Examiners' Report
Principal Examiner Feedback

Summer 2019

Pearson Edexcel Advanced Level
In Physics (WPH02) Paper 01Physics at Work

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General comment

The unit WPH02 covers the learners' ability to understand and apply the physics involved in waves, electricity and light, including quantum effects. The ability to apply their knowledge in a range of familiar and unfamiliar contexts was examined.

The learners' ability to see calculations through to a correct solution was generally good, as was their response to descriptive questions involving theories, such as atomic line spectra, that they had been directly taught. In other cases, particularly with questions involving unfamiliar contexts, it was clear that they were not answering the question given. It is very important that the learners carefully read and understand the question before starting to respond to it. The learner must look at the command word in the question; "state" means to just write the factor or variable required, with no explanation needed; "explain" requires reasoning or justification of the point made; "describe" means to give an account of a process or action, but there is no need to justify it with detailed theory. In general, there are likely to be several questions on a paper asking for an explanation, as we look to test the learners' understanding of the physics involved.

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

Section A

	Subject	% scoring the correct answer	Comment
1	I – V graphs	65%	This question was answered well. A few responses gave option B which is the shape of graph expected if V were plotted against I.
2	Electromagnetic spectrum	73%	It was well known that a mobile phone makes use of microwaves.
3	Longitudinal wave	34%	This question was poorly answered, and the responses seemed to be largely guesswork. The four options were fairly equally chosen. The choice should simply be restricted to B or C, which have the correct wavelength, but then getting the correct choice of B, which depends on phase, required a much higher level of understanding.
4	Standing wave	71%	The most common error was to choose C, with the 2/3 inverted.
5	Polarisation	38%	In order to make the planes of polarisation of the filters parallel, one has to be rotated by 90° more than the other (or 270°), which is option A. Many learners gave option B which would have returned the planes of polarisation to be perpendicular to each other.
6	Electron diffraction	61%	For the pattern shown, diffraction is involved in spreading the electron beam from the crystal, and superposition in forming the interference pattern, which is response B. The most common incorrect response was A, involving refraction.
7	Potential divider and diode	59%	The correct answer was 1.5 V, response C. Some ignored the potential divider and gave response D.
8	$I=nAve$	69%	
9	Units	66%	This involved the conversion of J s to base units.

10	Diffraction of sound	88%	

Section B

Q11a

This item was generally answered well, with clear working leading to the right answer for the resistance. The most common mistake seen was to use an incorrect equation for the area of cross section of the wire. If $\pi r^2 l$ or $2\pi r$ are used, then it is not an area that is being calculated and little credit can be given for the response. A common response was to use the diameter for r, or to neglect to convert the diameter to metres. To gain full credit in a "show that" style of question, the response needs to calculate the actual value of the quantity being requested. In this case, the value of resistance needs to be determined as $1.07 \times 10^3\ \Omega$. A reverse calculation, using the 1100 Ω to calculate the length required, for instance, would not gain full credit. The response below is a clear, correct answer to the question.

$l = 1{,}4\,m$

$d = 0{,}05\,mm \Rightarrow r = \frac{0{,}05}{2} = 0{,}025\,mm$

$A = \pi r^2 = 0{,}00196\,mm^2 = 1{,}96 \cdot 10^{-9}\,m^2$

$\rho = 1{,}5 \cdot 10^{-6}\,\Omega m$

$R = \frac{\rho l}{A} = \frac{1{,}4 \cdot 1{,}5 \cdot 10^{-6}}{1{,}96 \cdot 10^{-9}} = 1{,}07 \cdot 10^3 = 1070\,\Omega \approx 1100\,\Omega$

Q11b

This question was about how to obtain a greater accuracy of resistance value by using a wire of different length and diameter. A wire of greater diameter, with the length adjusted to give the same resistance, should be used since both the length and diameter can then be measured with a lower percentage uncertainty. Very few responses answered this question, and those that did often said the actual uncertainty in length or diameter would be reduced, which is incorrect. Many misunderstood the question and explained how the resistance could be increased slightly to make it closer to 1100 Ω, for which one mark could be awarded. Overall most responses talked about how a micrometer (or alternative) could be used, and how measuring in several places, taking averages, measuring different lengths and different diameters and producing graphs would improve the accuracy, which was not related to the question about using a different combination of length and diameter.

This was a good response:

- Using a greater value of length and and diameter would lead to les percentage orcertanity in measurements and to total percentage uncertanity would be low.
- Its betwer to use a larger length of nichrome using greater diamentrors would give value more close to the real value.

Q12a

Note that this question clearly asks for two observations. It is not asking for two theories, or two aspects of the quantum theory of light. It is most important that the learners answer the question that is asked. Perhaps the more usual question, and the one that most answered here, is to explain the photoelectric effect.
This is an example of a good response, which was very rarely seen:

Instant emission of electrons when electromagnetic radiation is shone on a metal surface.
Electromagnetic radiation, below threshold [illegible] frequency, doesn't cause any electron emission.

Most responses were about a single photon interacting with a single electron, and about the photons needing an energy greater than the work function, but these are not observations.

Q12b

Overall this was a more positive question and learners tended to do well here. A few used $v=f\lambda$ to calculate the speed of the electrons, and some used an incorrect mass for the electron, but it was good to see many correct and well laid out calculations. In the example below, the response clearly shows the calculation of the photon energy, of the work function, and then the photoelectric equation:

$\lambda = 1{,}2 \cdot 10^{-7} m$ $\Rightarrow f = \frac{c}{\lambda} = \frac{3 \cdot 10^{8}}{1{,}2 \cdot 10^{-7}} = 2{,}5 \cdot 10^{15} Hz$

$c = 3 \cdot 10^{8} ms^{-1}$

$E = hf = 2{,}5 \cdot 10^{15} \cdot 6{,}63 \cdot 10^{-34} = 16{,}6 \cdot 10^{-19} J$

$4{,}3 eV = 4{,}3 \cdot 1{,}6 \cdot 10^{-19} = 6{,}88 \cdot 10^{-19} J$

$E = \varphi + \frac{mv^2}{2} \Rightarrow \frac{mv^2}{2} = 16{,}6 \cdot 10^{-19} - 6{,}88 \cdot 10^{-19} = 9{,}72 \cdot 10^{-19} J$

$v = \sqrt{\frac{2 \cdot 9{,}72 \cdot 10^{-19}}{9{,}11 \cdot 10^{-31}}} = 1{,}5 \cdot 10^{6} ms^{-1}$

Q13a

There were a large number of correct responses here. It is clearly important that in the efficiency equation, the output power is the numerator. The two terms in the efficiency equation can be given in a number of ways, such as the power, the energy in a given time, the energy per m^2, but whichever variable is used, the numerator and denominator must be of the same form. Many worked out the energy in a given time which, although incorrect as no time was given, was allowed in this instance. This is a good, concise response:

Power input $= (800 \times 1{\cdot}6 \times 0{\cdot}95)$
$= 1216 w$
Power output $= (29 \times 7{\cdot}3)$
$= 211{\cdot}7 w$

Efficiency $= \frac{211{\cdot}7}{1216} \times 100$

Efficiency = 17.4 %

Q13bi

Most responses showed that the definition of e.m.f. had not been learnt. It must be emphasised that definitions of the basic physics terms need to be accurately learnt, since marks are gained very quickly with a correct response.

Q13bii

There is more than one way to complete this calculation correctly, but the response on the right is a good example. Most learners found this a difficult calculation, but it would be straightforward if e.m.f. and internal resistance were properly understood.

$$\text{e.m.f} = V + v$$
$$55 = 29 + (7.3 \times r)$$
$$\frac{55 - 29}{7.3} = r$$
$$r = 3.56\ \Omega$$
$$r = 3.6\ \Omega$$

Q14a

This was a fairly standard question about interference between the waves from two identical sources. It was disappointing to find large numbers of responses that did not realise superposition was occurring, and answered in terms of the Doppler effect, or about nodes and antinodes in a standing wave. A good example of a correct response is given below:

> The two loudspeakers act as coherent sources and produce waves which superpose with each other. When the path difference is $n\lambda$, the waves are inphase and constructive interferance happens and here the student hears a loud sound. When the path difference is $(n+\frac{1}{2})\lambda$, the waves are in antiphase and destructive interferance happens and here the student hears a quiet sound. Where there is constructive interferance, antinodes are formed. And where there is destructive interferance, nodes are formed.

As can be seen here, any reference to nodes or antinodes was ignored but not penalised. As in this response, the learners did not refer to the problems of observing the interference phenomena in an enclosed space, so did not gain the final mark.

Q14b

With two separate sources of sound, the frequencies would not be identical, and so the phase relationship would vary over time. This is something the learners would almost certainly need to work out for themselves in the exam room, and so it was a good test of their understanding of the physics involved.

Q15a

The physics involved in the formation of a line spectrum is another standard A Level question, so it was again disappointing that so many learners did not score any marks. There were, however, many responses which showed a good understanding of the reasons for the formation of such a spectrum. Because the light source is a distant galaxy, the spectrum observed would be an absorption spectrum, but as the question asked about atomic line spectra in general, a description of either an absorption or an emission spectrum was accepted.

Q15b

This was a difficult question because the photograph was not easy to understand. Consequently, only the best responses gave an acceptable answer. However, those that did recognised that it was an application of the Doppler effect, and some could then explain why the wavelengths at the top and bottom of the line were shifted. One of the common errors was to relate the shift in wavelength to the distance of the star from the Earth rather than to the rotation of the galaxy.

Q16a

This question was very commonly misread, and the question answered was concerned with the accuracy and resolution of the picture received. Therefore the responses referred to the wavelength, pulse length, time to return etc., none of which were actually relevant to this question but may well have been involved in questions set for previous papers. It is important for the learners to ensure they understand what the question is asking. This was a question about the fraction of the transmitted laser light that returns to the transducer.

Q16b

Most learners were able to use the equation $s=vt$ to calculate either a distance or a time. However, they were then unable to explain whether that would make it possible to detect the object. They could calculate the length of the laser pulse and note that it was less than the total distance travelled (2.0 m), or they could calculate the time for the pulse to return and note that it was more than the duration of the pulse. This is the type of response we expected:

$D = \frac{1}{2} Ct = \frac{1}{2} \times 3\times10^8 \times 5.0\times10^{9} = 0.75m$

0.75m is the smallest distance can be measured, which is less than 1.0m, so the car can be detected.

Q16c

The use of ultrasound rather than light would not be acceptable due to the time taken for the reflection to be received back at the transducer. This would result in inaccurate "mapping" of the car's surroundings, and the car would have moved on by the time the reflection was received. Often the responses were too vague, and just mentioned that the ultrasound travelled more slowly (a fact given in the question), or that accidents were likely to occur (without saying why).

Q17a

Overall, question 17 scored well, with the marks fairly evenly distributed over the full possible range. It therefore did discriminate well between learners of different ability.
17a was purely bookwork, and the learners just needed to recall the information. This is what we should see:

Total internal reflection occurs when the angle of incidence is greater than the critical angle.

The second condition is that the ray of light should be travelling from a more dense to a less dense medium.

As with Q13bi, it is important that students learn definitions well.

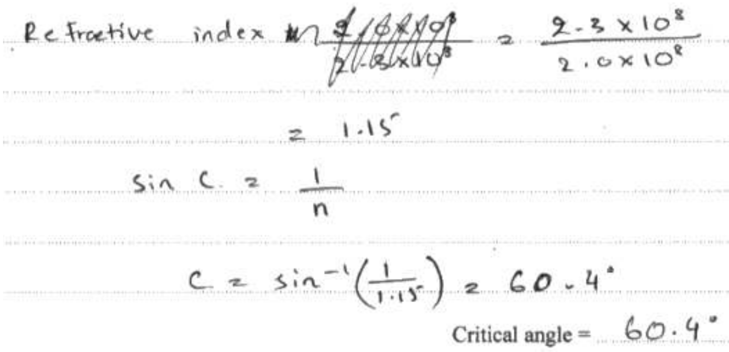
Q17b

When a question begins with the word "explain" it means we want to see the full reason for something happening, in this case for the light reaching the receiver. In this item, the examiner needs to be told that the angle of incidence was 45°, and not just have that implied by the rest of the response. The actual explanation here is quite simple, but there were many cases of marks not being awarded because the explanation lacked some basic steps in the argument.

Q17ci

In the majority of cases, full marks were awarded for this item. However, where the correct answer was not obtained, it was often quite difficult to follow the working given in order to award method marks. We often saw a calculation along the lines of $2.3 \times 10^8 / 2.0 \times 10^8$, which would be allowed if the final answer were correct, but otherwise needs rather more explanation.

The example below shows a fairly minimal but correct response:



Refractive index $= \frac{2.3 \times 10^8}{2.0 \times 10^8}$

$= 1.15$

$\sin C = \frac{1}{n}$

$C = \sin^{-1}\left(\frac{1}{1.15}\right) = 60.4°$

Critical angle = 60.4°

Q17cii

Most learners drew the ray being correctly refracted into the liquid. Since there would also be a weaker ray reflected vertically downwards from the interface, such a reflection was ignored. The mark would not be given if any other reflection were drawn.

Q17d

It was very rare for any responses to score two marks here. Many responses said that when the tank was full the light reaching the receiver would be reduced, but few then went on to say what the sensor would do, such as sounding an alarm. Others said what the sensor would do if the tank were full, but not how it would know.

Q18a

This is another item for which there is a standard response that needs to be learnt and understood. For the first mark, the responses often described an increase in vibration or speed of the electrons, rather than an increase in the vibration of the lattice atoms. For the second mark, we need an increase in the rate of collision of electrons with the lattice and not with each other. The response below gained all the marks.

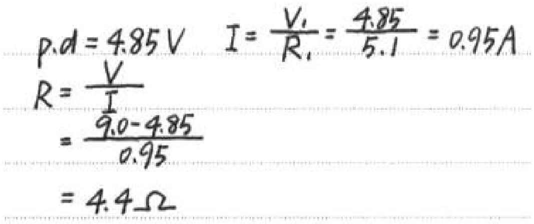
As temperature is increase, there is increased lattice ion vibration in the filament of the lamp. This causes increased collisions between electrons and ions. This results in decrease of drift velocity v and as $I = nqvA$, current decreases too. This results in increase in Resistance of the filament due to $R = \frac{V}{I}$ (keeping V constant)

Q18bi

The majority of learners did not understand what this question was asking. They tended to describe how the resistance of the lamp varied with time or temperature, and how that affected the current in the lamp. It was expected that they would tell us that the current was proportional to the p.d., and that the currents are the same in a series circuit.

Q18bii

A large number of learners were able to do this calculation. Many other learners wrote very confused working which made it difficult to mark. Choosing the wrong p.d. or resistance was common but did lead to a number of 'use of' marks being awarded. A correct response is given below:



Q18biii

Many were able to answer this item even if they could not do part ii. Units were sometimes wrongly given as J. Some learners used the wrong resistance, although it is given in the question, and some used the wrong p.d. All of the equations for power on the mark scheme were used. Other learners used a time and cancelled it, which was allowed even though the time was incorrect. Those who left the time in could not be credited with any marks.

Q18biv

A lot of the responses mentioned that the p.d. was constant, but fewer went on to say that this means that the resistance of the lamp must therefore be constant. About 20% of the responses gained both marks.

Q18bv

This item did not score well, and it seemed that the learners were not able to apply what they knew about the characteristics of a data logger to the experiment being performed. We were expecting a comment about the experiment – that it was completed in a very short time, and a relevant comment about the data logger – that it can take readings at very short intervals of time. Most of the responses just told us what the learners thought about data loggers, such as that they were more accurate (incorrect here), that they can plot a graph automatically (not necessary here), or that they can be set to work over a long period of time.

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 more careful reading and understanding of the 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:

- Fully understanding the question being asked.
- Give clear and complete working in any calculation.
- Learn standard definitions.

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