Examiners' Report
June 2017

IAL Physics WPH01 01

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 2017

Publications Code WPH01_01_1706_ER

Introduction

The two areas of physics covered by Unit 1 are basic mechanics and properties of matter. The unit is designed to examine the candidates on these subject areas in three distinct and important ways, testing their knowledge as described in the specification, their understanding of the physics involved, and their ability to apply that knowledge in numerical and unfamiliar contexts.

To give a few instances from this particular paper, question 12 tests the candidates' knowledge of energy transfers, and whether they know the correct equation to use to calculate the extension, question 15(b) tests their understanding of terminal velocity and free fall, and question 18 tests their ability to apply their knowledge of both mechanics and properties of matter to the jump of a flea. Overall, the candidates' responses showed that they were proficient in applying the physics they had learnt to the contexts described in this paper.

Candidates too often lost marks because they answered a slightly different question to the one asked, and we must emphasise the importance of carefully reading the question and understanding what is required in the response. For instance, question 12(a) asks for energy transfers in a catapult during the launch of a ball, not for those that occur while pulling the rubber strip of the catapult back, or those that occur as the ball travels through the air. For question 16(a) the candidate is asked to use a scaled vector diagram to determine a resultant force, so measurements from a vector diagram are needed, not calculated values. It was our intention in that question to test the candidate's skill in constructing an accurate vector diagram, and not their knowledge of trigonometry.

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.

Section A

Question	Subject	% correct	Correct response	Most common alternative
1	Vectors	94%	C	
2	Units	76%	D	A
3	F-e graph and elastic limit	58%	C	D
4	Forces	54%	D	B
5	Velocity-time graph	73%	B	A
6	Velocity-time graph	59%	C	D
7	Resolving a vector	66%	A	All chosen
8	Spring constant	77%	D	B
9	Projectile	68%	C	All chosen
10	F=ma	60%	C	A

As intended, the questions in the multiple-choice section scored quite highly, with an average of about 70%, but not so highly that they failed to discriminate between the candidates. A-grade candidates were typically scoring 90% while E grade candidates typically scored 63% on this section. 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 2 was answered well, but it was surprising how many candidates gave upthrust the units of pressure or stress rather than simply a force.

Question 3 was a simple force-extension graph for a wire, and the candidates were asked for the position of the elastic limit. There was a lot of confusion between the elastic limit and both the limit of proportionality and the yield point. The students are expected to know the names and definitions of these points on the graph.

Questions 5 and 6 concerned a velocity time graph for a ball thrown in the air. Most candidates were able to calculate the acceleration of the ball from the graph's gradient, although many ignored the negative sign. They found determining the distance from the area under the graph far more demanding: many just calculated distance as velocity × time even though the velocity was changing.

Question 10 required rather more thought, that a constant force results in a velocity that increases uniformly with time. A large minority chose the response that showed the distance moved increasing uniformly, i.e. the constant velocity.

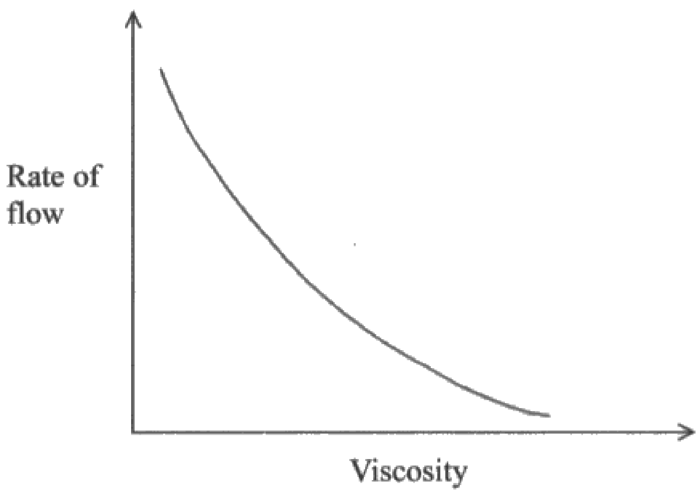
Question 11 (a)

Since this question is at the start of Section B, it was intended to be quick and simple to answer. The candidates are expected to know how the viscosity of a fluid affects the way it flows through a pipe, often requiring much more detail than is needed here. This question can score just a single mark for a rate of flow that reduces steadily in a reasonable way as the viscosity of the liquid increases.

The first response shown here is what we consider to be the fully correct response, of a rate of flow that is approximately inversely proportional to the viscosity. There are then two further common responses.

(a) Sketch, on the axes below, a possible graph to show how the rate of flow of blood varies with viscosity.

(1)



ResultsPlus
Examiner Comments

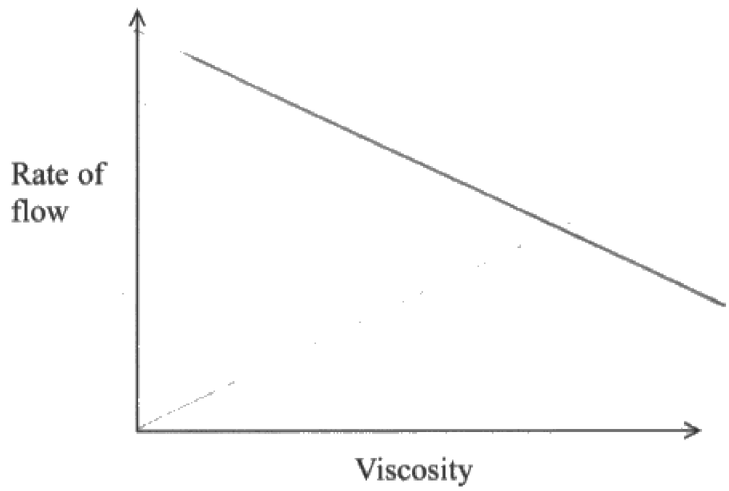
The line has been drawn carefully, recognising that it is a curve, and not meeting either axis.

ResultsPlus
Examiner Tip

"Sketch" in a question does not mean a rough drawing. It still needs to be drawn carefully, but without any quantitative requirements.

(a) Sketch, on the axes below, a possible graph to show how the rate of flow of blood varies with viscosity.

(1)



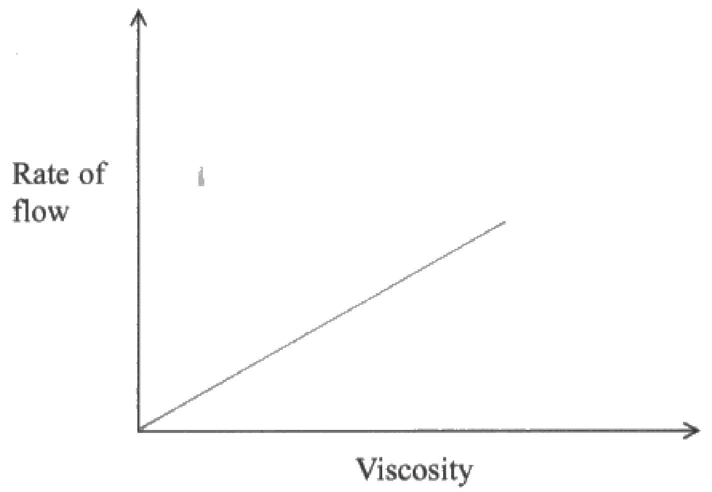
ResultsPlus

Examiner Comments

A straight line with a negative gradient was a very common response. Although not fully correct, it was awarded the mark as it showed clearly the trend for the rate of flow against the viscosity.

(a) Sketch, on the axes below, a possible graph to show how the rate of flow of blood varies with viscosity.

(1)



ResultsPlus

Examiner Comments

This was another very common response. It clearly shows an incorrect trend and so did not get the mark.

Question 11 (b)

A large number of candidates scored 2 marks for this 3-mark question. Candidates will have been taught that the viscosity of a liquid increases as its temperature is decreased and most were able to state that with reference to the blood flow, which gained mark 1. We would have liked them then to say that the increased viscosity led to a greater friction or resistance to flow, as many did, but we also accepted that this increased viscosity would lead to the reduction in flow rate they have probably described in part (a), gaining mark 2. The reduction in flow rate would in practice be fairly minimal because the heart would do something about it, by applying a greater force to the blood. It is this final point, for mark 3, about the greater force being required that the candidates rarely achieved, most just repeating the statement in the question that more work has to be done.

Note that the question is clearly asking what happens if the temperature is decreased. Although this did not apply to many candidates, there would be no credit for a response that describes the effect of an increasing temperature.

Also, a few candidates said that the viscosity would be high so the flow rate would be high. This statement is not necessarily true, as the absolute viscosity might still be low: we were looking for a comparative statement to gain the first mark.

The samples shown here are three typical responses from the candidates, just the first sample being fully correct, for the three marks.

(b) When the temperature of the body is reduced, the heart has to do more work in order to pump blood through the arteries.

In terms of viscosity, explain why.

(3)

A change in temperature affects viscosity. A lower body temperature will cause the blood viscosity to increase so the blood is more resistant to flow. Due to a higher viscosity, the heart has to apply more force to the blood to move it a given distance through the arteries. Due to an increase in force, work done also increases as work done = force x distance moved.

(Total for Question 11 = 4 marks)

ResultsPlus
Examiner Comments

This candidate starts by making the simple point that as the temperature falls, the viscosity of the blood will increase (mark 1). Then the important point is made that the resistance to flow increases (mark 2). Finally, that the heart therefore has to apply a greater force to the blood (mark 3). The response then goes on to explain why this greater force requires the heart to do more work. Although we were not expecting that explanation on this occasion, it is an important point that completes an excellent response.

ResultsPlus
Examiner Tip

A clear and concise response is most likely to succeed.

This response scored 2 marks.

- As body temperature decreases, viscosity increases ~~according to~~
- As viscosity increases, rate of flow of blood decreases
- Reduced rate of flow of blood will require the heart to do more work to pump blood.

ResultsPlus
Examiner Comments

This response is a very typical one that gained 2 marks only. Again, the response is clear and concise, but does not make the point about the greater force being required to pump the blood and so does not gain the third mark. The third point being made here is just a repeat of the statement in the question which the candidate is being asked to explain.

ResultsPlus
Examiner Tip

It might sometimes help an explanation to repeat a part of the question, but there can be no credit for doing that.

This response scored 1 mark.

Because viscosity is directly propotional to temperature, so when the temparature decrease viscosity increase which will give more friction, so the heart need to do more work because the friction increased.

ResultsPlus

Examiner Comments

This response is an example of one that includes a contradiction. It has viscosity both increasing and decreasing with temperature, so will not be given the mark. The candidate probably meant to say "inversely proportional".

ResultsPlus

Examiner Tip

Be careful with the use of mathematical terms.

Question 12 (a)

For this 4-mark question, the most common score for the candidates was 2.

Mark 1 would be awarded if the response stated that work was done by the rubber, or that work was done on the ball. Most candidates ignored this part of the question, i.e. "in terms of work done", and did not score this mark.

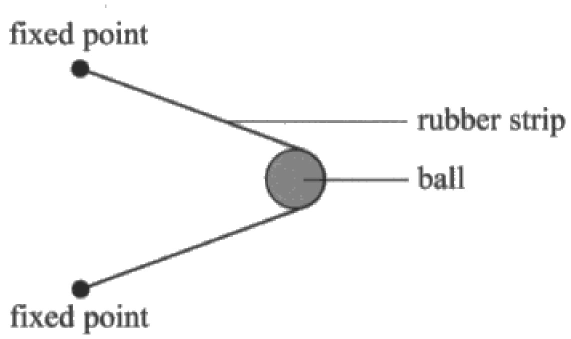
Marks 2 and 3 were for describing the initial elastic potential energy of the rubber, and the transfer to kinetic energy of the ball. Many lost the latter mark because they said some of the elastic energy would be transferred to gravitational potential energy. If that happened it would be after the launch, not during the launch of the ball.

Mark 4 was for noting that some of the elastic energy would become thermal energy in the rubber, a mark that few obtained. The transfer to thermal energy was often mentioned, either in the ball, or in the surroundings through friction with the air: this did not get the mark as it would happen after the launch.

The question was not answered as well as expected because the candidates did not properly read the question, and often described what energy transfers took place either while initially stretching the rubber, or after the launch while the ball was moving through the air.

This response was awarded the full 4 marks.

12 A simple catapult consists of a rubber strip connected to two fixed points as shown. It is used to launch a ball of mass m. When pulled back, the rubber strip extends by Δx and has a tension T. When launched, the ball is given a velocity v.



(a) Describe, in terms of work done and energy transfers, what happens immediately after the rubber strip is released to launch the ball.

(4)

Elastic strain energy is stored in the rubber strip when it is under tension. When the rubber strip is released, the rubber strip does work to return to its original length (elastic behavior) and exerts a restoring force on the ball. Elastic strain energy is transferred to kinetic energy of the ball and some is transferred to (thermal) internal energy of the rubber strip. Resultant force acts on the ball. Hence the ball accelerates with a velocity, v

ResultsPlus
Examiner Comments

This candidate has said that the rubber strip does work, has described the transfer of elastic strain energy stored in the rubber to kinetic energy of the ball, and added that some energy is transferred to thermal energy in the rubber strip. 4 marks awarded.

This response was awarded 2 marks.

(a) Describe, in terms of work done and energy transfers, what happens immediately after the rubber strip is released to launch the ball.

(4)

When the rubber strip is released, elastic potential energy in the rubber strips in transferred to the ball in the form of kinetic energy. This launches the ball over a distance as the ball is doing work. KE= work done

work done = Force x distance

ResultsPlus
Examiner Comments

This minimalist response gets 2 marks for the correct description of elastic energy in the rubber being transferred to kinetic energy in the ball. The statement that the ball is doing work is incorrect since the rubber is doing work on the ball.

The fact that there are 4 marks available for this question is an indication of the amount of detail required. This should have given the candidate a clue that more was required.

ResultsPlus
Examiner Tip

Take account of the number of marks available when deciding how much detail to give in your answer.

This response scored 1 mark

Elastic Strain energy is converted into kinetic energy and gravitational potential energy .

The work done is equal to elastic strain energy which is $\frac{1}{2} F \cdot \Delta x = \frac{1}{2} \cdot 2T \cdot \Delta x$

$= \cancel{\frac{1}{2} mg \cdot \Delta x}$.

ResultsPlus

Examiner Comments

The inclusion of gravitational energy in the transfer from elastic energy was a very common misunderstanding of the process involved. The candidate's thoughts are probably based on a different question involving an object being launched vertically, but even then the transfer to GPE occurs after the object has been launched.

Question 12 (b)

The correct answer to this 2-mark calculation was 6.3 cm, using the equation Eel = ½ FΔx. It was a straightforward calculation, involving substitution into the equation for elastic strain energy and rearranging the equation. The most common, and most serious error was to use the equation for work done (ΔW=FΔs), in this case tension × extension, which, as an error of physics, would lose both marks. Note that the correct equation of E_{el} = ½ FΔx was given in the list of data, formulae and relationships at the back of the exam paper. It was quite often noted that the candidate incorrectly rearranged the equation during the calculation. Provided that the candidate had already demonstrated a correct substitution into the right equation, the subsequent incorrect rearrangement of the equation only lost 1 mark.

This response scored 2 marks.

(b) When the tension in the rubber strip is 3.5 N, the energy stored is 0.11 J.

Calculate the extension of the rubber strip.

(2)

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

$\therefore \Delta x = \frac{2E}{F} = \frac{2 \times 0.11}{3.5} = \frac{11}{175} = 0.063\ m$

Extension = 0.063 m.

(Total for Question 12 = 6 marks)

ResultsPlus
Examiner Comments

This is a fully correct response, with the answer quoted to 2 significant figures (as the data given) and including the unit. Since the mark for the use of the equation is credited at the point of substitution, it could be safer to substitute the values into the equation before rearranging.

This response scored zero marks.

$k = F . \Delta x$

$\therefore \frac{0.11}{3.5} = \Delta x$

$\therefore \Delta x = 0.031 \text{ m}$

Extension = 0.031 m

ResultsPlus

Examiner Comments

As explained above, this was a very common response using the incorrect equation.

The following three responses scored a single mark. These are common errors which occur quite regularly throughout these exams, but are very easy to overcome with a bit of care, as explained on each sample.

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

$0.11 = \frac{1}{2} \times 3.5 \times x$

$0.11 = 1.75 \times x$

$x = \frac{0.11}{1.75} = 0.063$

Extension = 0.063

ResultsPlus

Examiner Comments

This would be an absolutely perfect response, but the answer is given without a unit.

ResultsPlus

Examiner Tip

Remember that a physics quantity nearly always consists of a magnitude and a unit. Both are required.

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

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

$\Delta x = 0.062\,m$

Extension = 0.062 m

ResultsPlus

Examiner Comments

The actual answer calculates as 0.0629 m. This response has been truncated to 0.062 m rather than rounding to 0.063 m.

0.062 m is the wrong answer and loses the second mark.

ResultsPlus

Examiner Tip

Do not truncate answers, but round them carefully to avoid wasting marks.

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

$0.11 = \frac{1}{2} \times 3.5\, \Delta x$

$\Delta x = 0.06\,m$

Extension = 0.06 m

ResultsPlus

Examiner Comments

This answer has been given to a precision of one significant figure, which is insufficient to demonstrate that an accurate calculation has been done.

ResultsPlus

Examiner Tip

Answers should not normally be stated to a single significant figure.

Question 13

This 4-mark question was designed to test the candidates' understanding of Newton's 3rd law, and its application to a situation where several forces are acting. Since the question does not specifically ask for a reference to Newton's laws it was not necessary on this occasion to refer to Newton's 3rd law, but the fact that the force of magnet A on magnet B is equal to the force of magnet B on magnet A was required. Some responses justified that the forces of attraction would be equal and opposite by Newton 3 but then went on to contradict themselves by saying that because magnet B was stronger than magnet A, it would exert a stronger force on A than A on B. In fact, it was very common to see the comment that magnet B causes a greater magnetic force than magnet A, a complete misunderstanding of the 3rd law.

For the first mark, candidates needed to clearly say that there was a downward force on A **in addition to the weight.** Many candidates said here that the weight of magnet A increased, which shows a misunderstanding of the way forces interact.

For the second mark, they should say that there was an upward or opposite force on B **due to A.** Many did not tell us that the extra upward force on B was due to A.

For the third mark we looked for the statements, often quite separate in the response, that the reading for A increases and that for B decreases.

The fourth mark was for a statement that the magnetic forces, or the changes in the readings, are equal. There were many misconceptions, as described above.

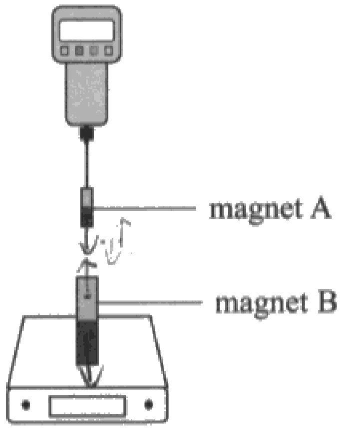
There were many other misconceptions seen in answer to this question. Many thought that the magnets would be made to accelerate by the magnetic forces. Many considered that the resultant force on magnet A would increase, whereas, of course, the resultant force is zero on both magnets, and the candidates need to be careful with the scientific terms they use. Note that any statement about there being an attractive force between the magnets has to be ignored as that is given in the question.

This good response gained all 4 marks.

*13 A student has two magnets, A and B. Magnet A is smaller and weaker than magnet B.

The weight of magnet A is determined using a digital spring balance and the weight of magnet B is determined using a top pan balance as shown.

When magnet A is moved to a position just above magnet B there is an attractive force between the two magnets and the readings on the two balances change.



Explain how the readings on the two balances will change.

(4)

Initially the reading on the the digital spring balance is the weight of magnet A, the reading on the top pan balance is the weight of magnet B. when A is moved above B. the poles are opposite, there is an attractive force exist. Due to Newton's third law, when A exert an upward force on B. B will exert an downward force on A. the magnitude of two forces are equal. So the reading on digital spring balance will increase because the reading = Weight of A + attractive force by B. the reading on top pan balance will decrease. because the reading = weight of B − the attractive for by A.

(Total for Question 13 = 4 marks)

ResultsPlus

Examiner Comments

This candidate has clearly understood that the magnets are exerting forces on each other, in opposite directions and of equal magnitudes. These forces are described as adding to the weight for magnet A and subtracting from the weight for magnet B. The candidate has clearly shown an understanding of the physics involved in this situation, and deserves the 4 marks.

This response gained just 1 mark.

The readings on the digital spring balance will increase and the readings on the top pan balance will decrease.
When magnet A is moved to the position above B, because of the opposite ~~direction of the magn~~ magnetic fields, ~~positive~~ ~~an~~ they will attract each other. During this process, the magnet B will drag magnet A downwards to make the reading's on digital spring balance increases. Magnet A will cause magnet B moves upwards a little, therefore the readings on top pan balance decreases. And because magnet A is smaller and weaker than magnet B, therefore the change on digital spring balance is bigger than that of the top pan balance.

ResultsPlus

Examiner Comments

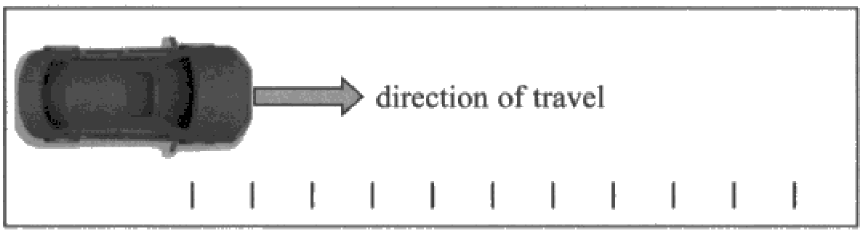
The mark is awarded for the first 2 lines where the correct changes in the readings are described. The only comment on the forces between the magnets is that "they will attract each other", a statement drawn from the question itself. Otherwise, the response is about movement rather than force (many other similar responses discuss accelerations) which does not demonstrate a correct understanding of the physics. The last 3 lines describe the very common misconception about there being a greater magnetic force from the larger magnet.

Question 14 (a)

There were two marks for this item: one mark for stating that the speed was an average because a total distance and time were used so that the speed was not an instantaneous one; the second for pointing out that the speed could be varying over the 0.5 s of the measurement.

Candidates were not very precise with their explanations, often commenting on an average being the mean of several readings, or that it was an average because it was not an instantaneous reading. Most candidates either gained a mark by commenting on the measurement method (total distance), or by commenting on the changing speed, but rarely gave both statements. Any description of the changing speed would be sufficient to gain the second mark, and we often saw comments that the car was accelerating or decelerating, both of which are good explanations for it being an average speed measured.

14 A camera may be used to determine if a car is exceeding the speed limit. The camera takes two photographs, at a time interval of 0.50 s, as the car travels over a set of equally spaced road markings as shown.



Measurements from the photographs enable the speed of the car to be calculated.

(a) Explain why the speed calculated is an average speed.

(2)

it is calculated by the equation $\frac{\text{total } \cancel{\text{displacement}} \text{ distance}}{\text{total time}}$ however speed may have not been constant throughout the travelled distance.

ResultsPlus
Examiner Comments

This good response gained both marks.

The candidate has clearly stated that total distance has been used in the calculation, and that the speed could be varying.

This response gained 1 mark.

Because average speed = $\frac{\text{total distance}}{\text{total time}}$. It has fixed distance and use O.T.S. So it's an average speed

ResultsPlus
Examiner Comments

There is no mention here that the speed could be changing. The fact that there are 2 marks for the question is a hint that two points are being sought in the response.

ResultsPlus
Examiner Tip

Use the number of marks as a guide.

Question 14 (b)

There were 4 marks for this calculation of the speed of the car.

Mark 1 was for correctly reading the distance travelled from the diagrams.

Mark 2 was for correctly using v=s/t to calculate the speed.

Mark 3 was for a correct conversion between km/h and ms^{-1}, either for the actual speed or for the speed limit.

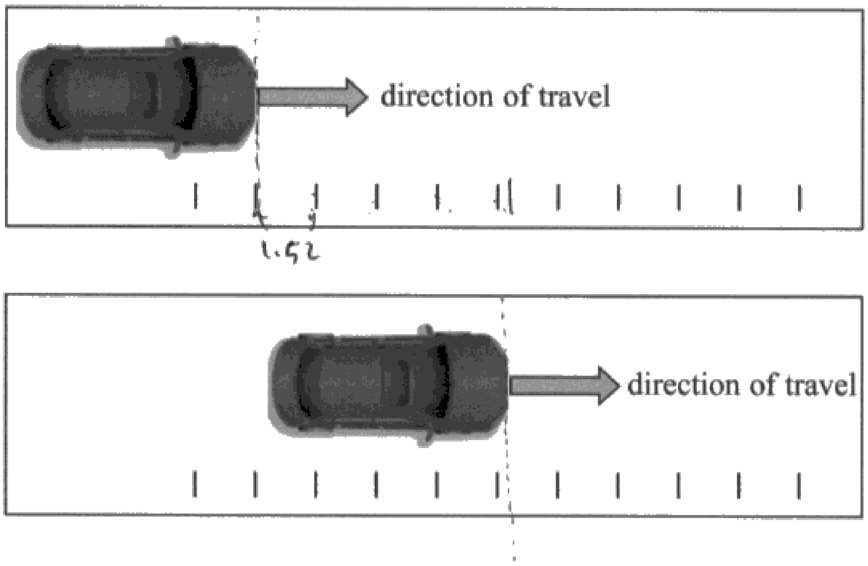
Mark 4 was for a correct final speed and a correct comparison with the speed limit showing that the speed was below the limit.

This question was generally answered well, and the greatest error the examiners found was the candidates' difficulty in correctly measuring and calculating the distance travelled. It was disappointing that most candidates took the distance moved along the road as exactly 4 divisions. We were hoping they would have been able to subdivide the divisions, giving the correct value of 4.2, but most just read the distance to the nearest whole division. THis was allowed, but when the divisions are as large as the ones in this question, we had hoped that they would have subdivided them. Many candidates took the number of divisions as 5, or took measurements from the start of the diagram, in which case they would lose both the first and final marks. The units conversion was generally done correctly, but a number of candidates lost the final mark by omitting to compare their answer for the speed with the speed limit, which was the requirement given in the question.

These three examples of the responses seen are all good responses that gained the full 4 marks, but in different ways. They show how different approaches by the candidates are both acceptable and welcome when answering questions like this one, where the context is probably not one with which they have had any practice. The responses show the candidates' ability to apply the physics they have learnt to a new situation.

(b) The diagrams below show the positions of a car at a time interval of 0.50 s.

The markings are painted on the road at intervals of 1.52 m.



$t = 0$ s

$t = 0.50$ s

The speed limit is 50 km per hour.

Determine, using information from the diagrams, whether the car was exceeding the speed limit.

(4)

4.2 intervals for 0.5 seconds

$4.2 \times 1.52 = 6.384$ m

$\frac{6.384\text{ m}}{0.5\text{ s}} = 12.76$ m/s

12.76 m/s $= 0.01276$ km/s

0.01276 km/s $= 45.9$ km/h.

∴ the car was not exceeding the speed limit.

ResultsPlus
Examiner Comments

This candidate has accurately measured the distance as 4.2 divisions and converted that to a distance. The speed has then been calculated, and converted to km/h, with a final statement that this puts the speed below the speed limit. We would have liked to see the statement that 45.9km/h<50km/h, but did not penalise that in the marking of this question.

ResultsPlus
Examiner Tip

Take readings accurately from a diagram, drawing lines on the diagram, if necessary, as this candidate has done.

$\circ$ speed = $\dfrac{\text{distance}}{\text{time}} = \dfrac{4 \times 1.52\,m}{0.5\,s} = \underline{\underline{12.16\,ms^{-1}}}$

$\circ$ $50\,km/h = \dfrac{50 \times 1000\,m}{1 \times 3600\,s} = \underline{\underline{13.88\,ms^{-1}}}$

12.16 ms^{-1} is speed of car, this is less than the speed limit of 13.88 ms^{-1}, hence car not exceeding speed limit.

ResultsPlus

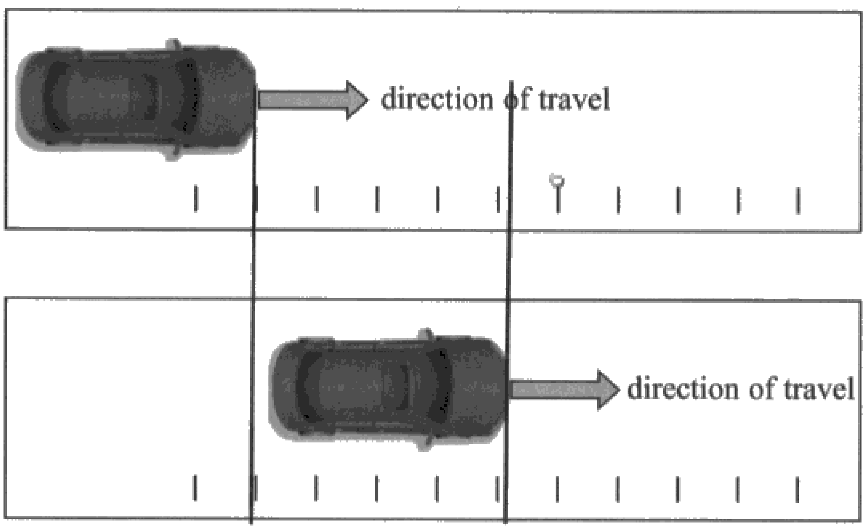
Examiner Comments

This candidate has converted the speed limit to 13.9km/h, which is perfectly acceptable. We allowed the use of just 4 divisions, and as the comparison of the correctly calculated speed in ms^{-1} with the speed limit in ms^{-1} is clear, all 4 marks are awarded.

(b) The diagrams below show the positions of a car at a time interval of 0.50 s.

The markings are painted on the road at intervals of 1.52 m.

0.8 cm = 1.52 m



$t = 0$ s

$t = 0.50$ s

The speed limit is 50 km per hour.

Determine, using information from the diagrams, whether the car was exceeding the speed limit.

(4)

$\dfrac{3.4}{0.8} \times 1.52 = 6.46\,m$

$50\,kmh^{-1} = \dfrac{50 \times 10^3}{3600}$

$V = \frac{6.46}{0.5}$ = 13.89 ms^{-1}

= 12.92 ms^{-1} • The speed of car is less than the speed limit. Hence, it was not exceeding.

ResultsPlus
Examiner Comments

This type of response was quite common, and is perfectly acceptable, although it might take a little longer to complete. The candidate has drawn onto the diagrams, measured the distance travelled with a ruler, and divided that by the actual length of each division to give the number of divisions and hence the true distance travelled.

ResultsPlus
Examiner Tip

Do not assume there is a single correct method. Go with the way you best understand.

Question 14 (c)

This item was worth a single mark for stating that there could be a parallax error in measuring the distance the car travels in the 0.5s. We were just looking for the word parallax, and we were expecting that word as it is a clear technical term. Many who seemed to understand the principle involved lost the mark for failing to say parallax.

There were many incorrect responses given, such as a zero error, human error, difficulty in reading the distance accurately, and reaction time.

This was a good response that gained the mark.

(c) The position of the camera may result in an error in the calculated speed.
Suggest why.

(1)

This is because if the camera is not exactly perpendicular to readings, this will cause parallax error and distance calculated will be incorrect.

(Total for Question 14 = 7 marks)

ResultsPlus
Examiner Comments

In this case we were just looking for "parallax", but the extra description is useful and another time might gain further credit.

The next two responses did not gain the mark.

This is because the car is not stopped exactly at the divisions, ~~so~~ the camera reading doesn't show the exact distance.

(Total for Question 14 = 7 marks)

ResultsPlus
Examiner Comments

This was quite a common response, but there is no reason for not mentally subdividing the large divisions, and is something the candidates at this level should be able to do.

ResultsPlus
Examiner Tip

There is no reason not to read a scale to a fraction of a division.

Reaction time ~~when~~ when using the camera.

ResultsPlus

Examiner Comments

This was another common, incorrect response. The camera does not have a significant reaction time.

Question 15 (a)

There were 5 marks for this question:

Mark 1 was for a tall container of oil, usually on a diagram, with the top of the oil shown.

Mark 2 was for two markers between which the fall of sphere was timed, often two rubber bands around the cylinder. The markers had to be away from the top and bottom of the oil, to allow the sphere to reach terminal velocity, and enable accurate determination of that velocity.

Mark 3 was for measuring the distance fallen with a metre rule or ruler. The word "calculate" was not allowed for "measure" as no calculation was involved at this point.

Mark 4 was for measuring the time for the sphere to fall between the markers, using a stopwatch or timer. For these marks, the stopwatch or metre rule need not be specifically referred to if listed in an apparatus list or labelled on a diagram. A few responses referred to the time of fall from when the sphere was dropped, which was clearly incorrect as it was not all at the terminal velocity.

Mark 5 was for a reference to repeating the measurements, particularly the time, and this mark was not often awarded.

For a very straightforward experiment, it was disappointing to see the difficulty the candidates had in describing it. This question was not about determining the viscosity of the oil, but many candidates went into great detail about how the mass and diameter of the sphere would be determined, and gave the equation into which they would be substituted. The question is clearly just about determining the terminal velocity of the sphere, and anything further will gain no credit but could take a lot of time.

In addition, the question only asks for the apparatus and the measurements. It does not ask how the measurements would be used, so it was not required to describe the calculation of the terminal velocity, as many did, often using a graph.

Good candidates were able to give a clear, labelled diagram, without unnecessary apparatus, and wrote concise and clear statements about the measurements to be made.

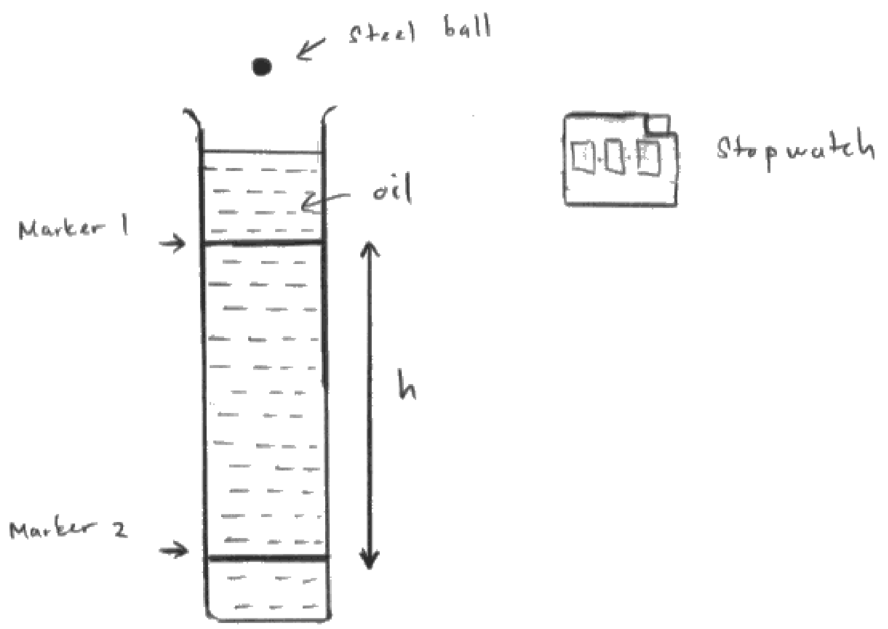
This first sample gets all 5 marks.

15 (a) A student investigated the motion of a small sphere falling through oil.

The sphere was released at the top of a cylinder containing oil and measurements were taken to enable the terminal velocity of the sphere to be determined.

Describe the apparatus the student should use and the measurements to be taken. The student does **not** have access to a motion sensor or a data logger. You may include a labelled diagram in your answer.

(5)



1. The diameter of the steel ball is measured using a micrometer screw gauge for a few times ~~at~~ in several different ~~orr~~ orientation and the average is taken.

2. The ~~ste~~ height between marker 1 and marker 2 is ~~ca~~ measured using a metre rule.

3. The steel ball is gently dropped from the top of the measuring cylinder

4. The stopwatch is started immediately once the steel ball passes through the first marker and stopped once it passes through the second marker.

5. Terminal velocity = $\frac{\text{distance travelled}}{\text{time taken}}$

6. Experiment is repeated and results are averaged out.

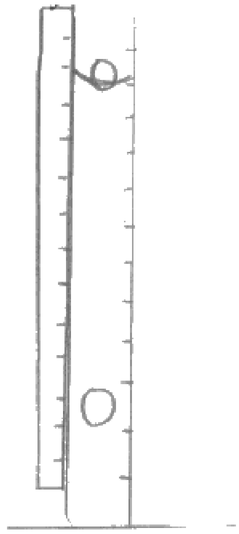
ResultsPlus
Examiner Comments

This diagram is drawn carefully, with a ruler, and is fully labelled, including an indication of the top surface of the oil - important when deciding where the top marker should be. The numbered steps in the written response make the method absolutely clear. The only problem is the inclusion of step 1, the measurement of the diameter, which is unnecessary.

ResultsPlus
Examiner Tip

If you draw a carefully labelled diagram, it often not only gains you marks but also focuses your mind on the method to be used.

This response gained one mark only for measuring the distance.



(5)

we many use a meter rule to measure the distance that the ball has fallen down

use a stopwatch to measure the time taken to reach the terminal velocity

a long cylinder is also needed to enables the ball to reach the terminal velocity.

~~use~~ use a small and dense ball to decrease drag

ResultsPlus

Examiner Comments

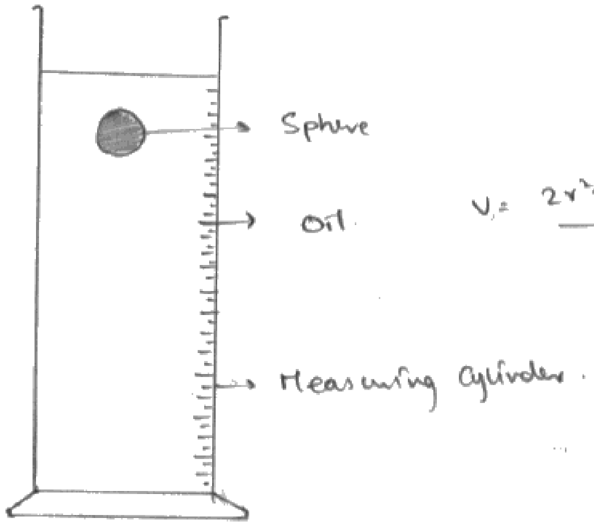
The diagram is somewhat carelessly drawn, and not labelled. There are no markers shown - the graduations are not sufficient. The time measured is the time to reach terminal velocity, so is incorrect. This candidate seems to have a reasonable understanding of the method, but an unclear drawing and lack of detail in the method have lost the marks.

ResultsPlus

Examiner Tip

Label diagrams.

This response gained a single mark for the diagram.



$$v = \frac{2r^2g(\rho}{9\eta}$$

The student must use a micrometer screw gauge to measure the radius of the sphere and an electric balance to record the mass. The density can be calculated $\rho_s = \frac{m}{v}$. Volume of the oil can be recorded using the measuring cylinder. Oil of known viscocity must be used. Using the balance first record the mass of empty cylinder and then cylinder with oil. Subtract the two to find mass of the oil. Work out the density of the oil using $\rho_f = \frac{m}{v}$. Find the velocity using $v = \frac{2\pi r^2 g(\rho_s - \rho_f)}{9\eta}$

Repeat the reading and take average for a reliable result.

ResultsPlus

Examiner Comments

This response occurred rather too often. Rather than the simple calculation of terminal velocity, this method requires the density of the oil and its viscosity to be known, along with the complex equation for terminal velocity. This equation would normally be used when determining the viscosity of a liquid, or when calculating the terminal velocity without doing an experiment, so the method was not allowed for this question.

Question 15 (b)

There were 6 marks for this question, 2 for the graph for a vacuum and 4 for the graph for oil.

Mark 1 was for stating that the vacuum graph showed a constant acceleration. That was often done by saying that the acceleration was *g*, or $9.8ms^{-1}$, but it was not sufficient just to describe the graph by saying the line was straight. This mark was commonly gained.

Mark 2 was for the reason that the acceleration was constant, and it was clear that the physics of free fall was not well understood. Few were able to say that in free fall, weight is the only force acting. It was not sufficient to say that there was no drag or no uprhrust; we were looking for the positive statement about the weight. It was surprising how many candidates seemed to think that the viscosity of a vacuum was significant, just rather less than of the oil.

Mark 3 was for the implication that in the oil there was both upthrust and drag. This did not have to be an explicit statement, and often was picked up when mark 5 was being checked.

Mark 4 was for a statement that the viscous drag increases as the speed increases. It was not sufficient to say, as many did, that the viscous drag increases with time, although it clearly does. Such a statement does not explain what is happening, and the question asks the candidate to "explain". A few said that the viscosity increased with velocity, clearly incorrect.

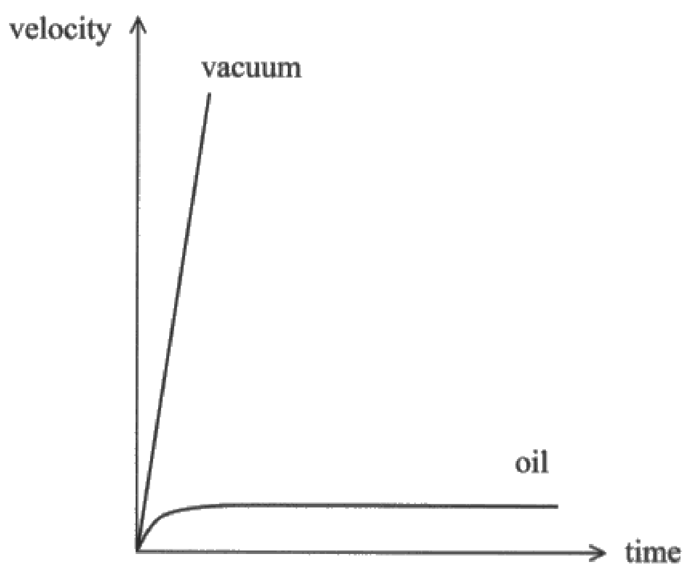
Mark 5 was for saying that the resultant force becomes zero (at the terminal velocity). This was often expressed in a form such as upthrust + drag = weight, which would also gain mark 3.

Mark 6 was for describing the terminal velocity. We were hoping that they would say that when terminal velocity is reached the velocity becomes constant or the acceleration becomes zero, but many neglected to mention terminal velocity.

This excellent response scored all 6 marks.

*(b) A teacher demonstrated the motion of a small sphere falling through a vacuum and through oil.

The teacher used a motion sensor and data logger connected to a computer. The computer plotted graphs of velocity against time for the sphere as shown.



Explain the differences between the shapes of the graphs.

(6)

When the sphere is ~~droped~~ dropped in vaccum it ~~mo~~ falls with constant accelerstion and the acceleration won't change as shown in graph, constant gradient of velocity vs time graph for vaccum, this is because the only weight acting on the sphere is it's weight (mass x g) thus there is no air to provide upthrust nor drag force. When sphere is dropped through oil at first ~~up~~ weight of sphere is greater than upthrust therefore it sinks but as it's velocity increases the drag force opposing the motion also increases due to viscocity of the liquid. Thus at one point Upthrust + drag force = weight of the sphere. The resultant force is zero ∴ sphere travells in constant speed reaching terminal velocity.

ResultsPlus

Examiner Comments

This candidate clearly does understand the physics of free fall, and explains the vacuum graph well. The existence of upthrust and drag when falling through the oil is well described, as is the reason for reaching terminal velocity.

Question 16 (a)

There was a total of 4 marks for this item.

Mark 1 was for drawing the two force vectors to scale. Although the examiners were quite lenient when it came to judging the drawing of the 16N and 19N vectors, we would have liked to see the scale used indicated, arrows on the vectors and labels beside them. Most candidates were able to correctly draw the two vectors and to score this mark. Some candidates rotated the diagram by 7° so that the 19N vector was horizontal on the paper, which was fine, and probably a good decision to make. However, such candidates then sometimes forgot to rotate the 16N force, or to add on the 7° when measuring the final answer.

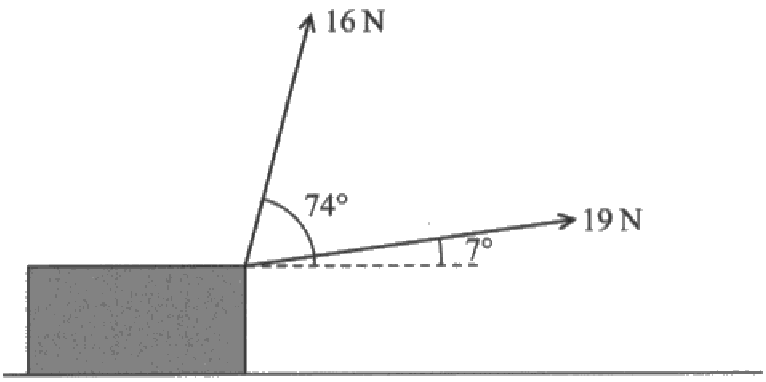
Mark 2 was for constructing and drawing the resultant force, either by the parallelogram method or the triangle method. The candidates found this construction harder than we had anticipated, and perhaps a bit more practice at such constructions would be helpful.

Marks 3 and 4 were for measurement of the magnitude and angle of the resultant force. A good number did this last part by calculation rather than by measurement from the drawing, and those who did so would not obtain the marks. The question asks the candidates to use the constructed vector diagram to determine the resultant, and so we were testing their drawing skills and knowledge of vector diagrams in this question, not their use of trigonometry.

Overall, a good number of the candidates answered this question well. In general, more practice at accurately constructing vector diagrams would be useful, as many lost marks through inaccurate drawing or measurement. Sometimes the candidates forgot to use the scale factor when converting the length of the resultant back into a force. Another common mistake was to miss the unit off the answer, especially the degree sign.

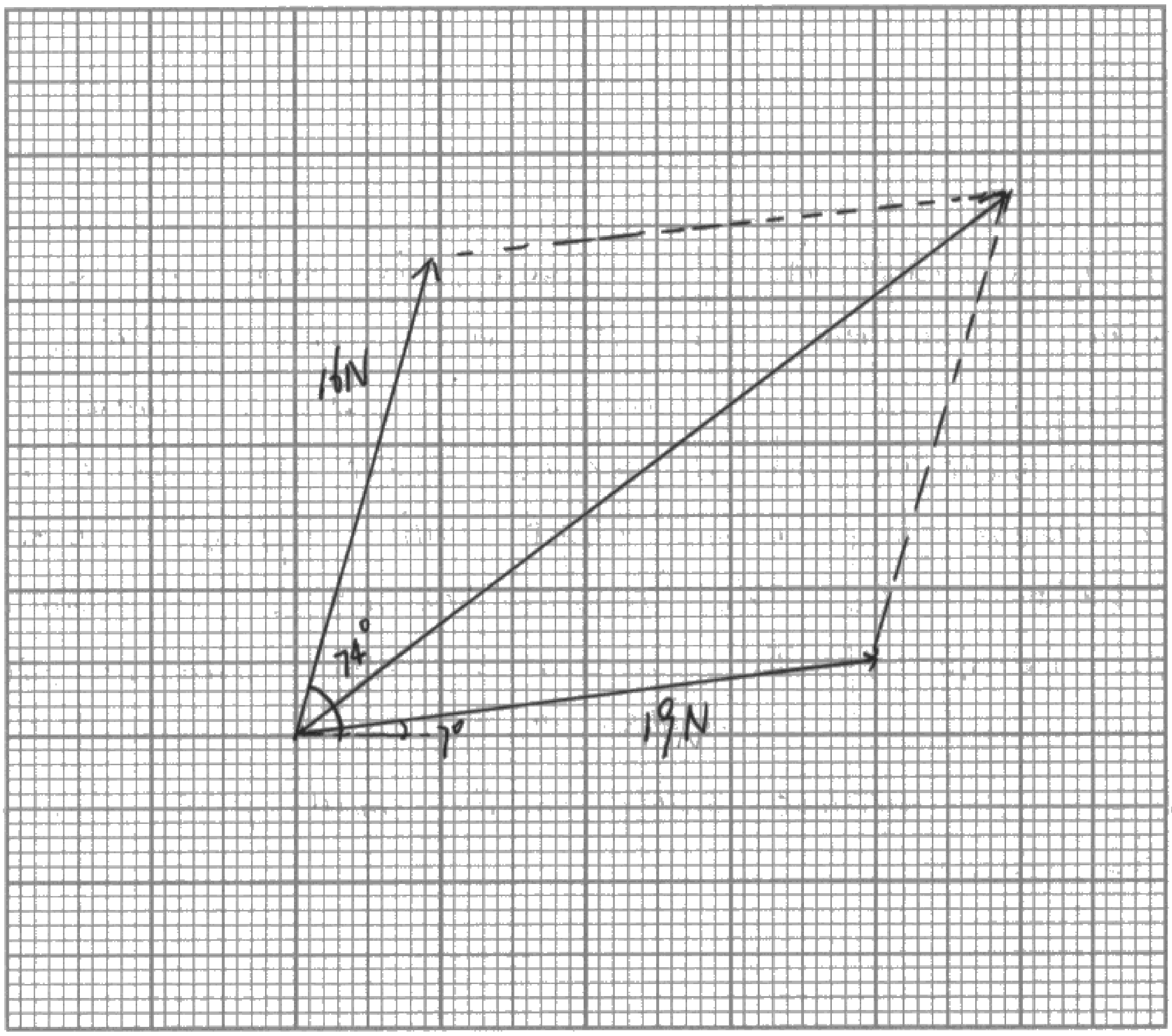
This good response gained all 4 marks, as did many of the responses we saw.

16 (a) Forces of 19 N and 16 N act on a box at angles to the horizontal of 7° and 74° respectively, as shown.



Construct a scaled vector diagram on the graph paper to determine the resultant of the two forces.

(4)



Magnitude of resultant force = 29 N

Direction of resultant force to the horizontal = 37°

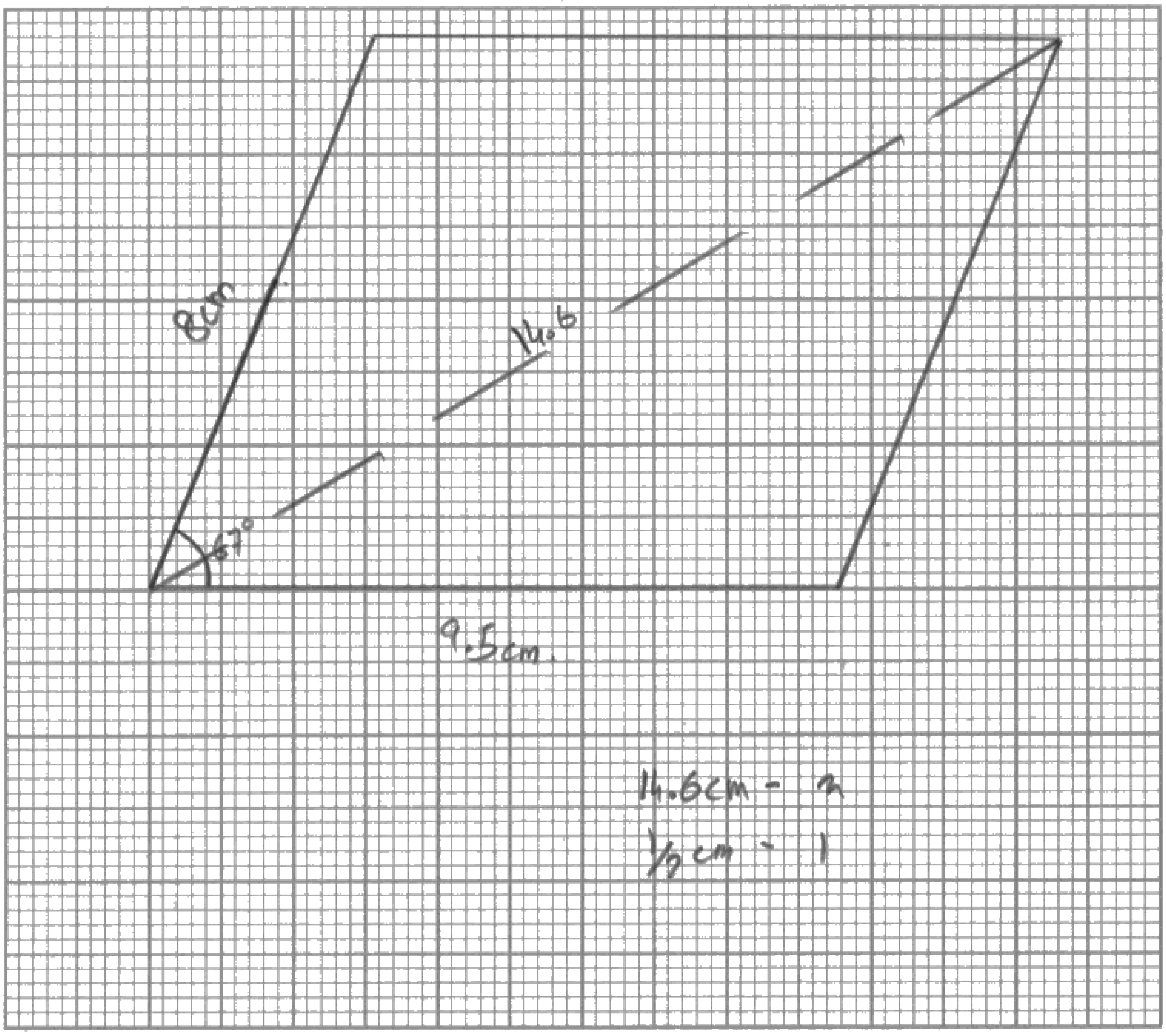
ResultsPlus
Examiner Comments

The vectors are carefully drawn and labelled, and the construction of the parallelogram is clear. It would have been helpful to state the scale used. The diagram is a good size, filling most of the graph paper.

ResultsPlus
Examiner Tip

Do not rush the drawing of an accurate diagram.

This gained 3 marks.



Magnitude of resultant force = 29.2 N.

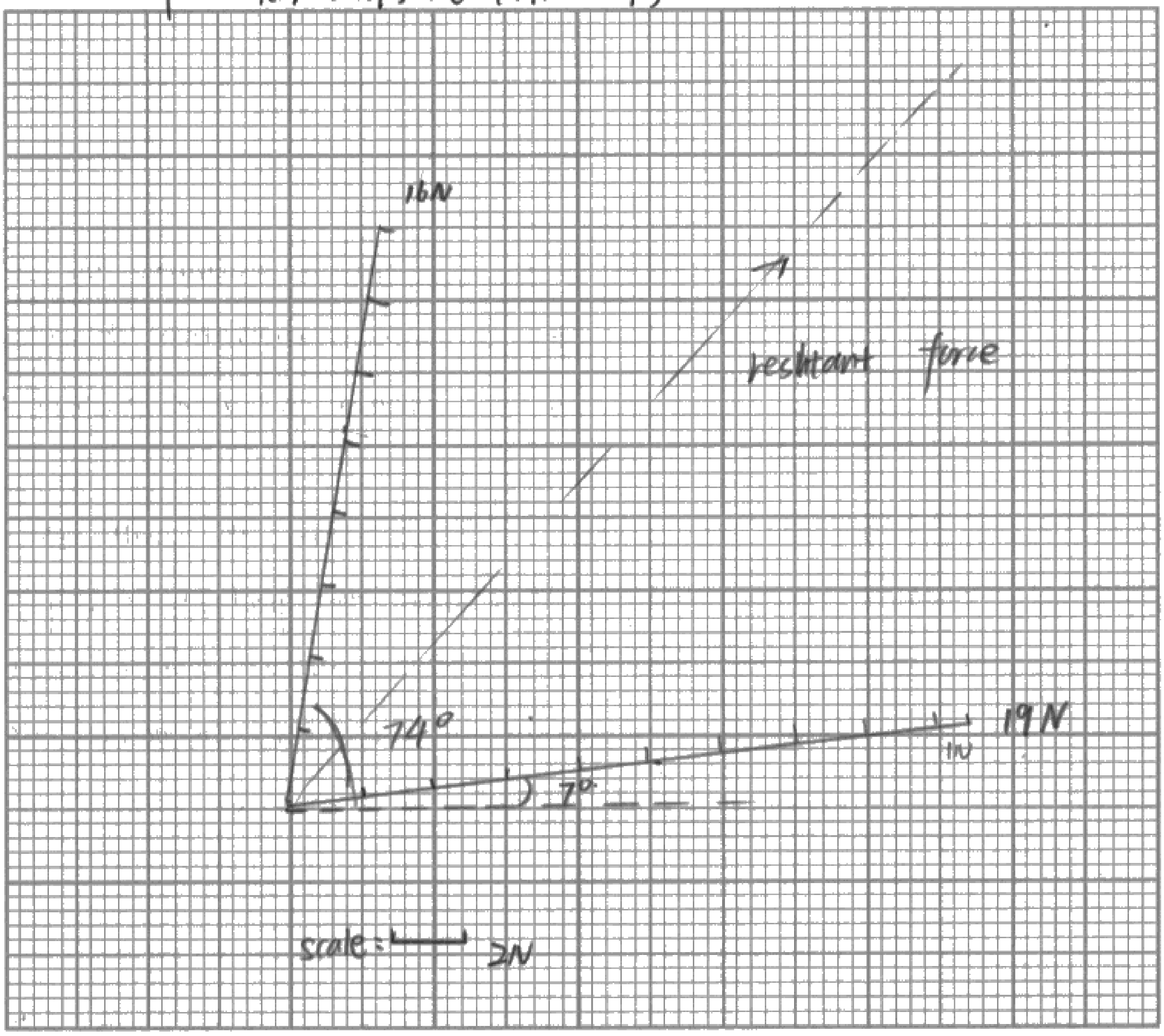
Direction of resultant force to the horizontal = 27°

ResultsPlus
Examiner Comments

We would have liked arrows on the vectors here, but the drawing is good. It has been rotated by 7° to make the 19N vector horizontal, and the 16N vector is likewise rotated. The parallelogram construction is shown, with an accurately drawn diagonal. However, the final angle is not measured accurately and the 7° for the rotation has not been added on.

This response was awarded the first mark only.

resultant force $= \sqrt{(19\times \sin 67^\circ)^2 + (16+19\times(\cos 67^\circ))^2} = 29.232\ldots \approx 29.2\,N$ **(4)**



Magnitude of resultant force = 29.2N

Direction of resultant force to the horizontal = 37.2°

ResultsPlus
Examiner Comments

There is no way of seeing how the resultant was constructed, and the answers were clearly determined by calculation.

ResultsPlus
Examiner Tip

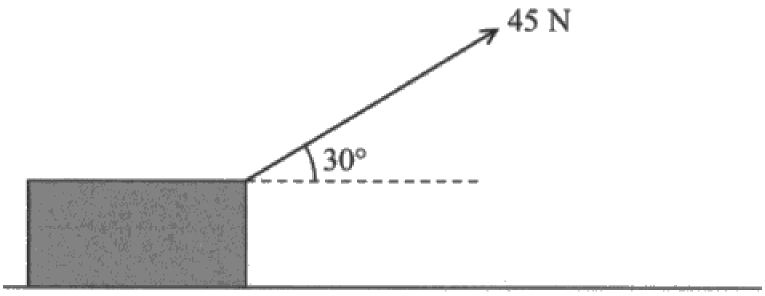
Please answer the question as it is written, even if, as here, more accurate methods are available.

Question 16 (b)(i)

There were 2 marks for this item, one for an arrow starting on the dot and directed to the left, labelled friction, and a second mark for an arrow vertically down, starting on the dot, and labelled weight, *mg* or *W* but certainly not gravity. Any additional forces led to the deduction of marks. This straightforward question was generally well answered.

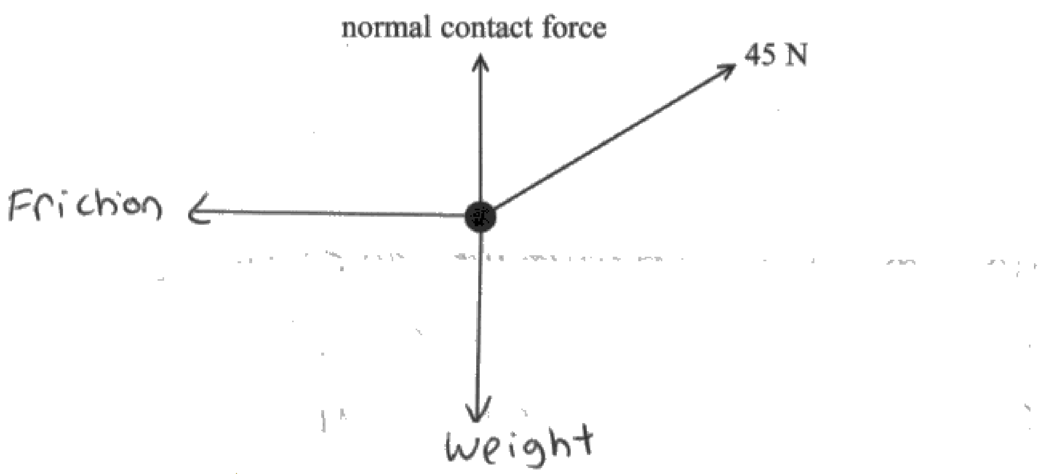
This correct response scored both marks. Those below were less than perfect.

(b) A force of 45 N is applied to the box at an angle of 30° to the ground as shown.



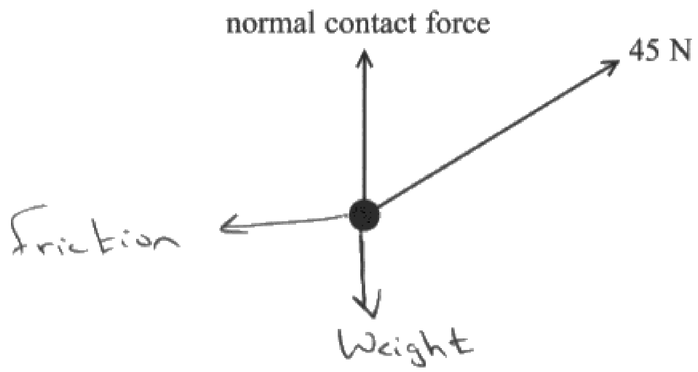
(i) Complete the free-body force diagram for the box. Assume the surface of the ground is not smooth.

(2)



ResultsPlus
Examiner Comments

Arrows are accurately drawn, with a ruler, starting on the dot and in the correct directions. We were not concerned about the length of the arrows here.

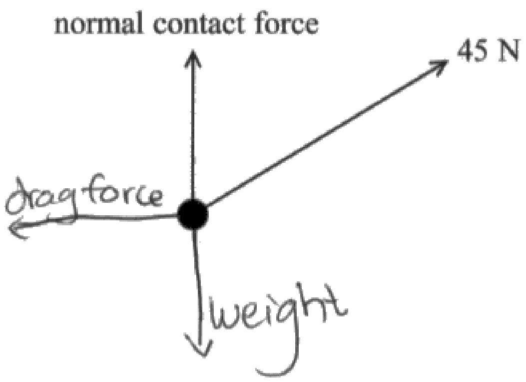


ResultsPlus
Examiner Comments

This response was rather carelessly drawn, and the friction arrow is clearly not horizontal, but did score 2 marks.

ResultsPlus
Examiner Tip

Use a ruler for straight lines on a diagram.



ResultsPlus
Examiner Comments

This is another fairly typical response, but again the drawing is rather careless, and in this case, the label "drag force" was not accepted. This is sliding friction between the box and the ground. It scored 1 mark.

Question 16 (b)(ii)

This 4 mark calculation was answered well by many candidates, but there was some confusion in combining the vertical component of the 45N with the weight to give the normal contact force with the ground.

Mark 1 was for showing how the vertical component of the 45N would be calculated, usually 45sin30°.

Mark 2 was for showing how the weight would be calculated, using *W=mg.*

Mark 3 was for showing that the normal contact force was equal to the weight minus the vertical component calculated above. It should be the weight minus 45sin30°. However, many candidates added these forces rather than subtracting them, which would lose this mark and the next answer mark.

Mark 4 was for the answer, which was 17 N.

(ii) Determine the normal contact force of the ground on the box.

mass of box = 4.0 kg

(4)

vertical component of 45N = cos(60) × 45
= 22.5N

weight of box = $\overset{(m \times g)}{4 \times 9.81}$
= 39.24 N

normal contact force = 39.24 − 22.5
= 16.74
= 17

Normal contact force = 17N

(Total for Question 16 = 10 marks)

ResultsPlus
Examiner Comments

This well written and fully correct response gained the 4 marks.

(ii) Determine the normal contact force of the ground on the box.

mass of box = 4.0 kg

(4)

w = 4 × 9.81 = 39.24

45sin30 = 22.5

NR − 39.24 = 22.5

NR = 22.5 + 39.24

NR = 61.74

Normal contact force = 61.7 N

(Total for Question 16 = 10 marks)

ResultsPlus
Examiner Comments

This common response was awarded the first 2 marks only, as the forces have been added. We might have expected that obtaining a contact force larger than the weight might have caused a rethink of the answer.

ResultsPlus
Examiner Tip

You should check that your answer is reasonable.

Question 17 (a)

There were 2 marks for this item, for stating and describing the property:

Mark 1 was for identifying the property as malleable.

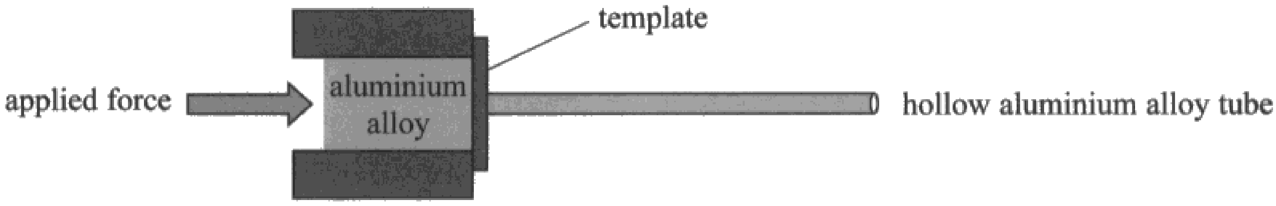
Mark 2 was for describing that property as undergoing plastic deformation under compression.

The candidates found it difficult to choose between malleable and ductile, with malleable just about being the more common choice. The alloy is being pushed through the template, not pulled, so malleable is correct. Most candidates could then say that there was a large plastic deformation, but a very large number then failed to describe it as being under compression. Some gave a choice of properties and so lost the marks.

The response below gained 2 marks.

17 A bicycle frame consists of hollow tubes made from an aluminium alloy.

(a) To produce the tubes, the aluminium alloy is pushed through a template as shown.



State and describe the property of the aluminium alloy that allows it to undergo this process.

(2)

Malleable, shows large plastic deformation under compression, can be beaten up into shape.

ResultsPlus
Examiner Comments

Both the property and the description are correct. The statement about being beaten into shape is a development of the idea of plastic deformation under compression, and so can be ignored by the examiners.

ResultsPlus
Examiner Tip

Learn clear, succinct definitions of terms, as in this response.

This response gains 1 mark.

Aluminium is malleable. It shows large plastic deformation when placed under a significant amount of stress. It can be bent and hammered into shapes due to this property.

ResultsPlus
Examiner Comments

The candidate gains mark 1 for "malleable", but, although describing the large plastic deformation, there is no indication that it is under compression, so loses mark 2.

ResultsPlus
Examiner Tip

Note the incomplete definition.

This response scored zero marks.

Because Aluminium is strong it won't break or fracture due to the applied force, and because it's malleable it can be hammered and forced into different shapes and thin sheets.

ResultsPlus

Examiner Comments

The candidate says the significant property is malleable, but also says it is strong. As the examiner has been given a choice of properties, mark 1 could not be awarded.

ResultsPlus

Examiner Tip

Be careful about giving the examiner a choice of answers when you are unsure of the correct response.

Question 17 (b)(i)

There were 3 marks for this item, one for yield point, one for the meaning of strength, and one for the meaning of tensile.

The majority of candidates had not properly understood the meaning of these terms, which is a pity as the marks for those who had learnt the definitions were easy to achieve. This is one of those situations where knowledge of physics is being tested, rather than its understanding or application.

In practice, "yield" can have many meanings, but as far as this examination specification is concerned, yield point is not the same as the elastic limit. At the yield point, a small increase in stress gives rise to a large increase in strain. We did insist on the word "increase", or similar, and not just "change", and the common response that a small stress produces a large strain is clearly incorrect as the stress is probably already large.

Strength as being the stress required to fracture was slightly better understood, although many described the word "strong" instead, and the candidates need to understand the difference, that even weak materials have a strength that can be measured. Very few told us what "tensile" meant, usually just requoting the word tensile in the response.

This good response gained all three marks.

(i) State what is meant by

(3)

yield point At this point the material shows a large increase in strain for a small increase in stress

tensile strength Maximum stress before breaking under tension.

ResultsPlus

Examiner Comments

The response gives the correct definition of all three words. "Under tension" is all we required for "tensile", but "when being stretched" or similar would be equally good.

ResultsPlus

Examiner Tip

The 3 marks give a clue to the 3 statements required.

This response would gain one mark for the description of "strength".

(i) State what is meant by

(3)

yield point is the point beyond which ~~where~~ a small change in ~~strain~~ stress produces a large change in strain.

tensile strength It is the maximum stress a ~~[illegible]~~ material can withstand before ~~breaking,~~ breaking.

ResultsPlus

Examiner Comments

The yield point is described in terms of a change of stress/strain rather than an increase, so does not get the first mark. A small reduction of stress would not result in a large reduction in strain.

There is no attempt to describe "tensile".

This response would get a single mark for describing "tensile".

(i) State what is meant by

(3)

yield point This refers to the onset of plastic deformation.

tensile strength This refers to the maximum amount of tension (tensile force) a material can withstand.

ResultsPlus

Examiner Comments

Yield point is confused with elastic limit, so does not get the first mark.

"Withstand" alone is not sufficient, we need before breaking or fracture. Withstand could mean before the plastic deformation begins. The same applies to the word "failure".

ResultsPlus

Examiner Tip

Learn definitions.

Question 17 (b)(ii)

This simple calculation was well answered. The candidates had to understand the meaning of strain, and how it is calculated, and the difference between extension and length.

Mark 1 was for correctly using strain = Δ*x*/*x*. The candidates had to use the strain from the table in the question, which most did, but some attempted to use the other data in the table also, so losing this mark, and mark 3.

Mark 2 was for adding the original length to Δ*x*. A surprising number of candidates failed to add the 80cm and quoted their value of Δ*x* as the length of the tube, which lost them both this and the final marks.

Mark 3 was for the answer of 90cm (usually 89.6cm).

This response is all that is required to gain all three marks.

(ii) A tube made from this alloy has an original length of 80 cm.

Calculate the length of the tube at fracture.

(3)

Strain $= \frac{\Delta x}{x}$

$0.12 = \frac{\Delta x}{0.80}$ $\Delta x = 0.12 \times 0.80 = 0.096$ m

$0.8 + 0.096 = 0.896$ m $= 89.6$ cm

Length of tube = 89.6 cm

ResultsPlus
Examiner Comments

A good and clear response with all the working shown.

This response was awarded marking point 2 only.

$$E = \frac{\sigma}{\varepsilon}$$

$$276 = \frac{310}{\frac{\Delta x}{0.08}}$$

$\Delta x = 14.034$ meter

$\therefore$ The length $= 14.034 + 0.08$

$= 14.119$ meter

$= 14.1$ meter (3 s.f.)

Length of tube = 14.1 mete

ResultsPlus

Examiner Comments

The candidate has somehow calculated a value for Δ*x* using other data from the table, but not using the strain on fracture. However, the original length has been added, and gains the second method mark even though there is a power of ten error in the value of the original length.

Question 17 (c)

This question demanded some reasonably good communication skills from the candidate. Most responses had some sensible physics points, but the way they were expressed and developed did not lead to the award of many marks. There were three marks in total for the item.

Mark 1 was for stating that the mass of the aluminium bicycle would be less than the mass of the steel bicycle. Most candidates were awarded this mark, but many did not mention the mass, just saying that the bicycle would be lighter, or would weigh less, neither of which would gain the mark.

Mark 2 was for saying that the rider would be providing the same force to the bicycle. That seems likely since in a race you would expect the rider to apply as much force as possible.

Mark 3 was for saying that, in such a case, the lower mass bicycle would have a greater acceleration.

An alternative approach for marks 2 and 3 is to say that if the rider is providing the same KE to the bicycle, the lower mass would result in a greater speed.

Mark 2 is the one that was most rarely seen, most candidates jumping to the higher speed or higher acceleration without further explanation.

Many candidates missed the point of the question by writing about quite different properties, such as the stiffness of the frame or its strength. These properties had not been given for steel anywhere in the question, and also had nothing to do with density.

This response gained all 3 marks.

(c) Bicycle frames can also be made from an alloy of steel. The density of the steel alloy is greater than the density of the aluminium alloy.

Explain why a bicycle with an aluminium alloy frame is better for racing.

(3)

density = $\frac{\text{mass}}{\text{volume}}$.

For equal volume, the mass of a bicycle with an aluminium alloy frame has lower mass. ~~the~~

As ~~the~~ resultant force = ma, for equal amount of force applied, the bicycle with lower mass experiences greater acceleration.

(Total for Question 17 = 11 marks)

ResultsPlus

Examiner Comments

The candidate tells us the mass is lower, and gives a reason. The fact that the force would be the same is stated, leading to a greater acceleration due to *F=ma*.

This response gained 2 marks, and uses the alternative reasoning concerning the kinetic energy of the bicycle.

Because the density of aluminium is lower than steel that the mass of bicycle maked of Al is lower than bicycle maked of steel. when ride the bicycle the chemistry energy of rider transform to kinetic energy of bicycle.
~~mass x 9.8 x h~~ kinetic energy = $\frac{1}{2}$ x mass x velosity^2 / velosity = $\sqrt{\frac{\text{chemistry energy}}{\frac{1}{2} \times \text{mass}}}$
so lower mass have a bigger velosity.

ResultsPlus
Examiner Comments

The first mark is gained for the lower mass, and the third mark for the greater speed. Unfortunately, the candidate does not mention that the KE would be the same.

This is an unfortunate response that does not quite get any of the marks, although each part of the response was very commonly seen.

because density of aluminum is lower than ~~stell~~ steel, producing an aluminum frame would be lighter, this would help in racing as it would take less force to accelerate the aluminum Bicycle

ResultsPlus
Examiner Comments

The response does not mention the mass, just that the bicycle would be lighter - probably referring to weight rather than mass.

While mentioning acceleration, the response does not say the acceleration would be greater, and nor is there a statement about the force being constant.

It is a pity that the response is too vague to get any of the marks, although the candidate has an awareness of the physics involved.

ResultsPlus
Examiner Tip

Be careful with the scientific terms used, such as mass, acceleration, velocity etc.

Question 18 (a)

There were two parts to this question.

Part (i) was a calculation of the velocity of the flea immediately after take-off, for 4 marks.

Mark 1 was for converting the power per kg to an actual power, buy multiplying the 660 W kg^{-1} by the mass of the flea (0.70 mg). There were many examples of this step being ignored, and the 660 being used directly as the power of the flea. There were also many errors in the powers of ten, in the 0.70 mg and later in the 0.85 ms.

Mark 2 was for calculating the energy transferred as the calculated power of the flea is applied for 0.85 ms.

Mark 3 is for using the kinetic energy equation to calculate the velocity of the flea with the energy calculated previously.

Mark 4 was for the answer of 1.1 ms^{-1}.

It was clear that some candidates need a great deal more practice in using powers of ten correctly. There were many poor attempts in this question, and students need to be taught carefully what the abbreviations and sub-multiples actually mean in powers of ten. The units used in this question were no more that GCSE level, but the ability to use all the SI prefixes is required.

Part (ii) went on to calculate the acceleration of the flea at take-off.

Mark 1 was for the use of the equation for acceleration.

Mark 2 was for the calculated acceleration as 1250 m s^{-2}.

This part of the question was usually well answered, with any error in the velocity being carried forward from part (i). Full credit is given if the "show that" value of 1 m s^{-1} from part (i) is used in the part (ii) calculation.

This good response gained all six marks.

18 In an investigation of the jump of fleas, measurements were taken from a high speed video.

The body of a flea can provide a maximum power of 660 watts per kilogram.

(a) A flea of mass 0.70 mg takes 0.85 ms to take-off from rest.

(i) Show that the maximum velocity of the flea is about 1 m s^{-1}.

(4)

~~W=~~ $P = 660 \times 0.7 \times 10^{-6}$
$= 4.62 \times 10^{-4}$ W
$W = Pt = 4.62 \times 10^{-4} \times 0.85 \times 10^{-3}$
$= 3.927 \times 10^{-7}$ J.
$E = \frac{1}{2}mv^2$.
$3.927 \times 10^{-7} = \frac{1}{2} \times 0.7 \times 10^{-6} \times v^2$.
$v = 1.06$ m/s

(ii) Calculate the average acceleration of the flea at take-off.

(2)

$a = \frac{v}{t} = \frac{1.06}{0.85 \times 10^{-3}} = 1247$ m/s²

Average acceleration = 1247 m/s²

ResultsPlus
Examiner Comments

Part (i) - This response shows clearly how the power of the flea is calculated, and then the value of the energy transferred. That is substituted into the kinetic energy equation and the velocity of the flea is correctly calculated.

Part (ii) - the acceleration is now correctly calculated.

ResultsPlus
Examiner Tip

If the working is made clear, as in this response, it is easier to give credit should the final answer calculated be incorrect.

Part (i) gained 2 marks. Part (ii) gained 1 mark.

18 In an investigation of the jump of fleas, measurements were taken from a high speed video.

The body of a flea can provide a maximum power of 660 watts per kilogram.

(a) A flea of mass 0.70 mg takes 0.85 ms to take-off from rest.

(i) Show that the maximum velocity of the flea is about 1 m s^{-1}.

(4)

$v = u + at$ $F = ma$ 0.0007

$P = F \times v$ (0.7) $\frac{660}{1000\,g} = \frac{x}{0.0007\,g}$

$3.927 \times 10^5\ W/s = F \cdot v$ Power $= 4.62 \times 10^{-4}\ W$

$\cancel{0.7} = 1.15\ m/s$ $\times 0.85\ ms$

$= 3.927 \times 10^5\ W/s$

$v = 1.15\ m/s$

(ii) Calculate the average acceleration of the flea at take-off.

(2)

$a = \frac{v-u}{t}$ $\cancel{u=0}$ $a = \frac{v}{t} = \frac{1.15\ m/s}{0.85\ ms}$

maxim velocity $v = 1.15\ m/s$ $\frac{1.15\ m/s}{0.85\ ms}$

$\frac{1.15}{0.085} = 13.529$

Average acceleration = $13.529\ m/s^2$

ResultsPlus

Examiner Comments

In part (i) the response gets the first 2 marks only. The power is calculated correctly, but there is a power of ten error in calculating the energy, and also the units of the energy are incorrect (W/s). However, these errors did not deny the candidate the second mark. The wrong equation is then used to calculate the speed.

Part (ii) has a power of ten error in the calculation, so gains the first mark only.

Question 18 (b)

Many candidates answered this projectile question well, perhaps rather better than in previous years. The independence of the vertical and horizontal motion was generally well understood, and most candidates realised the need to calculate the horizontal and vertical components of the take-off velocity. Calculating the time for the jump using the vertical component of the take-off velocity was the most challenging part of the calculation, and many candidates only found the time to the top of the path, forgetting that this time needed to be doubled.

There were four marks here:

Mark 1 was for showing how the vertical component of the take-off velocity should be calculated.

Mark 2 was for showing how equations of motion should be used to calculate the time of flight. This can be done either by using $v=u+at$ with $a=-g$ and $v=0$, which would give half the time of flight, or by using $s=ut+\frac{1}{2}at^2$ with $s=0$ and $a=-g$ which would give the full time of flight. Many of those who chose the former equation did not double the time.

Mark 3 was for multiplying the horizontal component of the take-off velocity by time.

Mark 4 was for the correct final answer of 0.14 m.

In multi-step calculations such as this one, candidates should be wary of rounding values mid-way through the calculation, as that can lead to a slightly incorrect final answer. They should always work to a larger number of significant figures than they will quote in the final answer.

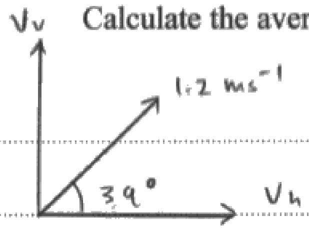
A number of candidates used the range equation to calculate the distance. Although such a response does not demonstrate an understanding of the physics involved, a correct answer determined by that method was allowed for full marks. However, any slight error in remembering the equation would be heavily penalised, as there would be no demonstration of any understanding of the physical processes involved.

Both the responses below gained all four marks.

(b) The measurements were repeated with many fleas. The average initial velocity of the fleas at take-off was 1.2 m s^{-1} at 39° to the horizontal.

Calculate the average horizontal distance that a flea would travel.

(4)



$V_h = 1.2 \cos 39°$ $\qquad$ $V_v = 1.2 \sin 39°$

$= 0.933 \text{ ms}^{-1}$ $\qquad$ $= 0.755 \text{ ms}^{-1}$

$U_v = 0.755$ $\qquad$ $a = \frac{v-u}{t}$ $\qquad$ Horizontal distance $= V_h \times 2t$

$V = 0$ $\qquad$ $= 0.933 \times 2(0.076981)$

$a = -9.81$ $\qquad$ $-9.81t = 0 - 0.755$ $\qquad$ $= 0.1436 \text{ m}$

$t = ?$ $\qquad$ $t = 0.076981 \text{ s}$

Average horizontal distance = 0.1436 m

ResultsPlus
Examiner Comments

This candidate has clearly shown the calculation of the horizontal and vertical components of the take-off velocity, has used the vertical motion to determine the time of flight, and then shown how the horizontal distance is calculated. As is usual in these theory papers, we did not penalise the excessive number of significant figures quoted in the final answer.

ResultsPlus
Examiner Tip

Note the clear layout of the working.

$$\text{Range} = \frac{u^2 \sin 2\theta}{g}$$

$$= \frac{(1.2)^2 \sin 2 \times 39}{9.8}$$

$$= 0.144 \text{ m.}$$

Average horizontal distance = 0.14 m.

ResultsPlus

Examiner Comments

This is an example of the range equation being used to calculate the horizontal distance. However this equation is not in the data provided, nor is it in the specification, and many candidates who attempted to answer the question this way lost a lot of marks. For instance, some used a component of the velocity for *v*. If the equation is misremembered, then all 4 marks would be lost.

ResultsPlus

Examiner Tip

It is best to use the equations given in the exam specification.

Question 18 (c)(i)

In general, the candidates were able to use the Young modulus and the area to calculate the force applied. However, they then very often calculated the energy stored as force × compression, forgetting the factor of ½. It was uncommon to see full marks for this question, as many other, somewhat careless, mistakes were made. Power of ten errors in calculating the area were common, with the μm not being well understood by all, and some even used volume where area was required.

There were five marks here:

Mark 1 was for demonstrating the use of the Young modulus equation.

Mark 2 for using the given value of strain to determine the stress.

Mark 3 was for multiplying the stress by the area to calculate the force.

Mark 4 was for using the candidate's calculated value for energy stored and the total energy of 0.80μJ to calculate the required percentage.

Mark 5 was for the correct percentage, which was 48.6%

This good response scored all five marks.

(i) For a particular jump, the total energy transferred from the pads and the leg muscles was 0.80 μJ.

Calculate the percentage of the energy for the jump that comes from the 2 pads.

Young modulus of resilin = 1.8×10^6 Pa
strain = 1.0

(5)

stress = strain · Young modulus = 1.8×10^6 Pa $\times 1.0 = 1.8 \times 10^6$ Pa

Force = stress × A = 1.8×10^6 Pa · $(60 \times 10^{-6} m)^2 = 6.48 \times 10^{-3}$ N

energy = $\frac{1}{2}$ · Force · compression = $\frac{1}{2} \cdot 6.48 \times 10^{-3}$ N · 60×10^{-6} m = 1.944×10^{-7} J = 0.1944 μJ

percentage = $\frac{0.1944 μJ}{0.8 μJ \times \frac{1}{2}}$ = 48.6%

Percentage of energy = 48.6%

ResultsPlus

Examiner Comments

It is clear that the Young modulus has been multiplied by a strain of 1.0, and the force then correctly calculated. The stored energy is correct, and the percentage is calculated for a single pad.

This response scored 3 marks.

(5)

$E = \frac{6}{\varepsilon}$ $\varepsilon = 1.0$ $6 = E \cdot \varepsilon = 1.8 \times 10^6$ Pa

$6 = \frac{F}{A} = 1.8 \times 10^6$ Pa $F = 1.8 \times 10^6 \times 60 \times 10^{-6} \times 60 \times 10^{-6}$

$= 6.48 \times 10^{-3}$ N.

$E = F \cdot S = 6.48 \times 10^{-3} \times 60 \times 10^{-6} = 3.888 \times 10^{-7}$ J

3.888×10^{-7} J $\times 2 = 7.776 \times 10^{-7}$ J

$\frac{7.776 \times 10^{-7}}{0.8 \times 10^{-6}} \times 100\% = 97.2\%$.

Percentage of energy = 97.2%

ResultsPlus

Examiner Comments

This response shows the most common mistake made. The force is correctly calculated, but the factor of ½ is omitted when determining the energy stored.

Question 18 (c)(ii)

There were two marks for this item for the two properties required.

Mark 1 was for saying the resilin needs to be elastic, or have a high elastic limit.

Mark 2 was for a low stiffness or low Young modulus.

Very few responses scored both of these marks. The mark for elastic was the most common, but many gave other incorrect properties such as malleable or strong. Incorrect properties were not penalised unless more than the required two properties were stated.

(ii) Suggest two properties of resilin that make it suitable to assist with the jump.

(2)

It is elastic, so it returns to its original shape after each jump, to provide the same energy for every jump. It has a low young modulus so that not too much force is applied by the legs of the inset

(Total for Question 18 = 17 marks)

ResultsPlus
Examiner Comments

This correct response scored both marks. The question did not ask for an explanation of the properties chosen, but this response does explain them well.

The resilin ~~[illegible]~~ has a low young modulus.
The elastic limit is high.

ResultsPlus
Examiner Comments

This somewhat minimalist response is all that was needed to score both marks.

* Resilin is strong (it has a high tensile strength) so it can withstand a high applied stress without breaking.
* Resilin is malleable because it deforms easily when a small compressible force is applied.

ResultsPlus

Examiner Comments

This response scored no marks. It shows a misunderstanding of the processes involved, and probably of the meaning of malleable.

Paper summary

Overall, the mean mark on this paper was 37/80, with a standard deviation of 15. The variety of questions, in terms of physics content and style, gave the candidates ample opportunity to demonstrate their proficiency in the subject.

- Based on their performance on this paper, candidates are offered the following advice:
- Make sure you 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.
- Use a ruler when drawing a vector diagram, and take care when taking measurements from pictures.
- Show all working in calculations, and only round the final 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

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

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Rewarding Learning