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

STUDENTS' ITEM RESPONSE ANALYSIS REPORT ON THE FORM TWO NATIONAL ASSESSMENT (FTNA) 2022

ELECTRICAL ENGINEERING

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080 ELECTRICAL ENGINEERING

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LIST OF SYMBOLS AND ABBREVIATIONS

A	Ampere
C	Capacitor
DC	Direct Current
e.m.f	Electromotive force
F	Farad
FTNA	Form Two National Assessment
H	Henry
L	Inductor
μ	micro
NECTA	National Examinations Council of Tanzania
Ω	Ohm
SIRA	Students' Item Response Analysis
V	Volt

FOREWORD

This report presents Students' Items Response Analysis (SIRA) on Form Two National Assessment in Electrical Engineering subject which was conducted in November 2022. The report aims to provide feedback to all educational stakeholders on the factors that contributed to the students' performance in Electrical Engineering subject.

The Form Two National Assessment (FTNA) is a formative evaluation which intends to monitor students' learning outcome and provide feedback that teachers, students and other educational stakeholders can use to improve teaching and learning process. This analysis justifies the students' performance in the Electrical Engineering subject. The students who attained high scores demonstrated their ability to understand the demands of the questions, knowledge, skills and competence in the subject matter, as well as mastery on calculation skills. However, students who scored low marks faced difficulties in responding to the questions due to their insufficient knowledge of the tested concepts.

This report will help to identify the students' strengths and weaknesses so as to improve learning before sitting for the Certificate of Secondary Education Examination (CSEE). It will help teachers to identify the challenging areas and take appropriate measures during teaching and learning process.

The National Examinations Council of Tanzania (NECTA) expects that the feedback provided in this report will highlight the challenges for which education stakeholders should take proper measures to improve teaching and learning of Electrical Engineering subject. Consequently, students will acquire knowledge, skills and competence indicated in the syllabus for better performance in future assessments and examinations.

The Council appreciates the contribution of all those who participated in the preparation of this report.

Dr. Said A. Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents a detailed analysis of the students' response to each question in the Electrical Engineering subject in the Form Two National Assessment (FTNA), 2022. The paper was comprised of three sections, namely A, B and C. Section A consisted of questions 1 and 2. Question 1 had ten multiple choice items, (i) to (x); these were set from topics of *Cells and Batteries, DC Circuits, Electrical Workshop Orientation, Electrical Draughting, Workshop Practice, Instruments and Measurements, Magnetism and Electromagnetism, Units* and *Electrical Engineering Science and Technology.* Question 2 consisted of five matching items (i) to (v) set from the topic of *Electrical Engineering Science and Technology.* The students were required to answer all items from this section. Each item carried 1 mark, making a total of 15 marks.

Section B consisted of seven short answer questions set from the topics of *Cells and Batteries, DC Circuits, Electrical Draughting, Instruments and Measurement, Magnetism and Electromagnetism* and *Workshop Practice.* The students were required to answer all questions in this section. Each question carried 10 marks, making a total of 70 marks.

Section C consisted of one structured question set from the topic of *Electrical Draughting,* with a total of 15 marks.

The analysis of the student's performance on each question is categorized into three grade ranges as shown in Table 1.

Table 1: Grade Ranges of the Students' Performance

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

A total of 387 students sat for the Electrical Engineering paper in the year 2022. Among them, 253 (65.4%) passed, whereas 134 (34.6%) failed. Thus, the students' performance in the Electrical Engineering subject in 2022 was good. In the year 2021, 271 (62.0%) of the students passed, whereas 166 (38.0%) failed. Therefore, the performance in the year 2022 has increased by 3.4 per cent. The students' grade scores are presented in Table 2.

Table 2: Students' Grade Scores in the Year 2022

Total Number of Students	Students' Grade Scores				
	A	B	C	D	F
387	4	15	95	139	134

The following section presents the analysis of students' performance on each question.

2.0 ANALYSIS OF STUDENTS' RESPONSE TO EACH QUESTION

2.1 SECTION A: OBJECTIVE QUESTIONS

2.1.1 Question 1: Multiple Choice Items

Question 1 comprised of ten (10) items, (i) to (x), constructed from the following topics: *Cells and Batteries, DC Circuits, Electrical Workshop Orientation, Electrical Draughting, Workshop Practice, Instruments and Measurements, Magnetism and Electromagnetism, Units and Electrical Engineering, Science and Technology.* The students were required to choose the correct answer from the given alternatives by writing its letter in the box provided. The total marks for this question were 10 since each item carried 1 mark.

A total of 387 (100%) students attempted this question. Among them, 109 (28.2%) scored from 0 to 2 marks; 276 (71.3%) scored from 3 to 6 marks; and 2 (0.5%) scored from 7 to 8. The overall performance was good since 278 (71.8%) of them scored from 3 to 10 marks. Table 3 illustrates their performance on this question.

Table 3: Student's Performance on Question 1

Scores	Number of Students	Percentage (%)	Remarks
0-2	109	28.2	Weak
3-6	276	71.3	Average
7-8	2	0.5	Good
Total	**387**	**100**	

The analysis shows that the students performed well on items (ii), (v), (vii) and (viii). These were set from the topics of *DC Circuit, Workshop Practice, Magnetism and Electromagnetism* and *Units* respectively.

The analysis further shows that few students responded correctly to items (i), (iii) and (iv). Most of the students had moderate knowledge of the concepts tested from the topics of *Cells and Batteries, Electrical Workshop Orientation* and *Electrical Draughting,* respectively.

In contrary, students had weak performance on items (vi), (ix) and (x) from the topics of *Instruments and Measurement, Electrical Workshop Orientation* and *Electrical Engineering, Science and Technology*, respectively.

The following part analyses the students' responses to each item of Question 1.

Item (i): *Among other types, Juma decided to buy a lead-acid battery for his car. Why do you think he preferred a lead-acid battery and not an alkaline battery?*

A *It is cheaper.* *B* *It has longer life.*
C *It is very lighter.* *D* *It is mechanically strong.*

The correct answer was A, *It is cheaper*. The students who opted for this alternative had acquired enough knowledge about batteries and cells, particularly the types of batteries. Those who chose for alternatives B, *It has longer life*; C, *It is very lighter* and D, *It is mechanically strong* had misconception between electric cells and batteries; hence, they provided the advantages of electric cells instead of those of a lead-acid battery. This response signifies that the students lacked basic knowledge of batteries, especially primary batteries.

Item (ii): *You are provided with the following appliances to install in a house: heater, cooker and washing machine. Why is it advised to connect the electrical appliances parallel in a circuit?*

A *They depend on each other.* *B* *They draw less current.*
C *They draw high current.* *D* *They operate independently.*

The correct response was D, *They operate independently,* and most of the students selected this alternative. These students had sufficient knowledge

about the concepts of *DC Circuits*, especially the characteristics of parallel circuits and the effects of connecting loads of different ratings parallel in a circuit. A few students opted for alternative A, *They depend on each other*; these failed to recognize that, when loads are connected in parallel, they draw different current values regardless of their sizes. However, the students who selected alternatives B, *They draw less current,* and C, *They draw high current* lacked knowledge about the type of connection which draws less or high current in a particular circuit, especially when several loads are to be installed. The students were supposed to understand that parallel load connection in the circuit aims to maintain constant voltage.

Item (iii): *A teacher ordered you to bring a first aid box after an accident occurred at the field. How would you identify the box?*

A *A white cross on a green background.*
B *A red cross on a white background.*
C *A white cross on a black background.*
D *A green cross on a white background*.

The correct answer was A, *A white cross on a green background.* The students who chose this alternative were aware of the international safety signs and their applications. The green background and a white cross are for directive or instructional signs. A few students who selected alternative B, *A red cross on a white background,* confused it with the 'Red Cross', which is used by the International Red Cross Organization and it is more widely recognized. The students who selected alternative D, *A green cross on a white background*, confused the colour arrangement with that of alternative A. those who selected alternative C, *A white cross on a black background* lacked sufficient knowledge about the background colours used for safety signs.

Item (iv): *Suppose you are required to draw an object in its actual size. What is the appropriate name for the scale required to draw the object?*

A *A double scale.* *B* *Magnified scale.*
C *Enlarge scale.* *D* *Full scale.*

The correct answer was D, *Full scale.* The students who selected this alternative had adequate knowledge of the representation of an object or structure that is of the same size as the actual object. Others selected alternatives A, *A double scale;* B, *Magnified scale;* and C, *Enlarged scale.*

These students had misconceptions about these alternatives and the actual size. They thought that the actual size of an object could be obtained by doubling, magnifying or enlarging the scale, which is wrong.

Item (v): *Suppose you got an electric shock when you touched the metallic part of an electric iron. What kind of electric shock is that?*

A *Fuse blown.* *B* *Earth leakage.*
C *Short circuit.* *D* *Open circuit.*

Most of the students selected alternative B, *Earth leakage,* which was the correct answer. These students had adequate knowledge of different types of faults which lead to electric shock. Earth leakage occurs when the current flows through an unintended path, such as a person, to the earth. A few students selected alternative A, *Fuse blown,* these did not understand that a blown fuse would isolate or disconnect the supply from the electric iron. Hence, no electric shock would occur even if a person touches the metallic part of the electric iron. Others selected alternatives C, *Short circuit,* and D*, Open circuit* because they had insufficient knowledge of types of electric faults and their causes. They failed to understand that, *short circuit* occurs when there is a direct connection between the live and neutral wires. Conversely, an *open circuit* is a break in a circuit that prevents current from flowing.

Item (vi): *You are required to measure a very high frequency but small current. Which instrument will you use?*

A *Thermocouple.* *B* *Electrodynamics ammeter.*
C *Moving coil galvanometer.* *D* *Open circuit.*

The students performed poorly on this item sinse most of them failed to recognize that A, *Thermocouple,* is an appropriate instrument for measuring a very high frequency but small current. They randomly selected alternatives B, *Electrodynamics ammeter,* and D*, Induction type ammeter*. These instruments are not suitable because they are used to measure large current and are not associated with frequency. Alternative C, *Moving coil galvanometer,* is used to measure small current but not high frequency.

Item (vii)*: How can you determine the presence of magnetic field in a material?*

A *By detecting the lines of magnetic flux.*
B *By noticing the deflection of a magnetic compass needle.*

C By heating the surrounding air.
D By touching magnetically affected area.

Item (vii) required the students to identify the method which can be used to determine the presence of magnetic field in a material. The correct response was B, *By noticing the deflection of magnetic compass needle*. Most of the students selected this alternative. These students realized that the magnetic field is an invisible region around the magnetic material. Therefore, it can be determined by using a device called a compass that uses the earth's magnetic field to indicate direction. Those who selected alternative A, *By detecting the lines of magnetic flux* could not understand that the lines of magnetic flux cannot be detected by our naked eyes. Therefore, it is not possible to determine the presence of the magnetic field of a material without using a proper device. The students who selected alternative C, *By heating the surrounding air*, and D, *By touching magnetically affected area*, lacked knowledge of the concepts of magnetism; hence, they failed to realize that the magnetic field cannot be detected by neither heating the surrounding air nor touching the affected area.

Item (viii): *Which of the following is the unit of inductance?*
A Ohm B Mho C Farad D Henry

This item was correctly responded by most of the students, who selected alternative D, *Henry.* It was simple for students to select *Henry* as a unit of inductance because it is the most widely used unit in electrical engineering. Those who selected alternatives A, *Ohm; B, Mho* and C, *Farad* were knowledgeable about the concept of electrical units but were confused by the units of resistance, conductance and capacitance, respectively; because they are also used in other basic components in electrical engineering.

Item (ix): *A worker got a strain after lifting a load by using a ladder. What could be the possible cause of the strain?*

A The load was heavy.
B The worker used a broken ladder.
C The angle of the ladder was not reasonable.
D The worker did not lift the load in a correct way.

Although the correct answer was D, *The worker did not lift the load in a correct way*, but most of the students wrongly opted for alternatives A, *The load was heavy*. They thought that lifting the heavy load could cause the

strain due to stress, but they did not consider the appropriate way/technique used to lift that load. Others opted for alternatives B, *The worker used a broken ladder* and C, *The angle of the ladder was not reasonable,* as they lacked knowledge that, if the worker uses the correct way or technique to lift the load, then a broken ladder and the reasonable angle of the ladder will not be among the causes of strain. The students were supposed to understand that lifting a heavy load improperly or with a poor technique and inappropriate equipment such as ladder can lead to strain as it puts extra stress on the muscles and joints.

Item (x): *A client is looking for a person who will produce specifications which will enable him to estimate the cost of the project. Who will you advice the client to call upon?*

A Cost engineer. *B Design engineer.*
C Contract engineer *D Project engineer.*

This item was poorly performed; only a few students chose the correct response *B, Design engineer.* The students who chose this alternative were knowledgeable about duties and responsibilities of electrical engineering personnel. They understood that the design engineer is responsible for designing and developing new projects with detailed specifications, and therefore, can estimate the cost of the project. Those who chose alternative A, *Cost engineer,* were attracted by the word "cost" which appeared in the question. In contrast, the students who selected alternative *C, Contract engineer,* thought that most of the projects are implemented by contractors. Therefore, they can estimate the cost of the project. They failed to understand that a contract engineer is responsible for managing the technical aspects of the project and not cost estimates. Those who selected alternative D, *Project engineer,* they associated it with the term 'project which appeared in the question. Therefore, they assumed that any cost of the project can be estimated by the project engineer. They did not recognize that the project engineer is responsible for coordinating and overseeing a specific project to ensure that it is completed as per client's satisfaction. The students' poor performance on this item indicates that they lacked knowledge about the duties and responsibilities of electrical engineering personnel.

2.1.2 Question 2: Matching Items

The question was set from topic of *Electrical Engineering, Science and Technology*. The question required the students to match the description of responsibilities in List A with the corresponding occupation in List B by writing the letter of the correct response below the item number in the table provided. The question was set as follows:

List A	List B
(i) A person responsible for producing the design specifications which enable the cost estimate of the project. (ii) The leader of a small team e.g electricians and trainees. (iii) A person responsible for carrying out testing, inspections and commissioning of electrical installation survey drawings. (iv) A person responsible for a number of large electrical jobs of different sites. (v) An electrician who is responsible for the whole plant.	A Foreman B Skilled operator C Service manager D Project manager E Engineer F Technician G Craftsman H Contractor

A total of 387 students (100%) attempted this question. Among them 318 (82.2%) scored from 0 to 1 mark; 65 (16.8%) scored from 2 to 3 marks; and 4 (1.0%) scored 4 marks. The students' performance on this question was, therefore, weak because only 69 (17.8%) passed. Table 4 shows the distribution of the students' scores on the question.

Table 4: Student's Performance on Question 2

Scores	Number of Students	Percentage (%)	Remarks
0-1	318	82.2	Weak
2-3	65	16.8	Average
4	4	1.0	Good
Total	**387**	**100**	

Table 3 shows that 82.2 per cent of the students had weak performance; most of them mismatched the items. For example, one student wrongly matched item (ii) in List A with response G, *Craftsman* in List B, instead of A, *Foreman.* This student had a misconception about the engineering occupational ranking as he/she failed to recognize that the responsibility of a craftsman is to test, repair and maintain electrical equipment or system to ensure they are operating correctly rather than leading a team of electricians and trainees which is the responsibility of a foreman. The students' response to this question implies that they had insufficient knowledge of the concepts tested from the topic of *Electrical Engineering, Science and Technology* especially in the area which covers duties and responsibilities of electrical engineering personnel. Extract 2.1 illustrate the incorrect responses to question 2.

List A	(i)	(ii)	(iii)	(iv)	(v)
List B	H	G	E	A	D

Extract 2.1: A sample of the incorrect responses to Question 2

Extract 2.1 shows that the student did not provide relevant responses to any item.

In contrast, 4 (1%) of the students scored 4 marks. These students matched four of the items correctly. However, no student scored all 5 marks allotted to this question. This implies that these students had sufficient knowledge about the concepts tested from the topic of *Electrical Engineering, Science and Technology*, especially in the area which covers duties and responsibilities of electrical engineering personnel. Extract 2.2 is a sample of the correct responses from one of the students.

List A	(i)	(ii)	(iii)	(iv)	(v)
List B	G	A	F	D	B

Extract 2.2: A sample of the correct responses to Question 2

In Extract 2.2, the student managed to match correctly four items out of the five descriptive responsibilities in List A to their corresponding occupations in List B but wrongly matched item (i) in List A with (G) in List B.

2.2 SECTION B: SHORT ANSWER QUESTIONS

2.2.1 Question 3: Cells and Batteries

The question had two parts (a) and (b) and was set as follows:

(a) You are supplied with three cells each with an e.m.f. of 1.5.V and an internal resistance of 1 Ω to light a touch. Draw a circuit diagram which shows the connection of the cells so that it can produce:
(i) A voltage more than 1.5 V.
(ii) A total voltage of 1.5 V.
(b) Find a total internal resistance of the cell in part (a) (i) and (ii).

This question was attempted by 387 (100%) candidates. Out of them, 186 (48.1%) scored from 0 to 2.5 marks; 107 (27.6%) scored from 3 to 6.5 marks; and 94 (24.3%) scored from 7 to 10 marks. This trend of performance verifies that the average number (51.9%) of the students had good performance.
Figure 1 is illustrative.

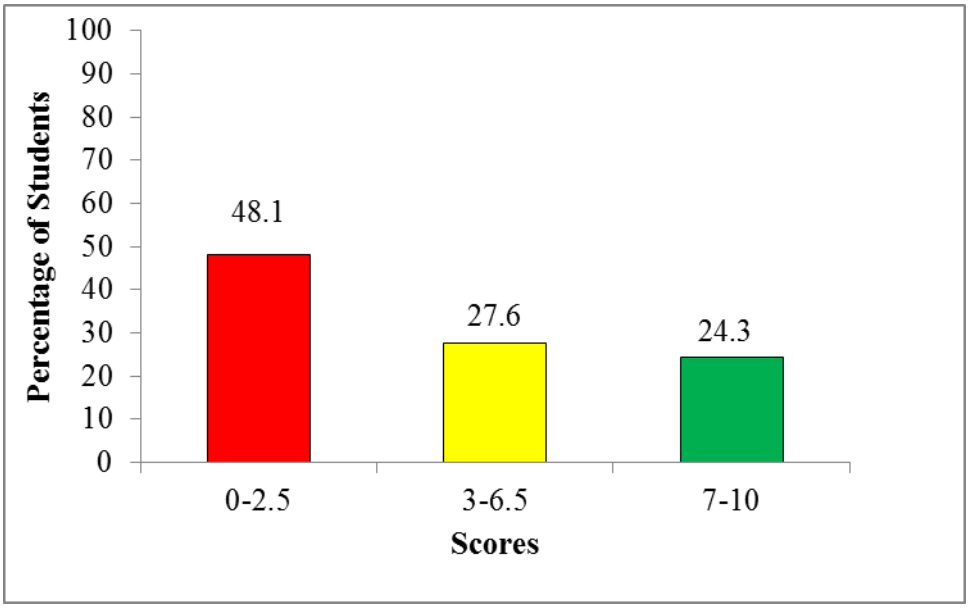
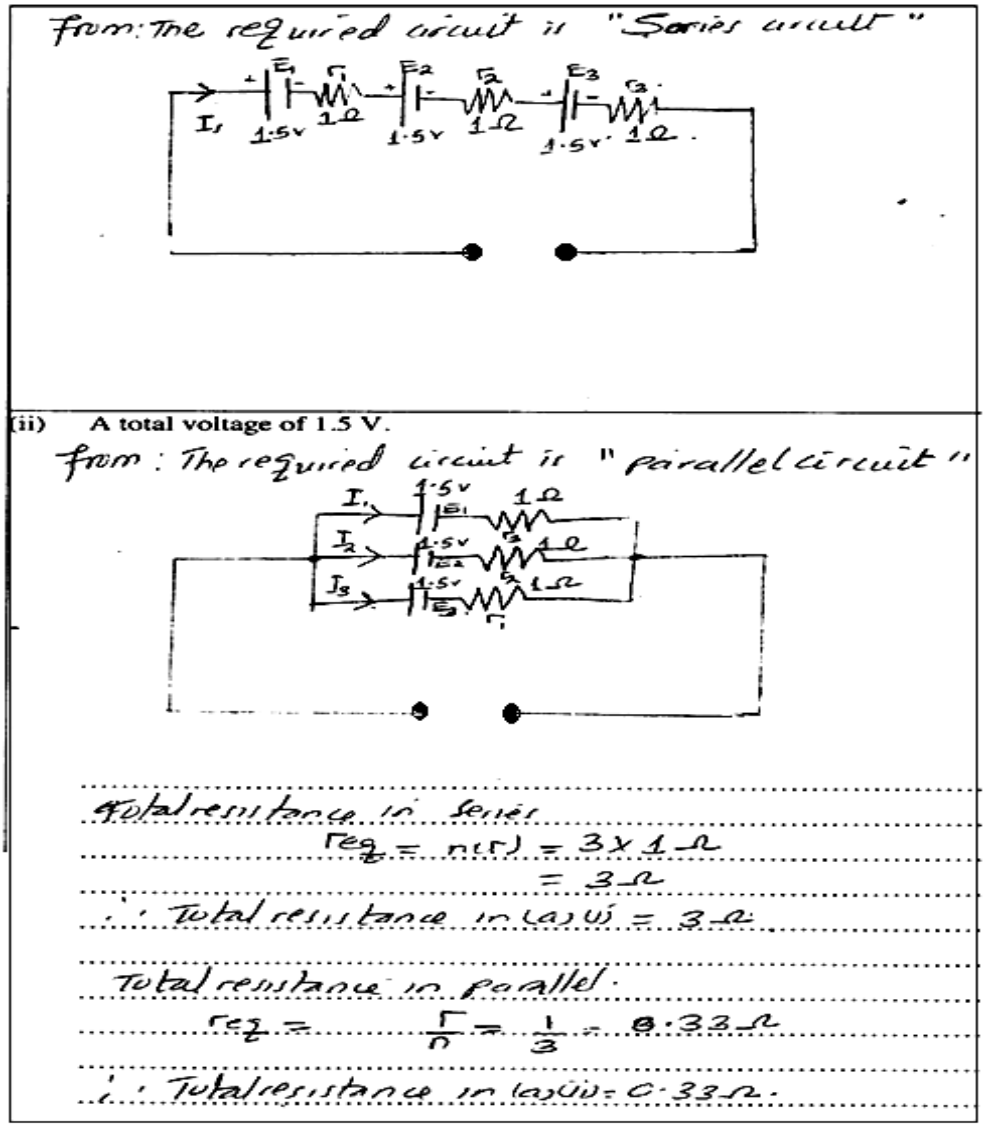


Figure 1: *Students' Performance on Question 3*

The statistical data shows that 51.9 per cent of the students performed averagely since they responded to the question partially. Most of them managed to draw circuit diagrams which show the connection of cells as

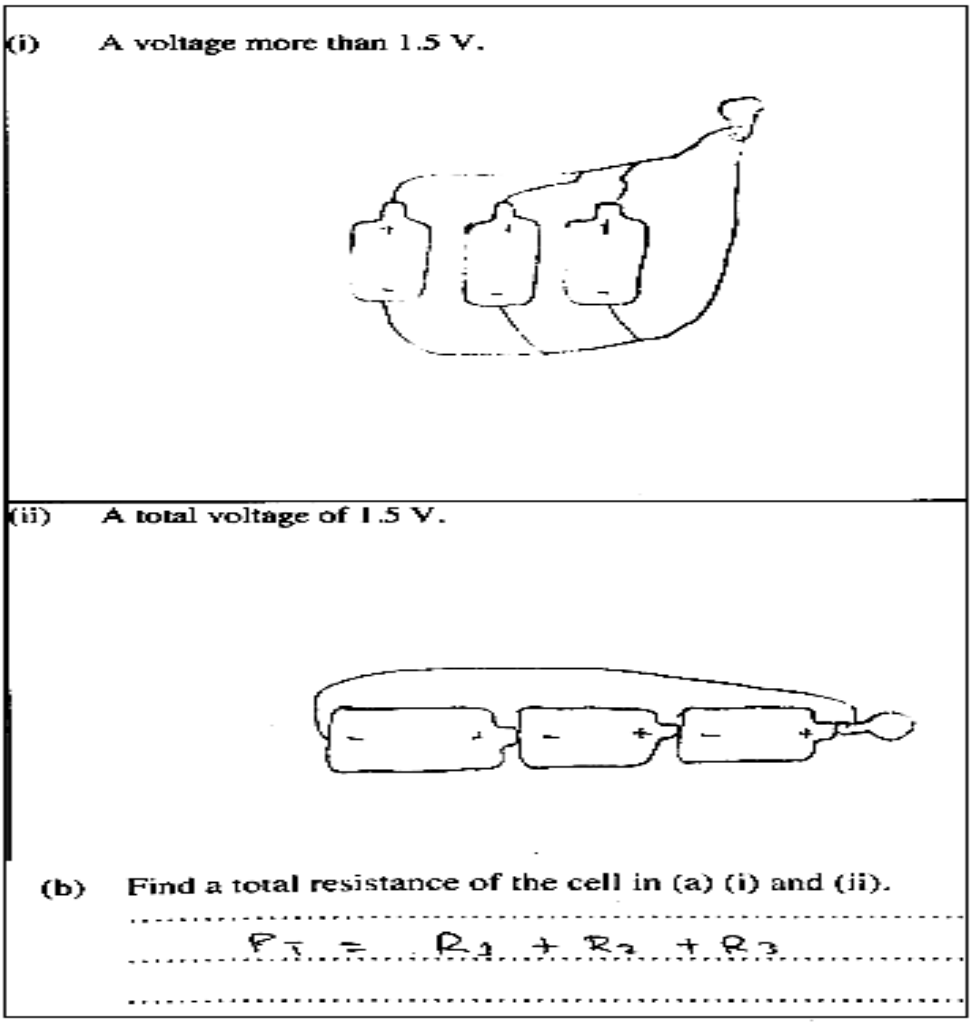
asked in Question 3 (a) (i) and (ii). However, some of the students failed to find the total resistance of the cell either in (b) (i) or (b) (ii) as they interchanged the formula for a series circuit with that of the parallel circuit. Extract 3.1 is a sample of the correct responses to Question 3.



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

In Extract 3.1, the student demonstrated the ability to draw circuit diagrams as required in Question 3(a) (i) and (ii). The student also applied the correct formula to calculate the total resistance in (b).

Furthermore, analysis shows that 186 (48.1%) of the students who scored low marks had inadequate knowledge about the subtopic of *Cells and Batteries*. They failed to recognize the correct arrangement which can produce voltage more than 1.5 V or exactly 1.5 V. Some of them failed to apply the correct formula to calculate the total resistance in series as well as in parallel. Other students calculated the total resistance in parallel connected cells by simply adding resistances instead adding up the reciprocal of each individual resistance and then taking the reciprocal of the sum. These students lacked skills and knowledge of concepts tested from the topic of *cells and battery* as Extract 3.2 illustrates.



Extract 3.2: A sample of the incorrect responses to Question 3

In Extract 3.2, the student drew both the series and parallel circuits, but he/she did not understand which one produces more voltage or maintains constant voltage. Also the student failed to apply the correct formula to calculate the total resistance in each circuit. The student's inability to provide the correct responses suggests that he/she lacked sufficient knowledge about cells and batteries.

2.2.2 Question 4: DC Circuit

The question was as follows: *You are given a practical assignment which has two parts. The first part is to construct a circuit with capacitors C_1 and C_2 connected in series. The second part is to construct a circuit with inductors L1 and L2 connected in series*.

(a) Draw the circuits to be used for the practical work.

(b) When C_1 and C_2 are 10 µF and 20 µF respectively, calculate the equivalent capacitance.

(c) When L_1 and L_2 are 17.6 H and 13.4 H respectively, determine the equivalent inductance.

This question was attempted by 387 (100%) of the students. Out of whom 95 (24.5%) scored from 0 to 2.5 marks; 166 (42.9 %) scored from 3 to 6.5 marks; and 126 (32.6%) scored from 7 to 10 marks. Figure 2 summarizes the performance of the students on this question.

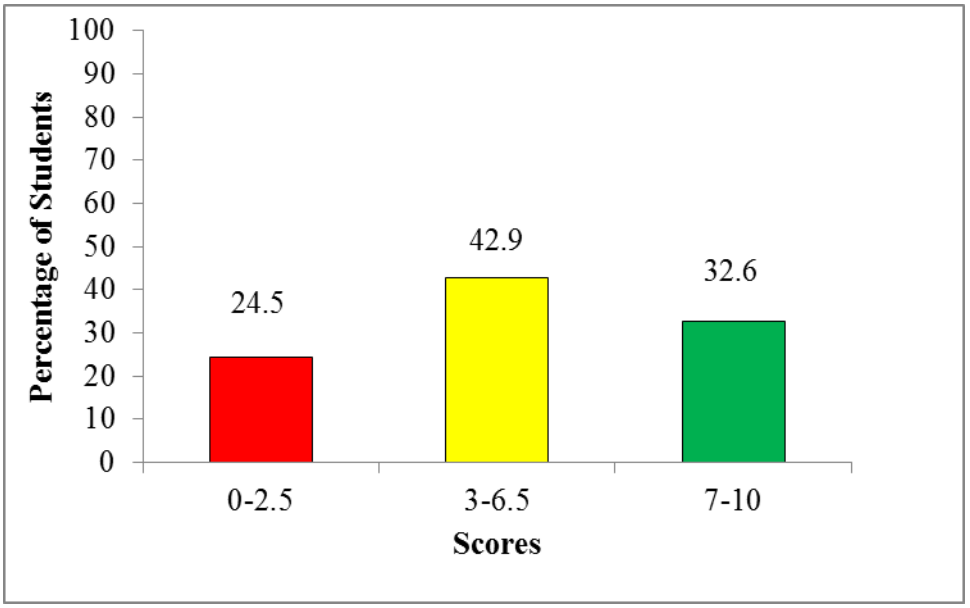
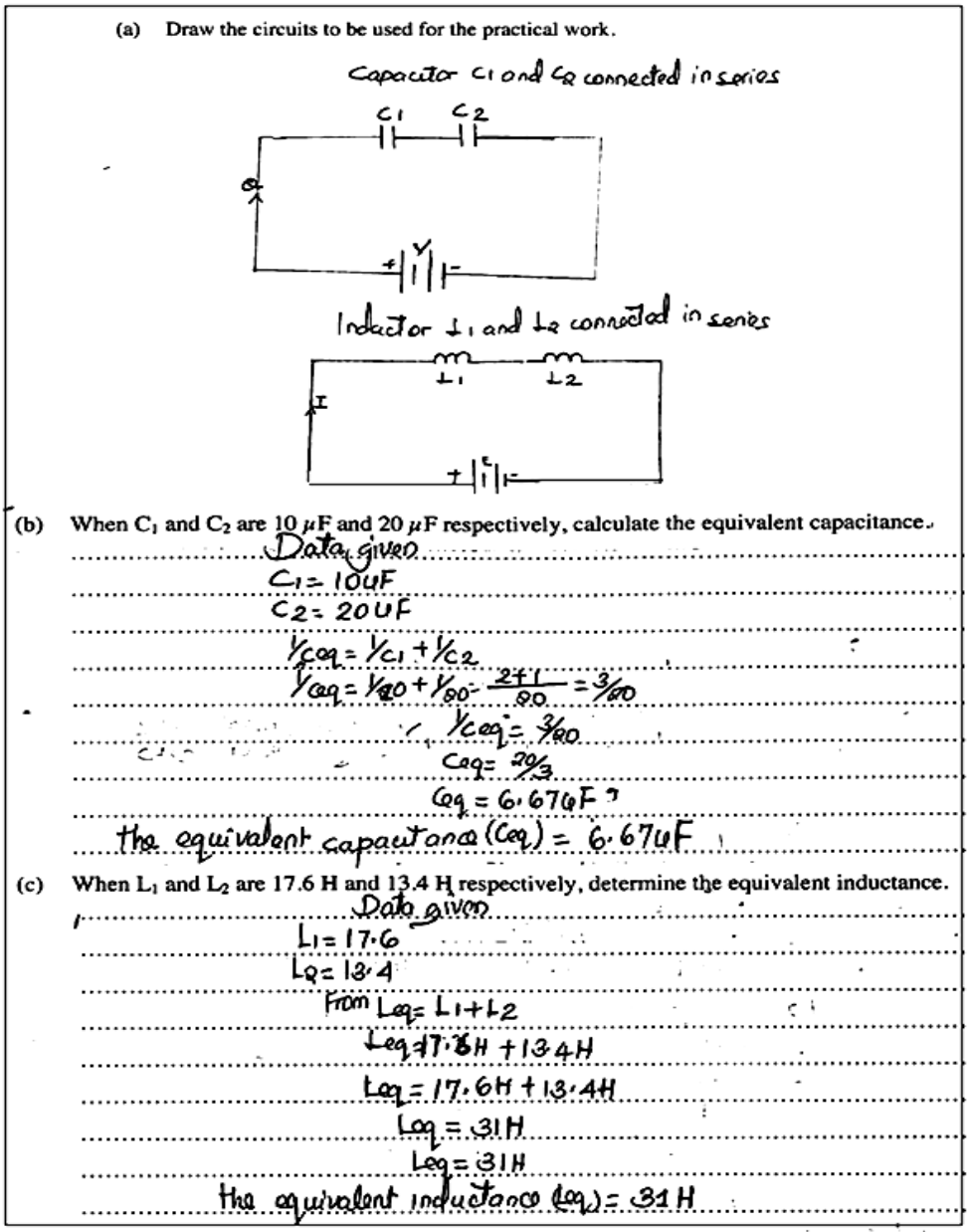


Figure 2: *Students' Performance on Question 4*

The students' general performance on this question was good, since 292 (75.5%) passed by scoring from 3 to 10 marks. Their good performance was contributed by their ability to use the symbols for the capacitor and inductor correctly to draw the series circuits to be used in practical work. Also they applied the correct formulas to calculate the equivalent capacitances and inductances for the given values as shown in Extract 4.1.

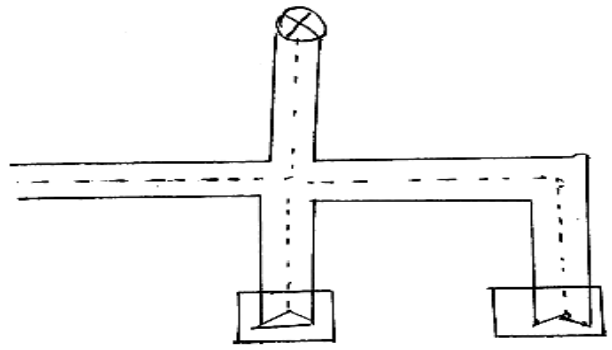


Extract 4.1: A sample of the correct responses to Question 4

Extract 4.1 shows that the student demonstrated his/her skills in using proper symbols to draw the required circuits for the practical work and applied the correct formulae to calculate the equivalent capacitances and inductances.

However, the analysis indicates that 86 (22.8%) of the students performed poorly. These students lacked knowledge particularly on the areas that required them to compute equivalent capacitances and inductances. For example, one student drew a single diagram containing both connections of capacitors and inductors in it. The student also interchanged the formulae for finding equivalent capacitances in a series circuit with that for a parallel circuit. Extract 4.2 is illustrative.

(a) Draw the circuits to be used for the practical work.



(b) When C_1 and C_2 are 10 μF and 20 μF respectively, calculate the equivalent capacitance.

Solution

$\frac{C_1 C_2}{C_2 C_1}$

$\frac{10\mu F + 20\mu F}{20 - 10} = \frac{30}{10} = 3$

∴ The equivalent capacitance 3

(c) When L_1 and L_2 are 17.6 H and 13.4 H respectively, determine the equivalent inductance.

Solution

$\frac{L_1 L_2}{L_2 L_1}$

$= \frac{17.6 + 13.4}{13.4 - 17.6} = \frac{31.0}{5.8}$

$31.0 \times 10 = 310$

$5.8 \times 10 = 58$

$= \frac{310}{58} = 5.3$

The equivalent inductance 5.3.

Extract 4.2: A sample of the incorrect responses to Question 4

In Extract 4.2, the student drew a wiring diagram of a single lamp with two switches instead of the circuit diagram for practical work. Conversely, the student failed to apply the correct formulae to calculate the equivalent capacitance and inductance. This student lacked knowledge about D.C Circuit, particularly about the passive and active components of electric circuits.

2.2.3 Question 5: Electrical Draughting

This question had two parts, namely (a) and (b) and was set as follows:

(a) Draw and give the applications of the following lines used in engineering field:
   (i) Continuous thin line with zigzag.
   (ii) Thin free hand continuous line.
   (iii)Continuous thick line.

(b) Explain the use of the following essential items in electrical draughting:
   (i) Grid paper
   (ii) Pencil
   (iii)Tee square
   (iv)Drawing board

A total of 387 students (100%) attempted the question. Their scores are categorized as follows: 168 (43.4%) of the students scored from 0 to 2.5 marks; 199 (51.4%) scored from 3 to 6.5 marks; and 20 (5.2%) scored from 6.5 to 9 marks. The students' performance on this question was average since 56.8 per cent of them scored from 3 to 9 marks. Figure 3 summarizes this performance.

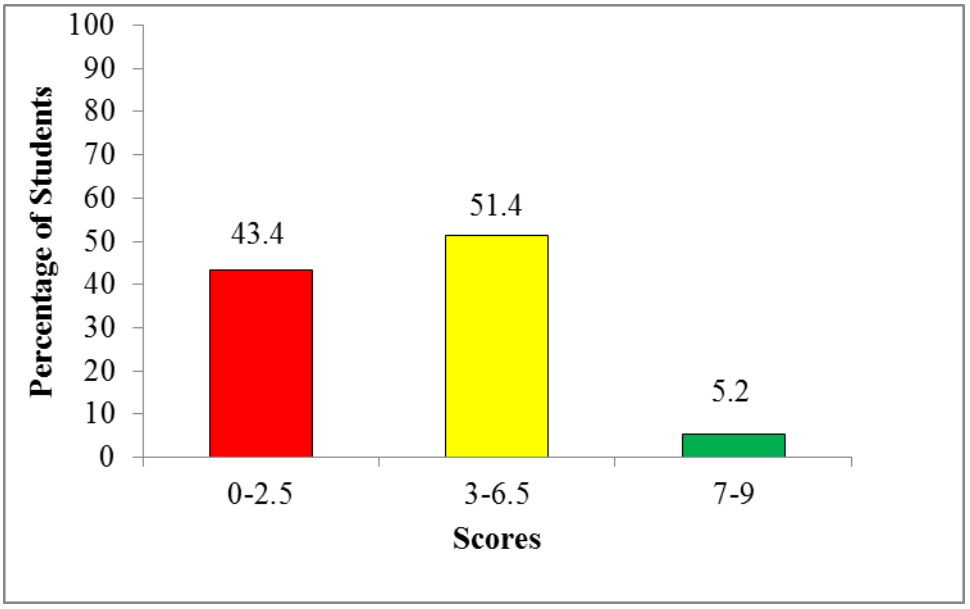


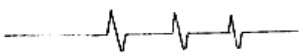
Figure 3: *Students' Performance on Question 5*

Based on the analysis, the general performance on this question was average, since 219 (56.6%) of the students scored average marks and above. Most of the students provided correct responses to some items of the question. However, 5.2 per cent of the students who scored from 7 to 9 marks provided the correct responses to more than four items of the question as illustrated in Extract 5.1.

5. (a) Draw and give the applications of the following lines as used in engineering field:

(i) Continuous thin line with zigzag

DRAWING



APPLICATION

Used to show an outline of incomplete figure or object

(ii) Thin freehand continuous line

DRAWING:

APPLICATION

→ Used to show an outline of object or figure in Free-hand drawing / sketching (drawing without instruments).

(iii) Continuous thick line

DRAWING

APPLICATION

→ Used to show a full visibility of an object or a figure.

(b) Explain the use of the following essential items in electrical draughting:

(i) Grid paper

→ Is a sheet used for drawing, normally has grid lines used for location

(ii) Pencils

→ Is the basic instrument used for drawing.
There are of 3 types ; Hard pencil, medium pencil and soft pencil.
(H-7H) → Hard pencils (HB and F) - Medium pencils B-7B (soft pencils)

(iii) Tee square

→ Is a T shaped instrument used to construct Vertical, horizontal and sloping lines.

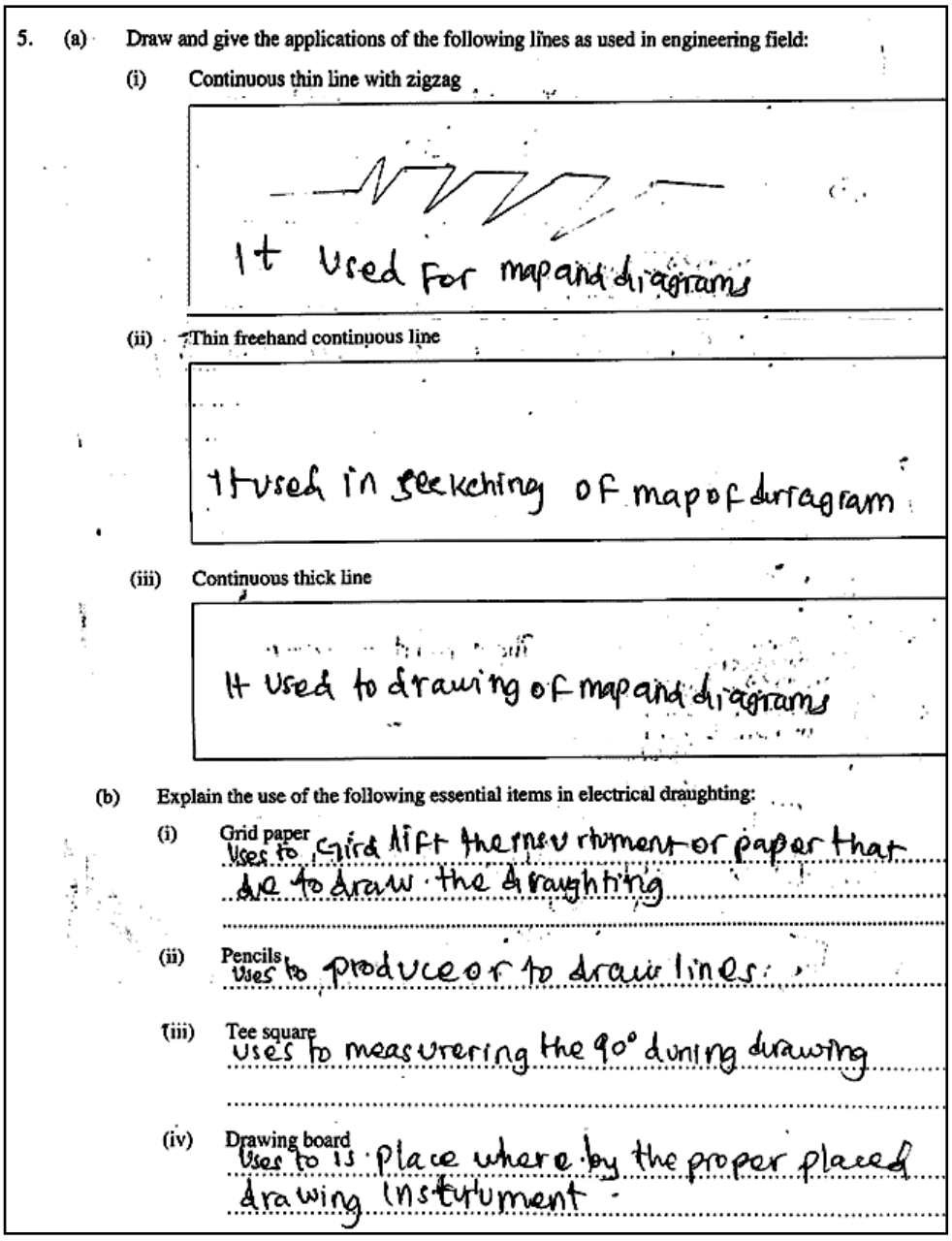
(iv) Drawing board

→ Is a four right angled board ; where the sheet or paper used for drawing is placed.

Extract 5.1: A sample of the correct responses to Question 5

Extract 5.1 shows that the student responded correctly to all parts of the question.

The analysis further shows that 168 (43.4%) of the students who scored below average had insufficient knowledge of the concepts tested from the topic of *Electrical Draughting*. The major challenge was the failure of the students to give the correct applications of the lines used in the electrical engineering field as requested in (a). In part (b), some of the students also failed to explain the use of the given essential items in electrical engineering. For example, one of the students wrongly responded to this part by writing (i) *Grid paper is the paper which contain small boxes which is used for drawing graph of different electric quantities* instead of *It is used for free hand sketching and early design of figures in engineering*. This student confused between grid paper and graph paper. Extract 5.2 illustrates a sample of incorrect responses from one of the students.



Extract 5.2: A sample of the incorrect responses to Question 5

Extract 5.2 shows that the student provided irrelevant responses to the items.

2.2.4 Question 6: Electricity

The question had two parts, (a) and (b), which were set as follows:

(a) A 100 V with a resistance of 250 Ω is used to illuminate girls' dormitory. The lamp is working for 24 hours a day. Determine:

(i) The current taken by the lamp.

(ii) The related power of the lamp.

(iii) The daily electrical energy consumed.

(b) Differentiate between electrical quantities in (a)(ii) and (a)(iii).

This question was attempted by 387 (100%) students. Of whom, 65 (16.8%) scored from 0 to 2.5 marks; 110 (28.4%) students scored from 3 to 6.5 marks; and 212 (30.0%) scored from 7 to 10 marks. Their performance was good since 322 (83.2%) of the students responded well. Figure 4 shows the students' performance on Question 6.

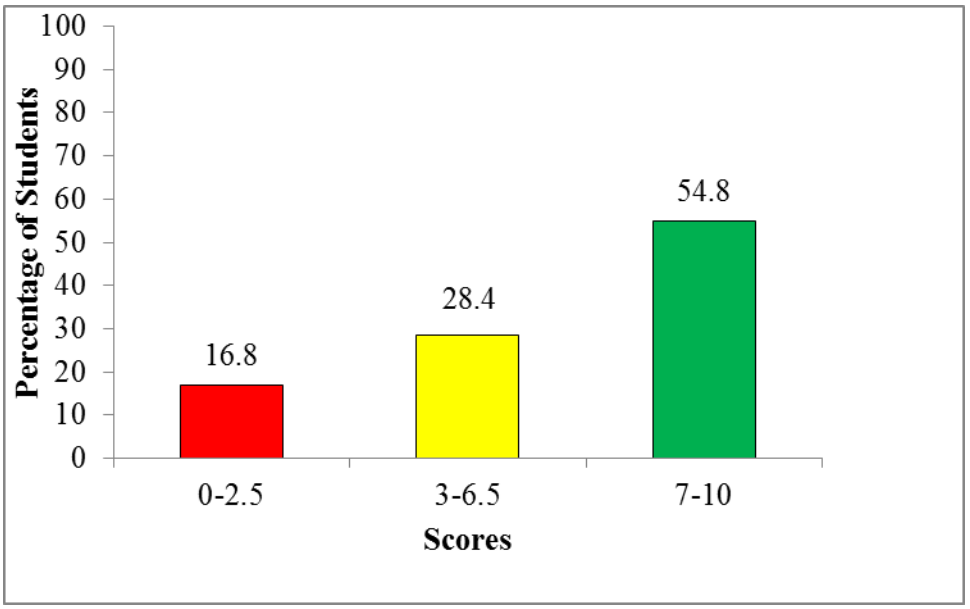
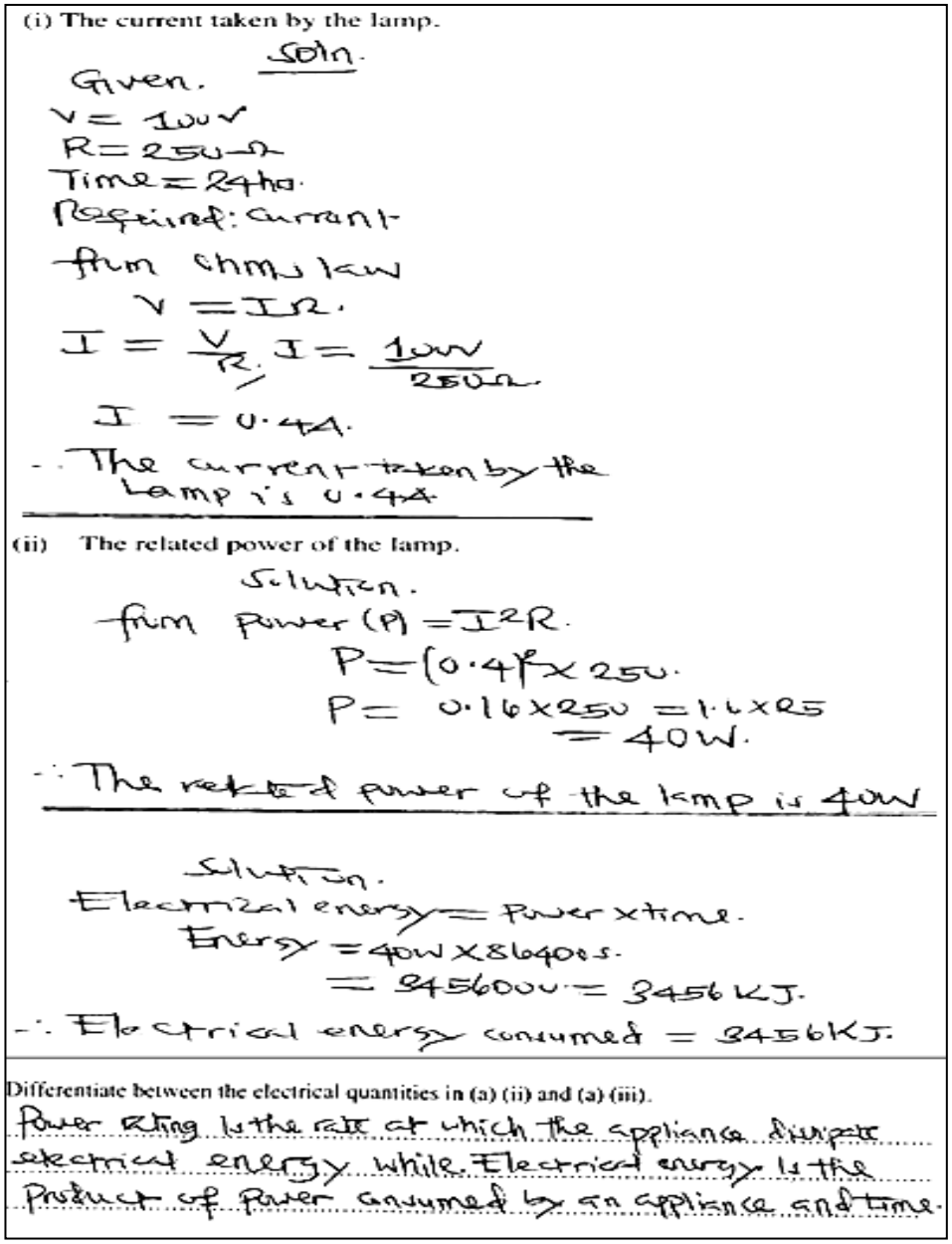


Figure 4: *Students' Performance on Question 6*

Analysis shows that most of the students who passed provided the correct responses to all parts of the question. They correctly determined the current taken by the lamp, the related power of the lamp and the daily electrical energy consumed. Also they correctly differentiated between the electrical quantities asked in part (b) of the question. These students had sufficient knowledge about the concepts tested in electricity as shown in Extract 6.1.

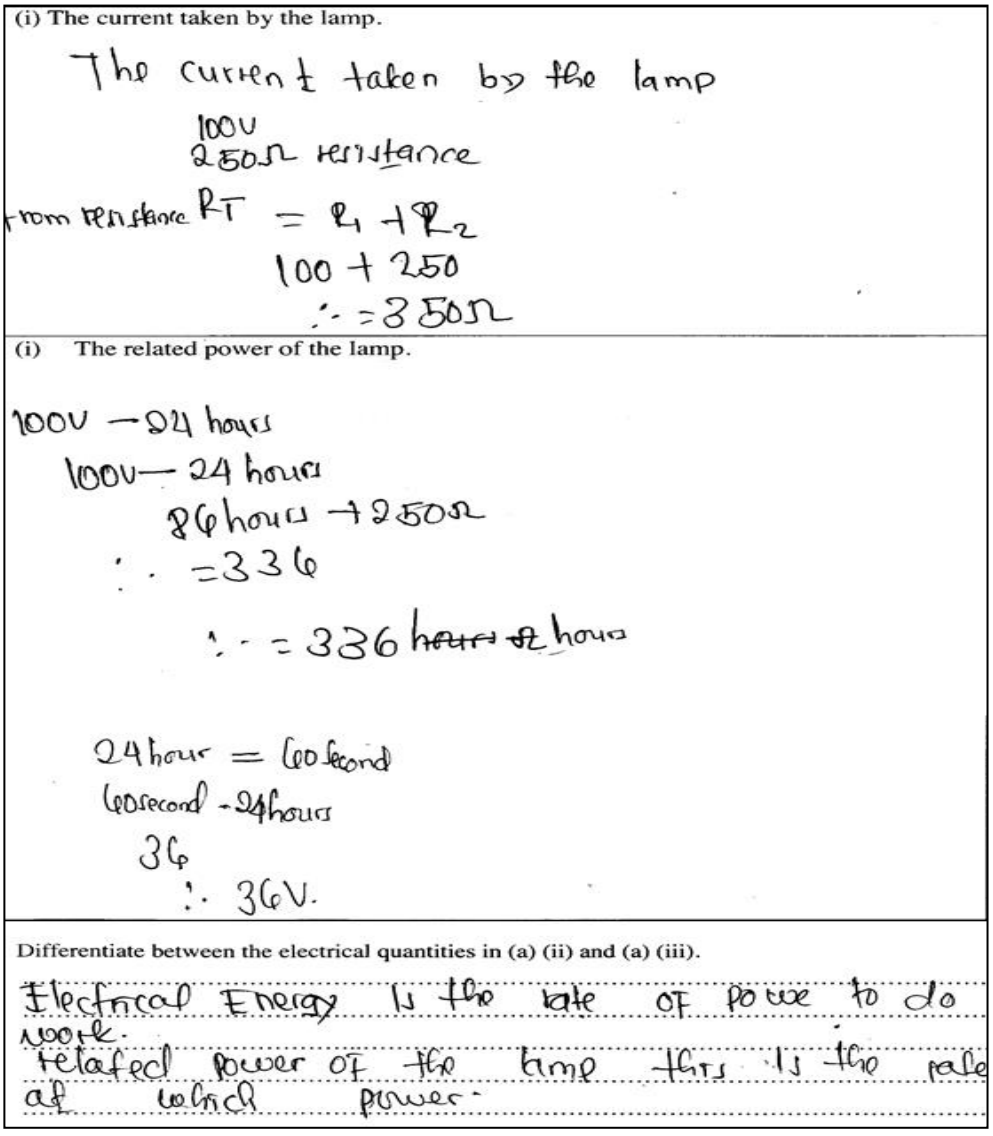


Extract 6.1: A sample of the correct responses to Question 6

In Extract 6.1, the student provided correct responses to all parts of the question.

Despite their good performance, 16.8 per cent of the students scored below average; of whom, 9 per cent scored zero. These students lacked sufficient knowledge about the concepts tested in the topic of *Electricity.* For example, in part (a) (i), one student calculated the current taken by the lamp

by using an incorrect formula, $\left(\text{Current } I=\frac{V}{R}\times\text{time}\right)$, instead of $\left(I=\frac{V}{R}\right)$. In addition, in (a) (ii), the student incorrectly used the formal $\left(P=V\times\frac{R}{t}\right)$ to calculate the power of the lamp instead of $\left(P=I^2R\right)$. Extract 6.2 is an example of the incorrect responses to the question.



Extract 6.2: A sample of the incorrect responses to Question 6

In Extract 6.2, the student applied incorrect formulas to all items of part (a). He/she determined current by just adding up the given quantities (voltage

and resistance) with different parameters. Also the student calculated the power of the lamp by subtracting *time* from *voltage*, which was wrong. Similarly, the student failed to differentiate the electrical power from electrical energy.

2.2.5 Question 7: Instruments and Measurements

The question had parts (a) and (b) and was set as follows:

(a) Explain the principles used in the operation of the following instruments:

(i) Moving iron instruments

(ii) Moving coil instruments

(b) Examine six advantages of permanent magnet moving coil instruments.

The question was attempted by 387 students (100%). their scores were categorised as follows: 371 (95.9%) of the students scored from 0 to 2.5 marks; the remaining 16 (4.1%) scored from 3 to 6 marks. No student score from 07 to 10 marks. Figure 5 summarizes the students' performance on this question.

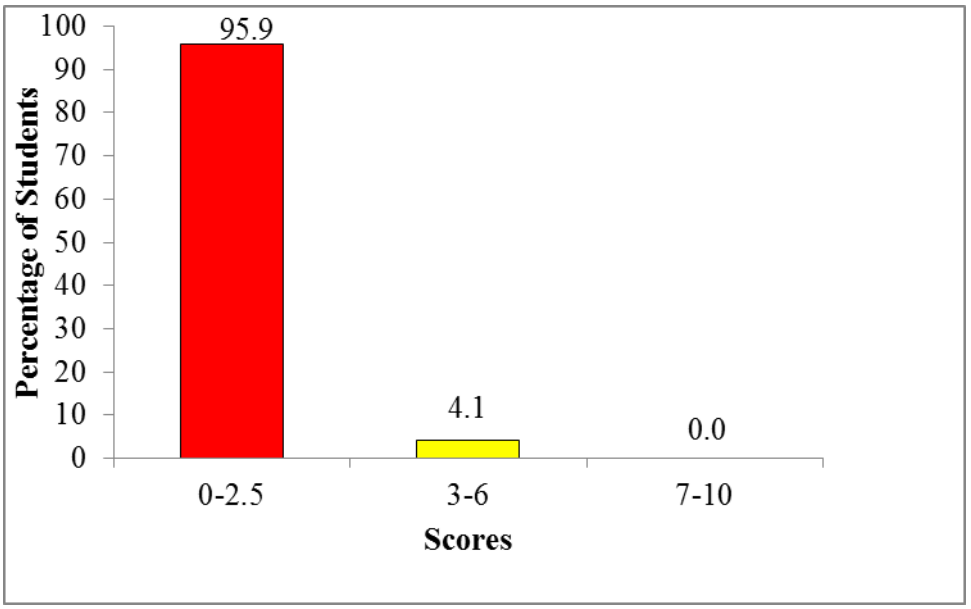
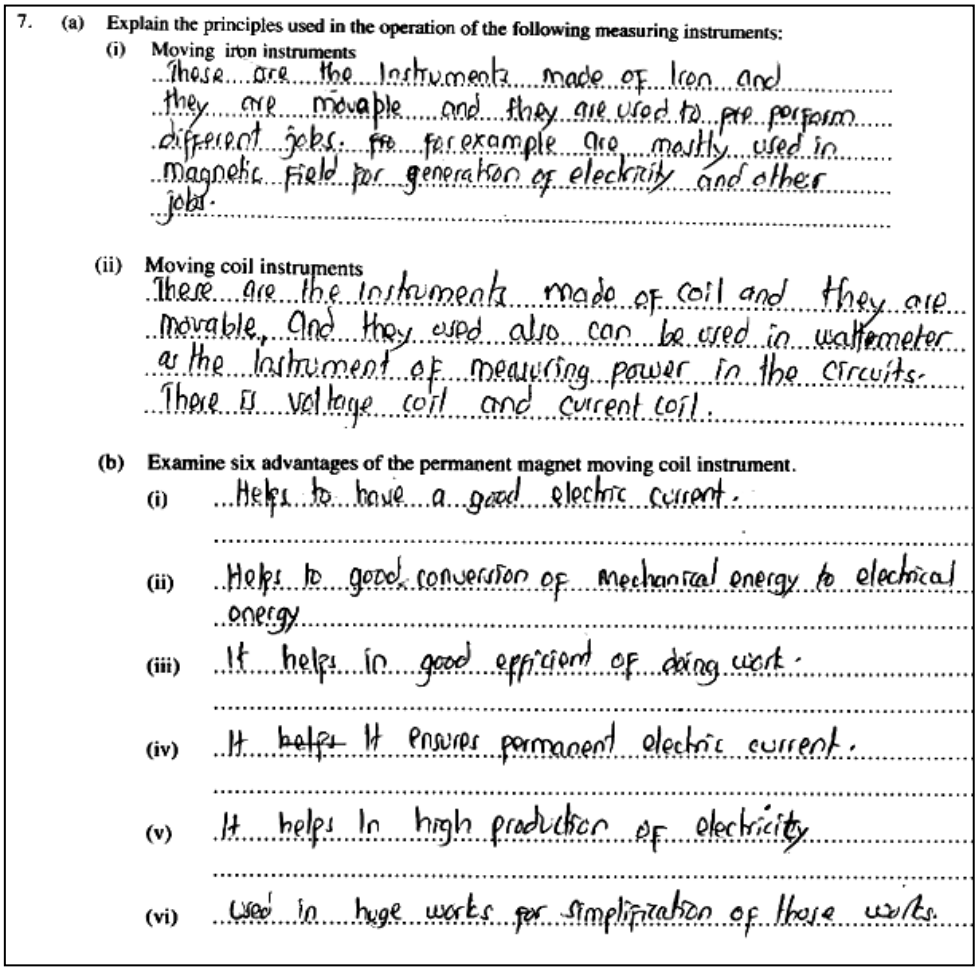


Figure 5: *Students' Performance on Question 7*

The students' general performance on this question was weak as statistical analysis reveals that only 16 (4.1%) of the students passed whereas 95.9 per

cent failed. Moreover, most of the students failed to explain the principle used in the operation of moving iron and moving coil instruments as well as to examine six advantages of permanent magnet coil instruments. For example, in part (a) (i), one student provided different types of measuring instruments such as *electrodynamic ammeter*, *voltmeter* and *thermometer*, instead of the principles of operation of moving iron instruments. In (a) (ii), the student mentioned "moving coil galvanometer"; which is a type of moving coil instruments instead of explaining the principle of operation of moving coil instruments. Extract 7.1 is the sample of incorrect responses to the question.


7. (a) Explain the principles used in the operation of the following measuring instruments:

(i) Moving iron instruments

These are the instruments made of iron and they are movable and they are used to are perform different jobs. Fro for example are mostly used in magnetic field for generation of electricity and other jobs.

(ii) Moving coil instruments

These are the instruments made of coil and they are movable, and they used also can be used in waltmeter as the instrument of measuring power in the circuits. There is voltage coil and current coil.

(b) Examine six advantages of the permanent magnet moving coil instrument.

(i) Helps to have a good electric current.

(ii) Helps to good conversion of mechanical energy to electrical energy

(iii) It helps in good efficient of doing work.

(iv) It helps It ensures permanent electric current.

(v) It helps in high production of electricity

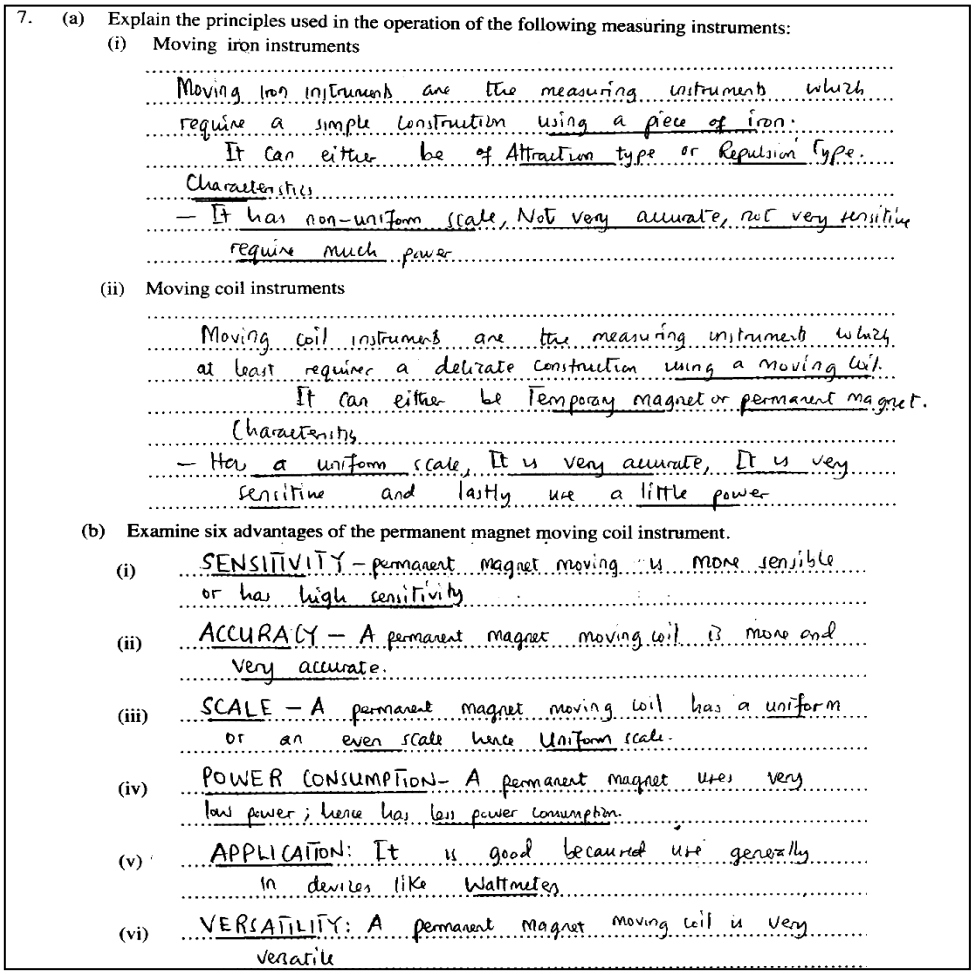
(vi) Used in huge works for simplification of those works.

Extract 7.1: A sample of the incorrect responses to Question 7

In Extract 7.1, the student explained the construction of the instruments instead of their principles of operation as required in part (a). Also in part (b), the student's responses relate to the advantages of electric machines.

This indicates that the student has failed to recall the concepts learnt in the topic of *Instruments and Measurements.*

The analysis also shows that 4.1 per cent of the students performed averagely. These students provided correct responses to only some items of the question. These students had acquired inadequate knowledge about *Measurements and Instruments* as Extract 7.2 presents.



7. (a) Explain the principles used in the operation of the following measuring instruments:

(i) Moving iron instruments

Moving iron instruments are the measuring instruments which require a simple construction using a piece of iron. It can either be of Attraction type or Repulsion type.

Characteristics

– It has non-uniform scale, Not very accurate, not very sensitive require much power

(ii) Moving coil instruments

Moving coil instruments are the measuring instruments which at least requires a delicate construction using a moving coil. It can either be Temporary magnet or permanent magnet.

Characteristics

– Has a uniform scale, It is very accurate, It is very sensitive and lastly use a little power

(b) Examine six advantages of the permanent magnet moving coil instrument.

(i) SENSITIVITY – permanent magnet moving is more sensible or has high sensitivity

(ii) ACCURACY – A permanent magnet moving coil is more and very accurate.

(iii) SCALE – A permanent magnet moving coil has a uniform or an even scale hence Uniform scale.

(iv) POWER CONSUMPTION – A permanent magnet uses very low power; hence has less power consumption.

(v) APPLICATION: It is good because use generally in devices like Wattmeter

(vi) VERSATILITY: A permanent magnet moving coil is very versatile

Extract 7.2: A sample of average responses to Question 7

Extract 7.2 shows that, in part (a), the student provided the correct characteristics of moving iron instruments as well as moving coil instruments but failed to explain the principles of operation of each instrument type. In part (b), the student provided correct responses to four

of the six items. This indicates that the students acquired partial knowledge about the concepts tested from the topic of *Instruments and Measurements.*

2.2.6 Question 8: Magnetism and Electromagnetism

The question asked as follows:

(a) Analyze three relationships between magnetic effect and electric current.

(b) You are provided with two coils P and Q which are mutually coupled. The mutual inductance between two coils is 0.24 H and the current in the primary winding increases from 0.2A to 0.6 A in 10 msec. If the secondary coil Q is wound with 400 turns; determine:

(i) The Average value of e.m.f in the secondary winding.

(ii) Change in flux.

A total of 387 students (100%) attempted this question. Analysis indicates that 335 (86.6%) of the students scored from 0 to 2 marks; 49 (12.6%) scored from 3 to 5.5 marks; and 3 (0.8%) scored 7 marks. No student scored full marks for this question. Generally, their performance on this question was poor. Table 5 summarizes the students' performance on this question.

Table 5: Student's Performance in Question 8

Scores	Number of Students	Percentage (%)	Remarks
0-2	335	86.6	Weak
3-5.5	49	12.6	Average
7	3	0.8	Good
Total	**387**	**100**	

The analysis shows that the overall performance on this question was poor because only 52 (12.6%) of them scored from 3 to 7 marks. Most of the students failed to analyze the relationship between the magnetic field and electric current in part (a) and apply the incorrect formula to calculate the values of the required parameters in part (b). For example, in responding to

part (a), one of the students mentioned electrical appliances that operate depending on the magnetic effect, such as electric bells and loudspeakers. Likewise in part (b) (i), another student used the formula for work done $\left[E=\frac{Ld}{t}\right]$ instead of the formula for the average value of e.m.f in the secondary winding, which is given by $\left[E=M\frac{\Delta l}{\Delta t}\right]$.This indicates that students had insufficient knowledge about the topic of *Magnetism and Electromagnetism*. Extract 8.1 is a sample of such responses.

8. (a) Analyze three relationships between magnetic effect and electric current.

(i) In the magnetic field contain magnetic flux Their is electric current and where There is electric current

(ii) The magnetic effect is Inversely proportional to the electric current
= NBIL

(iii) In an electric current There is magnetic flux flowing (Electric current ∝ magnetic flux)

(b) You are provided with two coils P and Q which are mutually couples. The mutual inductance between two coils is 0.24 H and the current in the primary winding increases from 0.2A to 0.6A in 10 msec. If the secondary coil Q is wound with 400 turns; determine;

(i) the average value of the e.m.f in the secondary winding.

$$\text{E.m.f} = \left(\frac{0.24}{0.6-0.2}\right) 400$$

$$= \frac{0.24}{0.4} \times 100 = \left(\frac{24}{40}\right) 400$$

$$= 240\text{V}.$$

∴ The Average value of E.m.f is 240V.

(ii) change in flux.

Change in flux = (0.6A − 0.2A) no of turns

$$= (0.4) \times 400$$

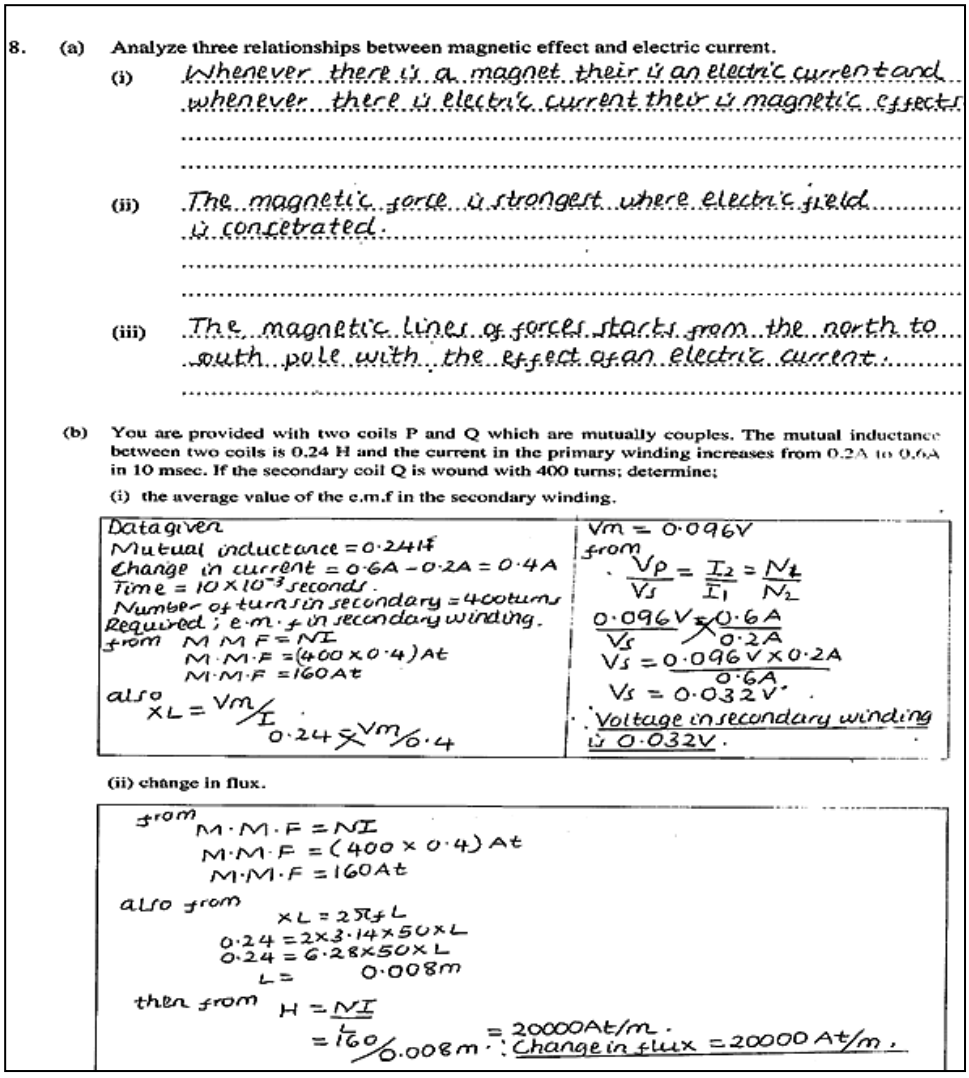
$$\therefore \Delta \text{ in flux} = 160$$

Extract 8.1*:* A sample of the incorrect responses to Question 8

Extract 8.1 shows that, in part (a), the student constructed sentences by using terms from the topic of *Magnetism and Electromagnetism* which is contrary to the demand of the question. The student provided the incorrect

formulae to calculate the average e.m.f in (b) (i) and the change in flux in (b) (ii). This indicates that the student lacked knowledge of the concept magnetism.

However, 0.8 per cent of the students who had satisfactory performance provided the correct responses to some items of the question; hence, they scored 7 out of the 10 marks allotted. This indicates that they had partial knowledge about the concepts of *Magnetism and Electromagnetism* as shown in Extract 8.2.


8. (a) Analyze three relationships between magnetic effect and electric current.

(i) Whenever there is a magnet their is an electric current and whenever there is electric current their is magnetic effects

(ii) The magnetic force is strongest where electric field is concetrated.

(iii) The magnetic lines of forces starts from the north to south pole with the effect of an electric current.

(b) You are provided with two coils P and Q which are mutually couples. The mutual inductance between two coils is 0.24 H and the current in the primary winding increases from 0.2A to 0.6A in 10 msec. If the secondary coil Q is wound with 400 turns; determine;

(i) the average value of the e.m.f in the secondary winding.

Data given
Mutual inductance = 0.24H
Change in current = 0.6A − 0.2A = 0.4A
Time = 10×10^{-3} seconds.
Number of turns in secondary = 400turns
Required; e.m.f in secondary winding.
from M M F = NI
M.M.F = (400 × 0.4) At
M.M.F = 160At
also $X_L = V_m / I$
$0.24 = V_m / 0.4$

$V_m = 0.096V$
from $\frac{V_p}{V_s} = \frac{I_2}{I_1} = \frac{N_1}{N_2}$
$\frac{0.096V}{V_s} = \frac{0.6A}{0.2A}$
$V_s = \frac{0.096V \times 0.2A}{0.6A}$
$V_s = 0.032V$.
∴ Voltage in secondary winding is 0.032V.

(ii) change in flux.

from M.M.F = NI
M.M.F = (400 × 0.4) At
M.M.F = 160At
also from $X_L = 2\pi f L$
$0.24 = 2 \times 3.14 \times 50 \times L$
$0.24 = 6.28 \times 50 \times L$
$L = 0.008m$
then from $H = \frac{NI}{L}$
$= 160 / 0.008m = 20000At/m$.
∴ Change in flux = 20000 At/m.

Extract 8.2: A sample of the correct responses to Question 8

Extract 8.2 shows that the student responded correctly to part (a) but failed to calculate the required parameters in part (b).

2.2.7 Question 9: Workshop Practice

This question required the students to identify the given symbols found in electrical drawings and give the purpose of each symbol.

A total of 387 (100%) students attempted this question. Among them, 209 (54.0%) scored from 0 to 2.5 marks; 164 (42.4%) scored from 3 to 6.5; marks and 14 (3.6%) scored from 7 to 8.5 marks. The students' performance on this question was average since 178 (46.0%) of them scored from 3 to 8.5 marks. Table 6 summarizes their performance.

Table 6: Student's Performance on Question 9

Scores	Number of Students	Percentage (%)	Remarks
0-2.5	209	54.0	Weak
3-6.5	164	42.4	Average
7-8.5	14	3.6	Good
Total	**387**	**100**	

Their average performance on this question was because 178 (46.0%) of the students scored from 3 to 8.5 marks. These students correctly responded to some of the items and incorrectly responded to a few items. Extract 9.1 is the sample of correct responses from one of the students.

9. Suppose you are required to do wiring of a house and you are provided with electrical drawings. Identify the following symbols found in the electrical drawings provided and give the purpose of each symbol.

(a) 

(a) One way switch two gang.
· Used in wiring circuit to controll the electrical-
Consumers either on or off.

(b) 

· Joining cables. It is used where two or more-
wires are joining to each other.

(c) 

· Incascent lamp.
· Itis used for emiting lighting.

(d) 

· Socket outlet.
· used in wiring circuits for diffesent purposes e.g.-
to provide electricity which dispated by source to the consu-
mmers.

(e) 

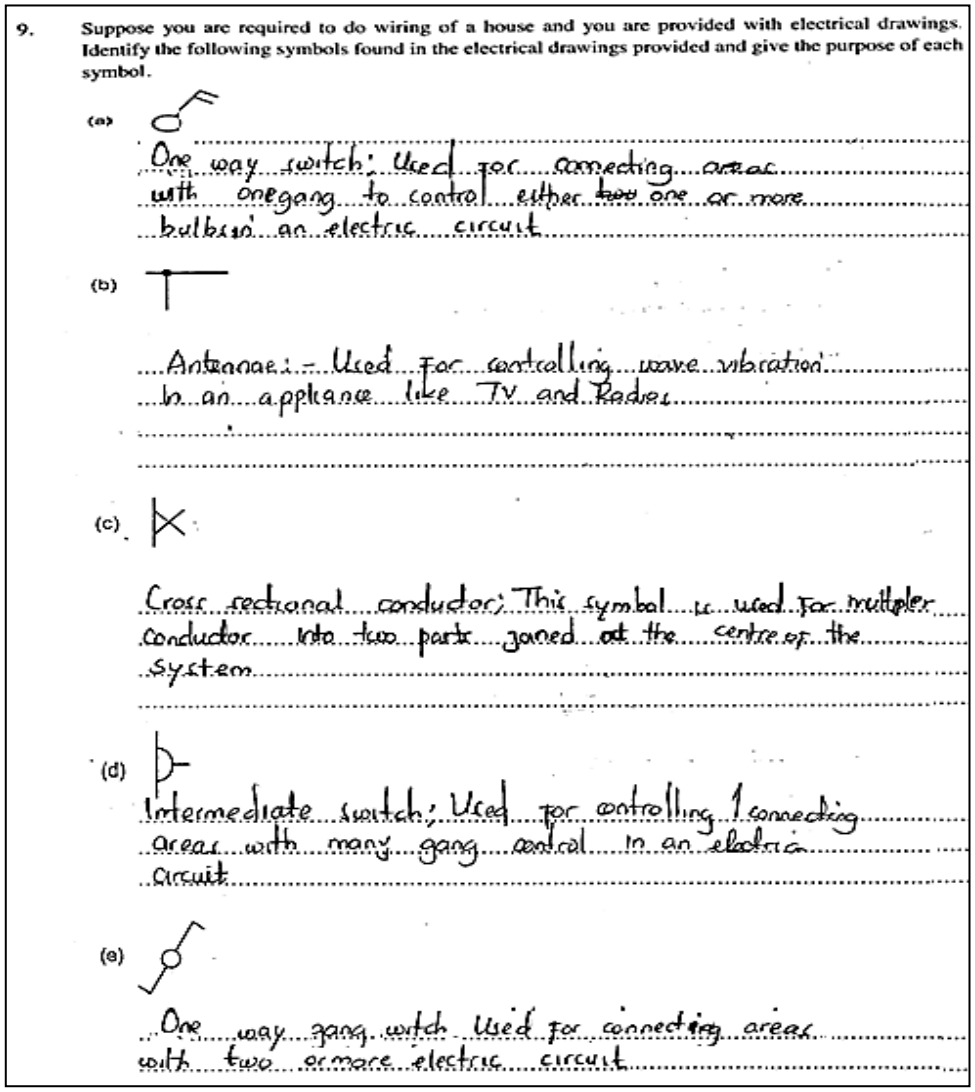
· two way switch one gan.
· used to controll a circuit on or off with two-
ways.

Extract 9.1: A sample of the correct responses to Question 9

In Extract 9.1, the student provided correct responses to parts (a), (c), (d) and (e) and correctly identified the symbol in (b); however, he/she failed to give its purpose. Nevertheless, the student demonstrated sufficient knowledge about electrical symbols and their applications.

Moreover, analysis indicates that 209 (54.0%) of students performed poorly. Among them, 10.6 per cent scored zero since they could neither identify symbols nor provide their purposes. Some of these students confused names and purposes of symbol in (a) with the one in (e) because the two symbols partly resemble. This indicates that these students acquired

little knowledge about electrical symbols and their applications. Extract 9.2 is a sample of the incorrect responses by one of the students.



9. Suppose you are required to do wiring of a house and you are provided with electrical drawings. Identify the following symbols found in the electrical drawings provided and give the purpose of each symbol.

(a)

One way switch; Used for connecting areas with onegang to control either two one or more bulbsin an electric circuit

(b)

Antennae:- Used for controlling wave vibration in an appliance like TV and Radio

(c)

Cross sectional conductor; This symbol is used for multiple conductor into two parts joined at the centre of the system

(d)

Intermediate switch; Used for controlling 1 connecting areas with many gang control in an electric circuit

(e)

One way gang witch Used for connecting areas with two or more electric circuit

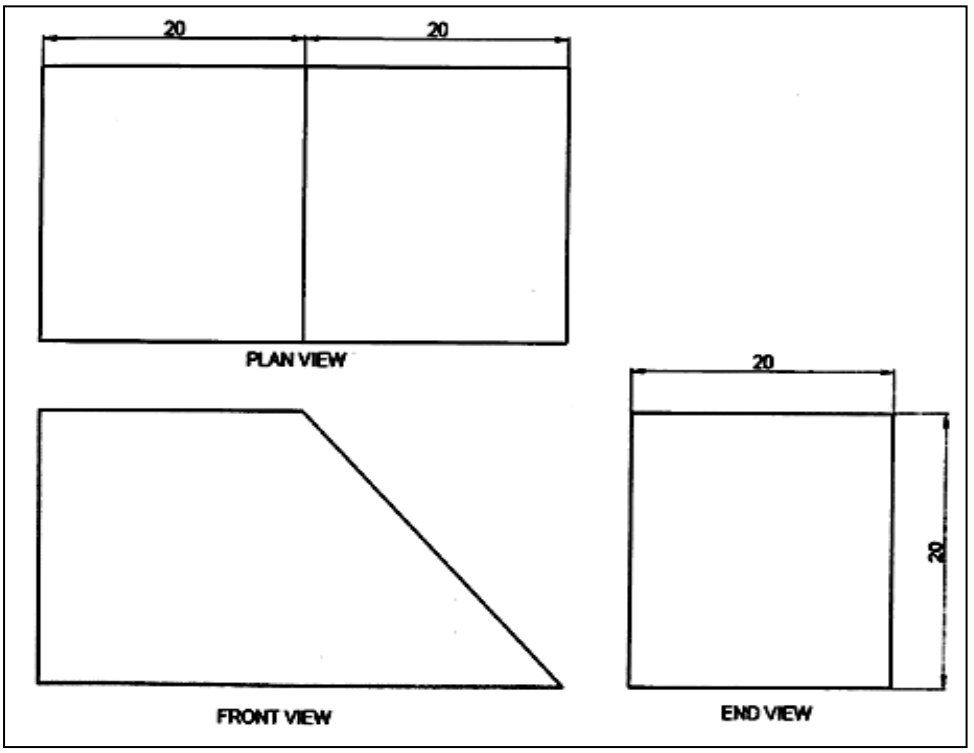
Extract 9.2: A sample of the incorrect responses to Question 9

In Extract 9.2, the student wrongly identified the symbols and provided incorrect purposes of each item. The student seemed to lack knowledge and practical skills in electric symbols and their applications.

2.3 SECTION C: STRUCTURED QUESTION

2.3.1 Question 10: Electrical Draughting

The question provided the students with an object represented in three different views: *Plan view*, *Front view* and *End view* drawn in third angle projection. It required them to construct an isometric drawing of the object in full size from the given views. All dimensions were in mm, construction lines were not to be erased and all drawings were to be neatly shown.



This question was attempted by 387 100%) students. Analysis indicates that 206 (53.2%) of the students scored from 0 to 4 marks; 89 (23.0%) scored from 4.5 to 9 marks; and 92 (23.8%) scored from 10 to 15 marks. Figure 6 summarizes their overall performance on the question.

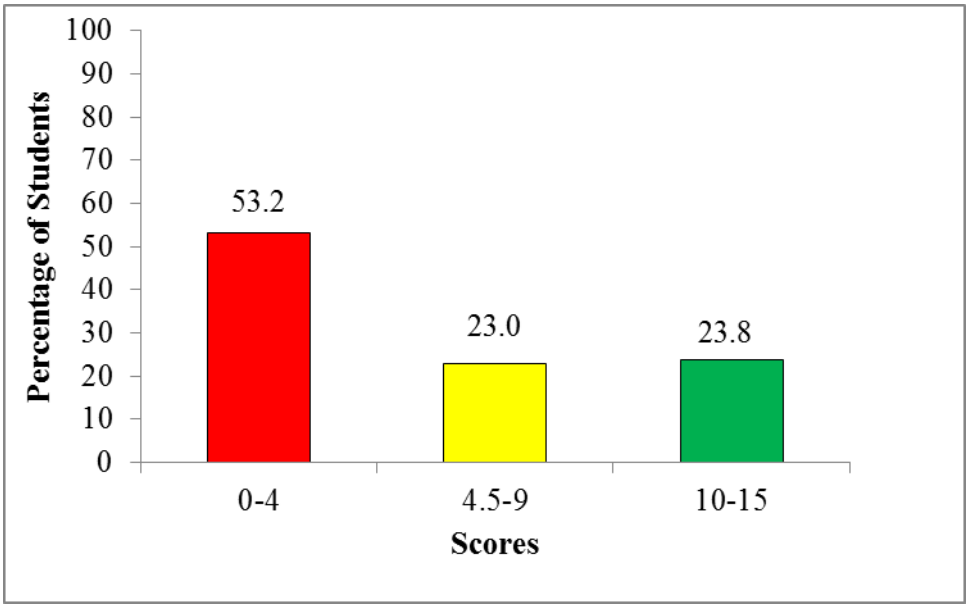
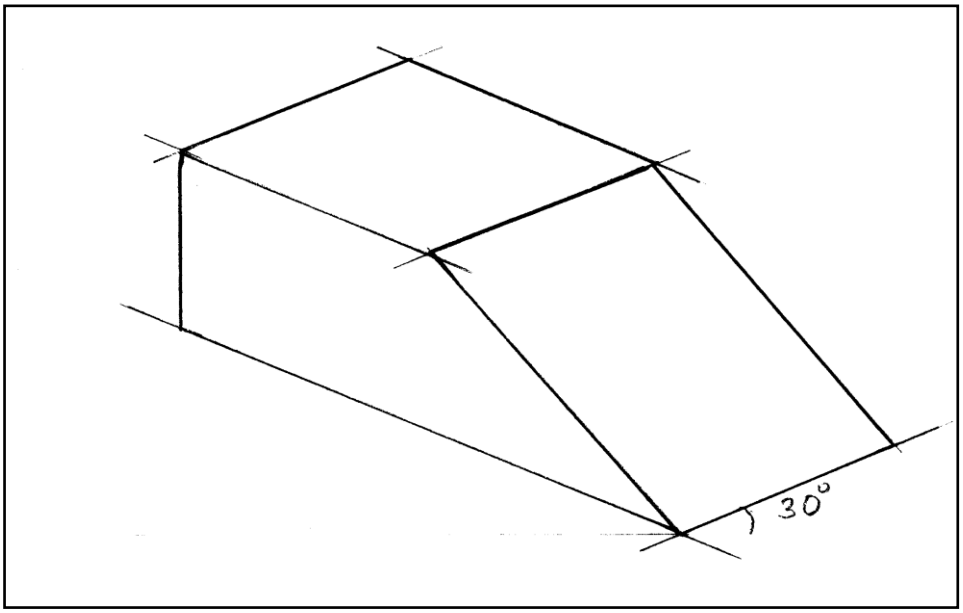


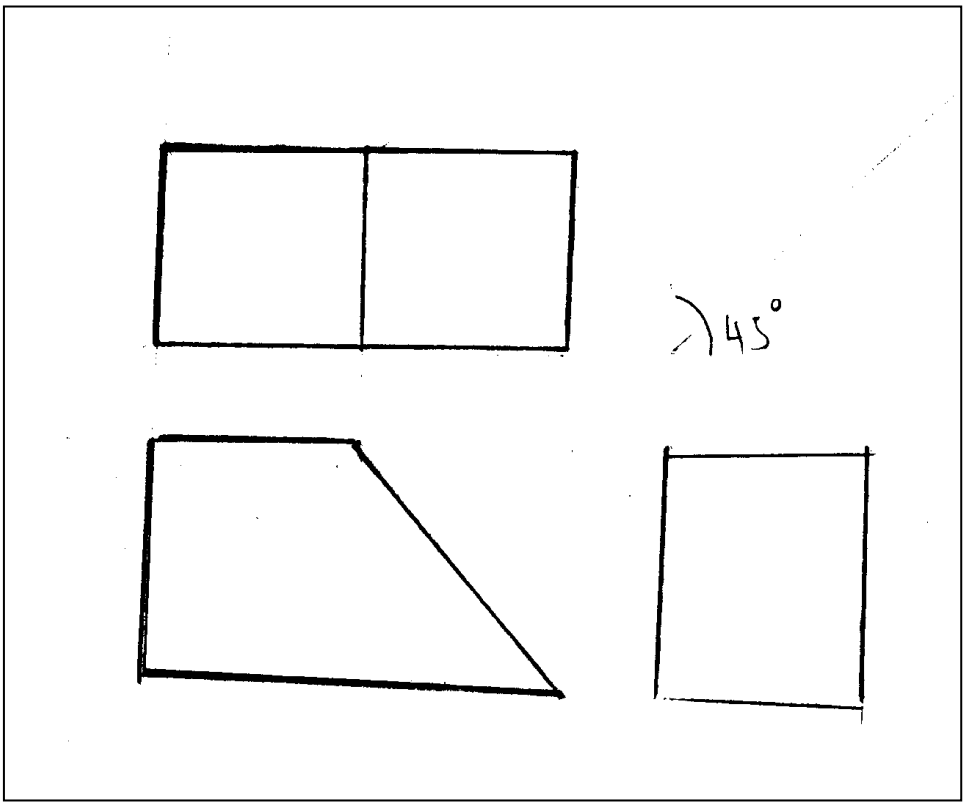
Figure 6: *Students' Performance on Question 10*

Figure 6 shows that the overall performance on this question was average because 181 (46.8%) passed. Most of the students correctly constructed the isometric drawing of the object in full size. Some of them presented the drawing in first angle projection. Extract 10.1 is the sample of correct responses by one of the students.



Extract 10.1: A sample of the correct responses to Question 10

Nevertheless, some students had weak performance on this question as they failed to produce the views in full size scale using isometric drawing. Some of these students presented the object using an oblique drawing as they set the object at 45 degrees instead of 30 degrees. Besides, one of the students drew just the cube in oblique (45º) presentation. This indicates that the students had partial knowledge and lacked enough exercises on pictorial drawing and orthographic projection. Hence, they failed to interpret and convert the given views as required. Extract 10.2 is illustrative.



Extract 10.2: A sample of the incorrect responses to Question 10

In Extract 10.2, the student redrew the three given views instead of constructing an object in the isometric projection. This student lacked practical skills in interpreting and converting views to an object.

3.0 STUDENTS' PERFORMANCE ON EACH TOPIC

The analysis of the students' performance on the topics which were assessed in the Electrical Engineering subject for the year 2022 indicates that the students performed well on *Electricity* (83.2%) tested in Question 6, *DC Circuit* (75.5 %) tested in Question 4, and *Cells and Batteries, DC Circuits, Electrical Workshop Orientation, Electrical Draughting, Workshop Practice, Instruments and Measurements, Magnetism and Electromagnetism, Units* and *Electrical Engineering, Science and Technology* (71.3%) tested in Question 1 which comprised 10 multiple choice items. The good performance on these topics signifies that the students had enough knowledge, skills and competence in the concepts included in the assessment. It also shows that they had ability to follow the required assessment instructions and identify the demands of the questions. They also had good mastery of the subject matter.

The topics on which the students had average performance were *Cells and Batteries* (51.9%), *Electrical Drawing* (51.8%) and *Workshop Practice* (46.0%). The students had such average performance on these topics because they provided fewer points than those demanded by each question. Moreover, some of them mentioned correct points without providing satisfactory explanations, mixed correct and incorrect responses and used appropriate formulae in calculations.

The students had weak performance on the topics of *Electrical Engineering, Science and Technology* (17.8%), *Magnetism and Electromagnetism* (13.4%) and *Instruments and Measurements* (4.1%).

The appendix summarizes the students' performance on each topic. The *green*, *yellow* and *red* colours are used to represent good, average and weak performances respectively.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The general performance of the students in Electrical Engineering for Form Two National Assessment (FTNA) in the year 2022 was good. Out of the 387 students who sat for the paper, 253(65.4%) passed, while 134 (34.6%) failed. Their good performance resulted from their ability to understand the demands of the questions, their knowledge, skills and competence in the subject matter, as well as their mastery on calculation skills.

The analysis shows further that the students' performance in both years remained the same (good) on the topic of *D.C circuits* and poor in the topic *Magnetism and Electromagnetism*. Conversely, the performance on the topic of *Instrument and Measurement* was good in 2021 but weak in 2022. In the topic of *Electricity*, however, the performance was weak in 2021, but good in 2022.

Several shortcomings have been revealed. These include the students' insufficient skills in responding to some of the questions, failure to understand the requirements of the questions and lack of practical skills in the topics of *Electrical Engineering, Science and Technology* and *Instruments and Measurements;* these topics were poorly performed. Another weakness observed was students' inability to apply appropriate mathematical formulae in computations as observed in the topic of *Magnetism and Electromagnetism;* which was also poorly addressed.

4.2 Recommendations:

Based on the observations made in the Students' Item Response Analysis (SIRA), the following recommendations are put forward to improve the performance of Form Two students on this subject.

(a) Students are advised to be keen in studying in order to acquire sufficient knowledge, skills and competences in the learned concepts in various topics as prescribed in the syllabus.

(b) The competence-based mode of material delivery should be practised in various topics. This will ensure that sufficient knowledge, skills, and competences are acquired and mastered by the Form Two students.

(c) Students should be guided through undertaking different computation exercises to strengthen their ability to tackle questions which require the application of formulae and calculations as observed in the topic *Magnetism and Electromagnetism*.

(d) Frequent use of drawing rooms to learn and practise on how to construct figures in different views of orthographic projection will improve students' competency in the topic of *Electrical Draughting*. Teachers should also guide the students through reading, interpreting and converting different views into the required objects.

(e) Students should be provided with hand-on workshop experience using real-world instruments and equipment that can help them understand the practical applications of the concepts they are learning, particularly in the topic of *Instrument and Measurements.*

Appendix

A Summary of Students' Performance Per Topic in the Electrical Engineering Subject for the Year 2022

S/n	Topic	Question Number	Percentage of Students who Scored 30 Per cent or Above	Remarks
1.	Electricity	6	83.2	Good
2.	D.C Circuits	4	75.5	Good
3.	Cells and Batteries, DC Circuits, Electrical Workshop Orientation, Electrical Draughting, Workshop Practice, Instruments and Measurements, Magnetism and Electromagnetism, Units and Electrical Engineering, Science and Technology.	1	71.3	Good
4.	Cells and Batteries	3	51.9	Average
5.	Electrical Drawing	5 & 10	51.8	Average
6.	Workshop Practice	9	46.0	Average
7	Electrical Engineering Science and Technology	2	17.8	Weak
8.	Magnetism and Electromagnesm	8	13.4	Weak
9	Instruments and Maesurements	7	4.1	Weak