THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2023

ENGINEERING SCIENCE

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT ON THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2023

035 ENGINEERING SCIENCE

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

Table of Contents

FOREWORD

The National Examination Council of Tanzania (NECTA) is pleased to issue this Candidates' Item Response Analysis Report (CIRA) on the Engineering Science subject for the Certificate of Secondary Education Examinations (CSEE), 2023. The aim of the report is to provide feedback to educational stakeholders regarding candidates' performance and the challenges they encountered while attempting the examination questions.

The Certificate of Secondary Education Examination (CSEE) is a summative evaluation designed to monitor learning progress and provide feedback to educators and other stakeholders to enhance teaching and learning methodologies.

The presented analysis aims to give feedback on possible reasons for candidates' performance in the Engineering Science subject. The report highlights the factors that significantly affected the candidates' performance in some questions. These factors include ability to identify the task of the questions, follow instructions and grasp the concepts related to the subject matter. On the contrary, the analysis reveals that candidates with weak performance faced various challenges in answering the questions. Some of these challenges include; inadequate knowledge and skills to visualize and understand relationships among objects, inability to comprehend and apply mechanical concepts, inadequate knowledge to analyze and solve mathematical problems especially those related to measurements, calculations, and conversions and poor drawing skills.

The National Examinations Council of Tanzania (NECTA) expects all education stakeholders to use the feedback and recommendations provided in this report to improve teaching, learning and candidates' performance in future examinations.

The Council would like to express its gratitude for the valuable input of all people who contributed to the preparation of this report.

Dr. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report narrates the candidates' performance on Certificate of Secondary Education Examination (CSEE) in engineering science subject conducted in November 2023. The examination was set based on the examination format. The report focuses on how the candidates performed on each question and identifies the questions which were well, averagely and poorly performed.

The Engineering Science examination consisted of eleven (11) questions divided into three (3) sections, A, B and C. Section A had two (2) questions, with a total of sixteen (16) marks. Question 1 had ten multiple-choice items each carrying (1) mark. These items were constructed from ten topics such as *Properties of Matter, Basic Electronics, Simple Machines, Electricity and Magnetism, Fluid Mechanics, Optics (Light), Sound wave, Heat, Measuring Instruments* and *Solar Energy and Energy Source.* Question 2 had six (6) homogeneous matching items which were set from the topics of *Linear Motion.*

Section C consisted of three (3) structured questions each carrying fifteen marks (15). The topics which were examined are *Sound wave, Optics (Light)* and *Turning Forces*. The candidates were required to answer all questions in section A and B and two (2) questions from section C.

The report evaluates the performance of candidates in each question. The performance is classified to weak, average, or good based on the percentage of candidates who scored 30% and above. Specifically, if the percentage of candidates who scored 0 to 29%, 30 to 64% and 65 to 100% respectively the colours red, yellow and green represent poor, average and good performance. The report includes extracts of samples of candidates 'responses to represent good and weak cases. However, graphs and charts have been used to summarize the candidates' performance on each question. Finally, the report includes an appendix that shows the overall performance of candidates for each question.

A total of 1574 candidates sat for the Engineering Science Examination in the year 2023, out of which 1181(75.03 %) passed well and 393(24.97%) failed. This represents an improvement of 0.43% compared to the year 2022 where 1075 (74.6%) passed and 366 (25.4%) failed.

Figure 1 demonstrates the students' performance in grades for two consecutive years 2022 and 2023.

The analysis of the examination results includes the requirements for each question as well as the strengths and weakness of the candidates' responses. The distribution of scores is represented using graphs, and the report concludes with recommendations for improvement.

The analysis of examination results includes an evaluation of each question's requirements and an assessment of candidate responses' strengths and weaknesses.

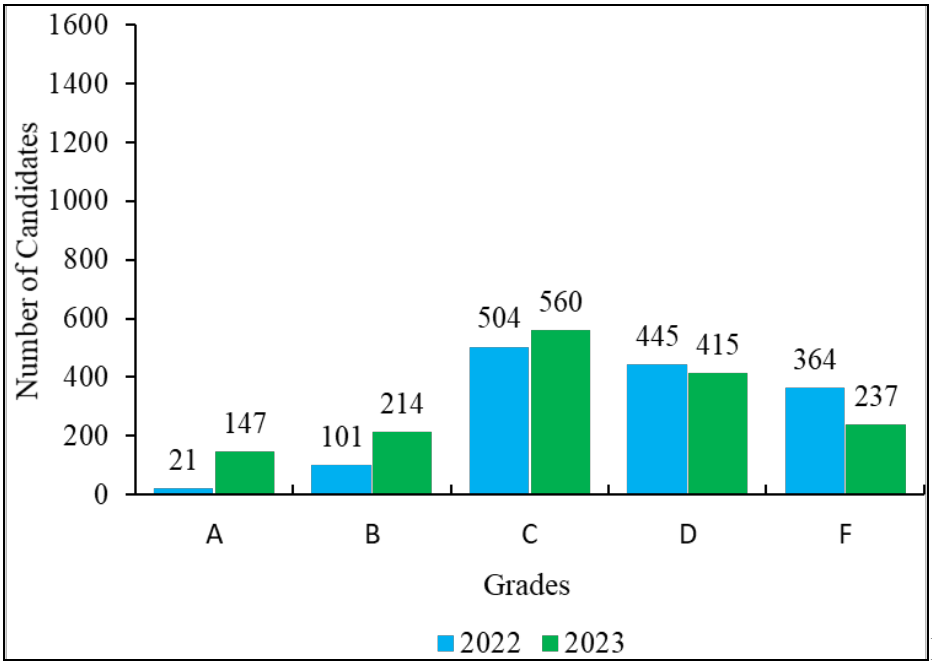


Figure 1: *Comparison of Candidates' Performance in 2022 and 2023*

2.0 ANALYSIS OF THE CANDIDATES' RESPONSES IN EACH QUESTION

The report provides an over view of the candidates' performance on each question. The analysis includes the types of questions, the topics from which they were created, their requirements, and the candidates' performance on each question.

2.1 Section A: Objective Questions

Section A consisted of two (2) questions. The first question was multiple-choice and consisted of ten (10) items; each item carrying one (1) mark. The second question was matching items and consisted of six (6) items, each item carrying one (1) mark. Therefore, the total marks for this section was sixteen (16).

2.1.1 Question 1: Multiple Choice Items

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

A total of 1574 candidates attempted the question. The analysis indicates that, 151 (9.59%) candidates scored from 0 to 2 marks, 959 (60.93%) candidates scored from 3 to 6 marks while 464 (29.48%) candidates scored from 7 to 10 marks. The majority of the candidates 1423 (90.41%) scored from 3 to 10 marks. Figure 2 shows candidates' performance in this question.

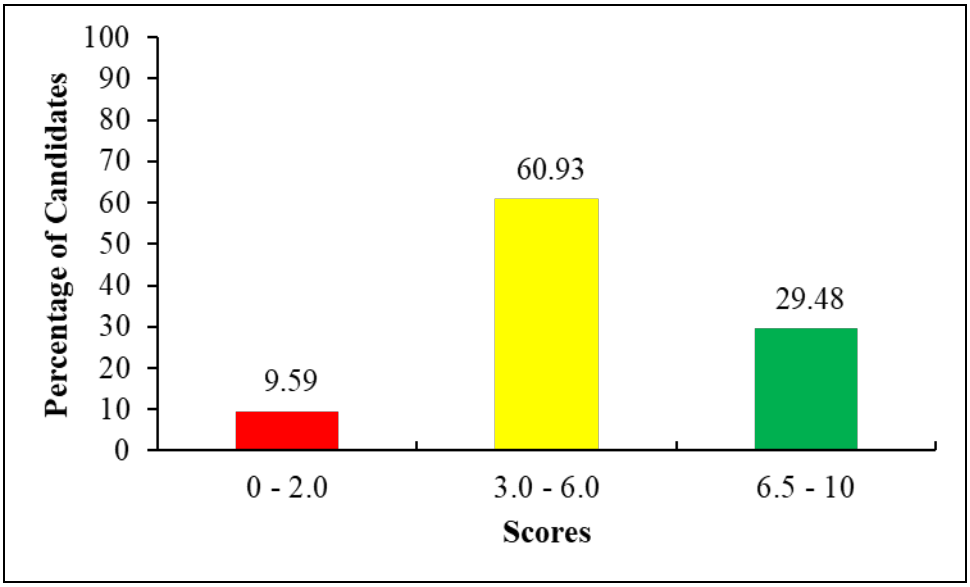


Figure 2: *The Candidates' Performance in Question 1*

According to the data presented in Figure 2 it is inferred that only 464 candidates (29.48%) scored good marks. Upon further analysis, it was discovered that the majority of candidates answered item (iii) correctly.

The item was related to the concept of given topics and measured the candidates' knowledge of understanding Measuring Instruments, Friction, Fluid Mechanics, Work, Energy and Power, Simple Machines, Turning Effect of a Force, Linear Motion, Heat (Part two) and Optics (Light). The results show the most candidates had adequate knowledge and were able to apply the skills of simple machine and heat for items (i), (v), (vi) were moderately correctly indicating knowledge in the relevant topics.

However, the item in which most of the candidates' selected wrong alternative was item (ix). The analysis of the candidates' responses for each item is presented as follows:

The question under item (i) was set from the topic of *structure and properties of matter.* The item was designed to test candidates' ability to describe real-life properties of matter. The question asked was:

Which property of liquid makes the surface of the liquid to behave like a fully stretched skin which in turn allows some small insects like bees to walk on it?

A *Elasticity* B *Plasticity* C *Surface tension*
D *Diffusion* E *Capillarity*

The correct answer was alternative C. *Surface Tension.* The majority of candidates chose option C. These candidates understood that surface tension results from the greater attraction of liquid molecules to each other (due to cohesion). Therefore, they were able to differentiate the terms surface tension from other distractors. However, some candidates chose other alternatives, A, B, D, and E, because they lacked proper concepts related to the properties of matter. Those who selected A *Elasticity* and B *Plasticity* were wrong because most solid materials exhibit elastic and plastic behavior and the statement of the question is about the property of the surface of liquid. Elasticity is the ability of a deformed material body to return to its original shape and size while plasticity is the quality of material to be easily shaped or moulded. Those who selected D *Diffusion* and E *Capillarity* were wrong because these two terms do not reflect the demand of the question. Diffusion is the net movement of molecules from an area of greater concentration to an area of lesser concentration and capillarity is the rise or depression of a liquid in a small passage such as a tube of small cross-sectional area.

Item (ii) was composed from the topic of *Electricity*, to test candidate's competency to identify and analyses the material with impurities which do not affect electrical behavior. The question was:

Identify the material with impurities which do not significantly affect its electrical behavior.

A *Extrinsic semiconductor* *B Intrinsic semiconductor*
C *N-type semiconductor* *D P-type semiconductor*
E Metal semiconductor

The correct answer was alternative B Intrinsic semiconductor. Only few candidates chose this response. These candidates understood that intrinsic semi-conductors possess pure semiconductor crystal that do not

affect its electrical behavior and they are knowledgeable that extrinsic semiconductor (N-type and P-type semiconductors) is one that has been doped during manufacture, for the purpose of giving it different electrical properties. Candidates who chose alternatives C, D, and E had inadequate knowledge on semiconductors with respect to electrical behavior.

Item (iii) was designed to assess the candidate's ability to identify the class of levers and corresponding examples of tools, based on the topic of *Simple Machines*. The question was:

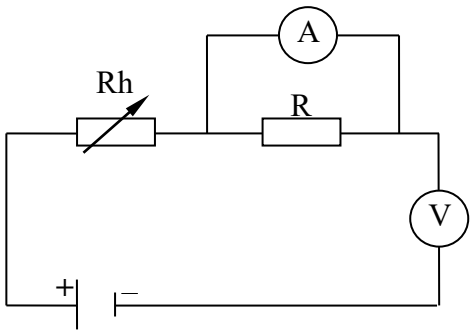
A teacher provided tools namely, shovel, nutcracker, wheelbarrow and scissor. Identify the tools which are in second class of lever.

A *Shovel and Wheelbarrow* B *Shovel and Scissor*
C *Wheelbarrow and Scissor* D *Nutcracker and Wheelbarrow*
E *Nutcracker and shovel*

The correct answer was alternative D. *Nutcracker and Wheelbarrow*. Majority of candidates chose alternative D, because they had an adequate knowledge that nutcracker and wheelbarrow falls on the second type of lever where the load is in the middle between the fulcrum and the effort. They understood that there are three types of levers named; (i) First class lever – the fulcrum is in the middle of the effort and the load. (ii) Second class lever – the load is in the middle between the fulcrum and the effort. (iii) Third class lever – the effort is in the middle between the fulcrum and the load. Some few candidates chose alternative A. *Shovel and Wheelbarrow*. They were wrong because shovel is in first class lever and Wheelbarrow is in second class lever. Also, those who chose alternatives B. *Shovel and Scissors* were wrong because both tools fall in class one lever. Those who chose alternative C, and E, were wrong because the named tools fall in second and first class lever respectively,

Item (iv) was set from the topic of '*Electricity*'. It intended to test candidates' competence on the proper ways to connect electrical appliances, which are ammeter and voltmeter in the circuit. The question was:

A candidate wanted to measure the resistance 'R' of a hair drier, unfortunately, she wrongly arranged the circuit as shown in the figure below. For the circuit to work correctly, what modification should be done?



A *Interchange the Rheostat and Resistor*
B Remove the Ammeter
C Move the Rheostat near the voltmeter
D Make the value of the Rheostat large
E Interchanging the Ammeter and voltmeter

The correct answer was alternative E. *Interchanging the Ammeter and Voltmeter*. Majority of the candidates, who chose option, E, had proper knowledge related to the types of connections involved when dealing with ammeter and voltmeter in the circuit. Moreover, ammeter should be connected in series along with an electrical component while voltmeter should be connected in parallel (across the terminals) for the electrical component to be measured. Some candidates chose incorrect alternatives A, B, C, and D. These candidates had no skills on the concepts related to connection of electrical components in the circuit.

Item (v) was generated from the topic '*Fluid Mechanics'*. It intended to measure candidates' ability to analyze the conditions/reasons/factors which contributed to sinking and floating of objects into the water and competence in applying the law of floatation in real life problems. The question was:

A class teacher and candidates witnessed a huge floating ship on sea water when they were offshore but a small iron nail sunk into the water. Teacher asked candidates why iron nail sunk while the huge ship floated. The candidates' responses were as follows:

(i) The density of the steel ball is greater than the average density of the ship
(ii) The density of the steel ball is less than the average density of the ship
(iii) The ship is hollow and contains air which minimizes its average density
(iv) The ship has a large volume and displaces a lot of water equal to its own weight
(v) The ship is also made of some wood and plastic materials

Whose responses were correct?
A (i), (ii) and (iii) *B (i), (ii) and (iv)* *C (i), (ii) and (v)*
D (i), (iii) and (iv) *E (ii), (iii) and (iv)*

The correct response was alternative D. *(i), (iii) and (iv).* Candidates who chose the correct alternative understood that the density of nail is much greater than the water. So it sinks easily and the density of the water displaced by the ship is equal to its weight, so it floats. However, other candidates who chose alternatives A, B, C, and E lacked proper concepts related to the law of floatation which states that *when a body floats in a liquid, the weight of the liquid displaced by its immersed part is equal to the total weight of the body*. Alternative A, B, C and E are not correct because the statement; *the density of the steel ball is less than the average density of the ship* contradicts with the root of the question.

Item (vi) was composed from the topic '*Optics (Light)*. It aimed to measure candidates' competency in analyzing the effects of coloured light onto a white screen as well as the colour filtering techniques. The question was:

When a candidate viewed a white sheet of paper through a piece of blue glass, the paper looked blue. Why is it so?
A A colour of the glass is reflected onto the paper
B The blue light is absorbed by the glass
C The blue light travels faster through the glass
D The glass absorbs all the colours except blue
E The glass adds blue light to the light coming from the paper

The correct answer was alternative D. *The glass absorbs all the colours except blue.* Those candidates who chose this option were succeeded to develop good competency on the concepts covered in the topic of optics. These candidates had adequate knowledge and understood that when a white screen consists of seven colours including blue, and the blue glass should allow the blue light, colour to pass through it, while white absorbing all other colours.

Some of the candidates who chose alternatives A and E had misconceptions on the areas related to reflection of light and addition of colours of white light. Other candidates chose incorrect options B and C, lacked proper concepts related to the reflection of light, addition of the colours of white light, appearance of coloured object under white light and appearance of white object under coloured light.

Item (vii) was extracted from the topic of '*Sound Wave'*. It intended to measure candidates' ability to identify sound parameters and to suggest ways to modify the quality of sound produced from a guitar. The question was:

A man was teaching his daughter to play guitar but frequency of the sound wave emitted from a guitar string was low. How would he increase the frequency of the guitar?

A By increasing the vibrating length
B By plucking the string harder
C By tightening the string
D By using a thicker string
E *By using thinner string*

The correct answer was alternative C, *by tightening the string*. The candidates who chose correct alternative were able to master the concepts related to sound waves. These candidates had competence in analysis that the frequency of the sound wave from a string is proportional to the tension exerted to the string. Tightening the string increases the tension in it, and hence increasing the frequency of sound produced.

Some candidates who chose incorrect alternative E, which *'By using thinner string'* failed to analyze that a thinner string produce high frequency sound than a thicker string only if they are made of same lengths, same material (density) and under same tension. Other candidates who chose other alternatives A, B, and D, had inadequate knowledge on the concepts related to sound wave parameters.

Item (viii) was set from the topic of *Heat.* It intended to measure candidates' competence in describing ways or methods through which heat get transferred between ends of materials. The question was:
A candidate placed one end of a piece of metal in a Bunsen burner flame and it became hot. Immediately after that, the other end became hot as well. Which process is described from this section?

A Induction	*B Insulation*	*C Radiation*
D Conduction	*E Convection*	

The correct response for this item was alternative D. *Conduction*. The candidates who chose the correct responses were able to describe the ways through which heat is transferred in solid matters such as a piece of metal being heated from one end and making the other end hot.

There were some candidates who chose incorrect alternative E, which was convection. These candidates failed to understood that a piece of metal was finally in physical contact with the flame and hence, conduction process to be involved rather than convection in which heat is transferred by movement of a heated fluid such as air or water.

Some candidates who chose incorrect alternatives A, B, and C had lack proper knowledge on the concepts related to methods of heat transfer in metal because induction is the process by which electricity or magnetism is passed between two objects or circuits without them touching each other, insulation is the act of protecting something by surrounding it with material that reduces or prevents the transmission of sound or heat or electricity and radiation is the energy that comes from a source and travels through space at the speed of light.

Item (ix) was set from the topic *Measuring Instruments*. It stipulated to measure candidates 'competence of using measuring instruments when measuring lengths of an objects. The question was as follows:
If you are asked to take measurement for small lengths with a great degree of accuracy, which tool would you employ?

A Meter rule *B Tape measure*
C Vernier caliper *D Vernier height gauge*
E *Micrometer screw gauge*

The correct answer for this item was alternative E. *Micrometer screw gauge*. Only few candidates, who chose this option, were able to identify the accuracy of the tape measure (1cm), meter rule (1mm), Vernier caliper (0.01cm) and Micrometer screw gauge (0.01mm). Also, they had adequate knowledge about accuracy of instruments since they understood that the greater degree of accuracy corresponds to the smallest unit which instrument can manage to measure.

Majority of candidates who chose incorrect alternative B, were confused with the term greater degree of accuracy and hence misleading them to opt for B. *Tape Measure,* which can measure greater distance (length). In other hand, those candidates who chose incorrect alternatives A, C, and D had inadequate knowledge related to instruments used to measure lengths and failed to understand the concepts applied in measuring instruments.

Item (x) was formulated from the topic of '*Sustainable Energy Sources*'. It aimed to test ability of candidates to identify the components of solar system as the source of Electrical energy. The question was:
Every candidate in a class was asked to list one main component of solar system and they named as follows:
(i) Panels (ii) Claps (iii) Cylinder (iv) Inverter (v) Racking (vi) Battery

Who listed the correct component of the Solar system?
A (i), (iii) and (iv) *B (ii), (iii) and (iv)* *C (i), (iv) and (v)*
D (i), (v) and (vi) *E (i), (ii) and (v)*

The correct answer was alternative C. *(i), (iv) and (v).* Those candidates who chose this alternative C, had adequate competence to describe the main components of solar system as their functions get concerned (i) *Panels* are those devices which are used to absorb the sun's rays and convert them into electricity or heat. (ii) *Racking* is the foundation upon which solar panels are mounted. (iii) *Inverter* it's a device that converts direct current (DC) electricity, which is what a solar panel generates, to alternating current (AC) electricity, which the electrical grid uses. Some candidates who chose incorrect alternative D, which was (i), (v) and (vi), were confused between Invertor and Battery. These candidates failed to understand that inverter is used to store electrical energy just after being produced.

However, the candidates who chose other incorrect alternatives A, B, and E had lacked knowledge about the components of solar system including their corresponding functions.

2.1.2 Question 2: Matching Items

Question two (2) was composed from topic of *Linear Motion.* The question asked the candidates to match items (i-vi) in list A with corresponding responses in list B. They were required to write the letter of correct response besides the corresponding item number. Each item in question is carrying one (1) mark, making a total of six (6) marks. The question was designed to assess the candidates understanding of Linear Motion. The question presented to the candidate was as follows.

Match the slope of linear motion in List A with their corresponding physical quantity in List B by writing the letter of the correct response beside the item number in the answer booklet provided.

List A	***List B***
(i) It is positive slope of velocity-time graph *(ii) It is a negative slope of velocity-time graph.* *(iii) It is a slope of distance-time graph.* *(iv) It is a slope of displacement- time graph.*	*A. Speed* *B. Displacement* *C. Velocity* *D. No acceleration* *E. Acceleration* *F. Retardation* *G. Constant velocity*

List A	*List B*
(v) It is a zero slope of displacement-time graph. *(vi) It is a zero slope of velocity- time graph.*	

This question was attempted by 1574 (100%) candidates; where by 117 (7.43%) scored from 0 to 1.5 mark, 325 (20.65%) candidates scored from 2 to 3.5 marks and 1132 (71.92%) scored from 4 to 6 marks. The performance on this question was generally good as 1457 (92.57%) of the candidates scored above 1.5 marks. Figure 3 shows candidates' performance in this question.

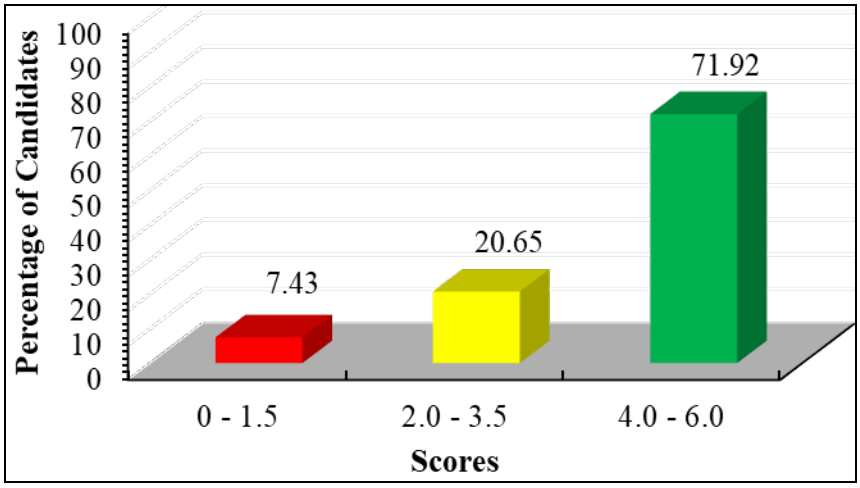


Figure 3: *The Candidates' Performance in Question 2*

The analysis of each candidate's response in each item is as follows:

In item (i) candidates were asked to identify the correct response that matches the statement *it is positive slope of velocity time graph*. The correct response was E. *Acceleration*. Most of the candidate who matched correctly had the ability to read and interpret the graph. They understood that an upward slope indicates positive acceleration. However, a few candidates chose optional B. *Displacement* as they had inadequate knowledge and practical skills on parameters of positive slope of velocity-time graph.

In item (ii) candidate were asked to identify the correct response that matches the statement *it is negative slope of velocity time graph*. The correct response was F. *Retardation* Most of the candidates, who matched correctly, had ability to read and interpret slope time graph. They understood that downward slope indicates negative acceleration, or deceleration, meaning the object is slowing down. Other candidates responded wrongly by choosing incorrect response; G. *Constant Velocity.* The candidates in this category had inadequate knowledge about negative slope of velocity time graph. These candidates did not understand that constant velocity is a velocity that does not change and does not vary with time.

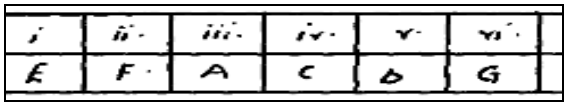
In item (iii) candidate were asked to identify the correct response that matches the statement *it is a slope of distance time graph*. The correct response was A. *Speed.* The candidates who chose the correct answer had ability to read and interpret the slop distance time graph. They understood that a sloping line indicates that the object is moving. The slope or gradient of the line in a distance-time graph equals the speed of the object. The faster the object moves, the steeper the line (and the greater the gradient). However, a few candidates chose optional C. *Velocity.* The candidates in this category had inadequate knowledge about speed which is a measure of how fast an object moves and can be measured as a distance per unit of time, such as kilometres per hour (km/h) or metres per second (m/s).

In item (iv) candidate were asked to identify the correct response that matches the statement *it is a slope of displacement time graph*. The correct response was C. *Velocity.* Most of the candidates, who matched correctly, understood that the slope of a displacement-time graph represents the velocity of the body. However, a few candidates chose optional A. *Speed* as they had inadequate knowledge and practical skills about velocity which is the rate of change of displacement. It is a vector quantity and is measured as a displacement per unit of time.

In item (v) candidate were asked to identify the correct response that matches the statement *it is a zero slope of displacement time graph*. The correct response was D. *No acceleration.* The slope of a displacement-

time graph represents the velocity of the body. If the gradient/slope is zero, then the velocity is zero. This means that the object is stationary, which is the same as saying it is at rest, therefore no acceleration. Other candidates responded wrongly by choosing incorrect response; H. *Initial velocity* The candidates in this category had inadequate knowledge about the term no acceleration. These candidates did not understand that the term no accelerations means that no external forces are acting on the object whereas initial velocity refers to the velocity in the beginning when the object starts moving.

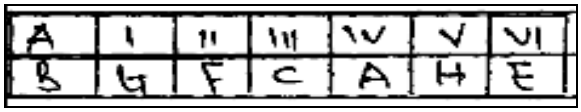
In item (vi) candidate were asked to identify the correct response that matches the statement *it is a zero slope of velocity time graph*. The correct response was G. *Constant Velocity.* Most of the candidates, who matched correctly, understood that the zero slope of a velocity-time graph represents the constant velocity of the body. However, a few candidates chose optional E. *Acceleration* as they had inadequate knowledge and practical skills about Constant velocity whereby the rate of change of position of an object remains the same throughout a period of time.



Extract 2.1: A sample of a correct response to question 2

Extract 2:1 describes a candidate response who was able to identify, organize, and match all electricity parameters required in both lists.

However, some of the candidates who scored low marks (0 to 1.5) were not able to write the proper parameters that correctly match with the physical quantities in list A. Extract 2.2 is the sample of an incorrect response of a candidate who scored 0 mark.



Extract 2.2: A sample of an incorrect response to question 2

In Extract 2.2 a candidate was not able to recognize and associate linear motion parameters with velocity time-graph.

2.2 Section B: Short Answer Questions

This section comprised of six (6) short answer questions which were set from topic of *Friction, Work, Energy and Power, Linear Motion, Strength of materials, Angular Motion, Projectile Motion and Electricity* Each question carried 9 marks, making a total of 54 marks. The scores were categorized into three ranges: Weak (0-2.5) marks, average (3-5.5) marks and good (6-9) marks. The analysis of each question is as follows:

2.2.1 Question 3: Friction, Work, Energy and Power

This question was composed from the topics of Friction, Work, Energy and Power. The question was intended to measure candidate's competency to determine the horizontal force required to push a block of metal and along a rough horizontal workshop floor, to estimate work done and power developed by a man pushing the block. The question was as follows:

A candidate was assigned to push a block of metal having of 75 kg along a horizontal workshop floor for a distance of 100 m in 2 minutes. If the predetermined coefficient of friction was 0.3, calculate; (a) the horizontal force required (b) the work done (c) the power

The question was attempted by 1574 (100%) candidates, out of these candidates, 409 (25.98%) scored from 0 to 2.5 marks, 695 (44.16%) candidates scored from 3 to 5.5 marks and 470 (29.86%) candidates scored from 6 to 9 marks. This data indicates that the general performance on this question was good since 1165 (74.02%) candidates scored from 3 to 9. Figure 4 shows candidates' performance in this question.

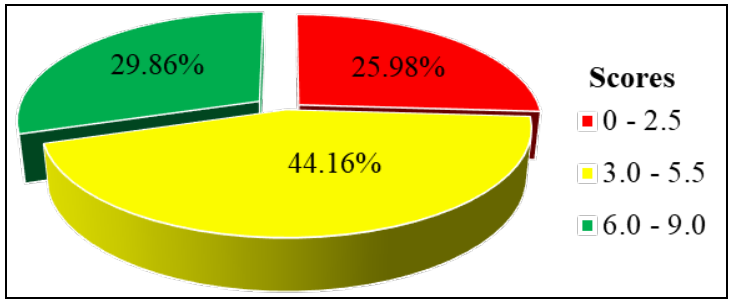


Figure 4: *The Candidates' Performance in Question 3*

The analysis of candidate's response in this question reveals that most of them had a good understanding on recalling engineering Units and formula. In part (a) they substituted the values to calculate horizontal force which is the product of weight of a stone and coefficient of friction. Coefficient of friction is the ratio of the frictional force resisting the motion of two surfaces in contact to the normal force pressing the two surfaces together. It is usually symbolized by the Greek letter mu (μ). Mathematically, $\mu = F/N$, where F is the frictional force and N is the normal force (b). They correctly applied the formula to calculate the required work done to push the block metal. Where's, Work done is the product of force and distance moved in the direction of the force $W=Fd$ where W is the work done and d is the distance (c) they substituted the known value of work done to calculate the power according to the work-time equation for power. Power $P= W/t$, where W is the work done and t is the time. The SI unit of power is Joules per Second (J/s). Extract 3.1 is a sample of the correct response.

solution

data

mass (m) = 75kg

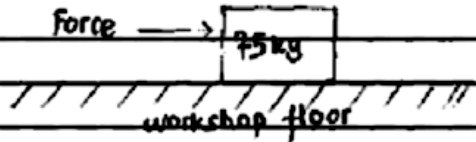
distance (d) = 100m

Time = 2minutes

Coefficient of friction (μ) = 0·3

horizontal force = ? required.

consider the diagram below.



from the above

friction force will be overcomed.

now,

Force = normal reaction × coefficient of friction.

$Fr = R \times \mu$

but

$R = \frac{Fr}{\mu} = W = mg$

$R = mg$

$R = 75kg \times 9.8N/kg$

$R = 735N$.

b, solution

from

workdone = force × distance

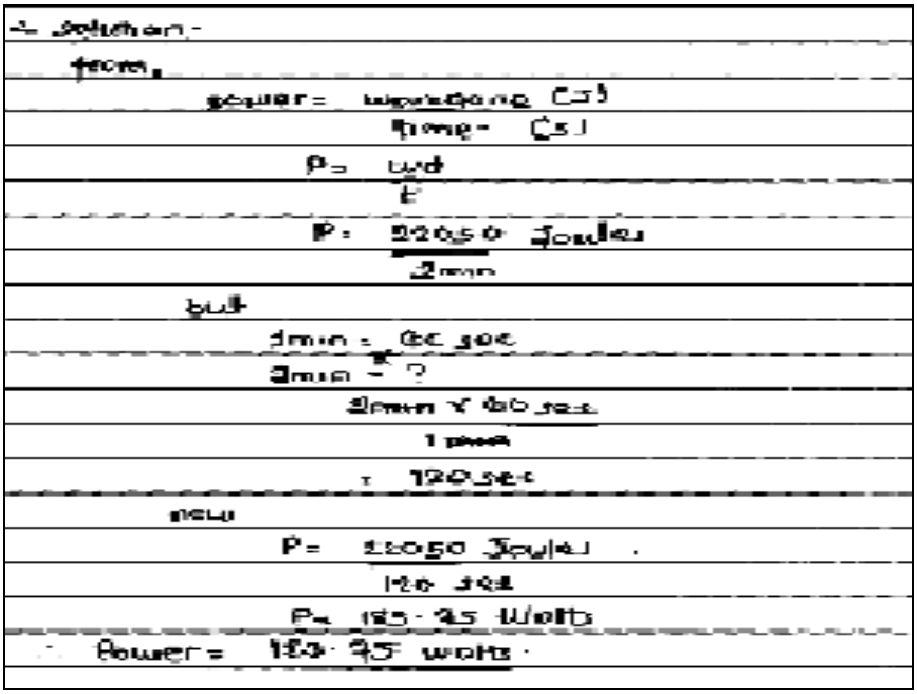
$w.d = F \times d$

$w.d = 220.5N \times 100m$

$w.d = 22050Nm$

$w.d = 22050$ Joules

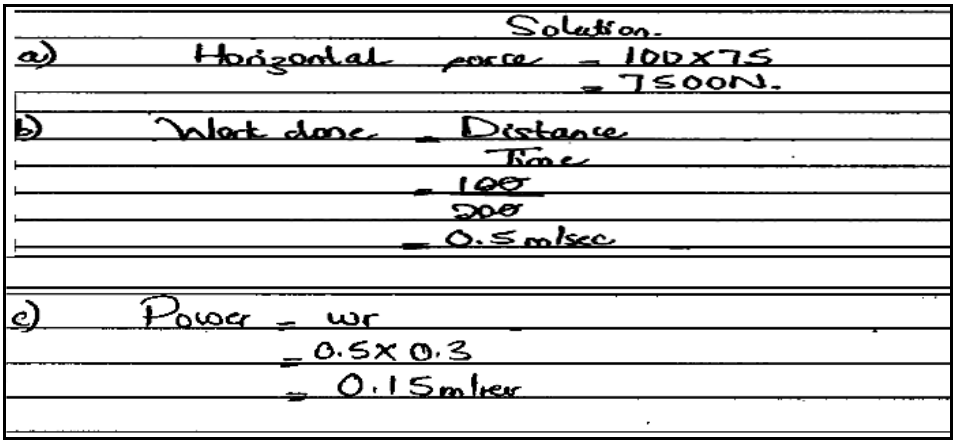
∴ the work done = 22050 Joules.



Extract 3.1: A sample of correct responses to question 3

Extract 3.1 shows candidate responses who applied the correct formulae and procedure to compute work done and Power developed.

On the other hand some of the candidates scored low (0-2.5) marks. 25.98 percent had lack proper knowledge on the concepts of Work, Energy and Power, Weight and Friction. Moreover, these candidates failed to write an appropriate formula for mathematical calculation. In part (a) candidates who scored 0 mark failed to calculate horizontal force required to push a block. These candidates didn't know the relationship between the weight of a stone and coefficient of friction; others didn't have ability to understand the relationship between work, force and distance. Extract 3.2 is the sample of an incorrect response of a candidate who scored 0 mark in question 3.



Extract 3.2: A sample of incorrect responses to question 3

In Extract 3.2 a candidate applied incorrect formulae of horizontal force, work done and power developed.

2.2.2 Question 4: Linear Motion

This question was composed from the topic of ′Linear Motion′. The question was designed to measure candidate's competency to analyze the effects of collision to both velocity and kinetic energy of the colliding bodies. The question was as follows:

Candidates' witnesses that, a truck of total mass 15 metric tons moving at 1 m/s, collided onto stationary truck of mass 10 tones. They also observed the two trucks automatically moved off together. From that situation calculate;

(a) their velocity.

(b) the kinetic energy of the trucks

(i) Before collision.

(ii) After collision.

The question was attempted by 1574 (100%) candidates, out of these candidates, 655 (41.61%) scored from 0 to 2.5 marks, 354 (22.49%) scored from 3 to 5.5 marks and 565 (35.90%) scored from 6 to 9 marks. This data indicates that the general performance was good since 919 (58.39%) candidates scored from 3 to 9 marks. Figure 5 shows candidates' performance in this question.

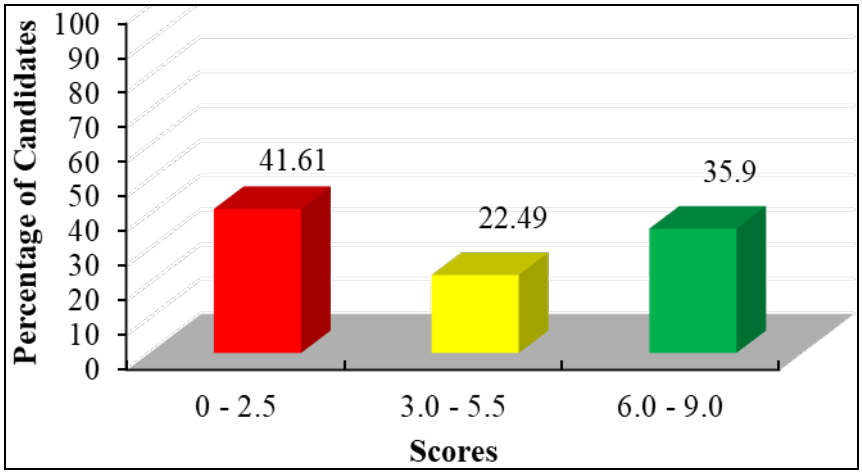
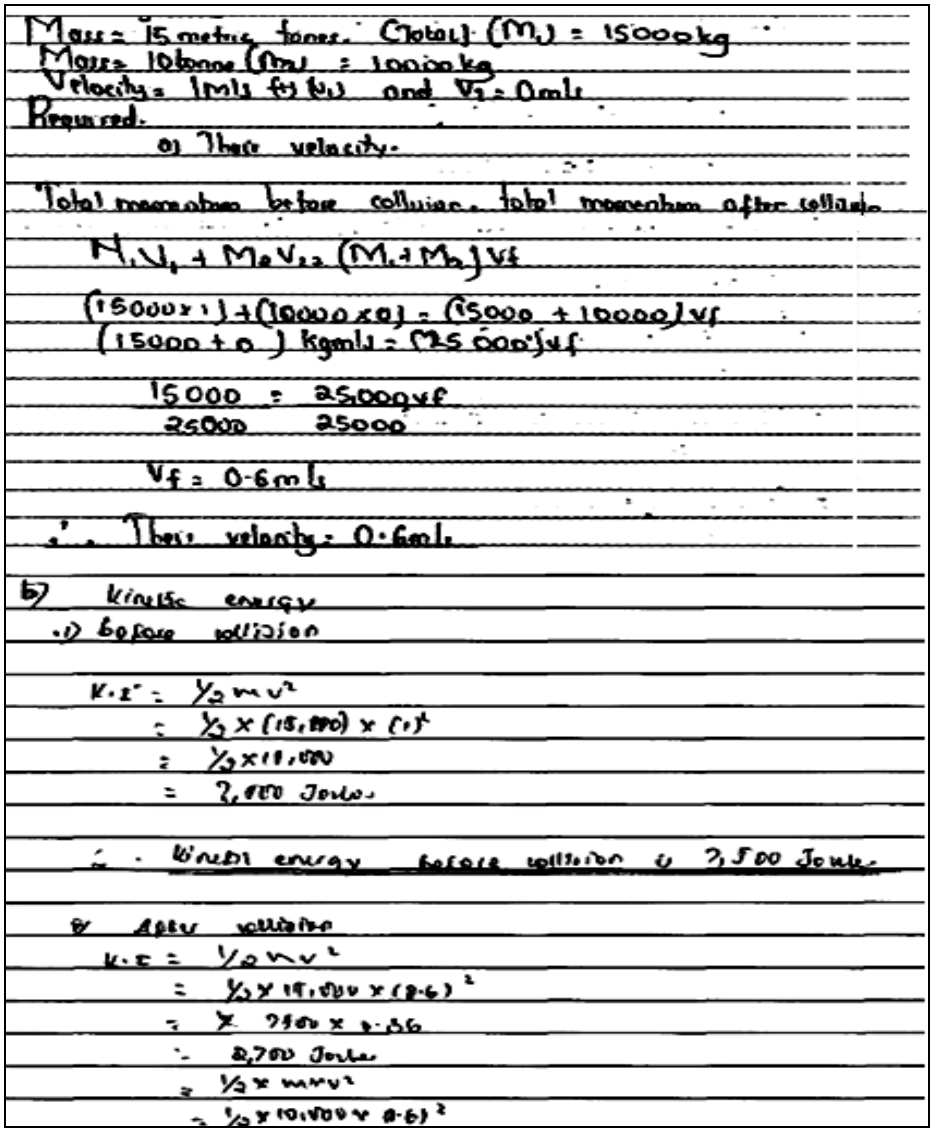


Figure 5: *The Candidates' Performance in Question 4*

The candidates who scored from 3 to 6 were able to recall relevant formula for linear momentum and substitute data correctly. These candidates understood that when a moving car, hits a stationary truck, the moving car's kinetic energy is transferred to the stationary truck, causing it to move forward. This results in a transfer of momentum from the moving car to the stationary truck. The force of the impact can cause damage to the car, truck and injuries to any occupants.

These candidates understood that the total momentum before collision is similar to the total momentum after collision. $M_1u_1+m_2u_2= (m_1+m_2)\ V_c$. They also understood that Kinetic energy is a half of the product of mass (kg) and the squared velocity (m^2/s^2). Extract 4:1 is the sample of a correct response of a candidate who scored all marks in question 4.


Mass = 15 metric tonnes. (Total) (M_1) = 15000kg
Mass = 10tonne (M_2) = 10000kg
Velocity = 1m/s for (V_1) and V_2 = 0m/s
Required.
a) Their velocity.

Total momentum before collision. total momentum after collision

$M_1V_1 + M_2V_2 = (M_1+M_2)V_f$

$(15000 \times 1) + (10000 \times 0) = (15000 + 10000)V_f$

$(15000 + 0)$ kgm/s $= 25000V_f$

$\frac{15000}{25000} = \frac{25000V_f}{25000}$

$V_f = 0.6$m/s

∴ Their velocity = 0.6m/s

b) Kinetic energy

i) before collision

K.E $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times (15,000) \times (1)^2$

$= \frac{1}{2} \times 15,000$

$= 7,500$ Joules

∴ Kinetic energy before collision is 7,500 Joule.

ii After collision

K.E $= \frac{1}{2}mv^2$

$= \frac{1}{2} \times 15,000 \times (0.6)^2$

$= \frac{1}{2} \times 7500 \times 0.36$

$= 2,700$ Joules

$= \frac{1}{2} \times mv^2$

$= \frac{1}{2} \times 10,000 \times 0.6^2$

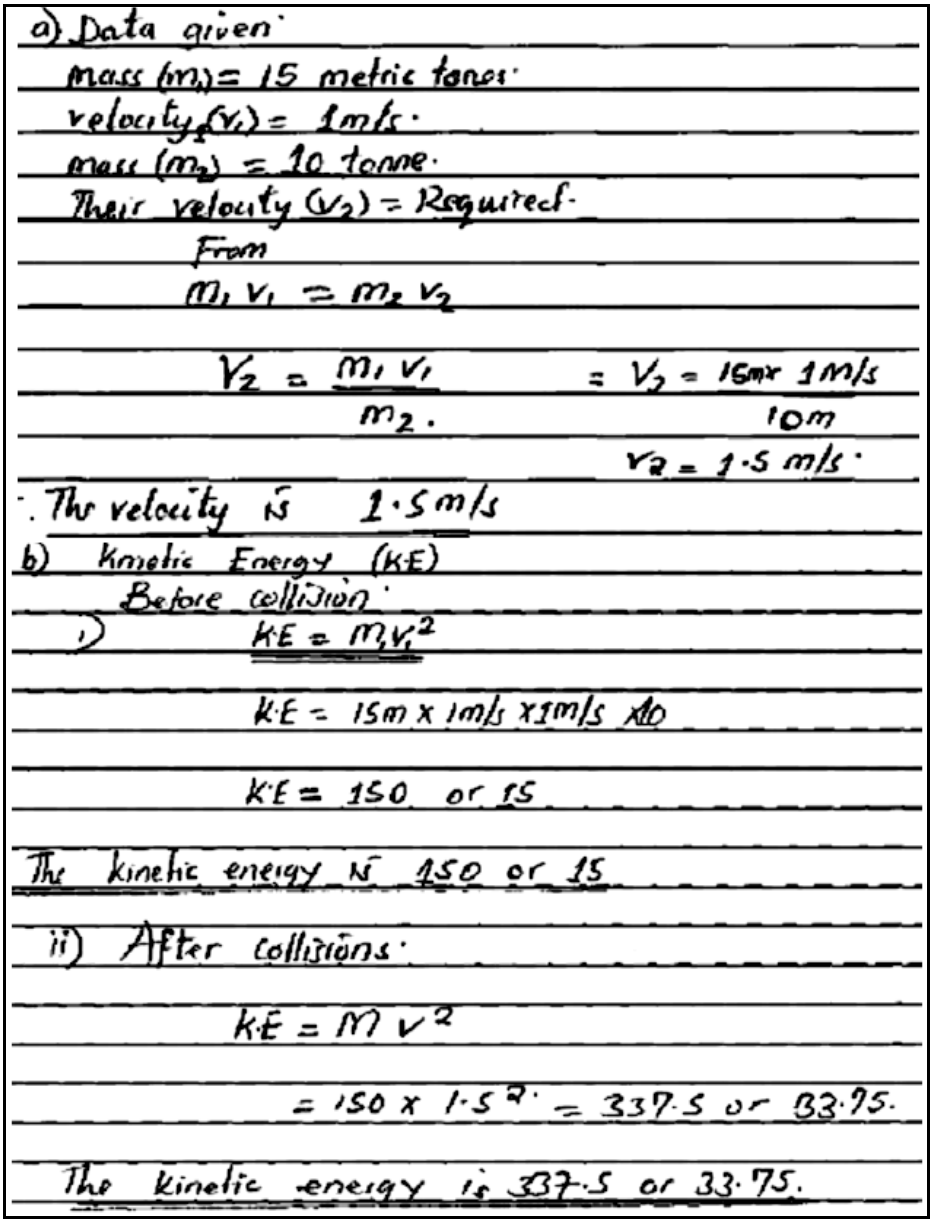
Extract 4.1: A sample of correct responses to question 4

Extract 4.1 shows responses from a candidate who was able to calculate the common velocity of the trucks and Kinetic Energy of the trucks before and after collision.

However, candidates who scored zero (0) mark: (i) failed to calculate the common velocity of the trucks; they were supposed to know precisely second and third Newton's Law of motion. Newton's second law of motion states that the time rate of change of the momentum of a body is

equal in both magnitude and direction to the force imposed on it. The momentum of a body is equal to the product of its mass and its velocity. A force applied to a body can change the magnitude of the momentum or its direction or both. For a body whose mass m is constant, it can be written in the form F = ma, where F (force) and a (acceleration). Newton's third law states that when two bodies interact, they apply forces to one another that are equal in magnitude and opposite in direction. The third law is also known as the law of action and reaction, (ii) failed to write relevant formula for linear momentum. Also, (iii) they were confused between collision and the third Newton's law of Motion.

In part (b) candidates were required to calculate the kinetic energy of the trucks before and after collision. Those candidates who scored below pass mark (0-2.5) failed to calculate the kinetic energy of the trucks before and after collision. These candidates didn't manage to recall proper formula for Kinetic energy which is K.E. = 1/2 m v^2 also they failed to substitute correct data. For example, one candidate wrote wrongly the formula for Kinetic Energy as K.E. = m v^2 instead of K.E. = 1/2 m v^2. Extract 4.2 is a sample of the incorrect response of a candidate to question 4.



Extract 4.2: A sample of incorrect responses to question 4

Extract 4.2 shows responses from a candidate who was not able to calculate the common velocity and kinetic energy of the trucks before and after collision.

2.2.3 Question 5: Strength of Materials

In this question candidates were required to calculate the Young's Modulus of Elasticity: It intended to test candidates' comptence in analyzing and applying concept related to Extension produced in a wire and the corresponding Tensile force applied.. The question was:

A wire 3m long and 3.15mm diameter is extended by 0.9mm when a tensile force of 200N is applied to it. Calculate the Young Modulus of Elasticity for the material of the wire.

The question was attempted by 1574 (100%) candidates, out of these candidates, 297 (18.87%) scored from 0 to 2.5 marks, 280 (17.79%) candidates scored from 3 to 5.5 marks and 997 (63.34%) candidates scored from 6 to 9 marks. This data indicate that the general performance was good since 1277 (81.13%) candidates scored from 3 to 9 marks. Figure 6 shows candidates' performance in this question.

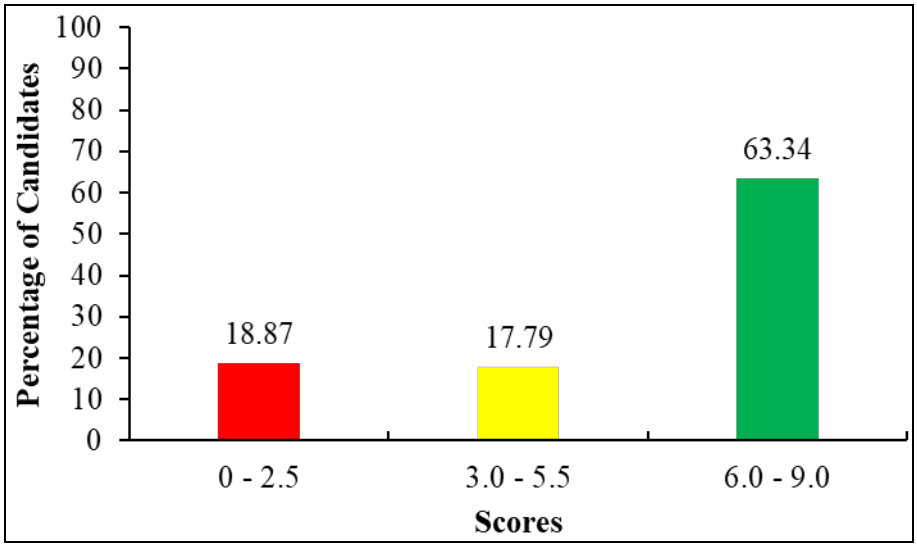
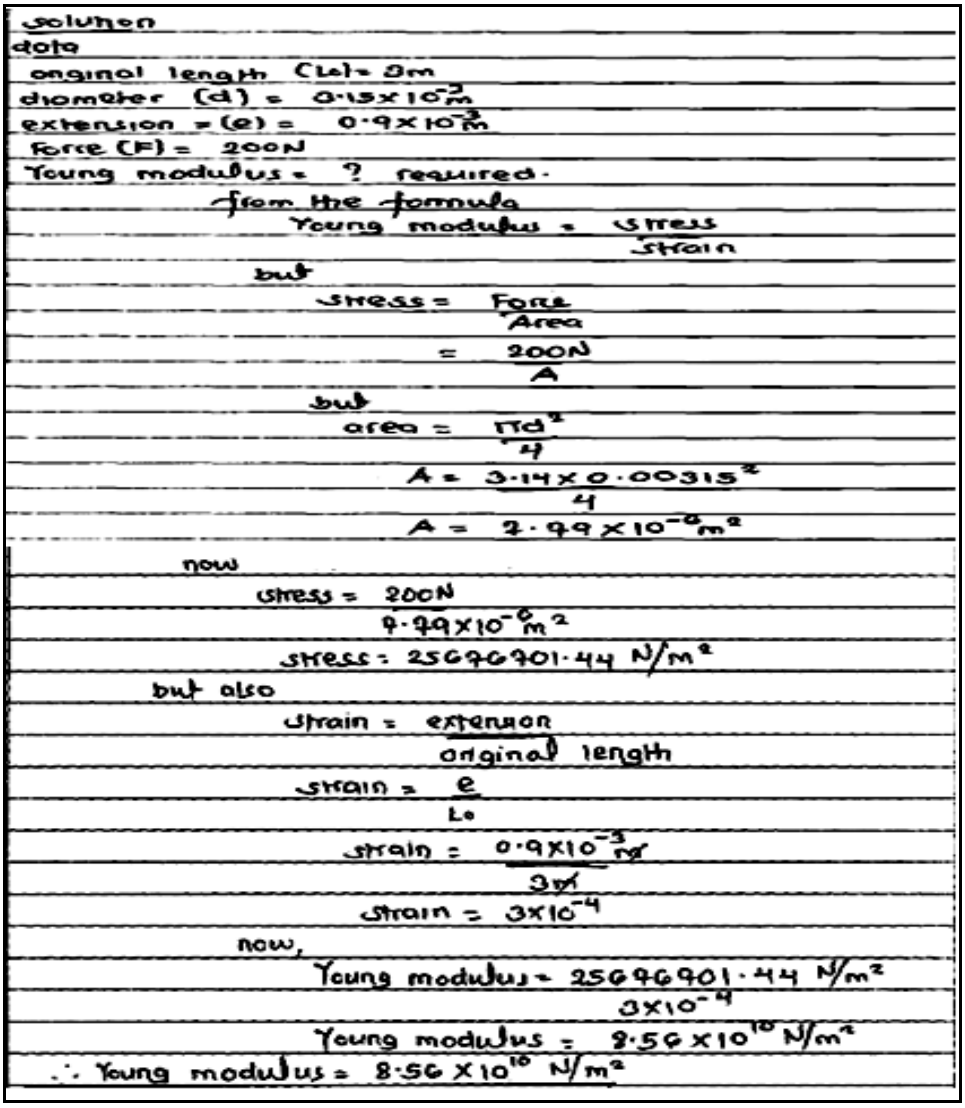


Figure 6: *The Candidates Performance in Question 5*

This was one of the well performed question since 1377 (81.13%) scored from 3 to 9 marks. Those candidates who performed well in this question had adequate knowledge on the concept of *Strength of Materials*, some of them were able to recall formula for (i) Young' Modulus which is mathematically calculated by dividing the value of stress over strain (ii) Tensile stress which obtained by dividing the load over its cross section

area (iii) Tensile strain is calculated by dividing extension over original length.

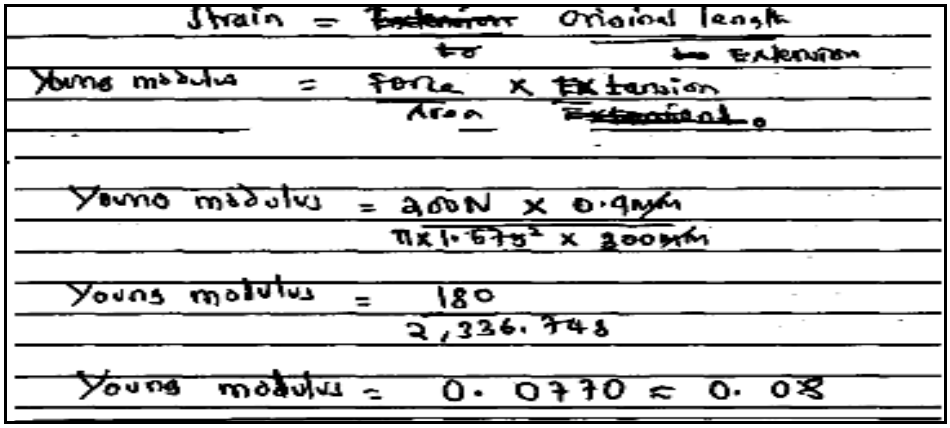
Some of candidates who scored average marks (3-5.5) managed to write correct formula for Young's Modulus but failed to organize the formula of stress, strain and cross sectional area. Hence, they ended up with average marks. Extract 5.1 is the sample of correct responses from a candidate who scored full marks in question 5.


solution
data
original length (Lo) = 3m
diameter (d) = 0.15×10^{-2} m
extension = (e) = 0.9×10^{-3} m
Force (F) = 200N
Young modulus = ? required.
from the formula
Young modulus = $\frac{\text{stress}}{\text{strain}}$
but
stress = $\frac{\text{Force}}{\text{Area}}$
= $\frac{200N}{A}$
but
area = $\frac{\pi d^2}{4}$
$A = \frac{3.14 \times 0.00315^2}{4}$
$A = 7.99 \times 10^{-6} m^2$
now
stress = $\frac{200N}{7.99 \times 10^{-6} m^2}$
stress = 25696901.44 N/m^2
but also
strain = $\frac{\text{extension}}{\text{original length}}$
strain = $\frac{e}{Lo}$
strain = $\frac{0.9 \times 10^{-3} m}{3m}$
strain = 3×10^{-4}
now,
Young modulus = $\frac{25696901.44 N/m^2}{3 \times 10^{-4}}$
Young modulus = $8.56 \times 10^{10} N/m^2$
∴ Young modulus = $8.56 \times 10^{10} N/m^2$

Extract 5.1: A sample of correct responses to question 5

In Extract 5.1 a candidate managed to calculate Young's Modulus of Elasticity.

The candidates who scored below pass marks (0-2.5) were about 297 (18.87%). This figure indicate that candidate had lacked knowledge of *Strength of Materials*. In this question, candidates who scored 0 mark: (i) failed to analyze concepts related to stress and strain that stress refers to the force applied to a material per unit area "σ = F/A", while strain is a deformation or change in the shape of the material that results from the applied force and is calculated by dividing a change in dimension due to applied stress over actual dimension. (ε) Strain formula = Δx/x (ii) failed to write the formula for calculating Young Modulus of Elasticity which is calculated by dividing the value of stress over strain. Extract 5.2 is the sample of incorrect responses from a candidate to question 5.



Extract 5.2: A sample of incorrect responses to question 5

In Extract 5.2 the candidate applied incorrect formulae to find strain parameters and therefore failed to substitute the correct values to calculate Young Modulus of Elasticity.

2.2.4 Question 6: Angular Motion

This question was set from the topic of *Angular Motion*. It aimed to measure candidates' competence to analyze the relationship between angular speed and linear speed of a point. Also, to apply the angular motion parameters, accordingly. The question was:

(a) *A fly wheel has two dots R_1 and R_2 on its surface as shown in Figure 2. Briefly describe the relationship of the angular and linear speed of the dots when a flywheel is rotated at a certain speed.*

(b) *A candidate rotated a fly wheel from rest and revolved with an acceleration of 0.5rad/s^2. Use this information to find;*

(i) the angular velocity of a flywheel

(ii) the angular displacement if the time is 10 seconds.

The question was attempted by 1574 (100%) candidates, out of these candidates, 840 (53.37%) scored from 0 to 2.5 marks, 433 (27.51%) candidates scored from 3 to 5.5 marks and 301 (19.12%) candidates scored from 6 to 9 marks. This data indicate that the general performance was average since 734 (46.63%) candidates scored from 3.0 to 9.0 marks. Figure 7 shows candidates' performance in this question.

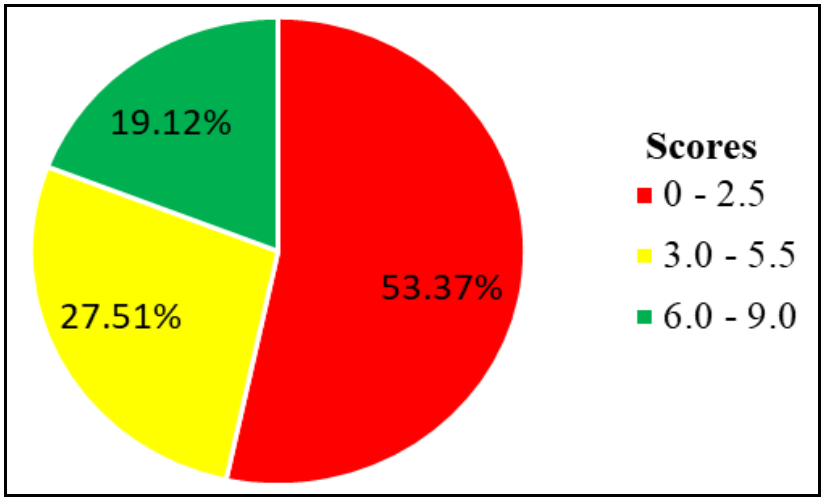
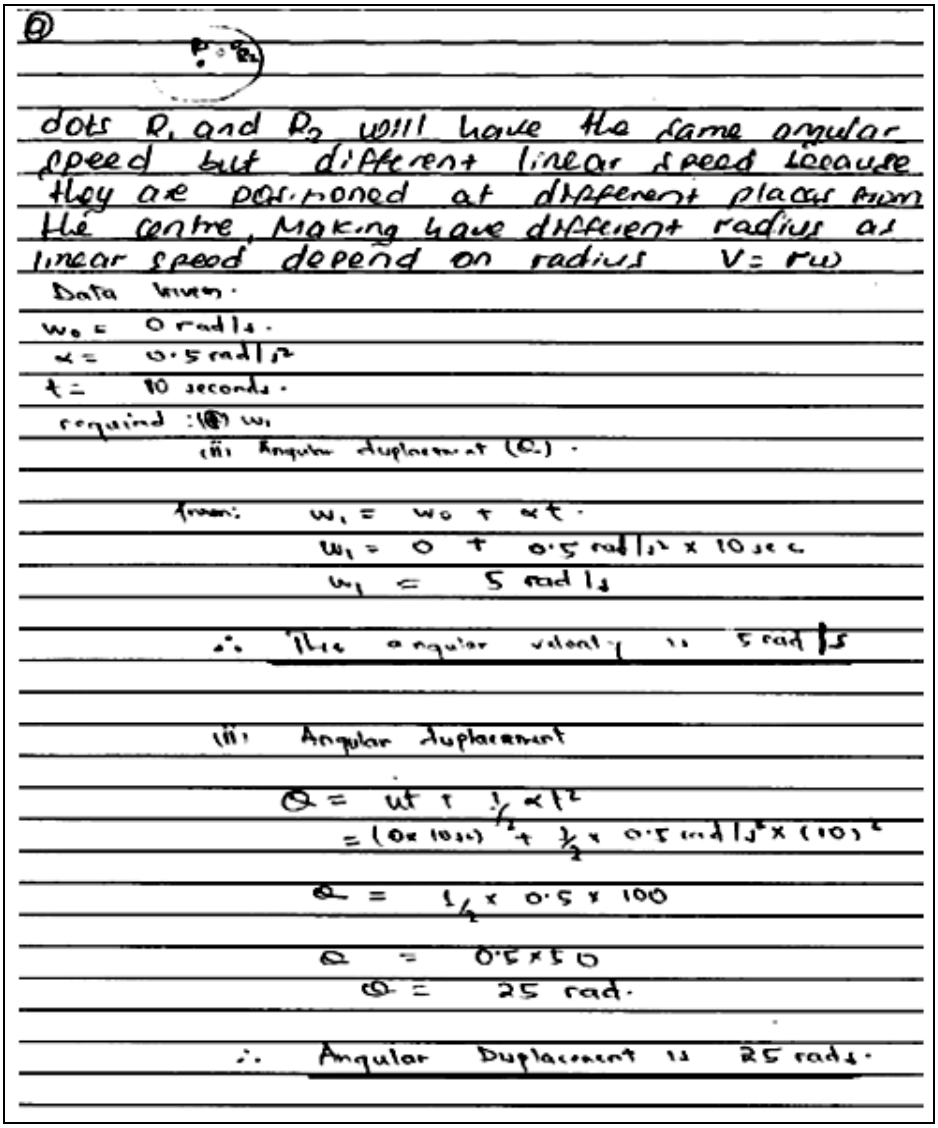


Figure 7: *The Candidates Performance in Question 6*

The candidates who scored average marks (3-5.5) managed to calculate angular velocity of a flywheel. In part (a) candidates who scored all marks were familiar on the concept of angular motions parameters. These candidates understood that the Angular speed for dots R_1 and R_2 will be the same since the angles swept by the dots are equal. Also, understood that the linear speed for dots will not be the same as the radial distance of the dots from axis of rotation of the wheel are not equal. In part (b) candidates who scored all marks were able to formulate equations for uniformly accelerated angular motion and apply them

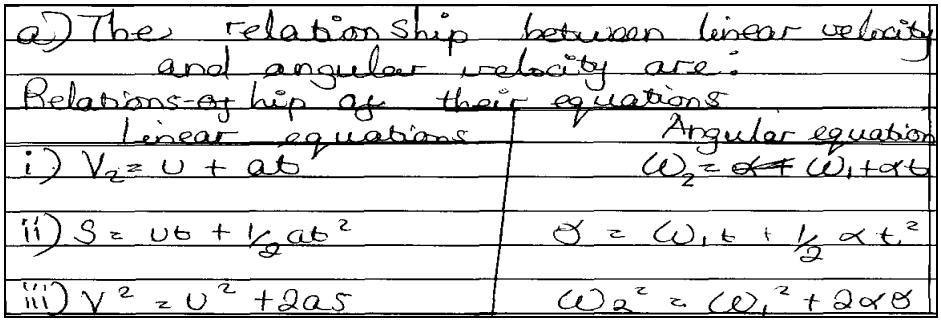
accordingly. Extract 6.1 is the sample of a correct response of a candidate who scored all marks in question 6.



Extract 6.1: A sample of correct responses to question 6

In Extract 6.1 the candidate was able to describe the relationship between angular speed and linear speed and to identify the proper formulae to determine angular velocity and angular displacement.

However, the candidates who scored below pass mark (0-2.5) were 840 (53.37%). This indicates that they had insufficient knowledge on angular motion. In this question, candidates who scored 0 mark: (i) failed to describe the relation between angular and linear speed of the flywheel of the dots R_1 and R_2. Most students who scored zero were supposed to understand that the angular speed for dots R_1 and R_2 will be the same if the rate of change of angular displacement will be the same for both dots. The linear speed for dots will not be the same if the rate of change of linear displacement (S_1 and S_2) differs ,In addition, they failed to write correctly the formulae for angular velocity ($\omega = \omega_o + \alpha t$) and angular displacement ($\theta = \omega_o t + \frac{1}{2} \propto t^2$) of a flywheel. More over most of the candidates lacked mathematical skills to substitute the values to get the correct answer. For example, one of the candidate, failed to identify the proper formulae to determine angular velocity, thus instead of using $W_2 = W_1 + \alpha t$, he/she used $W = \frac{\theta}{t}$ which led him/her to get wrong answer. Extract 6.2 is the sample of an incorrect response of a candidate to question 6.


a) The relationship between linear velocity and angular velocity are:

Relationship of their equations

Linear equations	Angular equation
i) $V_2 = U + at$	$\omega_2 = \omega_1 + \alpha t$
ii) $S = ut + \frac{1}{2}at^2$	$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$
iii) $V^2 = U^2 + 2as$	$\omega_2^2 = \omega_1^2 + 2\alpha\theta$

Extract 6.2: A sample of incorrect responses to question 6

Extract 6.2 shows that in part (a) a candidate provided similarity between linear equation and angular equation instead of the relationship between angular speed and linear speed of the dots. In part (b), the candidate failed to identify the proper formulae to determine angular velocity and angular displacement.

2.2.5 Question 7: Projectile Motion

The question was composed from the topic of '*Projectile Motion'*. It intended to assess candidates' competence on describing and analyzing both vertical and horizontal motion of a ball. The question was as follows:

Two boys are standing one east and another west 10 m apart and the eastern has to kick the ball to western boy. If the boy at east kicked the ball to the boy in west at an angle of 45° to horizontal, estimate the maximum height the ball will attain.

The question was attempted by 1574 (100%) candidates, out of these candidates,716 (45.49%) scored from 0 to 2.5 marks, 271 (17.22%) candidates scored from 3 to 5.5 marks and 587 (37.29%) candidates scored from 6 to 9 marks. This data indicate that the general performance was average since 858 (54.51%) candidates scored from 3-9 marks. Figure 8 shows candidates' performance in this question.

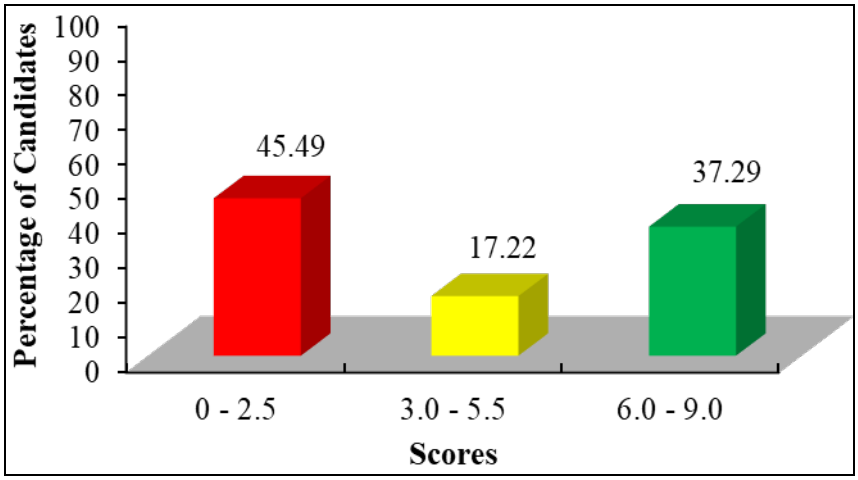
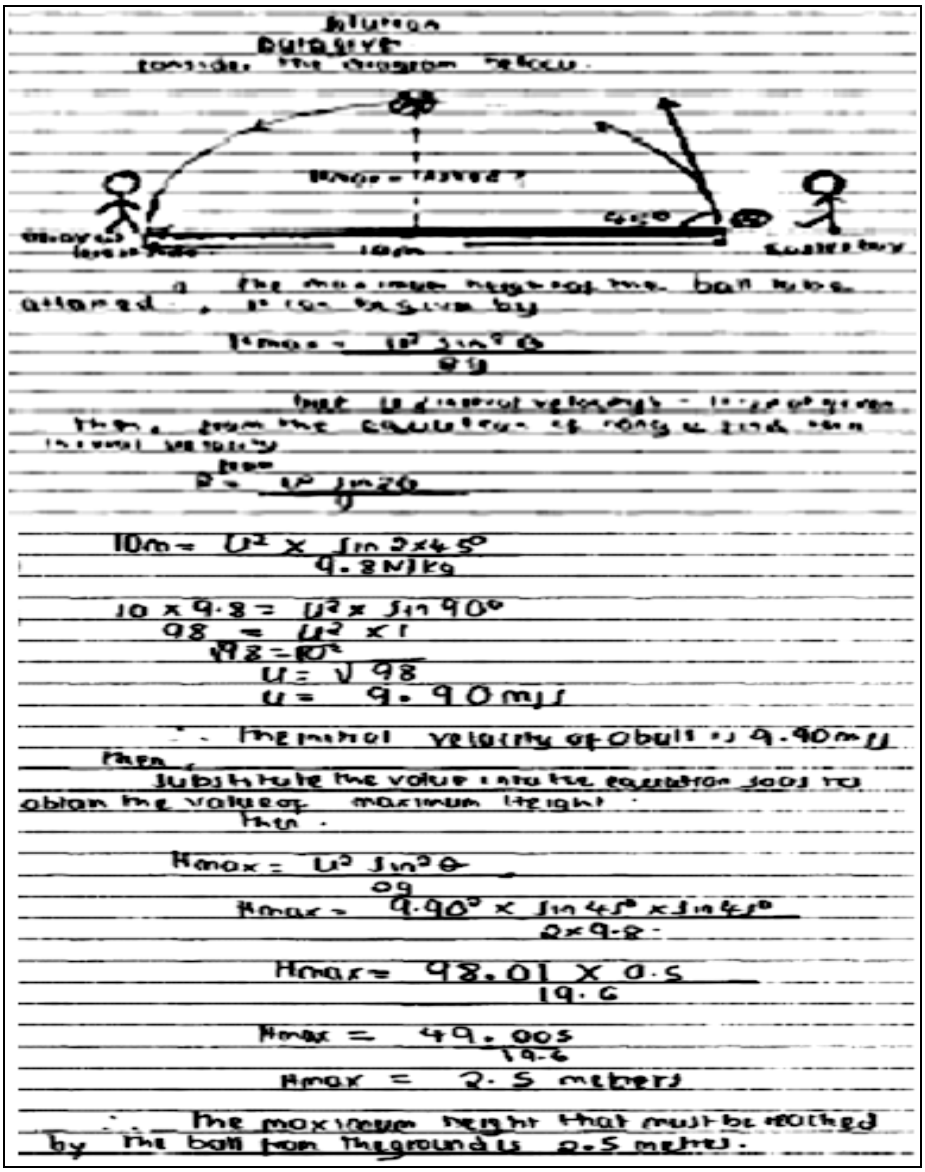


Figure 8: *The Candidates Performance in Question 7*

The candidates who scored average marks (3-5.5) were able to write correct equations for range and maximum height, but failed to organize and substitute the required data given into equations, in addition most of the candidates failed to apply trigonometric ratios accordingly. Therefore, they ended up with average marks.

However, the candidates who scored all marks had adequate knowledge of applications as they were able to write the correct formulae expressed

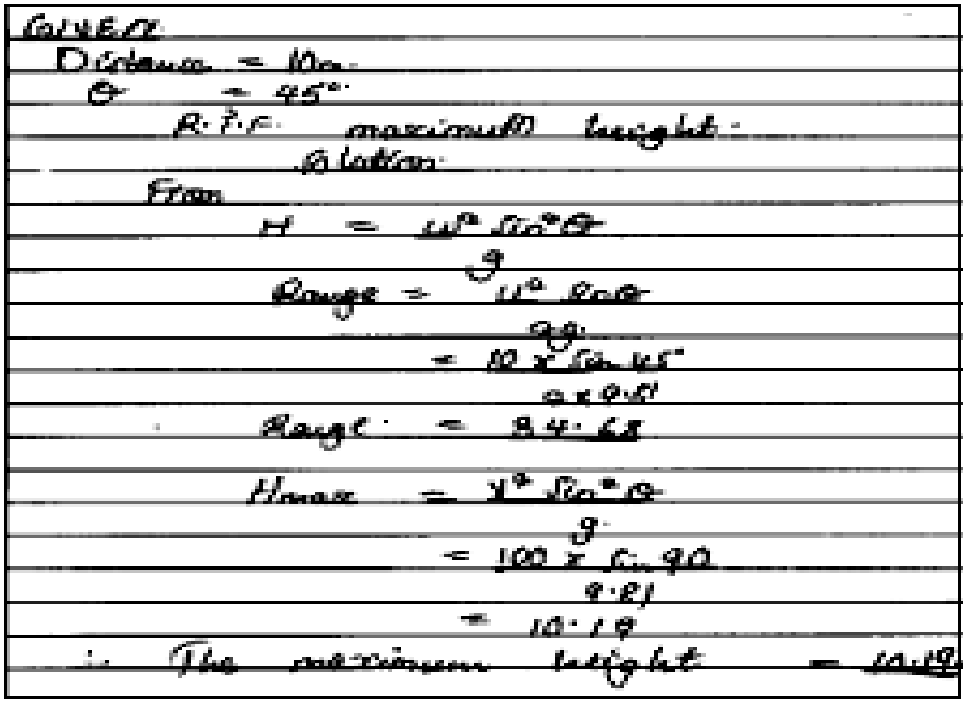
as $H = \frac{u^2 \sin^2 \theta}{2g}$ to estimate the maximum height of the ball. Extract 7.1 is a sample of a correct response of a candidate who scored all marks in question 7.



Extract 7.1: A sample of correct responses to question 7

In Extract 7.1, the candidate formulated and organized an equation for the horizontal range of a projectile to find the velocity of a ball and finally the maximum height reached by the ball.

On the other hand, the candidates who scored below the pass mark (0-2.5) lacked knowledge on the concepts of projectile motion. These, candidates failed to write equations to determine the range and therefore estimate the maximum height reached by the ball. This suggests that they lacked mathematical skills to interpret the given task into diagram which could help them to apply the proper formulae to analyses the data. Extract 7:2 is the sample of an incorrect response of a candidate who scored 0 mark in question 7.



Extract 7.2: A sample of incorrect responses to question 7

In Extract 7.2 a candidate used incorrect formulae in calculating the maximum height of the ball.

2.2.6 Question 8: Electricity and Magnetism

The question was composed from the topic of *Electricity*. It is intended to test candidates' competence on estimation of cost charged to operate electrical appliances and analyzing electrical circuit. The question was:

(a) A new type of light bulb has recently been invented. It produces the same amount of light as an ordinary (old) 1000 W bulb but uses only 25 W of electrical power. It is expected to last for 5000 hours.

(i) *How many kilowatt-hours does a 1000W lamp use in 5000hours?*

(ii) *How much will it cost if TANESCO charges 300 Tanzanian shillings for 1 kilowatt-hour?*

(b) *A house is on the main supply of 230 volts which supplies voltage to 1.5 kW hot plates, six 60W lamps and a 100 W refrigerator. The hot plates are on a different fuse line from the lighting circuit which includes the refrigerator. What amount of current flows through the fuses in each line when all appliances are in use?*

The question was attempted by 1574 (100%) candidates, out of these 870 (55.27%) scored from 0 to 2.5 marks, 533 (33.87%) scored from 3 to 5.5 marks and 171 (10.86%) scored from 6 to 9 marks. This data indicate that the general performance was average since 704 (44.73%) candidates scored from 3.0 to 9.0 marks. Figure 9 shows candidates' performance in this question.

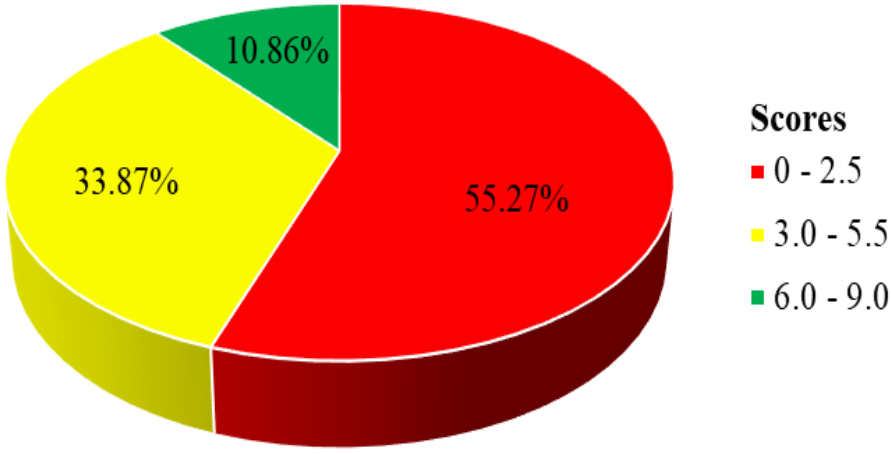
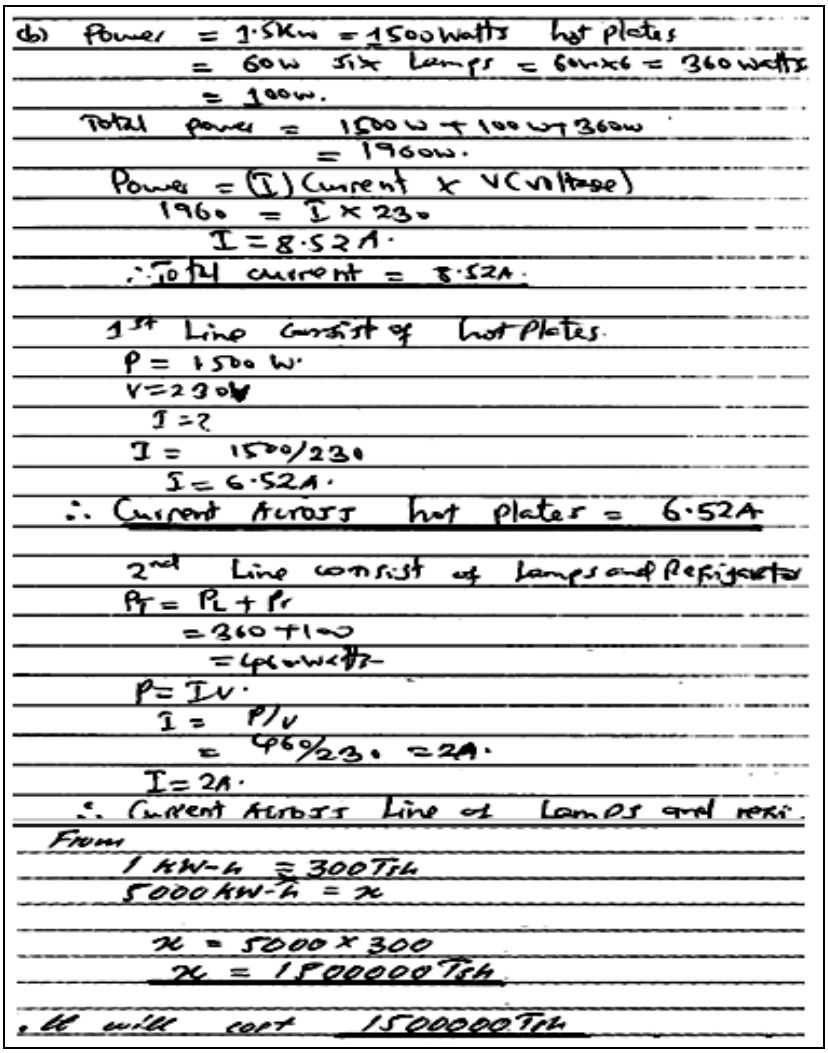


Figure 9: *The Candidates Performance in Question 8*

The candidates who scored average marks (3-5.5) were able to write correct formula for electrical energy and electrical power, and to substitute the data given correctly. However, some of the candidates failed to analyze the power loading in line one and line two. Hence, they ended up with average marks. Furthermore, analysis reveals that in part (a) the candidates who scored all marks were able to write correct

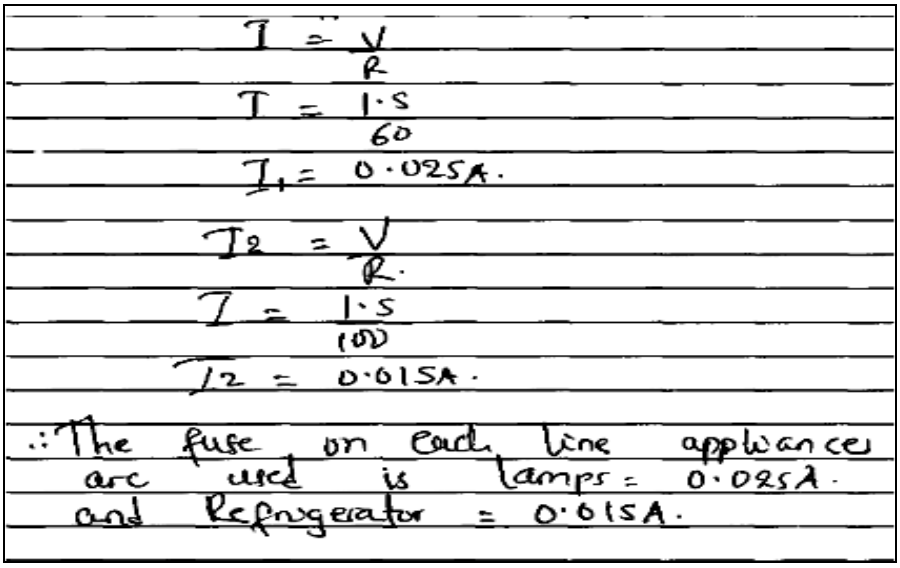
formula for electric energy and apply the data given to calculate the required cost of using electrical energy. Energy = Power x time. In part (b) they were able to write the correct formula for electric Current , I = $\frac{Power}{Volts}$ to analyze and identify the power loading in the fuse lines. Extract 8.1 is a sample of correct responses from a candidate to question 8.


b) Power = 1·5Kw = 1500 watts hot plates
= 60w six Lamps = 60w x 6 = 360 watts
= 100w.
Total power = 1500 W + 100 W + 360w
= 1960w.
Power = (I) Current x V (Voltage)
1960 = I x 230
I = 8·52A.
∴ Total current = 8·52A.
1st Line Consist of hot Plates.
P = 1500 W.
V = 230V
I = ?
I = 1500/230
I = 6·52A.
∴ Current Across hot plates = 6·52A
2nd Line consist of lamps and Refrigerator
$P_T = P_L + P_r$
= 360 + 100
= 460 watts
P = IV.
I = P/V
= 460/230 = 2A.
I = 2A.
∴ Current Across Line of Lamps and refri.
From
1 KW-h = 300 Tsh
5000 KW-h = x
x = 5000 x 300
x = 1500000 Tsh
. It will cost 1500000 Tsh

Extract 8.1: A sample of correct responses to question 8

In Extract 8.1 a candidate applied the correct formula to calculate electrical power, electric cost and the current required to hot plate, lamp and refrigerator.

On contrast, the candidates who scored below pass mark (0-2.5) had insufficient knowledge on electrical energy concepts. Most of the candidates were not able to recall correct formula for calculating electrical energy as they misinterpreted the instructions of the question by using 1000 W instead, of 25 W. Moreover, they lacked knowledge of the concept of electricity as they failed to write the correct formula for electric power and to analyze and identify the power loading in the fuse lines. Extract 8.1 is the sample of a incorrect response of a candidate to question 8.



Extract 8.2: A sample of incorrect responses to question 8

In Extract 8.2 a candidate applied incorrect formula in calculating electrical current and electrical energy.

2.3 Section C: Structured Questions

In this section, there were three (3) structured questions starting from question 9 to 11 each question carried fifteen (15) marks. The candidates were required to choose any two (2) questions with a total of thirty (30) marks which covered a range of topics, Sound Waves, Optics (light) and Turning Effect of a Force. The scores were categorized into three ranges: weak (0-4) marks, average (4.5-9.5) marks and good (10-15) marks. The analysis of each question is as follows.

2.3.1 Question 9: Sound Waves

The question was composed from the topic of 'Sound Waves'. It intended to assess the ability of candidates to describe and analyze the sound waves' parameters. The question was:

(a) *Define harmonics as applied to sound waves.*

(b) *A drum at station A is connected to a wire string at station B. A Man at station A beats the drum while another person at station B places his ear at the wire and hears two sounds, separated by a time interval of 0.8 seconds. If the velocity of sound in air and wire string is 330 m/sec and 6020 m/sec respectively, how far apart are the two men?*

(c) *The distance between two successive crests of water ripples in a ripple tank is 4.5 cm and their wave speed is 30 cm/sec. Determine the;*

(i) *Wavelength*

(ii) *Frequency*

(iii) *Period of the ripple.*

The question was attempted by 938 (100%) candidates, out of these, 544 (58.00%) scored from 0 to 4 marks, 319 (34.00%) scored from 4.5 to 9.5 marks and 75 (8.00%) candidates scored from 10 to 15 marks. This data indicate that the general performance of the candidates was average since 394 (42%) scored from 4.5 to 15 marks. Figure 10 shows candidates' performance in this question.

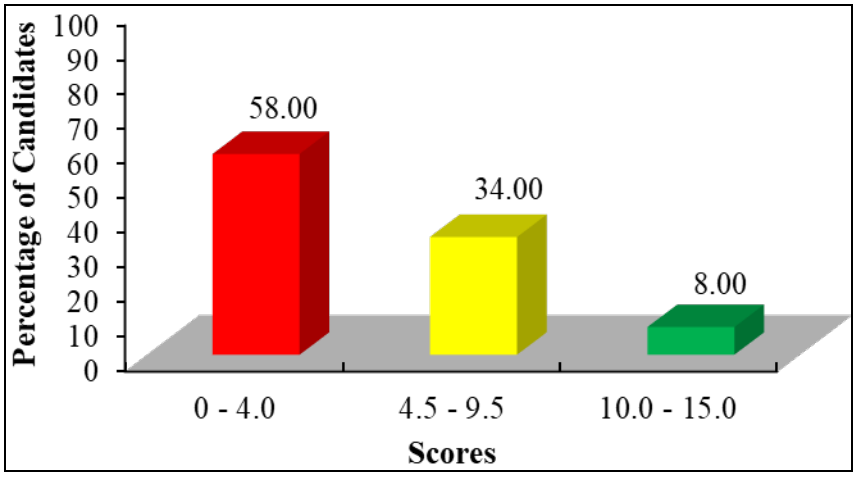
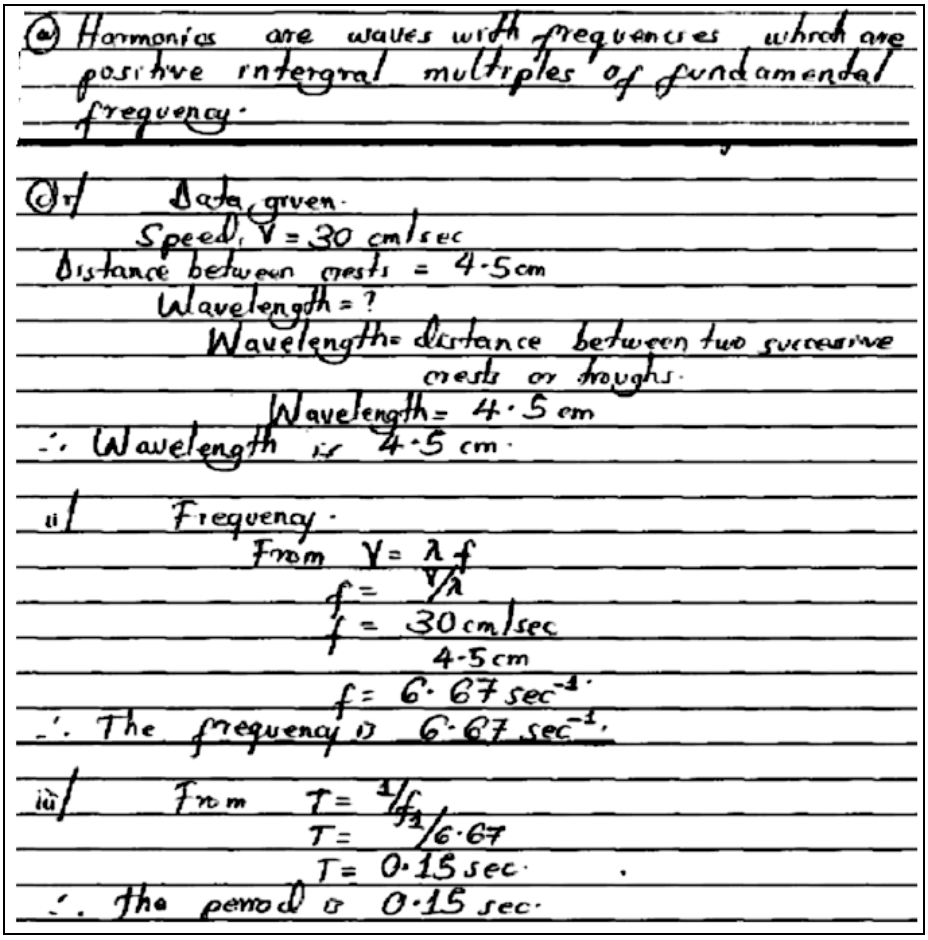


Figure 10: *The Candidates Performance in Question 9*

The candidates who scored average marks (4.5-9.5) were able to write correct formula for velocity, wave length and frequency of sound wave. However, they failed to write the correct formula for period of the ripple (wave) as they were confused with the term echo to identify that the speed is inversely proportional to time. They also failed to understand the demand of the question to find the distance between two men.

Further analysis show that the candidates who scored all marks were able to define the term harmonics as used in sound wave. In part (b) they were able to write correct formula for distance between two men and recognize that the sound with high speed will take minimum time to cover a distance between the men. Also they managed to apply simultaneous equations in computing the distance between the two men. In part (c) they applied mathematical skills to write the correct formula for wave length V= fλ, frequency f=v/λ and period of a sound wave $T=1/f$, hence to compute wave length, frequency and period of the ripples. Extract 9.1 is the sample of a correct response of a candidate who scored good marks in question 9.

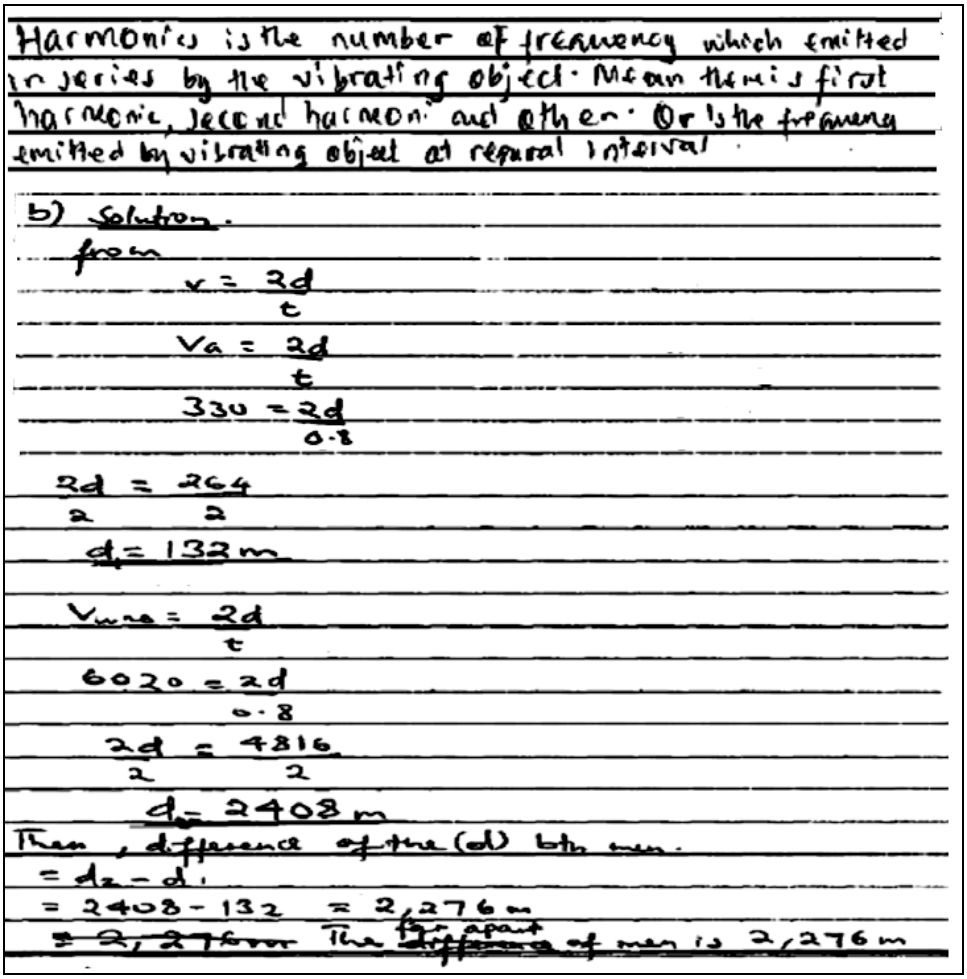


Extract 9.1: A sample of correct responses to question 9

Extract 9.1 shows a response from a candidate who was able to write the correct formula and apply simultaneous equations in computing the distance between the two men, the wave length, frequency and period of the ripples.

The responses of the candidate who scored 0 to 4 marks had several weaknesses. Most of the candidates lacked knowledge on harmonics and overtones concepts such as fundamental frequency. They were not able to differentiate between harmonics and overtone as used in sound waves. Also, they were confused with harmonics produced from the closed pipe and open pipe organs (sounding instruments).

In part (b) they failed to write correct formula for distance between two men, as they wrote $V=\frac{2d}{t}$ instead of $V=\frac{d}{t}$. They also failed to recognize that the sound with high speed will take minimum time to cover a distance between the men. In part (c) they lacked knowledge apply the correct formula for period of a sound wave and wave equation ($V= \lambda f$) by writing incorrect formula $T = 2\pi \sqrt{L/g}$ used in simple pendulum instead of the formula (T= 1/frequency, $T=1/f$) as used in sound wave. Extract 9.2 is a sample of an incorrect response of a candidate to question 9.


Harmonics is the number of frequency which emitted in series by the vibrating object. Mean the first harmonic, second harmonic and other. Or is the frequency emitted by vibrating object at regural interval

b) Solution.

from

$v = \frac{2d}{t}$

$V_a = \frac{2d}{t}$

$330 = \frac{2d}{0.8}$

$\frac{2d}{2} = \frac{264}{2}$

$d_1 = 132\,m$

$V_{wa} = \frac{2d}{t}$

$6020 = \frac{2d}{0.8}$

$\frac{2d}{2} = \frac{4816}{2}$

$d_2 = 2408\,m$

Then, difference of the (d) bth men.

$= d_2 - d_1$

$= 2408 - 132 = 2,276\,m$

$= 2,27$ from The [illegible] apart of men is $2,276\,m$

Extract 9.2: A sample of incorrect responses to question 9

Extract 9.2 shows a response from a candidate who applied incorrect formulae to determine the distance between two men, frequency and period of the ripple.

2.3.2 Question 10: Optics (Light)

The question was composed from the topic of *Optics (light).* It intended to assess the competence of candidates to describe and apply the second law of refraction. The question was:

(a) (i) Sketch a diagram which describe the second law of refraction of light.

(ii) A ray of light in air makes an angle of incidence 60 with a glass surface of refractive index 1.5. What is the angle of refraction?

(b) (i) The apparent depth of a swimming pool appears to be 0.5 m. If the refractive index of water is $\frac{4}{3}$*, calculate the real depth of water in the pool.*

(ii) A small object is placed at the bottom of a tall gas jar. If the glass jar is filled with water to a depth of 28 cm, how much is the object apparently displaced?

The question was attempted by 1400 (100%) candidates, out of these candidates, 377 (26.93%) scored from 0 to 4 marks, 648 (46.28%) candidates scored from 4.5 to 9.5 marks and 375 (26.79%) candidates scored from 10 to 15 marks. This data indicate that the general performance was good since 1123 (73.07%) majority of candidates scored from 4.5 to 15 marks. Figure 11 shows candidates' performance in this question.

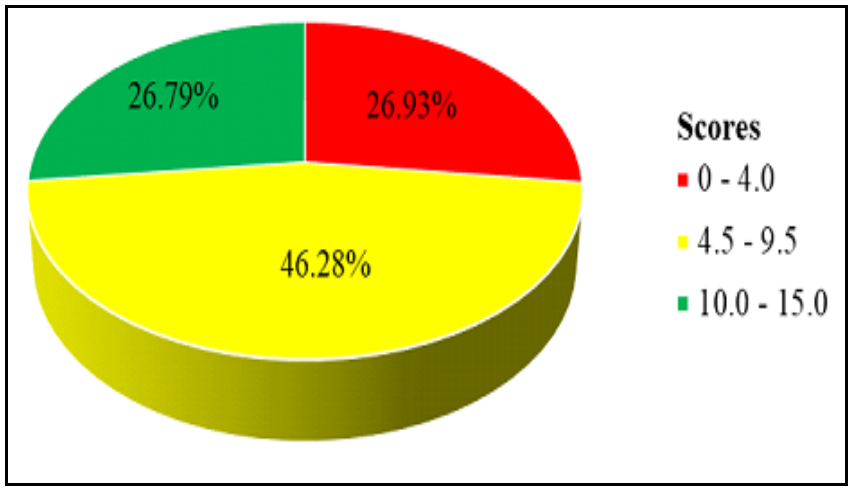
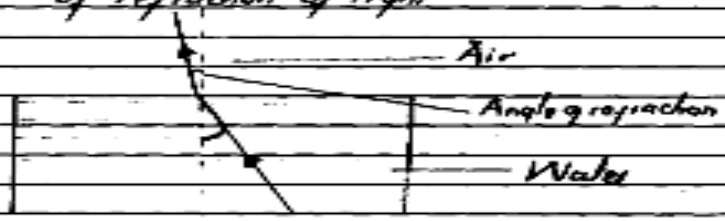


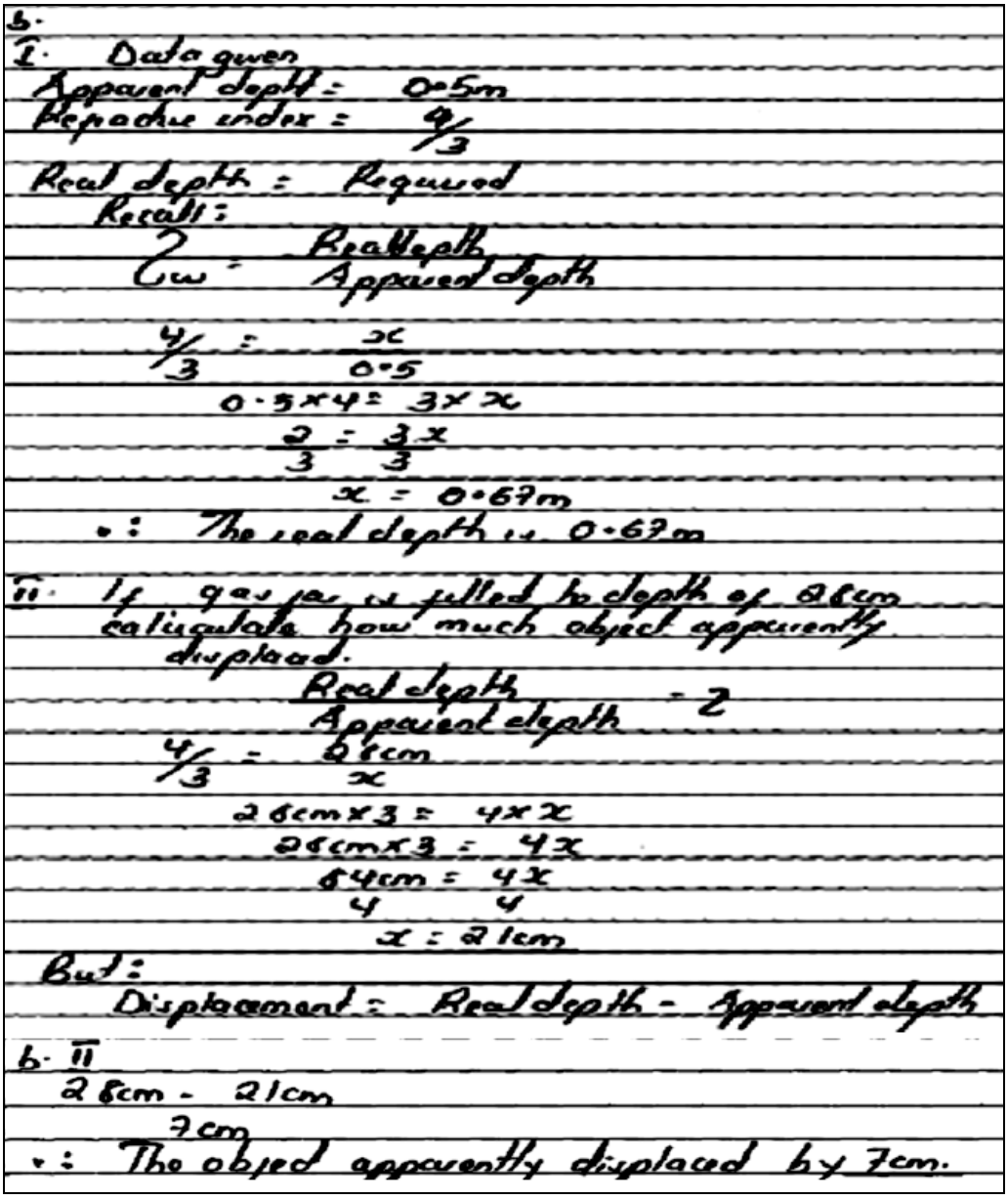
Figure 11: *The Candidates Performance in Question 10*

Analysis reveals that candidates who scored average marks (4.5-9.5) sketched graph of refraction of light and were able to write correct formula to calculate angle of refraction (Snell's Law). However, some of the candidates lacked mathematical skills to apply the concept of trigonometrical ratio. The candidates who scored all marks demonstrated good drawing skills in sketching the graph for refraction of light, also they were able to write correct formula for angle of refraction (Snell's law) such as: $n_1 \sin \theta_1 = n_2 \sin \theta_2$, where n_1 and n_2 are the refractive index of the first and second media, respectively, used to compute angle of refraction. In part (b) they were able to recall the correct equation for calculating real depth of water in the pool and apparent. Extract 10.1 is a sample of good response of a candidate who scored all marks in question 10.

a). Sketch diagram that describe second law of refraction of light



ii. Data provided:
Angle of incidence = 60°
Refractive index = 1.5
Angle of refraction = ?
Recall
$\frac{2}{1} = \frac{\sin i}{\sin r}$
$1.5 = \frac{\sin 60°}{\sin r}$
$\sin 60° = \sin r \times 1.5$
$\sin r = \frac{\sin 60}{1.5}$
$\sin r = \frac{0.866}{1.5}$
$\sin r = 0.577$
$\sin^{-1}(0.577) = \sin r$
$\sin r = \sin^{-1}(0.577)$
$\sin r = 35°14'$
∴ $\sin r$ is 35°
∴ Angle of refraction was 35°

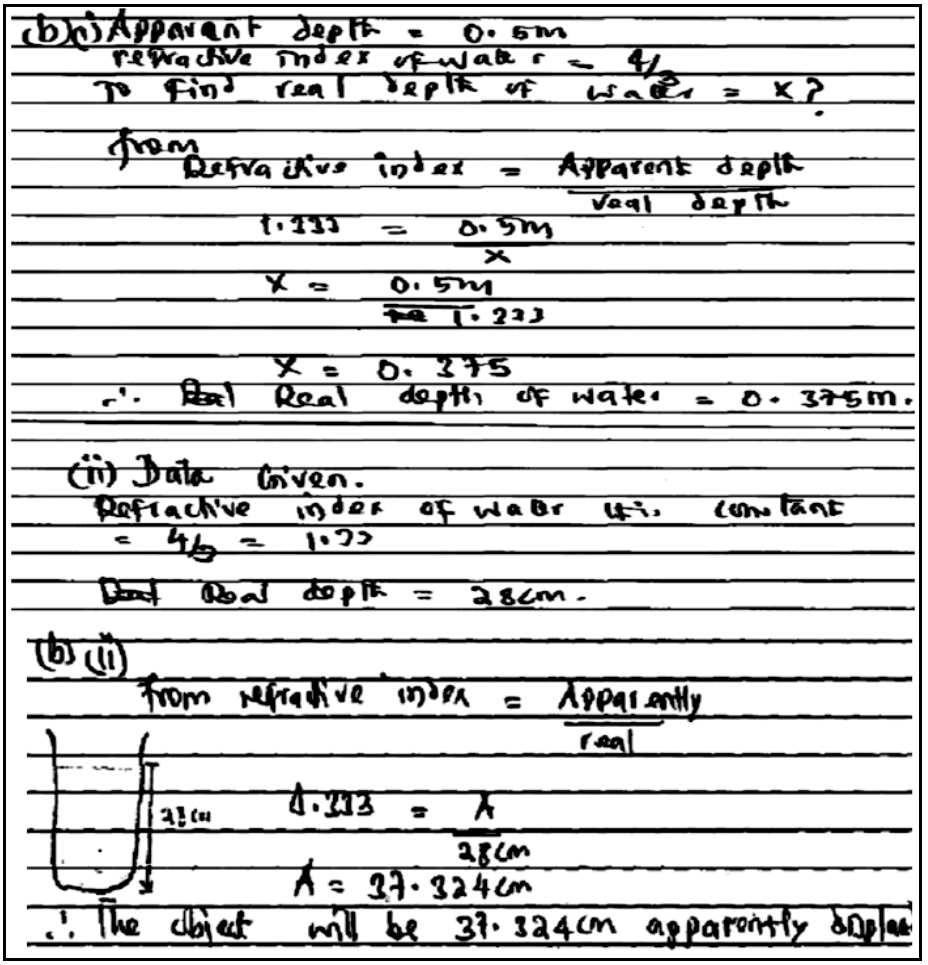


Extract 10.1: A sample of good responses to question 10

In Extract 10.1 a candidate was able to sketch, recall the correct equation and calculate the refractive index, real depth and apparent depth of water.

The candidates who scored low marks (0 – 4)lacked drawing skills to sketch graph for refraction of light, and the concept of Sneil's Law to determine the angle of refraction. Most of the candidates failed to

formulate the equation of relationship between real depth and apparent depth as used together with refractive index. Extract 10.2 is a sample of incorrect responses of a candidate who scored 0 mark in question 10.



Extract 10.2: A sample of incorrect responses to question 10

Extract 10.2 shows a candidate who was not able to sketch, recall formulae and calculate refractive index, real depth of water in the pool and apparent displacement.

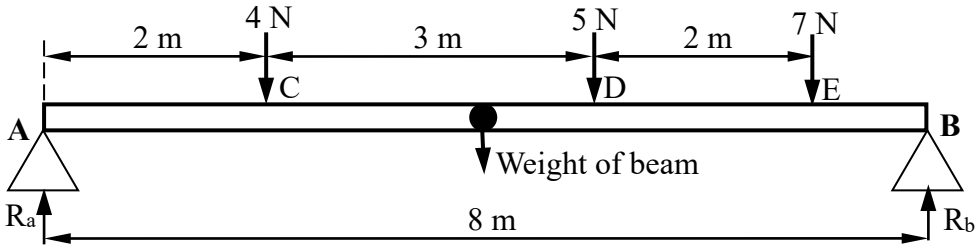
2.3.3 Question 11: Turning Forces

The question was composed from the topic of '*Turning Forces'*. It intended to measure the competence of candidates to describe, analyze and apply the concepts of turning forces. The question was:

A uniform beam AB, supported at its ends and carrying loads of 4 kN, 5 kN and 7 kN at C, D, and E respectively as shown in the figure below. If the reaction at B was R_b = 13 kN. Determine:

(a) The mass of the beam.

(b) The reaction at A.



The question was attempted by 810 (100%) candidates, out of these candidates, 442 (54.57%) scored from 0 to 4 marks, 111 (13.70%) candidates scored from 4.5 to 9.5 marks and 257 (31.73%) candidates scored from 10 to 15 marks. This data indicate that the general performance was average since (45.43%) of the candidates scored above 4 marks. Figure 12 shows candidates' performance in this question.

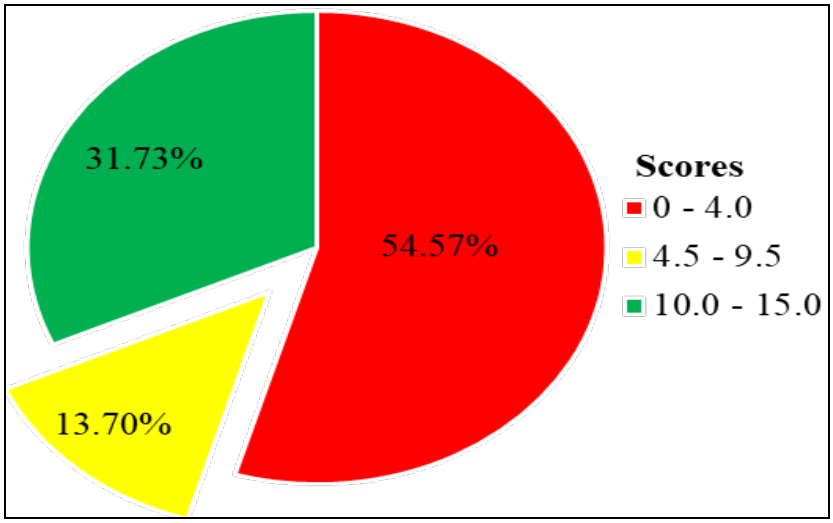
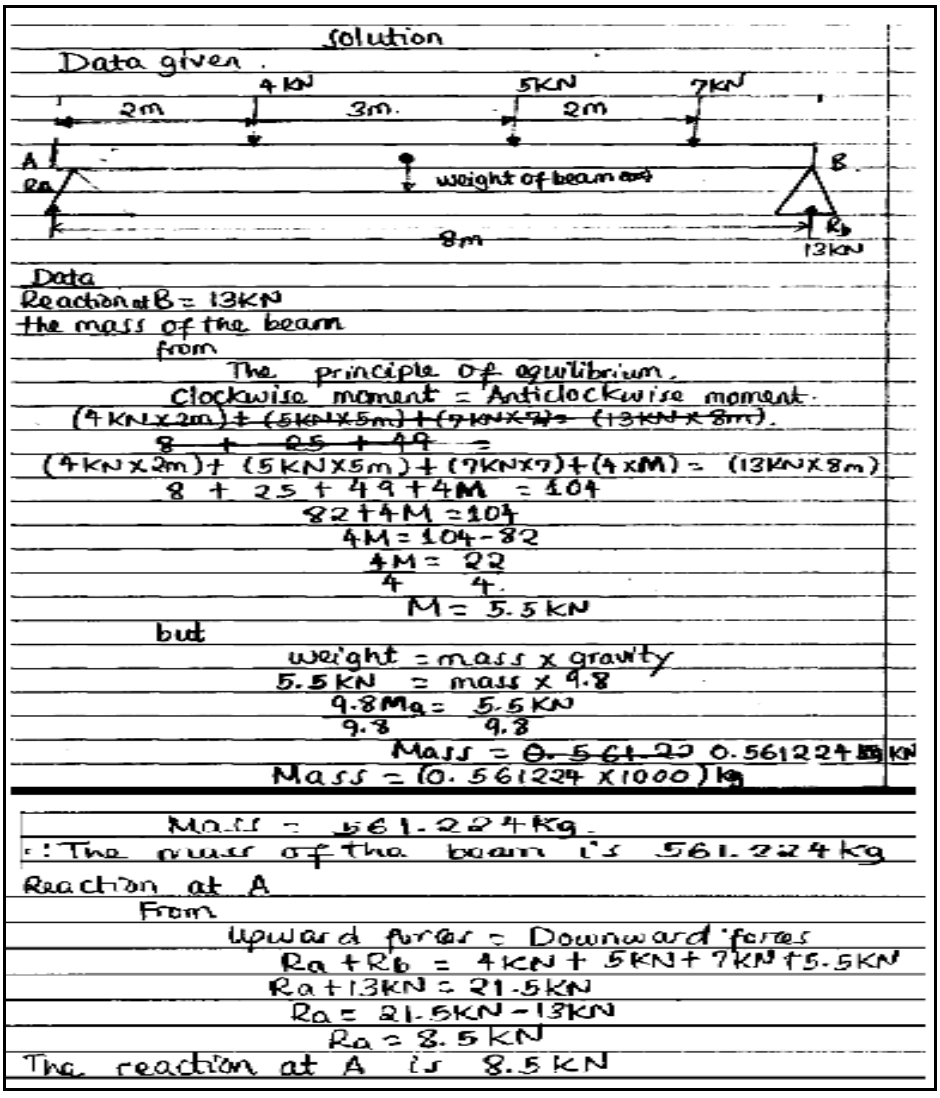


Figure 12: *The Candidates Performance in Question 11*

The candidates who scored average marks (4.5 - 9.5) managed to formulate the principle of moment and computed the weight of the beam but failed to convert into mass of the beam. Also, they were not able to

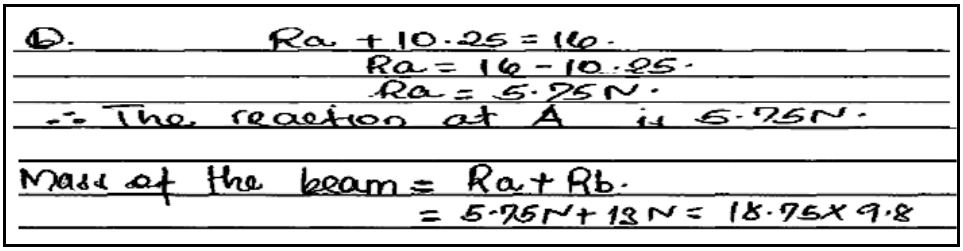
compute the reactions at point R_a because they failed to substitute the proper data. However, the candidates who scored all marks applied the principle of moment of a force to calculate mass of the beam. In addition, they demonstrated competence of computing the reactions at R_a of the beam but also to formulate the relation between sum of upward forces and downward forces for a beam to be in equilibrium. Extract 11.1 is a sample of correct responses of a candidate to question 11.



Extract 11.1: A sample of correct responses to question 11

In Extract 11.1 a candidate computed the weight of the beam, formulated and applied the principle of moment of a force. He/she also managed to convert the weight of the beam into mass.

However, the candidates who scored low marks (0 – 4) lacked knowledge of turning forces. Most of the candidates failed to formulate and apply the principle of moment of a force to determine the mass of the beam. They also failed to apply the 2nd conditions for equilibrium of parallel forces which says, sum of forces in one direction = Sum of forces in the opposite direction to determine the reaction at the support, A. Another weakness was lack of mathematical skills to formulate the relation between sum of upward forces and downward forces for a beam to be in equilibrium. Extract 11.2 is a sample of an incorrect response of a candidate to question 11.



Extract 11.2: A sample of incorrect responses to question 11

In Extract 11.2 the candidate failed to compute the required weight of the beam, formulate and apply the principle of moment of a force.

3.0 THE ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH TOPIC

A topic wise- analysis indicated that the performance of candidates on the multiple-choice questions from various topics was good, 90.42% of the candidates were above average and item (iii) from the topics simple machine was well performed, and the item (ix) was poorly performed.

The analysis of performance in the topics tested in the Engineering Science subject for the year 2023 indicates that, the candidates performed well in five (5) topics, average in six (6) topics. The candidates

demonstrated good performance in question 2 *linear motion (92.57%),* question 1 covering the topics of *Properties of Matter, Basic Electronics, Simple Machines, Electricity and Magnetism, Fluid Mechanics, Optics (Light), Sound wave, Heat, Measuring Instruments* and *Solar Energy and Energy Source (90.41%), Strength of Materials (81.13%), Force, Energy and Power (74.02%), Optics (Light)(73.07%)*. Candidates were able to identify the requirements of each questions and had adequate knowledge of the subject matter such as mechanics, electrical systems, the principles governing motion, including velocity, acceleration, and displacement. Also, they had problem-solving skills, and practical knowledge relevant to the area of study.

The topics in which the candidates' performed averagely were *Linear Motion (58.39%). Projectile Motion (54.51%), Angular Motion (46.63%), Turning Forces (45.43%), Electricity and Magnetism (44.73%), Sound Waves (42%).*The performance was average because some of the candidate failed partly to meet the requirement of the questions due to inadequate knowledge of the subject matter, insufficient knowledge of mathematical and problem solving and drawing skills.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The candidates' performance of the Certificate of Secondary Education Examination (CSEE) 2023 in Engineering Science subject was good as 75.03 percent passed. However, they faced some challenges while answering various questions on the topics of Projectile Motion, Angular Motion, Electricity and Magnetism, Turning Forces and Sound Waves. The candidates' weak performance has been contributed by the inability to: -

(a) Visualize and understand relationships among objects.
(b) Comprehend and apply mechanical concepts, including understanding how levers, pulleys, and other simple machines work together,
(c) Analyze and solve mathematical problems especially those related to measurements, calculations, and conversions.
(d) Interpret and understand technical drawings and diagrams.

4.2 Recommendations

In order to improve the candidates' performance in Engineering Science Subject, teachers are strongly advised to: -

(a) Plan to help learners acquire basic information and skills through experimentation, demonstration and modeling.

(b) Organize learners in small groups and one-on-one support system to enable students to interpret and practice various activities in drawings and diagrams.

(c) Assess and monitor candidate understanding throughout the learning process.

(d) Guide candidates to analyze and solve mathematical problems especially those related to measurements, calculations, and conversions.

Appendix

A Summary of Candidates' Performance Question-Wise in Engineering Subject for the Year 2023

S/N	Topic	Performance For Each Topic		Remarks
		Question Number	Percentage of candidates who Scored 30% or More	
1	Linear Motion	2	92.57	Good
2	Properties of Matter, Basic Electronics, Simple Machines, Electricity and Magnetism, Fluid Mechanics, Optics (Light), Sound wave, Heat, Measuring Instruments and Solar Energy and Energy Source.	1	90.41	Good
3	Strength of material	5	81.13	Good
4	Friction, Work, Energy and Power	3	74.02	Good
5	Optics (Light)	10	73.07	Good
6	Linear Motion	4	58.39	Average
7	Projectile Motion	7	54.51	Average
8	Angular Motion	6	46.63	Average
9	Turning Forces	11	45.43	Average
10	Electricity and Magnetism	8	44.73	Average
11	Sound Waves	9	42.00	Average