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

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2022

ELECTRICAL ENGINEERING SCIENCE

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082 ELECTRICAL ENGINEERING SCIENCE

Published by:
The National Examinations Council of Tanzania,
P. O. Box 2624,
Dar es Salaam, Tanzania.

TABLE OF CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

A	Ampere
A.C	Alternating Current
CIRA	Candidates' Items Response Analysis
mm	Millimeter
CSEE	Certificate of Secondary Education Examinations
D.C	Direct Current
E.M.F	Electromotive Force
H	Henry
µH	Micro Henry
Hz	Hertz
pF	Pico farad
kW	kilo Watt
L	Inductance
mA	milli ampere
mWb	milli weber
NECTA	National Examinations Council of Tanzania
^{o}C	Degree Centigrade
p.f	Power Factor
V	Volt
Ω	Ohm
R	Resistance
P.V.C	Polyvinyl Chloride
r.m.s	root mean square
$J/kg^{0}C$	Joules per kilogram per degree centigrade
I	Current
C	Capacitance
I	Instantaneous current
t	Time

FOREWORD

This report presents Candidates' Items Response Analysis (CIRA) on Form Four National Examination in Electrical Engineering Science subject which was conducted in November 2022. The report aims to provide feedback to all educational stakeholders on the factors that contributed to the candidates' performance in Electrical Engineering Science subject.

The Form Four National Examinations (CSEE) is a summative evaluation which intends to measure the knowledge, skills and competences acquired by the students in four years of instructional period of ordinary level of secondary education. The report therefore, provides feedback that teachers, students and other educational stakeholders can use to improve teaching and learning process. This analysis justifies the candidates' performance in the Electrical Engineering Science subject. The candidates who attained high scores demonstrated their ability to understand the requirement 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 difficulties in responding to the questions due to their insufficient knowledge of the tested concepts.

The National Examinations Council of Tanzania (NECTA) expects that the feedback provided in this report will enable teachers and other education stakeholders to take proper measures to improve teaching and learning process in Electrical Engineering Science subject. Consequently, prospective candidates will acquire knowledge, skills and competence indicated in the syllabus for better performance in future Form Four National Examination in Electrical Engineering Science subject.

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

Dr. Said A. Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents the analysis of the performance of candidates who sat for the Certificate of Secondary Education Examination (CSEE) 2022 in Electrical Engineering Science. The paper consisted of fourteen (14) questions which were categorized into three sections namely; A, B and C. Section A had one (1) multiple choice question with 10 items, set from various topics. The candidates were required to answer all the items in this section. Each item carried 1 mark, making a total of 10 marks. Section B consisted of nine (9) short answer questions. The candidates were required to answer all the questions in this section. Each question carried 05 marks, making a total of 45 marks. Section C consisted of four (4) structured questions. The candidates were required to answer three questions from this section. Each question carried 15 marks, making a total of 45 marks.

In this report, the analysis of candidates' performance is analyzed into three categories; good, average and weak indicated by green, yellow and red colours respectively. In each question the performance is regarded as good if 30% of the candidates their scores range from 65 to 100 per cent, average if the scores range from 30 to 64 per cent and weak if the scores range from 0 to 29 per cent.

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' examination scripts, graphs indicating distribution of candidates' scores and appendices are presented in this report for illustrations.

A total of 533 candidates sat for the CSEE in the Electrical Engineering Science subject in the year 2022. Among them, 472 (88.56%) candidates passed while 61 (11.44%) candidates failed. Generally, the candidates' performance in this paper is good. In the year 2021, a total of 349 (80.60%) candidates passed while 84 (19.40%) failed. Therefore, the candidates' performance in the year 2022 has increased by 7.96 per cent. The candidates' grade scores are presented in Table 1.

Table 1: The Candidates' Grade Scores in 2021 and 2022

Year	Clean Data	Passed		Percentage of Candidates and their Grade of Scores				
		No.	%	A	B	C	D	F
2021	433	349	80.60	6.70	11.55	37.41	24.94	19.40
2021	533	472	88.56	12.76	21.39	37.15	17.26	11.44

2.0 THE ANALYSIS OF THE CANDIDATES' RESPONSES TO EACH QUESTION

2.1 SECTION A: OBJECTIVE QUESTIONS

2.1.1 Question 1: Multiple Choice Items.

The question consisted of 10 multiple choice items (i-x) derived from the following topics: *Units, Transformer, Electromagnetism, D.C Machines, Safety Precautions, Instruments and Measurements, Effects of Electric Current* and *D.C Circuits.* The candidates were required to choose the correct answer from the given alternatives (A to E).

A total of 533 (100%) candidates attempted this question. Among them, 13 (2.4%) candidates scored from 0 to 2 marks; 222 (41.7%) scored from 3 to 6 marks and the remaining 298 (55.9%) scored from 7 to 10 marks. Generally, the candidates' performance was good since 520 (97.6%) passed. The candidates' performance on this question is summarizes in Figure 1.

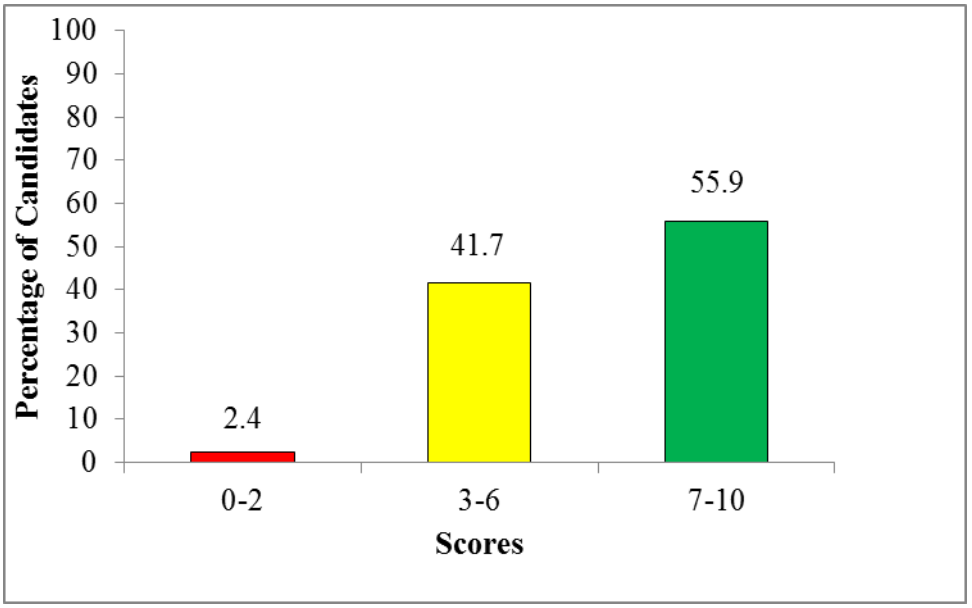


Figure 1*: The Candidates' Performance in Question 1*

The following is the analysis of the candidates' responses to each item.

(i) W*hich quantity is measured in farad as the nature and behaviors of electrical quantities are considered?*

A Reactance *B Inductance* *C Impedance*
D Capacitance *E Resistance*

This item was constructed from the topic of *Unit.* It was intended to measure the candidates' ability to relate various electrical quantities to its unit of measurement. The correct answer was D, *Capacitance*. The candidates who identified the correct alternative were knowledgeable enough in the topic of *Units*. However, those who selected alternatives A, *Reactance,* B, *Inductance* C, *Impedance* and E, *Resistance* lacked knowledge in the topic of units as they failed to recognize that those parameters are measured in *ohm* and not *farad*. The candidates were supposed to understand that resistance, inductance, impedance, and reactance are different electrical quantities that describe the behavior of electrical circuits. Capacitance describes the ability of a circuit element to store electrical energy in the form of an electric field, while resistance, inductance, impedance, and reactance describe the opposition to the flow of electrical current in a circuit.

(ii) *A Transformer having 1000 primary turns is connected to 250 V A.C supply. If secondary voltage is 400 V, what is the number of secondary turns?*

A 1700 *B 1800* *C 1600*
D 1650 *E 1550*

This item was set from the topic of *Transformers.* It aimed to test the candidates' knowledge on basic principles of transformers and the ability to use the turns' ratio formula to solve for unknown values. The item was well done by most of the candidates as they selected the correct alternative which was C, *1600.* This implies that they had enough knowledge of the tested concept. A few candidates who wrongly selected alternatives A, *1700,* B, *1800,* and E, *1550* proved to lack knowledge about transformers as they selected irrelevant responses. Those who selected alternative *D, 1650,* probably just summed up all numbers that appeared in this item. Generally, the candidates who selected wrong responses failed to remember the relationship between number of turns and supply voltage in transformer.

(iii) *How are the transformer laminations insulated from each other?*

A By mica strip *B By thin coat of vanish* *C By glass*
D By P.V.C *E By rubber insulation*

Item (iii) was constructed from the topic of *Transformers*. The item tested the candidates' knowledge about the insulation techniques used in transformers to prevent energy losses. Most of the candidates correctly selected alternative B, *By thin coat of vanish*. These candidates understood

that the thin coat of varnish serves as insulation between the laminations, preventing electrical conduction between them and preserving the magnetic isolation necessary for proper transformer operation. On the contrary, the candidates who selected alternatives A, By *mica strip; B, By glass*; D, *By P.V.C*; and E, *By rubber insulation* failed to realize that transformer laminations are not insulated from each other with those materials because they do not serve as electrical insulators and therefore, they do not block the flow of electrical current between components.

(iv) Which of the following devices apply magnetic effect to operate?

A Fuse *B Cell* *C Bell*
D Toaster *E Cooker*

This question was set to assess the candidates' knowledge and understanding of the properties of magnets and their applications in various devices. The item was constructed from the topic of *Electromagnetism* and the correct response was C, *Bell*. The candidates who selected this option had adequate knowledge on the applications of electromagnetism. However, a few candidates who selected incorrect alternatives A, *Fuse* D, *Toaster* and E, *Cooker* failed to understand that these appliances apply heating effects to operate. On the other hand, those who select alternative B, *Cell* did not recognize that *cell* operates under the chemical effect and not magnetic effect. In general, the candidates who missed this item had insufficient knowledge about electromagnetism and its application.

(v) Which one can cause accidents in an electrical workshop?

A Wearing goggles *B Sweeping the floor*
C Large working space *D Wearing loose sleeve shirts*
E Using wooden chairs

This question intended to measure the candidates' awareness of safety precautions and potential hazards in an electrical workshop. The item was set from the topic of *Safety Precautions.* Most of the candidates selected the correct alternative D, *Wearing loose sleeve shirts*. These candidates understood that wearing loose sleeve shirts in an electrical workshop can cause a safety hazard as they can get caught in machinery or equipment, potentially causing injury or an accident. A few candidates wrongly selected options A, *Wearing goggles* B, *Sweeping the floor* C, *Large working space* and E, *Using wooden chairs*. These candidates confused with the safety conditions which help to reduce risk or accidents in the workshop. This suggests that they lacked knowledge and ability to remember some concepts

learnt in the topic of *introduction to electrical engineering* particularly, safety precautions.

(vi) *Which statement is true about the purpose of the commutator in D.C. machine?*

A It takes away generated voltage.
B It converts output current to voltage.
C It converts D.C voltage to A.C voltage.
D It rectifies A.C voltage to D.C voltage
E It converts AC current to D.C current.

This item was constructed from the topic of *D.C machines*. The question tested the candidates' knowledge and understanding of concepts related to D.C machines and their ability to identify the function of the commutator. Most of the candidates correctly selected alternative D, *It rectifies A.C Voltage to D.C Voltage.* This shows that the concepts of d.c machines especially d.c generator was well understood. The candidates who selected alternative C, *It converts D.C Voltage to A.C Voltage* reversed the correct function of commutator in d.c. machine which is to convert a.c voltage to d.c. voltage. They failed to understand that a commutator does not convert d.c voltage to a.c voltage; rather it changes the direction of current flowing in the armature windings, hence constant voltage. Similarly, those who selected distractors A, *It takes away generated voltage*; B, *It converts output current to voltage* and E, *It converts AC current to D.C current* lacked knowledge of d.c machines, especially the concept of commutation. They failed to recognize that a commutator is a mechanical rectifier which converts the alternating voltage generated in the armature windings into direct voltage across the brushes.

(vii) *Where is it appropriate to use wattmeter for measuring purposes?*

A In measuring apparent power.
B In measuring true power.
C In measuring reactive power
D In measuring average power.
E In measuring estimated power

The item was constructed from the topic of *Instruments and Measurements*. It intended to test the candidates' knowledge in instrumentation, specifically, their ability to identify the appropriate use of wattmeter for measuring purposes.

The analysis of data shows that, many candidates responded correctly by selecting alternative B, *In measuring true power*. These candidates demonstrated their ability to relate electrical quantities to their appropriate measuring instruments. However, those who selected incorrect alternative, A, *In measuring apparent power* did not remember that apparent power is a combination of real power and reactive power, and therefore, it requires a different type of meter, such as a power factor meter to measure it accurately. The analysis further reveals that some of them opted for alternative C, *In measuring reactive power* because they failed to recognize that reactive power is the power that is returned to the source and cannot be used by the load, and therefore, it cannot be measured by a wattmeter. A wattmeter is used to measure the power consumption of the load. Those who selected D, *In measuring average power* or E, *In measuring estimated power* lacked practical skills on instruments and measurements because they failed to understand that average power and estimated power are obtained by calculations.

(viii) *What will happen in an induction motor if the air gap is increased?*
- *A* *Bearing friction will increase.*
- *B* *Windage losses will be more.*
- *C* *Copper losses will be reduced.*
- *D* *The power factor will be low.*
- E *The power input will be more*.

This question assessed the candidates' ability to recognize the basic principles and characteristics of induction motors, and was set from the topic of *D.C Machines*. The correct response was D, *Power factor will be low*. The item was correctly answered by few candidates. This performance indicates that most of the candidates lacked knowledge on the concepts about *D.C Machines*. The candidates who opted for alternatives A, *Bearing friction will increase* B, *Windage losses will be more* C, *Copper losses will be reduced* and E, *The power input will be more*, confused the items since all of them are used in induction motors. Similarly, some candidates lacked knowledge about losses which may occur in d.c machines and therefore, failed to identify the correct responses.

(ix) *Which of the following are the main effects of an electric current?*
A Magnetic, Electromagnetic and Electricity.
B Chemical, Magnetic and boiling
C Heating, repelling and attracting
D Magnetic, Heating and Electric
E Heating, Chemical and Magnetic

This item was set from the topic of *Effects of Electric Current*. The question intended to measure the candidates' ability to identify various effects that can be produced by an electric current. The correct response was E, *Heating, Chemical and Magnetic*. The candidates who chose the correct response demonstrated greater understanding of the concepts related to effects of electric current. On the contrary, those who selected incorrect responses A, *Magnetic, Electromagnetic and Electricity* and D, *Magnetic, Heating and Electric* were misled by the terms *electricity* and *electric* as they associated them with the term *electric* that appeared in the steam of the question. A few candidates who opted for B, *Chemical, Magnetic and boiling*, and C, *Heating, repelling and attracting* failed to recognize that boiling, repelling and attracting are not effects of an electric current, rather the outcomes of heating and magnetic effects respectively.

(x) *Why are electrical appliances connected in parallel?*
A Parallel circuit is simple in connection and economical.
B Appliances drew high current and power.
C Appliances drew high current and less resistance.
D Appliances in parallel reduce power loss and cost.
E *The operation of appliances is independent of* each other.

This question intended to measure the candidates' ability understand the principles of electrical circuits and give the reasons for connecting electrical appliances in parallel. The item was set from the topic of *D.C Circuits*. The correct response was E, *The operation of appliances is independent of each other*. Most of the candidates who chose the correct answer had adequate knowledge of D.C Machine. Some of them incorrectly selected alternatives A, *A Parallel circuit is simple in connection and economical* B, *Appliances drew high current and power* C, *Appliances drew high current and less resistance* and D, *Appliances in parallel reduce power loss and cost*. These candidates had insufficient knowledge and skills on the impact of arranging electrical appliances in series and parallel connections in the circuits.

2.2 SECTION B: SHORT ANSWER QUESTIONS

2.2.1 Question 2: Transformers

The question had two parts (a) and (b). Part (a) required the candidates to draw an electrical symbol of an air cored transformer. In part (b), they were required to calculate the efficiency of a transformer for a single phase transformer with an input and output power of 2 kW and 1.9 kW respectively.

The question intended to evaluate the candidates' ability to draw symbols which is used to represent transformers and their competence to apply mathematical formula to calculate efficiency of the transformer.

A total of 533 (100%) candidates attempted this question and their scores were as follows: 43 (8.1%) candidates scored from 0 to 1 mark; 332 (62.3%) scored from 2 to 3 marks and 158 (29.6%) candidates scored from 4 to 5 marks. The performance of the candidates on this question was good since 490 (91.9%) of them passed. Figure 2 summarizes the candidates' performance.

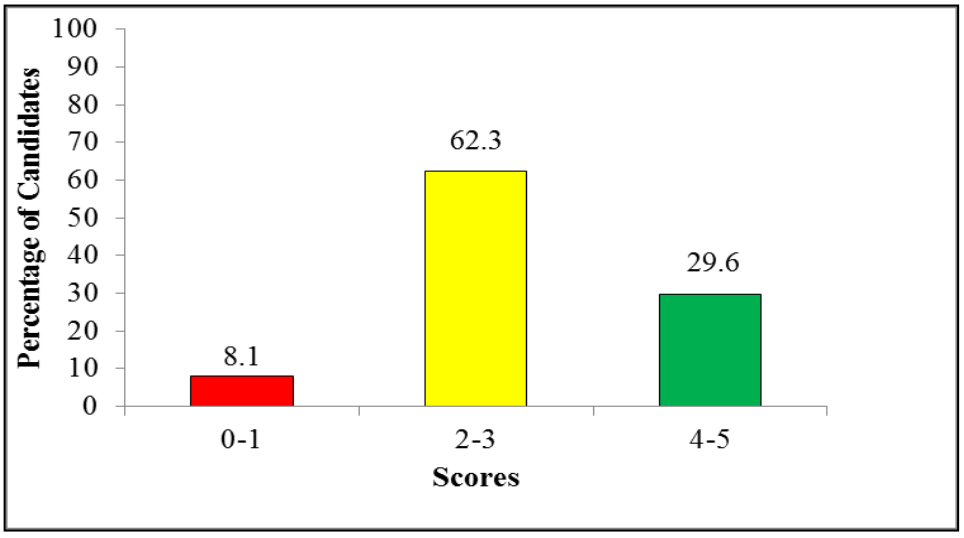
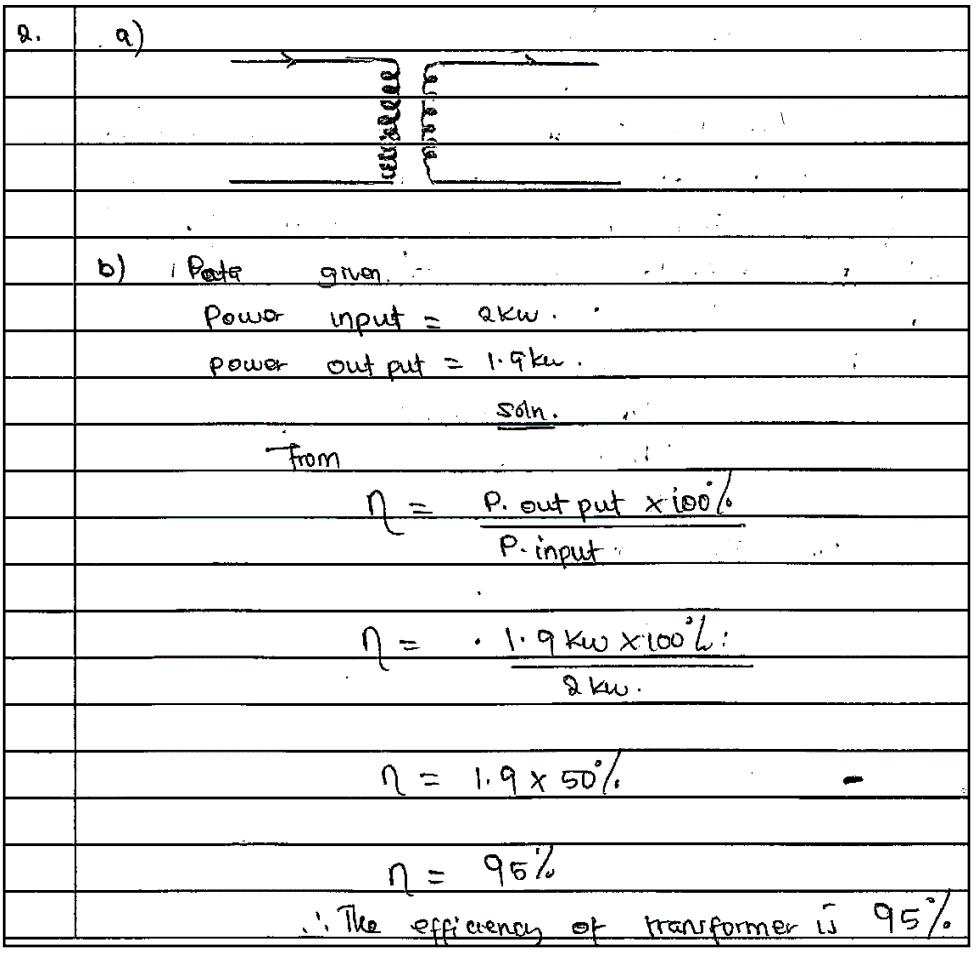


Figure 2: *The Candidates' Performance in Question 2*

The analysis of data shows that 490 (91.9%) candidates who scored from 2 to 5 marks were knowledgeable enough on the concepts of transformer. Most of them understood the question as they correctly drew the electrical

symbol of an air cored transformer and calculated its efficiency. Extract 1.1 shows a sample of correct responses from one of the candidates.

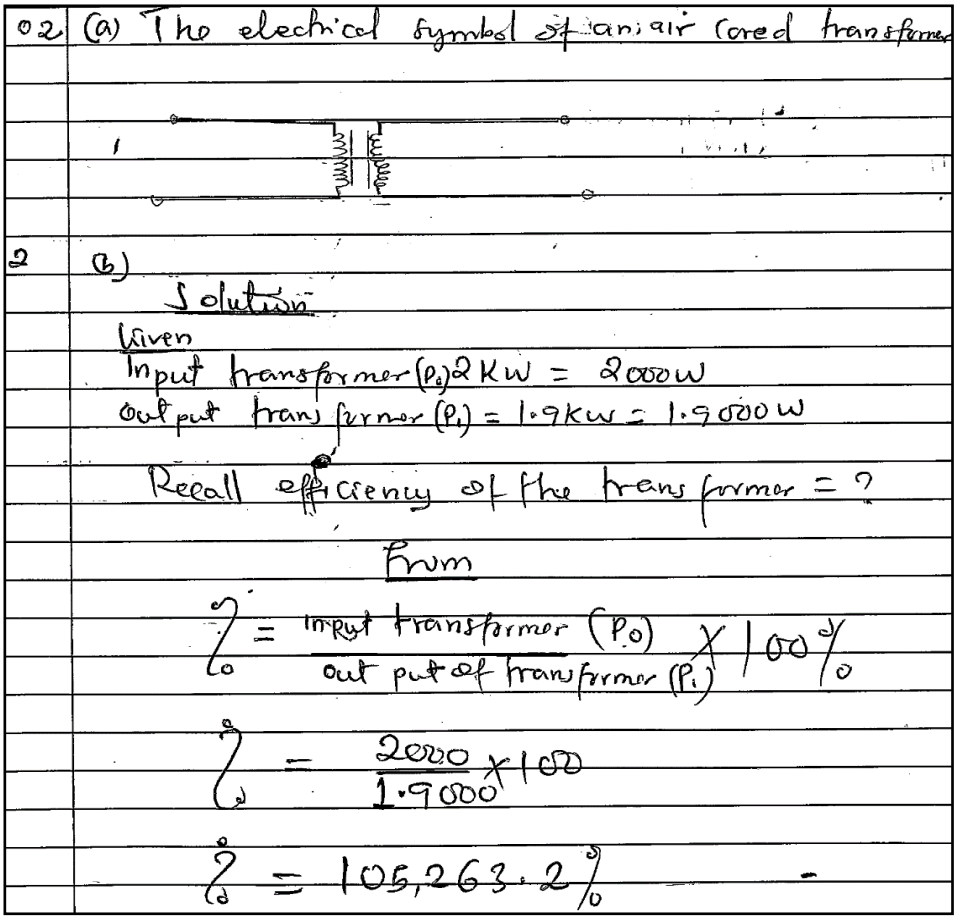


Extract 1.1: A sample of correct responses to Question 2

In Extract 1.1, the candidate correctly provided the electrical symbol and applied the formula and procedure to determine the efficiency of a transformer.

The analysis further shows that, 43 (8.1%) candidates scored 1 mark or less as they failed to meet the requirements of the question, and lacked knowledge on the concept of transformer. In part (a), most of them drew other types of transformers such as iron dust core transformer and iron cored autotransformer while others drew symbols which are undefined. For example, one of the candidates drew the construction of a transformer which is contrary to the requirements of the question. In part (b), some of them applied incorrect formula to find the efficiency of a transformer while others

did not attempt this part. Extract 1.2 illustrates a sample of incorrect responses from one of the candidates.



Extract 1.2: A sample of incorrect responses to Question 2

In Extract 1.2, the candidate drew the symbol of an iron cored transformer instead of air cored transformer as required in part (a). Likewise in part (b), he/she used an inverted formula to calculate the efficiency of the transformer.

2.2.2 Question 3: Instruments and Measurements

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

A moving coil instrument gives full-scale deflection with 15 mA and has a resistance of 5 Ω. Calculate the resistance required to enable the instrument to read up to:

(a) 1 A in parallel connection.

(b) 10 V in series connection.

A total of 533 (100%) candidates attempted this question. Among them, 142 (26.6%) scored from 0 to 1 mark, scored from 1.5 to 3 marks were 57 (10.7%) and the remaining 334 (62.7%) scored from 3.5 to 5 marks. In general, the performance was good since 391 (73.4%) candidates passed. The candidates' performance in this question is summarizes in Figure 3.

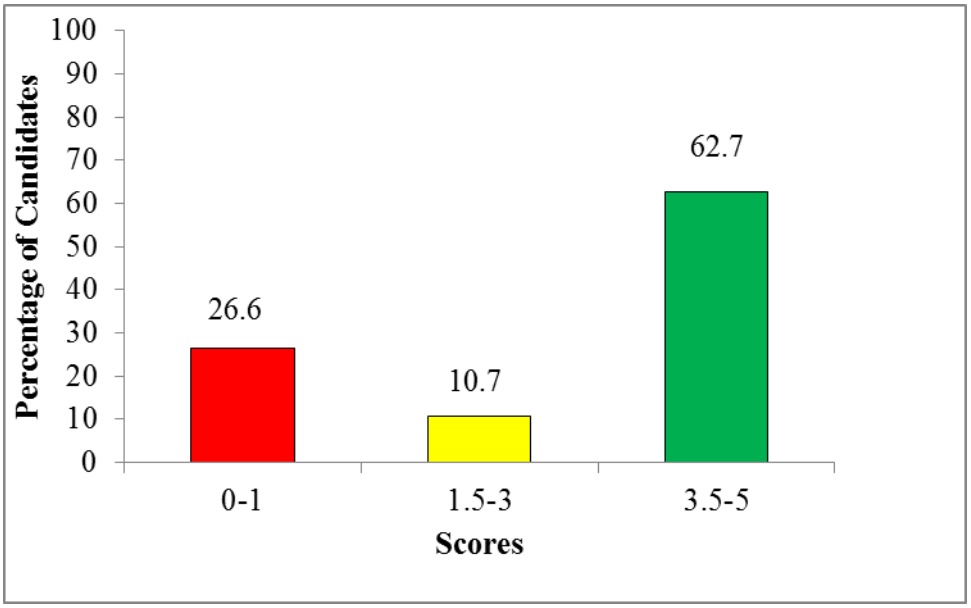
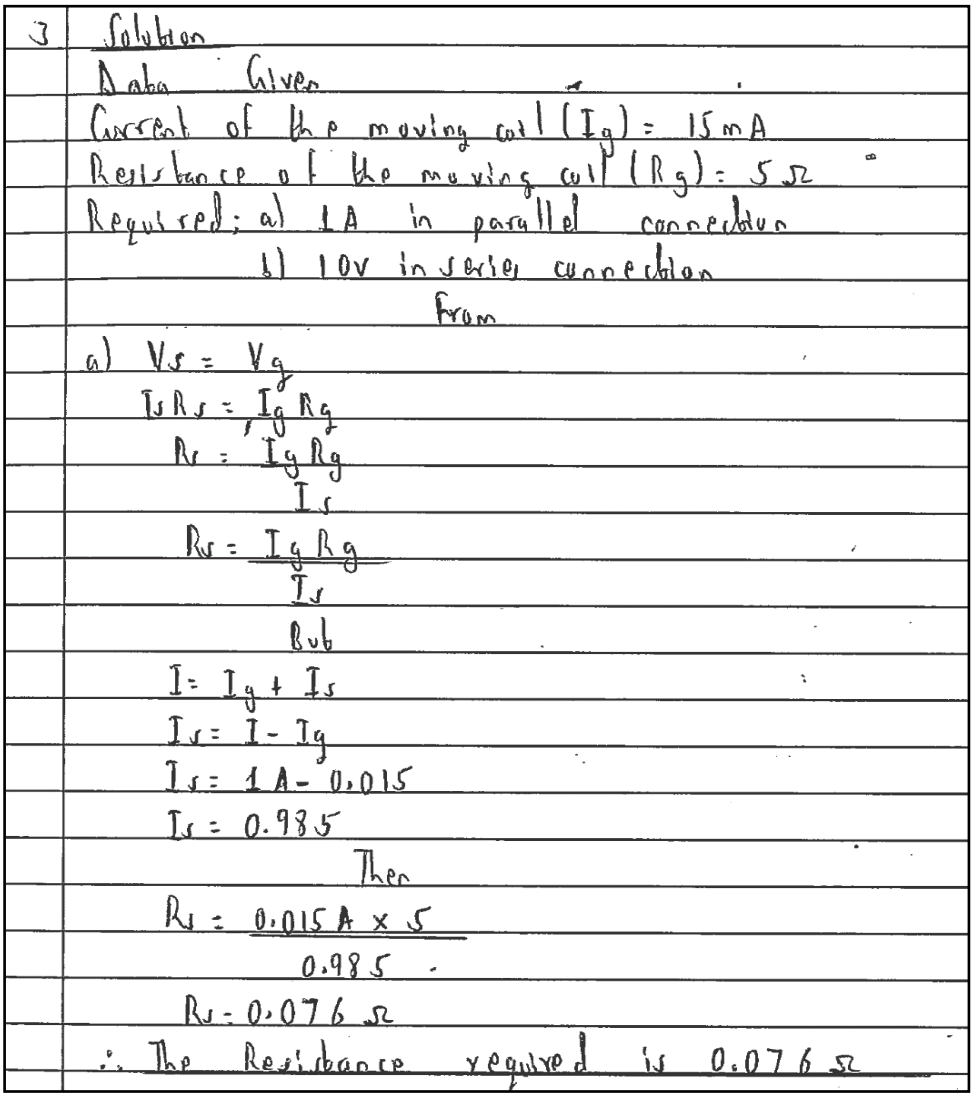


Figure 3: *The Candidates' Performance in Question 3*

The analysis reveals that 73.4 per cent of the candidates scored from 1.5 to 4 marks as they demonstrated their ability to apply correct formula to determine the value of resistance required to enable the instrument to read up to 1 A in parallel connection and 10 V in series connection. Their responses suggest that they had sufficient knowledge about measurements and instruments. Extract 2.1 shows a sample of correct responses from one of the candidates.

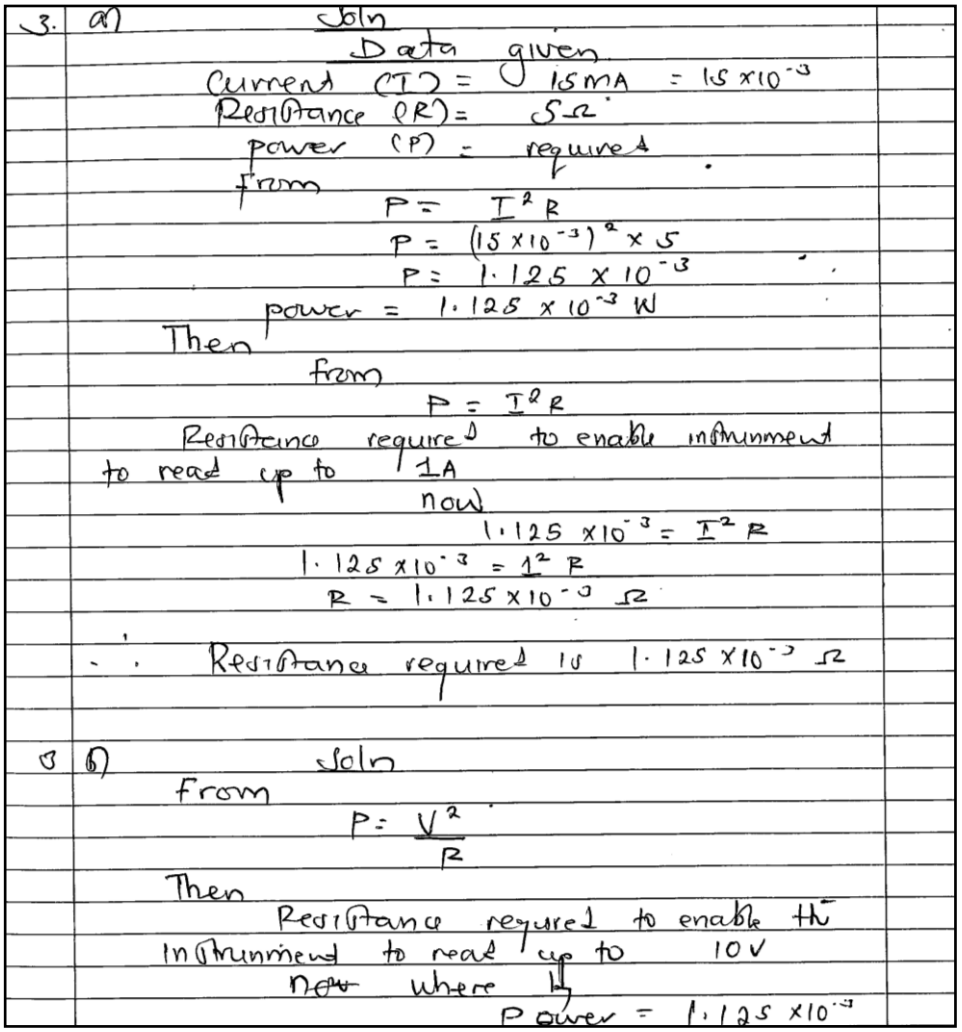


Extract 2.1: A sample of correct responses to Question 3

Extract 3.1 shows that the candidate applied a correct formula to calculate the value of the resistances required to be connected in parallel and in series with a moving coil instrument to meet the requirement of the question.

In spite of good performance, 142 (26.6%) candidates scored low marks, and among them, 22 percent scored zero. These candidates had inadequate knowledge on the topic of *Instruments and Measurements*. They applied incorrect formulae or followed wrong procedures in calculations which resulted in incorrect answers. Some of them used the formula of parallel and series connection interchangeably while others used irrelevant formula. For example, one of the candidates wrongly responded to both parts of the

question by using the formula $\left(R_m = \frac{V_m}{I_m}\right)$ in part (a) and $\left(V_m = I_m R_m\right)$ in part (b) instead of $\left(R_{sh} = \frac{I_{fs} \times R_m}{I - I_{fs}}\right)$ and $\left(R_s = \frac{V}{I_{fs}} - R_m\right)$ respectively. Whereby; R_m = meter resistance, V_m = meter voltage, I_m = meter current, R_{sh} = shunt resistance, R_s = series resistance and I_{fs} = full scale current. Extract 2.2 illustrates a sample of incorrect responses from one of the candidates.



Extract 2.2: A sample of incorrect responses to Question 3

In Extract 2.2, the candidate used the formula of calculating electric power in both parts of the question which is contrary to the requirement of the question.

2.2.3 Question 4: Batteries and Cells

The question was as follows: Calculate the supply voltage necessary for charging a battery of 110 cells at 30 A at the beginning and at the end of the charge. Each cell possesses a p.d of 2.1 volts at the beginning and 2 volts at the end of charge. Allow 0.06 Ω for the resistance of the connecting leads.

This question tested the candidates' ability to calculate the required supply voltage at the beginning and end of the battery charging process. Generally, it examined a combination of mathematical and conceptual skills related to Batteries and Cells.

A total of 533 (100%) candidates attempted this question, among them 417 (78.2%) scored from 0 to 1 mark, 86 (16.1%) scored from 1.5 to 3 marks, and 30 (5.6%) scored from 3.5 to 5 marks. Generally, the performance of the candidates was weak since only 116 (21.7%) candidates passed. Figure 4 summarizes the candidates' performance in this question

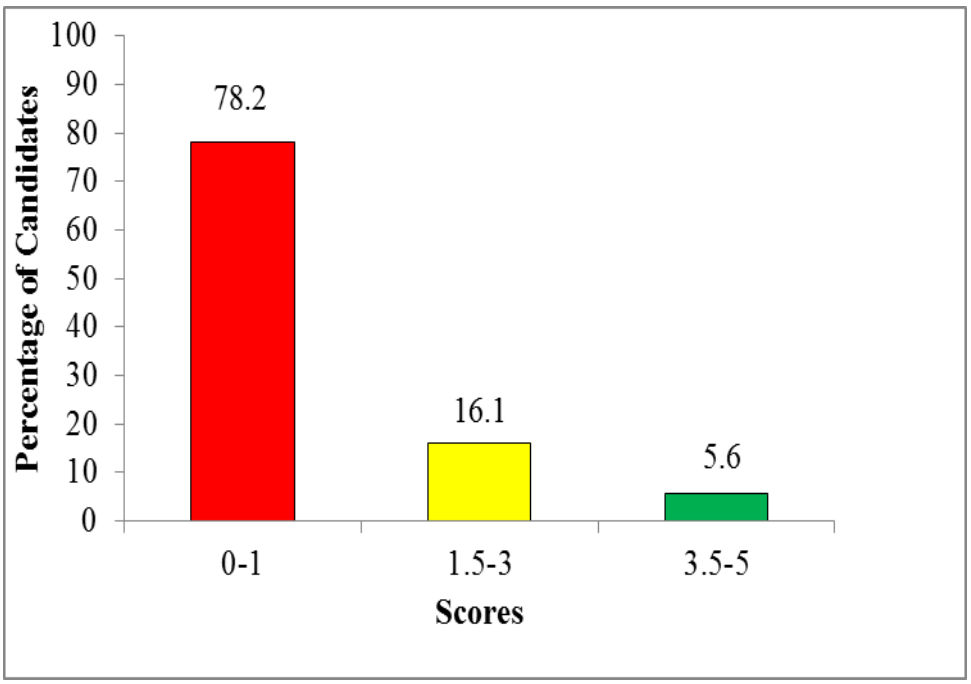
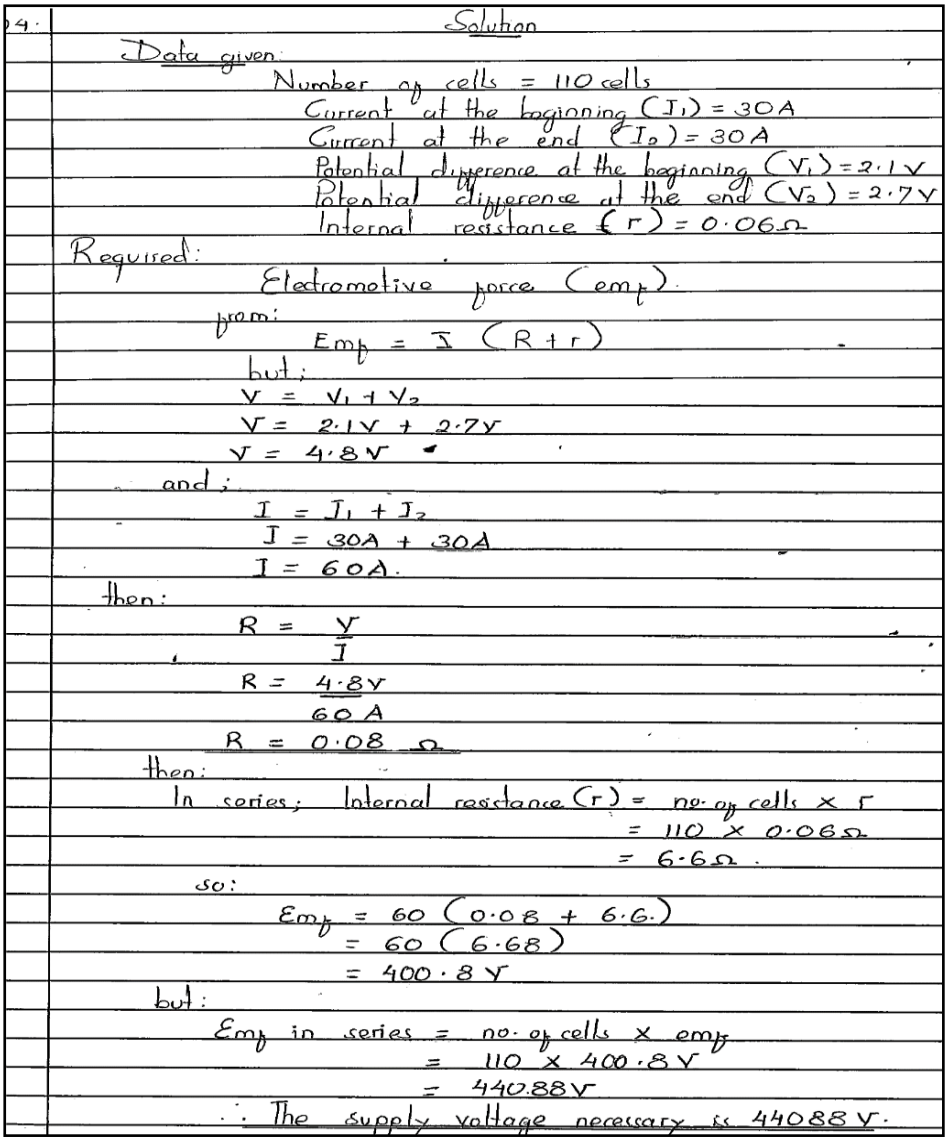


Figure 4: *The Candidates' Performance in Question 4*

The analysis of candidates' responses shows that 417 (78.2%) candidates had weak performance. Most of them failed to apply the correct formula to

calculate the supply voltage required for the charging of a battery. For example, one of the candidates wrongly interchanged the sign in the formula of calculating supply voltage by writing $(V= Eb-Ir)$ instead of $(V= Eb+Ir)$. Whereby V = supply voltage, Eb = Back e.m.f of the cell and Ir = internal resistance of the cell. The wrong responses indicate that the candidates had inadequate knowledge of the concepts tested on the topic of *Batteries and Cells*. Extract 3.1 illustrates a sample of incorrect responses from one of the candidates.


4: Solution

Data given:
Number of cells = 110 cells
Current at the bagining (I_1) = 30A
Current at the end (I_2) = 30A
Potential difference at the bagining (V_1) = 2.1V
Potential difference at the end (V_2) = 2.7V
Internal resistance (r) = 0.06Ω

Required:
Electromotive force (emf).

from:
$Emf = I(R + r)$

but:
$V = V_1 + V_2$
$V = 2.1V + 2.7V$
$V = 4.8V$

and:
$I = I_1 + I_2$
$I = 30A + 30A$
$I = 60A$.

then:
$R = \frac{V}{I}$
$R = \frac{4.8V}{60A}$
$R = 0.08\ \Omega$

then:
In series; Internal resistance (r) = no. of cells × r
= 110 × 0.06Ω
= 6.6Ω.

so:
$Emf = 60(0.08 + 6.6)$
$= 60(6.68)$
$= 400.8V$

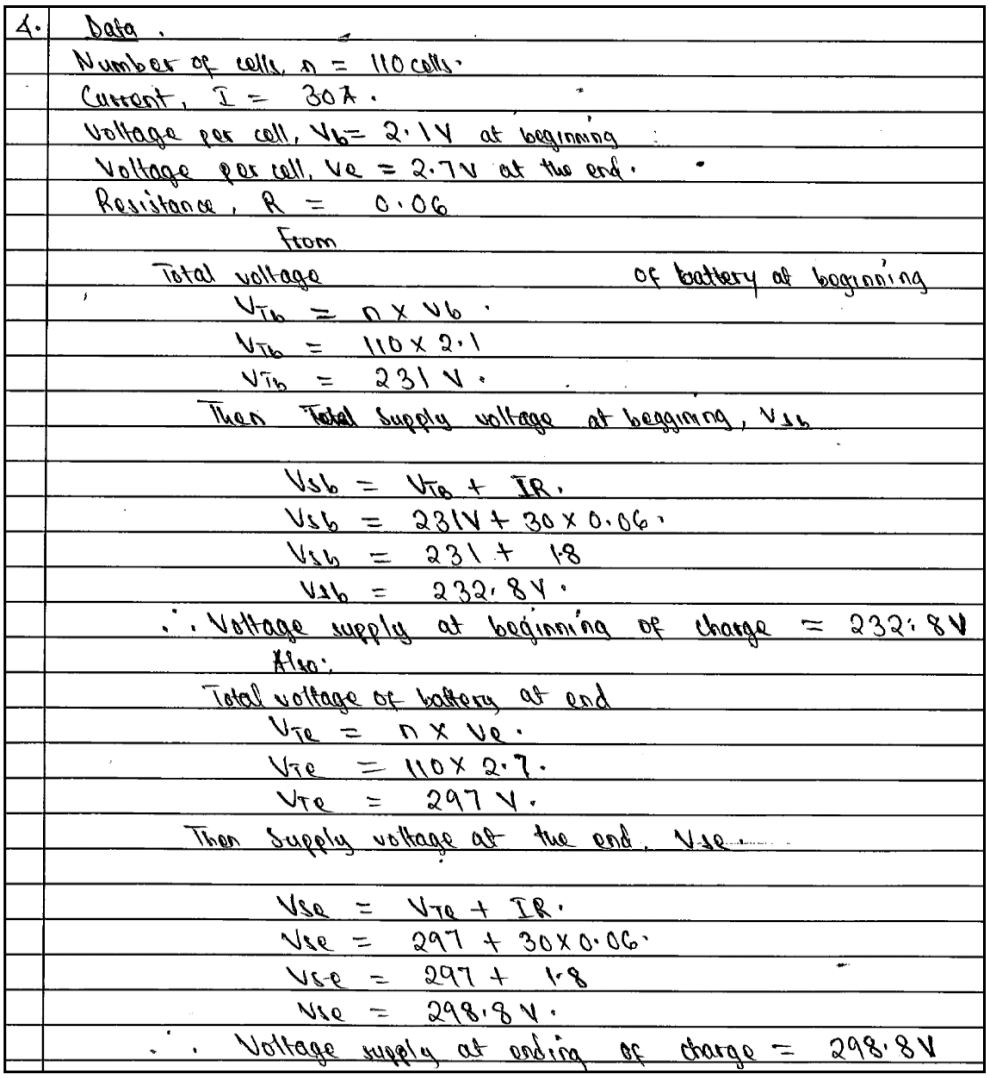
but:
Emf in series = no. of cells × emf
= 110 × 400.8V
= 44088V

∴ The supply voltage necessary is 44088V.

Extract 3.1: A sample of incorrect responses to Question 4

Based on Extract 3.1, the candidate applied a wrong formula and procedure to calculate the supply voltage required for the charging of a battery.

However, 116 (21.6%) candidates performed well and scored average marks and above. Most of them were able to calculate the supply voltage required for the charging of a battery. This indicates that they had sufficient knowledge of the concepts related to Batteries and Cells. Extract 3.2 shows a sample of good responses from one of the candidates.

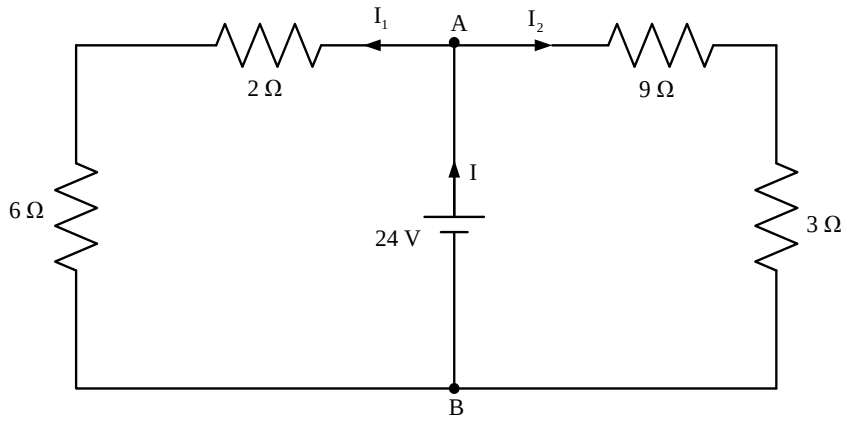

4. Data.
Number of cells, n = 110 cells.
Current, I = 30A.
Voltage per cell, V_b = 2.1V at beginning
Voltage per cell, V_e = 2.7V at the end.
Resistance, R = 0.06
From
Total voltage of battery at beginning
$V_{Tb} = n \times V_b$.
$V_{Tb} = 110 \times 2.1$
$V_{Tb} = 231$ V.
Then Supply voltage at begginng, V_{sb}
$V_{sb} = V_{Tb} + IR$.
$V_{sb} = 231V + 30 \times 0.06$.
$V_{sb} = 231 + 1.8$
$V_{sb} = 232.8$ V.
∴ Voltage supply at beginning of charge = 232.8V
Also.
Total voltage of battery at end
$V_{Te} = n \times V_e$.
$V_{Te} = 110 \times 2.7$.
$V_{Te} = 297$ V.
Then Supply voltage at the end. V_{se}
$V_{se} = V_{Te} + IR$.
$V_{se} = 297 + 30 \times 0.06$.
$V_{se} = 297 + 1.8$
$V_{se} = 298.8$ V.
∴ Voltage supply at ending of charge = 298.8V

Extract 3.2: A sample of correct responses to Question 4

Extract 3.2 shows that the candidate correctly applied the formula to calculate the supply voltage for charging a battery at the beginning and at the end of the charge.

2.2.4 Question 5: D.C Circuits

This question had two parts namely (a) and (b), and was presented as follows: *Study the circuit shown in the following circuit and answer the questions that follow.*



(a) Find the value of I_1 and I_2

(b) Calculate the total current I.

This question was intended to measure the candidates' competence in basic circuit analysis concepts particularly the use of Kirchhoff's laws to calculate current in D.C circuits. It also tested problem-solving skills in applying those concepts to real-world electrical circuits.

A total of 533 (100%) candidates attempted this question, and their scores were as follows; 125 (23.5 %) candidates scored from 0 to 1 mark; 58 (10.8%) scored from 1.5 to 3 marks, and 350 (65.7%) scored from 3.5 to 5 marks. The candidates' performance on this question is summarizes in Figure 5.

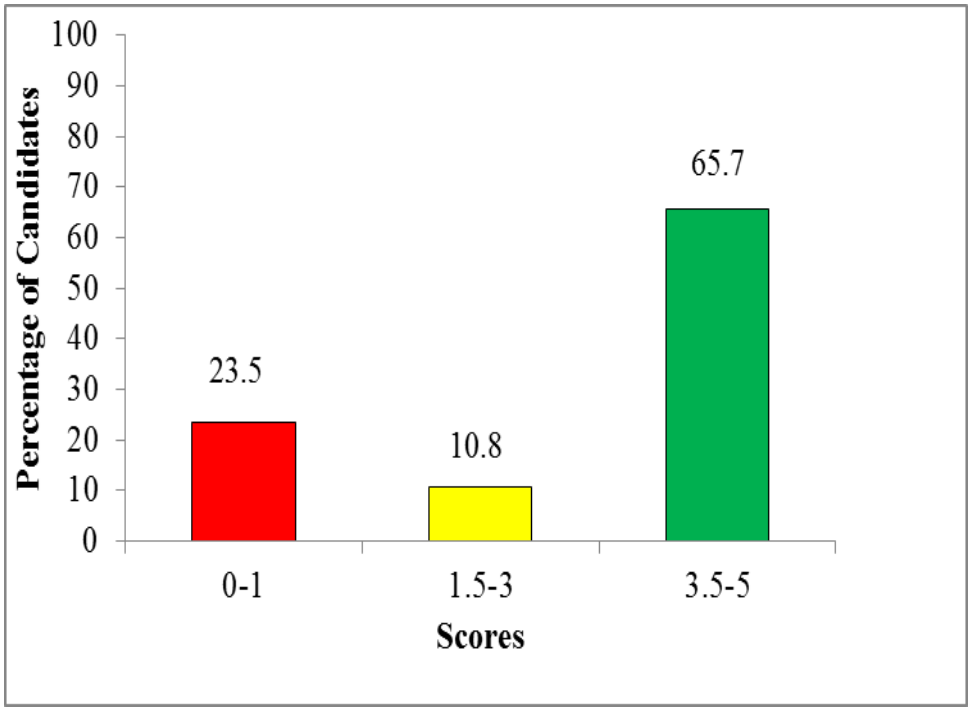
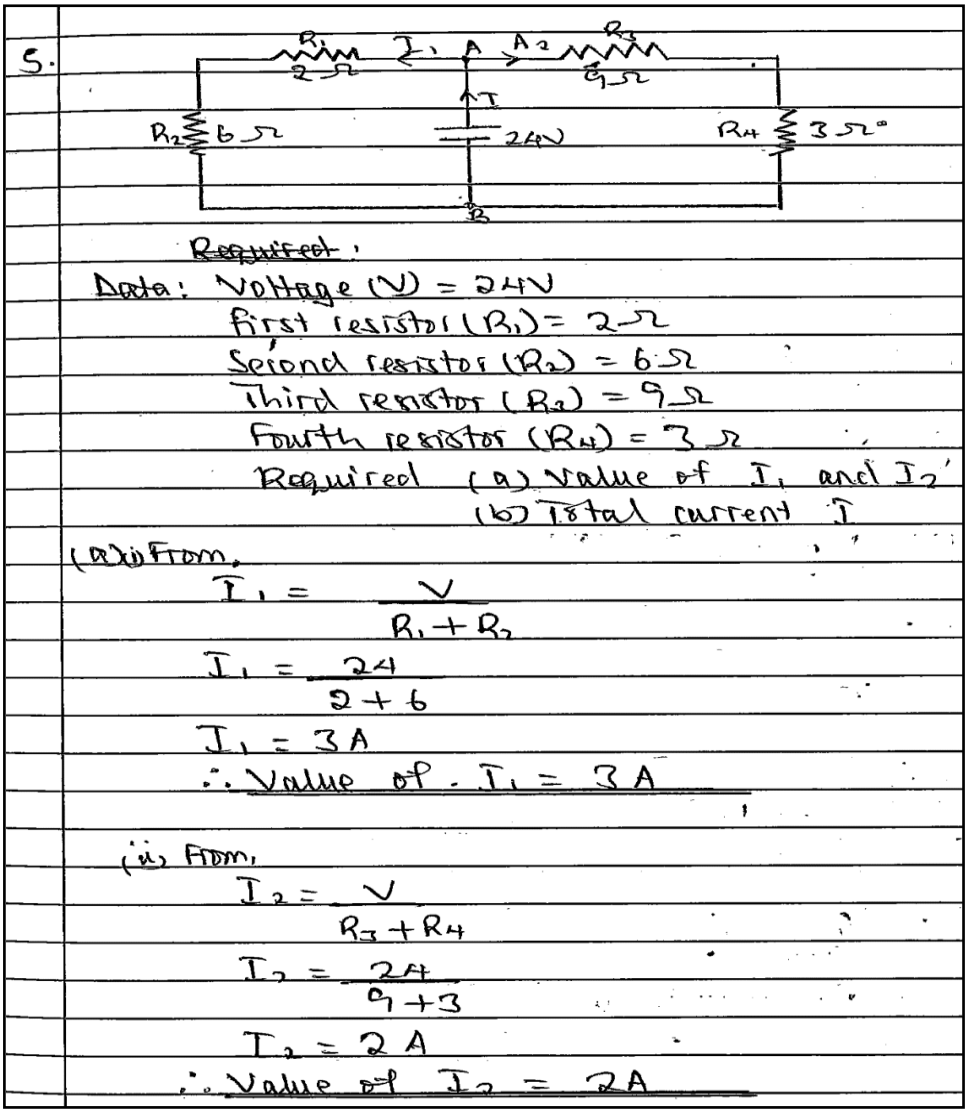


Figure 5*: The Candidates' Performance in Question 5*

Based on the analysis, the general performance in this question was good since 408 (76.5%) candidates scored average marks and above. Out of these candidates, 302 (56.7%) demonstrated ability to analyze the concepts of D.C circuits as they provided correct responses to each part of the question. Extract 4.1 shows a sample of good responses from one of the candidates.



Extract 4.1: A sample of correct responses to Question 5

In Extract 4.1, the candidate demonstrated the ability of applying correct formula to find the value of I_1 and I_2 as requested in part (a) and calculated the total current in part (b).

On the other hand, 23.5 percent of the candidates scored low marks (0-1) including 10.9 per cent who scored zero. Most of them wrote incorrect responses to either all or some parts of the question. Some of them failed to apply the Kirchhoff's law to find the values of currents as required in each part of the question. For example, one candidate formulated wrong equation to compute the values of currents in part (a) by writing:

$$\frac{V}{I_1} = R_1 + R_2 + R_3 + R_4$$

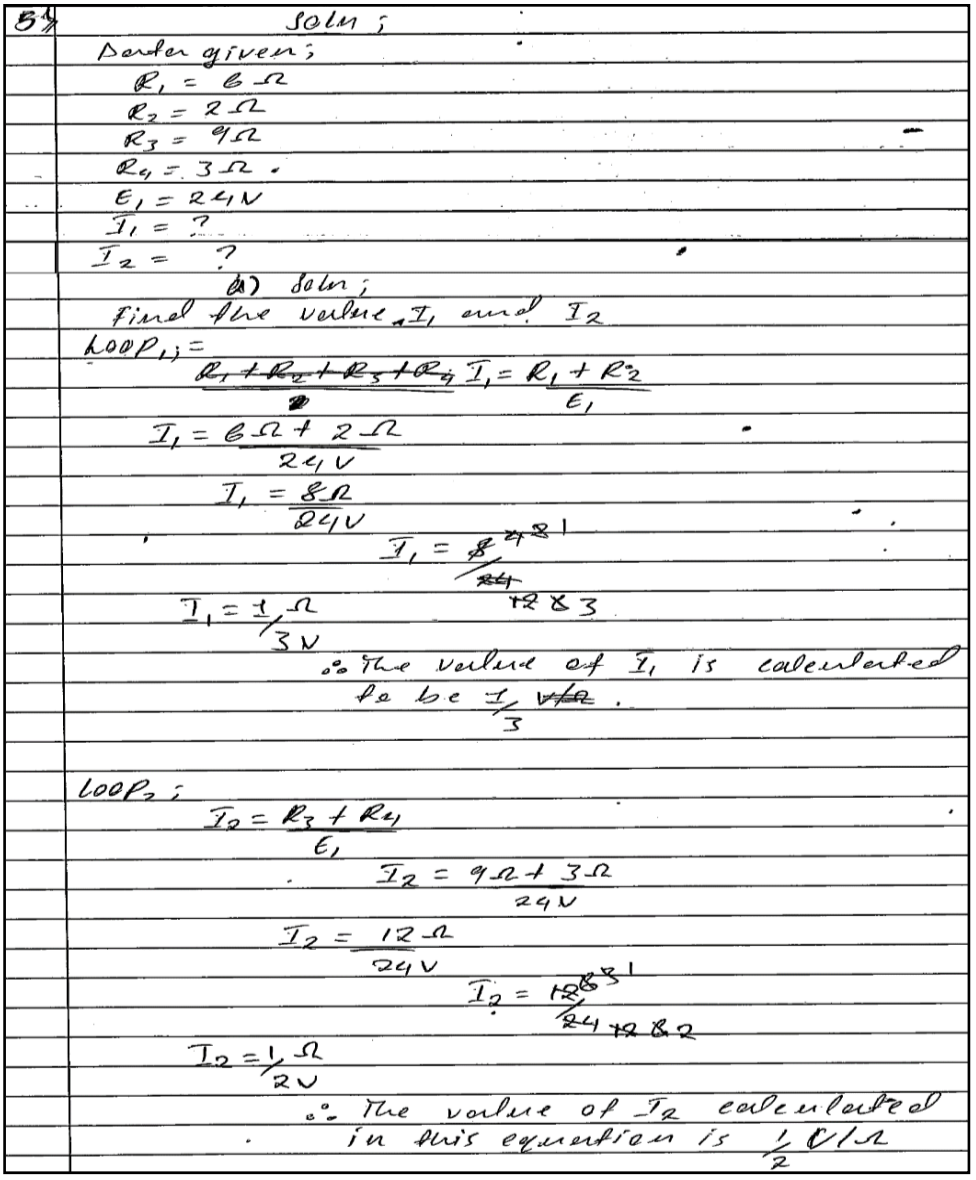
$$I_1 = \frac{V}{(6+2+9+3)}$$

$$I_1 = \frac{24}{20}$$

$$I_1 = 1.2A.$$

Where R = Resistance, V= Voltage and I = Current.

Extract 4.2 is a sample of incorrect responses from one of the candidates.



Extract 4.2: A sample of incorrect responses to Question 5

In Extract 4.2, the candidate formulated the formulae which are not relevant to any part of the question. This indicates that he/she lacked knowledge on application of Kirchhoff's law.

2.2.5 Question 6: Illumination

The question had two parts, (a) and (b), and it was asked as follows:

A lamp rated 230 V gives an illumination of 6000 lux and it takes 1.5 A from the mains. Calculate:
(a) Efficiency of the lamp.
(b) Mean spherical candle power.

The question was based on problem-solving and analytical skills: It was measured the candidates' ability to apply knowledge and concepts of illumination to calculate efficiency and mean spherical candle power of the lamp.

A total of 533 (100%) candidates attempted this question, and their scores were categorized as follows: 342 (64.2%) scored from 0 to 1 mark, 175 (32.8%) scored from 1.5 to 3 marks and 16 (3.0%) scored from 3.5 to 4.5 marks. These scores are summarized in Figure 6.

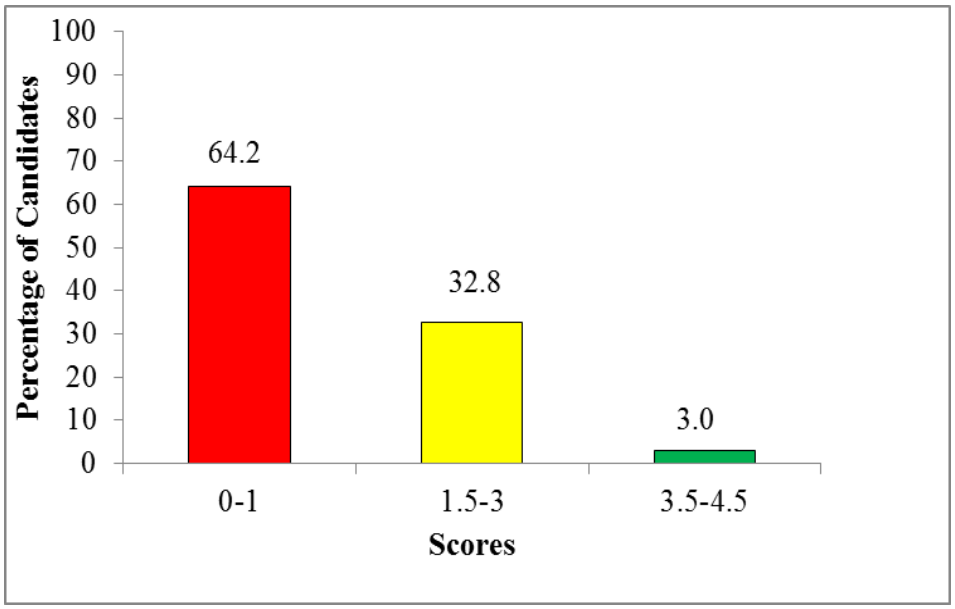
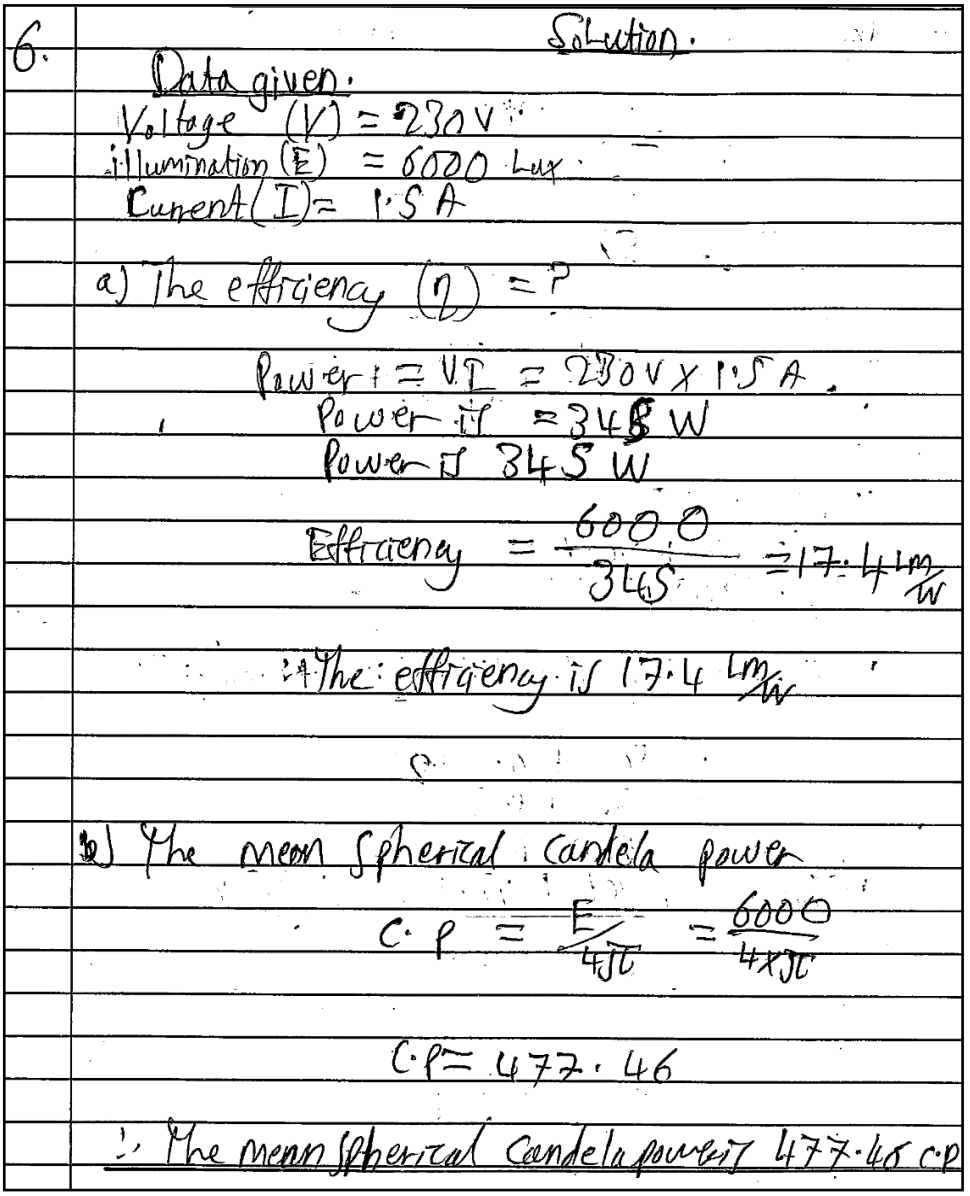


Figure 6*: The Candidates' Performance in Question 6*

Figure 6 indicates that the candidates' general performance on this question was average since 191 (35.8%) of them passed and 64. 2 per cent failed.

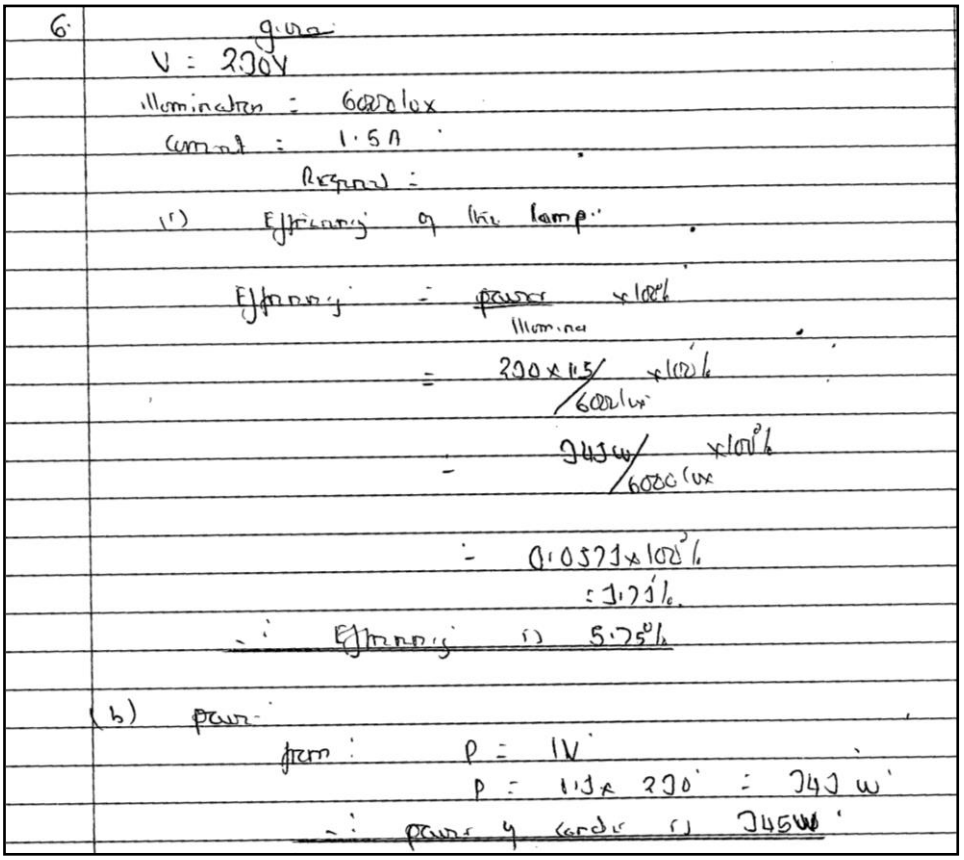
The candidates who scored average marks (1.5-3) provided the correct responses in one or some parts of the question. However, there was no candidate who scored all 5 marks allotted to this question. The major challenge was the failure of the candidates to apply the correct formula and followed appropriate procedure to calculate the parameters as per question demand. These candidates had partial knowledge of the concepts tested on the topic of *Illumination.* Extract 5.1 is a sample of average responses from one of the candidates.



Extract 5.1: A sample of average responses to Question 6

Extract 5.1 shows that the candidate managed to attempt the question correctly in both parts of the question.

On the contrary, most of the candidates who scored low marks (0-1) failed to calculate the illumination of lamp and the mean spherical candle power. This was due to lack of skills and technics to identify the requirements of the question. One among the misconceptions observed on candidates' responses is that some candidates calculated efficiency of the lamp by using the formula of calculating the ability of a device to convert energy into useful output which is given by $\left(\text{Efficiency}=\frac{\text{Output power}}{\text{Input power}}\times 100\%\right)$. The candidates in this category failed to understand that the efficiency of the lamp measures the ability of a light source to produce light and is given by the expression $\left(\text{Efficiency}=\frac{\text{Total illumination}}{\text{Power in Watts}}\right)$. Extract 5.2 shows a sample of incorrect responses to the question.



Extract 5.2: A sample of incorrect responses to Question 6

In Extract 5.2, the candidate reversed the formula of calculating the efficiency of a lamp by writing; $\left(\text{Efficiency}=\frac{\text{Power}}{\text{Illumination}}\right)$ instead of $\left(\text{Efficiency}=\frac{\text{Total illumination}}{\text{Power in Watts}}\right)$. Also he/she calculated the mean spherical candle power by using the formula of calculating electric power.

2.2.6 Question 7: D.C Machines

The question assessed the candidates' ability to solve problems related to D.C machines particularly generators. The question was as follows:

A 4 poles, long shunt compound generator supplies 100 A at a terminal voltage of 500 V. If the armature resistance is 0.02 Ω, series field resistance is 0.04 Ω, shunt field is 100 Ω and the brush drop is 2 V, find the generated E.M.F.

A total of 533 (100%) candidates attempted this question. The data analysis shows that 174 (32.6%) scored from 0 to 1 mark, 158 (29.7%) scored from 1.5 to 3 marks, and 201 (37.7%) scored from 3.5 to 5 marks. These scores suggest that the candidate's performance in this question was good since 67.4 per cent of them reached the pass mark or above. This performance is summarizes in Figure 7.

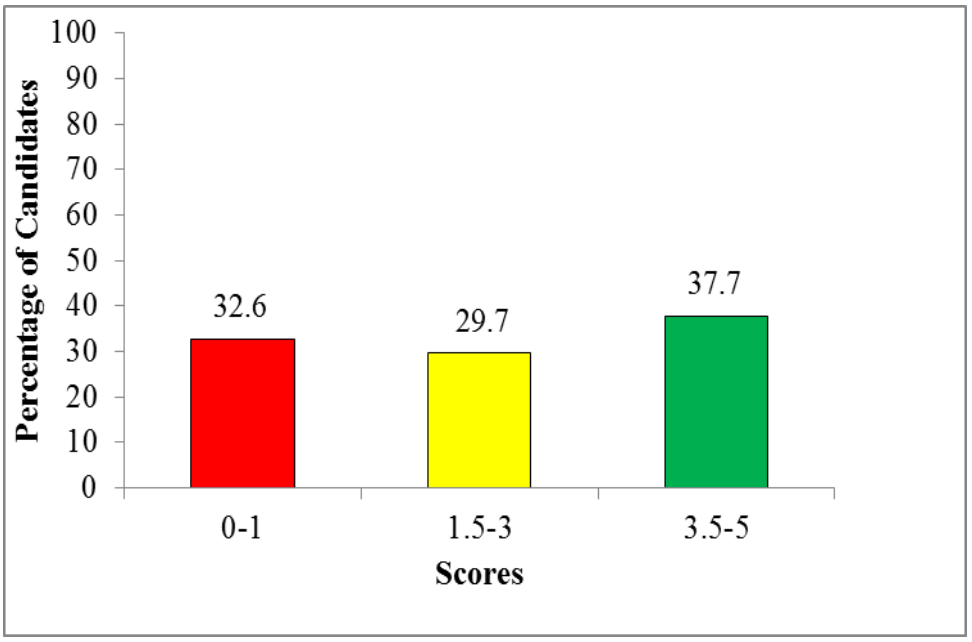
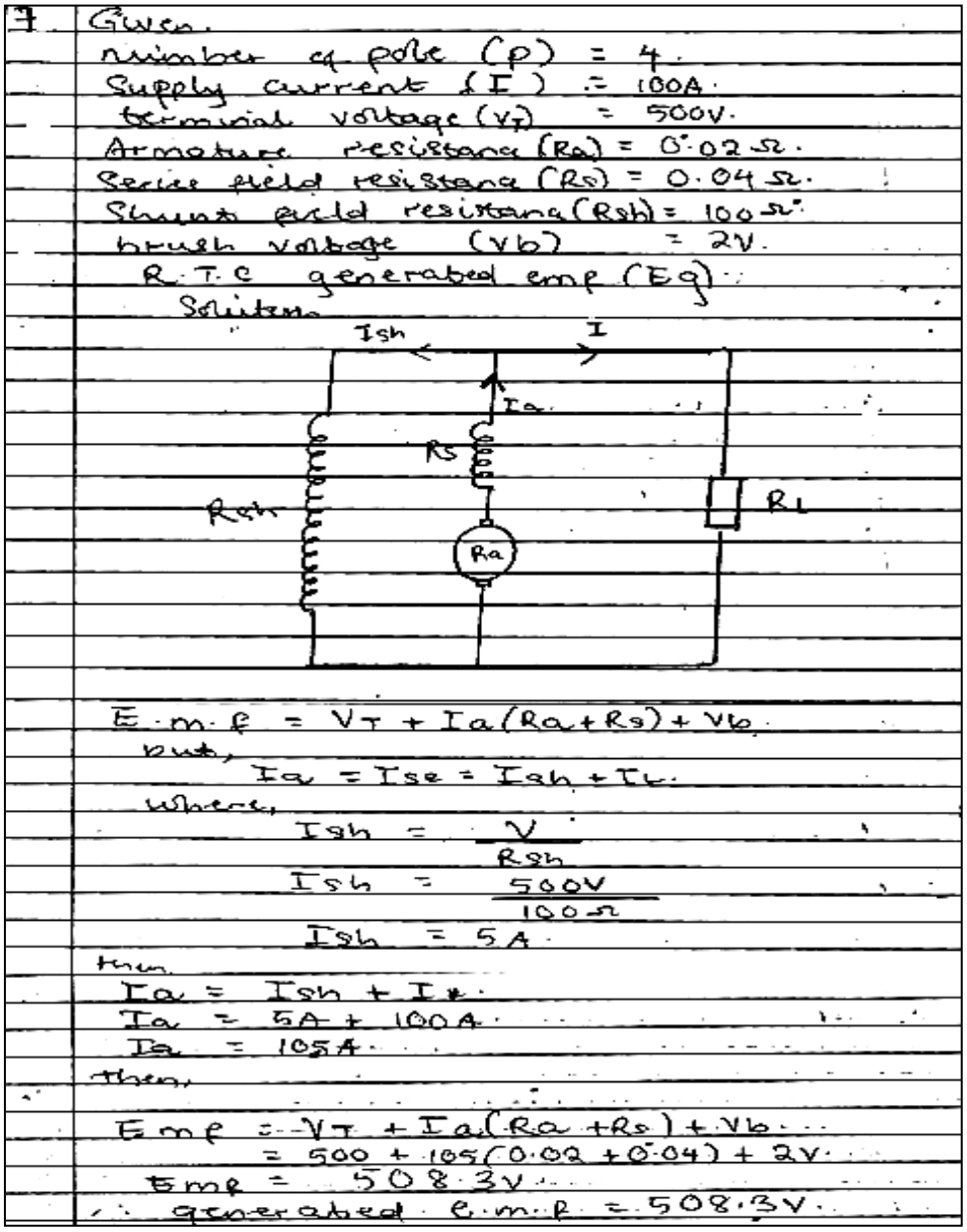


Figure 7*: The Candidates' Performance in Question 7*

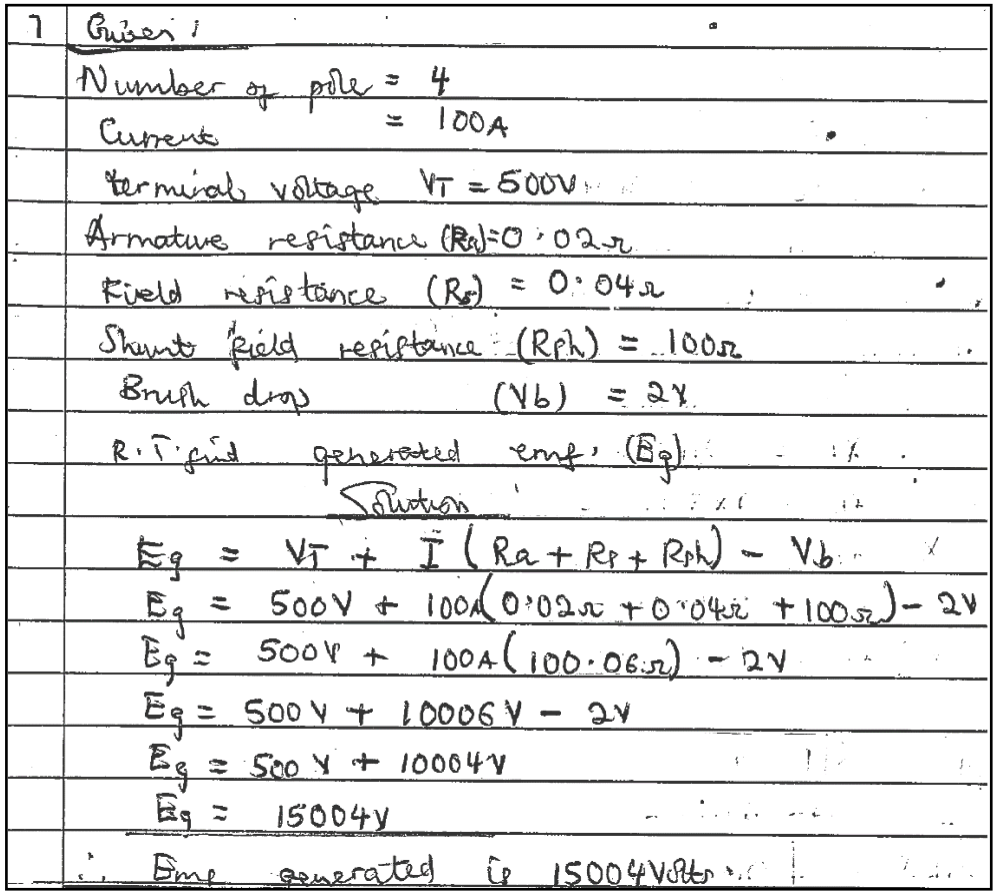
Figure 7 shows that 350 (69.7%) candidates had sufficient knowledge on the topic of *D.C machine as* they applied the correct formula to calculate the generated e.m.f. Extract 6.1 is a sample of correct responses from one of the candidates.



Extract 6.1: A sample of correct responses to Question 7

Despite of the good performance of the most of the candidates, there were 152 (32.6%) candidates who scored low marks (0-1). These candidates failed to apply an appropriate formula to find the value of generated e.m.f.

For example, one of the candidates used the incorrect formula given by $\{E_g = V + (I_{se} \times R_{se}) + V_b\}$ } to calculate the generated e.m.f. Whereby; *Eg* = generated e.m.f, *V* = terminal voltage, I_{se} = series field current, R_s = series field resistance and V_b = brush drop voltage. This formula describes the voltage drop across a resistive circuit that includes a series resistor. In order to determine the generated e.m.f, the candidates were supposed to use the formula $\{E_g = V_T + I_a (R_a + R_s) + V_b\}$. whereby; E_g = Generated e.m.f, V_T = terminal voltage, I_a = armature current, R_a = armature resistance, R_s = shunt field resistance and V_b = brush drop voltage. Extract 6.2 shows a sample of incorrect responses from one of the candidates.


7 Given:
Number of pole = 4
Current = 100A
Terminal voltage $V_T = 500V$
Armature resistance $(R_a) = 0.02\Omega$
Field resistance $(R_s) = 0.04\Omega$
Shunt field resistance $(R_{sh}) = 100\Omega$
Brush drop $(V_b) = 2V$
R.T.F generated emf, (E_g)
Solution
$E_g = V_T + I(R_a + R_s + R_{sh}) - V_b$
$E_g = 500V + 100A(0.02\Omega + 0.04\Omega + 100\Omega) - 2V$
$E_g = 500V + 100A(100.06\Omega) - 2V$
$E_g = 500V + 10006V - 2V$
$E_g = 500V + 10004V$
$E_g = 15004V$
∴ Emf generated is 15004Volts

Extract 6.2: A sample of incorrect responses to Question 7

In Extract 6.2, the candidate applied incorrect formula and procedure to perform calculation related to D.C Machines.

2.2.7 Question 8: Electric Heating

The question required the candidates to demonstrate their competence in applying relevant formula to find the efficiency of a water heater which heats 140 liters of water with a specific heat capacity of 4180J/kg/ºC from 10ºC to 60ºC in 3 hours, given that, the water is heated by a 3 kW heater element.

This question was attempted by 533 candidates, which corresponds to 100 per cent. The analysis of data indicates that 65 (12.2%) candidates scored from 0 to 1 mark, 91 (17.1%) scored from 1.5 to 3 marks, and 377 (70.7%) candidates scored from 3.5 to 5 marks. Generally, the performance in this question was good since 468 (87.8%) candidates passed. Most of them proved to have sufficient knowledge on the areas tested. Figure 8 present a summary of the candidates' performance.

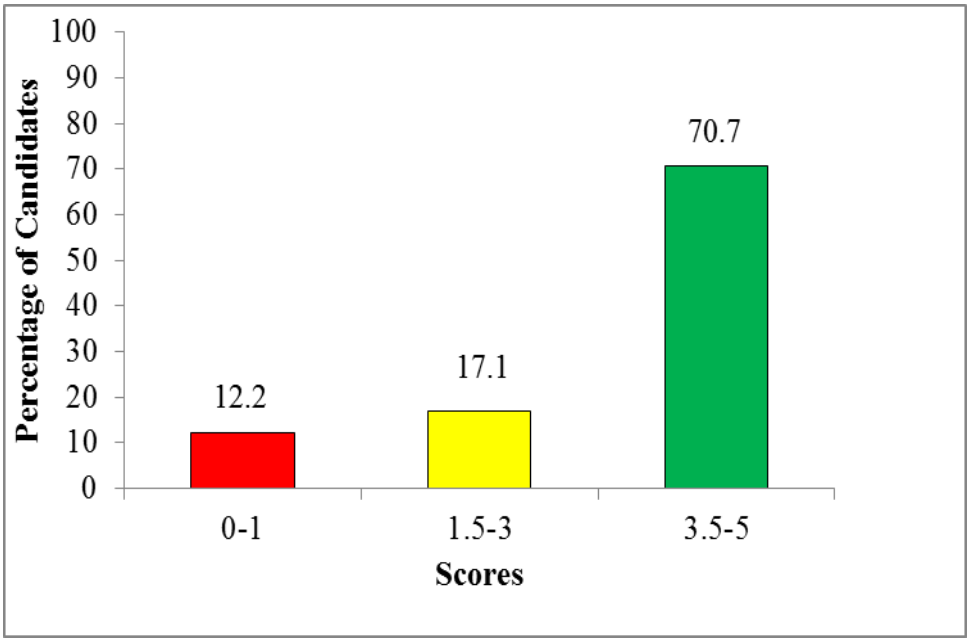
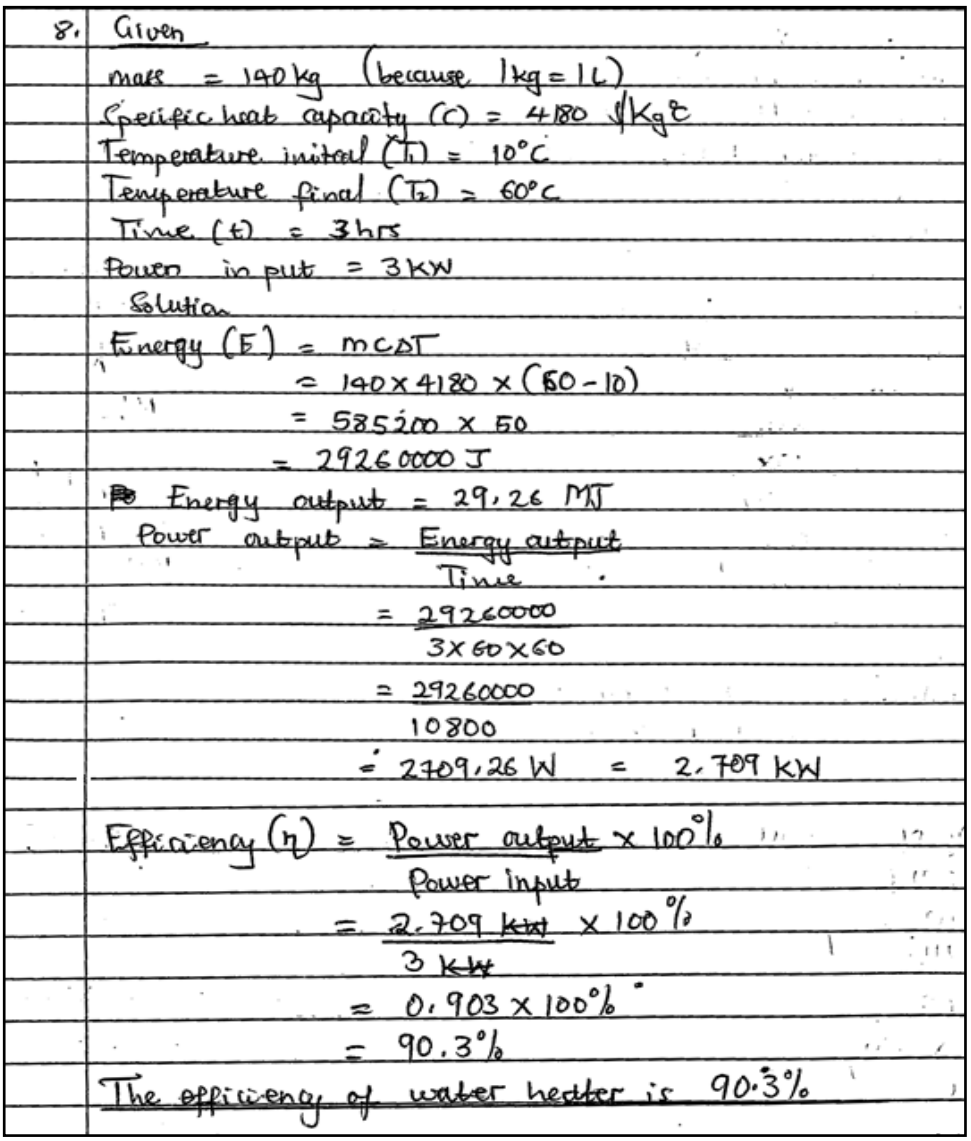


Figure 8*: The Candidates' Performance in Question 8*

The analysis of candidates' performance indicates that most of them demonstrated their ability to apply the correct formula to determine the efficiency of a water heater element. This suggests that they had sufficient knowledge of the concepts related to Electric Heating. Extract 7.1 shows a sample of correct responses from one of the candidates.



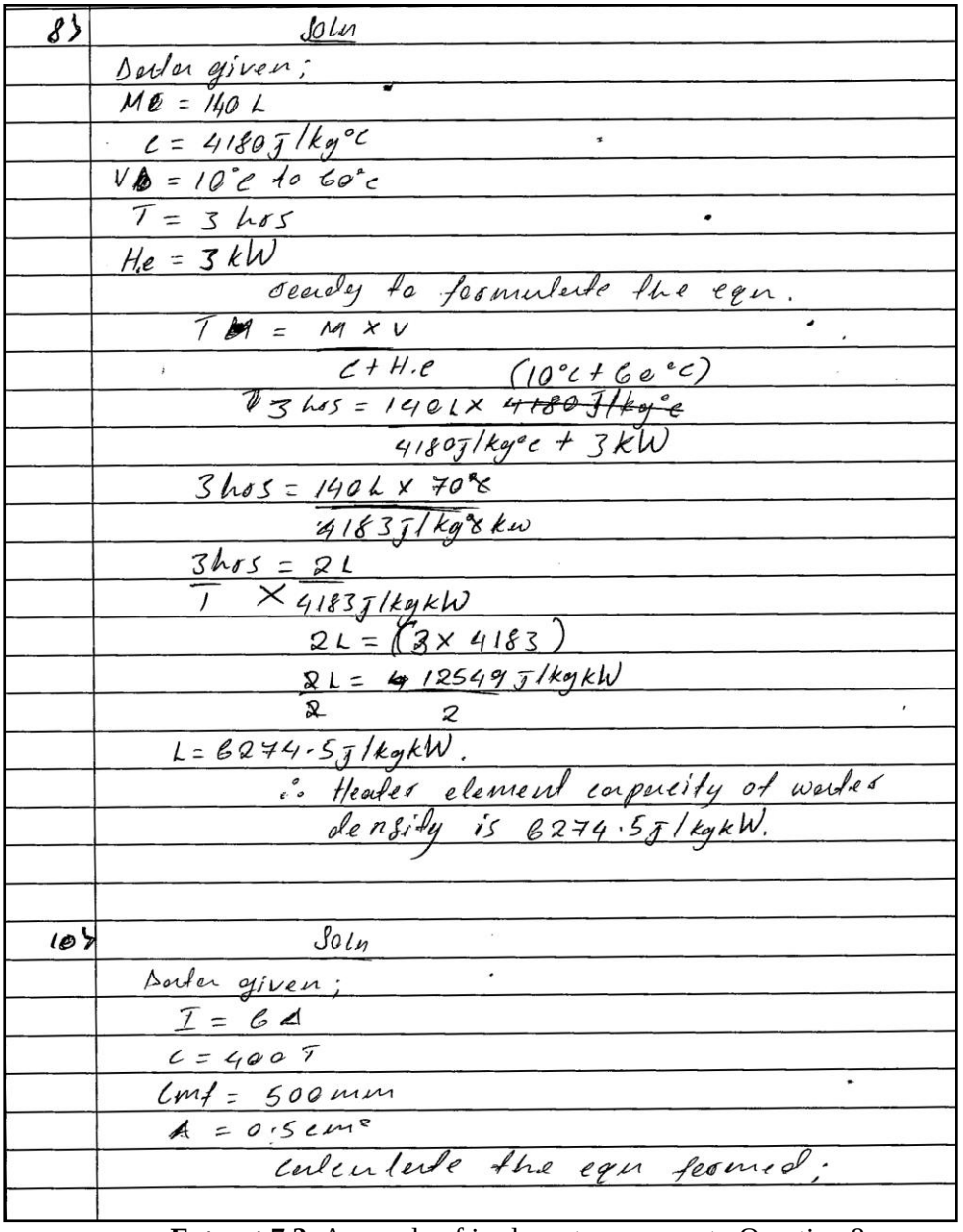
Extract 7.1: A sample of correct responses to Question 8

Extract 7.1 shows that the candidate applied the correct formula to calculate the efficiency of water heater element.

Despite the general good performance in this question, 17.1 per cent of the candidates performed averagely. Most of them wrote the correct formula of the efficiency but failed to substitute the given parameters into the formula to obtain the required value of the efficiency of water heater element.

The analysis further shows that 58 (12.2%) candidates had weak performance. These candidates had insufficient knowledge on the subtopic

of *Electric Heating*. They failed to apply the correct relationship of the given quantities (specific heat capacity, temperature, power and time) to obtain the formula to calculate the efficiency. For example, one of the candidates simply divided the product of the given values of temperature change, specific heat capacity and time by the quantity of water, which was not correct. Extract 7.2 is a sample of irrelevant responses from one of the candidates.


8) Soln
Data given;
M = 140 L
c = 4180 J/kg°C
V = 10°C to 60°C
T = 3 hrs
H.e = 3 kW
Secondly to formulate the eqn.
T = M × V / c + H.e (10°C + 60°C)
3 hrs = 140L × 4180 J/kg°C / 4180 J/kg°C + 3 kW
3 hrs = 140 L × 70°C / 4183 J/kg°C kw
3 hrs / 1 = 2 L / 4183 J/kg kW
2 L = (3 × 4183)
2 L / 2 = 12549 J/kg kW / 2
L = 6274.5 J/kg kW.
∴ Heater element capacity of water density is 6274.5 J/kg kW.
10) Soln
Data given;
I = 6 A
c = 400 T
Cmf = 500 mm
A = 0.5 cm²
Calculate the eqn formed;

Extract 7.2: A sample of irrelevant responses to Question 8

In Extract 7.2, the candidate applied the formula which was irrelevant to *Electric heating*, showing that he/she had insufficient knowledge on the concepts tested.

2.2.8 Question 9: A.C Voltages

In this question, the candidates were given the equation of an alternating current flowing through a certain circuit which is given by, $i=50 \sin 628 t$, and were required to determine: (a) the maximum value of current; (b) the r.m.s value of current, and (c) the frequency of the current.

A total of 533 (100%) candidates attempted this question, and out of those, 201 (37.7%) scored from 0 to 1 mark, 82 (15.4%) scored from 1.5 to 3 marks, and 250 (46.9%) candidates scored from 3.5 to 5 marks. Figure 9 summarises the performance of the candidates in Question 9.

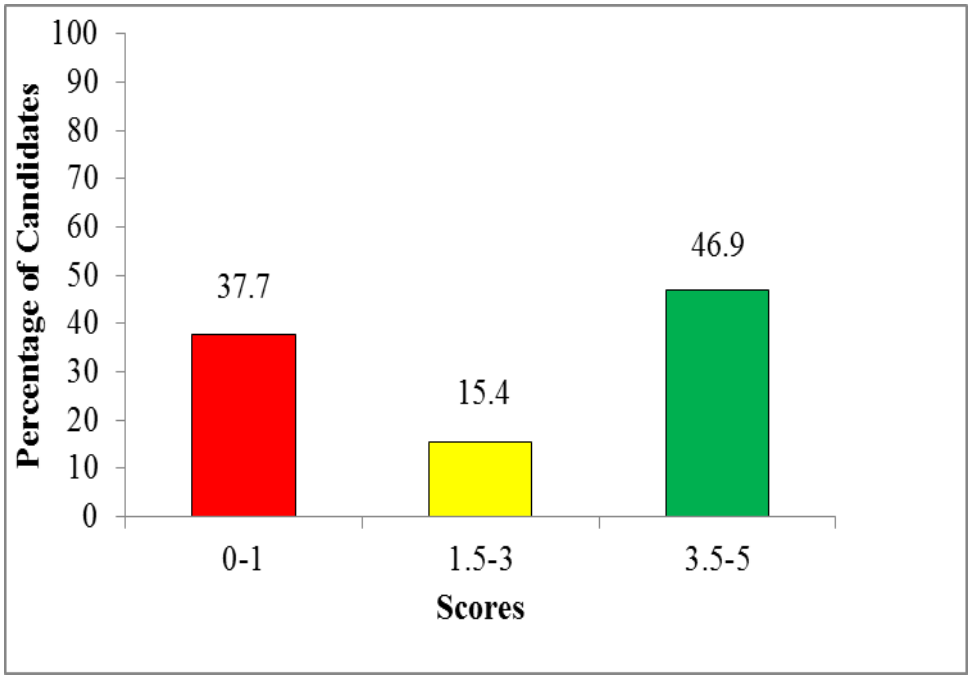
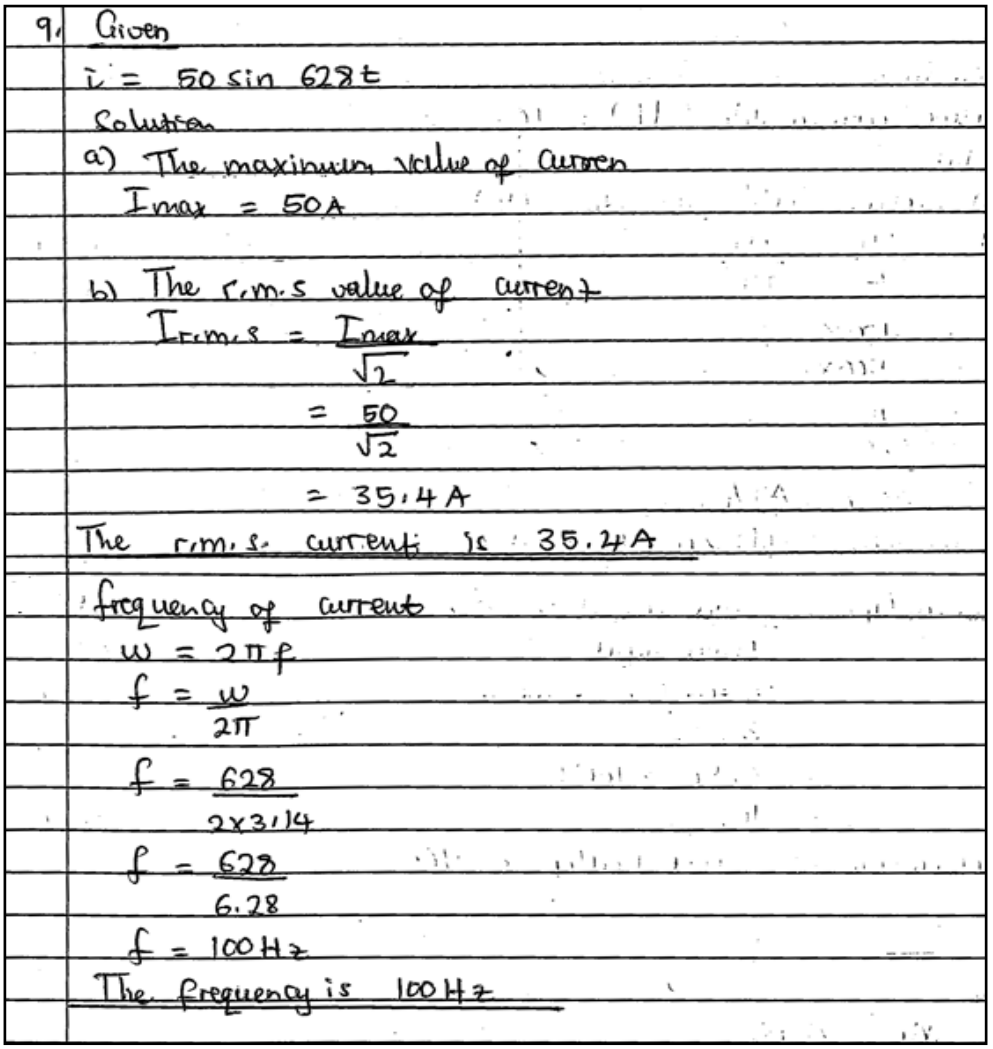


Figure 9: *The Candidates' Performance in Question 9*

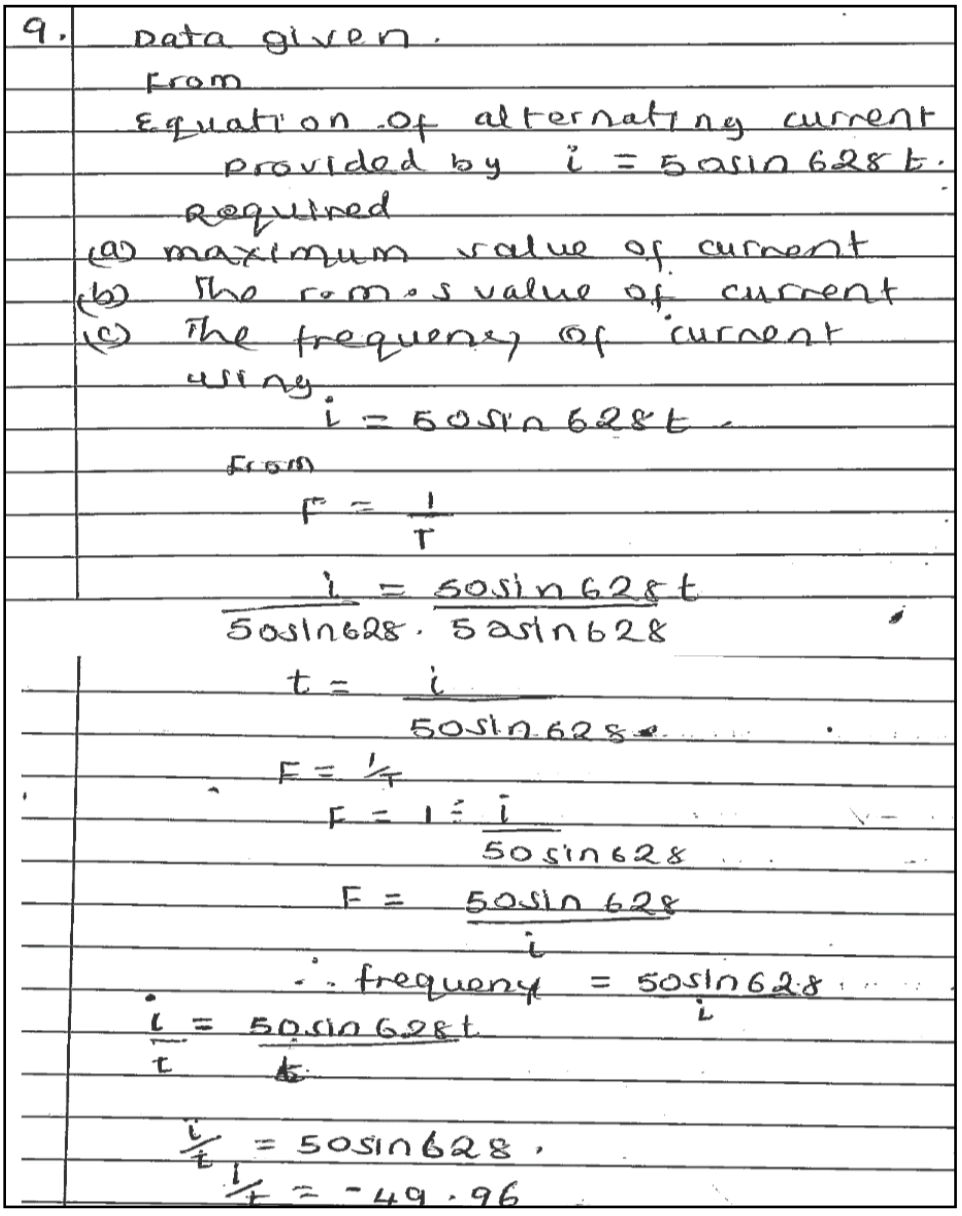
Figure 9 indicates that the candidates' performance was average since 62 per cent of them passed. This implies that the candidates had sufficient knowledge on the topic of *A.C Voltages*. They applied the correct formula to calculate the maximum value of current, the r.m.s value of current, and the frequency of current. Extract 8.1 is a sample of correct responses from one of the candidates.



Extract 8.1: A sample of good responses to Question 9

In Extract 8.1, the candidate correctly used appropriate formulae and made proper substitution to calculate the required parameters.

Despite good performance of the candidates, 24.9 per cent of them scored low marks (0-1) because they applied incorrect formula to calculate the values of the required parameters. For example, when responding to part (b), one of the candidates calculated the r.m.s value of current by using a wrong formula $I_{r.m.s} = I_{max} \times \sqrt{2}$ instead of $I_{r.m.s} = \frac{I_{max}}{\sqrt{2}}$. Extract 8.2 is a sample of incorrect responses from one of the candidates.



Extract 8.2: A sample of incorrect responses to Question 9

In Extract 8.2, the candidate calculated the frequency of current by using the formula $f = \frac{1}{t}$ instead of $f = \frac{\omega}{2\pi}$.The candidate confused the two formulas since both of them calculate the frequency of a repeating event but in different parameters.

2.2.9 Question 10: Electromagnetism

This question intended to assess the competence of the candidates to apply relevant formulae related to electromagnetism to calculate magnetic field density, flux density, and total flux in a coil wound over a non-magnetic material. The question was as follows:

A current of 6 A flows through a coil of 400 turns which is wound over a ring made from a non-magnetic material. The ring has a circumference of 500 mm and a uniform cross-sectional area of 0.5 cm^2. If the permeability of free space is $4\pi\times10^{-7}$ and relative permeability of non-magnetic material is 10, calculate: (a) the magnetic field density; (b) the flux density, and (c) the total flux.

A total of 533 (100%) candidates attempted this question and their scores were categorized as follows: 212 (39.8%) scored from 0 to 1 mark, 122 (22.9%) scored from 1.5 to 3 and 199 (37.3%) scored from 3.5 to 5 marks. No candidate scored above 5 marks. The candidates' performance in this question is summarized in Figure 10.

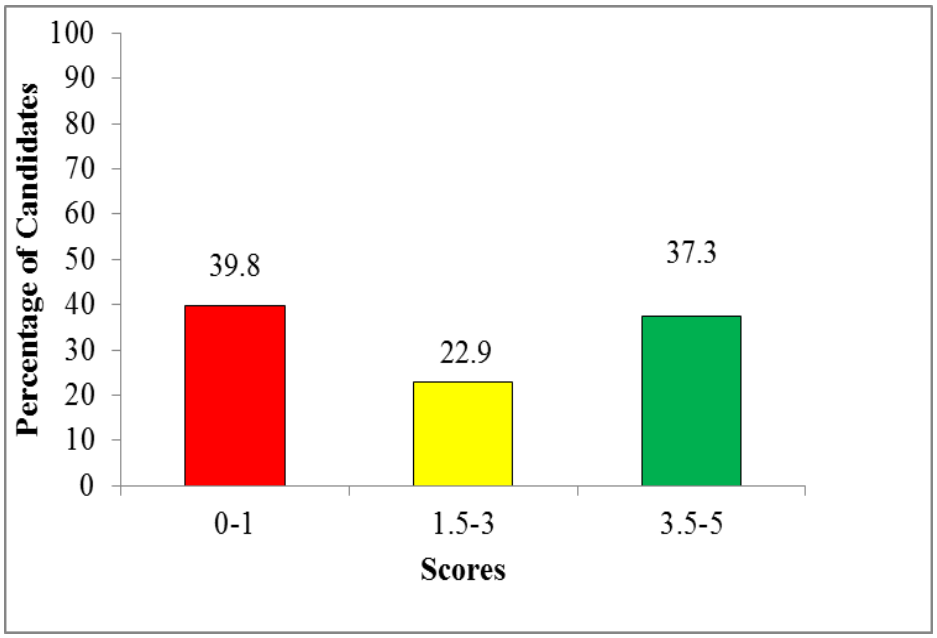
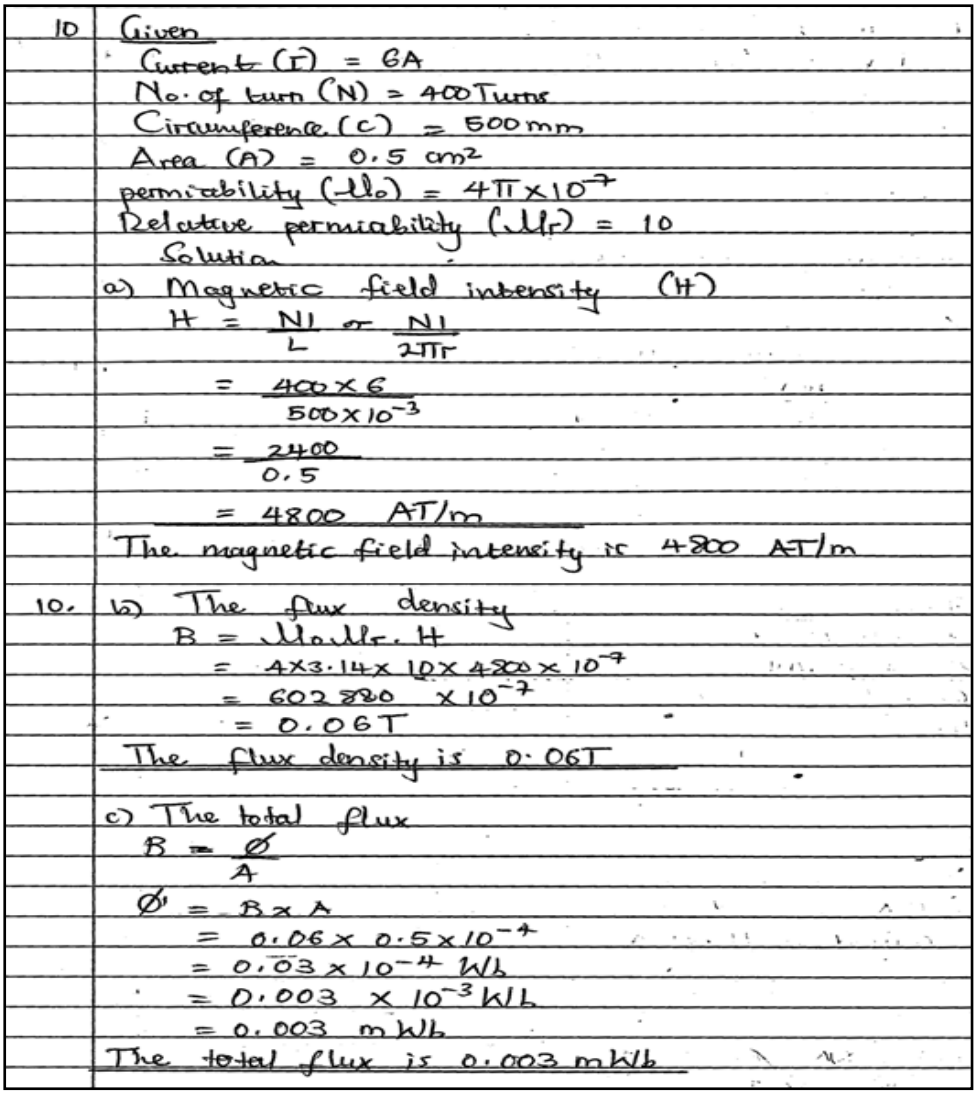


Figure 10: *The Candidates' Performance in Question 10*

Figure 10 indicates that the general performance of the candidates in this question was average since 60.2 per cent of the candidates scored average marks and above. Most of them correctly responded to more than two parts

of the question. This indicates that the candidates had sufficient knowledge of *Electromagnetism*. Extract 9.1 illustrates the performance.

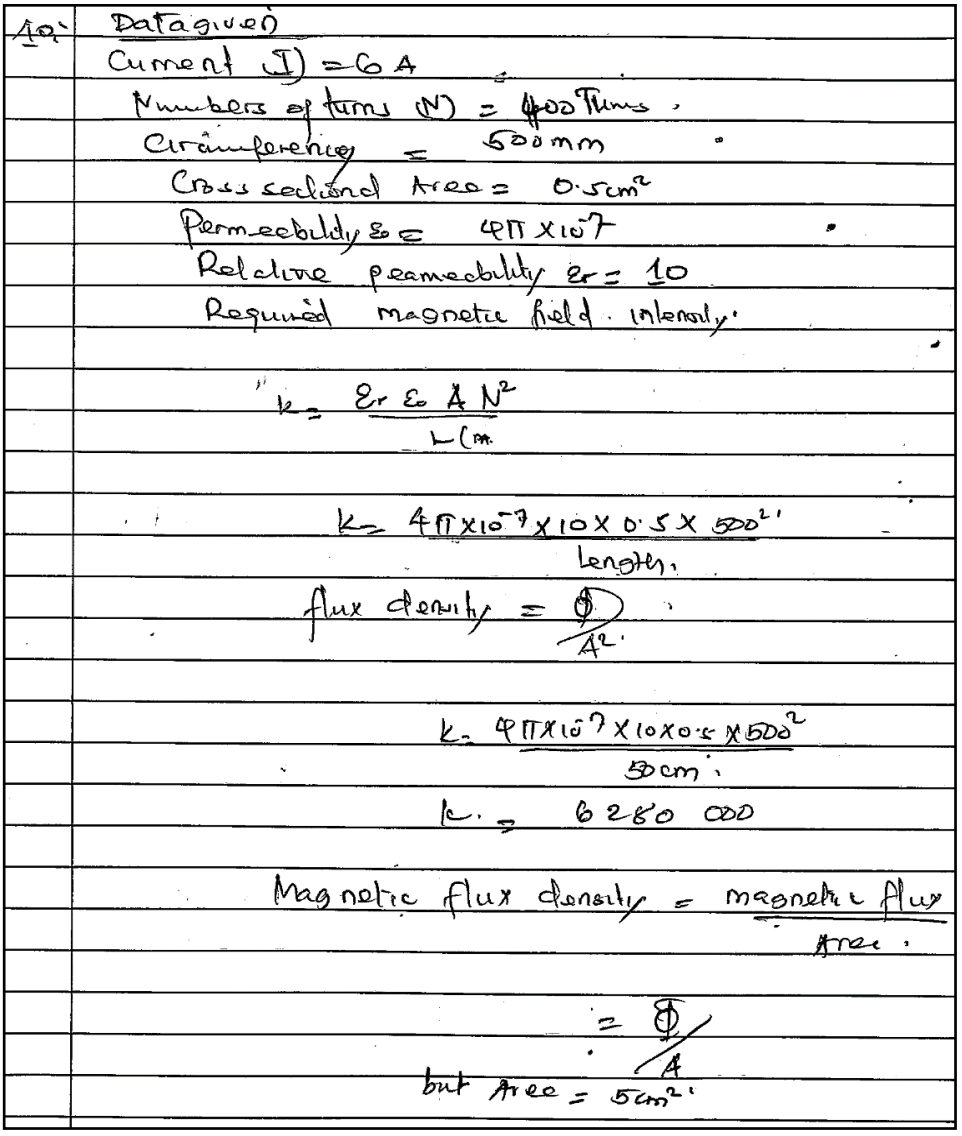


Extract 9.1: A sample of correct responses to Question 10

Extract 9.1 shows that the candidate applied the appropriate formulas to calculate the asked parameters in each part of the question.

Despite the average performance of the candidates, 39.8 per cent of the candidates had low scores (0-1) including, 29.6 per cent who scored zero. For example, one candidate applied an incorrect formula $\frac{\mu r \mu o A N^2}{L}$ to calculate both the magnetic field intensity and flux density. Similarly, the candidate responded to part (b) by multiplying the results obtained in parts

(a) and (b) to determine the value of the total flux. This candidate lacked knowledge and skills about *Electromagnetism.* Extract 9.2 shows a sample of incorrect responses from one of the candidates.



Extract 9.1: A sample of incorrect responses to Question 10

Extract 9.1 shows that the candidate applied incorrect formula in each part of the question.

2.3 SECTION C: STRUCTURED QUESTIONS

2.3.1 Question 11: Three Phase Circuits

This question had two parts, namely (a) and (b). In part (a), the candidates were required to briefly explain how each of the three major losses in A.C generator takes place, and in (b), they required to calculate the line current when three similar coil each having a resistance and inductance of 20 Ω and 0.05 H respectively, are connected in star to a three phase 50 Hz supply with 400 V between lines.

A total of 508 (95.3%) candidates attempted this question. Among them, 119 (23.4%) scored from 0 to 4 marks, 184 (36.2%) scored from 4.5 to 9.5 marks, and 205 (40.4%) scored from 10 to 15 marks. The performance was good since 389 (76.6%) candidates passed. The candidates' performance in this question is summarizes in Figure 11.

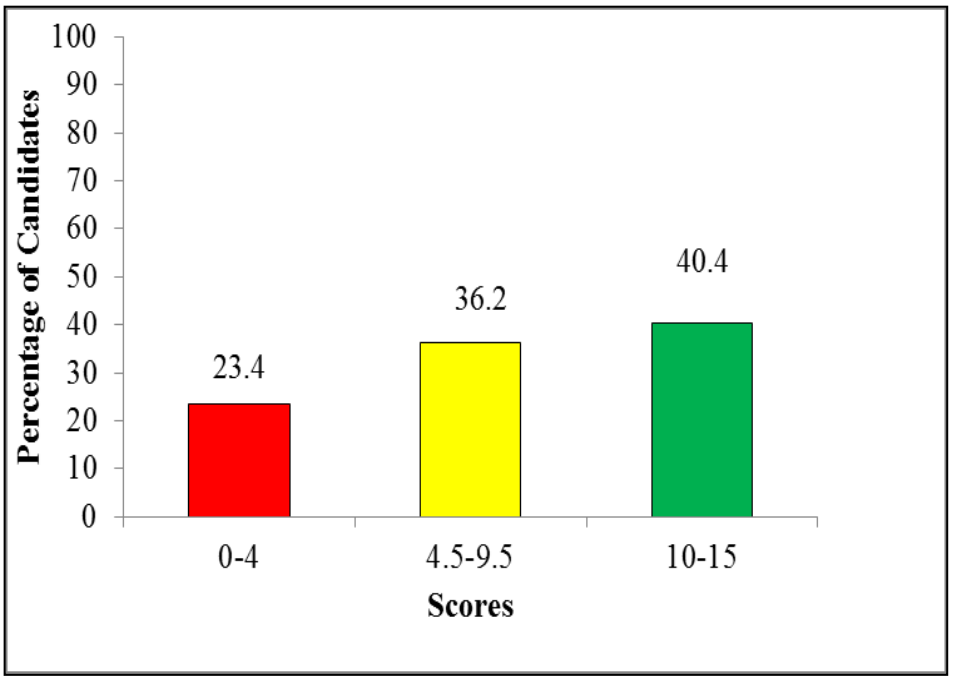


Figure 11*: The Candidates' Performance in Question 11*

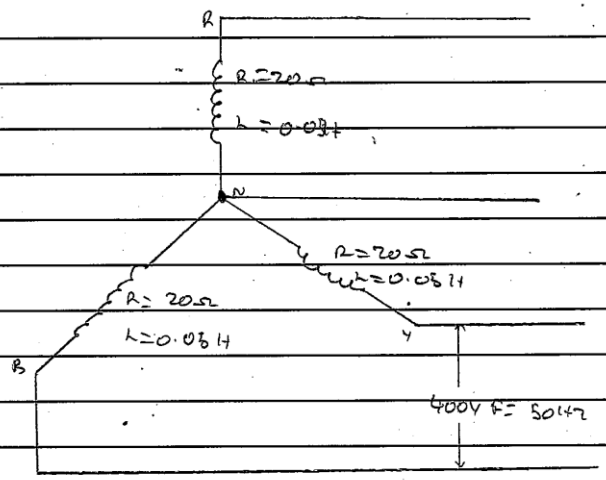
Based on Figure 11, 77.6 per cent of the candidates had good performance because they provided satisfactory responses in each part of the question. These candidates proved to have sufficient knowledge about *three phase circuits.* Extract 10.1 is a sample of correct responses from one of the candidates.

losses of energy in an A.C generator.

iii, Iron losses.

- These are eddy currents losses due to the energy lost in the production of magnetic flux and hysteresis losses due to the heating of the core and copper windings.

b, Delta form,



where, Resistance (R) = 20Ω

Inductance (L) = 0.05H

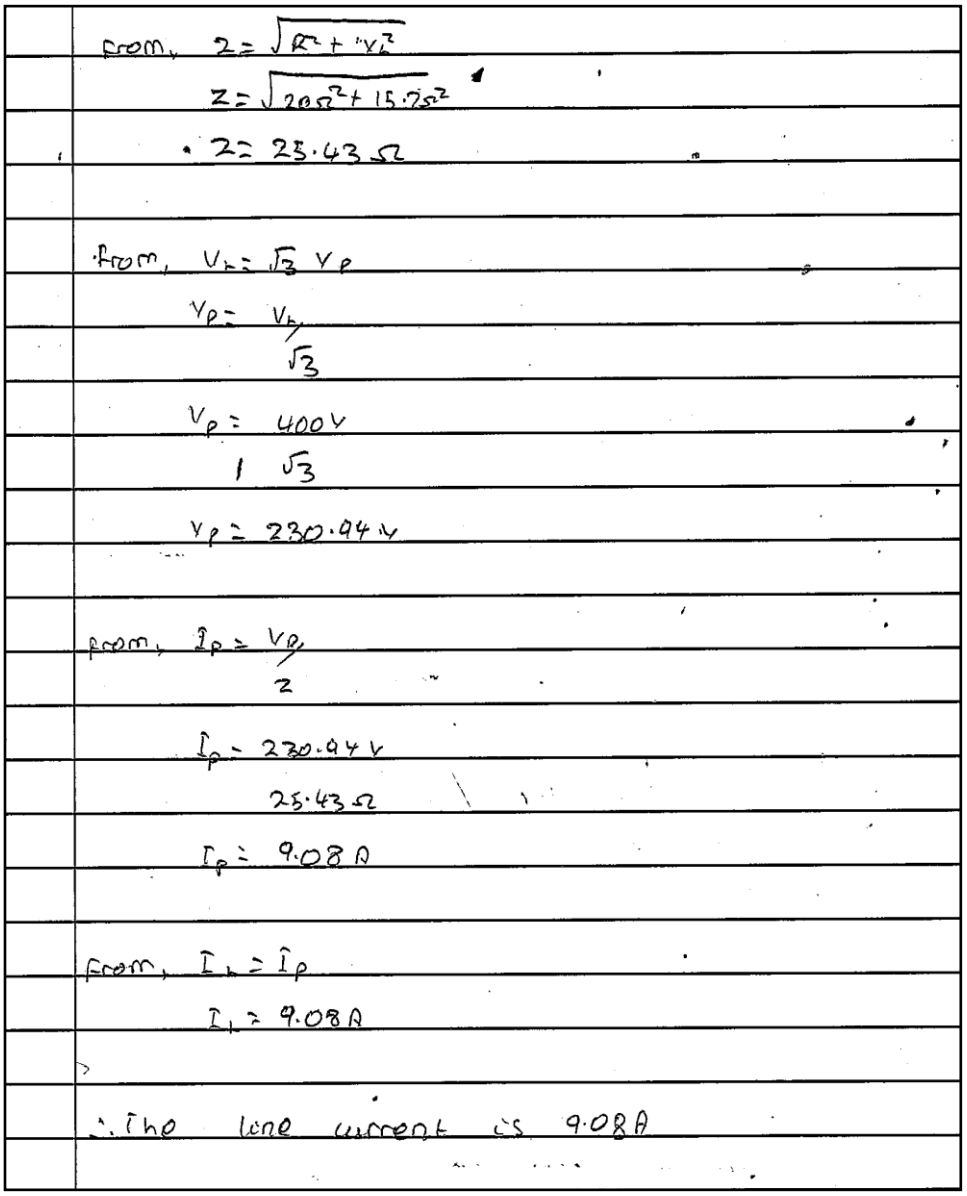
Line voltage (V_L) = 400V

Supply frequency (F) = 50Hz

From, Inductive reactance (X_L) = $2\pi FL$

$= 2 \times 3.14 \times 50Hz \times 0.05H$

$= 15.7\ \Omega$.

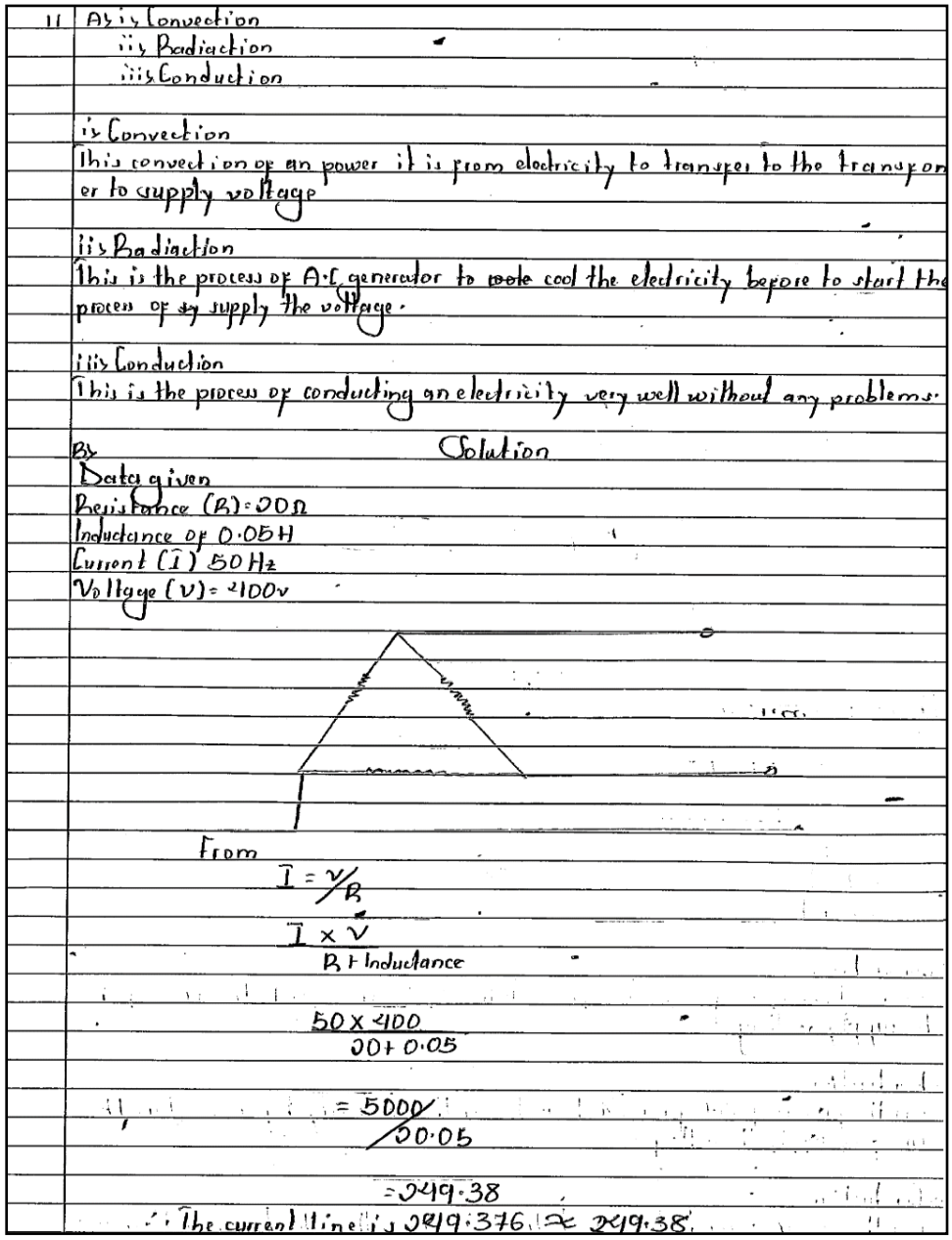


Extract 10.1: A sample of correct responses to Question 11

Extract 10.1 shows that the candidate explained how the three major losses in A.C generator take place as required in part (a). Also he/she correctly calculated the line current in part (b).

Conversely, 23.4 per cent of the candidates had weak performance as they scored from 0 to 4 marks. Out of these, 7.1 per cent scored zero. Some of the candidates failed to fulfil the requirements of the question while others had misconceptions about star and delta connected load and therefore, they

failed to recognize the appropriate formula to calculate the line current as asked in part (b) of the question. Extract 10.2 is a sample of poor responses from one of the candidates.



Extract 10.2: A sample of incorrect responses to Question 11

Extract 10.2 shows that the candidate provided the methods of heat transfer instead of major losses in A.C generator and how they take place.

2.3.2 Question 12: A.C Circuits

The question was constructed as follows: *A coil of resistance 100 Ω and inductance 100 μH is connected in series with a 100 pF capacitor. The circuit is connected to a 10 V variable frequency supply. Calculate:*

(a) The resonant frequency.
(b) The current at resonance
(c) The voltage across L and C at resonance then, comment on the voltage obtained.
(d) Q factor of a circuit.

The competence tested in this question was the ability of the candidates to apply the relevant formulas to solve the problems related to concepts of A.C circuits. It required the candidates' understanding of the concepts of inductance, capacitance, resistance, impedance, resonance, current, voltage, and Q factor in a circuit which consists of inductor, capacitor and resistor (LCR circuits).

The question was attempted by 396 (74.3%) candidates. The data analysis shows that 158 (39.9%) candidates scored from 0 to 4 marks, 139 (35.1%) scored from 4.5 to 9.5 marks, and 99 (25.0%) scored from 10 to 15 marks. The performance was average since 238 (60.1%) candidates passed. The candidates' performance in this question is summarizes in Figure 12.

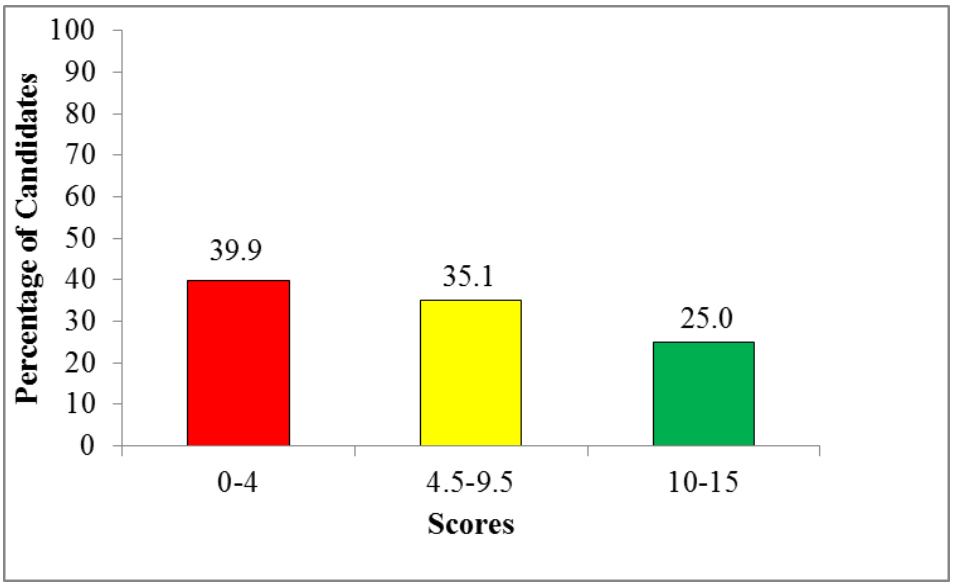
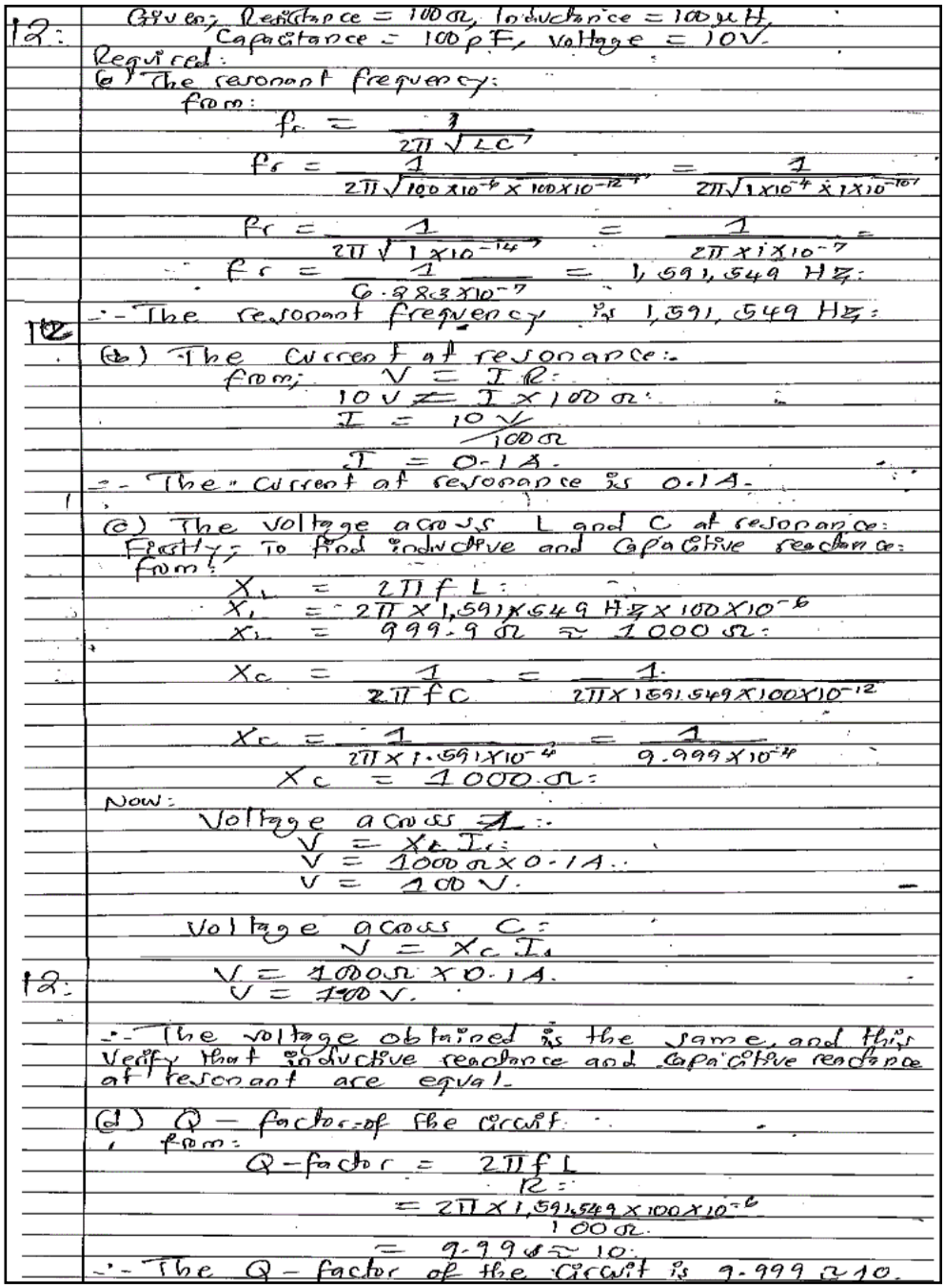


Figure 12: *The Candidates' Performance in Question 12*

Based on the data analysis, 60.1 per cent of the candidates scored good marks as they demonstrated the ability to apply correct formula to determine the value of the asked parameters in each part of the question. They justified having sufficient knowledge on the tested concepts about A.C circuits. Extract 11.1 presents good responses from one of the candidates.


12: Given; Resistance = 100Ω, Inductance = 100μH
Capacitance = 100pF, Voltage = 10V.
Required:
(a) The resonant frequency:
from:
$f_r = \frac{1}{2\pi\sqrt{LC}}$
$f_r = \frac{1}{2\pi\sqrt{100\times10^{-6}\times100\times10^{-12}}} = \frac{1}{2\pi\sqrt{1\times10^{-4}\times1\times10^{-10}}}$
$f_r = \frac{1}{2\pi\sqrt{1\times10^{-14}}} = \frac{1}{2\pi\times1\times10^{-7}}$
$f_r = \frac{1}{6.283\times10^{-7}} = 1,591,549\ Hz$
∴ The resonant frequency is 1,591,549 Hz.
12
(b) The current at resonance:-
from; $V = IR$:
$10\ V = I \times 100\ \Omega$
$I = \frac{10\ V}{100\ \Omega}$
$I = 0.1\ A$.
∴ The current at resonance is 0.1A.
(c) The voltage across L and C at resonance:
Firstly; To find inductive and capacitive reactance:
from:
$X_L = 2\pi f L$:
$X_L = 2\pi \times 1,591,549\ Hz \times 100\times10^{-6}$
$X_L = 999.9\ \Omega \approx 1000\ \Omega$:
$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi\times1591549\times100\times10^{-12}}$
$X_C = \frac{1}{2\pi\times1.591\times10^{-4}} = \frac{1}{9.999\times10^{-4}}$
$X_C = 1000\ \Omega$:
Now:
Voltage across L:
$V = X_L I_L$:
$V = 1000\ \Omega \times 0.1\ A$.
$V = 100\ V$.
Voltage across C:
$V = X_C I_C$
12: $V = 1000\ \Omega \times 0.1\ A$.
$V = 100\ V$.
∴ The voltage obtained is the same, and this verify that inductive reactance and capacitive reactance at resonant are equal.
(d) Q – factor of the circuit:
from:
$Q\text{-factor} = \frac{2\pi f L}{R}$:
$= \frac{2\pi \times 1,591,549 \times 100\times10^{-6}}{100\ \Omega}$.
$= 9.999 \approx 10$.
∴ The Q – factor of the circuit is $9.999 \approx 10$.

Extract 11.1: A sample of correct responses to Question 12

Extract 11.1 shows that the candidate correctly calculated the resonant frequency, the current at resonance, Q-factor of a circuit and the voltage across L and C, at resonance and therefore, correctly commented on the voltage obtained.

However, the analysis indicates that there were 158 (39.9%) candidates who performed poorly. These candidates lacked knowledge on A.C circuit particularly in computing the resonant frequency, the current at resonance, Q-factor of a circuit and the voltage across L and C, at resonance. For example, in part (a), one candidate calculated the resonance frequency by using the formula: $fr = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R}{L^2}^2}$. The candidate failed to recognize that he/she applied the formula for calculating resonance frequency in parallel circuit instead of series circuit as required. The correct formula was $fr = \frac{1}{2\pi\sqrt{LC}}$. Whereby, fr = resonant frequency, L= inductance, C = capacitance, R = resistance, and π = constant pie. Extract 11.2 is a sample of incorrect responses from one of the candidates.

12. Given)

$R = 100\Omega$

$L = 100MH = 1\times10^{-4}H$

$C = 100pF$

$V = 10V$

a) Resonant frequency;

from $w = 2\pi f$

But $w = \frac{1}{2}LI^2$

$\frac{1}{2}LI^2 = 2\pi f$

from $V = IR$

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

$I = \frac{10}{100} \Rightarrow 0.1A$

$\frac{1}{2}\times(1\times10^{-4})\times(0.1)^2 = 2\pi f$

$\frac{5\times10^{-7}}{2\pi} = \frac{2\pi f}{2\pi}$

$f = 7.96\times10^{-8}$ Hertz

∴ The frequency of resonant is ~~7.96×10^{-8} Hertz~~

b) Current at resonance

from $I = VCw$

$I = 10\times(100\times10^{-12})\times5\times10^{-7}$

$I = 5\times10^{-16}A$

∴ The current is $5\times10^{-16}A$

12. c) Voltage across C;

$I = VCw$

$(5\times10^{-16}) = V\times(100\times10^{-12})\times(7.96\times10^{-8})$

$\frac{(100\times10^{-12})(7.96\times10^{-8})}{(100\times10^{-12})\times7.96\times10^{-8}}$

$V = ~~62.8V~~\ 9.9V \approx 10V$

∴ The voltage at C is ~~62.8V~~ 10V

Extract 11.2: A sample of incorrect responses to Question 12

Extract 11.2 shows that the candidate created formulas which are irrelevant to the question, hence calculated the required parameters unsuccessfully.

2.3.3 Question 13: A.C Circuits

The question was set to test the competence of the candidates to analyze circuits containing resistors and inductors in parallel, and calculating various parameters such as current, impedance, and phase angle using relevant formulas and concepts from electrical circuit theory. It also tested the candidates' ability to draw a circuit diagram based on the given information. The question asked as follows:

An inductance (L) 0.0637 H is connected in parallel with 30 Ω resistor. The combination is supplied by 200 V of 60 Hz

(a) Draw the circuit diagram including the parameters provided.

(b) Calculate the following parameters:

(i) Current in each branch.

(ii) Impedance of the circuit.

(iii) Phase angle of the circuit.

(c) What will happen to the circuit characteristics if R is removed?

A total of 492 (92.3%) candidates attempted this question and their scores were as follows: 153 (31.1%) scored from 0 to 4 marks. 254 (51.6%) scored from 4.5 to 9.5 marks and 85 (17.3%) scored from 10 to 15 marks. The performance was good since 339 (68.9%) candidates passed. The performance is summarizes in Figure 13.

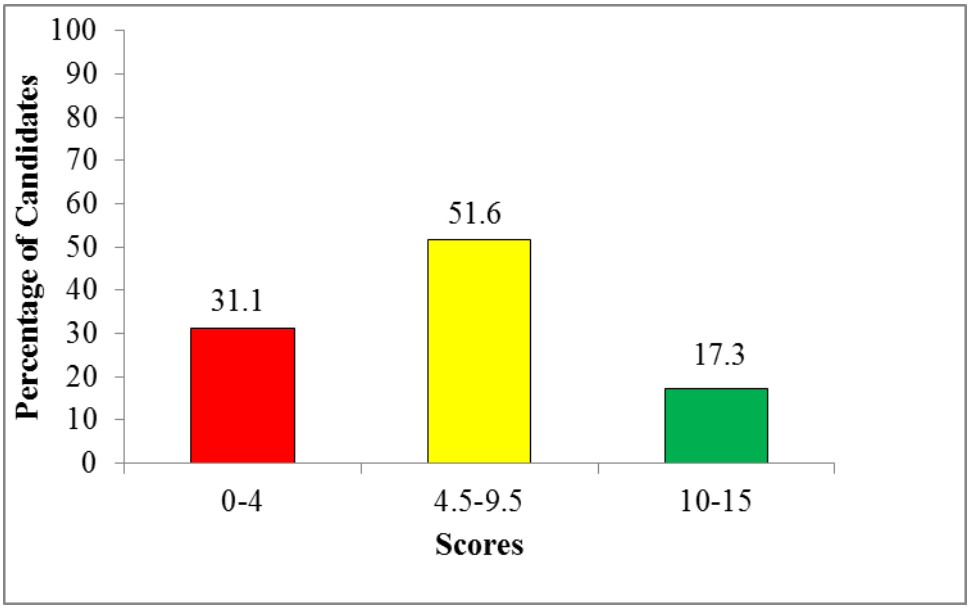
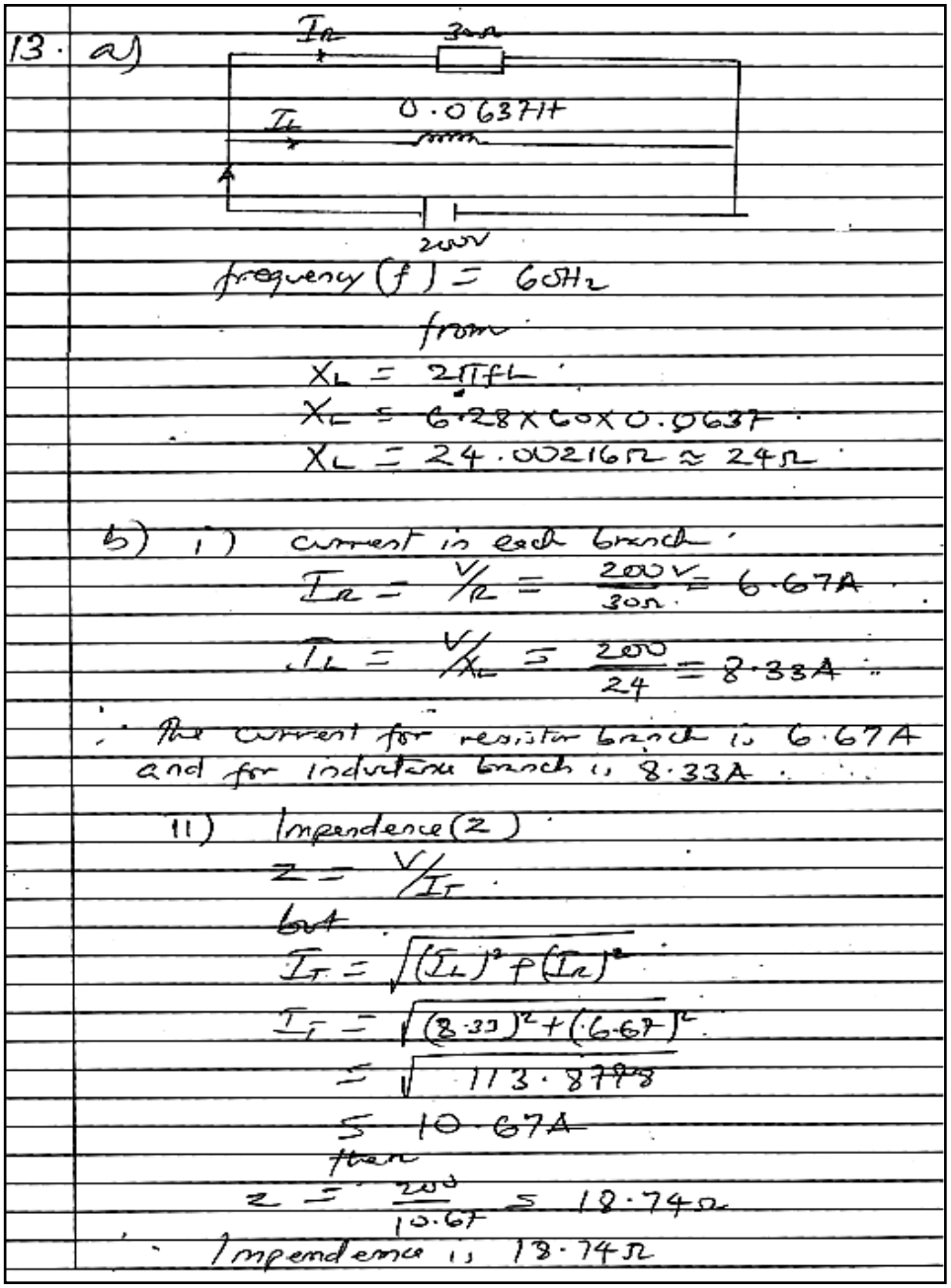
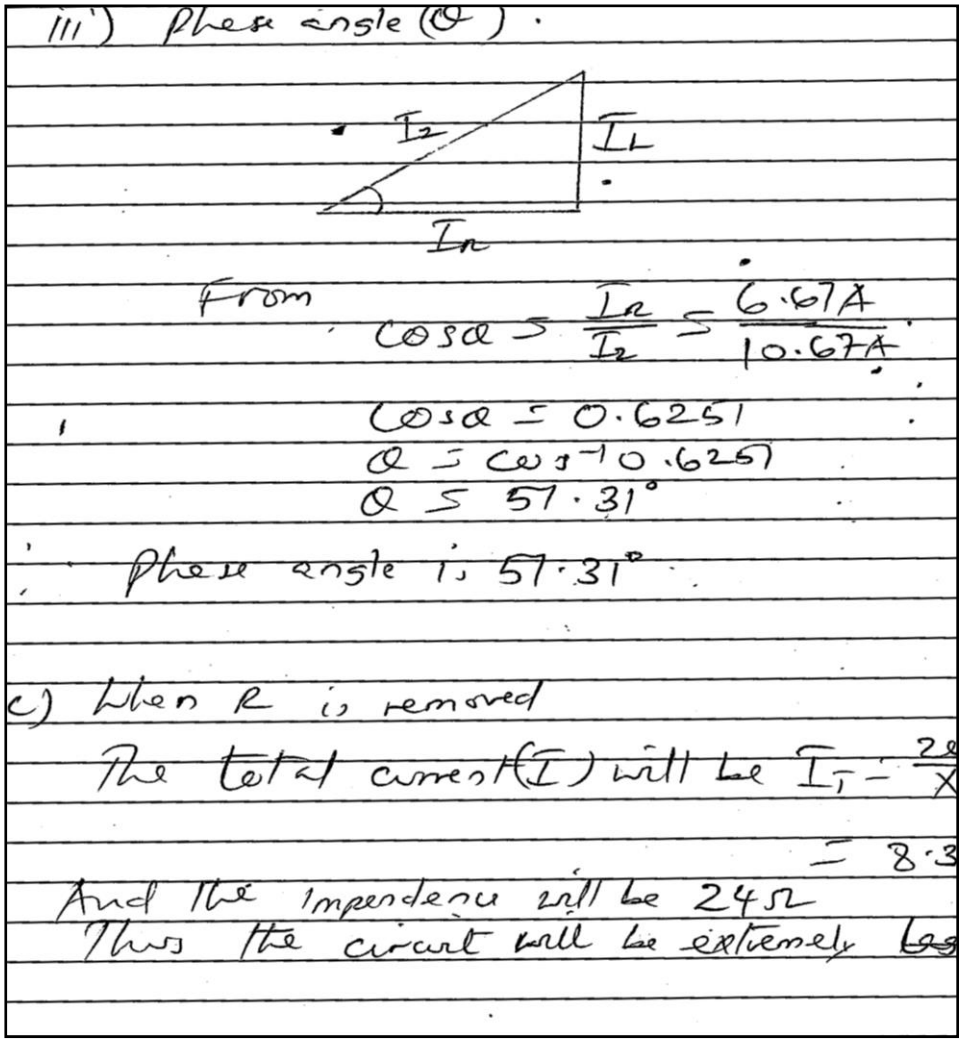


Figure 13: *The Candidates' Performance in Question 13*

The analysis of data shows that 68.9 per cent of the candidates who performed well managed to provide correct responses either in all parts or at least two parts of the question. Extract 12.1 is a sample response from a candidate with good performance.



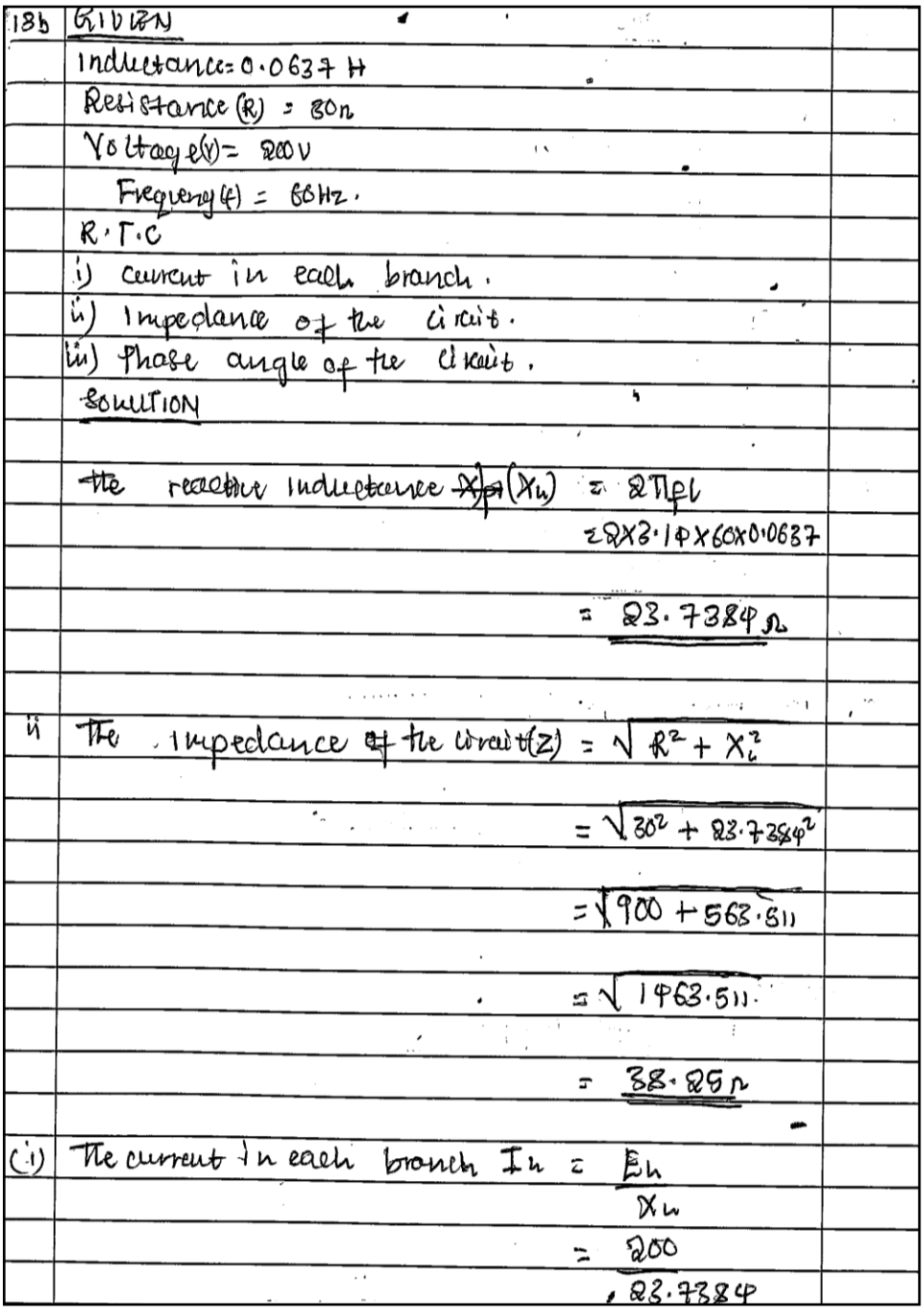


Extract 12.1: A sample of correct responses to Question 13

Despite the good performance in this question, 31.1 per cent of the candidates had weak performance. Most of them incorrectly responded to parts (b) (ii), (iii) and (c) of the question. For example, one of the candidates used the wrong formula $\left(Z = \sqrt{R^2 + XL^2}\right)$ to calculate the impedance of the circuit while the correct formula was $\left(Z = \frac{V}{I}\right)$. Where, Z = impedance, V = supply voltage, and I = circuit current.

Likewise, in part (b) (ii) the candidate calculated the phase angle by using the formula $\left(\theta = \cos^{-1}\frac{R}{Z}\right)$ instead of $\left(\theta = \cos^{-1}\left(\frac{I_R}{I}\right)\right)$. Whereby, θ = phase angle and I_R = current through resistor.

The candidate had confused the formulas for a parallel circuit with parallel-series circuit. Moreover, the candidates who missed part (c), failed to recognize that when the resistor, R is removed, the circuit remains with an inductor, hence, purely inductive. Extract 12.2 is a sample of incorrect responses from one of the candidates.



Extract 12.2: A sample of incorrect responses to Question 13

Extract 12.2 shows that the candidate applied inappropriate formulae and procedures to calculate the current in each branch, impedance and phase angle of the circuit.

2.3.4 Question 14: Conductors and Cables

The question tested the candidates' ability to relate the given parameters with the appropriate formulas to calculate the required quantities. The question was as follows:

(a) What is the importance of insulation part of the cable?

(b) Each conductor of 3-core copper cable, 178 meters long has a cross sectional area of 15 mm^2. The cable supplies power to a 413-V, 3 phase motor of 22 kW output which works at a full load at 0.72 p.f lagging with an efficiency of 87 per cent. Calculate:

(i) The voltage required at the supply of the cable

(ii) The power loss in the cable.

A total of 203 (38.1%) out of 533 candidates attempted this question. Among those who attempted, 156 (76.8%) scored from 0 to 4 marks, 33 (16.3%) candidates scored from 5 to 8 marks, and the remaining 14 (6.9%) scored from 10 to 15 marks. The performance of the candidates in this question was weak since 23.2 per cent of the candidates passed. The candidates' performance in this question is summarized in Figure 14.

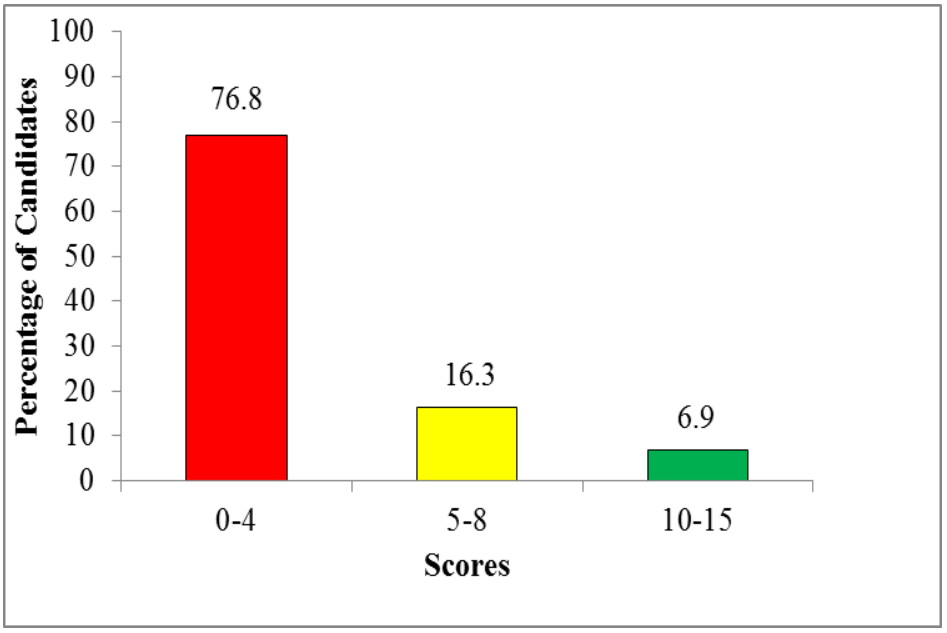
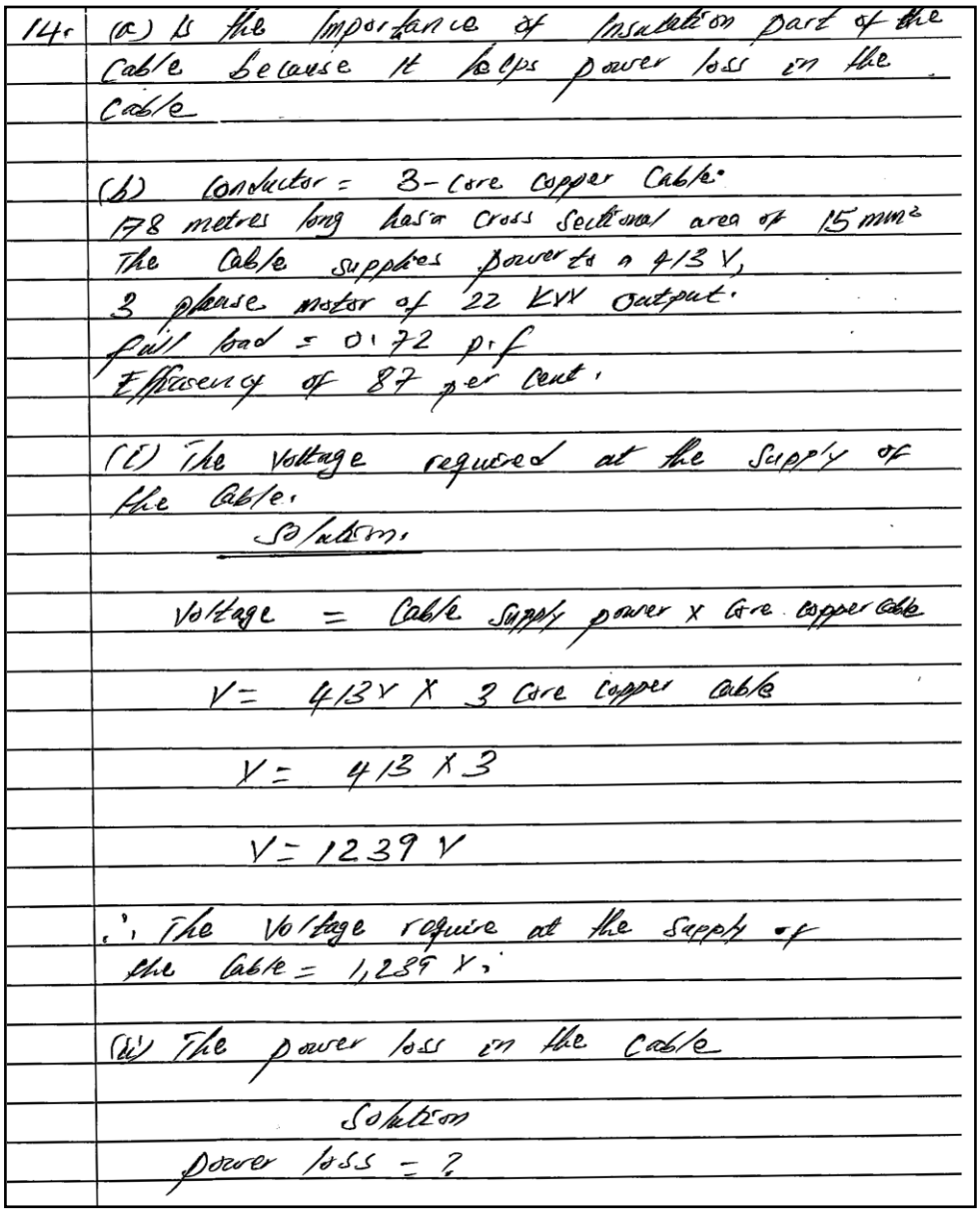


Figure 14: *The Candidates' Performance in Question 14*

The analysis reveals that the candidates' weak performance was caused by their failure to apply the correct formulas to calculate the parameters in part (b) of the question. Also 3.0 per cent of the candidates who scored zero could not provide correct responses to any part of the question. These candidates had insufficient knowledge on the subtopic of *conductors and cables.* For example, one of the candidates just took the product of the *supply voltage* and *power factor* as the response to part (b) (i). Extract 13.1 illustrates a sample of incorrect responses from one of the candidates.



14. (a) Is the importance of insulation part of the cable because it helps power loss in the cable

(b) Conductor = 3-core copper cable.
178 metres long has a cross sectional area of 15 mm²
The cable supplies power to a 413 V,
3 phase motor of 22 KW output.
full load = 0.72 p.f
Efficiency of 87 per cent.

(i) The voltage required at the supply of the cable.

Solution.

Voltage = Cable supply power x Core copper cable

V = 413 V X 3 Core copper cable

V = 413 X 3

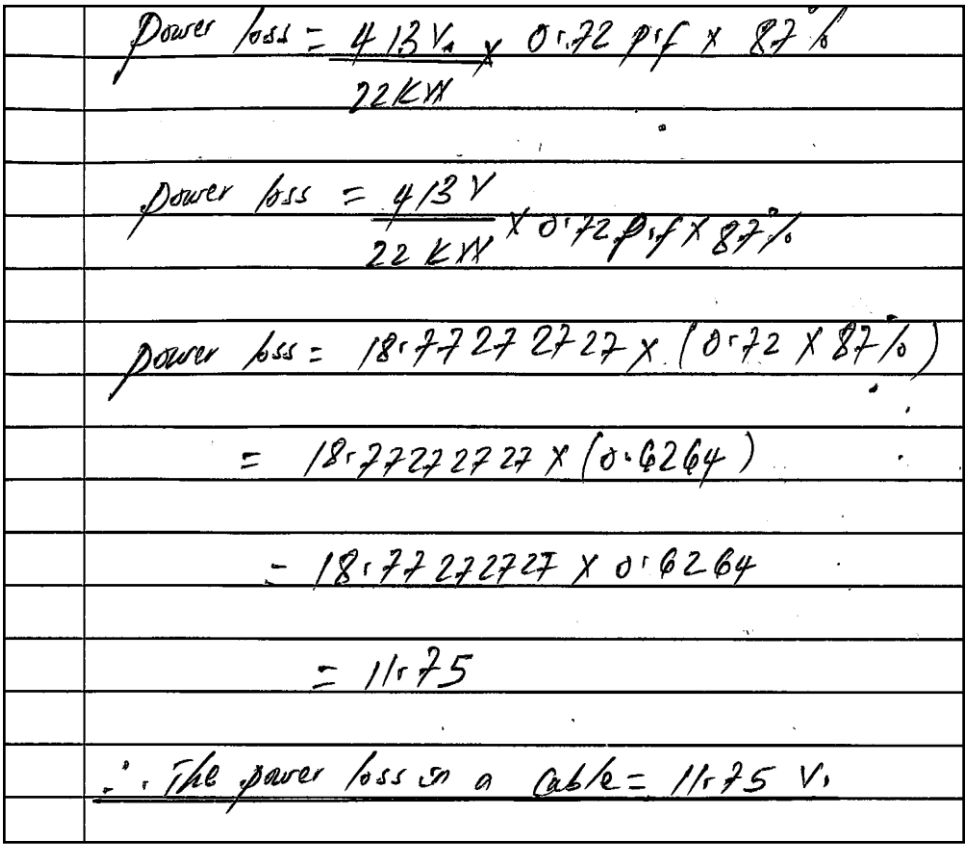
V = 1239 V

∴ The voltage require at the supply of the cable = 1,239 V.

(ii) The power loss in the cable

Solution

power loss = ?



Extract 13.1: A sample of incorrect responses to Question 14

Extract 13.1 shows that the candidate wrongly calculated the voltage required at the supply of the cable by multiplying the motor voltage by the number of cable cores. Likewise he/she applied inappropriate formulae and procedures to calculate the power loss in the cable.

Conversely, 14 (6.9%) candidates who had good performance were able to give the importance of insulation part of the cable and calculated the voltage required as well as the power loss in the cable. Extract 13.2 shows a sample of good responses from one of the candidates.

14 a) The importance of insulation part of the cable is to confine the electricity to the conductor or cable.

14 (b) length (L) = 178m
Area = 15mm²
power supplied = 22kw (output power)
supply voltage = 413V
power factor = 0.72 lagging
efficiency = 87%.
Task (i) voltage required at the supply.
(ii) power loss in the cable.

(i)
efficiency = output power / input power × 100%.
87% = 22000W / input power
input power = 22000 W / 0.87
input power = 25287.35632W

Power = $\sqrt{3}$ V I L cos ϕ
25287.35632 = $\sqrt{3}$ × 413 × IL × 0.72
IL = 25287.35632 / $\sqrt{3}$ × 413 × 0.72
IL = 49.09775988
IL ≈ 49.1A

also. R = ρL/A
L = 178m / 1m × 1000mm = 178000m.
A = 15mm²
ρ = 17.5 Ωmm.
Resistivity of copper material is 17.5 × 10⁻⁶ Ωmm.

Extract 13.2: A sample of good responses to Question 14

3.0 THE CANDIDATES' PERFORMANCE IN EACH TOPIC

The analysis of the candidates' performance in the topics which were examined in the Electrical Engineering Science subject for the year 2022 indicates that candidates performed well in the topics of *Units, Transformer, Electromagnetism, D.C Machines, Safety Precautions, Instruments and Measurements, Effects of Electric Current* and *D.C Circuits* (97.6%) tested in question 1 which comprised of 10 multiple choice items; *Transformer* (91.9%) tested in question 2*; Electric Heating* (87.8%) tested in question 8*; Three Phase Circuits* (76.6%) tested in question 11*; D.C Circuit* (76.5%) tested in question 5*; Measurements and Instruments* (73.4 %) tested in question 3*; D.C Machines (67.4%)* tested in question 7, and *A.C Circuits* (64.5%) tested in questions 12 and 13. The good performance on these topics was contributed by the candidates' sufficient knowledge, skills and competence on the concepts tested, and understanding of the requirements of the questions.

The topics with average performance were *A.C voltages* (62.5%) tested in question 9, *Electromagnetism* (60.2%) tested in question 10 and *Illumination* (35.8%) tested in question 6. The analysis indicates that the average performance was due to sufficient knowledge that the candidates had about the tested topics. However, in few items, some of the candidates provided fewer or incorrect points and failed to use appropriate formula to perform calculations.

The candidates had weak performance in the topics of *Conductors and Cables* (23.4%) tested in question 14 and *Batteries and Cells* (21.6) tested in question 4. The major challenge was the failure of the candidates to apply the correct formula to calculate the parameters as per the questions demand. A summary of the candidates' 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 Science on Form Four National Examinations (CSEE) in the year 2022 was good. Out of 533 candidates who sat for the paper, 472 (88.56%) passed, while 61 (11.44%) failed. The good performance of the candidates resulted from their ability to understand requirements of the questions, their knowledge, skills and competence in the subject matter, and their mastery of calculation skills.

The analysis further shows that the candidates' performance in both 2021 and 2022 remained good in the topic of *transformer*, *electric heating* and *three phase circuit*. On the other hand, the topic of *Instrument and Measurement* which had poor performance in 2021 had average performance in 2022.

However, few shortcomings have been revealed. These include the candidates' insufficient knowledge in responding to some of the questions, failure to understand the questions, and inability to apply appropriate mathematical formulae in computations as it was highly observed in the topics of *Conductors and Cables* and *Batteries and Cells* which was poorly done.

4.2 Recommendations

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

(a) Candidates are advised to be very keen in studying in order to gain sufficient knowledge, skills and competences of the learned concepts in various topics within the prescribed syllabus.

(b) The competence-based mode of material delivery should be put into practice in various topics. This will ensure sufficient knowledge, skills, and competences are acquired and mastered by the prospective candidates.

(c) Candidates should be guided to carryout different computation exercises to strengthen their ability to tackle questions which require application of formulae and calculations as observed in the topics of *Conductors and Cables* and *Batteries and Cells*.

Appendix

A Summary of the Candidates' Performance in each Topic in Electrical Engineering Science Subject for the Year 2022

S/n	Topic	Question Number	Percentage of Candidates who Scored 30 Per cent and Above	Remarks
1	Units, Transformer, Electromagnetism, D.C Machines, Safety Precautions, Instruments and Measurements, Effects of Electric Current and D.C Circuits	1	97.6	Good
2	Transformer	2	91.9	Good
3	Electric Heating	8	87.8	Good
4	Three Phase Circuits	11	76.6	Good
5	D.C Circuit	5	76.5	Good
6	Measurements and Instruments	3	73.4	Good
7	D.C Machines	7	67.4	Good
8	A.C Circuits	12&13	64.5	Good
9	A.C Voltages	9	62.3	Average
10	Electromagnetism	10	60.2	Average
11	Illumination	6	35.8	Average
12	Conductors and Cables	14	23.4	Weak
13	Batteries and Cells	4	21.6	Weak