Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

January 2019

Pearson Edexcel International Advance (Subsidiary) Level In Physics (WPH11)
Unit 1: Mechanics and Materials

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January 2019
Publications Code WPH011_01_1901_ER*

Introduction

This is the first time that the Pearson Edexcel International AS paper WPH11, Mechanics and Materials, has been sat by learners. Section A of the paper is worth 10 marks and consists of 10 multiple choice questions. This is followed by section B, consisting of 8 questions of increasing length comprising of short open, open-response, calculation and extended writing style questions.

The assessment for WPH11 is mostly similar to the legacy IAL specification. The specification has been broadened to include recognising vector notation (specification point 4), conservation of momentum in 1 direction (specification point 14), moments (specification point 15) and the efficiency equation (specification point 30). This specification now includes three core practicals, to determine the acceleration of free-fall, to use a falling ball method to determine the viscosity of a fluid and a method to determine the Young modulus of a material. These have been examined in the past but, to mirror the home 8PH01 specifications, these are now have been designated specification points making them a compulsory rather than optional part of the course. The content of the materials section of the specification has been reduced with fluid flow diagrams and definitions of mechanical properties such as brittle, ductile, hard, malleable, tough not included. In line with the new IAL qualification, the new assessment objective AO2b allocates about 10 marks of the paper to questions that require candidates to draw a conclusion. In addition to this the legacy QWC questions have been replaced by one 6 mark linkage question, question 14 for this exam series.

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. Some candidates found the length of some of the calculations to be challenging, often missing out key steps therefore only scoring 1 or 2 marks for interim steps. Some questions were not answered as well as would have been expected by many candidates; this was particularly evident in the 6 mark linkage question (14). The new regions of the specification, in particularly moments were not answered as expected. Many learners unable to progress correctly beyond use of the moments equation for one or two of the forces, with only the best able to determine the upwards reaction force at each the supports and use the principle of moments to construct a correct equation in terms of all of the moments involved.

Candidates that had a sound understanding of the physics involved did not always demonstrate this in their responses due to a lack of understanding of the context, often missing exactly what the question was actually asking. However, candidates from across all ability ranges usually managed to score some marks within these questions. A proportion of candidates lacked expertise in some areas of basic Physics including construction of vector diagrams, interpretation of a velocity-time graph, recall of a set practical and construction of a free-body force diagram. While the mathematical ability seen was strong, application to the context, in particularly the determining the correct resultant forces in questions 16aii and 18cii, was not as expected. One aspect some found to be challenging was the correct selection of values to be used, in particularly for question 16 where all of the stages of the rocket's approach to Mars were described, hence incorrect velocities and reversed substitutions for *u* and *v* into the correct suvat equations. This paper is 10 minutes longer than the legacy IAL and learners generally could complete the paper within this time although a small number did miss various combinations of sections of question 18.

Section A – Multiple Choice

Most learners scored between 5 and 8 out of 10, the mean being 5.8 for the multiple-choice items. More able learners did not perform as expected on this section, questions 2 and 4 in particularly as well as some on 9 and 10.

Some low scoring learners fared better on the multiple-choice questions than their higher scoring counterparts.

Explanations of the distractors are included in the mark scheme but a few, more significant, points are mentioned below.

Question 2

The most common incorrect response of B indicates that most learners assumed that the unfamiliar unit of kilwatt-hour was another way of writing kilowatts per hour and divided by the time of 3600 s rather than multiply, leading to the answer of 0.28 W.

Question 3

Distractors B and C were the most common incorrect responses, showing that the word 'best' was missed by many learners. While most learners recognised that Stoke's law applies to small and slow moving objects,few appeared to read through all of the distractorts to reach the correct response of D, many just clicking on the repsonse with the first correct property seen. Hence on this initial page of questioning, perhaps a proportionaltly small time was allocated for each repsonse.

Question 4

While all learners could calculate work done, far fewer could distinguish between the work done against the gravitational force (the gravitational potential energy) which was the useful energy output and the work done against frictional and gravitational forces, to move the box a distance of 10 m along the slope i.e. the total intput energy. Response (a), one that produced an efficiency greater than 100 %, should have been elimanated from any coinsideration but was selected by about one sixth of learners.

Question 6

Confusion between the acceleration and velocity of a projectile was evident, particularly with the most common incorrect reponse of B. Although they correctly identified that the initial acceleration is 9.81 $m\ s^{-2}$, the acceleration at the maximum height was confused by many with the velocity, assuming it to be 0. Only 45 % of learners selected the correct response of C which showed that the acceleration, due to the graviational force acting on the projectile is constant, regardless of the position of the projectile within its trajectory.

Question 9

As question 17 demonstrates, most learners are confident in their application of the formulae for the Young modulus and the stiffness constant. Fewer realise the significance of these properties, in that the stiffness constant only applies to a specified object, while the Young modulus is a general property of a material.

Question 10

The incorrect responses for question 10 formed a significant proportion of the responses seen however, there was no distinguishable incorrect response with learners equally divided between responses A, B and C. As density is inversly proportional to the volume, an increase in the dimentions of the cube by a factor of 1.5 would result in an increase in the volume by a factor of 1.5^3 and hence a decrease in the density by a factor of $1/1.5^3$ i.e. 0.296.

Section B

Question 11

Use of velocity -time graphs is skill that is assumed prior knowledge of when learners beingthe AS course and then re-inforced during the mechanics section of this module. While most responses indicated that the learners could correctly use the graph to calcualte the initial acceleration of 1.56 m s^{-2}, fewer could successfully read from the scale of the graph to select values that would correctly determine the negative acceleration of the object. Only one correct acceleration was required hence many responses scored the first 2 marking points for a value of acceleration . Only a small number however could go on to correctly describe the motion of the object, with the vast majority incorrectly stating that the object was decelerating from 9 seconds onwards. Only the best could correctly describe a period of deceleration from 9 to 12 seconds and from 12 seconds onwards an acceleration during which the object was travelling in the opposite direction. As mentioned earlier, the use both scales was not as would be expected from candidates sitting an AS paper.

Question 12

Question 12 was based upon specification point 11; the core practical to determine the acceleration of a freely-falling object. The equation of motion $v^2 = u^2 + 2as$ that the investigation in the question was to use was clearly stated at the beginning of the question, so learners should have been under no doubt as to which equation of motion they should base the variables to be measured and graph to be plotted upon. In addition to this, the release position of the wooden rod in relation to the one light gate was given therefore any methods that used the equation $s = ut + ½at^2$, as was commonly seen, could not be credited as the experiemental arrangement given would not be able to give a time for the rod to fall from rest to the lightgate.

Question 12 (a)

Both marking points were seen quite often, with a slightly higher proportion successfully scoring MP1 indicating that the length of the rod should be measured compared to MP2 indicating the distance from the release point to the light gate should also be measured. Those mentioning the measuring of distances were often unable to define which distance they were measuring with many stating that ‘the student should measure the height that the wooden rod is dropped from’ which was not specific enought for MP2. Fewer candidates were able to successfully mention both marking points.

Question 12 (b)

Learners rarely described the equation to calculate the velocity, and those who did regularly referred to the distance from the release point to the gate or did not specify which distance they were referring to at all. A significant number of responses included the additional of a second light gate, which then led in part (c) to a two light gate method, rather than a method for the given equipment. Only a very small proportion of learners recognised the importance of repeating so that a mean could be calculated, in order to determine an accurate value for v, as specified in the command sentence for (b) above.

Question 12(c)

Few responses scored 2 marks or more as the vast majority of learners suggested plotting velocity against time with the gradient being the acceleration, despite the question specifically telling them which equation of motion was to be used. For those who did describe a suitable graph, most could then go on to explain how the gradient could be used to determine a value for g. Only a very small number of responses included the step to obtain a range of values by repeating at different heights. The method described in parts (a) and (b) would only lead to a single height and corresponding velocity so this needed extending to obtain a set of values that could be plotted, enabling a graphical method to be used to determine g.

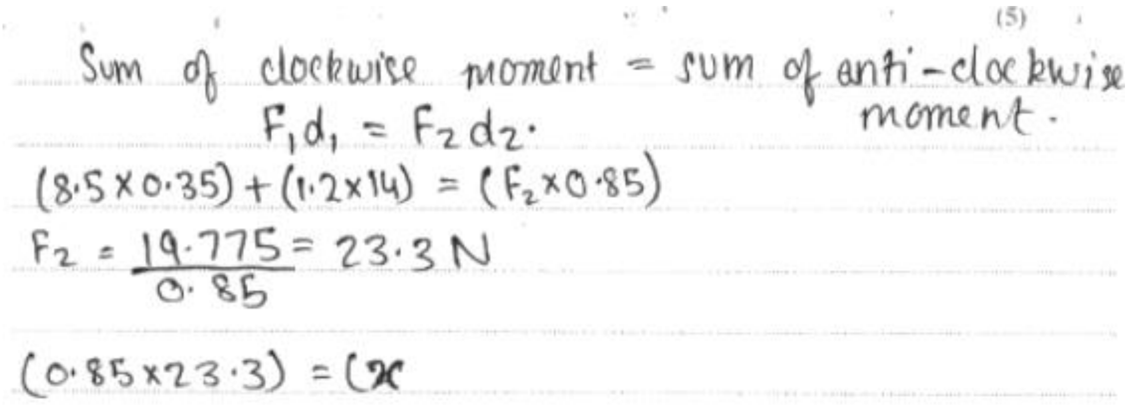
Question 13 (a)

This question examined another new part of the specification, specification point 15, moments. This was a straightforward question with all forces being perpendicular to the given distances however, many learners either did not consider the reaction force at A or found it difficult to determine a value for this force. Hence the most common mark awarded was 1, for MP3 as most learners could use the equation moment of a force = Fx with a sensible distance for one of the given forces. The distance had to be one that would, if part of a complete equation considering all forces, would be a correct moment from an end, A or the midpoint of the shelf.

Those that did manage to use $\Sigma F = 0$ i.e. the total upward force is equal to the total downward force, to determine the reaction force at each support could usually go on to use the principle of moments correctly to determine the distance of B from the left-hand end of the shelf. It was notable as to the number of responses that did not annotate the given forces and distances onto the diagram, particularly the upward reaction forces, a step that would have guided learners through this unstructured 5 mark question. Taking moments about A was most commonly seen.

Incorrect responses, particularly those that did not attempt to determine the reaction forces often involved taking moments about different pivot points and equating them.

The clip below is a typical response scoring 1 mark, just MP3 for use for moment of a force = *Fx*. The learner has taken moments from the left-hand side of the shelf and has omitted to consider the other reaction force at A as well as an incorrect distance from A for the weight and a distance of 0.85 m for B.


(5)

Sum of clockwise moment = sum of anti-clockwise moment.

$F_1 d_1 = F_2 d_2$.

$(8.5 \times 0.35) + (1.2 \times 14) = (F_2 \times 0.85)$

$F_2 = \frac{19.775}{0.85} = 23.3$ N

$(0.85 \times 23.3) = (x$

Question 13 (b)

Although many learners indicated that the force would increase, fewer were able to express clearly that this was due to the distance (to a pivot) being reduced. Few mentioned successfully anything about the moment remaining the same although, quite a few responses stated that the total clockwise moment still had to equal the anticlockwise moment which was insuffcient as both of those could have increased or decreased and should have clearly stated that the moment of bracket B had to remain constant.

Question 14

This question required a significant amount of given information of an unfamiliar context to be applied to the concepts of upthrust and resultant forces. Those who considered the volume of air to be more significant than the volume of the egg were rarely able to score more than 1 or 2 marks. In such responses they read the increase in volume of the air cell to be the increase of volume of the egg.

The vast majority of candidates chose Statement 2 on the assumption that the size of the egg would increase mostly resulting in incorrect descriptions of an increase in volume and hence upthrust resulting in net upward force and movement upwards of the egg. Those who went along the path that Statement 2 is correct were mostly unable to score any marks as their reasoning cited incorrect physics with only few managing to state that the weight would increase or the volume would remain constant.

Even those who had a good understanding that Statement 1 was correct often failed to score too heavily as they concentrated on talking about density changes rather than force changes or comparisons.

There were many discussions about upthrust being greater than weight, but these usually did not score IC5 as they were taking about statement 2. As for the other indicitive content points, they were probably awarded most often for the earlier points in the mark scheme.

Some candidates only wrote about one statement, meaning that it was impossible for them to achieve a full 6 mark score here and it should be noted that if the command word is 'assess' and if two pieces of information are given then it is expected that the response will refer to all the supplied information. In this case explaining why the incorrect statement was incorrect.

Question 15 (a)

The question asked for scaled vector diagram to be used i.e. drawn to determine the total momentum of the two spheres after the collision. While momentum in more than one dimention will not have been taught at this stage, it is expected that learners will have practised the construction of such diagrams and should be familiar with scaling and taking measurements from them.

Some good responses were seen with most producing a parallelogram rather than a triangle, with a small number using a compass to find the postion of the end of the resultant. However, diagrams often lacked labelling or arrows on at least one of the momenta, preventing MP1 from being awarded. Most candidates who attempted a diagram got the scaling correct, but a number were seen where one momentum arrow was drawn horizontally, and the other at 25° to it. This was a 'show that' question and, as adding 0.14 and 0.096 gave an answer within range, it was necessary to check that a correct method had been used in order to be able to award MP4.

Question 15 (b)

This should have been a straightforward 2 mark recall question. Although most attempted this question, the omission of sum or total prevented many from scoring MP1 and a large proportion forgot to mention that there should be no external forces or for it being in a closed system. Some referred to the resultant force rather than no external forces.

Question 15 (c)

This question was based on a new area of the specification, specification point 13, understand that momentum is defined as $p=mv$. While most learners understood the principle of conservation of momentum, as seen in part (b), fewer could then go on to apply this to the two spheres and use their value for resultant obtained in part (a) or even the 'show that' value of 0.2 kg m s^{-1}. The most common response seen was 0.096/0.12 = 0.8, just scoring MP1 for use of the equation. Some used 0.236, the total of the initial momenta, instead of a value from their diagram in (a), so could also only score MP1.

Question 16 (a) (i)

Learners generally understood how to attempt this question but the difficulty was increased as they had to select the relevant velocity for the parachute stage of the probe's approach to Mars from all of the information given on the diagram. Hence, those towards the lower end of the ability range may have used a velocity of 0 which was not credited as, at no point during the downwards motion of the probe was its velocity 0, the final velocity once landed not being considered. Other responses that used incorrect velocities from the question were still credited for their use of relevant equations of motion, most commonly, $v^2 = u^2 + 2as$, and many managed to score both marks here. Examiners did not award MP2 however if it was evident that u and v had been substituted in the wrong way round to produce a positive value for the acceleration.

Question 16 (a) (ii)

While the majority of responses were able to score 1 mark for either use of $F = ma$ or $W = mg$ very few could correctly identify that there needed to be a component of the the resistive force acting against the weight. Therefore only the best could contruct a correct equation for the resultant force and equate this to *ma*, an even smaller number were able to consider the direction of acceleration and resistive force to be oppostoe to weight. A significant proportion therefore, that managed to form the three term equation (weight –

resistive force = *ma*) only scored 1 mark due to not including a negative direction for the acceleration.

Question 16 (b)

Most responses included an attempt to calculate a quantity for comparision to the given values in the question, enabling learners to make an informed decision as to whether the probe was in free-fall during the final stage of its approach to Mars. The most common method was to attempt to calculate the acceleration although, as seen in 16ai, incorrect substitutions for velocities including 0, into the relevant equation of motion, were commonly seen. The subsequent explanations did not always make it clear what they were comparing their calculated value to in order to reach the conclusion that it was not in free fall.

It also became very evident that many learners have a poor understanding of what free fall means, a nescessary starting point as the equations of motion can only be used if the resistive forces are ignored. Therefore marking points 1 and 2 for explaining free fall and implying that there were resistive forces acting were not always awarded. Many who were unable to score MP1 often described the situation present in terms of forces when terminal velocity is achieved i.e. when the weight is balanced by resistive forces, rather than the absence of resitive forces.

The response below scored 2 marks, using the top mark scheme on the page. No credit could be given for stating that the calculated acceleration was not equal to the gravitational field strength as no explanation had been given as to the significalnce of the graviatational field strength in that the acceleration for free fall is 3.8 (m s^{-2}) and the acceleration should be equal to this value.

$s = 3.7 \times 1000$ $v = 150$ $u = 68$ a

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

$22500 = 4624 + 7400a$

$\frac{17876 = 7400a}{7400}$

$a = 2.4 \text{ ms}^{-2}$

free fall term is not correct in this context, because the calculated acceleration is less than the gravitational field strength on Mars.

Question 17 (a)

This question was attempted by the vast majority of learners, with most selecting values from the linear region of the graph to determine the Young modulus. However, a significant proportion of responses included power of 10 errors as the mega prefix for the stress was not always considered, leading to values for the Young modulus a factor of 10^6 out. However, this did not prevent anyone from gaining credit for use of the ratio of the two modulii (MP3) and for showing that the ratio is about 1.3(MP4). It is worth reinforcing to learners that graphs where such a small proportion of the overall graph is linear, should have a tangent drawn to get a bigger triangle and a more accure value for the quantity being determined. Most candidates scoring MP1 did not draw in their own tangent line, just took data from points early on in the graph.

A small number of candidates took the maximum values for stress and strain to use in their equation for the Young modulus. Such a method only made MP3 for the ratio of the moduli accessible.

Question 17 (b)

A significant proportion of learners chose to determine the area under the graph by approximating the area under the graph to a traingle. This was not considered to be an accurate method and resulted in a percentage reduction of around 25 %, rather than a value in the 12 % to 15 % range. MP1 required an attempt at a counting squares method or an approximation of the area under the graph to a series of shapes. Learners did not always realise that they had to calculate the percentage reduction in the energy, often just calculating a ratio of their calculated energy to the energy absorbed by the 2-day old sample. Although a range was give for MP3, due to the variance in the calculated area often due to missing out small regions when determining the area, few managed to obtain a value in range for the percentage reduction.

Question 17(c)

Learners appeared to be far more confident when answering this question with many scoring 1 or 2 marks, usually for a higher breaking stress (or the correct equivalent Physics) or the concrete being stiffer. Few manages to go on to explain a third point and MP3 was awarded infrequently. This question required comparision to be made between the properties at 2 days and at 28 days therefore, each property discussed had to make a comparision rather than a statement of the properties of of either block. This did prevent some from scoring, even if the Physics was known, and this style of question, quite commonly examining properties of materials often required comparative answers e.g. ‘stiffer’ rather than ‘stiff’ for a 28-day old block. Just to note that ‘withstands’ is an ambiguous term that does not nescessarily mean fracture and learners should be discouraged from using this to refer to the breaking point of a material.

Question 18 (a)

This free-body force diagram required a number of factors to be considered as well as the identification of the forces acting on the sledge and athlete; the direcion of each force, the correct label and the magnitude of these forces.

Most learners were able to draw the weight correctly and drew straight arrowed lines that touched the given spot. The drag and normal contact forces were not always at the correct angle, both in terms of their general direction and them not being at right angles to each other.

Learners should be reminded that a free body force diagram should not show components of forces e.g. $mg\text{Sin}\theta$ and $mg\text{Cos}\theta$ and should only show forces acting on the object required. It should also be noted that acceleration, velocity and equivalent terms are not forces, and that the resultant force or ma is not a force to be included in a free-body foce diagram.

The relative lengths of the arrows should indicate the size of the forces involved, relative to one another, and the arrowed line for the weigt should have been longer than both the line for the normal reaction and the friction.

Question 18 (b) (i)

Only those of A grade ability picked up marks for this question. This was mostly for identifying that initially the resitive forces are small or negligible; most referring to friction rather than more specifically (and correctly) to drag. Although very rare, some good responses were seen where learners could correctly identify that the component of the weight down the slope $mg\text{Sin}\theta$ would therefore be the resultant force and equated it to ma. Those who did get this far often had not scored MP1 and assumed there to also be a resitive force acting on the sledge which made the question difficult to answer.

Question 18 (b) (ii)

The context of his question and the subtle difference between the affect of the frictional forces between the slope and sledge and the air resitance was missed by most.

Many responses identified that the resistive forces would increase but few could specifically identify that it was the air resistance that was increasing and not the friction between the track and the sledge. Those with a correct description of the air resitance increasing did not always link this to an increasing velocity. The most common mark to award was MP3 as many learners identified the maximum velocity as the terminal velocity and could confidently explain the condition that no resultant force would lead to no more acceleration.

MP2 was rarely awarded as most learners who attempted to explain why the resultant force would be 0 mostly just explained that the weight would be equal to the frictional forces. The concept and often the language of the component of the weight down the slope, or parallel to the slope, escaping most.

Question 18 (b) (iii)

Learners on the whole did not link the idea of increased mass to increased surface area. The marks awarded for this question were usually due to a statement that the drag force would increase, often with an incorrect explanation as to why. Some responses presented a plausible argument that the increased weight would increase the reaction force and hence the frictional force but did not consider that the component of weight down the slope would also increase as a result, as would the mass being accelerated by the same proportion i.e. the acceleration would increase and not decrease with an increase in mass according to this reasoning.

Question 18 (c) (i)

Many scripts showed no attempt to complete this question. Those that realised that an inverse trig function of 0.2 was required mostly used sin or cos rather than tan. A gradient of 20 % means that the increase in height for the increase in horizontal distance is 1 to 20. Therefore, as these are the opposite and adjacent sides of the incline, relative to the horizontal, tan should be used.

Question 18 (c) (ii)

This extended calcualtion, without any interim steps, was found to be challenging and only the best learners could venture beyond a basic substitution into an equation for energy using the first marking route or $\Sigma F = ma$ and an equation of motion for the second marking route, analysing the situation sufficiently to produce a complete solution. Low scoring responses.

This question could be answered in terms of energy transfers
e.g. $\boldsymbol{E_k = E_{grav}}$ **+ the work done against frictional forces** and then use of work done = braking force × *L* or in terms of the resultant decelerating force **component of weight down slope + braking force =** ***ma*** to determine the

negative acceleration of the system and then use of their acceleration in $v^2 = u^2 + 2as$ or a combination of equations, where the displacement s is L.

Learners were mostly unable to pull together all of the forces or energies involved in this braking system that relies on both weight and friction to stop the sledge and athlete. As was also seen in question 16, constructing equations for resultant forces where more than one force needs to be considered is a concept that many learners do not appear to have sufficient understanding of and additional practice of such questions, both quantititvely and qualitively is recommended.

Summary

This paper provided learners 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 learners. 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 learners could benefit from more teaching time and extra practice on the following concepts and skills:

- Make sure that the core practicals are covered thoroughy, these are usually recall questions asking for details of these practicals.
- Annotate diagrams for all the forces when answering moments questions.
- Practice using $\Sigma F=ma$ where there is more than 1 force acting on an object, particularly with one or more force that requires a component to be determined in the direction of motion.
- Invest time when a large amount of information is presented in a question, to read the question so that no misunderstandings are present when answering the questions.
- Vector diagrams: Practise, making sure all directions and labels are included.

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