the attractive force increase ~~the~~ and the ball bearing accelerate so the velocity is increasing after 0.3s from the graph.

ResultsPlus
Examiner Comments

This response just gained the third mark.

It was a common mistake to only say that the velocity decreased, but that is just read from the graph and requires no interpretation. We did expect "decelerate" for the first mark. Students were more familiar with "accelerates" than "decelerates".

ResultsPlus
Examiner Tip

Do be prepared to use technical terms.

https://xtremepape.rs/

Question 13 (b)

For this question, it was expected that the students would draw a tangent at the far right hand end of the graph and determine its gradient. However, the majority of responses either did not have a tangent, or drew the tangent at the wrong point. It was clear that the students, overall, were unsure how to measure the gradient of a curved graph, and many just took two points on the line. The drawing of a tangent to determine the gradient of a curve should be a basic expectation for an A-level student.

Mark 1 is for either using the graph's gradient or using $\Delta v/\Delta t$. Either way, there must be no use of points on the line for a time less than 0.5s.

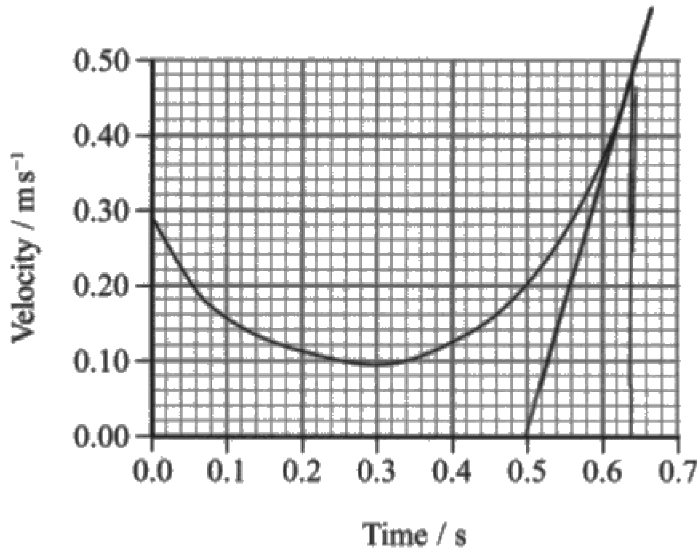
Mark 2 is for drawing the tangent at 0.64s.

Mark 3 is for an acceleration in the range 2.8 to 3.6 m s^{-2}.

The first response below shows a correct answer to the question. The other two show common mistakes.

13 A ball bearing moves across a horizontal bench towards a magnet as shown.

The velocity-time graph for the horizontal motion of the ball bearing up to the point of contact with the magnet is shown.



(b) Calculate the maximum acceleration of the ball bearing.

(3)

$\frac{0.45}{0.14} = 3.21 m s^{-2}$

Maximum acceleration = $3.21 m s^{-2}$

https://xtremepape.rs/

ResultsPlus
Examiner Comments

The tangent is drawn at the correct point on the graph, and the gradient is calculated from the triangle shown on the graph.

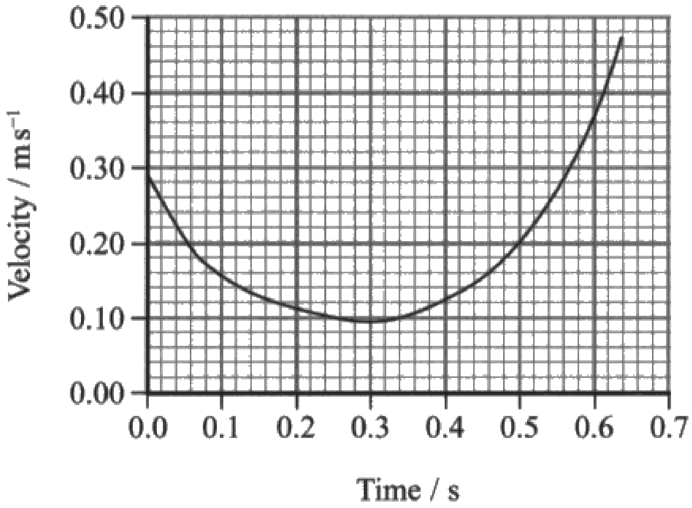
ResultsPlus
Examiner Tip

When taking readings from a graph, mark the points used on the graph as well as showing the calculation in the answer space.

https://xtremepape.rs/

13 A ball bearing moves across a horizontal bench towards a magnet as shown.

The velocity-time graph for the horizontal motion of the ball bearing up to the point of contact with the magnet is shown.



(b) Calculate the maximum acceleration of the ball bearing.

(3)

$a = \frac{v - u}{t}$

$= \frac{0.47 - 0}{0.64}$

$= 0.7343\ ms^{-2}$

Maximum acceleration = $0.7343\ ms^{-2}$

ResultsPlus
Examiner Comments

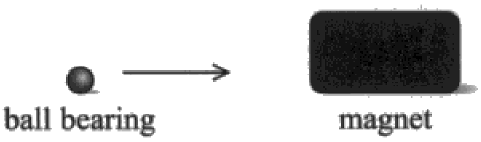
This very common response gained no marks. It just takes a point at the top end of the graph and divides the velocity by the time.

https://xtremepape.rs/

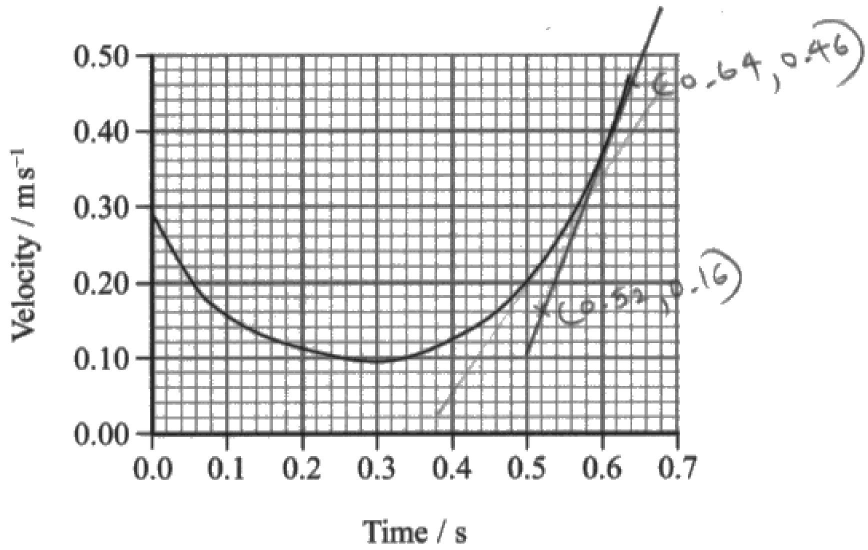
ResultsPlus
Examiner Tip

Understand how to find the gradient of a curved line.

13 A ball bearing moves across a horizontal bench towards a magnet as shown.



The velocity-time graph for the horizontal motion of the ball bearing up to the point of contact with the magnet is shown.



(b) Calculate the maximum acceleration of the ball bearing.

(3)

Gradient of graph = acceleration

$$\frac{(0.46 - 0.16)}{(0.64 - 0.52)}$$

Maximum acceleration = 2.5ms^{-2}

https://xtremepape.rs/

ResultsPlus
Examiner Comments

This response is close to being correct, but the tangent on the graph has not been drawn at the point of greatest acceleration. The curve can be seen moving away from the tangent at the top of the line. It gained the first mark only.

https://xtremepape.rs/

Question 14 (a)

We were hoping here for a statement that a tough material is one that will absorb a large amount of energy before fracturing. However, as there are other ways of describing a tough material, we also allowed:

- a material that undergoes a lot of plastic deformation before fracture.
- a material that can withstand a large impact force before fracture.

In all cases, the statement should include the mention of without breaking or without fracturing. Commonly we saw "before failure" but this might not involve an actual fracture and so it was not allowed. For completeness, since we are discussing a tough material rather than an object, it should be the energy per unit volume, but we did not insist on that. Many responses described the force required to fracture, which is strength, not toughness. Note that the question asks about a tough material, not just a description of toughness, so "a large amount" or a similar statement was required.

There was just a single mark for the question.

The first response below gains the mark, the others do not.

14 The toughness of a sample of a material can be measured using an Izod impact test.

(a) State what is meant by a tough material.

(1)

A material that can absorb a large amount of energy before fracturing

ResultsPlus
Examiner Comments

This is the simple statement we would like to see.

https://xtremepape.rs/

(a) State what is meant by a tough material.

(1)

a measure of ability of a material to absorb energy before breakage

ResultsPlus Examiner Comments

This is a description of toughness, not of a tough material.

ResultsPlus Examiner Tip

Make sure you fully understand the question.

(a) State what is meant by a tough material.

(1)

A material that can withstand a lot of force before breaking.

ResultsPlus Examiner Comments

This is the meaning of strong, not tough.

https://xtremepape.rs/

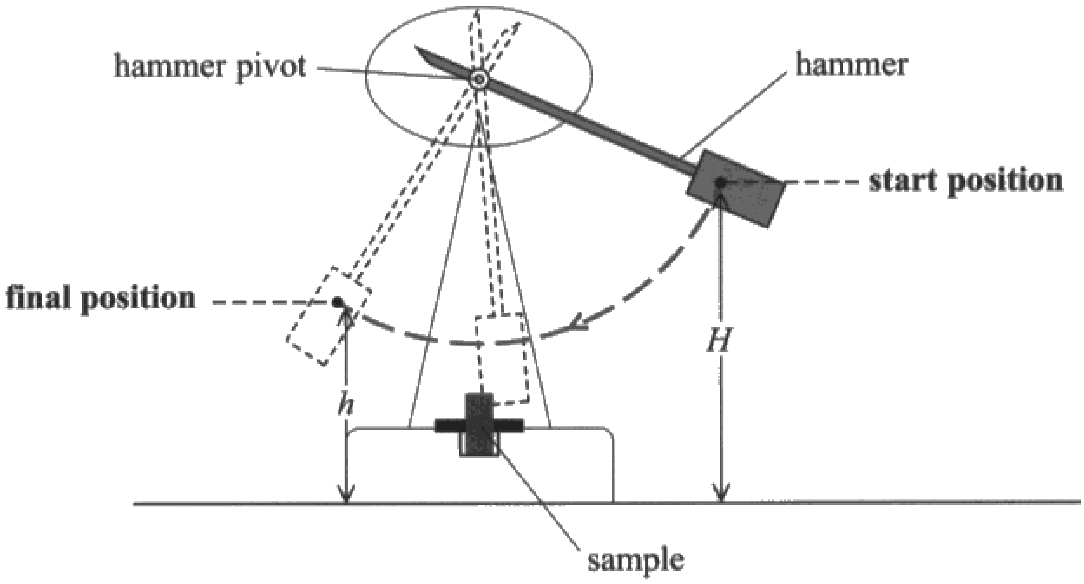
Question 14 (b) (i)

The response expected was one of:

- centre of gravity
- centre of mass

Because this is a technical term that the student should know, and the question asks for the name of the point, one of these names was required. Descriptions of the point were not allowed as alternatives.

(b) The diagram shows an Izod impact tester. A sample of the material is placed in the tester as shown. A pivoted hammer of mass *m* is released from a height *H* and strikes the sample. The sample breaks. The height *h* to which the hammer rises after the impact is measured.



(i) Name the point on the hammer to which the heights *H* and *h* are measured.

(1)

Centre of gravity. / Centre of mass

ResultsPlus Examiner Comments

This correct response gives both names. It is not normally advisable to give the examiner a choice of answers, but since these are both correct, the mark is awarded.

https://xtremepape.rs/

Question 14 (b) (ii)

To gain the single mark for this item, there had to be an equation not just an expression, and it had to use the variables given in the question.

The first sample below was awarded the mark, the others were not.

(ii) State an equation for the energy transferred to the sample.

(1)

mgH − Mgh = Energy transferred to Sample

ResultsPlus
Examiner Comments

The correct equation for the energy transferred.

(ii) State an equation for the energy transferred to the sample.

(1)

GPE → KE

mgh → $\frac{1}{2}mv^2$

ResultsPlus
Examiner Comments

This type of response was often seen, describing the energy transfer as the hammer falls, not for the energy transferred to the sample.

https://xtremepape.rs/

(ii) State an equation for the energy transferred to the sample.

(1)

mgH − mgh.

ResultsPlus
Examiner Comments

Another common response which did not gain the mark as this is not an equation.

ResultsPlus
Examiner Tip

The question asks for an equation, so it needs to start with E= or similar.

Question 14 (c)

This question asks how the toughness of the type of steel shown on the graph varies with temperature, and also asks for an explanation in terms of brittleness and malleability. It does not ask for a definition of any of those terms. The marks were as follows:

Mark 1 was for a statement that the toughness increases as temperature increases. That can be seen directly from the graph.

Mark 2 was for a statement that the steel is more brittle at low temperatures.

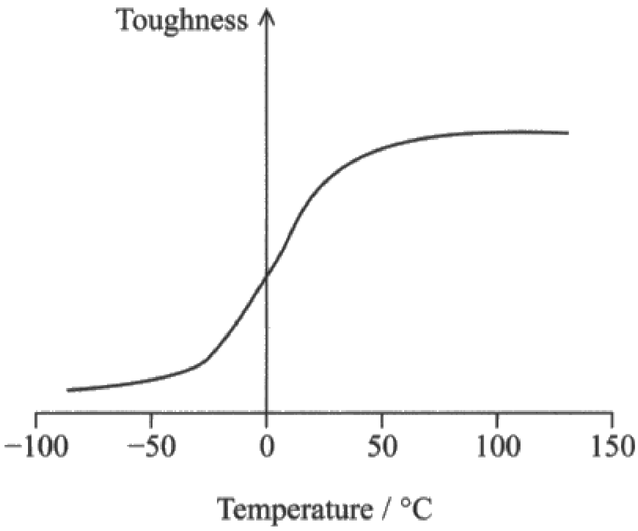
Mark 3 was for a statement that the steel was more malleable at high temperatures.

Extra statements such as about the meaning of brittle or about viscosity, were ignored, as long as they did not contradict a correct statement. For instance, saying that the steel is malleable at high temperature gains mark 3 but then saying it is brittle at high temperature would result in mark 3 being lost.

This first response gains all three marks. It states that the steel is brittle at low temperature, and so less tough, and that it is malleable at higher temperature and so becomes more tough.

https://xtremepape.rs/

(c) The Izod impact test can be used to measure the toughness of steel at different temperatures. The toughness of a particular type of steel varies with temperature as shown in the graph.



The brittleness and malleability of the steel also vary with temperature.

With reference to brittleness and malleability, explain how the toughness of this type of steel varies with temperature.

(3)

when the temperature becomes lower, the type of steel will become more and more brittle, this means it will break with little or no plastic deformation. So the Toughness will be lower. as temperature increases, the malleability of the steel increases, this means it shows large plastic deformation before failure under compression, so it becomes more and more ~~though~~. tough

(Total for Question 14 = 6 marks)

ResultsPlus
Examiner Comments

A good response, describing all the three terms required.

https://xtremepape.rs/

As the temperature of the steel decreases it becomes ~~more~~ brittle and does not go past it's limit of proportionality but as the temperature ~~decr~~ increases the steel becomes ~~more~~ malleable and is able to go past it's limit of proportionality and plastically deform.

ResultsPlus
Examiner Comments

This response gains marks 2 and 3 only since toughness has not been discussed.

ResultsPlus
Examiner Tip

The question about toughness has not been addressed.

https://xtremepape.rs/

As the temperature increases, the ~~vis steel expands and its density decreases~~ viscosity increases thus the rate of flow increases. The steel becomes malleable that is it can undergo large plastic deformation under compression. Whereas as temperature decreases viscosity decreases and the material becomes brittle.*

(Total for Question 14 = 6 marks)

* That is it breaks ~~tut~~ without ~~are~~ any plastic deformation under stress.

ResultsPlus
Examiner Comments

Several students included a discussion about the viscosity of the steel. While this showed a misunderstanding of the nature of the steel and the meaning of viscosity, any such statements were ignored when the item was being marked. This response gained the two marks for the discussion of brittleness and malleability.

https://xtremepape.rs/

Question 15 (a) (i)

For this 2 mark question, the marks were awarded for:

Mark 1 for an arrow vertically downwards, labelled as the weight.

Mark 2 for an arrow to the left and downwards, labelled as the air resistance, or a similar term.

If upthrust was added vertically upwards then it was ignored. Otherwise, if there were more than two forces then the maximum mark would be 1.

The lines should be straight, attach to the dot, and include an arrow to give the direction. The weight was generally drawn correctly, but there were some common mistakes which meant that some quite easily gained marks were not awarded.

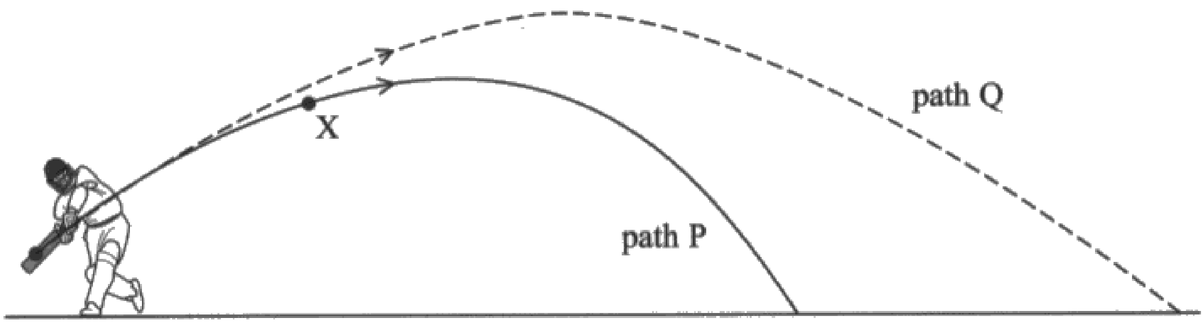
- The air resistance was often drawn horizontally to the left, rather than in the opposite direction to the current path of the ball.
- An extra "driving force" was drawn in the direction of travel of the ball.
- Sometimes the arrows were carelessly drawn, not attaching to the ball, or the weight not vertically down.
- Labelling the weight as "gravity", which is not a force, or as "*g*" which is an acceleration.

This example of the free-body force diagram did gain the mark.

https://xtremepape.rs/

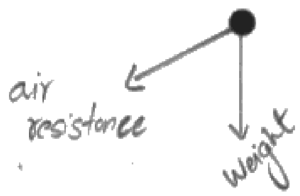
15 In a game of cricket, a player hits the ball, which takes path P.

Air resistance acted on the ball as it travelled through the air. If there was no air resistance, the ball would have followed path Q.



(a) (i) Draw a free-body force diagram for the ball when at the position marked X on path P.

(2)



ResultsPlus
Examiner Comments

This is a clearly drawn diagram, using a ruler, and the forces are correctly labelled.

ResultsPlus
Examiner Tip

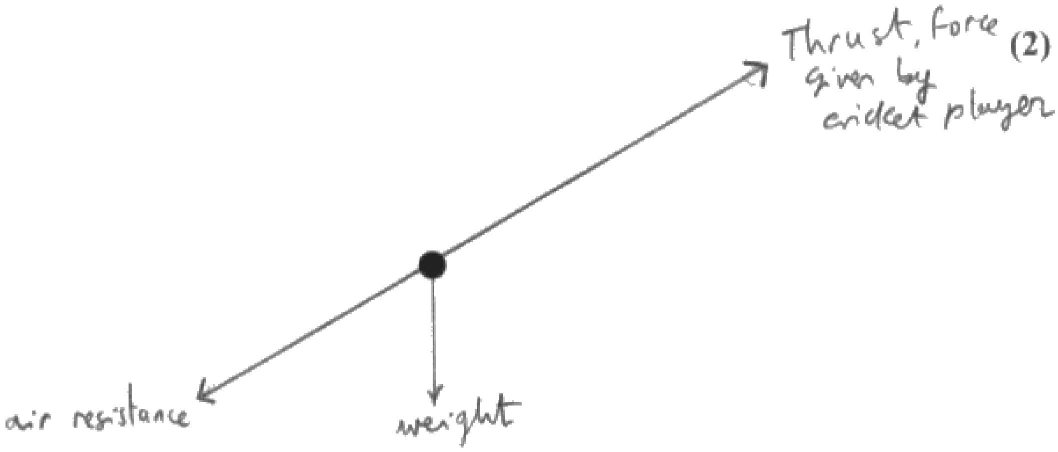
It is always best to use a ruler when drawing straight lines.

https://xtremepape.rs/

These responses did not gain the marks, for various reasons.

(a) (i) Draw a free-body force diagram for the ball when at the position marked X on path P.

(2)

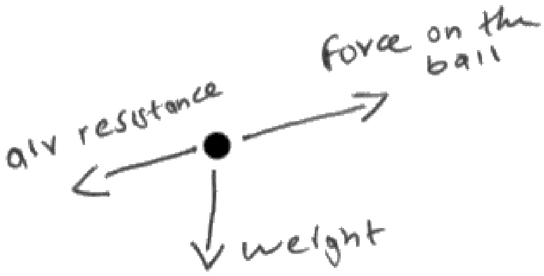


ResultsPlus
Examiner Comments

The weight and air resistance are clearly drawn and labelled, but the extra force added in the direction of travel shows a misunderstanding of Newton's laws.

(a) (i) Draw a free-body force diagram for the ball when at the position marked X on path P.

(2)



ResultsPlus
Examiner Comments

A carelessly drawn diagram. The weight is just about vertical, but not attached to the ball, and the air resistance is also not attached to the ball. Had a ruler been used, a more carefully drawn diagram would have been produced. As it is, this response did not score any marks.

https://xtremepape.rs/

Do not lose easy marks due to lack of care with drawing.

Question 15 (a) (ii)

This question concerned the reasons for the change in the expected path of a cricket ball when air resistance is included. There was a mark each for the two most obvious differences in the two paths, and the majority of the students gained these two marks. There was then a mark for each of the reasons for those two differences, which the students found much harder to obtain, often just saying that the differences were due to air resistance acting on the ball.

Mark 1 was for saying that for path P the distance travelled is less. Since this is a projectile question, normally a range calculation, most students gained this mark.

Mark 2 is for an explanation of the reduced range, which could only be considered if mark 1 had already been awarded. Many responses had the velocity decreasing due to the drag, but did not say it was the horizontal velocity so did not gain the mark.

Mark 3 is for saying that for path P the maximum height is lower.

Mark 4 is for the greater vertical deceleration, or greater vertical force downward, which again was dependent on gaining mark 3.

This question included quality of written communication, and so it was expected that the differences and their explanations would be described in a clear and orderly way.

Students seemed reluctant to consider horizontal and vertical components, despite this very obviously being a projectile question.

The first sample gained all 4 marks. It was quite rare for full marks to be gained on this question, because the students tended not to consider horizontal and vertical motion separately.

https://xtremepape.rs/

*(ii) Explain the differences between path P and path Q.

(4)

Path Q has no air resistance, so the horizontal velocity is constant. Path P shows a decreasing horizontal velocity so the horizontal distance travelled is significantly less.
The vertical deceleration of path P has a greater magnitude due to the forces opposing the motion of the ball. Therefore, a greater maximum height is reached on Path Q, ~~and it~~ which allows more time in the air before the ball lands.

ResultsPlus
Examiner Comments

This student has described the horizontal motion first, explaining how the decreasing horizontal velocity gives rise to a reduced horizontal distance travelled. The vertical motion is then considered, explaining how the greater vertical deceleration reduces the maximum height reached.

ResultsPlus
Examiner Tip

Projectile questions generally require horizontal and vertical motions to be considered separately.

https://xtremepape.rs/

This response was given 2 marks: mark 1 (in the first line) and mark 3 (in the last line).

*(ii) Explain the differences between path P and path Q.

(4)

The ball will travel with a longer distance for path Q compared to path P.
The vertical component of the ball at path Q is larger than path P.
The horizontal component of the ball at path Q is larger than path P.
The angle of the ball at path Q is larger than at path P.
The maximum height reached by the ball is higher at path Q than path P.

ResultsPlus
Examiner Comments

Candidates often, as here, referred to "the vertical component" and "the horizontal component" without saying what they are components of. In this case it is the velocity, or possibly the acceleration or the force. The ball itself does not have a horizontal component.

ResultsPlus
Examiner Tip

Beware of leaving words out for the examiner to complete.

https://xtremepape.rs/

Question 15 (b)

The question here is "Determine whether six runs are scored". The question is the same in principle as "Calculate the horizontal distance travelled by the ball", but it is a more practical context, and the students found it rather less straightforward because it involved deciding what needed to be calculated. There were also a number of possible ways to determine whether the six runs were scored, although the great majority of students calculated the range and compared it with the distance to the boundary. The possible methods were:

- Calculate the range and show that it is greater than 86m.
- Calculate the time it takes for the ball to reach the boundary (2.7s), and show that it is less than the time the ball is in the air (3.0s).
- Calculate the height of the ball above the ground after travelling the 86m horizontally to the boundary, showing that the height is >0.

The answer must finish with the statement that therefore the six runs are scored in order to get the 4^{th} mark.

An alternative method, used by a number of students, is to use the range equation. This equation is not in the specification, and when this question was set, it was intended to test the students' understanding of the physics of projectiles. Use of the range equation does not allow that test, and so should not be encouraged. It is a correct method, and so if the range equation is correctly used and the correct conclusion is drawn then the full marks are awarded. However, if the correct range is not found, there is no opportunity to obtain any method marks, so zero will be scored.

This first example is a correct and well written response, for all 4 marks.

https://xtremepape.rs/

(b) The ball was given an initial velocity of $35\,m\,s^{-1}$ at an angle of 25° to the horizontal. The horizontal distance from the player to the 'boundary' is 85 m. The player scores six 'runs' if the ball lands beyond the 'boundary' before it bounces.

Determine whether six 'runs' will be scored. Ignore the effects of air resistance.

(4)

Horizontal component = 35 cos 25 = $31.72\,ms^{-1}$

Vertical component = 35 sin 25 = $14.79\,ms^{-1}$

$v = u + at$

$0 = 14.79 + (-9.81t)$

$t = 1.5078\,s$

Total time of flight = 1.5078 × 2

= 3.0156 s

$V = \frac{S}{t}$

$31.72 = \frac{S}{3.0156}$

S = 95.65 m = 96 m

∴ Six runs will be scored

(Total for Question 15 = 10 marks)

ResultsPlus
Examiner Comments

The student has resolved the velocity vertically and horizontally, determined the time of flight, used that to calculate the range and then drawn the correct conclusion about the six runs being scored.

ResultsPlus
Examiner Tip

Do not forget the conclusion in this type of question.

https://xtremepape.rs/

This response scored 4 marks for the correct use of the range equation. However, many candidates tried to use this equation and made a mistake in the working, scoring them zero marks.

(4)

~~s = ut + cos~~ $R = \frac{u^2 \sin 2\alpha}{g}$

$= \frac{(35\,ms^{-1})^2 \times \sin(2 \times 25^\circ)}{9.81\,ms^{-1}}$

$= 95.7\,m$

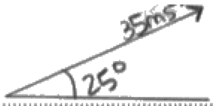
$95.7\,m > 85\,m$ ∴ six "runs" will be scored.

ResultsPlus
Examiner Comments

It is not helpful for candidates to attempt to learn complex equations that are not in the specification. They need to be able to demonstrate to the examiner their understanding of the physics involved, which is not possible using this equation.

These two examples show the alternative methods. Both score all 4 marks.

(4)



Horizontal velocity (V_H) = 35cos(25)
= $31.7\,ms^{-1}$

$V_v = 35\sin(25)$
$= 14.8\,ms^{-1}$

$u = 14.8\,ms^{-1}$ $v = u + at$
$v = 0\,ms^{-1}$ $0 = 14.8 - 9.81t$
$a = -9.81\,ms^{-2}$ $t = 1.51\,s$
$t = ?$

$1.51 \times 2 = 3.02\,s$

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

$31.7 = \frac{85}{t}$

$t = 2.68\,s$

Yes, 6 runs will be scored.

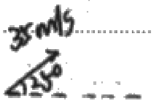
(Total for Question 15 = 10 marks)

https://xtremepape.rs/

ResultsPlus Examiner Comments

Here the time in the air is compared to the time to reach the boundary, showing that it reaches the boundary before it lands on the ground.

(4)



$35 m/s \times \cos 25° \times t = 85 m$

$t = 2.68 s$

when $t = 2.68$: $h = 35 m/s \times \sin 25° \times t - \frac{1}{2} \times 9.81 m/s^2 \times (2.68s)^2$

$= 4.41 m$

~~wh~~ $4.41 m > 0$

so six "runs" will be scored because when the ball travels for 85m horizontally, ~~the~~ it still hasn't ~~don't~~ ~~landedback~~ landed back on the ground. So it lands beyond the "boundary" before it bounces.

ResultsPlus Examiner Comments

This candidate has correctly calculated that the ball is still 4.4 m above the ground as it crosses the boundary.

https://xtremepape.rs/

Question 16 (a)

The students did not find this an easy question to answer. Being asked to criticise an incorrect statement is less straightforward than being asked to make the correct statement, but the question did expose some misunderstandings of the physics involved in Newton's laws.

- A few students seemed muddled about the difference between the first and second laws (and sometimes the third law).
- Many responses were unclear about the difference between an external force and a resultant force.
- Few students actually criticised the statement, preferring to just quote what they thought was a correct statement.
- Terms were often mixed up; descriptions of internal forces, original motion, certain speed, original style of motion, will keep moving etc.

There were 3 marks for the question:

Mark 1 was for saying that external force should be resultant force.

Mark 2 was for saying that "no motion" is not always true.

Mark 3 was for saying that there could be uniform motion.

Marks 1 and 3 could come from a correct statement of the first law, and these two marks were quite often scored. Although students often correctly stated the use of resultant force, they then sometimes reverted to using the term external force, showing that they did not really understand how different the terms are. Mark 2 would only be scored if there was a definite criticism of the statement, and this mark was much more rarely scored.

The first example below was given the full 3 marks, and is a correct, well written response. The other responses show some of the mistakes that were made.

https://xtremepape.rs/

16 (a) A student states Newton's first law of motion as

If there is no external force, there will be no motion.

Criticise this statement.

(3)

Newton's first law states that ~~a~~ an object will remain stationary or will have constant velocity if there is no resultant force acting on it. The student states that there will be no motion, however, the object may have motion, but will not have an acceleration. The student ~~also~~ states that there has to be an external force in order for there to be motion, but an external force may not cause a resultant force on an object.

ResultsPlus
Examiner Comments

This response gives the correct statement of the law, gaining the first and third mark for the first 3 lines.

The student then gives a full criticism of the errors in the statement in the question, saying that "no motion" might not be correct, with a good reason. This student also correctly criticises the "external force" statement, saying that an external force might not give rise to a resultant force as the forces could be balanced, a point that some other responses also made.

https://xtremepape.rs/

Newton's 1st law states that a moving object moves at a constant speed and a resting object rests as long as there is no resultant force acting on it.

- The student is partially correct ~~as of~~ because a resting object continues to rest if there's no force applied but he is ~~wrong~~ also wrong when he says there is no motion because a moving object continues to move, (has a motion) ~~even~~ but at a constant speed when there is no external force applied

ResultsPlus Examiner Comments

This candidate is almost correct, but reverts to "external force" in the last line of the response.

ResultsPlus Examiner Tip

Know the difference between internal, external and resultant forces, and use the correct term.

https://xtremepape.rs/

If no unbalanced force acts upon an object the object will remain stationary or move with constant velocity where acceleration is zero.

ResultsPlus
Examiner Comments

This response gained mark 1 and mark 3, but there is no criticism of the statement.

ResultsPlus
Examiner Tip

Understand that "criticise" means more than just give the correct statement.

https://xtremepape.rs/

Question 16 (b)

The students are asked to explain why pushing a trolley requires more work than pulling it, given certain conditions described in the question.

The 5 marks for the question were allocated as follows:

Mark 1 for saying that when pushing there is a component of the applied force acting downwards.

Mark 2 for saying that this causes the normal contact force to increase.

Mark 3 for saying that therefore the frictional force increases.

Mark 4 for saying that the increased friction leads to a greater applied force.

Mark 5 for $W=F \times d$ with F being the horizontal component of the applied force.

The first three marks were the ones most commonly scored, but that was usually not linked to the force required from the person for mark 4. The equation $W=F \times d$ was often quoted, but the terms were not defined, and so the student did not fully explain why the work done was greater.

The question could be answered by either explaining why pulling required less work or why pushing required more work. Several students decided to explain both, which was just a repetition of the physics, so wasted time.

Quite often we saw responses that gave the reason for the reduced work as being that the angle of the applied force when pulling was less that that angle when pushing. This was despite being told in the question that the angles were the same.

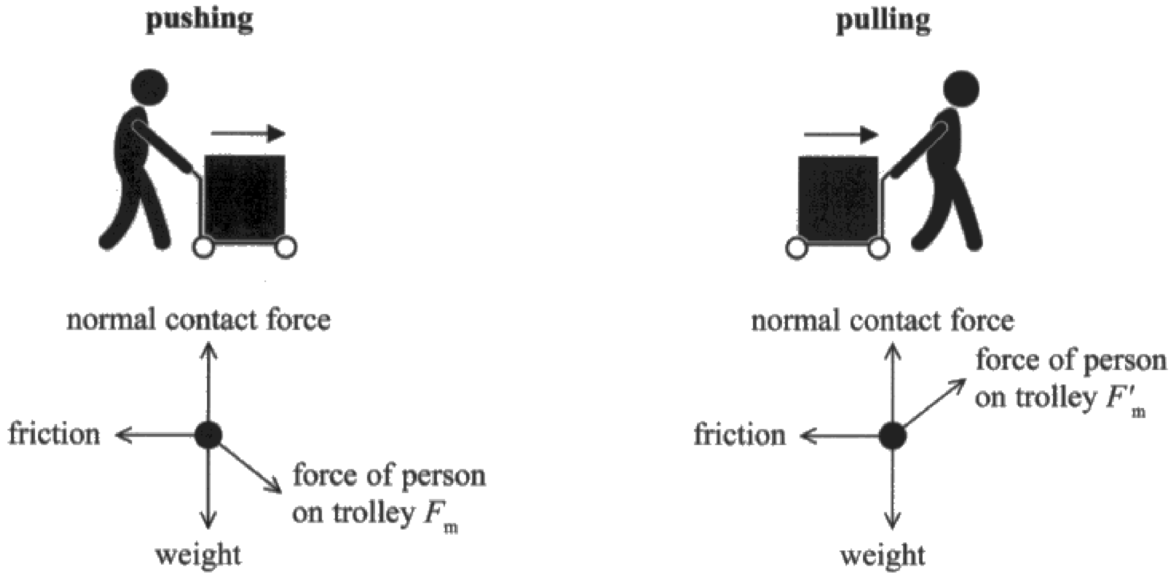
Others said that the extra downward force when pushing increased the weight of the trolley - a clear error of physics.

This response is a rare occurrence of one that gained the full 5 marks. "Force in the direction of motion" is sufficient to indicate that it is the horizontal component of the applied force that is being used.

https://xtremepape.rs/

*(b) The diagrams show a person pushing a trolley and pulling a trolley.

The angle θ between the arms of the person and the horizontal is the same for both pushing and pulling. Corresponding diagrams showing the forces on the trolley for pushing and pulling are also shown.



It can be assumed that the frictional force between the trolley and the ground is proportional to the normal contact force of the ground on the trolley.

Explain why pulling the trolley a certain distance requires the person to do less work than pushing the trolley the same distance.

(5)

In pulling the trolley there is a ~~comp~~ ~~com~~ component of the force in the horizontal as well as a vertical direction that is also pulling the trolley upwards. This upward ~~force~~ force due to pulling reduces the ~~normal~~ normal contact force and thus reduces the friction. This reduce in friction requires less ~~wo~~ force in the horizontal direction to pull the trolley. And as Work done = F(in the direction of motion) x distance moved the work done will be less. Conversly While pushing a component of force is also acting downwards which increases the normal contact force, increasing friction as well as the force required to move the trolley and thus increasing the work done.

https://xtremepape.rs/

ResultsPlus
Examiner Comments

A good, clear and well ordered response.

This response scored 3 marks.

Pushing the trolley would provide vertical force towards the ground, therefore increase the total amount of normal contact force, resulting in higher friction force. ~~Putting the trolley~~
Pulling the trolley would provide upward vertical force, therefore decrease the total amount of normal ~~[illegible]~~ contact force, resulting in lower friction fore. Higher energy needed to be ~~ex~~ expense to overcome higher friction ~~force~~ force, thus more work is done.

ResultsPlus
Examiner Comments

This response is more typical of the ones we saw. The first three marks are clear, but it becomes very vague about why the greater amount of friction gives rise to more work being required. In addition, time has been wasted dealing with pulling and pushing separately, since those first 3 marks are in the first 3 lines of the response.

ResultsPlus
Examiner Tip

There is rarely any need to give the same physics twice.

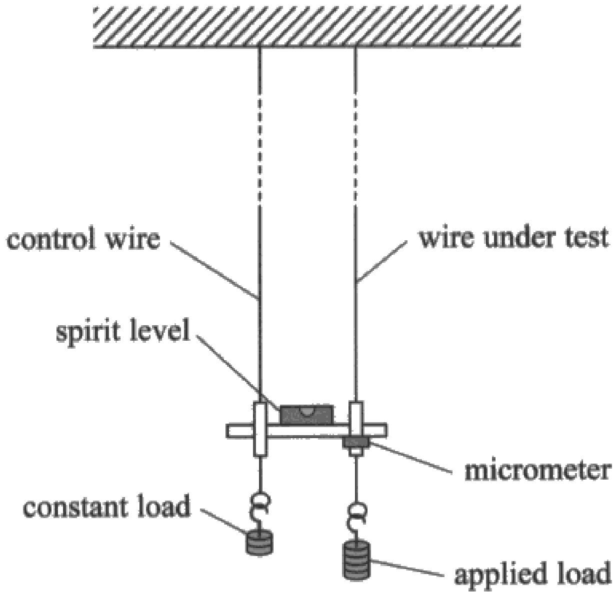
https://xtremepape.rs/

Question 17 (a)

The two additional measurements are the diameter and the original length of the wire, which should be an easy 2 marks. However, many students told us that they would measure the radius or the area of cross section, which is clearly impossible to do directly, and they missed the "original" from the length of the wire. Other quantities were often listed, such as the mass of the load and the extension, even though these were already discussed in the question.

The first response below is fully correct for 2 marks, and the others show common errors.

17 A student determined the Young modulus of a material, in the form of a wire, using the equipment shown. A control wire, with a constant load, was used as a comparison for measuring the extension of the wire under test.



Every time a known weight was added to the applied load the micrometer was adjusted until the spirit level was horizontal. The movement of the applied load was the same as the movement of the micrometer.

(a) List any additional measurements that are required for the student to determine a value for the Young modulus of the material.

(2)

• diameter of wire

• original length of wire.

ResultsPlus
Examiner Comments

This response is exactly what we would expect. A clear and precise answer.

https://xtremepape.rs/

(a) List any additional measurements that are required for the student to determine a value for the Young modulus of the material.

(2)

The original length of the wire.
The cross-sectional area of the wire.

ResultsPlus
Examiner Comments

This response gained 1 mark for the original length, but it is not possible to measure the cross sectional area - that must be calculated from the diameter.

ResultsPlus
Examiner Tip

If asked for a measurement, give a variable that it is possible to measure.

(a) List any additional measurements that are required for the student to determine a value for the Young modulus of the material.

(2)

metre rule, accurate to 1mm
micrometer screw gauge, accurate to 0.01mm

ResultsPlus
Examiner Comments

This response gives the measuring instruments that would be used, not the measurements that need to be taken. It therefore does not score any marks.

This is the answer to a different question, which may well have been asked previously, but does not answer the question set here.

https://xtremepape.rs/

ResultsPlus
Examiner Tip

Read the question carefully.

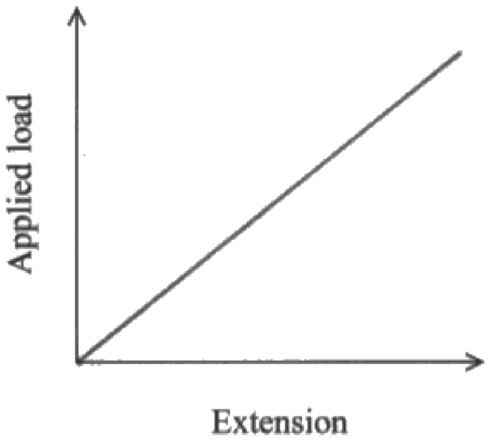
Question 17 (b) (i)

A straightforward question for 1 mark. The correct response is a straight line through the origin.

(b) The student plotted a graph of the applied load against the extension of the wire.

(i) Sketch the graph that you would expect the student to obtain.

(1)



ResultsPlus
Examiner Comments

This is the correct response for 1 mark.

ResultsPlus
Examiner Tip

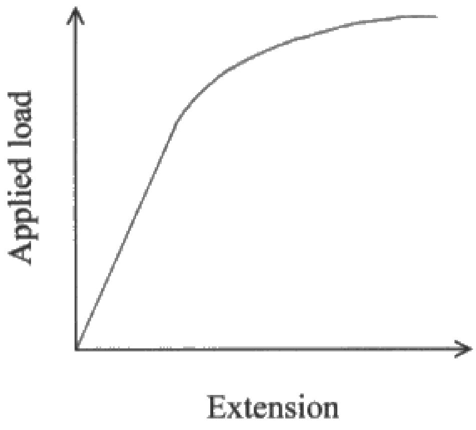
Please use a ruler for drawing a straight line. It makes it a lot clearer that it is what you intend.

https://xtremepape.rs/

(b) The student plotted a graph of the applied load against the extension of the wire.

(i) Sketch the graph that you would expect the student to obtain.

(1)



ResultsPlus Examiner Comments

This is a common response that takes the extension beyond the elastic limit and does not get the mark. To measure the Young modulus the wire remains below the limit of proportionality.

Question 17 (b) (ii)

There are 2 marks for explaining how the graph from the experiment can be used to determine the Young modulus.

Mark 1 is for saying that the gradient of the graph would be used. It must be of the given graph, so those who went on to plot a graph of stress against strain and took the gradient of that graph lost both marks for this question.

Mark 2 is for multiplying by the original length and dividing by the area of cross section. Those students who just said the length (missing the original or initial), or who just divided by the area of the wire (not the cross section) were not given this mark.

The first response below scored 2 marks, the second scored zero.

https://xtremepape.rs/

(ii) Explain how the student can use the graph to determine the Young modulus of the material. **(2)**

The student should calculate the gradient of the graph. gradient = $\frac{\Delta y}{\Delta x}$. He should then multiply the gradient by the $\frac{\text{original length of wire}}{\text{Cross sectional area of wire}}$ to get the young modulus.

ResultsPlus
Examiner Comments

A fully correct answer, clearly recorded.

Plot a graph using stress against strain Using the point ~~of~~ where only its before limit of proportionality, find the gradient which will give you the young Modulus.

ResultsPlus
Examiner Comments

In this response, a different graph is being plotted, so it is not the gradient of the given graph that is being used. This may well be the way that the student did perform the experiment and is a good form of analysis, but it is not as the question requires. No marks awarded.

ResultsPlus
Examiner Tip

Do please answer the question as it is set. You are asked how to use the given graph.

https://xtremepape.rs/

Question 17 (c)

In this question, there were up to a maximum of 2 marks for giving two advantages of using the first method to determine the Young modulus. These two could be chosen from:

- use of the micrometer
- use of a control wire
- that no pulley is required.

The students were then expected to give reasons for the two advantages they had chosen to describe, for the other 2 marks.

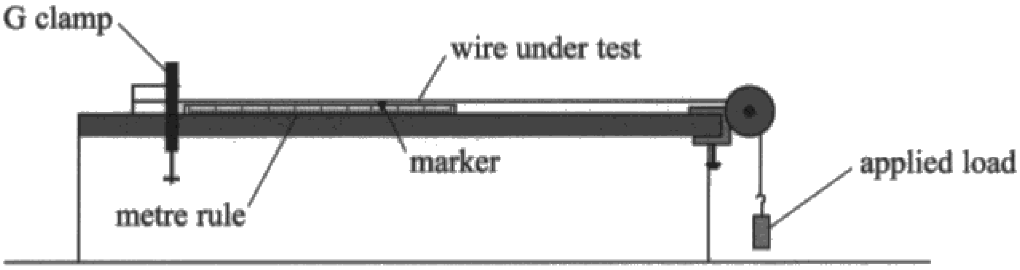
Control wire and micrometer were strong scorers for the advantages. There was confusion over the difference between accuracy and precision which caused marks not to be awarded for the explanation of the use of the micrometer. Very few students scored the explanation mark for the control wire and the explanation mark for the pulley was not often awarded as students simply said friction without an explanation as to its effect. Weaker students simply listed common causes of error such as human error parallax etc. A number of students thought the micrometer was being used to measure the diameter of the wire, which would lose them the advantage mark for the micrometer.

In fact, many students appeared to be totally unaware of the Searle's apparatus described and/or failed to understand how it worked. The method used was clearly explained in the question for those who had not met the apparatus previously, and it should be understood that a micrometer scale can be used for purposes other than measuring small diameters.

https://xtremepape.rs/

(c) A simpler method to determine the Young modulus of a material in the form of a wire is shown.

The position of a marker along a metre rule is recorded each time the applied load is increased.



Explain two advantages of using the first method, rather than the second method, to determine the Young modulus.

(4)

With the first set-up the control wire helps in accurate comparisons to be made. The first set-up uses a micrometer screw gauge which has a greater precision in measuring the extension as compared to a metre rule. The micrometer has a precision of 0.001mm.

With the first set-up the effects of temperature on the wire can be monitored as the change in temperature affects the extension. In the first set-up both wires will be affected by the temperature change hence the extension would be due to the addition of the mass, but for the second-set-up, the extension obtained may be wrong.

(Total for Question 17 = 9 marks)

ResultsPlus Examiner Comments

This response scored the full 4 marks. The advantage of using a micrometer is given as the improved precision in measurement of the extension, and the use of a control wire to compensate for temperature changes is clear.

https://xtremepape.rs/

Explain two advantages of using the first method, rather than the second method, to determine the Young modulus.

(4)

1) The first method has a control wire [thats parallel to wire underneath and prevents parallax error] that allows you to compare the change in length and therefore determine the extension

2) first method uses a micrometer to get an accurate value of ~~coarse~~ diameter and Hence calculate the cross sectional Area

ResultsPlus
Examiner Comments

The only mark in this response is for the control wire. The explanation about reducing parallax is a common guess but is incorrect. The use of the micrometer would normally score a mark, but it is being used here to measure the diameter of the wire rather than the extension.

ResultsPlus
Examiner Tip

Remember that micrometers are not only used to measure a diameter, although that is the most common use.

https://xtremepape.rs/

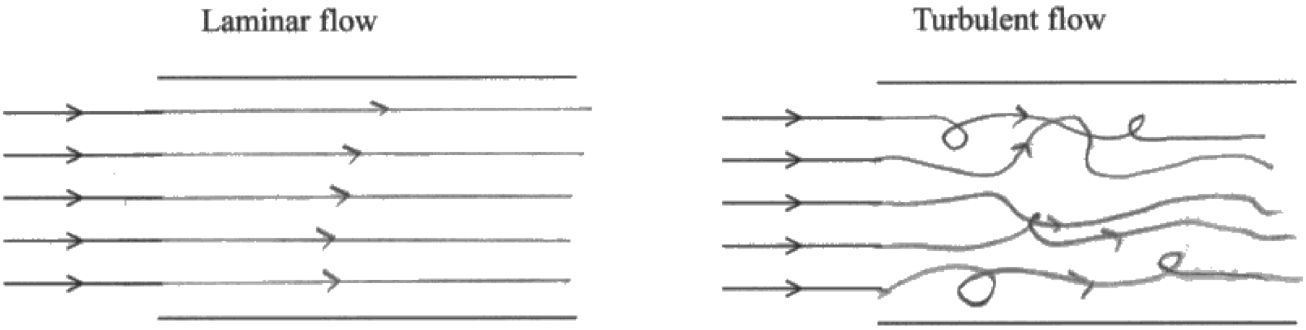
Question 18 (a)

Good marks were obtained for this question about the differences between laminar and turbulent flow. When adding to the diagrams, as stated in the question, the students were expected to continue the lines already drawn on the paper. This caused particular problems with the turbulent flow diagram, as many responses just showed a series of small isolated eddies without any actual flow lines. To gain the mark for turbulent flow, the flow lines had either to cross each other or include eddies. The great majority of responses scored the mark for the laminar flow diagram, but again, it would help if students would use a ruler to draw lines that they know should be straight.

18 The flow of the blood around the body is mostly laminar. The speed of the blood in the body is greatest on leaving the heart and at this point turbulent flow can occur.

(a) Add to the diagrams to show laminar flow and turbulent flow.

(2)



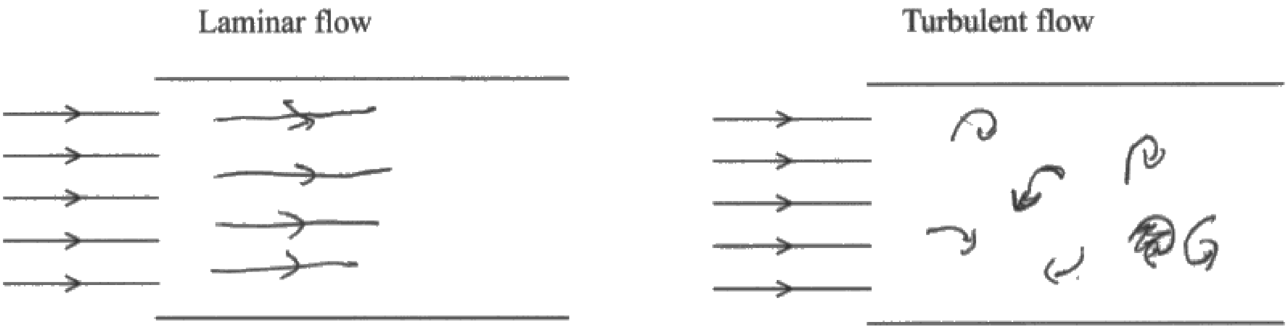
ResultsPlus
Examiner Comments

This response scored both marks, and is the kind of response we were hoping for.

18 The flow of the blood around the body is mostly laminar. The speed of the blood in the body is greatest on leaving the heart and at this point turbulent flow can occur.

(a) Add to the diagrams to show laminar flow and turbulent flow.

(2)



https://xtremepape.rs/

ResultsPlus
Examiner Comments

This response scored neither mark. The laminar flow lines did not continue the given lines, nor were they parallel or straight. The turbulent flow lines were isolated eddies, with no connection to the given lines.

ResultsPlus
Examiner Tip

Use a ruler for straight lines.

Question 18 (b) (i)

In this question, the students were given an equation for the power output of the heart and were asked to derive it using the principle of energy conservation. Overall, the energy conservation part was answered well, but the students found it difficult to include the blood density and the time element into a final equation. They must beware of working backwards from the given equation because they are being asked to derive the equation, not to show that it is correct.

The marks were awarded for:

Mark 1 for showing that the total energy of the blood is its kinetic energy plus its gravitational potential energy. A number of students equated KE and GPE, as though the KE was being transferred to GPE, and so they failed to score.

Mark 2 for including the KE and GPE equations. Most students gained these two marks.

Mark 3 for dividing the energy by time to give the power. Many students just divided by 1s, which was not considered sufficient for deriving an equation for power. It is not good enough just to say that the power is the energy transferred in one second, and write *P=E.* In fact, the difference between energy and power was often ignored in answers to this item.

Mark 4 was for using the density equation for the blood, and continuing the algebra through to derive the correct equation. In many cases, this mark was not obtained because the student did not show that the equation had been derived.

Many students would benefit from being taught how to lay out a derivation logically from first principles, as there were some very muddled statements which would have been clear had those students explicitly acknowledged the equation E=Pt. They need to be taught to understand the meaning of derivation.

https://xtremepape.rs/

(b) A student wishes to estimate the power output P of the heart. He argues that the heart has to pump out blood at a speed v and raise it to a height h above the heart.
He proposes the following equation for P.

$$P = \frac{1}{2}\rho Q v^2 + \rho Q g h$$

where Q is the volume of blood passing a point per second and ρ is the density of the blood.

(i) Derive this equation for P using the principle of conservation of energy.

(4)

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

$E = K.E. + G.P.E. = \frac{1}{2} m v^2 + mgh$

$\rho = \frac{m}{V} \Rightarrow m = \rho \times V$

$P = \frac{\frac{1}{2}\rho V v^2 + \rho V g h}{t} = \frac{1}{2}\rho \frac{V}{t} \cdot v^2 + \rho \frac{V}{t} \cdot gh$

Q = volume per second =>

$\Rightarrow P = \frac{1}{2}\rho Q v^2 + \rho Q g h$

ResultsPlus
Examiner Comments

This response is well laid out and achieved all 4 marks. The meaning of power in terms of energy is first stated, then the energy to be substituted is given. The equation for density is stated and worked through clearly to give the final required equation.

ResultsPlus
Examiner Tip

Understand what it means to derive an equation.

https://xtremepape.rs/

Question 18 (b) (ii)

For this question, the students were expected to use the equation given on the previous page, substitute the given values into it, and calculate the power of the heart. Many students obtained the correct answer, but the greatest problem for most seemed to be the conversion of the units for Q. They should not really have difficulty in converting cm^3 to m^3, and perhaps a bit more practice at this skill is needed. Other mistakes were noted, particularly forgetting to include *g* in the equation, and forgetting to square the velocity.

The marks were as follows:

Mark 1 for correctly converting the unit of Q. If this was done incorrectly the final answer mark would also not be scored, so the maximum mark would be 1.

Mark 2 was for correctly substituting into the equation.

Mark 3 was for the answer with its unit (0.42W). The unit did cause some problems here, with some either not giving a unit or giving the answer in J.

For the two responses below, the first scored all 3 marks, and the second shows the most common mistake we found and gained 1 mark.

(ii) Calculate the power output P of the heart when pumping blood to a height of 0.40 m above the heart. Assume that the speed of the blood has not changed since leaving the heart.

(3)

$\rho = 1100\,\text{kg m}^{-3}$

$Q = 95\,\text{cm}^3\text{s}^{-1} = 9.5 \times 10^{-5}\,\text{m}^3\text{s}^{-1}$

$v = 0.45\,\text{m s}^{-1}$

$P = \frac{1}{2}\rho Q v^2 + \rho Q g h$

$= \frac{1}{2} \times 1100 \times 9.5 \times 10^{-5} \times (0.45)^2 + 1100 \times 9.5 \times 10^{-5} \times 9.81 \times 0.4$

$= 0.01058062\underline{5} + 0.410058$

$= 0.420638625$

$\approx 0.421\,\text{W}$

$P = 0.421\,\text{W}$

https://xtremepape.rs/

ResultsPlus
Examiner Comments

This is a good, clear response. The unit is correctly converted and each step of the working is shown.

$\frac{95}{100} = 0.95 ms^{-1}$ $P = \frac{1}{2}\rho Q v^2 + \rho Q g h$

$P = \frac{1}{2} \times 1100 \times 0.95 \times (0.45)^2 + 1100 \times 0.95 \times 0.4 \times 9.81$

$P = 4206 W$

ResultsPlus
Examiner Comments

This response shows the most common mistake, which is to divide the value of Q by 100 rather than 100^3.

ResultsPlus
Examiner Tip

Take care with unit conversions.

Ask yourself whether your answer is reasonable - 4 kW is a very high power for a heart!

Question 18 (b) (iii)

A power greater than the value calculated will be required because work has to be done against friction as the blood moves along the arteries. This is because the viscosity of the blood has been ignored in the calculation. There may be other reasons why more power is required, but as far as the calculation in part (ii) is concerned, it is clear that ignoring friction is the major problem.

The two responses below could score the 2 marks, but each also shows a commonly found misconception.

https://xtremepape.rs/

(iii) Suggest why, in practice, *P* will have to be greater than the value calculated in (b)(ii).
(2)

Because there will be turbulant flow, so more work will need to be done against friction and against the turbulance to maintain same speed and height.

(Total for Question 18 = 11 marks)

ResultsPlus
Examiner Comments

This response gets the 2 marks for work being done against friction. Many students just said that the problem was that turbulent flow would occur, but in fact, even if the flow were laminar there would be friction that had been ignored in the calculation.

(iii) Suggest why, in practice, *P* will have to be greater than the value calculated in (b)(ii).
(2)

Temperature of blood may vary, ~~as well~~ thus viscosity may vary. ~~Drag~~ Work done against drag and turbulence not taken into account in calculation

ResultsPlus
Examiner Comments

This gets the marks for work done against drag, but the comments on the temperature and turbulence, or the variation of the viscosity are not relevant. Such changes would vary the friction in the blood, but not introduce it.

https://xtremepape.rs/

Question 19 (a)

Part (a)(i)

For this question, the student was required to calculate the initial downward acceleration on the system as it began to fall through the water. Since this was the initial acceleration, when the speed was zero, there was no drag on the system, so the only forces involved were weight and upthrust.

Mark 1 is for showing that the resultant force is the weight minus the upthrust. This step was commonly ignored, but those who were correct here generally obtained the 3 marks.

Mark 2 is for using the equation F=ma to calculate the acceleration. Many students only gained this mark, because they substituted only the weight or only the upthrust for *F*.

Mark 3 is for the correct acceleration, with its unit.

Part (a)(ii)

This is about why the system reaches a terminal velocity, and is very similar to questions that have been asked many times.

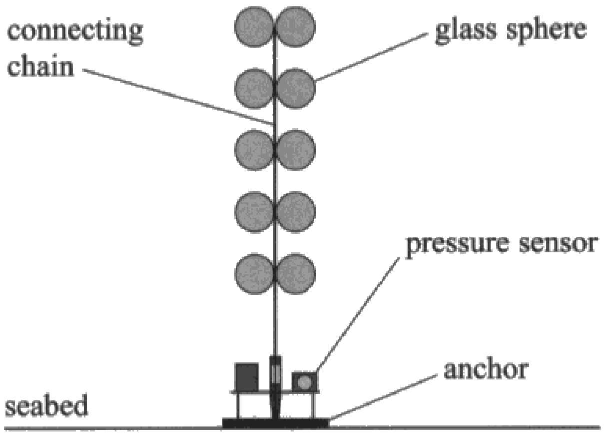
Mark 1 is for saying that as the speed increases the drag on the system also increases. It is not enough to say just that the drag increases as it falls, it must be linked to the speed. This fact was poorly understood by students, and they often wrote that the upthrust increased as the system descended and ignored drag completely.

Mark 2 is for saying that the resultant force becomes zero, or that weight becomes equal to upthrust plus drag.

It is important to remember that, in any question like this one, if a response is given in terms of an equation, all the symbols used must be defined.

https://xtremepape.rs/

19 An underwater system for detecting earthquakes is placed on the seabed. The system includes a pressure sensor and 10 glass spheres. The system is connected to a detachable anchor. Regular signals are sent, via satellite, to a central control station.



(a) The system and anchor are released just below the surface of the sea. They accelerate for a few seconds and then fall to the seabed at a constant velocity.

(i) Calculate the initial acceleration of the system and anchor.

(3)

total upthrust acting on the system and anchor = 2500 N
total mass of system and anchor = 470 kg

F=ma 4611 − 2500 = ma   F=mg
4.5 ms⁻² = a   =470 × 9.81
= 4610.7 N
= 4611 N

Initial acceleration = 4.5 ms⁻²

(ii) Explain why, after a few seconds, the system and anchor fall to the seabed at a constant velocity.

(2)

It is because in the start there is no drag but as the velocity increases the drag increases and becomes equal to weight so there is no resultant force (Drag + Upthrust) − Weight = 0

https://xtremepape.rs/

(iii) Calculate the drag force acting on the system and anchor as they fall at a constant velocity.

(1)

~~Flotingy~~ ~~4664638~~ U − W = D

= 2111 N

Drag force = ~~864838~~

ResultsPlus
Examiner Comments

(i) The weight, the resultant force and the acceleration are all correctly and clearly calculated, so 3 marks scored.

(ii) The student has stated that the drag increases as the velocity increases, and that the resultant force drops to zero, so 2 marks scored.

(iii) The correct answer is given for the drag force, with the unit, so 1 mark scored.

ResultsPlus
Examiner Tip

Learn how to fully explain terminal velocity. It is a question that is asked quite regularly.

(ii) Explain why, after a few seconds, the system and anchor fall to the seabed at a constant velocity.

(2)

Drag force increases, so resultant force decreases to 0 so there is no more acceleration

https://xtremepape.rs/

ResultsPlus
Examiner Comments

This response gets the second mark for saying that the resultant force becomes zero, but there is no reason given for the drag force increasing, so does not gain mark 1.

(i) Calculate the initial acceleration of the system and anchor.

(3)

total upthrust acting on the system and anchor = 2500 N
total mass of system and anchor = 470 kg

F = ma
2500 = 470a
a = 5.31914...
≈ 5.32 m/s²

Initial acceleration = 5.32 m/s²

(ii) Explain why, after a few seconds, the system and anchor fall to the seabed at a constant velocity.

(2)

The upthrust and the gravity slowly become equal until the net force is 0.
The constant velocity is known as the terminal velocity.

https://xtremepape.rs/

ResultsPlus
Examiner Comments

(a)(i) The weight is ignored in this response, which, surprisingly, occurred quite regularly. Just mark 2 is awarded for the use of *F=ma*.

(a)(ii) Mark 2 only. There are many errors here:

- The drag is being ignored despite it being the main cause of terminal velocity.
- Weight is being called gravity.
- We seem to have the upthrust slowly increasing.

All of these are misunderstandings of the physics involved, but all were seen regularly.

Question 19 (b)

To answer this question, students are given the upthrust on the system, and have to use that to calculate the volume of the water displaced and hence the diameter of the spheres. The marks are given as follows:

Mark 1 for using the given upthrust and dividing by the 10 spheres. The divide by 10 can be on the upthrust, or on the mass of water, or on the volume, but the calculation must be initially based on the upthrust. Many students used the drag from (a)(iii), which is not relevant now as that was for the falling system, or they used the weight from (a)(i), which includes the anchor, now released, and is not the weight of the water displaced. Others calculated the diameter and then divided that by 10, which is clearly incorrect.

Mark 2 is for the use of *W=mg*.

Mark 3 is for the use of *V=m/ρ*. Most responses scored marks 2 and 3.

Mark 4 is for the use of the equation for the volume of a sphere in terms of its diameter. Many students did not know this equation, or left the answer as the radius.

Mark 5 is for the correct diameter, with the unit.

https://xtremepape.rs/

(b) The system is re-floated every two years so that the batteries can be replaced. To re-float the system, the anchor is detached from the system and the glass spheres cause the system to rise to the surface of the water, leaving the anchor behind.

The total upthrust on the system due to the 10 glass spheres is 2500 N. It can be assumed that the upthrust on the rest of the system is negligible.

Calculate the diameter of one glass sphere.

(5)

density of sea water = 1030 kg m^{-3}

$\frac{2500}{10} = 250N$ = upthrust of one sphere.

upthrust = weight of fluid displaced

~~260 =~~ ~~1030~~ $F = dvg$

$250 = 1030 \times V \times 9.81$

$V = 0.023\ m^3$

$\frac{4}{3}\pi r^3 = 0.023$

$\sqrt{r^3} = \sqrt{\frac{0.023}{\frac{4}{3}\pi}}$

$r = 0.18m$

$d = 2r$

$= 0.18 \times 2$

Diameter of one glass sphere = 0.36m

ResultsPlus
Examiner Comments

This is an example of a fully correct response, leading to the correct diameter of 0.36m.

https://xtremepape.rs/

Upthrust = weight of water displaced

weight of water displaced by 10 spheres = $\rho_w V_{10s} g$

$\rho_w V_{10s}\, g = 2500$

$1030 \times V_{10s} \times 9.81 = 2500$

$V_{10s} = \frac{2500}{9.81 \times 1030} = 0.25\,m^3$

V of a sphere = $\frac{4}{3}\pi r^3$

V of 10 spheres = $0.25\,m^3$

$0.25 = \frac{4}{3}\pi r^3$ $\quad r^3 = \frac{0.25}{\frac{4}{3}\pi}$ $\quad r_{10} = \sqrt[3]{\frac{0.25}{\frac{4}{3}\pi}}$

$R_{10} = 0.39$ $\quad \therefore R_1 = \frac{0.39}{10} = 0.039$

$\therefore$ Diameter of 1 = $0.039 \times 2 = 0.078\,m$

Diameter of one glass sphere = 0.078m

ResultsPlus
Examiner Comments

This response shows the correct calculation of the whole volume of the 10 spheres, but the division by ten for the single sphere is not done until after a diameter has been calculated. The response does not therefore gain mark 1 or mark 5.

Question 19 (c) (i)

Why should the chain be made of a high strength material? There are two marks:

Mark 1 for saying what strength or strong means.

Mark 2 for the application to the chain in this equipment.

The 2 marks were rarely scored. Mark 1 for the meaning of strength was fairly often gained, although there was confusion with toughness, and prevention of plastic deformation was regularly mentioned. Few students could relate the strength requirement to the large weight of the anchor, or the large upthrust of the spheres, or just the large tension in the chain.

https://xtremepape.rs/

(c) When selecting the material for the connecting chain, all the forces that act on the chain are considered.

(i) Explain why the connecting chain should be made of a high strength material.

(2)

Because the ~~g~~ large upthrust of the ~~sphereces~~ spheres cause large tension force in the chain so it has to have a high ultimate tensile so it can withstand large tensile stress without breaking.

ResultsPlus Examiner Comments

This response does say what is meant by high strength, and relates that to the large tension in the chain caused by the large upthrust of the spheres.

A ~~materiall~~ material with high strength can absorb a lot of stress. A high strength material ~~be~~ goes through large plastic ~~dee~~ ~~deformation~~ deformation before breaking.

ResultsPlus Examiner Comments

This response scored neither mark. It was quite common to see reference to plastic deformation, but that is not to do with strength.

Because high ~~st~~ strength material could be tough and hard. So, It will undergo forces and absorb energy without breaking.

https://xtremepape.rs/

ResultsPlus
Examiner Comments

Zero marks. Strength, toughness and hardness are being equated here, and the energy statement is about toughness not strength.

ResultsPlus
Examiner Tip

You need to know the meaning of the terms used for the properties of materials - strong, tough, brittle, malleable, hard.

The chains will feel a ~~b~~ high tensile force upward, so to prevent plastic deformation, a high strength material is needed.

ResultsPlus
Examiner Comments

Again, this is all about plastic deformation, not the stress or force needed to cause fracture.

https://xtremepape.rs/

Question 19 (c) (ii)

This has to be an "additional" force, not one that has already been discussed in the question, and it has to be a force on the chain. Very few students gave the correct answer, which was water movement.

(ii) Suggest what causes an additional force on the connecting chain when the system is on the seabed.

(1)

The current of the water may cause viscous drag. Or the contact normal force of the ground.

ResultsPlus
Examiner Comments

This response scored the mark for the water currents. The contact force with the ground was ignored - it is not a force on the chain.

The upthrust of water on the connecting chain.

ResultsPlus
Examiner Comments

No mark. Upthrust is not an additional force - upthrust has already been discussed in the question.

https://xtremepape.rs/

Reaction force from the seabed to the anchor

ResultsPlus
Examiner Comments

No mark. The normal contact force of the sea bed on the anchor is often mentioned, but this is a force on the anchor, not the chain.

https://xtremepape.rs/

Paper Summary

The variety of questions, in terms of physics content and style, gave the students ample opportunity to demonstrate their proficiency in the subject.

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

- When asked to "explain", the student needs to give physical reasons for the event described.
- 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.
- Use a ruler when drawing a diagram in which the lines are intended to be straight.
- Show all working in calculations, and only round the final answer.

https://xtremepape.rs/

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

https://xtremepape.rs/

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London WC2R 0RL.

https://xtremepape.rs/