# CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDDUCATION EXAMINATION (CSEE) 2022 

## ENGINEERING SCIENCE

# CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2022 

## Published by

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

Dar es Salaam, Tanzania.

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## TABLE OF CONTENTS

foreword ..... iv
1.0 INTRODUCTION ..... 1
2.0 THE CANDIDATES' RESPONSES ANALYSIS IN EACH QUESTION ..... 2
2.1 SECTION A: Objective Questions ..... 2
2.2.1 Question 1: Multiple Choice Items ..... 2
2.2 SECTION B: Short Answer Questions ..... 11
2.2.2 Question 2: Periodic Motion ..... 12
2.2.3 Question 3: Simple Machines ..... 16
2.2.4 Question 4: Light (Optics) ..... 18
2.2.5 Question 5: Angular Motion ..... 22
2.2.6 Question 6: Simple Machines ..... 26
2.2.7 Question 7: Measurements ..... 29
2.2.8 Question 8: Electricity and Magnetism; Work, Energy and Power ..... 33
2.2.9 Question 9: Linear Motion ..... 37
2.2.10 Question 10: Heat ..... 40
2.3 SECTION C: Structured Questions ..... 45
2.2.11 Question 11: Electricity and Magnetism ..... 45
2.2.12 Question 12: Periodic Motion ..... 49
2.2.13 Question 13: Sound ..... 55
2.2.14 Question 14: Fluid Mechanics ..... 60
3.0 THE CANDIDATES' PERFORMANCE ANALYSIS IN EACH TOPIC ..... 65
4.0 CONCLUSION AND RECOMMENDATIONS ..... 65
4.1 Conclusion ..... 65
4.2 Recommendations ..... 66
Appendix: A Summary of Candidates’ Performance (Question-Wise) in 2022 ..... 67

## FOREWORD

This report presents Candidates' Items Response Analysis (CIRA) on Form Four National Examination in Engineering Science subject, which was conducted in November 2022. This report aims to provide feedback to all educational stakeholders on the factors that contributed to the candidates' performance in Engineering Science.

The Certificate of Secondary Education Examination (CSEE) is a summative evaluation, which intends to monitor students' learning and to provide feedback that teachers, students and other educational stakeholders can use to improve teaching and learning processes. This analysis shows justification for the candidates' performance in the Engineering Science subject. Factors that affected the candidates' responses include the candidates' failure to understand the demands of the questions, insufficient knowledge on some tested subject matters and lack of sketching skills.

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

The National Examinations Council of Tanzania (NECTA) expects that all educational stakeholders will use the feedback and recommendations provided in this report to improve teaching and learning as well as candidates' performance in the future examinations by the Council.

The Council appreciates the contribution of all those who participated to prepare this report.


Said Ally Mohamed
EXECUTIVE SECRETARY

### 1.0 INTRODUCTION

This report presents the candidates' performance on Certificate of Secondary Education Examination (CSEE) in Engineering Science subject. The report focuses on the candidates' competences as per ordinary level secondary education syllabus for Engineering Science subject. It analyses the candidates' performance and reveals how the candidates performed on each question by identifying the candidates' strengths and weaknesses in each question attempted. The report further presents the questions, which were attempted as well as those, which were skipped by most candidates.

The Engineering Science paper had 14 questions that were divided into three sections A, B, and C. Section A comprised of one (1) question consisting of ten (10) multiple-choice items each carrying 1 mark. Section B consisted of nine (9) short answer questions each carrying ten (10) marks. Section C consisted of four (4) structured questions each carrying fifteen (15) marks. The candidates were required to answer all questions in sections A and B, and choose three questions from section C .

In this report the candidates' performance in each question was considered as weak, average or good if the percentage of candidates who scored $30 \%$ and above ranged from 0-29, 30-64 or 65-100 respectively. Red, yellow and green colours respectively indicate the poor, average and good performances. Samples of candidates' responses are inserted as extracts to represents good and weak cases. In addition, graphs and charts have been used to summarize the candidates' performance in a specific question. In the last part of the report there is Appendix which shows the general candidates' performance (question- wise).

A total of 1441 candidates sat for the Engineering Science examination, whereby 1075 ( $74.6 \%$ ) candidates passed while 366 ( $25.4 \%$ ) failed. The candidates' performance in the year 2022 is higher by 3.9 per cent compared to 2021. In 2021 the candidates who sat for the examination were 1407, among them 994 ( $70.7 \%$ ) candidates passed and 413 (29.3\%) failed.

The analysis presents the requirements of each question, candidates' strengths and weaknesses in their responses. The percentage of candidates in each group of scores is presented using graphs. Finally, the report provides conclusion and recommendations.


Figure 1: Comparison of Candidates' Performance in 2021 and 2022

### 2.0 THE CANDIDATES' RESPONSES ANALYSIS IN EACH QUESTION

This part describes the performance of the candidates in each question. The analysis covers the type of questions, topics from which the questions were constructed, demands of the questions as well as the performance of the candidates in each question.

### 2.1 SECTION A: Objective Questions

Section A comprised of one objective question. It consisted of 10 multiplechoice items, each carrying 1 mark. Thus, this section carried 10 marks.

### 2.2.1 Question 1: Multiple Choice Items

This question had 10 items, (i) to (x). The topics, which were covered in this question were Strength of the Materials, Work, Energy and Power, Projectile Motion, Heat, Sound, Simple Machines, Linear Motion, Periodic Motion, Angular Motion, Light, Measurements, Electricity and Magnetism and Fluid Mechanics.

A total of 1441 ( $100 \%$ ) candidates attempted the question. The analysis indicates that, $348(24.1 \%)$ candidates scored from 0 to 2 marks.

Additionally, 921 (64\%) candidates scored from 3 to 6 marks while 172 (11.9\%) candidates scored from 7 to 10 marks. The majority of candidates ( $75.9 \%$ ) scored from 3 to 10 marks. This is one of the questions, which had good performance, as the majority of the candidates scored average, and above.


Figure 2: The Candidates' Performance in Question 1
The analysis of data in Figure 2 suggests that most of the candidates 1093 ( $75.9 \%$ ) scored 3 to 10 marks. These candidates provided the correct answers for 3 up to 10 items. Moreover, 348 ( $24.1 \%$ ) candidates failed as they were able to answer 1 or 2 items correctly. Only $3(0.2 \%)$ candidates scored 10 marks allocated to this question. These candidates had good understanding on the concepts tested.

Further analysis reveals that the item on which the majority of candidates responded correctly was item (vii). This item measured the concept on Simple Machines. The results suggest that the candidates had adequate knowledge on application of Velocity Ratio (V.R) equations to evaluate the parameters of the lever to obtain the relationship between effort arm and load arm with respect to Mechanical Advantage. Items (i), (iii), (v), (vi), (vii), (viii), (ix), and (x) were moderately selected correct, suggesting that majority of the candidates had necessary knowledge in the relevant topics. The item which most of the candidates selected the wrong alternative was item (ii). The analysis of candidates' responses in each item is presented as follows:

Item (i) was composed from the topic of 'Strength of the Materials'. It intended to measure candidates' competence in analyzing the mechanical properties of materials used in the construction field. The question was as follows:
A metal has to withstand a certain amount of stress for every unit of working stress. What does this statement represent in engineering material?

| A | Ductile | $B$ | Factor of Safety | $C$ | Young's Modulus |
| :--- | :--- | :--- | :--- | :--- | :--- |
| $D$ | Brittle | $E$ | Tensile strength |  |  |

The correct response was alternative B Factor of Safety. The candidates who chose alternative B understood that, the stress is capable to prevent failure is called working stress or allowable stress and for every unit of operating stress, a metal must be able to sustain a particular level of stress. Some candidates chose alternative E Tensile Strength because they failed to distinguish between factor of safety and tensile strength. They did not understand that, tensile strength is calculated by dividing the highest load a material can bear without breaking when it is stretched by the material's original cross-sectional area while factor of safety is a measure of the amount of stress the material can withstand before failing. Those who chose A Ductile and D Brittle did not understand that, ductile and brittle are properties of material in which a metal can be drawn into fine wire without breaking and the properties for metal which are easy to break when little force is applied on it, respectively. A few candidates chose alternative C Young's Modulus, these candidates did not understand that Young' Modulus is the ratio of tensile stress $(\sigma)$ to tensile strain $(\varepsilon)$. The candidates who chose alternatives $\mathrm{A}, \mathrm{C}$ and D were not able to distinguish between the properties of materials and the physical quantities that occur after a material has been acted upon by a certain force.

Item (ii) was composed from the topic 'Work, Energy and Power'. It intended to measure candidates' ability to apply the concepts of Work, Energy and Power in daily real life. The question was as follows:

A student spent 1 second to pull a load of 1 kg through 1 meter. What could be measured with respect to student's activity?

| A | Work | $B$ | Joule | $C$ | Energy |
| :--- | :--- | :--- | :--- | :--- | :--- |
| $D$ | Power | $E$ | Watt |  |  |

Most of the candidates who attempted this item chose the correct response D, Power. Majority of the candidates who failed to choose the correct answer opted for E, Watt. These candidates confused the terms Power and Watt. They could not realize that 'watt' is the unit of power obtained by dividing 1 joule of work done by spent time of 1 second. Those who chose A, B and C, they did not know that work is force times distance moved and energy is the capacity of doing work. They also did not know that joule is the unit of work as well as energy.

Item (iii) was set from the topic 'Projectile Motion'. It intended to measure candidates' ability to analyze the equations related to projectile motion. The question was:
Assume that the acceleration due to gravity on the surface of the moon is 0.2 times the acceleration due to gravity on the earth. If ' $R$ ' is the maximum range of a projectile on the earth's surface, what is the maximum range on the surface of the moon for the same velocity of projection?
A. $\quad 0.2 \mathrm{R}$
B. 2 R
C. 5 R
D. 4 R
E. 3 R

The correct response for the item was alternative C $5 R$. Most of the candidates chose distractors instead of the correct response. Through the analysis of their choices, it was revealed that they failed to apply the formula of the maximum range $(R)$ for a projectile on the surface of the earth which was $R=\frac{u_{o}{ }^{2} \sin 2 \theta}{g}$. Whereby $R$ is range, $u_{o}$ is initial velocity and $g$ is acceleration due to gravity. Furthermore, most of these candidates were not able to choose the correct option because every choice demanded prior calculation of the maximum range ( R ) for a projectile on the surface of the moon for verification. Instead, they gambled choosing other alternatives, which were not correct.

On the other hand, those who chose the correct option managed to recall the formula and had adequate knowledge and skills to calculate the range of projectile. They were able to write $\mathrm{R}=\frac{\mathrm{u}_{0}{ }^{2} \sin 2 \theta}{\mathrm{~g}}$ and substituted the data as a result they formulated the equation $\frac{\mathrm{u}_{\mathrm{o}}{ }^{2} \sin 2 \theta}{R}=\frac{\mathrm{u}_{\mathrm{o}}{ }^{2} \sin 2 \theta}{0.2 \mathrm{R}_{\mathrm{m}}}$. They further
reduced the equation to $\frac{1}{R}=\frac{1}{0.2 \mathrm{R}_{\mathrm{m}}}$ and then obtained the correct answer, $R_{m}$ $=5 R$.

Item (iv) was composed from the topic 'Heat'. It intended to measure candidates' ability to analyze the basic concepts of Heat Energy. The question was:

Students were observing the characteristics of molecules in the solid when the temperature of solid is raised. If you were among the students' what character will you observe?
(i) They oscillate at greater amplitudes.
(ii) The distance between them increases.
(iii) Attractive forces between them become stronger.
(iv) They move about freely.
(v) They fail to move about freely.

| A | (i), (ii) and (v) | B | (i), (ii) and (iii) | $C$ | (i), (ii) and (iv) |
| :--- | :--- | :--- | :--- | :--- | :--- |
| D | (ii), (iv) and $(v)$ | $E$ | (ii), (iii) and (iv) |  |  |

The candidates were required to make analysis on the descriptions provided and choose the correct answer. The correct answer for these item was C (i), (ii) and (iv) which were They oscillate at greater amplitudes, the distance between them increases and They move about freely respectively. It is known that temperature directly affects the movement of particles such as molecules. Therefore, molecules move faster when the temperature increases and move slower when decreases. On the other hand, those who chose other options did not know the properties of molecules when heated more, hence they chose either, options A, B, D or E, which were wrong. These students they did not know that (iii) and (v) which were Attractive forces between them become stronger and they fail to move about freely respectively are not the answers because there is no attractive force between heated molecules more than being allowed to separate by force that makes the molecules far apart from each other. They also did not know that molecules move about freely when heated instead of failing to move about freely. Therefore, in order to choose the correct answer, the candidate was required to have adequate knowledge about the properties of matter, especially the particles of molecules when the temperature is increased or decreased. Others from this group were confused
by the fact that in liquids and gases molecules are free to move. They failed to realize that when heat is applied to a solid body, the bond between the particles of the solid is weakened and start moving.

Item (v) was set from the topic 'Sound'. It intended to measure candidates' competence in applying the basic concepts of sound in real life situation. The question was:
A technician is building a music studio hall. What a technician should include to make the hall sound proof?
$\begin{array}{llll}\text { A } & \text { Rough walls and ceiling } & \text { B } & \text { Smooth walls and ceiling } \\ \text { C } & \text { Polished walls and ceiling } & \text { D } & \text { Smooth walls and ceiling } \\ \text { E } & \text { Thick walls and ceiling } & & \end{array}$

The correct response for this item was alternative A Rough walls and ceiling. The candidates who chose this response knew that smooth and hard surfaces are good reflectors of sound and while polished or coloured surfaces has nothing to do with reflection or absorption of sound. They knew that rough walls and ceiling are good absorbers of sound and can be used to make the hall to be sound proof. The majority chose alternative C Polished walls and ceiling. These Candidates did not know that the sound, which leaves the hall results from reflection that, occurs at hard, rough or thick wall. In addition, they did not know that the sound leaves the hall, through the openings such as windows after being reflected from the hard, rough or thick walls.

A few candidates chose options B Smooth walls and ceiling, D Glass walls and ceiling and E Thick walls and ceiling. They had no idea that smooth walls and glass walls have the same properties that is glass conducts sound very well. Glass does little to prevent noise from entering or leaving a room where at the same time smooth room also polished surfaces have nothing to do with the absorption of sound.

Item (vi) was composed from the topic Projectile Motion. It intended to measure candidates' ability to differentiate various concepts of projectile motion. The question was as follows:

Form Four students were asked to describe a path of a rocket when projected upwards. Suppose you were among them, which of the following would your response?

| A | Trajectory | B | Projectile | C |
| :--- | :--- | :--- | :--- | :--- |
| D | Maximum height | E | Trace path |  |

This item was one of the poorly performed items, since most of the candidates failed to choose the correct response. To identify the correct response, the candidates were supposed to differentiate the projectile parameters in options A to E. However, most of the candidates failed to identify the correct answer, which was A Trajectory. They had no idea that, trajectory is the flight path of a projectile motion. Those who chose B projectile had no idea that, projectile is a form of motion where an object moves in a parabolic path. The candidates who chose C, Range did not understand that range is a horizontal distance a projectile travels from the instant it is released until it returns to the same height at which it was released. Those who chose D, Maximum height were not conversant in the parameter of projectile as they described maximum height of projectile, which is the highest vertical position along its trajectory. Furthermore, those who chose E Trace path could not figure out that a path of a rocket when projected upwards is a trajectory; hence, they geared up choosing this wrong response.

Item (vii) was set from the topic Simple Machines. It intended to measure the candidates' competence in evaluating simple machines. The question was as follows:
Which of the following is expected to a lever with a long effort arm and short load arm?

| A | High load and high effort | B | High mechanical advantage |
| :--- | :--- | :--- | :--- |
| $C$ | Low mechanical advantage | D | Low load and low effort |
| E | High effort and low load |  |  |

The correct response for this item was alternative B High mechanical advantage. The candidates who chose this option understood that the velocity ratio $(V . R)$ of the lever is given by V.R $=\frac{\text { effort arm }}{\text { load arm }}$ and V.R $=\frac{\text { M.A }}{\text { Efficiency }} \times 100 \%$. From this formula, they realized that when the mechanical advantage (M.A) is high then $V . R$ is high as well. They also knew
that from V.R $=\frac{\text { effort arm }}{\text { load arm }}$, the lever with a long effort arm and short load arm will have high velocity ratio (V.R) and hence high mechanical advantage (M.A). On the other hand the candidates whose options were A High load and high effort, C Low mechanical advantage, D Low load and low effort and E High effort and low load failed to apply the V.R equations to evaluate the parameters of the lever so as to obtain the relationship between effort arm and load arm with respect to mechanical advantage.

Item (viii) was composed from the topic 'Linear Motion'. It intended to measure candidates' competence in solving real life problems involving linear motion. The question asked:
Students were investigating the relationship between mass and acceleration with regard to force. They observed that, a certain force produced a unit acceleration of $1 \mathrm{~m} / \mathrm{s}^{2}$ when it acted on a mass of 1 kg . Which physical quantity suits this relationship?

| $A$ | Impulse | $B$ | Momentum | $C$ | Newton |
| :--- | :--- | :--- | :--- | :--- | :--- |
| $D$ | Retardation | $E$ | Deceleration |  |  |

The correct response for this item was alternative C Newton. Most of the candidates managed to answer this item correctly. It seems they were familiar with the equations of linear motion such as $v=u+a t, S=u t+\frac{1}{2} a t^{2}, v^{2}=u^{2}$ +2 as and $F=$ ma. Whereby ' $v$ ' is final velocity, ' $u$ ' is initial velocity, ' $t$ ' is time taken, ' $F$ ' is force, ' $m$ ' is mass and ' $a$ ' is acceleration. These candidates were able to use the formula in the calculation and gained the return of the parameter as it was obtained from a certain force that produces a unit acceleration of $1 \mathrm{~m} / \mathrm{s}^{2}$ when it acted on a mass of 1 kg . As a result, they obtained the correct response Newton 'C' after substituting the unit of kg and $\mathrm{m} / \mathrm{s}^{2}$ into the formula $\mathrm{F}=$ ma which produced a unit which is Newton.

Those who chose alternatives A Impulse and B Momentum were not able to understand that; Impulse is the term that is used to describe or quantify the effect of force acting over time to change the momentum of an object. In addition, they did not recognize that, Momentum is the strength or force gained by motion produced from the product of mass and velocity. On the other hand, candidates who chose option D Retardation or E Deceleration confused that both terms represents the rate of decrease of velocity with
respect to time and has no influence on the relationship when a certain force produced a unit acceleration of $1 \mathrm{~m} / \mathrm{s}^{2}$ when it acted on a mass of 1 kg .

Item (ix) was set from the topic 'Periodic Motion'. It intended to test the candidates' ability to distinguish various types of motion applied in the Engineering field. The question was:

What type of oscillation motion is related to the restoring force proportional to the displacement taken from the midpoint?

| A | Projectile Motion | B | Circular Motion | Linear Motion |
| :--- | :--- | :--- | :--- | :--- | :--- |
| $D$ | Angular Motion | E | Harmonic Motion |  |

The correct response for this item was alternative E Harmonic Motion. The candidates who chose this alternative understood that the restoring force ( F ) is directly proportional to the displacement ( x ), that is $\mathrm{F} \alpha \mathrm{x}$. In addition, they understood that this type of oscillation is related to harmonic motion. In contrast, the candidates who chose A Projectile Motion, B Circular Motion, C Linear Motion or D Angular Motion lacked knowledge on the oscillation, which is to and fro motion of an object or a particle as its rest or equilibrium position. They could not realize that, projectile motion is the motion of an object thrown or projected into the air, subject to only the acceleration of gravity.

Those who chose option B Circular Motion did not figure out that circular motion is described as a movement of an object while rotating along a circular path. Furthermore, those who chose option C Linear motion they did not know that, according to Newton's first law of motion, objects do not experience any net force will continue to move in a straight line with a constant velocity until they are subjected to a net force. For those who chose option D Angular Motion were required to know that angular motion is the one in which the body moves along a curved path at a constant angular velocity.

In general, the candidates who chose the wrong options had no adequate knowledge on the objects' motion resulting from the external force. Hence, they couldn't identify the type of oscillation motion which is related to restoring force proportional to the displacement and hence selecting the right option.

Item (x) was composed from the topic Angular Velocity. It intended to test the candidates' competence in applying the concept of angular motion to solve real life problems. The question asked:

The tyres of two identical cars $A$ and $B$ are rotating with the same angular velocity. Under the same conditions car A moves faster than car B. What conclusion can be drawn about the size of the tyres of the cars?
$A \quad$ The tyres of $B$ are wider than of $A$
$B \quad$ The tyres of $A$ are smaller in diameter than those of $B$
$C$ The tyres of $A$ are identical in diameter to those of $B$
$D$ The tyres of $A$ are wider than of $B$
$E \quad$ The tyres of $A$ are larger in diameter than those of $B$

The correct response for this item was alternative E The tyres of A are larger in diameter than those of $B$. The candidates who chose alternative $E$ understood that the linear velocity $(v)$ and angular velocity $(\omega)$ of a car tyre with a radius $(r)$ are related by the equation $\mathrm{v}=\mathrm{r} \omega$. This shows that tyre with a large radius will move at a higher linear velocity than the one with a small radius. Knowing this fact, and being informed from the question that car A moves faster than car $B$, they managed to conclude that the tyres of $A$ are larger in diameter than those of car B.

On the other hand, the candidates who chose other alternatives did not understand the relationship between the linear velocity $(v)$ and the angular velocity $(\omega)$ of an object with rotation motion are connected by equation $v=r \omega$.

Some of the candidates who chose the wrong options were confused by the term identical. They thought the two cars were similar and had the same conditions in every parameter hence leading them to choose wrong alternative C The tyres of $A$ are identical in diameter to those of $B$.

### 2.2 SECTION B: Short Answer Questions

This section had nine (9) compulsory short-answer questions set from the topics of Periodic motion, Simple machines, Light (Optics), Angular motion, Electricity and Magnetism, Work, Energy and Power, Linear motion and Heat. Each question carried five (5) marks, making 45 marks. In this section, the scores were distributed in the following ranges: from 0 to 1.0 mark
(weak), from 2.0 to 3.0 marks (average) and 4.0 to 5.0 marks (good). The analysis of each question is as follows:

### 2.2.2 Question 2: Periodic Motion

This question was set from the topic Periodic Motion. It was designed to evaluate a candidate's ability to solve periodic motion-related engineering problems. The question was as follows:
(a) The figure below shows $a$ bob ' $C$ ' tied by string and attached to $a$ board. What are the two major conditions to be considered so that a stone can move in periodic motion with equal intervals of time?

(b) If a simple pendulum of length 0.49 m has a period of 1.4 seconds, find the period of a pendulum of length 1.96 m .

The question was attempted by 1441 ( $100 \%$ ) candidates. Figure 3 indicates that, 957 ( $66.4 \%$ ) candidates scored marks from 0 to 1 . Additionally, 475 ( $32.9 \%$ ) candidates scored from 1.5 to 3 marks; while $10(0.7 \%)$ candidates scored between 3.5 and 4 marks. This was the poorly performed question as the majority of candidates scored below average.


Figure 3: The Candidates' Performance in Question 2

This question had an average performance. The majority of the candidates (66.4\%) failed this question by scoring either 0 or 1 mark. The analysis shows that the candidates who scored 0 mark failed to state two major conditions to be considered so that a body can move in periodic motion with equal intervals of times in part (a). Additionally, they failed to recall that the periodic Time (T) of an oscillating pendulum is given by $T=2 \pi \sqrt{\frac{l}{g}}$ in part (b), whereby ' l ' is length of string and ' g ' is acceleration due to gravity. Further analysis indicates that the candidates did not know the two major conditions that enable the stone to move in periodic motion with equal interval of time, which are; Air resistance must be neglected and the body or object must oscillate about the vertical axis. They also did not realized that the restoring force must be proportional to the displacement and act opposite to the direction of motion with no friction as well as the frequency of oscillation does not depend on the amplitude. Extract 2.1 shows a sample of the candidates who scored 0 mark.

| 2. | a. 1. Speed at the movement. |
| :---: | :---: |
|  | 11. Distance or length between two points. |
|  | b. Given. |
|  | Length of pendulum $\left(L_{1}\right)=0.49 \mathrm{~m}$ |
|  | Time(t.) $=1.4 \mathrm{sec}$ |
|  | L.ongth of pendulam $\left(l_{2}\right)=1.96 \mathrm{~m}$ |
|  | Time $\left(t_{2}\right)$ is reauned |
|  | From $L_{1}=t_{1}$ |
|  | $L_{2} \quad t_{2}$ |
|  | $0.49=1.4$ |
|  | 1.96 tz |
|  | $t_{2}=1.96 \times 1.4$ |
|  | 0.49 |
|  | $=5.6 \mathrm{sec}$ |
|  |  |
|  | $\therefore$ The period of a pendulum of length 1.96 m is 5.6 sec |

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

Extract 2.1 is a sample of the poor responses from the candidate who wrote the wrong answers. In part (a), he/she was required to write Air resistance must be neglected and the body or object must oscillate about the vertical axis instead he/she wrote speed of the movement and distance of length between two points. In part (b), he/she provided the wrong formula, thus ended up with an incorrect answer.

Further analysis reveals that those who had an average performance were only able to provide either correctly answer in part (a) and failed in part (b) or failed part (a) and correctly answered part (b), thus scored average marks. For example, those who got all marks in part (b) they applied the formula $\frac{T_{2}^{2}}{T_{1}^{2}}=\frac{l_{2}}{l_{1}}$ that helped them to get the period of the pendulum, $\mathrm{T}_{2}$ and hence scored all the 3 marks in part (b). Others used the correct formula but started from $\mathrm{T}_{1}=2 \pi \sqrt{\frac{l_{1}}{g}}$ and $\mathrm{T}_{2}=2 \pi \sqrt{\frac{l_{2}}{g}}$ where they combined the two equations to get the correct formula.

On the other hand, there were those who got good marks. These candidates were able to answer parts (a) and (b). In part (a), these candidates were able
to demonstrate their understanding of the two major conditions to be considered so that a stone can move in periodic motion with equal intervals of time by writing two conditions where each candidate was able to demonstrate the competence they have on these conditions. In part (b), some were only able to write the formula but failed to substitute the required data.

No candidate scored all the 5 marks, only 9 ( $0.6 \%$ ) candidates among 1441 scored 4 marks. These candidates were either able to give one condition in part (a) and then attempt correctly part (b) or gave all the two conditions in part (a) and they applied the formula $\mathrm{T}_{1}=2 \pi \sqrt{\frac{l_{1}}{g}}$ and $\mathrm{T}_{2}=2 \pi \sqrt{\frac{l_{2}}{g}}$ but failed to formulate the formula $\frac{T_{2}^{2}}{T_{1}^{2}}=\frac{l_{2}}{l_{1}}$. Extract 2.2 portrays a sample of a candidate's response who scored 4 marks.

| 2 | (as) The two major conolitions to he courdead as |
| :---: | :---: |
|  | Liv omit Air ristance |
|  |  |
|  |  |
|  | (b) Data analy, 3. |
|  | $l_{i}=0.49 \mathrm{~m}$ |
|  | $T_{4}=1.4$ seconde |
|  | $l_{0}=1.96 \mathrm{~m}$ |
|  | T Tank $=$ Penod |
|  | Tram |
|  | $T_{1}=T_{2}$ |
|  | $\sqrt{1 / 9}=\sqrt{13 / a}$ |
|  | $T_{2}=T \sqrt{1 / 9}$ |
|  | $\tau_{2}=\frac{1 / \sqrt{1 / 9}}{\frac{1}{19}}$ |
|  | $T_{2}=\frac{1-4 \sqrt{1-96}}{10}$ |
|  | $\underline{\sqrt{0.4 / 10}}$ |
|  |  |
|  | $T=1.4 \times 0.44$ |
|  | $0.7 \times 0.31$ |
| 2 | (b) $\quad T_{2}=2 \times 0.44$ |
|  | 0.31 |
|  | $T_{2}=2.83 \ldots$ |
|  | $T_{2} \approx 2-8$ second. |
|  | U2 |
|  | $\therefore$ The prenid will be $2-8$ secoad. |
|  |  |

Extract 2.2: A sample of good responses to Question 2
Extract 2.2 is a sample of good responses from the candidate who wrote the correct answers in part (a) by writing one condition. In part (b), he/she was
able to write the correct formula and substituted the correct data thus, ending up with correct response.

### 2.2.3 Question 3: Simple Machines

This question was set from the topic Simple Machines. It intended to test the candidates' ability to evaluate simple machines. The question was:

School built a block and tackle of three pulleys in each block for the purpose of hauling loads. The lower block weighs 50N. Assume friction is negligible, what effort must be employed to raise a load of 350 N?

The question was attempted by $1441(100 \%)$ candidates. The results in Figure 4 indicate that, 1241 ( $86.1 \%$ ) of candidates scored from 0 to 1 mark; $195(13.6 \%)$ of candidates scored marks from 3 to 6 marks while 5 ( $0.3 \%$ ) of candidates scored from 4 to 5 marks. This is also one of the questions which was poorly performed by majority of candidates as they scored below average.


Figure 4: The Candidates' Performance in Question 3
The candidates who scored from 0 to 1 mark could not recall the formula of mechanical advantage which they could use to calculate the required effort. In this question, candidate had two things to remember. The first was to be aware that if frictional losses are neglected, the mechanical advantage of a
block and tackle is equal to the number of parts. In other words, the numbers of supporting rope parts are equal to Mechanical Advantage. These candidates could not realize that when a machine is assumed to be perfect its efficiency is 100 percent and therefore, its velocity ratio (V.R) is equal to its Mechanical Advantage (M.A). Another thing was to determine the total load resulting from the one employed to raise a load of 350 N and the lower block, which weighed 50 N . Some of those who failed were able to write the formula, but did not know how to obtain the mechanical advantage. Others used the value of the lower block weights of 50 N as a mechanical advantage instead of six (6). Extract 3.1 is the sample of a poor response of a candidate who scored 0 mark.


Extract 3.1: A sample of the poor responses to Question 3
Extract 3.2 shows a response from a candidate who was not able to calculate effort, which must be employed to raise a load of 350 N .

The candidates who scored from 1.5 to 3 marks knew that mechanical advantage is equal to velocity ratio which is equal to 6 and they were able to write the formula only that they could not understand the idea of adding up load of 350 N and the lower block weighs 50 N . So they ended up using the wrong load and got the wrong effort hence they scored with average marks.

Only 5 ( $0.3 \%$ ) candidates scored from 3.5 to 5 marks. The candidates who scored 4 were able to write the correct formula that Mechanical Advantage is equal to Velocity ratio, so in calculation he/she entered mechanical advantage as M.A instead of 6 . Those who got all 5 marks, were able to write formula and they recognized both tricks, where they were able to calculate effort thus they scored all the 5 marks. Extract 3.2 is the sample of a good response by the candidate who scored good marks.


Extract 3.2: A sample of good responses to Question 3
Extract 3.2 shows a response from a candidate who was able to calculate effort, which must be employed to raise a load of 350 N .

### 2.2.4 Question 4: Light (Optics)

This question was set from the topic Light (Optics). It intended to measure the candidates ability to determine the refractive indices of transparent materials. The question was as follows:
(a) A ray of light travels from a vacuum into a glass block of refractive index 1.6. Given that $\sin$ ' $i$ ' $=0.4$; Where ' $i$ ' and ' $r$ ' are incident and refraction angles respectively, calculate the value of sin ' $r$ '.
(b) A coin is at the bottom of a vessel 16 m deep. When viewed from the top of water surface, it appears as it is situated at height 12 m from the bottom of the vessel. What is the refractive index of the water?

The question was attempted by 1441 (100\%) candidates. Among them 157 ( $10.9 \%$ ) candidates scored from 0 to 1 mark; 244 ( $16.9 \%$ ) candidates scored from 2.0 to 3.5 marks; while 1040 ( $72.2 \%$ ) students scored from 3.5 to 5 marks. The majority $(89.1 \%)$ scored from 1.5 to 5 marks. This was the bestperformed question. Figure 5 shows the candidates' performance summarized in percentage.


Figure 5: The Candidates' Performance in Question 4
The analysis shows that the good number of candidates (89.1\%) scored average and above. Some of the candidates (54.5\%) who scored all marks, in part (a) were able to use the formula $\eta=\frac{\operatorname{Sini}}{\operatorname{Sinr}}$ to calculate the refractive index ' $\eta$ '. They were also able to substitute the correct data for $\eta=1.6$ and $\sin i=0.4$, thus obtained the correct response. In part (b), they used the correct formula $\eta=\frac{\text { Real depth }}{\text { Apparent depth }}$ and substituted data correctly thus obtained the right response. Those who scored high marks but less than 5 marks made some errors during calculation as a result they score less than 5 marks. For example, one candidate attempted the question correctly, but messed up by substituting the wrong data in part (b) instead of $\eta=\frac{16 \mathrm{~m}}{12 \mathrm{~m}}$
he/she substituted $\eta=\frac{12 \mathrm{~m}}{16 \mathrm{~m}}$, thus scored less than 5 marks. Extract 4.1 is a sample of the good responses.

| 4. | a.) Data given |  |
| :---: | :---: | :---: |
|  | Refractive Index $=1.6$ |  |
|  | $\sin \vec{\imath}=0.4$ |  |
|  | Task: Value of sin'r' |  |
|  | from; Refractive index (2) $=\sin$ i |  |
|  | $\sin r$ |  |
|  | $1.6=0.4$ |  |
|  | $\sin r$ | $\checkmark$ |
|  | $\sin r=0.4$ |  |
|  | 1.6 |  |
|  | $\sin r=0.25$ |  |
|  | $\therefore$ The value of sin $r$ is 0.25 . |  |
|  |  |  |
|  | b.) Data given |  |
|  | Real depth $=16 \mathrm{~m}$ |  |
|  | Apparent depth $=12 \mathrm{~m}$ |  |
|  | T ask: Refractive Endex of water. |  |
|  | From; Refractive index $=$ Real depth |  |
|  | Apparent depth |  |
|  | $2=16 \mathrm{~m}$ |  |
|  | 12 m , |  |
|  | $2=4 / 3$ |  |
|  | $\therefore$. The refractive index of water is 4/3. |  |

Extract 4.2: A sample of good responses to Question 3
Extract 4.2 is the sample of good responses from the candidate who managed to obtain the correctly answers in part (a). He/she wrote correct formula and calculated the value of $\sin \mathrm{r}$ correctly. $\mathrm{He} /$ she was able to calculate the refractive index of water in part (b).

Further analysis shows that, those who got average marks made some mistakes. For example, one candidate attempted part (a) only hence scored average marks. Others attempted part (b) only and ended up with average marks. The analysis reveals that, these candidates had difficult in
remembering the formula either refractive index in part (a) or refractive index of water in part (b).

A few candidates ( $10.9 \%$ ) who failed this question could not remember the formula in both parts (a) and (b). These candidates had inadequate knowledge in the concept of light that was to measure the ability to determine the refractive indices of transparent materials. Extract 5.1 is a sample of the poor responses by one of the candidates in this question.


Extract 4.2: A sample of poor responses to Question 4

Extract 4.2 is a sample of the poor responses from the candidate who got wrong answers in both parts. In part (a) he/she wrote wrong formula by swapping the formula $\eta=\frac{\operatorname{Sinr}}{\operatorname{Sini}}$ instead of $\eta=\frac{\operatorname{Sini}}{\operatorname{Sinr}}$. The candidate repeated the same mistake in part (b).

### 2.2.5 Question 5: Angular Motion

This question was composed from the topic Angular Motion. It intended to test the candidates' competence in applying the concepts of Angular Motion to solve problems on centripetal force and angular motion. The question was as follows:
(a) Why a car moving around a circular path does not turn over?
(b) A body of mass 0.5 kg is rotated round a horizontal circular plane of radius 2 m at a constant speed of $10 \mathrm{~m} / \mathrm{s}$. Find its angular velocity.

A total of $1441(100 \%)$ candidates attempted this question. Out of these, 421 ( $29.2 \%$ ) scored from 0 to 1.0 mark; 89 ( $6.2 \%$ ) scored from 1.5 to 3.0 marks; and $931(64.6 \%)$ scored from 3.5 to 5.0 marks. Generally, the candidates' performance in this question was good. This analysis is summarized in Figure 6.


Figure 6: The Candidates' Performance in Question 5
Most of the candidates ( $70.78 \%$ ) attempted this question correctly. Among these candidates, 64.6 percent had good performance as they scored 4 marks and above. For example, 30.3 per cent of the candidates who scored all 5
marks, were able to answer most of the parts of the questions correctly. They were able to state why the car can pass through the roundabout without overturning in part (a). some of them wrote that Centripetal Force moves inside the circle (towards the center of the circle). Others managed to explain that a body moving round a circular path does not turn over because, centripetal force which is directed towards the centre of the circle keeps the car in a circular path. These answers suggest that the candidates were aware of the force that causes an object to rotate following a circular path without entering or exiting the circle. In item (b), the candidates applied the skills they had to write the correct formula and calculate the speed in a circle. Others from this group created the formula and substituted the parameters to calculate the speed in the circle. The responses they provided signified their understanding and knowledge of calculating of angular velocity, which is the speed of change in the position of an object in relation to time. Extract 5.1 is a sample of the candidates' correct response.


Extract 5.1: A sample of good responses to Question 5

In Extract 5.1, the candidate was able to explain how a car moves around the circle and keeps the body from overturning in part (a). In addition, in part (b), the candidate was able to write and apply the correct formula and accurately calculated the angular velocity.

Most of the candidates who got average marks (6.2\%) they only managed to attempt correctly part (b), thus getting average marks, but they failed to explain part (a) why a car moving around a circular path does not turn over. Their knowledge about the centripetal and centrifugal forces were poor.

Therefore, some of them skipped part (a), while others provided just presumed replies and scored average marks. Others answered part (a) correctly and were able to write the correct formula in part (b), but failed to use the data correctly. They substituted wrong data like mass of a body 0.5 kg that was given in the question, hence they scored average marks.

Most of those who got low marks, attempted part (a) correctly, but did not remember the correct formula in part (b), thus they got 1 mark. Others in this group wrote incorrect answers in both parts (a) and (b), thus scored 0 . For example, one candidate wrote in part (a) a car moving around a circular path does not turn over because before the overturn the drive applies brake which is wrong. Extract 5.2 is the sample of poor responses from the candidate.

| 5. | b) Soln. |
| :---: | :---: |
|  | Data analysis. |
|  | Mass $=0.5 \mathrm{~kg}$ |
|  | radius $=2 \mathrm{~m}$. |
|  | accerelafion $=10 \mathrm{~m} / \mathrm{s}$ |
|  | Task: angular velocity. |
|  | $\because$ Find the momentum. |
|  | $\Psi=a r$ |
|  | $Q=a r$ |
|  | $\omega=10 \times 2$ |
|  | $\omega=20 \mathrm{~m} / \mathrm{s}$ |
|  | $I=m v$ |
|  | $=0.5 \times 10$ |
|  | $\because I=5 \mathrm{hgm} . \mathrm{s}$ |
|  |  |
|  | $\therefore \omega=F_{r}+a$ |
|  | $I+m g a$ |
|  |  |
|  | $=0.05 \mathrm{~N} \times 2+1$ |
|  | $5+0.5 \times 10 \times 10$ |
|  |  |
|  | $=0.1+1=1.1$ |
|  | $5+55$ 50 |
|  |  |
|  | $\propto=v$ |
|  | $r$ |
|  | $20=v \times 2$ |
|  | 2.2 |
|  | . |
|  | $\therefore$ The angular velarity is $10 \mathrm{~m} / \mathrm{s}$ |

Extract 5.2: A sample of poor responses to Question 5

In Extract 5.2 the candidate was not able to explain why a car moves around the circle and keeps the body from not overturning in part (a). In part (b), the
candidate was not able to write and apply the correct formula to calculate the angular velocity.

### 2.2.6 Question 6: Simple Machines

The question was set from the topic Simple Machine. It intended to measure candidates' ability in identifying simple machine parameter in the applications of chain, gear and belt drive. The question was as follows:
(a) (i) Why a belt drive is much preferred for transmission of motion in comparison to other means?
(ii) What is the advantage of using a chain when compared to belt drive?
(b) (i) What should be done for smooth transfer of motion and gears to mesh correctly when operating through gear drive?
(ii) What must be checked at a period of service of the machine, which employs belt drive?
(iii) What is involved between gears when the direction of motion from a given shaft has to be changed?

The analysis indicates that 1441 (100\%) candidates attempted this question. Among them, 91394 ( $96.7 \%$ ) scored from 0 to 1.0 mark; of whom 85.4 percent scored zero. Moreover, 3.2 percent of the candidates scored from 1.5 to 3.0 marks and 0.1 percent scored from 3.5 to 5.0 marks. The general performance of the candidates in this question was poor. Figure 7 illustrates this performance.


Figure 7: The Candidates' Performance in Question 6
This was the most poorly performed question. This shows that most candidates $(96.7 \%)$ who failed did not have enough knowledge related to the measured concepts of identifying simple machine parameters in the applications of chain, gear and belt drive.

The candidates who scored 0 failed to explain in part (a) (i) that, a belt drive is much preferred because it is simple to use and can be used with shafts that are very far apart. Furthermore, belt drive has low maintenance cost; has mechanism of preventing overload and jam; and has less friction as well. In part (a) (ii), the candidates failed to give the advantages of using a chain drive in comparison to belt. They did not know that, there is no slipping of the shaft, which is an advantage of using a chain drive in comparison to belt.

In part (b) (i), these candidates could not explain what should be done for smooth transfer of motion and gears to mesh correctly when operating through gear drive. They did not know that for smooth transfer of power through gears, pitch of the gears meshing should be equal. Also in part (b) (ii), the candidates failed to explain what must be checked when servicing the machine which employs belt drive. They did not know that the tension of the belt to the specification should be checked at a period of service of the machine or belt conditions (tear and wear of the belts). Finally, in part (b)
(iii), these candidates did not write any response regarding what happens between the gears where the direction of motion from a given shaft has to be changed. These candidates failed to explain that the direction of motion from a given shaft changes to another direction of shaft in motion by involving a third gear known as idler gear. These candidates were not conversant with the concepts of gear, belt and chain drives. Some of them, 163 (11.3\%) failed to answer correctly all the parts except one item in either part (a) or (b), hence they got 1 mark. Example one candidate answered part (a) (ii) correctly by proving one advantage of employing a chain drive over a belt drive that is, the "shaft never slips", so he/she scored only 1 mark. Extract 6.1 shows a sample of a poor responses extracted from the script of a candidate who scored 0 mark.


Extract 6.1: A sample of poor responses to Question 6

Extract 6.1 shows a sample of poor response of part (a) given by a candidate who failed to answer all parts of the question.

Analysis shows that $45(3.2 \%)$ candidates got average marks in this question. These candidates were able to answer some parts of (a) and (b) in various items, thus obtained an average score. The candidates in this category seemed
to answer more accurately the items (i) and (ii) in part (a) and the item (ii) of part (b).

On the other hand, the candidate who got 4 marks was able to answer all the items of part (a) correctly but in part (b) he/she managed to get only items (ii) and (iii) correctly. The candidate who got all 5 marks was able to explain in part (a) (i) that, "highly preferred because belt drives are easy to operate and may be applied with shafts that are spaced far apart". In part (a) (ii), he/she explained that, using a chain drive instead of a belt drive has the benefit of preventing shaft sliding. Furthermore, the candidate explained that Pitch of the gears' meshing should be equal for a smooth transfer of power through the gears and During a machine's service time or when the belt is in poor condition, the tension of the belt should be evaluated against the specifications in part (b) (i) and (ii) respectively. Also this candidate successfully explained that a third gear known as the idler gear is used to change the direction of motion from one shaft to another shaft in motion in part (b) (iii), thus managed to score all the 5 marks allotted to the question. Extract 6.2 is a sample of good responses provided by one of the candidates in this question.


Extract 6.2: A sample of good responses to Question 6
Extract 6.2 shows a sample of good responses from the candidate who managed to answer some parts of (a) and (b).

### 2.2.7 Question 7: Measurements

The question was set from the topic Measurements. It intended to measure candidates' ability to calculate densities of different substances. The question was as follows:

A student mixed $1000 \mathrm{~cm}^{3}$ of water with $800 \mathrm{~cm}^{3}$ of brine. If the density of water and brine were $1000 \mathrm{~kg} / \mathrm{m}^{3}$ and $1027 \mathrm{~kg} / \mathrm{m}^{3}$ respectively. Determine the density of the mixture formed.

A total of 1441 ( $100 \%$ ) candidates attempted this question, out of whom 569 ( $39.5 \%$ ) candidates scored from 0 to 1.0 mark; 275 ( $19.1 \%$ ) scored from 1.5 to 3.0 marks; and 597 ( $41.4 \%$ ) scored from 3.5 to 5.0 marks. Generally, the candidates' performance in this question was average. Figure 8 presents scores with respect to the percentage of the candidates.


Figure 8: The Candidates' Performance in Question 7
Almost 28.5 percent of the candidates who scored from 0 to 1.0 marks, got 0 . These candidates failed even to recall the equation $\rho=\frac{\operatorname{Mass}(\mathrm{m})}{\operatorname{Volume}(\mathrm{v})}$ for calculating the density of a substance. They could not determine the mass of water which would help them to find the mass of brine which is the summation of the mass of water and the mass of brine. Additionally, they could not remember to add the volumes of water and brine to get the volume of the mixture. Those who failed $158(11.0 \%)$ scored 0.5 or 1 mark. Some of them wrote the formula $\rho=\frac{\text { Mass (m) }}{\text { Volume (v) }}$ whereby ' $\rho$ ' is density but did not continue with the calculation. Others wrote the formula $m_{w}=\eta_{w} x V_{w}$ to find
the mass of water, thus getting a poor score. Extract 7.1 is a sample of poor responses to Question 7.


Extract 7.1: A sample of poor responses to Question 7

Extract 7.1 shows a sample of the responses from the candidate who did not provide correct answers. $\mathrm{He} /$ she failed to remember the density formula of calculating the density of a substance and therefore was not able to calculate the volume of the mixture.

The candidates 275 (19.1\%) who got average marks had partial knowledge in the concept of density of different liquids. These candidates did not sum up the mass of the mixture, therefore, they incorrectly applied the mass of the brine and its volume to calculate the density of mixture. They also did not know that the brine dissolves in water, thus increases the mass and volume of the mixture. The candidates were supposed to take the mass of the mixture (water and brine) and divide it by the volume of the mixture to get the density
of the mixture. Most of these candidates wrote formula for density correctly, but they substituted incorrect data.

The candidate who scored 3.5 to 5.0 marks were able to write the formula correctly and obtain the mass and volume of brine. Other candidates made some mistakes that caused them to fail to score all the 5 marks. On the other hand, the candidates who scored 5 marks knew that the basic equation for calculating the density ( $\rho$ ) of any substance was $\rho=\frac{\text { Mass (m) }}{\text { Volume (v) }}$. They were then able to calculate the mass of water $\left(\mathrm{m}_{\mathrm{w}}\right)$ using the formula $m_{w}=\rho_{w} \times V_{w}$. Similarity, they calculated the mass of brine ( $\mathrm{m}_{\mathrm{b}}$ ) using the formula $m_{b}=\rho_{b} \times V_{b}$. They finally applied the equation $\rho_{\text {mixture }}=\frac{\text { Total mass of mixture }\left(\mathrm{m}_{\mathrm{m}}\right)}{\text { Total volume of mixture }\left(\mathrm{v}_{\mathrm{m}}\right)}$ and substituted the correct data as a result they scored all 5 marks. Extract 7.2 is the sample of good responses to Question 7.


Extract 7.2: A sample of good responses to Question 7

Extract 7.2 shows a sample of good responses from the candidate who remembered the formula of density and therefore calculated the volume of the mixture correctly.

### 2.2.8 Question 8: Electricity and Magnetism; Work, Energy and Power

This question was composed from two topic of Electricity and Magnetism in part (a) and; Work, Energy and Power' in part (b). In part (a), the question intended to measure the candidates' ability to apply the basic concepts of Electricity and Magnetism while in part (b) the question intended to test candidates' ability to apply the knowledge of work, energy and power. The question was as follows:
(a) How will you determine the direction of the following?
(i) Magnetic field due to straight current carrying conductor.
(ii) Force exerted on a current carrying conductor, placed in a magnetic field.
(b) A tennis ball was held and released at a height of about 2 m . What is the difference between the energies possessed by a tennis at 2 m stationary and when it was released?

The question was attempted by 1441 ( $100 \%$ ) candidates, out of whom 952 $(66.1 \%)$ candidates scored from 0 to 1.0 mark; 324 ( $22.4 \%$ ) scored from 1.5 to 3.0 marks and 165 ( $11.5 \%$ ) scored from 3.5 to 5.0 marks. The candidates' performance in this question was categorized as average because 33.9 per cent of the candidates scored average and above. The graphical presentation of performance of the candidates is summarized in Figure 9.


Figure 9: The Candidates' Performance in Question 8

The candidates who scored 0 were unable to determine the direction of the magnetic field of a current-carrying straight conductor placed in a magnetic field in part (a) (i). Also, these candidates failed to explain how to determine force exerted on a current carrying conductor when placed in magnetic field in part (a) (ii). These candidates had to know that to determine the direction of the magnetic field due to a straight current carrying conductor, they had to apply the right hand grip rule or, the Maxwell's right hand screw rule. They were also required to know the force exerted on a current carrying conductor, placed in a magnetic field can be determined by applying the Fleming's left hand rule or, by applying the motor rule.

Furthermore, in part (b) these candidates could not differentiate between the potential and kinetic energies possessed by tennis at 2 m stationary and when released. They were supposed to know that the difference between the energies possessed by tennis at 2 m is the potential energy in which a body is based on its position in the field of force or by its state while kinetic energy is the energy possessed by a body due to its motion, i.e energy in a motion. Among the candidates who failed ( 0 to 1.0 mark), 146 ( $10.1 \%$ ) scored 1 mark as they answered one item of part (a) correctly. Extract 8.1 shows a poor response to Question 8.

| 8. | 11) You can determine the direction of fore exerted on the cument |
| :---: | :---: |
|  | camying conductor by looking the direction of the second. |
|  | frave in fleming's raht hand rule. |
|  | figure in flemings nght hand vole. |
| 8b) | Solution |
|  | Data analusis' |
|  | height $=2 \mathrm{~m}$. |
|  | Tuk:- difference in energy. |
|  | from: $P_{1} E=m \mathrm{Ch}$ |
|  | $P_{1} E=m \times 10 \times 2$ |
|  | $P \cdot E=20 \mathrm{~m}$ - (1). |
|  | $V^{2}=29 \mathrm{~h}$. |
|  | $v^{2}=2 \times 10+2$ |
|  | $v^{2}=40 \mathrm{~m} / \mathrm{s}$ |
|  | $k \cdot E=4 \mathrm{mv}$ 2 |
|  | $K E=1 / 2 \times 40 \times \mathrm{m}$. |
|  | 12 |
|  | $K C E=20 \mathrm{~m}$ - (1). |
|  | $\triangle E=20 \times 10$ |
|  | $\therefore$ the difference of energy is potentional energy |

Extract 8.1: A sample of poor responses to Question 8

Extract 8.1 is a sample of responses from the script of a candidate who was not able to explain how to determine the direction of the magnetic field due to straight current carrying conductor and force exerted on a current carrying conductor, placed in a magnetic field. He/she failed to differentiate the energies possessed by tennis at 2 m stationary and when it was released.

There were 324 ( $22.5 \%$ ) candidates, who performed averagely in this question answered correctly in either part (a) or (b). Some were able to explain clearly the difference between the potential and kinetic energies possessed by tennis when it is at 2 m stationary and after being released in part (b). Also they failed to explain how to determine the direction of the magnetic field due to a current-carrying straight conductor placed in a magnetic field in part (a) (i) and how to determine force exerted on a current carrying conductor as it is placed in magnetic field in part (a) (ii). For example, one candidate correctly wrote energies possessed by tennis at 2 m and in motion is potential energy and Kinetic energy. Some gave wrong answer to part (a) (i) and (ii) by exchanging the rule as Force exerted on a current carrying conductor, placed in a magnetic field is by applying the

Maxwell's right hand screw rule and the direction of the Magnetic field due to a straight current carrying conductor is by applying the Fleming's left hand rule. Based on this observation, it seemed they understood the concept of magnetic field due to a straight current carrying conductor and force exerted on a current carrying conductor, but they confused as to which concept was related to 'Maxwell's right hand screw rule' and that was related to 'Fleming's left hand rule'.

On the other hand, 165 candidates ( $11.4 \%$ ) who scored high marks were able to answer correctly only one of the items in part (a) and the entire question in part (b). Others answered correctly part (a) and partially in part (b) thus obtained high marks but less than 5 marks. Analysis on the responses of these candidates' shows that the candidates were able to answer most of the questions correctly, but made some mistakes in either item (a) or (b), hence led them to get a high mark but less than 5 marks.

The candidates who scored all the 5 marks, were able to determine the direction of the magnetic field due to a current-carrying straight conductor placed in a magnetic field in part (a) (i) and explained how to determine force exerted on a current carrying conductor as it is placed in magnetic field in (a) (ii). These candidates were also able to distinguish the energies possessed by tennis at 2 m as potential energy and when it released as kinetic energy which is the energy due to motion. Extract 8.2 shows a sample of good responses extracted from the script of a candidate.


Extract 8.2: A sample of good responses to Question 8
Extract 8.2 is a sample of responses from the script of a candidate who explained that, the direction of the magnetic field due to straight current carrying conductor is determined by Maxwell rule and the force exerted on a current carrying conductor placed in a magnetic field by Fleming's left hand
rule. $\mathrm{He} /$ she managed to differentiate the energies possessed by a tennis at 2 m stationary and when it was released.

### 2.2.9 Question 9: Linear Motion

This question was set from the topic Linear Motion. It intended to test candidates' competence in applying the concepts of Linear Motion to solve real life problems. The question was as follows:
(a) What will happen when two opposite moving objects collide?
(b) A collision occurred between two trucks, one of which had twice the mass of the other. If the two trucks remained motionless after collision; describe the relationship of their speeds just before collision?

The question was attempted by 1441 (100\%) candidates, out of whom 1140 ( $79.10 \%$ ) candidates scored from 0 to 1 mark; 158 ( $11.0 \%$ ) scored from 1.5 to 3 marks; and 143 ( $9.9 \%$ ) scored from 3.5 to 5 marks. From the analysis it is revealed that, 20.9 per cent of the candidates scored from 1.5 to 5 marks, thus, the general candidates' performance in this question was poor. The candidates' performance in Question 9 is presented graphically in Figure 10.


Figure 10: The Candidates' Performance in Question 9

The candidates 670 (46.5\%) who scored 0 mark were not familiar with the law of conservation of linear momentum. They failed to explain what happens when two opposite moving objects collide in part (a). In part (a),
they failed to understand the relationship between the collisions of two objects moving in different directions. They did not know that in this collision, both objects experienced a momentum, which is equal and opposite in direction. Such a momentum often causes one object to accelerate (gain more speed) and another object to slow down (lose speed).

In part (b), these candidates failed to describe the relationship of the speed of two cars just before collision when one car has twice mass of the other. These candidates did not know that in order to find this relationship, they were required to use a formula based on the law of conservation of momentum that is, the total momentum before and after the collision remains equal. They were supposed to formulate the equation $m_{1} u_{1}+m_{2} u_{2}=m_{1} v_{1}+m_{2} v_{2}$ whereby ' $m$ ' is mass, ' $u_{1}$ ' and ' $u_{2}$ ' is initial and final velocity of the first truck and ' $v_{1}$ ' and ' $v_{2}$ ' is the initial and final velocity of second truck, where the formula could lead to the relationship of $u_{1}=-\frac{1}{2} u_{2}$ which shows that the tracks were in different directions. Extract 9.1 is a sample incorrect responses.


Extract 9.1: A sample of poor responses to Question 9
Extract 9.1 shows the wrong response in part (a), as the candidate could not explain what would happen if two opposing moving objects collided. In addition, in item (b) he/she wrote incorrect information and rules.

Further analysis on question 9 showed that 158 candidates ( $11.0 \%$ ) scored average marks. These candidates were able to answer correctly part (a) and portions of part (b). For example in part (b) they were able to partially explain the relationship between trucks of which they wrote an equation $m_{1} u_{1}+m_{2} u_{2}=m_{1} v_{1}+m_{2} v_{2}$ and they did not continue to calculate to find the relationship $u_{1}=-\frac{1}{2} u_{2}$ which would enable them to describe the relationship between the velocities.

On the other hand, the candidates who scored all the 5 marks were familiar with the law of conservation of linear momentum. In part (a), they managed to explain that if two moving objects collide, may remain stationary (motion less) after collision or may move together in one direction and their total momentum remains constant, provided no external forces are acting. Moreover, based on the law of conservation of linear momentum, they were able to apply the equation $m_{1} u_{1}+m_{2} u_{2}=m_{1} v_{1}+m_{2} v_{2}$ to establish the equation $2 u_{1}=u_{2}$ or $u_{2}=\frac{u_{2}}{2}$ that describes the relationship of the trucks speeds before collision. Extract 9.2 shows a sample of good responses in Question 9.


Extract 9.2: A sample of good responses to Question 9

Extract 9.2 shows correct responses since the candidate explained what would happen if two opposing moving objects collide. In part (b), he/she wrote correct representation of common velocity after collision of objects and obtained the speed of the second truck.

### 2.2.10 Question 10: Heat

This question was composed from the topic Heat. It intended to test candidates' ability to apply the basic concepts of heat to solve problems with respect to the raise of temperature. The question was as follows:
(a) One student raised the temperature of a certain body by 1 K. Another student raised the temperature of a unit mass of a body by 1 K . What is the difference of the activities carried out by the students if they dealt in the same material?
(b) Determine the mass of copper of specific heat capacity of $390 \mathrm{~J} / \mathrm{kg}{ }^{\circ} \mathrm{C}$ that can be raised to temperature from $15^{\circ} \mathrm{C}$ to $60^{\circ} \mathrm{C}$ by absorbing 80 $k J$ of heat?

This question was attempted by 1441 (100\%) candidates. Among them, 352 ( $24.4 \%$ ) candidates scored from 0 to 1.0 mark of whom 16.0 percent scored 0 mark; 38.8 percent scored from 1.5 to 3.0 marks; and 36.8 percent scored from 3.5 to 5.0 marks. This is among the questions, which had good performance, because 75.6 percent of the candidates scored average marks and above. The graphical presentation of the candidates' scores with the respective percentage is shown in Figure 11.


Figure 11: The Candidates' Performance in Question 10

The candidates who scored full marks were able to differentiate the activities related to Heat Capacity and Specific Heat Capacity. In part (a), they managed to state that, Heat Capacity of the body is the quantity of heat required to raise the temperature of a body by $1 K$ while Specific Heat Capacity of the body is the quantity of heat required to raise the temperature of a unit mass ( 1 kg ) of the body by $1 K$. Therefore, they managed to state that the activity carried out by the first student was to determine Heat Capacity of the material of the body while with that of second student was to determine the Specific Heat Capacity of the same material of the body. Additionally, in part (b), they understood that the quantity of heat gained by a body when its temperature is raised from the temperature $\theta_{1}$ to the temperature $\theta_{2}$ is given by $\mathrm{Q}=\operatorname{mc}\left(\theta_{2}-\theta_{1}\right)$ whereby Q is quantity of heat, ' m ' is the mass, and $\theta_{1}$ and $\theta_{2}$ is the initial and final temperature. They then applied the formula to
calculate the mass (m) of the body and obtained the correct answer. Others from this group scored high marks but less than 5 as they answered part (a) correctly but miscalculated some portions of part (b). Extract 10.1 is a sample of good responses to Question 10.

| 10 | (b) Solution |
| :---: | :---: |
|  | Data analysis |
|  | Specific heat Caparity of Copeer ( C$)=390 \mathrm{~J} \mathrm{~kg}^{\circ} \mathrm{C}$ |
|  | Initial temperature of Copper $=15^{\circ} \mathrm{C}$ |
|  | Final temperature of copper $=60^{\circ} \mathrm{C}$ |
|  | Heat energy used $=80 \mathrm{~kJ}=80,000 \mathrm{~J}$ |
|  | $\therefore$ Task: Mass of Copper |
|  | from the formula, |
|  | $H=m c \theta$ |
|  | but $\theta=T_{1}-T_{2}$ |
|  | $\theta=60^{\circ} \mathrm{C}-15^{\circ} \mathrm{C}$ |
|  | $\theta=45^{\circ} \mathrm{C}$ |
|  | then; |
|  | $m=H$ |
|  | CO |
|  | $m=80,000 \mathrm{~J}$ |
|  | $390 \mathrm{~J} 1 \mathrm{~kg} \times \times 45^{\circ} \mathrm{C}$ |
|  | $m=80,0007 \times \mathrm{kg}$ |
|  | 1755078 |
|  | $m=4.56004 \ldots$ |
|  | $m \approx 4.56 \mathrm{~kg}$ |
|  | $\therefore$ The mass of copper is 4.56 kg |
|  | - l |

Extract 10.1: A sample of good responses to Question 10
In Extract 10.1, the candidate was able to remember the concepts of heat which involve the change of the temperature from $15^{\circ} \mathrm{C}$ to $60^{\circ} \mathrm{C}$, and therefore he/she substituted correctly the data to calculate the mass of copper in part (b). However, he/she was not able to give the difference of the activities carried out by the students as they dealt in the same material in part (a).

Some of the candidates 559 ( $38.8 \%$ ) who scored average marks, were able to answer part (a) correctly but in part (b), they just wrote the formula. Others answered only part (b) correctly, thus scored average marks. Analysis of
candidates' responses indicates that these candidates had partial knowledge with regard to the topic tested.

Some of the candidates who scored from 0 to 1 mark were able to answer correctly by defining either heat capacity or specific heat capacity of a body thus scored only 1 mark. The candidates who scored 0 mark were not able to differentiate between Heat Capacity and Specific Heat Capacity in part (a). They thus failed to state the difference between the activities carried out by the students on raising the temperature of the material by 1 K and on raising the temperature of a unit mass of the same material by 1 K . In addition, these candidates failed to apply the equation $\mathrm{Q}=\operatorname{mc}\left(\theta_{2}-\theta_{1}\right)$ to calculate mass of copper in part (b). The responses from this group of candidates shows that they lacked adequate knowledge and skill to tackle questions, which involves mathematical computation. Extract 10.1 is a sample of the poor responses to Question 10.


Extract 10.2: A sample of poor responses to Question 10

In Extract 10.2, the candidate could not differentiate the activity carried out by students to raise the temperature of a certain body by 1 K and of a unit mass of a body by 1 K in part (a). In part (b) he/she applied the wrong formula of heat to calculate the mass of copper.

### 2.3 SECTION C: Structured Questions

This section had four questions set from the topics of Electricity and magnetism, Periodic motion, Sound and Fluid mechanics. The candidates were required to answer three questions from this section; each question carried 15 marks to make a total of 45 marks. In this section, the scores were distributed in the following ranges: From 0 to 4.0 marks (weak), from 4.5 to 9.0 marks (average) and 9.5 to 15 marks (good).

### 2.2.11 Question 11: Electricity and Magnetism

This question was set from the topic Electricity and Magnetism. It intended to measure the candidates' competence in solving electrical problems in Engineering. The question was as follows:
(a) Show three ways in which the sensitivity of a moving-coil galvanometer can be increased.
(b) How do you place ammeters and voltmeters in a circuit?
(c) A voltmeter gives a full-scale deflection when the potential difference between its terminals is 1 V and its resistance is $400 \Omega$. How would you convert it to;
(i) give a full-scale deflection with a p.d of 10 V ?
(ii) work as an ammeter reading up to 250 mA ?

This question was attempted by 983 ( $68.2 \%$ ) candidates, of whom 453 $(46.1 \%)$ candidates scored from 0 to 4 marks; 271 ( $27.6 \%$ ) scored from 4.5 to 9.5 marks; and 259 ( $26.3 \%$ ) scored from 10 to 15 marks.

The candidates' performance in this question was average because 530 ( $53.9 \%$ ) candidates scored average and above. Figure 12 summarizes the candidates' performance in this question.


Figure 12: The Candidates' Performance in Question 11
Those who scored all the 15 marks were able to state three ways in which the sensitivity of a moving-coil galvanometer can be increased that is to increase the number of turns in a coil; through using stronger magnetics, and increase of the area of a coil. Additionally, in part (b), some of the candidates stated that, ammeter is always placed in series with load in the circuit while a voltmeter is always placed in parallel. In part (c) (i), they were able to convert the voltmeter, which read: 1 V to read up to 10 V . Furthermore, others explained that in order to achieve this conversion the resistor of high resistance ( $R_{m}$ ) which is a multiplier had to be connected in series with a coil of the original voltmeter. Additionally, they converted the voltmeter which was reading up to 1 V to an ammeter which read up to 250 mA of which some of them explained that; in order to make this conversion successful a resistor of low resistance ( $R_{s}$ ) called 'shunt' had to be connected in parallel with the coil of the original voltmeter. Their responses in part (c), reveal that some of these candidates accompanied their answer with a sketch giving notification that they were competent in the concept of shunt and multipliers. The candidates who scored good marks but less than 15 were able to answer the majority parts of the questions, but made a few errors that affected them from scoring all the 15 marks. Extract 11.1 is a sample of good responses of Question 11.

| 11.a) $\mathrm{Br}^{\text {by }}$ increasing the number at turns of the soil. |  |
| :---: | :---: |
| litby increasing the strength of the magnet. |  |
| iii) By increasing the crnss-sertional area of the coil |  |
|  |  |
| b) | -Ammetres ari sonnested in series with the cirsuit |
|  | $I$ (A) $\mathrm{MW}^{\text {I }}$ |
|  |  |
|  | - Voltmeters are connested in parallel with the circuit |
| (V) $\square$ |  |
| wn |  |
|  |  |
|  |  |
|  |  |
| c) | Solution |
|  | Data given. |
|  | $V_{g}=1 \mathrm{~V}$ |
|  | $R g=400 \Omega$ |
|  | From: $R_{m}=V-I R_{y}$ |
|  | $I$ |
|  | But $I=V$ |
|  | R. |
|  | $I=1 \mathrm{~V}$ |
|  | $400 \Omega$. |
|  | $I=2.5 \times 10^{-3} \mathrm{~A}$ |
|  | $\therefore R_{m}=10 \mathrm{~V}-2.5 \times 10^{-3} \mathrm{~A} \times 400 \Omega$ |
|  | $2.5 \times 10^{-3} \mathrm{~A}$ |
|  | $R_{m}=3600 \Omega$ |

Extract 11.1: A sample of good responses to Question 11

In Extract 11.1, the candidate correctly showed three ways in which the sensitivity of a moving-coil galvanometer can be increased in part (a). $\mathrm{He} /$ she managed to explain how the ammeter and voltameter are placed in a circuit in part (b). In addition, the candidate converted the $1 \mathrm{~V}, 400 \mathrm{Ohm}$ to give fullscale deflection with a p.d of 10 V in part (c) (i) and to work as an ammeter read up to 250 mA in part (c) (ii).

Therefore, 271 ( $27.6 \%$ ) candidates who got an average score were able to answer correctly some parts of the question. The analysis done in their responses shows that most of them answered partially part (b) and (c). Some answered part (a) and (b) correctly, but in part (c) they were only able to write a formula, thus ended up with average marks. Others were able to write formulae in part (c) (i) or (ii) and managed to calculate some of the
parameters correctly, thus scored between 4.5 and 9.5 marks. For example, one candidate only attempted part (c) as follows; Voltmeter conversion to ammeter operation for readings up to $250 \mathrm{~mA} . I_{m}=I_{T}-I_{V}$ and $I_{m}=\frac{V}{R}$, But $I_{v}=\frac{1 V}{400 \Omega} . \quad \mathrm{He} /$ she then manipulated and obtained $R_{m}=\frac{V_{v}}{I_{m}}=\frac{1}{0.2475}=4.04 \Omega$ and he/she concluded that The meter and the resistor shunt type will be connected in parallel. Therefore, the performance of this candidate in this question was average. From the candidates' responses it is revealed that they lacked sufficient knowledge and skills on how to position ammeters and voltmeters in a circuit in part (b) and to calculate the resistance of the multipliers and shunt resistor in part (c), as a result their answers led them into getting average marks.

However, the candidates who scored poor marks. Some of them scored 0 mark. These candidates were not able to answer correct any part, therefore they could not carry out any necessary substitutions of the given data. This suggests that these candidates did not acquire the necessary skills and competences in electricity, magnetism at large, and specifically on sensitivity of a moving-coil galvanometer and shunt and multiplier resistance as well. Further analysis on candidates' responses who suggests that there are some ( $24.1 \%$ ) who wrote a few responses because they had limited knowledge, which resulted in scoring below average. For example, some they failed to explain how they would convert the given voltmeter to work as an ammeter reading up to 250 mA . Extract 11.2 is a sample of poor responses to Question 11.

| 11. (ie) (a) (i) By rolling |  |
| :--- | :--- | :--- |
|  | (ii) By collecting to voltage |
|  | (iii) By collecting to circuit. |

Extract 11.2: A sample of poor responses to Question 11
Extract 11.2 shows that the candidate failed to give correct answers in all parts of the question. He/she was not able to explain how ammeter and voltmeter are placed in a circuit. Moreover, he/she failed to attempt part (c).

### 2.2.12 Question 12: Periodic Motion

The question was set from the topic Periodic Motion. It intended to measure the candidates' ability to solve numerical problems involving periodic motion. The question was as follows:
(a) A mass of 50 g hangs at the end of the spring. When 20 g is added to the end of the spring, it is stretched 7 cm more.
(i) Calculate the spring constant.
(ii) If 20 g is removed, what will be the period of the motion?
(b) A pendulum has a period of 2.0 seconds on the earth, what will be its period on the moon where acceleration due to gravity is six times smaller than that of the earth?

The question was attempted by 1128 (78.3\%) candidates, of whom 833 ( $73.8 \%$ ) scored from 0 to 4 marks; 223 ( $19.8 \%$ ) scored from 4.5 to 9.5 marks; and 72 ( $6.4 \%$ ) scored from 10 to 15 marks. The overall performance of this question was poor, since $73.8 \%$ of the candidates scored below average. Figure 13 summarizes the candidates' performance in this question.


Figure 13: The Candidates' Performance in Question 12
It was observed that, the candidates who scored 0 mark were not familiar with Periodic Motion. These candidates failed even to write the formula $\mathrm{F}=\mathrm{mg}$. This equation would have helped them to get the weight of a body hung on the spring. Also, the candidates failed to remember the formula $\mathrm{T}=2 \pi \sqrt{\frac{1}{\mathrm{~g}}}$ for calculating the Periodic Time (T). Therefore, they failed to calculate the spring constant and the period of the motion in part (a) (i) and (ii) respectively. They were also not able to calculate the period on the moon in part (b). These candidates lacked knowledge and skills in calculating parameters with regard to the topic of periodic motion. Others from this group managed only to write the formula, but totally made mistake in
substituting the data, thus they scored below the average. Extract 12.1 shows a sample of the poor responses.

| 12. | a). Solutions |
| :---: | :---: |
|  | f) Mass $=50 \mathrm{~g}$ |
|  | Mass $=20 \mathrm{~g}$ |
|  | elasticity $=7 \mathrm{~cm}$ |
|  | Task: Spring's constant? |
|  | $\therefore$ Change masses to force |
|  | $\because \$ 1 \mathrm{~kg}=1000 \mathrm{~g}$ |
|  | ? $\times 50 \mathrm{~g}$ |
|  | Khaspg $=0.05 \mathrm{~kg}=0.005 \mathrm{~N}$. |
|  | $100 \phi y$ |
|  | $\mathrm{lkg}=1000 \mathrm{~g}$ |
|  | $? \times 20 \mathrm{~g} \quad \mathrm{~kg} \times 26 \mathrm{~g}=0.02 \mathrm{~kg}=0.002 \mathrm{~N}$ |
|  | $100 \%$ g |
|  | $\therefore F_{\text {net }}=0.005 \mathrm{~N}+0.002 \mathrm{~N}$ |
|  | $=0.007 \mathrm{~N}$. |
|  |  |
|  | 1. $e=k f$ |
|  | $7 \mathrm{~cm}=k \times 0.007$ |
|  | $\therefore 7 \mathrm{~cm}=0.07 \mathrm{k}$ |
|  | 0.0070 .807 |
|  | $k=7$ |
|  | 0.007 |
|  | $\because K=100 \mathrm{~cm}$ |
|  | $\therefore$ The constant of the spring is 100 cm |

Extract 12.1: A sample of poor responses to Question 12

Extract 12.1 shows that, the candidate failed to calculate spring constant, period of motion and the period on the moon instead he/she wrote irrelevant solution as a result he/she scored 0 .

The 223 (19.8\%) candidates who had average performance were able to write correctly the formula in part (a) and (b) but made some mistakes in calculating various parameters. For example, one candidate was able to write all the formulae needed in part (a) and (b), but he/she could not convert the mass from grams to kilograms, therefore he/she got incorrect
answer. Other candidates could not use the relationship of gravity due to acceleration of the earth compared to that of the moon, which is 6 times that of the earth.

However, the candidates who scored all 15 marks demonstrated an excellent comprehension of knowledge and skills of the periodic motion. They applied correctly the formula $\mathrm{F}=\mathrm{mg}$ to calculate the force acting on the spring. Additionally, they applied the formula $\mathrm{F}=\mathrm{ke}$ to calculate the spring constant ( k . Likewise, they knew that the acceleration due to gravity at the moon $\left(\mathrm{g}_{\mathrm{m}}\right)$ is given by $g_{m}=\frac{1}{6} \times g_{e}$. Moreover, they managed to apply appropriately the equation of periodic time (T) which is $T=2 \pi \sqrt{\frac{1}{g}}$ to calculate the period on the moon. Those with high scores but less that 15 marks managed to remember all prerequisite information including formulae for calculating the spring constant (k) and periodic time ( T ) but made a few mistakes such as skipping some crucial steps or calculations. Extract 12.2 is an example of a good response to this question.



Extract 12.2: A sample of good responses to Question 12

Extract 12.2 shows the candidate who was able to apply correct formulae and calculated the spring constant in part (a)(i), period of the motion in part (a)(ii) and the period on the moon in part (c).

### 2.2.13 Question 13: Sound

This question was composed from the topic Sound. It intended to measure the candidates' competence in applying the basic concepts of sound in solving sound problem on reverberation and echo. The question was as follows:
(a) A sound note of 100 vibrations per second is reflected back to an observer from a wall 34 m away in 0.2 s . With the aid of sketch, determine the sound note.
(b) A person standing 99 m from the foot of a tall cliff claps his hands and hears an echo $0.6 s$ later. With the aid of sketch, determine the velocity at the instance.
(c) A student shouted while standing between two vertical cliff 480 m from the nearest cliff. She heard the first echo after $3 s$ and the second $2 s$ later. With the aid of sketch, compute the following:
(i) Velocity of sound in air.
(ii) Distance between the cliffs.

The analysis shows that 1223 (84.9\%) candidates attempted this question whereby 409 ( $33.4 \%$ ) candidates scored from 0 to 4 marks; 365 ( $29.9 \%$ ) scored from 4.5 to 9.5 marks; and 449 ( $36.7 \%$ ) scored from 10 to 15 marks. The analysis of candidates' scores is summarized in Figure 14.


Figure 14: The Candidates' Performance in Question 1

This was one of well-performed questions, since 66.6 percent scored average and above. The candidates who scored all the 15 marks understood that when a sound is reflected from a wall, the distance (s) traveled by the sound to the wall and back to the observer is twice the distance between the observer and the wall. Therefore, they drew relevant sketches to illustrate this concept. They also established the formula $v=\frac{2 d}{t}$ and managed to calculate the velocity of sound in air in part (b). in part (a), they managed to compute the velocity of sound in air and the distance between the cliffs. From their responses, it seemed that the candidates were familiar with the applications of echo and had the capability to calculate distances using the formula $S=\frac{v t}{2}$. Further analysis shows that there were candidates who got high but not all 15 marks. These candidates were able to answer most parts of the question correctly but made some mistakes. For example, one candidate made mistake of calculating total time taken to hear the first echo as he/she used the formula $t_{1}=\frac{d_{1}}{v}$ instead of $t_{1}=\frac{2 d_{1}}{v}$, therefore, obtained wrong response. Others failed to draw sketches, resulting in missing some marks allotted thus avoiding them from getting all the 15 marks. Extract 13.1 is a sample of the candidate's responses who performed well in this question.



Extract 13.1: A sample of good responses to Question 13

Extract 13.1 is the correct response shown by a candidate. $\mathrm{He} /$ she drew a good sketch and then established the formulae, which was used to compute the sound note in (a), the velocity of sound in air in part (b) and the Distance between the cliffs in part (c).

Most of the candidates who performed averagely 365 (29.9\%), skipped some parts of the question. However, for the parts which were answered correctly shows that, the candidates understood that, the total distance traveled for one echo is twice the distance from the observer to the cliff that is, $s=2 \mathrm{~d}$. They wrote the formula to calculate the total time taken for an echo ' $t$ '. They were also able to define ' $t$ ' as equal to time taken to hear the first echo and ' $t_{2}$ ' as time taken to hear the second echo. Therefore, they obtained the total time that was used to find the velocity of sound in air in part (a). In part (b), the candidates were able to calculate the distance between cliffs by using a formula $d_{2}=\frac{\mathrm{vx} \mathrm{t}}{2}$ to get the distance ' $\mathrm{d}_{2}$ '; They summed up ' $\mathrm{d}_{1}$ '; +' $\mathrm{d}_{2}$ '; to get the total distance between the cliffs.

The candidates 409 ( $33.4 \%$ ) who scored 4 marks or less, lacked sufficient knowledge on the topic of sound. They were not able to calculate the velocity of sound in air and the distance between the cliffs as they failed to remember the formula. Others remembered the formula for velocity, but could not remember the concept of the distance traveled by an echo which is twice the distance from the observer. Extract 13.2 shows a poor response from one of the candidates.

| 18 | ll Dillan. blues L-lll |
| :---: | :---: |
|  | fles $v=$ 91 73 |
|  | 3 |
|  | $=3$ |
|  |  |
|  |  |
|  |  |
| 12 | 11) Nuk - 7/d |
|  | - 5 |
| . | $l=800 \mathrm{~m}$ |
|  |  |
|  | Dlllone b-lwwn |
|  |  |
|  |  |
|  |  |
|  | (b) $9 / 0 \mathrm{l}=94 \mathrm{~N}$ |
|  |  |
|  |  |
|  | $\operatorname{Cos} v=11$ |
|  | $\frac{2 \times 44}{0-6}$ |
|  |  |
|  | $C=3>\mathrm{m} / \mathrm{s}$ |
|  | Dhe volcec 1/ 33 |
|  | Mo valume ls 33 |

Extract 13.2: A sample of poor responses to Question 13

In Extract 13.2, the candidate was not able to determine the sound note in part (a). He /she also failed to determine the velocity of sound in air and distance between the cliffs in part (c).

### 2.2.14 Question 14: Fluid Mechanics

This equation was set form the topic Fluid Mechanics. It intended to measure candidates' competence in applying the basic concepts of fluid mechanics to solve problems with respect to body floating on fluids. The equation was:
(a) A piece of cork of $100 \mathrm{~cm}^{3}$ is floating on water of density $1 \mathrm{~g} / \mathrm{cm}^{3}$. If the density of cork is $0.25 \mathrm{~g} / \mathrm{cm}^{3}$; what force (in newton's) would be needed to immerse the cork completely?
(b) A balloon has a volume of $10 \mathrm{~cm}^{3}$ on the ground and the fabric of the balloon weighs 80 N . Suppose it is filled with hydrogen of density 0.09 $\mathrm{kg} / \mathrm{m}^{3}$, and the air density is $1.2 \mathrm{~g} / \mathrm{cm}^{3}$; Estimate the maximum weight additional to that of the hydrogen and fabric which the balloon can lift.

The question was attempted by 988 ( $68.6 \%$ ) candidates, of whom 589 ( $59.6 \%$ ) scored from 0 to 4 marks; 294 ( $29.8 \%$ ) scored from 4.5 to 9.5 marks; and 105 ( $10.6 \%$ ) scored from 10 to 15 marks. The overall performance in this question was average, because 40.4 percent of the candidates scored average and above. Figure 15 summarizes the candidates' performance on this question.


Figure 15: The Candidates' Performance in Question 14

The candidates who scored 0 mark lacked adequate knowledge on the density, Archimedes' Principle and Law of Floatation as well. These candidates did not understand that the formula of density ' $\eta=\frac{m}{v}$, could have helped them to calculate the mass of a cork in part (a). Furthermore, the law and principle could have helped them to determine the weight of water displaced (upthrust) and could use it to calculate the volume of cork immersed in the water, which in turn they could have applied to calculate the density of water displaced. The density obtained could be used to calculate the weight of water displaced, thus this weight is equal to the force needed to immerse the cork completely. In part (b), the candidates failed to estimate the maximum weight that needed to be added to the hydrogen and fabric so that the balloon could rise. They did not know that upthrust due to air on the balloon is equal to the weight of air displaced. Furthermore, they
did not know that, this weight is equal to a product of mass and acceleration due to gravity, whereas mass can be obtained from the density formula. Extract 14.1 is an example of poor answers to this question.

| 184 | e) Data given |
| :---: | :---: |
|  | Corlc $100 \mathrm{~cm}^{3}$ |
|  | Nensity $1 \mathrm{~g} / \mathrm{cm}^{3}$ |
|  | Density of eouk $0.25 \mathrm{~g} / \mathrm{cm}^{3}$ |
|  |  |
|  |  |
|  | b) Data given |
|  |  |
|  | Volume 10 cm |
|  | Weight 80 M |
|  | 1 ensity $0.091 \mathrm{cy} / \mathrm{m}^{3}$ |
|  | Density $1.2 \mathrm{~g} / \mathrm{cm}^{3}$ |
|  | Soution |
|  |  |
|  | $=30 \mathrm{~N} \times 10 \mathrm{~cm}$ |
|  | $0.09 \mathrm{ky} / \mathrm{mi}^{3}$ |
|  |  |
|  | 300 N |
|  | 0.09 |
|  |  |
|  | 60 N |

Extract 14.1: A sample of poor responses to Question 14

In Extract 14.1, the candidate was not able to calculate the force that would immerse the cork completely in part (a). $\mathrm{He} /$ she also failed to estimate the maximum additional weight to that of the hydrogen and fabric, which the balloon can lift.

Other candidates who scored from 0.5 to 4 marks lacked adequate knowledge and skills in answering this question, as some of them wrote only the density formula and skipped other parts. Some wrote the correct formula and did some few steps in the calculations.

The candidates who scored average marks were able to use the correct formula in some parts of their calculations.

The good responses provided by the candidates who scored all the 15 marks were unveiled by their correctness of the calculations performed. These candidates applied well the Law of Flotation and Archimedes' Principle in performing calculations in part (a) and (b). They knew that, from the Archimedes' Principle, when a body is totally or partially immersed in a fluid the weight of the fluid displaced is equal to the up-thrust acting on the body. They also knew that, from the Law of Flotation, when a body floats in a fluid the weight of the fluid displaced is equal to the weight of the body immersed and is equal to weight of the up-thrust on the body. Having known how to application the above law and principle, the candidates computed the force needed to immerse the cork completely. In addition, these candidates were able to apply the above laws/principle to estimate the maximum additional weight to weight of hydrogen and the fabric which the balloon can lift. The candidates who scored high marks but less than 15 marks were able to perform some calculation as employing the stated principle and the law. They also had the knowledge and skills to calculate the force that would be needed to just immerse the cork completely and maximum additional weight lifted in part (a) and (b) respectively. Inability to manipulate all steps of calculation noted was the main challenge for these candidates. Therefore, this group of candidates inaccurately calculated the force in part (a) and weight lifted in part (b). Extract 14.2 shows a sample of good responses by one of the candidates.

| 16. | (a) Dafa |
| :---: | :---: |
|  | $V_{c}=100 \mathrm{~cm}^{3}$ |
|  | $f_{c}=1 \mathrm{~s} / \mathrm{cm}^{7}$ |
|  | $f_{c}=0.25$ |
|  | Tagk = Tho force formmane the cosk |
|  | Po7n |
|  | Prom $f=\mathrm{ms}$ |
|  | $p=\rho V s$ |
|  | $f_{w}=(1 \times 100) \times 5$ |
|  | 1000 |
|  | $f_{\text {c }}=0.1 \times 10$ |
|  | $\mathrm{fux}^{\text {f }}=1.0 \mathrm{~N}$ |
|  |  |
|  | $f_{e}=(0.25 \times 100) \times 10$ |
|  | 1000 |
|  | $f_{c}=25 \times 10$ |
|  | 1000 |
|  | $F_{C}=0.25 \mathrm{~N}$ |
|  | $\Delta f=A_{c}-f c$ |
|  | $\Delta f=(1-0.25) N$ |
|  | $\Delta f=0.75 \mathrm{~N}$ |
|  | $\therefore$ The force requit eat to immerse ine cork - |
|  | completely is 0.75 N . |
|  | (b) $\triangle a+a$ |
|  | $V_{6}=10 \mathrm{~cm}^{3}$ |
|  | $m_{p_{6}}=80{ }^{\prime}$ |
|  | $\mathrm{f}_{\mathrm{h}}=0.09 \mathrm{ks} / \mathrm{m}^{3}$ |
|  | fair $=1.2 \mathrm{~s} / \mathrm{cm}^{3}$ |
|  | (b) Task. addeliona) wersh). |
|  | $\mathrm{PO}^{\prime} \mathrm{n}$ |
|  | $W_{W_{r}}=80 \mathrm{~N}+\mathrm{Sh}_{3} \times \mathrm{s}$ |
|  | $=80 \mathrm{~N}+0.09 \times 10 \mathrm{~cm}^{3} \times 10$ |
|  | but $1 \mathrm{~m}=100 \mathrm{~cm}$ |
|  | $\therefore \triangle \mathrm{m}^{3}=10^{-2} \mathrm{~m}^{3}$ |
|  |  |
|  | $\omega_{1}=800 \sim 0.09 \times 10 \times 10^{-6} \times 10$ |
|  | $\omega_{6}=80 \mathrm{~N}+100 \times 0.09 \times 10^{-8}$ |
|  | $\omega \mathrm{h}=80 \mathrm{~N}+9 \times 10^{-6} \mathrm{~N}$ |
|  | $\omega b=80 \mathrm{~N}+0.000009 \mathrm{~N}$ |
|  | Lb $=80.000009 \mathrm{~N}$ |
|  |  |
|  | $W_{\text {arer }}=\operatorname{four}^{\text {ar }} \times V \times 5$ |
|  | $=12000 \times 10 \times 10^{-2} \times 10$ |
|  | $=1.2 \times 10^{4} \times 10^{4} \times 10^{-1}$ |
|  | $=0.12$ |
|  | $\Delta f=80.000009$ |
|  | - 0.12 |
|  | $=79.880009 \mathrm{~N}$ |
|  | $\therefore$ The $m$ aximum actutional wasbl to lhat o7- |
|  | hydrogen ond fabric which ine bollon canlizis ... |
|  | 79.880009 N . |

Extract 14.2: A sample of good responses to Question 14
Extract 14.2 shows the work of the candidate who was able to calculate the force that would immerse the cork completely in water.

### 3.0 THE CANDIDATES' PERFORMANCE ANALYSIS IN EACH TOPIC

The analysis of performance in the topics tested in the Engineering Science subject for the year 2022 indicates that, the candidates performed well in four (4) topics, average in three (3) topics, and poor in three (3) topics.

The candidates demonstrated good performance in the topic of Light-Optics (89.1\%); Strength of Materials, Work, Energy and Power, Projectile Motion, Heat, Simple Machine, Linear Motion, Periodic Motion, Angular Motion, Measurement, Electricity and Magnetism and Fluid Mechanics, which were tested in multiple choice question (75.9\%); Heat (75.6\%); Angular Motion (70.8\%) and Sound (66.6\%).

The topics in which the candidates performed averagely were Measurement, (60.5\%); Electricity and Magnetism (43.9\%) and Fluid Mechanics (40.4\%).

The topics in which the candidates performed poorly were Periodic Motion (29.9\%); Linear Motion (20.9\%) and Simple Machine (8.5\%).

### 4.0 CONCLUSION AND RECOMMENDATIONS

### 4.1 Conclusion

The performance of the candidates on the Certificate of Secondary Education Examination (CSEE) in Engineering Science subject was good. Despite having a good performance, the candidates encountered some challenges in answering various questions in Engineering Science subject. These challenges included; lack of adequate knowledge on the concepts in responding to some of the questions, lack of sketching and computational skills particularly in the topics of Simple Machines, Linear Motion, and Periodic Motion, which were poorly performed. Another weakness observed was some candidates' failure to understand the requirements of the questions.

### 4.2 Recommendations

Based on the finding from the analysed data; the following are therefore recommended:
(a) Recommendations to Students

Students should do more exercises on application of formulae on concepts related to conservation of momentum in Linear Motion, Periodic Motion and Simple Machines topics observed to have poor performance.
(b) Recommendations to Teachers
(i) Teachers should guide students on identifying different application of belt, gear and chain drives and how to differentiate their uses and solve problems based on these simple machines.
(ii) Teachers should guide students on doing more practice on how to place ammeter in series and voltmeter in parallel as a means of getting them to remember the way ammeters and voltmeters are placed in a circuit.

Appendix: A Summary of Candidates' Performance Question-Wise in 2022

| S/N | Topic | Performance For Each Topic |  | Remarks |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Question Number | Percentage of Students who Scored 30\% or More |  |
| 1. | Light (Optical) | 4 | 89.1 | Good |
| 2. | Strength of the materials, Work, Energy and Power, Projectile Motion, Heat, Sound, Simple Machines, Linear Motion, Periodic Motion, Angular Motion, Light, Measurements, Electricity and Magnetism and Fluid Mechanics | 1 | 75.9 | Good |
| 3 | Heat | 10 | 75.6 | Good |
| 4 | Angular Motion | 5 | 70.8 | Good |
| 5 | Sound | 13 | 66.6 | Good |
| 6 | Measurements | 7 | 60.5 | Average |
| 8 | Electricity and Magnetism | 8 \& 11 | 43.9 | Average |
| 9 | Fluid Mechanics | 14 | 40.4 | Average |
| 10 | Periodic Motion | 2 \& 12 | 29.9 | Weak |
| 11 | Linear Motion | 9 | 20.9 | Weak |
| 12 | Simple Machines | 3 \& 6 | 8.6 | Weak |

