THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2019

082 ELECTRICAL ENGINEERING SCIENCE

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FOREWORD

The National Examinations Council of Tanzania (NECTA) is pleased to issue this *Candidates' Item Response Analysis* (CIRA) report in order to provide feedback on the candidates' performance. This report analyses their performance on the Certificate of Secondary Education Examination (CSEE) 2019 in Electrical Engineering Science subject. The report is intended to give feedback to future candidates, teachers, examiners and other key education stakeholders on the general performance and specific areas of weakness that the candidates demonstrated in their responses. Furthermore, the report gives recommendations to improve performance in the future.

The report is mostly based on NECTA results' statistical data and responses obtained from the candidates' scripts which are used as illustrations. The report analysed the candidates' responses to each question and identified factors which hinder good performance of the candidates. Such factors include candidates' inability to interpret the requirements of the questions, failure to use the correct formulae in solving problems and the lack of knowledge and skills in various topics. Each factor has been explained using extracts from the candidates' scripts for illustrations.

The National Examinations Council of Tanzania hopes that the feedback provided in this report will be useful to education stakeholders and the suggestions provided will enable them to take appropriate measures to enhance the candidates' performance in future.

The National Examinations Council of Tanzania (NECTA) would like to thank various educational stakeholders who, in one way or another, devoted their energy and time to provide important inputs that have been used in preparing this report.

Dr Charles E. Msonde
EXECUTIVE SECRETARY

LIST OF SYMBOLS AND ABBREVIATIONS

μ	Micro
A	Ampere
A.C	Alternating Current
CIRA	Candidates' Items Response Analysis
CSEE	Certificate of Secondary Education Examinations
D.C	Direct Current
emf	Electromotive force
Hz	Hertz
KJ	Killo Joule
mA	Milli Ampere
NECTA	National Examinations Council of Tanzania
p.f	Power Factor
r.p.m	Revolution per Minutes
V	Volt
W	Watt
Ω	Ohm

1.0 INTRODUCTION

The Electrical Engineering Science Examination was comprised of Sections A, B and C. Section A consisted of one multiple choice question with 10 items: (i) to (x). The items were set from the topics of *Unit, Nature of Electricity, Instrument and Measurements, Transformer, D.C Machine, A.C Motors, D.C Circuits, Effects of Electric Current* and *Electric Heating.* The candidates were required to answer all questions from this section. Each item carried 1 mark making a total of 10 marks.

Section B consisted of 10 short answer questions set from the topics of *A.C Voltage, Batteries and Cells, A.C Machines, Transformer, Electromagnetism, Three Phase Circuits, Illumination and D.C Machines.* The candidates were required to answer all questions in this section. Each question carried 15 marks, making a total of 45 marks.

Section C consisted of 4 structured questions set from the topics of *Transformer, D.C Machine, Electric Heating* and *A.C Circuit*. The candidates were required to answer 3 questions. Each question carried 15 marks, making a total of 45 marks.

A total of 353 candidates sat for Electrical Engineering Science paper. Among them, 279 (79.04%) passed, while 74 (20.96%) candidates failed. Therefore, the candidates' performance on this paper is good. The analysis of the candidate's performance on each question is categorized into three grade ranges as shown in Table 1.

Table 1: **Categories of the Grade Ranges of the Candidates' Performance**

Range in %	0 – 29	30 – 64	65 – 100
Remark on performance	Weak	Average	Good

The report presents a detailed analysis of the candidates' performance indicating the specific areas of strengths and weaknesses in attempting the questions. Graphs, charts as well as samples of good and poor responses from the candidates' scripts have been used to illustrate such responses.

Finally, the report provides recommendations for the improvement of candidates' performance in future.

2.0 ANALYSIS OF CANDIDATES' RESPONSE TO EACH QUESTION

A detailed analysis and general evaluation of the candidates' responses to each question are done in this part to indicate the candidates' performance and the challenges encountered in responding to a particular question.

2.1 SECTION A: OBJECTIVE QUESTIONS

2.1.1 Question 1: Multiple Choice Item

The analysis of the candidates' responses to question 1 is based on the 10 multiple-choice items: (i) to (x). The candidates were required to choose the correct answer from the given alternatives A – E and write its letter beside the item number.

A total of 353 candidates attempted this question. Among them, 31 (8.8%) performed poorly; they scored from 0 to 2 marks. The candidates who performed averagely were 246 (69.7%); they scored from 3 to 6 marks. The remaining 77 (21.5%) demonstrated good performance; they scored from 7 to 10 marks. This performance is illustrated in Figure 1.

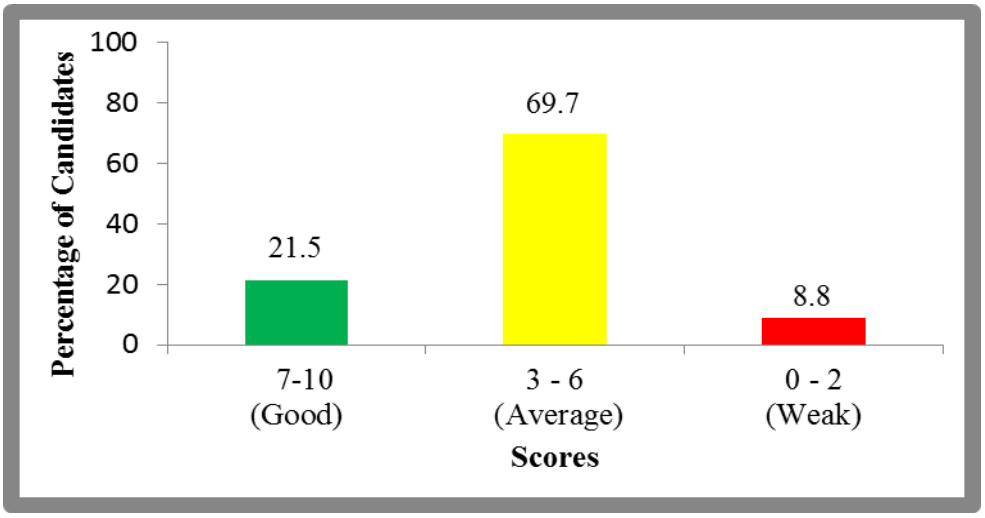


Figure 1: *Candidates' Overall Performance in Question 1*

Figure 1illustrates that, the overall performance of the candidates on this question was good since 322 (91.2%) candidates demonstrated average to good performance. These candidates had an adequate knowledge of the concepts tested.

Furthermore, the analysis of the candidates' responses shows that most of them managed to choose the correct answers in items (i), (ix) and (x) but averagely performed on items (iv), (vi) and (viii).

However, 8.8 percent of the candidates demonstrated weak performance. These candidates lacked knowledge about the tested items. For example, most of the candidates failed to select the correct responses in items (ii), (iii) and (v).

In item (ii), which required the candidates to choose the alternative phase sequence if RYB is the given phase sequence of a three phase system, most of the candidates chose alternative D, *BYR,* instead of C, *RBY*. These candidates reversed the arrangement of litters from the given sequence without considering the direction of phase rotation. They lacked knowledge about the concept of phase sequence as used in three-phase circuits.

In item (iii), which required the candidates to choose a typical example of universal electrical measuring instrument, most of them chose alternative D, *Wattmeter,* instead of E, *Avometer*. These candidates misinterpreted the term *'Universal'* by assuming that power; which is measured by using wattmeter is the universal electric quantity. They did not recognize that the Avometer measures both current and voltage from which power can be obtained. This signifies that the candidates lacked practical knowledge about measuring instruments.

Moreover, in item (v), which requires the candidates to select the reason for transformer cores to be laminated, most of them selected alternative B, *To reduce hysteresis losses,* instead of A, *To minimize eddy current.* These candidates misconceived the terms 'hysteresis' and 'eddy current' as both of them are types of transformer losses. This shows that the candidates had an inadequate knowledge of transformers, particularly transformer losses.

2.2 SECTION B: SHORT ANSWER QUESTIONS

2.2.1 Question 2: A.C Voltage

The question required the candidates to calculate the instantaneous value of the current for a sinusoidal varying alternating current of the frequency of 60 Hz which has a maximum value of 15 A at an angle of 0^0.

The question was attempted by 317 candidates. Their scores were as follows: 268 (84.5%) candidates performed poorly as they scored 0 to 1 mark; 44 (13.9%) candidates performed averagely because they scored from 1.5 to 3 marks, and 5 (1.6%) candidates scored from 3.5 to 5 marks, which indicated good performance.

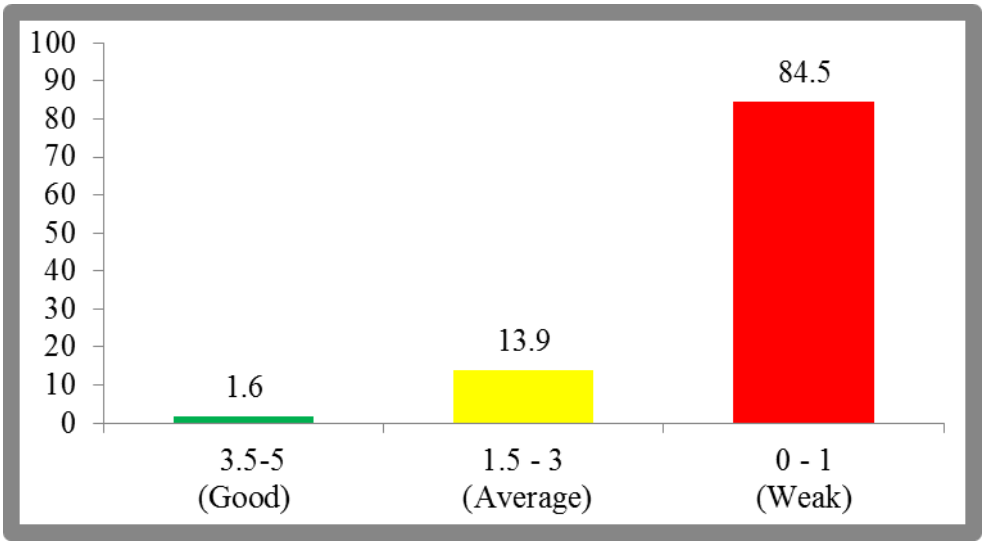
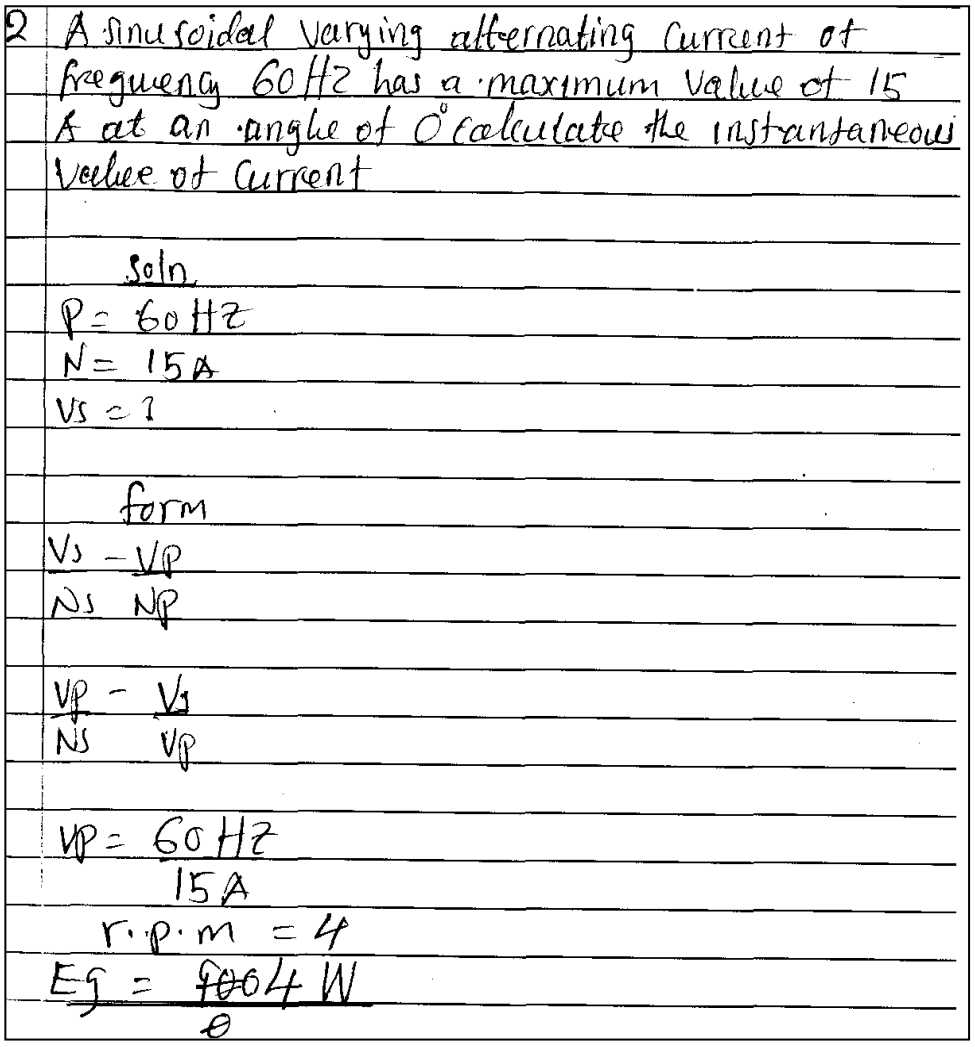


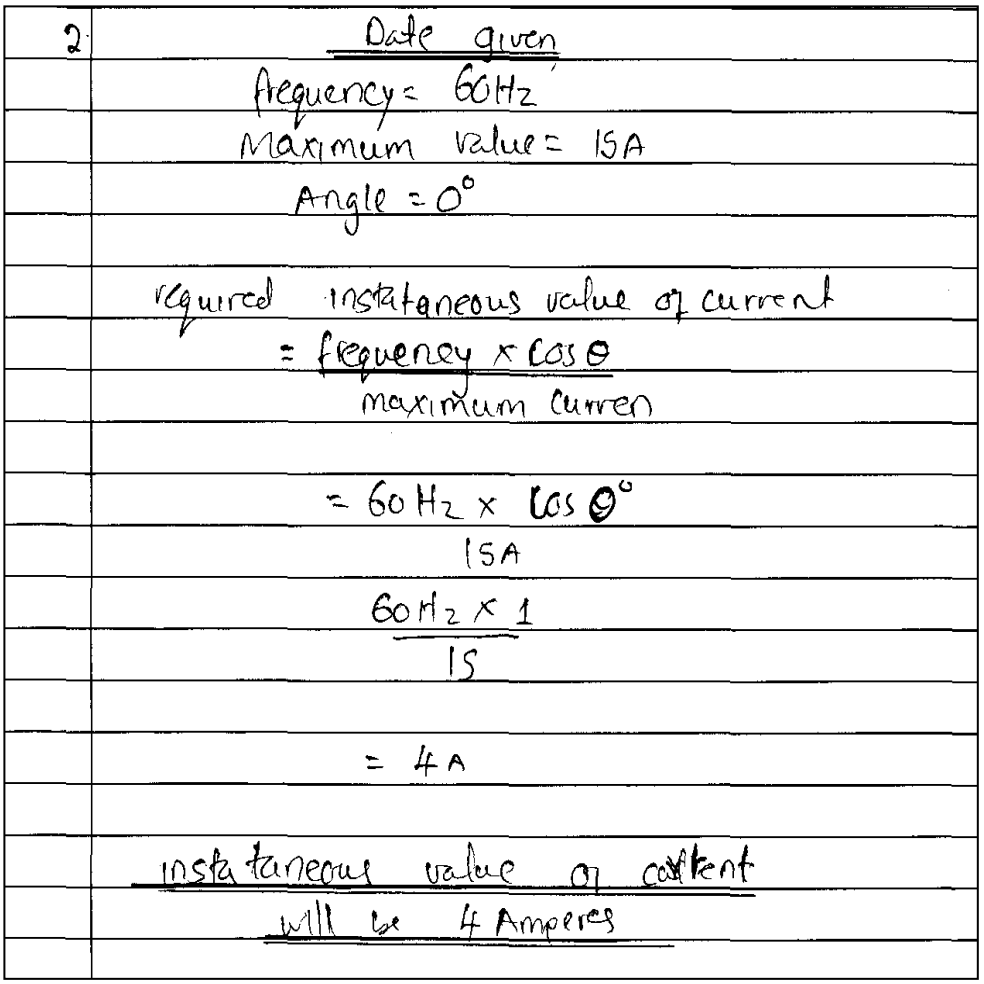
Figure 2: *Candidates' Overall Performance on Question 2*

Figure 2 shows that the overall performance of the candidates on this question was poor since only 15.5 percent of the candidates passed. The majority failed to recall the formula to calculate the value of instantaneous current. Some of them managed to calculate only the revolution speed but they failed to incorporate it into the appropriate formula to calculate instantaneous current. This indicates that the candidates lacked adequate knowledge of A.C Voltages and its associated calculations. Extracts 2.1 and 2.2 illustrate samples of poor responses to the question.



Extract 2.1: A sample of incorrect responses by one of the candidates

The extract show that this candidate decided to use the transformer turns ratio equation to calculate the revolution speed, which is wrong. As the result, he/she failed to calculate the correct value of the instantaneous current as required by the question.

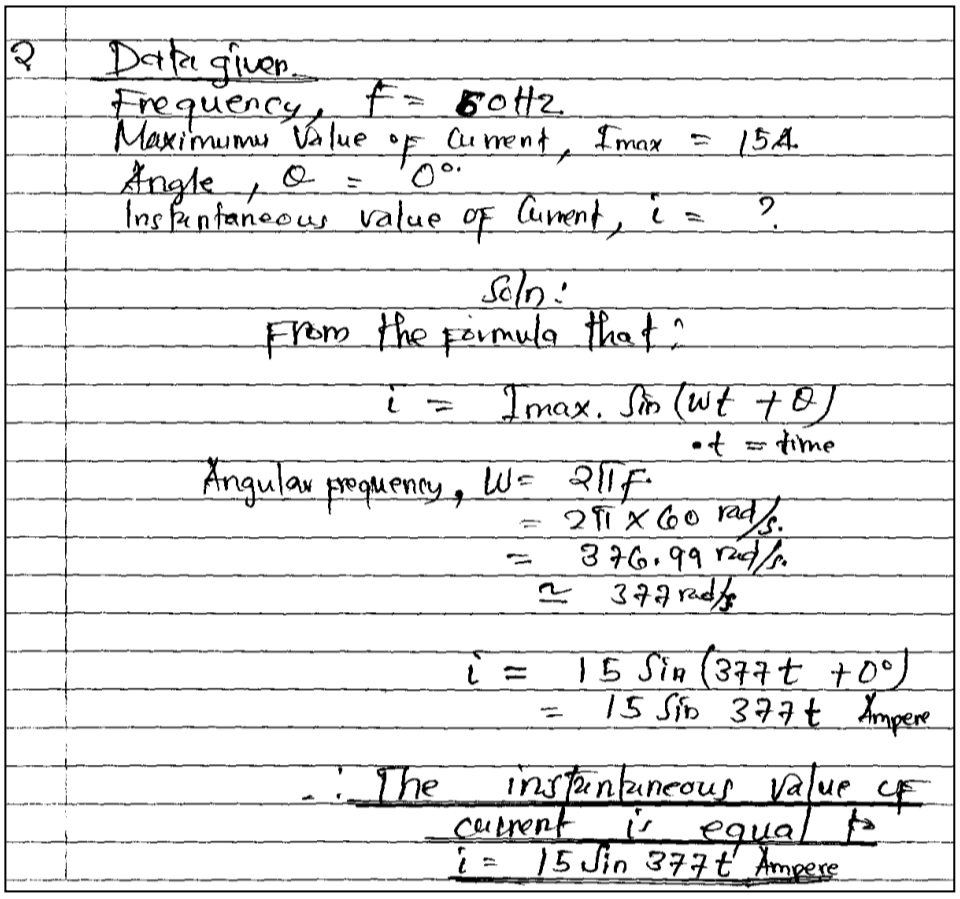


Extract 2.2: A sample of candidates' incorrect response to question 2

Extract 2.2 show that the candidate formulated his/her own mathematical relationship and used for in it the data given in the question to calculate the instantaneous value of current, thus scored zero.

The analysis further showed that 13.9 percent of the candidates attained average performance. They managed to provide the correct formula to calculate revolution speed, but they failed to use it to calculate the instantaneous value of current. These candidates proved to have partial knowledge of A.C Voltages. However, 5 (0.6%) candidates managed to score all the 5 marks allotted to this question. These candidates managed to apply the correct formula to calculate the instantaneous value of current. This result postulates that the candidates had an adequate knowledge of

A.C voltages. A sample of good responses from one of the candidates is represented in Extract 2.3.



Extract 2.3: A sample of candidate's good responses to question 2

This candidate managed to apply correctly the formula to calculate angular speed and applied it to calculate the instantaneous value of current. This implies that the candidate acquired sufficient knowledge about this topic

2.2.2 Question 3: Batteries and Cells

This question measured the candidates' knowledge of charging and discharging batteries by asking:

Suppose your friend is charging a battery in your room, and you need to call your friend when the battery is fully charged. What are the five necessary indications for a fully-charged battery?

The question was attempted by 288 candidates. Among them 209 (72.6%) scored from 0 to 1 mark; 61 (21.2%) scored from 1.5 to 3 marks and 28 (6.2%) scored from 3.5 to 5 marks. Figure 3 summarizes the overall performance of the candidates on this question.

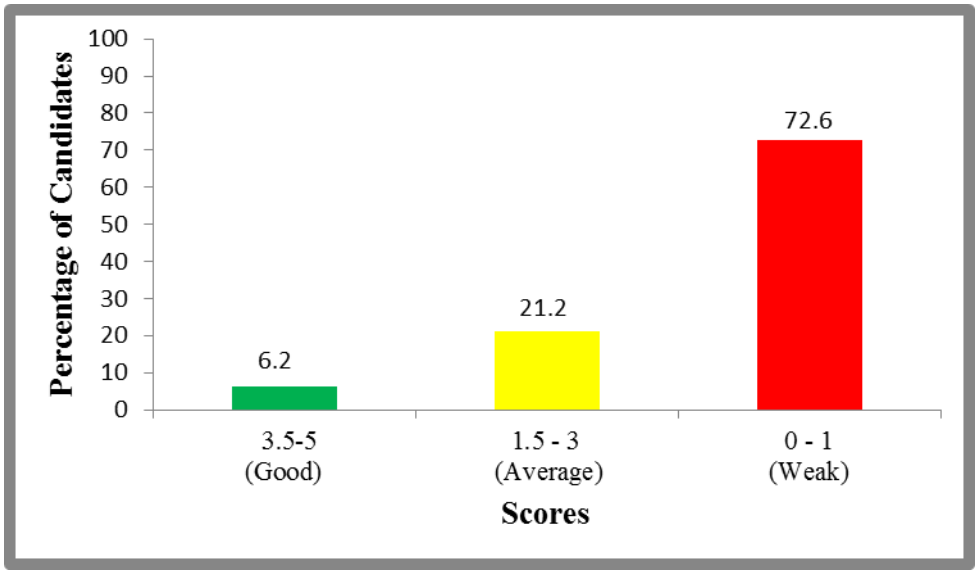
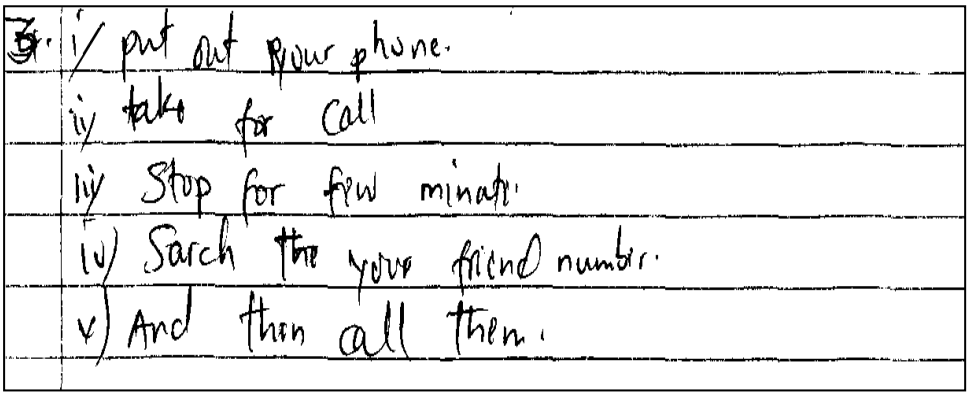


Figure 3: *Candidates' Overall Performance on Question 3*

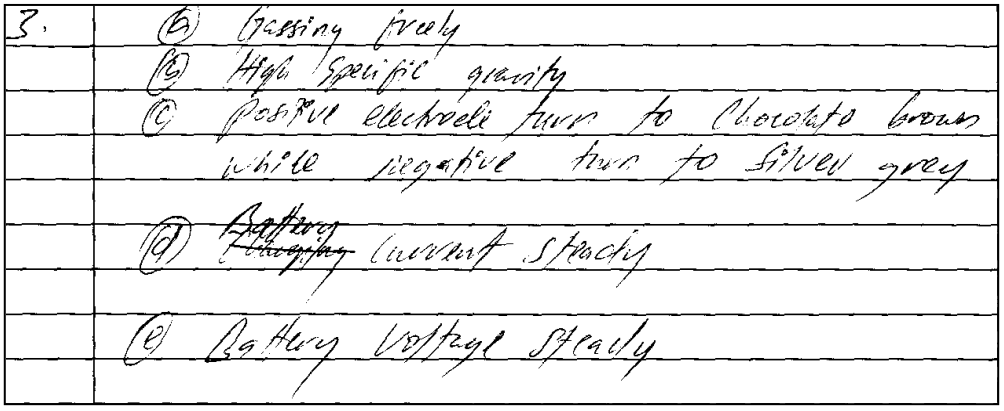
Figure 3 clearly show that the candidates' overall performance on this question was poor since a few (27.4%) candidates passed. These candidates had insufficient knowledge about Batteries and Cells. For example, one candidate provided wrong indications for a fully-changed battery by writing "*electromagnetic fuse, current, voltage, maximum fuse and magnetism*". Another candidate wrote: "*(i) Doesnot continue consuming electricity, (ii) will expand* and *(iii) temperature of a battery will increase*". This suggests that the candidates had insufficient practical knowledge about batteries and cells, particularly about the charging and discharging of batteries. This performance is illustrated in Extract 3.1.



Extract 3.1: A sample of candidates' incorrect responses to question 3

In Extract 3.1, the candidate outlined the procedures used to make a phone call instead of giving the necessary indications of a fully-charged battery. This candidate failed to understand the demand of the question.

Drawing on Figure 3, only 6.2 percent of the candidates managed to score 3-5 points. Among them, 1.7 percent managed to provide the necessary indications for a fully charged battery; hence, they scored full marks. Extract 3.2 is illustrative.



Extract 3.2: A sample of candidates' good responses to question 3

In Extract 3.2, the candidate demonstrated adequate knowledge about batteries and cells because he/she correctly mentioned five necessary indications of a fully-charged battery.

2.2.3 Question 4: A.C Machines

The question consisted of two parts in which the candidates were required to determine:

(a) Synchronous speed.

(b) Slip speed for a three phase, 4 pole, 50Hz induction rotor when is running at 1440 rpm.

A total of 342 (96.9 %) out of 353 (100%) candidates attempted this question. The candidates' performance shows that 124 (36.3%) candidates scored from 0 to 1 marks, 136 (39.7%) scored from 1.5 to 3, whereas 82 (24.0%) candidates scored from 3.5 to 5 marks. The general performance on this question is presented in Figure 4.

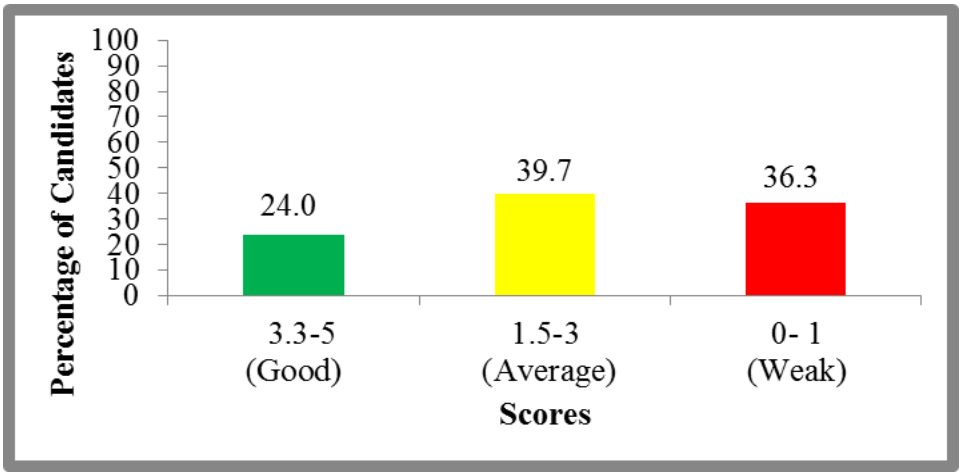
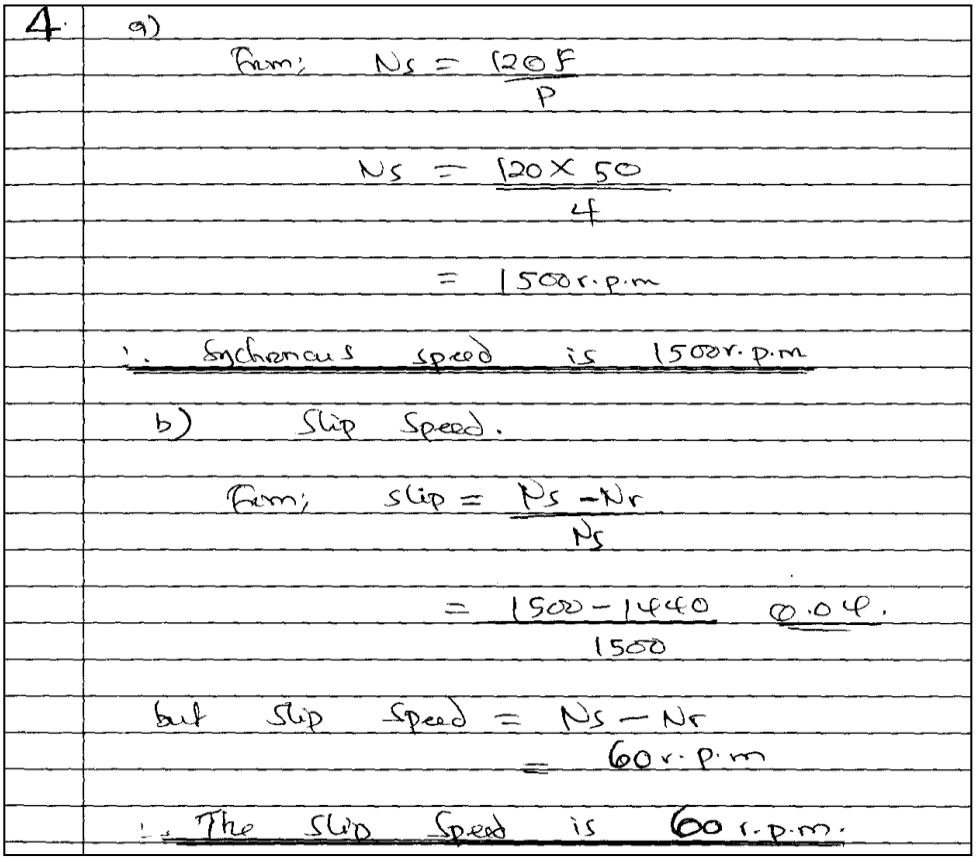


Figure 4: *Candidates' Overall Performance on Question 4*

Figure 4 shows that the general performance of the candidates on this question was average because 63.7 percent of the candidates passed. However, 36.3 percent of the candidates failed. Most of the candidates who passed managed to provide the correct response to both parts of the question. These candidates acquired adequate knowledge of the topic of A.C machines. The figure also shows that 39.7 percent of the candidates performed averagely as they managed to provide correct answers to one part of the question, but they failed to do so to the other part. Some of them failed to recall the correct formula used to calculate the synchronous and slip speed of a machine. Extract 4.1 is a sample of good responses from one of the candidates.



Extract 4.1: A sample of good responses by one of the candidates

The extract show that the candidate managed to apply the correct formula to calculate the synchronous and slip speed. This implies that the candidate had an adequate knowledge of A.C machines.

However, the 36.3 percent of the candidates who performed poorly had inadequate knowledge of A.C machines. These candidates failed to recall and apply the correct formula used to calculate synchronous and slip speed. Most of them used the two formulae interchangeably. Extracts 4.2 and 4.3 illustrate poor performance on this question.

4. Data;

$N_r = 4$

$F = 50Hz$.

$N_s = 1440$ r.p.m.

From;

a) Synchronous speed $= \frac{F_r}{N_s}$

$N = \frac{F_r}{F_s}$.

$4 = \frac{F_r}{50}$

$F_r = 4 \times 50$

$= 200$

Synchronous speed is 200.

b) $S = \frac{N_s - N_r}{N_s}$.

$= \frac{1440 - 4}{1440}$

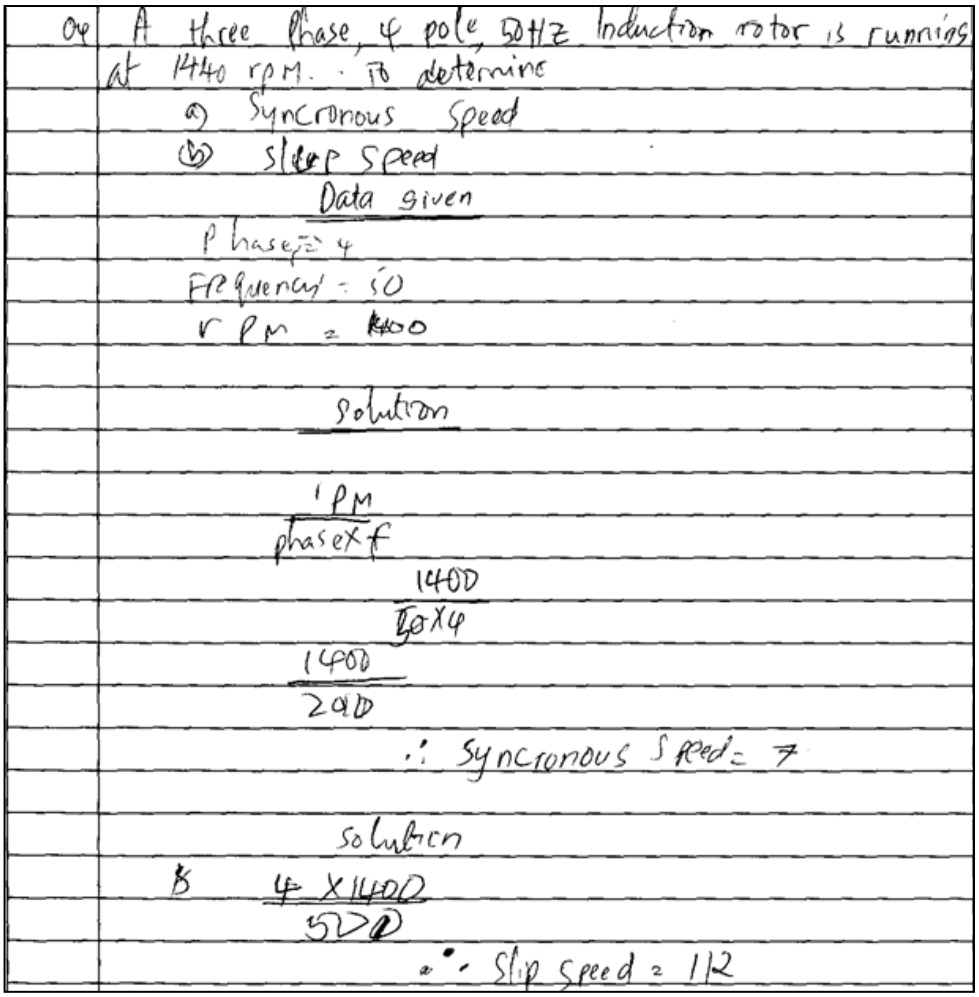
$= \frac{1436}{1440}$

$= 0.997$

The slip speed is 0.997.

Extract 4.2: A sample of incorrect responses by one of the candidates

The responses in Extract 4.2 show that the candidate applied incorrect formulae to calculate synchronous speed in (a). He/she simply multiplied the frequency of the machine by its number of poles, which is wrong. The candidate also applied irrelevant relationship between rotor speed and slip speed. This led him/her to the wrong answer in part (b). The candidate lacked knowledge of A.C machines.



Extract 4.3: A sample of incorrect responses to question 4

Extract 4.3 shows that the candidate divided the rotor speed by the product of frequency and the number of poles to determine the synchronous speed in part (a); this approach is wrong. Likewise in part (b), the candidate used the wrong formula to calculate sleep speed. The candidate divided the product of the number of poles and rotor speed by the line frequency; hence, he/she scored zero.

2.2.4 Question 5: Transformer

The question required the candidates to calculate the suitable value of primary turns for a given transformer having 3300/230 V, 50 Hz single phase transformer and operates at the maximum flux density of 1.2 Wb/m^2 in the core. The effective cross sectional area of the transformer core is 150 cm^2.

The question was attempted by 336 candidates and their scores were as follows: 138 (41.1%) candidates performed poorly as they scored from 0 to 1 mark; 51 (15.2%) candidates scored averagely from 2 to 3 marks and the rest 147 (43.7%) candidates indicated good performance as they scored from 4 to 5 marks. Figure 5 summarizes the overall performance on the question.

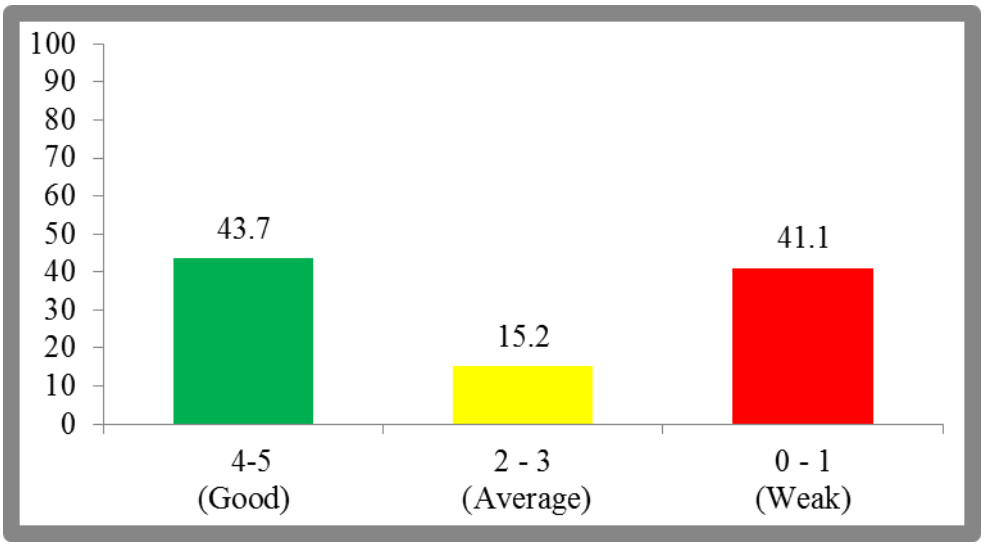
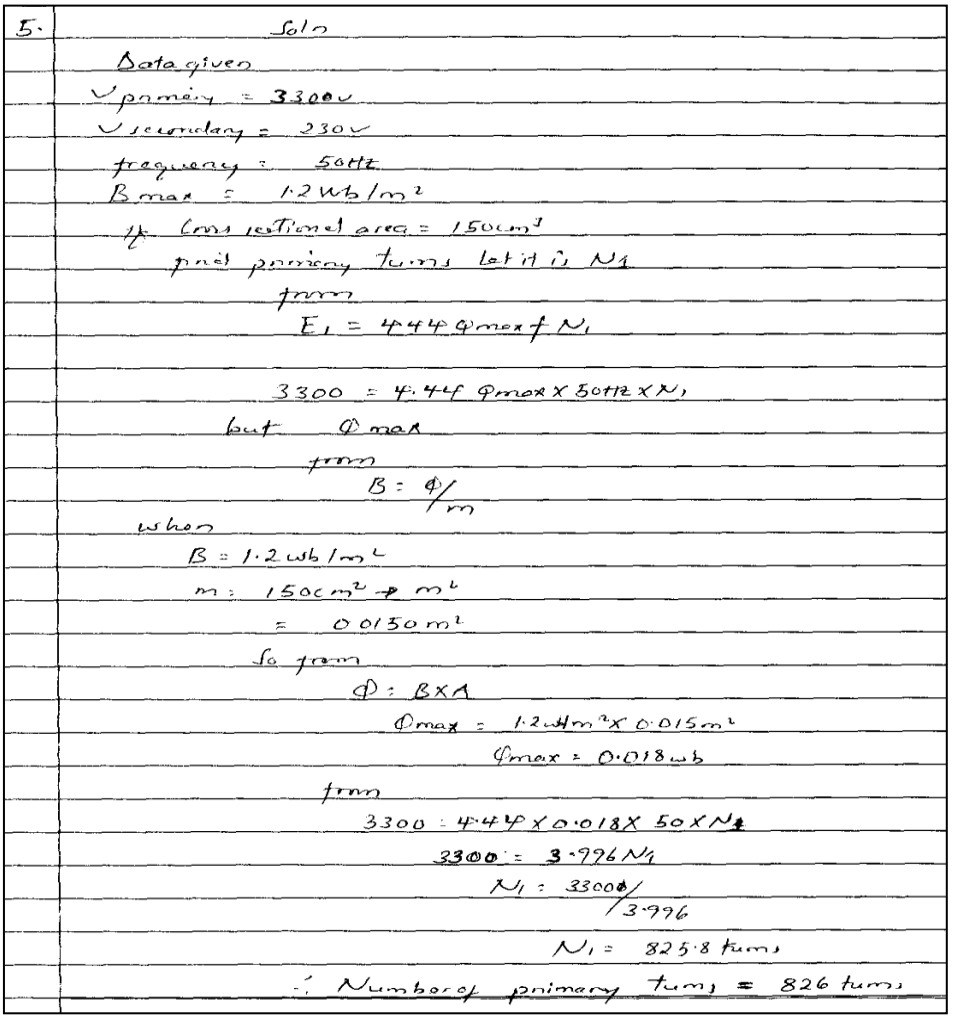


Figure 5: *Candidates' Overall Performance in Question 5*

Figure 5 shows that; the general performance of the candidates on this question was average since 58.9 percent of the candidates passed. These candidates proved to have an adequate knowledge about transformers. Most of them calculated correctly the suitable value of the primary turns of the transformer. Extract 5.1 illustrate a sample of candidates' good responses to the question.



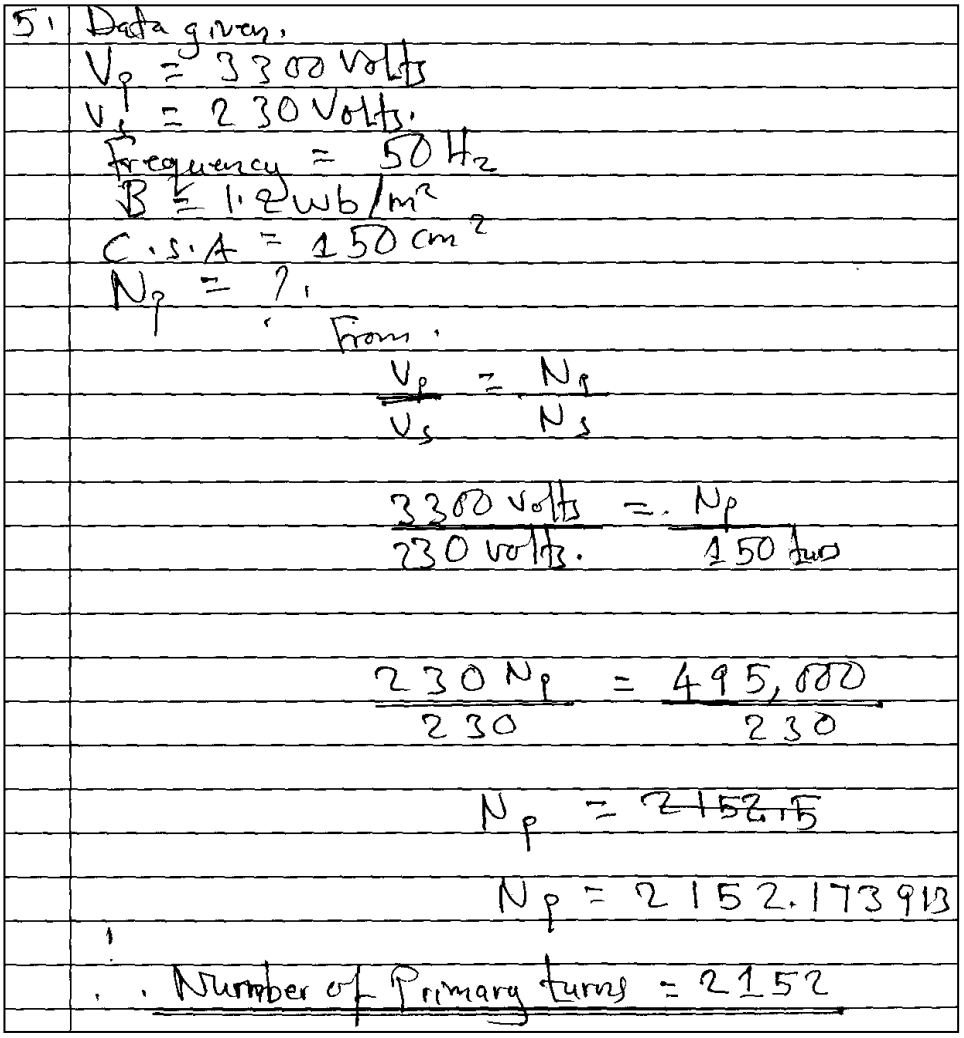
Extract 5.1: A sample of good responses to question 5

Extract 5.1 show that, the candidate managed to apply the correct formula to calculate the number of the primary turns of a transformer. This implies that the candidate acquired sufficient knowledge about this topic.

Those who performed below average failed to deduce the formula to calculate the primary voltage of the transformer. Therefore they obtained the wrong answer.

Although the candidates' overall performance on this question was average, 41.1 percent of candidates scored below average; among them 25.9 scored zero. These candidates confused the ratios used in transformers with other ratios used in electromagnetism because transformers are operated based on

the principles of electromagnet induction. Likewise, some of them failed to deduce the formula for calculating the primary voltage of the transformer; hence, they scored zero. These candidates lacked adequate knowledge of transformers. Extract 5.2 illustrate a sample of candidate's poor responses to the question.


5. Data given,
$V_p = 3300$ Volts
$V_s = 230$ Volts.
Frequency $= 50\ Hz$
$B = 1.2\ wb/m^2$
$C.S.A = 150\ cm^2$
$N_p = ?$
From:
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$
$\frac{3300\ volts}{230\ volts.} = \frac{N_p}{150\ turns}$
$\frac{230 N_p}{230} = \frac{495,000}{230}$
$N_p = 2152.5$
$N_p = 2152.173913$
∴ Number of Primary turns = 2152

Extract 5.2: A sample of poor responses to question 5

The response in Extract 5.2 shows that the candidate failed to equate the ratios of the given quantities to calculate the value of the primary turns of the transformer. Therefore, he/she scored zero. The candidate's response indicated that he/she had insufficient knowledge about transformers.

2.2.5 Question 6: Electromagnetism

The question was set as follows:

The mutually inductance between two coils is 240 mH. Suppose the current in one coil changes from 15 A to 6 A in 12 ms. Calculate the average induced e.m.f in the other coil.

There were 317 (89.8%) candidates who attempted this question. Among them, 91 (26.7%) scored zero; 26 (7.4%) scored 1 mark; 60 (18.9%) scored from 2 to 3 marks. Furthermore, the analysis shows that 140 (44.2%) candidates scored from 4 to 5 marks. these are considered to have performed well. Figure 6 shows the distribution of the candidates' scores.

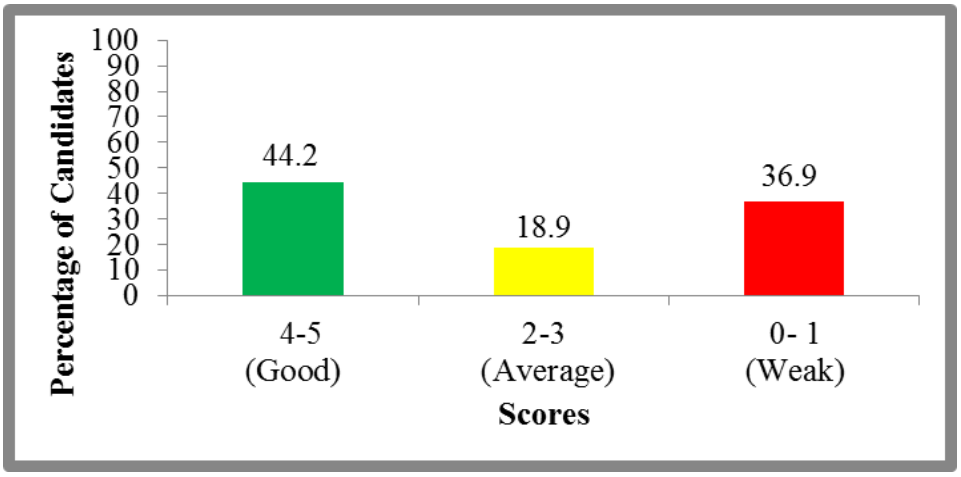
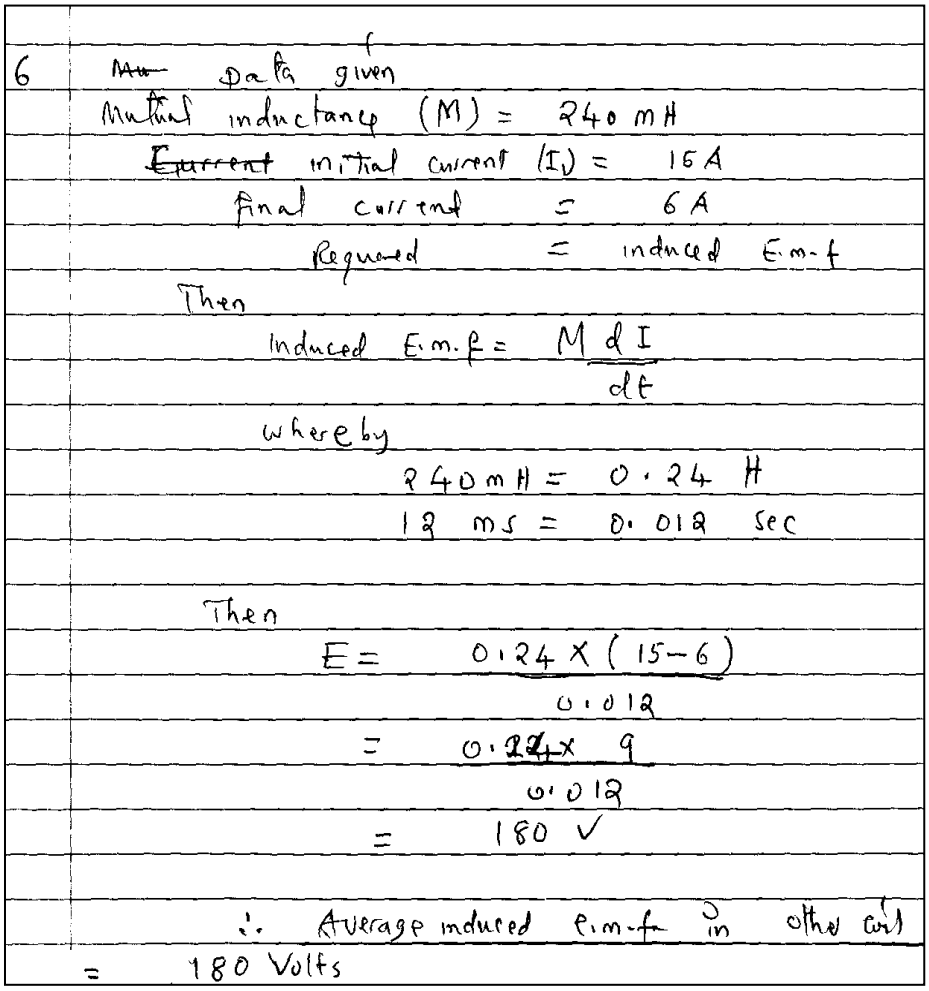


Figure 6: *Candidates' Overall Performance on Question 6*

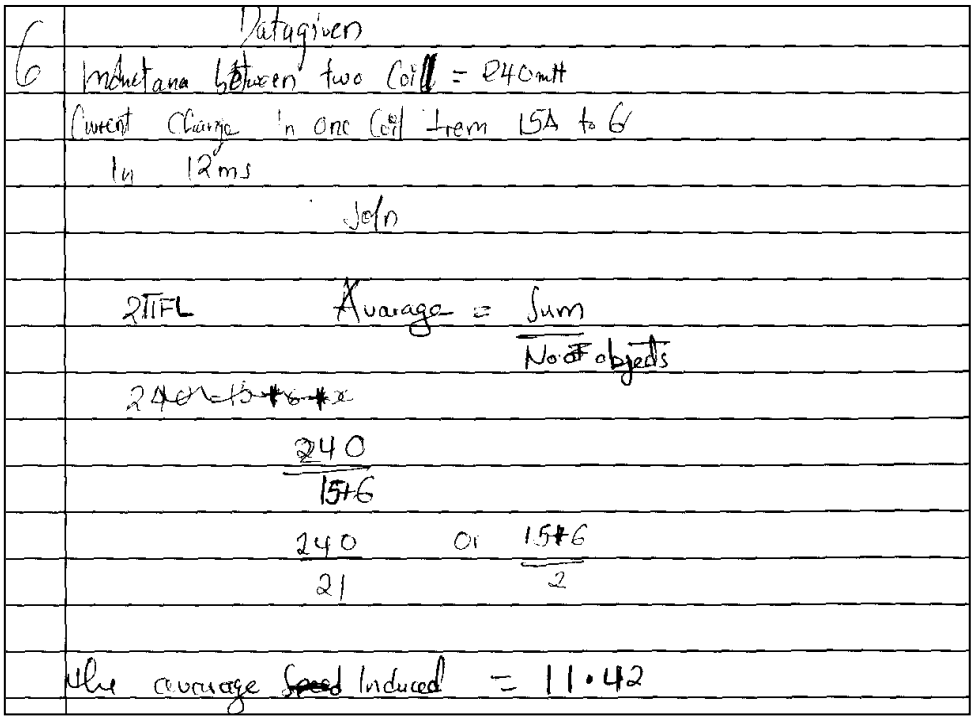
Figure 6 show that, the candidates' performance on this question was average. This is because 200 (63.1%) candidates managed to score from average and above. Most of them correctly applid the formula to calculate the value of average induced e.m.f while others managed to calculate only the change in current, but they failed to incorporate it into the general formula used to calculate the average induced e.m.f. These candidates demonstrated an adequate knowledge of Electromagnetism. Extract 6.1 presents a sample of good responses to the question.



Extract 6.1: A sample of good responses to question 6

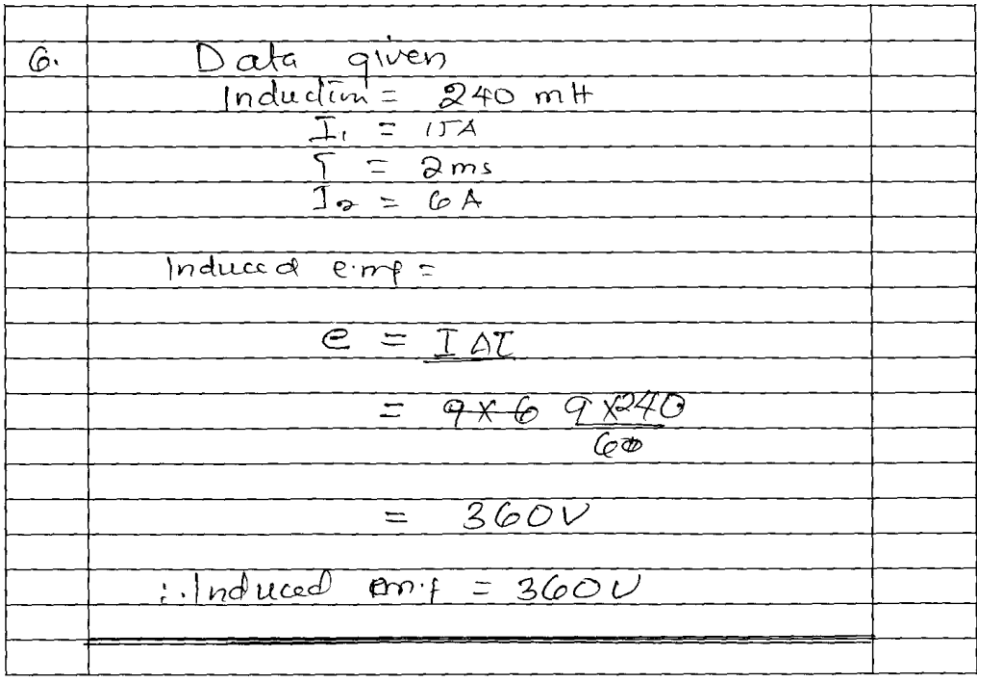
Extract 6.1 shows that the candidate managed to apply the correct formula to calculate the average induced e.m.f. of the other coil. Accordingly, he/she scored full marks. This implies that he/she had an adequate knowledge about electromagnetism.

Furthermore, the analysis shows that 117 (36.9%) candidates performed poorly. Among them, 91 (28.7%) scored zero and the remaining 26 (8.2%) scored 1 mark. These candidates seemed to lack knowledge about Electromagnetism. Some candidates also provided incorrect responses. Extracts 6.2 and 6.3 illustrate candidate's poor responses to the question.



Extract 6.2: An incorrect response to the question

Extract 6.2 shows that the candidate was not knowledgeable about the term 'average' as he/she transferred the knowledge and concepts used in finding normal statistical averages. Thus, he/she divided *sum* by the *number of objects* instead of using the following formula: $Induced\ e.m.f\ (E) = \frac{M\Delta I}{Dt}$.



Extract 6.3: A sample of an incorrect response to question 6

Likewise, Extract 5.3 shows that the candidate presented incorrect response. He/she wrongly multiplied and divided the numbers of the data given in the question instead of the correct formula for induced e.m.f. This candidate demonstrated poor mastery of the topic of electromagnetism particularly in calculating the induced e.m.f.

2.2.6 Question 7: D.C Circuits

The question had two parts: (a) and (b). It was set as follows:
If the potential difference across a resistor is 5200 mV when it carries a current of 1.2 kA; calculate:

(a) The power consumed by the resistor
(b) The resistance of the resistor

The question was attempted by 347 candidates. Their scores were as follows: 30 (8.6%) candidates performed poorly as they scored from 0 to 1 mark; 39 (11.3%) candidates performed averagely because they scored 1.5 to 3 marks; and the majority 278 (80.1.%) candidates demonstrated good

performance. They scored from 3.5 to 5 marks. Figure 7 summarizes the overall performance on this question.

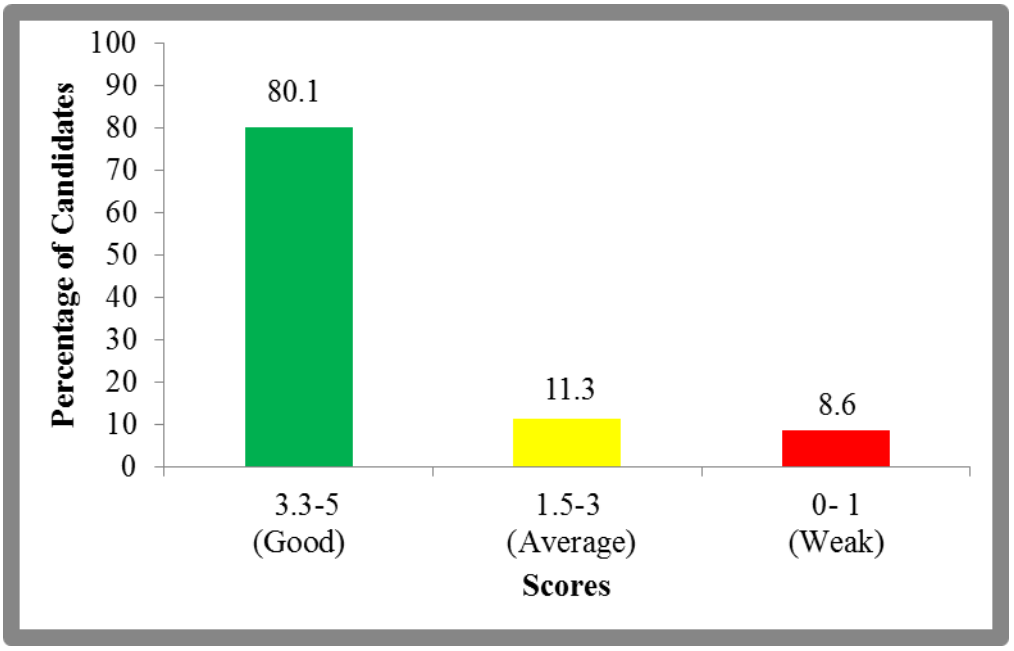
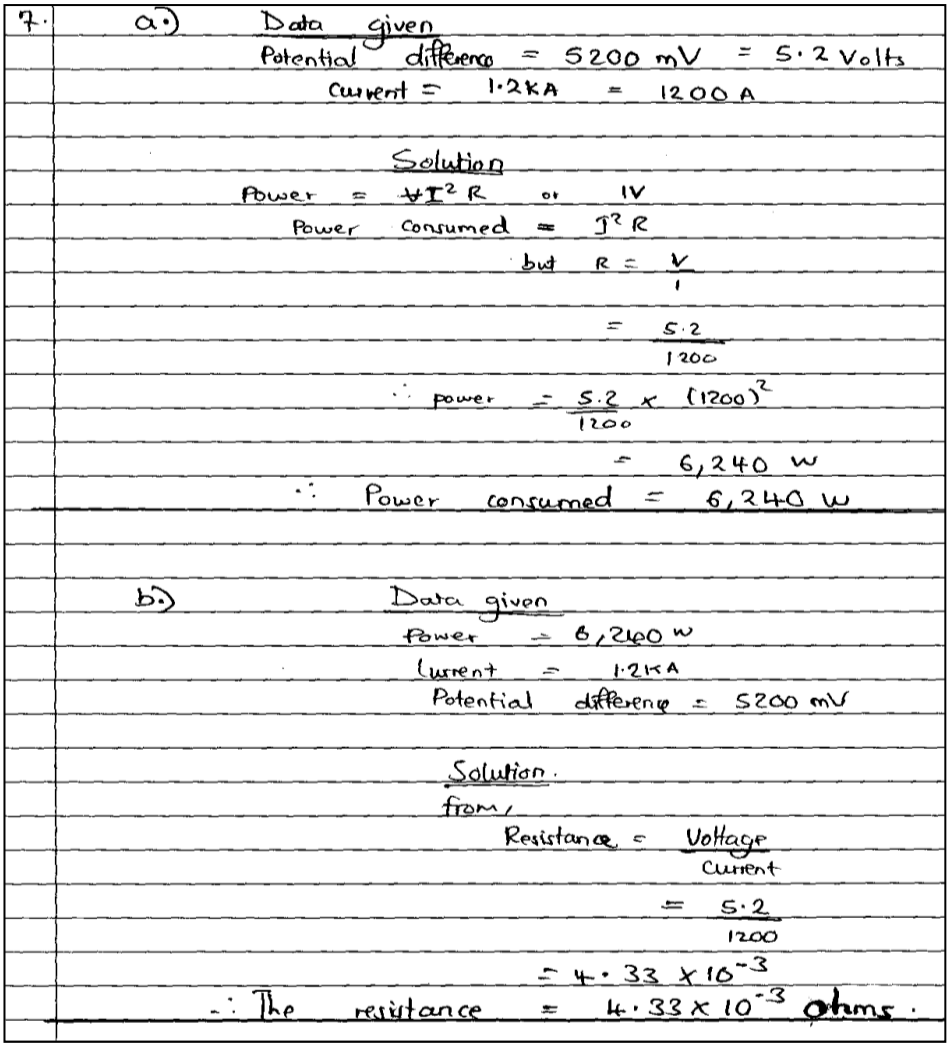


Figure 7: *Candidates' Overall Performance on Question 7*

Figure 7 indicates that the overall performance of the candidates on this question was good since 317 (91.4%) scored from average and above. These results proved that the candidates had sufficient knowledge of D.C circuits specifically about electrical power and energy. Most of them managed to provide correct responses to all parts of the question. Extract 7.1 illustrate a sample of good responses.

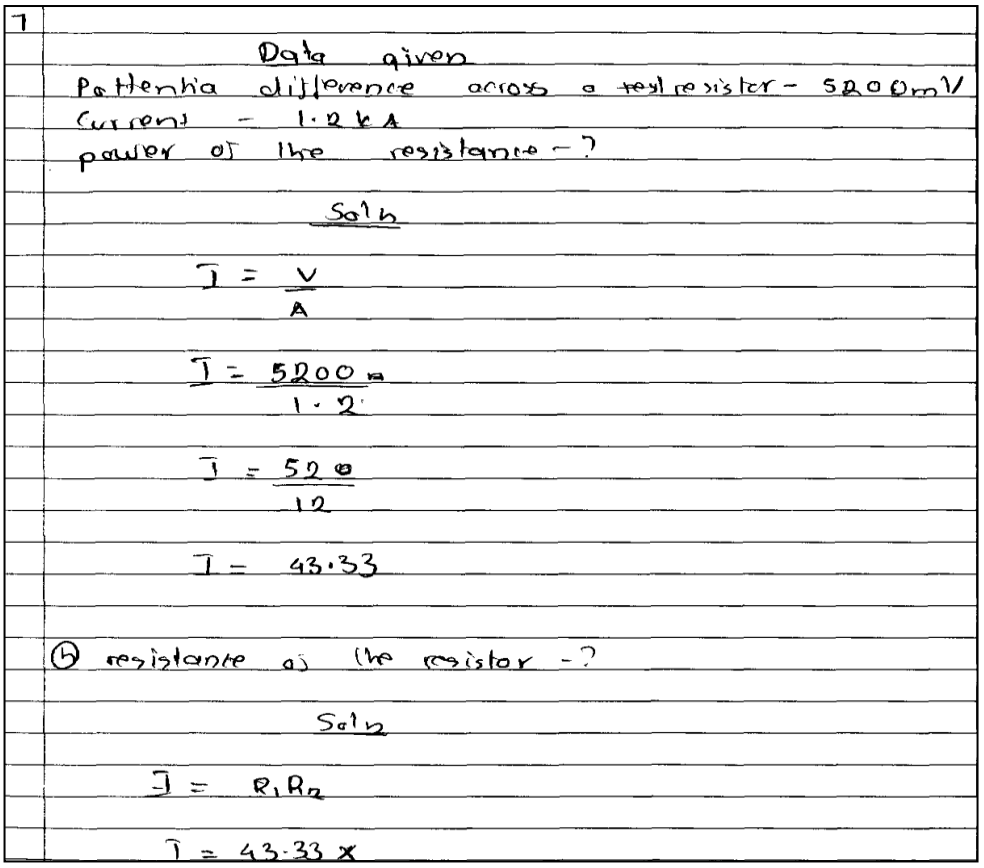


Extract 7.1: A sample of good responses by one of the candidates

In Extract 7.1 the candidate managed to recall and apply the correct formulae to calculate the power consumed in (a) and the resistance of a resistor in (b). This candidate demonstrated high competence in the area of D.C circuits.

In contrast, 30 (8.6%) candidates who attempted this question performed poorly. Among them, 15 (4.3%) scored zero. They failed to provide the correct responses to all parts of the question. The other group of 15 (4.5%) candidates scored 1 mark. These candidates managed to provide less than one correct response. The analysis concluded that the candidates were

incompetent on the area of D.C circuits. A sample of incorrect responses is shown in Extract 6.2.


7

Data given

Pothenhia difference across a resistor - 5200hm V

Current - 1.2 k A

power of the resistance - ?

Soln

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

$I = \frac{5200}{1.2}$

$I = \frac{520}{12}$

$I = 43.33$

(b) resistance of the resistor - ?

Soln

$I = R_1 R_2$

$I = 43.33 x$

Extract 7.2: A sample of incorrect responses by one of the candidates

Extract 7.2 illustrates that, the candidate failed to apply Ohm's Law as he/she could not transform the given quantities into their unit symbols. Therefore, the candidate failed to deduce the formula used to calculate power and resistance of the resistor. This candidate was not well knowledgeable about D.C circuits.

2.2.7 Question 8: Three Phase Circuits

This question had two parts, (a) and (b), which required the candidates to:

(a) use a sketch to illustrate how loads are arranged in a circuit for 3-phase delta connection.

(b) calculate the phase current of three identical coils connected in delta across 415V, 50Hz, 3 phase supply with line current of 20A at a power factor of 0.8 lagging.

The question was attempted by 339 (96.0%) candidates out of 353 (100%) candidates who sat this paper. The candidates who scored from 0 to 1 were 89 (26.3%). Among them 84 (24.8%) scored zero. There were 100 (29.5%) candidates who scored from 1.5 to 3 marks and 150 (44.2%) who scored from 3.5 to 5 marks. Figure 8 summarizes the overall performance on the question.

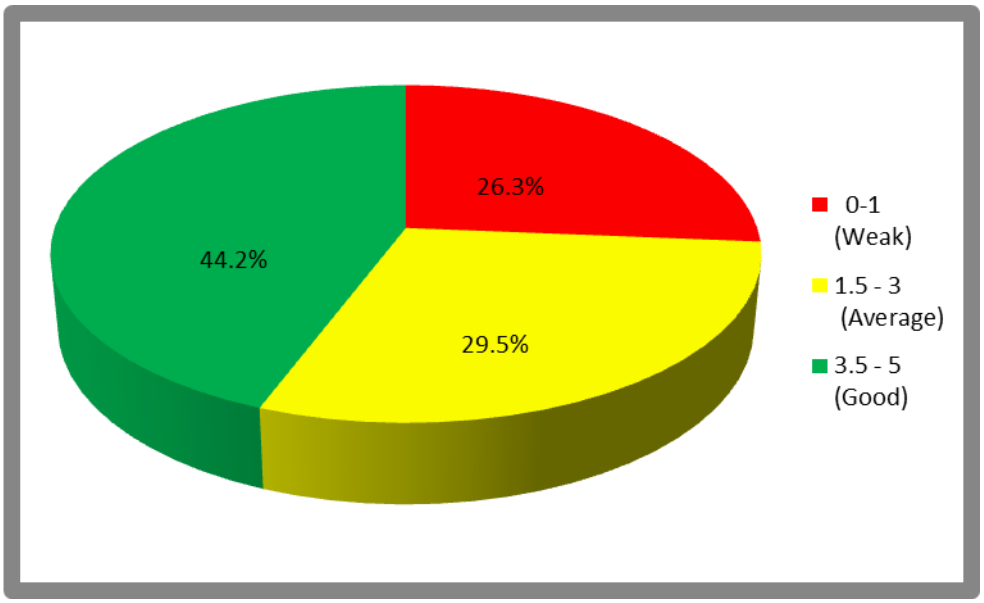
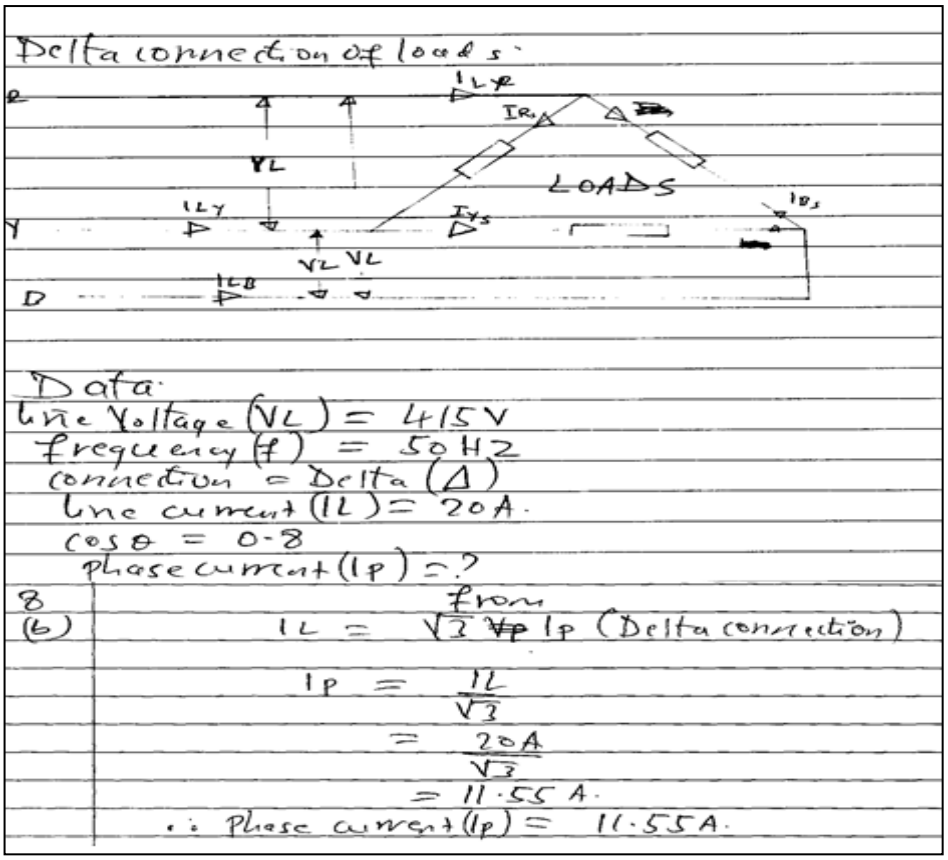


Figure 8: *Candidates' Overall Performance on Question 8*

Figure 7 indicates that the performance of the candidates on this question was good since 73.7 percent scored from average and above. Furthermore, the analysis show that 2.7 percent of the candidates managed to provide correct responses in all parts of the question, whereas 71 percent managed to give correct responses to some of the parts. This performance revealed

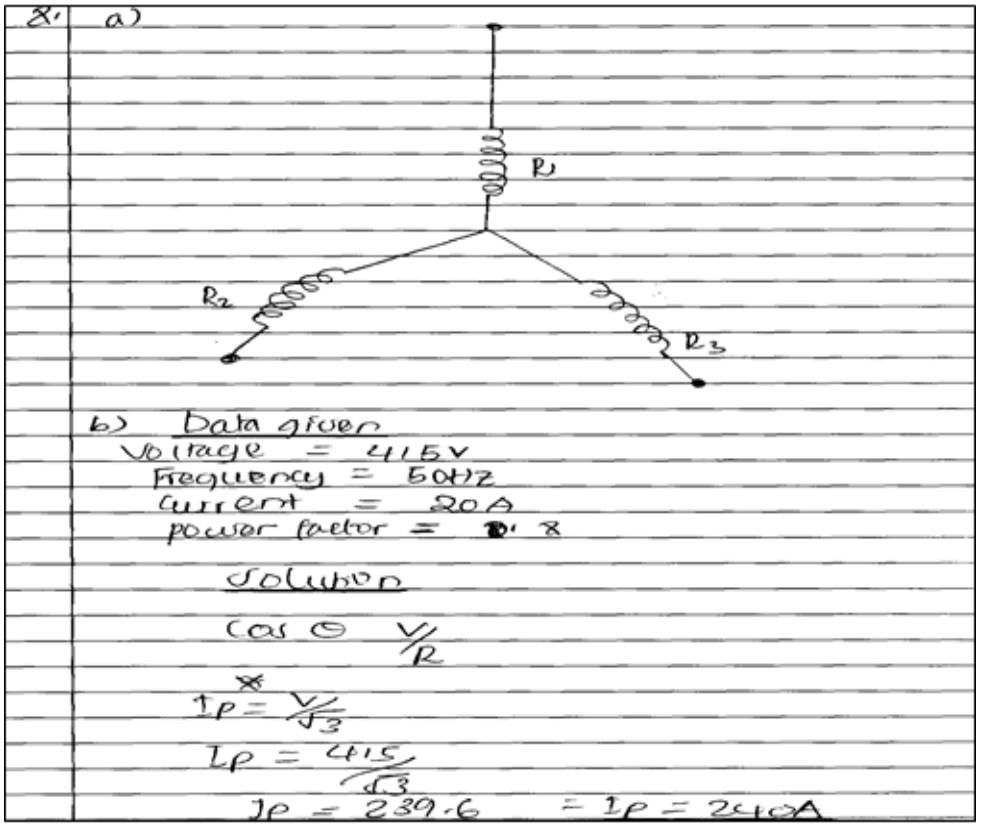
that the candidates had adequate knowledge on three phase circuits. Extract 7.1 shows a sample of good responses by one of the candidates.



Extract 8.1: A sample of good responses to the question

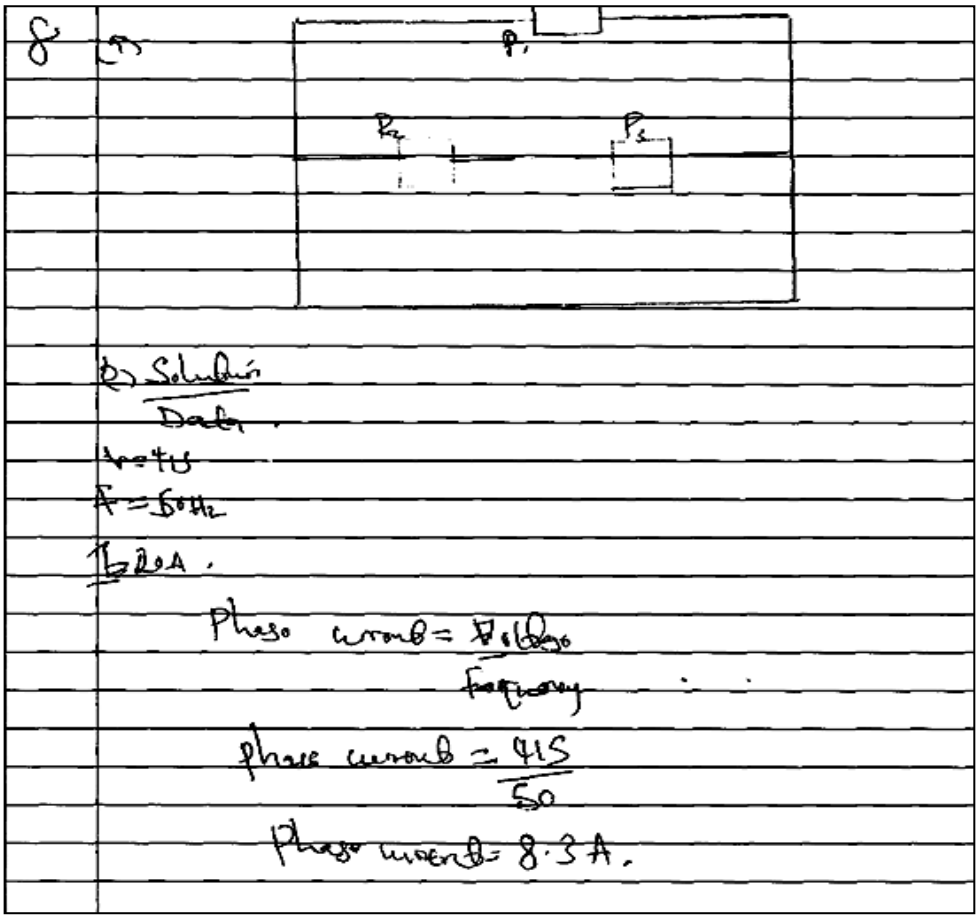
The extract shows that the candidate managed to use the sketch to illustrate how loads are arranged in a circuit for the 3-phase delta connection as required in part (a). He/she also showed an adequate knowledge about three-phase circuits; accordingly, he/she clearly applied the correct formula to calculate the phase current in part (b).

The analysis also shows that 89 (26.3%) candidates performed poorly. These candidates had inadequate knowledge of three-phase A.C circuits. They could not attempt this question. Most of them failed to draw correctly three-phase delta connections. They also applied incorrect formula to calculate the value of phase current. Others provided responses which were completely irrelevant to the requirement of the question. Extract 8.2 and 8.3 are presented as samples to illustrate poor responses to the question.



Extract 8.2: A sample of poor responses to the question

In Extract 8.2 the candidate drew a star connection instead of a delta connection in part (a) and applied the power factor formula instead of the phase current formula in (b). This suggests that the candidate was not knowledgeable about the terms and concepts used in three-phase circuits.



Extract 8.3: A sample of poor responses by one of the candidates

Extract 8.3 shows that the candidate completely failed to provide the correct responses in all parts of the question. Instead, he/she provided a sketch which is contrary to the 3-phase circuit in (a). The candidate also used the voltage per volt ratio to calculate the phase current, which is absolutely wrong. The candidate's poor performance signifies that he/she could not identify the types of 3-phase circuit connection or tackle questions which involved calculations.

2.2.8 Question 9: Illumination

This question was set as follows:
The illumination in a drawing room of 30 m by 10 m is 250 lux. The room requires a number of 300W filament lamps. If the coefficient of utilization is 0.4, maintenance factor is 0.9 and the luminous efficiency of each lamp is 14 *l*m/w; determine the number of lamps required.

The question was attempted by 321 candidates. Their scores were as follows: 115 (35.8%) candidates scored from 0 to 1 mark; 130 (40.5%) candidates scored from 1.5 to 3 marks and the rest 76 (23.7%) scored from 4 to 5 marks. Figure 9 shows the candidates' performance on this question.

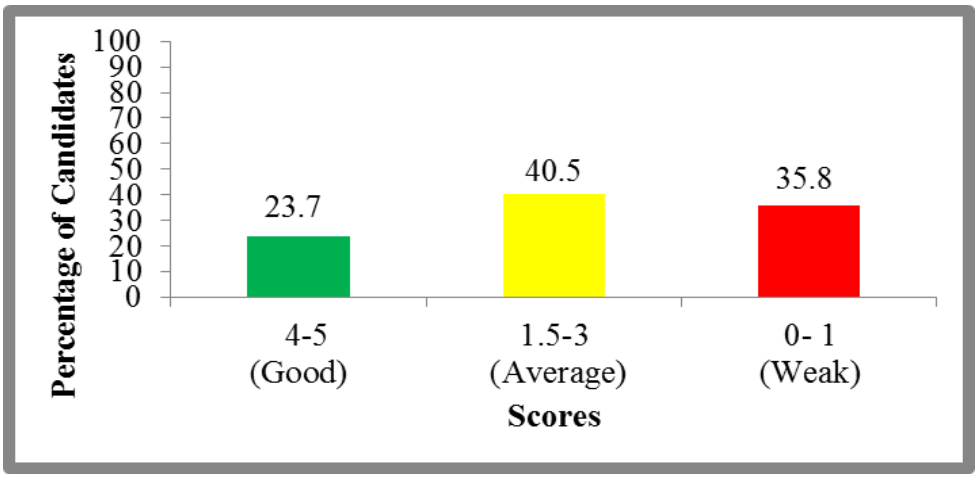
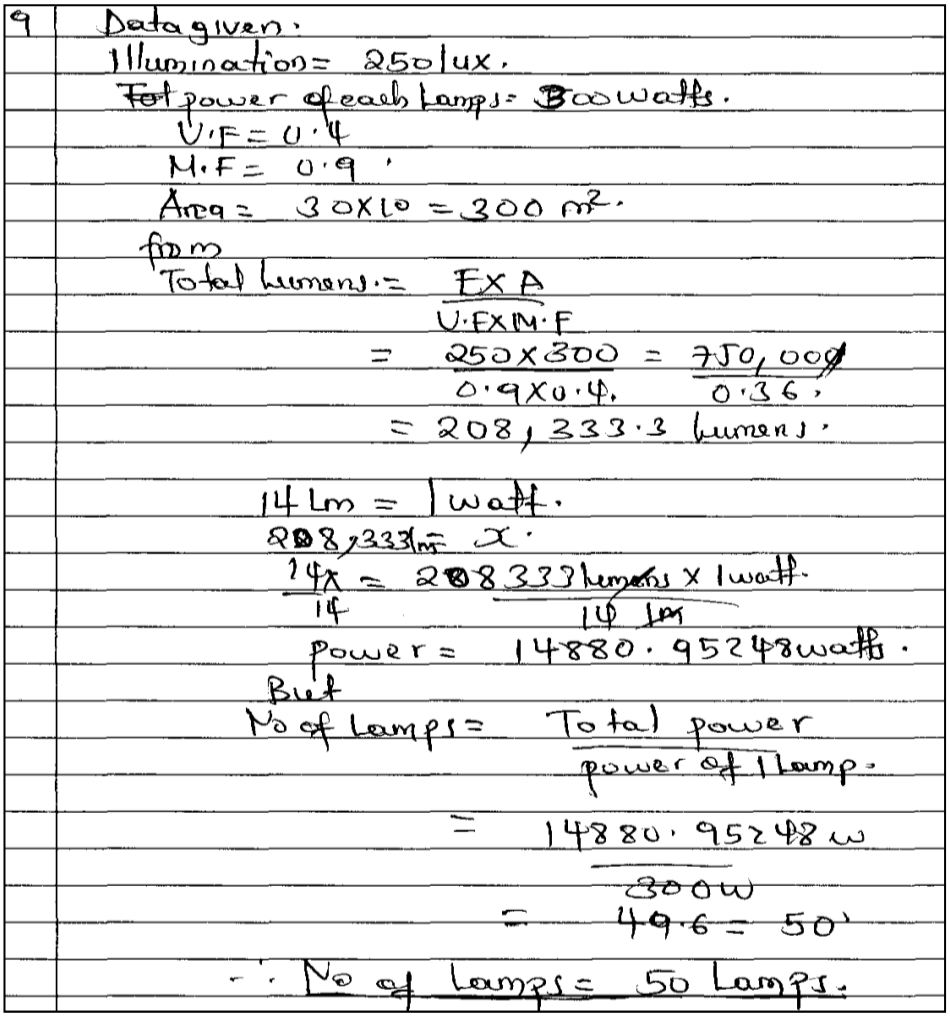


Figure 9: *Candidates' Overall Performance on Question 9*

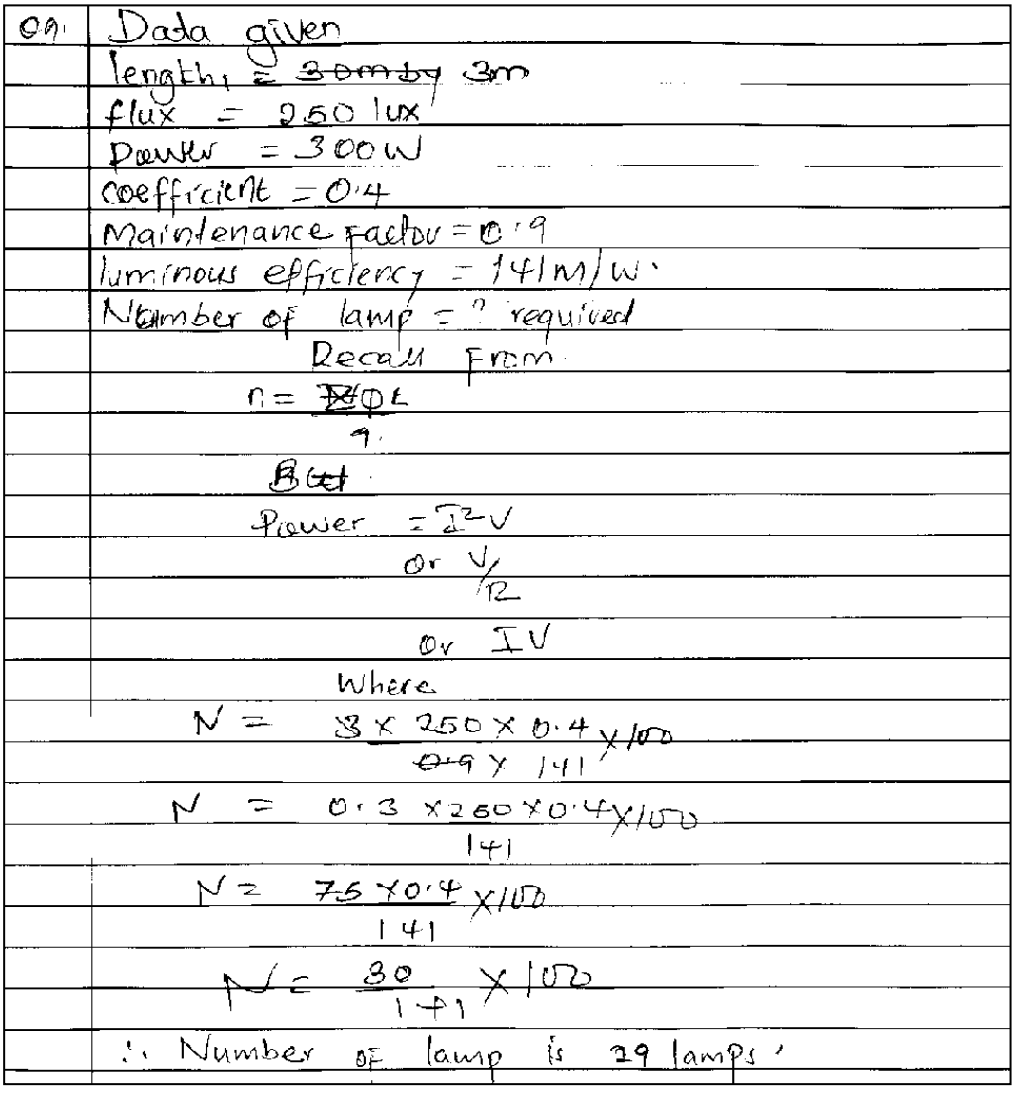
Figure 9 shows that the candidates' general performance in this question was average since 64.2 percent of them passed. The candidates with the average scores and above had sufficient practical knowledge about illumination. Most of them managed to apply correct formula to determine the number of lamps required. However, a few of them managed to obtain the total lumen, but they failed to substitute it in the general formula to calculate the number of lamps required. Extract 9.1 is a sample of good responses by one of the candidates.



Extract 9.1: A sample of a candidate's good responses to question 9

In extract 9.1, the candidate correctly applied the formula and substituted the given data. Hence, he/she determined the number of lamps required. This candidate was knowledgeable about illumination particularly in tackling calculations related to illumination.

However, the analysis shows that 115 (35.8) candidates performed poorly. Most of them provided wrong answers. This implies that the candidates had inadequate knowledge about illuminations. For example, one candidate multiplied all the values of the parameters given in the question and considered the obtained product to be the number of lamps required. Extract 9.2 is illustrative.



Extract 9.2: An incorrect response by one of the candidates

In Extract 9.2 the candidate failed to recall the formula and procedures for determining the number of lamps required. Instead, he/she applied Ohm's law and calculated the power which was not required. This implies that the candidate lacked practical knowledge of the concepts pertaining to illumination.

2.2.9 Question 10: D.C Machines

The question had two parts: (a) and (b). It was set as follows:
A 240V d.c series motor is consuming 45 A. If the resistance of an armature and series field winding is 0.3Ω and 0.2Ω respectively; calculate:
(a) Brush Voltage.
(b) Back e.m.f.

A total of 327 candidates attempted this question. Their scores are categorized as follows: 260 (79.5%) candidates scores from 0 to 1 mark, 64 (19.0%) scored from 1.5 to 3 marks and 5 (1.5%) scored from 4.5 to 5 marks. Only 4 (1.2%) candidates scores all the 5 marks allotted to this question. Figure 10 shows the candidates' general performance.

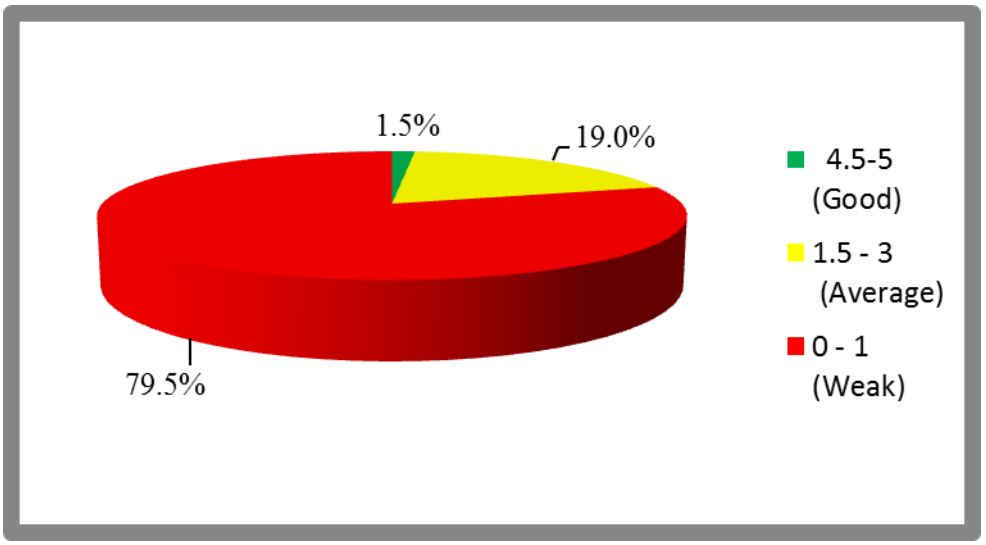
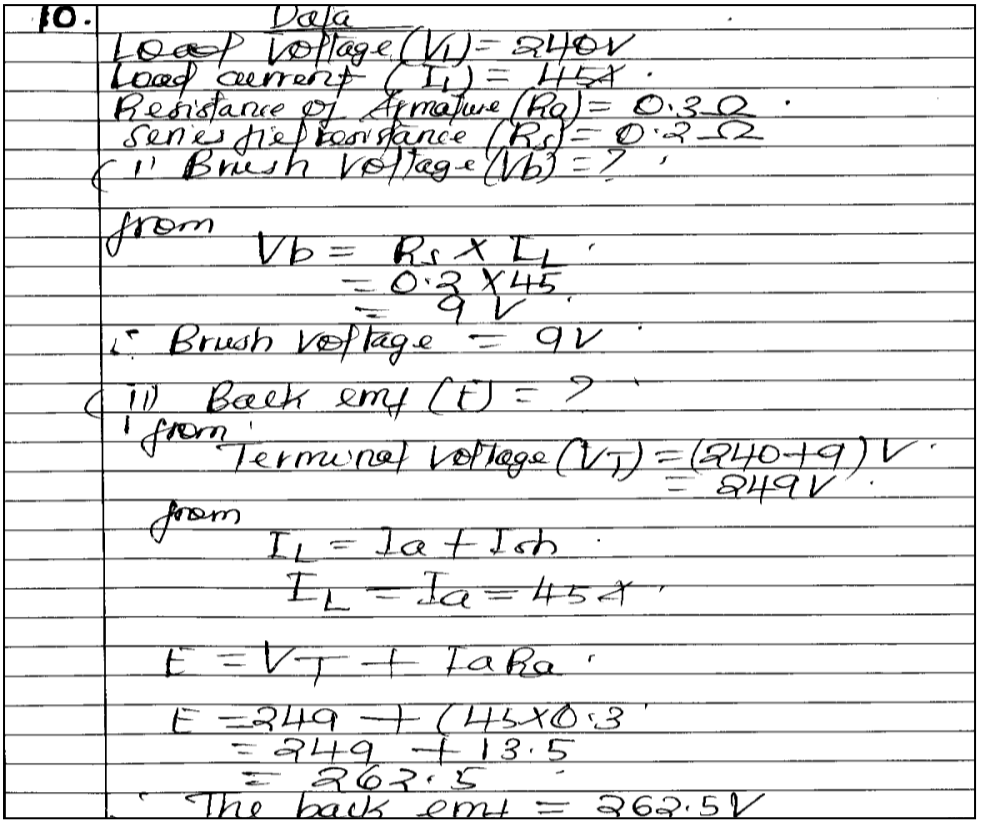


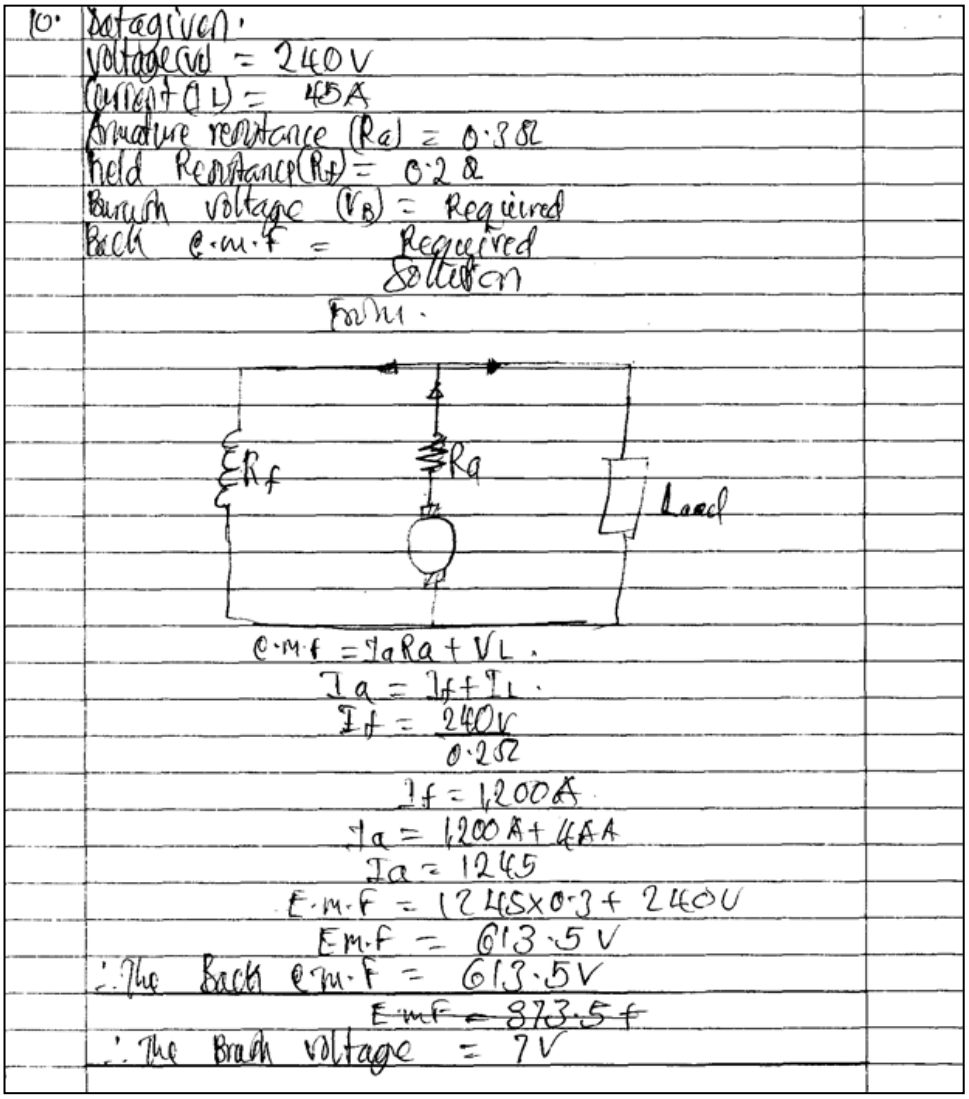
Figure 10: *Candidates' Overall Performance in Question 10*

Figure 10 shows that the candidates' performance on this question was poor since only 5 (1.5%) out of the 327 (100%) candidates who attempted this question scored above average. The question involved the application of the respective formulae to compute various parameters. The major weakness shown by the candidates was their failure to apply the correct formula in computation. This shows that they were not competent in tackling the questions which involve calculations. Another reason for their unsatisfactory performance was the incorrectness of the result in one item which resulted in the provision of the wrong answer in the other related item. Extracts 10.1 and 10.2 exemplify the candidates' poor responses to this question.


10.
Data
Load voltage (V_L) = 240V
Load current (I_L) = 45A
Resistance of Armature (R_a) = 0.3Ω
Series field resistance (R_s) = 0.2Ω
i) Brush Voltage (V_b) = ?
from $V_b = R_s \times I_L$
$= 0.2 \times 45$
$= 9V$
∴ Brush voltage = 9V
ii) Back emf (E) = ?
from
Terminal voltage (V_T) = (240+9) V
= 249V
from
$I_L = I_a + I_{sh}$
$I_L = I_a = 45A$
$E = V_T + I_a R_a$
$E = 249 + (45 \times 0.3$
$= 249 + 13.5$
$= 262.5$
∴ The back emf = 262.5V

Extract 10.1: A sample of poor responses by one of the candidates

The extract shows that the candidate used the formula for brush voltage drop instead of brush voltage in part (a). In (b), the candidate applied the formula for shunt motor instead of series motor to calculate back e.m.f; hence, he/she scored zero. Therefore, the candidate showed a lack of practical and computational skills in D.C machines.

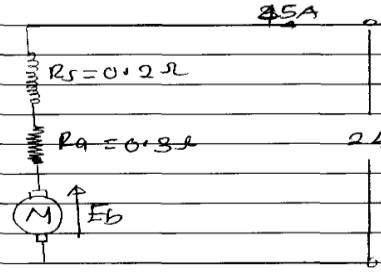


Extract 10.2: A sample of poor responses by one of the candidates

In Extract 10.2, the candidates failed to provide correct answers in all parts of the question. He/she was failed to recall and apply formula to calculate the brush voltage and back e.m.f. The incorrect answer in part (i) led to the wrong answer in part (ii).

Besides, a few candidates (19.0%) had average performance. These candidates managed to recall partially the concepts and formulae related to D.C machines. However, they failed to use the right formula in some cases. Thus, they provided incorrect answers to some parts of the question. The analysis also shows that 1.2 percent of the candidates managed to score all the 5 marks allotted to this question. These candidates correctly recalled and applied the formula to calculate brush voltage and back e.m.f. Extract 10.3 shows the correct response taken from the script of one of the candidates who scored higher marks.

10 Data given.
voltage supply (V) = 240V
Current (I) = 45A
Ae) series field resistance (R_s) = 0.2Ω
Armature resistance (R_a) = 0.3Ω.
19 Required to calculate Brush voltage.



Brush voltage = V − IsRs.
= V − IRs.
= 240 − 45X0.2
= 240V − 9V
Brush voltage = 231V
Thus the brush voltage is 231V

(ii) Require d to find back e.m.f

Back e.m.f = voltage brush − IaRa.
= 231V − 45X0.3
= 231V − 13.5V
= 217.5V
Thus the back e.m.f is 217.5V

Extract 10.3: A sample of good responses by one of the candidates

Extract 9.3 is a response by the candidate who was conversant with the concepts covered in the topic of D.C machines. The candidate applied appropriate formulae to calculate brush voltage and back e.m.f.

2.3 SECTION C: STRUCTURED QUESTIONS

2.3.1 Question 11: Transformer

The question had two parts: (a) and (b). It was set as follows:
A 30 kVA, 2000/400 V transformer has the constant and variable losses of 350 W and 400 W respectively. If the transformer operates at 0.8 power factor, calculate the transformer efficiency at the following conditions:
(a) on full load
(b) on half full load

This question was attempted by 287 candidates. Among them, 84 (29.3%) candidates scored from 0 to 4 marks; 73 (25.4%) scored from 5 to 9 marks; 130 (45.3%) scored from 10 to 15 marks. The general performance of candidates on this question is summarized in Figure 11.

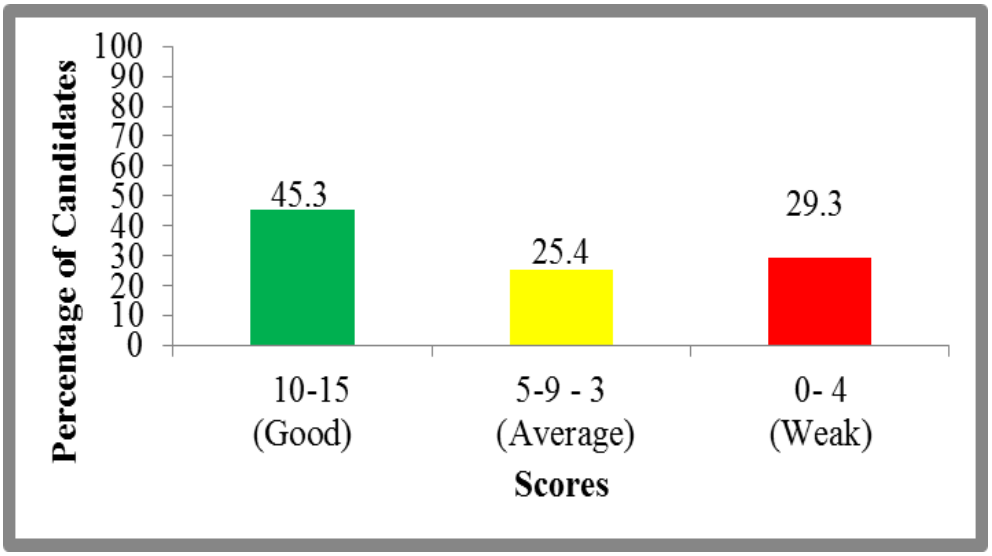
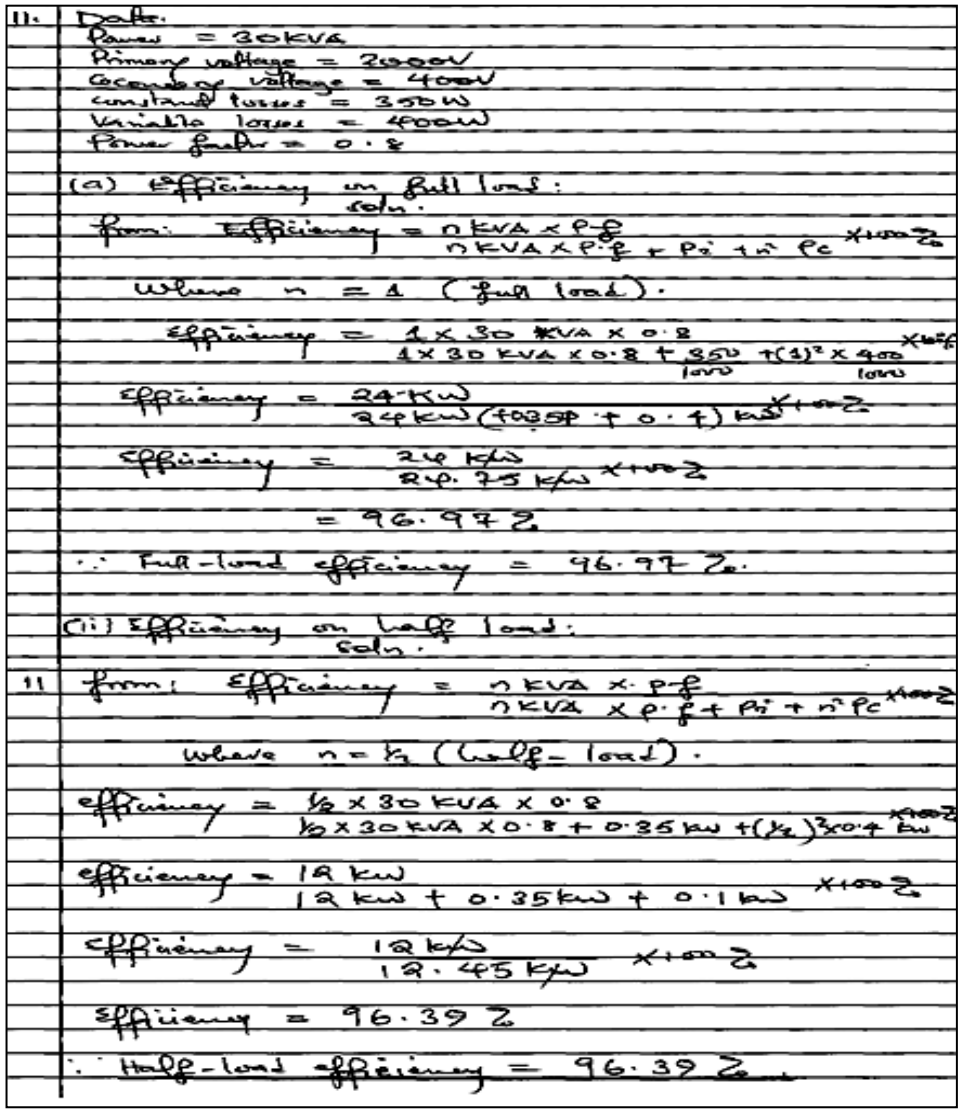


Figure 11: *Candidates' Overall Performance in Question 11*

Figure 11 shows that the overall performance of the candidates in this question was good since 70.7 percent of the candidates who attempted this question passed. Only 29.3 percent failed. This performance indicates that the candidates were knowledgeable about transformers. Accordingly, they

correctly recalled and applied the proper formula to calculate the transformer efficiency in half and full load. This could because the candidates acquired the knowledge of transformers in other related subjects. Therefore, it helped them to transfer the knowledge and apply it to tackling this question. Extract 11.1 illustrates a sample of good responses to the question.

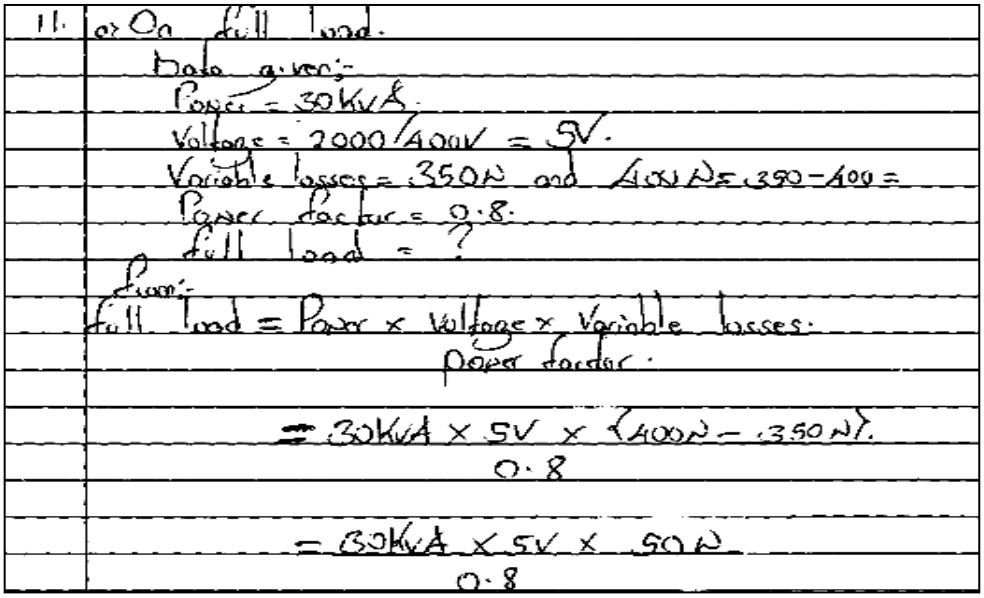


Extract 11.1: A sample of good responses by one of the candidates

Extract 10.1 shows that the candidate scored all 15 marks allotted to this question. He/she applied the right formulae and the data given in his/her

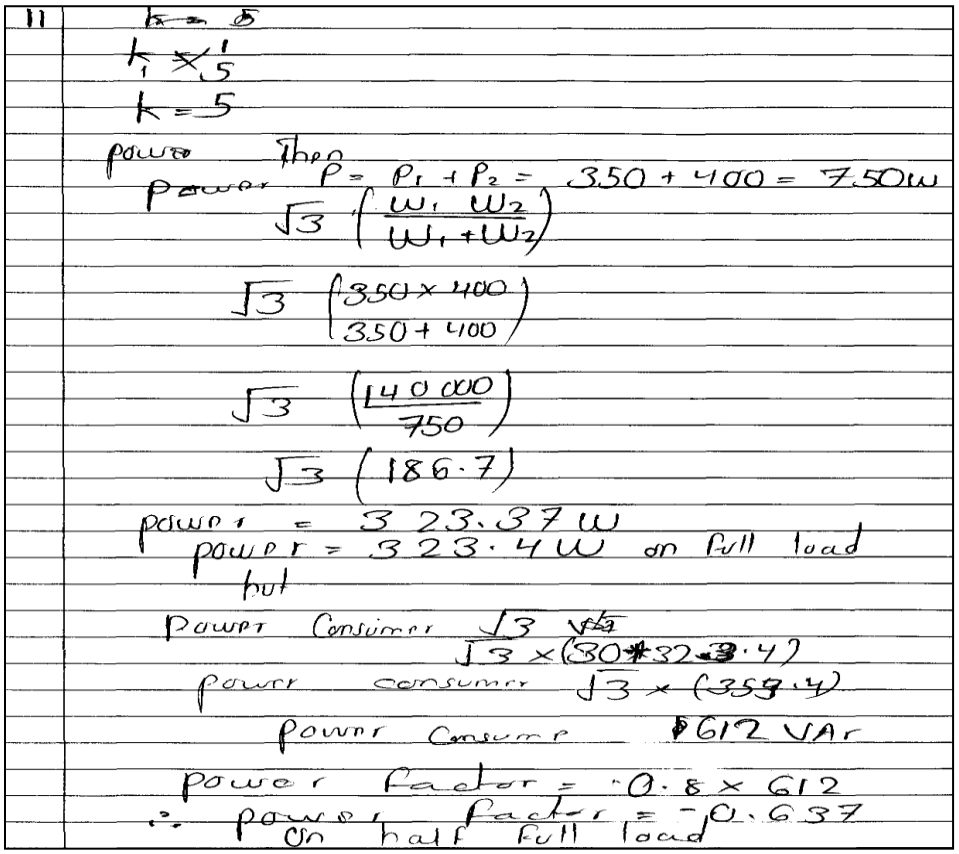
computation. This performance shows that the candidate was knowledgeable about transformers.

The analysis also shows that, out of 29.3 percent of the candidates who attained poor performance, 14.6 percent scored zero. Most of them applied the wrong formulae to calculate the transformer efficiency at full load and half full load. In some instances, they provided the formula that did not relate to the question. These candidates lacked knowledge of transformers. Extracts 11.2 and 11.3 are samples of poor responses by the candidates.


11. a) On full load.
Data given:-
Power = 30KVA.
Voltage = 2000/400V = 5V.
Variable losses = 350W and 400W = 390-400 =
Power factor = 0.8.
full load = ?
From:-
full load = Power x voltage x Variable losses.
power factor.
= 30KVA x 5V x (400W - 350W).
0.8
= 30KVA x 5V x 50W
0.8

Extract 11.2: A sample of poor responses to question 11

In Extract 11.2 the candidate attempted only part (a) of the question. In addition, he/she could not find the transformer efficiency at full load. He/she used the wrong formula. As a result he/she scored zero. This suggests that the candidate lacked knowledge about transformers.



Extract 11.3: A sample of poor responses to question 11

Extract 11.3 shows that the candidate was not knowledgeable enough about transformers. He/she used the wrong formula which does not apply to transformers.

2.3.2 Question 12: D.C Machine

The question had two parts: (a) and (b). It was composed as follows:

A long shunt compound generator delivers a load current of 30 A at 400 V and has the armature resistance of 0.04 Ω. The series field shunt and shunt resistances are 0.03 Ω and 250 Ω respectively and the contact voltage drop of each brush is 1V.

(a) By using the information given, draw a circuit diagram which represents a log shunt compound generator with all components present.

(b) Calculate the following parameters:
    (i) The armature current
    (ii) The generated voltage

A total of 286 candidates attempted this question. There were 118 (41.3%) candidates who performed poorly. They scored from 0 to 5 marks. Those who scored from 5 to 9 marks were 51 (17.8%). These were considered to have attained average performance. The rest 117 (40.9%) candidates scored from 10 to 15 marks. The general performance on this question is summarized in Figure 12.

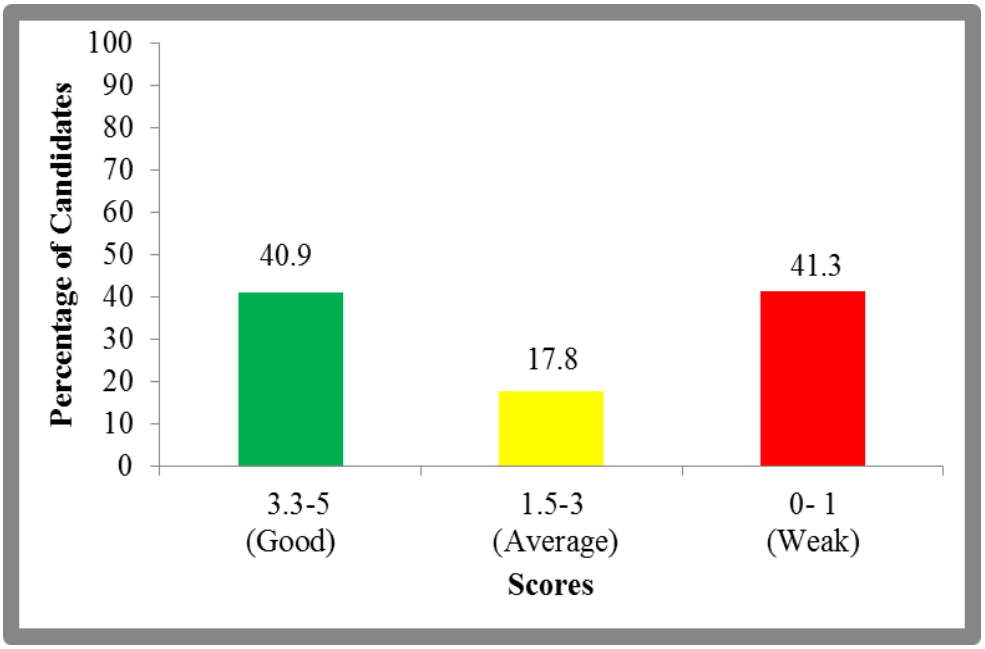


Figure 12: *Candidates' Overall Performance on Question 12*

The general performance of the candidates on this question was average. Figure 12 shows that a total of 168 (58.9%) candidates passed because they from scored average and above.

The analysis further indicates that 69 (24.1 %) candidates got all the 15 marks. These candidates demonstrated an adequate knowledge of D.C machines particularly of D.C generators. They managed to provide the correct responses to all parts or to more than one part of the question. Most of them drew correctly a circuit diagram to represent a long shunt compound generator and calculated the armature current as well as the

generated e.m.f. Extract 12.1 presents a sample of good responses by one of the candidates.

12. Data given

$I_L = 30A$

$V_L = 400V$

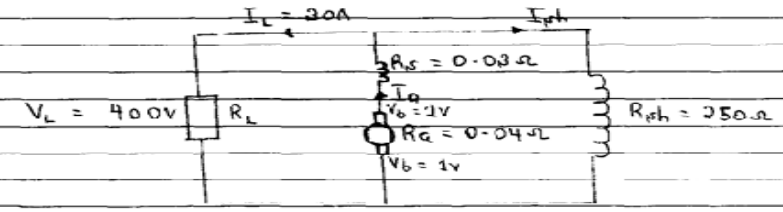
$R_a = 0.04\Omega$

$R_s = 0.03\Omega$

$R_{sh} = 250\Omega$

$V_b = 1V$

(a) A circuit diagram which represent a long shunt compound generator with all component present.



12 (b) To calculate

(i) The armature current (I_a)

From, $V_{sh} = I_{sh} R_{sh}$

$I_{sh} = \frac{V_{sh}}{R_{sh}} = \frac{V_L}{R_{sh}}$

Since $V_L = V_{sh}$.

$I_{sh} = \frac{400V}{250\Omega}$

$I_{sh} = 1.6A.$

but $I_a = I_{sh} + I_L$

$I_a = 1.6A + 30A$

$I_a = 31.6A$

∴ The armature current is 31.6A.

(ii) The generated voltage (E_g)

From the formula

$E_g = V + I_a(R_a + R_s) + V_b \times 2$

$E_g = 400 + 31.6(0.04 + 0.03) + 1 \times 2$

$E_g = 400 + 31.6 \times 0.07 + 2$

$E_g = 400 + 2.212 + 2$

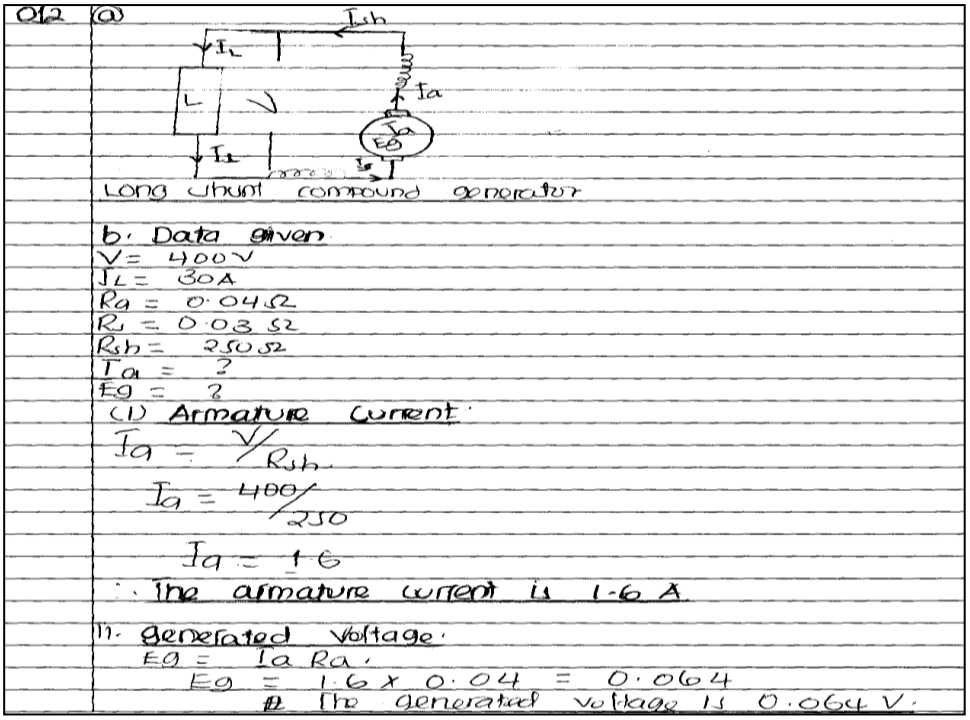
$E_g = 404.212V$

∴ The generated voltage is 404.212 V

Extract 12.1: A sample of candidates' good responses to question 12

Extract 12.1 shows that the candidate attained knowledge and skills about D.C generators. He/she correctly drew a circuit diagram to represent a long shut compound generator in part (a) and circulated the value of the parameters asked in part (b).

Despite the average performance of the candidates, 41.3 percent of the candidates attained poor performance. Among them 52 (18.2%) failed to draw a circuit diagram to represent a long shunt compound generator. They also applied the wrong formulae to calculate the value of the asked parameters. Thus, they scored zero. The rest 66 (23.1%) candidates scored from 1 to 4 marks. These candidates managed to provide correct responses to only some items of the two parts of the question. For example, one candidate drew a series-parallel D.C circuit using the resistances given in the question instead of a long shunt compound generator. Their performance shows the lack of enough knowledge and skills in the area of D.C machines, specifically D.C generators. An example of incorrect responses given by one of the candidate is illustrated in Extract 12.2.



Extract 12.2: A sample of candidates' poor responses to question 12

Extract 12.2 shows that the candidate drew a series D.C generator instead of a long shunt compound generator in part (a). The candidate was uncertain about how to connect the field resistance, series resistance and shunt resistance to come up with the required long shunt compound D.C generator. The candidate also applied the wrong formulae to calculate the armature current and generated voltage in part (b).

2.3.3. Question 13: Electric Heating

The question had three parts: (a), (b) and (c). It was set as follows:

(a) What conditions would you take into consideration if you are required to estimate the electric power in the space heater? Give five conditions.

(b) Briefly explain three ways through which electric heat can be transferred from one part to another.

(c) If the temperature of the mass of 4500 g of water is raised from 40 ^{0}C to 120^{0}C and the specific heat capacity of water is 4200 kJ/kg^{0}C; find out the energy used in kilowatt-hours.

This question was attempted by 227 (64.3%) out of the 353 (100%) candidates who sat this paper. Performance analysis indicates that 40 (17.6%) candidates scored from 0 to 4 marks; 155 (68.3%) scored from 5 to 9.5 marks; and the remaining 32 (14.1%) scored from 10 to 15 marks. Figure13 illustrates the overall performance on this question.

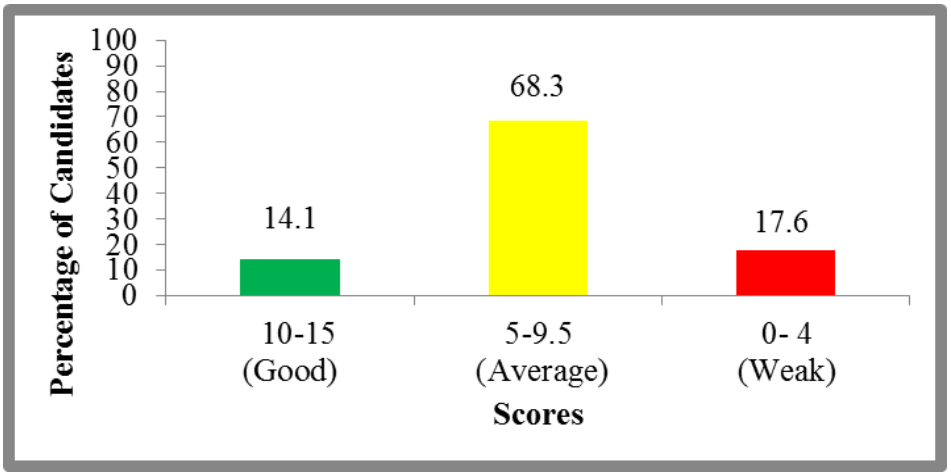


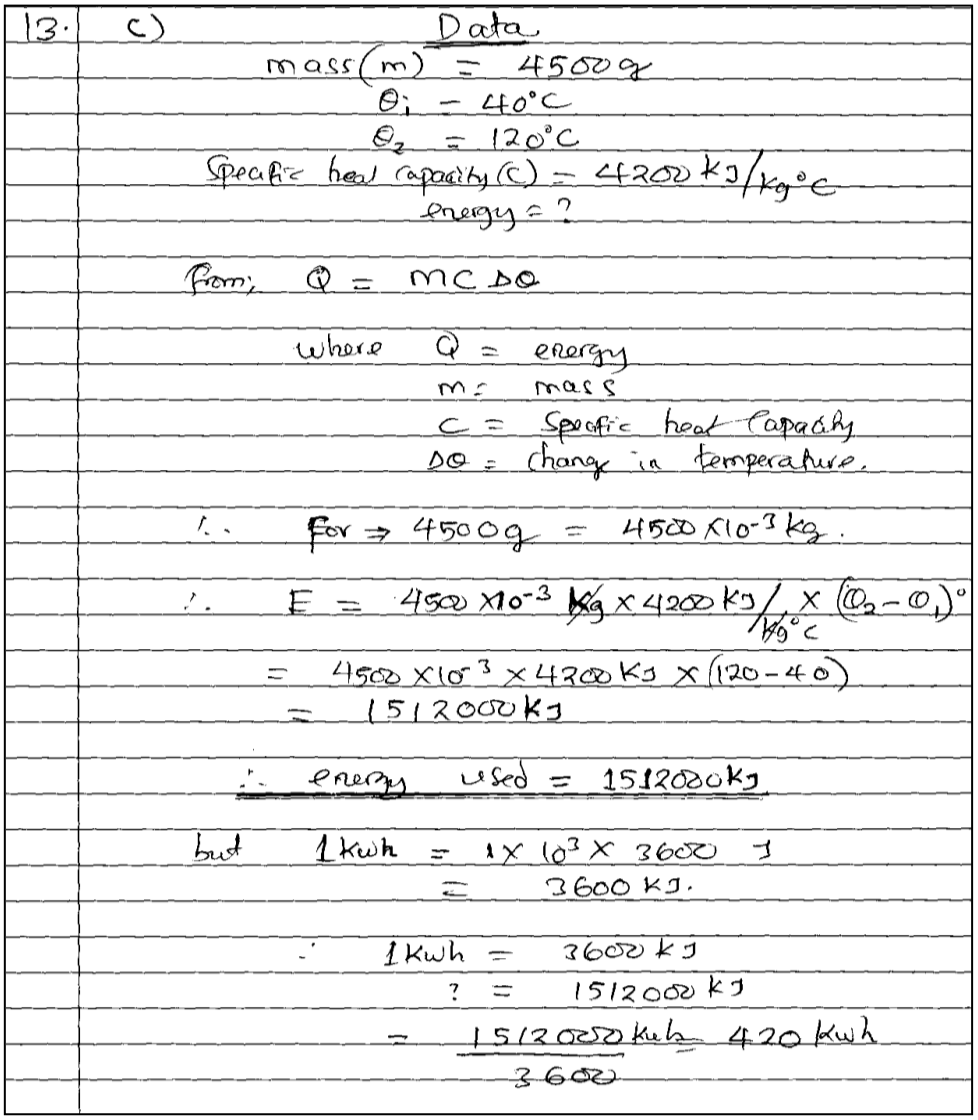
Figure 13: *Candidates' Overall Performance on Question 13*

Considering Figure 13, the general performance on this question was good. The statistical analysis reveals that a total of 187 (82.4%) candidates passed. They scored from average and above marks. However, 40 (17.6%) candidates failed because they scored below average.

The candidates who performed well had an adequate knowledge of electric heating. They managed to provide correct responses to more than one part of the question. Most of them correctly explained three ways through which heat can be transferred as required in part (b). Likewise they calculated the energy used and presented it in kilowatt hour as required in part (c). Some of the candidates with average performance failed to give conditions to be taken into consideration when estimating electric power in the space heater as required in part (a) of the question. Extract 13.1 presents a sample of good responses by one of the candidates.

13. a) i) The materials of the building.
ii) Number of air exchanges per hour (usually taken as 2)
iii) Difference between outside and inside temperature.
iv) Size and number of windows
v) The positon or direction of the house example facing North or South.

13. b) (1) Radiation. This is the method whereby heat is transferred from one body to another which are not physically in contact. The heat reaches the other body without heating the intervening space. example the sunrays reaches the ground by radiation.
~~(2) Conduction.~~
(2) Conduction. This is the method of heat transfer in solid bodies which are physically in contact. example is when you touch a hot object, you will feel the heat into your hand by Conduction.
(3) Convection. This is the transfer of heat by means of convectional current and this is usually in liquids. for example when a liquid is heated in a vessel the heat is transferred throughout the liquid by Convection.

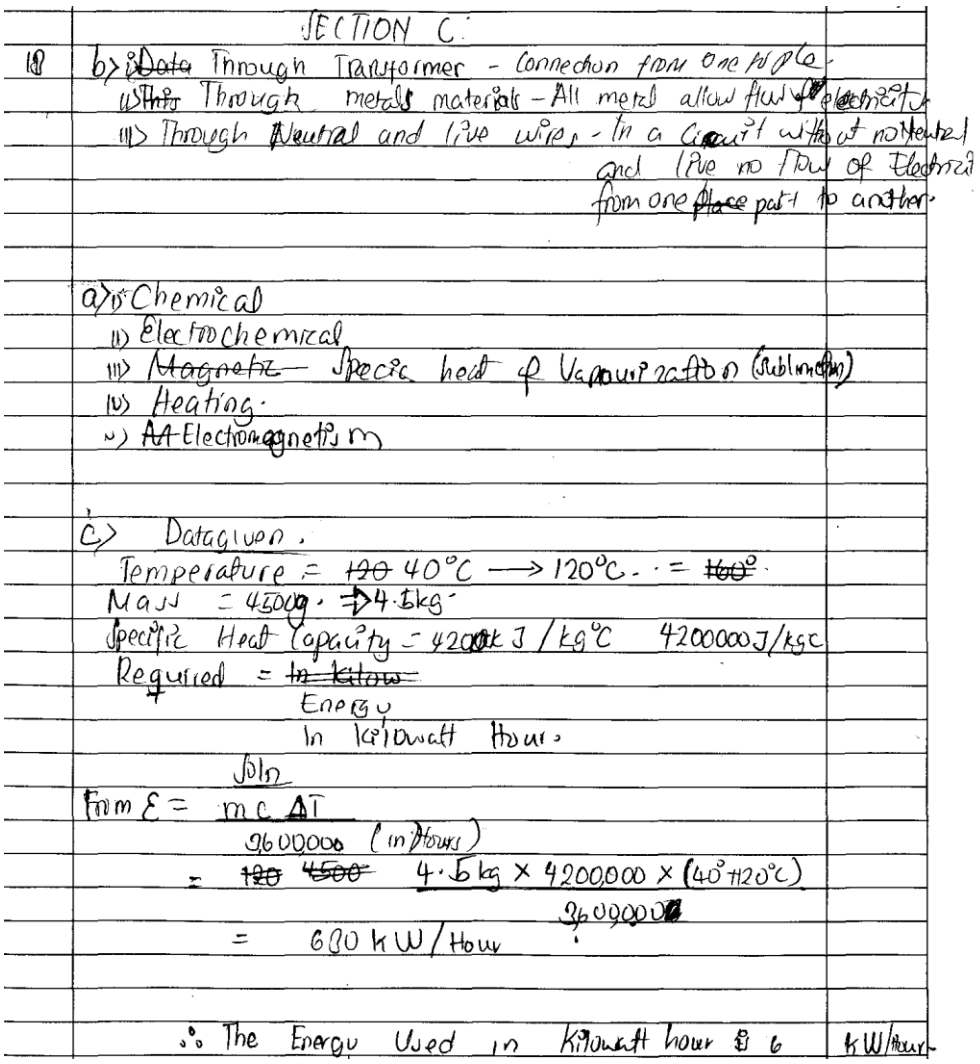


Extract 13.1: A sample of good responses to question 13

Extract 13.1 shows that, in part (a), the candidate clearly gave the conditions to be considered in estimating electric power in the space heater. He/she explained the ways of transferring heat as required in part (b). Likewise and in part (c), the candidate applied the correct formula to calculate the energy in kilowatt-hour.

The analysis also revealed that 46 (19.25%) candidates performed poorly. These candidates had inadequate knowledge of Electric heating. They either provided unsatisfactory responses to all parts of the question or

correctly answered in less than two items. For example, in part (b) some of the candidates mentioned the effects of electrical current instead of the ways of transferring heat from one part to another. As a result, they attained low scores. The candidates' poor performance is further illustrated in Extracts 13.2 and 13.3.


SECTION C

13 b) i) ~~Data~~ Through Transformer - Connection from one ~~place~~ to another.
ii) ~~This~~ Through metals materials - All metal allow flow of ~~electricity~~
iii) Through Neutral and Live wires - In a circuit without neutral and live no flow of Electrical from one ~~place~~ part to another.

a) i) Chemical
ii) Electrochemical
iii) ~~Magnetic~~ Specific heat of Vaporization (Sublimation)
iv) Heating.
v) ~~AA~~ Electromagnetism

c) Data given.
Temperature = ~~120~~ 40°C → 120°C. = ~~160°~~
Mass = 4500g. ⇒ 4.5kg.
Specific Heat Capacity = 4200 J/kg°C 4200000 J/kgC
Required = ~~in kilow~~
Energy
in kilowatt Hour.

Soln
From $E = \frac{mc\Delta T}{3600000}$ (in Hours)

$= \frac{4.5kg \times 4200000 \times (40°+120°C)}{3600000}$

$= 630$ KW/Hour

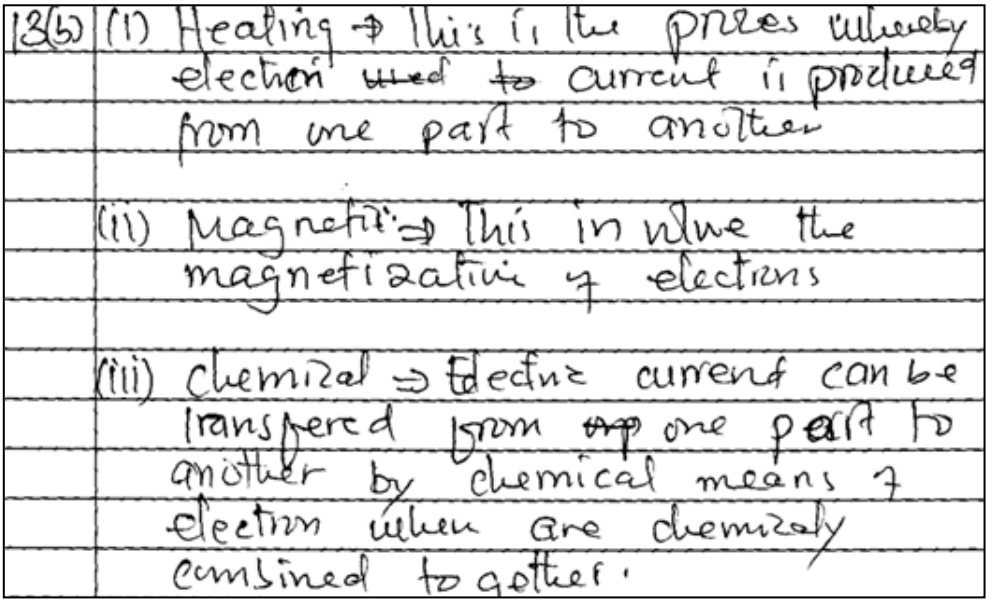
∴ The Energy Used in Kilowatt hour is 6 KW/hour

Extract 13.2: A sample of candidates' poor responses to question 13

In Extract 13.2, the candidate provided incorrect answers to all parts of the question. For example, in part (a), the candidate mentioned the effect of the electric current in a conductor material while, in part (b) the candidate explained ways of distributing electricity instead of ways of transferring

heat. In part (c), the candidate used inappropriate formula to calculate energy. This is the reason he/she scored zero.

Another example of the candidates' poor responses is shown in Extract 13.3.


13(b) (i) Heating ⇒ This is the process whereby electron used to current is produced from one part to another

(ii) Magnetic ⇒ This is where the magnetization of electrons

(iii) Chemical ⇒ Electric current can be transfered from ~~one~~ one part to another by chemical means of electron when are chemicaly combined together.

Extract 13.3: A sample of incorrect responses on question 13

Extract 13.3 shows that the candidate wrongly attempted part (b) of the question. He/she presented the effects of electric current instead of the ways of transferring heat. This suggested that, the candidate was not knowledgeable about electric heating. Therefore, he/she confused the terms.

2.3.4 Question 14: A.C Circuit

The candidates were required to answer the following question:

(a) Categorize three main types of power of A.C circuits and their units.

(b) A circuit consists of a 110 Ω resistor in parallel with a 40 μ capacitor and is connected to a 230 – V, 50 Hz supply. Using the information given, calculate:

(i) The resistive current
(ii) The capacitive current
(iii) The supply current
(iv) The circuit phase angle

(v) The circuit impedance.

A total of 233 (66%) candidates opted for this question. There were 61 (26.2%) candidates who scored from 0 to 4 marks; 100 (42.9%) scored from 4.5 to 9.5 marks; and 72 (30.9%) candidates scored from 10 to 15 marks. The candidates' overall performance on this question is summarized in Figure 14.

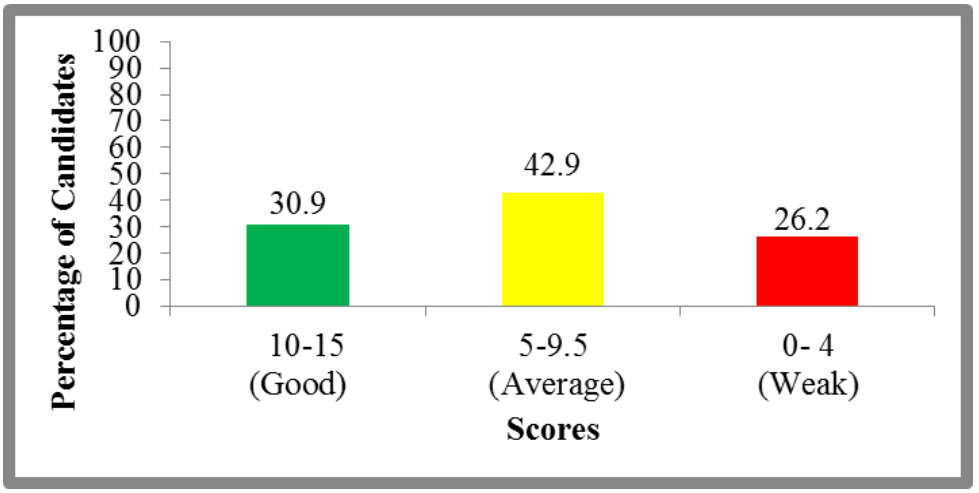


Figure 14: *Distribution of Candidates' Scores in Question 14*

Figure 14 show that 172 (73.8%) out of the 247 candidates who attempted this question passed while 61 (26.2%) failed. Accordingly, the general performance of candidates on this question was good. Most of the candidates who scored from average and above acquired had adequate knowledge of the concepts related to A.C circuits. Extract 13.1 is a sample of good responses by one of the candidates.

14 (a) (i) Reactive power (Q) — SI unit VAr

(ii) Active power (P) — SI Unit Watts (W)

(iii) Apparent power (S) — SI unit Volt-Ampere (VA)

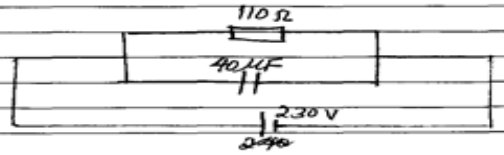
(b) Data given.

$R = 110\,\Omega$

$C = 40\,\mu F$

$V = 230\,V$

$f = 50\,Hz$



14 (b) (i) Reactive Current (I_R).

from: $R = \frac{V}{I_R}$

$\frac{110}{1} = \frac{230}{I_R}$

$\frac{230}{110} = \frac{110 I_R}{110}$

$I_R = 2.1\,A$.

∴ Reactive Current = 2.1A.

(ii) Capacitive Current. (I_C).

from: $X_C = \frac{V}{I_C}$

But; $X_C = \frac{1}{2\pi f C}$

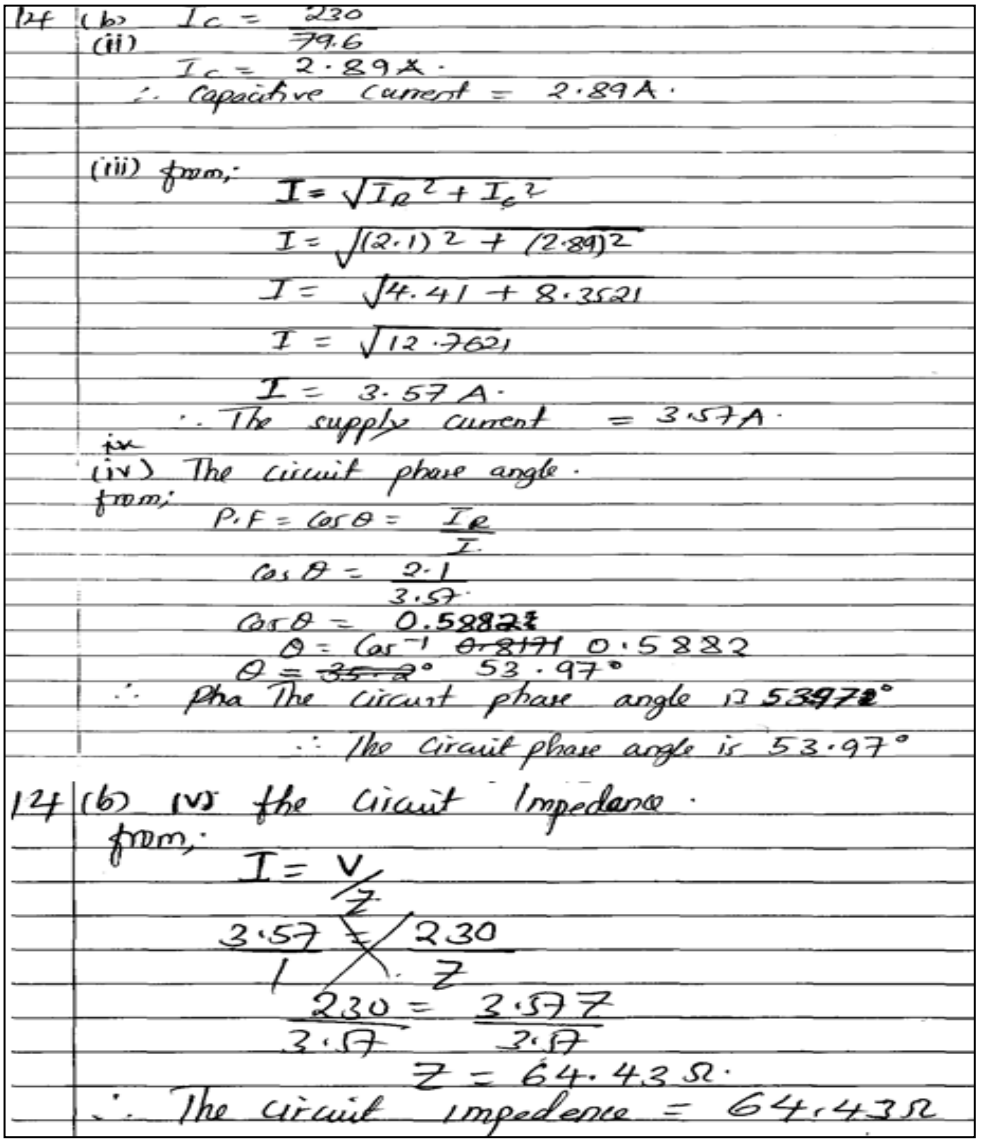
$X_C = \frac{1}{2\pi \times 50 \times 40 \times 10^{-6}}$

$X_C = \frac{1}{0.01256}$

$X_C = 79.6\,\Omega$

from: $X_C = \frac{V}{I_C}$

$\frac{79.6}{1} = \frac{230}{I_C}$

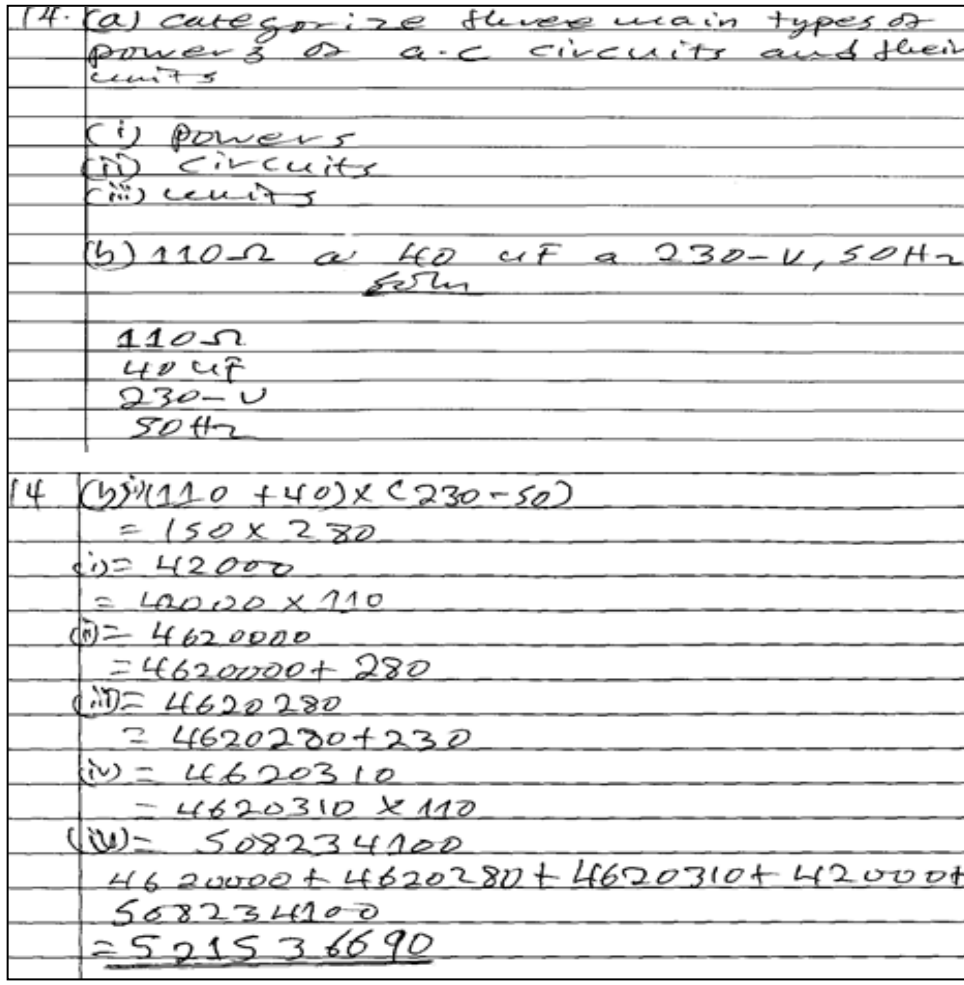


Extract 14.1: A sample of good responses by one of the candidates

In Extract 14.1 the candidate clearly categorized the main types of power of A.C circuits and their unit in part (a). In part (b), he/she correctly applied the formula to calculate the values of the asked parameters.

Besides, out of 61 (26.2%) candidates who attained poor performance, 3.4 percent failed to provide the correct responses to either of the two parts. Most of these candidates had a misconception between powers of A.C and D.C circuits in part (a). They also encountered challenges in performing

calculations pertaining to A.C circuits. They failed to calculate the correct answers as required in part (b). These candidates demonstrated inability to retrieve what they learned about A.C circuits. Extract 14.2 is a sample of poor responses by one of the candidates.


14. (a) categorize three main types of powers of a.c circuits and their units

(i) powers
(ii) circuits
(iii) units

(b) 110Ω a 40 uF a 230-V, 50Hz

110Ω
40 uF
230-V
50Hz

14 (b)(i)(110 + 40) × (230 - 50)
= 150 × 280
(i) = 42000
= 420000 × 110
(ii) = 46200000
= 46200000 + 280
(iii) = 46200280
= 46200280 + 230
(iv) = 46200310
= 46200310 × 110
(v) = 5082341000
46200000 + 46200280 + 46200310 + 42000 + 5082341000
= 521536690

Extract 14.2: A sample of poor responses by one of the candidates

In Extract 14.2, the candidate picked the words *power*, *circuits* and *units* from the first sentence of the question and used them as his/her responses to part (a). The candidate also provided incorrect answers in part (b) and (c). He/she used the formulae that does not relate to the question. The candidate demonstrated inadequate knowledge of A.C circuits.

3.0 SUMMARY OF CANDIDATES' PERFORMANCE ON EACH TOPIC

The analysis of the topics which were examined in the Electrical Engineering Science subject for the year 2019 show that the candidates demonstrated good performance on **five** topics and average performance on **five** topics. However, they demonstrated poor performance on **two** topics.

The topics that were well performed include *D.C Circuits* (91.4%), *Electric Heating* (82.4%), *A.C Circuits* (73.8%), *Three Phase Circuits* (73.7%), and *Various Topics* from which *Multiple-choice* items were developed (91.2%). The good performance on these topics signifies that the candidates were well equipped with knowledge, skills and competence in these topics.

The five topics on which the candidates performed averagely were *Transformers* (64.8%), *Illumination* (64.2%), *A.C Machines* (63.7%), *Electromagnetism* (63.1%), and *D.C Machine* (39.6%). This average performance shows the candidates had partial knowledge, skills and competence in these topics.

The candidates also performed poorly on the topic of *Batteries and Cells* (27.4%) and *A.C Voltage* (15.5%). The analysis shows that the candidates lacked sufficient knowledge and practical skills in these topics.

A summary of the detailed analysis of the candidates' performance on each topic is also presented in the **Appendix**. In summary, *Green, Yellow and Red* colours represents good, average and weak performance respectively.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The general performance of the candidates on the Electrical Engineering Science examination in the year 2019 was good. Out of the 353 candidates who sat the examination 279 (79.04%) passed while 74 (20.96%) failed. In the year 2018, 377 candidates sat this subject examination. Among them, 276 (73.21%) candidates passed while 101 (26.79%) failed. This signifies that the performance of the candidates in the year 2019 has increased by 5.85 percent in comparison to that of year 2018. Table 2 compares grade scores of the candidates in the years 2018 and 2019.

Table 2: Candidates' Grade Scores in the year 2018 and 2019

Year	Candidates Grade Scores					
	SAT	**A**	**B**	**C**	**D**	**F**
2018	377	15	36	129	96	101
2019	353	27	37	117	98	74

Despite the good performance of the candidates on this examination, some few weaknesses were observed. These include the candidates' inadequate knowledge, lack of practical skills and incompetence in some topics, particularly *A.C Voltages* and *Batteries & Cells*. These were poorly performed.

Another weakness observed was the inability of some candidates to deal with the questions that involved mathematical computations and their failure to understand the requirements of the questions.

It is expected that the weaknesses noted in this report will be used as a guideline to all educational stakeholders to enhance teaching and learning processes to improve future candidates' performance in the Electrical Engineering Science subject.

4.2 RECOMMENDATIONS

From the weaknesses observed in the analysis of the candidates' item responses, the following are recommended:

(i) Teachers should provide enough exercise and tests to candidates especially on areas which involve calculations. This will strengthen students' ability in this area.

(ii) Teachers should use laboratory and workshops in teaching *A.C Voltages* and *Batteries & Cells* so that the candidates may conduct experiments and practical tasks for long term memory and easy understanding.

(iii) The candidates should take serious initiatives on how to acquire knowledge and skills in tackling questions from various topics such as performing practical works as well as paper tasks exercises.

(iv) The candidates should be well oriented in the common terms used in composing questions to enable them to understand the demands of the questions.

Appendix

A summary of Candidates' Topic-wise Performance in Electrical the Engineering Subject

S/N	Topic	Qn. Number	Percentage of Candidates who Scored Average and Above	Remarks
1	D.C Circuits	7	91.4	Good
2	Multiple Choice Items From Various Topics	1	91.2	Good
3	Electric Heating	13	82.4	Good
4	A.C Circuits	14	73.8	Good
5	Three Phase Circuits	8	73.7	Good
6	Transformers	5 & 11	64.8	Average
7	Illumination	9	64.2	Average
8	A.C Machines	4	63.7	Average
9	Electromagnetism	6	63.1	Average
10	D.C Machines	10 & 12	39.6	Average
11	Batteries & Cells	3	27.4	Weak
12	A.C Voltages	2	15.5	Weak