THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

STUDENTS' ITEMS RESPONSE ANALYSIS REPORT ON THE FORM TWO NATIONAL ASSESSMENT (FTNA) 2023

ENGINEERING SCIENCE

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) 2023

035 ENGINEERING SCIENCE

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

TABLE OF CONTENTS

FOREWORD

This report presents analysis of Student's Items Response Analysis (SIRA) on the Form Two National Assessment (FTNA) for Engineering Science subject held in November 2023. The report presents the feedback to educational stakeholders on the performance and the challenges students faced while attempting assessment questions.

The Form Two National Assessment (FTNA) is a formative evaluation used to monitor student's learning and to provide feedback that teachers, students and other education stakeholders can use to improve teaching and learning process.

The analysis presented in this report aims to contribute towards understanding the possible reasons behind the students' performance in Engineering Science subject. The report highlights the factors that significantly contributed to the student's good performance in some questions. These factors include the ability to identify the task of the questions, follow instructions and understand the concept related to the subject matter. In contrast, the students with weak performance faced challenges such as inadequate knowledge and skills on the assessed topics, lack of mathematical skills and failure to interpret the tasks and demonstrate their drawing skills on the questions.

The National Examinations Council of Tanzania (NECTA) expects that the recommendations provided in this report will help various education stakeholders, school managers, teachers and students to enhance teaching and learning as well as students' performance in future assessments.

The Council would like to express its sincere appreciation to all who were involved in processing the statistical data that have been used in the preparation of this report.

Dr. Said A. Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents the analysis of students' performance who sat for the Form Two National Assessment (FTNA) 2023 in Engineering Science subject. The report highlights the strength and weaknesses observed to some of the students in attempting the assessment questions.

The assessment for Engineering Science was divided into three sections, A, B and C, consisted of ten (10) questions. Section A comprised of two objective questions. The first question had ten (10) multiple-choice items, each carrying 1 mark. The second question had five (5) matching items, each carrying 1 mark.

Section B consisted of seven (7) short answer questions, each carrying ten (10) marks. In addition, Section C had one structured question carrying (15) marks. Students were required to answer all questions.

The report evaluates the performance of students in each question. The performance is classified as weak, average and good if student's marks range between 0-29, 30-64 and 65-100 per cent indicated by red, yellow and green colors respectively. Samples of students' responses are inserted to represent good, average and weak cases. Moreover, graphs and charts have been used to summarize the students' performance on each question. Finally, the report includes an appendix that shows the overall performance of students for each question and drew conclusion and recommendations that might help to improve students' performance in the future assessments.

In 2023, a total of 1,889 students sat for the Engineering Science assessment. Among them, 1122 (59.4%) students passed and 767 (40.6%) students failed. This shows a significant improvement of 12.37% compared to the previous year 2022 where 855 (47.03%) students passed and 963 (52.97%) students failed. Figure 1 illustrates the grades achieved by the students in the two consecutive years 2022 and 2023.

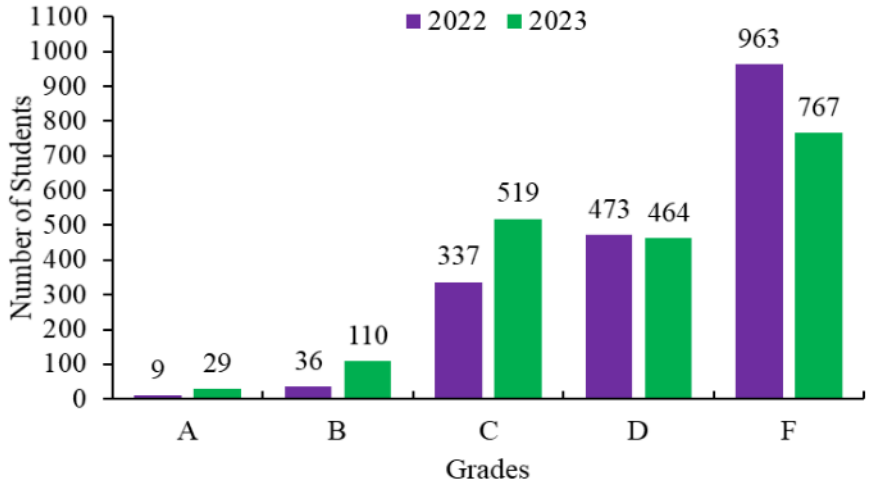


Figure 1: Comparison of Students' Performance in 2022 and 2023

Figure 1 illustrates an increase in the number of students who scored grades A, B, and C in 2023 compared to 2022. However, many students scored grades D and F in both years.

2.0 ANALYSIS OF THE STUDENTS' RESPONSES IN EACH QUESTION

This section describes what was expected in each question, the statistical analysis based on students' performance and figures showing the summary of students' performance based on the score intervals. The section further provides reasons for the students' success and failure to respond to each assessment item and samples of correct and incorrect responses to support the addressed strengths and weakness shown by different students when attempting the questions.

2.1 SECTION A: Objective Questions

Section A had two questions 1 and 2. Question 1 consisted of 10 multiple-choice items each carrying (1) mark. Question 2 had 5 matching items each carrying one (1) mark. This section had a total of fifteen (15) marks. The analysis of each question is as follows:

2.1.1 Question 1: Multiple Choice Items

This question had 10 items, (i) to (x). The topics, which were covered in this question were *Measuring instruments, Friction, Fluid Mechanics, Work, Energy and Power, Simple Machine, Turning Effect of a Force, Linear*

Motion, Heat (Part two) and *Light*. The question required the students to choose the correct answer from among the given alternatives and write its letter in the box provided.

A total of 1889 students attempted this question whose scores were as follows: 256 (13.55%) scored from 0 to 2 marks, 1393 (73.74%) scored from 3 to 6 marks while 240 (12.71%) scored from 7 to 10 marks. These scores show that the general performance in this question was good because 1633(86.45) per cent of the students scored the pass mark or above. Figure 2 presents a summary of students' performance.

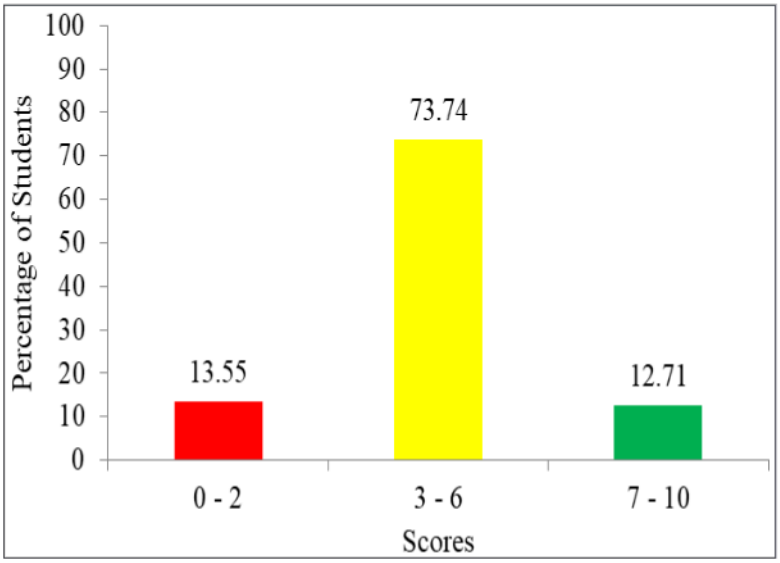


Figure 2: The Students' Performance in Question 1

Item (i) was composed from the topic of *Measuring Instrument*. The question intended to measure student's ability in using measuring instruments. The question was:

An auto electrician wanted to measure diameter of a wire to an accuracy of 0.01cm. Which measuring instrument should be used?

A. Micrometer screw gauge *B. Vernier caliper*
C. Tape measure *D. Engineers caliper*

The correct answer was alternative B, *Vernier caliper*. The students who chose this option understood that, the Vernier

caliper is an instrument that can measure an accuracy of 0.1mm which is equivalent to 0.01cm. However, some students chose alternative A, *Micrometer screw gauge*, because they confused between the limits of accuracy of the micrometer screw gauge which is 0.01mm and that of the Vernier caliper which is 0.01cm. Those who chose alternative C, *Tape measure*, did not understand that tape measure is an instrument used to measure distances (lengths) and large diameters.

Item (ii) was composed from the topic *Friction*. It intended to test student's ability to identify ways to minimize friction that results in heat, noise and wear. The question was as follows:

How can you minimize the friction that leads to unnecessary heat, noise and wear?

A. *By reducing the speed of rubbing surface in contact*
B. *By increasing the areas of the rubbing surface in contact*
C. *By lubricating the rubbing surfaces in contact with grease and oil*
D. *By replacing the rubbing surfaces parts with parts of graphite material*

Most of the students who attempted this item chose the correct answer C, *By lubricating the rubbing surfaces in contact with grease and oil*. This shows that they were familiar with the ways of minimizing friction. However, those who chose option A, B and D, had inadequate knowledge of friction specifically about the methods used to minimize friction between the moving parts of machines. The friction on a moving part can only be minimized by lubricating the rubbing surfaces in contact with grease and oil and not otherwise.

Item (iii) was set from the topic *Fluid Mechanics*. It intended to measure students' ability to analyze the relationship

between an up thrust acting on a body and the weight of the liquid it displaces. The question was:

A form two teacher demonstrated practically the upthrust acting on a body and the weight of a liquid it displaces. Which law was demonstrated by the teacher?

A The law of buoyancy *B The law of floatation*
C The law of sinking *D The law of submerged*

The correct response was alternative A, *The law of buoyancy*. Most of the students selected correct response because they were able to identify the relationship between up thrust acting on a body and the weight of the liquid it displaces. However, some students chose alternative C and D due to lack of knowledge of these concepts. Option B. *The law of floatation* attracted some students because they failed to interpret the distinctive conditions for a body to float.

Item (iv) was constructed from the topic '*Work, Energy and Power*. It measured students' capability to calculate the velocity of an object by using equations related to Potential energy and kinetic energy. The question was:

Magesa released an apple of mass 'm'(kg) to fall freely from a height of 'h'(m). What will be the velocity of an apple just before hitting the ground?

A. mgh *B.* $\frac{2mg}{h}$ *C.* $\sqrt{2gh}$ *D.* $\sqrt{\frac{mg}{h}}$

The correct alternative for this item was C, $\sqrt{2gh}$. The students who opted the correct response had mathematical skills to evaluate the Kinetic Energy (K.E) and Potential Energy (P.E) using the equation $K.E = \frac{1}{2}m\ v^2$ and $P.E = mgh$, respectively. Most of the students got the expression for velocity of an apple by making v the subject to the equation of $K.E = \frac{1}{2}mv^2 = P.E = mgh$ which gives $v^2=2gh$ hence $v = \sqrt{2g_h}$. However, the students who chose alternatives A, B and D lacked computational skills as they applied a wrong formula of determining kinetic energy. For

instance, one of the students used the $K.E = \frac{1}{2}mv$ which was incorrect. The correct formula to be used was supposed to be $K.E = \frac{1}{2}mv^2$.

Item (v) was set from the topic *Force*. It intended to test students' ability in applying the basic ideas of force in real life situation and ability to resolve a force into perpendicular components. The question was:

A motor vehicle mechanic set a small troll in motion on a horizontal surface by a force (F) Newtons. He pulled it by a means of a rope inclined at 30^0 to the horizontal. How would you represent the horizontal force due to force F?

A. $F\ x\ Cos\ 30^0\ N$ *B.* $F\ x\ Sin\ 30^0\ N$

C. $F\ x\ Cos\ 60^0\ N$ *D.* $F\ x\ Sin\ 60^0\ N$

The correct response for this item was alternative A. $F\ x\ Cos\ 30^0\ N$. The students who chose the correct answer had knowledge to resolve a force into horizontal components. Moreover, they demonstrated their drawing and analytical skills to relate with trigonometric ratios in resolving a force into horizontal and vertical components. However, some students failed to score a mark due to lack of enough knowledge to find resultant force acting at a point and resolving a force into parallel and perpendicular components. In addition, they missed the concept of trigonometric ratios and Pythagoras theorem to determine sine and cosine of the given angles. On the other hand, those who chose alternative B. $F\ x\ Sin\ 30^0\ N$ and C. $F\ x\ Cos\ 60^0\ N$ were wrong because both values yield vertical component. Those who selected alternative D, F $x\ Sin\ 60^0\ N$ were wrong because the horizontal force produced act from a different direction.

Item (vi) was set from the topic *turning forces*. It intended to test students' competence on applying turning effect of a force in real life situation. The question was:

Form two students visited a school workshop to learn torque of forces. One of them was assigned to untighten a wheel nut. The student failed to untighten a nut until the teacher gave him a circular pipe. What was the circular pipe for?

A. To increase force *B. To reduce the torque*

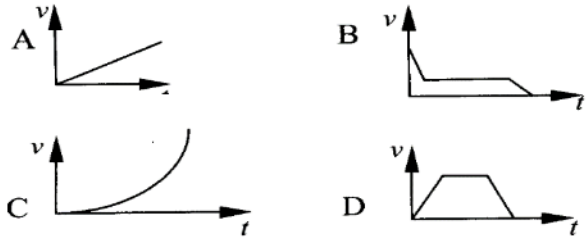
C. To reduce force *D. To increase the torque*

The correct answer was D, *To increase the torque.* Most of the students applied properly the knowledge of force in responding to the question. They understood that the turning effect of a force depends on the magnitude of force and perpendicular distance of a point from the line of action of a force. In contrast, some students chose incorrect alternative C, *To reduce force*. These students failed to recognize that the use of circular pipe has no effect on the magnitude of the force applied instead of affecting the size of the torque. A few students who chose incorrect alternatives A and B had little knowledge about turning effect of a force.

Item (vii) was set from the topic '*Linear Motion*. It intended to measure students' ability to represent and interpret graphs of motion. The question was:

In a racing car competition, a speedo meter of one racing car reads the following values of velocity 'v' in time 't' as indicated in the following table:

t(s)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
v(m/s)	0	12	24	36	48	60	60	60	60	60	50	40	30	20	10	0



Suggest velocity – time graph for the motion of the car:

The correct answer was alternative D. The students who chose the correct option had drawing skills and enough knowledge of representing the motion of a car using the graph. However, the students who chose alternatives A, B and C, lacked the proper concepts of representing the motion of the car in velocity time graph. Most of these students faced difficulty in describing the functionalities of Newton's Laws of motion for a body moving in a straight line.

Item (viii) was constructed from the topic *Heat.* It intended to measure students' competence in applying both kinetic theory of matter and gaseous laws in real life situation. The question was:

A person left his car on a full sunlight in a parking lot and went shopping. He came back and found out that the pressure of air inside a car tire is increased. What caused a change of the tyre pressure?

A Size of air molecules *B Number of air molecules*
C Speed o fair molecules *D Mass of air molecules*

The correct response for this item was alternative C. *Speed of air molecules*. Most of the students selected correct response. This suggests that they had adequate knowledge on the concept of kinetic theory and gaseous laws. Some of the students chose alternatives A, *Size of air molecules* which was incorrect. The students in this category misinterpreted size of air molecules and speed of air molecules. However, the students who chose other incorrect alternatives B and D failed to interpret the mechanism of gas laws and the movement of particles (air molecules) based on kinetic theory of matter.

Item (ix) was set from the topic '*Simple machine*. It intended to assess students' ability to interpret the concept of simple machine as applied in hydraulic press. The question was as

follows:

A man uses a hydraulic press to lift a container. If the hydraulic press is frictionless, what will be the mechanical advantage of the press?

A Greater than velocity ratio *B Equal to velocity*

C Small than velocity ratio *D Twice than velocity ratio*

The correct option for this item was alternative B, *Equal to velocity ratio.* The students who chose the correct answer had ability to describe Mechanical Advantage, Velocity Ratio and Efficiency of a simple machine. They understood that when a machine is frictionless, its efficiency is exactly 100%. Other students responded wrongly by choosing incorrect responses; A, C, and D. The students in this category had inadequate knowledge about the relationship between Mechanical advantage, Velocity ratio and Efficiency.

Item (x) was set from the topic of *Light.* It tested the students' ability to analyze features of images formed in pinhole camera. The question was as follows:

A student was studying the properties of images formed in a pinhole camera. When he places a candle several centimeters from the hole of the camera, a very small image was produced on the screen of the camera. Suggest the adjustment that can be made on the camera or box to produce a magnified image on the screen.

A To move the candle away from the pin hole

B To move the box away from the candle

C To move the box closer to the candle

D To make the hole larger than the pin hole

The correct response was alternative C, *To move the box closer to the candle*. Analysis of data reveals that, most of the students chose the correct answer. This might be due to adequate knowledge on the characteristics of the image formed on a pinhole camera that, in order to magnify image

the camera box must be closer to the object. However, some students opted for incorrect alternative A, B and D showing that they had inadequate knowledge of light specifically the concept of pinhole camera and its principle of action.

2.1.2 Question 2: Matching Items

This question comprised of five (5) items structured from the topic of Electricity. In this question, each item carried one (1) mark making a total of five (5) marks. The students were required to match each of description of terms in Electricity in List A with the corresponding concept from List B. The question was as follows:

Match the electrical parameters in list A with their corresponding components in list B by writing the letter correct response beside the item number in the table provided.

List A	List B
(i) *It allows electric current to pass through human body and metals* (ii) *It prevents serious electrical shocks.* (iii) *It prevents the quantity of electricity.* *(iv) It is a potential difference between two points.* (v) *It prevents over loading of electric circuit.*	*A An electric lamp* *B Conductors* *C Coulomb* *D Earth rod* *E Electric current* *F Fuse* *G Resistance*

There were 1889 students who attempted the question. Out of these, 440 (23.29%) scored from 0 to 1 mark, 886 (46.90%) scored from 2 to 3 marks, and 563 (29.80%) scored from 4 to 5 marks. The performance on this question was good as 1449 (76.70%) of the students scored the pass

mark or above. Figure 3 presents a summary of the students' scores.

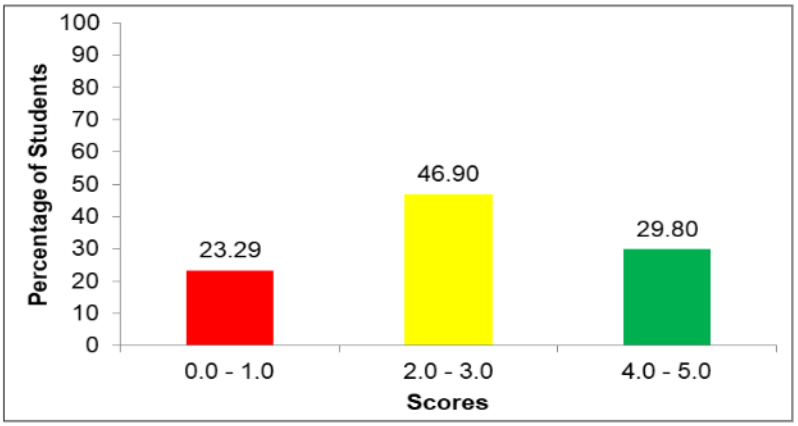


Figure 3: The Students' Performance in Question 2

The analysis of students' performance in each item is as follows:

In item (i), the students were asked to identify the correct response that matches the phrase *It allows electric current to pass through human body and metals*. The correct response was B, *Conductors*. Most of the students who matched correctly had the ability to identify the materials that allow the flow of electric current. However, a few students chose the optional response G, *Resistance*, as they had inadequate knowledge and practical skills regarding the material substances that conduct and resist the flow of electric current.

In item (ii), students were required to identify the correct response that matched the statement *It prevents serious electrical shocks*. The correct response for this matching item was D *Earth rod*. Students who chose the correct answer were able to describe the function of the earth rod. They understood that the earth rod, when buried in the ground, prevents all serious electric shocks. Other students responded incorrectly by choosing the wrong response, E *Fuse*. These students did not understand that the earth rod is a solid copper rod buried in the ground to eliminate all fault electric current and fuse is a glass container with a piece of

wire designed to disconnect the internal circuit from the power main in the event of overflow of electric current.

In item (iii), the students were required to identify the correct response which matches the statement "*It prevents the quantity of electricity"*. The correct respond for this matching item was G *Resistance.* The students who chose the correct answer had ability to describe the function of resistance. They understood that resistance is essential in order to ensure that current flows at the appropriate level in circuits. Other students responded wrongly by choosing incorrect response; H. *Voltage drop.* The students in this category had inadequate knowledge about resistance. These students did not understand that resistance is a measure of the opposition to current flow in an electrical circuit and is measured in ohms (Ω), whereas voltage drop is the amount of voltage loss that occurs through all or part of a circuit.

Item (iv), required students to identify the correct response that matched correctly with the statement *It is a potential difference between two points* The correct response was H *Voltage drop.* The students who chose the correct answer had an adequate knowledge on the concept of voltage drop. Other students responded wrongly by choosing incorrect response; F. *Fuse*. The students in this category had inadequate knowledge about voltage drop. These students did not understand that voltage drop is the amount of voltage loss that occurs through all or part of a circuit due to inherent resistance. Excessive voltage drop in a circuit can cause light to flicker or burn dimly, heaters to heat poorly and motors to run hotter than normal and burn out while a fuse is glass container with a piece of wire designed to disconnect the internal circuit from the power main in the event of overflow of electric current.

In item (v), students were required to provide correct response that matched the statement "*It prevents over loading of electric circuit"* The correct respond for this matching item was F *Fuse.* The students who chose the correct answer had ability to describe the function of a fuse.

They understood that a fuse is glass container with a piece of wire designed to disconnect the internal circuit from the power main in the event of overflow of electric current. However, a few students chose optional D. *Earth rod* The students in this category had inadequate knowledge about an electric fuse a device which is designed to melt and separate

Answer

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

in the event of overflow of electric current. Extract 2:1 is a sample of the correct responses from one student who scored good marks in this question.

Extract 2.1 A sample of a good response to Question 2

In Extract 2.1, a student correctly recognized and associated all electricity parameters in List A with their corresponding responses in List B.

However, some of the students who scored low marks (0 to 2.5) failed to write the proper parameters that correctly matches with the corresponding application in list A. Extract 2.2 is a sample of incorrect responses of a student who scored 0 marks.

Answer

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

Extract 2.2: A sample of incorrect response to Question 2

In Extract 2.2, a student failed to recognize and associate electricity parameters with their components.

2.2 SECTION B: Short Answer Questions.

This section comprised of seven (7) short answer questions which were set from the topic of *Turning effect of a force, Heat (part two), Electricity, Measurement, Simple Machines and Force*. Each question carried 10 marks, making a total of 70 marks. The scores

were categorized into three ranges: Weak (0 -2.5) marks, average (3-6.5) marks and good (7-10) marks. The analysis of each question is as follows:

2.2.1 Question 3: Turning Forces

In this question, students were required to determine the magnitude of the support and reactions at A and B. It was set from the topic of Turning forces, intended to measure students competence on sketching, labelling and applying the principle of moment to find the reactions at the points of supports. The questions was:

A uniform beam 4m long, is simply supported at two points A and B. Point A is 0.5m from left-hand end and the point B is 1.5m from the right-hand end. The beam carries loads of 600N at the left end, 800N at its centre and 400N at the right end. Determine the magnitude of the support reactions at A and B.

The question was attempted by1889 students and their scores were as follows: 1083 (57.33%) scored from 0 to 2.5 marks, 527 (27.90%) scored from 3 to 6 marks and 279 (14.77%) scored from 6.5 to 10 marks. From this data, it can be inferred that the general performance was average since 806 (42.67%) students scored the pass mark and above. The score ranges used to grade students' performance in this question are presented in Figure 4.

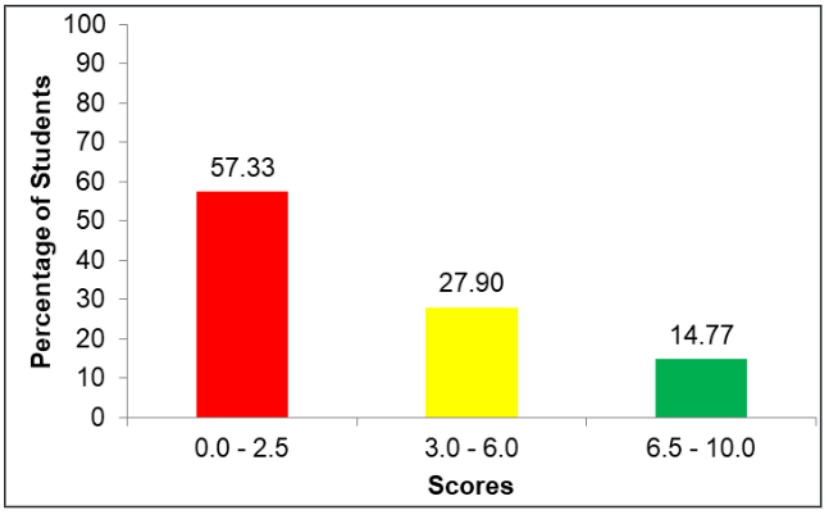
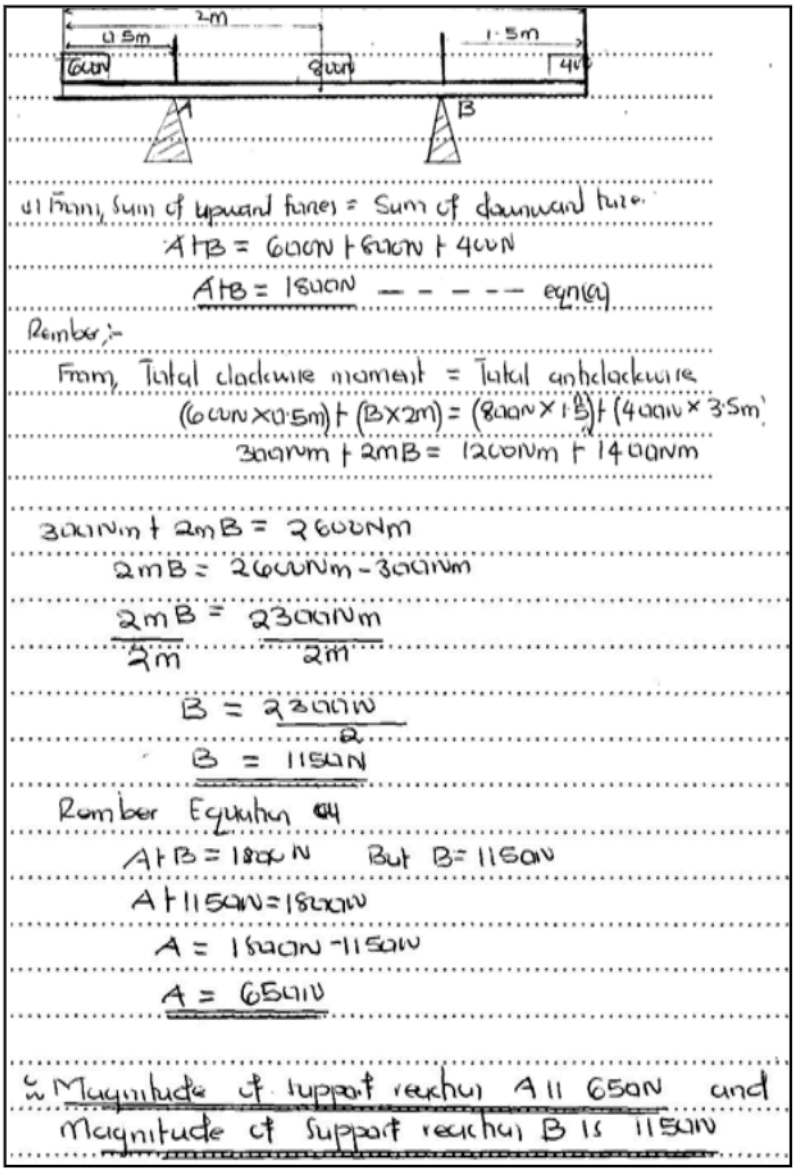


Figure 4: The Students Performance in Question 3

The students who scored from 3 to 6 marks had partial knowledge about turning forces especially the conditions for equilibrium of parallel forces. Some of them clearly sketched the free force diagram indicating the position of forces but failed to utilise the principle of moments to determine the magnitude of reactions forces at point A and B. However, a few students who performed well interpreted correctly the positions of forces and their corresponding distances on the sketched diagrams. This was because they were able to deduce the correct rotational point that balanced the beam. Furthermore, they demonstrated sufficient knowledge of the conditions for a body to be in equilibrium as; (i) Sum of clockwise moment about any point on a body is equal to the sum of anticlockwise moment about that point. (ii) The sum of forces acting in one direction must be equal to the sum of forces acting in opposite direction. The students in this category understood that the sum of upward forces should be equal to the sum of downward forces (loads) (1000 N). They were also able to use the appropriate formula to calculate the magnitude of the reaction forces at the support A and B. Extract 3.1 is a sample of students' good responses in this question.

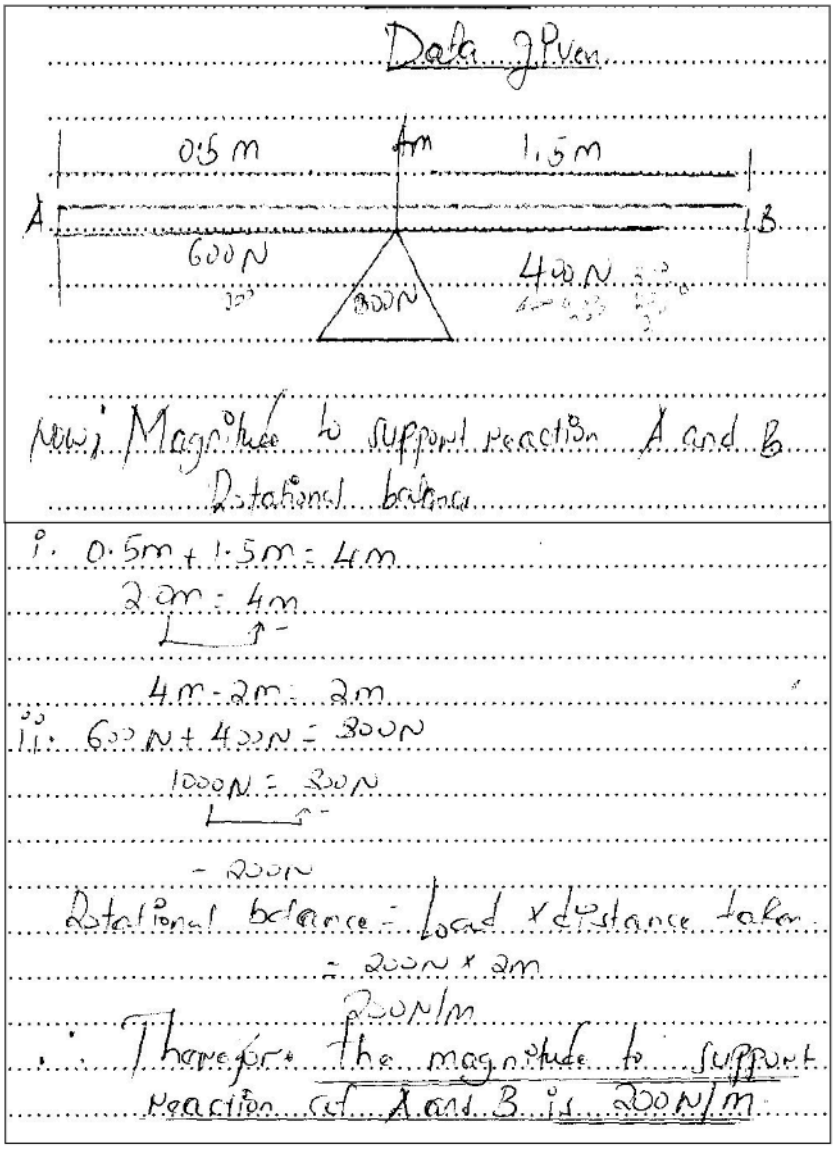


Extract 3.1: A sample of good responses to Question 3

Extract 3.1 shows responses from a student who was able to sketch clear diagram, managed to apply the principle of moments to compute the reactions at points A and B.

In contrast, the students who performed poorly were not able to calculate the reaction forces acting at the points of supports A and B of the light beam. This was contributed by poor mathematical skills and failure to apply the conditions

for the body to be in equilibrium in conjunction with the principle of moments. Extract 3.2 is a sample of students' incorrect responses in this question.



Extract 3.2: A sample of poor responses to Question 3

Extract 3.2 displays a student's work who failed to sketch, label, and write the principle of moments, leading to an inability to determine the magnitude of reactions at points A and B.

2.2.2 Question 4: Heat (Part two)

The question was constructed from the topic of *Heat (Part two)* . It intended to assess the students skills on determining the length of the tube at different conditions of temperature. The questions was as follows:

In a sugar industry the copper tubes of the boiler are 4.2m long at a temperature of 20°C. Determine the length of the tubes when:

(a) Surrounded only by feed water at 10°C.

(b) The boiler is operating and the mean temperature of the tubes rises to 320°C. Assume the coefficient of linear expansion of copper to be $17x10^{-6}K^{-1}$.

According to the data, 1889 students attempted the question. Out of these students, 1468 (77.71%) scored from 0 to 2.5 marks, 312 (16.52%) scored from 3 to 6 marks, and 109 (5.77%) scored from 6.5 to 10 marks. This suggests that the overall performance was weak since 1468 (77.71%) students scored from 0 to 2.5. The score ranges used to grade the students' performance in this question are shown in Figure 5.

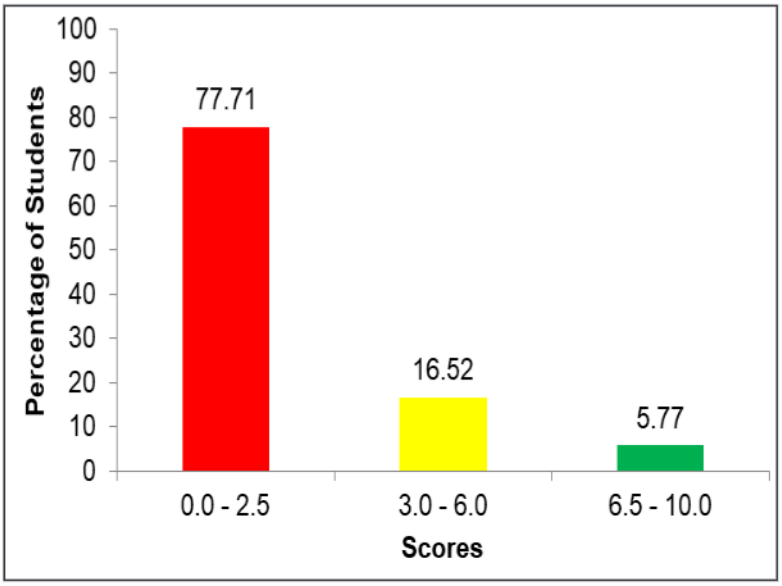
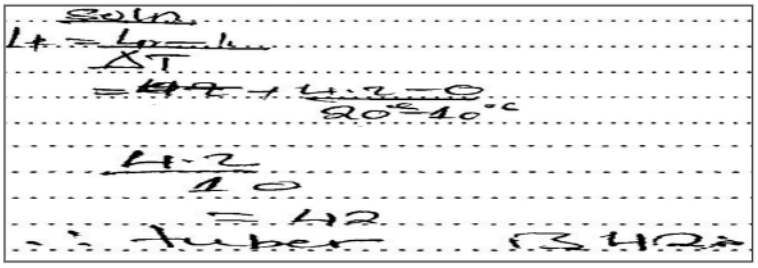


Figure 5: The Students Performance in Question 4

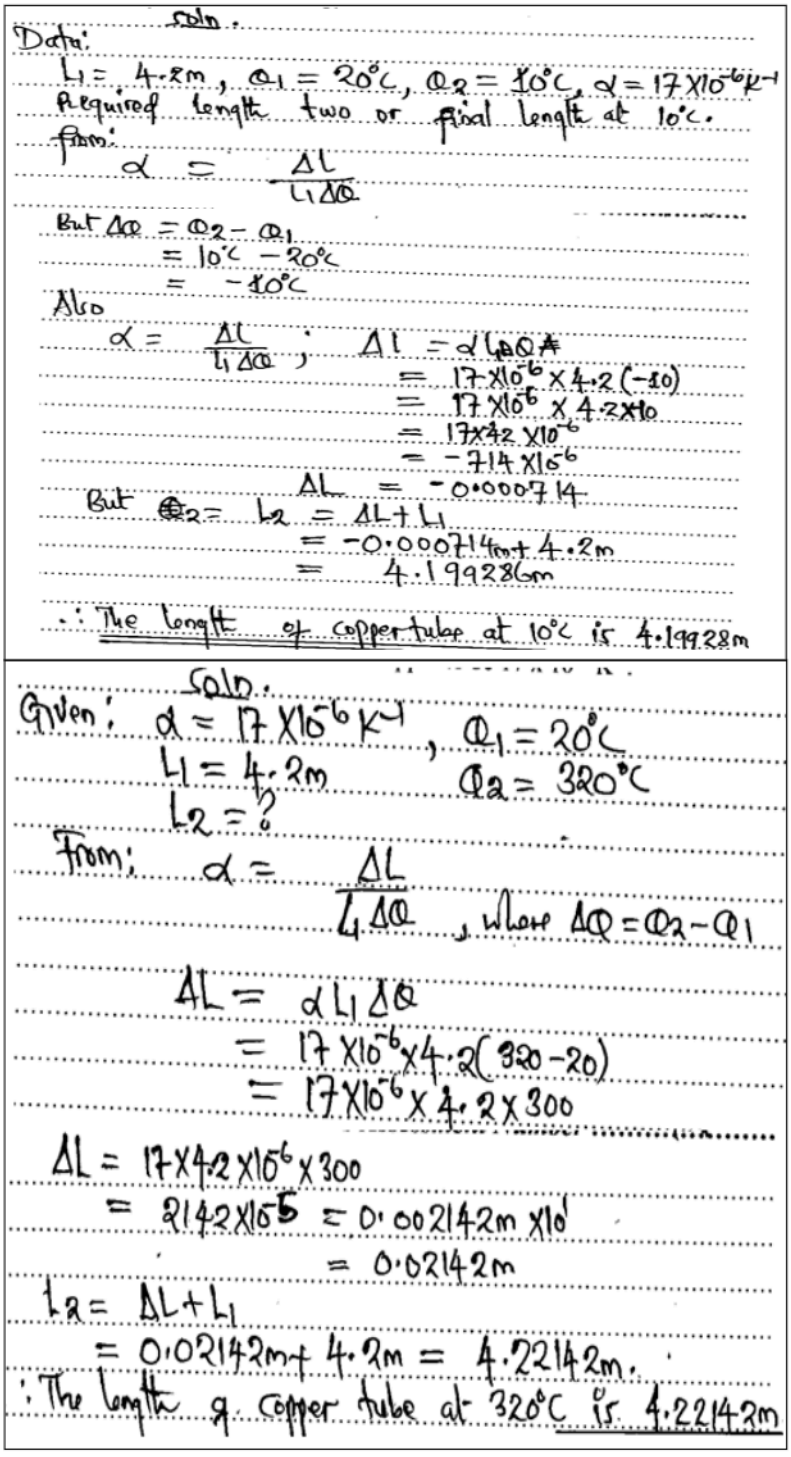
The students who scored below the pass mark (0-2.5) lacked mathematical skills to write the proper formula of thermal expansion equation. Most of the students failed to substitute the correct data given and therefore to compute the length of the tubes according to the given conditions in both parts (a) and (b). In addition, some students failed to comprehend the best way of finding the change in temperature where by adding instead of subtracting them hence obtained the incorrect value. For instance, one of the students used the formula $L = (L_0 + \alpha) + L_1$ which was incorrect. The correct formula was supposed to be; $L = L_0[1 + \alpha\Delta T]$ which on correct substitution could give the correct answer. Extract 4.1 is the sample of incorrect response of a student who scored 0 marks.



Extract 4.1: A sample of poor responses to Question 4

Extract 4.1 show responses from a student who applied the wrong formula, $L_1 = \frac{l_0 + l}{\Delta T}$ which made him/her to come up with incorrect value of length.

A certain group of students scored from 3 to 6 marks for a thermal expansion equation question. They were able to write the correct formula but failed to substitute the given data appropriately, which resulted in incorrect answers, leading to average marks. However, a small percentage of students, specifically 34 (1.8%), scored full marks. These students possessed sufficient knowledge to formulate accurate thermal expansion equations, enabling them to determine the necessary length of tubes based on the given conditions. An extract from a well-performing student's response is given in Extract 4.2.



Extract 4.2: A sample of correct responses to Question 4

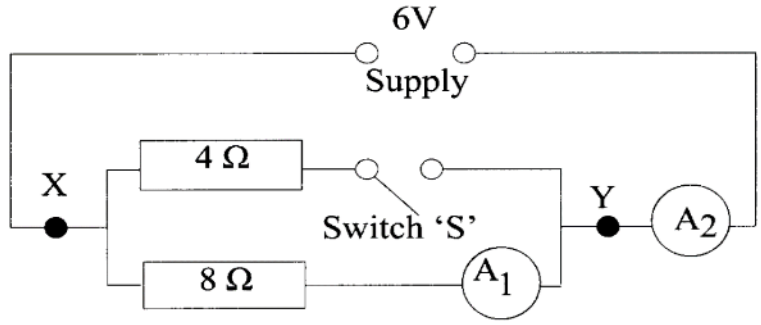
Extract 4.2 shows a response from a student who applied mathematical skills to formulate the proper thermal

expansion equation used to compute the required length of the tubes.

2.2.3 Question 5: Electricity

This question comprised of four parts (a), (b), (c) and (d). It intended to test students' knowledge on Electricity principles which are in parallel and series circuit, open and closed circuit and also to determine the value of correct flowing through A_1 and A_2. The question was:

Study careful the Figure given and answer the questions that follow:



(a) When switch 'S' is closed , will the current flowng through A_1 be less or greater than the cureent flowing through A_2?

(b) When the switch 'S' is opened , why is the current flowing through A_2 is smaller than when the switch is closed ?

(c) Why when the switch 'S' is open , the current flowing through ammeter A_1 and A_2 is the same?

(d) Calculate the equivalent resistance between point X and Y when S is closed.

Out of 1889 students, who attempted the question, Among them, 983 (52.04%) scored from 0 to 2.5 marks, 684 students (36.21%) scored from 3 to 6 marks and 222 students (11.75%) scored from 6.5 to 10 marks. Based on this data, it can be inferred that the overall performance was average since only 986 students (47.96%) scored the pass mark or above. Figure 6 provides a summary of the students' performance in this question.

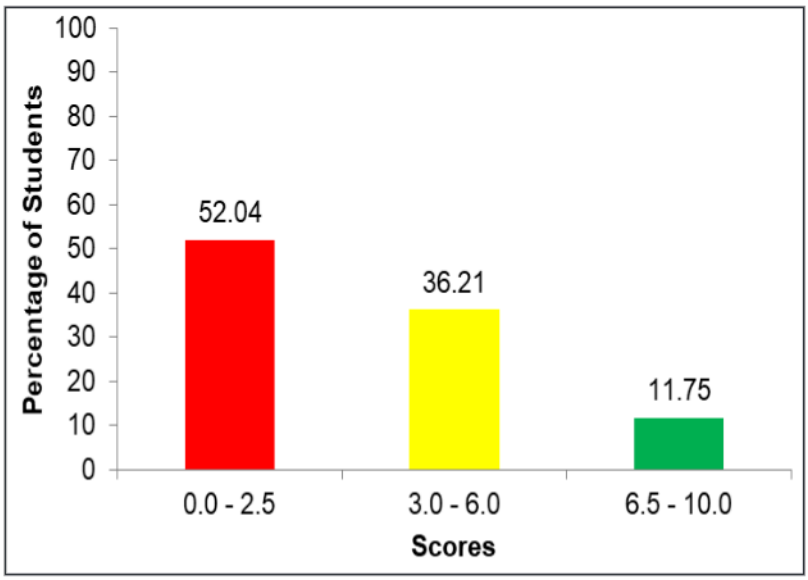
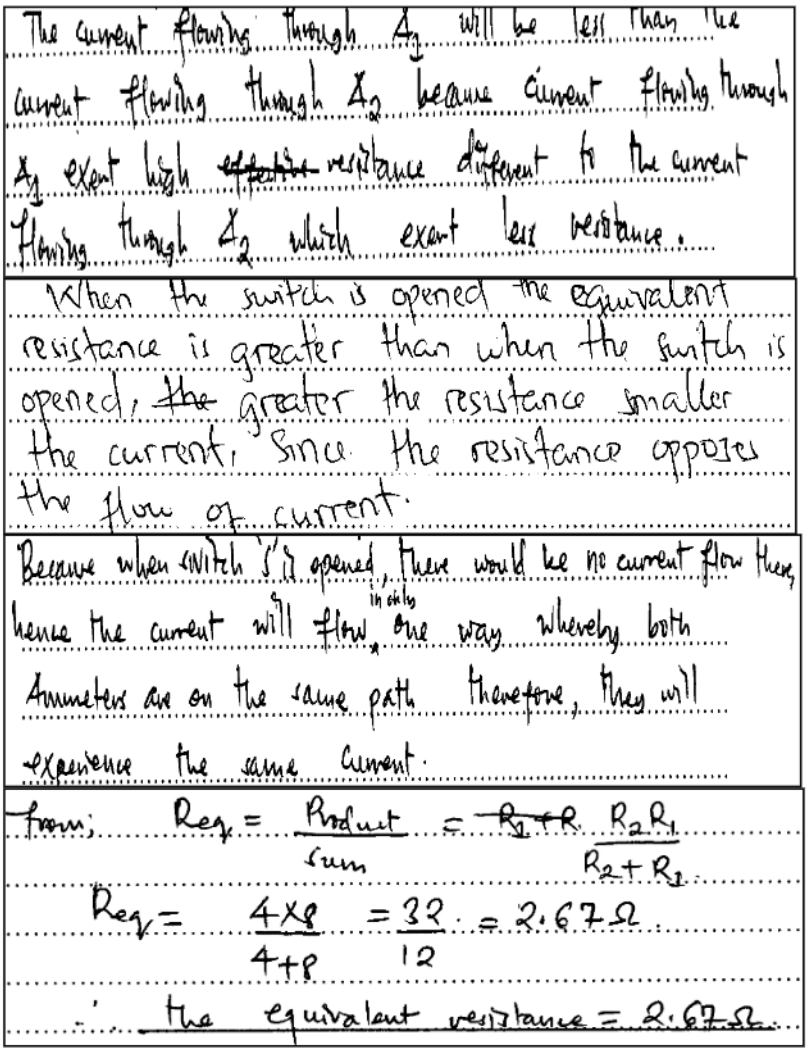


Figure 6: The Students Performance in Question 5

The students who scored average marks (3-6) understood the concept of electricity. Some of them provided the correct responses to part (a) and (b) but they failed to formulate equations for parallel and series connection of the electrical circuits, therefore to calculate the equivalent resistance between points X and Y when switch 'S' is closed. However, the students who performed well in this question had adequate knowledge of the concept of current electricity. Most of the students in this category had ability to describe and analyse electrical components given in the circuit diagram. Some of them used proper procedure to formulate equations of parallel and series connection to determine the required value of equivalent resistance. Extract 5.1 is a sample of responses from one of the students who gave the correct answer to this question.



Extract 5.1: A sample of good responses to Question 5

In Extract 5.1 student managed to answer all parts of the question correctly. This implies that the students acquired appropriate competences on the concept of current electricity.

On the other hand, the students who scored below pass mark (0 -2.5) had insufficient knowledge about the concept of electricity, specifically to analyses the behavior of the circuits when resistors are connected either in parallel or series. In part (a), most of the students who scored 0 mark failed to understand that when switch 'S' is closed according to the given circuit diagram the current flowing through A_1 will be less than the current flowing through A_2. This is

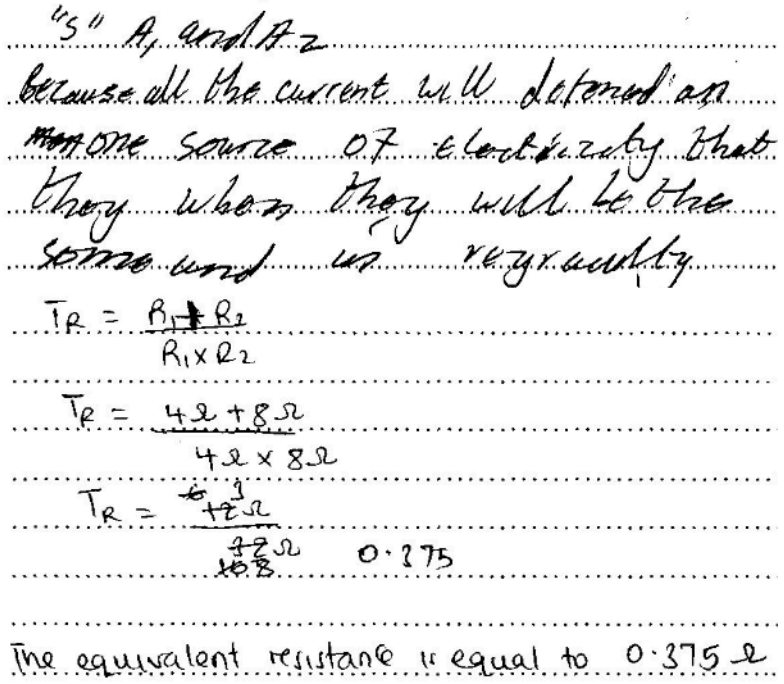
because the resistance 4Ω and 8Ω are connected in parallel, hence the currents flowing through A_2 is the sum of the current flowing via switch and that through ammeter A_1 such that its total resistance is less than the resistance of A_1

In part (b), they faced difficulty to comprehend that when switch 'S' is opened the current through ammeter A_2 will be smaller than that when the switch is closed. This happens because when the switch S is opened the effective resistance of the circuit is 8Ω which is larger than the effective resistance of the circuit (2.67Ω) when the switch is closed. Therefore, the current flowing through 8Ω will be smaller due to more resistance offered to the flow of current and finally less current will pass through ammeter A_1 and then to ammeter A_2.

Consequently, in part (c), most of the students lacked the knowledge that when switch 'S' is opened the current through ammeter A_1 and A_2 will be the same because both ammeters will experience the same flow of current due to 8Ω resistors. Moreover, in part (d), they failed to describe the process of calculating the equivalent resistance between points X and Y when switch 'S' is closed due to inadequate knowledge about series and parallel arrangement of resistors. Extract 5.2 is the sample of weak responses from one of the students.

The current flowing through A_1 will be ~~low~~ high because in A_2 has much resistance which oppose current.

Because when switch is opened there is more resistance in A_2 rather than in A_1 that is why there is small current.



Extract 5.2: A sample of weak responses to Question 5

Extract 5.2 shows a response from a student who comprehended wrongly in most parts of the question. In part (d) She applied incorrect formula $T_R = \frac{R_1 + R_2}{R_1 \times R_2}$ instead of $T_R = \frac{R_1 \times R_2}{R_1 + R_2}$ to calculate the equivalent resistance.

2.2.4 Question 6: Turning Forces

This question was divided into two parts, (a) and (b). It intended evaluate an individual's practical knowledge and abilities related to mechanical concepts, machinery, and tools. The question was as follows:

(a) Why is it recommended to use a spanner of longer stem to loosen a nut on a bolt?

(b) *The lighting gear on a vehicle body is situated 3 m from the pivot. If the body contains two loads of 15 kN and 7.5 kN whose centres of gravity are 0.8 m and 2 m respectively from the pivot, calculate the vertical force required from the gear to raise the body.*

This question was attempted by 1889 (100%) students whose scores were as follows: 1454 (76.97%) scored from 0 to 2.5 marks, 356 (18.85%) scored from 3 to 6 marks and 79 (4.18%) scored 6.5 to 10 marks. Generally, the students' performance in this question was weak as 1454 (76.97%) students scored from 0 to 2.5 marks. Figure 7 summarizes the performance of students in this question.

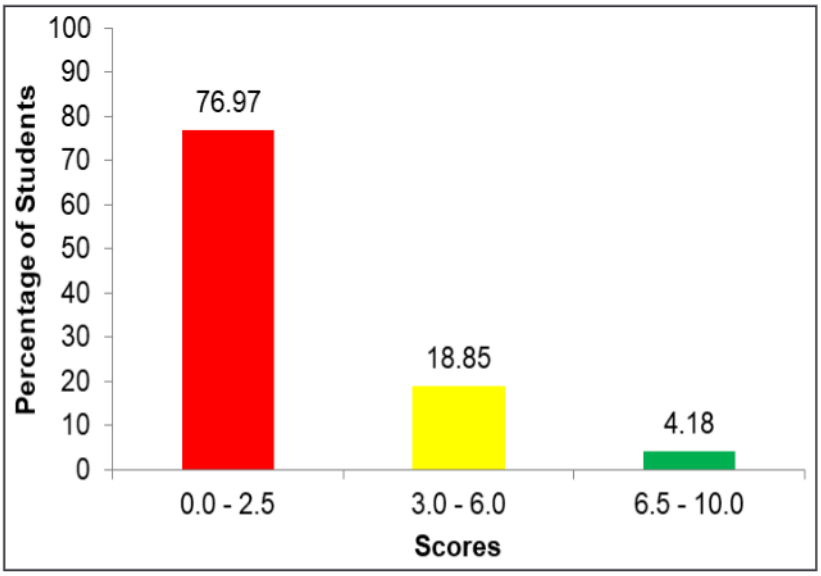
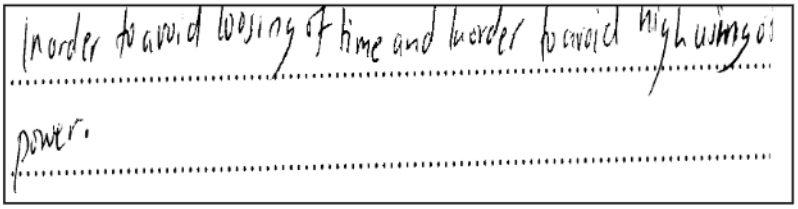


Figure 7: The Students Performance in Question 6

The students who scored below the pass mark (0-2.5) had inadequate knowledge about the concept of turning effect of force. In part (a), most of the students faced difficulty to analyses the factors on which the turning effect of force depends on, hence to explain the significance of using a spanner of longer stem to loosen a nut on a bolt. For example, one student wrote: *In order to make the spanner to be strong* while another student wrote: *To avoid the spanner to break*. These students failed to understand that turning effect of a force depends on its magnitude and

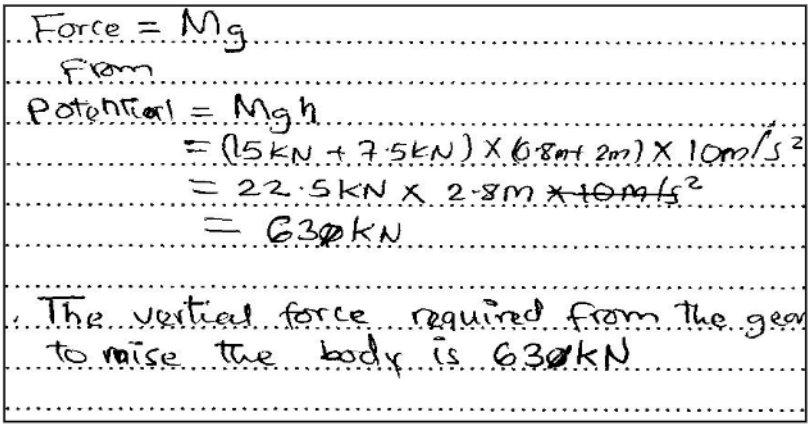
distance from the turning point. Extract 6.1 is a sample of weak responses from a student who scored zero in question 6 (a).



Extract 6.1: A sample of incorrect responses to Question 6(a)

In Extract 6.1, the student suggested employing a spanner of longer stem in order to avoid loss of high power and time, which is incorrect response based on the turning forces.

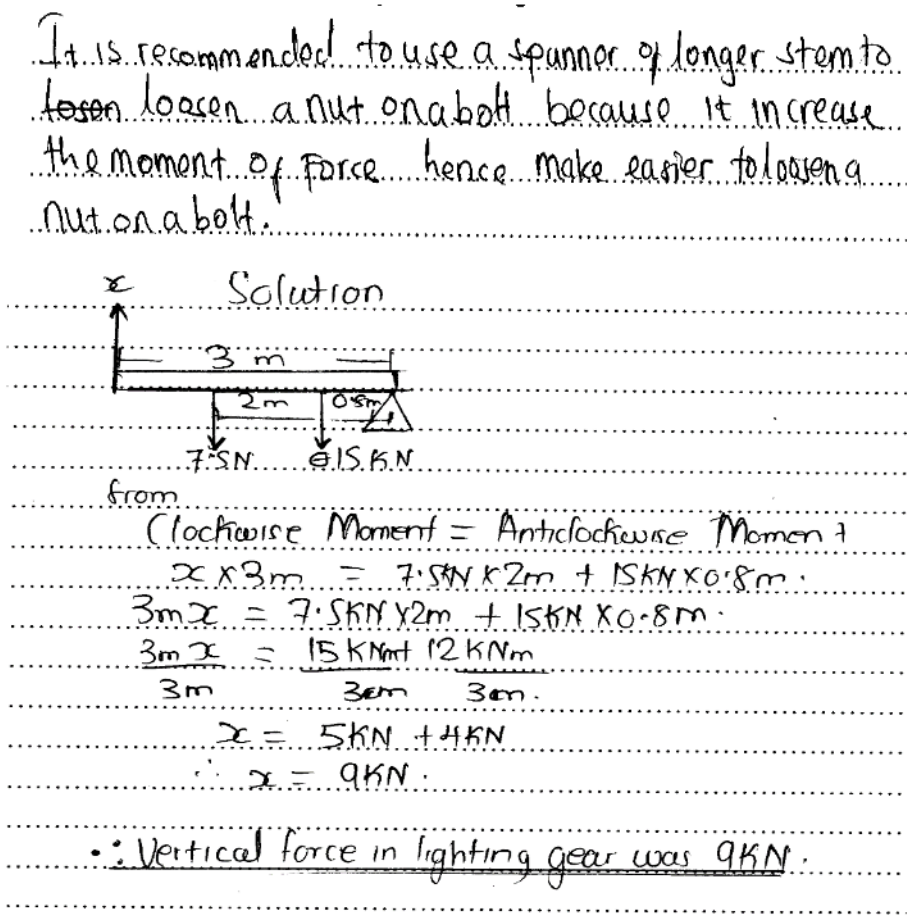
In part (b), the question aimed at assessing the ability of the student to find the reaction at the point of support. The students who performed poorly were not able to calculate the vertical force required from the gear to raise the body. This was contributed by lack of mathematical skills and failure to apply the conditions for equilibrium of parallel forces in conjunction with the principle of moments. Extract 6.2 is a sample of students' incorrect responses in question 6(b).



Extract 6.2: A sample of incorrect responses to Question 6(b)

In Extract 6.2, a student computed wrongly the vertical force required from the gear to raise the body. On the other hand, she failed to apply the principle of moments about the pivot.

However, some of students who scored average marks (3-6) managed to sketch, label and recall the principle of moment but failed to substitute correctly the data given, hence ended up with incorrect value of vertical force required to raise a body. In contrast, the students who performed well had proper knowledge of turning effect of a force. Most of the students in this category had ability to sketch, labels and formulate the required principle of moment which enabled them to calculate the required vertical force. In addition they were able to justify the purpose of using a spanner of longer stem to loosen a nut. Extract 6.3 is a sample of student's correct responses to this question.



Extract 6.3: A sample of the correct responses to Question 6

In Extract 6.3, a student responded correctly in all parts of the equation and hence scored full marks.

2.2.5 Question 7: Simple Machines

This question comprises of three parts, namely (a), (b) and (c). It intended to test students' competences on the applications and concepts of simple machines. The question was as follows:

A simple machine raises a load of 120 kg through a distance of 1.2 m. The effort applied in the machine is 150 N and it moves through a distance of 12m. Determine:

(a) The mechanical advantage.
(b) Velocity ratio
(c) The efficiency of the machine.

This question was attempted by 1889 (100%) students, of those 424 (23.13 %) scored from 0 to 2.5 marks, 381 (18.53%) scored from 3.0 to 6.0 marks and 1084 (58.34%) scored 6.5 to 10 marks. These scores suggest that the students' general performance in this question was good, since 1465 (76.87%) of them scored the pass mark or above. Figure 8 shows the performance of the students in this question.

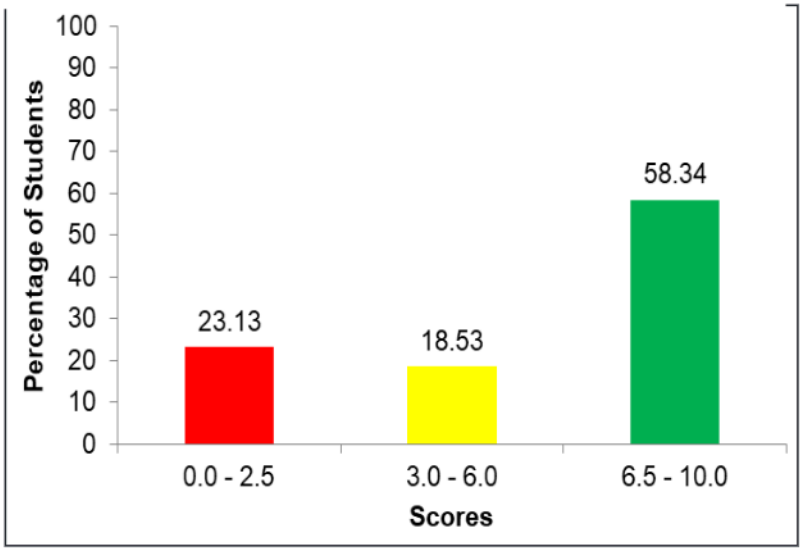
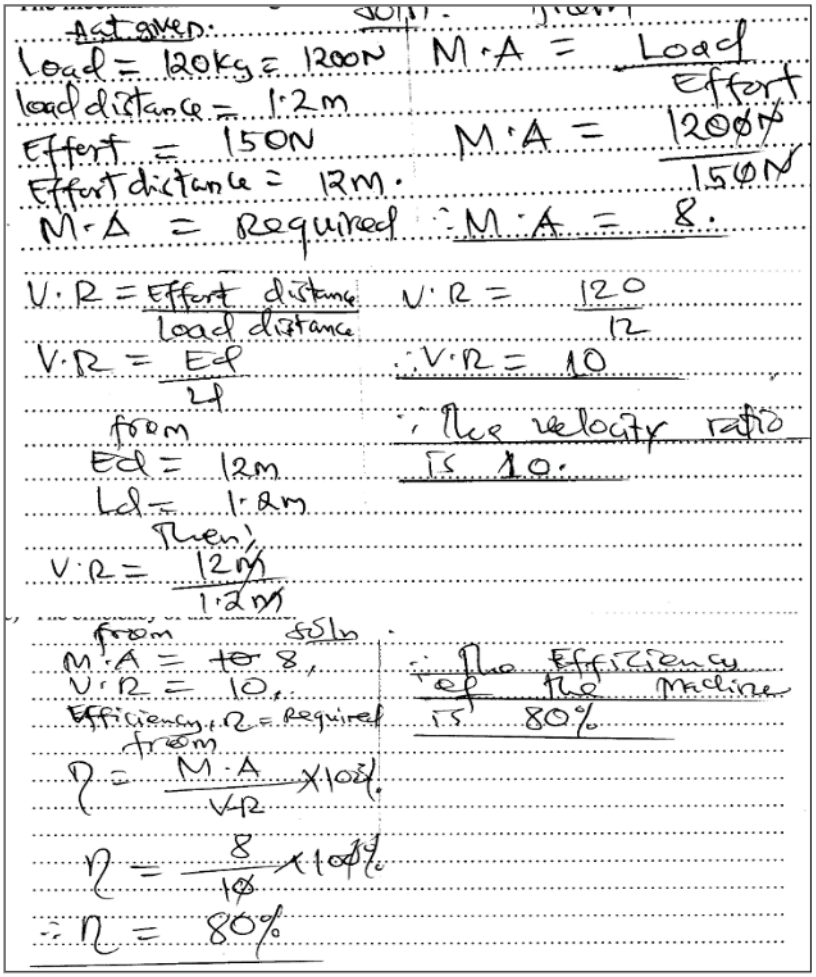


Figure 8: The Students Performance in Question 7

The students who scored high marks had ability to write the correct formulae which led them to compute mechanical

advantage, velocity ratio and efficiency of the simple machine. Other students also managed correctly to stipulate the work output (work done by load) and work input (work done by effort) which enabled them to determine the efficiency of the machine. Furthermore, they demonstrated sufficient knowledge and analytical skills to determine the velocity ratio and mechanical advantage. However, some of the students who scored average marks (3.0-6.5) were able to write some of the correct formulae and applied mathematical skills to compute mechanical advantage but they failed to compute velocity ratio and efficiency of simple machine. Extract 7.1 is a sample of good responses from a student who scored all marks in question 7.

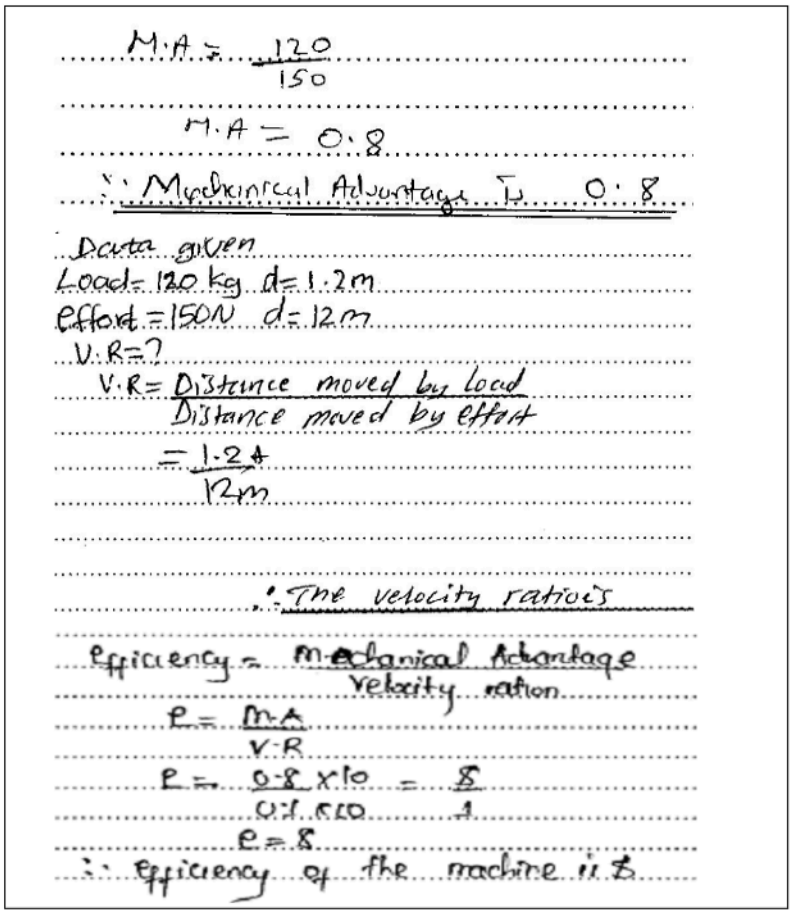


Extract 7.1: A sample of the correct responses to Question 7

The analysis of the students' responses reveal that the students who scored below the pass mark (0-2.5) lacked the knowledge on the concept about Simple Machine. Some of the students who scored 1 mark were able to write the correct formula but some of them failed to relate Load (N) = Mass (kg) x Gravity (m/s^2). In part (a) and (b) some students used inappropriate approaches to determine mechanical advantage and velocity ratio.

For example, one student used the formula, $M.A = \frac{1}{\text{Effort}}$ and $V.R = \frac{\text{Force applied}}{\text{Load}}$ instead of $M.A = \frac{\text{Load}}{\text{Effort}}$ and $V.R = \frac{\text{Distance moved by effort}}{\text{Distance moved by Load}}$ respectively.

Moreover, in part (c) some of students failed to provide and use suitable formula to determine the efficiency of the machine. This suggests that most of the students in this category lacked mathematical skills to interpret and evaluate the given tasks. Extract 7.2 shows a sample of incorrect responses from one of the students who scored low marks.



Extract 7.2: A sample of incorrect responses to Question 7

In Extract 7.2, a student reversed the parameters in the formula to find the velocity ratio. In part (c) She also applied incorrect formula $e = \frac{M.A}{V.R} \times 10$ with wrong data instead of $e = \frac{M.A}{V.R} \times 100\%$ to determine efficiency of the machine.

2.2.6 Question 8: Measuring Instruments

The question had four parts (a), (b), (c), and (d). The aim of this question was to assess students' ability to sketch, formulate equation, apply equation to find volume of the irregular solid and to determine the density of the irregular solid. The question was as follows:

A student performed an experiment to measure the density of a solid with an irregular shape by means of measuring cylinder and recorded the results as follows:
Mass of an irregular solid, m = 178 g.
Initial volume of water in the measuring cylinder, V_1 = 80 cm^3.
Final volume of water in the measuring cylinder, V_2 = 80 cm^3.

(a) Draw a neat sketch diagram to show the levels of water in the measuring cylinder:
(i) Before the solid is immersed.
(ii) After the solid is immersed.

(b) Formulate an equation to find the difference in volume V_3 in terms of V_1 and V_2.

(c) Use the equation you have formed in (b) to find the volume of the irregular solid.

(d) Determine the density of the irregular solid.

This question was attempted by1889 (100%) students, whose scores were as follows: 416 (22.02%) scored from 0 to 2.5 marks, 367 (19.11%) scored from 3.0 to 6.5 marks and 1106 (58.87%) scored from 7 to 10 marks. The students' performance in this question was good since 1473 (77.98%) students scored the pass mark and above. Figure 9 is a graphical presentation of these scores.

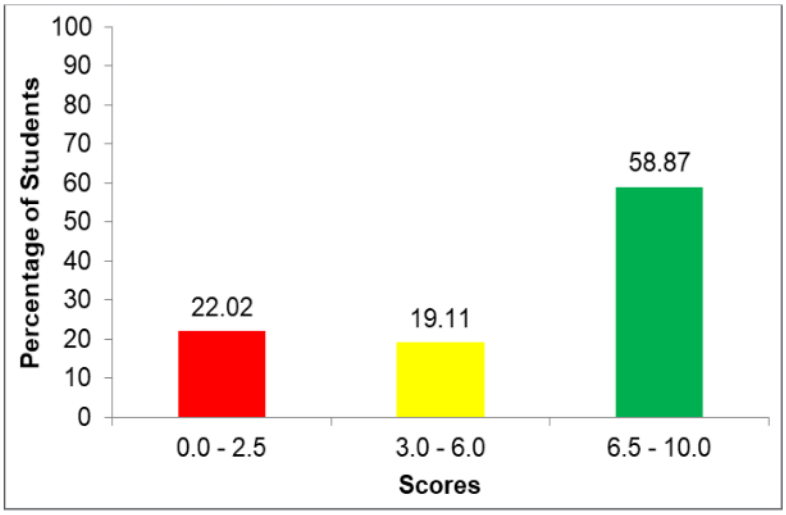
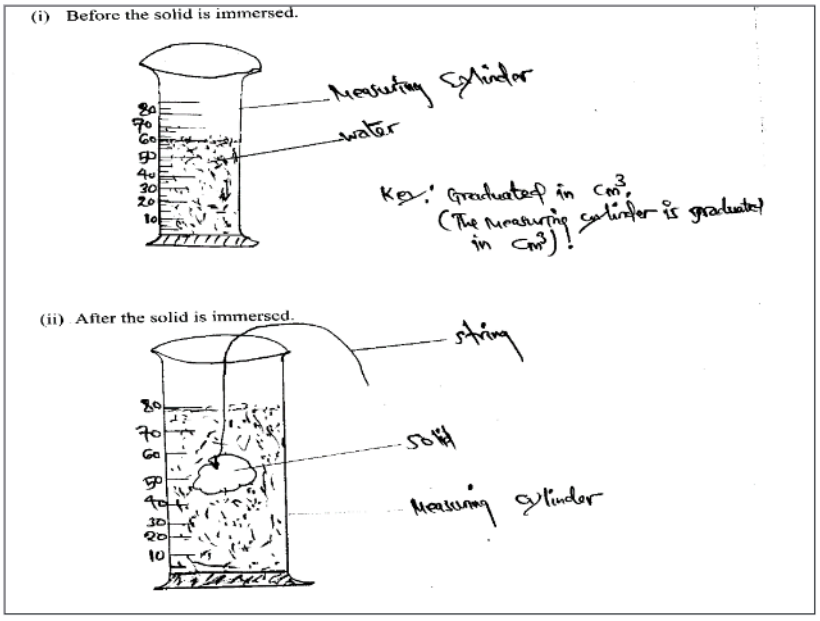
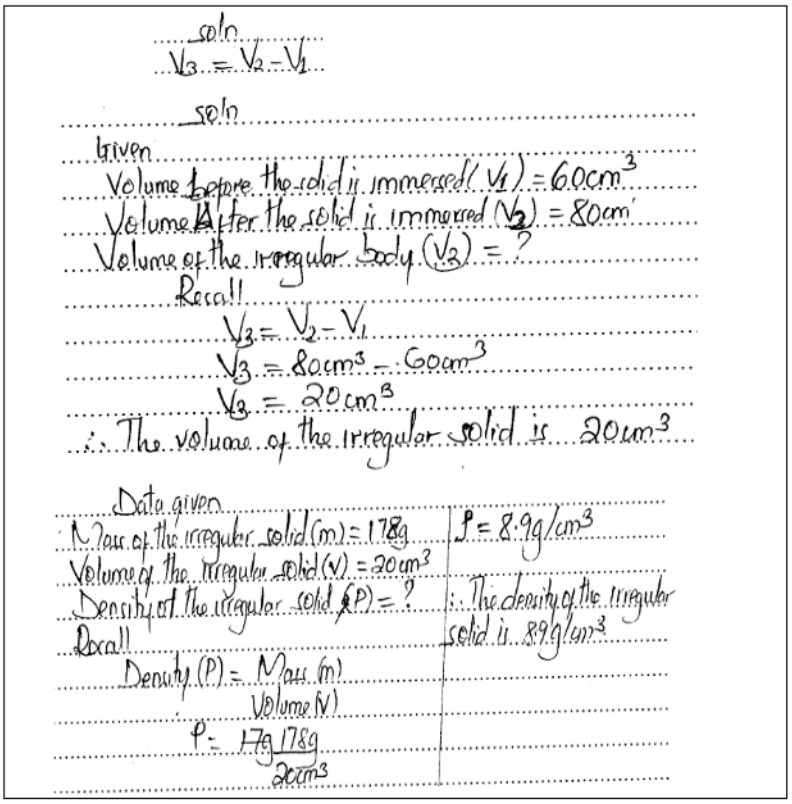


Figure 9: The Students' Performance in Question 8

The analysis of data reveals that some of students who scored average marks (3 - 6.5) had ability to sketch diagram showing the levels of water in the measuring cylinder before the solid is immersed and formulate proper equation to find the difference in volume V_3, in terms of V_1 and V_2. However, they lacked analytical skills to make correct substitution of data ended up with incorrect values of the volume of irregular solid.

The students who scored higher marks in part (a), demonstrated their drawing skills by providing a net sketch diagram showing the levels of water in the measuring cylinder before and after the solid is immersed. They also showed their competence in part (b), (c) and (d) by formulating an expression used to determine the difference in volume and density of irregular solid. Extract 8.1 is a sample of good responses from a student who scored higher marks in question 8.





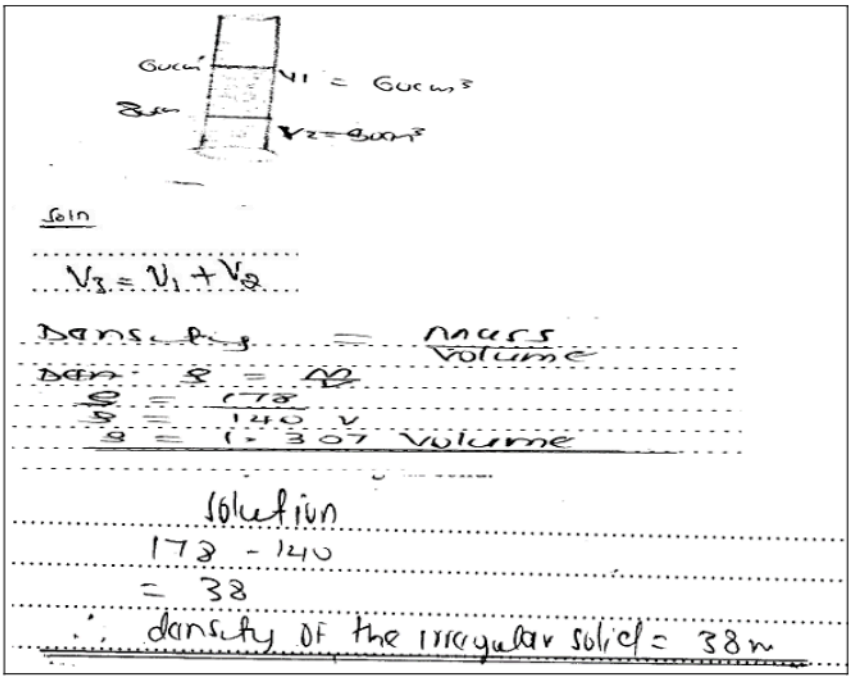
Extract 8.1: A sample of good responses to Question 8

Extract 8.1 shows a response from a student who had competence of computing the volume and density of irregular solid.

Despite the good performance shown by majority (77.98%) of the students in this question, some (22.02%) students scored below the pass mark (0-2.5). These students lacked knowledge about measuring instruments, specifically measuring cylinder to measure volume and hence density of irregular solid.

In responding to part (a), the students who failed this part lacked specific skills of drawing a neat sketch diagram of measuring cylinder showing different levels of water before and after the solid is immersed. For instance, one student drew a container of irregular shape. Some students drew beakers without specifying the difference in meniscus of water inside before and after immersing an irregular solid. In part (b), (c) and (d) of the question, most of the students failed to identify and use proper equations and formulae to

determine the volume and density of irregular solid. Extract 8.2 shows a sample of incorrect responses provided by one of the students in this question.



Extract 8.2: A sample of incorrect responses to Question 8

In Extract 8.2, a student drew a sketch diagram indicating the incorrect values of initial and final volume of the liquid. She also applied inappropriate formula and procedure ended up with wrong answers.

2.2.7 Question 9: Forces

In this question, the students were required to determine the resultant force by resolving into horizontal and vertical components. The question intended to measure students' competence on sketching, labelling and formulating resultant force formula. Also to determine the resultant force by resolving it into vertical and horizontal components. The question was as follows;

Two poles were used to support one point of the tent. The forces of the two poles with their angle of inclination to the point of action are 5 N at 25° and 8 N at 112° respectively.

Determine the resultant force by resolving these forces into horizontal and vertical components.

This question was attempted by 1889 (100%) students whose scores were as follows: 1862 (98.57%) scored from 0 to 2.5 marks, 26 (1.38%) scored from 3 to 6 marks and 1(0.05%) scored from 6.5 to10 marks. The general students' performance in this question was weak since majority (98.57%) of the students scored below the pass mark. Figure 10 summarizes the students' performance in this question.

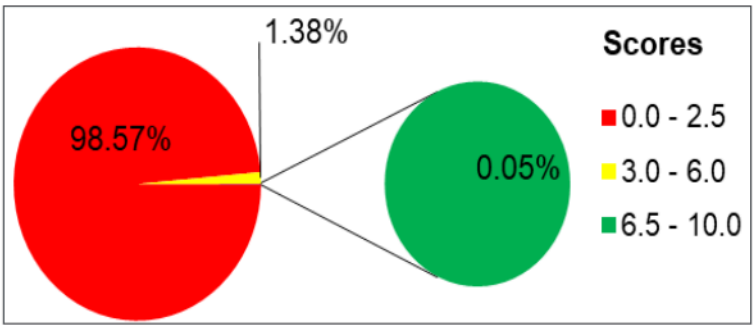
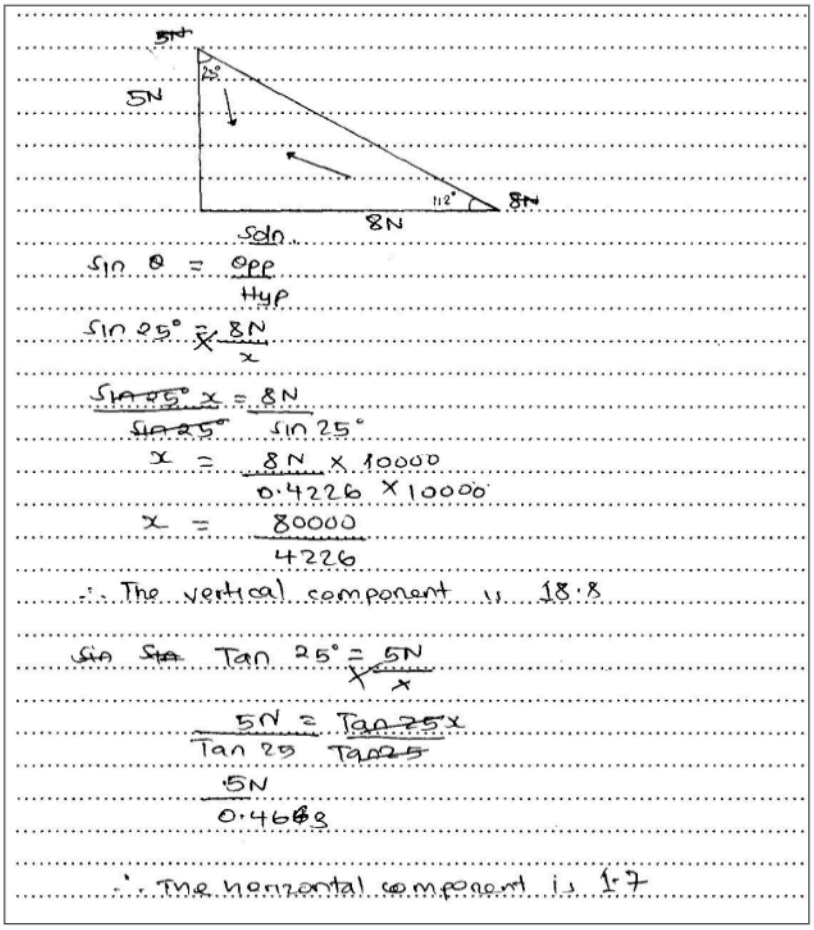


Figure 10: The Students Performance in Question 9

The students who scored low marks demonstrated insufficient knowledge about the concept of forces. Due to this, most of the students failed to interpret the given information into free force diagram so as to resolve the forces into horizontal and vertical components. Furthermore, they lacked mathematical skills on trigonometric ratios and Pythagoras theorem to determine the sine and cosine of angles and hence the resultant force. Extract 9.1 is a sample of student's incorrect responses to this question.

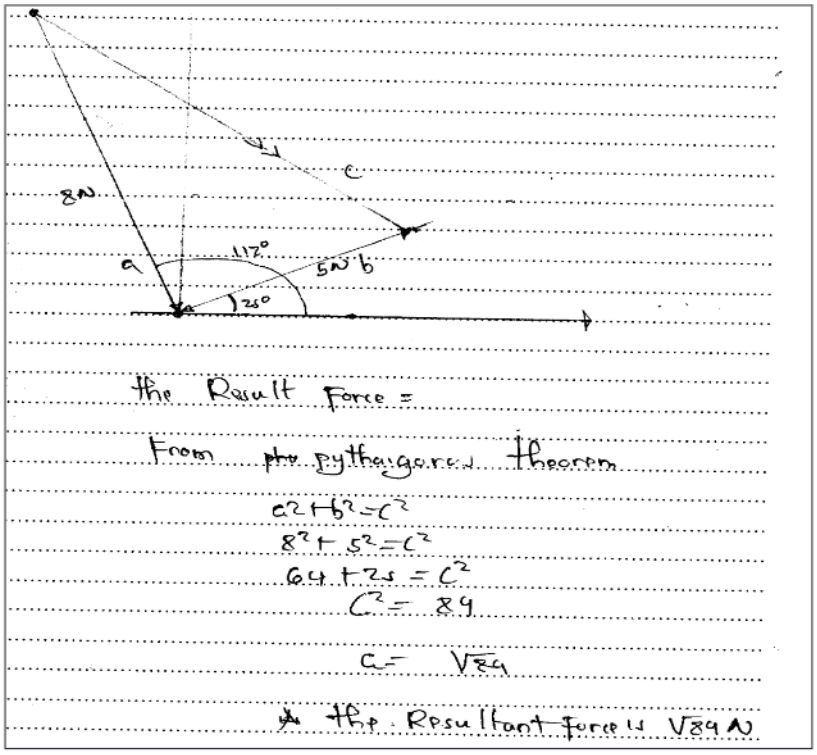


Extract 9.1: A sample of incorrect responses to Question 9

In Extract 9.1, a student drew a triangle instead of a free force diagram showing the direction of force. S/he also failed to determine the resultant force by resolving the forces into horizontal and vertical components.

On the other hand, some of the students who scored average marks (3- 6.5) clearly drew diagram of forces of the two poles with their angle of inclination to the point of action but failed to determine the resultant force by resolving the forces into two components. Further analysis reveals that, a few students who scored good marks demonstrated their ability on sketching and labeling clearly the diagram of forces with their angle of inclination. However, they faced difficulty to apply proper formulae and follow appropriate procedure to compute the resultant force. Extract 9.2 is a sample of

responses from one student who scored average marks in this question.



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

Extract 9.2 shows a response from a student who is competent in sketching the diagram and showing the direction of forces with their angle of inclination. He/she missed the concept of trigonometric ratios which led to incorrect answer of the resultant force.

2.2.8 Question 10: Linear Motion

The question was constructed from the topic of motion in a straight line and aimed to test students' skills of question solving, sketch drawing and applying the knowledge and understanding of the linear motion in our daily life. The students were required to sketch velocity time graph, determine distance covered for all journey and write proper formulas to determine acceleration during the first 3s, 15s and 5s. The question was as follows**:**

The bus started for rest and in 30 seconds reached a speed of 20m/s. the speed remained steady for 15 second and decrease steadily until the bus stopped in 5 seconds later.

(a) Draw a velocity time graph.

(b) Use the diagram in (a) to calculate;

(i) the distance covered from start to end of the journey.

(ii) the acceleration during the motion

This question was attempted by 1889 (100%) students, of those 815 (43.14%) scored from 0 to 4 marks, 494 (32.66%) scored from 4.5 to 9.5 marks and 580 (24.19%) scored from10 to 15 marks. These scores suggest that, the students' performance in this question was average since 56.85% of the students scored the pass mark or above. Figure 11 is a graphical presentation of students' performance in question 10.

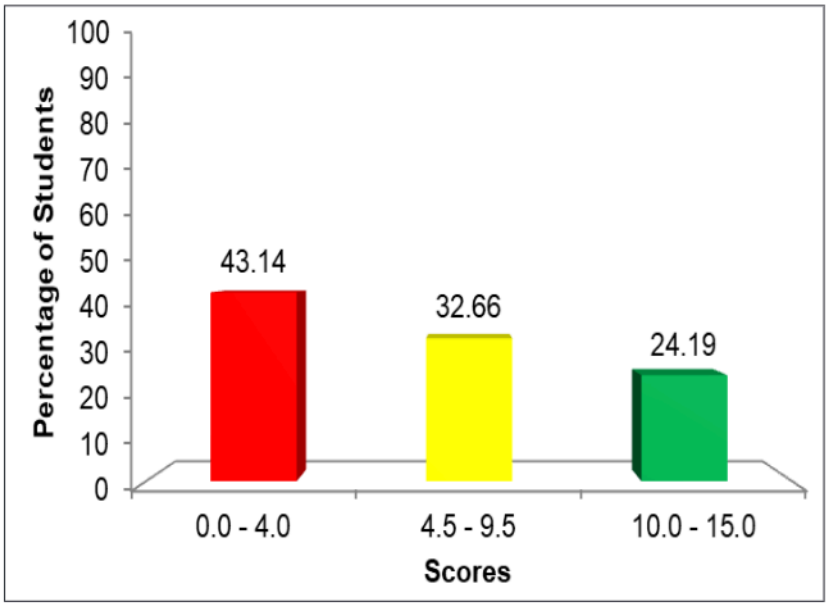
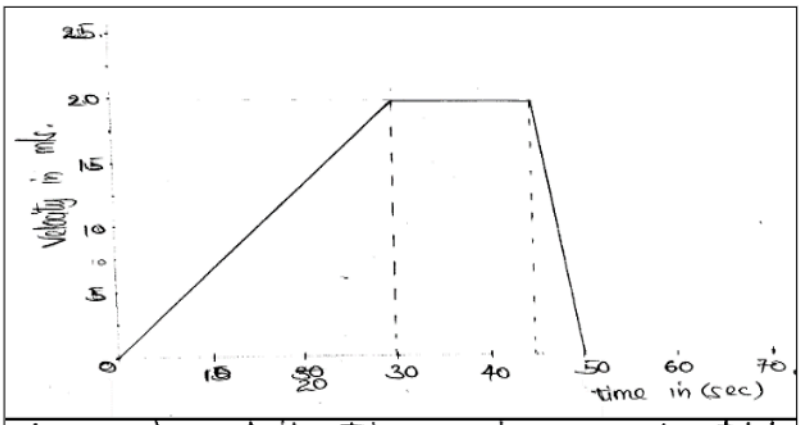


Figure 11: The Students Performance in Question 10

The analysis shows that, students who scored higher marks in part (a) demonstrated their drawing skills since they were able to sketch and label clearly the diagram of a velocity time graph. In part (b) of this question, most of the students interpreted correctly the distance travelled by a bus with the

$$\text{Area} = \frac{1}{2}(a + b) \times h.$$

Furthermore, they properly applied Newton's equations of motion such as $v = u + at$ and $s = v \times t$ to determine the acceleration during the motion and distance travelled by a bus respectively. This suggests that most of the students in this category had adequate knowledge about motion in a straight line. Extract 10.1 is a sample of good responses from one student who scored higher marks in this question.



Area under velocity-Time graph represent total distance covered.

From the graph

Area of Trapezium.

$A = \frac{1}{2}(a+b)h$.

$A = \frac{1}{2}(15+50)20$.

$A = 65 \times 10$

$= 650m$.

Case 1.

During first 30sec.

$a = \frac{\Delta v}{t} = \frac{v-u}{t}$.

$a = \frac{20-0}{30}$

$a = 0.67 m/s^2$.

Case 2.

During 15sec

Note: The speed at that time was constant

If speed is constant the acceleration is zero because there is no change in velocity.

∴ During 15 sec acceleration was $0 m/s^2$.

Case 3.

During last 5sec.

$a = \frac{\Delta v}{t} = \frac{v-u}{t}$.

$a = \frac{0-20}{5} = \frac{-20}{5}$

$a = -4 m/s^2$.

Means there is decelleration.

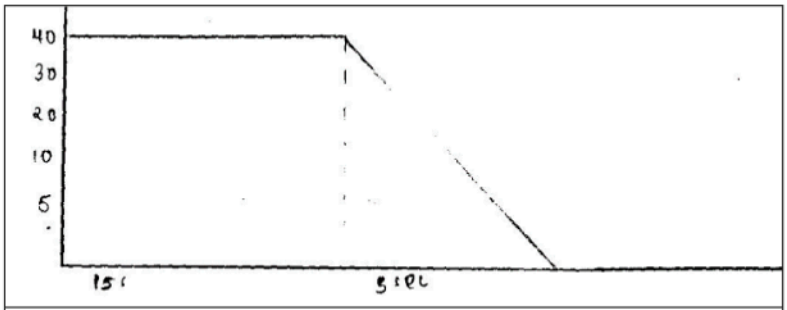
∴ Acceleration during last 5seconds was $-4 m/s^2$

Extract 10.1: A sample of good responses to Question 10

Extract 10.6 shows responses from a student who correctly drew a velocity time graph. Consequently, he/she applied

proper formulae and procedures to determine the acceleration during the motion and distance travelled by a bus.

The students who scored low marks (0 to 4) had inadequate knowledge about motion in a straight line. Most of them missed the concept of velocity-time graphs for uniformly accelerated motion. Owing to this, they failed to assess and draw the velocity time graph for the motion of a bus. In addition, some of the students in this category lacked the analytical skills to express and apply proper Newton's equations of motion to find the acceleration, retardation and hence the distance travelled by a bus. Extract 10.2 is a sample of incorrect responses from a student who scored low marks in question 10.



Soln:

Data given

Time (t_1) = 20sec

Speed (u) = 20m/s

Time (t_2) = 15 sec

Time (t_3) = 5sec

$s = ut + \frac{1}{2}at^2$

$s = 20m/s \times 50s + \frac{1}{2} \times 0.4 m/s^2 \times (50s)^2$

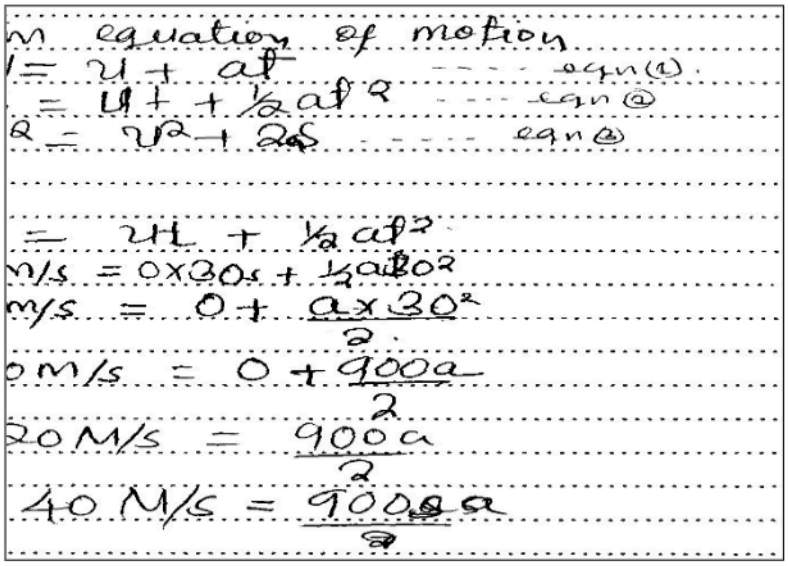
$s = 0m + \frac{1}{2} \times 0.4 m/s^2 \times \overset{1250}{\cancel{2500}} s^2$

$s = 0m + 0.4 m/s^2 \times 1250 s^2$

$s = 0m + 500m$

$s = 500m$

∴ Distance covered from start to end of the journey is 500m.



Extract 10.2: A sample of incorrect responses to Question 10

In Extract 10.2, student in part (a), wrongly drew the graph without labeling the axes. In part (b), he/she applied Newton's equations of motion but failed to make the correct substitution of data to compute the distance and acceleration during the motion.

3.0 THE ANALYSIS OF STUDENTS' PERFORMANCE IN EACH TOPIC

The Engineering Science assessment for the year 2023 had a total of eleven (11) topics which were: *Measuring Instruments; Friction; Fluid Mechanics; Light; Work, Energy and Power; Electricity; Simple Machines; Linear Motion; Turning Forces; Heat* and *Forces.*

The analysis of the students' performance indicates that 86.45 per cent of the students had good performance in Question 1 which was set from the topics: *Measuring instruments, Friction, Fluids Mechanics, Work, Energy and Power, Simple Machines, Turning forces, Linear motion, Heat (part two)* and *Light.* However, other topics with good performance were: *Measuring instruments (77.98%)* and *Simple Machines (76.87%).* Such students were able to identify the requirement of each question and had adequate knowledge of the subject matter. Mastery of mathematical skills was another reason that contributed to good performance among the students, especially in questions that involved the use of formulae.

The students' performance was average in three topics of Electricity (62.33%), Linear Motion (56.85%) and Turning Forces (32.85%). The students performed averagely due to partial attempt to some parts of the questions. This was contributed mainly by lack of knowledge and insufficient mathematical skills. Moreover, the students in this category, though memorized some concepts, they failed to attempt the parts which needed drawing skills.

The weak performance was observed in the topics of *Heat (*1.4322.29%) and *Forces (*1.43%). This performance was mainly attributed by students' poor mathematical skills resulting from the use of incorrect formulae. In some cases, the students failed to comprehend the requirement of the questions, due to inadequate knowledge of the assessed concepts and lack of drawing skills. As a result, they failed to interpret and draw appropriate diagrams in the topics of Electricity, Forces and Linear Motion. The analysis of the students' performance per topic is summarized in Appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The general performance in Engineering Science assessment was average (52.13%). The analysis of the students' performance reveals that students faced some challenges when attempting the questions. It was observed that, insufficient knowledge was one of the main reasons for the weak performance by most of the students, because many students provided irrelevant responses relating to the demand of the questions.

Further analysis has shown that, lack of mathematical skills posed a significant barrier to the performance of many students. They failed to apply correct formulae and lacked skills on manipulation of the data. Hence, they ended up with incorrect answers. Moreover, lack of drawing skills contributed the low performance of students particularly, in interpreting the circuit diagram, drawing the free force diagram and velocity time graph.

4.2 Recommendations

In order to improve the performance in Engineering Science subject, teachers are strongly advised to:

(a) Encourage students continue learning and practicing computation skills that are required in solving different questions involving calculations.

(b) Guide students explain and apply theories, laws and principles used in Engineering Science to analyse different concepts.

(c) Provide consistent students' self-motivation which promotes competence of academic skills.

(d) Facilitate students to apply deductive thinking to derive equations of motion in a straight line and other topics.

(e) Create competence based exercises and tests during formative assessment and evaluation.

(f) Emphasize on experimentation, demonstrations and drawing activities in order to enable the students develop competence in various topics.

(g) Guide students to derive expression for a resultant force and resolve a force into vertical and horizontal component by calculation and scale drawing.

Appendix: A Summary of Students' Performance Question-Wise in 2023

S/N	Topic	Performance For Each Topic		Remarks
		Question Number	Percentage of Students who Scored an Average of 30% or More	
1.	Measuring Instruments, Friction, Fluids Mechanics, Work, Energy and Power, Simple Machines, Turning Forces, Linear Motion, Heat (Part two) and Light.	1	86.45	Good
2.	Measuring Instruments	8	77.98	Good
3	Simple Machine	7	76.87	Good
4	Electricity	2 & 5	62.33	Average
5	Linear Motion	10	56.85	Average
6	Turning Forces	3 & 6	32.85	Average
7	Heat (Part two)	4	22.29	Weak
8	Forces	9	1.43	Weak