Examiners' Report
Principal Examiner Feedback

January 2022

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.

Section A – Multiple Choice

The majority of the multiple choice questions had more than 50% of the students get the correct answer. The least successfully answered of this section were **Q4, Q6, Q7 and Q10**.

On **Q4**, the majority of incorrect answers were C or D. Perhaps this was due to the fact that some students might imagine that "the ions in the thermistor vibrate less" and "the ions in the thermistor vibrate more" could not both be incorrect?

Q6 had a close link with Q5. More students correctly answered Q5, but when this was extended futher in Q6 there were more incorrect answers. The most common of these incorrect answers was A.

Q7 tested a common misconception that has been tested on this unit previously. Many students appear to be unaware that all of the points between two adjacent nodes of a stationary wave are in antiphase with all of the points in the next node-to-node distance. Many of the incorrect answers were B, which was surprising as even on a progressive wave these two points would have been in antiphase rather than in phase as suggested by the answer.

For **Q10**, it can only be assumed that some of the students did not recognise the word "not" in the question, as the most common incorrect answers were A and B, both of which clearly do happen when the light intensity on the LDR is increased.

Section B

Q11 (a)

This was a straightforward calculation of resistivity for the first two marks of Section B. Most students managed with this quite easily and scored both marks. The most common mistakes were to get resistivity and resistance confused in the equation (which resulted in a mark of 0) or the correct answer with incorrect or no units (which results in a mark of 1).

Q11(b)

Although a two-step calculation was required in order to achieve the 3 marks on this question, the majority of students scored all of the marks with a completely correct calculation. One of the more surprising aspects was that the most common reason for students failing to achieve all 3 marks was the omission of units on the answer.
Other mistakes were:
(1) Failing to recognise that the charge needed to be that for an electron. Many candidates inserted the mass of an electron instead.
(2) Using resistivity as R in $R = V/I$.
(3) Trying to incorporate the length of the wire (0.45m) into their calculation.

Q11(c)

A descriptive question which was generally answered very well for all 3 marks, or poorly for 0 marks. The main reason for the 0 mark responses was an assumption that as length of wire does not appear in the equation $I = nqvA$, that changing the length did not affect the drift velocity of the electrons. However, as the current is affected by changing the length of the wire, this obviously had a knock-on effect with the drift velocity. Most of the students who realised this then went on to score either 2 or 3 marks.
Some students clearly misread the question and thought that it had asked them to consider what happened when the length of the wire had doubled.

Students are reminded that when a question asks for comments on a suggestion, the answers should be in words and not algebra. A number of students decided to amalgamate the equations for resistivity and drift velocity to show that halving length would double the drift velocity. However, many of these attempts were not very clear at all, and were very difficult to award any credit for as they simply discussed one factor increasing, rather than doubling, as required in the mark scheme.

A significant number of students seemed to feel that altering the length of the wire would either affect n or A in the equation, neither of which are correct. Some of the arguments around these terms changing were used to show that drift velocity did double, but these were not awarded credit as they were based on an incorrect argument.

Q12 (a)

Although this was a fairly standard question about the pulse-echo method of detecting features using ultrasound, some students were clearly distracted by the use of the word "gap" in "air gap" and assumed that it was a question about diffraction. Thankfully, many of these students did go on to achieve some or all of the marks by discussing what the question was actually about.
The most commonly awarded marking point was MP1, as many students correctly used the word "reflection" rather than words such as "bounced" which would not be accepted. MP2 was also achieved quite often, although it was not always clear what time was being recorded or measured in some answers.

A significant number of students used general terms which were not properly comparative, such as "the ultrasound returns quicker if there is an air gap". Students need to firstly be aware that the word "quicker" could be confused with "speed" rather than "time", whilst we are also not sure what the ultrasound is returning quicker than. For a full answer, there needed to be reference to the fact that the time of return was shorter than in an RSJ without an air gap.

Q12 (b)

MP1 was very clearly the most commonly awarded marking point on this question. Very few students scored more than one mark, as few recignised the link to the resolution being improved by having a smaller wavelength. There were also a significant number of students who thought that this question was more closely related to the energy of the wave, quoting $E=hf$ and stating that the greater the energy, the greater penetration the ultrasound would have.

Q13

A standard description of the evidence to show that light behaves like particles during the photoelectric effect. Both in this specfication (WPH12) and in the previous specification (WPH02), questions expecting students to discuss the photoelectric effect have been common. However, there are still far too many students who discuss the energy levels in atoms (electrons being excited, dropping down and releasing photons), which is not relevant to this question.

A fair number of students gave very good answers to this question, although a lot of them focussed too heavily on why the photoelectric effect did not demonstrate the wave nature of light. The question had only asked why it was demonstrating the particle nature of light.

Although there was much discussion of terms such as threshold frequency, a number of students failed to give a clear indication of how this was relevant to the release of electrons. Statements such as "the presence of a threshold frequency demonstrates the particle nature of light" occurred commonly in answers, without any link to relevant detail. The indicative content marks 2,3 and 4 were the most commonly seen.

Q14 (a)

This is a calculation question, based upon Core Practical 6. Although the Young's slits equation is not part of this specfication, a number of students attempted to use that equation, which is not appropriate for a diffraction grating. As a result, many ended up scoring a maximum of 1 mark due to the fact that the number inserted as "*d*" in the equation was actually "*D*" from the Young's slits equation (the slit to screen distance).

Even those who used the Young's slits equation often worked out the angle by using the tangent function. However, there were also a few who, recognising that the diffraction grating contained sin θ, assumed that opposite/adjacent was sin, resulting in them not achieving the first marking point. Some used Pythagoras to calculate the hypotenuse, then used this to generate a value for sin θ, which was perfectly acceptable.

Generally speaking, those who knew how to calculate *d* scored 3 or 4 marks, with the only thing preventing the full marks for some students being an incorrect power of 10 on their calculation.

Perhaps as there is a term beginning with the letter "*n*" in the diffraction gratings equation, a number of students substituted this value as the number of slits per mm into the equation, with *d* often as the slit to screen distance.

Q14 (b)

Although it was felt that the context of this question was not particularly unusual, there were a significant number of students who did not realise that the answer was meant to be in terms of interference/superposition. Some focussed their answers purely on the diffraction aspect of the diffraction gratings, explaining why light spreads out when it passes through the gaps. Many gave good detailed explanations of how the amount of diffraction relates to the size of the gap, but this was not relevant to explaining why bright dots appeared on the screen.

Generally, for the majority who realised that this was all about constructive superposition, marking points 1 and 3 were usually awarded. The least achieved mark was marking point 2. Some discussed answers in terms of path difference, which is not a suitable way of describing interference from multiple slits of a diffraction grating. So answers were only accepted in terms of phase difference.

Q14 (c)

This question was not particularly well answered, with lots of vague responses not addressing the differences expected when white light was used instead of the red laser.

It would appear that very few students have seen this practical undertaken with white light, as most were not aware that there would be a central white dot with spectra either side. A reasonable number realised that there would be spectra ("rainbow" was accepted, even though it is not the best terminology). However, those who discussed different colours often made vague statements such as "there won't just be red dots, there will be other dots of different colours too".

A minor number of students clearly thought that the question was considering coherence, with the combination of wavelengths in white light suggesting to them that no coherent pattern would be formed on the screen at all, resulting in the whole screen being black.

Q15 (a)

A poorly answered question, with very few correct responses. Most seemed to focus on aspects that were not relevant to this particular question, such as a perceived reduction in percentage uncertainty (which would not happen if measuring values to to 0.5cm, which is larger than the smallest division on the metre rule). Other standard practical question responses, such as "more accurate", "more reliable", "less human error" were often seen.

Considering that this question related to Core Practical 5, it was surprising that so many students were not aware of the difficulties of judging the position of nodes on a string with the eye.

Q15 (b)(i)

This was a complex, multiple-step calculation that also required data to be extracted from a graph, so it is unsurprising that relatively small numbers of students achieved all 5 marks on this question.

The most commonly achieved marking point was the first one where the gradient had to be calculated. It is worth noting that students should attempt to use as much of the best fit line as possible in terms of attempting to work out the gradient, so it was surprising to see so many students not taking the very end of the graph where, at a $1/f$ value of 0.08s, the value of d was 2.7m.

The node to node distance is $\lambda/2$, so once the gradient had been calculated, students were supposed to multiply this value by 2 in order to work out the speed of waves on the string. However, this was rarely done, meaning that students could only gain access to 3 marks (MP1, MP3 and MP4). The lack of this factor of 2 would commonly lead to a final answer of 0.5kg.

Some students did not make it very clear that, when they had calculated the Tension in the string, that they were dividing this value by g to work out the mass. A number of students also did the whole question algebraically, without ever entering any data into the working shown. This is not advised, as an incorrect answer at the end can result in no marks being awarded whatsoever.

Q15 (b)(ii)

Another quite difficult application of the same Core Practical 5. Doubling the mass per unit length results in a decrease in the speed of the waves on the string, but the mass per unit length is square rooted in the equation, so this leads to the gradient being divided by $\sqrt{2}$ to work out the new line.

A significant number of students clearly felt that if one factor in the equation has been doubled, then the gradient should also be doubled. This often occurred amongst those who had calculated the value of mass in (i) correctly.

It was disappointing to see so many examples where the student had not drawn a new line on the graph at all.

Q16 (a)

A pretty standard definition for A level Physics, and has been on various specifiations with this board over the last 15-20 years. In spite of this, the average score on the question was still around 1 out of 2. Due to the similarity of the descriptions, this generally means that half of the students scored 2 marks, half of them scored 0 marks.

The main reasons for failing to achieve marks are generally for failing to highlight clearly enough exactly what was parallel / perpendicular to what. There were also a few who failed to mention vibrations or oscillations. There were hardly any who confused the directions of vibrations between the two types of waves.

Q16 (b)(i)

This proved a little more tricky for some students to explain than had originally been thought. The issue was that many saw a ray approaching the boundary at 90° and stated "the angle of incidence is 90°" which it is not. Apart from that, there were many good answers which combined both the angle of arrival and the angle of incidence correctly.

Q16 (b)(ii)

At this stage of Q16, there was no expectation that students would know the answer to the later sections of the question, so the diagram was intended to be constructed using the basic understanding that the refractive index of prism B was greater than the refractive index of prism A. As a result, students would not be expected to know whether the ray hitting the left hand side of prism A refracted at the boundary or underwent TIR. Due to this, the mark scheme accepted both alternatives.

Most students were able to draw the normal line correctly at the boundary between A and B, with the most common mistakes being to draw the normal line parallel with the ray that entered prism A in the first place. Many drew the refracted ray correctly, but the reflected ray was less commonly drawn correctly. The least commonly awarded mark was the final one, due to an inability by some to recognise the direction of refraction upon leaving the prisms.

With an average mark of around 2 out of 4, this question proved to be quite a good discriminator, with plenty of students scoring each of the 5 possible totals (0,1,2,3 and 4).

Q16 (b)(iii)

This was generally a well-undertaken calculation, with students often scoring all 3 marks. If anything, the biggest challenge was for students to recognise the angle of incidence from the diagram, with quite a few using 60° or 90°. As with this type of question from previous series, the other issue was getting the refractive index values the wrong way round in the equation.

Q16 (c)

Marking point 2 was often seen, with many recognising that only transverse waves can be polarised. However, some vague answers often prevented the awarding of marking point 1.

A significant number of students clearly mentioned the light being polarised, but only after it had passed through the polarising filter. Even though the word "emerging" was in brackets in the mark scheme, implying that it did not need to be seen, any student clearly stating that the light was only polarised after it had passed the polarising filter could not score MP1.

If the light had been unpolarised before it passed through the polarising filter, there would be no variation in intensity as the filter was rotated, showing that it had to be polarised before reaching the filter.

Q17 (a)

A complex, multiple-step calculation which was generally answered very well by candidates. Quite a few students scored all 6 marks, and showed some very clear working as well.

There were two main routes to achieving the marks, and students often combined both in order to finally get to the answer. Those who started by calculating the whole circuit current often then went on to calculate the potential difference across the parallel section separately.

The main issues for students were generally two aspects. One was an occasional failure to correctly calculate the resistance in parallel as 2Ω. The other was a failure to realise the way that the current split in parallel, often chosing a higher current for the higher resistance path. There was also occasional evidence that students had just decided that the whole circuit current was split equally along each branch.

Q17 (b)

It was good to see that so many students recognised that $P = I^2R$ was probably not the best equation to use if one is trying to explain how the power changes in a circuit when the resistance changes. One mark responses often started with the idea that the resistance did increase, and that as current remained constant, the power also increased.

A significant number of students recognised that it was better to use one of the other power equations to answer the question, as each of them only involved one variable to calculate power. In spite of this, one of the common mistakes via these alternative routes was to fail to mention that V remained constant. Occasionally, students also failed to conclude about whether the suggestion was correct or not.

Q18 (a)

There were lots of very good answers to this question, with the majority scoring all 4 marks (including the conclusion that the light was red). Those who did not score all of the marks often assumed that the light was blue as they had only calculated frequency (which was 4.59×10^{14} Hz, whilst blue light had a wavelength between 450 and 495 nm).

Oddly enough, the next most commonly seen mistake was to either miscalculate the difference between the two energy levels or just using one of the energy levels rather than the difference between them.

Q18 (b)

The main difficulty for this question appeared to be the inability of a significant number of students to convert 8.60 light years into a distance in metres. There were often examples of students failing to multiply by the speed of light, or the number of days in a year. There were were also quite a few who inserted an incorrect number of days per year such as 356.

In spite of this, it was pleasing to see that those who did arrive at a suitable distance managed to use $4\pi r^2$ much more commonly than has been seen on previous papers of this specification. However, due to the difficulties of converting the distance into metres, it was rare for a student to score all 4 marks on this question.

Q18 (c)

A tricky final question, made all the more tricky by the fact that it was similar, but not the same, as a question that had appeared in a recent WPH12 paper. In the previous paper, students were asked to explain why different gases when excited gave out different frequencies of light. Many students on this paper clearly assumed that the same question was being asked here, so often did not gain much credit. This question was only referring to hydrogen gas, so reference to other gases having different energy levels (to hydrogen) was not relevant.

Paper summary

As with previous series, some of the more complex calculations were performed with great skill by a number of the students taking the examination. A number of the shorter written answers were also handled well.

Some areas where students have not performed very well on previous series have been re-assessed on this paper in modified ways. Some have shown a significant improvement from previous performance, most notably the increased numbers of students attempting to use $A = 4\pi r^2$ in questions using the inverse square law.

However, other aspects being re-assessed have not been answered well. Most notably, there are clear misunderstandings regarding how Core Practical tasks are undertaken, with this paper highlighting a lack of understanding in key aspects of Core Practicals 5 and 6.

There also continues to be a significant number of students who cannot distinguish between the photoelectric effect experiment and the observation of light released when electrons drop energy levels in atoms. Questions that are about just one of these experiments are often answered with a mixture of details from both. The fact that the photoelectric effect results in emission of electrons, whereas the dropping of electrons in energy levels results in emission of photons, often makes it difficult for students to achieve many marks on questions where they have chosen the wrong description.

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