CARIBBEAN EXAMINATIONS COUNCIL

REPORT ON CANDIDATES' WORK IN THE CARIBBEAN ADVANCED PROFICIENCY EXAMINATION

MAY/JUNE 2003

PHYSICS

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GENERAL COMMENTS

UNIT I

The examination on this unit consisted of two papers. Paper 01 consisted of nine compulsory questions. Paper 02 also consisted of nine questions, with Section A containing three compulsory questions (which tested Experimental Skills (XS) and Use of Knowledge (UK)). Section B consisted of six questions based on the three modules and candidates had to respond to three questions in this section.

PAPER 1

OVERALL PERFORMANCE

The average mark out of the total of 90 for this paper was 30.31. This paper tested Knowledge and Comprehension and Use of Knowledge. Fifty per cent of the marks on this paper was allotted to Recall. Hence, teachers must ensure that students pay particular attention to the objectives that lend themselves to this skill.

Module 1

Question 1

The examiners were disappointed by the number of candidates who knew so little about dimensions and experimental errors that they could not even score one mark on this question. Part (a) required candidates to state the principle underlying the checking of equations using simple dimensional analysis. If they could not do this they had little chance of successfully applying this principle in Part (d).

There were some good responses to Part (c) by the more able candidates but others failed to see that finding the fractional error required the computation of the fractional error in each quantity separately and then adding these values together.

[Answer: (c) 12% or 0.12]

Question 2

Most candidates were able to score at least a portion of the marks in this question about projectile motion. The derivation of the formula for the horizontal range for an object projected horizontally (Part (b)) was done satisfactorily but the next section which asked how Newton’s laws were applied seemed to be beyond the average candidate. The explanations of how to find the velocity proved to be difficult for many candidates – all the examiners expected was an explanation of how the vertical velocity *gt* could be added to the constant horizontal velocity *u* by means of a vector diagram.

Question 3

Part (a) asked candidates whether a floating object would have the same fraction submerged when gravity changed. Few of them were able to deduce that, since the weight of displaced water equals the weight of the object, their masses would be the same. Changing the gravitational field would not change this relationship and the mass, and therefore volume, of water displaced would not be affected.

It was obvious from the responses to Part (b) that Archimedes' principle was not well understood. The examiners recommend that teachers might well spend some extra time on this topic, rather than assuming that because it occurs in the SCEC syllabus it has been mastered by all students. It was most disappointing to see the large number of candidates who could not even score one mark on this question.

[Answers: (b) (i) 0.74 N 625 kg m $^{-3}$]

Module 2

Question 4

Simple harmonic motion proved to be a difficult topic for candidates who did not have good analytical and mathematical skills. There was a wide range of scores on the question with a significant number of candidates scoring from zero to two out of ten.

Part (a) required candidates to, in effect, define s.h.m. This caused no problems for the average candidate. However, even though the symbols were defined in Part (b) and the formula for the velocity given, many candidates could proceed no further.

The graphs for the kinetic and potential energy of the body were fairly well known though there were some sinusoidal curves and straight lines submitted too. The fact that the total energy remained constant and was equal to the sum of these two types of energy at any point in time was required Part (d) but only the minority of candidates saw this.

[Answers: (b) (i) 1.3 s (ii) 1.0 m s^{-2}]

Question 5

The performance of candidates on this question about refraction of sound waves was much better than that on most of the other questions. Marks were generally lost when candidates had the relative refractive index inverted in Part (b), perhaps because they could not accept that for sound passing from air into water the index is less than 1. This kind of confusion could be avoided if candidates learned the law of refraction in the form $n_1 \sin \theta_1 = n_2 \sin \theta_2$ and used this form even when calculating critical angles. Several candidates managed to "fudge" the correct answer for Part (b)(ii) even though they had the refractive index incorrect in Part (b)(i).

Many candidates labelled the diagrams in Part (c) poorly and this caused even the more able candidates to fail to earn high marks.

[Answers: (b) (i) 0.22(ii) 12.7^o]

Question 6

The calculations in this question about diffraction and the diffraction grating were generally performed satisfactorily but the written answers left much to be desired. Teachers should, be aware of the tendency of students to concentrate on the mathematical parts of questions when they are practicing for examinations and try to encourage those under their supervision to produce the written answers as well and submit them for correction.

[Answer: (c) 5 orders]

Module 3

Question 7

This topic which was based on heat capacity, was well understood and the scores were higher than on the other Module 3 items. Weaknesses evident included confusion of heat capacity *of an object* with specific heat capacity *of a substance* and an inability to understand the concept of internal energy in Part (b) (ii).

[Answer: (b) (i) 198 W]

Question 8

This question was poorly answered. There was a surprisingly large number of candidates who could show little evidence of having studied *stress* and *strain*.

Those candidates who did understand the theory of deformation in wires often made careless errors with the powers of ten in their calculations and few candidates managed to score more than 80% of the marks.

[Answers: (b) 1.8 x 10^8 N m^{-2} (c) (i) 360 N (ii) 0.27 J]

Question 9

The parts on this question about thermal conduction required written answers rather than calculations. The responses were uniformly poor. A few candidates scored more than four out of ten marks.

The mechanism of conduction in a metal compared to the mechanism in a piece of wood needed to be explained in Part (a). It was surprising how few candidates mentioned the importance of free electrons in good conductors.

Those candidates who attempted Part (b) rarely saw the difference in the approaches in measuring conductivity of good and bad conductors in terms of minimizing heat loss whilst getting sufficient temperature difference in one case as opposed to getting sufficient heat flow in the other and therefore gained little credit.

PAPER 2

OVERALL PERFORMANCE

The average mark out of the total of 90 for this paper is 32.40.

Question 1

The scores on this question testing basic principles of measurement, using an electronic timing method to determine g as an example, were disappointing. Very few candidates realised that the "scatter" of the times would only allow the mean time to be quoted with two significant figures i.e. 0.37 ± 0.1 s. and the attempts at finding g from the mean time rarely used the correct equation of motion. The experiment might not have been very accurate (g=9.5m s^{-2}) but the candidates should have been able to see that they had made a mistake when they gave ridiculous values for the acceleration of free fall.

There was much confusion about the difference between random errors and systematic errors.

Question 2

Many of the weaker candidates were unable to get very far with this question because they did not know how to take logarithms of $T = al^n$ to obtain a linear function. Of those who did, some lost marks by not drawing up a table in Part (a) to show the values they were plotting even though the paper rubic says "All working MUST be clearly shown".

The graph plotting was generally done well and most candidates were able to find n from their graphs but finding a proved to be more difficult, with many candidates trying to use the "false intercept" on the graph's vertical scale rather than doing the required calculation.

[Answers (b) 0.52 (c) 0.055]

Question 3

Seven of the ten marks available in question 3 about heating water in a kettle were awarded for writing rather than calculation. Since many of the candidates seemed to lack the ability to write clear logical explanations or concise descriptions the scores were often quite low.

Part (a) merely required candidates to say that there were heat losses from the kettle and the rate of heat loss increased as the kettle got hotter. If this was understood then it should have been easy to go on in Part (c) to suggest ways of improving the accuracy such as lagging the kettle or using only the lower temperature values.

[Answer (b) 5400 J kg^{-1} K^{-1}]

SECTION B

Module 1

Question 4

The derivation of the relationship between centripetal acceleration and angular velocity was quite well known though many candidates lost marks due to poor annotation of their mathematical arguments. However, Part (b) was not well understood and few candidates were able to successfully find the orbital period of the Moon.

Many candidates were able to correctly deduce the centripetal acceleration of the rotating mass in Part (c) but because they failed to draw freebody diagrams in Part (c) (ii) they were often unable to calculate the tension in the string.

[Answers: (c) (i) 7.85 rad s^{-1} 12.3 m s^{-2} (ii) 0.62N 0.79 N]

Question 5

The responses to Part (a) were for the most part quite satisfactory though many candidates failed to realise that an object falling at its terminal velocity would have a constant kinetic energy.

Reversing the force on the box as shown in the graph in Part (b) would cause a loss in kinetic energy but few candidates took this into account and therefore lost 3 marks unnecessarily. However, the calculations in Part (c) were successfully completed by the majority of those who attempted this question.

[Answers: (b) (ii) 20 J (ii) 14 J (c) (i) 460 m s^{-1} (ii) 5.1 x 10^9 J]

Module 2

Question 6

Part (a) of this question on sound was done well by most candidates though some were unable to mark the period and the wavelength on the relevant axes.

The responses to Part (b) were generally good but those for Part (c) were poor because candidates failed to see that only the resonant frequencies which produced wavelengths such that $l = 3/4\lambda$ *or* $l = 5/4\lambda$ would fit in the given range.

Part (d) tested candidates' ability to use a given formula. Their comprehension skills were often not up to the task, the most common error being the substitution of the mass instead of the mass per unit length.

[Answers: (b) (ii) 1 x 10^{-4} W m^{-2} 4 x 10^{-17} W (c) 0.93m & 1.54m (d) 44 Hz]

Question 7

The descriptions of the Young's slit experiment in Part (a) tended to be theoretical rather than practical, perhaps because most of the candidates had never seen the actual experiment performed. However most candidates were able to gain full marks for the theory in (i) and (iii).

Whilst they were able to calculate the wavelength of the light used in the situation described, many candidates were unable to write clear answers to the other sections of Part (b) and consequently lost a significant portion of the marks.

[Answer: (b) (i) 5.64 x 10^{-7} m]

Module 3

Question 8

The calculations of the root mean square velocity of three molecules in Part (a) were surprisingly poorly done but candidates generally displayed a sound knowledge of the kinetic theory of gases.

Except for the final answer requiring the molar heat capacity at constant volume to be deduced from the earlier results the performance on Parts (b) and (c) about the application of gas laws was quite good with many of the better candidates scoring close to full marks.

[Answers: (a) (ii) 4.3 v 5.2v (b) (i) 4350 J (ii) 2.5 x 10^{-3} m^3 (ii) 1.25 x 103 J
(c) (i) 3100 J (ii) 20.7 J mol^{-1} K^{-1}]

Question 9

This question about pressure in liquids elicited many good responses. Though some of the weaker candidates attributed the low density of gases to "lighter molecules", most candidates had little trouble demonstrating a good understanding of the topic.

The calculations in Part (c) were usually done accurately and candidates who chose this question earned high marks.

UNIT 2

This was the first year that Physics Unit 2 was examined on open syllabus. Paper 01 consisted of nine compulsory questions. Paper 02 consisted of nine questions. Section A was compulsory and candidates had a choice of three questions, one from each module.

PAPER 1

OVERALL PERFORMANCE

The average mark out of a total of 90 for this paper was 36.52. This paper tests recall of basic concepts and definitions and a considerable proportion of the marks on this paper are available for simple recall and comprehension.

Teachers should ensure that their students pay adequate attention to the relevant specific objectives that demand recall.

Module 1

Question 1

The examiners were pleased to see the number of candidates who were able to score full marks on this question about capacitors. Weaker candidates most commonly lost marks through their inability to give a logically consistent derivation of the formula for combining capacitors in series.

[Answers: (c) (i) 44.3 pF (ii) 5.5 x 10^{-6} J]

Question 2

The performance of candidates on this question was below the required standard. It was surprising that so many candidates at this level could state neither Faraday's Law nor Lenz's Law.

The numerical exercise in Part (c) would have been handled better if candidates had drawn a diagram (or annotated the one given) to show the triangle formed by the moving bar before trying to calculate the area and the flux. The better candidates realized that the induced e.m.f. could be calculated quickly from $E = Blv$ and gained marks in Part (c)(iii) even though the previous responses were incorrect.

[Answers: (c) (i) 70.6 m^2 (ii) 31.8Wb (iii) 31.8 V]

Question 3

The performance on this question about resistance and e.m.f. was fair and even the weaker candidates were was able to score at least half of the marks in Parts (a) (b) and (c). However, perhaps because they tried to fill in the given table without showing any working, even the better candidates failed to score many marks in Part (d).

[Answers: (d) I = 1/30 A (=0.033 A); I = 0, V = 12.9 volt]

Module 2

Question 4

Very few candidates were able to use the given graph in Part (c) to deduce that the p.d. across the silicon diodes whilst they are conducting is 0.6V. This led to some poor scores on this item even though most candidates were able to recall correctly the properties and uses of semi-conductors required in Parts (a) and (b).

[Answers: (c) (i) –1.4, -2.6V]

Question 5

The evidence provided by the responses to this question about the operational amplifier would seem to indicate that a lot of candidates had not studied this topic at all. Even those who had and were able to score in the factual Parts (a), (b) and (c) were unable to use their knowledge in Part (d). The net gain of the circuit could be found by multiplying the gain of each Part (Gain = 6 x –10 x –10) but too many candidates added instead.

[Answers: (d) (i) 600(ii) 6.0 V]

Question 6

In General, candidates seemed to know much more about digital electronics than analogue and so the scores on this question were better. However, there was still a significant fraction of the population which scored zero.

Parts (a) (b) and (c) about truth tables and circuit diagrams were done well and many of the better candidates scored full marks. Part (d) was a little more challenging since it required the design of a circuit but, even so, there was a pleasing number of candidates who were able to score all 10 marks.

Module 3

Question 7

This question elicited some very good responses. Some candidates lost a mark for not knowing that radiation of wavelength 83 nm would be in the ultraviolet region of the spectrum. The weaker candidates lost marks mostly because they wrote confused answers to Parts (a) and (b) about the photoelectric experiment.

[Answers: (c) (i) 20 e V (d) (i) 3.6 x 10^{15} Hz (ii) 83 nm]

Question 8

Confused explanations of why a vacancy in an inner shell is required for an atom to emit an X-ray photon caused most candidates to lose at least two marks in the written Part (Part (a)) of this question. Only the better candidates were able to handle the mathematics of the exponential in Part (b) and so the mean score on this question was quite disappointing.

[Answer: (b) (ii) 484 W m^{-2}]

<u>Question 9</u>

There was a large number of candidates who were able to score eight or nine out of ten on this question about nuclear fission. The one mark that seemed to elude the majority was for Part (c) (ii) where candidates failed to realise that the energy released would appear as kinetic energy which would be shared by the 3 neutrons.

As in other questions on this paper the written answers were generally poor and this caused many candidates not to do well on the relatively simple Part (a).

[Answers: (c) (i) 173 MeV]

PAPER 2

OVERALL PERFORMANCE

The average mark out of a total of 90 for this paper was 38.51. This paper tested a wide range of skills, which consequently requires teachers to provide appropriate opportunities for their development.

<u>Question 1</u>

Part (a) required the drawing of a potential divider circuit to obtain the I-V characteristic of a semi-conductor diode. Some credit was awarded for the use of a rheostat instead, even though this circuit would not allow a variation of V when the diode was not conducting a current. The responses did not in the main reflect any evidence that the experiment had been conducted in class.

For some candidates the given equation in Part (b) triggered the idea that a log graph should be plotted which was not helpful since the question gave part of the actual I-V graph. All that was required was to choose two points from the graph and, substituting in the given equation twice, find n. A could then be found using the value of n to yield the equation $I = \frac{1}{2} V^3$. The better candidates were able to do this successfully although many of them gave decimal values for the constants rather than integers.

<u>Question 2</u>

Most candidates recognized that the circuit in Part (a) was a non-inverting amplifier and were able to use the correct formula to obtain the expected gain of 4.

There was a typing error in the labeling of the graph axes in Part (b) on the paper which most candidates recognized immediately: the few who did not were still able to obtain the correct gain from the graph in Part (c) and were not disadvantaged. The examiners were pleased with the performance in this section.

[Answers: (a) 4 (c) (i) 4.0 ± 0.1 (ii) 4.0 ± 0.1 (iii) 13.0 ± 0.1 V]

Question 3

Most candidates were able to complete the table of results from an investigation of the photoelectric effect and proceeded to choose good scales to plot the required graph, Parts (a) and (b). However, many candidates were not able to recall accurately Einstein's photoelectric equation and were therefore unable to score many marks in Part (c). Only the better candidates were able to use the gradient of the graph to obtain h and then calculate the work function from the threshold frequency, which could be read off from the intercept.

[Answers: (a) 9.6, 8.2 (c) (i) 6.5 x 10^{-34} J.s (ii) 4.6 x 10^{-19} J]

Module 1

Question 4

The performance on this question about the application of electrostatics was weak. Most candidates scored well in Part (a) but the explanations provided in Part (b) were poorly written. Although candidates seemed to know the relevant facts they could not relate them to the given situation in a logical manner.

The numerical problem about coalescing water drops in Part (c) proved to be difficult for most candidates since they thought that joining two drops to produce one with double the volume of water would mean that the drop had twice the original radius.

[Answers: (b) (ii) 1800 N C^{-1} (c) (i) 5.4 x 10^{-5} m (ii) 794 V]

Question 5

This was the more popular of the two Module 1 questions. The derivation of the formula for drift velocity in Part (a) was well known and many candidates scored full marks.

The attempts at the numerical Parts (b), (c) and (d) were good for the most part.

[Answers: (b) (i) 45.5 A (ii) 12.6m (c) 1.22 x 10^{-3} m s^{-1} (d) (i) 2.92 x 10^{-24} N (ii) 8.6 N]

Module 2

Question 6

A minority of the candidates attempted this question and demonstrated, in the first two parts, a good understanding of the theory of the operational amplifier. However, marks were lost by candidates adding the grains of the amplifiers in Part (b) instead of multiplying and some candidates were not able to suggest a practical use for the buffer circuit labelled B. They tended to make general statements instead of suggesting an actual use such as converting a low impedance voltmeter to one of high impedance.

Part (c) proved to be more challenging and only the better candidates realized that a summing amplifier was required. They were then, for the most part, able to successfully choose suitable values for the resistors and complete the design of the circuit.

[Answers: (b) (ii) –6 V (iii) 6.5 V]

Question 7

This proved to be the more popular of the two questions in Module 2; however, the responses were very disappointing.

Candidates who attempted Part (a), gave the correct answer for the root mean square voltage in Part (a)(i), but were often unable to see that a root mean square value was also required for the equivalent current in Part (a)(ii), indicating to the examiners that the principle was poorly understood.

In Part (b) candidates' explanations of the operation of an ideal transformer were not written in a clear logical manner and few of them scored more than half marks. If candidates had used a diagram (which only the better ones did) and based their explanations on this the responses might have been more organized and more likely to have included enough relevant points to score the full seven marks.

In Part (c), the lack of understanding of the difference between peak and r.m.s values was quite evident here and many candidates were unable to calculate the correct values of the current from the voltage and the given power output.

[Answers: (a) (ii) 1.84 A (c) (i) 71 (ii) 13 A 9.2 A (iii) 0.18]

Module 3

Question 8

In part (a) candidates experienced difficulty in stating clearly and precisely what was meant by *wave-particle duality* and the *de Broglie hypothesis*.

Part (b) required the use of Einstein's photoelectric equation and the relationship between maximum kinetic energy and stopping potential. Once these equations were recalled most candidates found it easy to substitute the given values to obtain the correct answers. However, some of the weaker candidates faltered because they did not have a clear understanding of the meaning of the symbols they used.

[Answers: (b) (i) 5.7×10^{-7} m (ii) 1.5×10^{-19} J (iii) 0.94 V]

Question 9

This question about radioactivity was no less popular than the other Module 3 question but the scores were lower. The responses in Part (a) (i) suffered from the same deficiency in the writing explanations as in the previous questions.

The numerical problems in Parts (b) and (c) proved to be difficult for the average candidate. Obtaining the correct answers required more than mere substitution in formulae – the description of the use of technetium to monitor blood flow had to be read carefully first so that the process could be understood and the appropriate data selected.

[Answers: (b) (ii) 8.2 x 10^{-7} s^{-1} (ii) 1.2 x 10^{6} (c) (i) 1/11.3 or 8.9%, 3.5, 4.4 x 10^{9} years]

Internal Assessment

In general, the standard of the practical work needs to be improved. Although there were some excellent submissions the examiners also noted an increase in the repetition of experiments which could be deemed suitable for CSEC Physics.

Often the 'research' projects produced could, have been compiled by merely extracting information from the listed sources with little original input from the candidates. The moderators were challenged to reconcile the mark schemes supplied with the scores awarded. There is much room for improvement in this area.

However, projects which involved data collection by the candidates more often reflected the standard expected at this level. Even so, the criteria listed in the mark scheme did not always match the CXC criteria for Planning and Designing, Analysis/Interpretation etcetera. It is important that teachers take more care in ensuring that the criteria selected reflect the true nature of the skill being tested and that the assigned marks can be justified.

It was also pleasing that the choice of projects submitted was varied and interesting and tended to indicate that candidates enjoyed this part of the programme. Candidates were able to pursue their own particular preference with some degree of freedom.