Examiners' Report
Principal Examiner Feedback

October 2022

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

October 2022
Publications Code WPH12_01_ER_2210

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.

A significant aspect of A level courses in Physics is to establish whether students are able to apply their understanding to unusual scenarios, so many of the questions relate to examples that students would have been unlikely to have studied on their courses. However, the principles described in the specification can all be directly applied to these scenarios.

There are 5 core practical activities within this section of the specification, and at least one of these is usually covered in some depth in each paper. It is expected that all students will have undertaken these practical activities themselves, which makes them much more familiar with the measuring techniques required.

Section A – Multiple Choice

The average student score on this section was 6/10. There were 3 questions that more than 50% of the students answered correctly. These were Q2, Q3 and Q4, with only 34% getting the correct answer for Q2.

Interestingly, the majority of incorrect answers for Q2 were B and C, indicating that many students considered that a greater energy level jump corresponded to a greater wavelength. The fact that B and C were scored with around equal numbers of students suggests that a number were also not sure whether a jump up or a jump down in energy levels resulted in the emission of photons.

On Q3, students should be careful to note the position of the ammeter. The majority of the incorrect answers were C, showing that candidates were aware that the circuit current would increase. However, the voltmeter reading would increase for the resistor as the p.d. across the thermistor would decrease.

On Q4, the majority of incorrect answers related to thinking that the centre of a compression is the only place where the displacement of the molecules is zero. However, this occurs at both compressions and rarefactions.

The best answered questions were Q1, 9 and 10, all with at least 75% of the students getting the correct answer.

Section B

Q11

This question was rarely answered in terms of both diffraction and interference, which resulted in students being unable to access all 3 marks. A number of students were clearly not sure of which wave properties were demonstrated by this process, so it was common to see discussion of nodes, antinodes, compressions, rarefactions. Those who realised that both diffraction and interference were involved commonly scored all 3 marks.

Q12 (a)

This is a core practical so there is an expectation that students will know this circuit well. It was not a surprise, therefore, that many students achieved 2 or 3 marks on this. The typical mistakes were not to include a component that would enable more than one reading of voltage and current to be made, and positioning the voltmeter in an incorrect place in the circuit. A small number of students failed to include any component with resistance in the external part of the circuit.

Q12 (b)

To a certain extent, this content has been assessed on a number of occasions in previous papers. On this occasion, students did not need to draw the graph themselves, so they needed to explain how the e.m.f. and internal resistance were determined from the graph.

Although many students were able to recognise that the y-intercept would be the e.m.f., there were several common mistakes made with the other marking points.

The 1st marking point required a version of the equation that included both V and I, as these were the variables plotted on the axes of the graph. So equations such as $\varepsilon = IR + Ir$ were not accepted on their own. A number of incorrect equations, such as $\varepsilon = V - Ir$, were seen.

For the 2nd marking point, the format of the equation needed to be changed so that it matched the $y = mx + c$ format (i.e. $V = (-r)I + \varepsilon$). Unfortunately, this was rarely seen.

For the 4th marking point, as on many previous occasions, the gradient mark could only be awarded if the student stated that the gradient was minus r. A significant number of students were confused about the wording for this and made contradictory statements such as "the gradient is minus r, so the internal resistance is the inverse of the gradient".

Amongst the students usually scoring 0/4 on this question, it was commonly suggested that the gradient of the graph was R, as $R = V/I$.

Q13 (a)

This was generally a well-answered question, with the majority of students scoring all 4 marks. Most of the correct answers were from students using the method that is listed first on the mark scheme, although a significant number used the alternative shown on the mark scheme.

The most common mistakes were from those who were unable to apply the rules for series and parallel resistances correctly, often failing to invert the parallel combination equation.

Rounding of values within the calculation often resulted in answers slightly below or above 6 ohms. However, the working out was usually clear enough to see how this answer had been obtained. It is worth noting that as the values of resistance both in the question and the answer were whole numbers, bald answers of 6 ohms were not accepted on this question.

Q13 (b)

On previous papers, the three parts to this question might often appear combined in multiple-step calculations. However, on this occasion they were separated to enable students who had not correctly calculated the cross-sectional area to get full error carried forward marks on (ii) and (iii).

Overall, this part was answered very well, with an average score of more than 4/6 for the three parts combined. The most common mistakes were to confuse resistance and resistivity in part (ii), and to not include the charge of the electron in the calculation for part (iii).

Q14 (a)

Students clearly found this question very difficult to put into the correct terminology. Many answers simply discussed general descriptions of the photoelectric effect, rather than answering this specific question. On "explain" questions, it is important not just to try and answer in terms of equations, without any explanation of what the terms in the equations stand for.

Q14 (b)

As has been the case in previous series, students generally score well on such multi-step calculations, and this type of calculation has appeared on a number of occasions previously. The only difference on this occasion was the need for a conclusion as to which light source had been used.

This question was no exception to what has been seen in previous series where students commonly made mistakes with conversions from eV to

J, and with not inserting the mass of the electron in the kinetic energy formula. Otherwise, it was answered well.

A considerable number of students chose to do a reverse calculation to establish the speed of the electron from each of the given frequency values. This can be a very time-consuming method to determine an answer, although in this case such students were lucky that the first of the light sources stated (A) was the correct answer. With such questions ("deduce") it would be helpful if students attempt a calculation which leads to one of the values given, rather than doing it in a reverse way.

Q15 (a) (i)

Although the majority of students scored both marks on this question, it was not answered as well as originally expected. A number of students attempted to calculate a percentage difference by taking the difference between the two given frequencies, and then dividing by 100, rather than one of the given frequencies.

The mark scheme shows that there were a number of appropriate ways in which this question could be answered, although the first version given was by far the most commonly seen from responses seen.

Q 15 (a) (ii)

Students always appear to find these longer, linkage questions more tricky to answer. However, it is still disappointing to see the large numbers of students who left the answer space for this question completely blank, with no attempt at an answer. Those who attempted it often gained some credit for their work, although the first two indicative content points were rarely awarded to scripts seen.

Some of the confusion with the first two indicative content points might have been related to the fact that in part (i), students were asked to show that the two frequencies would be heard as the same frequency. This led to some then stating on part (ii) that the waves were coherent as they had the same frequency. However, they are still two different frequencies, so would not be coherent. This also meant that they would not have a constant phase difference.

The majority of students picking up 4 or more marks gained them by correctly stating indicative content points 3 to 6.

Although there have been a few questions similar to this on previous papers from this unit on this specification, it is important that students recognise differences between questions, which often mean that marking points from previous questions will not necessarily apply to this question. For example, no credit was awarded for references to path differences on this question. That is because it is assumed that both sounds travel the same distance to reach the person, so there would not be a path difference. Also, some students had clearly remembered a previous question where a listener had experienced constructive interference at one ear, and destructive at the other ear. However, this was due to sounds coming towards the listener from different directions, and did not apply to the question on this paper.

Q15 (b)

Although this was a tricky, multiple-step calculation, the majority of students accessed at least 2 marks, and quite a few gained all 4 marks. The main error for a significant number of students was the lack of the factor of 2 when calculating the wavelength, most of these quoting the wavelength as 0.187m.

Perhaps a result of (a)(i), some students decided that when they used the equation for speed on a string, they would use the difference in frequencies, rather than doing two separate calculations. Some did something similar with working out the difference in speeds and doing a single calculation. Both of these routes ended up failing to achieve all 4 marks, as $(882)^2 - (880)^2$ does not give the same answer as $(2)^2$.

Q16 (a)

Although there were a lot of correct answers for part (i), it is important to remember that when calculating the critical angle, it is not always between media where one of the substances is air or a vacuum. In this case, the two media had refractive index values of 1.48 and 1.43, and both needed to be considered in the calculation. Many students ended up using just one of these values to calculate the critical angle.

Quite a few students ended up scoring 2 marks only on (i), as they failed to show their answer to at least one more significant figure than the given value, a requirement of "show that" questions.

On part (ii), it was important for students to directly measure the angle of incidence from the diagram, a fact that was clearly described in the question. However, far too many students decided to write an answer that indicated no such measurement had been taken. So although a number of students clearly stated both the 2nd and 3rd marking points, the lack of any evidence to explain why it would totally internally reflect resulted in scoring no marks.

A worrying number of students thought that the angle of incidence was 10°, and a few also thought it was 90°.

Q16 (b) (i)

This turned out to be a question where the majority of students scored either 1 mark or all 3 marks. The key difference was to recognise that as the light was travelling along a material where the refractive index was 1.48, it would not be travelling at the speed of light in a vacuum. Those who did not consider the refractive index often ended up with an answer of 2.3×10^{-4} s. A very small number used the wrong refractive index value in the calculation.

Q16 (b) (ii)

The relatively low average score on this question was largely due to the fact that the 2nd marking point was dependent upon awarding the 1st marking point. Many students did not relate their answers to the critical angle, which was essential for a full explanation. There were a number of vague statements which did not gain credit for the 2nd marking point, such as "total internal reflection is easier".

Q17 (a)

The two parts of this question represented a very simple 2 mark calculation, followed by a rather difficult 4 mark multiple-step calculation. The fact that the average score on the 2 mark question was better than the average mark on the 4 mark question is testimony to this.

On part (i), students just had to take the given values for V and I and multiply them. Most did this successfully, although there were a few who failed to give their answer to at least one more significant figure than the "show that" value given in the question. A small number decided to calculate resistance using the V and I values given, and then using a different power equation to calculate power.

On part (ii), a significant majority of students did not read the question carefully, and decided to calculate a number of electrons (rather than photons) by calculating the total charge and dividing it by the charge per electron. Unfortunately, as this method did not generally involve any calculation of energy values, many of these students scored 0 marks.

Q17 (b)

This was not very well answered, largely due to the fact that the majority of students did not clearly relate the lower wavelength with a greater photon energy. A significant number felt that wavelength of light would not affect the number of photons if the power emitted was the same, so scored 0 marks. Even those who recognised that each photon would have greater energy often felt that this would not have any bearing on the number of photons if the power were to be the same.

Q17 (c)

Although a majority of students scored marks on this question, the lack of the 1st marking point for a number resulted in a total of 1 mark overall. Those who had the correct formula for area usually scored all 3 marks, except for the students who decided to halve the distance given before using that as r in the equation.

Q18 (a)

This question showed a clear misunderstanding from a number of students. The vast majority of incorrect answers simply took the given angle of 14° for the first order maximum and doubled it to get 28° for the second order. In the diffraction grating equation, the factor that doubles when moving from the first order maximum to the second order maximum is sinθ, not θ.

Other common mistakes were to measure the angles directly from the diagram (even though it was not to scale) or to use an incorrect formula for this question, such as $n_1\sin\theta_1 = n_2\sin\theta_2$.

Q18 (b)

The students who understood what the question was asking them to do generally scored well, as they took heed of the instruction to describe a graphical method. The less successful answers commonly quoted the diffraction grating formula, but didn’t express it in a graphical way throughout.

For those using a correct method, the 1st and 3rd marking points were often achieved, but there is an expectation that students should state that they calculate the gradient rather than simply telling us what the gradient represents; they are meant to be describing the method.

Q18 (c)

Considering that this was the last question on the paper, it was pleasing to see that it was rare for this question to be left as a blank answer. This suggests that students did not struggle for time to complete the paper.

There were many correct answers, by a variety of methods. However, the method shown on the mark scheme was the preferred method, rather than a number of unusual backward methods employed by students.

Although they were, in some cases, allowed full credit if described properly, it did seem a little unusual that so many students decided to do a backward argument from 300 lines per mm, in an attempt to show that either λ or θ would not be correct if the value marked on the diffraction grating was right. It is much more logical to do a full calculation to show that there are 149 lines per mm, so 300 lines per mm cannot be correct.

One of the most common mistakes was from students who calculated sinθ using opposite/adjacent. This usually resulted in an answer of 152 lines per mm, which only scored 2 marks (2nd and 3rd only).

Some who tried to compare values of d ended up with power of 10 errors, so the values they were attempting to compare were not comparable e.g. comparing 3.33×10^{-3} m with 6.69×10^{-6} m.

Paper summary

As in previous series, the calculations were performed very well on the whole by this cohort of students. There were slightly more mathematical questions on this paper than in some of the other WPH12 papers in the past, but some of these (such as Q17aii) proved very tricky for the majority of the students.

The longer, descriptive, answers proved as tricky as usual, with Q11, Q14a, Q15aii and Q17b proving to be challenging to most.

Q12 and Q18 both referred to core practicals, and Q12 was answered significantly better. Although some of this may well be due to the position within the paper, the difference in performance between the two questions may well be due to the nature of the practical activity in each question. Centres are reminded again of the need to ensure that their students have hands-on experience of doing these practical tasks to enable easier access to questions relating to them.

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom