# STUDENTS’ ITEMS RESPONSE ANALYSIS REPORT ON THE FORM TWO NATIONAL ASSESSMENT 

 (FTNA) 2022
## PHYSICS

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

## 031 PHYSICS

## Published by

The National Examinations Council of Tanzania, P. O. Box 2624,

Dar es Salaam, Tanzania.
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## FOREWORD

The National Examinations Council of Tanzania (NECTA) among other things is mandated to administer examinations and assessments at national level. The Form Two National Assessment (FTNA) aims at assessing the competences needed to be acquired by the student after two years of study at Ordinary Secondary Education level. The competences required are well stipulated in the current Physics syllabus for secondary education.

The 2022 Students Item Response Analysis (SIRA) report of the Form Two National Assessment (FTNA), for the 031 Physics subject has been prepared to provide feedback to education stakeholders about the responses given by the students in the assessment items. The report also helps in understanding reasons for the particular performance of students in the Physics subject.

The performance of students in Physics was generally weak as 18.21 per cent passed. Students had good performance on the multiple choice question which consisted of ten (10) items set from various topics. The students had an average performance in the topic of Simple Machines and weak performance in the topics of Sustainable Energy Sources, Newton's Laws of Motion, Motion in a Straight Line, Temperature, Magnetism, Forces in Equilibrium and Current Electricity.

This report highlights factors that contributed to the students' performance. These include failure to follow instructions, inability to understand the demands of the questions, poor English language proficiency, inadequate knowledge about the concepts assessed and insufficient skills of drawing and solving numerical problems. The feedback about the students' performance provided will enable the policy makers, education administrators, school managers, teachers and students to identify proper measures to be taken in order to improve students' performance in future assessments.

The Council would like to express its sincere appreciation to the examination officers, examiners and others who participated in the preparation of this report. The Council is also grateful to staff members who were involved in processing the statistical data that have been used in this report.


Dr. Said Ally Mohamed

## EXECUTIVE SECRETARY

### 1.0 INTRODUCTION

This report presents a detailed analysis of the Students' Items Response Analysis (SIRA) in 031 Physics assessment for the 2022 Form Two National Assessment (FTNA). The assessment intended to assess competences acquired by the Form Two students based on the 2010 Physics Syllabus for Secondary Education. The specific competences tested included the ability of the students to: practice safety rules in daily life; apply basic principles of scientific investigation; make appropriate measurements of physical quantities; use scientific skills to identify the nature and properties of matter; apply electricity and magnetism knowledge in daily life; apply laws of motion in dealing with moving objects; use simple machines to simplify work; and practice environmental conservation by adopting appropriate sustainable energy sources.

The Physics assessment paper comprised of ten (10) questions which were grouped into three sections, namely A, B and C. Section A had two (2) questions with a total of 15 marks. Question 1 had ten multiple choice items which were constructed from ten (10) topics. The topics included; Introduction to Physics; Introduction to Laboratory Practice; Measurements; Force; Archimedes Principle and the Law of Flotation;, Structure and Properties of Matter; Pressure; Light; Work, Energy and Power and Static Electricity. Question 2 had five (5) homogeneous matching items which were set from the topic of Simple Machines. Section B had seven (7) questions set from the topics of Magnetism, Temperature, Newton`s Laws of Motion, Motion in a Straight Line, Simple Machines, Forces in Equilibrium and Sustainable Energy Sources. Each question carried ten (10) marks. The section had a total of 70 marks. Section C had one (1) question constructed from the topic of Current Electricity and carried 15 marks. The students were required to attempt all the questions in Section A, B, and C.

A total of 632,152 students sat for this assessment and among them 114,830 ( $18.21 \%$ ) passed the assessment and 515,734 (81.79\%) failed. In the year 2021, the students who sat for this assessment were 600,229 out of whom 185,991 ( $31.03 \%$ ) passed while 413,403 ( $68.97 \%$ ) failed. This indicates that the students` performance in Physics for the year 2022 has dropped by $12.82 \%$. Table 1 shows the analysis of the students' performance in 2022 as compared to that of 2021 and 2020.

Table 1: The Students' Performance Percentage in Terms of Grades from 2020 to 2022 in Physics Subject

| Year | Number of students | A |  | B |  | C |  | D |  | F |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | No. | \% | No. | \% | No. | \% | No. | \% | No. | \% |
| 2020 | 598,386 | 7,847 | 1.31 | 10,567 | 1.77 | 38,312 | 6.40 | 78,217 | 13.07 | 463,443 | 77.45 |
| 2021 | 600,229 | 12,740 | 2.12 | 16,328 | 2.72 | 58,819 | 9.80 | 98,104 | 16.34 | 413,403 | 68.87 |
| 2022 | 632,152 | 2,519 | 0.40 | 4,874 | 0.77 | 29,851 | 4.72 | 77,586 | 12.27 | 515,734 | 81.58 |

The Table 1 indicates that majority of the students scored grade D and F for the three consecutive years. Besides, in all the three years, a number of students who scored A to C has been alternately rising and dropping. Nevertheless, the number of students who sat for the Physics paper has been increasing from 2020 to 2022.

Section 2.0 of this report analyses the performance of the students in each question. The analysis begins with description of what the students were supposed to do and how they responded to each question. It also highlights some misconceptions observed. Thereafter, the section summarizes the reasons behind the students` performance in a particular question. Extracts representing samples of the students' best and poor responses have been included to clearly show what a student did in his/her script. Graphs and charts are used to summarize the students' performance in each of the questions.

The percentage of performance in each of the question, is divided into three categories namely; weak, average and good performance. The performance is considered to be weak if the marks of a student range from 0-29 per cent. If the marks of the student range from $30-64$ per cent it is considered as average performance. Good performance ranges from 65-100 per cent. Red, Yellow and Green colours have been used to indicate weak, average and good performance respectively. The report contains Appendix I which indicates the general performance in each of the topics and Appendix II which compares the topic-wise students' performance between 2021 and 2022.

Finally, the report draws a conclusion and gives recommendations that might help to improve the students' performance in the future assessments.

### 2.0 ANALYSIS OF THE STUDENTS' PERFORMANCE IN EACH QUESTION

This section covers the type of the questions, the topics from which the questions were set as well as the students' performance in each question.

### 2.1 Section A: Objective Questions

This section consisted of two objective questions. Question one had ten multiple choice items which had 10 marks and question two had five items each carrying 1 mark to make a total of 5 marks.

### 2.1.1 Question 1: Multiple Choice Questions

This question comprised of ten (10) multiple choice items numbered from (i) to (x). The question items were constructed from ten (10) topics which are: Introduction to Physics; Introduction to Laboratory Practice; Measurement; Force; Archimedes' Principle and the Law of Flotation; Structure and Properties of Matter; Pressure; Light; Work, Energy and Power and Static Electricity.

Students were required to choose the correct answer among the four given alternatives ( $\mathrm{A}, \mathrm{B}, \mathrm{C}$ and D ), and write the correct letter against the corresponding item in the box provided. Each item weighed 1 mark, making a total of 10 marks for this question.

The question was attempted by $632,152(100 \%)$ students. Figure 1 shows the students' performance in this question. The analysis of the data indicates that 167,209 ( $26.45 \%$ ) of the students scored from 0 to 2.0 , 344,144 ( $54.44 \%$ ) scored from 3.0 to 6.0 and 120,799 ( $19.11 \%$ ) scored from 7.0 to 10.0 marks. The general performance of the students in this question was good as 464,943 ( $73.55 \%$ ) students scored from 3.0 to 10.0 marks.


Figure 1: Students' Performance in Question 1
Item (i) was constructed from the topic of Introduction to Physics. The students were required to identify the argument which described the mathematical language that is used in Physics. The given alternatives were; A. Matter occupies space, B. Density is mass per volume, C. Volume is amount of space occupied and D. Physics is a branch of science. The correct answer was B. Density is mass per volume. The density is a quantity in which mass and volume relate mathematically as Density $=\frac{\text { mass }}{\text { volume }}$. Most of the students managed to choose the correct response, showing that the concept of Introduction to Physics was well understood by most of them. However, a few students chose incorrect alternatives A, C or D because they failed to distinguish normal Physics statements which are mathematically expressed. Those who opted for distractors A. Matter occupies space and $C$. Volume is amount of space occupied by the body did not understand that though matter occupies space and has volume, the statement was not expressed using mathematical language. Other few students who opted for D. Physics is a branch of science, failed to link between this category of science to mathematical expression. Generally, students who failed to choose the correct answer, had insufficient knowledge on how mathematics is used to communicate Physics phenomena.

Item (ii) was set from the topic of Introduction to Laboratory Practice. The students were required to provide a correct procedure of providing the first aid to a student who has got an electric shock and fell unconscious in the

Physics laboratory. The given alternatives were A. Administer breath exercise, B. Call the physicist, C. Call other students and D. Contact a medical doctor. The correct response was $A$. Administer breath exercise. Most of the students answered correctly this item indicating that they had enough competence in the topic of Introduction to Laboratory Practice specifically on how to administer first aid. The students who chose distracters B and C did not understand well the topic of Introduction to Laboratory Practice. Students who opted for response D. Contact a medical doctor, had some ideas about first aid but failed to follow the distinctive steps for administering first aid to the victim. The students were supposed to kow that contacting a medical doctor is a last option in administering first aid.

Item (iii) was constructed from the topic of Measurement. In this item, an empty glass was placed on the digital balance and its mass was 43.63 g . Water was then added into the cup and the balance recorded a new mass of 71.06 g . The students were required to determine the mass of water. The question intended to measure the ability of students to measure and compute mass of liquids numerically. The given alternatives were $A$. $114.69 \mathrm{~g}, B .27 .43 \mathrm{~g}, C .71 .06 \mathrm{~g}$, and $D .43 .63 \mathrm{~g}$. The correct response was B. 27.43 g . The correct computation was as follows;

Mass of empty glass cup $=43.63 \mathrm{~g}$
Mass of glass cup and water $=71.06 \mathrm{~g}$
Exact mass of the water $=$ Mass of glass cup with water - Mass of an empty glass cup
Exact mass of water $=71.06 \mathrm{~g}-43.63 \mathrm{~g}=27.43 \mathrm{~g}$
Hence, the exact mass of water $=27.43 \mathrm{~g}$.
Most students failed to provide the correct response. The reason might be due to lack of mathematical computational skills since the correct response was obtained after performing mathematical operations. Some students managed to compute the water mass correctly. Those who added the masses of an empty glass cup and that of the glass with water got 114.69 g . This was not correct because in this case the mass of an empty bottle was counted twice. Those who chose C. $71,06 \mathrm{~g}$ lacked the idea that this was the mass of water plus the mass of an empty bottle.

Item (iv) required the students to give a reason why machine engines are filled with lubricant oil. The item was constructed from the topic of Force. The given alternatives were; A. To reduce friction between moving parts, $B$ To increase the viscosity between moving parts, $C$. To balance the forces acting between moving parts, and D. To return the twisted solids to their former state. The correct response was $A$. To reduce friction between moving parts. Most of the students responded correctly. However, a few students opted for the alternative $B$. To increase the viscosity between moving parts. These students failed to interpret that, viscosity is the measure of fluids' resistance to flow. The students were supposed to understand that lubricants like oil and grease are examples of viscous fluid, and their function is to reduce the friction in moving parts of machines. Thus they could have not confused the use of lubricant oil and the type of viscous fluid.

Item (v) was constructed from the topic of Archimedes' Principle and the Law of Flotation. The students were required to give reasons on why ship sinks deeper in fresh water than in the sea water. The given alternatives were $A$. Fresh water is denser than sea water, B. The density of sea water is same as of the ship, C. The sea water is denser than fresh water and D. Sea water and fresh water have the same density. The correct response was $C$, The sea water is denser than fresh water. Most of the students selected the correct response. Those who answered the item correctly suggested that they had adequate knowledge on the concepts of Density and Relative density, Archimedes Principle and the Law of Flotation. Some of the students chose alternative A. Fresh water is denser than sea water which was incorrect. The students in this category interchanged the properties (density) of fresh water with those of sea water. Other students responded wrongly by choosing an alternative B . The density of sea water is the same as the density of ship. The students in this category failed to interpret the distinctive conditions for a body to float.

Item (vi) assessed the students' competences in the topic of Structure and Properties of Matter. They were required to give a correct response as to why a perfume takes a shorter time to diffuse in air than in the water. The given alternatives were as follows: A. Air molecules are fresh compared to water, B. Air molecules are packed closer compared to those of water, C. Water molecules are less far apart compared to those of air and D. Water molecules move with high speed compared to those of air. The correct
response was $C$. Water molecules are less far apart compared to those of air. Students who chose the correct answer indicated to have enough knowledge of the concept of diffusion. However, many students chose wrong alternatives showing that they had inadequate knowledge of Structure and Properties of Matter on diffusion of molecules. This was attributed to the fact that the students failed to understand the effect of concentration of molecules on rate of diffusion. They were supposed to understand that diffusion occurs faster in air than in water, because the force of attraction between the particles in air is weaker than that in water. Thus, the air particles are far apart and free to move. If the perfume particles are introduced in the air, they will also be free to move as the air particles are weakly bound.

Item (vii) was set from the topic of Pressure. Students were required to select the correct response which shows the relationship between pressure and area from the given alternatives. The alternatives were as follows: $A$. On decreasing area, pressure increases $B$. On increasing area, pressure increases, C. On decreasing area, pressure increases D. On changing area, nothing happens. The correct answer was C. On decreasing area, pressure increases. Most students applied properly the knowledge of pressure in responding to this question. However, a few students chose incorrect answers because they failed to interpret the relationship of parameters in the mathematical equation, Pressure $=\frac{\text { NormalForce }}{\text { Area }}$. In the equation, pressure is inversely proportional to the area and vice versa. That is to say as the area increases pressure decreases; Pr essure $\alpha \frac{1}{\text { Area }}$. A few students who chose incorrect answer had little knowledge on pressure.

Item (viii) was set from the topic of Light. The students were required to select the process in which a parallel beam of incident light is reflected as a parallel beam in one direction. The given alternatives were A. Diffuse reflection, B. Internal reflection, C. Regular deflection, and D. Regular reflection. The correct response was D. Regular reflection. In order to get the correct alternative, the students were supposed to know the concept of regular reflection and diffuse reflection of light rays. That is, In regular reflection, the reflecting surface is so smooth such that all reflected rays are in parallel to each other and in one direction, while in diffuse reflection, the
incident beam of light meets a rough surface such that the rays are reflected in different direction. The following diagram distinguishes between regular and diffuse reflection of light.


In item (ix), the students were assessed in a topic of Work, Energy and Power. They were required to choose the correct response on determining the kinetic energy of the object with mass 5 kg moving at a speed of 10 $\mathrm{m} / \mathrm{s}$. The alternatives given were $A .50 \mathrm{~J}, B 250 \mathrm{~J}, \mathrm{C} .150 \mathrm{~J}$ and D. 100 J. The correct response was B. 250 J . Most of the students failed to answer the item correctly because they applied a wrong formula of determining kinetic energy. For instance, one of the students used the formula $K . E=\frac{1}{2} m v$ which was incorrect. The correct formula was supposed to be used was;
$K . E=\frac{1}{2} m v^{2}$
where $\mathrm{m}=$ mass and $\mathrm{v}=$ speed

$$
\mathrm{m}=5 \mathrm{~kg} \text { and } \mathrm{v}=10 \mathrm{~m} / \mathrm{s}
$$

Then $K . E=\frac{1}{2} \times 5 \mathrm{~kg} \times(10 \mathrm{~m} / \mathrm{s})^{2}$
Kinetic energy $=250 \mathrm{~J}$
Therefore, the answer was alternative B. which is 250 J
A few students opted for an alternative A. 50 J . These students calculated the momentum $(\mathrm{m} \times \mathrm{v})=(5 \times 10) \mathrm{kgm} / \mathrm{s}=50 \mathrm{kgm} / \mathrm{s}$ instead of calculating the kinetic energy expressed in $J$.

In item (x), the students were asked to choose the value of a capacitor required to replace a set of $3 \mu \mathrm{~F}, 6 \mu \mathrm{~F}$ and $9 \mu \mathrm{~F}$ capacitors that were
connected in parallel. The item was constructed from the topic of Static Electricity. The given alternatives were A. 1.64 $\mu$ F, B. 16.4, $\mu F$ C.18.0 $\mu F$ and $D$. $1.8 \mu F$. The correct response was C. $18.0 \mu F$. Most of the students responded well to this item. The students who performed well had adequate computational skills that they applied on the concept of Static Electricity. For parallel connection of capacitors, the equivalent capacitor is obtained by summing up the capacitance of individual capacitors; $C_{T}=C_{1}+C_{2}+C_{3}$, ( C represents the capacitance of the capacitor). The students who opted for an alternative $A .1 .64 \mu F$, failed to differentiate between parallel and series connection of capacitors. Thus, they used the formula $\frac{1}{C_{T}}=\frac{1}{C_{1}}+\frac{1}{C_{2}}+\frac{1}{C_{3}}$ which was not correct to calculate the equivalent capacitance of the capacitors connected in series. This led the students to opt for an alternative A. $1.64 \mu \mathrm{~F}$ which was the wrong answer. Other students opted for distractors D. $1.8 \mu \mathrm{~F}$ because though they used the correct formula, they failed to manipulate properly the decimal places during their computation. As a result, they ended with two decimal places.

### 2.1.2 Question 2: Matching Items

This question comprised of five (5) items constructed from a topic of Simple Machines. In this question, each item carried one (1) mark making a total of five (5) marks. The students were required to match each of the descriptions of terms in simple machine in List A with the corresponding concept from List $\mathbf{B}$. The question was as follows:

Match each of the descriptions of the terms used in simple machines in List $\mathbf{A}$ with the corresponding concept used in simple machines in List B by writing a letter of the correct response below the item in the table provided.

| List A | List B |
| :---: | :---: |
| (i) The ratio of the distance moved by effort to the distance moved by the load. | A A simple pulley <br> B Combination pulley |
| (ii) The ratio of the load raised steadily by a machine when an effort or force is applied. | C Efficiency <br> D Lever |
| (iii) A fixed wheel with a rope passing round a groove in the wheel's circumference. | E Mechanical advantage <br> F Single fixed pulley |
| (iv) The ratio of the work output to the work input times $100 \%$. | G The block and tackle pulley system <br> H Velocity ratio |
| (v) Consists of a rigid bar that moves about a fixed point. |  |

A total of $632,152(100 \%)$ students attempted this question and their scores were as follows: 242,413 ( $38.35 \%$ ) scored from 0 to $1,238,066$ ( $37.66 \%$ ) scored from 2.0 to 3.0 and $151,673(23.99 \%)$ scored from 4 to 5 marks. Figure 2 summarizes the students' performance in this question. The scores indicate that students' performance was average as 389,739 $(61.65 \%)$ students scored from 2 to 5 out of 5 marks.


Scores
Figure 2: Students' Performance on Question 2

In item (i), the students were required to provide the correct response that matches correctly with the description "The ratio of the distance moved by effort to the distance moved by the load". The correct answer was $H$, velocity ratio. Most of the students chose the correct response indicating that they had understood the concept of Simple Machines. A few students opted for distractor $E$, mechanical advantage. The students in this category failed to distinguish between Mechanical Advantage and Velocity Ratio. The students were supposed to know that mechanical advantage is the ratio that expresses how much load a machine carries compared to effort applied and defined as the ratio of load to effort. $\left(M . A=\frac{\text { Load }}{E f f o r t}\right)$
In Item (ii), students were required to write the letter of the response which matched correctly with the statement "The ratio of the load raised steadily by a machine when an effort or force is applied". The correct response was E, Mechanical advantage. Most of students matched it correctly showing that they had adequate knowledge of simple machines. However, a few students failed to remember the definition or formula for Mechanical advantage that $M \cdot A=\frac{\text { Load }}{\text { Effort }}$. Yet, other students confused mechanical advantage with velocity ratio and thus wrongly opted response E . Mechanical advantage.

Item (iii) asked the students to provide a suitable response that matched correctly with the statement, "A fixed wheel with a rope passing round a groove in the wheel's circumference". The correct response was F, Single fixed pulley. The item was matched correctly by most of the students. However, a few of them lacked the knowledge of simple machines on the concept of types of pulleys. For instance, one of the students incorrectly chose A. simple pulley. The simple pulley can either be fixed or movable. Other students were attracted to use simple pulley because the word correlated with the name of the topic of simple machines.

In Item (iv), the students were required to provide the term which matched the statement, "The ratio of the work output to the work input times $100 \%$ ". The right response was C. Efficiency. Majority of students matched the phrase correctly because they were able to recall that, Efficiency $=\frac{\text { work output }}{\text { work input }} \times 100 \%$.

In item (v), students were required to identify the term referring to the statement, "Consists of a rigid bar that moves about a fixed point". The correct response was $D$, Lever. Most of the students correctly matched the statements with its corresponding terms which was attributed to the adequate knowledge of Simple Machines. A few students, who failed to get the correct responses had little understanding on the concept of lever. Extract 2.1 shows responses from a student who managed to match all the items correctly.

| (i) | (ii) | (iii) | (iv) | (v) |
| :---: | :---: | :---: | :---: | :---: |
| $H$ | $E$ | $F$ | $C$ | $D$ |

Extract 2.1: A sample of the student's correct responses in question 2
In extract 2.1, a student matched all the items of the question correctly and scored full marks.

| (i) | (ii) | (iii) | (iv) | (v) |
| :---: | :---: | :---: | :---: | :---: |
| $E$ | H | G | F | C |

Extract 2.2: A sample of the student's incorrect responses in question 2
In extract 2.2, a student matched all items of the question incorrectly.

### 2.2 Section B: Short Answer Questions

Short answer questions had seven (7) items which were constructed from seven topics. The topics included Magnets, Temperature, Newton's Laws of Motion, Motion in a Straight Line, Simple Machines, Forces in Equilibrium and Sustainable Energy sources.

### 2.2.1 Question 3: Magnetism

The question had two parts, namely (a) and (b). In part (a), the students were required to differentiate between ferromagnetic and paramagnetic materials by giving typical examples and their uses. In part (b), the students were required to advice a laboratory technician on three appropriate ways of storing magnets so that they can last longer.

The question was attempted by $632,152(100 \%)$ of the students out of which: $563,620(89.16 \%)$ scored from 0 to 2.5 mark; 50,388 ( $7.97 \%$ )
scored from 3.0 to 6.0 marks and $18,144(2.87 \%)$ scored from 6.5 to 10.0 . The overall students' performance in this question was weak as majority of them $(89.16 \%)$ scored marks below average. Figure 3 summarizes the students' performance in Question 3.


Figure 3: The Students' Performance in Question 3
The students who performed weakly in this question (scored $0-2.5$ marks) failed to give examples and uses of ferromagnetic and paramagnetic materials. Some had inadequate knowledge on how to store magnets as it was required in part (b) of the question. Students who performed averagely responded well on the uses of ferromagnetic and paramagnetic materials, but failed to give correct examples. For instance, one of the students wrote incorrectly aluminium and copper as examples of ferromagnetic materials. Other students wrote cobalt, iron and nickel as examples of paramagnetic materials. Such responses from students were not correct showing that they did not understand the criteria for the material to be classified as ferromagnetic or paramagnetic in nature.

The students were supposed to recognize that ferromagnetic materials are strongly attracted to both poles of magnets whereas paramagnetic materials are weakly attracted to a single pole. Conversely, the atoms of a ferromagnetic material have net dipole moment whereas those of paramagnetic materials do not. So, some examples of ferromagnetic materials include: iron, nickel and cobalt while examples of paramagnetic
materials encompass: Tungsten, Caesium, Aluminium, Lithium, Magnesium and sodium.

Another misconception observed from the students' scripts was failure to provide the correct uses of ferromagnetic and paramagnetic materials. Some of the students wrote the methods of magnetization and others wrote ways of demagnetizing the magnets. For example, one of the students wrote the uses of ferromagnetic and paramagnetic materials as "used in stroking the magnet and use direct current. Also heating and hammering the magnet." The students were supposed to know that ferromagnetic materials are used to make permanent magnets such as iron, steel nickel and cobalt while paramagnetic materials are materials used to make temporary magnets.

In part (b) of the question, most of the students failed to give the appropriate ways of storing magnets. Instead they gave irrelevant concepts which could not be well defined. For instance, one of the students wrote "shading the magnet in order for a magnet to apply the forces it should be kept closer to iron fillings." The statement had no proper meaning. The students were supposed to know that some of the ways of storing magnets include: keeping the magnet away from ferrous objects like steel shelves and tools; storing magnets in pairs with unlike poles facing each but covered with magnetic keepers and avoiding high temperature on magnets (i.e Avoid over heating). Other methods are keeping magnets away from strong magnetic and electric fields; avoiding severe stress such as vibrations or mechanical impacts on the magnets; and keeping magnets in a dry place i.e avoid moisture. Extract 3.1 is a sample of students' incorrect responses to Question 3.


Extract 3.1: A sample of the incorrect responses to Question 3
Extract 3.1, shows responses from a student who had some ideas on the examples of ferromagnetic and paramagnetic materials but swapped them. In part (b), the student wrote some of the ways of minimizing friction in machine parts instead of the appropriate ways of storing the magnets.

Students who managed to score high marks in this question were able to differentiate ferromagnetic materials from paramagnetic materials with examples and uses. They were also able to provide the correct ways of storing magnets so that they could last longer. The students in this category demonstrated their sufficient knowledge of the concept of Magnetism. Extract 3.2 is a sample of correct responses in this question.
3. (a) Differentiate ferromagnetic materials from paramagnetic materials by giving their typical examples and. uses,






 Aluminium and soft Irons. They are usually used in forming temporary magnets like electromagnets which are used.

(b) Advice a laboratory technician three appropriate ways of storing magnets so that they can last longer. $\quad$ ( 6 marks) i|. $\frac{\text { Storing magnets by using magnet Keepers ' when magnets.................. }}{1}$

 i.) Storing magnets a way from ferromagnetic materials 'Ferromagnetic
 source of tong el leith can magnetic..........................................................

Extract 3.2: A sample of the correct responses to question 3
In extract 3.2, the student managed to answer correctly all parts of the Question.

### 2.2.2 Question 4: Temperature

This question comprised of parts (a) and (b). Part (a) of the question required the students to use the concept of kinetic theory of matter to explain the concept of temperature as the degree of hotness or coldness of the body. In part (b), the students were required to (i) convert temperature of porridge from Kelvin to Celsius scale and (ii) calculate the equilibrium temperature in Kelvin (K) obtained after mixing water of equal masses but different temperatures.

The question was attempted by 632,152 (100\%) students whose scores were as follows: 567,815 ( $89.82 \%$ ) scored from 0 to 2.5 marks; 61,825 $(9.78 \%)$ scored from 3.0 to 6.0 marks; and 2,512 ( $0.40 \%$ ) scored from 6.5 to 10 marks. Generally the students' performance in this question was weak as only $64,337(10.18 \%)$ scored from 3.0 to 10 marks. Figure 4 summarizes students' performance in this question.


Figure 4: Student's Performance on Question 4
The analysis of the students' responses revealed that those who scored low marks in this question lacked the knowledge on the concept of temperature and were incompetent in the measurement of temperature. In part (a), most of the students failed to respond to the argument that temperature is the degree of hotness or coldness of the body on the basis of kinetic theory of matter. In this part, students were supposed to state the effect of increase or decrease in temperature of a body on kinetic theory of matter. The students were supposed to state the kinetic theory of matter as that; "Matter is made
up of tiny particles known as atoms or molecules" these particles are in continuous motion hence they possess kinetic energy. Since the particles are in continuous motion, it means that they possess kinetic energy. As the temperature of the particles or molecules increases also their speed increases. If the speed is increased, the kinetic energy increases. Therefore, according to the kinetic theory of matter, temperature is the measure of kinetic energy possessed by the particles in a given substance.

The analysis of the students' responses from their scripts indicates that most of them had no insight on kinetic theory of matter, hence failed to integrate it with the concept of temperature. Some of them stated kinetic theory of matter as "anything that has mass and occupies space." This was not correct because it is the definition of matter. Other students wrote the requirement of the question while others skipped it. This is an indication that majority of the students had little knowledge about the concept of temperature in relation to kinetic theory of matter.

In part (b) (i), some of the students failed to convert temperature from Kelvin to Celsius scale. For instance, one of the students used an incorrect formula $T=(\theta-213) K$ to convert Kelvin to centigrade scale. The students were supposed to use the formulae $T=(\theta-273) K$. In this part of the question, students were expected to proceed as follows:
Celsius scale to Kelvin scale:
$T=(\theta+273) K$
Kelvin temperature scale to Celsius scale:
$\theta=(T-273)^{o} C$
To convert from a temperature from Kelvin scale to Celsius scale;
$\theta=(T-273)^{o} C$.
Temperature given was 350 K , then,
$\theta=(350-273){ }^{\circ} C$
$\theta=77{ }^{\circ} \mathrm{C}$
Therefore, temperature of the porridge was $77{ }^{\circ} \mathrm{C}$
In part (b) (ii), some students failed to comprehend the best way of finding the average temperature, hence obtained the incorrect value of temperature. Some of them added and others subtracted the two temperatures. However, these approaches were not correct. The students were supposed to know
that equilibrium temperature is obtained by calculating the average temperature of their mixture.
$\theta=\frac{\theta_{1}+\theta_{2}}{2}$
Where:
$\theta$ is the equilibrium temperature
$\theta_{1}$ is the temperature of water in pot one $=15^{\circ} \mathrm{C}$
$\theta_{2}$ is the temperature of water in pot two $=45^{\circ} \mathrm{C}$
$\theta=\frac{15^{\circ} \mathrm{C}+45^{\circ} \mathrm{C}}{2}=\frac{60^{\circ} \mathrm{C}}{2}=30^{\circ} \mathrm{C}$
Extra 4.1 is a sample of responses from a student who did not perform well.
4. (a) A Form Two student was arguing that temperature is the degree of hotness and coldness of a body and it is impossible to explain this concept by using the kinetic theory of matter. How can you refute this argument?

(4 marks) In. do. by... first definipon and of kinetic energy which is


 motion of an obicul. ic k.
(b) (i) You wake up in the morning and find your classmate at the school kitchen shouting, "The morning porridge is very hot! Its temperature is 350 K ". What temperature is this on the Celsius scale?
(3 marks)
Temp: In ${ }^{\circ} \mathrm{C} \Rightarrow 350 \mathrm{~K}-213^{\circ} \not \subset=137$
$\therefore$ The temperature in celsius scale is $1 B 8^{\circ} \mathrm{C}$.
Sol
Data given.
Temperature $=350 \mathrm{~K}$
Temperakeren:
$\Rightarrow$ Temperature in $\quad(=k-213$
$=350 k-213 V=137$
$=137^{\circ} \mathrm{C}$.
:The temperature in Celcius is $137^{\circ} \mathrm{C}$
(ii) Your aunt is preparing water for a newborn baby to bath. There are two pots of water which are equal in mass. One is at $15^{\circ} \mathrm{C}$ and the other is at $45^{\circ} \mathrm{C}$. If the water from the two pots is mixed so as to get an equilibrium temperature suitable for the baby to bath, what will be the equilibrium temperature in Kelvin after mixing?
(3 marks) sols
Temp $=15^{\circ} \%$
Temp ra $=45^{\circ} \mathrm{C}$
Temp $=k=$ ?
Total temperature ${ }^{\circ} C=15^{\circ} c+45^{\circ} c=60^{\circ} c$.
Temp tad: $60^{\circ} \mathrm{C} \rightarrow \operatorname{Lemp}_{p} \mathrm{k}=60^{\circ} \mathrm{c}+213^{\circ}=273 k$.
$=213 \mathrm{~K}$
$\because T$ mperabure in kelvin is 273 k.

Extract 4.1: A sample of the incorrect responses to Question 4
In extract 4.1, the student applied the formulae $\mathrm{T}=(\theta-213) \mathrm{Kinstead}$ of $\mathrm{T}=(\theta-273) \mathrm{K}$ which made him/her to come up with the wrong value of the temperature.

The students who performed well in this question had good understanding of the concepts of temperature and kinetic theory of matter. In addition to this, they demonstrated good mathematical skills. These students were able to calculate the equilibrium temperature and converted the temperature scales as required. Extract 4.2 is a sample of responses from a student who responded well to this question.
4. (a) A Form Two student was arguing that temperature is the degree of hotness and coldness of a body and it is impossible to explain this concept by using the kinetic theory of matter. How can you refute this argument?
(4 marks)
 . Kinatic...neony of matter which states hat "Al! Al... .. matter is made up of very tiny particles that . are in constant motion" Temperature as the deane of hotness and coldness of a body can be explained
 temperature increases (hotness), the spared of the tiny
 .temperature is low (coldness). The spened...of hasue...tiny. partishla decrease and hay be rome contrachel.
(b) (i) You wake up in the morning and find your classmate at the school kitchen shouting, "The morning porridge is very hot! Its temperature is 350 K ". What temperature is this on the Celsius scale?
(3 marks)
I. would convent the ..temperature of non mem:
ng....porridge.....from kelvin to degree celciot.......
.That in:
From: $T=\left(\theta^{\circ}+273\right) k$
$\theta=(T-273)^{\circ} \mathrm{C}$
$\theta=(350 k-273)^{\circ} \mathrm{C}$
$\theta=(350-273)^{\circ} \mathrm{C}$
$\theta=77^{\circ} \mathrm{C}$
$\theta=77^{\circ} \mathrm{C}$
The temperature of porndge at 350 oik is equal. to $77^{\circ} \mathrm{c}$...to the celcius scale
(ii) Your aunt is preparing water for a newborn baby to bath. There are two pots of water which are equal in mass. One is at $15^{\circ} \mathrm{C}$ and the other is at $45^{\circ} \mathrm{C}$. If the water from the two pots is mixed so as to get an equilibrium temperature suitable for the baby to bath, what will be the equilibrium temperature in Kelvin after mixing?
(3 marks)


Extract 4.2: A sample of correct responses to Question 4

### 2.2.3 Question 5: Newton's Laws of Motion

The question consisted of parts (a) and (b). In part (a), the students were required to identify the forces acting on a book when it is placed on a table. In part (b), the students were required to (i) state the suitable law of motion that explains the phenomenon of an athlete standing in a boat and throwing an object out of the boat where the boat tended to move in the opposite direction to that of the object. Part (b) required the students to calculate the initial speed at which the trolley will move when a boy of mass 55 kg is standing in a stationary boat jumps onto a trolley of mass 90 kg , if the initial speed of a boy was $5 \mathrm{~m} / \mathrm{s}$.

This question was attempted by $632,152(100 \%)$ students. The analysis of the data indicates that $612,575(96.90 \%)$ scored from 0 to 2.5 marks; $18,528(2.93 \%)$ scored from 3.0 to 6.0 marks; and 1,049 ( $0.17 \%$ ) scored from 6.5 to 10 marks. These data indicate that the general performance in this question was weak as $612,575(96.90 \%)$ scored from 0 to 2.5 marks. Figure 5 shows the students' performance in this question.


Figure 5: Student's Performance on Question 5
The students who scored low marks in this question had an inadequate knowledge of the concept of Newton's Laws of Motion especially, the third Newton's law of motion and the principle of conservation of linear momentum. Some of the students failed to identify the forces acting on a book placed on the table in part (a). For example, one of the students wrote
"stable force, friction force, resistance force and cohesion force" instead of action force, force of gravity, weight, and downward force. Also, the student could have written reaction force, upward force, normal reaction and normal force. Moreover, in part (b) (i), some students failed to provide the suitable law for an athlete standing on a boat throwing an object out of the boat in opposite direction. Some of them wrote the "Newton's first" and others the "second law of motion" which were incorrect responses.

In this assertion, the students were supposed to understand that, in every interaction, there is a pair of forces acting on the two interacting objects. The size of forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Students were also had to bear in mind that forces always come in pairs, that is equal and opposite action-reaction force pairs. So, the law which governs this phenomenon is the Third law of motion.
In part (b) (ii), some students used inappropriate approaches to determine the initial speed of the trolley. For example, one of the students used the formula, speed $=\frac{m_{2}-m_{1}}{\text { time }}$. This relation is incorrect and is not used in the Physics subject.

Others strived to utilize the correct concept of conservation of momentum but failed to interpret the correct formula to be used. For example, one of the students wrote "momentum before collision equals to momentum after collision; $m_{1} v_{1}=m_{2} v_{2}$." However, the student forgot that as the boy jumped into a trolley, their total masses added up to $\left(m_{1}+m_{2}\right)$ and hence moved with common velocity, $v$. Therefore, they were supposed to use the relation;
$m_{1} u_{1}+m_{2} u_{2}=\left(m_{1}+m_{2}\right) v$. Where, $m_{1}$ and $m_{2}$ are masses of the boy and the trolley respectively, while v is the common velocity.
$\mathrm{m}_{1}=55 \mathrm{~kg}, \mathrm{~m}_{2}=90 \mathrm{~kg}, \mathrm{u}_{1}=5 \mathrm{~m} / \mathrm{s}, \mathrm{u}_{2}=0$
$\mathrm{m} /=55 \mathrm{~kg} \times 55 \mathrm{~m} / \mathrm{s}+90 \mathrm{~kg} \times 0 \mathrm{~m} / \mathrm{s}=(55+90) \mathrm{kg} \times v$
$275 \mathrm{kgm} / \mathrm{s}=145 \mathrm{~kg} v$
$v=1.896 \mathrm{~m} / \mathrm{s}$.
Extra 5.1 is a sample of incorrect responses from one of the students who attempted this question.


Extract 5.1: A sample of the incorrect responses to Question 5
In extract 5.1, a student wrongly identified the forces and incorrectly calculated the speed as, $S=\frac{m a s s}{\text { time }}, S=\frac{m_{2}-m_{1}}{\text { time }}$ and substituted the value of the velocity in a place of time. The student got an incorrect value for the initial velocity of the trolley, thus lost all the marks.

The students who performed well in this question had good understanding of the concepts of Newton's Law of Motion. They also demonstrated good mathematical skills as they used the correct formula to calculate the initial velocity. Extract 5.2 is a sample of students' correct responses in this question.


Extract 5.2: A sample of the correct responses to Question 5
In extract 5.2, the student answered all the parts of the question correctly and scored all the marks.

### 2.2.4 Question 6: Motion in a Straight Line

This question had two parts, namely (a) and (b). In part (a), students were required to correct the argument that "acceleration is a scalar quantity
because it describes the rate of change of speed of an object". In part (b), the students were required to calculate (i) height at which birds fall from the tree to the ground (ii) time taken by the bird to hit the ground. It was provided that the bird falls and strikes the ground with a velocity of $80 \mathrm{~m} / \mathrm{s}$.

The question was attempted by 632,152 (100\%) students out of whom $576,943(91.27 \%)$ scored from 0 to 2.5 marks, 39,454 ( $6.24 \%$ ) scored from 3.0 to 6.0 marks and $15,755(2.49 \%)$ scored from 6.5 to 10 marks. The general performance in this question was weak since 576,943 (91.27\%) of the students scored below 3.0 marks. Figure 6 shows a summary of the students' performance in question 6.


Figure 6: Students' Performance on Question 6
Students who scored low marks in part (a) had insufficient knowledge about the concept of motion in a straight line. Thus, they were not able to give the correct answer to most parts of the question. Some students agreed with statement that acceleration is the rate of change of speed instead of connecting it. Others incorrectly defined the acceleration as the scalar quantity and deceleration as the vector quantity.

Some students used incorrect formula to calculate the height and time taken by the bird to hit the ground in part (b) (i) and (ii). For instance, one of the students used the incorrect formula; $h=u+g t^{2}$ and $t=\frac{1}{2} u+g v$ to
calculate the height and time, respectively. Other students used the concepts of simple machines to find the height and time. This was also not correct.

Majority of the students failed to calculate the height and time. This suggested insufficient knowledge of the topic of Motion in a Straight Line as well as poor computational skills. In order to answer the question correctly, the students were supposed to consider the definition of acceleration as "is the rate of change of velocity". Moreover, since the velocity is a vector quantity, the acceleration is also the vector quantity. In part $b$ (i), the students were supposed to use the concept of freely falling object and apply $v^{2}=u^{2}+2 g h$ to calculate the height. Students could also use the concept of conservation of energy that is "total mechanical energy at the top $=$ total mechanical energy at the bottom".

$$
\begin{aligned}
& \frac{1}{2} m v_{1}^{2}+m g h_{1}=\frac{1}{2} m v_{2}^{2}+m g h_{2} \\
& 0+m g h_{1}=\frac{1}{2} m v_{2}^{2}+0 \\
& m g h_{1}=\frac{1}{2} m v_{2}^{2} \\
& h_{1}=\frac{v_{2}^{2}}{2 g}
\end{aligned}
$$

In part b (ii), the students were supposed to use the Newton's first equation of linear motion to calculate the time taken by the bird to hit the ground: $v=u+g t$
$t=\frac{v-u}{g}$.
Students could have also used the Newton's second equation of linear motion: $t=\sqrt{\frac{2 h}{g}}$ to calculate the time. Extract 6.1: showed incorrect answer from one of the students in this question.
6. (a) On your way back home, you hear two Form Two students arguing that acceleration is a scalar quantity because it describes the rate of change of speed of an object. How will you correct their argument?
The acceleration of gravity: us...... Used only.
in the .......waler only.
(b) Suppose a bird is on the tree at a certain height above the ground and a boy at rest threw a stone to hit the bird on the tree. If the bird falls and strikes the ground with a velocity of $80 \mathrm{~m} / \mathrm{s}$ :
(i) What will be the height of the bird from the ground?
(3 marks)

(ii) Calculate the time taken by the bird to hit the ground.
(3 marks)


Extract 6.1: A sample of the incorrect responses in Question 6
In extract 6.1, the student failed to state whether acceleration is a scalar or a vector quantity. Similarly, he/she employed the concept of simple machines to determine the height of the bird from the ground and the time taken by the bird to hit the ground, instead of using the concept of motion in a straight line particularly, the motion under gravity.

Students who scored good marks in this question had sufficient knowledge of the concept of motion in a straight line especially the aspect of rate of change velocity as well as the motion under gravity. These students
correctly explained that acceleration is a vector quantity as it has both magnitude and direction. Consequently, majority of the students applied the appropriate formula and systematic procedures to calculate the value for the height and time. Extract 6.2 is a sample of responses from one of the students who performed in this question.
6. (a) On your way back home, you hear two Form Two students arguing that acceleration is a scalar quantity because it describes the rate of change of speed of an object. How will you correct their argument?
(4 marks)

- Acceleration is a vector quantity, because it describes the rate of change of of celerity of an object. As velocity is a ve.vetow quantity as It has both magnitude and doection and acceleration is described of the rato of change of velocity and hence, acceleration .... if a vector quantity os it in involves velour... and not spp.
(b) Suppose a bird is on the tree at a certain height above the ground and a boy at rest threw a stone to hit the bird on the tree. If the bird falls and strikes the ground with a velocity of $80 \mathrm{~m} / \mathrm{s}$ :
(i) What will be the height of the bird from the ground?
(3 marks)

(ii) Calculate the time taken by the bird to hit the ground.
(3 marks)


Extract 6.2: A sample of student's correct responses to Question 6

In extract 6.2, the student provided correct answers to all parts of the question and scored full marks.

### 2.2.5 Question 7: Simple Machines

This question comprised of two parts namely (a) and (b). In part (a), the students were required to (i) give a simple machine that could be used to lift a heavy load vertically to the roof (ii) show how the mechanical advantage and velocity ratio relate to the angle of inclination in an inclined plane. In part (b), the students were required to calculate the amount of force applied at the end of a handle with a length of 40 cm and a pitch of 0.5 cm is used to lift a car whose mass is 350 kg . The students were given that efficiency of the screw-jack was $45 \%$.

This question was attempted by 632,152 (100\%) students whose scores were as follows: 607,922 (96.17\%) scored from 0 to $2.5 ; 20,556$ ( $3.25 \%$ ) scored from 3.0 to 6.0 ; and $3,674(0.58 \%)$ scored from 6.5 to 10 marks. Generally the students' performance in this question was weak as 607,922 ( $96.17 \%$ ) students scored from 0.0 to 2.5 marks. Figure 7 summarizes the performance of students in this question.


## Scores

$\square 0.0-2.5$
3.0-6.0

■6.5-10.0

Figure 7: Student's Performance to Question 7
The students who scored low marks in part (a) (i) failed to identify the type of simple machine which can be used to lift a heavy load vertically to the
roof. Majority of these students failed this part because they demonstrated insufficient knowledge about Pulleys. Due to this, some students mentioned other types of simple machines contrary to the requirements of the question. Moreover, some students proposed the use of "levers, screw jacks and inclined planed" which in fact cannot lift heavy loads to the roof. In part (a) (ii), some students showed to have inadequate knowledge on understanding the relationship between the angle of inclination, velocity ratio and mechanical advantage. For instance, one of the students defined incorrectly the velocity ratio as " $V \cdot R=\frac{\text { Distance moved by the load }}{\text { Distance moved by the effort }}$ " and mechanical advantage as M.A $=\frac{\text { Effort }}{\text { Load }}$ ". The former formula defines the reciprocal of velocity ratio while the latter is the reciprocal of the mechanical advantage. So, this student confused the two quantities and got incorrect answers.

The students who performed poorly in part (b), failed to recall the formula to calculate the velocity ratio of the screw-jack. Although some other students managed to use the correct formula to calculate the velocity ratio of the screw jack, they failed to convert the mass of the car into weight. Extract 7.1 is a sample of responses from one of the students who gave incorrect answers to this question.

```
7. (a) (i) If you want to lift a heavy load vertically to the roof, which simple machine
                    will be used?
                        heay of load it simple pondelun
(ii) How is the mechanical advantage and velocity ratio of an incline plane related to the angle of inclination?
(3 marks)
Angle of undenatuen is a angle formed by bey the magnetic axis ord the honeuntal and tote: mechanical aduantege it the rato of the dutance moved by of fort the durance moved by the load.
(b) A Physics teacher was driving on a rough road. The right front tyre of the car ran over a sharp object and got a puncture. The teacher used a screw-jack with a handle which has a length of 40 cm long and a pitch of 0.5 cm to lift a car whose mass is 350 kg . If the efficiency of the screw-jack is \(45 \%\), calculate the amount of force applied at the end of the handle when lifting the car.
( 6 marks)
```



```
Length \(=40 \mathrm{am}\)
RIch \(=0.5 \mathrm{~cm}\)
Mas \(=350 \mathrm{~kg}\)
r of sew jock \(=45^{\circ} \%\)
Length \(x\) Patel
\(40 \times 0: 5=20 \mathrm{~cm}\)
```

Extract 7.1: A sample of the incorrect responses to Question 7
In extract 7.1, the student wrote a simple pendulum as a simple machine to be used to lift a heavy load vertically to the roof. However, this was not correct because a simple pendulum creates a repeating, oscillating motion which is applied in motion under gravity and not in simple machines. In part (a) (ii), the student stated the angle of inclination in terms of Earth's magnetic field instead of using the concept of simple machines.

The students who scored high marks in part (a) (i), correctly named the type of pulley system that can lift heavy loads vertically. They also included single movable pulley, single fixed pulley, wheel and axle, combination pulley, block and tackle system and hydraulic press. The students in this category demonstrated sufficient knowledge on the subject matter, particularly on the concept of the pulley systems.

In part (a) (ii), students who managed to perform well showed that when the angle of inclination is smaller the easier to move the load. As the angle of inclination is made small, the effort is reduced, and the effort distance increases. As a result, the mechanical advantage and the velocity ratio increase. A few students showed that the smaller the angle of inclination, the greater the velocity ratio. They also showed that the smaller the angle of the inclination, the greater is the mechanical advantage.
Some students derived the relationship as $M \cdot A=\frac{1}{\sin \theta}$ and $V \cdot R=\frac{1}{\sin \theta}$ where $\theta$ is the inclination angle.
In part (b) some students who performed well used the correct formula $V \cdot R=\frac{2 \pi R}{\text { Pitch }}$ to calculate the velocity ratio of a screw-jack. They were able to calculate the load by using the formula:
Load to be lifted=mass of the car $\times$ acceleration due to gravity. The values obtained were used to compute the effort. Since the efficiency can be determined through the relationship between mechanical advantage and velocity ratio.
Efficiency $=\frac{\text { M.A }}{\text { V.R }} \times 100 \%$
Then;
$M \cdot A=V \cdot R \times$ Efficiency

But $M \cdot A=\frac{\text { Load }}{E f f o r t}$

Thus Effort $=\frac{\text { Load }}{M \cdot A}$
Extract 7.2 shows a sample of correct responses from one of the students who scored high marks in this question.
7. (a) (i) If you want to lift a heavy load vertically to the roof, which simple machine will be used?
Pulley:
$\qquad$
(ii) How is the mechanical advantage and velocity ratio of an incline plane related to the angle of inclination?
(3 marks)

(1) When paction is ignored
Ind to bo dance moved
by The load
(1) $\cup R=\frac{\varepsilon-d}{1-d}$ be angle 0 indinalicn
$\sin \theta=\frac{l-d}{\varepsilon-1}$
$M \cdot A=U \cdot R$
$M \cdot A=1 / \sin \theta=E \cdot a$
$l-d$.

Therefore
$M \cdot \Delta=$
$\sin \operatorname{e}$
(b) A Physics teacher was driving on a rough road. The right front tyre of the car ran over a sharp object and got a puncture. The teacher used a screw-jack with a handle which has a length of 40 cm long and a pitch of 0.5 cm to lift a car whose mass is 350 kg . If the efficiency of the screw-jack is $45 \%$, calculate the amount of force applied at the end of the handle when lifting the car.

$$
V R=502 \cdot 4:
$$



Extract 7.2: A sample of the correct responses to Question 7

In extract 7.2, the student managed to answer all parts of the question correctly. This implied that the student acquired appropriate competences on the concept of simple machines and their related computation.

### 2.2.6 Question 8: Forces in Equilibrium

This question comprised of two parts, namely (a) and (b). Part (a) required the students to explain the concepts of (i) centre of mass and (ii) moment of force. In part (b), the students were required to find the reactions P and Q at the supports C and D of a light beam AB when a load of 9 N was placed at point O , where DO was 30 cm and CO was 70 cm . The students were given the following diagram showing the forces that were at equilibrium.


The question was attempted by 632,152 (100\%) students out of whom 559,537 ( $88.51 \%$ ) scored from 0 to $2.5,63,845$ ( $10.10 \%$ ) scored from 3.0 to 6.0 and $8,770(1.39 \%)$ scored from 6.5 to 10.0 marks. Generally the students' performance in this question was weak as 559,537 ( $88.51 \%$ ) scored from 0 to 2.5 marks. Figure 8 shows the performance of the students in this question.


Figure 8: Students' Performance in Question 8
In part (a), the students who performed poorly, failed to explain correctly the concepts of centre of mass and moment of force. This was a result of inadequate knowledge or skills on the concept of centre of mass and moment of force. Most of them explained the centre of gravity instead of centre of mass. Some students gave the explanation of work done instead of the moment of force. The students might have confused these concepts because work done and the moments of a force have closely related definitions. However, these can be differentiated by directions of force. That is, in the moment of force, the distance is perpendicular to the direction of force while in the work done, the distance is in parallel (same) with the direction of force.

In part (b), the question aimed at assessing the ability of the student to find the reactions at the points of supports. The students who performed poorly were not able to calculate the reaction forces acting at the points of supports D and C 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 8.1 is a sample of students' incorrect responses in this question.
8 (a) Explain the following terms as applied in forces in equilibrium.
(i) Centre of mass
(2 marks) this moans is the mol de of the mass and that is called centre of mass
$\qquad$
(ii) Moment of force
force 15 the pall per unit area.
(b) A light beam $A B$ rests on supports at $C D$. A load of 9 N is placed at $O$, where $D O$ is $30 \mathrm{~cm}, \mathrm{CO}$ is 70 cm as shown in Figure 1. Find the reactions $P$ and $Q$ at the supports.
(6 marks)


Figure 1

$$
\begin{aligned}
& \text { Solution } \\
& 30 \times 70 \times 9 \\
& \approx 18900 \times 9 \\
& \text { The answer is } 189900
\end{aligned}
$$

Extract 8.1: A sample of the incorrect responses to Question 8
In extract 8.1, the student explained wrongly the terms centre of mass and moment of force. On the other hand, he/she failed to apply the principle of moments about either C or D to find the required reactions P and Q at the point of supports.

The students who scored high marks in part (a) of this question managed to explain the concepts of centre of mass as the point on the object where all
mass of the particles appear to be concentrated. Other students also managed correctly to explain the moment of force (M) as "the product of force ( $F$ ) and perpendicular distance (d) from line of action." i.e $M=F \times d$.

In part (b) of this question, a few students who performed well interpreted correctly the positions and their corresponding distances shown on the diagram given. 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 ( P and Q) were equal to downward force ( 9 N ). They were also able to use the appropriate formula to calculate the total upward force and downward force as follows;
Total upward force $=P+Q$
Downward force $=9 \mathrm{~N}$.
The moment of force Q about point C and the moment of force P about C .
Moment of force 9 N about $\mathrm{C}=9 \times 70 \mathrm{~cm}$ anticlockwise moment
$P \times 100 \mathrm{~cm}=9 \times 70 \mathrm{~cm}$
$P=\frac{9 \mathrm{~N} \times 70 \mathrm{~cm}}{100 \mathrm{~cm}}$
$P=6.3 \mathrm{~N}$
But from $P+Q=9 N$
$Q=9 N-P$
$Q=9 N-6.3 N$
$Q=2.7 \mathrm{~N}$
Some students used alternative method by taking moment about D .

$$
\begin{aligned}
& Q \times 100 \mathrm{~cm}=9 \mathrm{~N} \times 30 \mathrm{~cm} \\
& Q=\frac{9 \mathrm{~N} \times 30 \mathrm{~cm}}{100 \mathrm{~cm}}
\end{aligned}
$$

$Q=2.7 \mathrm{~N}$
Extract 8.2 shows a sample of responses from one of the students who performed well in this question.


Extract 8.2: A sample of the correct responses to Question 8
In extract 8.2, the student correctly explained the terms centre of mass and the moment of force. Consequently, he/she applied the principle of moment to find the reactions P and Q at the point of supports.

### 2.2.7 Question 9: Sustainable Energy Sources

This question comprised of two parts, namely (a) and (b). In part (a), the students were required to give scientific advice to school management about energy source which could be used to develop a min power plant using either water or wind energy sources. In part (b), the students were required to give reasons as to why people are warned by Geophysicists not to build houses near geothermal power plants.

The question was attempted by 632,152 (100\%) students out of whom $615,130(97.31 \%)$ scored from 0 to 2.5 marks; 12,602 ( $1.99 \%$ ) scored from 3.0 to 6.0 marks; and $4,420(0.70 \%)$ scored from 6.5 to 10 marks. This data indicates that the general performance was weak as 615,130 ( $97.31 \%$ ) majority of students scored below the average mark (from 0 to 2.5 marks). Figure 9 shows the performance of students in this question.


Figure 9: Student's Performance in Question 9
Part (a) of this question was context-based as it needed students to describe or compare the advantage of each renewable energy sources provided over the other. If the school is near to wind resource potential, then the school was to opt for wind energy source in the project. If the school was located in areas with plenty of water, a school was to opt for min water power plant. The students who failed to respond correctly to this question provided neither advantages of water energy sources nor the wind energy sources. Most of the students skipped this part of the question and thus, lost all marks allotted to it. Another challenge which faced the
students in answering this part of the question was a language barrier. This was justified by responses from their scripts as some of them defined the term "matter" instead of providing scientific advice as per the question's demand. In general, the students who did not perform well had insufficient knowledge on the types, merits (advantages) and demerits (disadvantages) of various energy sources which are sustainable.

In responding to part (b), students were required to identify the negative effects of building houses near geothermal power plants. However, some students were not able to provide the negative effects. Most of them provided advantages of geothermal energy source contrary to the requirements of the question. For instance, one of the students responded that "geothermal energy source does not require large area and it's independent of weather and it is renewable." It is true that in developing a geothermal power plant does not require a large space. However, this was not the question's demand. Most of the students skipped this part of the question and lost all the marks.

Generally, the students were supposed to understand that geothermal energy is associated with volcanic activities which can release harmful gases such as hydrogen sulphide. During drilling holes in the ground, the stability of the land is disturbed; therefore the area can be susceptible to earthquakes. Extract 9.1 is a sample of students' incorrect responses to this question.


Extract 9.1: A sample of the incorrect responses to Question 9
In extract 9.1, the student managed to define and provide the states of matter instead of giving a scientific advice on either to use water or wind sources for the school management to develop the min plant project. He/she also, failed to provide the reasons as to why people should not build houses near geothermal power plants.

Despite the poor performance shown by majority of the students in this question, a few students scored high marks. These students were able to assess and advice the school management on the importance of either using water or wind as energy sources for developing power plant. They were
also able to explain the negative effects of geothermal energy when houses are built near power plants. Extract 9.2 is a sample of a student's correct responses to this question.
9. (a) Suppose your school has a plan to develop a min power plant project from either water or wind sources and the school management is seeking for a scientific advice from you. What will you advise them on this matter? Use two points.
(5 marks)

(b) People are warned by Geophysicists not to build houses near geothermal power plants. Give two reasons for this warning.
( 5 marks)


Extract 9.2: A sample of the correct responses to Question 9
In extract 9.2, a student responded correctly all parts of the question and scored full marks.

### 2.3 Section C: Short Answer Question

This section had one question and the students were required to attempt it.

### 2.3.1 Question 10: Current Electricity

This question comprised three parts, namely (a), (b) and (c). In part (a), the students were required to provide five electrical components that can be used in preparing the experiment for determining the relationship between voltage and current. Part (b) of the question required the students to draw a simple electric circuit which would be suitable for the experiment to determine the relationship between voltage and current. In part (c), the students were required to explain how would the electrical devices be connected for measuring the current and potential difference (p.d) in the simple electric circuit drawn in part 10 (b).

A total of $632,152(100 \%)$ students attempted this question out of whom $521,072(82.43 \%)$ scored from 0 to 4 marks; 89,028 ( $14.08 \%$ ) scored from 4.5 to 9.5 marks; and $22,052(3.49 \%)$ scored from 10.0 to 15.0 marks. These scores indicate that the general performance of the students was weak since 521,072 ( $82.43 \%$ ) students scored below 3.0 marks. Figure 10 summarizes the students' performance in this question.


## Scores

Figure 10: Students' Performance to Question 10
The students who scored low marks (from 0.0-4.0 marks) failed to provide the required electrical components. The students in this category failed to distinguish the terms such as voltage, resistance and current from electric components such as voltmeter, variable resistor or rheostat and ammeter. In
some cases, the students wrote the electrical components from other concepts like a capacitor, which in reality, comes from the topic of Static Electricity.

In responding to part (b), the students who failed this part had inadequate knowledge and lacked specific skills of drawing electric circuits to demonstrate the Ohm's Law. Some students drew the electric circuit with the Voltmeter connected in series in the circuit and an ammeter connected in parallel. However, this was on contrary to the fact because ammeters are connected in series with other electrical components, while voltmeters are connected across the resistor and in some cases across the cell or battery. Yet other students reversed the connection of the two electrical measuring instruments, hence lost the marks.

It was also observed that some students had insufficient knowledge on understanding some of the electric symbols used in electric circuit. Thus, they swapped the terms voltage with voltmeter, current with ammeter, and resistance with resistor. Some of the students did not know how to connect the battery in the circuit. As a result they swapped the positive with negative terminals and vice versa. For instance, one of the students drew $\stackrel{-}{-+}$ to represent a cell instead of $\stackrel{+}{\dagger} \vdash^{-}$.

In part (c) of the question, some of the students did not understand the demand of the question as they provided explanation on the terms current and potential difference instead of stating how the electrical devices for measuring current and potential difference are connected. They also failed to identify the type or kind of an instrument used to measure current as well as potential difference in the circuit. Extract 10.1 shows a sample of incorrect responses provided by one of the students in this question.


Extract 10.1: A sample of the incorrect responses to Question 10
In extract 10.1, the student provided a list of some general instruments and chemicals that are used in school laboratories instead of electrical components to demonstrate the Ohm's Law in part (a). In part (b), the student drew a diagram showing the charging of an object by conduction, a concept found in static electricity instead of a simple electric circuit to demonstrate Ohm's Law experiment in current electricity.

Despite the weak performance shown by students in this question, some of them ( $17.57 \%$ ) managed to score high marks (from 10.0-15.0). In part (a), the students in this category provided a correct list of electrical components such as standard resistor, rheostat, voltmeter, ammeter, connecting wires, source of electrical energy (cell, battery) and key/switch/plug key that could be used in a circuit to demonstrate Ohm's Law.

The students who performed well in part (b) of this question, were able to use electric components stated in part (a), to draw the appropriate electric circuit used to determine the relationship between current and potential difference (p.d). These students drew a suitable complete path (loop) for the current to flow from the source (battery) through external device and back to the battery.

In part(c), the students were able to explain how the electrical devices are connected in the circuit in order to measure the current and potential difference. Extract 10.2 shows a sample of responses from one of the students who answered this question correctly.
10. Suppose you are asked by your teacher to prepare electrical components and instruments for an experiment to determine the relationship between voltage and current;
(a) Give five electrical components that can be used in this experiment. (5 marks)

- Voltmeter
- Ammeter
- Variable resistor
- Resistors
- Battery
- Wires and switch
$\qquad$
(b) Draw a simple electric circuit which will be suitable for that experiment. (5 marks)

(c) From the simple electrical circuit drawn in 10 (b), how will you connect the electrical devices used for measuring the current and the potential difference?

The device for measuring current is Ammeter, ... will be placed in series with other electric components:
The device for measung potential difference is Voltmeter will. be placed parallel to the constant resistor.

Extract 10.2: A sample of the correct responses to Question 10
In extract 10.2, the student identified correctly the devices which could be used to determine the relationship between the voltage and current in a circuit and properly showed how they are connected in it. Consequently, he/she managed to give the correct names and uses of devices that could be used to measure the potential difference (potential drop) and electric
current. Finally, the student correctly showed how the devices should be connected in the electric circuit.

### 3.0 ANALYSIS OF THE STUDENTS' PERFORMANCE

### 3.1 Students' Performance in Each Topic

The 031 Physics assessment for the year 2022 assessed a total of eighteen (18) topics. The topics assessed were: Introduction to Physics; Introduction to Laboratory Practice; Measurement; Force; Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Pressure; Light; Work, Energy and Power; Static Electricity; Simple Machines; Magnetism; Newton's Laws of Motion; Motion in a Straight Line; Forces in Equilibrium; Sustainable Energy Sources; Current Electricity; and Temperature.

The analysis of the students' performance indicates that 73.5 per cent of the students had good performance in Question 1 which was set from the topics : Introduction to Physics; Introduction to Laboratory Practice; Measurement; Force; Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Pressure; Light; Work, Energy and Power and Static Electricity.

The students' performance was average (32.74\%) in the topic of Simple Machines assessed in Question 2 and Question 7. The average performance of the students in this topic was taken as an average performance of the students in the two questions. The students performed averagely due to partial attempt to some parts of the questions particularly in 7 (a) (ii) and 7 (b). This was contributed mainly by insufficient mathematical skills. Moreover, the students in this category, though memorized some concepts, they failed to attempt the parts which needed critical thinking.

The weak performance was observed in the topics of Current Electricity (17.57\%); Forces in Equilibrium (11.49\%); Magnetism (10.84\%); Temperature (10.18\%); Motion in a Straight Line (8.73\%); Newton's Laws of Motion (3.10\%); and Sustainable Energy Sources (2.69\%) which were assessed in Questions $10,8,3,4,6,5$ and 9 respectively. This performance might have been influenced 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 English language proficiency. The weak performance of students in these topics was also attributed to the lack of drawing skills. As a result, they failed to draw the appropriate electric circuit diagram in the topic of Current Electricity. The analysis of the students' performance per topic is summarized in Appendix I.

### 3.2 Comparison of the Students' Performance between 2021 and 2022 in Topic-wise

The comparison of students' performance in terms of topics assessed in FTNA 2022 and 2021 indicates that there is a drop or rise in performance in some of the topics. The performance of the students shows that there is a tremendous drop in performance from $81.3 \%$ in 2021 to $73.5 \%$ in 2022 for the multiple choice items in Question 1 which were constructed from various topics. This might be due to the fact that some of the topics set in 2021 are different in setting styles although they have the same level of difficult from those set in 2022. However, the performance was generally, good in both 2021 as well as 2022 in Question 1 containing different topics.

In the topic of Simple Machines, the students' performance was average in the two consecutive years, despite the minor differences between them. On the other hand, there was a noteworthy drop in performance in the topic of Current Electricity in which the performance of the students in 2022 was weak ( $17.57 \%$ ) compared to the performance in 2021 which was average $(31.8 \%)$. The weak performance in this topic was a result of insufficient competences shown by the students through their responses.

The weak performance of the students was also noted in the topics of Forces in equilibrium. In this topic, the performance has continued to be weak for both 2021 (5.5\%) and 2022 (11.49\%). The topics of the Motion in Straight Line and Newton's Laws of Motion had also weak performance in the two consecutive years. The analysis of data reveals that the topic of Motion in Straight Line had significant decrease in performance by a factor of $9.67 \%$, where the performance in 2021 was 18.4 per cent and 8.73 per cent in 2022. For the case of Newton's Laws of Motions, the students' performance have been extremely weak, as the performance in 2021 was 8.0 per cent and in 2022 was 3.10 per cent.

Similarly, the students performed weakly in the topic of Magnetism because their performance in 2022 was 10.84 per cent as compared to 67.3 per cent in 2021.

In general, the students' performance was weak in 2022 as compared to 2021 because of the insufficient competences that they attained in the concepts of the respective topics.

### 4.0 CONCLUSION AND RECOMMENDATIONS

### 4.1 Conclusion

The general performance in the Physics assessment was weak ( $18.21 \%$ ). The analysis of the students' performance reveals that students faced great challenges when attempting the questions. It was observed that, inadequate knowledge was one of the main reasons for the weak performance by most of the students, because many students provided irrelevant responses pertaining 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 mathematical manipulation. Hence, they ended up with incorrect answers. Moreover, poor English language proficiency caused some students to provide responses with grammatical errors, and thus failed to convey their ideas. Likewise, the lack of drawing skills influenced the performance of students particularly, in the drawing of electric circuits which demonstrates Ohm's Law experiments. As a result, majority of the students failed to draw the electric circuit appropriately.

### 4.2 Recommendations

In order to improve the students' performance in the future assessments, teachers are urged to:
(a) lead students to discuss circuit components by using electric instruments such as Battery, Cell, Resistors, Ammeters, Voltmeters, Switches and Connecting wires. Similarly, they should guide them through gallery walk techniques to identify the basic electric symbols by using a chart containing all basic electric symbols.
(b) guide students to perform activities of pulling or pushing objects and observe the resulting motion of objects by using materials like suspended pieces of wood, hinged door and hinged window. They should also organize students' gallery walk presentations by using materials such as knife edge, metre ruler and different masses to give the meaning of centre of gravity and study the principle of moments.
(c) display different types of magnetic and non-magnetic materials and organize for their testing on magnetic behaviour by using magnets, iron rod, nickel rod, copper rod, steel rod, cobalt plate, glass block, razor blades and a piece of wood. Consequently, through question and answer technique, guide students by using bar magnets, short steel bars, small pieces of wood and two pieces of soft iron while demonstrating the ways of storing magnets.
(d) lead students to measure the temperature of different bodies by using a thermometer, hot water and cold water. Likewise, lead them through question and answer technique to derive the S.I units of temperature.
(e) guide students to determine the rate of change of velocity with a help of velocity-time graph, graph paper, rubber and pencil. Similarly, encourage students to use Think-Pair-Share method to organize their ideas on a body thrown upwards and for a falling body.
(f) lead students to deduce the relationship between linear momentum before and after collision by using two trolleys and various masses. They should also, organize students in groups to discuss the applications of Newton's third law of motion by using car belt and stand-on weighing scale.
(g) lead students to discuss the generation of electricity from water with a help of a diagram of hydroelectric power plant. Likewise, organize educational visit to a place where windmill is used by using wind mill, nails, wood, glue and a box.
(h) emphasize on experimentation, demonstrations and drawing activities in order to enable the students develop competence in various topics.
(i) facilitate students to apply deductive thinking to derive equations of motion in a straight line and other topics.
(j) create competence based exercises and tests during formative assessment and evaluation.

Apart from teachers' recommendations, students are encouraged to:
(i) continue learning and practising computation skills that are required in solving different questions involving calculations.
(ii) use English language in their day to day communication in order to strengthen their ability to properly explain various Physics concepts in English.
(iii) read Physics text and reference books so as to acquire more competences in the subject matter.

## APPENDICES

Appendix I: A Summary of Students' Performance in the Physics Subject in each Topic in 2022

| S/N | Topic | Question <br> number | The \% candidates <br> who scored an <br> average of 30\% or <br> above | Remarks |
| :---: | :--- | :---: | :---: | :---: |
| 1 | Multiple Choice Items | 1 | 73.55 | Good |
| 2 | Simple Machines | $2 \& 7$ | 32.74 | Average |
| 3 | Current Electricity | 10 | 17.57 | Weak |
| 4 | Forces in Equilibrium | 8 | 11.49 | Weak |
| 5 | Magnetism | Weak |  |  |
| 6 | Temperature | 4 | 10.84 | Weak |
| 7 | Motion in a Sraight <br> Line | 6 | 8.73 | Weak |
| 9 | Newton's Laws of <br> Motion | 5 | 3.10 | Weak |
| 10 | Sustainable Energy <br> Sources | 9 | Weak |  |

Appendix II: A Graph of Comparison of Students' Performance between 2021 and 2022 in Terms of Topics


