Examiners' Report
January 2012

GCE Physics 6PH01 01

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Introduction

This paper enabled candidates of all abilities to demonstrate their knowledge and apply their understanding of the specification. Responses demonstrated good progression from GCSE to similar topics at AS level and there was a good understanding of the new concepts that the candidates had been taught. The paper differentiated between all abilities with questions such as 14 and 16 challenging the most able candidates in their ability to apply their knowledge of forces and Newton's Laws to given contexts. The calculations were mostly attempted across all ability ranges but lower ability candidates often omitted a step within the calculation and were not able to obtain full marks.

This paper did not penalise for significant figures as is addressed in the practical unit. Correct use of significant figures when calculating a quantity or quoting an answer as well as accurately reading from a calculator by rounding appropriately rather than truncating the number are important skills and should be reinforced throughout the teaching of the course.

Section A

Performance was good in this section with many candidates scoring 9 or 10. Questions 2 and 4 were the only questions that scored below 50 % in this section. Question 2 relied on candidates remembering that the Pascal is the unit used of stress (a concept which was not tested quantitatively anywhere else in this paper) and being able to manipulate the units and indices when dividing by m^2 successfully. The lack of experience of the latter appeared to cause the most problems. Question 4 required candidates to remember that a component of a vector at 90^o to itself is 0, most tried to resolve hence the frequency of responses C and D.

Multiple Choice Question	**Subject**	**Percentage of candidates who answered correctly**	**Most common incorrect response**
1	Vector and scalar quantities	98	A
2	Equivalent units	46	D
3	Vector addition using Pythagoras	94	C
4	Components of forces	29	C ,D
5	Newton's first Law	65	B
6	Stokes' Law	89	B
7	Young's Modulus	56	C,B,A
8	Gravitational Field Strength	95	C
9	Forces on an object rising through a fluid at constant velocity	75	A
10	Acceleration-time graph	62	A

Question 11

Many candidates managed to score just 1 mark here, mainly for explaining the difference between compressive and tensile using the correct language. Many candidates just repeated the stem of the question in these descriptions. Some candidates did remember to define what stress is but too often just quoted the formula from the back of the booklet without defining the terms.

SECTION B

Answer ALL questions in the spaces provided.

11 Explain the difference between compressive strain and tensile strain.

Compressive strain is ~~a measure of how much the material~~ the change in length of a material when it is compressed by a certain force : Compressive strain $= \frac{\Delta l}{l}$. Tensile strain is a measure of extension comparing to the material's original length when it is streched. tensile strain $= \frac{x}{l}$

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Examiner Comments

This candidate did not manage to describe the differences between the change in length when under tension/compression.

Although they quoted D*l*/*l* and x/*l* for strain, which alone is insufficient, there was also a qualititative explanation of extension compared to original length which was sufficient.

ResultsPlus

Examiner Tip

When trying to explain a quantity, especially one which has been given at the back of the formula booklet as a formula, symbols must be defined. This also applies to symbols used in explanations in all questions so that the examiner is clear about which quantity you are discussing. Ambiguous letters used as abbreviations can often mean another quantity which may contradict your answer and lose you the mark.

SECTION B

Answer ALL questions in the spaces provided.

11 Explain the difference between compressive strain and tensile strain.

Compressive strain is the strain needed to compress an object while tensile strain is the strain needed to pull the object

ResultsPlus

Examiner Comments

The candidate seems to have confused strain and force here. No attempt to explain strain and compress is really just a repeat of the stem of the question and is insufficient to describe compressive. Pull was acceptable for describing tensile but both explanations were required.

ResultsPlus

Examiner Tip

When asked to explain or define a scientific term do not take words directly from the stem of the question as you have not demonstrated to the examiner any additional knowledge.

SECTION B

Answer ALL questions in the spaces provided.

11 Explain the difference between compressive strain and tensile strain.

Compressive strain is the decrease of orginal length and tensile strain is the increase of orginal length.

ResultsPlus

Examiner Comments

Correct description of compressive and tensile. 1 mark.

Question 12

This question was answered successfully by many candidates. Most candidates managed to identify that the viscosity was decreasing. The main source of error was candidates who did not explain that the oil would be spreading at a faster rate and tended to just describe it as spreading easier or more. This question is testing the link between viscosity of a fluid and its rate of flow hence a reference to the speed of the oil is required.

Explain the difference that using a hot pan would make to how the oil spreads.

A hot pan would increase the temperature of the oil, which would make the oil less viscous. Therefore the oil would spread out faster than it would if the pan was cold.

ResultsPlus

Examiner Comments

A good response scoring 2 marks where the candidate has clearly compared a hot pan to a cold pan with the oil spreading out 'faster'.

ResultsPlus

Examiner Tip

Be careful when you are asked to compare 2 situations. Here you have been asked to compare a hot pan to a cold pan so an answer demonstrating a comparison is needed e.g. faster not just the oil will travel fast.

Explain the difference that using a hot pan would make to how the oil spreads.

Using a hot pan means that the viscosity of the oil is lower, so it flow more easily around the pan.

ResultsPlus

Examiner Comments

Just 1 mark for lower viscosity. Flows more easily is insufficient, more detail needed such as it will flow faster.

Question 13

The majority of candidates managed to score at least 2 marks for this question. The marks for naming that the shield requires a malleable property and the decorations require a ductile property were the most commonly awarded. The subsequent definitions of these materials were variable, some candidates managing to identify that the copper demonstrates large plastic deformation. For malleable, just recognition that it undergoes plastic deformation was sufficient. Very few candidates were able to define these properties with enough detail to score all 5 marks and include that it is malleable when under compression and ductile when under tension.

*13 The metal copper probably gets its name from the Mediterranean island of Cyprus, which was an important source of the metal in ancient times. Copper was versatile because it could be beaten to make large flat objects, such as shields, as well as being drawn into wires which could be used decoratively.

Name and define the property of copper that makes it suitable for this method of making shields and the property that makes it suitable for making wires.

The property which makes it good for shields is that copper is malleable, so it is easily flattened and moulded as it deforms plastically, although sometimes losing strength.
However, the property which enables it to be drawn into ~~[illegible]~~ wires. is that it is ductile, so it will deform plastically without losing strength into wires.

ResultsPlus
Examiner Comments

This response scored 3 marks. The candidate has identified the 2 properties but forgot to mention that the ductile property requires a large plastic deformation. No link made between beaten and compression and drawn and tensile.

*13 The metal copper probably gets its name from the Mediterranean island of Cyprus, which was an important source of the metal in ancient times. Copper was versatile because it could be beaten to make large flat objects, such as shields, as well as being drawn into wires which could be used decoratively.

Name and define the property of copper that makes it suitable for this method of making shields and the property that makes it suitable for making wires.

Copper is good for beating into shields because it's very malleable. This means it has a large amount of plastic deformation when being compressed. That makes it good for beating into shields or panels.

Copper is also very ductile making it good for drawing out into wires. This means it has large plastic deformation when extended and can be made into thin items, like wire.

ResultsPlus

Examiner Comments

This response scored 5 marks. Identifying both properties. A reference for each property to a (large) amount of plastic deformation and a reference to the forces being compressive for the malleable property.

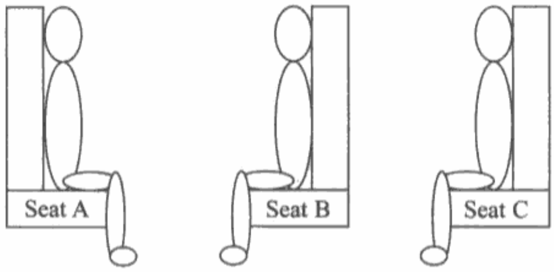
Question 14

All candidates found the applied nature of this question challenging. Many not understanding what is physically going on and therefore often discussing C hitting seat B, B moving out of their seats and a force acting on A to propel them out of their seat and into passenger B. A lack of understanding of N1 was evident with the majority of candidates. N3 was successfully described, mainly correctly for passenger C, however, to describe C's motion i.e. a (resultant) force acting on C needed to be identified and not the source of the force.

Two marks were available and often awarded for just describing what an observer would see (first and last marking points on the mark scheme). Therefore just realising that A will collide with B and that C will remain in their seat would get 2 marks. The candidates had difficulty explaining these observations in terms of forces and Newton's laws. Although N1 was often quoted (as was N3), it had to be applied to the situation for passenger A. Many candidates realised that A would leave their seat but could not link this to N1 and described that they would just continue moving but discussed that the chair gave them a force so they could accelerate forwards.

*14

Direction of travel



The diagram shows three passengers sitting on a train that is travelling at a high speed in the direction shown. Seat belts are not used on trains.

With reference to one of Newton's laws of motion, explain why seat C is the safest seat for a passenger to be sitting on in the event of a rapid deceleration. You may assume that the seats all remain fixed firmly to the floor and do not break.

According to the 1st law of motion, things at rest or at constant velocity remain so unless an unbalanced force acts on them. This is the case for the passenger in seat A; when the train ~~stand~~ suddenly decelerates, their inertia continues to move them forward until they hit the person in seat B. But seat C is facing away from the direction of travel so a sudden stop just falls them in to their seat.

(Total for Question 14 = 4 marks)

ResultsPlus
Examiner Comments

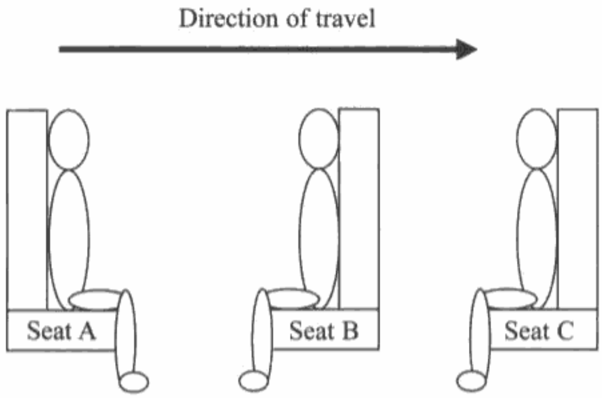
4 marks.

Marks for identifying that A (continues) to move forward and that C stays ('falls into') in their seat. N1 quoted but clearly identified as being the reason for passenger A's movement. The movement of passenger A has been correctly identified as continuing to move forward with a mention of inertia here. This candidate has grasped the situation here and had a good understanding of the first law. The candidate did not describe the forces acting on C or the fact that they decelerate.

ResultsPlus
Examiner Tip

When quoting Newton's laws, unless you have been specifically asked to just state them, they need to be in the context of the question. Identify which body in the case of N1 is continuing forwards and will therefore have a constant velocity. For N3 identify the 2 bodies involved; state the body causing one of the forces and the body it acts on and vice versa as well as their directions when describing the law e.g. passenger C exerts a force on the chair (in the direction of motion of the train) and the chair exerts a force on passenger C in the opposite direction.

*14



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With reference to one of Newton's laws of motion, explain why seat C is the safest seat for a passenger to be sitting on in the event of a rapid deceleration. You may assume that the seats all remain fixed firmly to the floor and do not break.

Newtons first law states that if all of the forces acting on a body are in equilibrium, then the body will travel at a constant velocity.
In The event of rapid deacceleration, the person will continue to travel (foreward in the direction of the travel, because they have no seat belt on to provide a resultant force to decelerate them with the train. This means that they will keep on travelling at the constant velocity, until they squish Person B (who provides the force to slow them down).

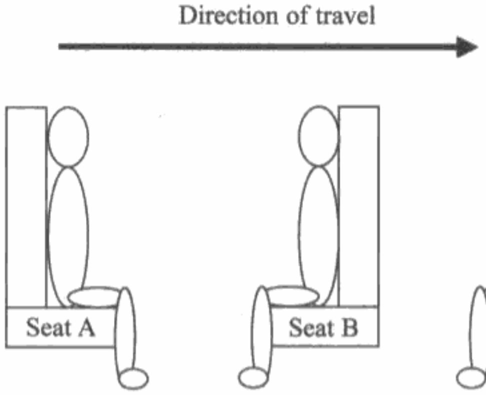
(Total for Question 14 = 4 marks)

ResultsPlus
Examiner Comments

This response scored 0 marks.

The candidate has described N1 but has not applied it to an individual passenger and, as passengers A and C use this law differently in this situation the candidate needs to specfically refer to A.

*14



The diagram shows three passengers sitting on a train that is travelling at a high speed in the direction shown. Seat belts are not used on trains.

With reference to one of Newton's laws of motion, explain why seat C is the safest seat for a passenger to be sitting on in the event of a rapid deceleration. You may assume that the seats all remain fixed firmly to the floor and do not break.

Seat C is the safest for a passenger to be sitting on in the event of a rapid deceleration as seat A and seat B are less safe. Seat A, in the event of a rapid deceleration, will feel a force when the train decelerates and using Newton's Third Law of Motion, the seat will exert an equal and opposite force on the passenger in seat A and cause the passenger to fall forwards into the passenger of seat B and this is why seat B is less safe as well. Seat C is the safest seat as the passenger is facing the opposite direction to the direction of travel, the passenger in seat C will feel a force but a force on the seat.

(Total for Question 14 = 4 marks)

ResultsPlus
Examiner Comments

This response scored 1 mark. The candidate has identified that there is a force involved with keeping C in their seat but is muddled in their description of it. They needed to say that the chair exerts a force on C, here they have passenger C feeling a force 'ON' the seat.

Although, according to this candidate, the mechanism of A getting to B involves a force, they have identified that passenger A will leave their seat and collide with B (1 mark).

Question 15 (a) (i)

Nearly all candidates scored both marks. Just 1% scored 1 mark, mostly because they did not quote the final answer to 2 sf as is required in a 'show that' question. Most common reason for scoring 0 marks was the use of 45° instead of 42°.

The photograph shows a lawnmower being used to cut grass.

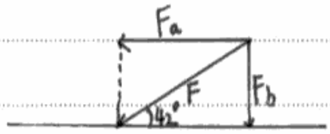
(a) (i) In order to push the lawnmower, a minimum force of 650 N must be applied to the handle of the lawnmower at an angle of 42° to the horizontal.

Show that the horizontal component of the force is about 500 N.

(2)

because $F_b = 650 \times \sin 42$ $F_a = \cos 42 \times 650$

so $F_a \approx 500$ N



ResultsPlus
Examiner Comments

Final answer not quoted to 2 sf , just the 1 mark for seeing 650 cos 42 .

The photograph shows a lawnmower being used to cut grass.

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Show that the horizontal component of the force is about 500 N.

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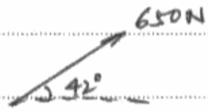


$650\cos 42^\circ$

$= 483$ N //

ResultsPlus
Examiner Comments

Correct answer to at least 2 sf. 2 marks.

Question 15 (a) (ii)

Nearly all candidates scored at least 1 mark for multiplying a force by a distance. 54 % managed to use the correct force of 483 N(or 500N) and the distance of (15 x 7) of 105 m.

As with many attempts at calulations by weaker candidates in this paper, the correct formula was usually selected and substituted into but not all of the information was used.

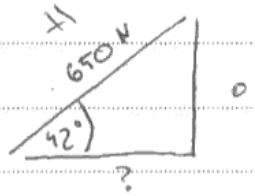
The photograph shows a lawnmower being used to cut grass.

(a) (i) In order to push the lawnmower, a minimum force of 650 N must be applied to the handle of the lawnmower at an angle of 42° to the horizontal.

Show that the horizontal component of the force is about 500 N.

(2)

cos 42 × 650 = 483.04 N which can be round up to 500 N ✓



(ii) The lawnmower is used to cut 15 strips of grass, each 7 m long.

Calculate the work done by the person pushing the lawnmower.

(2)

Work done = F × displacement

= 650 × 15 × 7

= 68250 J

Work done = 68250 J

ResultsPlus

Examiner Comments

The applied force rather than the component calculated in (a)(i) has been used. Just 1 mark for use of ΔW= FΔs.

The photograph shows a lawnmower being used to cut grass.

(a) (i) In order to push the lawnmower, a minimum force of 650 N must be applied to the handle of the lawnmower at an angle of 42° to the horizontal.

Show that the horizontal component of the force is about 500 N.

(2)

650 cos 42 = 483.0441366 N

≈ 483.04 N

483.04 N ≈ 500 N

(ii) The lawnmower is used to cut 15 strips of grass, each 7 m long.

Calculate the work done by the person pushing the lawnmower.

(2)

Work done = force x distance

650 N x 7 = 4550 Nm

Work done = 4550 Nm

ResultsPlus
Examiner Comments

1 mark for use of $\Delta W = F\Delta s$. An incorrect force and an incorrect distance have been substituted in. This is a straightforward response, clearly following on from the previous part of (a).

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Examiner Tip

If an item is still within the same part of a question then it is likely that the calculations will follow on. Before substituting in just any value of force in this case, check to see why the part you are answering follows on from the previous part and select the correct force. Information is rarely given without a use for it. Directly above the question for (ii) is the information that there are 15 strips of grass in total. This information needed to be used.

Question 15b

This question required a qualitative understanding of $\Delta W = F\Delta s$. Most candidates understood that the force would be less and could score at least 1 mark. However, most failed to describe successfully the reason why. Many just stating that it was due to the angle being smaller.

Some weaker candidates repeated the stem of the question and just explained that the force would be a minimum rather than the minimum force being less.

This photograph shows a lawnmower with the top section of the handle horizontal.

Explain how this changes the minimum force required to push the lawnmower.

(2)

With this lawnmower, all of the force is applied in the direction of travel. This means the minimum force required for the same amount of force as the other will only be 483N,

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Examiner Comments

2 marks. The candidate has the correct idea that all the force applied is now in the direction of motion. They have not specifically referred to less force but have stated that a minimum force of 483 N will now be required, which given that they were told earlier in the question that is with the other lawnmower it is 650 N, is sufficient to imply a lower applied force.

This photograph shows a lawnmower with the top section of the handle horizontal.

Explain how this changes the minimum force required to push the lawnmower.

(2)

It would lower the minimum force required to push the lawnmower as the angle of the handle compared to the horizontal is now significantly smaller.

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Examiner Comments

Typical 1 mark answer. Reference to the angle of the handle being reduced without applying this to the forces involved.

This photograph shows a lawnmower with the top section of the handle horizontal.

Explain how this changes the minimum force required to push the lawnmower.

(2)

Having the handle horizontal decreases the verticle component of the minimum force required to push the lawnmower, it also increases the horizontal component which means less force is needed to push the lawnmower

(Total for Question 15 = 6 marks)

ResultsPlus

Examiner Comments

1 mark for less force. The candidate has the idea that the vertical component of force has reduced but did not go as far as to say that there is no vertical component of force.

Question 16 (a) (i)

Most (over 75%) of candidates could correctly describe both laminar and turbulent. Many responses only included a negative explanation such as in laminar the layers do not mix and in turbulent the layers mix. The majority of candidates just wrote every description they had been taught for each response which was not necessary. 1 correctly worded description was all that was required.

(i) Explain what is meant by laminar flow and turbulent flow.

(2)

Laminar flow

They move in a straight line in one direction. The layers do not mix up. They donot form eddies.

Turbulent flow

They donot move in a straight line and varies their direction. The layers mix. They form eddies.

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Examiner Comments

2 marks. A clear reference to layers not mixing for laminar and layers mix as well as form eddies for turbulent. Use of 'they' is unclear as it could refer to particles or the fluid and is not obvious from the stem of the question. Fortunately the candidate had written enough in subsequent sentences here to explain these terms.

ResultsPlus

Examiner Tip

Be specific when answering a question. Try not to use words such as 'they' as the examiner will not know what you are referring to. Mention as in this case, the fluid.

(i) Explain what is meant by laminar flow and turbulent flow.

(2)

Laminar flow

Flow with a constant velocity and lines don't mix

Turbulent flow

lines mix and eddies form

ResultsPlus

Examiner Comments

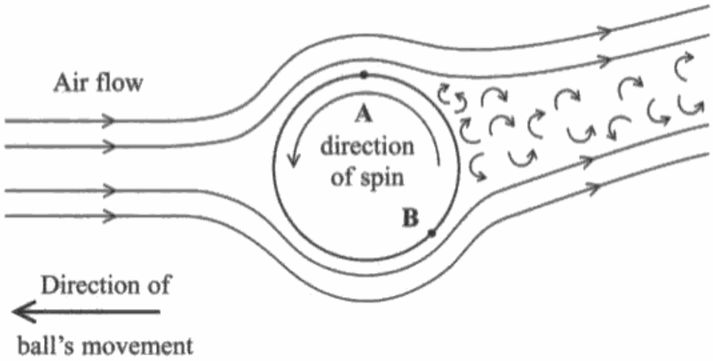
Correct explanation for turbulent. It is difficult to correctly describe laminar in terms of velocity and the candidate must refer to the velocity at a point being constant as the velocity between layers will differ.

Question 16 (a) (ii)

As with all applied areas of question 16, this was very poorly answered. Clearly candidates are very comfortable being able to define turbulent flow but have very little understanding of what causes turbulent flow. Nearly every response which managed to score the mark had identified that the direction of spin was in the opposite direction to the flow of the air at A (or vice-versa at B). Ideally the candidate would have realised that this causes a greater relative velocity between the air and the surface at A which causes a larger region of turbulent flow. Some candidates that scored 0 had grasped that the air flow and spin were in opposite directions but failed to identify as to whether these were at A or B. As both A and B are mentioned in the stem of the question, the candidate needed to be very clear as to which part of the ball they were referring to.

16 In the game of table tennis a ball is hit from one end of the table to the other over a small net.

(a) Making a table tennis ball spin when it is hit can affect its flight. The diagram shows the path of air around a spinning ball. It contains regions of laminar flow and turbulent flow. The flow changes from one to the other at points A and B.



(i) Explain what is meant by laminar flow and turbulent flow.

(2)

Laminar flow

~~The~~ Layers of flow do not cross and at any one point over time the velocity remains constant.

Turbulent flow

Layers of flow cross forming vortices and eddy currents, and at any one point over time the velocity changes.

(ii) The ball is spinning in the direction shown in the diagram.

Suggest why there is a larger region of turbulent flow on the top of the ball than the bottom.

(1)

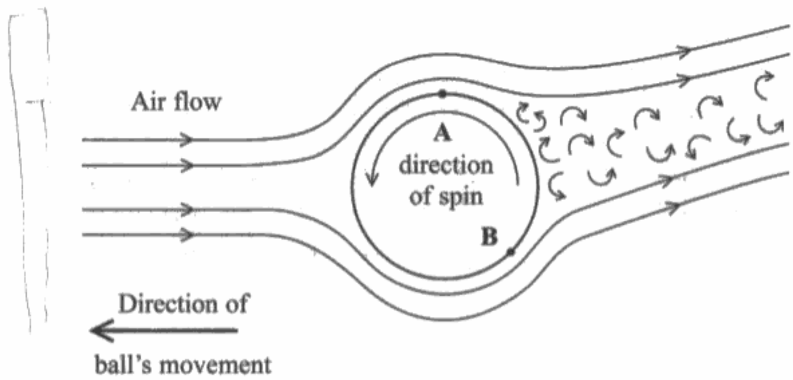
Because the spin at the top is going in the opposite direction to the air flow, so the ~~relat~~ velocity of the fluid relative to the ball will be much higher at the top, causing turbulent flow.

ResultsPlus
Examiner Comments

Excellent answer, 1 mark. This also included reference to the velocity of the fluid relative to the velocity of the ball.

16 In the game of table tennis a ball is hit from one end of the table to the other over a small net.

(a) Making a table tennis ball spin when it is hit can affect its flight. The diagram shows the path of air around a spinning ball. It contains regions of laminar flow and turbulent flow. The flow changes from one to the other at points A and B.



(i) Explain what is meant by laminar flow and turbulent flow.

(2)

Laminar flow

The fluid layer's do not abruptly change velocity of direction with respect to each other and no mixing of fluid layers occurs.

Turbulent flow

Mixing of fluid layers occurs, resulting in the formation of eddies.

(ii) The ball is spinning in the direction shown in the diagram.

Suggest why there is a larger region of turbulent flow on the top of the ball than the bottom.

(1)

The top of the ball is moving at a greater velocity than the bottom.

ResultsPlus
Examiner Comments

This scored 0 marks. The candidate may have understood that the greater region of turbulence is due to a greater relative velocity at the top but failed to describe this clearly enough.

Question 16 (b)

This question was not answered well, many candidates just repeated the question and failed to realise that this is a Newton's 3rd law question hence requiring a reference to the law and/or reference to both bodies involved and the direction of each force. Again, just a bold statement of N3 without being applied to the forces would not gain a mark. Incorrect use of upthrust and drag was seen here.

There was poor use of the word 'force', many candidates choosing to discuss the ball being pushed or forced upwards. Many candidates omitted such terms altogether, using 'deflected' from the stem of the question which did not allow them to get a mark.

(b) The diagram shows that the air is deflected upwards after passing the ball.

Explain why this means there must be a downwards component of force on the ball in addition to its weight.

(2)

According to newtons 3rd law all forces have an equal and opposite force therefore if the ball is pushing the air upwards the air must also be pushing the ball downwards.

ResultsPlus
Examiner Comments

This scored 2 marks. Although the candidate did refer to the ball pushing the air upwards rather than the force of the ball on the air etc, they had both bodies and the direction of the forces identified.

(b) The diagram shows that the air is deflected upwards after passing the ball.

Explain why this means there must be a downwards component of force on the ball in addition to its weight.

(2)

There has to be another force acting downward to be able to overcome the upthrust and deflect the air upwards.

ResultsPlus
Examiner Comments

Reference to upthrust. The candidate has really just repeated the question without attempting to answer it.

Question 16 (c) (i)

This question was answered well by the more able candidates. The requirement to use both the horizontal motion and the vertical motion confused weaker candidates who often used a u = 31 ms^{-1} when substitutingthe time into $s = ut + 1/2\ at^2$.

Although truncation errors are not penalised, quite a few candidates were seen to drop the 7 from the time of 0.0 87 s, giving a distance of 0.031 m). This is a poor practice and the accuracy of reading from a calculator mid calculation needs to be encouraged.

(c) Spinning a table tennis ball allows it to be hit harder and still hit the table on the other side of the net.

(i) A table tennis ball is hit, without any spin, from one end of a table so that it leaves the bat horizontally with a speed of 31 m s^{-1}. The length of the table is 2.7 m.

Show that the ball falls a vertical distance of about 4 cm as it travels the length of the table.

(3)

$s = ut \Rightarrow t = \frac{s}{u} = \frac{2.7m}{31ms^{-1}} = 0.087\,s$

h means vertical distance

so $h = \frac{1}{2}gt^2 = \frac{1}{2} \times 9.81ms^{-2} \times (0.087s)^2$

$= 0.037m = 3.7\,cm \approx 4cm$

So the ball falls a vertical distance of about 4 cm as it travels the length of the table.

ResultsPlus

Examiner Comments

Use of horizontal velocity to calculate the time of the journey. Time then substituted into $s = ut + 1/2\ at^2$ (or as the case here just $1/2\ gt^2$) and the correct answer of 0.037 m obtained.

Question 16 (c) (ii)

This part of the question demonstrated that the majority of candidates had not grasped what was being asked in the question. Most believed that the question was asking how the ball can gain extra height to get over the net as oppose to drop a greater distance in the same time.

The few candidates that did understand the difference between a ball with spin and one without often failed to use the correct language needed for the 3rd marking point and discussed the ball falling faster rather than a greater distance.

By this stage most had forgotten about part b and did not realise the significance of the 4cm. Candidates should be reminded that the items within a question part are linked together.

(ii) The net is 15 cm high. Explain how the spin helps the ball hit the table on the other side of the net.

(3)

the spin makes the air turbulant, this makes the ball travel less as more energy is used in turbulant flow so the ball stops before the end of the table. Without spin it only lifts 4cm, ~~[illegible]~~ but the net is 15cm, so the spin helps raise the ball.

ResultsPlus

Examiner Comments

Candidate described the spin giving the ball lift to travel a greater distance upwards to get over the net. This scored 0 marks.

(ii) The net is 15 cm high. Explain how the spin helps the ball hit the table on the other side of the net.

(3)

The spin helps because # it makes the ball travel faster and allows for the ball to drop through the air faster. This is because the vertical component of the ball is greater when it is hit with spin, therefore helping it to hit the table on the other side of the net.

ResultsPlus

Examiner Comments

The candidate had the correct idea that the ball needs to be travelling in a downwards direction. Unfortunately the motion was in terms of speed and not distance. A vertical component is mentioned but they did not state whether they meant acceleration, force or just the velocity.

ResultsPlus

Examiner Tip

When mentioning components if decribing motion, they must be accompanied by a quantity such as velocity, acceleraion, force etc.

(ii) The net is 15 cm high. Explain how the spin helps the ball hit the table on the other side of the net.

(3)

- The spin creates an extra downward force on the ball.
- This extra force causes it to travel further downwards in the same space of time.
- If the force is big enough it allows it to travel more 15 cm downwards, causing the ball to strike the table.

ResultsPlus

Examiner Comments

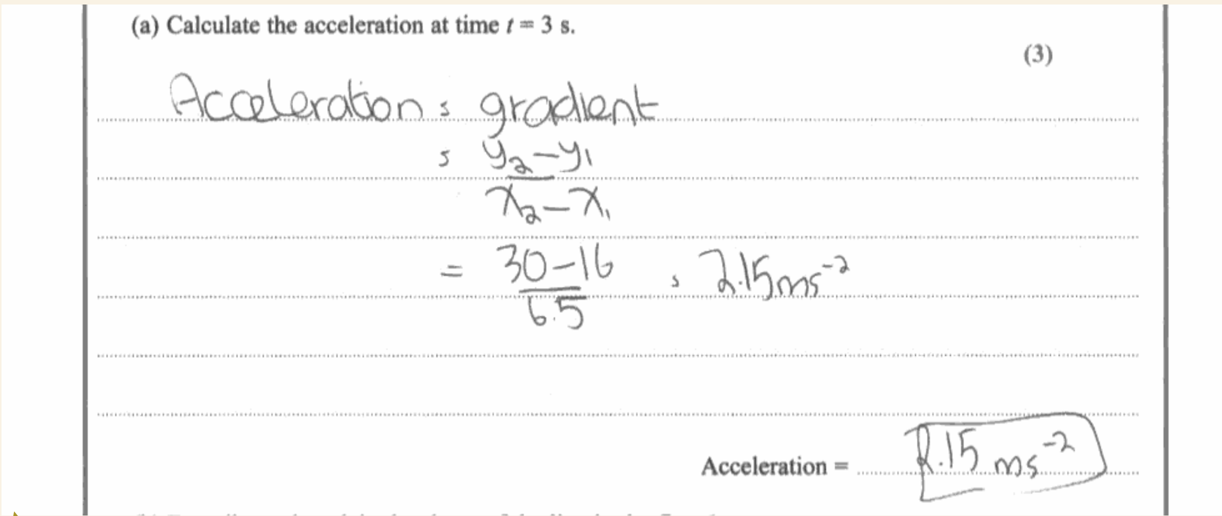
This response scored 2 marks. Correct statement about a greater downward force on the ball and the conclusion that a greater downward distance will be travelled in the same space of time, even with a reference to the 15 cm. Unfortunately the missing link between force and the distance travelled in the same time has been omitted, i.e. the acceleration.

Question 17 (a)

Most candidates managed to score at least 1 mark here for identifying that the acceleration is the gradient. Not all tangents drawn were accurate enough to enable the candidate to calculate a gradient worthy of three marks. Even though the graph was small, if a long enough tangent had been drawn (as should be encouraged) sufficient accuracy should have allowed the candidate to calculate a value in range and score all 3 marks.

Some candidates used the cord between t = 0 s and t = 6 s. This was allowed as the gradient of the cord was the same as the gradient had an accurate tangent been drawn at t = 3 s. However many candidates attempted to use a = (v-u)/t and assumed u was 0, v was 21 m s^{-1} and t = 3 s calculating an acceleration of 7 ms^{-2}. These candidates had frequently drawn in a tangent at t = 3 s but did not seem to know how to use it. Therefore many candidates not realising that suvat equations can only be used where the acceleration is constant.

2 out the 3 marks in this questions were accessible to all candidates i.e. drawing a tangent and attempting to find a gradient, even if not accurate enough for all 3 marks. The poor quality of responses across all ability ranges here has demonstrated the need for practice as the skill of drawing a tangent and finding the gradient is new and was not required at GCSE.



(a) Calculate the acceleration at time $t = 3$ s.

(3)

Acceleration = gradient

$= \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{30-16}{6.5} = 2.15 ms^{-2}$

Acceleration = 2.15 ms^{-2}

ResultsPlus
Examiner Comments

Full marks.

Gradient taken (and stated)

Raw data from graph written in to show working

Answer accurate enough to fit in the narrower range required for 3 marks as given in the mark scheme with the correct unit.

ResultsPlus
Examiner Tip

When a question requires any information to be taken from a graph, always state what you are doing eg acceleration = gradient and then include the values taken in your working out (eg (30-16)/6.5) rather than just quoting a ratio without any explanation.

(a) Calculate the acceleration at time $t = 3$ s.

(3)

~~Acceleration = area under graph~~

~~= ½ b × h =~~ ~~= 3 × 13~~

~~= 0.6 × 3 × 8~~ ~~= 39~~

~~= 12~~

~~Area = 12 + 39~~

Acceleration = gradient of graph

Gradient = y/x

= 21/3

Acceleration = 7 m/s²

ResultsPlus

Examiner Comments

Although the candidate had correctly identified that the acceleration is the gradient of the graph they then just found the velocity/time at 3 seconds, assuming this to be the gradient.

ResultsPlus

Examiner Tip

Acceleration is the gradient of a velocity-time graph.

If the acceleration is non-uniform (and the graph curves) then a tangent needs to be drawn at the velocity or time mentioned in the question.

Make sure that a large triangle is drawn to reduce the error in your value of acceleration.

Question 17 (b)

Most candidates managed to score at least 1 mark for this question. The weaker candidates could describe the shape of the graph i.e. state it is a curve/has a changing gradient. Many then added to this by identifying that the acceleration was not constant. At this stage some candidates then confused the acceleration with velocity and said that the car was decelerating rather than having decreasing acceleration.

Very few candidates attempted to explain why there was a reduction in the acceleration, with no reference to forces at all. Just 7 % of candidates scored all 4 marks.

(b) Describe and explain the shape of the line in the first 6 s.

(4)

In the first 6 seconds the driver is decelerating as his velocity is decreasing as he travels. After this point he continues at a constant velocity. The decelerating can be seen as the line becomes less steep in the first 6 seconds and acceleration ~~is~~ is average velocity divided by time.

ResultsPlus

Examiner Comments

1 mark for identifying the change in gradient.

ResultsPlus

Examiner Tip

As mentioned above the candidate has confused decreasing acceleration with deceleration.

(b) Describe and explain the shape of the line in the first 6 s.

(4)

it is a ~~constant~~ positive decreasing acceleration.

- This is because the driving force is constant
- F=ma ∴ car accelerates.
- as speed increases air resistance increases.
- ∴ the resultant force decreases
- ~~thus~~ ∴ as F decreases a begins to decrease

ResultsPlus

Examiner Comments

No description of the graph. Correct explanation that the acceleration is decreasing, that the air resistance increased and that the resultant force has decreased. All 4 marks.

Question 17 (c)

This question was answered well with 71 % of candidates obtaining the mark. The minimum answer required was just zero (no units) . Many chose to write more but some equated a constant velocity with constant force and scored no marks.

(c) Describe the resultant force on the car between times $t = 6$ s and $t = 16$ s.

(1)

the resultant force is constant.

ResultsPlus
Examiner Comments

0 marks. Confusion of velocity with force as the car was travelling at constant velocity.

(c) Describe the resultant force on the car between times $t = 6$ s and $t = 16$ s.

(1)

Resultant force is zero because velocity is constant hence acceleration is zero.

ResultsPlus
Examiner Comments

Good answer and although it is just 1 mark the candidate has explained why the force is zero.

Question 17 (d)

The most common correct approach for candidates to answer this question was to calculate the total distance and then divide by the total time of 50 s to obtain the average speed hence automatically showing a value less than the given value of 22 ms^{-1}. Some candidates approximated the area under the graph bit too generously and obtained a value out of range from the final mark but could still get 3 out of 4 marks. A small minority of students managed to accurately sample the velocity at small enough regular intervals to be able to also obtain a value in range (not a method to be encouraged). Most of the incorrect answers seen were from candidates who just identified 4 velocities (2 constant and 2 approximated mean values whilst accelerating and decelerating) and then averaged them, scoring 0.

Although this question did not directly ask the candidates to find the total distance travelled the mention of 'average speed' in the question should have been enough to remind students that average speed = total distance travelled/time. As with q17a a weakness with candidates in using graphs in calculations has been highlighted.

(d) Show that the average speed of the car does not exceed the average speed limit of 22 m s^{-1}.

(4)

$$\text{average speed} = \frac{\text{total distance}}{\text{time}}$$

$$= \frac{42+140+9+10+160+650}{50}$$

$$= \frac{1011}{50}$$

$$= 20.22\ ms^{-1}$$

ResultsPlus

Examiner Comments

Total distance found (and in the correct range between 900 and 100 m) and average velocity calculated, 4 marks.

ResultsPlus

Examiner Tip

Remember that average velocity = total distance/time.

(This is not given on the formula sheet)

(d) Show that the average speed of the car does not exceed the average speed limit of 22 m s^{-1}.

(4)

Average speed = $\frac{\text{final speed + initial speed}}{2}$

= $\frac{13+18}{2}$

= 15.5 ms^{-1}

So the average speed of the car does not exceed the average speed limit of 22 ms^{-1}.

ResultsPlus

Examiner Comments

The candidate has just found the average of the initial and the final velocity, ignoring the fact that there is a whole range of velocities.

Question 18 (a)

This was answered well with the majority of candidates scoring at least 1 mark. Many candidates had understood what was required but by using incorrect language then missed out on a second mark by mentioning that the blades 'rotate'. This is just a repeat of the stem of the question and an answer in terms of the 'work done' formula was required.

The answer either required a statement that the wind exerts a force (on the blades) causing them to move as an application of work done = force x distance moved in the direction of the force or a reference that work done is a transfer of energy and then identifying where the transfer takes place e.g. KE of wind to (KE of) blades.

Candidates who answered in terms of a transfer of energy tended to miss out on the second mark as they could not describe the specifics of the energy transfer accurately e.g. KE of wind to (KE of) blades.

As seen in question 16 many candidates used everyday expressions when discussing force such as the wind forces or pushes the blades rather than the precise physics of 'the wind exerts a force on the blades'.

(a) Explain why we can say that the wind is doing work on the blades.

(2)

work is a transfer of energy, and the kineti energy of the wind is transfered to electrical energy by moving the blades, therefore the wind is doing work on the blades.

ResultsPlus

Examiner Comments

This candidate scored just 1 mark for identifying that a transfer of energy is involved. They did not answer the rest of the question in context (i.e. wind and blades) and did a direct energy transfer between the KE of the wind and electrical energy.

(a) Explain why we can say that the wind is doing work on the blades.

(2)

The wind is applying a force to the blades which moves them, as the blades move (rotate) they are covering a distance. So we have the two variables to calculate work done:

Work done = Force x distance.

ResultsPlus

Examiner Comments

Both marks awarded.

ResultsPlus

Examiner Tip

When asked how a concept such as work done is being applied to a specific example, think about how you would normally find the work done. Then answer the question in terms of how you find the work i.e. what applied the force and what happened e.g. it moved a distance of.....

Question 18 (b)

Most candidates could attempt successfully parts (i) and (ii). Some candidates did not treat the volume of air as a cylinder but as a sphere and failed in their attempt to find the volume. Part (iii) was also answered well but some candidates either forgot to square the velocity, sometimes omitting to write the squared in as they substituted in the values. Other candidates used the volume in place of velocity when substituting. Part (iv) required candidates to successfully find 59 % of the energy and divide by 5 to get the power. Most candidates forgetting that they had just calculated the energy over a 5 second period and not dividing by 5. Some poor attempts to find 59% with candidates dividing by 59 or even finding 41 % of the energy instead.

(b) The area swept out by one blade, as it turns through 360°, is 6000 m^2. Wind at a speed of 9 m s^{-1} passes the turbine.

(i) Show that the volume of air passing through this area in 5 seconds is about 300 000 m^3.

(2)

area of circle = 6000 m^2 9 × 5 = 45 m

volume = area × distance

45 × 6000 = 270,000 m^3

$de = \frac{m}{V}$ $m =$

(ii) Calculate the mass of this air.

density of air = 1.2 kg m^{-3}

(2)

$1.2\ kg m^{-3} \times 270,000\ m^3 = 324,000$

mass = density × volume

Mass = 324,000 kg.

(iii) Calculate the kinetic energy of this mass of air.

(2)

$kE = \frac{1}{2} mv^2$ $0.5 \times 324000 \times 9^2 = 13,122\ kJ$

Kinetic energy = 1.31×10^7 J

(iv) Betz's law states that a turbine cannot usefully transfer more than 59% of the kinetic energy of the wind.

Use this law to find the maximum power output of the wind turbine.

(2)

$13,122,000 \times 0.59 = 7,741,980\ J$ ÷ 5 seconds

÷1000 = 1.55×10^3 KW

Maximum power = 1.55×10^3 KW

ResultsPlus
Examiner Comments

Every step correct scoring in order 2,2,2,2. Correct units included in parts ii, iii and iv. No unit error in part (i) as it is a show that question.

(b) The area swept out by one blade, as it turns through 360°, is 6000 m². Wind at a speed of 9 m s⁻¹ passes the turbine.

(i) Show that the volume of air passing through this area in 5 seconds is about 300 000 m³.

(2)

~~volume = mass / density~~ 9 x 6000 = 54000

54000 x 5 = 270000 m³

(ii) Calculate the mass of this air.

density of air = 1.2 kg m^{-3}

(2)

mass = volume x density

210000 × 1.2 = 324 000

Mass = 324 000

(iii) Calculate the kinetic energy of this mass of air.

(2)

K.E = ½(mv²)

K.E = ½ (324000 x 9²) = 13122000

Kinetic energy = 13122000 J

(iv) Betz's law states that a turbine cannot usefully transfer more than 59% of the kinetic energy of the wind.

Use this law to find the maximum power output of the wind turbine.

(2)

13122000 / total power × 100 = 59

13122000 / total power = 0.59

13122000 / 0.59 = 22240677.97

Maximum power = 22240677.97 J

ResultsPlus
Examiner Comments

In order 2,1,2,0.
(i) Full marks.
(ii) Unit omitted.
(iii)Full marks.
(iv) Incorrect attempt at finding 59 % and no attempt made to divide by 5 and find the power.

ResultsPlus
Examiner Tip

To find the output of a quantity when given the efficiency use:

Output = Input x efficiency/100.

Question 18 (c)

Very few candidates managed to grasp the idea that not all the energy from the wind will transfer to the blades with all the other candidates suggesting energy transfers after the energy had been transferred to the blades.

(c) Suggest a reason why it is not possible to usefully transfer 100% of the kinetic energy of the wind.

(1)

Because some energy is lost in the frictional forces of the turbine spinning also some energy will be lost though the sound created by the turbine.

ResultsPlus
Examiner Comments

Incorrect answer discussing energy transfers after the initial transfer from the wind to the blades.

(c) Suggest a reason why it is not possible to usefully transfer 100% of the kinetic energy of the wind.

(1)

Not all the wind passes flowing through the turbine. As turbines rotate, wind flows in between them. Therefore it is not possible to transfer 100% of the kinetic energy of the wind.

ResultsPlus

Examiner Comments

This candidate scored 1 mark. They realised that all the calculations involved in this question, starting with (b)(i) assume that the entire cylinder of wind that passes through the turbine will transfer all of its energy to the blades. Therefore, by explaining that not all the wind will pass though the blades they have explained why that figure is too high.

Question 18 (d)

Most candidates scored at least 1 mark. Most responses seen gave a long list of disadvantages of wind energy, some of which were not relevant as the question had asked specifically for limitations of using wind turbines to provide power. Therefore references to cost, noise and comparisons to other energy generation methods were ignored.

Most candidates identified that the variation in wind speed was a limitation.

(d) Suggest the limitations of using wind turbines to provide power.

(2)

- Wind speed is not constant
- Max power of single turbine is low compared to a diesel generator. So lots of wind turbines are needed. Large area required.
- Density of air changes. ~~high~~ So E_K changes

ResultsPlus
Examiner Comments

2 marks.

1 mark for 'wind speed not constant'. 2nd mark for mentioning that lots of wind turbines are needed.

(d) Suggest the limitations of using wind turbines to provide power.

(2)

To use wind turbines, the presence of a certain velocity of wind must be present otherwise it does not work. Using wind turbines occupy a lot of space.

ResultsPlus
Examiner Comments

This scored 2 marks.

Idea that the turbines require a minimum amount of wind to generate the electricity and a second limitation of the requirement for lots of space (to generate significant amounts of power).

Question 19(a)

For this question candidates were required to identify the conditions needed for a material to obey Hooke's law and then make a comment relating to the graph as to why it cannot be used to show this relationship, such as identify that it is of length and not extension, the length cannot be 0 as the spring has a length, state the length of the spring.

This question was not answered well. The majority of candidates who managed to score usually got a mark for quoting force is proportional to extension. This was done by rote with candidates not realising that they are directly proportional and losing the second mark. There was confusion between the use of length and extension in Hooke's law, many candidates believing that they are interchangeable and that as long as a graph like this shows proportionality, the law is obeyed.

(a) The student concludes that the spring does **not** obey Hooke's law because the line does not pass through the origin.

Explain why this conclusion is incorrect.

(2)

The spring does obey Hookes law be cause the force is directly proportional to the length ∴ $F \propto x$

ResultsPlus
Examiner Comments

This scored 0 marks. The candidate has mentioned length instead of extension.
F proportional to x did not have the terms defined so no marks there either.

(a) The student concludes that the spring does **not** obey Hooke's law because the line does not pass through the origin.

Explain why this conclusion is incorrect.

(2)

Hookes law states that Force is Proportional to length, which, as shown by the Constant gradient, This spring does, whether or not it Passes through the origin is irrelevant

ResultsPlus
Examiner Comments

Hooke's law: force is proportional to length as shown by the constant gradient - 0 marks.

Reference to the graph: This spring does (obey Hooke's law) whether or not it passes through the origin is irrelevant. - 0 marks.

(a) The student concludes that the spring does **not** obey Hooke's law because the line does not pass through the origin.

Explain why this conclusion is incorrect.

(2)

Hooke's law states that force ∝ extension. The origional length of the spring could not be 0 ~~on so therefore the graph~~ so the line can never pass through the origin. force is proportional to extension

ResultsPlus
Examiner Comments

Good answer scoring 2 marks.

Correct reference to Hooke's law and a credible reason for the graph not passing through the origin that the spring could not have a length 0.

Question 19 (b) (c)

This question was answered well by most candidates. Some candidates did forget to subtract the original length in part b(i) when taking a gradient to find k and/or in part c(i) when using either ½kx²or ½FΔx to calculate energy.

Nearly all candidates could attempt part c(ii) to calculate the height of the spring after release, however, many candidates did not convert the mass of the spring into kg, losing out on the third mark. Some candidates took a slightly less direct route to find the height by transferring all the EPE to KE to find the the spring's initial velocity and then using equations of motion to find the height reached (still attaining 3 marks).

(b) Show that the spring constant is about 30 N m^{-1}.

(2)

$F = k\Delta x$

$7 = k \times (27.5 - 2.5) \times 10^{-2}$

$k = 28 \text{ N m}^{-1}$

$\approx 30 \text{ N m}^{-1}$

(c) When the student is removing the masses the spring is accidentally released when its length is 23 cm. The spring flies up into the air.

(i) Show that the energy stored in the spring is about 0.6 J when its length is 23 cm.

(2)

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

$\frac{1}{2} \times 5.7 \times 0.23 = 0.6555 \text{ J}$

(ii) Calculate the maximum height the spring could reach above its point of release.

mass of spring = 5 g

(3)

$0.6555 \text{ J} = \frac{1}{2} mg\Delta h$

$0.6555 = 0.005 \times 9.81 h$

$h = 13.36 \text{ m}$

Maximum height = 13.36 m

ResultsPlus

Examiner Comments

(b) Gradient successfully found, answer to 1 more significant figure than the show that value. 2 marks

(c)(i) Length and not extension used in $E = \frac{1}{2}F\Delta x$ therefore 0 marks.

(c)(ii) Elastic strain energy = mgh and the mass has been converted into kg. Error carried forwards from part (c)(i) for energy, correct answer and unit. 3 marks.

ResultsPlus

Examiner Tip

Remember that the Δx when calculating Hooke's law, strain and elastic strain energy is the EXTENSION and not the length.

(b) Show that the spring constant is about 30 N m^{-1}.

(2)

~~$\frac{29.2}{(31 \times 10^{-2})}$~~ $F = k\Delta x$

$= \frac{0.8}{(31 \times 10^{-2})}$ $\frac{(31 \times 10^{-2}) \cdot 8}{(31 \times 10^{-2})}$

$=$ 25.8.

(c) When the student is removing the masses the spring is accidentally released when its length is 23 cm. The spring flies up into the air.

(i) Show that the energy stored in the spring is about 0.6 J when its length is 23 cm.

(2)

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

$(0.5)(5.3)(23 \times 10^{-2}) = 0.6095$

$= 0.61$ J.

(ii) Calculate the maximum height the spring could reach above its point of release.

mass of spring = 5 g

(3)

$= mg\Delta h$.

$0.61 = mg\Delta h$.

$h = \frac{0.61}{(9.81)(5}$

Maximum height = ...

ResultsPlus

Examiner Comments

(b) No mark awarded as gradient not taken as the candidate has just divided a value of force by extension.

(c)(i) 0 marks as the candidate has used length and not extension in $E = \frac{1}{2}F\Delta x$.

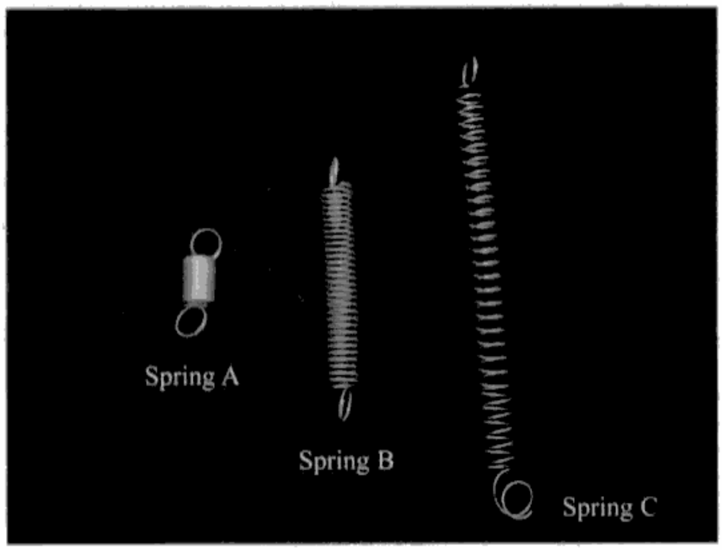
(c)(ii) 2 marks as the elastic strain enrgy has been equated to $mg\Delta h$ and then values substituted in. No final answer and the mass has not been converted into kg.

Question 19 (d)

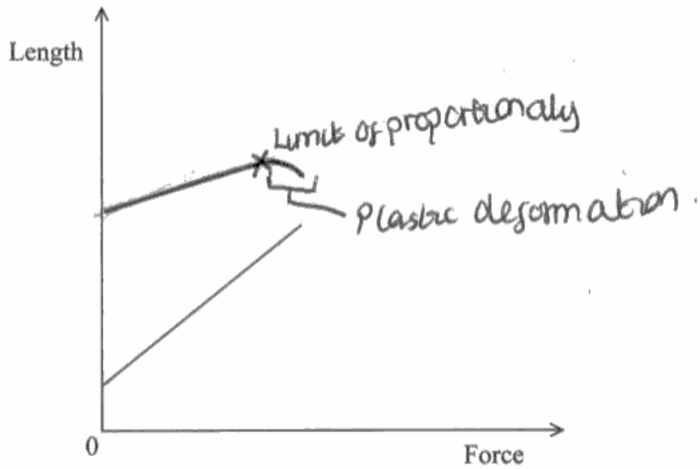
This question required the candidate to compare 2 identical springs, A and C after their loads had been removed. Many candidates failed to realise that the springs initially were identical (as was stated in the stem of the question) and often drew completely new lines onto the axis, this often led to discussions about the stiffness as a difference between the springs. Few candidates also noted that C had more force added to it, which had to be inferred.

The graph scored very poorly as most candidates did not realise that the axis (although consistent with those in part (a)) were not the same way round as is traditionally drawn in most text books. Therefore, although many candidates realised that spring C was the same initially as A and therefore continued the graph on from the one given, they then curved it to the horizontal rather than the vertical. Very few candidates, even those who wrote about plastic deformation extended the graph back to the length axis to show the permanent deformation. A mark was available for the elastic limit or yield point correctly identified and labelled. However, the most common point identified was the limit of proportionality.

(d) Several other students carry out similar investigations using identical springs. The photograph shows some of their springs at the end of their investigations.



Spring A is the same length before and after the investigation. The graph for this spring is shown below.



On the axes opposite sketch the graph for spring C and use it to help you describe the difference in the behaviour of springs A and C.

(6)

The gradient for spring A is much steeper this would mean the k constant is greater and the stiffness in spring A is greater than that of spring C* Also, the line for spring A begins lower down this is because it has a shorter original length compared to spring C.

*meaning a greater force is need to extend the length of spring A compared to same extension in spring C

Also, the line for spring A is linear suggesting that no plastic deformation has occured nor has the limit of proportianality been reached only elastic deformation unlike spring C which reaches the limit of proportionality and begins plastic deformation showed by the curve

(Total for Question 19 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

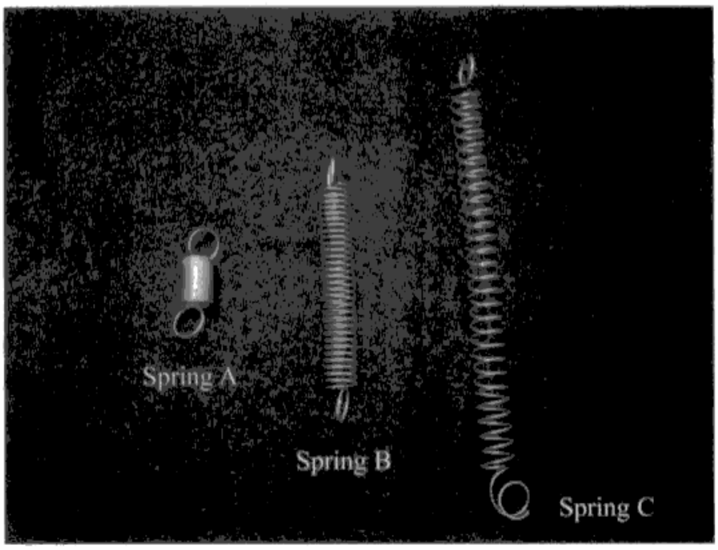
ResultsPlus

Examiner Comments

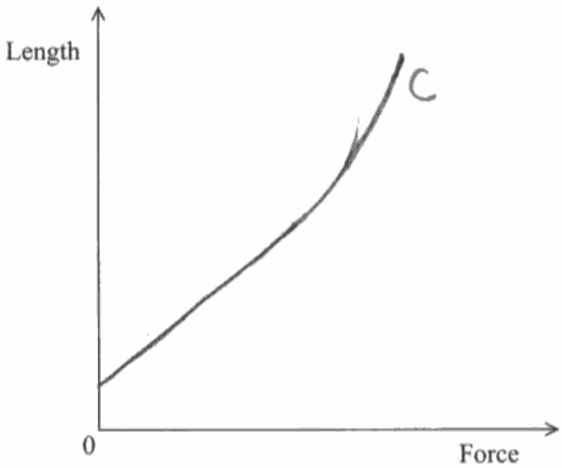
Graph: No marks for the graph as the candidate has not realised that the springs are identical initially and the graph curves the wrong way.

Explanation: Some confusion with stiffness and therefore A requiring more force than C. Just 2 marks for A deforms elastically and C deforms plastically.

(d) Several other students carry out similar investigations using identical springs. The photograph shows some of their springs at the end of their investigations.



Spring A is the same length before and after the investigation. The graph for this spring is shown below.



On the axes opposite sketch the graph for spring C and use it to help you describe the difference in the behaviour of springs A and C.

(6)

Spring A obeyed Hooke's law ~~because~~ ~~and~~ and deformed elastically, meaning it returned to its original shape after being extended. Spring A did not exceed its elasticity limit or its proportionality limit, because the graph for it is straight. Spring C obeyed Hooke's law for ~~as~~ long as spring A did (as they were identical) but eventually it exceeded its elastic limit and began to deform plastically. This meant it would not return to its original length.

(Total for Question 19 = 15 marks)

ResultsPlus
Examiner Comments

Scored 5.

2 for graph: 1 for continuing from the original graph and curving, 1 mark for the direction of the graph being upwards.

3 for explanation: A not past elastic limit, A deformed elastically, C deformed plastixcally, A returned to its original length and C did not. Only a **maximum of 3 marks** here even though 4 correct points.

Paper Summary

In order to improve their performance, candidates should:

- Not just quote formulae or laws when answering a question; state which law etc you are referring to and then describe it in the context of the question.
- Read through your work and check whether it is clear from your answer which object, part of an object etc. you are referring to.
- Show your working out, even if you are finding the gradient of a tangent remember to include in your response all the numbers you have used and how they have been used.
- When using symbols in explanations they must all be defined somewhere in your answer.
- Double check they have substituted in the correct value. Often the parts within a question lead on from one another and there could be many values of e.g. force on the page so select carefully.

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