C A R I B B E A N E X A M I N A T I O N S C O U N C I L

REPORT ON CANDIDATES' WORK IN THE
CARIBBEAN ADVANCED PROFICIENCY EXAMINATIONS®
MAY/JUNE 2021

PHYSICS

GENERAL COMMENTS

CAPE Physics is a two-unit subject with each unit consisting of three modules. Both units, Units 1 and 2, are examined by three papers. Papers 01 and 02 are external examinations while Paper 031, the School-Based Assessment (SBA), is examined internally by teachers and then moderated by CXC. Private candidates write Paper 032, which is an alternative to the SBA.

The 2021 examination was carried out between late July and early August in the middle of the global pandemic, COVID–19. To cope with the spread of the disease, all countries across the region put protocols in place with restrictions on movement. This interfered with the delivery of course content. The Council, recognizing and acknowledging the shortcomings of the modified content delivery, decided to compensate by providing candidates with a list of topics on which they could concentrate when studying for Paper 02 of the examination. The list of topics provided for both units of Physics is shown below.

Unit 1	**Unit 2**
Motions	Electrical Quantities
The Effect of Forces	Electrical Circuits
Harmonic Motion	Electric Fields
Properties of Waves	Capacitors
Physics of the Ear and Eye	Operational Amplifiers
The Kinetic Theory of Gases	Particulate Nature of Electromagnetic Radiation
Heat Transfer	Radioactivity

DETAILED COMMENTS

UNIT 1

Paper 01 — Multiple Choice

Paper 01 consisted of 45 multiple-choice items. It was designed to provide adequate coverage of the content with items taken from all sections of the syllabus. Approximately 93 per cent of candidates earned acceptable grades, Grades I–V on this paper. The mean percentage score was 69.

Paper 02 — Structured Questions

Paper 02 consisted of three compulsory questions, one drawn from each of the following modules in the syllabus:

- Module 1: Mechanics
- Module 2: Oscillations and Waves
- Module 3: Thermal and Mechanical Properties of Matter

Each question was worth 30 marks. The mean percentage score was 32 and marks ranged from 0 to 85.

<u>Question 1</u>

This question examined aspects of both linear and circular motion. It required candidates to

- plot and interpret the velocity–time graph of a parachutist's descent from an aircraft and identify the forces acting on the parachutist during different stages of the descent
- identify and calculate parameters of the motion of a car negotiating a frictionless banked circular track
- recall some of the characteristics of geostationary satellites.

The mean score for this question was 10.7 with a standard deviation of 4.6. Marks obtained ranged from 0 to 26.

In Part (a), candidate performance on the plotting of the graph was fair. For Part (b), there was much confusion regarding the interpretation of the graph. It seemed that the mental hurdle candidates needed to overcome was a subconscious interchange of the variables of motion. For example, a straight line of positive slope might be interpreted as increasing acceleration, constant velocity, constant acceleration or even increasing velocity.

Most candidates answered Part (c) correctly although many of them used the terms 'lift', 'gravitational force' and 'upthrust'; these were not appropriate for the context.

For Part (d) (i), most candidates had a vague idea that circular motion involved acceleration but very few were able to isolate the central concept that acceleration can be change of direction only as distinct from change of speed. Most candidates had correct answers to Part (d) (ii); in Part (d) (iii), most candidates were able to provide at least one correct response.

Parts (e) (i)–(iii) were fairly well done although a high proportion of candidates did not know or could not determine which physical characteristics of the earth determined the orbital radius of a geostationary satellite.

Recommendations

- It would be helpful for teachers to constantly remind students that when working on problems (especially graphical problems) involving the variables of motion, they need to be very careful not to fall into traps of intuition. Students need to constantly keep in mind the definition of each variable and the relationships between them.
- When solving problems to which the answer is a numerical value of acceleration, it is useful to compare the result with "*g, the acceleration due to gravity*" in order to check whether the result makes sense.

<u>Question 2</u>

This question was about Simple Harmonic Motion (SHM) and sound waves. It sought to examine whether candidates could

- recall definitions of SHM and the variables used to describe it
- calculate some of the parameters of SHM
- draw a graph of damped SHM and give real-life examples of its occurrence
- recall some of the formulae governing the apprehension of sound waves by the human ear and perform calculations using them.

The mean score for this question was 9.4 with a standard deviation of 7.8. Marks obtained ranged from 0 to 30.

Most candidates earned full marks for Parts (a) (i)–(ii) as they were able to correctly define the terms *amplitude* and *period*. For Part (b), a significant proportion of candidates were unable to state the conditions necessary for SHM. Parts (c) (i)–(iii) were fairly well done. In cases where marks were lost, this was due to an incorrect recall of a formula, incorrect substitution, or algebraic and arithmetic errors.

For Part (d) (i), most candidates earned three or more of the five marks allocated for plotting the damped oscillation. Marks were lost for inappropriate scale or inaccurate amplitudes. It should be noted that in a damped oscillation, the amplitude does not decrease from period to period in stepwise fashion but in a gradual linear way throughout the motion. There were many No Responses (NRs) for Part (d) (ii).

Where attempts were made to respond to Parts (e) (i)–(iv), a very common error was to confuse frequency of sound with intensity of sound. In many cases where errors arose in calculations, it could be attributed to lack of familiarity with the equations and with the dimensions of the quantities involved. It appears that this part of the syllabus was either not well taught or not taught at all.

Recommendation

A recurring problem in solving physics problems is the large number of candidates who submit impractical values as answers to calculations, for example, the mass of block in laboratory spring mass experiment = 107 kg. Candidates are reminded that whenever they perform a physics calculation, the answer should lie within the boundaries of practicality. An impractical answer should be seen as a cue to double-check the calculation.

<u>Question 3</u>

This question tested candidates' knowledge of

- the kinetic theory of gases
- heat transfer via radiation and conduction.

The question was fairly done overall. There were a significant number of NRs. Most candidates who attempted the question got most of their marks from the graphical portion of the question. The mean score was 9 with a standard deviation of 6.8. Marks obtained ranged from 0 to 30.

For Part (b) (i), many candidates were able to state three assumptions of the kinetic theory of gases. Most candidates got Part (b) (ii) correct. However, some candidates used the correct equation but did not convert their temperatures from degrees Celsius to Kelvin. In addition, some of those who did convert to Kelvin used +273 rather than +273.15 as expected at CAPE level.

A few candidates got Part (b) (ii) correct but many only reached as far as calculating the number of moles, as they could not distinguish between moles and number of molecules. Of those candidates who got this part of the question correct, most of them used pV = nRT and then went on to calculate the number of molecules. Very few candidates used the expression pV = NkT.

Several candidates did not attempt Part (b) (iii). A few candidates knew the equation, and received one mark, but were unable to indicate what the symbols meant, that is, they did not know that *m* was the mass of one molecule. As a result, many of those candidates used the mass of the gas. Also of note is the fact that many candidates in attempting to work out this question, did not change the mass of the gas from g to kg.

Part (c) (i) was well done as most candidates were able to fill out the table correctly. For Part (c) (ii), the graph was well drawn. Most candidates obtained full marks for their graph with only a few losing marks for scaling. For Part (c) (iii), many candidates attempted to calculate the gradient of the line; however, many forgot to put in the factor ($x10^9$) in the calculation and so only got one mark for read off. Also, many candidates did not know the radiation equation and of those who knew it, only a few knew to equate the gradient to σA. Of note is the fact that several candidates used the equation $P = \sigma eAT^4$. However, while some of them used e = 1, some left the area in terms of e.

For Part (d), many candidates provided roundabout explanations with a lot of irrelevant information. Only a few candidates were able to adequately describe both mechanisms with enough detail to get full marks.

Recommendations

- Attention must be given to the formulae in Kinetic Theory of Gases and Heat Transfer with emphasis on the meaning of the individual terms.
- Mathematical and algebraic manipulation must be given special attention as many candidates, even if they knew the equations, were unable to manipulate the equation correctly to calculate the quantity needed.
- Integration with the Chemistry teacher may be necessary to ensure proper understanding of certain concepts, for example, the mole concept.
- Candidates are encouraged to use several texts, outside of the CXC study guide, for study.

Paper 032 — Alternative to School-Based Assessment (SBA)

This paper was not well done. The mean score was 19.1 out of 45 with a standard deviation of 7.0. Marks obtained ranged from 5 to 35.

<u>Question 1</u>

This question required candidates to perform an experiment to investigate the refractive index of a glass block. This is a standard experiment and many candidates seemed to be able to perform the experiment well, as evidenced by their results. Most were able to complete the table correctly. For the most part, graphs were well plotted, and most candidates recognized that the gradient of the line represented the refractive index of the glass block.

<u>Question 2</u>

This question was fairly well done. Candidates were required to complete the calculations for an experiment for which they were given results. Most candidates were able to complete the table and plot the appropriate graph correctly. Of note however, is the fact that many candidates upon plotting the graph, did not draw a peak between the two maximum values given but drew a plateau line.

After having drawn the graph, many candidates did not answer the rest of the question correctly. Only one candidate was able to state the fact that there were two temperature values for each voltage value, and that that made the thermometer unsuitable for use.

Only a few candidates were able to state one reason why having an ice bath was significant and even fewer were able to give modifications that could have been made to the experiment for it to be more accurate. Some candidates recognized that having an ice bath in industry would be difficult to maintain and manage but could not give any other reason why this type of thermocouple would not be ideal in an industrial application.

Question 3

This question required candidates to plan and design an experiment to determine the acceleration due to gravity using the basic Atwood machine. It was very clear from the performance that this was not something that was familiar to candidates. While there were only a few NRs in this question, many candidates scored zero because they did not know what the Atwood machine was and how it could be used to determine the acceleration due to gravity. Although the use of the Atwood machine is suggested in the syllabus as a practical activity to demonstrate Newton's second law, it seems that little to no attention was paid to it and so candidates just did not know how to answer the question.

Recommendation

Candidates need to ensure that they take the time to check the syllabus and familiarize themselves with the experiments required.

UNIT 2

Paper 01 — Multiple Choice

Paper 01 consisted of 45 multiple-choice items. It was designed to provide adequate coverage of the content with items taken from all sections of the syllabus. Approximately 95 per cent of the candidates earned acceptable grades, Grades I–V on this paper. The mean percentage score was 75.

Paper 02 — Structured Questions

Paper 02 consisted of three compulsory questions, one drawn from each of the following modules in the syllabus:

- Module 1: Electricity and Magnetism
- Module 2: AC Theory and Electronics
- Module 3: Atomic and Nuclear Physics

Each question in this section was worth 30 marks. The mean percentage score was 34 and marks ranged from 0 to 86.

Question 1

This question tested candidates' knowledge of

- charging a parallel plate capacitor
- the derivation for potential gradient and electric field strength between charged parallel plates.

The question was fairly well done. There were very few No Responses (NRs). The majority of candidates attempting the question got most of their marks from the graphical portion of the question. The mean score for this question was 9.9 with a standard deviation of 6.8. Marks obtained ranged from 0 to 30.

Many candidates answered Part (a) (i) incorrectly. For Part (a) (ii), most candidates were not aware of the movement of charges between the power supply and the uncharged capacitor. For Part (b), the graph was well drawn, and most candidates obtained full marks with only a few losing marks for drawing a smooth curve.

Part (c) (i) was well done. Most candidates were able to calculate $1/e$ correctly and read off the corresponding time constant from the graph. Part (c) (ii) was also well done. Many candidates knew the equation and were able to correctly calculate the value of the capacitor. A few candidates did not know that $1\ M\Omega = 1 \times 10^6\ \Omega$.

Only a few candidates got Part (c) (iii) correct. Some candidates did not know which equation to use to calculate the initial charge. While other candidates knew the equation Q = CV, they did not know how to calculate the voltage and so they were unable to calculate the charge. Part (c) (iv) was very poorly done. Many candidates did not know the equation and even those who knew the equation, did not realize that the dielectric constant should be multiplied by the permittivity of free space. There were quite a few NRs for this part of the question.

Part (d) was very poorly done. Only a few candidates knew the derivation. It was clear that this concept was unfamiliar to candidates. Also, candidates mixed up the use of the E's — Electric Field Strength and Energy. There were only a few candidates who were able to do the derivation correctly. Many candidates got no marks.

Recommendations

- A practical approach to the teaching of capacitance is needed so that students can understand the proper circuit required for charging a capacitor.
- A review of static electricity must be done especially as it relates to the movement of charges.
- The topics of equations and definitions of variables for the equations need to be covered.
- The derivation of the relationship between potential gradient and electric field strength must be taught.

Question 2

This question tested candidates' ability to

- recall the properties of an operational amplifier when operating in open loop or closed loop configurations
- place the amplifier in a closed loop circuit to achieve a specified gain
- demonstrate graphically the effects of saturation on amplifier performance
- use the operational amplifier to realize a D/A converter.

The mean score for this question was 9.5 with a standard deviation of 6.6. Marks obtained ranged from 0 to 29.

For Part (a), most candidates were able to recall three properties of an ideal operational amplifier but few of them could link these properties in a coherent way to the behaviour of the amplifier in a circuit.

For Parts (b) (i)–(ii), a significant number of candidates could not draw the circuit diagram of a non-inverting amplifier from memory and so could not derive the input–output relationship for this amplifier. Many candidates lost marks for Part (b) (iii) because they did not seem to know the range of values of resistors that are employed in practical electronic circuits. Very few candidates were able to obtain full marks for Parts (b) (iv)–(v). There were a very large number of NRs.

Responses to Parts (c) (i)–(iii) were exceedingly poor. Most candidates appeared to be unfamiliar with the topic and offered non-salient responses. A few candidates made decent attempts at the portion of the question where inputs to the D/A converter were required.

Recommendation

A recurring problem in solving physics problems is the large number of candidates who submit impractical values as answers to calculations, for example, resistors used in the design of operational amplifier closed loop amplifier $R_1 = 1\Omega$; $R_2 = 10\Omega$. Candidates are reminded that whenever they perform a physics calculation, the answer should lie within the boundaries of practicality. An impractical answer should be seen as a cue to double check the calculation.

Question 3

The major topics of this question were the attenuation of e/m waves when passing through solid matter, the photoelectric effect and radiocarbon dating.

The question examined whether candidates could

- plot on a semi-logarithmic graph, the decrease in count rate from a gamma emitting source as the radiation passes through varying thickness of an absorber
- describe the photoelectric effect, explain the relationship between stopping potential and the maximum kinetic energy of ejected photoelectrons and express this relationship mathematically
- calculate the maximum velocity of photoelectrons for a given experiment
- explain radiocarbon dating and perform associated calculations.

This was the best performing question on the paper. The mean score for this question was 11.2 with a standard deviation of 6.6. Marks obtained ranged from 0 to 29.

Performance on Parts (a) (i)–(iv) was satisfactory. The most common error was that of forgetting to convert from logs when analysing graphical data to yield real-world results. For Parts (b) (i)–(iii), most candidates were able to describe the photelectric effect succinctly, express the important variables in a simple algebraic expression and use that expression to calculate a value for the maximum speed of emitted photoelectrons.

For Part (c), the calculations for radiocarbon dating were well done when attempted. Many candidates, although they could not provide a clear explanation of how radiocarbon dating was accomplished, were able to do the calculations.

Paper 032 — Alternative to School-Based Assessment (SBA)

The mean score for this paper was 19 out of 45 with a standard deviation of 7.5. Marks obtained ranged from 3 to 33.

<u>Question 1</u>

This question required candidates to perform an experiment to verify the resistors in series equation. Most candidates seemed to be able to perform the experiment well, as evidenced by their results. Most were able to complete the table correctly and do the correct calculations. However, many were unable to state what the calculated answers meant and even fewer were able to give proper precautions or suggestions on how the experiment could have improved. This is a basic experiment and should have been covered in the content of the module. However, these concepts were not well known.

Question 2

This question was poorly done. Most candidates scored zero and very few were able to do anything beyond the graph. Many were unable to calculate the time for the Technetium to become less harmful and were unable to give proper precautions for the experiment.

Question 3

This question required candidates to plan an experiment to test the manufacturer's nameplate power rating of an electric iron. Very few candidates were able to draw a circuit that could have been used to obtain results to test the claim. Many could not describe an experiment to obtain current and voltage values to calculate the power of the iron.

Recommendation

Candidates need to ensure that they take the time to check the syllabus and familiarize themselves with the experiments required.