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) 2024

ENGINEERING SCIENCE

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035 ENGINEERING SCIENCE

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FOREWORD

This assessment report presents analysis of Students' Items Response Analysis (SIRA) on the Form Two National Assessment (FTNA) in Engineering Science subject, which was conducted in 2024. The report presents feedback to students, teachers, parents and other educational stakeholders to monitor student's progress and identify areas of improvement.

The Form Two National Assessment (FTNA) aims to monitor students' academic progress throughout their learning journey, providing continuous feedback that supports improvement and reduces the risk of failure. Additionally, it enables teachers and educational stakeholders to enhance the quality of teaching and learning processes and make more informed administrative decisions.

The analysis presented in this report aims to contribute towards understanding the possible reasons behind students' performance in Engineering Science subject. The report highlights the factors that significantly contributed to the students' good performance in some questions. These factors include the ability to identify the requirement of the question and ability to manipulate arithmetical calculation, knowledge on laws, principles and formulae with respect to Engineering Science subject. In contrast, the students with weak performance faced challenges such as inadequate knowledge and skills on the assessed topics, lack of mathematical skills, failure to interpret the tasks and demonstrate their drawing skills on the questions and poor English language proficiency.

The National Examinations Council of Tanzania (NECTA) believes that, the report will be useful to teachers, parents and other education stakeholders because the results of assessment findings can lead to better decision of how to improve the quality of teaching and learning processes for attainment of required instructional objectives in the future assessment.

The Council appreciates the efforts made by all who in one way or another contributed to the preparation of this report.

Dr. Said A. Mohammed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report provides useful information on students' Performance of the Form Two National Assessment (FTNA) in Engineering Science subject. Using the Engineering Science Syllabus, the students were assessed based on the competencies acquired in their two years of Secondary education.

The examination paper had three sections, A, B and C. Section A consisted of two objective questions, which were multiple-choice items and matching items. This section carried a total of 15 marks. Section B consisted of seven short answer questions, which carried a total of 70 marks, and section C had an essay question, which weighed 15 marks. All questions in all sections were compulsory.

This report provides feedback to our stakeholders on students' performance; showing both student' strengths and weaknesses. The student' performance in each question/topic has been categorized using the ranges of 0 to 29 (weak performance), 30 to 64 (average performance) and 65 to 100 (good performance). In this report, the students' performances are presented in different colours: whereby the red colour stands for weak performance, the yellow colour for average performance and the green colour for good performance

A total of 1,721 students sat for the Engineering Science FTNA 2024, where 881 (51.19%) passed and 840 (48.81%) failed. The students' performance in 2024 has decreased by 7.85% when compared to the year 2023 in which 1,122 (59.40%) passed and 567 (40.60%) failed. The analysis of the students' performance in 2024 compared to the year 2023 is summarized in Figure 1.

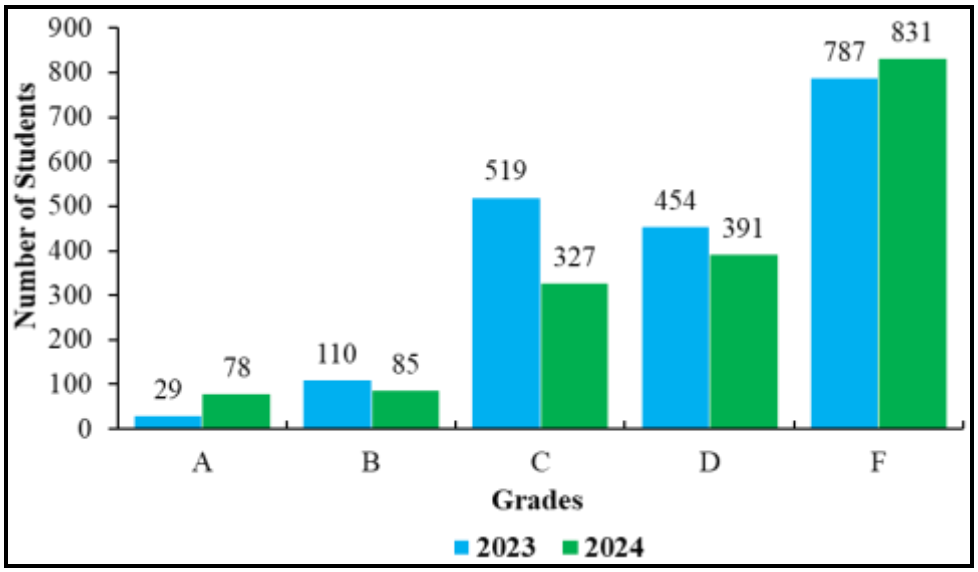


Figure 1: *Comparison of Students' Performance in 2023 and 2024*

2.0 ANALYSIS OF THE STUDENTS' RESPONSES IN EACH QUESTION

The report provides an overview of students' performance on each question. The analysis includes types of questions, their requirements, the topic from which the questions were constructed and the students' performance regarding their responses. The students' performances have been categorized as good, average and weak. Good performance ranges from 65 to100 percent, average performance ranges from 30 to 64 percent and weak performance ranges from 0 to 29 percent. In addition, green, yellow and red colours are used in chart or graphs to represent these categories respectively.

2.1 SECTION A: OBJECTIVE QUESTIONS

This section comprised of two objective questions. A multiple-choice, question with ten (10) items, each carried 1 mark, making a total of ten (10) marks and matching items question with five items each item was worth 1 mark, making a total of 5 marks. The whole section had 15 marks.

2.1.1 Question 1: Multiple Choice Items

This question had 10 items, (i) - (x). Students were required to choose the most correct answer among the given alternatives and write its letter in the

box provided. The items were set from eleven topics which are: *Work, Energy and Power, Light (part one), Heat (part one), Electricity, Measurement, Linear Motion, Sound, Friction, Turning Forces* and *Simple Machines (part one).*

A total of 1,716 (100%) students attempted the question. The analysis indicates that, 291(16.96%) students scored from 0 to 2 marks, 1,316 (76.69%) students scored from 3 to 6 marks while 109 (6.35%) students scored from 7 to 10 marks. These scores indicate that, students' performance in this question was good, since 83.04 percent of students scored 3 marks and above. Figure 2 shows students' performance in this question.

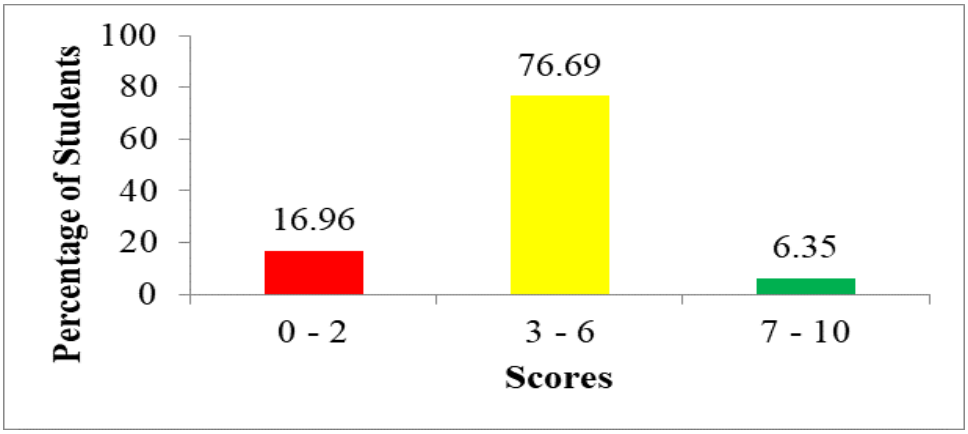


Figure 2: *The Students' Performance in Question 1*

The analysis reveals that the performance achievement for this question was good as 1425 (83.04%) students scored above pass mark. Few students 109 (6.35%) scored extraordinary high marks. This shows that these students had adequate knowledge of the tested subject matter. On the other hand, students who scored low marks (0-2), failed to select the correct responses from the provided alternatives. The analysis of each item is as follows:

Item (i) was set from the topic Work, Energy and Power. The question intended to measure students' competence in identifying the forms of energy. The question was:

A car burns large amount of fuel to provide energy when climbing up a hill at an increased speed. What kind of energy does the car transform?

A *Heat energy to Mechanical energy*
B *Chemical energy to Heat energy*
C *Chemical energy to Mechanical energy*
D *Heat energy to Chemical energy*

The correct answer was alternative *C, Chemical energy to Mechanical energy.*
The students who selected alternative C, knew, that fuel before burnt possess chemical energy, which is then transformed to heat energy as it burns to produce heat. As a result, heat expands gases that push against pistons and thereby creates the mechanical energy that causes the car to increase speed. Students who chose alternative *A, Heat energy to Mechanical energy*, failed to understand that raw fuel does not generate heat, unless it burns. Students who chose alternative *B, Chemical energy to Heat energy*, failed to identify the transformation of heat energy to kinetic energy, a type of mechanical energy that causes the car to increase its speed. Students, who chose option *D, Heat energy to Chemical energy*, were not aware that some reactions consume thermal energy. For, example, endothermic reactions convert thermal energy into chemical energy, which causes the surroundings become colder, these reactions seem to make energy disappear and thus cannot provide energy sufficient for the car to climb up a hill at an increased speed.

Item (ii) was composed from the topic *Light (part one),* and it assessed ability to identify the types and applications of plane mirrors. The question was:

What are the applications of plane mirrors?

A *Plane mirrors are used in hair salons*
B *Plane mirrors are used as domestic shaving mirrors*
C *Plane mirrors are used as cars' side mirrors*
D *Plane mirrors are used in periscopes*

The correct answer were alternatives A, B and D. The students who chose either of the correct options had adequate knowledge of applications of plane mirrors. Few students who chose incorrect option C, *Plane mirrors are used as cars' side mirrors,* had insufficient knowledge on mirrors and

their applications, as convex mirror are suitable for car side.

Item (iii) was constructed from the topic of *Heat (part one)* and it measured students' competence to describe the mode of heat transfer in a domestic vacuum flask (thermos). The question was:

A domestic vacuum flask (thermos) prevents loss of heat due to conduction, convection and radiation. How does the inner glass vessel with a vacuum between wall prevent heat loss?

A	*By conduction and radiation*	*B*	*By radiation and convection*
C	*By convection only*	*D*	*By convection and conduction*

The correct answer was alternative *D*. Those who chose the correct answer knew that heat at inner glass vessel could be lost by conduction, which involves the direct contact of two objects with different temperatures. Metals such as copper exhibit high thermal conductivity, they also recognized that convection occurs in fluids due to the movement of heated particles. When a fluid is heated, the particles near the heat source absorb energy and vibrate more rapidly. Therefore, the vacuum between the two glass walls prevents conduction and convection of heat through the sides. Those who chose alternative *A*, and *B* had inadequate knowledge of heat transfer through radiation because it operates through the emission of electromagnetic waves, which does not require a medium for heat to be transferred. Those who chose alternative C were not aware of three modes of heat transfer.

Item (iv) was composed from the topic Electricity and it assessed students' ability to analyse the effects of rubbing a positively charged insulating rod with the neutral piece of fabric. The question was:

A rod of an insulating material with positive charge was rubbed with a piece of fabric. The fabric was then tested for electric charge. Which result would you expect on piece of fabric?

A *A positive charge equal to that on the rod*
B *A negative charge equal to that on the rod*
C *A positive charge less than that on the rod*
D *A negative charge greater than that on the rod*

The students who chose correct answer was alternative *B*, understood that, the number of electrons transferred from a piece of fabric is equal to the

number of electrons that the rod of an insulating material with positive charge gains. Since electrons carry a negative charge, a piece of fabric becomes positively charged by the same amount that the rod becomes negatively charged. Those who chose wrong options *A, C* and *D*, failed to comprehend with the process of charging a body by rubbing. In addition, they lacked knowledge on the properties of the three particles of matter (proton, electron and neutron) as they failed to recognize that only electrons are free to move. Moreover, they failed to understand that when a rod and a piece of fabric are rubbed together, electrons are transferred from one body to the other. Thus, total charge before rubbing is equal to the total charge after rubbing.

Item (v) was generated from the topic of *Measurement* and tested students' ability to explain the concept of relative density of a substance. The question was as follows:

Four students were discussing the measurements of relative density of a substance. Each student stated the meaning of the relative density as follows;

1 *Relative density is the ratio of the mass of a substance to the mass of an equal volume of water.*

2 *Relative density is the ratio of the weight of a substance with certain volume to the weight of water with the same volume as that of substance.*

3 *Relative density is the ratio of the density of a substance to the density of an equal volume of water.*

4 *Relative density is the ratio of the volume of a substance to the mass of an equal volume of water.*

Who were correct among these students?

A	*1, 2 and 4*	*B*	*1, 3 and 4*
C	*1, 2 and 3*	*D*	*2, 3 and 4*

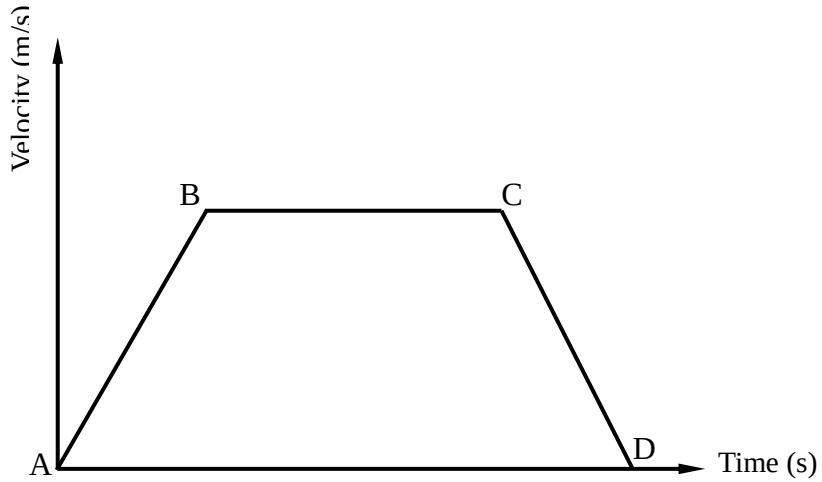
The correct response was alternative *C, 1, 2* and *3*. Students who chose alternative C had enough knowledge of determining the relative density of the substance. Those who selected alternatives *A, B* and *D* had an inadequate knowledge on the concept of relative density as the fourth

student stated the definition of relative density as the *ratio of the volume of a substance to the mass of an equal volume of water*, which is not correct.

Item (vi) was constructed from the topic *Linear Motion*. It aimed to measure students' competency in analysing the velocity-time graph, as well as to assess students' ability to describe graphical representation of a motion of a car in a straight line and acceleration from the velocity-time graph. The asked question was as follows:

The figure below is a velocity-time graph which represents the motion of a car travelling on a straight road from point A to point D, via point B and C.

How would you describe the acceleration of a car?



A Acceleration is positive from A to B, zero from B to C and negative from C to D.
B Acceleration is negative from A to B, zero from B to C and positive from C to D.
C Acceleration is zero from A to B, positive from B to C and negative from C to D.
D Acceleration is zero from A to B, negative from B to C and positive from C to D.

The interpretation of the graph reveals that the correct answer was alternative *A, Acceleration is positive from A to B, zero from B to C and*

negative from C to D. Students who chose the correct answer A, had adequate understanding on the concepts of the velocity-time graph. Students understood that slope of the line on a velocity-time graph is zero. If the acceleration is zero (i.e., a horizontal line). If the acceleration is positive, then the slope is positive (i.e., an upward sloping line). If the acceleration is negative, then the slope is negative (i.e., a downward sloping line). Those who chose alternative *B, C* and *D*, failed to interpret the graph and lacked knowledge about the application of the principle of velocity-time graph in real life situation.

Item (vii) intended to measure students' ability to explain the factors affecting the velocity of sound in air. The question was as follows:

Why is velocity of the sound in air different in summer and in winter period?

A *Because density of air is higher in summer period.*
B *Because pitch of sound halves in summer period.*
C *Because density of air is lower in summer period.*
D *Because pitch of air doubles in winter period.*

The correct answer was alternative *C, Because density of air is lower in summer period.* The students who chose correct answer understood that velocity of sound is higher in summer than in winter because in summer, the sun evaporates more water from the surface as a result, the moisture in the atmosphere is denser which makes the velocity of sound in air travel faster. These students knew that velocity of sound is inversely proportional to the square root of the density. As the density of the air decreases, the velocity increases. In addition, the velocity of sound in air increases as the temperature increases. Those who chose alternative *A, Because density of air is higher in summer period,* did not understand the variation of velocity of sound in summer and in winter. Those who chose alternatives B, and D had inadequate knowledge about velocity of sound and pitch, since the velocity of sound waves are determined by the medium itself and remain constant regardless of changes in pitch.

Item (viii) was set from the topic *Friction* and it measured students' ability to explain the effects of friction and ways to minimize them. The question was as follows:

Teacher asked the Form Two Students, 'why do we apply suitable lubricant to the surfaces of machine parts which slides over each other?' Students' responses were as follows;

(i) To reduce friction between the moving surface
(ii) To reduce the wear on the surfaces
(iii) To carry away any heat which is generated at the surfaces.
(iv) To protect the metal surfaces against rust and corrosion

Which of the stated reasons were correct?

A	*(i), (ii) and (iii)*	*B*	*(i), (iii) and (iv)*
C	*(i), (ii) and (iv)*	*D*	*(ii), (iii) and (iv)*

Most students who chose the correct alternative *A (i), (ii) and (iii)* knew the application of suitable lubricant to the surfaces of machine parts which slides over each other. Students who chose wrong alternatives *B*, *C* and *D*, interpreted wrongly the methods of minimizing friction and that of preventing rust and corrosion, which is done by the application oil, grease, paint or by galvanizing.

Item (ix) was set to test student's ability to formulate the conditions for equilibrium. The question was set from the topic of *Turning Force*. The question was as follows:

You *were given a seesaw with several forces. Thereafter you discovered that the sum of the moments acting on a seesaw was equal to zero but the sum of upward and downward forces was not equal to zero. What can you conclude?*

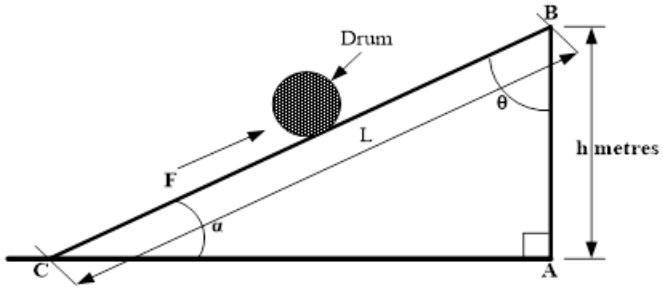
A The seesaw was rotated to clockwise or anticlockwise.
B The seesaw was moved vertically upward or downward.
C The seesaw was remained stationary or moved horizontally.
D The seesaw was tilted to angle 30^o or 45^o.

The students who chose the correct alternative B, *The seesaw was moved vertically upward or downward*, had adequate knowledge of the application of the conditions for the body to be in equilibrium. They understood that when, all the forces act upon an object are balanced, then the object is in a state of equilibrium. For the body to be in equilibrium the net force acting

upon the object must be zero. In addition, the net torque acting upon the object must also be zero. A seesaw is a long narrow board with a center pivot point. A child sits on each end they take turns pushing off the ground to transfer the weight to the other side. If a child girl were to sit on the end of a seesaw and a heavier man were to sit on the other side, the man would have to sit closer to the pivot point than the little child. Those who chose incorrect options *A, C* and *D*, failed to associate the two necessary conditions for the body to be in equilibrium as they lacked knowledge on the principle of moments and the effects of forces.

Item (x) aimed to test ability of students to analyse, the relationship between angle of inclination **α**, angle of depression **θ** and the length **L** of the plane of constant height **h**. The question was set from the topic of *Force*. The question was asked as:

A man has to roll an empty drum steadily along an inclined plane from the ground to position B which is ***h*** *metres above the ground as shown in the figure. In the first attempt, a maximum effort* ***F*** *failed to roll the drum steadily to position B. What modification would you recommend so that the drum could be rolled steadily to position B with maximum effort* ***F****?*



A *Reduce the length of the inclined plane L*
B *Reduce the size of angle θ*
C *Increase the length of the inclined plane L*
D *Increase the size of angle α*

The correct answer was alternative *C Increase the length of the inclined plane L*. Those students, who chose alternative *C*, were able to associate properly the relationship between angle of inclination, angle of depression and the length of the plane of constant height. Therefore, they recognized that increasing the length of the plane reduces the angle of inclination while angle of depression increases, and hence the drum could be rolled steadily

to position B with the maximum effort F. Those students who chose wrong alternatives *A, B* and *D,* failed to relate the given parameters to determine angles and length of the inclined plane in order to roll the drum steadily to position B with maximum effort F.

2.1.2 Question 2: Matching Items

Question two (2) was composed from the topic of *Linear Motion* and *Turning Forces*. The question asked the students to match items (i-v) in list A with corresponding responses in list B. They were required to write the letter of correct response besides the corresponding item number. Each item carried one (1) mark, making five (5) marks. The question was designed to assess the students' ability to analyse and sort out the effects of forces with the corresponding statements. The question was as follows:

Match the effect of force in List A with their corresponding response in List B by writing a letter of the correct response below the item number in the table provided.

	List A	***List B***
(i)	*The measure of its tendency to cause a body to rotate about specific point or axis.*	*A. Couple* *B. Equilibrium* *C. Impulse* *D. Inertia* *E. Moment of a force* *F. Neutral equilibrium* *G. Stable equilibrium* *H. torque*
(ii)	*The forces for turning a steering wheel applied by hands at opposite sides with equal forces but opposite in direction.*	
(iii)	*It continues in its existing state of rest or uniform motion in a straight line, unless is changed by an external force.*	
(iv)	*It is a measure of the force that can cause an object to rotate about an axis.*	
(v)	*It is equal to the change of momentum of an object, when mass is constant.*	

The question was attempted by 1,716 (100%) students; where by 684 (39.86%) scored from 0 to 1 mark, 783 (45.63%) students scored from 2 to 3 marks, and 249 (14.51%) scored from 4 to 5 marks. The performance on

this question was generally good as 1,032 (60.14%) of the students scored above pass mark. Figure 3 shows students' performance in this question.

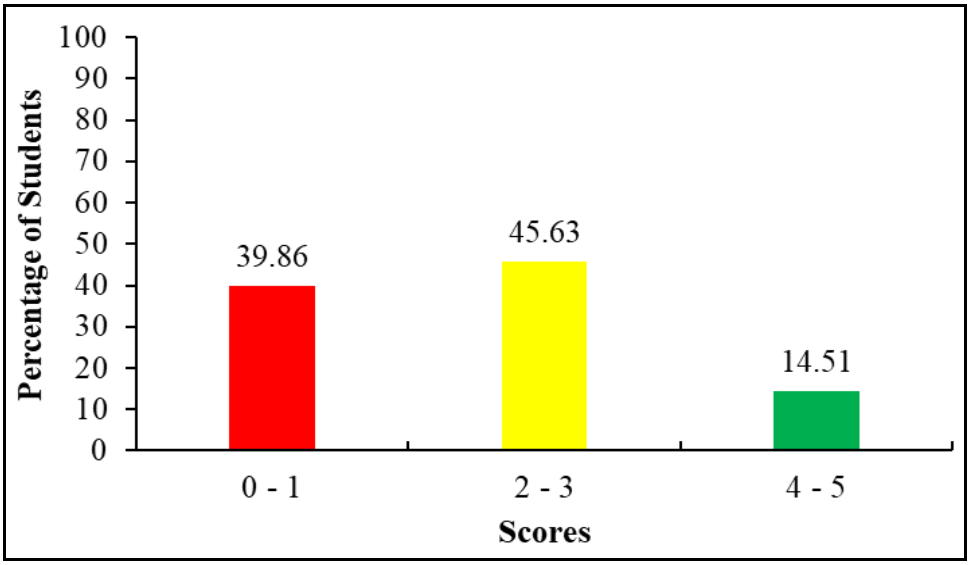


Figure 3: *The Students' Performance in Question 2*

The analysis of the student response in each item is as follows:
In item (i), the students were required to identify the correct response that matches the statement *The measure of its tendency to cause a body to rotate about specific point or axis.* The correct response was E, *Moment of a force.* Most of the students were able to choose the correct answer. This indicates that, students were able to state and determine moment of a force. However, some students chose an incorrect option A, *Couple*, misinterpreted the concepts of moment of a force and couple which is a pair of equal parallel forces pointing in opposite directions.

In item (ii) the students were required to identify the correct response that matches the statement *The forces for turning a steering wheel applied by hands at opposite sides with equal forces but opposite in direction.* The students, who chose the correct response A, *Couple*, understood the conditions for two forces to form a couple and their application in real life situation. Other students chose H. *Torque*, failed to understand that torque is a measure of the force that can cause an object to rotate about an axis. These students lacked the appropriate knowledge and mathematical skills on the application of couples.

In item (iii) the students were required to identify the correct response that matches the statement *It continues in its existing state of rest or uniform motion in a straight line, unless is changed by an external force.* The correct answer was response D, *Inertia*. Those students who chose the correct option were familiar with the law of Inertia (Newton's First Law of Motion). However, students who chose incorrect options F, *Neutral Equilibrium,* failed to demonstrate their skill on stationary or moving objects.

In item (iv) the students were required to identify the correct response that matches the statement *It is a measure of the force that can cause an object to rotate about an axis.* The correct response was H, *Torque.* Students who chose this option understood the importance of torque for engineering machinery, controlling movement, ensuring the functionality of mechanical systems and strength of tools. However, some of the students chose an incorrect option D. *Inertia*.

In item (v) the students were required to identify the correct response that matches the statement *It is equal to the change of momentum of an object, when mass is constant.* The correct answer was response *C, Impulse*. The students who selected C recognized that, impulse is the change of momentum as it can be deduced from the Newton's 2nd Law of Motion. Nevertheless, some students opted incorrect response B, *Equilibrium.* Extract 2.1 is a sample of students' good responses to question 2.

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

Extract 2.1: A sample of good responses to Question 2

In Extract 2.1, a student correctly recognized and associated all the effects of force in List A and the corresponding parameters in List B.

However, some of the students who scored low marks (0 - 2) failed to match the effects of force with their corresponding responses. Extract 2.1 is a sample of a poor response of a student who scored 0 mark to question 2.

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

Extract 2.2: A sample of a poor responses to Question 2

In Extract 2.2, a student was not able to recognize and associate all the effects of force in List A and the corresponding parameters in List B.

2.2 SECTION B: SHORT ANSWER QUESTIONS

This secton comprised of seven (7) short answer questions which were set from topics of *Electricity, Heat (part two), Simple Machines (part one), Turning Forces, Friction, Work, Energy and Power and Linear Motion.* Each question carried ten (10) marks, making seventy (70) marks. The pass mark of these questions was 3 marks. The student response analysis of each question is as follows:

2.2.1 Question 3: Electricity

This question was composed from the topics of Electricity. The question assessed the ability of students to describe the components of an atom and the application of the fundamental law of charges with conjunction to the mode of action of the gold leaf electroscope to identify the types of charges. The question was as follows:

(a) Briefly describe the components of an atom. Give three elements.

(b) By using sketches, comment on the behaviour of the leaf of the electroscope when;

(i) the object has negative charge

(ii) the object has positive charge

This question was attempted by 1,716 (100%) students; where by 846 (49.30%) scored from 0 to 2.5 marks, 732 (42.66%) scored from 3 to 6 marks, and 138 (8.04%) scored from 6.5 to 10 marks. The performance on this question was generally good as 870 (50.70%) of the students scored above the pass mark. Figure 4 shows students' performance in this question.

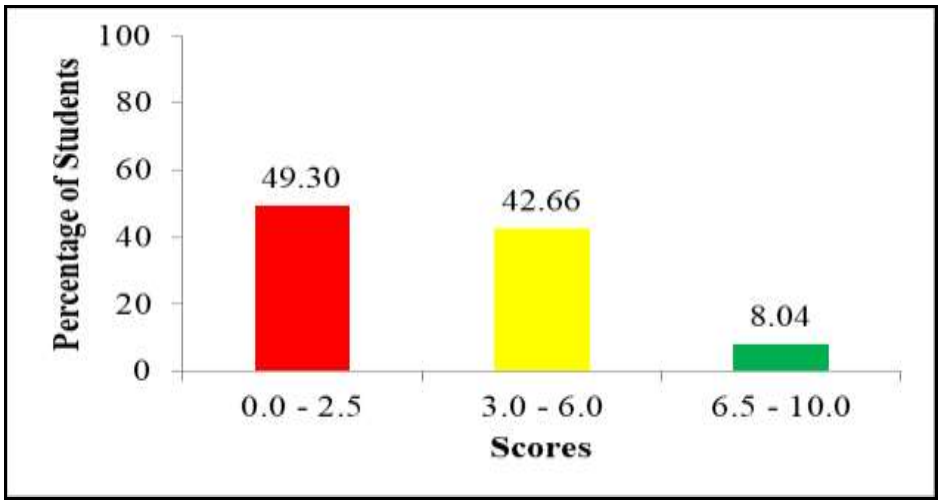


Figure 4*: The Students' Performance in Question 3*

The students who scored low marks had insufficient knowledge about electricity. In part (a), they failed either to identify or to describe the components of an atom. Moreover, in part (b), they provided incorrect sketches of the gold leaf electroscope which indicates that the students were unfamiliar with the structure of the electroscope and its application. Extract 3.1 is a sample of the students' poor responses to question 3.

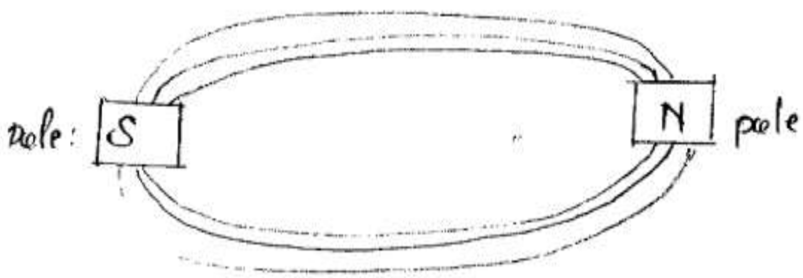
(i) - Atom can neo neither be created nor destroyed - atom you may create it and you may destroy due to eat Component;

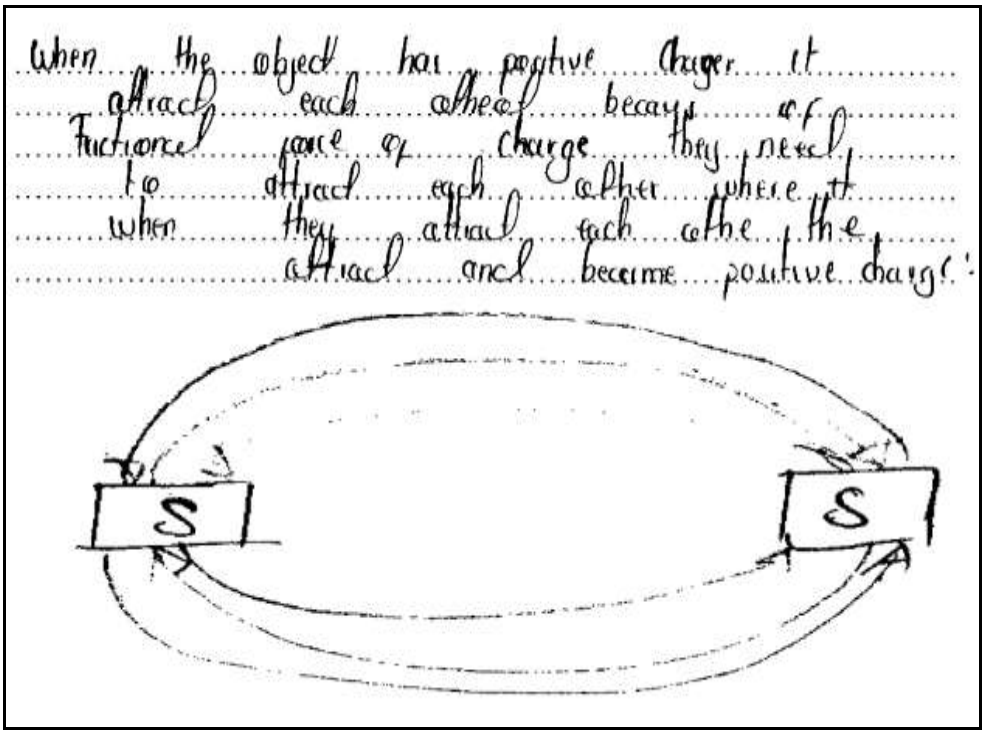
(ii) Matter is an a small pa tiny par pa practicle wich form an atom. So a matter is an small tiny practicle but it can form an atome;

(iii) Atom has the same Atomic mass but different Atomic number; an atom has the same atomic mass where it all atoms has the same mass but different atomic number, ~~each~~ each atomic mass has it own atomic number;

When an object has neghative charge it Repeal;

Because have different charge that why the reape repeal they could have the same charge the could attract each other but because they have different charge the will repeal;





Extract 3.1: A sample of poor responses to Question 3

In Extract 3.1, a student provided irrelevant description of the components of the atom and failed to apply the fundamental law of charges in electroscope.

The students who scored average marks (3-6), had inadequate knowlegde of electricity. They failed to apply the fundamental law of charges to describe the deflection of the leaf of the electroscope. Some of them managed to describe the three components of the atom.

Nevetherless, some students scored above average marks (6.5 -10), since they correctly described structure of the atom, the mode of the gold leaf electroscope and application of the fundamental law of charges. Extract 3.2 is a sample of the students' good responses to question 3.

(a) Briefly describe the components of an atom. Give three elements.

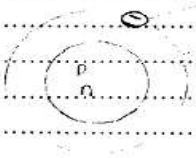
(i) Protons

- This are positively charged components of atoms. They can be detected on the gold leaf electroscope when the gold leaf is positively charged and also protons are found inside the nuclear

(ii) Electrons

- This are negatively charged component of an atom.

Example:



(iii) Neutron

- This is a neutral component of an atom
- It is found inside nuclear

(b) By using sketches, comment on the behaviour of the leaf of the electroscope when;

(i) the object has negative charge.

- The ~~electroscope~~ gold leaf electroscope when it is negatively charged and then you plagre an object that has negative charge the brass plate increase devergence and when there is no it decreases

(ii) the object has positive charge

- when the gold leafe is charged with positive ~~electron~~ charge when you plare an object with positive charge it increase in devergence ~~and when~~ .

Extract 3.2: A sample of good responses to Question 3

Extract 3.2 shows a student described correctly the components of the atom, application of the fundamental law of charges and the behaviour of the leaf of the electroscope.

2.2.2 Question 4: Heat

In this question, students were required to determine the final pressure and volume of the gas. The competence tested is the application of the gas laws which are Boyle's and Charles's Law in practical situations. Another competence is the manipulation of units' conversions of temperature and pressure as well as applying them to the problem. The question was as follows:

A certain mass of gas is contained in a cylinder by a piston. The temperature of the gas is 15^{o}C, pressure is 1.3 bar and its volume is 1.6 ltr. The gas is allowed to expand to a volume 5.6 ltr at a constant temperature, and then the temperature is raised to 70^{o}C at a constant pressure. What is the final pressure and volume of the gas?

The question was attempted by 1,716 (100%) students; where by 1,516 (88.35%) scored from 0 to 2.5 marks, 160 (9.33%) students scored from 3 to 6 marks, and 40 (2.33%) scored from 6.5 to 10 marks. The general performance was poor as 1,516 (88.34%) of the students scored below the required pass mark. Figure 5 shows students' performance in this question.

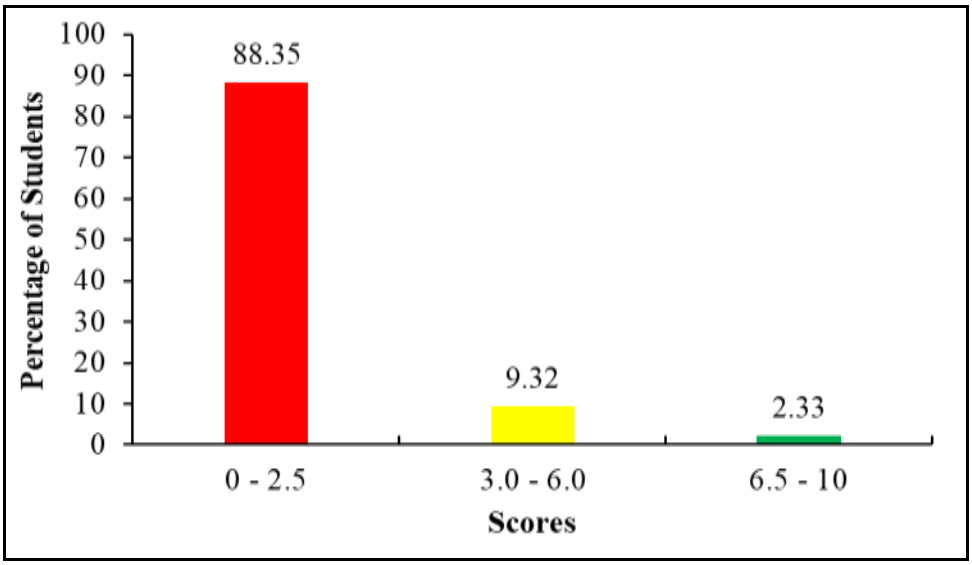
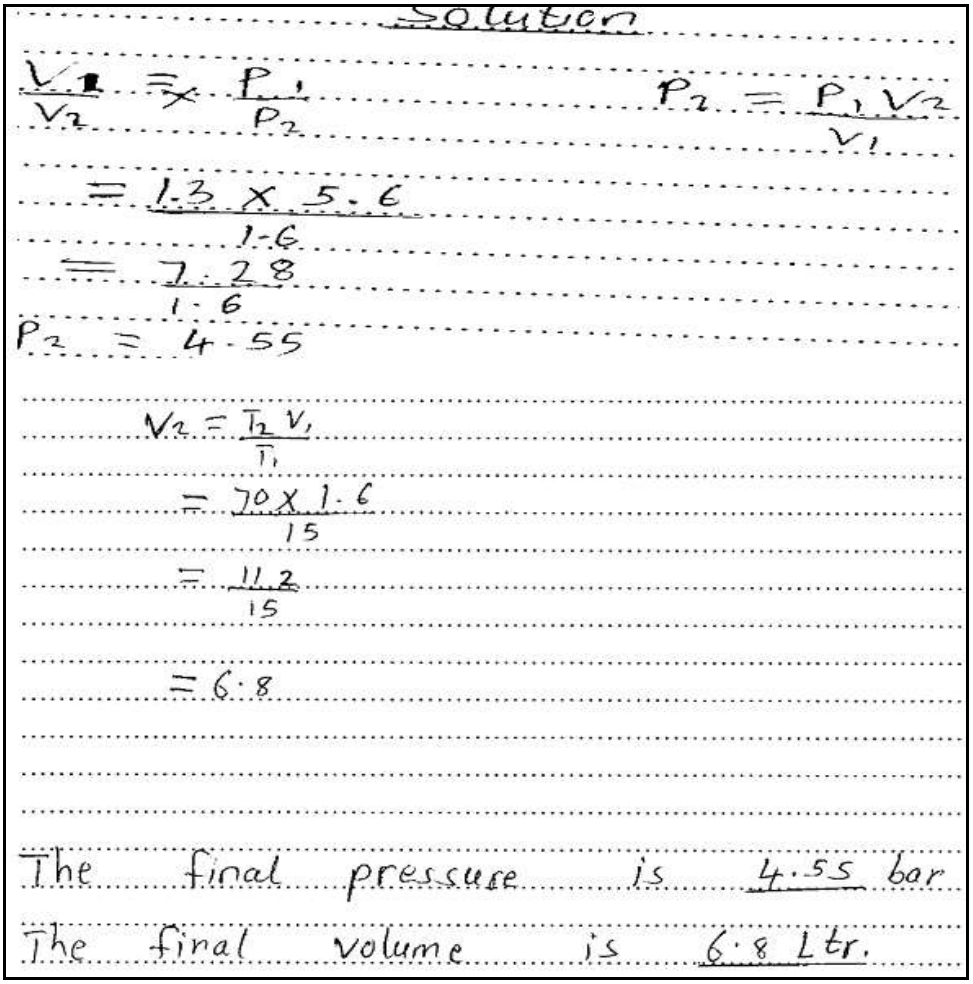


Figure 5: *The Students' Performance in Question 4*

The students who scored below the pass mark (0-2.5) lacked knowledge to analyze and derive the gas laws equations. Also, they failed to convert the degree Celsius into Kelvin. Moreover, some of them provided inappropriate formula like $P_1V_2 = P_2V_1$ and $\frac{V2}{T1} = \frac{V1}{T2}$ instead of $P_1V_1 = P_2V_2$ and $\frac{V1}{T1} = \frac{V2}{T2}$ to determine volume and pressure of gas, respectively, where 'P' is the pressure, 'T' is the temperature and 'V' is the volume of the gas. Extract 4.1 is a sample of the students' poor responses to question 4.

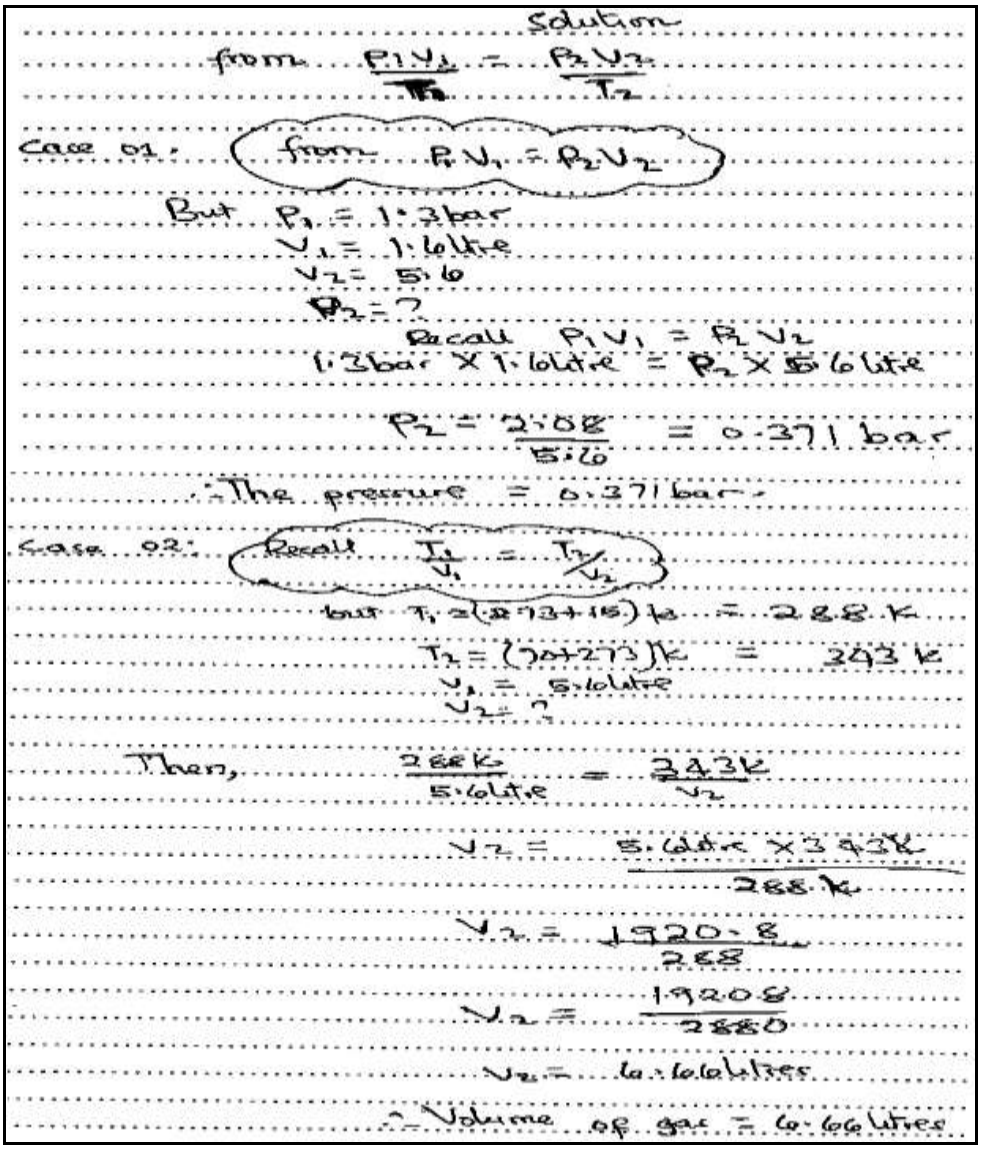


Extract 4.1: A sample of the incorrect responses to Question 4.

In Extract 4:1, a student failed to appply properly the correct formula related to the Boyle's law and the Charle's law to calculate the final pressure and volume of the gas.

The students who scored average marks (3 - 6) managed to convert correctly the degree Celsius (^oC) to thermodynamic temperature scale (the Kelvin). They wrote relevant formula to either the Boyle's law or the Charle's law. In addition, they failed to compute the final pressure and volume of the gas.

However, students who scored above average marks (6.5-10) had adequate understanding on the topic of Heat (part two) specifically on the concept of expansion of gases, as they were able to explain the three laws of gas. Furthermore, they deduced correctly equations of the Boyle's law and the Charle's law, which led them to compute the final pressure and volume of the gas. Extract 4.2 is a sample of the students' good response to question 4.



Extract 4.2: A sample of good responses to Question 4

Extract 4.2 shows responses from a student who correctly analysed the Boyle's law and the Charle's law to calculate the final pressure and volume of the gas.

2.2.3 Question 5: Simple Machines

The question intended to assess students' ability to determine mechanical advantage, velocity ratio and efficiency of a screw jack. The question was as follows:

A driver uses a screw jack to support the axle of his lorry of load 5.6 kN. The screw jack has an effort arm of effective radius of 318 mm and a single-start square thread of 5 mm lead. Determine the efficiency of the jack if an effort of 70 N is required to raise the car's axle.

This question was attempted by 1,716 (100%) students; where by 683 (39.80%) scored from 0 to 2.5 marks, 727 (42.37%) students scored from 3 to 6 marks, and 306 (17.83%) scored from 6.5 to 10 marks. The overall performance on this question was good as 846 (60.20%) students scored above pass mark. Figure 6 shows students' performance in this question.

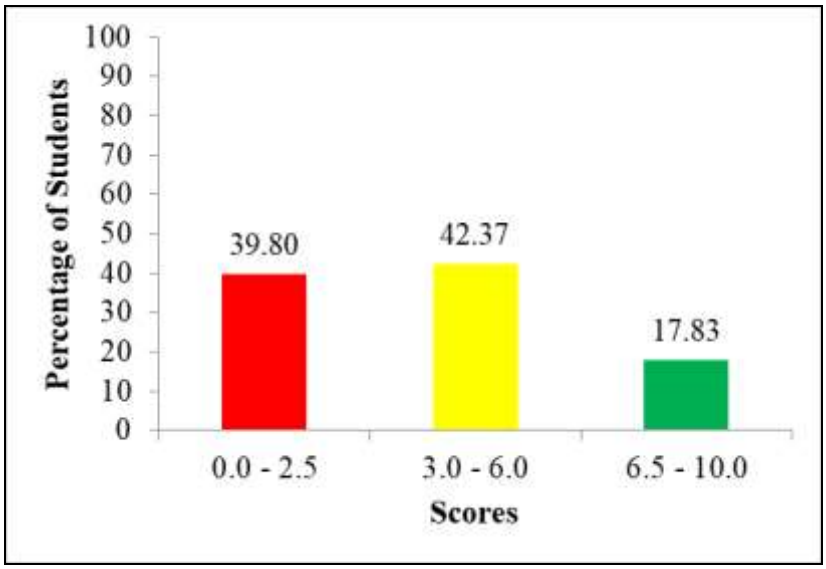
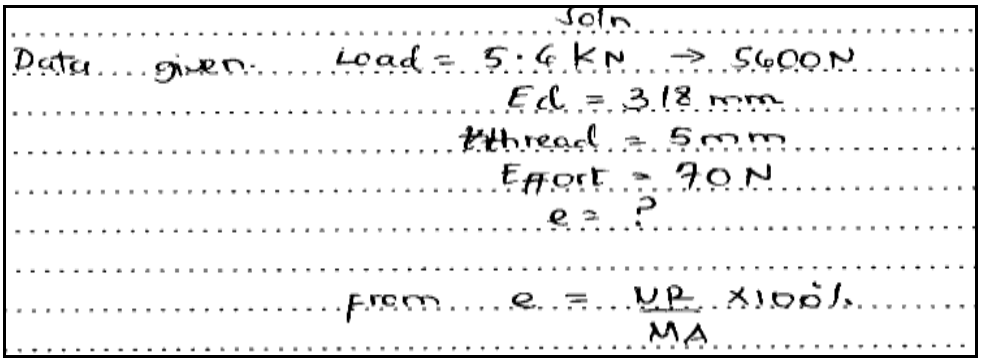


Figure 6: *The Students Performance in Question 5*

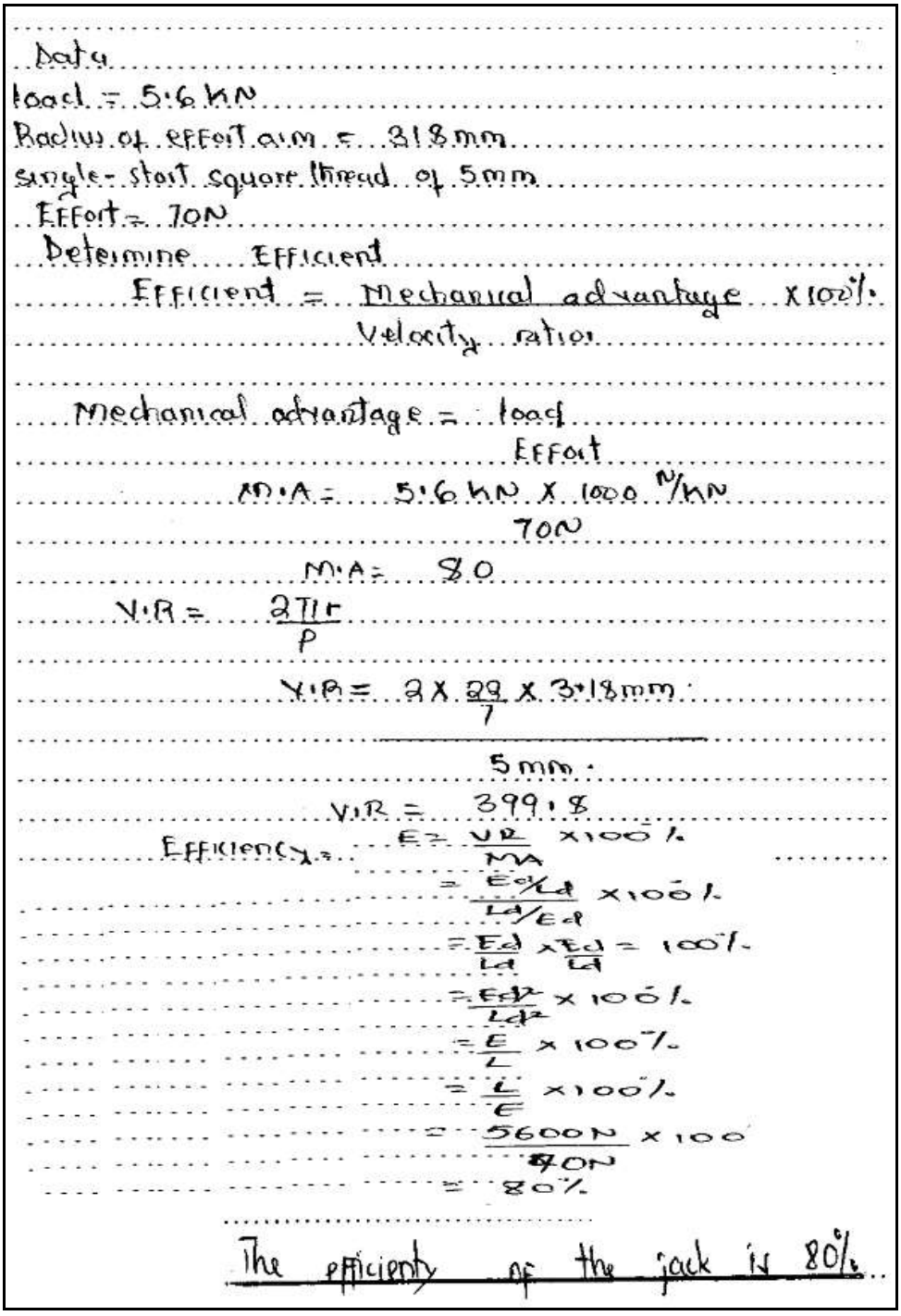
The students who scored low marks (0-2.5) failed to derive and apply the proper formula to determine mechanical advantage, velocity ratio and efficiency of a screw jack. Some of them wrote the incorrect formula as $\text{M.A} = \frac{\text{E}}{\text{L}}$ instead of $\text{M.A} = \frac{\text{L}}{\text{E}}$, efficiency $= \frac{\text{V.R}}{\text{M.A}} \times 100\%$ instead of efficiency $= \frac{\text{M.A}}{\text{V.R}} \times 100\%$, and $\text{V.R} = \frac{2\text{R}}{\text{P}}$ instead of $\text{V.R} = \frac{2\pi\text{R}}{\text{P}}$, where, 'V.R' is the velocity ratio, 'L' is the load and 'E' is the effort. Extract 5.1 is a sample of students' poor response to question 5.



Extract 5.1: A sample of incorrect responses to Question 5

Extract 5:1 shows responses from a student who applied wrong formula to calculate mechanical advantage, velocity ratio and effiency of the screw jack.

The students who scored average marks (3-6) correctly calculated the mechanical advantage and efficiency, but wrote wrong formula in determining velocity ratio of the screw jack. These students did not recognize that, the term 'lead' mean the pitch of the screw jack. However, some students scored 6.5 to 10 marks. These students had adequate understanding of the topic of simple machines, specifically on the velocity ratio of screw jack. Extract 5.2 is a sample of the students' good responses to question 5.



Extract 5.2: A sample of good responses to Question 5

Extract 5.2 shows responses from a student who correctly determined the efficiency of the screw jack.

2.2.4 Question 6: Turning Forces

The question aimed to assess students' ability to draw and to find the force exerted on each end support of the bridge. The question was as follows:
A uniform bridge 32 m long weigh 50× 10^3kg and a lorry weighing 15× 10^3kg is positioned 8 m from one end of the bridge. Considering that, the weight of the bridge will act at its centre of gravity halfway along it, draw the force diagram and find the force exerted on each end support of the bridge.

A total of 1,716 (100%) students attempted this question; where by 1,260 (73.43%) scored from 0 to 2.5 marks, 227 (13.23%) students scored from 3 to 6 marks, and 229 (13.34%) scored from 6.5 to 10 marks. The performance on this question was poor as 1,260 (73.43%) of the students failed. Figure 7 shows students' performance in this question.

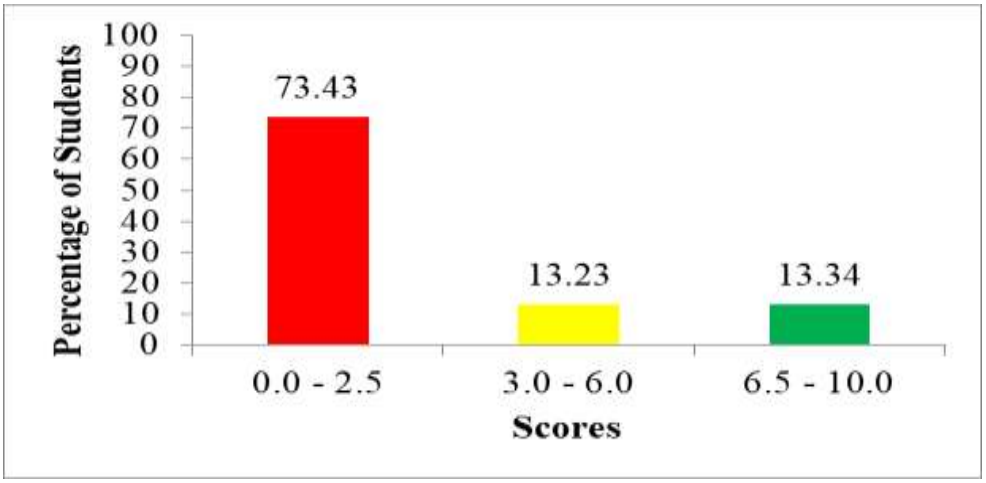
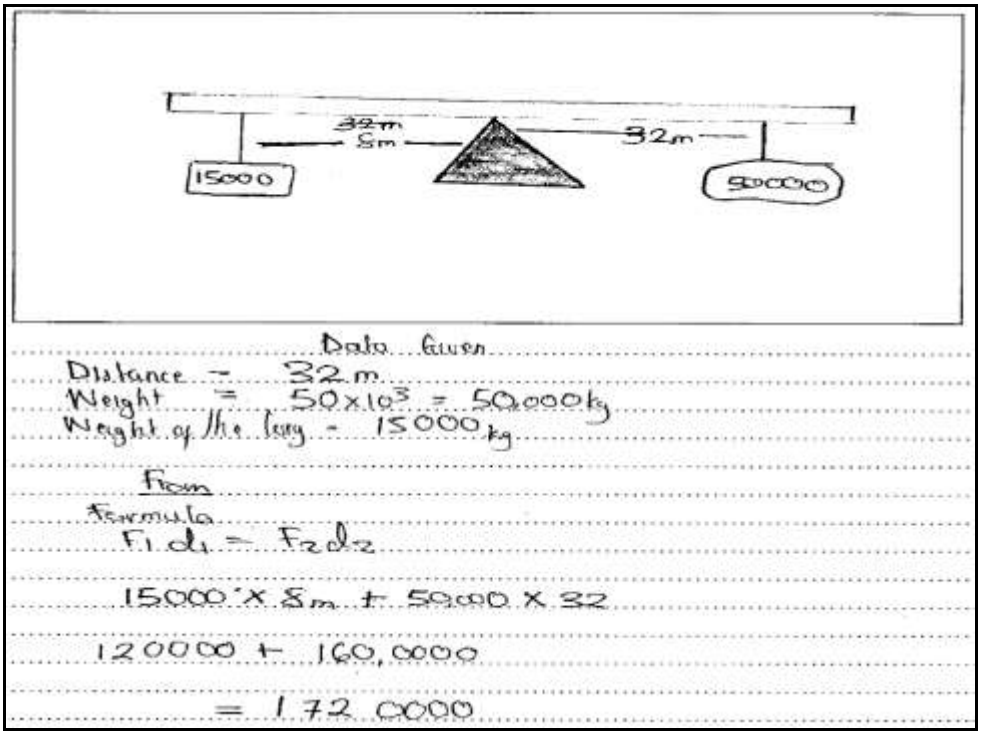


Figure 7: *The Students Performance in Question 6*

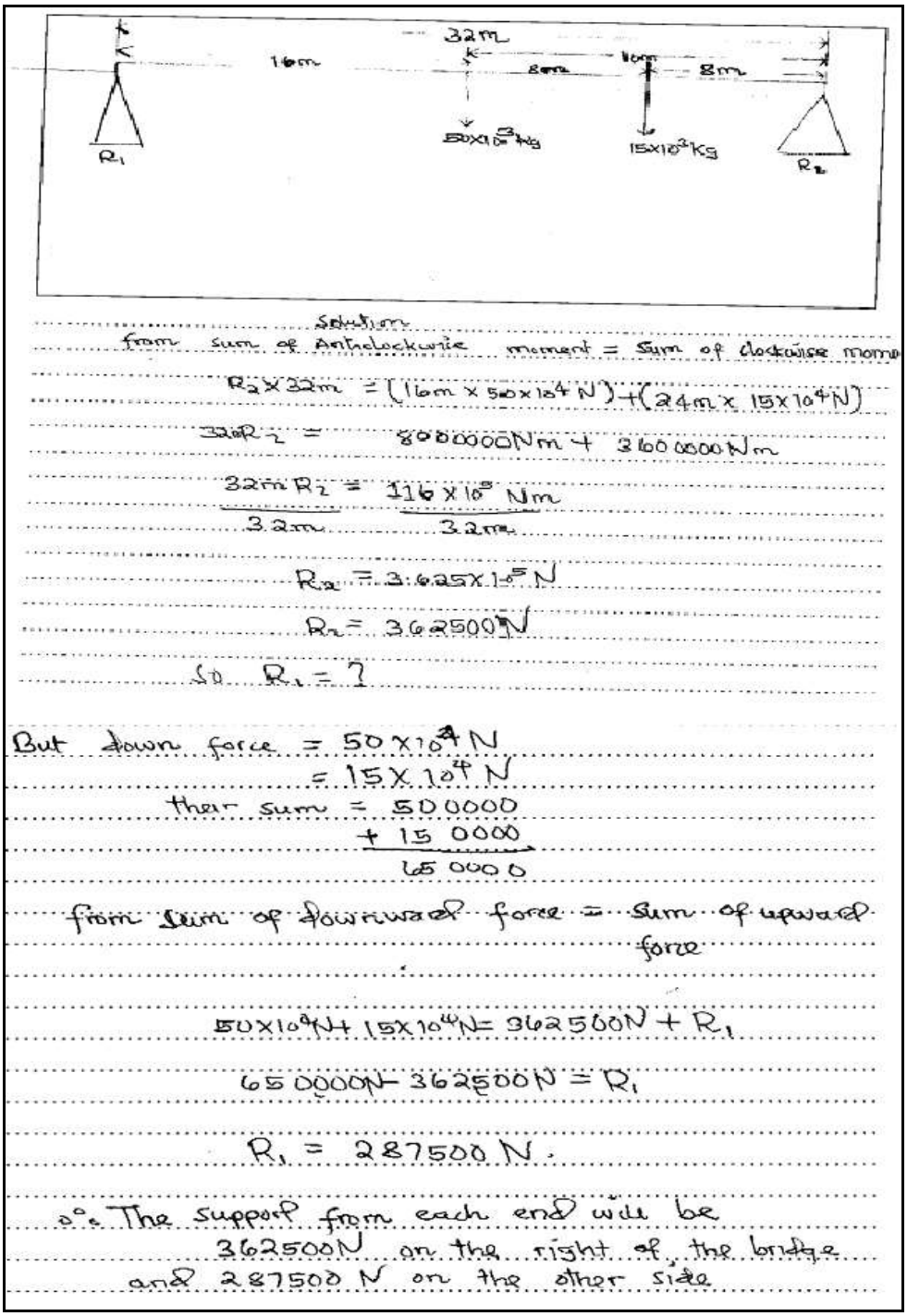
The students who scored low marks (0-2.5) provided incorrect force diagram. In addition, they failed to analyse and apply the conditions for equilibrium to find the force on each end support of the bridge. Also, they failed to apply the principle of moments about a point. Extract 6.1 is a sample of students' poor responses to question 6.



Extract 6:1 A sample of poor responses to Question 6

Extract 6.1 shows a students' responses who drew incorrect force diagram and failed to comprehend the conditions for equilibrium to find the force on each end support of the bridge.

Students who scored the average marks (3-6), drew correctly the force diagram and provided the correct statements describing the conditions for equilibrium; *the sum of upward forces = the sum of downward forces as well as the sum of clockwise moment = sum of anticlockwise moments*. However, these students lacked mathematical skills to manipulate simultaneous equations to calculate the force on each end support of the bridge. Only few students 456 (26.57%) scored above average marks (6.5-10). They had sufficient understanding of the topic of Turning Forces specifically on the application of the principle of moments and solving the simultaneous involved. Extract 6.2 is a sample of students' good responses to question 6.



Extract 6.2: A sample of good responses to Question 6

In Extract 6.2, a student managed to apply the conditions for equilibrium with conjunction to the principle of moments about a point and correctly

computed the force exerted on each end support of the bridge.

2.2.5 Question 7: Friction

The question intended to assess students' competence on applying the law of friction to determine the value of mass of the box.

A force of 50 N is applied to the box containing books to make it slide over a horizontal floor. If the coefficient of friction between the box and the floor is 0.5, find the mass of the box.

The question was attempted by 1,716 (100%) students; in which 1,054 (61.42%) scored from 0 to 2.5 marks, 205 (11.95%) students scored from 3 to 6 marks, and 457 (26.63%) scored from 6.5 to 10 marks. The performance on this question was average as 662 (38.58%) of the students scored slightly above pass mark. Figure 8 shows students' performance in this question.

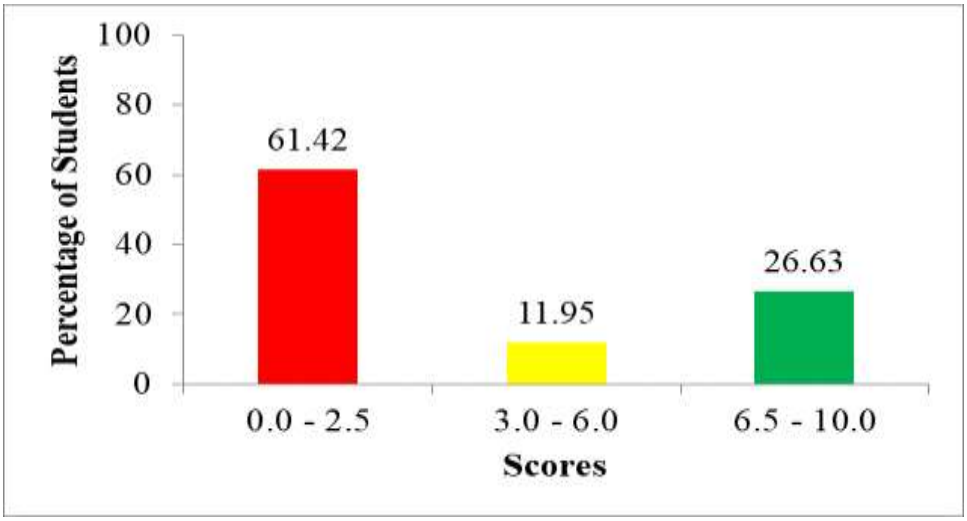
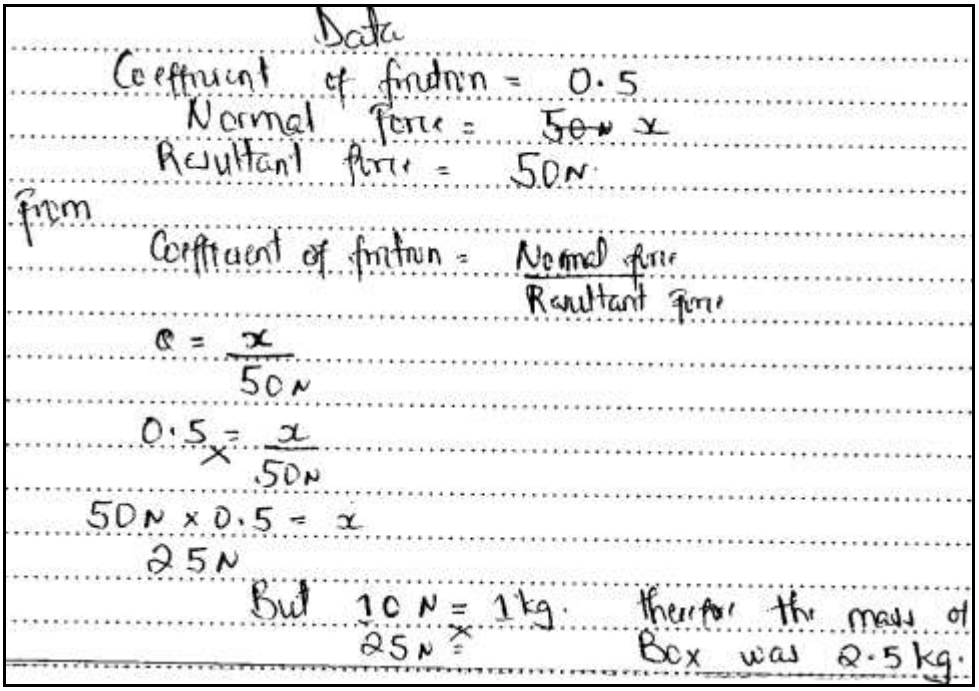


Figure 8: *The Students Performance in Question 7*

Most of the students were able to apply the formula $\mu = \frac{F}{R}$ *and* $R = mg$ to determine the mass of the box. Whereby 'μ' is the coefficient of friction, 'F' is the frictional force, 'R' is the reaction force, 'm' is the mass of a box and 'g' is the gravitational force. In addition, they substituted correctly the values of the data, to compute the mass of the box.

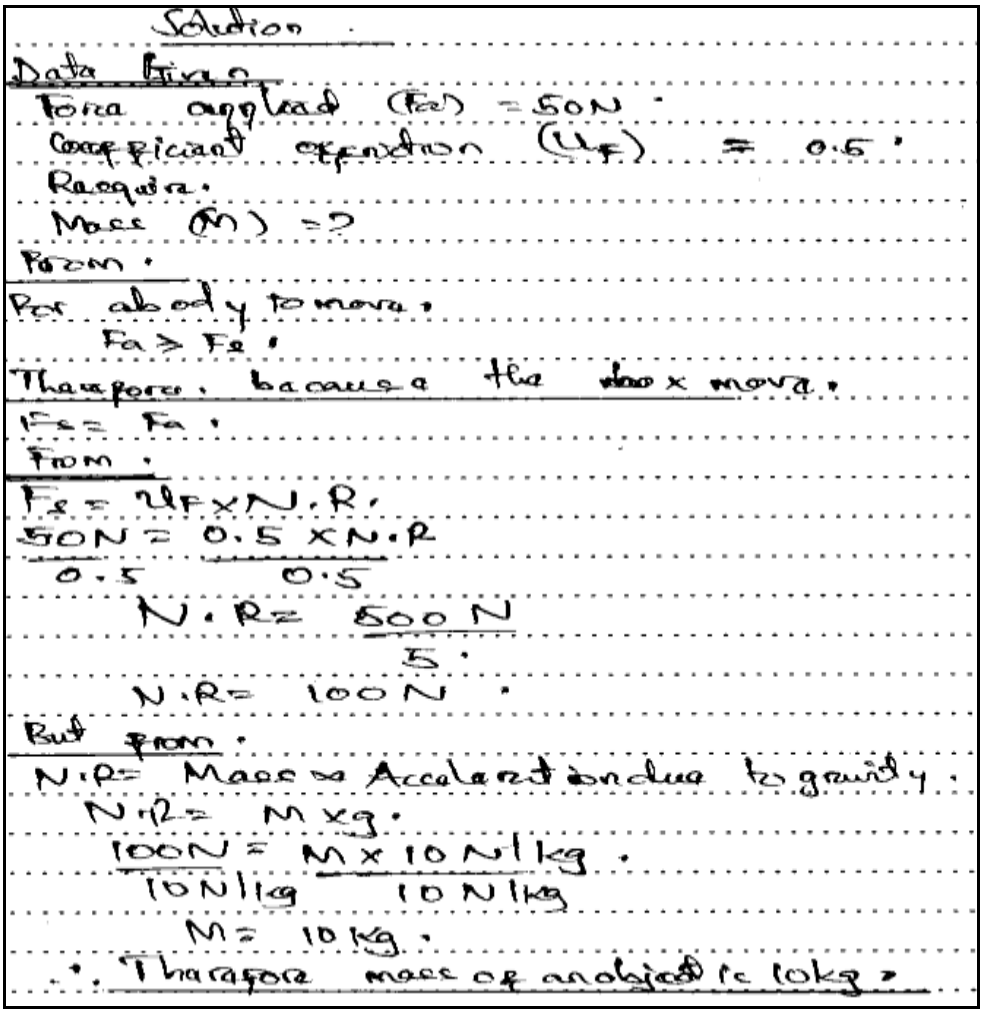
Those students who scored below pass marks (0-2) applied wrong equation of the law of friction. Some of them interchanged the formula and wrote $\mu = R/F$ which is wrong. Extract 7.1 is a sample of students' poor responses to question 7.



Extract 7.1: A sample of poor responses to Question 7

In Extract 7.1, a student who was unable to recall, analyse and apply the laws of friction to compute the mass of the box.

However, some few students who scored average marks (3-6) wrote correctly the equation of friction but failed to compute the correct value of the mass of the box. These students lacked mathematical skills to compute the value of the mass of the box. However, students who scored above average marks understood the laws of friction and correctly derived the equation that described the laws of friction and applied correctly formula to compute the mass of the box. Extract 7.2 is a sample of students' good responses.


Solution
Data given
Force applied (Fa) = 50N
Coefficient of friction (μ_F) = 0.5
Required:
Mass (M) = ?
Form:
For a body to move:
Fa ≥ Fs
Therefore, because the box move:
Fs = Fa
From:
Fs = μ_F x N.R
50N = 0.5 x N.R
0.5 0.5
N.R = 500 N
5
N.R = 100 N
But from:
N.R = Mass x Acceleration due to gravity
N.R = M x g
100N = M x 10N/kg
10N/kg 10N/kg
M = 10kg
∴ Therefore mass of an object is 10kg

Extract 7.2: A sample of good responses to Question 7

In Extract 7.2, a student scored all the marks since she/he correctly applied the fumula $\mu = \frac{F}{R}$ and $R = mg$ to find the mass of the box.

2.2.6 Question 8: Work, Energy and Power

The question required the students to calculate the kinetic energy and acceleration of the vehicle. The question was as follows:

A man accelerated a 10 tons' vehicle from initial velocity to a velocity of 20 m/s in 3 seconds and he found that, the kinetic energy was changed to 355 kJ. Calculate;

(a) The velocity of the vehicle before acceleration.

(b) The acceleration of the vehicle.

This question was attempted by 1,716 (100%) students; where by 1,317 (76.75%) scored from 0 to 2.5 marks, 350 (20.39%) students scored from 3 to 6 marks, and 49 (2.86%) scored from 6.5 to 10 marks. The performance on this question was weak as 1,317 (76.75%) of the students scored below the pass mark. Figure 9 shows students' performance in this question.

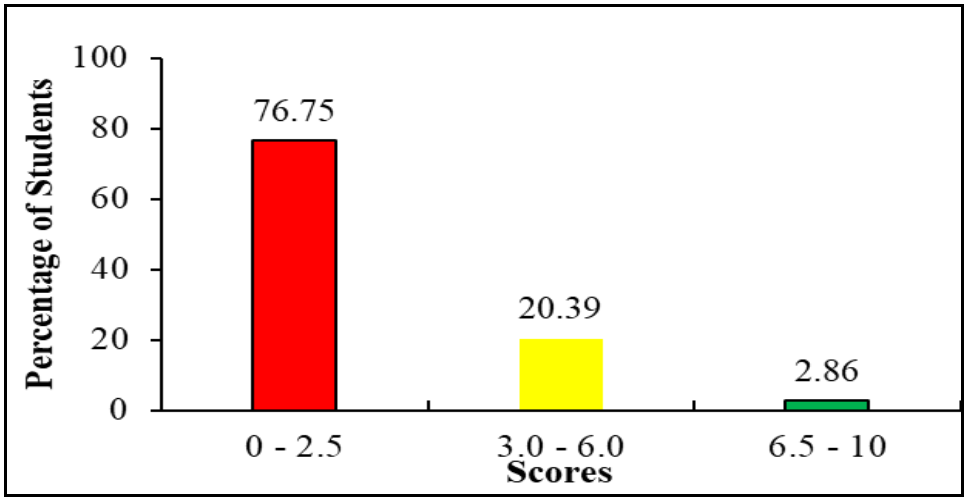
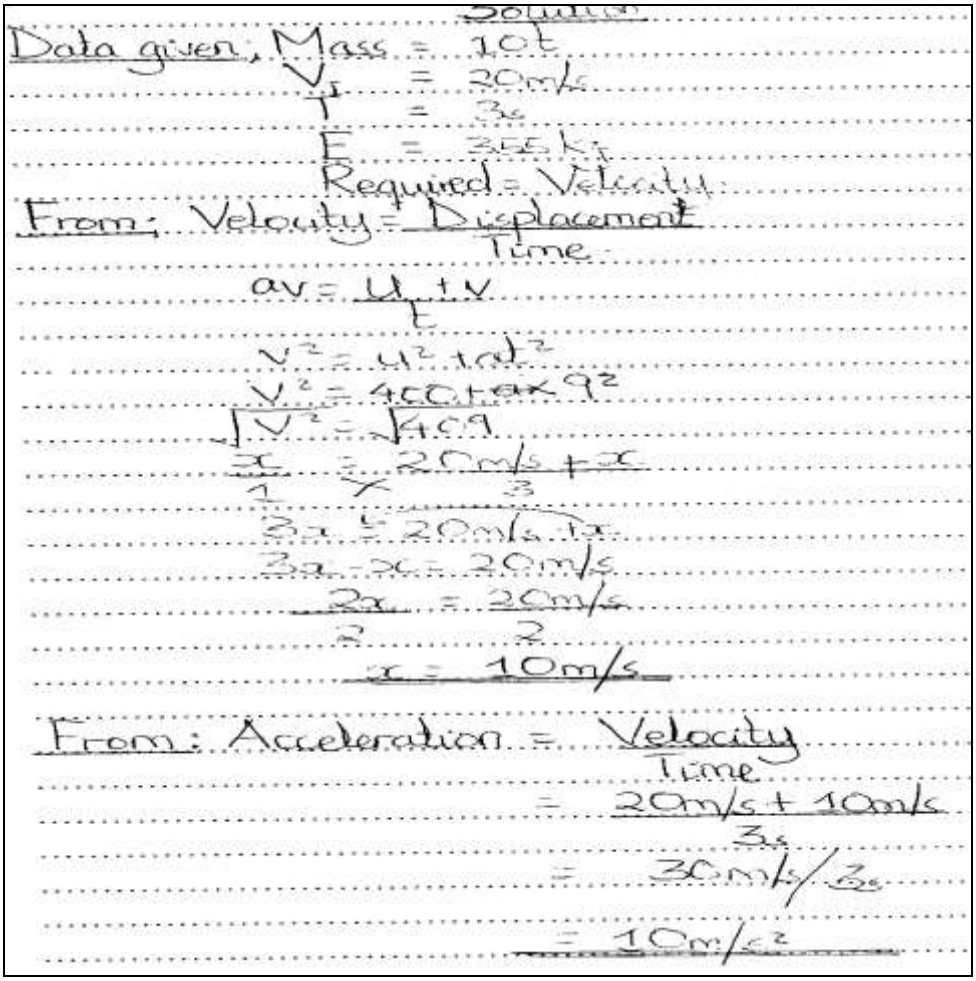


Figure 9: *The Students Performance in Question 8*

Those students who scored below pass mark (0-2.5) failed to interpret the task of the question. In part 8 (a), they failed to associate the change of kinetic energy and change of velocity, since some of them wrote wrong formula as $Velocity = \frac{Displacement}{Time}$, wrong formula $av = \frac{u+v}{t}$, and $V^2 = U^2 + at^2$ *instead of* $\text{K.E} = \frac{mV^2}{2}$, $\Delta K.E = \frac{m(V^2-U^2)}{2}$ and $a = \frac{v-u}{t}$. Where, 'K. E' is the kinetic energy, 'm' is the mass, 'v' is the final velocity and 'u' is the initial velocity. In part 8(b), students applied wrong the formula. $av = \frac{Initial\ velocity + final\ velociy}{2}$ instead of $a = \frac{Final\ velocity - Initial\ velociy}{t}$, where 'a' is the acceleration. Extract 8.1 is a sample of students' poor responses to question 8.

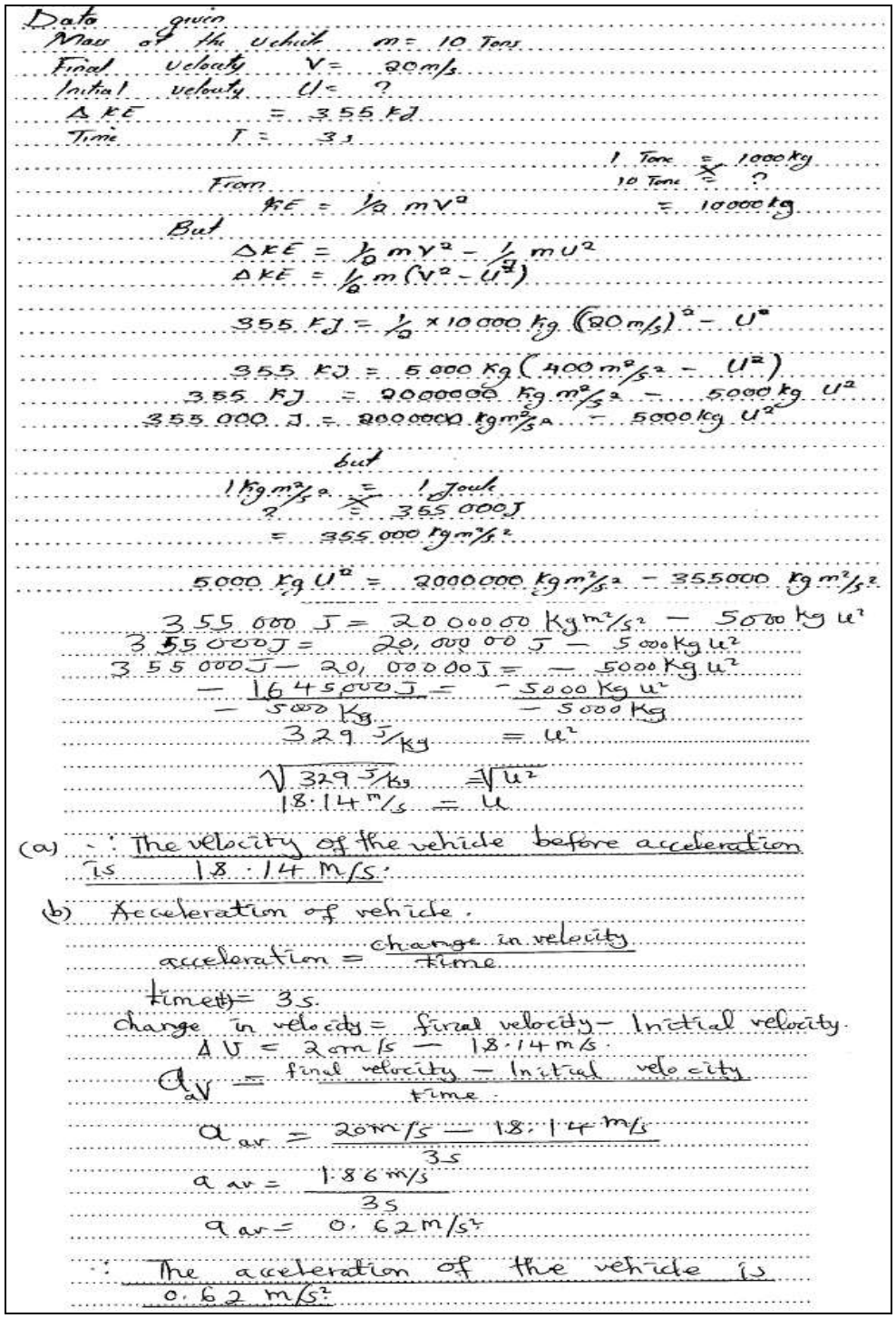


Extract 8.1: A sample of poor responses to Question 8

In Extract 8.1, a student failed, to apply the formulas; $\mathrm{K.E} = \frac{mV^2}{2}$, $\Delta K.E = \frac{m(V^2 - U^2)}{2}$ and $a = \frac{\mathrm{v-u}}{t}$ to compute the mass of the box.

However, some few students who scored average marks (3-6) wrote correctly the formula $K.E = \frac{mV^2}{2}$ and $a = \frac{v-u}{t}$ but failed to manipulate $\Delta K.E = \frac{m(V^2 - U^2)}{2}$ to obtain the value of Kinetic Energy. Other students who scored above average marks (6.5-10) managed to apply all the formulas related to the change of kinetic energy, change of velocity and acceleration. Intact, these students had sufficient mathematical skills to organize and compute the final velocity and acceleration of the car. Extract

8.2 is a sample of students' good responses to question 8.


Data given
Mass of the vehicle m = 10 Tons
Final velocity V = 20 m/s
Initial velocity U = ?
ΔKE = 355 kJ
Time T = 3s

1 Tone = 1000 kg
10 Tone = ?
= 10000 kg

From KE = ½ mV²

But
ΔKE = ½ mV² − ½ mU²
ΔKE = ½ m(V² − U²)

355 kJ = ½ × 10000 kg ((20 m/s)² − U²

355 kJ = 5000 kg (400 m²/s² − U²)
355 kJ = 2000000 kg m²/s² − 5000 kg U²
355 000 J = 2000000 kg m²/s² − 5000 kg U²

but
1 kg m²/s² = 1 Joule
? = 355 000 J
= 355 000 kg m²/s²

5000 kg U² = 2000000 kg m²/s² − 355000 kg m²/s²

355 000 J = 2 000 000 kg m²/s² − 5000 kg u²
355 000 J = 20, 000 00 J − 5000 kg u²
355 000 J − 20, 000 00 J = − 5000 kg u²
− 1645000 J = − 5000 kg u²
− 5000 kg − 5000 kg
329 J/kg = u²

√329 J/kg = √u²
18.14 m/s = u

(a) ∴ The velocity of the vehicle before acceleration is 18.14 m/s.

(b) Acceleration of vehicle.

acceleration = change in velocity / time

time(t) = 3s.

Change in velocity = final velocity − Initial velocity
ΔV = 20 m/s − 18.14 m/s.

a_av = final velocity − Initial velocity / time

a_av = 20 m/s − 18.14 m/s / 3s

a_av = 1.86 m/s / 3s

a_av = 0.62 m/s²

∴ The acceleration of the vehicle is 0.62 m/s²

Extract 8.2: A sample of good responses to Question 8

In Extract 8.2, a student managed to recall and appy the correct formula $\mathrm{K.E} = \frac{mV^2}{2}$, $\Delta K.E = \frac{m(V^2-U^2)}{2}$ and $a = \frac{\mathrm{v-u}}{t}$ to compute the final velocity and acceleration of the car.

2.2.7 Question 9: Linear Motion

The question intended to assess students' ability to apply velocity-time graph to estimate the total distance covered by the car. The question was as follows:

A car was driven through corrugated road at a speed of 12 m/s for 6 second and then it was accelerated for 4 seconds to a speed of 25 m/s. this speed was maintained for 4 seconds until the brake was applied for 2 seconds to stop the car. By the aid of velocity-time graph, estimate the total distance covered on this journey.

This question was attempted by 1,716 (100%) students; where by 1,245 (72.55%) scored from 0 to 2.5 marks, 256 (14.92%) students scored from 3 to 6 marks, and 215 (12.53%) scored from 6.5 to 10 marks. The performance on this question was poor as 1,245 (72.55%) of the students scored below pass mark. Figure 10 shows students' performance in this question.

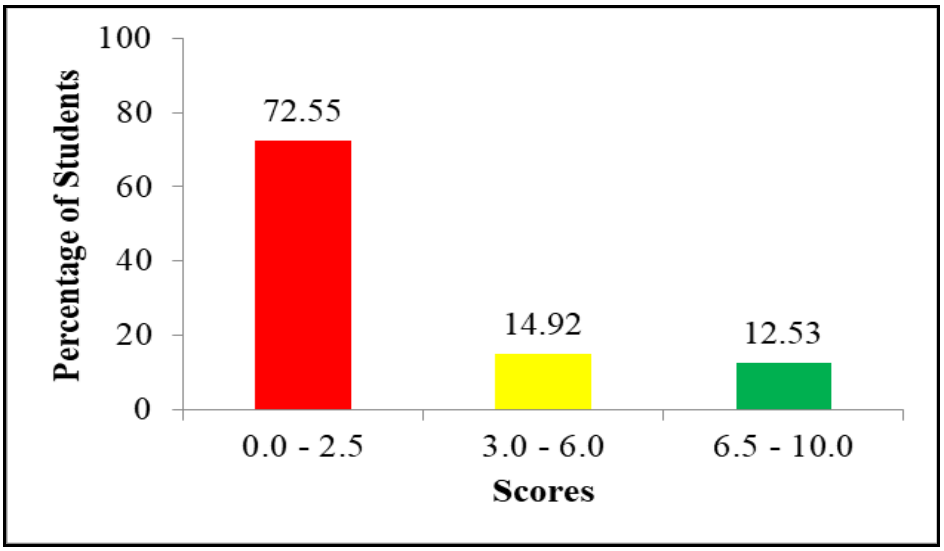
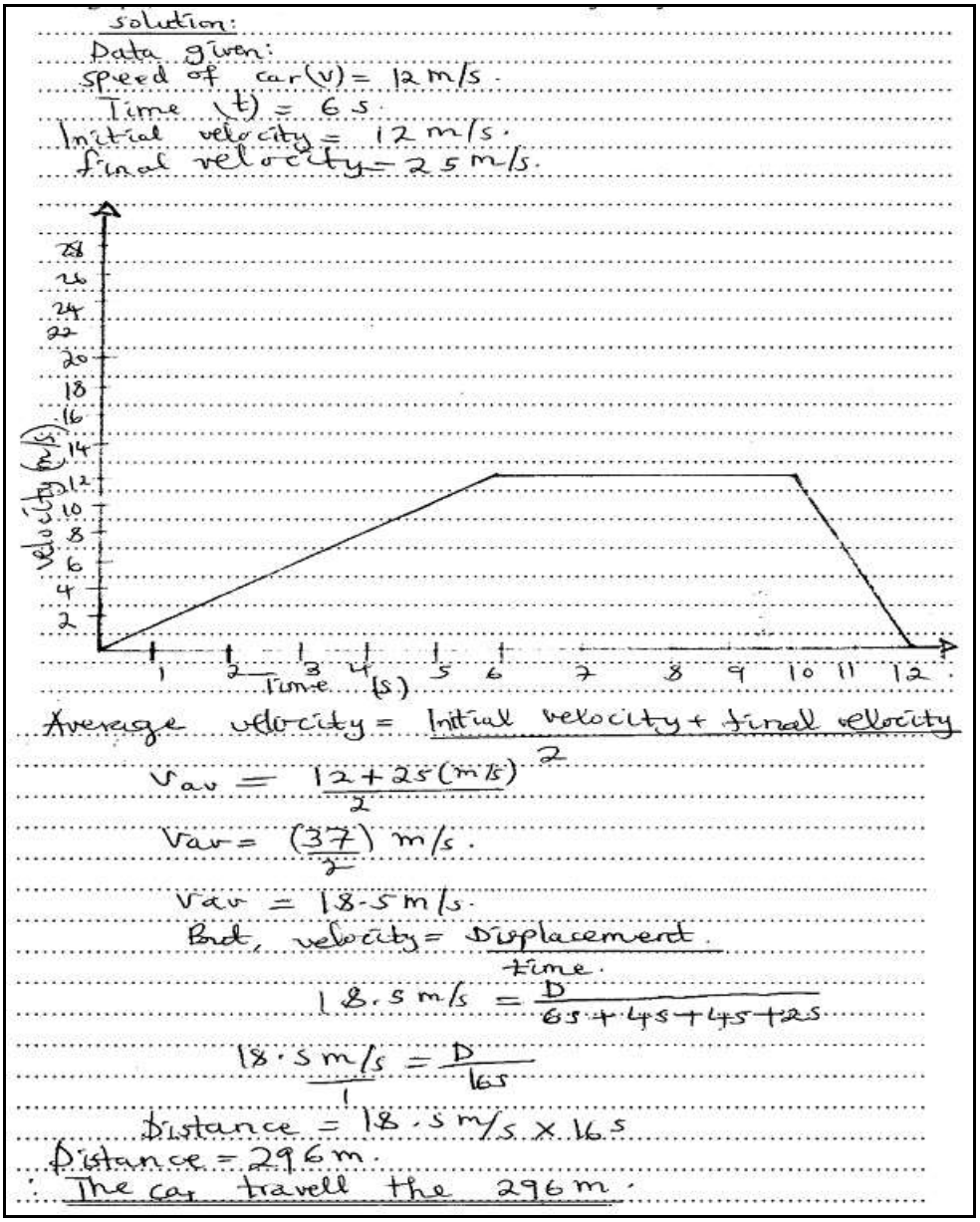


Figure 10: *The Students Performance in Question 9*

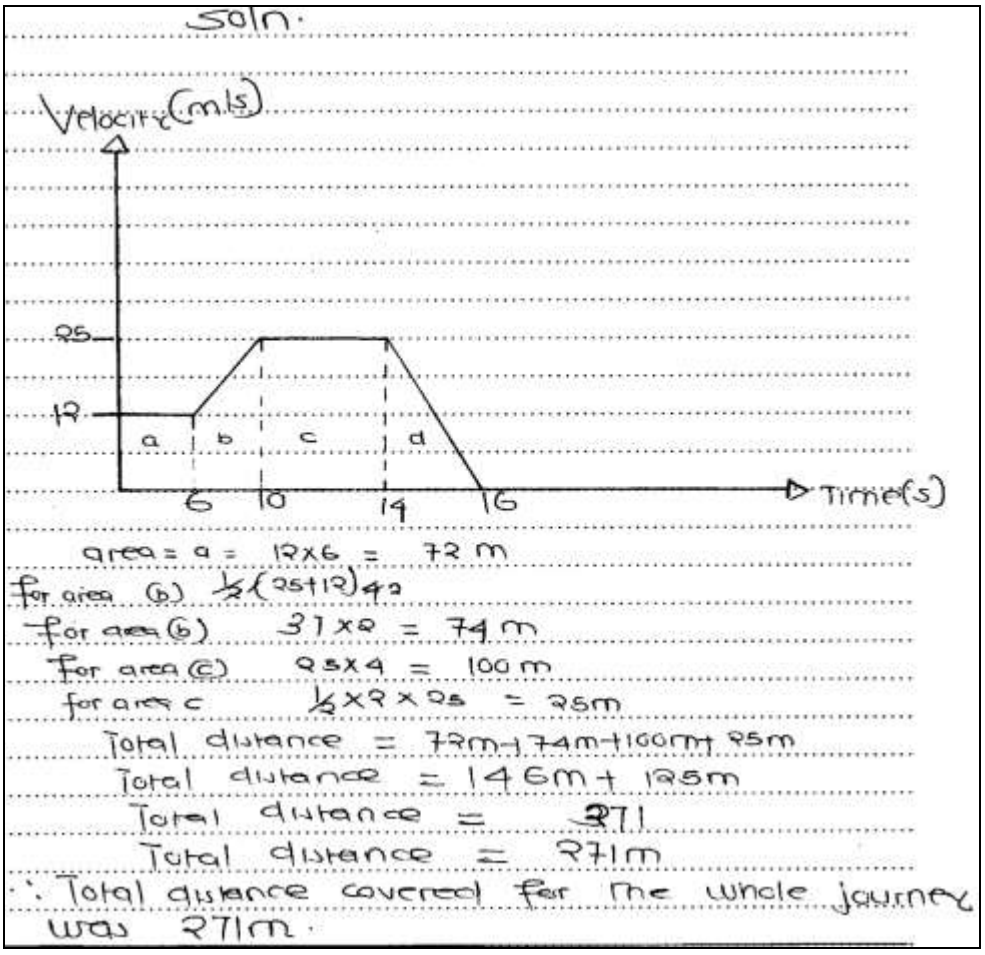
Students who scored below pass mark (0-2.5) provided incorrect sketch of graph. Also, they failed to recognize that the area under the velocity-time graph represents the total distance covered by the car. Additionally, they were not able to indicate the values of time and velocity on the respective axes. Extract 9.1 is the sample of poor responses of a student to question 9.



Extract 9.1: A sample of poor responses to Question 9

In Extract 9.1, a student provided incorrect sketch of velocity-time graph and wrong estimate of the total distance covered.

Students who scored average mark (3-6) provided correct sketch of velocity-time graph, they also understood that the area under the velocity-time graph represents the total distance covered by the car. Moreover, they succeeded to compute the distance covered in the first 6 seconds meanwhile they failed to identify the correct dimensions required to find the distances for each portion of the sketch. Nevertheless, some students scored above average marks (6.5-10), had proper understanding of the topic of linear motion specifically the use of velocity-time graph to describe motion of the car and determination of total distance from the graph. Also, these students had sufficient mathematical skills to find areas of rectangle $(A = L \times W)$, triangle $(A = \frac{1}{2} bh)$ and that of trapezium $(A = \frac{1}{2} (a + b) h)$. Extract 9.2 is the sample of a good responses of a student to question 9.



Extract 9.2: A sample of good responses to Question 9

In Extract 9.2, a student was able to interpret the velocity-time graph and use the areas obtained under the graph to estimate the total distance covered by the car.

2.3 SECTION C: STRUCTURED QUESTION

This section had one (1) structured essay question, extracted from the topic of Heat (part two) carrying fifteen (15) marks. The analysis of this question is as follows:

2.3.1 Question 10: Heat

The question intended to assess the ability of students to compute the value of the pressure and to estimate the volume of air at S.T.P. The question was as follows:

(a) When a motor car tyre was tested in a garage at a temperature of 17^{o}C was found to have a pressure of 290 ×10^{3}Pa. assume that the volume of the air inside the tyre remains constant, what would be the value of the pressure after the tyre has been exposed in the sun so that its temperature rises to 27^{o}C?

(b) At a temperature of 27 ^{o}C, a volume of air in a motorcycle tyre at a gauge pressure of 750mmHg is 3000cm^{3}. Estimate the volume of the air inside the tyre of the motor cycle at the Standard Temperature and Pressure (S.T.P).

The question was attempted by 1,716 (100%) students; where by 1,307 (76.17%) scored from 0 to 2.5 marks, 215 (12.53%) students scored from 3 to 6 marks, and 194 (11.31%) scored from 6.5 to 10 marks. The general performance of students was poor as 1,307 (76.17%) of them scored below pass mark. Figure 11 shows students' performance in this question.

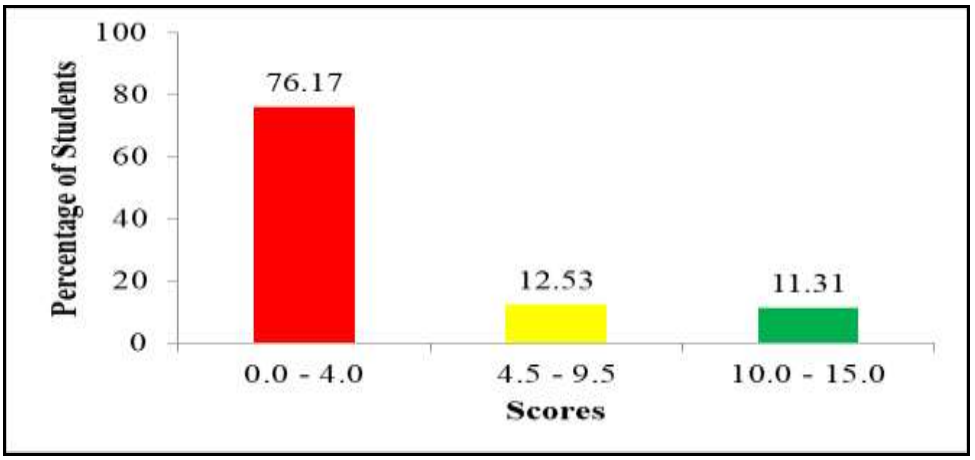
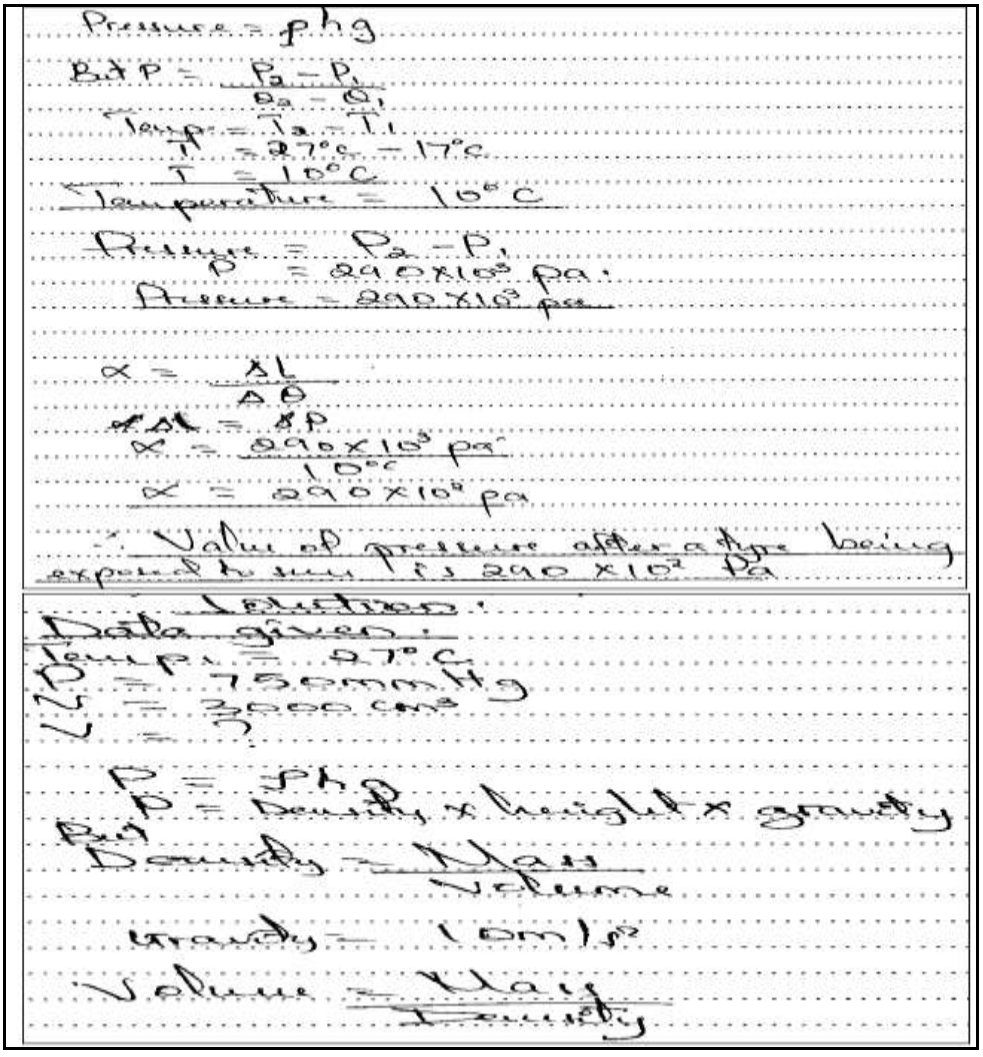


Figure 11: *The Students Performance in Question 10*

The students who scored low marks (0-4.5) lacked knowledge of thermal expansion of gases specifically on the application of the Pressure law and the general gas equation. Also, they wrote irrelevant formula of pressure as

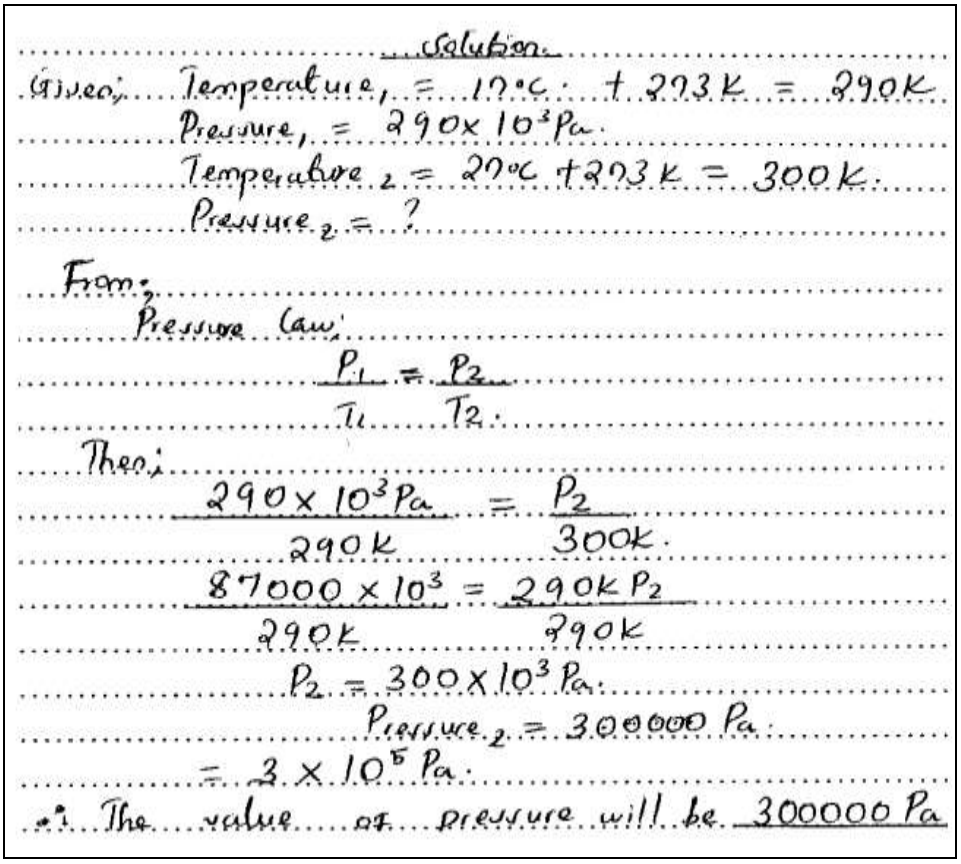
$P = \rho hg$ instead of $\frac{P1}{T1} = \frac{P2}{T2}$ in determining the final pressure of the gas as per question 10 (a). In part 10 (b), some students wrote wrong formula of volume as $volume = \frac{mass}{density}$ instead of $\frac{P1V1}{T1} = \frac{P2V2}{T2}$ as per the question demands, where by 'P' is the pressure, 'V' is the volume and 'T' is the temperature. These students failed to distinguish the concepts of pressure due to liquid and pressure due to expansion of gas. Extract 10.1 is a sample of the students' poor responses to question 10.

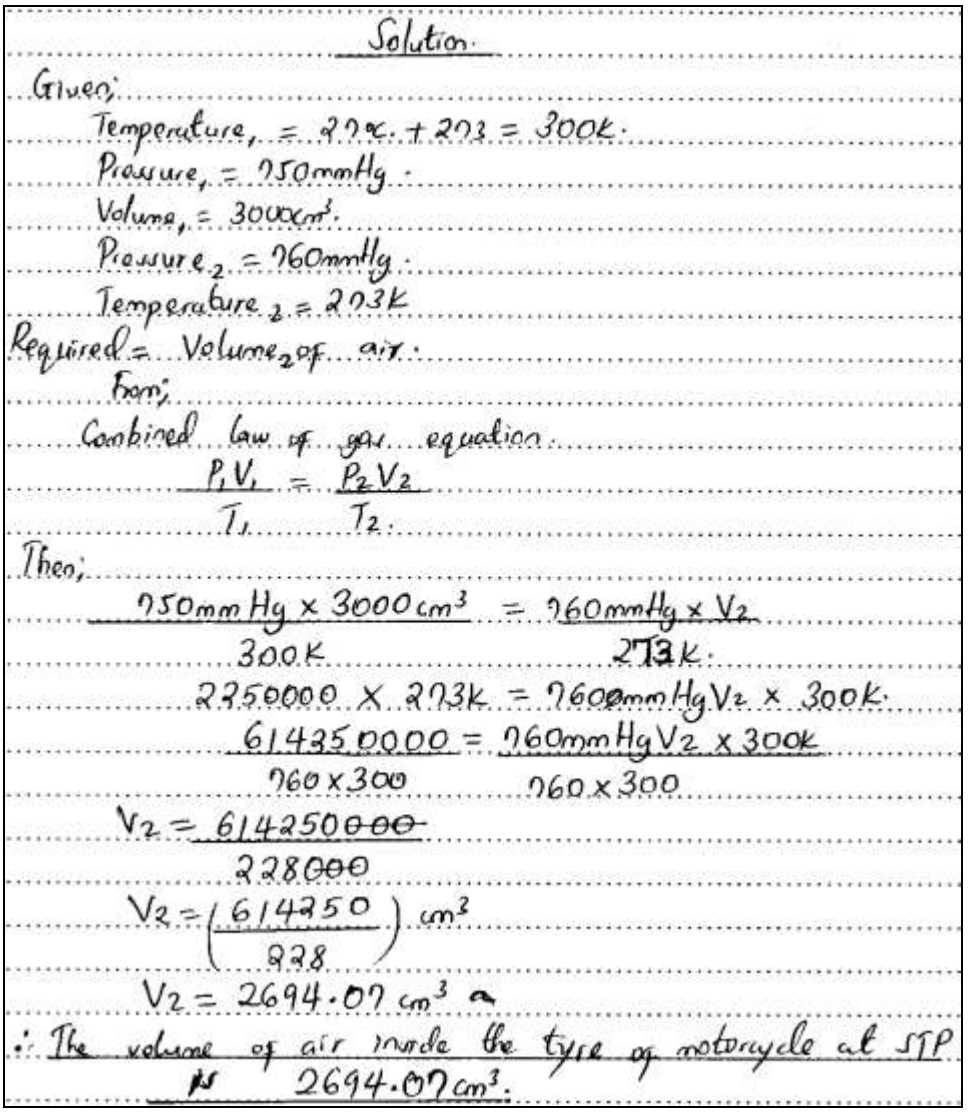


Extract 10.1: A sample of poor responses to Question 10

In Extract 10.1, a student applied improper formula to associate to the pressure law and the general gas equation to find the new pressure and volume of the gas.

The students who scored average marks (5.0-9.5), properly converted the degree Celsius (^oC) to thermodynamic temperature scale (Kelvin) and they used correct formula $\frac{P1}{T1} = \frac{P2}{T2}$ in part 10 (a). However, they used incorrect formulas to determine temperature and pressure value at Standard Temperature and Pressure (S.T.P) in part (b). Conversely, students who scored above average marks (10-15) had sufficient knowledge on the thermal expansion of gases. Extract 10.2 is a sample of the students' good responses to question 10.


Solution.
Given; Temperature, = 17°C + 273 K = 290K
Pressure, = 290 x 10^3 Pa.
Temperature 2 = 27°C + 273 K = 300K.
Pressure 2 = ?
From;
Pressure Law;
$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
Then;
$\frac{290 \times 10^3 Pa}{290K} = \frac{P_2}{300K}$.
$\frac{87000 \times 10^3}{290K} = \frac{290K\, P_2}{290K}$
$P_2 = 300 \times 10^3$ Pa.
Pressure 2 = 300000 Pa.
= 3×10^5 Pa.
∴ The value of pressure will be 300000 Pa


Solution.

Given;

Temperature$_1$ = 27°c + 273 = 300k.

Pressure$_1$ = 750mmHg.

Volume$_1$ = 3000cm^3.

Pressure$_2$ = 760mmHg.

Temperature$_2$ = 273k

Required = Volume$_2$ of air.

From;

Combined law of gas equation.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Then;

$$\frac{750mmHg \times 3000cm^3}{300K} = \frac{760mmHg \times V_2}{273K}$$

$$2250000 \times 273k = 760mmHg V_2 \times 300k$$

$$\frac{614250000}{760 \times 300} = \frac{760mmHg V_2 \times 300k}{760 \times 300}$$

$$V_2 = \frac{614250000}{228000}$$

$$V_2 = \left(\frac{614250}{228}\right) cm^3$$

$$V_2 = 2694.07\ cm^3$$

∴ The volume of air inside the tyre of motorcycle at STP is 2694.07cm^3.

Extract 10.2: A sample of good responses to Question 10

Extract 10.2 shows responses from a student who was able to organize, apply the pressure law and the general gas equation to compute the value of the pressure and estimate the volume of air at standard temperature and pressure (S.T.P).

3.0 THE ANALYSIS OF STUDENTS' PERFORMANCE IN EACH TOPIC

The topics which were assessed in Engineering Science subject for the year 2024 include *Work, Energy and Power, Light (part one), Heat (part one), Electricity, Measurement, Linear Motion, Sound, Friction, Turning Forces* and *Simple Machines (part one).* The analysis indicates that the students performed well in the topics of *Work, Energy and Power, Light (part one), Heat (part one), Electricity, Measurement, Linear Motion, Sound, Friction, Turning Forces and Simple Machines (part one) (*83.04%) tested in question 1. The topics with average performance were *Simple Machines (part one) (60.20%), Force (60.14%), Electricity (50.70%)* and *Friction (38.58%).* The analysis indicates that the average performance was due to students' partial knowledge of the tested topic. Moreover, some students provided few or incorrect points in some of the terms and failed to use correct formulas to perform calculations. The topics in which the students performed poorly were *Linear Motions (*27.75%), *Turning Forces (*26.57%), *Work, Energy and Power (*23.25%) and *Heat (*17.75%). The poor performance was due to failure of some students to meet the requirements of the questions caused by inadequate subject knowledge, limited mathematical and problem-solving skills, as well as drawing skills. A summary of the students' performance on each topic is presented in the Appendix.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The students' performance on the Form Two National Assessment (FTNA) 2024 in Engineering Science subject was good as 881(51.19%) students passed. This performance indicates that students had ability to recall and use appropriate skill to manipulate and solve competence based problems and mathematical calculation. In addition, most of the students had good skill in drawing. On the other hand, 840 (48.81%) students who scored low marks lacked knowledge and skills of the subject matter.

4.2 Recommendations

(a) From the students' inadequate performance observed in this analysis, it is recommended that;

(i) Teachers should adhere and follow the guidelines and principles for competency-based assessments throughout the teaching and learning process.

(ii) In the topic of *Linear Motions*, *Turning Forces*, Work, Energy and Power and *Heat*, teacher should assist students through investigation, group discussion, to apply the required principles and formulae.

(iii) Teachers should provide tasks, which demand the students to do mathematics to improve their competence in mathematical manipulation.

(iv) Teachers should lead students to prepare wall charts, which show some of the formula used in calculations to make them remember easier.

(b) In order to have good performance in Engineering Science Subject, teachers are strongly advised to: -

(i) Provide to students an ample time to have regular practice and review the Engineering Science materials.

(ii) Use a variety of Pedagogy like discussion, demonstrations and computerized approaches to enhance effective teaching and learning.

(iii) Provide adequate resources of materials to students during practical work.

(iv) Organize educative field trips to improve the knowledge and understanding on practical works.

APPENDIX

A Summary of Students' Performance Question-Wise in 2024

S/N	Topic	Performance For Each Topic		Remarks
		Question Number	Percentage of students who Scored 30% or More	
1	*Work, Energy and Power, Light (part one), Heat (part one), Electricity, Measurement, Linear Motion, Sound, Friction, Turning Forces and Simple Machines (part one)*	1	83.04	Good
2	Simple Machines	5	60.20	Average
3	Linear Motion, Turning Effect of a Force	2	60.14	Average
4	Electricity	3	50.70	Average
5	Friction	7	38.58	Average
6	Linear Motions	9	27.45	Weak
7	Turning Forces	6	26.57	Weak
8	Work, Energy and Power	8	23.25	Weak
9	Heat	4 and 10	17.75	Weak