Examiners' Report/
Principal Examiner Feedback

Summer 2013

GCE Physics (6PH02)
Paper 01R: Physics at work.

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This is the fifth summer series in which Unit 2: Physics at Work has been examined. The assessment structure is the same as that of Unit 1: Physics on the Go, consisting of Section A with ten multiple choice questions, and Section B with a number of short answer questions followed by some longer, structured questions based on contexts of varying familiarity.

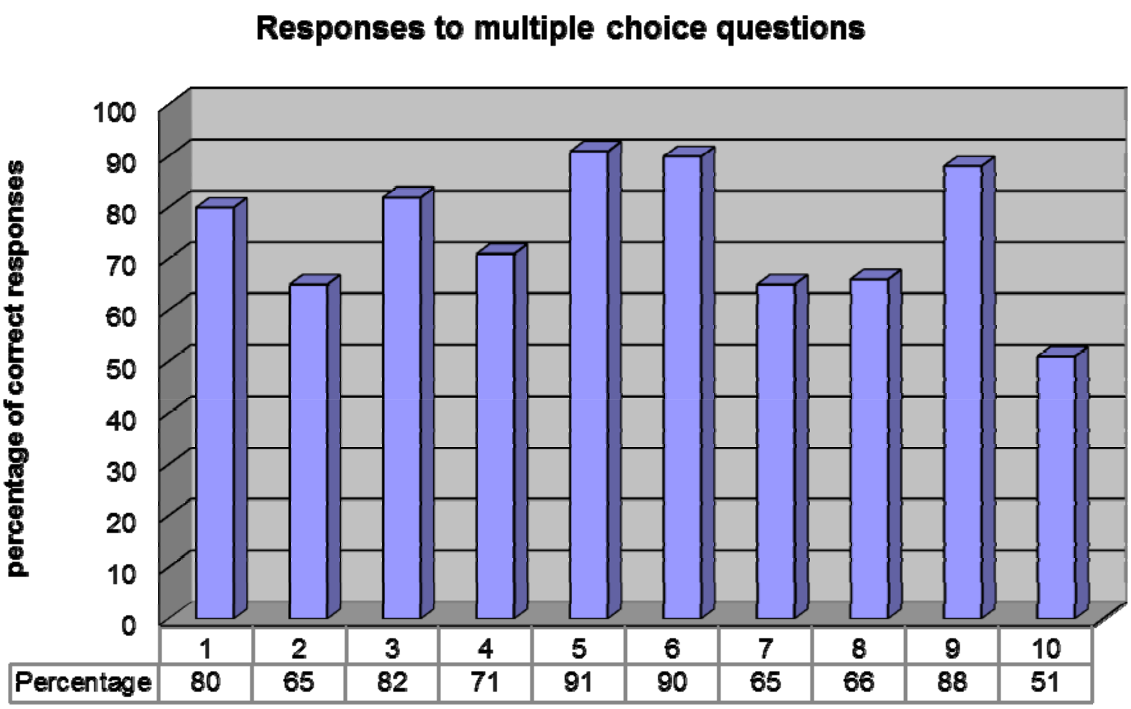
This paper allowed candidates to demonstrate their knowledge of content across the whole specification for this unit, showing progression from GCSE or its equivalent and answering questions to the depth appropriate to their level of understanding.

There was less confusion about quantum phenomena than has sometimes been seen, with very few using photoelectric effect explanations when discussing spectra, for example.

For many candidates, areas for improvement include learning definitions for standard terms in detail and being able to identify specific parts of longer explanations of phenomena that apply to particular situations.

Section A

Question	percentage of correct responses
1	80
2	65
3	82
4	71
5	91
6	90
7	65
8	66
9	88
10	51



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Candidates performed well on the majority of the multiple choice questions in Section A, with questions 2, 7, 8 and 10 causing the most difficulty.
For question 2, candidates not choosing B usually selected D, suggesting that they are familiar with the general form of the graph for a non-ohmic conductor and that they know a filament bulb is one. They need to concentrate on a way of deciding which shape matches a positive temperature coefficient and which a negative temperature coefficient.
Question 7 had B as the favoured incorrect choice. This is a true statement, but not one that explains negative temperature coefficient behaviour, a link with question 2.
B was the common incorrect choice for question 8. This is understandable as students are much more likely to refer to an ampere as a coulomb per second than they are to refer to a coulomb as an ampere second, making coulomb seem more 'basic'.
The common incorrect choice for question 10 was C. This would be correct if the x-axis represented time, but here at any given position Y is a quarter of a cycle ahead of X.
Section B

<u>Question 11</u>
The majority of candidates scored at last one mark, the most commonly awarded being the mark for a comment about current being the same in series or splitting up for a parallel arrangement. They often suggested that the current would change if the resistance changed but failed to be specific about an increase in resistance for the circuit or that the current would decrease.

<u>Question 12</u>
The great majority gained all three marks for this question, following the normal pattern of scoring more highly for calculations than for descriptions and explanations. Candidates occasionally lost a mark by omitting the unit and a small minority gave the 'lost volts' as their final answer.

<u>Question 13</u>
(a) More than a quarter of the entry scored full marks, and most got at least two. Where two marks were awarded they were for identifying diffraction at the double slit and linking light bands to constructive interference or the associated path difference or the similar description for the dark bands. The second and third marks were not fully achieved for a variety of reasons all involving a lack of correct detail in the answer. Some candidates mentioned the path differences but didn't mention constructive and destructive interference. Others merely discussed 'crest meets crest, trough meets trough'. Some lost a mark by mentioning waves being 'out of phase' rather than 'in antiphase' and some stated phase difference but described it in terms of wavelength.
(b) Nearly half of the candidates obtained a mark for describing coherence, many of those not gaining the mark referring to a constant path difference, which would be true with or without coherence. Although a lot of extra information from candidates in parts (a) and (b) showed that they were well aware that coherence is required for interference, very few understood why and could explain it. Explanations rarely went beyond saying just that you can't get interference without coherence.
(c) Slightly under half of the entry got a mark here, often for just saying it must be a wave rather than linking it to interference or diffraction.

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Question 14

(a) Most candidates quoted $Q = It$ for the first mark, but only about a third made a clear link between the quantities and the units as required. Very few took the approach of full conversion of Ah to C.

(b-d) This sequence presented little difficulty. When students reversed the numerator and denominator in the efficiency calculation, obtaining an answer greater than 100% did not always suggest to them that they try again. On the other hand, those who made a slip in part (b) or part (c) generally used their answers to obtain a percentage below 100% regardless of which was input and which was output.

Question 15

(a) Over half of the students got two marks or more, and most of the rest got one mark. Marks were lost through lack of precision in expression or not addressing the second part of the question, why refraction occurs for light entering the Earth's atmosphere, in sufficient detail. Candidates nearly always mentioned a change in density or speed, but often just referred to light 'bending'. This is not sufficient for a description of refraction as it equally implies a curved path. On the specific case of the Earth's atmosphere, they mentioned a change in speed, but often did not state that this change was a decrease, as suggested by the diagram.

(b) Nearly everyone used the Snell's law formula, but only about two thirds used the correct angle of incidence, the rest usually selecting 26°. Most used 64° calculated the angle of refraction correctly, and nearly half of the entry went on to find the change in direction.

Question 16

(a) While well over three quarters gained three marks for completing the calculation, the proportion gaining full marks was under half because the line was often not drawn on the graph. The question didn't state 'use the graph', but candidates should recognise from it that different points would give different values of resistivity, so the best way to find 'the' resistivity would be to use the gradient of a best fit line.
Errors occasionally seen included omitting the unit, calculating from a pair of values that gave a result outside the accepted range, converting 100 cm to m incorrectly and getting R and ρ mixed up in the formula.

(b) Candidates again lost marks by not giving answers to the specific situation described. They often said that the temperature would be affected and resistance would change without specifying an increase in either. Overall, half of them got the mark for temperature increase, often saying it gets hot, and a half of those the second mark.
Some tried to interpret the precaution in terms of personal safety, saying it might cause a shock or a burn.

(c) The question referred to the table, so precautions needed to be related to accuracy in the measurement of length, current or potential difference. Only about a sixth chose a suitable precaution. One of the most frequent suggestions was repeating the measurement of diameter and calculating the average, but diameter, radius and cross-sectional area were not variables in the table. Common accepted precautions were ensuring that the wire was

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straight, avoiding parallax errors in reading analogue meters and avoiding zero errors.

<u>Question 17</u>

(a) While few candidates scored full marks, a majority got at least two and the range of marks was distributed progressively across the ability range. Most students appeared to understand the general process, and some even added details of absorption spectra although this was not specified, but others were limited by imprecise language and lack of detail in their answers.
The most common marks were for describing moves to higher or lower energy levels and for stating that energy levels are discrete, often in those words. They only rarely referred to changes, or jumps, of unspecified direction.
Many students linked energy level changes to photon emission, but did not clearly state that the energy from the change is given out in the form of a photon.
The limited number of energy level differences, rather than just energy levels, was described more rarely still, as was the precise link between the quantity of energy in the change and the energy of the photon, although the equation was sometimes quoted.
Unlike previous occasions, there were very few references to work function or other aspects of the photoelectric effect.

(b) A good majority identified the Doppler effect, although some opted for red shift and lost credit. Most who identified blue shift could state that the wavelength decreased or the frequency increased, although some were unsure of the correct orientation of these quantities with regard to the visible spectrum. Most who got that far knew that the star was approaching the Earth, although some just stated that it was close rather than getting closer.

(c) A quarter of candidates got this mark. For those who did, particle behaviour tended to be mentioned more often than wave behaviour.

<u>Question 18</u>

(a) Over half got at least one mark, but under half of these were awarded the second. Elements of the description were present in most responses, but frequently in insufficient detail or not worded precisely. The mark most commonly awarded was for compressions and rarefactions. When candidates mentioned the direction of the oscillations, they often said something like ‘the oscillations are parallel to the wave movement’. This answer requires the description of the direction of the oscillations (or displacement) and the direction of energy transfer, and the imprecise term ‘wave movement’ could be associated with either and is not sufficient to gain the mark. ‘Move’, ‘motion’ and ‘movement’ are terms best avoided in this context.

(b) Nearly half identified the reason for clicks, but, despite the comparison with continuous sound, many failed to link them with the reasons for pulses they knew from the pulse-echo technique and attempted descriptions in terms of animal behaviour. Others had some understanding but could not express it clearly.

(c) (i-ii) Half complete this completely for four marks, and the great majority calculated the time and applied distance = speed × time. Things went awry

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for a certain proportion at this stage through omitting the factor of 2 required in pulse-echo calculations.

A number of students got the frequency of the clicks confused with the frequency of sound, thinking that 16 Hz could be ultrasound, and calculated a wavelength of 96 m.

(c)(iii) Nearly half gained the mark. Of those who didn't, many mentioned that the sound would return to the dolphin more quickly but did not suggest any consequences.

(d) Most students repeated the range calculation from part (c)(ii) for the bat and only got a single mark if they mentioned that the speed of sound in air, of for the bat, was lower. Hence, most of them decided the dolphin had the advantage. This shows a failure to appreciate the meaning of the term 'precise'.

Some used 16 Hz as a frequency to calculate a corresponding wavelength for air and water. Others attempted to use the time between clicks for a pulse length calculation. It may be that stating the speed of sound for air led candidates to believe that a calculation was required. 19 (b) was a bit like this in asking a question and presenting data, but in 19 (b) they were specifically asked to carry out a calculation and had the required data.

Of those who successfully argued that the wavelength, or pulse length, in air is shorter, only a minority linked it to better resolution.

Question 19

(a) Most candidates got the marks for a general understanding of the photoelectric effect, but the marks for more precise description and application to the particular situation was awarded less frequently. Over two thirds got at least two marks for the idea that photons cause the emission of electrons. Over half the entry proceeded to the third mark, often for a correct reference to work function or for linking the emitted photons to the flow of current.

Some failed to get the mark for the work function through imprecise expression, often mixing it up with threshold frequency, for example 'the photon must have a frequency greater than the work function', or 'the electron must absorb more energy than the threshold frequency'. For the final mark on the mark scheme they needed to refer to the lack of photons and the consequent lack of photoemission, but they did not always make this link explicit. Occasionally they said that the photons would have insufficient energy in the dark, but this did not seem to be a reference to infrared radiation from the surroundings.

A number of candidates wrote everything they knew about the photoelectric effect, often correctly and often containing quotes from previous mark schemes. While it is reassuring that they have learned the full details of the phenomenon, they need to be able to select which are needed to explain specific situations.

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(b) Close to half got the full four marks, again displaying greater facility with calculations than explanations, even when they are more embedded in the context.
Some candidates failed to convert eV to J and some stopped after having done so. Units were occasionally omitted. A number of candidates completed the calculations but couldn't make a suitable comparison with visible light and/or ultraviolet to complete the explanation. Candidates approached the question in different ways, often starting from the wavelength limits of the visible spectrum.

(c) The majority defined amplitude satisfactorily, adding sufficient detail to 'maximum displacement' which is not sufficient alone as it could refer to a distance travelled in a straight line. Some stated the vertical distance between a crest and a trough or said things like maximum distance from a centre.

(d)

(e) There was a widespread lack of understanding of this part of the question, although nearly half scored at least one mark. A significant proportion of the candidates thought that the frequency of the light changed in some way and that this was related to the frequency of sound produced. Some connected the pattern with standing waves and described the production of nodes and antinodes or discussed longitudinal waves. Many other candidates did little more than repeat the question without much added detail.
Of the candidates who displayed an appreciation of the context, many were unable to set out the links from the pattern to the current in a sufficient number of linked steps in a logical order. About a third got two marks for two links, such as a greater intensity causing the emission of more electrons and more electrons causing a greater current.

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