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Examiners' Report
Principal Examiner Feedback

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Pearson Edexcel International Advance Subsidiary Level
In Physics (WPH12)
Paper 01 Waves and Electricity

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Introduction

This unit assesses student understanding of the topics of Waves and Electricity (specification points 33 to 80). Section A has 10 multiple choice questions, whilst section B contains a mixture of short and long answer questions, calculations, and one 6 mark linkage question.

As with all A level courses, this paper assesses both the ability of students to understand the content, and their ability to apply this understanding to a number of different applications.

This section of the specification contains core practicals 4 to 8. These are practicals that students are expected to have undertaken themselves, and questions about these practicals can be asked within the papers. Question 17 was centred around Core Practical 5, whilst aspects of Core Practical 8 appeared in Question 12.

Section A – Multiple Choice

On average, students scored between 5 and 6 marks out of 10 on this section. Question 8 was the most successfully answered, although it was the only multiple choice that more than two thirds of students answered correctly. Three of the questions were answered correctly by less than half of the students. These were questions 3, 5 and 10. Generally, these could be considered to be the multiple choice questions that required the highest levels of application of understanding to a novel situation.

Section B

Q11 (a)

This question was generally answered very well, with the significant majority of students scoring both marks. Most were able to insert both of the given refractive index values along with the angle of incidence given in the question. Only a small number failed to include both refractive index values, or got the refractive index values the wrong way round in the equation. A small number decided to only use one of the given refractive index values in the calculation, implying that they were working out the angle of refraction for a boundary between one of the materials and air. For those who had the correct numerical answer, there were a very small percentage who forgot to include the correct units.

Q11 (b)

This part of the question proved more demanding, considering that the equation as listed in the formula sheet only included one refractive index (n). Many students did not realise that they had to work out the ratio of the refractive indices before inserting that into the equation as "n". Of course, some chose to go back to the base equation $n_1\sin\theta_1 = n_2\sin\theta_2$, where one of the angles was 90°, and this could also lead to the correct answer. In spite of the greater difficulty of this question, once again the vast majority of students scored 1 or 2 marks.

Q12 (a)

This question was generally answered well, and both alternative methods were seen frequently. As both of the resistors were in kΩ, if the calculation was done consistently the effect of having kΩ was negated; so many students scored both marks without needing to show any sort of conversion. Almost three quarters of students scored both marks, with the majority of incorrect answers being related to either using the wrong resistance value in calculations, or simply finding the potential difference across the other resistor (0.27V). It was concerning to see a large number of students trying to establish a whole circuit current using just one of the resistance values given, rather than adding them together.

Q12 (b)

A number of students were unable to access the marks on this question, suggesting that they did not have a full grasp of the practical issues that could make an idealised voltmeter reading differ from a measured one.
It was clear that a number of students when answering part (a) had not taken full notice of the fact that the resistances of the resistors were in kΩ, so on part (b) more generosity was being given to those who suggested that the internal resistance of the cell could be a cause of the different voltmeter reading. When awarding marks, this was the mark that was awarded most commonly. A significant number of students mentioned about resistance in the wires or connections, but very few considered the resistance of the voltmeter in the correct way. Indeed, some answers suggested that the voltmeter was supposed to have no resistance, as they mentioned that the reading on the voltmeter would be different if the voltmeter had a resistance.

Q13 (a)

More than half of the students scored full marks on this question, demonstrating an understanding of both the calculation and the conclusion required. The majority of the students scoring 2 marks failed to make a relevant conclusion based upon their calculation. Some of these did not make any conclusion whatsoever. However, there was also a significant number who concluded that there would be constructive interference between the waves as the calculated wavelength matched the graph wavelength, thus making them unsuitable for noise cancelling.

The original conception of the question was that students would calculate the wavelength mathematically and then compare it to the graph wavelength. However, perfectly acceptable alternatives involved taking the wavelength from the graph and substituting it into the equation to calculate either the frequency or speed. Most of the students who did this had no problem identifying that 850 Hz was the same as the 0.85 kHz given in the question.

Q13 (b)

Students tend to find the 6 mark linkage questions difficult to access. There were a reasonable number of students who scored 0, 1, 2, 3 or 4 marks in total on this question, but very few scored 5 or 6. This was largely due to the fact that more than one aspect of physics was required in order to fully answer the question. A full answer needed to discuss both the aspect of diffraction allowing the sound to reach the ear on the other side of the head, as well as discussing the interference between the engine noise and the ANR sound. The majority of even the high scoring students focussed entirely on the effect of interference and how it was perceived differently for each ear.
Although it is pleasing to recognise that some students have seen past paper questions, it is important to note that questions which look similar at the outset may well not be identical. A question with a similar diagram to the one given on this question appeared in the previous specification paper WPH02 in June 2017. On the earlier paper, the question was purely about the effects of diffraction, and how the amplitude of sound decreased over distance. It was only really the first indicative content mark on this paper where diffraction was relevant, so students focussing purely on diffraction did not tend to score very well.
There was a good understanding of the interference effects from a lot of students who clearly understood that a loud sound would be related to constructive interference whilst a quiet sound was due to destructive interference. However, very few students managed to link this to the calculation they had completed in part (a). As such, indicative content point 6 was also rarely awarded.

Q14 (a)

The majority of students scored this definition mark. It is a standard definition, yet many students forget that it is the “minimum” energy required, rather than just the energy required. A small number of students wrote confused answers where it was not entirely clear if photons or electrons were being released during the process. Although the “surface of a metal” part of the answer was bracketed (meaning that it did not need to be stated in order to be able to consider awarding the mark), a number of students clearly stated that the electron was being released from an incorrectly identified location e.g. from the ground state of an atom. These students did not score the mark even if they had correctly stated that the work function was the minimum energy required to release an electron.

Q14 (b)

It is pleasing to see that so many students were able to answer this question with a full 3 mark response. Although the calculated answer for the work function came out to be slightly different to the one given in the table (when considering the third significant figure) this did not cause an issue when coming to a conclusion. However, there were a significant number of students who determined the work function, and then named more than one metal that could be used for the plate. This suggested that they might be confusing the question with another style of question where candidates are given a photon energy and then have to determine which of the metals would release electrons. In this case, however, there was an expectation that only one metal should be named.
Aside from the calculation part of the question, it was also good to see that so many candidates knew that they had to select the metal from the table, rather than simply calculate the work function.
The majority of incorrect answers appeared to be trying to substitute numbers into the kinetic energy formula, rather than simply using the given value. However, most students were able to calculate photon energy for the first marking point.

Q14 (c) (i)

This question proved to be a good discriminator between students of different abilities, as relatively equal numbers of students scored 0, 1, 2 or 3 marks. However, as with the previous calculation, the most common score was 3 marks.
There were two main errors made for students who did not achieve full marks. The first was a failure to recognise that for marking point 2, the energy that was required was the work function value from the table at the start of the question. Some students used the photon energy they had calculated in part (b), whilst others used the kinetic energy given in part (b). The other error was for a significant number of students who did not recognise that the intensity provided was in mWm^{-2} rather than Wm^{-2}. So the most common incorrect answer seen was 0.118 seconds.

Q14 (c) (ii)

The low marks achieved for this part of the question can largely be attributed to the fact that many students failed to mention the role of photons in the particle theory of light. Indeed, a significant number repeated information that had been given in the lead up to the question, such as "the electrons are released instantaneously". The photoelectric effect equation $hf = \Phi + \frac{1}{2} mv^2$

should be considered as an equation demonstrating the conservation of energy. Hence descriptions should discuss the role of photons in transferring all of their energy to the electrons at the surface of the metal. The wave theory also suggests that energy is provided by the light to the metal surface, but this is a gradual process and could not explain the instantaneous release of electrons.

Q15 (a)

This question was answered very well, with the majority of candidates scoring all 3 marks. In spite of this, a number of mistakes were seen when substituting values into the given equation, most commonly associated with forgetting to square certain terms.
Considering that energy levels questions about hydrogen appear quite frequently in examinations (as hydrogen is the simplest atom to work with), there is a possibility that some students might have been aware of the ionisation energy of a hydrogen atom as being 13.6eV. As such, this meant that there needed to be some clear evidence of working that resulted in the correct answer, so bald answers of 13.6eV were not accepted. However, the majority of students showed very clear working that made it easy to score the response.

Q15 (b)

As with question 14 (c) (i), there were large numbers of students who achieved each of the possible marks available on this question, so scores of 0, 1, 2, 3, 4 and 5 were seen frequently. The most commonly awarded mark was 2, usually as a result of students successfully inserting values into the given equation for the radius of the atom. However, there was some confusion over whether the mass of an electron or a neutron should be inserted into this equation, with some candidates doing the same calculation twice (one with the elctron mass, one with the neutron mass).
Many students did not realise that they should perform a calculation to establish a de Broglie wavelength for the neutron, so failed to score anything beyond the first two marking points. Those who did use the de Broglie equation appeared to be more aware that the mass of the neutron (rather than the electron) needed to be used in the calculation, although there were still some who used the incorrect mass.
Unfortunately, those candidates who used the incorrect mass in the first equation tended to get answers for atom radius and neutron wavelength that were very similar, concluding that the student was incorrect. There is no internal error carried forward within a question, so the conclusion was dependent upon correct calculation of the two values which should have been different enough to conclude that the student was incorrect.

Q16 (a)

This question was written to be one of the harder parts of the paper, and this clearly proved so in terms of the answers produced by the students. When answering questions about refraction, students should be aware that although all waves can be refracted, terms such as "refractive index" and "optical density" are generally only applied to light waves. This question was about sound waves, but many chose to answer it as if it were related to light waves. Another issue in terms of the way this question was answered was due to students not focussing clearly on what was happening between 700m and 900m, the depths considered in the question. The whole concept of refraction taking place gradually when there is no clear "boundary" between one material and another was poorly understood. This is perhaps due to the fact that the majority of practical exercises consider light travelling from air into glass or perspex when there is a sudden change of material. However, many waves such as the ones in this question (or earthquake waves travelling through the earth) change direction gradually. A few students realised that in order to reflect at 700m, there had to be total internal reflection taking place, and a few of these also clearly stated that the angle of incidence was greater than the critical angle when this happened.
The most commonly awarded marking points were marking points 1, 4 and 5, with marking points 2 and 3 very rarely seen.

Q16 (b)

A number of students scored marking point 2 on this question, but very few achieved marking point 1. There needed to be a clear recognition that the path shown in diagram B was actually a longer distance than a wave continuously travelling at 900m depth, but few considered it in their argument. Most commonly, marking point 2 would simply be linked back to the question stating that it took less time to arrive.

Q16 (c)

Students are expected to have a general understanding of factors that can affect the speed of waves in different substances, and it was pleasing to see that well over half of the candidates were able to name at least one of the possible factors to explain why the speed of sound waves varied with water depth. Although a number of students were discussing refractive index again, the most common incorrect answers tended to be those who listed "wavelength" and "frequency" as the two main factors.

Q17 (a)

This question required a full understanding of how a stationary wave is produced, along with explaining the formation of nodes and antinodes.

However, a number of students were unable to describe the situation technically-enough, often omitting correct statements relating to amplitude or interference. The majority of students scored at least one mark on the question. The most commonly awarded marking points were 1 and 3, although a significant number did manage to correctly state marking point 2.

Q17 (b)

It was disappointing to see that a question which related to the analysis of a core practical was answered so poorly. A large number of students did not realise that they should be writing about how equations could be combined in order to draw a straight line graph. Many of these students simply repeated information from the question, discussing that if f2 was proportional to W, there would be a straight line through the origin. Unfortunately, none of that information explained why f2 would be proportional to W, which was needed for the marks.
Those students who did realise that they needed to combine two separate equations to lead to the expression required commonly scored well, although some of these still failed to replace T with W in the equation; showing an equation with T instead of W could not explain why f2 would be proportional to W.
Many of the students who scored well on this question still failed to achieve marking point 4, as they did not clearly state that the components making up the gradient would be constant.

Q17 (c)

Very few candidates achieved these marks. There were two alternative methods for achieving marking point 1, as it was not an expectation that all students would have used a Cathode Ray Oscilloscope at this point in their A level course. In spite of this, the CRO option was seen more commonly than the video camera option. Generally, the main reason for a number of students failing to achieve marks on this question was due to them suggesting use of the graph that had been described in part (b). Unfortunately, many of the students using this argument did not realise that the frequency that they would use to plot the graph was the one they were intending to check, which made it an unsuitable method to check the frequency.
Clearly both alternatives to marking point 1 would lead to students determining a time period for the motion, so the further processing would need them to invert this to calculate frequency (marking point 2). Unfortunately, as most of the students did not suggest a method for measuring the time period of the wave, the second marking point was inaccessible to them, even though it was not dependent on them having achieved marking point 1.

Q17 (d)

On such a question as this, common scores would be 1 or 3 marks, due to the fact that marking point 3 could only be gained if students had recognised that the wavelength was equal to 2*L* (marking point 2). However, there were still a number of candidates who scored 2 marks in total for this question, as there were a lot of unit errors on the answer. A number of students failed to rearrange the equation correctly, although these students could still potentially access marking point 2. The most common incorrect answer seen was 1.7×10^{-3} kgm^{-1}, which was a result of using λ as the length of the string. This scored marking point 1 only.

Q18 (a)

This question had a really good range of responses, with fairly similar numbers of students achieving each of the available mark totals for the question. Impressively, the two most common scores achieved were 5 and 6, showing that the students had a generally good understanding. This is to be particularly commended considering that the calculations required to achieve the answers were complex and in multiple steps.

The fact that this question tested many sections of the electricity topic made it quite challenging. For the first two marking points, students needed to understand how to work out the resistance of parallel branches of a circuit. For the third marking point, they needed to understand resistance in series. For the fourth marking point they needed to use $I = V/R$, and the fifth marking point required the use of a relevant power equation. Many students coped very well with all of these stages in order to achieve a correct power value for resistor A. However, some students were confused about how the p.d. or current would share between components, so gained an incorrect value for B, C or D.

Of the lower scoring students, some simply tried to use a power equation straight away (commonly using the p.d. for the whole circuit {10V} along with the resistance of an individual resistor {2Ω} in the equation $P = V^2/R$). Others who attempted the resistors in parallel commonly forgot to invert the equation so calculated a parallel resistance of 0.75 Ω. Some assumed that they should use the resistors in parallel formula with all 3 resistors (B, C and D) treated as being in parallel with each other.

Q18 (b)

As with part (a), there were a number of students answering this question that did not make a distinction between the situation for the whole circuit and the situation for the individual resistors. A number of incorrect responses started with a correct suggestion that the total resistance of the circuit increased, but then followed it by applying the equation $P = V^2/R$ to the whole circuit to determine that the power was reduced. However, if further calculations had been required for this question, students would have discovered that the power or resistor A decreased, but that the power of resistors B and C increased. Therefore no credit could be given to students who were implying that as the power of the whole circuit decreased, that

the power of A would also decrease.
Although the question clearly stated that no further calculations were required, some candidates decided to calculate the new power values anyway, which gained no credit unless they were clearly linked to there being a lower p.d. or lower current through resistor A.

Q18 (c)

Similar questions to this have been set previously on both this paper and its predecessor WPH02. Students continue to find it quite a challenging question to tackle, as the wording needs to be precise. It was pleasing to see so many students using correct terminology relating the the exact particles involved, although there was still a common lack of linking to other correct terminology e.g. not linking the idea of more collisions between electrons and atoms to the rate of this occurring. Although there was a fair spread of students scoring each of marking points 1, 2 and 3, very few achieved marking point 4.

Paper summary

The students taking this paper generally demonstrated a good understanding of the mathematical demands of the specification, with some of the longer, multiple step, calculations (such as Q18a) scoring very well indeed.
Some of the written answers were good, although this tended to be better when the questions were not as strongly applied. Question 16 expected students to apply taught Physics principles to a different scenario with a different wave type, which proved difficult for some. It is hoped that students continue to undertake as much past paper work as possible to enable them to be more familiar with some of the different applications of the theory. It is worth reminding centres and students that much of the content for WPH12 is identical to that on the previous paper WPH02, so these can generally be used for practice.
Answers to Question 17 demonstrated that it is important for students to have undertaken the core practical tasks, so that they have a good understanding of how results taken in experiments can be used to construct graphs that will enable constants such as the mass per unit length to be determined.

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