Moderators’ Report/
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Pearson Edexcel
International Advanced Level
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Paper 01: Physics at Work

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General

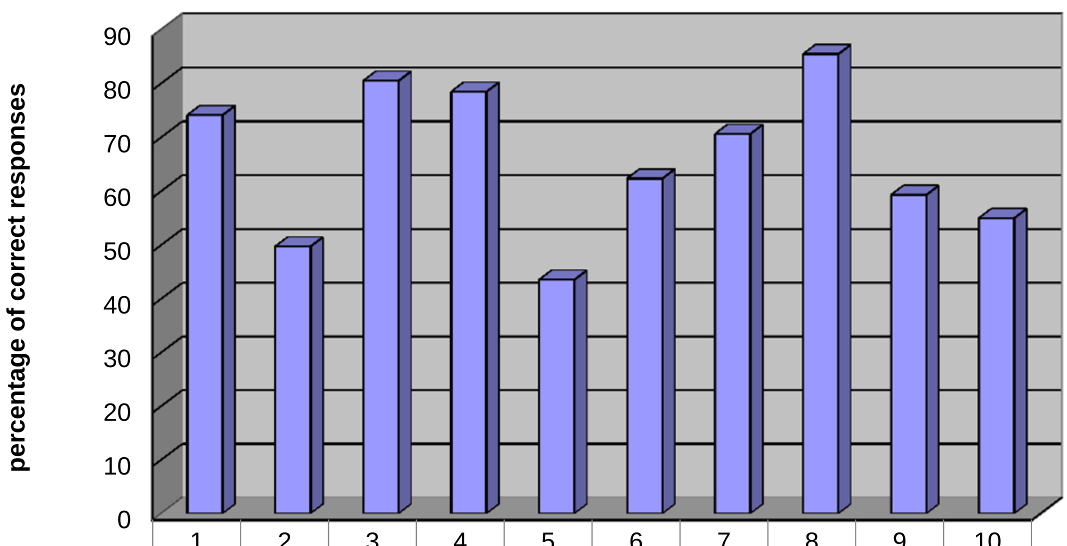
This paper offered opportunities for students of all abilities to demonstrate their knowledge and understanding of Physics in a range of applications. It was generally found that questions involving calculations were answered more successfully than those requiring longer descriptions. In questions involving common definitions and standard descriptions, students at the lower end of the performance range usually displayed familiarity, but without the required detail to gain credit.

Section A

The performance in this section was good, with E grade students commonly scoring about 6 and A grade students about 8 marks on the 10 multiple choice questions in this section.

The overall responses to the individual multiple choice questions are as shown.

Responses to multiple choice questions



	1	2	3	4	5	6	7	8	9	10
Percentage	74	50	80	78	44	62	71	85	59	55

In some answers a certain incorrect response was chosen more frequently than others.

<u>Question 2</u>

The favoured incorrect response was A, with students thinking that the distance between two compressions is only half a wavelength.

<u>Question 5</u>

Again involving wavelength, the most common incorrect response was A. This is likely to be due to confusion between L/2 and λ/2 rather than to students picturing 2 whole wavelengths in the pipe at the lowest frequency.

Question 9

C was the most frequent incorrect answer, with students applying the formula correctly but neglecting to take the 4 cells into account.

Section B

Question 11

(a) A large majority of students completed both parts successfully for 5 marks. Students occasionally only gave the answers as 590 W m^{-2} and 90 A respectively without calculating to the extra significant figure required in a 'show that' question. While some initially arrived at answers of about 45 A for part (ii), they then realised that they needed to account for two panels.
(b)(i) This was also completed correctly by the majority. Some attempted, unsuccessfully, to solve it using power rather than charge, perhaps because it wasn't named specifically as such but indicated by the unit kC. Others rearranged $I = Q/t$ incorrectly.
(b)(ii) Only about a tenth of students gained credit here, usually for an answer suggesting varying flux density. Some only referred to maximum current without making its significance clear by reference to $Q = It$. The majority attempted to answer in terms of unwanted energy transfers or just low efficiency, but this was not relevant when they had been told a maximum output current.

Question 12

(a) Most students scored at least one mark for their sketch, but not quite half got two marks. Sometimes this was because the graph had not been completed for negative current and potential difference, but most often it was because it resembled the characteristic of a filament lamp rather than a thermistor. Some drew a curve with a significant section along the x axis, as for a diode, although they still gained the symmetry mark.
(b) This was not well answered, with just under half obtaining one mark or more, most commonly for indicating an increase in charge carrier density. Many answers continued to mention relevant factors, but more like a description than an explanation of why one stage followed from another. The increase in current was usually mentioned, but without supporting reference to $I = nAvq$. Similarly, increased current was followed by reference reduced resistance, but without reference to $R = V/I$. Students often referred to increased amplitude of vibration of lattice ions, although not in those words, but did not explain how this was linked to increased potential difference.

Question 13

(a) About a quarter of students were awarded two marks and half just one mark. The most common mark not awarded was for emission of an electron. When the first mark was not given it was because the answer only referred to incident light without mentioning photons or, more commonly, because they only said that 'one photon releases one electron' and didn't discuss the idea of energy transfer. Sometimes students said that photons were released, either by confusion with the term photoelectrons or a more explicit reference to spectrum emission, such as discussion of electrons moving to higher levels.

(b)(i) Over half the entry gained at least half of the marks, although a greater proportion completed the calculations correctly but omitted one or both units, J s being omitted most frequently even though it is on the back pages of the paper, limiting themselves to a maximum of two marks.

There were several ways to complete the question, but surprisingly few used the simplest method of obtaining the work function from the *y* intercept first. Some made it more complicated by using simultaneous equations. The final mark for their first calculation required the answer to be within a given range for accuracy. This was occasionally not awarded due to inaccurate extrapolation of the line, but much more frequently because a small triangle had been used for the calculation of the gradient.

(b)(ii) Only a quarter of students were awarded at least one mark, with a fifth of these scoring two marks. As is often the case with this topic, many students were answering a different question to the one on the paper, sometimes even quoting from previous mark schemes. There are many aspects involved in the photoelectric effect, but this question concentrated on how wave theory could not explain it, and, in particular, could not explain the graph obtained for the experiment described. Instead of addressing this, many based their answer on how it can be explained using particle theory, 'one photon releases one electron' often being quoted here as well as in part (a). The answers also often discussed the effect of intensity, but there is no information about intensity anywhere in the question. If anything, students should assume it has been kept constant as a control variable. Where students di have the idea that there shouldn't be a threshold frequency for wave theory it was frequently expressed too imprecisely to be given credit, for example saying 'there needs to be a certain frequency' in this experiment rather than 'light needs to be above a certain frequency'. The idea of energy accumulation with waves was also sometimes implied without sufficient clarity to award a mark.

Question 14

(a) This is a standard definition but only a quarter of students were awarded the mark. Some referred to the energy level as a position, for example as a shell or orbit. Others referred to the amount of energy that would need to be absorbed for a transition. The idea of a discrete energy was not generally expressed in a precise enough way.

(b)(i) A standard description, with about half of the entry receiving at least one mark and a third of them being awarded both. While students usually referred to electrons moving to a higher and then a lower energy level, although some only mentioned the second, the link to energy absorbed or emitted was often missing. Sometimes the energy emitted was included, but it was not linked to a photon. Sometimes only light was mentioned and sometimes nothing at all.

There were some references to shells and a number of students wrote about the photoelectric effect.

(b)(ii) The first part of the calculation, to obtain 2.11 eV, was successfully completed by two thirds of students, but only about a quarter of those were able to complete the question by adding the correct energy level. Students usually just added 2.11 eV to their diagram, above or below the other level, and some used -7.25 eV.

A number were limited to one mark because they converted 5.14 eV to joule and then could not proceed.

(c) About a third of the entry gained at least one mark, usually for stating that different frequencies or wavelengths of light are emitted, but only a fifth of those were awarded both marks. A successful reference to different differences in energy levels was not usually seen. Some just referred to different energy levels and some just to different numbers of energy levels. Some students just repeated ‘different spectra’ without reference to frequencies or wavelengths or photons. A few even said that atoms were emitted.

Question 15

(a) A majority scored on this question, with about one in six receiving both marks. The most common mark was for a correct reference to the factor of two. Students often did not specify the speed of light, 'speed of the pulse' being quoted regularly, or state that the calculation needed was distance = speed × time, often just saying 'use $v = s/t$' or even 'use $s = d/t$'.

(b)(i) The majority were able to apply distance = speed × time straightforwardly, but many went wrong by applying a factor of 2 when it was not required. There were some power of ten errors and occasional missing units.

(b)(ii) Few students scored on this question. Many focused on significant figures, missing the point that using a pulse a few centimetres long justifies quoting an answer to the nearest kilometre despite there being 6 significant figures in the kilometre value. They did not realise that the uncertainty should be less than the quoted value, or link the length of the pulse with uncertainty at all.

(b)(iii) Fewer than one in ten were awarded this mark, probably because students did not actually consider the question as it was written before writing an answer from a previous mark scheme, 'so a pulse is received before the next is sent'. With a round trip time of 2.5 seconds and ten pulses per second this is impossible. Some other answers showed some understanding but were too imprecise.

(c)(i) While few had little difficulty applying the formula, about a quarter were limited to one mark through power of ten errors or omitting the unit. The power of ten errors were often caused by problems with the prefix 'm', sometimes being used a 10^{-6} and sometimes 10^{6} – mistaking milli for mega.

(c)(ii) Nearly half of students gained one or more marks, about a third of these gaining two. The most common mark was for suggesting that diffraction would be minimised, but the mark for saying that the aperture is much larger than the wavelength was less often awarded because it missed the idea of 'much'. Many discussions just referred to maximum diffraction when wavelength matches aperture without describing the situation when this isn't so.

Students rarely made any reference to the problems caused by diffraction, many even suggesting that it is necessary for this procedure, for example to spread over the whole lunar surface.

Question 16

(a)(i) About a quarter scored here, a fifth of those receiving two marks. The first mark was for making a relevant conclusion from the results in the table, but many just referred to the change in the current for one arrangement, or noted that current decreased with increasing load without specifying the arrangement or just said that a particular arrangement always had a greater current than the other one, despite the results in the table. Others didn't refer to the results at all but explained the difference in the conductive properties of fresh and salt water in terms of dissolved salts. Some weren't helped by misinterpreting the circuits and assuming that the parallel or series arrangements referred to the resistance.

When students could interpret the table they rarely made the connection to the arrangement in the different types of water by explicitly linking poorer conductor to higher resistance, usually just leaving the answer in terms of good and bad conductors.

(a)(ii) About three quarters applied the cell equation correctly, but only a quarter of the entry went on to complete it successfully by taking 5 cells into account. Students occasionally confused e.m.f. and p.d. or internal resistance and load resistance in the equation.
(a)(iii) For many students this was another example of answering a question from a previous paper, in this case, explain why a high resistance voltmeter can be used to measure e.m.f.
Students are more likely to meet circuits with the voltmeter connected across the resistor only, whereas in this circuit it is connected across the ammeter as well. A minority of students were given credit for realising that the voltmeter is measuring terminal potential difference, so the normal arrangement will only work if the ammeter has negligible resistance. Many referred to the ammeter diverting current from the voltmeter, although a voltmeter is required to draw negligible current anyway. They did not often refer to the potential difference across the ammeter.
A number of students did not appear to recognise the word 'negligible'.
(b) A large majority were able to apply the resistivity equation correctly with an area and a length. A significant proportion of these, however, used the wrong area and, occasionally, the wrong length, so they were limited to one mark. A minority got resistance and resistivity the wrong way round or used a volume instead of an area. The incorrect area used most frequently was that of one of the long sides, even when 13.5 cm was used correctly as the length, or the total area of six sides.
About half used the correct values, but only about a third of students completed it correctly and included the correct unit. Errors in the final stage also included powers of ten from centi- and kilo-, but some used a factor of 100 for the area conversion rather than squaring it to use 10 000. The unit was sometimes mΩ, which is milliohm, not ohm metre.
(c) A good majority completed this part correctly. The errors seen included not applying the factor of 400 in the calculation, and some did not use ms correctly for the time.

Question 17

(a) The question asked for a method to measure time, but many answers gave an alternative method for speed, often based on $v = f\lambda$. Many methods involved light gates and dataloggers, but the way the beam would be broken was not explained successfully, despite some attempts involving things like little boats on the water surface.
Overall, nearly a half of the entry were awarded at least one mark, but a relatively small proportion were awarded more. The most common marks were for suggesting the use of a video or camera or for a comment about reducing the effect of reaction time. Of those students who suggested filming the waves, surprisingly few went on to say what they would do then. Very few responses based on video techniques included a scale for measuring distance. Students who just referred to human error did not get the mark for reaction time.
(b) Over two thirds scored on this question, but under half of those got both marks. The most common mark was for the same frequency. Many quoted a constant phase difference or constant phase relationship to get a mark, but some said 'same phase difference', which is not sufficient as it must be the same over time to be constant. Others referred to a constant path difference or constant phase.

Some struggled to express either idea when they said 'they vibrate at the same time'. This might refer to frequency or phase, but it is not sufficiently clear for either.

(c)(i) A majority got at least two marks, with nearly half of the entry getting three marks. Students had a good overall understanding of the interference pattern here, but their marks were limited by lack of detail, either through misapplying terms or missing steps in the explanation.

At the simplest level, students described interference occurring, but only in terms of peaks and troughs adding to create maxima and minima. Better students answered in terms of phase difference and linked it correctly to constructive and destructive interference, but they did not always explain how path difference lay behind the phase difference and they rarely made reference to amplitude. Instead of amplitude, uncredited answers were given in terms of disturbance, such as 'maximum disturbance', or simply, again uncredited, as maxima and minima.

The error of saying merely 'out of phase' instead of 'antiphase' was occasionally seen. Sometimes students answered in terms of path difference without reference to phase. Sometimes they were mixed up, such as a phase difference of λ or a path difference of 2π. Lack of detail was sometimes seen in path difference descriptions, such as 'they are in phase when the path difference is nλ, but in antiphase when the path difference is nλ/2' without specifying that n should be odd in the second case.

(c)(ii) About half of the students got a single mark for substituting their value of wavelength in $f = v/\lambda$, but, since their value of wavelength was usually outside the accepted range, only a quarter of the students got more than one mark. Students very rarely attempted to use more than one wavelength on the diagram. Where they did it, was more often measuring the distance between several points of maximum amplitude along the antinodal line. The individual measurements of wavelength were frequently also between two such points, similar to measuring the diagonal of a square rather than the side.

Summary

Based on their performance on this paper, candidates should:

- Learn definitions in detail so they can be quoted fully, using the required terminology,
- Check that their quantitative answers represent sensible values and check their calculations when they do not.

Grade Boundaries

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