CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

MAY/JUNE 2013

PHYSICS

GENERAL COMMENTS

In 2013, the number of candidates who wrote the Unit 1 examination increased to 3621 from 3141 in 2012; the number of candidates who sat the Unit 2 examination increased to 2659 candidates from 2278 in 2012.

Overall, candidate performance improved. However, the improved performance on Paper 01 was not commensurate with the performance on Paper 02. The following concerns were noted for Paper 02 in both units.

There were instances where candidates failed to pay attention to the number of significant figures when writing final answers to questions, although the penalty was stated at the front of the examination papers. It is important that teachers impress upon their students the importance of significant figures. It seems that candidates did not completely appreciate that an answer cannot be more accurate than the accuracy of the variables/data used in the calculation.

Too many candidates stated their answers as a number only, without including the relevant unit. Teachers should emphasize to their students that all physical quantities have a magnitude and a unit.

A large number of candidates seemed to find it difficult to compose an adequate response to questions which require extensive verbal discourse. Questions in which the action word is *explain, describe* or *discuss* often elicited very weak responses.

Teachers are encouraged to take note of these concerns and to devise corrective measures. Students should be provided with adequate opportunities to practise writing answers to this type of question with particular attention being given to a structured approach. Some teachers may even find it useful to provide exemplars with sequentially numbered points designed to reinforce the logic of an explanation or discussion.

UNIT 1

Paper 01 – Multiple Choice Questions

This paper comprised 45 questions with 15 questions based on each of the three Modules: Module 1– Mechanics, Module 2 – Oscillation and Waves, and Module 3 – Thermal and Mechanical Properties of Matter.

The performance of candidates on this paper was good. The mean score was 73 per cent; the standard deviation was 9.89; and reliability was 0.93.

Candidates performed best on Module 2, then Module 1 followed by Module 3. In each case the mean performance on the Module was greater than 54 per cent.

DETAILED COMMENTS

Paper 02 – Structured and Free Response Questions

<u>Question 1</u>

Most candidates made a fair attempt at this question.

For Part (a) (i), many candidates encountered difficulties calculating the expected values for the table because they did not use the value of *g* provided in the table of constants at the front of the examination paper opting instead to use a value of 10 m/s^2, which for most purposes is acceptable at the CSEC level but not at the CAPE level. Teachers should encourage their students to use the relevant values provided in the table of constants for all calculations in the examination.

In Part (a) (ii), many candidates overlooked plotting the point (0,0) from the data provided in the table and 1:3 scales were used in many instances. Teachers should encourage their students to use all the data provided when making plots and selecting a suitable scale.

For Part (a) (iii), the majority of candidates calculated the gradient of the graph and assumed that it was the height from which the ball was dropped ─ seemingly not recognizing that the height from which the ball was dropped was the area under the velocity/time graph.

In Part (b) (i), too many candidates did not recognize that *g* ought to have been negative in both these questions.

For Part (b) (ii), some candidates seemed to have interpreted *show* to mean that a qualitative description was required and presented an explanation, and in some cases an accompanying diagram. Teachers need to be aware of this and indicate to their students that *show* can have both qualitative and quantitative interpretations.

Overall, candidates' scores on this question were satisfactory with about 40 per cent of candidates attaining scores greater than 6.

<u>Question 2</u>

This question was attempted by all candidates. The majority of candidates scored within the range 7─14 marks. The modal mark was 13.

In Part (a), many candidates were unable to state the explicit similarities and differences between transverse and longitudinal waves, and to cite appropriate examples of each. Consequently, candidates lost some or all of the marks in this question.

For Part (b), while many candidates knew the wave equation, a number of them did not accurately factor into their calculations the temperature dependence of the speed of sound. Most candidates scored either 1 or 2 marks in this section. Teachers should emphasize this relationship to their students.

Part (c) was generally well done by candidates. The biggest challenge was candidates' inability to choose an appropriate scale for the values to be plotted. However, most were able to use the graph plotted to determine the speed of sound. A few calculated the speed of sound by non-graphical methods. Teachers need to be aware of this and to urge their students that when instructed to *use the graph* that they should so do.

Overall, this question was fairly well done with approximately 70 per cent of the candidates scoring 7 marks or more.

<u>Question 3</u>

Performance on this question revealed that the mathematics skills of many candidates are weak. This weakness in mathematical skills contributed to the unsatisfactory performance. The modal mark for this question was 2.

Parts (a) – (b) require the use of a given formula to deduce the appropriate units. However, the formula given had a typographical error. The examining committee apologizes for the error and the inconvenience to the candidates.

In Part (c), many candidates attempted to do the ratio but they did not know how to introduce the constant of proportionality, k. Candidates who introduced the constant mistakenly thought that it was Boltzmann's constant, and used this in their calculations. Many candidates did not know how to do the manipulations to get the 1.07 asked for in the question. This led to strange mathematics, in which too many candidates presented anything they thought would get the desired answer.

Teachers should encourage students to practise the correct way of writing root-mean-square speed using symbols. The majority of candidates did not write this correctly, using many variations instead of the correct $\sqrt{< c^2 >}$ or $\sqrt{\overline{c^2}}$.

Teachers and students should also pay adequate attention to mathematical skills necessary for performing calculations in Physics. Too many candidates could not make a serious attempt at this question as they did not know the difference between a square and square-root.

Candidates performed best on Part (d). However, several candidates

- missed the concept that the volume remained constant through the process.
- did not use the correct symbols, using $pV = NRT$ or $pV = nrT$ instead of $pV = nRT$.
- had poor math skills which prevented them from transposing the formula to get the correct answer for the new value of n.
- used the general gas equation with some indicating that if V is constant then $p = nRT$.

Part (e) proved to be the most difficult part of the question for those who attempted it. While some candidates knew that the work done was the area under the graph, many of them did not calculate this correctly. They either did not calculate the whole area, or they did not use the scale on the graph correctly. Many also used the method of counting squares to find the area.

This method was not the most appropriate for the question, but it could be done. Some candidates read off the wrong values, and others found the gradients of the lines. Some candidates even used W = p ΔV, disregarding the fact that the pressure was not constant for the process.

The majority of candidates who attempted Part (f) did fairly well, even if they could not do any other part of the question.

This question again was not a difficult one, however, it did indicate that the mathematics skills of many candidates were lacking and this contributed to poor performance on the question.

<u>Question 4</u>

Overall, this question was poorly done.

In Part (a), the definition was worth two marks and most candidates did not produce a response that was satisfactory enough to gain both marks.

While most candidates demonstrated a general understanding of the concept of *moments*, the ability to use this knowledge to answer the question was lacking. For example, the fulcrum (pivot) of a see-saw lies at its centre, but in the diagrams, most candidates illustrated the persons sitting at the 'ends' of the see-saw with the fulcrum 'shifted' close to the 100-kg person. More importantly, it was not made clear that the distance of the 50-kg person has to be *at least twice* that of the 100 kg person from the pivot to achieve balance and/or lift.

Again, in Part (b) (i) an accurate definition proved challenging. Candidates did not include the concept of 'a system of colliding objects' or 'with no external forces acting.'

In Part (b) (ii), several candidates did not properly identify the momentum equation which would have subsequently allowed them to accurately substitute the values of the velocities from the table to achieve the mass ratio. This led to them *incorrectly* equating for example, $m_1 u_1 + m_1 v_1 = m_2 u_2 + m_2 v_2$, where *u* represented velocity before collision and *v* represented velocity after collision.

Additionally, most of those who were able to accurately simplify the equation were unable to correctly obtain the ratio. Instead they derived its reciprocal.

For Part (b) (iii), most candidates were able to effectively state the general equation for the kinetic energy of the objects but did not calculate the total kinetic energy before collision. In their calculations, many candidates either omitted the $'\frac{1}{2}'$ or forgot to square the *v*. A few of them used the momentum equation.

In Part (c), most candidates who gained results from their calculations correctly inferred whether the collision was elastic or inelastic.

<u>Question 5</u>

In general, the responses to this question were fairly good. The majority of candidates earned between 3 and 11 marks, with a modal mark of 10 from a maximum of 15.

For Part (a), some candidates did not realize that the stationary wave consisted of two full wavelengths occupying the distance of 0.4 m. When the alternative formula of $f_n = nv/2L$ was used, many candidates used n = 5 nodes as opposed to 4 antinodes and so produced an incorrect answer. It was also expected that at this level, candidates ought to be using $v=f\lambda$ as opposed to using speed = distance /time to solve for wave parameters.

The responses for Part (b) were quite poor since a large number of candidates did not know the equation $v=\sqrt{(T/\mu)}$.

In Part (c), many candidates did not correctly interpret the word *determine* and simply defined the wave parameters required. It was also evident that many candidates could not correctly transpose a simple mathematical equation to solve for unknowns. Many candidates also appeared to be unable to recognize that the angles given in the equations supplied were expressed in degrees. Teachers are encouraged to ensure that all their students are familiar with and can manipulate problems expressed either in radians or degrees.

For Part (d), the majority of candidates did not pay attention to the frequency of the wave and attempted to describe applications that were not associated with waves with an ultrasonic frequency. Also, explanations given for the practical application were often quite unsatisfactory.

It is suggested that in order to prepare for questions of this nature, teachers should strive to provide students with opportunities via research projects, or presentations to appreciate the applications of Physics in daily life and (ii) to place more emphasis on the teaching of stationary waves and practice questions.

<u>Question 6</u>

Although, this question was attempted by most of the candidates, the majority did not perform well. The modal mark was 2.

In Part (a), the majority of candidates did not draw a 3D diagram. In a few cases where candidates drew a 3D diagram, they failed to label the area *A* properly. Some who drew and labeled the 3D diagram properly were unable to prove the equation, hence earning the marks for the diagram but not for the proof.

For Part (b) (i), most candidates were able to apply the formula to calculate the pressure at a depth of 2.5 km. In this question, however, a number of candidates used ‘G’─ the universal gravitational constant, instead of *g* ─ the acceleration of gravity, to perform the calculation. Teachers should make the distinction between both of these constants very clear to their students.

In Part (b) (ii), most candidates knew the formula for Young’s modulus (stress/strain). However, many of them were unable to move beyond the recall of this formula to calculate the decrease in length of one side of the cube.

For Part (c) (i), there is a clear distinction among proportional limit, elastic limit and yield point in terms of definition and position on the force/extension graph. Many candidates did not seem to know this distinction ─ indicating that *x* on the graph was the elastic limit when in fact it was the proportional limit. Teachers need to be aware of this and to point out the difference among these three terms to their students.

In Part (c) (ii), many candidates did not make the distinction between *strain* and *strain energy* and hence could not calculate strain energy using either area under that graph or the formula *½ Fx*. As a result, many candidates got this question wrong.

Generally, this question was fairly well done by the candidates but converting from one prefix to another seemed to be challenging for many of them (gigapascals to pascals).

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

Question 1

For this experiment, candidates were required to list the apparatus required to determine Young’s modulus for a wire specimen. A diagram of the set-up was required as well as the procedure, manipulation of the results and the method for calculating the Young’s modulus of the wire.

A significant number of candidates could not list the apparatus required for this experiment. Candidates suggested that the vernier calipers should be used instead of a vernier scale. Few candidates could produce the correct diagram for the experiment. While most candidates could state the procedure used to execute the experiment, few could present it in the correct order.

Candidates seemed unsure of what was required when asked to manipulate the results. Most of them could recall the equation for Young’s modulus, *E = Stress ÷ Strain*, but failed to state that the quantity could be obtained if a graph was plotted and the gradient was determined. Candidates did not link the gradient of the stress/strain graph and the Young’s modulus of the wire.

Question 2

Candidates were required to conduct an experiment to investigate the refraction of light at an air/perspex boundary using a light source and a number of pins.

There was no clear indication that some candidates could actually set up the apparatus. There was some evidence that suggested that a rectangular block had been used by some candidates. Many candidates measured the angle between the straight side of the glass block and the ray rather than the angle between the ray and the normal.

Those candidates who correctly measured the angles α and β were able to complete the table showing these angles and the values for sin α and sin β.

Few candidates could produce graphs with the appropriate scale. Some candidates plotted graphs of sin β versus sin α.

Extrapolation of the line proved difficult for most candidates. Some candidates tried to calculate the critical angle rather than using the graph to find the value.

Question 3

Candidates were required to find the specific heat capacity of an unknown liquid by manipulating the data provided, plotting a graph and finding the gradient of the graph.

There was very little difficulty in completing the table and plotting the graph. Most candidates were able to determine the gradient; however, there was some difficulty in calculating the value of the specific heat capacity.

Candidates were challenged in transposing the equation, $V\ I\ T = m\ c\ \Delta T$, to find the value for c, the specific heat capacity, given that the gradient of the graph would yield $\Delta T/t$ and the transposed equation would yield $t/\Delta T$. Very few candidates recognized that the gradient had to be inverted in order to find the value for the specific heat capacity, c.

There was enough evidence to indicate that candidates understood the precautions that were necessary for the execution of the experiment.

UNIT 2

Paper 01 – Multiple Choice Questions

This paper comprised 45 questions with 15 questions based on each of the three Modules:
Module 1 – Electricity and Magnetism, Module 2 – AC Theory and Electronics, and Module 3 – Atom and Nuclear Physics.

The performance of candidates on this paper was quite good. The mean score was 74 per cent; the standard deviation was 10.03; and reliability was 0.94.

Candidates performed best on Module 1, then Module 3 followed by Module 2. In each Module, the mean performance on the Module was greater than 59 per cent.

UNIT 2

Paper 02 – Structured and Free Response Questions

Question 1

Most candidates scored very high marks on this question ─ approximately 65 per cent of the candidates scored more than eight marks of the fifteen.

In Part (a), the majority of candidates were able to draw the required circuits and to derive the expected expression for resistors in parallel.

Part (b) (i), was well done by most candidates. Weaker candidates were unable to score the marks here because of poor mathematical skills.

Part (b) (ii) was perhaps the most challenging for the candidates. About 50 per cent of them were able to earn the marks while some of the remaining candidates had difficulty determining the total current I_T and those who did calculate I_T, were unable to follow through to calculate V_2 because they did not realize that they had to use $V = I\,R_{eq}$.

Part (c) (i) was generally well done by candidates. The only observed challenge that candidates seemed to have had in this question was selecting an appropriate scale for the graph of I *vs* V_T. A few candidates interchanged the axes and plotted V_T *vs* I instead.

For (c) (ii), most candidates were able to read off points to calculate the gradient but the problem in many cases was the selection of the points. Many of them did not select a large triangle. Teachers need to be aware of this and to impress upon their students the importance of selecting points that create a triangle of adequate size.

Question 2

This question was not very well done with just about 40 per cent of the candidates scoring at least seven marks. Most candidates who attempted this question earned the 2 marks allocated to Parts (a) (i) and (iii), but many did not get the one mark allocated to Part (a) (ii), which required them to read off the value from the graph. Candidates did not seem to recognize that *unity gain bandwidth* was equivalent in meaning to the bandwidth for a gain of unity.

For Part (b) (i), majority of the candidates failed to recall that both inverting and non-inverting amplifiers utilize negative feedback so that many of the circuit diagrams were drawn inaccurately.

In Part (b) (ii), some candidates seemed not to have realized that they were required to use the resistor values supplied earlier in the question to calculate the gain of the amplifier so a number of them lost the calculation mark. A significant number of candidates misread 330 KΩ for 300 Ω and so arrived at an incorrect value for the gain.

In Part (b) (iii), the instruction *use the open loop gain-frequency curve* seemed to have been ambiguous to some candidates as many of them did not indicate the required value on the graph.

For Part (b) (iv), many candidates did not get the answer required. Although they knew the correct formula, they were unable to manipulate it appropriately.

There seemed to have been some ambiguity in candidates' interpretation of what the questions in Part (b) were asking. In Part (b) (v), candidates seemed to have believed that the op amp was removed from the circuit (based on the wording of Part (b) (iv) before) and in Part (b) (vi), candidates did not recognize that the circuit being referred to was the one in Part (b) (v).

Overall, candidates performed unsatisfactorily on this question.

Question 3

Performance on this question was fair.

Part (a) of the question was the most widely known and contributed significantly to the marks gained by candidates.

In Part (b), a considerable number of candidates did not seem able to convert energy from Joules to eV and vice versa. Although the more well-known derived units can be used wherever applicable, candidates need to realize that many of the more specialized areas of Physics (and indeed of other sciences which use physical units) use their own set of units and it is important that they are able to convert from one set of units to another.

For Part (c), candidates were required to plot a graph of *Stopping Potential vs Wavelength*. Perhaps the fact that most physics experiments require the plotting of a straight line, many candidates used the points provided to plot a straight line when the relationship between these two variables would yield a curve. The situation was further confused by the fact that the last section of the question required candidates to use their graph to obtain a value for the cut-off wavelength, a result construed to have been more easily obtained from the intercept of a straight-line graph.

Question 4

In Part (a) (i), the proof was generally well done.

For Part (a) (ii), the calculation of V using the given expression elicited some strange responses because many candidates substituted the values of the variables correctly but managed to get the wrong answer. Others substituted the wrong values for the variables although several of these were given in the answer booklet. A fairly significant number of candidates appeared to be unfamiliar with the meaning of the prefix *kilo*.

The indications are that many candidates need to be guided on the proper use of calculators. Students who complete the CAPE Physics programme should have an ingrained knowledge of the more common quantitative prefixes. Such prefixes on a prominently displayed poster in the Physics laboratory could be of some help in achieving this objective.

In Part (b) (i), the calculation was well done for the most part but many candidates did not recognize that they needed to use the right hand grip rule to get the direction of the magnetic field. Teachers should place a bit more emphasis on the application of this rule by assigning and correcting practice problems which require its use.

Part (b) (ii) a) was poorly done. The majority of candidates did not recognize that the horizontal component of the electrons' velocity would be parallel to the magnetic field and hence would be unaffected by it.

In Part (b) (ii) b), very few candidates recognized that the vertical component being perpendicular to the field will experience a constant force perpendicular to the direction of motion, that is, a centripetal force which will cause the electrons to move in a circle.

For Part (b) (ii) c), the majority of candidates did not seem to understand what was required. In fact, this part of the question discriminated between the very good candidate and the average one. The good candidates were able to come up with partial answers and a few well prepared ones were able to produce completely correct answers. Teachers are encouraged to explain, probably with the aid of models, what happens to a charged particle moving in a magnetic field.

<u>Question 5</u>

In Part (a), nearly half of the candidates failed to realize that with three inputs there would be eight possible unique combinations of ones and zeros.

Students must be able to count in binary and realize that N binary digits can be used to represent 2^N different numbers (or combinations of ones and zeros).

For Part (b) (i), the majority of candidates did not seem to understand that what was required here was an explanation of how the operational amplifier was used as a comparator in the given circuit. Too many of them tried to explain how the entire circuit functioned. Teachers should provide their students with some experience in qualitative circuit analysis. One of the skills that should be derived from the study of electronics at this level is the ability to analyse simple circuits. Candidates should be able to explain the function of each component and subsystem of simple circuits.

Because of candidates' inability to analyse circuits component by component or subsystem by subsystem, many of them provided the answer to Part (b) (ii) in their response to Part (b) (i). There was no penalty for this. Nonetheless, teachers should emphasize the basics of writing examination answers and encourage students to answer questions in the contexts in which they are asked.

For Part (b) (iii), while a considerable number of candidates were able to describe the operation of a relay in detail, they could not give the reason why it was necessary in this particular circuit.

Part (c) required the use of equations which were not explicitly stated in the syllabus. Candidates were not penalized.

<u>Question 6</u>

Performance on this question was unsatisfactory. Several candidates were unable to earn at least one of the 15 marks allocated. This was particularly evident in Part (c).

Part (a) focused on the decay of a radioactive particle and was generally well known by prepared candidates. However, too many candidates were unable to earn the mark allocated to this part.

For Part (b), candidates were required to manipulate an equation that models radioactive decay. It was evident that for the majority, the necessary mathematical skills were lacking.

Part (c), required candidates to calculate the activity of radioactive nuclei and this presented difficulty for most candidates. Again, it was evident that the necessary mathematical skills were lacking.

In Part (d), candidates were presented with a circuit to model the decay of a radioactive isotope.

Again, the performance on Part (d) was similar to that of Part (c) revealing a lack of necessary mathematical skills.

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

Question 1

Candidates were required to heat a sample of water to 100 °C, measure the resistance of a thermistor and record the resistance from a digital multimeter. The data was used to complete a table of temperature in °C, resistance in temperature in kelvin. Further, the natural logarithm of the resistance and the reciprocal of the kelvin temperature were also required.

A graph of ln *R* versus *1/T* was required from which the thermal exponent of the thermistor was determined.

The resistance of the thermistor at a temperature of 71°C was to be extracted from the graph.

Candidates had little difficulty completing the table. There were a few instances where temperature was not given in kelvin.

Most candidates were able to compute the natural logarithm of the resistance and the reciprocal of the kelvin temperature.

Many candidates did not draw graphs with the appropriate scale. Those who produced graphs of appropriate scale were able to draw the line of best fit.

Candidates were required to determine, from the graph, the resistance of the thermistor when the temperature was 71°C. Those candidates who were able to successfully plot the graph were able to extract this information from the graph.

Question 2

Candidates were required to complete a table using an equation that was provided.

Many candidates did not realize that the quantity a, in the equation, had units m x 10^{-6}, and this was not considered when finding the value of a^3. As a result, their values for q were incorrect. Those who recognized this fact were able to successfully complete the table. Very few candidates could explain why droplets moved in different directions, or why the chamber had to be irradiated with x-rays. In addition, very few responses explained why the experiment would only work for a limited range of voltages.

Too many candidates were not able to use the graph of terminal velocity versus time to determine the separation of the plates. Those candidates who successfully determined the separation of the plates were also successful in finding the terminal velocity of the oil drop.

Question 3

Candidates were required to design an experiment for collecting data to plot the gain – frequency curve of an inverting amplifier.

The majority of candidates could not correctly list the apparatus that was required or draw the circular circuit. In many cases, candidates merely drew the circuit for an inverting amplifier without including the input signal or the means of measuring either the input or output.

Few candidates could outline the procedure for conducting the experiment, tabulate the results or describe the treatment of the results. Few candidates realized that the *log-frequency* graph had to be plotted.

Paper 031─Report on School Based Assessment (SBA)

The following issues arose out of the moderation exercise for both Units 1 and 2.

Number of Assessments

At several centres only two assessments were done for each skill. Some teachers continue to misinterpret a clause in the CAPE Physics Syllabus (p. 67), Specific Guidelines for Teachers #5, which states:

The mark recorded for each skill assessed by practical exercises should be average of *at least two* separate assessments.

As a result, many centres submitted two assessments only for each skill. In some of these situations, the two exercises did not satisfy the basic CAPE standards and therefore moderators were hard pressed to fine legitimate exercises to moderate.

Assessment of Manipulation and Measurement

In some cases, there was no way of verifying how the manipulation and measurement scores were determined. There was no record of the marks in students' books.

Mark Scheme

- The number of centres for which mark schemes were not submitted remains a cause for concern and *may lead to delayed results for such centres.*

- There were several cases where mark schemes were inadequate for some skills. Some centres continue to assess exercises using criteria that do not match the skill, for example, many centres include plotting points as Analysis/Interpretation criteria when it is an Observation/Recording/Reporting skill. Invariably, too many marks were assigned to these criteria. This practice inflated students' marks.

- Some centres failed to show how marks were assigned to the criteria. While the marks were assigned, it was unclear how the marks were awarded and almost always, candidates were awarded full marks. The team also noted that the criteria must be specific to the task at hand. In an attempt to use the same criteria for more than one exercise, some centres allowed the use of a common mark scheme. There were cases in which one mark scheme was constructed to 'fit' all exercises. This is not recommended. *Centres are urged to comply with the CXC SBA guidelines***.**