Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

October 2019

Pearson Edexcel International Advanced Subsidiary Level
In Physics (WPH11)
Paper 01 Mechanics and Materials

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Introduction

The unit WPH11 covers the students' ability to understand and apply the physics involved in basic mechanics and properties of materials. Their ability to apply their knowledge in a range of familiar and unfamiliar contexts were examined.

The students' ability to answer questions requiring a calculation and a numerical answer was generally good, even where complex and multi-stage calculations were involved, such as the two-level golfing range of Q13(a). However, in the many questions where the physics of a phenomenon had to be explained, they did very much less well. An example is question 13(b) where the changes to the projectile path of a golf ball caused by air resistance had to be explained. This type of question tests the students' understanding of the physics involved, as well as their knowledge of the facts and ability to recall, and so is an important test of their strength in the subject.

Students often explained the effect required and then went on to describe the converse, which offered no extra credit but did take a lot of time. Students should learn to use the time to plan their responses correctly and focus on providing a complete accurate explanation.

A general point that should be noted is that where symbols are used, in equations, on graphs, or as shorthand in a written response, those symbols should be defined in the response even where they are generally accepted symbols, unless they are defined in the question.

The standard of written English seen by the examiners in this paper did not, in most cases, cause any difficulty. The students were able to record their knowledge of the subject clearly, even if not in the best English. Apart from the * questions, where the structure of the students' responses was being assessed along with the physics, lack of skill in written English was not penalised, as long as the responses were clear and unambiguous.

Multiple Choice

	Subject	% scoring the correct answer	Comment
1	Prefixes	75%	The meaning of micro- was well understood, but many thought that centi- meant 10^2.
2	Units	54%	A large number of students gave A as their answer, giving the units of force rather than moment.
3	Treatment of experimental data	44%	It was very common for A to be given as the answer, which uses area = πd^2 rather than πr^2. Most students correctly realised that 1.36 was an anomalous reading and ignored it.
4	Work as the area under a graph.	68%	Most students correctly understood that the area under a stress-strain graph did not represent the work done.
5	Vector components	90%	A small number of responses gave the difference between the velocities, rather than the difference of the squares.
6	Force diagram	72%	The large majority of the responses recognised that W_c was incorrectly placed, but a few thought it incorrect that the weight of the table acted at a point below its surface.
7	Newton's third law	55%	
8	Power as rate of energy transfer	36%	There was no clear indication of a misunderstanding in the responses to this question. All three incorrect responses were equally likely to be chosen.
9	Object in free fall.	18%	The great majority of the students gave B as their answer, assuming that the sphere would fall at twice the velocity in the second interval as in the first and so fall twice as far. However, those are the velocities at the end of the time intervals, and the average velocity in the second interval is three times that of the first.
10	$F=kx$ for a spring	80%	

Q11

Most students appeared to understand the concepts for this question, but the wording used in their answers was frequently imprecise. Few students correctly described horizontal force or horizontal work done, and because this question asks for an explanation, a clear statement that the horizontal component of the force was $F\cos\theta$ was required, not just an implication by its use in the equation for the work done. Despite the statement in the question that the force F was constant, many responses stated that F would increase as θ increased. The response below give a full and clear explanation.

workdone by the force F on the box is the
horizontal component of force F × distance traveled.
horizontal component of force F = F cos θ
when θ increase the horizontal component of force ~~increas~~ decrease
Then the workdone on the box by F decrease.

Q12(a)

Most correct answers to this question used $mgh=Fd$. Those who chose to use ½ mv^2 generally forgot (or didn't understand) to set the acceleration as negative to show the trolley slowing, and often used g as the value for acceleration. The velocity at the end of the slope can be calculated using an equation of uniformly accelerated motion. If that is done then the use of g as the acceleration, implying a vertical fall, is incorrect physics and will not be awarded the mark.

Q12(b)

This question involved the conservation of energy as the trolley ran down the slope, and then the conservation of momentum in the collision. The sample below is a clear and consise response:

$\frac{1}{2} m u_A^2 = mgh$

$u_A = \sqrt{2gh}$

Use conversation of momentum: $mu_A + mu_B = mv_A + mv_B$

$\sqrt{2gh} + 0 = 2v$

$v = \frac{\sqrt{2gh}}{2} = \sqrt{\frac{gh}{2}}$

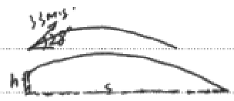
∴ the student was correct.

However, many students attempted to equate the gravitational potential energy of the single trolley with the kinetic energy of the combined trolleys after the collision, ie $mgh = ½(2m)v^2$, ignoring momentum completely. It was surprising that any such question on collisions did not immediately trigger students to use momentum!

Note that, in common with many questions in the new specification for this exam, the response is expected to include a conclusion, in this case that the student in the question was correct.

Q13(a)

Questions of this type, where the student is being asked to do a calculation in order to make a deduction, will be common now in IAL exams. Had the question just asked for the required height of the platform to be calculated it would have been much more straightforward, but because a height is given and the question asks whether it is sufficient, there are a large number of approaches possible, as laid out in the mark scheme. The most straightforward is shown in the following response:



$S = 92m + 10m = 102m$

$V_x = 33m\cdot s^{-1} \times \cos 28° = 29.1 m\cdot s^{-1}$

$V_y = 33m\cdot s^{-1} \times \sin 28° = 15.5 m\cdot s^{-1}$

$S = vt$, $t = \frac{S}{V} = \frac{102m}{29.1ms^{-1}} = 3.51s$

~~$h = vt + \frac{1}{2}at^2 = 15.5 \times 3.51 - \frac{1}{2} \times 9.81 \times (3.51)^2 =$~~

$h = vt + \frac{1}{2}at^2 = 15.5 \times 3.51 - \frac{1}{2} \times 9.81 \times (3.51)^2 = -5.96m \approx -6.0m$

$6.0m > 4.5m$

so an upper level at a height of 4.5m is not sufficient to ~~po~~ produce this increase.

This response calculates the vertical and horizontal components of the initial velocity, and most students gained the mark for doing that. The required time of flight is then calculated and used to determine the final vertical displacement below the initial position (−5.9 m), i.e. the height of the platform required. An alternative would be to use the quadratic to calculate the actual time of flight for a final displacement of −4.5 m, and use that to determine the actual range (99.8 m). Whatever method is chosen, the final mark is for an appropriate comparison between the actual value and the required value, and a conclusion, in this case that the 6.0 m calculated is greater than the actual 4.5 m so the platform height would be insufficient.

Q13b

In this question, marks are awarded for the structure and lines of reasoning demonstrated by the response, as well as the content of the answer.

The majority of students were able to identify the difference in distance and height in their responses, but the remainder of their answers showed a lack of detail, or misunderstanding of the physics involved. Half the marks were awarded for an explanation of the vertical motion, and half for the horizontal. Students generally explained the horizontal motion better, but often failed to specifically state that they were describing horizontal motion.

When describing vertical motion, students very rarely stated whether they were talking about upwards or downwards motion and often did not seem to appreciate that the velocity would decrease on the way up even without air resistance. Students sometimes referred to a forward acceleration or force for horizontal motion – a fundamental misconception.

The following response was one of the better responses seen, and gained 5 of the 6 marks:

In trajectory with air resistance, the Horizonal veloc is decreasing. There is force opposite to direction of motion so there is horizontal deceleration. Lower Horizonal velocity leads to ~~a~~ lesser range or horizontal distance covered.

In trajectory with air resistance, air resistance acts downwards on the ball along with the weight of ball so there is more resultant downward force so the vertical deceleration is greater. The time of the flight decreases so ~~~~, the maximum height decreases.

In the first paragraph, the student describes a horizontal deceleration, leading to a lower horizontal velocity and therefore a shorter range. Note that we need to be clear about the horizontal motion – a "backward force" might not be horizontal and is just a general effect of air resistance. The second paragraph describes the force downwards as being the weight plus the drag, so that the vertical deceleration is greater leading to a lower maximum height. However, this response fails to note that this is during the upward part of the motion.

Q14(a)(i)
This was a fairly straightforward question, requiring the response that the moment *Ud* was anticlockwise, so would return the boat to an upright position or would balance the clockwise moment caused by the wind. Few students were able to state both the anticlockwise nature of the moment and what its effect would be. The idea that the upthrust acted through the centre of gravity of the displaced water would have been new to the majority of the students, but they were told this in the question, and it is important for students to be able to analyse the physics involved in unfamiliar situations.

Q14(a)(ii)
Students seemed to find this section particularly challenging. Many had the idea that the boat would rotate further, but were unable to explain why, and their descriptions of this were often unclear. Students did not seem to understand how *d* would vary in size, dependent on the moving lines of action, nor how the size of the moment would reduce.
The sample below is an example of a good response:

> The distance from the centre of gravity G to the line of action of the upthrust U would be smaller which make the anticlockwise moment Ud smaller since moment Ud = U×d, which would make the boat tilt more heavily in clockwise direction.

This student has clearly described the change in the distance *d*, and the effect it would have on the stability of the boat.

Q14(b)(i)
To respond well to this question, it was necessary for the students to understand that the point X was the centre of gravity of the displaced water, as they are told at the beginning of the question. Very few responses showed an understanding of this point, and therefore the responses seen consisted generally of a number of disconnected points, the most common of which was that the weight of the boat increases.

Q14(b)(ii)
If students achieved a mark here, it was generally for identifying an increase in drag. Many answers suggested the boat would sink, or need more energy for propulsion. It was rare for the increase in drag to be explained by the increase in the area of contact between the boat and the water.

Q15(a)(i)
This question concerns a core practical that is required by the exam specification. It should therefore be a familiar practical to the students, and they can expect to be asked for a clear and concise method as here, or to explain or modify the method as required. The responses seemed to indicate that many students were not familiar with the practical exercise, and those who were often did not give a clear statement of the steps required in carrying out the practical. The examiners noted the following points that could help future students in answering this type of question:

- The question asks for a method using a stopwatch and a metre rule. Those who chose to use light gates or a video camera therefore gained fewer marks.
- The question asks for a method to measure the terminal velocity. It was therefore a waste of time to describe how the viscosity of the liquid would be determined.
- When the question says "You may add to the diagram" that is generally a hint to the student that to do so would help provide a good response. In this case, drawing the two marks on the diagram was a lot

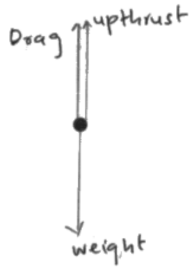
quicker than describing them in words, although it should be remembered that the additions to the diagram should be labelled.

Q15(a)(ii)
Very few responses showed a good understanding of the meaning of percentage uncertainty. Many students gave a reason why the terminal velocity might be different, for instance because the sphere touched the side of the cylinder or because turbulent flow would set in, but that is not what is being asked here. The question is about the percentage error in the calculated terminal velocity, and this will be larger because the time interval measured is shorter while the absolute uncertainty in the time is the same.

A larger sphere has greater weight. when the sphere reaches terminal velocity Upthrust + Drag = Weight. the change in drag is greater than the change in upthrust. The drag of the sphere increases and it increases the terminal velocity. For the same distance. the time taken to travel is shorter. So the human reaction time compared with the measured value will be larger. so it increases the percentage uncertainty.

The sample above gained all 4 marks and is one of the few good responses noted. The student has explained why the time of fall would be shorter and why that gives rise to a greater percentage uncertainty.

Q15(b)(i)
This very simple question to draw a free body force diagram usually gained all 3 marks, but the use of a ruler, as in the sample shown, would take very little time, and would often avoid students missing out on marks because the arrows were not vertical or did not connect with the dot. It must be remembered that each force should be labelled with the appropriate name.



Q15(b)(ii)
This calculation was often well done with the use of the correct formulae, substitutions and working. Some responses equated weight to drag and omitted upthrust, and so were limited to 2 of the 4 marks. Many students used the terminal velocity equation, substituting the correct values to get the final answer for viscosity, which was allowed the full credit on this occasion. However, it must be noted that any mistake in remembering the equation, which is not in the specification, or in the substitution of values would result in a failure to gain any credit since the student has not indicated any of the physics involved. The students should be encouraged to use the simpler equations given in the exam specification, so that they can be credited with marks showing an understanding of the process.

$U + D = W$ $\qquad V = \frac{4}{3}\pi r^3$

$\rho V g + 6\pi\eta r v = W$ $\qquad = \frac{4}{3}\pi(4.8\times10^{-3})^3$

$(1.1\times10^3)(4.63\times10^{-7})(9.81) + 6\pi\eta(4.8\times10^{-3})(0.16)$ $\qquad = 4.63\times10^{-7}\ m^3$

$= 3.5\times10^{-2}$

$4.996233\times10^{-3} + 0.014476458\eta = 3.5\times10^{-2}$

$\eta = 2.07$ Pa s

This well laid out response clearly shows the way the data is processed to the correct answer.

Q16(a)
There were very few answers referring to numerical values taken from the graph, and those which did often used incorrect values, either strain, gradient or the elastic region. It was also rare to see a reference to breaking stress, or a comparison between compression and tension as the question requires.

Q16(b)
This item was generally well answered, but many students used the stress at the elastic limit rather than the breaking stress required, and others used the wire's diameter in area = πr^2.

Q16(c)(i)
This will be an unfamiliar context for most of the students, and the question is testing whether they are able to use the information given earlier in the question, as well their knowledge of the physics involved in the properties of materials, to explain the advantage of giving the concrete an initial compression. As is often observed, the students were not good at applying their knowledge of physics to an unfamiliar situation. Most of the marks gained in this question were for describing the properties of the steel rods, with only a few explaining how they improved the overall breaking stress.

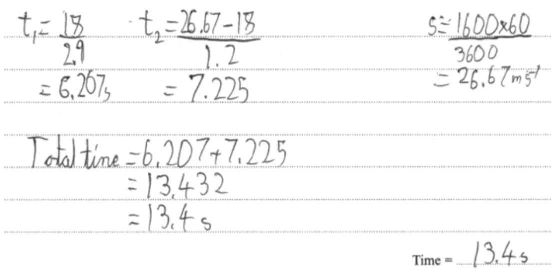
Q16(c)(ii)
It was pleasing to see that most students recognised that the wire would remain deformed after the force was removed, rather than just being deformed. However, very few responses went on to explain how this would prevent the concrete from being compressed.

Q17(a)(i)
The great majority of the responses correctly stated that the gradient of the graph would be less in third gear than in first gear.

Q17(a)(ii)
Most responses gained these two marks. The method could be to take readings from the graph at the two gear change points, or to draw a straight line onto the curve and take readings of the gradient of that line.

Q17(a)(iii)
There were some good, yet simple answers to this question. These generally made use of the equation presented in the question (P=Fv), with a recognition that if velocity increased then force must decrease, although some answers incorrectly suggested that if the power was constant, then the force should also be constant.
Some responses also identified that the acceleration was decreasing with higher gears, therefore the force must decrease. Although this reasoning is correct physics, it is not a correct response to a question about the power of the car.

Q17(b)(i)
Most responses correctly showed the conversion from mph to m s^{-1}. Most then realised that only the first two gears would be used but did not always use them correctly. Some had the whole acceleration in first gear, others wholly in second gear. Some averaged the acceleration between the first two gears, and many calculated the whole time up to the maximum for the second gear. However, a large number of correct responses were seen, and the one shown below is an example.


$t_1 = \frac{18}{2.9} = 6.207s$ $t_2 = \frac{26.67-18}{1.2} = 7.225$ $s = \frac{1600\times60}{3600} = 26.67 m s^{-1}$

Total time = 6.207 + 7.225
= 13.432
= 13.4 s

Time = 13.4 s

Q17(b)(ii)
As this is a straightforward explanation of terminal velocity, it was surprising how few responses gained the full marks. Perhaps the students have not understood that terminal velocity does not just apply to a falling sphere. Many students responded that any engine has a maximum speed at which it will work. Some said the maximum speed was to avoid accidents or comply with speed limits. It is important to explain to students that the theory of terminal velocity will apply whenever an object is moving through a fluid.

Paper Summary

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

A greater understanding of the context and question being asked would have helped many students. 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 students could benefit from more teaching time and extra practice on the following concepts and skills:

- Being able to concisely and clearly describe the main points involved in carrying out a standard experiment.
- Practice at applying their expertise in physics to unfamiliar situations.

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