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Summer 2016

Pearson Edexcel GCE
in Physics (6PH02)
Physics at Work

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This is the penultimate summer series in which Unit 2, Physics at Work, will be 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.

The paper allowed candidates of all abilities to demonstrate their knowledge and understanding of Physics by applying them to a range of contexts with differing levels of familiarity.

Candidates at the lower end of the range could complete straightforward calculations involving simple substitution and limited rearrangement, including structured series of calculations, but could not always tackle calculations involving several steps, a choice of variables or extra factors, such as the factor of 2 for echo-location or using radius when given diameter. They also knew in outline standard definitions, but often omitted key technical terms, and similarly knew some significant points in explanations linked to standard situations, such as standing waves, but missed important details and did not always set out their ideas in a logical sequence, sometimes just quoting as many key points as they could remember without particular reference to the context.

Steady improvement was demonstrated in all of these areas through the range of increasing ability and at the higher end all calculations were completed faultlessly, most definitions were given with all the required details and most points were included in ordered explanations of the situations in the questions.

Section A

The multiple choice questions discriminated well, with performance improving across the ability range for all items. Candidates around the E grade boundary typically scored about 5 and A grade candidates usually got 8 or more correct.

The percentages with correct responses for the whole cohort are shown in the table.

Question	Percentage of correct responses
1	62
2	58
3	86
4	48
5	97
6	64
7	88
8	68
9	91
10	84

Question 11

Nearly all students solved this two-step calculation in a straightforward way.

Question 12

Two thirds of candidates scored at least two marks by identifying diffraction and saying that it showed that electrons demonstrate wave behaviour. Only about one in ten completed the explanation with an explicit statement that diffraction is wave behaviour.

Question 13

While most candidates made a statement about polarised light oscillating in a single plane or a single direction, they did not all answer the specific question by saying this was vertical.

A common answer was 'vertically polarised light oscillates only in the vertical plane which is perpendicular to the direction of wave travel'. The plane of oscillation is not perpendicular to the direction of wave travel, it includes the direction of wave travel.

Occasionally students would refer to the direction of wave movement, which is ambiguous and could refer to oscillations. It is best to avoid words like move and motion when describing waves.

Students rarely distinguished polarised light from unpolarised light by describing oscillations in all planes for the latter.

Question 14

(a) and (b): A large minority of students completed both parts fully for 7 marks and the majority gained at least 5 marks. The most common errors were all in part (b). These were using an incorrect p.d. for output power and trying to calculate efficiency with the powers 'upside down'.

Question 15

(a) The majority gained at least 2 marks for this fairly standard photoelectric effect context, with a large minority scoring 3 or more.
Some candidates limited their discussion to light in general when explaining the minimum frequency and did not refer to photon energy or energy provided by photons, even if they described the one to one ratio of absorbed photons to emitted photoelectrons.
When explaining the effect of intensity candidates often just referred to more photons and more electrons and did not introduce the idea of rate, e.g. more photons per second. A greater time would result in more of both without any change in intensity.

(b) A good majority completed this calculation correctly. Nearly all candidates applied $E = hf$ and the electron charge, but some did not use the difference in frequencies.

Question 16

(a) The students usually described a change in density or the speed of light but sometimes were not precise enough describing the change in direction, for example by saying the light bends. They rarely discussed the effect on the apparent point of origin of the light.

(b) Both marks were usually awarded for this question. Some candidates incorrectly gave the answer as 2.25×10^8 m s^{-1} instead of 2.26×10^8 m s^{-1} after reading 2.2556 from their calculator display. The data were given to 3 significant figures, so, while 2.3×10^8 m s^{-1} was quite acceptable, answers given to 3 significant figures had to be correct to 3 significant figures.

(c) (i) Two of the marks for part (i) depended on accurately measuring the angle, and this was not always done. Some candidates also had a problem applying Snell's law for light going from a denser medium to a less dense medium.
(ii) A fair number of candidates did not add anything to the diagram, or only added the emergent ray without extrapolating it back through the water.

Question 17

(a) (i) The majority described superposition or interference between waves travelling in opposite directions. The lack of detail or use of imprecise terms often limited the marks awarded. Some were not credited if they only referred to superimposition rather than superposition and others used 'out of phase' instead of antiphase. Reference to amplitude was required for the third mark, but candidates often just mentioned maxima or maximum displacement.
(ii) Unless they repeated the original pattern, most candidates gained at least one mark for a node at the closed end and over half also added an antinode at the open end. Of those, about half correctly identified the relevant frequency.

(b) While a fifth of the entry completed this calculation correctly, difficulties for others included reading a frequency from the graph correctly and calculating the corresponding wavelength from the length of the tube.

Question 18

(a) (i) Most suggested precautions were not relevant to accuracy of the results of this investigation, such as insulating the beaker or making sure the wire had the same diameter along its length. Candidates were asked to explain their precautions, but relevant precautions were often given without a reason, or the desired outcome of a precaution was stated without a suggestion of how to achieve it. For example, some candidates stated that the coil should be fully submerged but not why. Others wrote that the thermometer and coil should be at the same temperature but did not suggest how. Overall, about a quarter of the entry suggested a relevant precaution with a reason.
(ii) Candidates often discussed avoiding human error, more readings, automatically plotting graphs, more significant figures and so on, none of these being awarded the mark. The first of those ideas needed to be linked to achieving truly simultaneous readings and the second to the frequency of measurements, i.e. the number in a given time and not just the number.

(b) (i) The great majority scored this mark, but some did not because they just said the line doesn't pass through zero.
(ii) While more than half scored at least 1 mark, lack of precision and detail meant that the marks did not often rise above 2. Candidates often referred to the increase in temperature making the lattice ions vibrate, as if from being stationary, without the idea of an increase, e.g. in the amplitude of vibration. Similarly, they would often refer to an increase in collisions between electrons and lattice ions without referring to the increased rate. An increased number can just depend on time. Sometimes they just wrote about 'more collisions' without reference to electrons or ions or just said that

electrons would collide more frequently, but not mention what they were colliding with. Many candidates did not refer to $I = nAvq$ and $R = V/I$ as required to obtain the last 2 marks.

(c) Nearly all candidates applied the resistivity equation correctly. A small minority rearranged it incorrectly and a few did not divide the diameter by 2 before calculating the cross-sectional area. Occasionally candidates omitted the unit of length in their answers.

(d) Nearly half of the entry gained 2 marks for their response to this question. A surprising number either wrote the resistance on the temperature answer line or did not read a correct temperature corresponding to their calculated resistance from the graph. Oddly, some who calculated 14.4 Ω gave a temperature of 34 °C by misreading the resistance scale. Such candidates should be sure to look at the scale values either side of the point of interest to ensure they interpret the scale correctly.

Question 19

(a) The great majority got the correct answer, but some did not apply the factor of 2 correctly.

(b) Candidates commonly were awarded 1 or 2 marks here. Some based their answers on the Doppler Effect, apparently thinking that a shift in frequency is related to distance between source and receiver rather than relative velocity. The marks most commonly awarded were for identifying a shorter wavelength, saying the pulses return in a shorter time, referring to avoiding overlapping pulses and monitoring the prey's position more frequently. Accuracy was often mentioned, but not with supporting detail.

(c) The majority got the first mark for linking change in frequency or wavelength with the Doppler Effect or relative motion. Most of these candidates got another mark for describing the situation for one direction of relative motion correctly, but not all described the opposite direction.

Summary

Based on their performance on this paper, candidates are offered the following advice:

- Learn definitions in detail so they can be quoted fully, using the required terminology.
- Check that quantitative answers represent sensible values and to go back over calculations when they do not.
- Learn standard descriptions of physical processes, such as spectrum formation the Doppler Effect and interference, and be able apply them to specific situations, identifying the parts of the general explanation required to answer the particular question.
- Be sure to know the standard SI prefixes.
- Be sure you know the command words and understand the level of required response for each of them, e.g. explain would mean a candidate must say why something happens and not just describe what happens.
- Explanations can often be supported by reference to formulae on the data, formulae and relationships sheet.
- When reading from graphs, look at the scale values either side of the point of interest to be sure to interpret the scale correctly.
- Physical quantities have a magnitude and a unit and both must be given in answers to numerical questions.
- Note that there will always be an increase in the total number of occurrences of a regular event over time and consider whether the rate should be compared with the prior situation rather than the number, for example a greater rate of collisions (18bii) or more photons per second (15a).

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