Examiners' Report
Principal Examiner Feedback

January 2017

Pearson Edexcel International
Advanced Subsidiary Level
In Physics (WPH01) Paper 01
Physics on the Go

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This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. Many candidates showed a good progression from GCSE to AS level, with prior knowledge extended and new concepts taught and understood well. The longer open response style questions were generally answered well with the shorter, usually two or three mark, questions not always scoring as expected due to the detail required and lack of precision with explanations.

The longer mark questions on this paper were more mathematical than text based and candidates did not answer such items as expected. These items were no more difficult than in previous years however they may have appeared more challenging to candidates as they may not have been written in the same style they would have seen in past papers. Misunderstanding of the concepts as well as confusion between vector quantities being used only enabled many candidates to score method rather than full marks for such items. Most responses showed reasonably clear working out so that marks could be awarded if the final answer was incorrect.

There were a large number of blank spaces, including the multiple choice items. A blank space will always score zero and candidates should always make an attempt at answering the question as some correct Physics in the early stages can often score a couple of marks. For example, in 15ci just saying that increasing mass increases the terminal velocity, without justification, is quite an intuitive response and would score a mark, even if no additional Physics to justify this statement can be added.

The mean mark on the paper as a whole was 30.4; this was 6.4 marks lower than the mean on same paper last June and 8.1 marks lower than on the WPH01 paper last January. The spread of marks around the mean was the same as last June and January. However, as is commonly seen on the IAL paper, this was particularly noticeable around the E grade boundary where there was a greater spread of marks compared to that at the A grade boundary. Timing was an issue for some candidates as items towards the end of the paper were left blank on some scripts, usually as a result of spending too long on the multiple choice items. The mean score for questions 1 to 10 across all candidates was 5.8 although there was little variation between E and A grade candidates.

<u>Section A</u> – Multiple Choice

	Subject	Percentage of candidates who answered correctly	Most common incorrect response
1	Units	68	A and C
2	Kinetic energy	49	A
3	Work done	84	-
4	Distance and displacement	87	-
5	Resolution of a ruler	19	B
6	Reliability and validity	68	D
7	Upthrust	53	D
8	Centre of gravity	36	A and C
9	Properties of materials	59	A
10	Elastic strain energy	61	D

While most of the multiple choice items were answered as anticipated for lower ability candidates, more able candidates did not perform as expected on this section. The marks for this section were lower than usual with very few candidates answering all 10 responses correctly. Timing was an issue on the paper as a whole for some candidates and some low scoring candidates fared better on the multiple choice items than their higher scoring counterparts, demonstrating that a disproportionate amount of time was spent by some on this section.

An explanation of the distractors is now included in the mark scheme but a few, more significant, points are mentioned below.

Question 1

This is a very straight forward item that some candidates may have rushed through. To determine the base units for a derived unit, the candidates need only substitute the units into an equation for that quantity. In this instance mgh is probably the most simple equation as each of the quantities is usually expressed in SI base units, then simple algebra can be used to combine terms to reach a correct answer of kg m^2 s^{-2}.

Question 2

Using the equation for kinetic energy at the back of the paper, E_k is proportional to v^2 therefore the graph should be that of a positive quadratic i.e. D. Candidates are expected to recognise and sketch graphs of linear, quadratic and inverse functions.

Question 5
The resolution of a ruler is 1 mm so any measurements taken and recorded in cm or m should be recorded to 3 significant figures. A, B, and D are all just different ways of expressing the measurement to just 2 significant figures.

Question 6
A time measurement is a valid measurement to take, regardless of how it is measured, if *g* is to be determined. However, due to errors that are introduced when using a stopwatch compared to light gates, the repeated results are not likely to be similar i.e. reliable for the group using the stopwatch.

Question 7
When the object is immersed in the water the resultant force is equal to the weight – upthrust. In air, the resultant force is just the weight as the upthrust is negligible. Therefore the reading on the spring balance would decrease by an amount equal to the upthrust acting on the object in the water.

Question 8
This question was found to be quite challenging by many and if not known some quick working out was required rather than guessing. Doubling the density but halving the diameter gives a mass that is four times smaller. To balance the rod there has to be an equal weight of rod on either side of the pivot. Therefore the weight to the right of the pivot needs to not only include all of the weight of the right of the rod, it also needs a proportion of the weight of the left hand rod. Hence the pivot should be placed to the left of O.

Section B

Question 11
In general, this question scored 0 or 3 depending on the approach of the candidate. Those that chose the method using $P = Fv$ (a formula that is not on this specification) tended to score 0. Such candidates assumed that the force was the weight of the air, demonstrating a lack of understanding of the context. Not all candidates that used the correct formula managed to put forward convincing evidence that the kinetic energy is only equal to the power if taken to be over 1 second. Some candidates set out their work well with substitution into power = E_k/t, using 1 s for the time. Failing to square the velocity in the kinetic energy formula or omitting the power of ten were the main reasons why candidates using the correct approach did not score full marks.

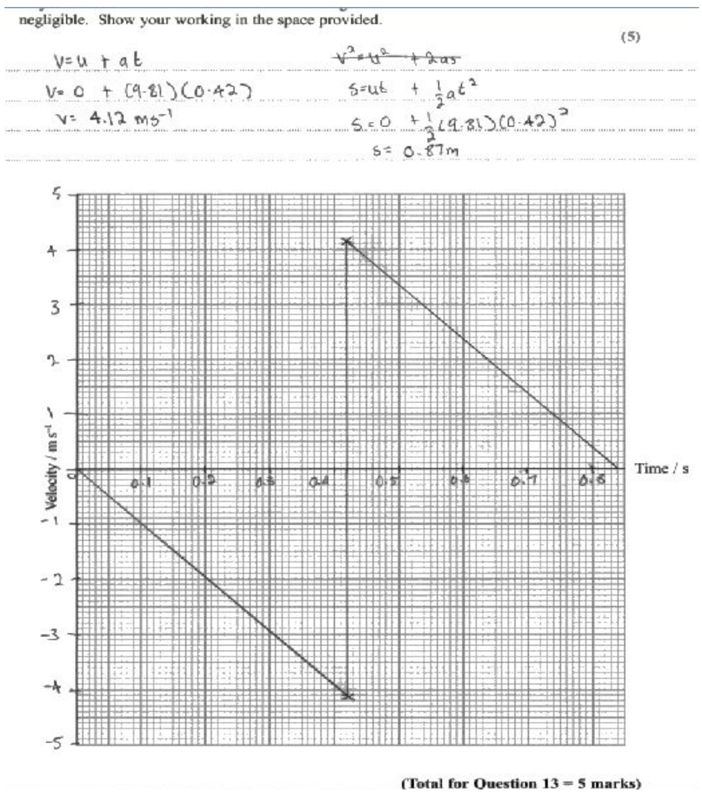
Question 12
(a) Many candidates scored one mark for this question for stating that the (applied) force is proportional to the extension for Hooke's law to be obeyed. Some candidates made reference to the graph going through the origin or the straight part of the graph instead of the limit of proportionality however, the elastic limit was frequently used in place of limit of proportionality. This specification refers to the elastic limit and limit of proportionality as separate points on a force-extension graph therefore candidates should be able to distinguish between these two points. Some answers incorrectly referred to stress and strain.
(b)(i) As the force is increased beyond the limit of proportionality the material will initially still be elastic. It is only once the material has exceeded the elastic limit that plastic deformation will begin. Many potentially good responses failed to score any marks as they did not refer the point at which the behaviour changes and could gain

no credit for their explanation of elastic or plastic behaviour. Some candidates answered correctly in terms of the force no longer being proportional to the extension. The few that attempted to describe the behaviour in terms of the increase in force causing a greater extension, usually tripped up by referring to the force producing a large extension rather than the increase in force.

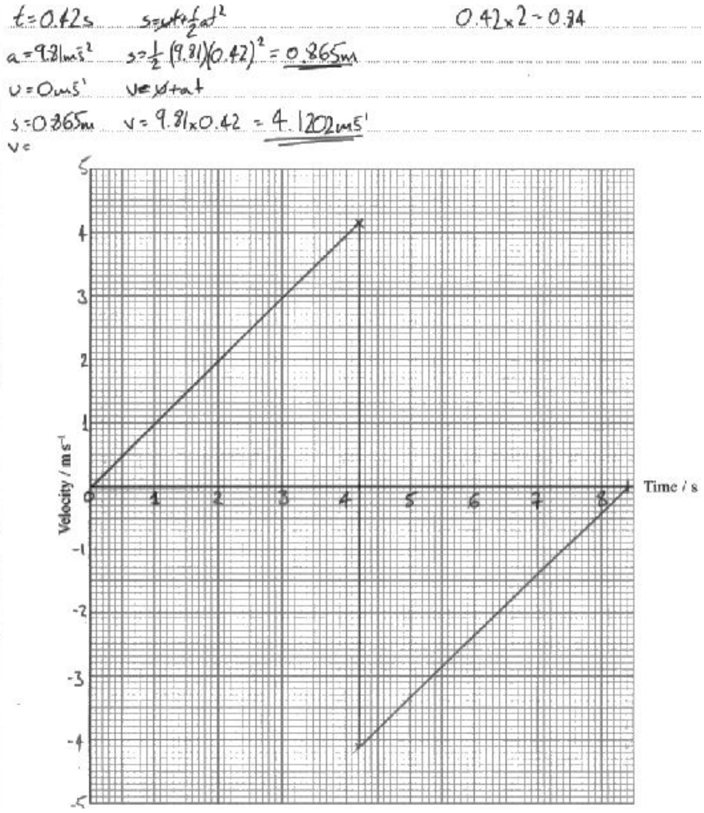
Question 13

Questions requiring candidates to plot a graph using only a few pieces of information demonstrates well the understanding of the subject as a whole. More thought and knowledge is required than just using an equation is required to score well. While the vast majority of candidates could correctly calculate the maximum velocity of the ball, the first skill that candidates were required to demonstrate was the scaling of the axes. This required then to appreciate that the total time involved was 0.84 s as the ball bounces and that the direction of the ball would change once the ball had bounced. The scaling mark cost many good candidates 3 of the 5 marks, as without it many could not pick up the two plotting marks (MP3 and 5).
Common errors included:
Assuming the given time of 0.42 s was for the entire motion of the ball and therefore using half the given time in the correct equation
Assuming that the impact time was not negligible and therefore drawing a line with a positive gradient linking the positive and negative velocities over the time of impact
Incorrect plotting, out of the 1 square (2mm) tolerance
No plotting at all, just sketching the graph for a bouncing ball. Thus missing the instruction to show any working and use the given information.
Although direction was not defined and candidates could choose this themselves, the vast majority of candidates took down to be positive.

The example below scored all 5 marks.



The example below scored just 2 marks. The time axis has been incorrectly scaled so therefore the scaling mark (MP2) and both plotting marks (MP3 and MP5) could not be awarded.

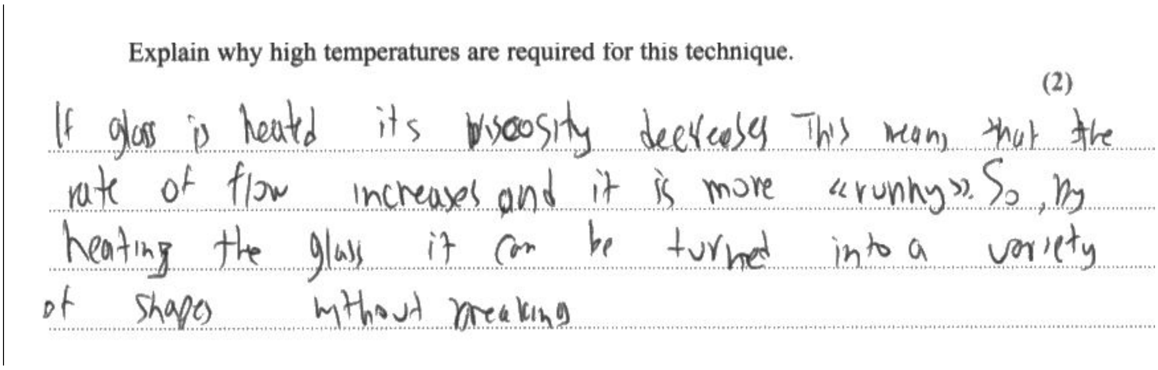


Question 14

Q14(a)
Most candidates showed a good understanding of the relationship between temperature and viscosity. Most identifying that glass is brittle at low temperatures with some recognising that at high temperatures it becomes ductile or the viscosity decreases. Some candidates made their response too complex by attempting to describe how the molecular structure of the glass will vary with temperature. Many spoke of the glass changing state at high temperature rather than describing a decrease in viscosity to change the behaviour of the glass to ductile.
Candidates should have made clear within their response as to whether they were discussing the behaviour of the glass at high or low temperatures. Some candidates were unable to score MP2 as they did not link the ductile behaviour to the higher temperatures. Some candidates listed the behaviour of the glass at high temperature as being both ductile and malleable. While both would create plastic deformation, the question states that the glass is to be used in optical fibres. Candidates are expected to appreciate that this would require the drawing of the glass into thin strands i.e. under tension and hence ductile. Responses that gave lists of contradicting statements could not be awarded marks. Such practices of writing too much about a subject should be discouraged, as often there will be contradicting statements and no credit can be given.

Q14(b)
The vast majority of candidates could correctly take the information from the graph and state that the viscosity would decrease with increasing temperature. Due to the language used, fewer candidates managed to score the second marking point as a reference to the flow of the glass at higher temperatures was required.

An example of a good response that scored 2 marks is shown below. Descriptions of low viscosity in terms of 'runniness' should be avoided and candidates should be encouraged to always discuss viscosity in terms of rate of flow.


Explain why high temperatures are required for this technique.

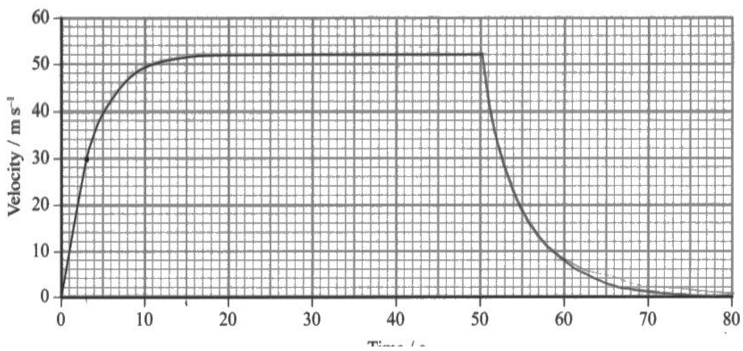
(2)

If glass is heated its viscosity decreases This means that the rate of flow increases and it is more «runny». So, by heating the glass it can be turned into a variety of shapes without breaking

Question 15

Q15(a)
The command word for this question required an explanation of the shape of the graph rather than just a description of its shape in terms of the velocity or acceleration as time progresses. This question provided good discrimination between the candidates of different abilities, although the more able candidates did not always answer as well as expected.
Although many candidates knew that the weight was acting downwards, very few managed to explain that this was the only force acting initially. The mark scheme for MP1 demonstrates the many ways that this could have been expressed. A typical answer tended to state that initially the weight was greater than the drag and the upthrust, this would not score the first mark. Most candidates managed to link the increase in velocity to an increase in drag however fewer candidates managed to then describe the decreasing gradient in terms of the decreasing resultant force for MP3. To the credit of the teaching nearly all candidates identified that the final period of constant velocity was obtained when the forces were balanced, scoring the final marking point.
Free-fall and terminal velocity has appeared on quite a number of previous exam series. To explain the motion of the object falling many more points could be made. The most significant features of the graph i.e. initial maximum gradient, decreasing gradient and a gradient of zero were identified as the main features that candidates would be required to explain in terms of their knowledge of physics. Generally however, an answer in terms of the initial, decreasing and then zero resultant force with explanations as to why the resultant force is changing will cover any requirements of the question.

Q15(b)
Again, as seen in question 13, a small addition to a graph can demonstrate enormously a candidate's understanding of the context and the Physics involved. This should not be an unfamiliar context to many candidates however the graphs produced were of varying quality. A vertical line was not acceptable as it would assume that the skydiver decelerated instantaneously i.e. the parachute provided an infinite acceleration. Therefore a slight negative gradient was required.
Examiners expected to see a deceleration over a short period of time (no more than 10 s) to a lower value of terminal velocity. Although the example below has the correct shape graph for a deceleration they have drawn this over 20 s which was too long. They also have the skydiver decelerating to a rest rather than a lower value of the terminal velocity. Therefore, what looks, on first inspection like a good graph actually scored 0 as the Physics has not been applied sensibly to the context.



Q15(c)(i)
While many candidates managed to identify that the terminal velocity would increase if the mass of the skydiver was greater, few managed an explanation in terms of the increased drag that would be required to equal the greater weight. Many candidates were thinking along the right lines in stating that the time taken to reach the terminal velocity would be greater, but often did not link this to a greater terminal velocity or give an explanation as to why it would take longer, i.e. to reach a greater terminal velocity.

Q15(c)(ii)
There were some good answers seen to this question but powers of expression failed some candidates who suggested 'fall horizontally'. A few candidates did not realise the significance of the question numbering and the 'before he opened his parachute' in part (c)(i). Therefore responses that referred to the parachute a means of increasing the surface area were not awarded MP2.

Q15(d)
It can be seen from the given graph that terminal velocity is reached very shortly after leaving the plane therefore candidates had to appreciate that both skydivers were travelling at the same speed when the first parachute was opened. Less able candidates assumed that opening the parachute created an upwards acceleration, moving the skydiver upwards, rather than just a deceleration. However, many managed to score this first mark. An appreciation that the filming skydiver just continued as the same constant velocity was not realised by many, with many responses referring to this skydiver continuing to accelerate, thus MP2 was not awarded as frequently.

Question 16

Q16(a)(i)
A large number of correct answers were seen but most that did not score here gave examples of pairs of forces in equilibrium, of different types, demonstrating that Newton's third law pairs are still not well understood.

Q16(a)(ii)
A higher proportion of marks were scored here compared to part (a)(i). Candidates were required to qualify the direction by stating that the directions were opposite so 'different direction' was insufficient. Candidates were more successful at describing the similarities although many chose to state the magnitude in addition to their answer.

Q16(b)
Some very good responses were seen, particularly in parts (i) and (ii), but there were also many blank; a pity as the candidates probably knew enough physics to achieve a few of the marks. Using $W = mg$ in part (i) and $F = ma$ in part (iii) were very straightforward marks to score and most candidates that attempted these questions picked up those marks.

Q16(b)(i)
Many answers showed clear working and a good understanding of the resolution of forces. Weaker candidates could work out the weight of the box but then either omitted to equate the resultant of the weight and the reaction to the vertical component of the man's pull or omitted the normal contact force altogether. The trigonometry skills of candidates did vary widely as some were unable to select the correct trig function for the vertical component of the man's pull on the box. Candidates should be encouraged to annotate diagrams or draw their own to include labelled angles and resolved components of forces.

Q16(b)(ii)
Many candidates, irrespective of how part (a)(i) was answered were able to resolve the force obtained in the previous question to the horizontal to obtain the magnitude of the frictional force acting on the box. Many candidates chose to use the 'show that' value of 400 N from part (i) which was perfectly acceptable and could enable candidates to pick up all 3 marks.

Q16(b)(iii)
Part (iii) of this question required the candidates to consider the two objects as one as they were accelerating together. Many that attempted this question did not always appreciate this and tried to use $\Sigma F = ma$ based on the acceleration of just one of the objects, usually the man. Resolving horizontally the forces are:
$\text{friction}_{\text{man}}$ – horizontal pull of box on man + horizontal pull of man on box – $\text{friction}_{\text{box}}$ $= ma$
With m being the combined mass of the man and the box and the forces of the man on the box and the box on the man cancelling out as they are equal and opposite. The magnitude of the force of the man on the box and vice versa had increased from the value calculated in part (i) however the frictional force between the box and the ground was still the same.
Many candidates managed to pick up one or two marks even if they couldn't get to the final answer by using F = ma for one or both of the accelerating objects.

The response below scored (i) 4, (ii) 3, (iii) 2 marks. Part (i) is self-explanatory and very well set out, in part (ii) the candidate chose to use the show that value rather than their calculated value and obtained a correct answer. In part (iii) the candidate has separated out the two accelerating objects and is just considering the forces acing on the man. To treat the man and the box as separate objects the candidate would have to use ΣF = ma for each object to obtain the pull of the man on the box and the box on the man and then the friction between the ground and the man. Therefore to award marks to the correct physics this response was treated as though the candidate had just used the incorrect mass rather than the incorrect resultant force, scoring MP1 and 3.

(b) The angle between the pull of the man on the box and the horizontal is 35°. The mass of the box is 85.0 kg.

(i) Show that the pull of the man on the box is about 400 N.

normal contact force of the ground on the box = 620 N

(4)

$620 + T\sin 35 = 85 \times 9.81$

$T\sin 35 = 833.85 - 620$

$T = 372.84\text{N}$

$\approx 400\text{N}$

(ii) The box moves at a constant speed towards the man.

Calculate the frictional force between the box and the ground.

(3)

$F_r - T\cos 35 = 0$

$F_r = T\cos 35$

$= 400 \times \cos 35$

$= 327.66\ \text{N}$

(iii) The man increases his pull on the box. The man and the box start to move together in the same direction with an acceleration of 0.200 m s^{-2}.

Calculate the frictional force between the ground and the man.

mass of man = 90.0 kg

(4)

N2L →

$F = ma$

$F_r - T\cos 35 = 90 \times (0.200)$

$F_r = 18 + 400(\cos 35)$

$F_r \quad 345.66\ \text{N}$

Frictional force between the ground and the man = 345.66N

(Total for Question 16 = 14 marks)

Question 17

Q17(a)

The context of this question would have been unfamiliar to most candidates however the responses seen, particularly by middle ability candidates were encouraging. However, many did not always answers as concisely as they could, spending more time than should be necessary on this question.

A straightforward response stating the measuring device as a micrometer or digital Vernier callipers was required for MP1. We did not accept Vernier callipers alone as their resolution is
10^{-4} m, i.e. 10 × larger than that for the micrometer and digital callipers. The candidates then had to describe how the measurements would be taken and used. Multiple times without the addition of differences in the position or orientation was not sufficient, a point missed by many. The results would then be used by taking the average.

A fair number of alternative unworkable methods were stated such as wrapping string around the wire to measure the circumference or placing several wires together in the jaws of the micrometer and then dividing the measurement by the number of wires.
Many candidates missed the second line on the question and discussed all the measurements to be taken, usually with the description of the diameter almost as an afterthought at the end of the response.

Q17(b)

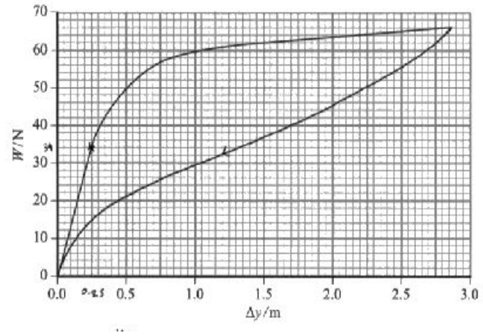
Many candidates recognised that the extension of the wire would be very small however, only a small number managed to score MP2, usually for the idea that this system magnifies the original extension. Only the best candidates referred to the percentage uncertainty with most making reference to accuracy, precision, error and uncertainty. A ruler would have also been used had Δl been measured directly therefore the accuracy, precision etc. would be the same. However, as Δy is a greater measurement, the percentage uncertainty is smaller.

Q17(c)(i)

Most candidates understood the procedure involved but a surprisingly large proportion did not take values from the graph from within the linear region, usually opting to take the end point of the graph. As Δl, the extension, is proportional to Δy, the measurement taken, this graph could just be treated as a standard force-extension graph. A number of candidates did not use corresponding W and Δy values from the graph and misreading the scale was more frequently seen than usual with such graphs. Finally, a noticeable number of candidates that obtained the final answer forgot to include a unit, so could only score 4 of the possible 5 marks.

Q17(c)(ii)

Although many candidates simply missed completely this part of the question, many that attempted it assumed wire would go back to its original length once the force is removed. The mark scheme did not expect candidates to realise that the gradient of the graph should be the same as the initial gradient, and a straight line, of any (positive) gradient, from the end point of the graph would have been acceptable. However, these were rather rare, many attempting to draw a type of hysteresis shape curve.



Question 18

Q18(a)
For those candidates that attempted this question many managed to pick up at least one mark with the most able candidates managing to usually score 2 or 3 marks. The entire jump has two periods where there is a transfer from gravitational potential energy to kinetic energy; movement along the slope down the inrun and then the jump itself through the air from the platform to landing. Candidates had to be clear as to which part of the jump they were referring to hence MP1 and MP3 were the most frequently awarded as less precision as to which part of the jump was being referred to was required. As gravitation potential energy is transferring to kinetic energy throughout the jump, it is the kinetic energy that the ski jumper has as they leave the platform (horizontally) that determines their landing velocity and distance travelled.

Q18(b)(i)
This question required the candidates to calculate the vertical velocity on landing and then use the ratio of the vertical and horizontal velocities to determine the direction. The direction of the velocity on landing is not the same as the direction of the total displacement from take-off to landing. The direction of the displacement to the vertical is also 55° so candidates should be wary when using this paper for practice that this is not the correct angle. Common errors included using a combination of velocity and displacement to calculate their direction and using the horizontal velocity of 28 m s^{-1} for u in $v = u + at$. Rarely was a velocity vector diagram drawn to support the candidate's thinking and such diagrams should be encouraged.

Q18(b)(ii)
This question required the candidates to calculate the displacement after 4 seconds and then subtract 120 m to determine the points scored. Many approaches were possible for this response as candidates had more information than was required and candidates that presented their work in clear stages invariably did very well. The most common method was to calculate the vertical distance using ½ gt^2 and the horizontal distance using v_Ht and then use Pythagoras to find the displacement. The most common incorrect method was to use the range equation which was not appropriate as the ski jumper did not have a parabolic trajectory as the launch was horizontal (no initial vertical velocity). Weaker candidates were seen to use the initial horizontal velocity mixed in with vertical variables in suvat equations but often these candidates could score MP3 for subtracting 120 m from their displacement.

Q18(c)
The vast majority of candidates chose air resistance, drag of friction due to the air. Others were not as specific and referred to friction, often followed by a discussion of motion down the slope rather than through the air. Most candidates managed to score at least one mark with many picking up three of the four marks. MP2 required a good understanding of the vertical and horizontal motion and was awarded the least as most candidates did not appreciate that the vertical acceleration would decrease and that there would be a horizontal deceleration due to air resistance. Many choosing to describe a vertical deceleration. Only MP2 covered any new knowledge, MP1,3 and 4 could all have been awarded to a good GCSE student demonstrating the gap in some candidate's understanding of vertical and horizontal projectile motion.

Summary

This paper provided candidates with a wide range of contexts from which their knowledge and understanding of the physics contained within this unit could be tested.

A greater understanding of the context and question being asked would have helped many candidates. A sound knowledge of the subject was evident for many but the responses seen did not reflect this as the specific question was not always answered as intended.

Based on their performance on this paper, some candidates could benefit from more teaching time and extra practice on the following concepts and skills:

- Slow down during the multiple choice items so that key words in the command sentences and distractors are not missed
- Correct scaling of graphs if a graph is to be plotted
- Learn correct explanations and definitions of key terms
- Look at more examples using Newton’s first law, particularly for forces acing opposite to the direction of an object moving at a constant or increasing velocity
- Practice using substitution into suvat equations, particularly in examples where more information than needed is provided and you have to select which variables to use
- Draw diagrams when answering vector questions, particularly if direction or a resultant is required

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