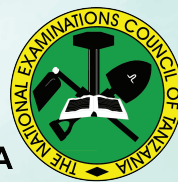




THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA



CANDIDATES' ITEM RESPONSE ANALYSIS
REPORT ON THE CERTIFICATE SECONDARY
EDUCATION EXAMINATION (CSEE) 2023

ELECTRICAL ENGINEERING



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080 ELECTRICAL ENGINEERING

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LIST OF SYMBOLS AND ABBREVIATIONS

A	Ampere
μ	Micro
A.C	Alternating Current
C	Capacitance
CIRA	Candidates' Items Response Analysis
CSEE	Certificate of Secondary Education Examinations
D.C	Direct Current
F	Farad
Hz	Hertz
I	Current
k	Kilo
lm/m ²	Lumens per square meters
m	Milli
NECTA	National Examinations Council of Tanzania
p.f	Power Factor
R	Resistance
r.m.s	Root mean square
r.p.m	Revolution per minute
t	Time
TANESCO	Tanzania Electric Supply Company Limited
V	Volt
W	Watt
ρ	Resistivity
Ω	Ohm

FOREWORD

This report presents the Candidates' Items Response Analysis (CIRA) on Form Four National Examination in Electrical Engineering subject which was conducted in November 2023. It aims to provide feedback to all educational stakeholders on the factors that contributed to the candidates' performance in Electrical Engineering subject.

The Form Four National Examinations is a summative evaluation that measures the student's knowledge, skills, and competencies in four years of the instructional period of ordinary-level of secondary education. The report provides feedback that teachers, students and other educational stakeholders can use to improve the teaching and learning process. This analysis justifies the candidates' performance in the subject of Electrical Engineering. The candidates who attained high scores demonstrated their ability to understand the requirements of the questions, their knowledge, skills and competence in the subject matter, and their mastery of calculation skills. However, candidates who scored low marks faced difficulty in responding to the questions due to insufficient knowledge of the tested concepts.

The National Examinations Council of Tanzania (NECTA) expects that the feedback provided in this report will shed light on the challenges for which teachers and other education stakeholders should take proper measures to improve the teaching and learning process in Electrical Engineering subject. Consequently, prospective candidates will acquire the knowledge, skills, and competences indicated in the syllabus for better performance in future.

The Council appreciates the contribution of all those who prepared this report.



Dr. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of candidates who sat for the Certificate of Secondary Education Examination (CSEE) 2023 in Electrical Engineering subject. The paper consisted of eleven (11) questions categorised into three sections: A, B and C. Section A consisted of questions 1 and 2. Question 1 had ten multiple-choice items, (i) to (x). These items were set from the topics of *Units, D.C Circuits, Electrical Workshop Orientation, Illumination, A.C Machines, Transformers and Cells and Batteries*. Question 2 consisted of six matching items, (i) to (vi) set from the topic of *D.C Circuit*. The candidates were required to answer all items in this section.

Section B consisted of six (6) short answer questions. The candidates were required to answer all the questions in this section. Each question carried nine (9) marks, totalling 54 marks. Section C consisted of three (3) structured questions. The candidates were required to answer two questions from this section. Each question carried 15 marks, totaling 30 marks.

This report analyses candidates' performance into three categories namely good, average, and weak, indicated by green, yellow, and red colours, respectively. In each question, performance is regarded as good if the scores range from 65% to 100%, average if the scores range from 30% to 64%, and weak if the scores range from 0% to 29%.

The report also presents the requirement of each question, the percentage of the candidates who attempted the question with their scores and the possible reasons for their performance. Extracts from the candidates' scripts, graphs indicating the distribution of candidates' scores, and appendices are presented in this report for illustration.

A total of 320 candidates sat for the Electrical Engineering paper in 2023, of which, 298 (93.13%) passed, whereas 22 (6.87%) failed. Thus, the candidate's performance in Electrical Engineering was good. The candidates' grade scores are presented in Table 1.

Table 1: Candidates' Grade Scores in the Year 2023

Year	Clean Data	Passed		Failed		Percentage of Candidates and their Grade of Scores				
		No.	%	No.	%	A	B	C	D	F
2023	320	298	93.13	22	6.87	22	47	160	69	22

2.0 THE ANALYSIS OF THE CANDIDATE'S RESPONSES TO EACH QUESTION

This part analyses the performance of the candidates in sections A, B, and C. It presents the strengths and weaknesses of the candidates as they respond to each question.

2.1 SECTION A: OBJECTIVE QUESTIONS

This section consisted of questions 1 and 2, totaling 16 marks. Question 1 consisted of 10 multiple-choice items with ten (10) marks, and question 2 consisted of 6 matching items with six (6) marks. For question 1, the performance is regarded as good if the score ranges from 7 to 10 marks, average if the score ranges from 3 to 6 marks and weak if the score ranges from 0 to 2 marks. For question 2, the performance is regarded as good if the score ranges from 4 to 6 marks; average if the score range from 2 to 3 marks and weak if the score range from 0 to 1 mark. The analysis of their responses is as follows:

2.1.1 Question 1: Multiple Choice Items

The question consisted of 10 multiple-choice items (i-x) covering the following topics: *Units, D.C. Circuits, Electrical Workshop Orientation, Illumination, A.C Machines, Transformers, and Cells and Batteries*. The candidates had to choose the correct answer from the five given alternatives (A to E).

A total of 320 (100%) candidates attempted this question. Among them, 11 (3.44%) scored from 0 to 2 marks, 155 (48.43%) scored from 3 to 6 marks, and 154 (48.13%) scored from 7 to 10 marks. Figure 1 illustrates the candidates' performance in this question.

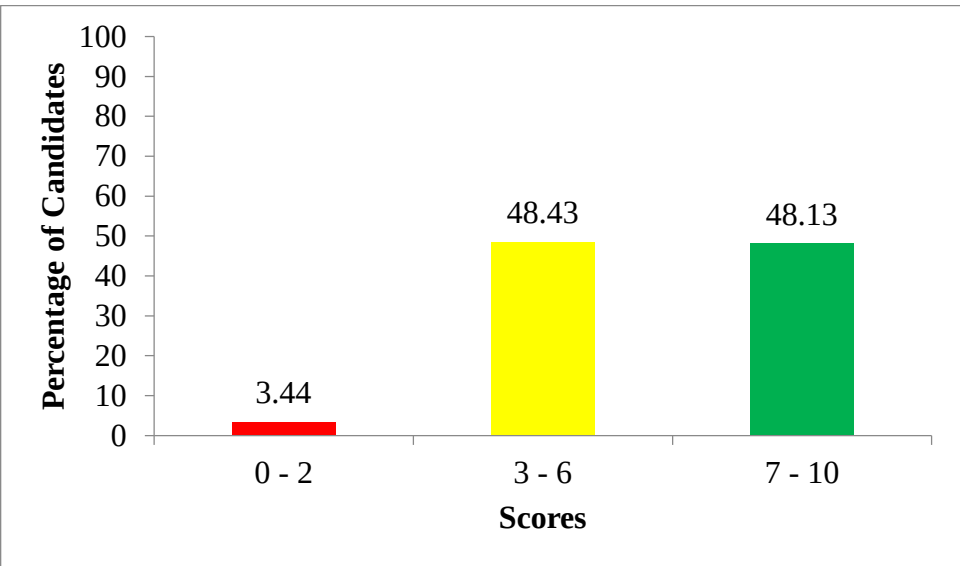


Figure 1: *The Candidates' Performance in Question 1*

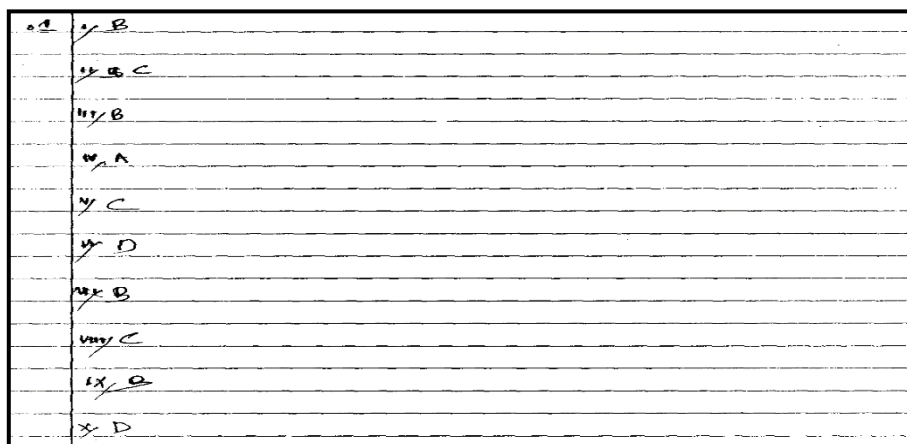
Figure 1 shows that the candidates' general performance on this question was good since 309 (96.56%) had average or above. These candidates chose the correct responses to almost all the items, implying they had adequate knowledge of the covered content. Extract 1.1 shows a sample of candidate's good responses.

Q.N	I	II	III	IV	V	VI	VII	VIII	IX	X
ANS	D	A	D	C	E	A	C	B	C	B

Extract 1.1: A sample of good responses to Question 1

In Extract 1.1, the candidate correctly chose nine items out of ten. For item (ix), the candidate incorrectly chose C instead of E. None of the candidates scored all marks in this question.

Despite the candidates' good performance on this question, 11 (3.44%) had weak performance. These candidates failed to select at least two correct answers out of ten given items. This indicates that they had inadequate knowledge on the subject contents covered by these items. Extract 1.2 shows a sample of candidate's incorrect responses.



Extract 1.2: A sample of incorrect responses to Question 1

In Extract 1.2, the candidate failed to provide the correct answers to any of the items indicating that he/she had inadequate knowledge about the topics asked in the question.

The analysis of candidates' responses to each item from (i) to (x) is as follows:

Item (i) was constructed from the topic of *Units*. It was intended to measure the candidate's knowledge on units of measurement used for electrical energy consumption. The question was as follows;

Mr Kipara is a domestic consumer of electrical energy in Tanzania, and he wants to make payment for his bill in October 2023. In which unit will the quantity be measured?

- | | | |
|--------------------|------------------|------------------|
| A Kilo-ampere-hour | B Kilowatt | C Kilovolt-hour. |
| D Kilowatt-hour | E Kilojoule-hour | |

The data analysis shows that many candidates responded correctly by selecting alternative D, *Kilowatt-hour*. These candidates demonstrated their ability to associate electrical quantities with their respective units of measure. Those who selected the incorrect alternative, A, *Kilo-ampere-hour*, might have confused it with *Kilowatt-hour*, which was the correct answer as both involve units of electrical measurement. However, a kilo-ampere-hour is a unit of electric current, not energy consumption. The analysis further reveals that some of them opted for alternative B, *Kilowatt*, because they failed to recognise that *Kilowatt* is a unit of power and not energy consumption. On the other hand, those who selected C, *Kilovolt-hour*, might have mistaken *Kilovolt-hour* for the correct answer, *Kilowatt-hour*, as they needed to understand that *Kilovolt-hour* is a unit of electrical potential energy and not energy consumption. Likewise, the candidates who selected option E, *Kilojoule-hour*, might have mistakenly thought that it is a valid unit of measurement for electrical energy consumption simply because a *joule* is the standard unit of energy. However, this unit is not standard in electricity billing or electrical energy measurement.

Item (ii) was set from the *D.C Circuits* topic. It aimed to assess the candidate's set of skills to identify the characteristics of parallel circuits and ability to apply the relevant formula to calculate total resistance in such circuits. The question was as follows:

Suppose you are required to build a parallel circuit with two resistors, R_1 and R_2 . Which formula would represent the circuit?

$$\begin{array}{lll} \text{A} & \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}. & \text{B} \quad R_T = \frac{1}{R_1 + R_2}. \quad \text{C} \quad R_T = R_1 + R_2 \\ \text{D} & R_T = \frac{R_1 + R_2}{R_1 R_2}. & \text{E} \quad R_T = \frac{2R}{R_1 + R_2}. \end{array}$$

Most of the candidates selected alternative A, $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$, which was the correct answer. These candidates had adequate knowledge of *D.C circuits*. They understood that in a parallel circuit, the total resistance is inversely proportional to the sum of the reciprocals of the individual resistances. A

few candidates selected alternative B, $R_T = \frac{1}{R_1 + R_2}$. This option presents a

formula for calculating total resistance in a series circuit, which does not apply to the given scenario. Others selected alternatives C, $R_T = R_1 + R_2$. These Candidates might have confused between series and parallel circuits. They were supposed to understand that, in a series circuit, the total resistance is simply the sum of the resistances of each component (resistors) connected in series. Each resistor's resistance adds linearly to find the circuit's total resistance. In a parallel circuit, the total resistance is equal to the reciprocal of the sum of the reciprocals individual resistances. Those who selected options D and E lack knowledge about *D.C Circuits*, particularly in parallel circuits and the formula for calculating total resistance. Hence, they were guessing the answer.

Item (iii) was constructed from the topic of *Electrical Workshop Orientation*. The question measured the candidate's ability to identify the application of different hand tools used in electrical work, specifically for twisting several conductors in a junction box. The question was as follows;

You are required to twist several conductors in a junction box. Which hand tools would you use to accomplish the task?

- | | | |
|----------------------------|------------------------|----------------------|
| A <i>Side cutter</i> | B <i>Wire stripper</i> | C <i>Screwdriver</i> |
| D <i>Combination plier</i> | E <i>Clow hummer</i> | |

The correct response was D, *Combination plier*. The candidates who opted for this alternative had acquired enough knowledge about *Electrical Workshop Orientation*, particularly the concept of electrical tools and their uses. They understood that a combination plier is a versatile tool commonly found in electricians' toolboxes due to its ability to perform multiple tasks efficiently, including twisting wires.

Those who opted for alternative A, *Side cutter*; B, *Wire stripper*; C, *Screwdriver*; and E, *Clow hummer*, lacked the skills of assessing the suitability of tools for a specific task. These candidates may also have lacked practical experience of using hand tools for electrical tasks, which made them fail to decide which tool would be most appropriate for twisting

conductors in a junction box. The candidates should understand that a *side cutter* is designed to cut wires cleanly and precisely and not to twist conductors. Wire strippers are designed to remove the insulation from wires without damaging the conductor underneath. They are not ideal for twisting wires together as they lack gripping and twisting capabilities. Screwdrivers are used for driving or removing screws. They are unsuitable for twisting wires together as they lack the necessary features for securely grasping and holding wires. Also, a claw hammer is primarily used for driving nails or extracting them. It lacks the precision and grip required for twisting wires together.

Item (iv) was set from the topic of *Illumination*. It assessed the candidates' knowledge and skills of lighting schemes, particularly electric circuits associated with fluorescent lamps and starters. The question was as follows;

A fluorescent lamp circuit has a capacitor which is incorporated with a starter. What is the function of the capacitor?

- | | | | |
|---|--------------------------|---|------------------------|
| A | To limit fluctuation. | B | To increase impedance. |
| C | To correct power factor. | D | To rectify power. |
| E | To decrease impedance. | | |

The correct response was C, *To correct power factor*. The candidates who chose the correct response demonstrated a greater understanding of the concepts related to *Illumination*, particularly the lighting scheme. On the contrary, those who selected incorrect response A, *To limit fluctuation*, should realised that this is not typically the primary function of the capacitor in a fluorescent lamp circuit with a starter. In a fluorescent lamp circuit, voltage fluctuations generally are minimised or controlled by using a ballast. The candidates who responded to B, *To increase impedance*; D, *To rectify power*; and E, *To decrease impedance* did not understand that the capacitor is incorporated with the starter in a fluorescent lamp circuit so as to correct the power factor. Fluorescent lamps are inductive loads, which can cause a lagging power factor in the circuit. The capacitor helps to offset this lagging power factor, by improving the overall efficiency of the circuit.

It does not rectify power, limit fluctuation, increase impedance or decrease impedance in this context.

Item (v) was set from the topic of *A.C Machines*. It assessed the candidates' ability to apply their knowledge of induction motor operation and power factor correction to identify the function of phase advancers. The question was as follows:

Why phase advancers are connected in parallel with induction motors?

- | | |
|-----------------------------------|-----------------------------------|
| A <i>To reduce vibrations.</i> | B <i>To reduce copper losses.</i> |
| C <i>To control motor speed.</i> | D <i>To reduce noise.</i> |
| E <i>To improve power factor.</i> | |

The correct alternative was E, *To improve the power factor*. The candidates who selected this option understood well the effect of connecting a phase advancer in parallel with induction motor. Phase advancers are connected in parallel with induction motors to improve the motor's power factor. This is done by providing additional magnetising current to the motor, which helps to bring the current waveform closer to the voltage waveform, by improving the power factor. Other candidates wrongly selected option A, *To reduce vibration*. These candidates failed to understand that vibrations in motors can be caused by various factors such as mechanical imbalances, misalignment, or resonance. Addressing vibrations typically involves mechanical adjustments or improvements to the motor's design or installation rather than electrical modifications like phase advancers.

On the other hand, the candidates who selected alternative B, *To reduce copper loss*, C, *To control motor speed* and D, *To reduce noise*, lacked knowledge about the concepts tested regarding *A.C Machines*. Although candidates were familiar with induction motors and power factor correction, they struggled to apply this knowledge to the scenario presented in the question. They were unable to connect the function of phase advancers with improving the power factor.

Item (vi) was constructed from the topic of *Transformers*. This question aimed to test the candidate's understanding on transformer construction

principles and the reasons behind the use of specific materials such as thin layers of silicon steel. The question was as follows:

Why transformer core is constructed by using the assembly of thin layers of silicon steel material?

- A *To limit fluctuation* B *To increase impedance*
- C *To correct power factor* D *To rectify power*
- E *To decrease impedance*

Most candidates correctly responded to this item by selecting alternative A, *To reduce eddy current losses*. Candidates recognised that the use of thin layers of silicon steel increases the resistance to the flow of the eddy currents due to the laminated structure and effectively reduce the losses associated with them. They were also familiar with transformer construction principles, especially magnetic core lamination. However, those who opted for option B, *To increase heat losses*; C, *To reduce the voltage in secondary*; D, *To increase current in the primary*; and E, *To increase the voltage in primary*, lacked a comprehensive understanding on how transformers work, including the relationship between the core material and losses. Therefore, they could not relate the significance of using thin layers of silicon steel and reduction of losses.

Item (vii) was set from the topic of *D.C Circuits*. The candidates were tested on their ability to relate the cross-sectional area of a conductor and various electrical properties. The item also tested the candidates' knowledge on electrical principles, particularly Ohm's Law and the factors affecting resistance. The question was as follows:

What will be the effect if the cross-sectional area of a conductor is doubled?

- A *The length of that conductor will be halved.*
- B *The diameter of that conductor will be halved.*
- C *The resistance of that conductor will be halved.*
- D *Resistivity of the conductor will be doubled.*
- E *The length of that conductor will be doubled.*

The correct response was C, *The resistance of that conductor will be halved*. The candidates who chose the correct answer had adequate knowledge about *D.C Circuits*. According to Ohm's Law ($V = IR$), resistance (R) is inversely proportional to the cross-sectional area (A) of the conductor. Therefore, if the cross-sectional area is doubled, the resistance will be halved. A larger cross-sectional area provides more paths for current flow, consequently resistance is reduced. Some of the candidates incorrectly selected alternatives A, *The length of that conductor will be halved* and E, *The length of that conductor will be doubled*, as they could not realize that changing the cross-sectional area of a conductor does not affect its length. Length and cross-sectional area are independent variables. The candidates who opted for alternative B, *The diameter of that conductor will be halved*, were wrong because doubling the cross-sectional area does not necessarily halve the diameter of the conductor. The diameter depends on the shape of the conductor, which may remain the same when only the cross-sectional area is altered. However, the candidates who selected alternative D, *The Resistivity of the conductor will be doubled*, were not familiar with Ohm's Law and its application; therefore, incorrectly assumed relationships between variables without considering the relevant principles. The candidates were supposed to understand that the resistivity of a material is a property that does not change based on the cross-sectional area of the conductor. It depends on the material itself, not its dimensions.

Item (viii) assessed the candidates' ability to apply their knowledge of electrical principles, such as Ohm's Law and power ratings and provide the reasons of connecting appliances to power sockets rather than lamp sockets. The item was constructed from the topic of *Illumination* and was as follows;

Why electrical appliances are connected to the power sockets and not to lamp socket?

- A *Power socket allow more current to flow.*
- B *Power socket are always earthed.*
- C *The rate of charge for power sockets is cheaper.*
- D *The voltage of power socket is higher.*
- E *Power sockets always are not earthed.*

The correct response was B; *Power socket are always earthed*. The candidates who chose the correct response demonstrated a greater understanding on the concepts related to *Illumination*, particularly in determining the most suitable socket type for connecting electrical appliances. These candidates understood that power sockets are typically designed to be earthed as part of electrical safety standards and regulations. Earthed sockets provide an additional safety measure in electrical systems by connecting the electrical circuit to the ground. The grounding helps to protect against electric shock in case of faults or malfunctioning appliances. On the contrary, for those who selected incorrect response A, *Power socket allows more current to flow*, did not know that the amount of current flowing depends on the appliance and its power requirements, not just the socket type. Likewise, for the candidates who selected C, *The rate of charge for power sockets is cheaper*; were supposed to understand that the cost of electricity is not determined by the socket type rather by the electricity provider and the tariff plan. The socket type does not affect the rate of charge. Few candidates who opted for D, *The voltage of power socket is higher*, lacked knowledge about electrical appliances and sockets. These candidates were supposed to understand that the voltage supplied to power sockets is standardised regardless of the socket type. The voltage remains the same whether it's a power socket or a lamp socket (the voltage remains constant across different sockets). Those who selected E, *Power sockets are not always earthed*; lacked knowledge about electrical safety standards and practices.

Item (ix) was set on the topic of *Cells and Batteries*, and it aimed to test the candidates' ability to apply the knowledge of electrochemistry and to rectify a local action fault in a primary cell. The question was as follows:

How can a local action fault in the primary cell be rectified?

- A *By amalgamating the copper electrode with mercury.*
- B *By amalgamating the copper electrode with lead acid.*
- C *By amalgamating the zinc electrode with lead acid.*
- D *By amalgamating the zinc electrode with alkaline.*
- E *By amalgamating the zinc electrode with mercury.*

The correct response was E, *By amalgamating the zinc electrode with mercury*, because this action involves coating the surface of the zinc with a thin layer of mercury. This process helps to suppress local action by forming an amalgam layer that protects the zinc surface from further corrosion. The mercury acts as a barrier, preventing the impurities from coming into contact with the electrolyte and reduces the occurrence of self-discharge. Nevertheless, some candidates responded incorrectly by choosing option A, *By amalgamating the copper electrode with mercury*. They were not aware that local action faults typically occur at the zinc electrode, not at the copper electrode. Those who selected B, *By amalgamating the zinc electrode with lead acid*, C, *By amalgamating the zinc electrode with lead acid* and D, *By amalgamating the zinc electrode with alkaline*, demonstrated a weak understanding on *Cells and Batteries*, specifically primary cells.

Item (x) was set from the topic of *Electrical Workshop Orientation*. It was intended to measure the candidates' understanding on the importance of safety rules and precautions in an electrical workshop. The question was as follows:

Before studying practical works in electrical workshop, students are instructed on safety rules and precautions to consider when working in the workshop. Why is it important to study them?

- A *In order to maintain workshop discipline.*
- B *In order to prevent accidents in a workshop.*
- C *In order to know various workshop rules and regulation.*
- D *In order to create students confidence in the workshop.*
- E *In order to be familiar with job descriptions of the workshop.*

The correct response was B, *To prevent accidents in a workshop*. The candidates who opted for this option demonstrated a fair understanding on safety rules and precautions that should be taken in an electrical workshop. Overall, the emphasis on accident prevention is a fundamental aspect of safety training in any workshop setting. The candidates selected this option because it aligns with the basic understanding of the purpose of safety rules

and precautions. However, those who opted for alternative A, *To maintain workshop discipline*, could not realise that maintaining discipline is essential in a workshop setting but the primary purpose of studying safety rules and precautions is to ensure the safety of individuals working in the workshop, rather than only focusing on discipline. On the other hand, the candidates who opted for C, *To know various workshop rules and regulations*, were wrong because safety rules and precautions specifically focus on preventing accidents and injuries rather than just knowing the rules. Likewise, those who selected D, *In order to create students' confidence in the workshop*, failed to realise that the primary goal of instructing safety rules and precautions is to prevent accidents rather than solely focusing on students' confidence building. Those who selected option E, *In order to be familiar with job descriptions of the workshop* were also wrong. These candidates were supposed to understand that safety rules and precautions are more concerned with ensuring the physical safety of individuals rather than familiarising them in job descriptions.

2.1.2 Question 2: Matching Items

The question was set from the topic of *D.C Circuits*. The question required the candidates to match the electric circuit characteristics in List A with the corresponding terms in List B by writing a letter of the correct response beside the item number in the answer booklet provided. The question was as follows:

Match the electric circuit characteristics in **List A** with the corresponding terms in **List B** by writing a letter of the correct response beside the item number in the answer booklet provided.

List A	List B
(i) A conducting path through which an electric can flow.	A Non-linear circuit
(ii) Its parameters are constant.	B Passive network
(iii) Its parameters change with voltage or current.	C An electric circuit
(iv) Properties are the same in either direction.	D Linear circuit
(v) Developed when a number of parameters or electric elements combine in any arrangement.	E Active network
(vi) Contain one or more than one source.	F Unilateral circuit
	G Bilateral circuit
	H Electric network

A total of 320 (100%) candidates attempted this question. Among them, 105 (32.81%) scored from 0 to 1 mark; 133 (41.56%) scored from 2 to 3 marks; and 82 (25.63%) scored from 4 to 6 marks. Figure 2 shows the distribution of the candidate's scores on the question.

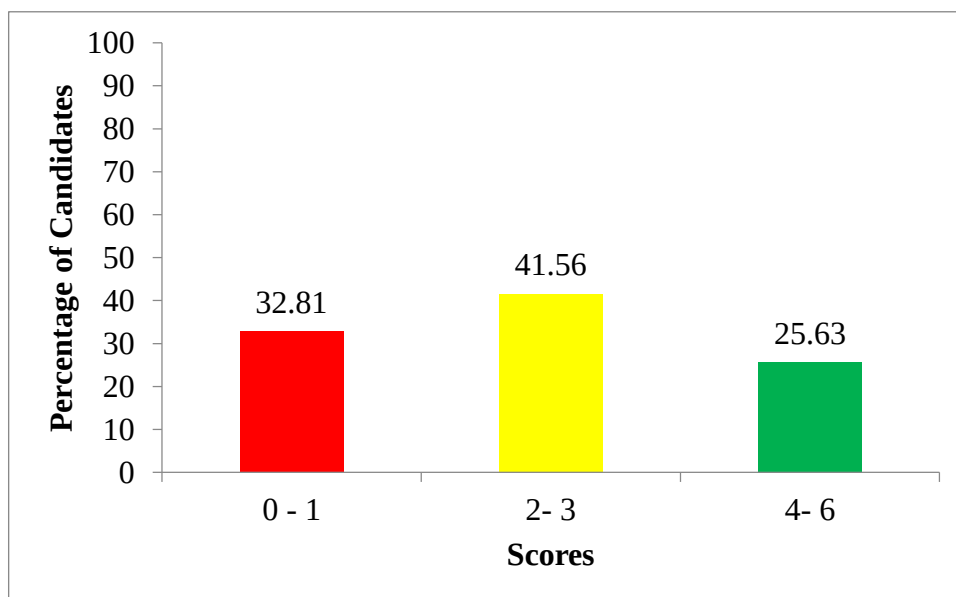


Figure 2: The Candidates' Performance in Question 2

Figure 2 indicates that the candidates' performance in this question was good because 215 (67.19%) passed as they scored from 2 to 6 marks. These candidates matched most or all the items correctly. This implies that the candidates had sufficient knowledge about the concepts tested from the topic of *D.C Circuits*, especially in the area which covers electric circuits' characteristics. On the other hand, 105 (32.81%) candidates had weak performance. Among them, 25 (7.82%) scored zero. These candidates demonstrated insufficient knowledge of the tested concepts regarding *D.C Circuits*. They misinterpreted the characteristics described in List A and incorrectly matched them with terms in List B. For example, they have mistaken the characteristics of linear circuits for those of nonlinear circuits or vice versa. The analysis of candidates' responses to each item is as follows:

Item (i) stated that: *A conducting path through which electric current can flow*. The correct response was C, *an electric circuit*. The candidates who matched the item correctly demonstrated their ability to understand the fundamental definition of an electric circuit. They recognised that the item describes an electric circuit's primary function or characteristic, providing a path for the flow of electric current. Some candidates incorrectly misinterpreted the characteristics and matched the item with H (*Electric network*). These candidates failed to understand that the characteristic described in item (i) refers to a broader network or system of electrical components rather than simply a conducting path for electric current. They might have thought that an "electric network" encompasses the concept of a conducting path, leading them to the wrong selection. Candidates who incorrectly matched with the rest of the alternatives needed to gain more knowledge on the basic principles of electric circuits and their fundamental characteristics.

Item (ii) stated that: *Its parameters are constant*. The correct response was D, *Linear circuit*. The candidates who correctly matched this item demonstrated knowledge and understanding on the characteristics of linear circuits. Other candidates mismatched this item. For example, one candidate wrongly matched the item with response E, *Active network*,

instead of D, *Linear circuit*. This candidate demonstrated a partial understanding on linear and nonlinear circuits. The candidates were supposed to understand that while active networks can exhibit linear behaviour under certain conditions, not all active networks are linear circuits. Therefore, there are similarities between active networks and linear circuits, but they are distinct concepts with different characteristics and applications.

Item (iii) stated that: *Its parameters change with voltage or current*. The correct answer was A, *Non-linear circuit*. Candidates who selected this option had good understanding of the behaviour of non-linear circuits. They recognised that the parameters change with voltage or current in non-linear circuits, leading to non-linear relationships between input and output variables. On the other hand, some candidates wrongly matched this item with option G, *Bilateral circuit*. These candidates wrongly associated the term "parameters change with voltage or current" with a bilateral circuit. However, both bilateral and non-linear circuits can exhibit behaviour independent of the direction of current flow. In bilateral circuits, the relationship between voltage and current remains the same regardless of the direction of current flow. In contrast, the electrical properties may change in non-linear circuits irrespective of the current direction.

Item (iv) stated that: *Properties are the same in either direction*. The correct response was F, *Unilateral circuit*. Most of the candidates matched this item correctly. This implies that the candidates had sufficient knowledge about electric circuit characteristics. They clearly understood that "unilateral" typically refers to something that only occurs or acts in one direction. Therefore, in the context of electrical circuits, a unilateral circuit is one in which its properties vary depending on the direction of current flow. Examples of unilateral circuits include rectifiers, which allow current to flow in one direction only. In contrast, some candidates incorrectly matched this item with the rest of the responses. These candidates lacked knowledge related to electric circuit characteristics. They needed a solid understanding of the concepts and principles related to electric circuits.

They should be familiar with terms such as linear, non-linear, bilateral, and unilateral circuits and their associated characteristics.

Item (v) stated that: *Developed when a number of parameters or electric elements combine in any arrangement.* The candidates who opted for H, *Electric network* got it correct. These candidates demonstrated to have a good understanding of electrical systems and networks, including how components are interconnected to form functional systems. On the other hand, candidates who incorrectly matched the item with the remaining options lacked knowledge of electric circuit characteristics and the ability to interpret the characteristics provided in the question.

Item (vi) stated that: *It contains one or more source.* The correct answer was E, *Active network*. The candidates' who accurately matched the items had a comprehensive understanding of active components and their role in electrical circuits. They recognise that, in an electrical system, an "active network" refers to a network or circuit that contains active components capable of generating, amplifying, or processing electrical signals. It is a device which can control the flow of electrical energy and perform signal manipulation or amplification functions; hence, it requires a source of electrical power to operate. The candidates who incorrectly matched this item might lack a clear understanding of what constitutes an active component in an electrical circuit. They could not recognise that active components, such as transistors or operational amplifiers, require a source of electrical energy to function. Extracts 2.1 and 2.2 are the samples of the candidate's correct and incorrect responses, respectively.

Q.	i.	C
	ii.	D
	iii.	A
	iv.	F
	v.	H
	vi.	E

Extract 2.1: A sample of correct responses to Question 2

In Extract 2.2, the candidate correctly matched six electric circuit characteristics in List A with their respective terminology in List B.

2	LIST A	LIST B
	I	A
	II	E
	III	B
	IV	H
	V	G
	VI	D

Extract 2.2: A sample of incorrect responses to Question 2

Extract 2.2 shows that the candidate did not provide relevant responses to all the items. The candidate incorrectly matched all the items in List A to those in List B. This suggests that the candidate had a weak understanding of *D.C Circuits*, particularly electric circuit characteristics.

2.2 SECTION B: SHORT ANSWER QUESTIONS

This section had six (06) compulsory short answer questions, which carried 09 marks each, totalling 54 marks. The performance is regarded as good if the score range from 6.0 to 9.0 marks, average if the score range from 3.0 to 5.5 marks and weak if the score range from 0 to 2.5 marks for each question in this section. The analysis of their responses is as follows:

2.2.1 Question 3: Transformers

The question consisted of five parts, (a), (b), (c), (d), and (e), which were designed to assess the candidates' ability to apply mathematical formulas to calculate transformer parameters based on given data. The question was as follows;

A customer brought a faulty transformer at your school workshop for a service. The transformer is specified to operate at 40 kVA single-phase with 400 and 100 number of turns on the primary and secondary, respectively. The primary side of a transformer is designed to be connected to a 2000 V; 50 Hz supply. Calculate the following transformer parameters to fulfil the customer's requirement:

(a) Secondary voltage on open circuit.

- (b) *Primary current.*
- (c) *Secondary current.*
- (d) *Maximum value of flux.*
- (e) *The volt per turn on the secondary side.*

Based on the statistical data, out of the 320 (100%) candidates who attempted this question, the minority of them, 35 (10.93%), scored from 0 to 2.5 marks, while 42 (13.13%) of the candidates scored from 3 to 5.5 marks and 243 (75.94%) of the candidates scored from 6 to 9 marks. The overall performance was good since 285 (89.07%) performed well. The candidate's performance in this question can be seen in Figure 3.

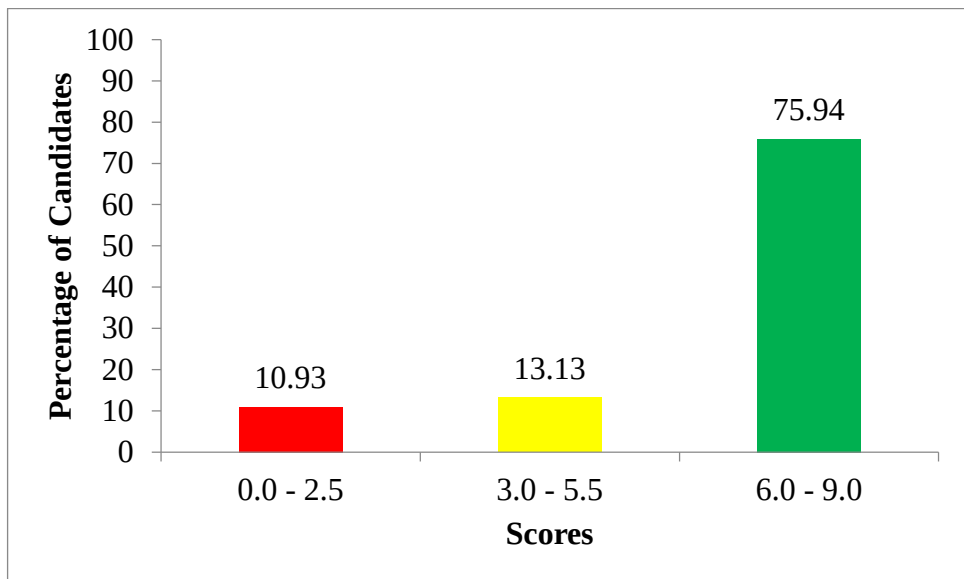


Figure 3: *The Candidates' Performance in Question 3*

According to the statistical data, most of the candidates, 285 (89.07%), performed well by scoring 3 to 9 marks on this question. Most of them succeeded to apply the appropriate mathematical formula to calculate secondary voltage in an open circuit, primary current, secondary current, maximum flux value, and the volt per turn on the secondary side. Extract 3.1 provides examples of correct responses to question 3.

3

data given

Apparent power (S) = 40 kVA

$$N_1 = 400 \text{ turns}$$

$$N_2 = 100 \text{ turns}$$

$$V_1 = 2000 \text{ V}$$

$$f = 50 \text{ Hz}$$

Task a) Secondary voltage on open circuit from

$$\frac{N_1}{N_2} = \frac{V_1}{V_2}$$

$$\frac{N_2}{N_1} = \frac{V_2}{V_1}$$

$$V_2 = \frac{V_1 N_2}{N_1}$$

$$V_2 = \frac{2000 \text{ V} \times 100}{400}$$

$$V_2 = 500 \text{ V}$$

∴ The secondary voltage is 500V

b) Primary current from

$$P = I_1 V_1$$

$$I_1 = \frac{P}{V_1}$$

$$I_1 = \frac{40,000 \text{ VA}}{2000 \text{ V}}$$

$$I_1 = 20 \text{ A}$$

∴ The primary current is 20A

3	e)	Secondary current $\text{from } \frac{V_1}{V_2} = \frac{N_2}{N_1} = \frac{I_2}{I_1}$ $N_1 = \frac{I_2}{I_1}$ $I_2 = \frac{N_1 I_1}{N_2}$ $I_2 = \frac{400 \times 30}{100}$ $I_2 = 80 \text{ A}$ ∴ The Secondary current is 80A
	d)	Maximum value of flux $\text{from } E_1 = 4.44 f_1 N_1 \Phi_m$ $\Phi_m = \frac{E_1}{4.44 f_1 N_1}$ $= \frac{2000 \text{ V}}{4.44 \times 50 \times 400}$ $= 0.0235295 \text{ wb}$ $\approx 0.023 \text{ wb}$ ∴ The Maximum flux is 0.023wb
	e)	The voltage per turn on the secondary side $E_1 = 4.44 f_1 N_1 \Phi_m$ $\frac{E_1}{N_1} = 4.44 f_1 \Phi_m$
3	e)	$\frac{E}{N} = 4.44 \times 50 \times 0.0235$ $\frac{E}{N} = 5 \text{ V/turn}$ ∴ The voltage per turn is 5V/turn.

Extract 3.1: A sample of the correct responses to Question 3

In Extract 3.1, the candidate demonstrated the ability to recall and apply an appropriate formula to calculate the values for parts (a), (b), (c), (d) and (e), signifying he/she had adequate knowledge on *Transformer*.

However, the analysis shows that 35 (10.93%) candidates scored low marks. These candidates failed to apply the correct formula for parts (a)-(e) to calculate the required parameters. For instance, in response to part (a), one candidate used an incorrect formula to find the secondary voltage by

writing $\frac{V_p}{V_s} = \frac{N_s}{N_p}$ instead of $\frac{V_p}{V_s} = \frac{N_p}{N_s}$. Others copied the given data

without attempting either of the items. The incorrect answers indicate that the candidates lacked sufficient understanding on the concepts tested in the topic of *Transformers*, especially in the computational part. Extract 3.2 illustrates such responses.

3	Data given Primary Turns = 4000 Secondary Turns = 100 N Primary voltage = 2000 Frequency = 50 Hz Secondary Voltage = α Primary Current = α Maximum value of flux = 20 The vol per turn on the Secondary $I_T = 210 \text{ kVA}$ a) Secondary voltage on open circuit From the formula $\frac{V_p}{V_s} = \frac{N_p}{N_s} \frac{I_s}{I_p}$ Solution $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\frac{2000}{\alpha} = \frac{4000}{100}$ $\frac{2000 \times 100}{4000} = \frac{\alpha \times 4000}{4000}$ $\alpha = \frac{20000}{4000}$ $\alpha = 50 \text{ V}$ The secondary voltage is 50V
---	--

Primary Current.

From the Formula

$$\frac{V_p N_p I_s}{V_s N_s I_p}$$

Soln

$$\frac{N_p I_s}{N_s I_p}$$

$$\frac{400N}{100N} \times \frac{40kVA \times 10^3}{2}$$

$$\frac{400N \times 2}{400N} = \frac{100N \times 40kVA \times 10^3}{400N} = \frac{4000000}{400}$$

Primary Current = 100 000 A

∴ The Primary Current is 100 000 A.

Secondary Current

Formula

$$\frac{V_p I_s}{V_s I_p}$$

$$\frac{200V I_s}{50V \times 100000}$$

$$\frac{200V \times 100000A}{50V} = \frac{50V \times I_s}{50V}$$

$$= \frac{20000000}{50} = 400000A$$

The Secondary Current is 400000A.

Maximum value Flux

$$\Phi = VI \sin \phi$$

$$50 \times 400000 \sin \phi$$

$$\Phi = 15$$

e)	The volt per turn on the secondary side
	$\frac{V}{N} = \frac{50}{100}$
	$= 500 \text{ volt / turn}$
	$\frac{E_2}{N_2} = \frac{500 \times 100}{100}$
	$= 5000 \text{ volt / turn}$
	Answer:
	The volt per turn on the secondary side is 5000

Extract 3.2: A sample of incorrect responses to Question 3

In Extract 3.2, the candidate wrongly copied the data from the question. For instance, he/she copied $E_s = 200 \text{ V}$ instead of $E_s = 2000 \text{ V}$, leading to incorrect computation, though the candidate had the correct formula, $E_2 = \frac{E_1 \times N_2}{N_1}$ in part (a). Also, the candidate failed to interpret that the 40 kVA

given is the transformer power rating and not the current. It is the kilo Volt-Ampere (kVA) rating of an electrical transformer that indicates the size and nature of the electrical load that the transformer can endure. It is necessary to consider the maximum load that the device is expected to be compatible with. The equation he/she used $\frac{N_p}{N_s} = \frac{I_s}{I_p}$ was correct only if I_p was given.

This led to incorrect computation for parts (b) and (c). In part (d), the candidate used the wrong formula; instead of; $\phi_m = \frac{E_2}{4.44 \times f \times N_2}$, the

candidate equated $\text{flux} = V I \sin \theta$; which is the formula for calculating reactive power. It is unrelated to the subject posed since it relates to inductive and capacitive A.C loads, where θ is the phase angle between voltage and current. The candidate generally did not comprehend that electric transformer calculations are necessary for numerous safeguards to preserve transformer efficiency for load power handling.

2.2.2 Question 4: Measuring Instruments

This question intended to test the candidates' ability to calculate the resistance required to extend the reading range of a moving coil instrument, which is about the basic principles of parallel and series connections in electrical circuits. The question was as follows:

Suppose you are in a school workshop and you have been asked to measure various electrical quantities. Before starting your measurement, you found out that the workshop has only a permanent magnet moving coil instrument which is designed to give a full-scale reading of 25 mA when the potential difference across its terminal is 75 mV. To extend the range of the instrument, calculate the resistance to be connected in:

- (a) *Parallel to enable the instrument to read up to 5 A.*
- (b) *Series to enable it to read up to 20 V.*

Analysis shows that, 320 (100%) candidates attempted this question. Out of those, 75 (23.44%) scored from 0 to 2.5 marks, 39 (12.19%) scored from 3 to 5.5 marks, and 206 (64.37%) scored from 6 to 9 marks. Overall, the candidates' performance was good, as 245 (76.56%) candidates passed. Figure 4 summarises the candidate's performance in this question.

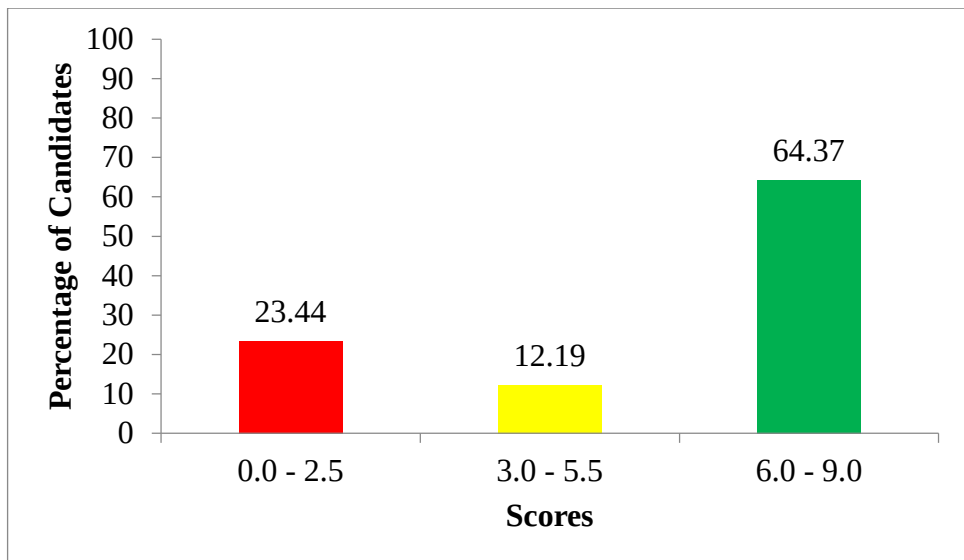


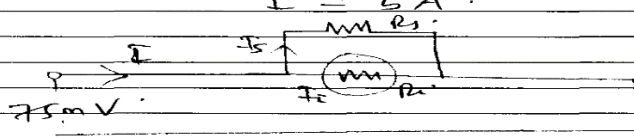
Figure 4: *The Candidates' Performance in Question 4*

According to the data, 245 (76.56%) of candidates scored from 3 to 9 marks, indicating their ability to apply the correct formula for determining the resistance value needed to enable the instrument to read up to 5 A in parallel and 20 V in series connection. Their responses indicate that they possess adequate knowledge about *Measuring Instruments*. Extract 4.1 displays a sample of correct responses from one of the candidates.

04. ^{given}
 full s.d (I_c) = 25 mA
 f.s.d = 75 mV

a) as ammeter

$I = 5A$



Resistance (R_s) = $\frac{I_c R_i}{I - I_c}$
 $= \frac{0.025 \times R_i}{5 - 0.025}$

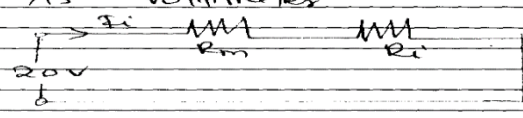
$R_i = \frac{V_c}{I_c} = \frac{75}{25} = 3 \Omega$

Then $R_s = \frac{0.025 \times 3}{5 - 0.025}$

04 a) $R_s = \frac{0.075}{4.975}$
 $R_s = 0.015075$
 $R_s \approx 0.0151 \Omega$

$\therefore$ The resistance have to be connected has value of 0.0151 Ω

b) As voltmeter



$V = 20V$

$R_i = \frac{75}{25} = 3 \Omega$

Resistance (R_m) = $\frac{V}{I_c} - R_i$
 $= \frac{20}{0.025} - 3$
 $= 800 - 3$
 $= 797 \Omega$

$\therefore$ The resistance is 797 Ω

Extract 4.1: A sample of correct responses to Question 4

Extract 4.1 shows that the candidate applied a correct formula to calculate the values of resistance required to be connected in parallel and in series with a moving coil instrument to meet the requirement of the question.

Despite good performance, 76 (23.44%) candidates scored low marks; among them 19 (25.00%) scored zero. These candidates failed to apply the correct formula in parts (a) and (b) to calculate the required resistance for parallel to enable the instrument to read up to 5 A and series to read up to 20 V from the given instrument setup. For example, one of the candidates had an idea that, Ohm law can be represented as $V = IR$ and therefore, directly divided $\frac{75 \text{ mV}}{5 \text{ A}}$ for part (a) without considering the mentioned 25 mA, which was to be subtracted from the (5 A). The candidates' incorrect answers suggest lack of understanding of *measuring instruments* concepts and inability to apply appropriate formulas. Extract 4.2 provides a sample of such responses.

4. (a)

$$R_m = \frac{I_m R_m}{I_a - I_m}$$

$$= \frac{25 \times 10^{-3} \times 75 \times 10^{-3}}{5 - 25 \times 10^{-3}} = 0.07 \text{ m}$$

4b) $R_m = \frac{V}{I_m} - R_m$

$$= \frac{20}{1 \times 10^{-3}} - 25 \times 10^{-2} = 1.9 \times 10^3$$

10b $\Rightarrow R_f = \frac{V}{I}$

$$R_f = \frac{0.2 - 0.1}{0.1} = 1$$

$$R_f = \frac{100}{0.1} = 1000 \text{ u}$$

Extract 4.2: A sample of incorrect responses to Question 4

In Extract 4.2, the candidate failed to understand that, for a range extension of voltage measurement in a moving coil instrument, a resistance is connected in series with internal meter resistance. For the constant value of current, resistance connected in a series connection has a higher voltage drop than a parallel or shunt connection. Thus, the value of the series resistance is given by $R_m = \frac{\text{potential drop across the terminal}}{\text{instrument current}}$, the shunt

resistance required for full-scale deflection corresponding to $R_{sh} = \frac{R_m}{\frac{I}{I_m} - 1}$.

Instead, the candidate failed to use the formulae to calculate parallel resistance to allow the instrument to read up to 5 A, and series resistance to enable it to read up to 20 V. However, in part (a), the candidate used an instrument amperage reading of 1 A instead of 5 A, resulting in an incorrect answer. Additionally, in part (b), the candidate mistakenly used

$R_m = 25 \text{ mA}$ in the equation instead of 3Ω , obtained from; $R_m = \frac{75 \text{ mV}}{25 \text{ mA}}$.

The candidate misinterpreted the given data, leading to an incorrect substitution in the equation. Additionally, the candidate lacked proper labelling, mistakenly labeled fuse for a resistor.

2.2.3 Question 5: Illumination

This question intended to test the candidates' ability to apply knowledge of illumination lighting schemes to compute the parameters for effective design based on the given specifications. The question assessed problem-solving skills by measuring candidates' ability to apply *Illumination* concepts to calculate lumens per lamp and mean spherical candle power for each lamp. The question was as follows:

Your school maintenance teacher asked you to assess the effectiveness of the lighting scheme for a reading room of (45 x 10) m in size. The room is illuminated by 20 lamps, which produces an average illumination of 35 lm/m². The utilisation factor and depreciation factor are considered to be 0.8 and 0.6, respectively. Find;

(a) *The total lumens required.*

- (b) *The lumens per lamp.*
- (c) *The mean spherical candle power of each lamp.*

According to the data, 320 (100%) candidates attempted this question. Among them, 111 (34.69%) scored from 0 to 2.5 marks, 113 (35.31%) scored from 3 to 5.5 marks, and 96 (30.00%) candidates scored from 6 to 9 marks. The performance was generally good, as 209 (65.31%) candidates passed. The summary of the candidate's performance in this question is shown in Figure 5.

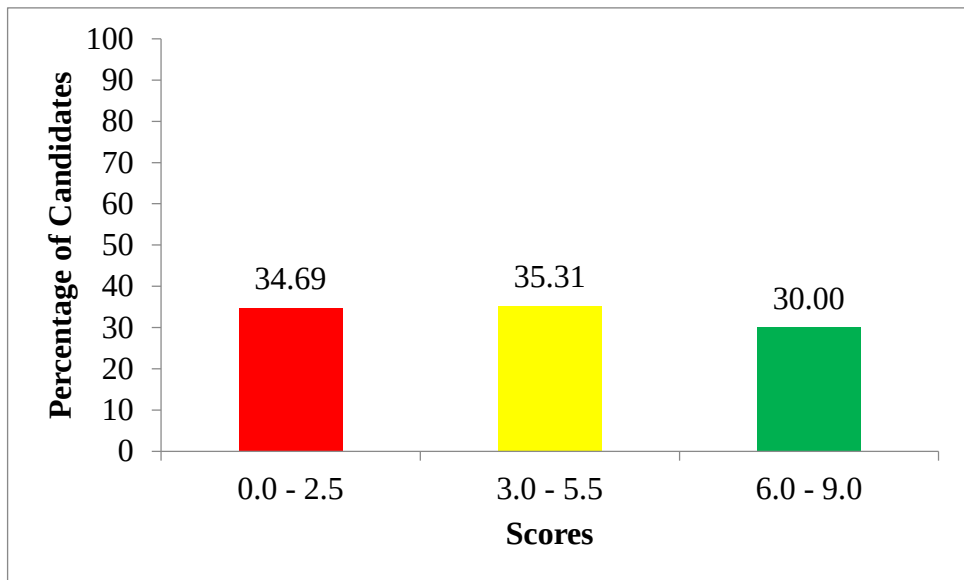


Figure 5: *The Candidates' Performance in Question 5*

Further, analysis indicates that 209 (65.31%) of the candidates with good performance demonstrated to have enough knowledge on *Illumination*. They demonstrated good computational skills in finding the values of the total lumens required, the lumens per lamp, and the mean spherical candle power of each lamp in parts (a)-(c). Extract 5.2 shows a sample of such responses.

Q5.	Soln.
	Data Given:
	Area of the room, $A = 45 \times 10 \text{ m}^2$.
	Number of lamps, $n_p = 20$.
	Illumination, $E = 35 \text{ lm/m}^2$.
	Utilization Factor, $u \cdot f = 0.8$.
	Depreciation factor, $d \cdot f = 0.6$.
	Required;
	a) The Total lumens Required Φ .
	From:
	$\Phi = \frac{E \times A}{M \cdot F \times U \cdot F}$
	but;
	$M \cdot F = \frac{1}{d \cdot f}$
	$M \cdot F = \frac{1}{0.6}$
	$M \cdot F = 1.66$
Q5.	a) Now. $\Phi = \frac{35 \text{ lm/m}^2 \times 45 \times 10 \text{ m}^2}{0.8 \times 1.66}$
	$\Phi = 11859.929 \text{ lm} \approx 11859.94 \text{ lm}$
	$\therefore$ Total lumens required is 11859.94 lm .
	b) The Lumens Per lamp Φ/l_p .
	From:
	$\Phi/l_p = \frac{\Phi}{n_p}$
	$\Phi/l_p = \frac{11859.94 \text{ lm}}{20 \text{ lamps}}$
	$\Phi/l_p = 592.997 \text{ lm/lamp}$
	$\therefore$ There is 592.997 lumens per lamp.
	c) The mean spherical candle power per lamp.
	From: $M \cdot S \cdot C \cdot P = \frac{\Phi \text{ per lamp}}{\omega}$
	But:
	$\omega = 4\pi$ ----- since it is spherical.
	Then $M \cdot S \cdot C \cdot P = \frac{592.997 \text{ lm}}{4\pi \text{ steradians}}$
	$M \cdot S \cdot C \cdot P = 47.489 \text{ Cd}$
	$\therefore$ Mean spherical candle power per lamp is 47.489 Cd .

Extract 5.1: A sample of correct responses to Question 5

In Extract 5.1, the candidate provided the correct responses using the proper formula and following the correct computation procedures. This signifies that he/she had adequate knowledge of the *Illumination* topic, specifically the illumination scheme.

On the contrary, 111 (34.69%) candidates who scored low marks (0 to 2.5), failed to calculate the total lumen per lamp and the mean spherical candle power for each lamp. They seemed to have difficulty in remembering and applying the appropriate formula for parts (a)-(c). For instance, some wrote an incorrect formula,

lumen = $\frac{ExA}{MF \times DF \times \theta}$ instead of

Total lumen = $\frac{\text{lumens} \times \text{depreciation factor}}{\text{utilization factor}}$. Others seemed to guess the

equation as one of the candidate incorrectly calculated lumen by the

formula $Lm = \frac{Lm/m^2}{A}$. Extract 5.2 presents a sample of incorrect responses to the question.

5.	GIVEN
	Area = (45 x 10) m
	efficiency (%) = 35 lm/m ²
	illumination = 20 lamp.
	U.F = 0.8
	d.F = 0.6
a.	$\theta = \frac{E \times A}{(U.F \times d.F)}$
	$= \frac{20 \times 450}{0.8 \times 0.6}$
	$= 18750 \text{ lumen.}$
b.	$= \frac{\text{lumens}}{\text{lamp}}$
	$= \frac{18750}{20}$
	$= 937.5 \text{ lm/lamp.}$
c.	$P = \frac{\theta}{\eta}$
	$= \frac{18750}{35}$
	$P = 535.7 \text{ W}$
	$p = \frac{\theta}{\eta}$
	$= \frac{18750}{35}$
	$P = 937.5 \text{ W}$

Extract 5.2: A sample of incorrect responses to Question 5

Extract 5.2 shows that in part (a), the candidate seems to have knowledge about illumination equations but failed to convert the depreciation factor (DF) to maintenance factor (MF), by applying, $MF = \frac{1}{DF}$, resulting to an equation, $\text{Total lumen} = \frac{EA}{UF \times MF}$. Since the answer for part (a) determines the answers for both parts (b) and (c); hence, the candidate got wrong for both parts, despite having the correct formula. Furthermore, the candidate failed to recognise that the SI unit of mean spherical candle power is Candela and not Watt. It seems that the term power attracted the candidate to use Watts as the SI unit of mean spherical candle power.

2.2.4 Question 6: AC Circuits

The question comprised of two parts, (a) and (b), and it aimed to evaluate candidates' comprehension on the benefits of AC over D.C in power transmission and distribution. Furthermore, candidates were expected to demonstrate proficiency in applying pertinent formulas for instantaneous current. The question was as follows;

The Tanzania Electric Supply Company Limited (TANESCO) transmits and distributes AC power with a frequency of 60 Hz and an AC of 12 A.

(a) Why did the company prefer an A.C. instead of a D.C power supply? Give five reasons.

(b) Write the equation of the instantaneous value of the supplied current.

Analysis shows that, 320 (100%) candidates attempted the question. Out of these, 195 (60.94%) candidates scored from 0 to 2.5 marks, 104 (32.50%) scored from 3 to 5.5 marks, and 21 (6.56%) scored from 6 to 9 marks. The overall performance of the candidates was average, as 125 (39.06%) candidates passed. Figure 6 summarises the performance of the candidates in this question.

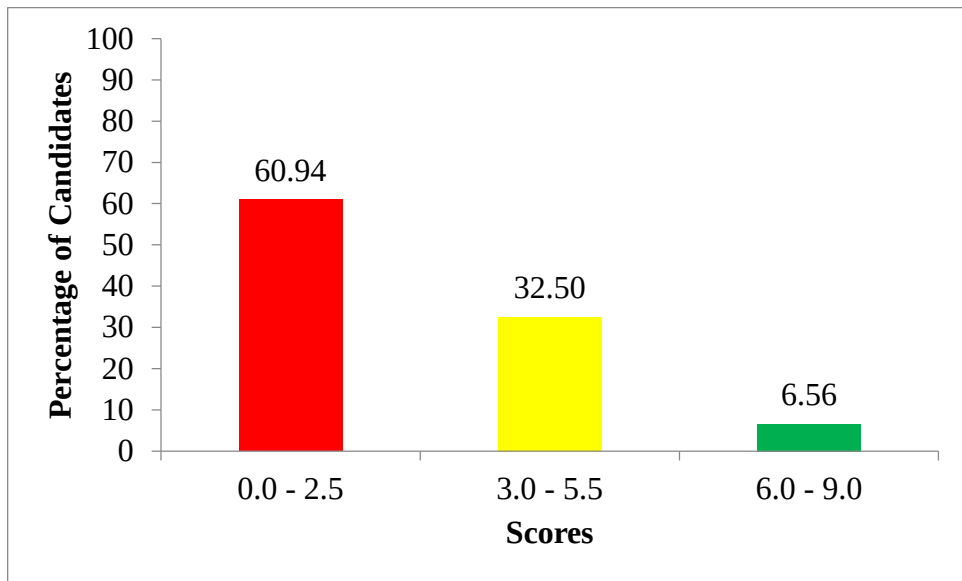


Figure 6: *The Candidates' Performance in Question 6*

The analysis of the candidate's performance in this question indicates that 195 (60.94%) failed to attempt the question correctly. Most of those who failed could not explain why the company preferred an AC instead of a D.C power supply. For example, one candidate responded to the question by writing, "higher current, reduced eddy current, higher resistivity, and higher efficiency" the reasons that did not correlate with the question asked. For part (b), most candidates failed to recall the formula for instantaneous current and hence, used the formula, $i = I_{rms} \sin \omega t$ instead of $i = \sqrt{2} I_{rms} \sin \omega t$, where I_{rms} is root mean square current. Other candidates just copied the given data without further attempts. Extract 6.1 provides a sample of such responses.

6. (a)	(i) because the frequency in ac are designed by the 50Hz, are complete cycle.
	(ii) because the ac are resistance of the around than d.c.
	(iii) because the distribution of the ac in the electrician are increase than the d.c.
	(iv) because the TANESCO not use the 60Hz in the transform are cause dearth, or in the impedance complete
	(v) because the technician are not power in the circuit in the frequency cycle
6(b)	The equation of the instantaneous value of the current are.

Extract 6.1: A sample of incorrect responses to Question 6

In Extract 6.1, the candidate seemed to have a language barrier, as the answers he/she provided do not make logical sense. For instance, the candidate mentioned, "Because the technician is not power in the circuit in the frequency cycle". Generally, the response provided fails to address the requirements and is semantically and grammatically incorrect. In a different context, the candidate understood that TANESCO uses 50 Hz, but this information was insufficient to address the question.

On the contrary, 25 (39.06%) candidates who scored good marks (3 to 9) provided the correct responses to the large part of the question. They gave reasons of using A.C for transmission and distribution and managed to recall the equation to calculate the instantaneous current. Extract 6.2 shows a sample of the correct responses to the question.

6.	a)	i. A.c power supply can be transmitted at longer distances than d.c power supply
		ii. A.c power supply can be stepped up or down depending to demand of people.
		iii. A.c power supply can be induced from one circuit to another.
		iv. A.c power supply is more economical in many devices such as a.c generator, trans transformer and a.c motor
		v. A.c power supply can be converted into dc power supply by using rectifier so can used in dc devices such as radio.
	b)	soln
		Data given
		frequency (f) = 60 Hz
		supplied current (I_m) = 12 A
		from
		Equation; $i = I_m \sin \theta$
		But $I_{rms} = \frac{I_m}{\sqrt{2}}$
		$I_m = I_{rms} \sqrt{2}$
		$I_m = 12 \times \sqrt{2}$
		$I_m = 16.9705 \dots$
		$I_m \approx 17 A$
		But; $\omega = \frac{\theta}{t}$
		$\theta = \omega t$ $\theta = \omega t$
		But; $\omega = 2\pi f$
		$\omega = 2 \times 3.14 \times 60$
		$\omega = 376.8 \text{ rad/s}$
		$\therefore i = 17 \sin 376.8t$

Extract 6.2: A sample of correct responses to Question 6

In Extract 6.2, the candidate responded correctly to both parts of the question. The candidate was able to point out reasons for preferring A.C over D.C for transmission and also identified the instantaneous current which is given by $I_{max} = \sqrt{2} I_{rms} \sin \omega t$, where I_{rms} is the root mean square current. This particular candidate was the only one who scored full

marks for this question, indicating that the candidate had sufficient knowledge of A.C circuits.

2.2.5 Question 7: Capacitor and capacitance

The question evaluated the candidates' capacity to sketch and compute the electrical parameters associated with capacitor configuration. The question was as follows:

Suppose you are in the school electrical workshop for a practical session. The teacher gave you three capacitors having capacitances of $4\ \mu\text{F}$, $6\ \mu\text{F}$ and $12\ \mu\text{F}$ and assigned you to connect them in series across a $500\ \text{V D.C}$ main.

- a) Draw the circuit.*
- b) Calculate the values of:*
 - (i) Equivalent capacitance of the combination.*
 - (ii) Charge on each capacitor.*
 - (iii) Potential difference across each capacitor.*

A total of 320 (100%) candidates attempted this question. The data analysis indicates that among them, 59 (18.44%) candidates scored from 0 to 2.5 marks, 144 (45.00%) scored from 3 to 5.5 marks, and 117 (36.56%) scored from 6 to 9 marks. The overall performance is good, as 261 (81.56%) candidates passed. Figure 7 summarizes the candidate's performance in this question.

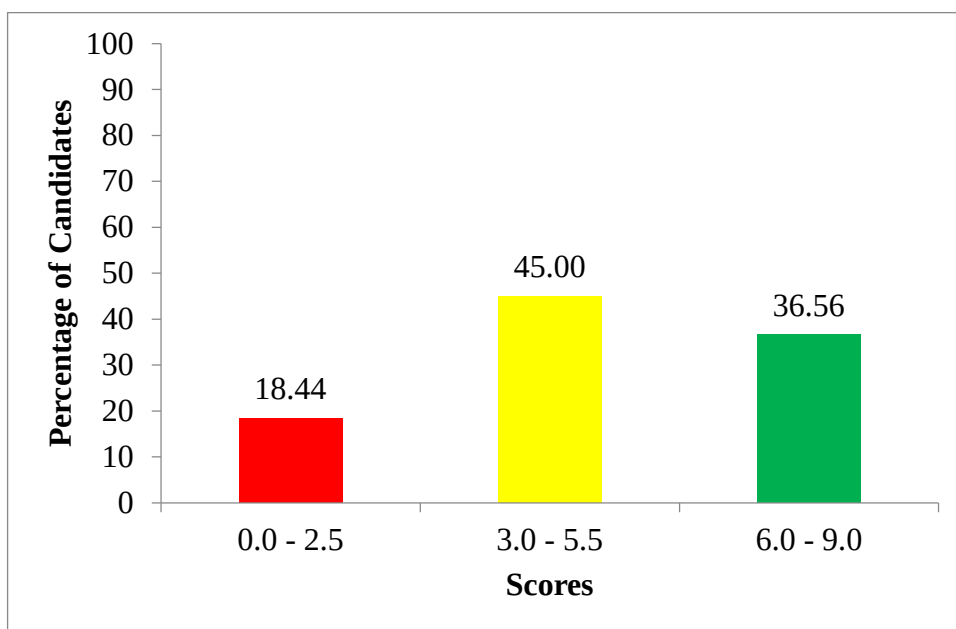
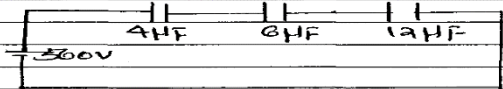


Figure 7: *The Candidates' Performance in Question7*

It appears that most of the candidates performed well on this question. About 261 (81.56%) scored from 3 to 9 marks. Most of them demonstrated knowledge on *capacitors and capacitance*, as they could use the correct symbol of the capacitor to draw the required circuit and calculate the parameters in part (b), as shown in Extract 7.1.

7 Solution
Data analysis
 $C_1 = 4 \mu F$ $C_2 = 6 \mu F$
 $C_3 = 12 \mu F$
 $V = 500V$

a) Circuit



b) Equivalent capacitance from

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12}$$

$$= \frac{3+2+1}{12}$$

$$\frac{1}{C} = \frac{6}{12}$$

$$C = 12/6$$

$$C = 2 \mu F$$

$\therefore$ Equivalent capacitance is 2 μF

Charge on each capacitor from

$$C = \frac{Q}{V}$$

7 b) Charge $Q_T = CV_T$

$$= 2 \times 10^{-6} \times 500$$

$$= 2 \times 10^{-6} \times 500$$

$$Q_T = 0.001 C$$

Total charge = 0.001 C

$$= 0.001 C$$

Total charge = charge on each capacitor

$$= 0.001 C$$

$\therefore$ The charge on each capacitor is 0.001 C

Potential difference across each capacitor from

$$Q = CV$$

$$V = \frac{Q}{C}$$

$$V_1 = \frac{Q}{C_1}$$

$$= \frac{0.001}{4 \times 10^{-6}}$$

$$V_1 = 250 V$$

$$V_2 = \frac{Q}{C_2}$$

$$= \frac{0.001}{6 \times 10^{-6}}$$

$$= \frac{500}{3}$$

$$V_2 = 166.667 V$$

$$V_3 = \frac{Q}{C_3}$$

7	b) iii/ $N_3 = \frac{0.001}{12 \times 10^6}$
	$= \frac{250}{3}$
	$N_3 = 83.33V$
	∴ The potential across 4μF capa
	ctor, 6μF capacitor and 12μF capacitor
	are 250V, 166.667V and 83.33V respectively

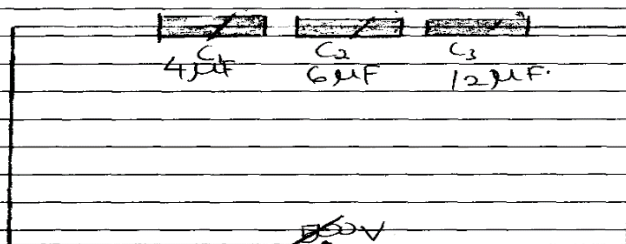
Extract 7.1: A sample of correct responses to Question 7

Extract 7.1 indicates that the candidate demonstrated proficiency in using accurate symbols to sketch the necessary circuits and applying the relevant formula to compute the equivalent capacitances, charge, and potential difference for parts (a) and (b). This demonstrates the candidate's competence in the subject matter.

Furthermore, the analysis reveals that 59 (18.44%) candidates performed poorly. These candidates demonstrated lack of knowledge, particularly in the areas that required them to compute equivalent capacitances. Most candidates failed to draw the equivalent circuit and calculate the parameters asked. For instance, most candidates drew a series configuration instead of parallel for part (a). It was also observed that the majority of the candidates confused the series equation with that of parallel. The use of incorrect formula is also a problem among them; for instance, one of the candidates calculated quantity of charge by writing $Q = \frac{V}{C}$ instead of $Q = CV$. Others

wrote $Q = \frac{1}{2}CV^2$, which is the equation for energy in a capacitor. The wrong responses indicate that the candidates had weak understanding in the topic of *Capacitor and Capacitance*. Extract 7.2 illustrates a sample of such responses.

7. (a) The diagram of circuit.



(i) Equivalent Capacitance of the combination.

soln

from $C_T = C_1 + C_2 + C_3$

$$C_T = 4 \mu F + 6 \mu F + 12 \mu F$$

$$C_T = 22$$

$\therefore$ The total capacitance is $22 \mu F$.

(ii) Charge in each capacitor.

- Charge of C_1 .

Given That: $C_1 = 4 \mu F$
Voltage = $500V$

$$Q = 11000$$

while $C = 22$.

@ potential difference in capacitor one.

given: $Q = 2000C$

$$C = 22$$

$$Q = CV$$

$$\frac{2000}{22} = \frac{22V}{22}$$

$$V = 250.9$$

$\therefore$ potential difference is $250.9 V$.

@ potential difference in capacitor two.

Given: $Q = 3000C$

$$C = 22$$

from: $Q = CV$

$$\frac{3000}{22} = \frac{22V}{22}$$

$$136.36 = V$$

$\therefore$ potential difference in capacitor two is $136.36 V$.

@ potential difference in capacitor three.

Given: $Q = 6000C$

$$C = 22$$

from: $Q = CV$

$$\frac{6000}{22} = \frac{22V}{22}$$

$$V = 6000C$$

$$22$$

$$V = 272.73$$

$\therefore$ potential difference in capacitor three is 272.73 .

Quantity of charge = ?
From: $Q = CV$
$Q = 4 \times 500$
$Q = 2000 \text{ c}$
$\therefore$ The quantity of charge to the first capacitor is 2000 c
- Quantity of charge to the first ^{second} capacitor.
- given: $Q = \text{required}$
$C = 6 \mu\text{F}$
$V = 500 \text{ V}$
from: $Q = CV$
$Q = 6 \times 500$
$Q = 3000 \text{ c}$
$\therefore$ The quantity of charge to the second capacitor is 3000 c.
- Quantity of charge to the third capacitor.
given: $Q = \text{Required}$
$C = 12 \mu\text{F}$
$V = 500$
from: $Q = CV$
$Q = 12 \times 500$
$Q = 6000 \text{ c}$
$\therefore$ The quantity of charge to the third capacitor is 6000 c
(ii) Potential difference across each capacitor
^{isn't} Total quantity of charge = 6000 c + 3000 c + 2000 c
= 11000

Extract 7.2: A sample of incorrect responses to Question 7

In Extract 7.2, the candidate drew a series connection circuit but mistakenly used the symbol of resistor in place of capacitor. Furthermore, the candidate used wrong formula of calculating equivalent capacitance in parallel to that of series by writing; $C_{eq} = C_1 + C_2 + C_3$ instead of

$$C_{eq} = \frac{C_1 C_2 C_3}{C_1 C_2 + C_2 C_3 + C_1 C_3} \text{ for series. Moreover, he/she used the switch}$$

symbol for supply, which is incorrect. This signifies that the particular candidate had inadequate knowledge on electrical symbols. Nevertheless, the candidate correctly used the formula for calculating quantity of charge as the product of voltage and capacitance ($Q = CV$) for part (b)(ii). However, since the answer to this part depends on the answer to part (b)(i), resulted to a wrong value of the potential difference, V . Moreover, for part

(b)(iii), the candidate mistakenly associated potential difference with the quantity of charge (Coulombs) instead of Voltage. The candidate wrote the total charge quantity is given by the formula $Q_T = Q_1 + Q_2 + Q_3$. The candidate could not realize that, when capacitors are connected in series, they are all connected along one path and to the same voltage source. Each capacitor has the same charge, and each capacitor has different voltages that add up to the voltage source's voltage.

2.2.6 Question 8: Cells and Batteries

The question aimed to assess the candidates' capacity to apply the appropriate formulas to solve problems related to the concepts of *Cells and Batteries*. To calculate the current, the candidates had to master the skills related to battery connection and internal resistance. The question was structured to test the application of these concepts in problem-solving scenarios. The question reads as follows;

You have been given four leclanche 'cells to be connected in a series-parallel arrangement for a particular purpose. The connection should have two branches with two cells in each. The e.m.f. of each cell is 1.5 V, and an internal resistance of $3\ \Omega$ is found in the combination. Consider that the external circuit is connected with the resistor of $3\ \Omega$. Calculate:

- (a) The total internal resistance.*
- (b) The total current.*
- (c) The current through each cell.*

A total of 320 (100%) candidates attempted the question. According to the data analysis, 170 (53.13%) candidates scored from 0 to 2.5 marks, 97 (30.31%) scored from 3 to 5.5 marks, and 53 (16.56%) scored from 6 to 9 marks. The overall performance was average since 150 (46.87%) candidates scored above average. The summary of the candidate's performance in this question is shown in Figure 8.

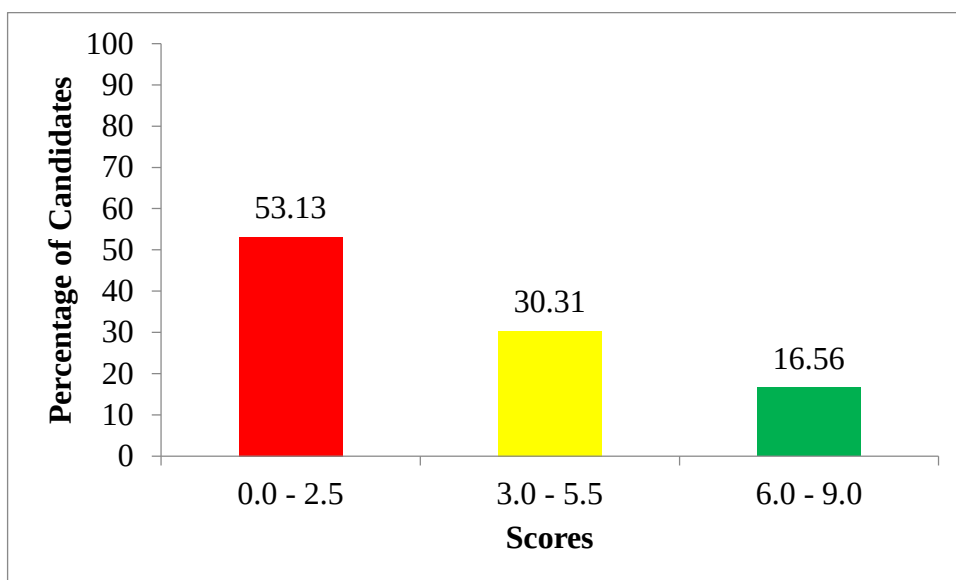


Figure 8: *The Candidates' Performance in Question 8*

According to the data analysis, 170 (53.13%) candidates performed poorly. These candidates lacked knowledge on *Cells and Batteries* as most of the candidates failed to apply the correct formula to calculate the total internal resistance, the total current, and the current through each cell, as asked in parts (a), (b), and (c), respectively. For example, one of the candidates incorrectly calculated total internal resistance by using the wrong formula

$r_T = r_1 + r_2$, instead of $r_T = \frac{\text{resistance of series group}}{\text{number of parallel group}}$. The answer for part

(a) determine the answer to parts (b) and (c); as a result, most of them got wrong answers. In addition, most of the candidates interchanged the capacitor and resistor symbols in their drawing. Extract 8.1 presents a sample of incorrect responses from one of the candidates.

08. (a) THE DIAGRAM WHICH TO SHOW IN SERIES - PARALLEL ARRANGEMENT

the total internal resistance by which formuler.

$R = \frac{V}{I}$, $R = \frac{\text{Voltage}}{\text{Current (I)}}$

Data given that
Resistance = $3, 3, 3$
Voltage supply = 1.5
Current = x
but,
 $R = \frac{V}{I}$
 $R = \frac{1.5}{x}$
 $3 + 3 = \frac{1.5}{x}$
 $x = 6 \times 1.5 = 9$
 $x = 9$
the total internal resistance is 9 ohm .

08. (b) the total current
Data given that
by which formuler
 $I = \frac{V}{R}$
Data given that
(I) current = x
Voltage supply = 1.5
Resistance = $3 + 3 = 6$
but, the
 $I = 3 + 3 + 1.5 = 7.5$
 $I = 7.5$
∴ the total of current is 7.5 A .

(c) the current through each cells.
from
 $I_T = \frac{1}{I_1} + \frac{1}{I_2}$
 $I_T = \frac{1}{I_1} + \frac{1}{I_2} + \frac{1}{I_3} + \frac{1}{I_4}$
but the end.
 $I_T = \frac{1}{I_1} + \frac{1}{I_2} + \frac{1}{I_3} + \frac{1}{I_4}$
 $I_T = \frac{1}{3} + \frac{3}{3} + \frac{3}{3}$
 $I_T = \frac{1}{3} + \frac{1}{3} = \frac{2}{3}$
 $I_T = \frac{1}{3} + \frac{1}{3} = \frac{2}{3}$
 $I_T = 6 \text{ A}$
∴ the current through each cell is 6 A .

Extract 8.1: A sample of incorrect responses to Question 8

In Extract 8.1, the candidate failed to realise that when the cells are connected in parallel, the current will be divided among various cells ($i_T = i_1 + i_2 + i_n$), while the e.m.f is the same for the cells ($E_1 = E_2 = E_n$)

and total resistance is given by the formula $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_n}$. When

cells are connected in parallel, the e.m.f will be divided among various cells ($E_T = E_1 + E_2 + E_n$), while the current is the same for the cells ($i_1 = i_2 = i_n$) and the total resistance becomes $R_T = R_1 + R_2 + R_n$. Since they are two branches, as mentioned in the question, the two principles are applicable. For example, in part (a), the candidate calculated the internal resistance by

using the formula $R = \frac{V}{I}$. The candidate used inappropriate formula to

calculate total internal resistance taking into account the connection for series and parallel as stated in the question. For series connection, the branch total current is given by $r = r_1 + r_2$ where $r_1 = r_2 = 3\Omega$; thus, $r = 6\Omega$, which is for both branches. The total internal resistance is then becomes

$r_T = \frac{\text{resistance of series group}}{\text{number of parallel group}}$. In addition, the candidate drew the diagram

incorrectly by using the capacitor symbol instead of resistor for cells and failed to indicate the power source symbol, V. In addition, the candidate misunderstood the question by calculating the resistance using

$R_T = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$, which is wrong. For part (b), the candidate

erroneously took the summation of resistance and voltage to calculate the total current ($I_T = R_1 + R_2 + E$). He/she failed to realise that the total current

$I_T = \frac{E}{R_T + r_T}$. In addition, the candidate considered the current through

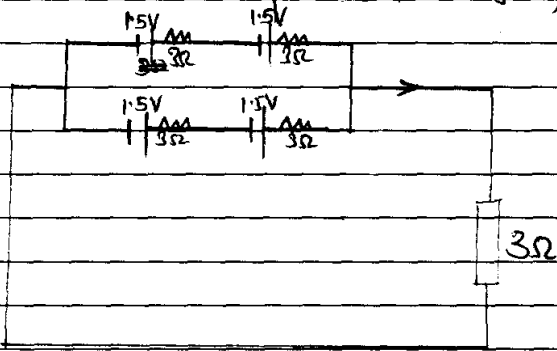
each cell as $I_T = \frac{1}{I_1} + \frac{1}{I_2} + \frac{1}{I_3} + \frac{1}{I_4}$, failing to comply with the principles

guiding the connection.

On the contrary, 150 (46.87%) candidates scored average marks on the question according to the data analysis. They were able to apply the correct

formulas to determine the value of the parameters in each part of the question. They demonstrated an average understanding of the concepts related to *Cells and Batteries*. Extract 8.2 shows excellent responses from one of the candidates.

8. Soln
 data given.
 Number of cells = 4
 Emf of each cell = 1.5V
 Internal resistance = 3Ω
 Resistor = 3Ω
 Required;
 a) The total internal resistance
 consider following this diagram;



from

$$r_T = r_1 + r_2$$

$$r_T = 3\Omega + 3\Omega$$

$$r_T = 6\Omega = r_{12}$$

$$r_T = \frac{r_1 r_2}{r_1 + r_2}$$

$$r_T = \frac{6 \times 6}{6 + 6}$$

$$r_T = \frac{36}{12}$$

$$r_T = 3\Omega$$

$\therefore$ The total internal resistance is 3Ω

8. b) The total current

from

$$E_T = I(r + R)$$

But; $E_T = 1.5V + 15V$

$$E_T = 3V$$

$$I = \frac{E_T}{r + R}$$

$$I = \frac{3}{3 + 3}$$

$$I = \frac{3}{6}$$

$$I = 0.5A$$

$\therefore$ The total current is 0.5A

c) Current through each cell

$$I_{\text{each}} = \frac{I_T}{2}$$

$$I_{\text{each}} = \frac{0.5A}{2}$$

$$I_{\text{each}} = 0.25A \text{ cell}$$

$\therefore$ Current through each ~~resistor~~ is 0.25A

Extract 8.2: A sample of correct responses to Question 8

Extract 8.2 shows that the candidate correctly calculated the internal resistance, the total current and the current through each cell and followed the correct computational procedures to arrive at the final answer. This implies that the candidate had adequate knowledge of cells and batteries and proper computational abilities.

2.3 SECTION C: STRUCTURED QUESTIONS

This Section consisted of three (3) structured questions. The candidates were required to answer two questions from this section. Each question carried 15 marks, making a total of 30 marks. The performance is regarded as good if the score ranges from 10.0 to 15.0 marks, average if the score ranges from 4.5 to 9.5 marks and weak if the score range from 0 to 4.0 marks for each question in this section. The analysis of their responses is as follows:

2.3.1 Question 9: Illumination

The question tested the candidates' practical and design skills. It required them to apply their knowledge and concepts of *Illumination* to design a two-way switch structured. The question was designed in a manner that it tested the application of these concepts in real-life problem-solving scenarios. The question was as follows:

The steel conduits were used to install a circuit of two lamps in a school dining hall by using a one-way switching system in parallel connection. The hall contains two entrances positioned on the opposite sides of the hall.

- (a) Design a circuit diagram to change the previous installation by increasing the number of lighting points from two to four. Apply a two-way switching system from the entrance position of the hall.*
- (b) Why steel conduits were chosen to install the circuit in the hall rather than plastic conduit which is cheaper? Give three reasons.*

According to the data analysis, out of 320 (100%) candidates, 198 (61.88%) attempted the question. Among these, 111 (56.06%) candidates scored from 0 to 4 marks, 46 (23.23%) scored from 4.5 to 9.5 marks, and 41 (20.71%) scored from 10 to 15 marks. The overall performance was average, as 87 (43.94%) of the candidates who attempted the question passed. The candidate's performance in this question is summarised in Figure 9.

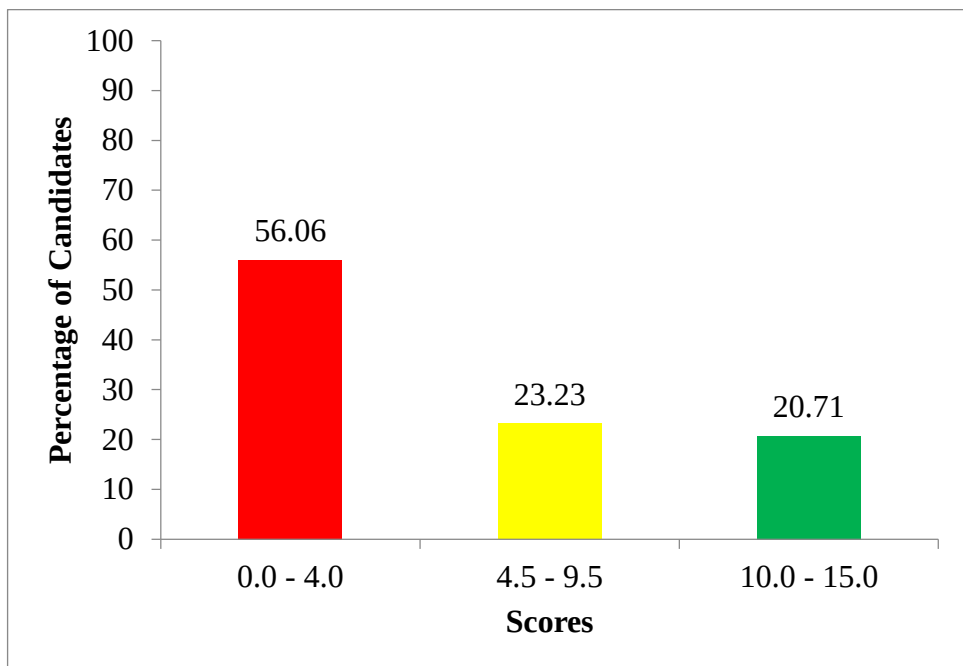
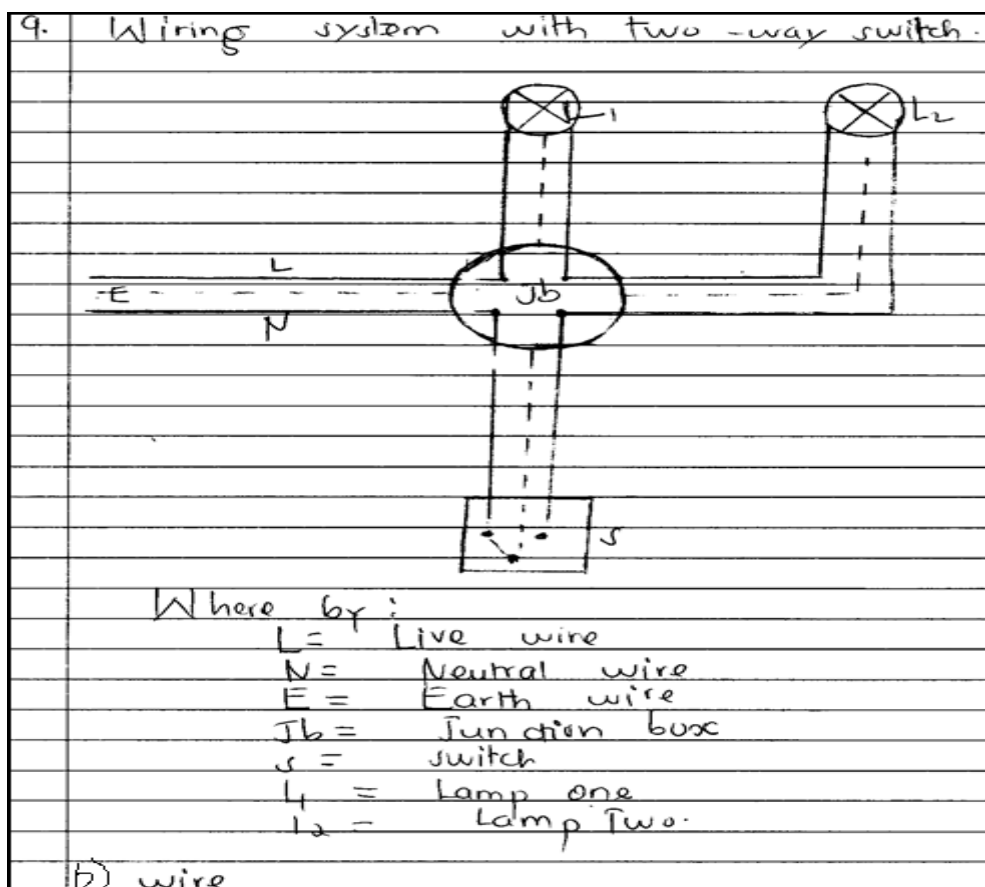


Figure 9: *The Candidates' Performance in Question 9*

The data analysis shows that, 111 (56.06%) candidates failed to design the required circuit. The candidates' drawings were not correct and neat. Most of them used a one-way switch instead of a two-way switch, and some mixed up electrical symbol. For example, one candidate used the capacitor symbol and referred to it as a lamp. Additionally, most of the candidates could not explain why steel conduits were chosen to install the circuit in the hall rather than plastic conduits. One candidate wrote that steel conduits are chosen because "they protect from electric shock and can carry many wires". This indicates that the candidates had a poor understanding on the topic. Extract 9.1 illustrates a sample of incorrect responses.

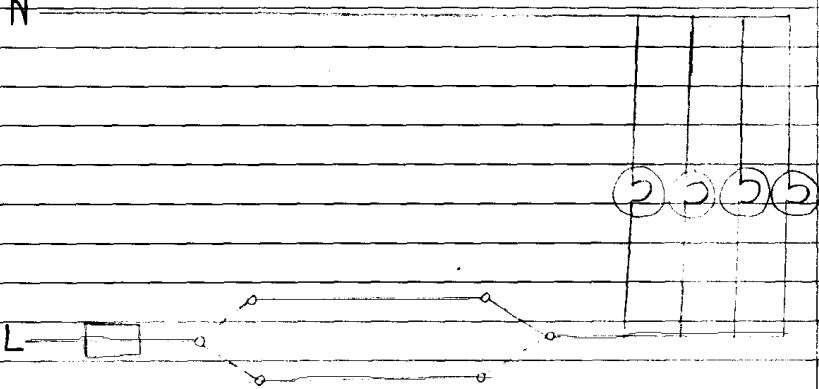


Extract 9.1: A sample of incorrect responses to Question 9

In Extract 9.1, the candidate failed to draw a two-way switch that could control four lamps from two different positions, as the drawing extracted represents a different switching configuration. The extracted drawing shows that the candidate schematic is two lamps (L1 and L2) connected in series controlled by a two-way switch (S). He or she failed to recognise the question's demanded for four lamps controlled by two-way switch. According to the extracted drawing, the candidate employed a two-way switch (S) but needed to grasp that two two-way switches are required for two-way light control, with three terminals, COM, L1, and L2. The L1 terminals of both switches are linked to phase, and the L2 terminals of both switches are connected to one end of the bulb terminal, with the other end of the bulb terminal connected to the neutral of the AC supply. He/she

likely knew that two-way *switching* had to use a two-way switch instead of being able to switch from two different positions. The candidate was supposed to understand that a parallel connection should be used instead of a series connection for the lamp's connection. Additionally, the candidate did not attempt part (b), which required him/her to explain why conduits were chosen to install the circuit in the hall instead of cheaper plastic conduits. This demonstrated lack of understanding on the concepts tested.

On the contrary, 87 (43.94%) candidates scored good marks as they could draw the necessary circuit and explain the benefits of metal conduits. They also demonstrated practical skills and knowledge on the *Illumination* topic. Extract 9.2 illustrates a sample of such response from one of the candidates.

q.	
a.	 Circuit diagram
b.	- i It is strong and live at a long time. - ii Steel conduits does not affecting of mechanical damage. - iii Steel conduits does not affect with water, fire, sun and other condition.

Extract 9.2: A sample of correct responses to Question 9

Extract 9.2 shows that the candidate correctly designed the required circuit by including all necessary elements and could state the advantages of metal conduits over the plastic conduits. That signifies competence in the particular topic

2.3.2 Question 10: Current Electricity

This question intended to test the application of knowledge on series and parallel circuits in real life situation and mathematical skills to compute the required value using Ohms law. The question was as follows:

In most cases, electrical Engineers recommend using parallel arrangement rather than series arrangement in electric circuits.

- (a) Why do they prefer such an arrangement? Give three reasons.*
- (b) You have been given a circuit consisting of three resistors connected as per the recommended arrangement. The current in the first resistor is 0.1 A, and the power dissipated in the second is 3 W. The voltage across the third is 100 V, and the total current reading is 0.2 A. Determine:
 - (i) The ohmic value of the resistors.*
 - (ii) The total resistance.**

Out of 320 (100%) candidates, 285 (89.06%) attempted this question. Based on the data analysis, 62 (21.75%) candidates scored from 0 to 4 marks, 93 (32.63%) scored from 4.5 to 9.5 marks, and 130 (45.62%) scored from 10 to 15 marks. The overall performance was good, as 223 (78.25%) candidates scored average marks and above. The candidate's performance in this question is summarised in Figure 10.

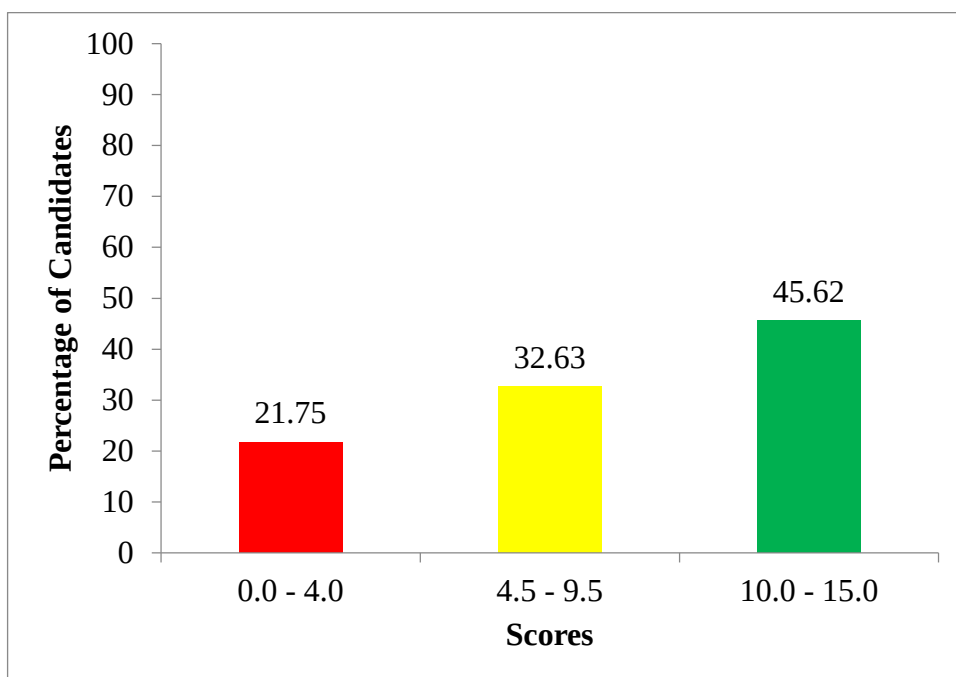
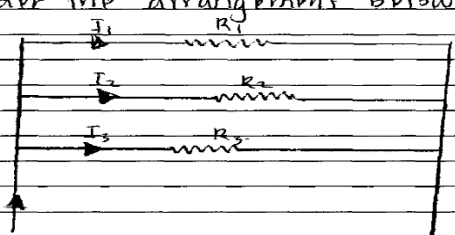


Figure 10: *The Candidates' Performance in Question 10*

According to the data analysis, 223 (78.25%) candidates scored good marks as they could explain the advantages of parallel connection compared to the series circuit and calculated the required parameters asked in part (b). They also justified their knowledge on the tested concepts about *Current Electricity*. Extract 10.1 presents good responses from one of the candidates.

10.	(a) Three (03) advantages of parallel arrangement over series arrangement. (i) In parallel arrangement each point operate independently from each other. For example when one lamp breaks, other lamps will continue to operate effectively. (ii) In parallel arrangement, the total current is the summation of individual's point current and therefore in case of lighting it gives a very bright light. (iii) In parallel arrangement, the total resistance is reciprocal summation of the individual's point resistance and hence it is always less than total resistance in series connection. Therefore the opposition force to the current flowing in parallel connection is less than in series connection. This is given by: $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$ (b) Data Given: Current flow in first resistor $\{I_1\} = 0.1A$ Power dissipated in second resistor $\{P_2\} = 3W$ Total current reading $\{I_s\} = 0.2A$ Required to determine: → Continue next page
-----	--

10	(b) (i) The Ohmic value of the resistors Consider the arrangement below:  From Ohm's law $V = IR$ Recall → Since the resistors are in parallel connection therefore, the voltage across each resistor and source is the same: $V_s = V_1 = V_2 = V_3 = 100V$ For the first resistor $\{R_1\}$ From $R_1 = \frac{V}{I_1}$
----	--

But:

$$\text{Power } (P) = \text{Voltage } (V) \times \text{Current } (I)$$

For first resistor

From:

$$R_1 = \frac{V}{I_1}$$

$$R_1 = \frac{100V}{0.1A}$$

$$R_1 = 1000\Omega$$

For second resistor:

From:

$$R_2 = \frac{V^2}{P_2}$$

$$R_2 = \frac{(100V)^2}{3}$$

$$R_2 = 3333.33\Omega$$

For third resistor:

From:

$$R_3 = \frac{V}{I_3}$$

But:

$$I_T = I_1 + I_2 + I_3$$

Thus:

$$I_3 = I_T - (I_1 + I_2)$$

→ continue next page

10.

(b) → From previous page

i.e.

$$I_3 = I_T - (I_1 + I_2)$$

$$= 0.2A - (0.1A + 0.03A)$$

$$= 0.2A - 0.13A$$

$$= 0.07A$$

$$I_3 = 0.07A$$

Thus:

$$R_3 = \frac{V}{I_3}$$

$$\frac{100V}{0.07A}$$

$$= 1428.57\Omega$$

Therefore:

Ohmic value of the resistors

i.e.

First resistor = 1000Ω

Second resistor = 3333.33Ω

Third resistor = 1428.57Ω

10	(b)
	(ii) The total resistance.
	Recall
	Total resistance in parallel connection is the summation of the reciprocal of the resistors
	From:
	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
	$\frac{1}{R_T} = \frac{1}{1000\Omega} + \frac{1}{33333\Omega} + \frac{1}{1478.5\Omega}$
	$\frac{1}{R_T} = 0.002\Omega$
	$R_T = 500\Omega$
	Therefore
	Total resistance $\{R_T\} = 500\Omega$

Extract 10.1: A sample of correct responses to Question 10

Extract 10.1 shows that the candidate correctly interpreted the question and applied the correct formula to compute the required parameters in part (b). Moreover, the candidate provided advantages in parallel and series arrangement in electric circuits. The candidate provided a supportive equation, $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$, which strongly signifies that he/she understood the topic adequately.

Furthermore, the analysis shows that 62 (21.75%) candidates who attempted this question performed poorly. Several candidates failed to explain why electrical engineers recommend using parallel arrangement

rather than series arrangement in electric circuits, as asked in part (a). For example, one candidate wrote that; "make the place safe and secure, prevent light from slowing down, good method and low efficient". This response indicates that a particular candidate was just guessing the answers. For part (b), most candidates failed to apply the correct equation to compute the resistances in parts (i) and (ii). Moreover, others just copied the given data from the question without attempting it. It seems these candidates had weak understanding of the topic. Extract 10.2 provides a sample of such responses.

10. a) i) The parallel arrangement has a more electric power
 ii) The parallel arrangement the voltage is transfer in all circuit.
 iii) When the circuit is connected in parallel the current or light in the all lamp are same compared a series connection.

b. Given
 Current in first resistor (I_1) = 0.1 A
 Power in second resistor = 3 W
 Voltage in third resistor = 100 V
 Total current = 0.2 A.

i) Solution
 Resistor (R_1)

$$P = I^2 R$$

$$R_1 = \frac{P}{I^2}$$

$$= \frac{3}{0.1^2}$$

$$R_1 = 300 \Omega$$

Resistor (R_2) = From $P = I^2 R$

10) $R = \frac{P}{I^2}$
 $= \frac{3}{0.2^2}$
 $= 75 \Omega$

Resistor (R_3)
 From Power = Voltage $\times$ Current
 $P = VI$
 OR $R = \frac{V}{I}$
 $= \frac{100}{0.2}$
 $= 500 \Omega$

11) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
 $\frac{1}{R_T} = \frac{1}{300} + \frac{1}{75} + \frac{1}{500}$
 $\frac{1}{R_T} = \frac{37500 + 150000 + 22500}{1125000}$
 $\frac{1}{R_T} = \frac{210000}{1125000}$
 $R_T = \frac{1125000}{210000}$

Extract 10.2: A sample of incorrect responses to Question 10

In Extract 10.2, the candidate failed to respond correctly for parts (a) and (b). For instance, he/she wrote, “The parallel connection has more electric power”. Such responses show that the candidate failed to understand that electric power is not determined by the connection but the rate at which a

current delivers energy. He/she failed to realise that the parallel arrangement is used for domestic circuits since it allows each electrical device to operate independently from the others. This means that if one device or circuit fails, it does not affect the operation of the other devices on the same circuit.

Moreover, in part (b), the candidate seems to know how power relates to voltage and current, thus $R = \frac{P}{I^2}$ and Ohms Law $V = IR$, but he/she substituted wrong data, that is (0.2 A), which is the total current, instead of (0.1 A) for the first resistor, thus obtaining the wrong answer. The candidate had a correct equation for equivalent resistance in parallel which is $\frac{1}{R_T} + \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$, but he/she failed to get correct answer since the R_1 , R_2 , and R_3 values were incorrectly calculated.

2.3.3 Question 11: A.C Machines

This question examined the candidates' problem-solving and analytical skills through computational tasks. The question involved applying knowledge and understanding of A.C motors to calculate specific parameters for a three-phase A.C motors to meet predefined specifications. The question was as follows:

A factory Engineer designed a three-phase motor with the following specifications; 6 poles which uses a 50 Hz frequency. The motor capacity was 42 kW and a speed of 970 r.p.m. From the experiment carried out in the factory, it was realised that the motor had 1.2 kW stator losses and friction and windage losses of 1.8 kW. Calculate the following parameters to check the motor performance before getting in use:

- (a) Synchronous speed.
- (b) Slip of the motor.
- (c) Slip speed.
- (d) Rotor frequency.
- (e) Stator output power.
- (f) Rotor input power.

- (g) Rotor output losses.
- (h) Useful power output.

Out of 320 (100%) candidates, 157 (49.06%) candidates attempted this question. Based on the data analysis, 39 (24.84%) candidates scored from 0 to 4 marks, 85 (54.14%) scored from 4.5 to 9.5 marks, and 33 (21.02%) scored from 10 to 15 marks. The overall performance was good since 118 (75.16%) candidates scored average marks and above. Figure 11 provides a summary of the candidate's performance in this question.

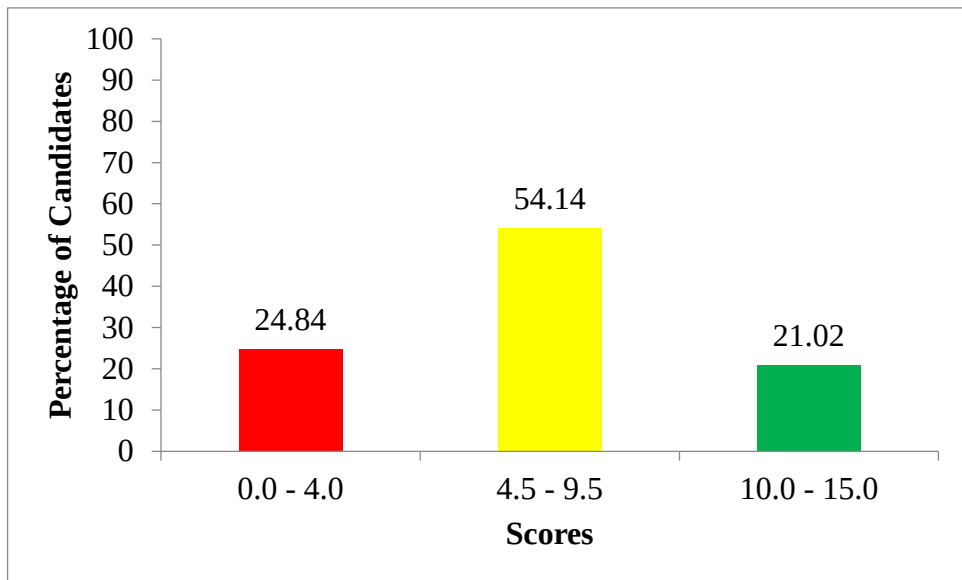


Figure 11: *The Candidates' Performance in Question 11*

According to statistical data, 118 (75.16%) candidates scored above average in this question. This justifies that, the candidate had sufficient knowledge of the tested concepts on A.C. Machines, specifically A.C. motors, as they demonstrated proficient computational skills to find the values for parts (a) to (h). Extract 11.1 presents good responses from one of the candidates.

11.	Power of motor (P_i) = 42 000 W
	speed of rotor (N_r) = 970 r.p.m
	losses
	(i) stator losses = 1.2 kW = 1.2×10^3 W.
	(ii) friction and windage losses = 1.8 kW = 1.8×10^3 W
	Task
	(a) synchronous speed (N_s).
	from; $N_s = \frac{120F}{P}$
	Then; $N_s = \frac{120 \times 50}{6}$
	Hence; $N_s = 1000$ r.p.m
	(a) $\therefore$ The synchronous speed is 1000 r.p.m.
	Task (b) slip of motor (s).
	from; $s = \frac{N_s - N_r}{N_s}$
	Then; $s = \frac{(1000 - 970)}{1000}$ r.p.m
	$s = 0.03$
	(b) $\therefore$ The slip of the motor is 0.03 or 3%.
	Task (c) slip speed
	$\therefore$ slip speed = $N_s - N_r$.
	Then slip speed = $(1000 - 970)$ r.p.m
	slip speed = 30 r.p.m
	(c) $\therefore$ slip speed will be 30 r.p.m
	Task (d) Rotor frequency (f_r)
	from; slip (s) = $\frac{f_r}{f}$

11. (d) From; $s = \frac{f_r}{f}$

But; $f_r = sF$

where; $s = 0.03$

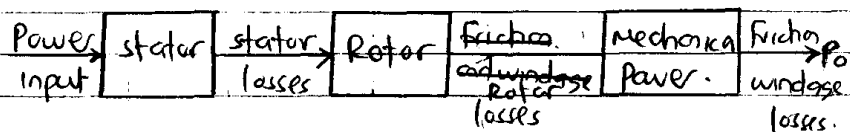
$F = 50 \text{ Hz}$

Then; $f_r = 0.03 \times 50 \text{ Hz}$

Hence; $f_r = 1.5 \text{ Hz}$

$\therefore$ The rotor frequency is 1.5 Hz .

(e) Task; stator output power



Task; stator output power

Given;

Input power = 42000 W

stator losses = 1200 W

stator output power = ?

From; stator output power = Input power - stator losses

stator output power = $(42000 - 1200) \text{ W}$

stator output power = $40,800 \text{ W}$

$\therefore$ stator output power will be $40,800 \text{ W}$.

(f) Task; Rotor Input power

From; stator output = Rotor Input

Hence; Rotor Input = Input power - stator losses

Then; Rotor Input = $(42000 - 1200) \text{ W}$

Rotor Input = $40,800 \text{ W}$

$\therefore$ Rotor Input power = $40,800 \text{ W}$.

Extract 11.1: A sample of correct responses to Question 11

In Extract 11.1, the candidate successfully recalled the formula to compute the parameters in all parts of the question.

On the contrary, a few candidates, 39 (24.84%), failed to calculate the values of the required parameters in part (a) - (h). Most of them could not recall the equation; they just copied the given data with no further attempt. Others mixed the equation of one parameter with that of the other. For example, in responding to part (d), one of the candidates wrote rotor frequency, $f_r = \frac{120f}{p}$, which is the proper formula for calculating synchronous speed (N_s) in part (a). Furthermore, for in part (b) he/she wrote slip = $N_s - N_r$ instead of slip $\frac{N_s - N_r}{N_s}$, whereas N_s is synchronous speed and N_r is motor speed. The equation the candidate provided was only correct if it was for part (c). The incorrect answers confirm that the candidates lacked sufficient understanding of the concepts tested in the topic of *A.C Machines*, particularly in applying formulas. Extract 11.2 is a sample of incorrect responses.

$$\text{slip} = \frac{N_1 - N_2}{N_1} \times 100\%$$

$$= \frac{970 - \cancel{970}}{970} \times 100\%$$

$$= 0\%$$

$\therefore$ The slip of the motor = 0%

$$\text{e) slip speed} = \frac{P \cdot f}{120}$$

$$= \frac{6 \times 19400}{1200}$$

$$= 970 \text{ rpm}$$

$\therefore$ The slip speed = 970 rpm

11. (2) $f_{\text{m}} N = \frac{P}{120}$

$$f = \frac{120N}{P}$$

$$= \frac{120 \times 970}{6}$$

$$= \cancel{19400}$$

$$= 19400 \text{ Hz.}$$

$$= 19.4 \text{ KHz.}$$

(3) Rotor input power = $42 \text{ kW} + 1.2 \text{ kW}$
 $+ 1.8 \text{ kW}$
 $= 45 \text{ kW}$

$\therefore$ The rotor input power = 45 kW.

(4) stator output power = $42 \text{ kW} - (10 \text{ kW})$
 $= 42 \text{ kW} - 3 \text{ kW}$
 $= 39 \text{ kW.}$

$\therefore$ The stator output power = 39 kW.

Extract 11.2: A sample of incorrect responses to Question 11

In Extract 11.2, the candidate applied wrong formulas to calculate the asked parameter. For instance, the candidate calculated slip of a motor by using;

$$\text{Slip} = \frac{N_1 - N_2}{N_1}, \text{ which is equivalent to: } \text{slip} = \frac{N_s - N_r}{N_s}.$$

But he/she considered $N_s = N_r = 970 \text{ r.p.m.}$ which is incorrect. It was supposed to be

calculated by using $N_s = \frac{120f}{p}$, where f = frequency and p = number of poles. Furthermore, the candidate used incorrect formulas for most of the parts. Additionally, for part (e), the candidate knew the correct formula: *Stator output power = stator input P – stator losses*, but he/she couldn't get the correct answer because of considering stator losses to be (3 kW) instead of (1.2 kW), which was mentioned in the question.

3.0 THE CANDIDATES' PERFORMANCE IN EACH TOPIC

The analysis of the candidate's performance in the topics which were examined in the Electrical Engineering subject for the year 2023 indicates that candidates performed well in the topics of *Units*, *D.C Circuits*, *Electrical Workshop Orientation*, *Illumination*, *A.C Machines*, *Transformers* and *Cells and Batteries* (96.56%) tested in question 1, *Transformer* (89.07%) tested in question 3; *Capacitors and Capacitances* (81.56%) tested in question 7; *Current Electricity* (78.24%) tested in question 10; *Measuring Instruments* (76.56%) tested in question 4; *A.C Machines* (75.16%) tested in question 11 and *D.C Circuit* (67.19%) tested in question 2. The candidates' good performance on these topics was contributed by their sufficient knowledge, computational skills, and competence in the concepts tested, as well as their understanding of the requirements of the questions.

The topics with average performance were *Illumination* (54.63%), tested in questions 5 and 9; *Cells and Batteries* (46.87%), tested in question 8; and *A.C Circuits* (39.04%), and tested in question 6. The analysis indicates that the average performance was due to the candidates' fair knowledge of the tested topics. However, some candidates provided few or incorrect points in some of the items and failed to use correct formulas to perform calculations. A summary of the candidate's performance in each topic is presented in the Appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The general performance of the candidates in Electrical Engineering subject on Form Four National Examinations (CSEE) in the year 2023 was good. Out of 320 candidates who sat for the examination, 298 (93.13%) passed, whereas 22 (6.87%) failed. The candidates' good performance resulted from their ability to understand the requirements of the questions, knowledge, skills, and competence in the subject matter.

However, a few shortcomings have been revealed. These include the candidates' insufficient knowledge in responding to some of the questions, failure to understand the demand of the questions, poor communication skills and inability to apply appropriate formulae in computations, especially in the topic of *AC Circuit*.

4.2 Recommendations

Based on the observations made in the Candidates' Item Response Analysis (CIRA), the following recommendations are made to improve performance in this subject.

- (a) Candidates must dedicate themselves to study thoroughly to acquire a deep understanding, skills, and proficiency in the subject matter covered within the prescribed syllabus.
- (b) It is essential to implement a competence-based approach during delivering of learning materials across various topics so as to ensure that prospective candidates acquire and master the necessary knowledge, skills, and competencies.
- (c) Candidates should be encouraged to do more computational exercises to improve skills in dealing with questions that involve applying formulas and calculations especially from topics of *D.C Circuits*, *A.C Circuits*, and *Cells and Batteries*, which were observed to be challenging to most candidates.

- (d) During teaching and learning process, teachers should start with simple examples and gradually progress to more complex ones related to the relevant concepts. This will provide candidates with the opportunity to practice and build confidence, and finally, achieve the intended goals.
- (e) Candidates need to put more effort into learning English language skills to develop effective communication abilities and accurately interpret questions, thus improving their overall academic performance.
- (f) Teachers should incorporate technology during teaching and learning process, such as educational software, online resources, and interactive multimedia, to enrich the learning experience. This approach is efficient in making complex subjects more accessible, hence promoting candidates' understanding of that particular aspect.

Appendix

A Summary of the Candidates' Performance in Each Topic in Electrical Engineering Subject for the Year 2023

S/n	Topic	Question Number	Percentage of Candidates who Scored 30 per cent and above	Remarks
1	Units, D.C circuits, Electrical Workshop Orientation, Illumination, A.C Machines, Transformers and Cells and Batteries	1	96.56	Good
2	Transformers	3	89.07	Good
3	Capacitors and Capacitances	7	81.56	Good
4	Current Electricity	10	78.24	Good
5	Measuring Instruments	4	76.56	Good
6	A.C Machines	11	75.16	Good
7	D.C Circuits	2	67.19	Good
8	Illumination	5 & 9	54.63	Average
9	Cells and Batteries	8	46.87	Average
10	A.C Circuit	6	39.04	Average

