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Examiners' report

PHYSICS A

H556

For first teaching in 2015

H556/02 Autumn 2021 series

Version 1

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

Reports for the November 2021 series will provide a broad commentary about candidate performance, with the aim for them to be useful future teaching tools. As an exception for this series they will not contain any questions from the question paper nor examples of candidate responses.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Paper 2 series overview

H556/02 is the second of the three assessed components of GCE Physics Specification A. The component is worth 100 marks and assesses content from modules 1, 2, 4 and 6 of the specification. It is split into two sections; Section A consists of 15 multiple choice questions (MCQs) allowing a breadth of the content to be assessed, while Section B consists of ten short and structured questions. Section B allows for content to assessed in more depth including development in the two level of response (LoR) questions, practical skills and calculations involving several stages. Practical skills and techniques form the basis of several questions and is an integral part of the assessment.

The Data, Formulae and Relationships booklet is a valuable resource in the examination and significantly reduces the need for rote learning of data and equations, so allowing candidates to demonstrate their knowledge and application of physics.

The duration of the examination paper is 2 hours 15 minutes and the weighting of this component is 37%.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• answered all the multiple choice questions and generally showed appropriate working to assist them • used suitable scientific terminology when necessary • read all the instructions on the two LoR questions and answered each section if possible • followed the command terms appropriately • had good recall of definitions • set out calculations clearly, using symbols where appropriate to show the process.	• missed opportunities to convert units with prefixes • answered questions in a different way to what was asked • had unstructured mathematical solutions making it unclear where it was going • drew careless diagrams without appreciating the need for detail and precision • gave simplistic responses to LoR questions, without attempting to answer every aspect • made arithmetic errors despite setting up the calculation correctly.

Section A overview

Section A has 15 MCQs each with four responses, covering content from modules 1, 2 ,4 and 6.

Space is allocated on the question paper to allow for working, calculations and written thoughts, although none of this is necessary for credit. Candidates may use any methods they wish to reach the correct answer, such as short-cuts or intuition.

Questions 2, 3 and 11 proved to be the most accessible whereas Questions 4, 5 and 12 were the most challenging.

Comments on individual questions

Question 1

The correct response is **D**. This question was correctly answered by the majority of candidates, although almost all the incorrect responses were **C**, presumably as candidates are aware that it is the e.m.f. that is induced but less familiar with Faraday's law in general.

Question 2

The correct response is **A**. This question was correctly answered by the vast majority of candidates, who were able to select the correct terms applicable.

Question 3

The correct response is **D**. It was encouraging to see that a large number of candidates were able to select the correct answer. Although a relatively straightforward calculation, it does involve two unit conversions (mA to A, and hours to seconds), which if not done would generate one of the distractors. Many candidates showed their working here as they would in a structured question and this is always helpful when the calculation involves more than one stage.

Question 4

The correct response is **C**. Candidates often find the electric field questions challenging and this was again the case as this question was correctly answered by only one third of the candidates. Many candidates drew arrows on the diagram to assist them. Response **D** was the most common distractor; linking this to gravitational fields would produce a zero field strength at **P** which is likely to be the reason.

Question 5

The correct response is **D**. This question also proved to be challenging as not many candidates will have come across this style of circuit before. Therefore in most cases, it will have to have been worked out from application of conventional current flow. It would likely be evident that LED **Q** is lit, probably accounting for the very few candidates selecting response **B**. Many candidates incorrectly selected response **A**, presumably as its polarity is the same as **Q**.

Question 6

The correct response is **C**. Although this question may not have followed the traditional route for a capacitor decay, it proved to be accessible to many candidates. Several filled in the table completely which appeared to be a helpful strategy, or set up stages of the calculation alongside the question. Those that showed little or no working tended to opt for response **A** using a constant subtraction for each time interval.

Question 7

The correct response is **B**. This question was correctly answered by around two thirds of candidates. There appeared to be various routes to the correct solution; many opted to work out a current in terms of *R*, but the more elegant working was in terms of simple ratios which demonstrated a good understanding of p.d. in a series circuit. Encouragingly, very few candidates opted for response **A**, which was a p.d. below that of the thermistor alone. It should be noted that a couple of candidates put a '7' in the answer box – as correct working had been shown by them, and leading to the correct numerical value this was credited by examiners. However, this cannot be guaranteed to occur in other cases and candidates are to be encouraged to put only the correct letter.

Question 8

The correct response is **A**. A good number of candidates were able to correctly identify the new fringe separation. Most correctly identified the appropriate equation from the booklet and set out the solution either as ratios or by direct calculation. Quite a large fraction who achieved the correct response showed no working, suggesting that this is a relatively simple calculation probably done directly into a calculator.

Question 9

The correct response is **B**. Around two thirds of candidates were able to correctly calculate the frequency; this question relies on the candidate appreciating that there is more than one complete cycle in the tube and then evaluating the correct wavelength. It is then a straightforward calculation. As expected, most of the incorrect responses were **A**, where the wave equation had simply been used with the given numbers. Several candidates drew on the diagram to help in their calculation of the wavelength, although some thought that the wavelength was two thirds of the tube length, rather than four fifths.

Question 10

The correct response is **B**. This is another question which was correctly answered by around two thirds of the candidates. The simple solution is through determining the current through **Z** and the p.d. across it thereby finding the product. Working demonstrated some tortuous routes, such as calculating all the resistances, which does indicate a lack of confidence about circuit calculations. However, in many cases this did lead to the correct answer.

Question 11

The correct response is **C**. Although not a particularly challenging question, it was encouraging to see around three quarters of entrants getting the correct solution. The most common incorrect response was **A**, suggesting that the idea of time period is not necessarily well understood.

Question 12

The correct response is **D**. Electromagnetism is another challenging set of concepts, resulting in a relatively low number of students obtaining the correct answer. Working showed that many of the candidates appreciated that the field needed to be resolved and were able to select the right trigonometrical function. However, by far the most common mistake was to ignore the turns and to simply calculate the flux through the coil. Whether this is a misconception or simply looking at the 'coil' on the diagram is unknown, however candidate should be reminded of the difference between turns and coils.

Question 13

The correct response is **A**. Around half of candidates were able to select the correct response. Although it would seem appropriate to write out some simple decay sequence, many candidates showed little working here. Some were able to get the correct response (probably through mental arithmetic) but incorrect responses may simply have been down to a lack of knowledge of nuclear changes, most likely in the beta decay. Incorrect responses were spread fairly evenly among the distractors, again suggesting that this topic was not well understood.

Question 14

The correct response is **B**. The formula booklet is pretty essential here as the ultrasound reflection formula is one of the least memorable. Although there are a couple of stages to this calculation, most candidates were able to answer this correctly and this suggests a confidence (and perhaps suitable practice) in this topic. However, and unusually, some candidates did not provide a response to this question.

i	**OCR support**	An awareness of the Data, Formulae and Relationship booklet and its content and structure is valuable here, avoiding the need to recall potentially complex formulae. Candidates can save themselves time by using the booklet frequently in preparation for the examination and thereby gain an appreciation of its value.

Question 15

The correct response is **C**. The responses are terms used frequently when studying data, but as around only one half of the candidates were able to get the correct response, it is clear that they are not fully understood. A little perplexingly, the most common incorrect response was **B**, as it is difficult to see how this data could be considered linear. This does show how easy it is to assume that candidates are confident in their use of terminology, just because they are frequently used.

Section B overview

Section B has ten short answer, structured questions, covering content from modules 1,2,4 and 6, including questions involving practical work, calculations and problem solving.

Lines are allocated on the question paper for writing and space for diagrams and calculations. Working for calculations is always to be encouraged.

Questions 18, 20 and 25 proved to be the most accessible overall whereas Questions 16, 17 and 22 were the most challenging.

Comments on individual questions

Question 16

This question covers parts of the waves topic from module 4 including experimental techniques and methods.

Question 16(a)(i)

This question should be a relatively simple introduction to the section, using a familiar formula to calculate a wavelength. Nearly all candidates were able to correctly make wavelength the subject of the equation, and the majority were able to select the correct frequency to use. Those that chose the other frequency could score 1 mark if correctly followed through.

Question 16(a)(ii)

This question was poorly answered in general; very few candidates appreciated the need to use a signal generator to produce varying frequencies and seemed to think that the oscilloscope would do this. Many candidates used diagrams (yet not always labelled) to show their apparatus. Although many did appreciate that the upper limit is reached when the hearing stops, few also then went on to say how the frequency could actually be determined.

Question 16(b)

This question is clear that the differences and similarities should be based on the oscillations. Few candidates did this, but other routes could be used to gain credit. Candidates should be careful not to create lists in this style of question and simply produce a single response, as contradictions can be penalised.

Question 16(c)

This question required a knowledge of how to practically determine the refractive index using the given apparatus. It was clear that candidates were not sure how to carry out this experiment correctly and responses often were confusing with a misconception of what the critical angle is. It was often not clear what angle was being measured as many different angles were usually drawn on the diagram. Many candidates showed the ray of light entering the straight face of the block which would make it impossible to determine the critical angle.

Question 17

This question covers part of the quantum physics topic from module 4.

Question 17(a)

This is a standard definition which candidates should be able to state. Candidates should remember that the work function is a minimum energy. There is occasionally a misconception regarding ionisation, and also some careless use of language for the removal of the electron. Words such as escape and eject are acceptable, but terms such as dislocation are not clear enough. The definition does not require the statement that it is from the surface of the metal this time, but that does not mean that it will not be required in the future.

17(b)(i)

The question is clear that the response needs to be given in terms of photons and energies. Many candidates discussed threshold frequencies, and although often correct, does not answer the question. The link between photon energy and frequency needs to be clear and not just a simple dependency – the simple solution for this is to state the equation. The final marking point requires the candidate to appreciate that only one photon can be absorbed by one electron. Standalone statements such as "there is a 1:1 relation" is meaningless in this context unless qualified. Many good candidates were able to score at least 3 marks on this question and it was clear that this is a well understood aspect. There is sufficient space for a fully clear answer and candidates are always to be reminded of the need for conciseness in such a response.

?	**Misconception**	Some candidates missed opportunities for marks by describing the effect wholly in terms of frequency, rather than energy.

17(b)(ii)

This is a novel development on what is a common calculation of kinetic energy and as such created some challenge for some candidates. Many were able to score the first marking point, either by converting from eV to joules, or by the calculation of the photon energy. Few candidates scored 2 or 3 marks, as generally an error such as using the speed of light for the electrons occurred. However, a good number of stronger candidates were able to achieve all 4 marks and set out their solutions clearly. It should be noted that the first 3 marks are for setting up the calculations and not the evaluations. This is to not penalise candidates too early for calculational errors and as always highlights the clear need for setting out working as well as possible.

Question 18

This question covers part of the charge and current topic from module 4.

Question 18(a)(i)

This question required the candidates to appreciate that the sum of the emfs will lead to an anticlockwise conventional current. This question was answered well by the majority of candidates, however a number put two directions on, one from each cell.

?	**Misconception**	The unusual setting out of the circuit meant that some candidates were unsure whether parts of the circuit were in series or parallel. This could have been overcome by following the circuit or even by redrawing it.

Question 18(a)(ii)

This calculation required the candidate to set out the whole circuit in one. Around one third did not score any marks on this question as they attempted to treat each cell individually and then produce some form of average. Other common misunderstandings included treating the 0.5 ohm and 0.8 ohm resistors as if they were in parallel, and adding the emfs.

Question 18(a)(iii)

This question was well done by a large number of candidates, many of whom scored full marks by correctly following through with their value of current from the previous part. Few candidates used the diameter instead of the radius when determining the cross sectional area, and for the most part the setting out of the calculation meant that credit could be given even if arithmetic errors occurred later.

Question 18(a)(iv)

Candidates were expected to provide any method of cooling the circuit, or preventing it heating in the first place. A wide variety of solutions were given and as long it is viable, it was credited.

?	**Misconception**	Some candidates gave perfectly viable solutions, but these involved changes to the circuit, which was not allowed in the question. It is very important to make sure than any response does fit what is being asked.

Question 18(b)

This is the first LoR question on the paper. This question is based on a standard physics practical, so the experimental set up should have been familiar to many candidates. While a holistic approach is taken to the marking, there are key points which should be present for the award of given levels. The question is structured in two main parts: the determination of E and r, and then the calculation of R and P for the table. However, each of these parts contain additional instructions which were often ignored by the candidates. For the emf and internal resistance, an explanation of the method used was required, the most usual way would be based around a rearrangement of $E = V + Ir$. For the resistance and power, a qualitative description of how they are related is needed, along with an appreciation that when the internal resistance equals the load resistance the power is at its maximum. For the most part, candidates carried out the calculations well, completing the table and identifying E and r correctly, but did not give suitable and detailed descriptions leading to them being limited to lower levels. Very few discussed the resistance and power relationship at all, despite it being a reasonably simple pattern. It is very important that candidates make note of all that is required in a LoR question if they are to access the higher levels. The vast majority of candidates did sufficient work to place them in Level 2.

?	**Misconception**	Many candidates missed opportunities to achieve a higher level by not explaining their reasoning and not describing the pattern of R with P.

Question 19

This question covers part of the electromagnetism topic from module 6.

Question 19(a)

This question requires the candidates to identify the direction of the field and also to appreciate that the magnitude of the field reduces as the distance from the wire increases. Only around half were able to apply the right hand rule correctly to determine the direction, and only around 10% scored both marks. The increasing separation of the field lines with distance was poorly done for the most part. Many candidates kept the same separation, however those that may have attempted to increase this did not do with any clarity, so that parts of the circle would decrease. In general, the quality of the circles meant that it was difficult to be sure what the candidate's intention was. Some candidates were confused by the leader line, thinking it was the wire and attempted to draw a pattern around this. The question is clear that the diagram represents a top-view.

Question 19(b)

This question is based around a common experiment used to determine the magnetic flux density of a pair of magnets and the experimental design should have been familiar to many candidates, along with the use of $F = BIL\sin\theta$ from the data booklet. The first mark is for identifying the magnitude of the force as being the change in the apparent weight on the balance. Several candidates simply used the reading with the wire, or did not change the mass unit to kg. However, those who managed to get the correct reading for the force generally went on to calculate the magnetic flux density correctly. The uncertainties for two readings were given, and most candidates correctly calculated a percentage uncertainty of 5.3%. The final answer required the correct number of significant figures. Some candidates either did not see this, or ignored it, leaving their final answer in different significant figures. It was noted that several candidates underlined this instruction and in general they tended to follow it. It is good practice to do this.

Question 20

This question covers part of the capacitors topic from module 6.

Question 20(a)

This question comes from the learning outcome 6.1.3(c) in the use of an equation in a capacitor-resistor circuit. Candidates are required to determine the time at which a potential difference is met, which involves the use of logarithms. It was noted that many candidates were confident in their use of logarithms and were able to make some progress through their solution. Most candidates calculated the time constant correctly, taking into account the unit prefixes, and substituted this into an equation. However a large proportion used the discharging (rather than the charging) equation to calculate the time and some credit could be allowed for this. Less than one fifth of candidates scored all marks on this question.

Misconception	Many candidates seemed uncertain which equation to use, applying the simpler discharging equation. While the charging and discharging equations are given in the data booklet, it is not stated which is which, so candidates must make sure they know which to apply.

Question 20(b)

This question is likely to be an unfamiliar scenario to many candidates and so required some careful reading. The first mark is for a single straight line of best fit; many candidates simply joined up the first and last point, which produced a line that did not produce an even distribution of points above and below. The gradient calculation was well done by most candidates, leading to a value within the tolerance. Although the given equation is likely to be unknown, most candidates were able to appreciate how to determine the value of *k* and did so successfully. Over half of the candidates were able to achieve full marks on this question.

Question 21

This question covers part of the using X-rays topic from module 6.

Question 21(a)

While many candidates were aware of the Compton effect and were able to give some description, the lack of use of appropriate scientific terminology meant that some were unable to score any marks. The first marking point requires it to be clear that an electron is removed from the atom. A significant number of candidates described this in terms of moving shells, or excitation. The second marking point required the candidate to express that the photon had a lower energy (or equivalent) which again was often answered carelessly. Despite some good general descriptions, over half the candidates did not achieve a mark on this question.

Misconception	As the Compton effect is further evidence for the particulate nature of light, it is important that this description is given in terms of photons. Several candidates gave an otherwise good description but gave it in terms of waves.

Question 21(b)

There were many routes to a final answer in this question. Those candidates who set out their working carefully, used letters to represent the calculated quantity, and set this out in several stages tended to be the most successful. Some calculated the energy at the surface before going on to apply the attenuation formula, and others carried out the attenuation on the intensity. Each method can be credited at various stages, but it is important that a clear structure is shown. Many candidates attempted to change cm^{-1} to m^{-1} by dividing by 100, whereas the better candidates appreciated that the units of distance and attenuation constant would cancel in the exponent. Several candidates used the incorrect formula energy = power / time which can be a common misconception. The correct formula is in the data booklet if required.

Question 21(c)

Many candidates used a technique that did not use X-rays (such as ultrasound) so could score no marks. Those that correctly identified the CAT scan did, in general, identify a correct advantage. Answers which were vague (along the lines of clearer) could not be credited. This question is directly from the learning outcome 6.5.1(g)

Question 22

This question covers part of the diagnostic methods in the diagnostic methods in medicine topic from module 6.

This question is directly from the learning outcome 6.5.2(e). Candidates were expected to describe the basic principles of the PET scanner and use this to describe how to locate fluorine-18 nuclei. This question was poorly answered by many candidates and over half scored zero marks. Of that, there were a significant number who gave no response. However, there were some excellent responses that demonstrated a genuine understanding of the process. Several candidates thought that the beta-plus particles were electrons and from that point would have difficulty in making progress. The short half-life seemed to cause some confusion, and several candidates felt that this was a key part of the question. Of the candidates who explained the principles of operation clearly, some were unable to explain that it is a time *difference* between the arrival of the gamma rays at the detectors that is used for location.

Question 23

This question covers part of the nuclear fission and fusion topic from module 6.

Question 23(a)

For this question, the candidates need to explain the role of these components in terms of their interactions with neutrons and those who did not mention neutrons at all in their responses could not score any marks. Many candidates went beyond what was required and explained what effect this has on the reactor, such as controlling the rate of reaction. In general, this question was not answered well.

?	**Misconception**	Many candidates gave vague statements regarding the function of these components rather than an explanation.

Question 23(b)

This is the second LoR question. This is designed to assess knowledge of the two nuclear energy reactions and to calculate energy release using some given data. The differences between the fission and fusion reactions were generally well answered although many candidates explained differences in design, operation and waste more than the reactions. The similarities were often not as clear however several candidates gave excellent responses in terms of binding energies and mass differences. Candidates were also expected to complete a calculation to show which produces more energy output per kilogram. This is challenging calculation to follow through fully, but most candidates were able to make some attempt, even if it was only converting MeV to J. Only better candidates realised 2 nuclei of deuterium were used for one fusion reaction. While a small number of candidates did correctly calculate the energy per kilogram, they tended to state that fusion produced more energy rather than a feeling that they are basically equivalent. As usual with LoR questions, a holistic approach is taken to the marking and candidates can access higher levels without necessarily reaching all the marking points. Even so, relatively few candidates were able to access Level 3, generally due to poor calculations and/or descriptions.

Question 24

This question covers part of the electric fields and magnetic fields topic from module 6.

Question 24(a)(i)

This question asks for a calculation to show the value of the vertical acceleration in an electric field. The magnitude of the electric field strength first needs to be calculated, followed by the acceleration from Newton's second law. Candidates are reminded that a **show** question needs to be answered in detail and that each stage should be clear. Roughly equal numbers of candidates scored full marks or zero on this question.

Question 24(a)(ii)

As with the previous question, there is the need to make sure that the calculation leading to the given answer is clearly set out.

Question 24(a)(iii)

Most candidates appreciated the need to use an equation of motion in their solution, but a significant number of candidates used an initial horizontal velocity in the expression, leading to an incorrect answer. There were also an unusually large number who gave no response. Candidates should appreciate that if they have been given *show* questions, then it is likely that these values will be used in alter questions.

?	**Misconception**	Many candidates included an initial vertical velocity – it may be helpful to think of this process as analogous to that of projectile motion.

Question 24(b)

Nearly all candidates appreciated that the path should be downwards, but many did not take the care needed for it to be clear that the deflection at the end of the plate should be the same. Some candidates drew an 'x' on their sketch, which was helpful in determining if the intention to draw it the same had been made.

Question 24(c)

This question was quite poorly answered, with many candidates not even mentioning the magnetic field. Few appreciated that the magnetic field needs to be placed perpendicularly to the electric field, although most could state the $EQ = BQv$. However, in a description, there was some confusion about the 'fields' being equal rather than the 'forces'. No candidate gave a suitable description for the last mark but could access it through use of $v = E/B$.

Question 25

This question covers parts of the radioactivity and nuclear fission and fusion topics from module 6.

Question 25(a)(i)

This question expects the candidates to appreciate that the activity is related to the half-life. The majority of candidates were able to successfully answer this question although a number did not make it comparative and simply said that X had a short half-life.

Question 25(a)(ii)

Not many candidates recognised that the penetrating powers of the radiations through glass were required for the response; most referred to the ionising (and so harmful to health) properties of both sources.

Question 25(b)(i)

This question was correctly answered by the vast majority of candidates.

Question 25(b)(ii)

This final calculation required some careful structure and several stages. An encouraging number were able to work through the solution to its conclusion. Some rounded intermediate calculations too early and so lost the final 3 significant figures mark. Several candidates also missed the division by the nucleon number, either as a slip or perhaps they did not appreciate that this was what was required. Even the weakest candidates realised the need to apply $E = mc^2$, but would only gain credit here if they had calculated a mass difference. Some candidates also miscalculated the number of protons and neutrons in the carbon nucleus, which meant that they were limited to a maximum of 2 marks.

Key teaching and learning points – comments on improving performance

- Encourage the use of underlining or highlighting terms in questions.
- For questions with extended writing, consider the use of bullet points for clarity and to avoid contradiction.
- Keep the number of significant figures high during intermediate stages of a calculation.
- Make note of requests for significant figures in final answers for calculations.
- Learn definitions for common physical quantities.
- Aim to use clear scientific terminology.

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