Examiners' Report
Principal Examiner Feedback

January 2018

Pearson Edexcel International Advanced Subsidairy Level
Physics (WPH02)
Unit 2: Physics at Work

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General Introduction

The specification examined and assessment structure of the paper is the same as that of the GCE legacy 6PH02 paper. Section A of the paper contains 10 multiple choice questions while section B contains questions of increasing length and usually of increasing demand. Unit 2, Physics at Work, examines dc Electricity and Waves providing a transition for learners between GCSE and A2. Although there is no overlap with the other units, the skills and concepts covered, are used as a basis for the teaching of the concepts in units 4 and 5.

This paper enabled learners of all abilities to apply their knowledge to a variety of styles of examination questions. Many learners showed a good progression from GCSE to AS level, with prior knowledge extended and new concepts taught and understood well. learners who had experience of a wide range of practical demonstrations fared better on some questions as this helped them to apply their physics knowledge in different contexts.

Section A – Multiple Choice

	Subject	Percentage of learners who answered correctly	Comment
1	SI units	89	The high percentage scoring correctly demonstrates a good understanding of the definition for current and recognition of SI units.
2	Radiation flux	63	Most common incorrect response was A. This would have been due to incorrect conversion of mm^2 to m^2
3	Phase difference	73	Common incorrect response was D. Ratio (160/340) inverted.
4	e.m.f., internal resistance and terminal p.d.	76	Common incorrect response was B. This could have been due to learners treating the terminal potential difference as a supply p.d.
5	Efficiency	51	All incorrect responses were commonly seen, demonstrating that learners had difficulty applying the efficiency equation to a cell in a circuit. Incorrect responses C and D also had a mismatch of power and energy.
6	The Doppler Effect	89	A high percentage scoring correctly with A being a common incorrect response. This incorrect response states that wavelength would decrease.
7	The diode	60	Common incorrect response was A. This would have been due to not recognising how to determine the p.d. across the resistor.
8	Energy of a photon	67	Common incorrect response was A. This incorrect response gives the time between emissions.
9	Change in resistance of a filament bulb with temperature	68	Common incorrect response was A. Maybe learners were thinking of thermistors. Knowing that the resistance of a filament bulb increases with temperature can lead only to B being the correct response.
10	Use of $I=nAvq$	67	Both D and C were common incorrect responses. Both of these incorrect responses indicate learners thinking that the current in wire X would be greater.

Section B

Question 11:

(a) Most learners understood which equations to use but did not then always choose correct values for potential difference, current or resistance. Many learners did not correctly determine the p.d. across the 62 Ω resistor, for example it was common to see P = $9^2/62$. Alternatively they incorrectly used the total value of resistance in the circuit (62 Ω +50 Ω). Whilst this may have still gained MP2 they will have reached an incorrect answer.

(a) Calculate the power dissipated in the 62 Ω resistor.

(A). $I = \frac{V}{R_1+R_2} = \frac{9\,V}{112\,\Omega} = 0.08$ A.

$P = I^2R = 0.400$ W.

(b) Most learners realized that they needed to use the formula for resistors in parallel but a significant number then failed to use it correctly. The most common mistake seen was not remembering to invert their answer, so they ended up adding a value for $\frac{1}{R}$ to the 50 Ω. Those learners who clearly showed correct substitution of 57 Ω and 62 Ω into the formula could at least secure MP1.
This answer scores full marks. They have shown correct use of a formula for resistances in parallel in two different ways. It is important that learners show all their working.

Calculate the total resistance of the circuit. (3)

$\frac{1}{R_1} = \frac{1}{62} + \frac{1}{57}$ $\therefore R_1 = \frac{62\times57}{62+57} = 29.7\,\Omega$

$\therefore R_T = R_1 + R_2 = 50 + 29.7$

$= 80\,\Omega$

Total resistance of circuit = 80 Ω

Whilst this learner scores MP1, with clear substitution into the correct formula on the first line, they have carried out the calculation incorrectly so do not score MP2 and MP3.

Calculate the total resistance of the circuit.

$\frac{1}{R_P} = \frac{1}{62} + \frac{1}{57}$

$3534 R_P = 57+62$

$R_P = 0.03\,\Omega$

$R_T = 50 + 0.03 = 50.03\,\Omega$

Total resistance of circuit = 50.03 Ω

Question 12:

(a) learners did well on this question, recognition that this was an example of diffraction. Most could also describe why, with comparison of the wavelength and the size of the gap.

Since the wavelength of the microwave is equal to the size of the gap, substantial diffraction takes place. Diffraction causes the microwaves to spread out as it posses through the gap and microwaves can be detected at point x.

(b) This is a classic question on constructive and destructive interference but within a different context. MP1 required reference to the context of the two waves that are diffracted from the gaps. learners who had memorized a previous mark schemes were less likely to score this mark. Most learners then continued to describe the conditions for constructive and destructive interference, with constructive interference (MP3) scoring more frequently. For destructive interference, learners need to be aware of the difference between the terms *out-of-phase* and in *antiphase*. There is also confusion over the difference between path and phase difference, with path difference being incorrectly described in terms of π, and phase difference incorrectly described in terms of λ. The question asks why maximum and minimum intensity are observed. In order to achieve MP5, learners needed to link the intensity observed to the amplitude of the wave at these points and not simply repeat the question.

This answer scores full marks.

two coherent waves meet,
superposition occurs
the two waves arrive with a path difference.
When path difference = $n\lambda$, waves are in phase.
constructive interference, causing maximum amplitude
Hence causing maximum intensity.
when path difference = $(n+\frac{1}{2})\lambda$, waves are in antiphase
destructive interference, causing zero amplitude
Hence causing minimum intensity

Question 13:

(a)(i) This is a definition that learners are expected to know. A common mistake was an answer given in terms of energy and not frequency.

(i) State what is meant by the threshold frequency.

(1)

Minimum frequency needed for the photons to release an electron from the surface of a particular metal.

(a)(ii) Many learners were able to score at least one mark, but were let down by poor written descriptions. Some learners failed to mention photons which would have limited their mark to one (MP4). When describing the particle theory it is impossible to pick up marks if a learner fails to mention photons. Some learners, when writing about wave theory for MP4, mentioned that the energy of the photon would eventually be transferred. This demonstrates a lack of understanding about the particle and the wave theories of light. MP1 was the most frequently scored mark. For MP4 it needed to be clear that the energy of the wave is transferred *to the electron* and *at any frequency.*

This answer scores full marks.

*(ii) Explain how the existence of a threshold frequency supports the particle theory of light and not the wave theory of light.

(4)

In particle theory of light, light is made up of discrete bundles of energy called photons. ~~When light~~ Energy of a photon is proportional to its frequency, as shown by E=hf. When light is illuminated, one photon interacts with one electron only and give the electron all of its energy. Since a minimum amount of energy is required for an electron to be emitted from a metal surface, it means that the photons need to have a certain amount of energy. This corresponds to a minimum value of frequency. In wave theory, energy can be built up in the electrons when illuminated with light waves. As long as enough time is given, the electron can accumulate enough energy and be emitted, regardless of the frequency of light.

(b) There were several ways in which this question could be answered. A significant number read a value of 5.4 eV from the graph but did not appreciate that it was a value for kinetic energy, but used it as a value for *hf* (or even a value for work function). Very rarely, it was seen that a learner tried to extrapolate the line on the graph back to the y-axis to determine a value for work function. Whilst this is a valid method, learners are not generally expected to extend a graph beyond the graph area. A significant number were not aware of what to use as the value for *m*.

This scores full marks.

$E = \frac{1}{2}mV^2$

$5.4eV = \frac{1}{2} \times 9.11\times10^{-31}kg \times V^2$

$8.64\times10^{-19}J = \frac{1}{2} \times 9.11\times10^{-31}kg \times V^2$

~~[illegible]~~

$V \simeq 1380000\ ms^{-1}$

Question 14:

(a) The idea of two waves was well established but learners did not express the idea that they travel in opposite directions. The use of the term *superposition* was common but the mis-spelling superimposition was not accepted. MP1 and 2 frequently awarded with some not stating that nodes and antinodes are formed for MP3.

A standing wave is produced by the superposition of a progressive wave travelling in one direction and its reflection travelling in the opposite direction producing nodes and antinodes.

(b) It was necessary in this question for learners to use the correct physics with use of $v=f\lambda$ since the question is with reference to a standing wave. learners using $v = s/t$ did not gain credit even though they arrived at the same numerical answer. Having correctly calculated a value for wavelength of 1.52 m many learners used a "time period" of 6.0 ms, reading across one and a half cycles on the graph. A significant number of learners did not realise that the length of the string would be equal to half the wavelength

Question 15:

(a) A good number of correct answers were seen for this question. Some learners prefer to carry out one big calculation on questions such as this. However, in the case of an incorrect final answer it becomes more difficult to award interim marks if they are "hidden" within the calculation, such as the correct use of a factor of 2.

(b) Not well answered, with a large number of learners not relating their answer to the question but falling back on similar, but not the same, questions from previous papers. An incorrect response of 'one pulse needs to return before the next one is emitted' was commonly seen.

Question 16:

(a) Most learners were aware that there are more collisions in the wire but a significant number did not know that electrons collide with metal ions. An answer referring to electrons colliding with electrons was commonly seen. It was very rare for a learner to explain this in terms of the potential difference.

(a) Explain, in terms of conduction electrons, why the resistance increases with the length of the wire.

(3)

As the length of wire increases, ~~the time of~~ electrons will collide with lattice ions more times, which reduce the drift velocity. due to $I = nAqv$, the current of the wire will decrease. when the voltage is constant, due to $R = \frac{V}{I}$, the resistance will increase.

(b) MP1 was scored, most commonly for 'micrometer'. On the whole this question was well done although a significant number did not appreciate that the measurement needed to be made at different places or orientations

(b) Describe how the student should measure the diameter of the wire as accurately as possible.

(3)

Measure the diameter of wire at different points using a micrometer. Calculate mean, this reduces percentage uncertainity as it gives average result.
Repeat several times and take average.

(c) Most learners realised that use of the resistivity equation was required. Those who scored full marks calculated a gradient from the graph to give a value for *R/l* which was then substituted into the equation. A large number of learners failed to take into account the fact that the graph does not go through the origin and so simply read two corresponding values for *R* and *l* from the graph. It was encouraging to see very few unit errors for resistivity (for example $\Omega\ m^{-1}$).

(d) Very low scoring. The error of 1 Ω shown on the graph would give a 10 cm error in the measurement of length, so errors in measuring length (e.g. parallax) would not cause this. Many gave very general responses, such as 'zero error', with no further information.

Question 17:

(a)(i) The question asks to describe how the percentage of sugar affects the path of the ray, so in order to answer this question, there needed to be some mention of whether the percentage of sugar was high or low. Many failed to use the reference earlier in the question to refractive index. However they could still have gained MP2 for referring to the angle of refraction or amount of refraction. Many wrote 'the path moves closer to the normal' but this is not explicitly referring to the refractive ray or angles to gain MP2.

(a)(ii) MP1 was commonly scored. Many learners failed to read from the graph correctly and so having calculated a correct value for μ they then gave an incorrect value for the percentage of sugar. In this case, rounding errors were not penalised although it was common to see 1.466 rounded to 1.46.

(b)(i) learner responses demonstrated that many had memorised a definition for a plane polarised wave without actually understanding what a plane is. Many answered in terms of the direction of the oscillations, remembering previous mark schemes, but would have failed to score any marks. MP2 was rarely awarded.

(i) Explain what is meant by the plane of polarisation.

(2)

The plane (which includes the direction of propagation of the wave) to which the oscillation of the polarized light is restricted.

(b)(ii) MP1 was awarded more often than MP2, although some learners lacked clarity as to what was rotated by 90 degrees to what. In many cases it seemed the initial unpolarised light was at 90°. learners tended to treat both the filters as if they were both acting on the light at the same time and so missed the initial transition from unpolarised to polarised light. The filters had been named in the question (A and B) to help learners write clear answers by referring to the relevant filters.

Explain how the alignment of the two polarising filters, A and B, ensures that no light is detected.

(2)

They should be aligned perpendicular to each other so that ~~the~~ light transmitted by A B blocked by B.

(b)(iii) Few learners had any idea of what was going on in this question and it was rare to award 2 marks. learners are generally too quick to answer questions without sketching out what is going on and this really needed careful thought. No credit was given for repeating the question "plane of polarisation is rotated". Understanding that it has been rotated by a small angle was demonstrated by a few learners. The need for the use of *components* has been expected in previous papers but learners still do not seem comfortable with this.

The following response scores MP2 only

As the container is filled. the plane of polarisation is change. there is some component of light is parallel the direction of filter B and pass though but the component of light which is perpendicular is blocked out. not all light passes through. so the intensity is less.

The following response scores MP1 only

This is because the light is rotated by an angle less than 90° by the drink so polarising filter B is still absorbing / blocking some of the light from filter A so the intensity is reduced.

(b)(iv) Many learners could access marks here. A significant number talked about a different practical where two filters are rotated relative to each other at 90° and 180°. Demonstration of polarimeters may have helped.

rotate the filter and record the angle , until the ~~light sensor is~~ There is no light detected by the light sensor. This angle ~~[illegible]~~ can repersent the Precentage of sugar.

Question 18

(a) Quite a lot of learners realised that this question was about energy levels and could access MP1 to 3. Some did not express their answers well and there was confusion over what was moving up and down the energy levels, with use of atoms, electrons, molecules, particles and photons all seen. As in previous papers, learners need to be more careful in their reference to *E=hf.* To gain any credit this must be used with reference to the energy of the photon. Simply writing "*E=hf*" on its own, somewhere in their answer, does not gain credit.

(5)

When the charged particles ~~have~~ ~~collect~~ ~~a collision~~ collide with the atoms of gases, they transfer energy to the gases and the electrons of gases are excited after absorbing the energy. The electrons gets to a higher energy levels but falls back to a lower energy levels later and ~~emit~~ emits ~~energy~~ a photons with energy equal to the difference between two energy levels. So light is emitted.

(b) Not very well answered with a lot of repetition of the information given in the question. Some learners recognised that there will be more collisions and so more photons. Less well understood was that intensity is linked to the number of photons per unit time.

When there are more charged particles and oxygen atoms, then more electrons ~~sat~~ in the oxygen atoms will be excited. When they de-excited, more number of ~~ele~~ excited electrons leads to more photons being emitted. Number of photons emitted per unit time increases, hence intensity of light increases.

(c) The use of the word 'certain', as in 'certain energy levels', is very commonly seen in energy level questions. However in this case "certain/discrete energy levels" does not mean the same thing as "*different* energy levels" which is what was needed for MP1. Repeating information given in the question does not gain credit, but the ideas needed for MP2 and MP3 could be surmised from earlier parts of the question.
This answer does not gain MP1 but is awarded MP2 and 3.

Each gas ~~release a~~ emits a specific colour. The colours emitted when observing other planets allows us to deduce what these gases are due to the colour ~~released~~ emitted being uniquely identified. The intensity of those colours also helps us determine the amount of gas present ~~surrounding~~.

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 greater understanding of the context and 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. Practical demonstrations (or simulations) do help learners with their understanding and application of concepts.

Based on their performance on this paper, some learners could benefit from more teaching time and extra practice on the following concepts and skills:

- Appreciation of the significance of a graph that does not pass through the origin.
- Practise at writing longer written answers and in particular referring back to the context of the question. Rote learning of similar mark schemes from previous papers does not demonstrate understanding of the question being answered.
- Writing down all steps in a longer calculation helps to secure marks if the final answer is incorrect.
- The wave and the particle nature of light. Understanding and use of the idea of a photon.
- Analysing a displacement-time graph for a standing wave.
- Application and discussion of physics in unfamiliar contexts.

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