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 SECONDARY EDUCATION CERTIFICATE® EXAMINATION

MAY/JUNE 2013

ELECTRICAL AND ELECTRONIC TECHNOLOGY TECHNICAL PROFICIENCY EXAMINATION

GENERAL COMMENTS

The number of candidates who wrote the examination this year was 3 738. This was a decrease of approximately six per cent compared with entries for 2012. Overall, candidate performance for 2013 was slightly worse than that of 2012, with 62 per cent of candidates earning Grades I–III compared with 65 per cent for 2012. This slight decline in overall performance is reflected in a slight decline in performance on Profiles 1 and 2. Profile 1, Knowledge, declined by approximately four per cent compared with the performance in 2012. Performance on Profile 2, Application, declined by approximately four per cent compared with performance in 2012. Performance on Profile 3, Practical Ability, was comparable to the performance in 2012. Candidates did well on the practical project of the School Based Assessment (SBA). However, there is room for improvement on the written project. Competencies tested in Paper 01 (Multiple Choice) and Paper 02 (Essay and Problem Questions) were Knowledge and Application.

DETAILED COMMENTS

Paper 01 — (Multiple Choice)

This paper consisted of 60 multiple-choice questions, testing the profile dimensions of Knowledge and Application. Candidate performance on this paper was comparable to performance in 2012. The mean score achieved was 32.1 against 32.0 for 2012. The highest score attained in 2013 was 56 compared with 58 for 2012. However, the analysis shows that there is still the need for better and broader coverage of Modules 1-4 and 6-7 of the syllabus. The results also indicate that candidates need practice in responding to the multiple-choice format used in the paper.

Paper 02 — Essay/Problem

The paper consisted of THREE sections: — Sections A, B and C. Section A consisted of five short-answer questions. Candidates were required to attempt all five questions. Each question was worth eight marks.

Section B comprised FOUR questions. Candidates were required to answer any THREE of the four questions. Each question was worth 20 marks.

Section C comprised TWO questions — each worth 20 marks. Candidates were required to answer any ONE question.

Candidate performance on this paper was comparable to performance in 2012. The mean score achieved was 30.6 (25.5 per cent) compared with 33.8 (28.2 per cent) in 2012. The highest score attained was 93 compared with 98 for 2012. Paper 02 continues to pose a challenge to many candidates.

SECTION A

Question 1

This question tested candidates' knowledge and understanding of the series/parallel resistor combination. Most candidates were able to name at least three factors that affect the resistance of resistors. Candidates' responses in order of popularity were: (i) length (ii) cross-sectional area (C.S.A.) (iii) type of material used and (iv) temperature (ambient).

Candidates were unclear as to the difference between the words 'resistivity' and 'conductivity'. Candidates appeared not to understand the term *cross-sectional* area, since they used terms such as *surface area*, *width* and loosely used the terms *size* and *thickness* to refer to C.S.A.

Most of the candidates' marks were obtained in Part 1 (a) of the question.
Part (b) of the question tested the basic concept of Ohm's Law and series/parallel combination computations. This part was not well done. Most candidates were able to compute the equivalent resistance of two resistors in parallel. However, computation of the equivalent resistance of three resistors in parallel posed some challenges to candidates. Because of this, candidates were unable to correctly calculate the total resistance and total current of the circuit. Some candidates applied the series concept to the parallel computation.

Teachers need to dedicate more time to getting their students to understand technical terms such as cross-sectional area (C.S.A.) and resistivity. Additionally, teachers need to ensure that students are able to distinguish between *diameter*, *size*, *width* and *surface area* in relation to cross-sectional area.

The mean score for the question was 4.0, with 18 per cent of the candidates achieving full marks. Seventeen per cent of the candidates scored zero.

Question 2

Part (a) of this question tested the candidate's knowledge and application of methods of charging secondary batteries and the calculations for *total internal resistance* of the cells, *total circuit resistance*, *total circuit current* $I_{L,}$ and *terminal voltage* of the battery. The majority of candidates responded by listing the equipment used in charging secondary batteries, such as battery chargers and alternators, instead of the methods that were required.

Those candidates who had difficulty with Part (a) were unable to complete Part (b) ii–iv correctly. Most candidates were unable to calculate the terminal voltage of the battery.

The correct responses for this question are shown below.

Part (a) (i) Constant current charge

(ii) Constant voltage charge

(iii) Trickle charge

(iv) Floating charge

(v) Boost charge

Part (b) (i) Total internal resistance of the cells r = 0.8/4 = 0.2Ω

(ii) Total circuit resistance RT = r + RL = 0.2 + 0.8 = 1Ω

(iii) Total circuit current IL = E/RT = 2/1 = 2A

(iv) Terminal voltage of the battery $V_T = I_T \times R_L = 2 \times 0.8 = 1.6V$

Eighty-seven per cent of the candidates attempted this question. The mean score for the question was 1.0, with three candidates achieving full marks. Fifty-one per cent of the candidates scored zero on the question. The high percentage of candidates scoring zero on this question indicates that greater attention needs to be paid to this section of the syllabus.

Question 3

This question tested candidates' knowledge of single phase transformers and laminated core types used to construct transformers. It also tested the application of formulae to calculate power loss and power efficiency of transformers.

Candidates, for the most part understood (Part (a) (i) and provided the correct response to the question. A few candidates confused the term 'motor' with the term 'transformer'. These Candidates' responses to Part (a) (ii) were the answers that were required for Part (a) (i).

Candidates performed fairly well in Part (b) of the question. Some candidates, however, used the transformer ratio instead of power calculations to answer the question. Teachers need to provide specific examples of types of single-phase transformers, and avoid broadly stating that there are step-up and step-down transformers. Teachers should provide examples of core construction and not focus only on the material of the core. Additionally, teachers can disassemble a transformer to show the core. To help students to better understand the calculation for transformer efficiency, teachers should show the derivation of the efficiency formula.

The following is an expected solution

a) i) Double-wound transformer; autotransformer

ii) Core-type construction; shell-type construction

Output Power, $P_0 = V_S I_S$

$$P_0 = 100V \times 10A$$

$$P_0 = 1000W$$

Total loss, L = iron loss + copper loss

L = 55W + 20W

L = 75W

Input power, $P = P_0 + L$

P = 1000W + 75W = 1075W

$$\eta = \frac{\text{output}}{\text{input}} \times 100$$

$$\eta = \frac{1000}{1075} \times 100 = 93.0\%$$

Seventy-eight per cent of the candidates attempted this question. The mean score for the question was 1.6, with two candidates achieving full marks. Twenty-seven per cent of the candidates scored zero. The high percentage of candidates scoring zero on this question indicates that greater attention needs to be paid to this section of the syllabus.

Question 4

This question tested candidates' ability to identify PN junction diodes that are forward and reverse biased, when polarity changes at the supply terminals of a bridge rectifier.
Although a high percentage of candidates were able to place the correct answers (i) a) D1 and D2 and (i) b) D3 and D4, it was observed that

i) many of the candidates confused Part (i) (a) responses with those of (b)
ii) there were many instances where some candidates simply listed one correct diode for each bias instead of the two expected.

Part (a) (ii) tested candidates' knowledge of the output waveform of the full wave bridge rectifier. The answers expected for a) and b) in this section were positive half waves with the negative clipped. While many responses were drawn correctly, in a number of cases it was observed that responses were in the form of

i) a complete sine wave, or pulsating without the space after the positive peak.
ii) leading and lagging sine waves.

Part (b) (i) tested candidates' ability to explain the effects of (i) reverse bias and (ii) forward bias on a PN junction diode. The responses required were

i) when the diode is reverse biased, electrons in the N region are attracted to positive electrodes of the bias voltage, while the holes in the P region are attracted to the negative. Reverse bias prevents electrons from crossing the border.

ii) when the diode is forward biased, the P region is connected to the positive electrode of the bias voltage and the N region is connected to the negative electrode of the bias voltage. Forward bias allows electrons to cross over the PN junction.

Many candidates were unable to explain the depletion region properly. Nevertheless, they were able to indicate whether conduction would take place or not. It appeared that some candidates did not know what the answer should be. In a few cases candidates were able to obtain full marks.

Eighty-one per cent of the candidates attempted this question. The mean score for the question was 2.1, with thirty-eight candidates achieving full marks. Thirty-six per cent of the candidates scored zero. The high percentage of candidates scoring zero indicates that greater attention needs to be paid to this section of the syllabus.

Question 5

This question tested candidates' knowledge and application of knowledge to semi-conductor devices and transistor biasing.

Part (a) was well done by the majority of candidates. They showed knowledge of forward and reverse biasing.

Part (b) required candidates to state the amount of emitter current that flows through (i) the base terminal and (ii) the collector terminal of an npn transistor. This part of the question was answered in terms of description; for example, higher/lower rather than using percentages.

The majority of candidates who attempted Part (c) of the question got it incorrect. They were unable to apply Ohm’s Law in an electronic circuit to calculate the standing current and the base voltage.

Expected Solution

(a) Forward bias and reverse bias

(b) Base current is very small, approximately 5% of transistor valve and collector

current is large, approximately 95% of transistor current.

(c) (i) Is = Vcc /R1 + R2

= 12/16k = 0.75ma

(ii) Vbe = IsR2

=).75ma X 1K = 0.75v

Sixty-six per cent of the candidates attempted this question. The mean score for the question was 1.3, with nine candidates achieving full marks. Forty-six per cent of the candidates scored zero. The high percentage of candidates scoring zero on this question indicates that greater attention needs to be paid to this section of the syllabus.

SECTION B

Question 6

This was an electrical question which required knowledge and application of knowledge to the single-phase induction motor and some of its starting circuits. This was an optional question which was very popular. Approximately sixty-one per cent of the candidates attempted this question.

Parts (a) and (b) were knowledge based, requiring candidates to recognize the circuit diagrams of the starting circuits of the single-phase induction motor and its various components. Many candidates were unable to identify the motors shown in the diagram. They, however, were able to identify the various parts of the starting circuit. Some candidates were able to use the exact technical terms as indicated in the solution.

Part (c) required candidates to understand the operation of the induction start and the capacitor start capacitor run starting circuits of the single-phase induction motor.

Part (c) (ii) was not well answered since many candidates did not understand the purpose of the capacitors in the capacitor start capacitor run single-phase induction motor.

Part (c) (iii) required the candidates to show knowledge of motor reversal. Most candidates got one of the two available marks since they did not provide very specific answers.

None of the candidates achieved full marks. The highest mark attained in this question was 19. Seventy-one per cent of candidates achieved marks which ranged from satisfactory to very good. Only eight candidates scored zero on the question.

Solution

(a) (i) Inductor start

(ii) Capacitor start capacitor run

(b) A Centrifugal switch

B Start winding

C Run winding

D Squirrel cage rotor

E Centrifugal switch

F Run capacitor

G Start capacitor

H Start-run winding

(i) In Figure 6, the inductor start single-phase motor, the start winding is not continuously rated and is designed to be used to start the motor only.

In Figure 7, the capacitor start capacitor run single-phase motor, the start winding is continuously rated and remains in the circuit when this motor is running.

(ii) In Figure 7, component F is a run capacitor that is rated for continuous operation. The run capacitor improves the power factor of the AC motor. Component G is a start capacitor that improves the start performance of the motor. It is switched out as the motor speed builds.

(iii) One method of changing the direction of rotation of a single phase motor is to reverse the connection of the start winding at the motor terminals.

<u>Question 7</u>

This question tested candidates' knowledge of and application of knowledge of the electrical principles applied in the construction of a three-phase, four-wire electrical installation. Candidates were expected to:

(i) Identify the type of AC supply used for a small industrial installation

(ii) Name the parts of an industrial installation supplying lighting and power (motors) sub circuits.

(iii) Describe each type of AC supply.

Candidates' knowledge of the following was also tested:

(i) Causes of a short circuit
(ii) Effects of a short circuit
(iii) Operation of a fuse
(iv) Definitions of current rating and Fusing current and
(v) Formula for calculating fusing factor

For Part (a) (i), candidates could not differentiate the incoming supply as 3 0/ 4 wire. Some responses given were 110/220V AC.

In Part (a) (ii), candidates used different terminologies to describe the parts of the diagram. Candidates gave the parts of a distribution system instead of the expected responses which were the main switch and lighting and power (motor) main switch and lighting and power distribution panels. Some candidates used switches, fuse and other outlets.

For Part (a) (iii), the candidates did not understand that a 3 0/ 3wire and a 1 0/ 2 wire were required. Instead, they mentioned how power is generated and the different types of energy used to generate electricity.

Part (b) (ii) of the question tested the application of electrical principles. It was the most popular part of the question. The candidates performed generally well. They, however, had some difficulty applying the terminology used. In responding to the question, candidates did not use key words like *bane conductors, in contact, and touching*. Some of the expected responses should have been incorrect connecting of contact relay made between L & L or L & H and L & Earth.

In Part (iii), candidates gave the purpose of the fuse as a protective device instead of describing its operating principle, which is based on excess current creating heat and opening, breaking or burning the fuse element.

Part (c) of the question was not well answered and candidates tended to interchange the components of the formula used for calculating fusing factor. The fusing factor formula is as follows:

Fusing Factor = Fusing Current/Current Rating.

Fifty-three per cent of the candidates attempted this question. The mean score for the question was 4.3, with none of the candidates achieving full marks. Twenty-two per cent of the candidates achieved marks ranging from 7 to 18. Seventy-eight per cent of the candidates scored marks ranging from 0 to 6. The high percentage of candidates scoring low marks on this question indicates that greater attention needs to be paid to this section of the syllabus.

<u>Question 8</u>

This question tested candidate's knowledge and application of knowledge in relation to the common emitter transistor amplifier circuit using the H Bias. This was not a very popular question. About twenty-three per cent of the candidates attempted this question.

Part (a) (ii) of this question was attempted by most of the candidates. Generally, candidates were able to identify the biasing resistors R_1 and R_2 for TR_1 and R_5 and R_6 for TR_2.
A popular response to Part (iii) was simply "coupling capacitor".

In Part (iv) of the question, some candidates gave the values of the capacitors rather than the type of capacitor that was required.

Most candidates who attempted this question did not attempt Part (b). Those who attempted this part provided varying responses as captured below:

(i) In calculating TR1 base voltage some candidates treated the resistors as a series branch, whilst others who treated it as a potential divider selected the wrong resistors to do the calculations.

(ii) Many candidates used the correct formula to correctly calculate the emitter voltage.

(iii) Many candidates were able to calculate the emitter current.

(iv) In calculating the voltage drop across R3 most candidates used the correct formula but inserted incorrect values.

(v) Candidates used Vbe voltage instead of the voltage across VRc and found the sum rather than the difference.

RECOMMENDATIONS

- Teachers need to distinguish between the H Bias and other transistor configurations.
- Emphasis should be placed on the calculation of VR_1 and VR_2 noting they are in series only for this calculation.
- When calculating RB they are considered to be in parallel (R_1 and R_2).
- The purpose of C_2 must be clearly distinguished. It is for the purpose of coupling the stages and blocking D.C.
- There is need for clear distinction between TYPE and VALUE.
- As far as Part (b) is concerned, more practice in this type of question is required.

Ninety-five per cent of the candidates scored seven or lower, out of a possible twenty marks. The mean score for the question was 1.9, with none of the candidates achieving full marks. Forty-seven per cent scored zero. The very high percentage of candidates scoring low marks on this question indicates that the topic was not understood by candidates and that greater attention needs to be paid to this section of the syllabus.

Question 9

This question tested the candidates' ability to differentiate types of input and output devices and identify different types of computer memory. It also tested candidates' knowledge of information transfer and their ability to explain the operation of the two-input AND-gate through description of the output states, the truth table and the simple electric.

This question proved to be very popular, with 82 per cent of candidates attempting it. In some cases the candidates' responses were excellent. A fair percentage of candidates had an excellent grasp of the concepts tested.

Part (a) of the question was generally well done, with a minority of the candidates confusing input and output devices.

Part (b) was not well answered. In responding to this question about type and form of communication, some candidates used terms such as *software*, *wire/wireless*, *network*, and signal, instead of terms such as digital and binary. The incorrect use of terms resulted because these candidates concentrated on information transfer rather than the types and forms of communication.

Part (c) was generally well done, with candidates showing greater interest in answering with the truth table and the electric circuit precisely, rather than describing the operation of the AND-gate in words.

The mean score for this question was 11.1, with eight per cent of the candidates scoring full marks. Seventy-one per cent of the candidates had marks ranging from 8–20. One per cent of the candidates scored zero.

Solution

(a) (i) Input devices

- Mouse, roller ball, touch pad, touch screen, game controllers, keyboard
- Light pens, CD-ROMs, microphones

(ii) Output devices

- Printers
- Monitors (VOU)

(iii) Two types of computer memory

- Read only memory (ROM)
- Random access memory (RAM)

(b) (i) Digital communication is used to transfer information between the components in the computer.

(ii) The digital communication between the components of the computers is in the form of binary numbers.

(c) (i) a) When logic 0 is applied to A and B the diodes D_1 and D_2 are forward biased with 0V on the anodes giving Logic 0 Output.

b) When logic 1 is applied to A and logic 0 to B, diode D_1 is reversed biased and diode D_2 are forward biased and the anode of D_2 is 0V giving logic 0 output.

c) When logic 0 is applied to A and logic 1 is applied to B, diode D_1 is forward biased and D_2 is reverse biased and the anode of D_1 is 0V, giving logic 0 output.

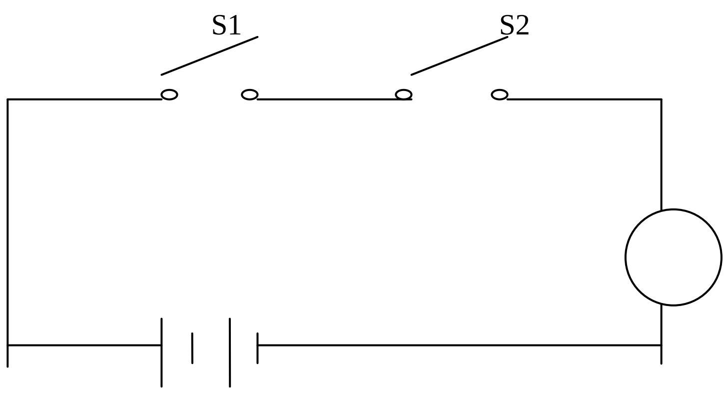
d) When logic 1 is applied to both A and B diodes, D_1 and D_2 are reverse biased with 5 V on the anodes giving logic 1 output.

(c) (ii)

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Figure 1 Truth Table

(c) (iii)



Question 10

This question tested candidates' knowledge and the application of the principles for the construction and operation of the quick start fluorescent lamp. The question also tested candidates' ability to perform calculations on a series RC circuit.

Though the question was popular, responses were poor, with the majority of candidates scoring between 2 and 6 marks.

Candidates were able to identify components and recall required equations; however, there were several areas of weak performance

- Limited knowledge and application of the function of components.

- Candidates used generic terms in their responses, for example, the component labelled E (earthed metal) was generally referred to as a protective device, when in this circuit, it is used in assisting in striking the lamp.

- Drawing and labelling of diagrams
  In Part (b) (i), candidates were unable to correctly draw the phasor diagram.

- Solving equations involving indices.
  Most candidates were unable to perform the calculations in section (b) (ii) a) to d).

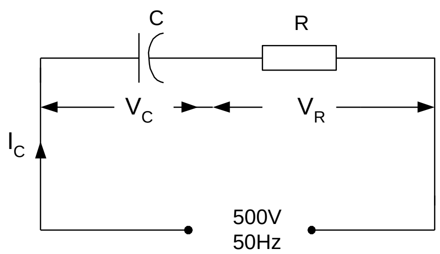
RECOMMENDATIONS

Teachers should therefore ensure that their instruction involves:

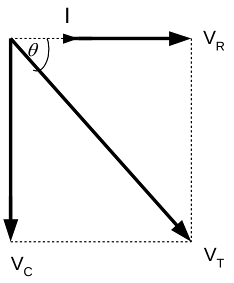
- Projects which would enable candidates to connect and test different types of fluorescent circuits.

- Performing computations involving indices.

- Drawing fully labelled diagrams.



- Constructing phasor diagrams (Solution is given below).



- RC and RL circuit analysis in a sequential order (see calculations below).

(a) Calculating Capacitive Reactance

$$X_C = \frac{1}{2\pi fC}$$

$$= \frac{1}{2 \times 3.14 \times 50 \times 10 \times 10^{-6}}$$

$$= \frac{10^6}{3140}$$

$$= 318.47\,\Omega$$

(b) Impedance

$$Z = \sqrt{R^2 + X_C^2}$$

$$= \sqrt{5^2 + 318.47^2}$$

$$= 318.51\Omega$$

(c) Currentin the circuit

$$I = \frac{V}{Z}$$

$$= \frac{500}{318.57}$$

$$= 1.57\text{Amps}$$

(d) power factor

$$\text{p.f} = \frac{R}{Z}$$

$$= \frac{5}{318.51}$$

$$= 0.157 \text{ lead}$$

The mean score for this question was 3.9, with none of the candidates scoring full marks. Approximately 11 per cent of candidates had scores ranging from 8–15. Eighty-nine per cent of candidates scored seven marks or lower. The high percentage of candidates achieving low scores on this question suggests that greater attention needs to be paid to this topic in the syllabus.

Question 11

This question tested the candidates' knowledge of and application of electrical principles of the three circuit components of a three-phase auto-transformer motor. Candidates were unable to answer the questions based on the principles of the auto transformer and its applications in providing the reduced voltage to start the motor and the application of line voltage when the motor reaches full speed.

This was not a very popular question, with approximately ten per cent of the candidates attempting it. The candidates' responses showed they had limited knowledge of operating principles of the three-phase motor. Candidates were unable to describe the terms *slip*, *single–phasing* and *star connection*. It was evident that the candidates did not ful understand how an operator of a three-phase motor could be protected from an electric shock.

The mean score for this question was 2.8, with none of the candidates achieving full marks. Approximately three per cent of candidates achieved marks ranging from 8-15. Ninety-seven per cent of candidates scored seven marks or lower. The very high percentage of candidates achieving low marks suggests the need for greater attention to be placed on this aspect of the syllabus.

Solution

(i) a) Isolator switch
b) Auto-transformer

(ii) a) An isolator switch is used to isolate the motor circuit from the three phase supply

b) The auto-transformer is used to supply a reduced voltage to limit the motor-starting current.

c) The three-phase induction motor transforms the electrical energy from the supply to mechanical energy at the rotor shaft.

(b) (i) Synchronous speed is the speed of the rotation of the magnetic field in the stator of the three-phase motor.

(ii) Slip is the difference in the speed of rotation of the magnetic field in the stator and the speed of the rotation of the rotor.

(iii) Single-phasing is the effect produced when an open circuit occurs on one of the lines of phase conductors supplying a three-phase motor.

(iv) Star connection is established when three start or three finish terminals of the three windings of a three-phase motor are connected and the line or phase conduction is connected to the other end terminals of each winding.

(c) (i) A reduced voltage motor starter, (star-delta) limits the starting current by using a switching operation, which connects the motor windings in STAR in the start position and ‘DELTA’ in the RUN position.

(ii) A non-reduced voltage motor starter (direct-on-line) connects the line or phase conductors directly across the motor windings.

(d) (i) When a three-phase motor is single-phasing it continues to run but overheating occurs in one winding as it carries a larger current to sustain rotation.

(ii) By earthing or grounding exposed metal parts of the motor. When a line or phase conductor comes into contact with earthed metal a low resistance to earth or ground is established that produces a large current that operates the motor. An excess current protection device then disconnects the motor from the supply.