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Examiners' report

PHYSICS A

H556

For first teaching in 2015

H556/02 Autumn 2020 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.

i	Reports for the Autumn 2020 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 exam 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 exam paper and the mark scheme can be downloaded from OCR.

Paper 2 series overview

H556/02 is one of the three assessed components of GCE Physics A. The Modules 1, 2, 4 and 6 of the specification are assessed in this paper. The paper is worth 100 marks and is split into two sections. Section A contains 15 multiple choice questions (MCQs) and allows the breadth coverage of the specification. Section B includes short-answer style questions, two level of response (LoR) questions, problem solving, calculations and practical. The assessment of practical skills, as outlined in Module 1 (Development of practical skills in physics) and Module 2 (Foundations of physics), is an integral part of the paper. The Data, Formulae and Relationships booklet is a valuable resource in examination and allows candidates to demonstrate their application of physics without the need to rote learn physical data, equations and mathematical relationships. The weighting of this component is 37% and duration of the examination paper is 2 hours 15 minutes.

The H556/01 component has weighting of 37% - it assesses material from Modules 1, 2, 3 and 5.

The H556/03 component has weighting 26% - it assesses material from all Modules (1 to 6) and as such, it is an overarching and synoptic assessment of the whole specification.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• answered most of the multiple choice questions and made good use of the spaces provided to do any quick analysis or calculations • demonstrated good practical skills and awareness of scientific methodology and techniques, e.g. Questions **4**, **5**, **18** and **19bii** • made judgements and reached conclusions based on experimental data by calculating percentage uncertainty, e.g. Question **19bi1** • made excellent use of information provided in the Data, Formulae and Relationship booklet when doing calculations, e.g. Questions **7**, **10**, **17a**, **17b**, **19bii3**, **20cii**, **21bi**, **21bii**, **23ai**, **23b** and **25b** • had well-structured solutions with clear manipulation of equations, good substitution and wrote the final responses to appropriate significant figures • demonstrated good use of calculators, especially handling powers of ten • demonstrated good comprehension of command words such as *describe*, *explain*, *show*, etc • wrote concise physics in extended response questions, e.g. Questions **18** and **21c** • correctly used scientific vocabulary in explanations and descriptions, e.g. Questions **16b**, **17c**, **18**, **20ci**, **21a**, **21c**, **22bii** and **24b**.	• wrote all the steps and calculations when answering numerical multiple choice questions - this was unnecessary and time-consuming because most calculations could have been done on calculators • demonstrated poor recall of basic definitions and misunderstood key concepts, e.g. confusing *phase difference* and *path difference* in Question **20ci** • truncated or rounded numbers prematurely within calculations, which led to incorrect final responses, e.g. Questions **19bii3**, **20cii** and **23bii2** • did not underline (or circle) key data and terms in the questions, particularly in the MCQs.

Section A overview

There are 15 multiple choice questions (MCQs) in Section A from a range of topics from Modules 1, 2, 4 and 6 of the H556 specification. This section is worth 15 marks and candidates are expected to spend about 30 minutes.

Section B overview

Section B includes short-answer style questions, problem solving, calculations and practical. It also includes two level of response (LoR) questions. In each LoR question, candidates can score a maximum of 6 marks. This section is worth 85 marks and candidates are expected to spend about 1 hour 45 minutes.

Comments on responses by question type

Multiple choice questions

Some of the questions, such as Question **1** on identifying the medical technique used to determine the speed of blood in arteries and Question **15** on the diffraction of electrons by a thin film of graphite, are expected to be done quickly without much reasoning. Other questions, such as Question **7** on capacitor-resistor circuit, requires a bit more thinking and solving time. Each question has ample space for scribbling down key terms or equations – but the bulk of the numerical work is expected to be done on the calculators. It is important for candidates to insert their correct response for each question in the square box provided.

All questions showed a positive discrimination, and the less able candidates could access the easier questions. MCQs require careful inspection. Candidates can annotate text and diagrams if it helps to get to the correct responses. No detailed calculations are expected on the pages, so any shortcuts, or instinctiveness, can be used to get to the correct responses.

Questions **2**, **12**, **14** and **15** proved to be straightforward, allowing most of the candidates to demonstrate their knowledge and understanding of physics. At the opposite end, Questions **9** and **11** were more challenging, and as such, were accessible to the top-end candidates.

Level of response questions in Section B

The two level of response questions in this paper are questions **18** and **21c**. Both questions required extended writing. A holistic approach to marking is used, with marks given according to answers matching descriptors for the various levels. Verbose responses and concise responses can score equally – examiners expect wide-ranging styles.

In Question **18**, candidates had to design and describe an experiment with a thermistor wrapped around with a resistance wire, and then analyse and evaluate the experimental data from the planned experiment to determine the values of k and n in the expression $P = kR^n$ (P = power of the coil and R = resistance of thermistor). This question was designed to assess practical skills of planning, implementation, analysis and evaluation from Module 1 of the specification, together with mathematical skills of graphs from section M3. Generally, candidates analysed the data quite well but the planning of the experiment often assumed that the power dissipated by the thermistor was the same as that of the coil wrapped around it. The circuits drawn were often incomplete or had meters connected incorrectly.

In Question **21c**, candidates had to analyse and evaluate data, and estimate the density of nuclei using the information provided. Most responses focused on the analysis and the estimation of density parts of the question. The description of the density of the three nuclei often lacked clarity and completeness. The density of the three nuclei was independent of the nucleon number – this important conclusion from **Fig. 21.1** was missed out by many candidates.

Other Section B questions

Questions requiring calculations were generally done well, with most candidates using a range of mathematical methods to solve problems. Most solutions were set out clearly and logically and were relatively easy to follow.

There were missed opportunities when answering questions requiring explanations and reasoning. In physics, candidates who learn their definitions and understand physical principles always do well in questions requiring textual responses. It is important to embed scientific vocabulary without contradictions or ambiguity. For example, in Question **28ci**, it was important to understand the term *phase difference* when explaining the formation of the fringes. Too many candidates confused this with *path difference* and scored nothing for their elaborate responses. The most frequent incorrect response was '*constructive interference occurs when the path difference is* λ*,* 2λ*,* 3λ*, etc*' – instead of '*constructive interference occurs when phase difference is* $0°$*,* $360°$*, etc'.*

Common misconceptions

The most common misconceptions and missed opportunities in the H556/02 November 2020 paper are outlined below.

	Misconception	**Question 20aii** The intensity of a sound wave is directly proportional to amplitude^2. The most common incorrect responses here were either $4 \times 7.8 = 31.2$ nm or $2 \times 7.8 = 15.6$ nm. The correct amplitude of $\sqrt{2} \times 7.8 = 11$ nm, was often spoilt by writing the amplitude in metres on the answer line.

	Misconception	**Question 22a** The current-carrying wire **Y** moves to the left because it is magnetic field of the other current-carrying wire **X**. The direction of the force can be determined from Fleming's left-hand rule. The most common misconception here was that wires experience a force because of either electric fields or the negative electrons within the wires.

	Misconception	**Question 24b** Candidates often interchanged the functions of the three components required in this question – collimator, scintillator and photomultiplier tubes. For example, '*the scintillator changes light photons into an electrical pulse*', when it should have been the photomultiplier tubes.

	Misconception	**Question 25b** A small number of candidates were perplexed by the lg(photon energy / eV) on the horizontal axis of the graph. The minimum energy required for pair-production was taken from the graph to be lg6 = 0.78 eV instead of 1.0×10^6 eV.

Key teaching and learning points – comments on improving performance

Improving techniques for multiple choice questions (MCQs):

Many candidates write too much when answering numerical questions; this is unnecessary and time-consuming. Some questions just require basic knowledge of physics or definitions. The specific comments on the two questions below outline possible strategies when tackling MCQs. These comments can be generalised and applied to other comparable questions in this paper.

Question **7** is about a capacitor charging circuit and recognising that CR is the time constant of the circuit. The potential difference (p.d) across the resistor will decay exponentially with time. The p.d. across the resistor at time t = 0 will be 10 V. Straight away, option A can be ruled out as the answer. Option C can also be ruled out because 4.2 s is the time taken for the p.d. to halve –'half-life' is not equivalent to time constant. Everything now hinges on the definition of time constant, as the time taken for the p.d. to drop to e^{-1} or 0.37 of its initial value. This leaves D as the correct answer. The question is not assessing any elaborate physics, just explicit understanding of time constant. About two-thirds of the candidates got the correct answer. Some MCQs will be testing basic knowledge and application of physics, and any gaps will lead to unnecessary guessing of answers. The important lesson here is to learn your definitions.

Question **13** is all about two key ideas: electric potential is inversely proportional to the distance from the centre of the charge and the scalar nature of electric potential. The negative charge of –1.5Q implies that the potential at point P cannot be positive, therefore C and D can be eliminated. The two discrete potentials at point P are + 40 V and – 60 V. The total potential at point P must therefore be the algebraic sum of these two potentials, which makes A the correct answer. B is simply the magnitude of the potential produced by the charge of –1.5Q, and it proved be a good distractor. Identifying the key physics, and avoiding detailed calculations are both important when tackling numerical MCQs. Any calculations that may be required can be done on calculators, once the key equations have been identified, e.g. Questions **5**, **9**, **10**, **11** and **14**.

Improving techniques for descriptive questions:

Learning definitions and scientific terms are important aspects of answering questions with command terms such as describe and explain. Candidates often write too much, and occasionally contradict earlier correct statements. This can be avoided by writing responses using short sentences or in bullet points. The specific comments on the two questions below outline how performance may be improved. These comments can be generalised and applied to other comparable questions in this paper.

Question **20c** is all about superposition of light from a double-slit and explanation of the fringes in terms of phase difference. This is where underlining or circling the key term phase difference would have been helpful. A significant number of candidates described constructive and destructive interferences, without mentioning phase difference or writing about path difference instead. Inspecting questions, and reflecting before writing, are all important aspect of examination work - these skills can be learnt through practise.

Question **21a** is all about the composition of a carbon-14 atom, with the question specifically mentioning fundamental particles and hadrons. Most candidates wrote lucidly about the quark combination of the two hadrons (neutrons and protons). Electrons were known to be leptons, and identified as being fundamental particles. Unfortunately, the quarks were rarely mentioned as also being fundamental particles. The question can be answered either in short sentences or in bullet points. The key thing is not to miss anything or to add a statement that contradicts earlier good physics. The most common error here was mentioning that electrons too were made from quarks. It is best not to write too much - keep the physics clear and succinct.

Guidance on using this paper as a mock

This H556/02 paper can be used by centres as a mock paper. This paper has gone through all the OCR quality and scrutiny processes and is aligned in terms of structure and depth to previous papers. This examination paper can provide candidates the opportunity to do the following:

- improve knowledge and application of physics
- improve time-management skills when tackling the whole paper in 2 hour 15 minutes
- improve scientific vocabulary
- understand the expectations of command terms such as *state*, *describe*, *explain*, etc.
- improve mathematical, algebraic and graphical skills
- improve presentation of numerical responses, and learn the benefit of using calculators to carry through values from intermediate calculations
- improve practical skills of planning, implementation, analysis and evaluation
- improve how to answer level of response questions
- learn how the mark scheme can be used to maximise marks.

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