



THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA



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

BASIC MATHEMATICS



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041 BASIC MATHEMATICS

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FOREWORD

This report is based on the Candidates' Item Response Analysis (CIRA) on the Secondary Education Basic Mathematics National Examination which was conducted in November 2023. The preparation of this report was meant to provide feedback to all education stakeholders on the factors that contributed to the candidates' performance in the Basic Mathematics examination.

The Certificate of Secondary Education Examination (CSEE) intends to evaluate candidates' skills and knowledge gained in their four years of secondary education. The examination results provide feedback to teachers, students and other education stakeholders for the purpose of improving teaching and learning. The evaluation revealed that, 74.58 per cent of the candidates who sat for the Basic Mathematics examination failed. The candidates encountered several challenges including: failure to represent mathematical information by using graphs and figures; inability to formulate inequalities, expressions and equations; failure to apply correct formulae, rules, theorems, properties and mathematical procedures when performing mathematical computations; and lack of skills to simplify and solve mathematical expressions, equations and inequalities.

The Council believes that the feedback provided in this report will help students to identify their strengths and weaknesses to improve their learning before sitting for the examination. It will also help teachers to identify the challenging areas and take appropriate measures during the teaching and learning process.

The National Examinations Council of Tanzania (NECTA) believes that the feedback provided in this report will help to solve the challenges that contributed to the failure of candidates. Similarly, it will guide education stakeholders through taking appropriate measures to improve teaching and learning of the Basic Mathematics subject. As a result, students will acquire the intended knowledge, skills and competences for better performance in future examinations.

Lastly, the Council appreciates the contribution of all those who prepared this report.



Dr. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents both statistical and descriptive analyses of the candidates' item responses on the Certificate of Secondary Education Examination (CSEE) 2023 in the Basic Mathematics subject. The report also provides reasons for the candidates' success and failure to respond to the examination items.

The data analysis reveals that, out of 529,348 candidates who sat for Basic Mathematics examination in CSEE 2023, only 134,094 (25.42%) candidates passed, where in CSEE 2022, only 104,488 (20.08%) candidates passed out of 521,886 candidates who sat for the examination. Comparatively, the performance has increased by 5.34 per cent in CSEE 2023.

Based on the Basic Mathematics examination format, the paper consisted of two sections, A and B. Each question in Section A carried six (6) marks while each question in Section B carried 10 marks and candidates were required to answer all questions from both sections.

The candidates' performance on each question was rated as *Good*, *Average* or *Weak* given the percentage of candidates who passed was 65 – 100, 30 – 64 or 0 – 29 per cent, respectively.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE ON EACH QUESTION

This part provides the analysis of the candidates' performance on each question. The analysis includes the description of the requirements of the question, summary on how the candidates responded to the questions and the sample extracts of the candidates' correct and incorrect responses. This part also entails the factors that contributed to candidates' success and failure to get the correct responses to each question. The analysis of the candidates' performance and graphical presentation were done based on the score intervals of 6.0 – 4.0, 3.5 – 2.0 and 1.5 – 0.0 out of 6 marks in Section A; and 10 – 6.5, 6.0 – 3.0 and 2.5 – 0.0 out of 10 marks in Section B on each question to mean *Good* performance, *Average* performance and *Weak* performance, respectively.

2.1 Question 1: Numbers, Fractions, Decimals and Percentages

This question consisted of two parts, (a) and (b). Part (a)(i) intended to examine whether or not the candidates were able to arrange the numbers $0.\dot{6}$, $\frac{3}{5}$, and 20% of $\frac{13}{4}$ in ascending order of magnitude. Part (a)(ii) intended to examine whether they were able to perform mixed operations on integers in the expression $13 - 2 \times 3 + 14 \div (2 + 5)$. Part (b) examined whether they were able to find the Lowest Common Multiple (LCM) of 2, 3, and 5 by using the method of listing the multiples.

The data analysis reveals that 232,297 (43.9%) candidates passed this question and among them, 7,701 (1.5%) candidates scored all the allotted marks. Generally, the performance was average despite the fact that 118,338 (22.4%) candidates scored zero on this question. The candidates' performance on question 1 is summarized in Figure 1.

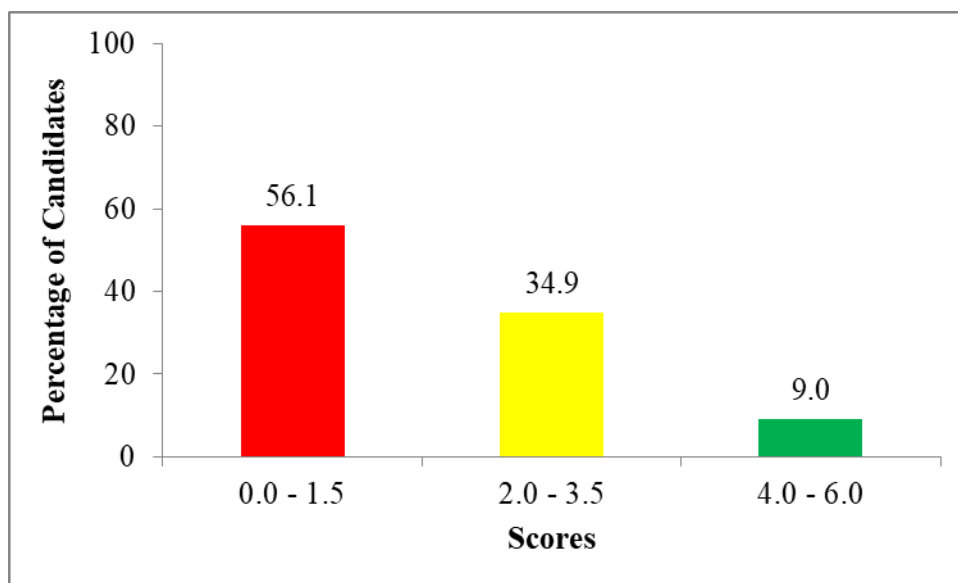


Figure 1: *Candidates' performance on question 1*

The analysis of responses shows that the candidates who answered the question correctly were able to apply the knowledge and skills gained after learning the concepts of numbers, fractions, decimals and percentages. In part (a)(i), the candidates were able to write the given numbers in ascending order. This was achieved by using different approaches. Some of the candidates succeeded to convert the numbers into decimals, that is

$0.\dot{6} = 0.666\dots$, $\frac{3}{5} = 0.6$, and 20% of $\frac{13}{4}$ as $\frac{20}{100} \times \frac{13}{4} = 0.65$. Thereafter, they used the resulting decimals to arrange the given numbers in ascending order. Other candidates converted the given numbers into fractions to get $\frac{2}{3}$, $\frac{3}{5}$ and $\frac{13}{20}$. They multiplied the resulting fractions by the LCM of their dominators to obtain the whole numbers, that is $\frac{2}{3} \times 60 = 40$, $\frac{3}{5} \times 60 = 36$ and $\frac{13}{20} \times 60 = 39$. The whole numbers obtained were used to arrange the given numbers in ascending order. Also, some of the candidates converted the fractions into percentages such that $\frac{2}{3} \times 100\% \approx 66.67\%$, $\frac{3}{5} \times 100\% = 60\%$ and $\frac{13}{20} \times 100\% = 65\%$. Similarly, the resulting percentages were used to arrange the given numbers in ascending order. In part (a)(ii), the candidates applied correctly the BODMAS rule when determining the value of the expression $13 - 2 \times 3 + 14 \div (2 + 5)$ to get 9, which is the correct answer.

In part (b), the candidates who scored all allocated marks were able to list the multiples of 2, 3 and 5 as follows: Multiples of 2 are 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, ... Multiples of 3 are 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, ... Multiples of 5 are 5, 10, 15, 20, 25, 30, ... Finally, they identified the LCM of these lists to obtain 30, which is the correct answer. Extract 1.1 shows a sample of responses from a candidate who answered this question correctly.

01.	(a, (i)	solution
	To arrange $0.\dot{6}$, $\frac{3}{5}$ and 20% of $\frac{13}{4}$ in ascending order.	
	To change them into Percentage.	
	Let $x = 0.\dot{6}$	
	$10x = 6.6$	
	$10x - x = 6.6 - 0.6$	
	$\frac{9x}{9} = \frac{6}{9}$	
	$x = \frac{2}{3} \times 100\%$	
	$0.\dot{6} = 66.67\%$	
	$\frac{3}{5} \times 100\%$	
	$\frac{3}{5} = 60\%$	
	20% of $\frac{13}{4}$.	
	$\frac{20}{100} \times \frac{13}{4}$	
	$\frac{13}{20} \times 100\%$	
	20% of $\frac{13}{4} = 65\%$	
	$\frac{3}{5}$, 20% of $\frac{13}{4}$ and $0.\dot{6}$	

	(ii) $13 - 2 \times 3 + 14 \div (2+5)$.
	Soln
	$13 - 2 \times 3 + 14 \div (2+5)$
	$= 13 - 2 \times 3 + 14 \div 7$
	$= 13 - (2 \times 3) + 2$
	$= 13 - 6 + 2$
	$= 13 + 2 - 6$
	$= 15 - 6$
	$= 9$
	$\therefore 13 - 2 \times 3 + 14 \div (2+5) = 9$
Q1.	bs solution.
	Multiples of 2 are: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22,
	24, 26, 28, 30, 32, 34, 36 ---
	Multiples of 3 are: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30,
	33, 36, 39 ---
	Multiples of 5 are: 5, 10, 15, 20, 25, 30, 35, 40, 45.
	$\therefore$ The LCM is 30.

Extract 1.1: A sample of correct responses to question 1

In Extract 1.1, part (a)(i), the candidate correctly converted the given numbers into percentages. He/she used the resulting percentages to arrange the numbers in ascending order. In part (a)(ii), he/she applied the BODMAS rule to get the correct value of the given expression. In part (b), the candidate listed the multiples of the numbers correctly and then identified the LCM.

On the other hand, the analysis of responses shows that the candidates who failed to answer this question correctly had insufficient knowledge and skills on the concepts of numbers, fractions, decimals and percentages. In part (a)(i), the candidates failed to arrange the given numbers in ascending order because they were not able to recognize that $0.\dot{6}$ is equal to $\frac{2}{3}$ and 20% of $\frac{13}{4}$ is equal to $\frac{13}{20}$. In part (a)(ii), they failed to evaluate the expression $13 - 2 \times 3 + 14 \div (2+5)$ as a result of failure to apply correctly

the BODMAS rule. In part (b), the candidates were unable to list the multiples of 2, 3 and 5, hence they failed to obtain the LCM. Also, some candidates listed the factors instead of multiples of 2, 3 and 5. Moreover, many candidates used a wrong method to get the LCM of the given numbers. They used the method of prime factorization contrary to the requirement of the question. Also, other candidates had a misconception that, the multiples of the given numbers are the squares, that is multiples of $2=4$, multiples of $3=9$, and multiples of $5=25$. They computed the LCM of 4, 9, and 25. These responses suggest that, the candidates did not acquire the examined competences during their learning process. Extract 1.2 shows a sample of responses from a candidate who answered this question incorrectly.

1.	Q) i) Arrange the given numbers in ascending order of magnitude.
	$0.\dot{6}\frac{3}{8}$ and 20% of $\frac{13}{4}$
	Solution.
	$0.\dot{6}\frac{3}{8}$ and 20% of $\frac{13}{4}$
	$0.\dot{6}\frac{3}{8} + 20\% \frac{13}{4}$
	$= 0.39 + 93\%$
	$0.39 + 93\%$
	$0 = 132\%$
	There fore :-
	$0.\dot{6}\frac{3}{8}$ and 20% of $\frac{13}{4}$
	$= 0.\dot{6} + \frac{3}{8} \times 20\% + \frac{13}{4}$
	$= 0.39 \times 93\%$
	$= 0.3627.$
	$\therefore$ The numbers in ascending order of magnitude is 0.3627.

	Q1 ii) $13 - 2 \times 3 + 14 \div (2 + 5) =$																												
	Soln																												
	$13 - 2 \times 3 + 14 \div 2 + 5 =$																												
	$13 - 2 = 11$																												
	$11 \times 3 = 33$																												
	$33 + 4 = 47$																												
	$47 \div 2 = 23$																												
	$23 + 5 = 28$																												
	$13 - 2 = 11 \times 3 = 33 + 14 = 47 \div 2 = 23$																												
Q1 b)	Soln																												
	multiple of 2 = 4																												
	multiple of 3 = 9																												
	multiple of 5 = 25																												
	then LCM																												
	<table border="1"><tr><td>2</td><td>4</td><td>9</td><td>25</td></tr><tr><td>2</td><td>2</td><td>9</td><td>25</td></tr><tr><td>3</td><td>1</td><td>9</td><td>25</td></tr><tr><td>3</td><td>1</td><td>3</td><td>25</td></tr><tr><td>5</td><td>1</td><td>1</td><td>25</td></tr><tr><td>5</td><td>1</td><td>1</td><td>5</td></tr><tr><td></td><td>1</td><td>1</td><td>1</td></tr></table>	2	4	9	25	2	2	9	25	3	1	9	25	3	1	3	25	5	1	1	25	5	1	1	5		1	1	1
2	4	9	25																										
2	2	9	25																										
3	1	9	25																										
3	1	3	25																										
5	1	1	25																										
5	1	1	5																										
	1	1	1																										
	$\therefore \text{LCM} = 2 \times 2 \times 3 \times 3 \times 5 \times 5 = 900$																												
	therefore; the LCM of multiples of 2, 3 and 5 are 900.																												

Extract 1.2: A sample of incorrect responses to question 1

In Extract 1.2, part (a)(i), the candidate performed irrelevant calculations on the given numbers. He/she was not able to arrange the numbers in ascending order. In part (a)(ii), the candidate failed to apply the BODMAS rule to evaluate the given expression. In part (b), the candidate failed to list the multiples of the numbers since he/she interpreted wrongly the meaning of multiples which resulted to an incorrect answer.

2.2 Question 2: Exponents, Radicals and Logarithms

The question had two parts, (a) and (b). In part (a), candidates were required to find the values of x and y that satisfy the system of simultaneous equations $5^{(x-2y)} = 25$ and $3^{2x} \div 3^y = 3^4$. In part (b), candidates were required to solve the equation $4 + 3\log_3 x = \log_3 24$.

The data analysis shows that 107,506 (20.3%) candidates passed this question. This indicates that, the candidates' performance on this question was weak. The analysis also shows that, 11,442 (2.2%) candidates scored full marks while 373,604 (70.6%) candidates scored zero. The candidates' performance on question 2 is summarized in Figure 2.

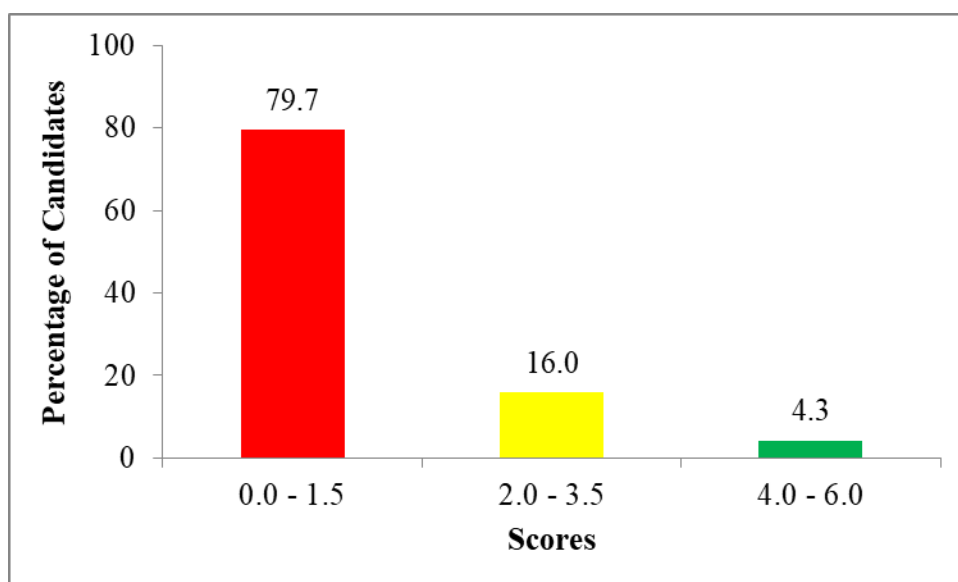


Figure 2: *Candidates' performance on question 2*

The analysis shows that, majority of the candidates performed poorly on this question due to lack of competence on the basic concepts of exponents, logarithms and simultaneous equations. The responses from those candidates show that the learning process on the examined competences did not yield the expected outcomes. In part (a), the candidates were not able to re-write the given exponential equations to the same bases, which was an essential step in solving the given system of equations. For example, they re-wrote $5^{(x-2y)} = 25$ as $5x - 10y = 25$ or $5^{(x-2y)} = 25$ as $x - 2y = 25$ and $3^{2x} \div 3^y = 3^4$ as $2x \div y = 3^4$ which were incorrect. Other candidates

managed to rewrite the given exponential equations to the same bases and generated correct equations but failed to solve the resulting linear simultaneous equations. In part (b), the candidates failed to solve the equation $4 + 3\log_3 x = \log_3 24$ as a result of lack of knowledge and skills on the application of laws of logarithms. They treated the equation $4 + 3\log_3 x = \log_3 24$ as $4 + 3x = 24$, while others re-wrote it as $7\log_3 x = \log_3 24$. Moreover, some candidates illogically solved the equation $4 + 3\log_3 x = \log_3 24$ by taking the constant term 4 and multiplied it by $3x$ while ignoring $\log_3$ to get $12x = 24$. Extract 2.1 shows a sample of responses from a candidate who answered this question incorrectly.

02. a)	$\begin{cases} 5^{(x-2y)} = 25 \\ 3^{2x} \div 3^y = 3^4 \end{cases}$
	$\begin{cases} 5x - 10y = 25 \\ 6 \times 3^{2x} \div 3^y = 3^4 \end{cases}$
	$\begin{cases} 5x - 10y = 25 \\ 2x - y = 4 \end{cases}$
	$\begin{cases} 10x - 20y = 50 \\ 10x + 5y = 20 \end{cases}$
	$20y - 5y = 50 - 20$
	$15y = 30$
	$y = 2$
	$2x - y = 4$
	$2x - 2 = 4$
	$2x = 4 + 2$
	$2x = 6$
	$x = 3$
	$\therefore \text{value of } x = 3, y = 2$

Ⓐ	$4 + 3 \log_3 x = \log_3 24$
	$4 + \log_3 x^3 = \log_3 24$
	$\frac{2 \mid 24}{2 \mid 12}$
	$4 + x^3 = 24$
	$x^3 = 24 - 4$
	$x^3 = 20$

Extract 2.1: A sample of incorrect responses to question 2

In Extract 2.1, part (a), the candidate failed to apply the laws of exponents to find the values of x and y that satisfy the given equations. He/she wrongly interpreted the system of equations. In part (b), the candidate lacked knowledge and skills on the laws of logarithms, hence he/she made illogical calculations.

On the other hand, the analysis of responses shows that the candidates who performed well on this question applied their competences on the basic concepts of exponents and logarithms. In part (a), they applied correctly the laws of exponents to rewrite the given exponential equations so that the terms have the same bases. They expressed $5^{(x-2y)} = 25$ as $5^{(x-2y)} = 5^2$ and $3^{2x} \div 3^y = 3^4$ as $3^{2x-y} = 3^4$. Thereafter, they considered that, if the bases are the same, then the exponents must be equal. They used this relationship to get the equations, $x - 2y = 2$ and $2x - y = 4$. They solved the equations simultaneously to get $x = 2$ and $y = 0$, which is the correct solution.

Further analysis shows that, there were candidates who applied common logarithms on both sides of the given exponential equations. For instance, they expressed $5^{(x-2y)} = 25$ as $\log 5^{(x-2y)} = \log 25$ and $3^{2x} \div 3^y = 3^4$ as $\log (3^{2x} \div 3^y) = \log 3^4$. Thereafter, they used the power law of logarithms to obtain the equations $x - 2y = 2$ and $2x - y = 4$. In part (b), the candidates were able to solve the equation $4 + 3 \log_3 x = \log_3 24$ by applying the laws of logarithms. They used the power law of logarithms to convert the equation into $\log_3 x^3 + \log_3 81 = \log_3 24$. Thereafter, they used the product law of logarithms to obtain $\log_3 81x^3 = \log_3 24$ which gives the equation

$81x^3 = 24$. They solved the equation obtained to get $x = \frac{2}{3}$. Extract 2.2 shows a sample of responses from a candidate who answered this question correctly.

2	a)	solution
		Given that:
		$5^{(x-2y)} = 25$
		$5^x \times 5^{-2y} = 5^2$
		$x - 2y = 2 \dots \dots \text{eqn(i)}$
		$3^{2x} = 3^4$
		3^y
		$3^{2x-y} = 3^4$
		$2x - y = 4 \dots \dots \text{eqn(ii)}$
		Solve simultaneously
		$\begin{array}{r l} 2 & x - 2y = 2 \\ 1 & 2x - y = 4 \end{array}$
		$\begin{array}{r l} & 2x - 4y = 4 \\ - & 2x - y = 4 \end{array}$
		$-3y = 0$
		$-3 \quad -3$
		$y = 0$
		From; $2x - y = 4$
		$2x - 0 = 4$
		$2x = 4$
		$\frac{2x}{2} = \frac{4}{2} \quad x = 2$
		$\therefore$ The value of $x = 2$ and the value of $y = 0$

2	b)	solution
		$4 + 3\log_3 x = \log_3 24$
		$4 + 3\log_3 x = \log_3 8 + \log_3 3$
		$4 + 3\log_3 x = \log_3 8 + 1$
		$3 + 3\log_3 x = \log_3 8$
		$\log_3 x^3 + 3 = \log_3 8$
		$\log_3 x^3 - \log_3 8 = -3$
		$\log_3 (x^3/8) = -3$
		$3^{-3} = \frac{x^3}{8}$
		$\sqrt[3]{\frac{1}{3^3}} = \sqrt[3]{\frac{x^3}{2^3}}$
		$\frac{1}{3} = \frac{x}{2}$
		$\frac{3x}{3} = \frac{2}{3}$
		$x = \frac{2}{3}$

Extract 2.2: A sample of correct responses to question 2

In Extract 2.2, part (a), the candidate correctly applied the laws of exponents and mathematical skills on solving linear simultaneous equations in two variables to obtain the correct values of x and y . In part (b), the candidate applied correctly the laws of logarithms to convert the logarithmic equation into a polynomial equation. He/she solved the resulting equation to get the correct solution.

2.3 Question 3: Sets and Probability

The question consisted of two parts, (a) and (b). In part (a), candidates were given the universal set $\xi = \{15, 30, 45, 60, 75\}$ and the subsets, $A = \{15, 45\}$ and $B = \{30, 60\}$. They were required to find $(A \cup B)'$ and represent the given information in a Venn diagram. In part (b)(i), the question stated that “In a class of 50 students, 35 are boys and 15 are girls. If a student is chosen at random, what is the probability that he is a boy?”. In part (b)(ii), candidates were given the information that “Jonika has two shirts, blue and red. He also has three trousers, black, green and yellow”. By using a tree diagram, they were required to find the probability that he will put on a blue shirt and black trouser.

The data analysis shows that 3,970 (0.8%) candidates got full marks out of 62,277 (11.8%) candidates who passed this question, which indicates that the performance was weak. However, it was observed that 377,995 (71.4%) candidates scored zero. Figure 3 presents a summary of the candidates’ performance on question 3.

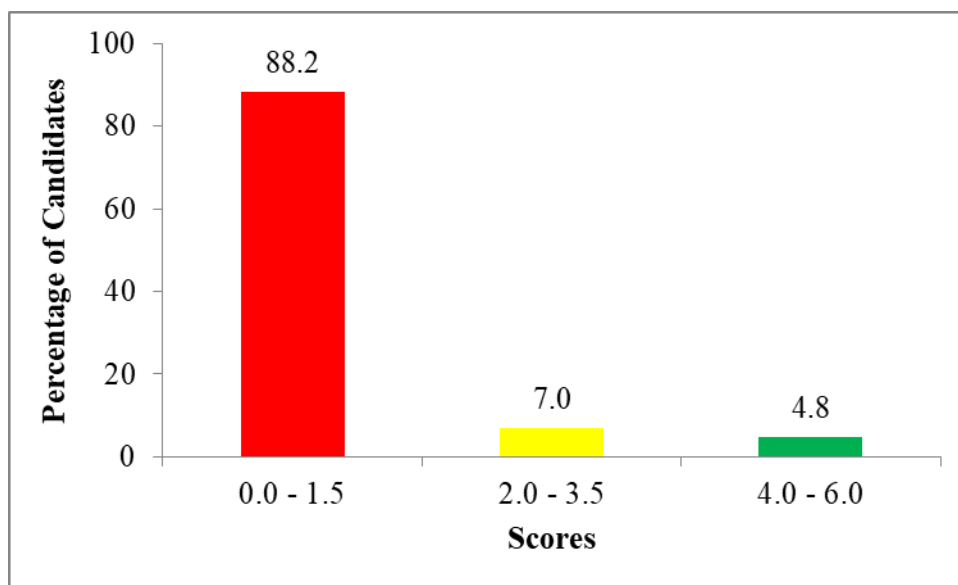


Figure 3: *Candidates’ performance on question 3*

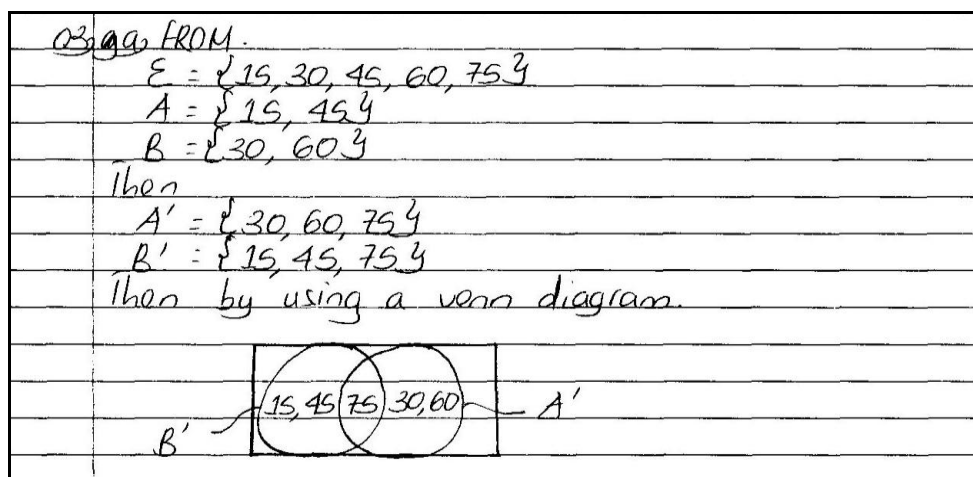
The response analysis shows that the candidates who performed poorly on this question have insufficient knowledge and skills on the basic concepts of sets and probability. In part (a), they failed to determine the elements of

the sets $(A \cup B)$ and $(A \cup B)'$. This failure led to wrong presentation of information in a Venn diagram. Some candidates misinterpreted the terms “intersection” and “compliment” of sets since they placed the element 75 in the intersection of the sets, A and B. They failed to recognize that the sets, A and B are disjoint and the element 75 is a member of the complement of $A \cup B$. In part (b)(i), the candidates were not able to recall the correct formula for the probability of an event. They wrote $P(E) = \frac{n(S)}{n(B)}$ instead

of $P(B) = \frac{n(B)}{n(S)}$, where $n(S)$ is the number of students in the class, $n(B)$ is

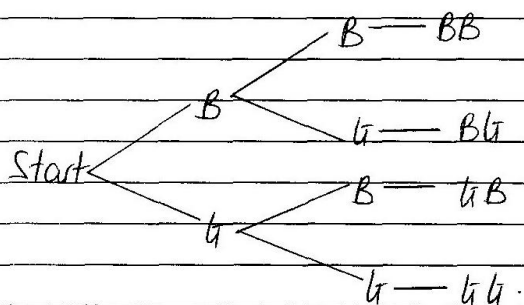
the number of boys in the class and $P(B)$ is a probability that the chosen student is a boy. Upon substitution of the given data, they got $P(E) = \frac{50}{35} = \frac{10}{7}$, which is an incorrect answer. In part (b)(ii), the

candidates misinterpreted the information from the word problem. Thus, they failed to draw a well labelled tree diagram. Hence, they made incorrect calculations of the required probability. Some candidates drew tree diagrams properly but they applied irrelevant formulae like $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ instead of $P(A \cup B) = P(A) \times P(B)$ for two independent events A and B. Extract 3.1 shows a sample of responses from a candidate who answered the question incorrectly.



Q3) b) i) Then.

FROM: By using a tree diagram.



FROM $n(S) = 50$

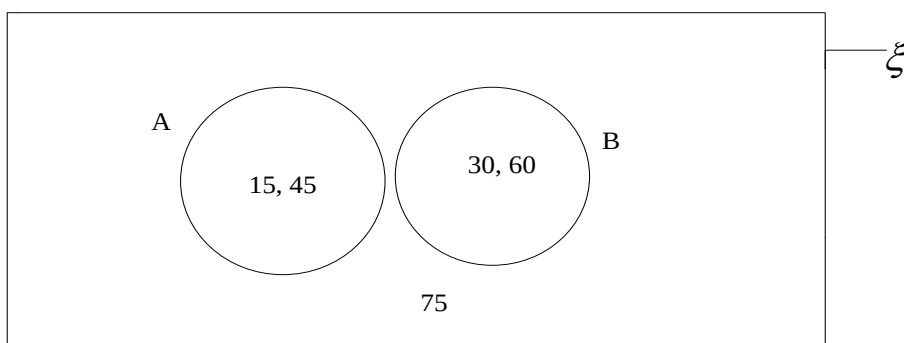
$n(E) = 3$

FROM $P(E) = \frac{n(E)}{n(S)}$

$$P(E) = \frac{3}{50}$$

∴ The probability is $P(E) = \frac{3}{50}$.

Despite the weak performance, there were candidates who performed well on this question. The candidates were able to apply the knowledge and skills developed after learning the basic concepts of sets and probability. In part (a), they were able to identify the elements of $A \cup B$ which were $A \cup B = \{15, 30, 45, 60\}$. Next, they determined the set $(A \cup B)' = \{75\}$. Lastly, they appropriately represented the information in a Venn diagram as follows.



In part (b)(i), the candidates were able to determine the probability of the event that the student chosen is a boy. They correctly identified the number of elements in the sample space and applied the correct formula,

$P(B) = \frac{n(B)}{n(S)}$, to compute the required probability. Upon using the

information from the Venn diagram, they obtained $P(B) = \frac{7}{10}$, which is the

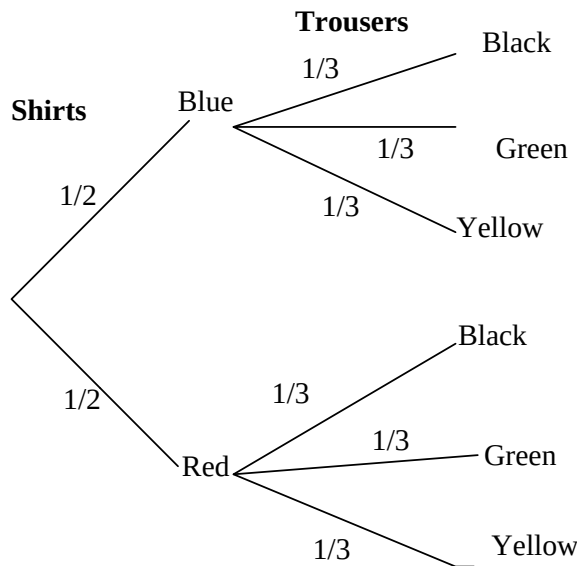
correct answer. In part (b)(ii), the candidates were able to use a tree diagram to present the given information. They deduced the elements of the sample space from the tree diagram. That is,

$S = \{B_S B_T, B_S G_T, B_S Y_T, R_S B_T, R_S G_T, R_S Y_T\}$, where B_S represents a blue shirt, R_S represents a red shirt, B_T represents a black trouser, G_T represents a green trouser and Y_T represents a yellow trouser. Thus,

they got $n(S) = 6$, $E = \{B_S B_T\}$ and $n(E) = 1$. They were able to apply the

correct formula, that is $P(E) = \frac{n(E)}{n(S)}$. Finally, they made proper

substitutions and computations to get $P(E) = \frac{1}{6}$. Moreover, some of the candidates recognized that the two events are independent. Thus, they used a tree diagram to determine the probability of each event as follows.



From the tree diagram, the candidates applied the correct formula, $P(\text{Blue and Black}) = P(\text{Blue}) \times P(\text{Black})$, where $P(\text{Blue}) = \frac{1}{2}$ and $P(\text{Black}) = \frac{1}{3}$. They made proper substitution and performed correct computations to obtain $P(\text{Blue and Black}) = \frac{1}{6}$. Extract 3.2 shows a sample of responses from a candidate who answered the question correctly.

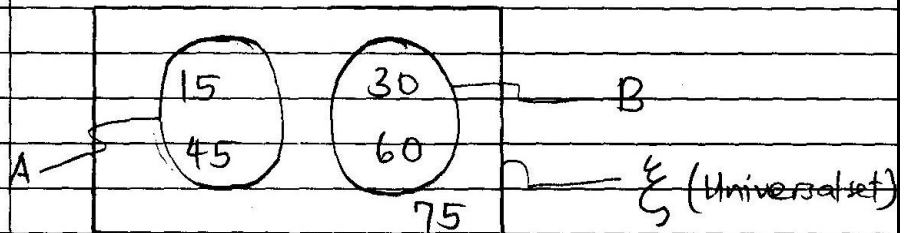
3. a) $\Omega = \{15, 30, 45, 60, 75\}$.

$A = \{15, 45\}$

$B = \{30, 60\}$.

$(A \cup B) = \{15, 45, 30, 60\}$.

$(A \cup B)^c = \{75\}$



3 b) D soln.

no of girls = 15

no of boys = 35

Total no = 50.

Probability = $\frac{n(\text{Events})}{n(\text{Sample spaces})}$

$P(\text{Boy}) = \frac{n(\text{Boys})}{n(\text{Sample spaces})}$

$P(\text{Boy}) = \frac{35}{50}$

$P(\text{Boy}) = \frac{7}{10}$

$\therefore$ Probability that The chosen was boy = $\frac{7}{10}$.

3 b, (ii) Soln

Trousers : black, green and yellow
 Shirt : blue and red

```

graph LR
    Start --> shirt
    Start --> Red
    shirt --> blue
    blue --> Trousers_black[black]
    blue --> green
    blue --> Yellow
    Red --> Trousers_black_2[black]
    Red --> green
    Red --> Yellow
  
```

$n(S) = 6$
 $n(E) = 1$
 $P(E) = \frac{n(E)}{n(S)} = \frac{1}{6}$

$\therefore$ The probability that he will wear blue shirt and black trouser is $\frac{1}{6}$

Extract 3.2: A sample of correct responses to question 3

In Extract 3.2, part (a), the candidate correctly determined the set $(A \cup B)' = \{75\}$ and represented the information in a Venn diagram. In part (b)(i), the candidate extracted correct data from the word problem and applied a suitable formula to get the correct answer. In part (b)(ii), the candidate sketched a well labelled tree diagram and used it to get the required probability.

2.4 Question 4: Coordinate Geometry and Vectors

This question comprised two parts, (a) and (b). In part (a), candidates were required to show that the triangle whose vertices are $A(4, -4)$, $B(-6, -2)$, and $C(2, 6)$ is isosceles. In part (b), the question stated that, “A man walks 4 km from village P to village Q and then 3 km to village R. If village Q is $N60^\circ E$ of P; and R is $N30^\circ W$ of Q, (i) represent the information in a well labelled diagram and (ii) find the resultant displacement of the man from P to R”.

Based on the data analysis 49,027 (9.3%) candidates passed this question, of which 95 (0.02%) candidates scored all the allotted marks. Overall, the candidates’ performance on this question was weak. On the other hand, 420,031 (79.4%) candidates scored zero on this question. A summary of the candidates’ performance on question 4 is shown in Figure 4.

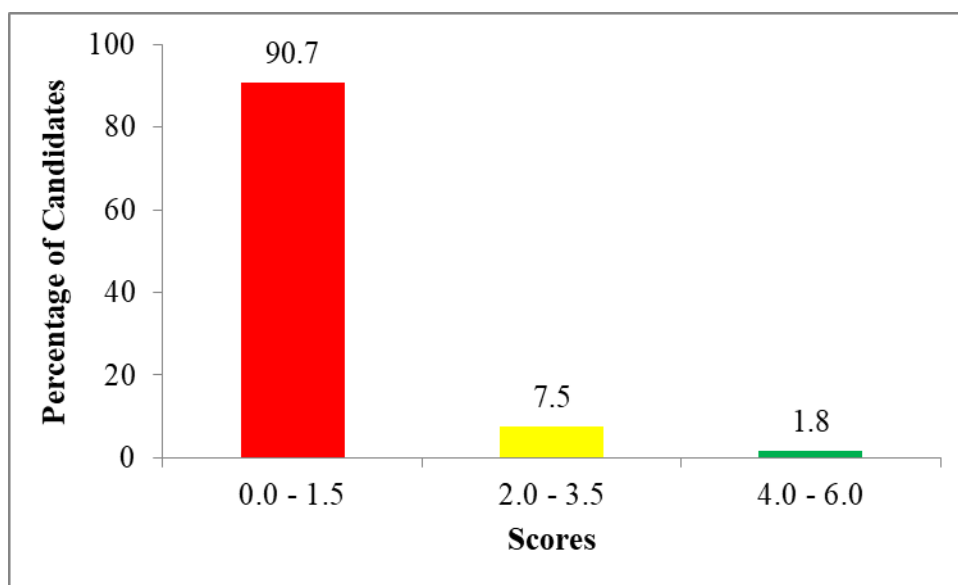
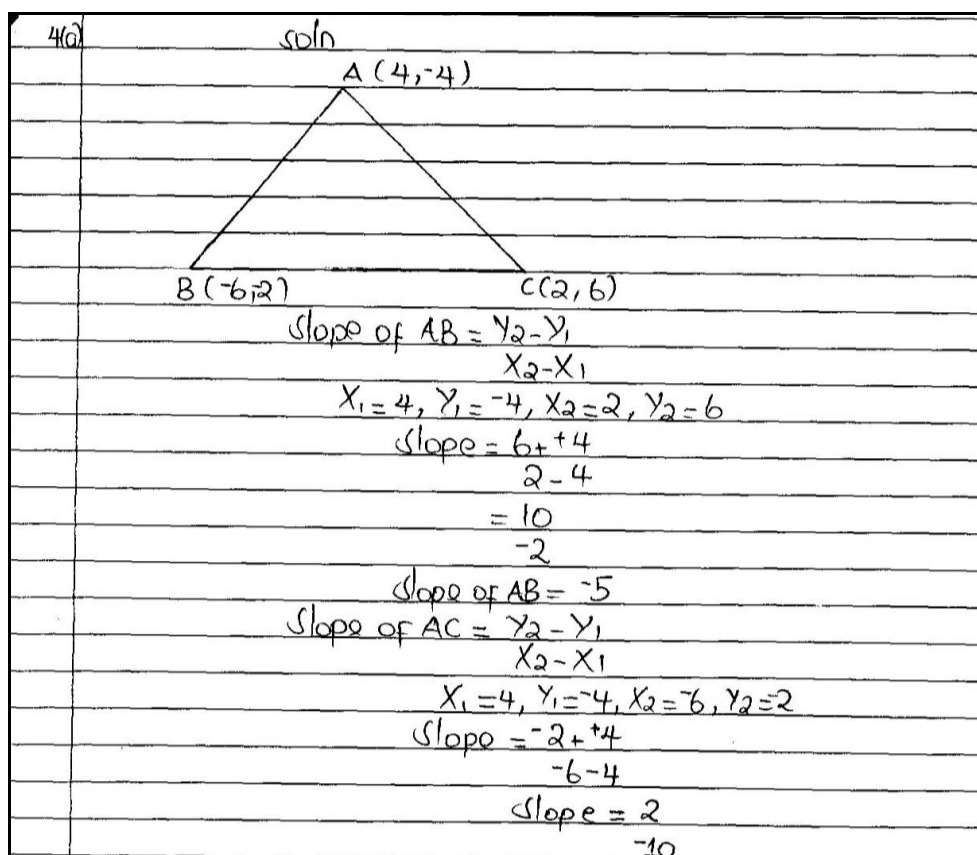
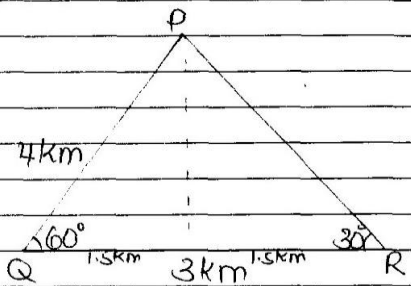


Figure 4: *Candidates’ performance on question 4*

According to the response analysis, most of the candidates performed poorly on this question. The candidates had insufficient knowledge and skills on the basic concepts of coordinate geometry and vectors. In part (a), some of the candidates applied incorrect distance formulae such as $d = \sqrt{(x_2 + x_1)^2 + (y_2 + y_1)^2}$, which led to wrong values of the lengths of the sides of the triangle ABC. Thus, they were not able to prove that the given

points form an isosceles triangle. Other candidates applied the correct distance formula but substituted wrongly the values of the coordinate points. Furthermore, some candidates applied inappropriately the formula for the mid-point to find the distance between two points. Thus, they could not manage to provide clear and logical arguments in their proofs. In part (b), the candidates failed to interpret and extract useful information from the word problem that were necessary in drawing the vector diagram. Some of the candidates drew right-angled triangles without indicating the directions of P, Q, and R. Other candidates applied incorrect formulae to find the resultant displacement such as $R_D = D_1 + D_2$ instead of applying the Pythagoras' theorem, $\overline{PQ}^2 + \overline{QR}^2 = \overline{PR}^2$. Moreover, some of the candidates could not recognize that the triangle PQR is a right-angled triangle. They wrongly applied the sine rule $\frac{R}{\sin R} = \frac{Q}{\sin Q}$. Extract 4.1 shows a sample of responses from a candidate who answered this question incorrectly.



4(b)(i)	soln
	
4(b)(ii)	soln
$\cos R = \frac{\text{Adj}}{\text{Hyp}}$ $\cos 30^\circ = \frac{1.5}{x}$ $x (\cos 30^\circ) = 1.5$ $x = \frac{1.5}{\cos 30^\circ}$ $x = 1.73 \text{ km}$ $= 1.73 \text{ km}$ $\therefore$ The resultant displacement is 1.73 km	

Extract 4.1: A sample of incorrect responses to question 4

In Extract 4.1, part (a), the candidate wrongly used the concept of gradient to show that the triangle ABC is an isosceles. In part (b)(i), the candidate interpreted wrongly the given information. He/she failed to represent properly the given information in a diagram. In part (b)(ii), the candidate applied trigonometric ratio of cosine to find the resultant displacement.

However, there were candidates who performed well on this question. The candidates had sufficient knowledge and skills on coordinate geometry and vectors. In part (a), the candidates demonstrated good understanding on the application of the distance formula, $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ to show that the vertices $A(4, -4)$, $B(-6, -2)$ and $C(2, 6)$ form an isosceles triangle. They substituted the coordinates of the given vertices in the formula, $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ to get the lengths of the sides of the triangle as follows:

$$\overline{BC} = \sqrt{(2+6)^2 + (6+2)^2} = \sqrt{128} \text{ units,}$$

$$\overline{AC} = \sqrt{(2-4)^2 + (6+4)^2} = \sqrt{104} \text{ units and}$$

$$\overline{AB} = \sqrt{(-6-4)^2 + (-2+4)^2} = \sqrt{104} \text{ units.}$$

They observed from the computations that the two lengths of the sides of the triangle ABC are equal, that is $\overline{AC} = \overline{AB} = \sqrt{104}$ units. Thus, they concluded that the triangle ABC is isosceles. Other candidates located the vertices A(4, -4), B(-6, -2) and C(2, 6) on the xy-plane correctly and measured the distance joining the points by using a ruler to get the approximate values of the lengths of the triangle, that is $\overline{AC} \approx 10.2$ units, $\overline{BC} \approx 11.3$ units, and $\overline{AB} \approx 10.2$ units. Similarly, they concluded that, the triangle ABC is isosceles because its two sides have equal lengths.

In part (b)(i), the candidates were able to interpret and correctly represent the information in a well labelled diagram. In part (b)(ii), they applied Pythagoras' theorem correctly to find the resultant displacement from P to R, that is $\overline{PQ}^2 + \overline{QR}^2 = \overline{PR}^2$ which resulted to $\overline{PR} = \sqrt{4^2 + 3^2} = 5$ km. They determined the direction of the resultant displacement using the trigonometric ratio of $\tan \theta = \frac{3}{4}$ to get $\theta = 36^\circ 52'$ or 36.9° which enabled them to obtain the direction of R from P, that is $60^\circ - 36.9^\circ = 23.1^\circ$. Thereafter, they concluded that the resultant displacement of R is 5 km in the direction N23.1°E of P. The responses from these candidates demonstrate good understanding on the examined competences. This signifies that, they have acquired sufficient knowledge and skills during the learning process. Extract 4.2 shows a sample of correct responses from one of the candidates who answered this question correctly.

4(a)	For isosceles triangle, two sides are equal in length.
	From distance formula, $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
	For distance $\overline{AB}$
	$A(4, -4)$ $B(-6, -2)$ let A be (x_1, y_1) , $B(x_2, y_2)$
	$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
	$d = \sqrt{(-6 - 4)^2 + (-2 - (-4))^2}$
	$d = \sqrt{(-10)^2 + (2)^2}$
	$d = \sqrt{100 + 4}$
	$d = \sqrt{104}$
	$d = \sqrt{104}$ units.
	For distance $\overline{BC}$
	$B(-6, -2)$ $C(2, 6)$ let B be (x_1, y_1) $C(x_2, y_2)$
	$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
	$d = \sqrt{(2 - (-6))^2 + (6 - (-2))^2}$
	$d = \sqrt{(8)^2 + (8)^2}$
	$d = \sqrt{64 + 64}$
	$d = \sqrt{128}$
	$d = \sqrt{128}$ units
	For distance $\overline{AC}$
	$A(4, -4)$ $C(2, 6)$ let A be (x_1, y_1) C be $(2, 6)$.
	$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
	$d = \sqrt{(2 - 4)^2 + (6 - (-4))^2}$
	$d = \sqrt{(-2)^2 + (10)^2}$
	$d = \sqrt{4 + 100}$
	$d = \sqrt{104}$
	$d = \sqrt{104}$ units
	Since distance $\overline{AB}$ and $\overline{AC}$ are equal that is $\sqrt{104}$ units
	$\therefore$ The triangle whose vertices are $A(4, -4)$
	$B(-6, -2)$ and $C(2, 6)$ is an isosceles
	triangle. Hence shown.

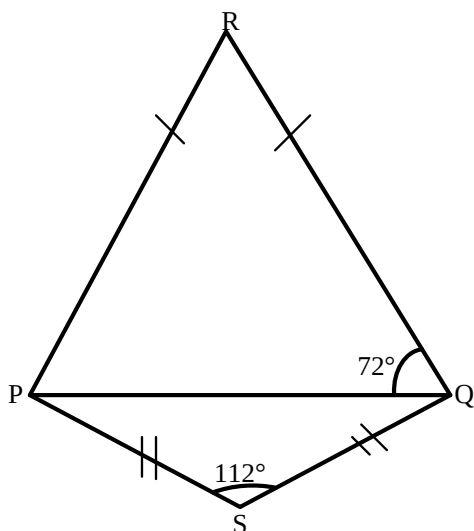
4.b)	
i)	
ii)	$a^2 + b^2 = c^2$ $(4\text{km})^2 + (3\text{km})^2 = c^2$ $16\text{km}^2 + 9\text{km}^2 = c^2$ $\sqrt{25\text{km}^2} = c$ $c = 5\text{km}$ $\tan \theta = \frac{3}{4}$
4.b)	
ii)	$\tan \theta = \frac{3\text{km}}{4\text{km}}$ $\tan \theta = 0.75$ $\theta = \tan^{-1}(0.75)$ $\theta = 36.9^\circ$ $= 60^\circ - 36.9^\circ$ $= 23.1^\circ$ So, resultant displacement of the man from P to R is 5 km N23.1°E.

Extract 4.2: A sample of correct responses to question 4

In Extract 4.2, part (a), the candidate applied the distance formula correctly to show that the triangle ABC is isosceles. In part (b)(i), the candidate interpreted the information correctly and he/she represented them in a well labelled diagram. In part (b)(ii), the candidate managed to find the resultant displacement of the man from P to R. He/she applied the Pythagoras' theorem and trigonometry to obtain the correct answer.

2.5 Question 5: Geometry, Perimeters and Areas

This question consisted of two parts, (a) and (b). In part (a), candidates were required to find the size of the angle RPS in the following figure, given that $RPQ = PQR$ and $SPQ = SQP$.



In part (b), candidates were required to find the height of a triangular field whose base is 60 m, given that its area is equal to the area of a rectangular field which is 72 m long and 40 m wide.

According to the data analysis, 82,483 (15.6%) candidates passed this question and among them, 27,054 (5.1%) candidates scored all the allotted marks. This indicates that the candidates' performance on this question was weak. However, the data analysis shows that 413,228 (78.1%) candidates scored zero on this question. Figure 5 presents the candidates' performance on question 5.

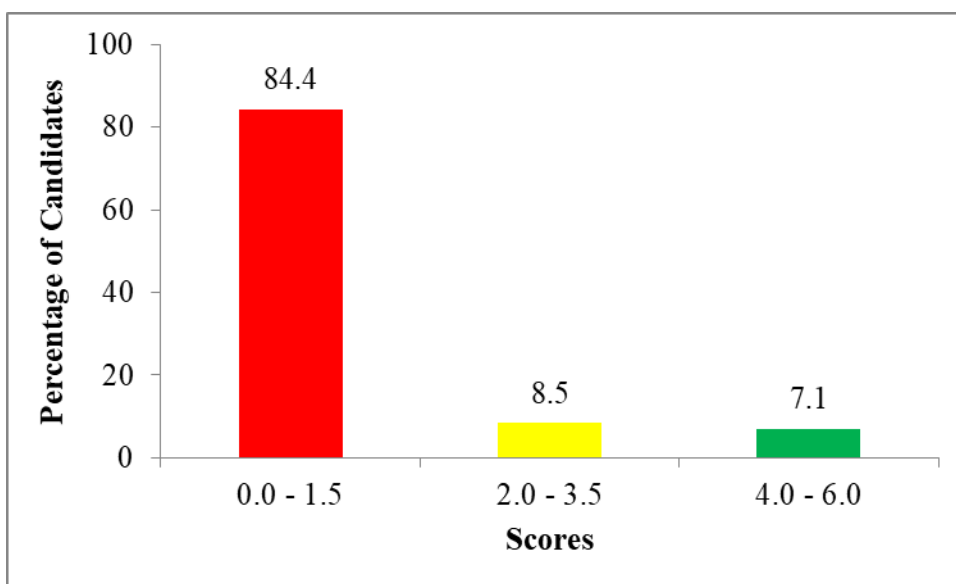


Figure 5: *Candidates' performance on question 5*

The analysis of responses shows that most of the candidates performed poorly on this question. The candidates lacked knowledge and skills on the examined competences. In part (a), the candidates were unable to recognize the angle properties of isosceles triangles. They failed to recall that, the base angles of isosceles triangles are equal. For instance, some of the candidates argued that $\hat{R}PQ = \hat{S}PQ$ and $\hat{S}PQ = \hat{Q}RP$ instead of $\hat{R}PQ = \hat{P}QR$ and $\hat{S}PQ = \hat{S}QP$, respectively. Other candidates argued that $112^\circ + \hat{P}RQ = 180^\circ$, which is incorrect. In part (b), the candidates failed to find the height of a triangular field as required. They interpret the problem wrongly and applied irrelevant formulae. For instance, they applied wrong formulae for areas of rectangular and triangular fields such as length + width and $2 \times \text{base} \times \text{height}$, respectively. These responses show that the candidates failed to develop the intended competences when studying the basic concepts of geometry, perimeters and areas. Extract 5.1 shows a sample of responses from a candidate who answered this question incorrectly.

5 a) Find the size of the angles RPS

$RPS = (\text{From } \triangle PQR)$
 $RPS = \cancel{180} + \angle PQR = 180$
 $RPS = 112 + \angle PSQ = 180$
 $RPS = 180 - 112$
 $RPS = 68^\circ$

5: b/ From ^{rectangular} triangle formula.

Base $\times$ Height.

Where

Base = 60m

Height = 72m

Recall as follows:

$60m \times 72m = 4320m$

Area of the rectangular = 4320m.

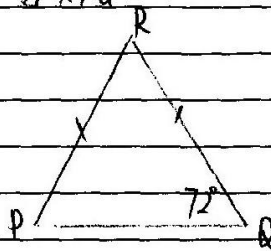
Extract 5.1: A sample of incorrect responses to question 5

Extract 5.1 shows that, in part (a), the candidate had a misconception on the properties of interior angles of a triangle. He/she performed irrelevant calculations on angles that led to an incorrect answer. In part (b), the

candidate interpreted the word problem incorrectly and applied a wrong formula.

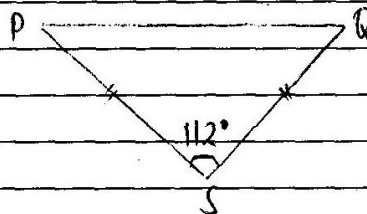
Contrarily, the candidates who performed well on this question had gained relevant competence after learning the basic tenets of geometry, perimeters and areas. In part (a), the candidates applied the properties of sum of interior angles of a triangle to determine the angle RPS. That is, $\hat{P}\hat{S}Q + \hat{S}\hat{P}Q + \hat{S}\hat{Q}P = 180^\circ$. Since SPQ is an isosceles triangle, then $\hat{S}\hat{P}Q = \hat{S}\hat{Q}P$. Thus, they deduced that $112^\circ + 2\hat{S}\hat{P}Q = 180^\circ$ and obtained $\hat{S}\hat{P}Q = 34^\circ$. Thereafter, they recognized that $\hat{R}\hat{P}Q = \hat{R}\hat{Q}P = 72^\circ$ and $\hat{R}\hat{P}S = \hat{R}\hat{P}Q + \hat{S}\hat{P}Q$, which implies that $\hat{R}\hat{P}S = 72^\circ + 34^\circ = 106^\circ$. In part (b), the candidates were able to interpret the word problem correctly. They successfully used relevant formulae to find the height of the triangular field. The formulae used are area of a rectangle = length $\times$ width and area of a triangle = $\frac{1}{2} \times \text{base} \times \text{height}$. They calculated the area of a rectangular field using the given dimensions, that is area of a rectangular field = $72\text{ m} \times 40\text{ m} = 2,880\text{ m}^2$. Since the area of the rectangular field is equal to that of a triangular field, they computed the height of the triangular field after equating the areas of the two fields. That is, $2,880\text{ m}^2 = \frac{1}{2} \times 60\text{ m} \times \text{height}$, where 60 m is the length of the given base of the triangular field. Finally, they concluded that the height of the triangular field is 96 m. Extract 5.2 shows a sample of responses from a candidate who answered the question correctly.

Q5. 9. Considering ΔRPQ



Since the triangle is isosceles,
 $\therefore \angle RPQ = 72^\circ$

Considering ΔPQS .



Since the triangle is isosceles, $\angle SPQ = \angle SQP$
Letting $\angle SPQ$ be x .

$$112^\circ + x + x = 180^\circ$$

$$112^\circ + 2x = 180^\circ$$

$$2x = 180^\circ - 112^\circ$$

$$2x = 68^\circ$$

$$x = \frac{68^\circ}{2} = 34^\circ$$

$$\therefore \angle SQP = \angle SPQ = 34^\circ$$

$$\text{But, } \angle RPS = \angle RPQ + \angle SPQ$$

$$\therefore \angle RPS = 72^\circ + 34^\circ$$

$$\therefore \angle RPS = 106^\circ$$

was weak. The analysis also shows that, 15,634 (3.0%) candidates scored all the allotted marks while 282,955 (53.5%) candidates scored zero. The candidates' performance on question 6 is summarized in Figure 6.

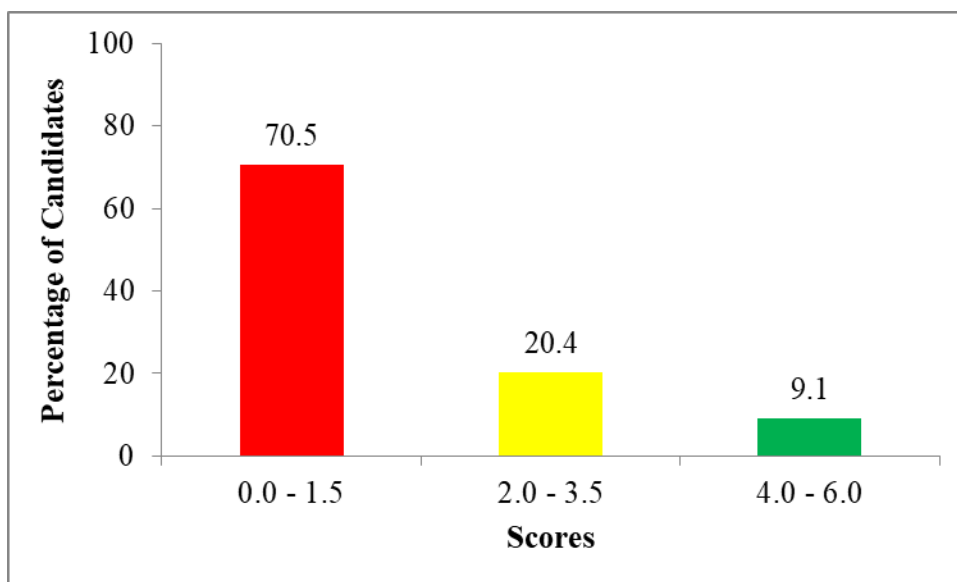


Figure 6: *Candidates' performance on question 6*

The analysis of the responses reveals that majority of the candidates performed poorly on this question. The candidates failed to answer this question correctly due to lack of knowledge and skills on the concepts of metric units, rates and variations. In part (a), the candidates performed conversions of metric units incorrectly. For instance, they used the relation $1 \text{ km} = 100 \text{ m}$ instead of $1 \text{ km} = 1000 \text{ m}$ which led to wrong answers. Further analysis reveals that some of the candidates failed to perform the correct mathematical operations. They performed the division operation to obtain the distance covered in two days such as $\frac{24 \text{ km}}{2} = 12 \text{ km}$, which is wrong. Instead, they were required to multiply, that is $24 \text{ km} \times 2 = 48 \text{ km}$. In part (b)(i), they failed to establish the equation that relates the buying price and selling price due to lack of competence on the concept of direct variations of quantities. Some of the candidates calculated the sum of the buying price and selling price, which is a wrong approach. In part (b)(ii), most of the candidates failed to adhere to the requirement of the question. For instance, some of the candidates applied the formula for percentage

profit, $\% \text{ profit} = \frac{\text{profit made}}{\text{buying price}} \times 100\%$. Also, other candidates applied the

formula for simple interest, that is $I = \frac{PRT}{100}$. In this case, the responses from

these candidates suggest that the learning process did not give the intended outcomes. Extract 6.1 shows a sample of responses from a candidate who answered this question incorrectly.

6.	a) Anna walk 24 everyday
	and metre metres the distance walk 2 days
	Soln
	1 day = 24 km
	2da = ?
	$d = \frac{2 \text{ day} \times 24 \text{ km}}{1 \text{ day}}$
	$2 \times 24 \text{ km} = 28 \text{ km} \therefore \text{the distance} = 28 \text{ km}$
6	b)
	buying and selling Tshs 20,000 and 18,000
	PER
	$\frac{20,000 + 18,000}{100}$
	$\frac{38,000}{100} = 380$
	0.15
	(2) the equatio the relates the buying price and the
	Selling prices is 38,000
	(7) the new price when the buying price is 0.15

Extract 6.1: A sample of incorrect responses to question 6

Extract 6.1 shows that, in part (a), the candidate failed to convert correctly the measurements in kilometres into metres. In part (b), the candidate failed to establish the relationship between the buying price and selling price. He/she performed irrelevant calculations.

Despite the fact that the performance was weak, the analysis of responses shows that candidates who performed well on this question were competent on the basic concepts of metric units, rates and variations. They demonstrated the assessed competences on the examined concepts. In part (a), they converted correctly the metric units of length using the relationship, $1\text{km}=1,000\text{m}$ to convert 24km into $24,000\text{m}$. Thereafter, they multiplied $24,000\text{m}$ by 2 to get $48,000\text{m}$, which is the correct answer. Others multiplied 24km by 2 to obtain 48km and then converted the resulting kilometres into metres as required. In part (b)(i), the candidates defined the variables, B and S to represent the buying price and selling price, respectively. Thereafter, they determined an equation connecting the two variables in a direct proportional relationship. That is $B \propto S$ implying that $B = kS$ or $S = \frac{1}{k}B$. They used the initial conditions $B = \text{Tshs } 18,000$ and $S = \text{Tshs } 20,000$ to obtain the constant of proportionality, that is $k = \frac{9}{10}$. Finally, they substituted the value of k in the equation to get $B = \frac{9}{10}S$ or $S = \frac{10}{9}B$, which is the equation that relates the buying price and selling price. In part (b)(ii), the candidates calculated the 15% increase of buying price before adding the result with initial buying price to get the new selling price, that is $B = 15\% \times \text{Tshs } 18,000 + \text{Tshs } 18,000 = \text{Tshs } 20,700$. They substituted the new buying price in the equation to determine the new selling price, that is $\text{Tsh } 20,700 = \frac{9}{10}S$ such that $S = \text{Tsh } 23,000$, which is the required new selling price. Extract 6.2 is a sample of responses from a candidate who answered this question correctly.

6	(a)	Soln
		Given that
		1 day = 24 km
		2 days = $\frac{X}{X}$
		$X = 48 \text{ km}$
		From
		1 km = 1000 m
		48 km = $\frac{X}{X}$
		$X = 48000 \text{ m}$
		$\therefore$ The distance she walks in two days is 48000 m.
06	(b)(i)	Given Buying price (B) = 18,000 Selling price (S) = 20,000 $B \propto S$ $B = kS$ $k = \frac{B}{S} = \frac{18,000}{20,000}$ $k = \frac{9}{10}$ $\therefore$ The equation is $B = \frac{9}{10} S$
	b(ii)	15% Increase = $\frac{15}{100} \times 18,000$ $= 2700$ Buying price = $18,000 + 2700$ $= 20,700$ From $B = \frac{9}{10} S$ $S = \frac{10}{9} B = \frac{10}{9} \times 20,700$ $S = 23,000$ $\therefore$ The new selling price is 23,000 Tshs

Extract 6.2: A sample of correct responses to question 6

Extract 6.2 shows that, in part(a) the candidate related the distance covered and time taken correctly. He/she converted the measurements in kilometres into metres as required. In part (b)(i), the candidate transformed the word problem into algebra using appropriate symbols to get the equation that relates the buying price and selling price. In part (b)(ii), the candidate computed correctly the new selling price by substituting in the equation the buying price that includes an increase of 15%.

2.7 Question 7: Ratios, Profit and Loss and Accounts

This question consisted of two parts, (a) and (b). In part (a), candidates were given the information that “Ally and Jane shared 64,000 shillings in the ratio 3:5, respectively”. They were examined whether or not they are able to find the difference between the shares of the two persons. In part (b), candidates were examined if they were able to extract a trial balance as at 28th February, 2022 from Mr. Mrisho’s transactions which he recorded in the following cash account:

CASH ACCOUNT

DR				CR			
Date	Particular	Folio	Amount	Date	Particular	Folio	Amount
Feb. 1	Capital		1,500,000	Feb. 2	Purchases		1,000,000
Feb. 2	Sales		1,200,000	Feb. 6	Transport		200,000
Feb. 3	Sales		800,000	Feb. 27	Purchases		1,400,000
				Feb. 28	Balance	c/d	900,000
			3,500,000				3,500,000
March 1	Balance	b/d	900,000				

The data analysis reveals that 184,584 (34.9%) candidates passed this question, of which 47,415 (9.0%) candidates scored full marks, which indicates that the performance was average. However, it was noted that 266,962 (50.4%) candidates scored zero on this question. Figure 7 presents a summary of performance on question 7.

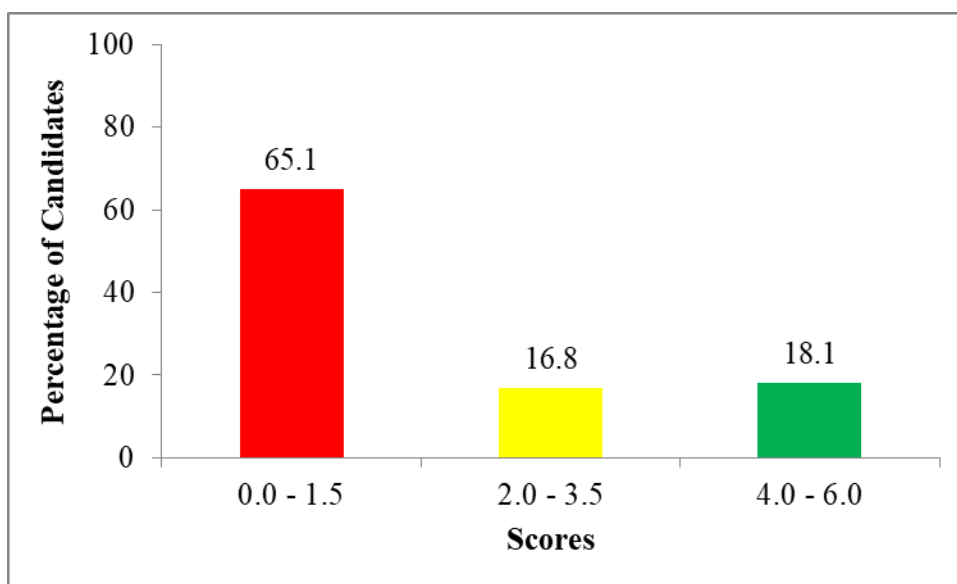


Figure 7: *Candidates' performance on question 7*

The analysis of the responses shows that the candidates performed this question averagely. Some of candidates who performed well had sufficient knowledge and skills gained after learning the basic tenets of ratios, profit and loss, and accounts. In part (a), the candidates computed correctly the required shares from the given amount and ratio. That is, $\frac{3}{8} \times \text{sh } 64,000 = \text{sh } 24,000$ as Ally's share and $\frac{5}{8} \times \text{sh } 64,000 = \text{sh } 40,000$ as Jane's share. Finally, they calculated the difference in shares to get $\text{sh } 40,000 - \text{sh } 24,000 = \text{sh } 16,000$. In part (b), the candidates were able to prepare a trial balance from the given cash account. They recorded correctly the particulars and amounts in the Debit and Credit sides. Finally, they balanced the accounts by carrying down a balance of 900,000 in the Credit side such that each side has a total amount of 3,500,000. Extract 7.1 is a sample of responses from a candidate who answered the question correctly.

7. (a)	soln			
	total ratio = 3+5 = 8			
	Ally = $\frac{3}{8} \times 64,000$			
	= 24,000/-			
	Jane = $\frac{5}{8} \times 64,000$			
	= 40,000/-			
	Difference = 40,000/- - 24,000/-			
	= 16,000/-			
	$\therefore$ The difference between their shares is 16,000/-			
07. b)	Solution			
	MR. MUKHIA TRIAL BALANCE AS			
	AT 28 th FEBRUARY, 2022			
	S/N	NAME OF ACCOUNT	Dr	Cr
	01.	Capital		1,500,000
	02.	Stores		2,000,000
	03.	Purchases	2,400,000	
	04.	Transport	200,000	
	05.	Cash	900,000	
		Total.	3,500,000	3,500,000

Extract 7.1: A sample of correct responses to question 7

Extract 7.1 shows that, in part (a), the candidate was able to find the share of each person using the given amount and ratio. He/she computed the difference in shares to get the correct answer. In part (b), the candidate extracted correctly the trial balance from the given cash account.

In contrast, there were candidates who performed poorly on this question. The candidates failed to answer the question correctly due to lack of competence on the basic concepts of ratio, profit and loss, and accounts. In part (a), majority of the candidates were unable to find the difference between the shares of the two persons. Some of the candidates divided the given amount, Tshs 64,000 by 3:5, that is $64,000 \div 3:5$ and obtained 182.8

which is an incorrect answer. Also, other candidates performed illogical arithmetics and calculations such as $64,000 - 3.5 = 63.9$ and $3 \div 5 = 0.6$. Further analysis shows that there were candidates who calculated the shares of the two persons wrongly after failing to get the correct sum of the ratios.

They calculated the shares as $\frac{3}{10} \times 64,000 = 19,200$ shillings and $\frac{5}{10} \times 64,000 = 32,000$ shillings instead of $\frac{3}{8} \times 64,000 = 24,000$ shillings and $\frac{5}{8} \times 64,000 = 40,000$ shillings.

In part (b), the candidates were unable to extract a trial balance from the given cash account. They posted wrong entries due to lack of competence on the concept of trial balance. For instance, in the purchases account, they posted 1,400,000 instead of 2,400,000. Moreover, there were candidates who failed to compute the total amounts in the debit and credit sides. Further analysis shows that some of the candidates prepared a balance sheet, trading account or a ledger instead of a trial balance. The responses from those candidates show inadequate competence on the concept of accounts. Extract 7.2 is a sample of responses from a candidate who answered the question incorrectly.

07.a.	$3:5 = 64000$
	$\frac{3}{5} \times 64000$
	x
	$3x = 5 \times 64000$
	$3x = 10666$
	$3x = 320,000$
	$3 \quad 3$
	$x = 106666.7 =$
	$106666 - 64000$
	$= 42666 \text{ l} =$
	$\therefore \text{Ally got } 42666 \text{ l} = \text{ and Jane got } 106666 \text{ l} =$
	$\text{The difference between their shares is } 64000 \text{ l} =$

7(b) TRIAL BALANCE:			
Date	Particular	Amount	Dr or Cr.
February 1	Capital	15 000 000	Dr.
February 2	Sales	1 200 000	Dr.
February 2	Purchases	1 000 000	Cr.
February 3	Sales	800,000	Dr.
February 6	Transport	200,000	Cr.
February 27	Purchases	1 400,000	Cr.
February 28	Balance c/d	900,000	Cr.
March 1	Balance b/d	900,000	Dr.

Extract 7.2: A sample of incorrect responses to question 7

Extract 7.2 shows that, in part (a), the candidate lacked the knowledge on ratios, as a result he/she failed to find the difference between the shares. In part (b), the candidate lacked knowledge on the format of a trial balance. He/she prepared an incorrect trial balance.

2.8 Question 8: Sequences and Series

This question comprised two parts, (a) and (b). In part (a), candidates were required to write the first four terms of a sequence whose general term is $n(2n-1)$ and to explain whether it is an arithmetic progression or geometric progression. In part (b), they were required to find the sum of the fourth and ninth terms of an arithmetic progression, given that the sum of the first eleven terms is 517 and the first term is 7.

Based on the data analysis, 41,233 (7.8%) candidates passed this question, which indicates that the performance was weak. Further analysis shows that 2,258 (0.4%) candidates scored full marks while 462,521 (87.4%) candidates scored zero. The candidates' performance on question 8 is summarized in Figure 8.

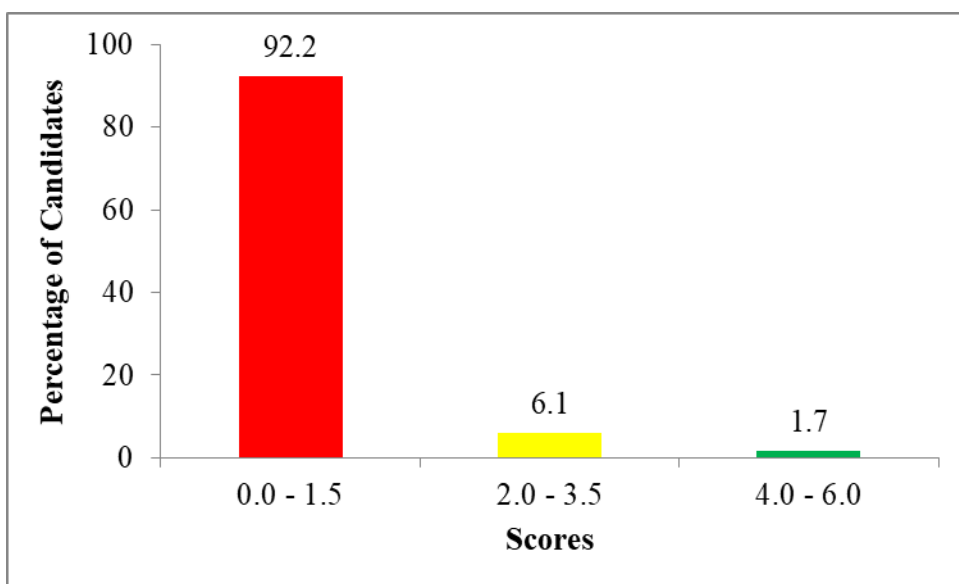


Figure 8: *Candidates' performance on question 8*

The analysis of responses shows that the candidates who failed to answer this question correctly had inadequate knowledge and skills on the concept of sequences and series. In part (a), the candidates were unable to use the given information to determine the first four terms of the sequence. They failed to establish that $A_n = n(2n-1)$ for $n=1, 2, 3, 4$, which was an essential step in finding the first four terms of the sequence. Some of the candidates misinterpreted the phrase “the first four terms” to incorrectly mean “the number of terms, that is $n=4$ ”. They computed only one term of the sequence for $n=4$ to get 28. In part (b), the candidates faced difficulties in recalling the formula for finding the sum of the first n terms of an arithmetic progression. They wrote incorrect formulae such as $S_n = \frac{n}{2} [2A_1 + (n-d)1]$.

Further analysis shows that there were candidates who applied the correct formula for calculating the sum of the first n terms of the progression but they made wrong substitutions and performed inappropriate computations. Moreover, some of the candidates failed to apply the formula, $A_n = A_1 + (n-1)d$ for the n^{th} term of an arithmetic progression in order to compute the values of the fourth and ninth terms of the progression. Based on these responses, the candidates had inadequate knowledge and skills on

the examined competences. Extract 8.1 is a sample of responses from a candidate who answered this question incorrectly.

89	soln.
	A + 4
	$A + 3d = n(2n - 1)$
	$A + 3d = 2n^2 - n$
	8.
	$A = 2n^2 - n - 3d$
	$2n^2 - n - 3d = 2n^2 - n$
	This is arithmetic progression
86)	soln.
	$S_n = \frac{n}{2} (2A_1 + (n-1)d)$
	$517 = \frac{11}{2} (2 \times 7 + (11-1)d)$
	$517 = 5.5 (14 + (10)d)$
	$517 = 5.5 (24d)$
	$517 = 132d$
	$132 \quad 132$
	$d = 3.9$
	First term $A_1 = 7$ $A_2 = 34.3$
	$A_2 = 10.9$ $A_9 = 38.9$
	$A_3 = 14.8$
	$A_4 = 18.7$
	$A_5 = 22.6$
	$A_6 = 26.5$
	$A_7 = 30.4$
	The sum of fourth and ninth term
	$21 \quad 18.7 + 38.9$
	$= 56.9$

Extract 8.1: A sample of incorrect responses to question 8

In Extract 8.1, part (a), the candidate failed to list the first four terms of the sequence. Hence, he/she was not able to give the required conclusion. In

part (b), the candidate failed to make correct calculations. Thus, he/she was not able to determine the values of the fourth and ninth terms and their sum.

On the other hand, the analysis of responses shows that the candidates who performed well on this question had adequate knowledge and skills on the basic concepts of sequences and series. They applied properly the competences developed during the learning process. In part (a), the candidates were able to list the first four terms of the sequence by setting $n=1, 2, 3, 4$ in the general term $n(2n-1)$ to obtain the sequence 1, 6, 15, 28. They were also able to conclude that, the sequence is neither an arithmetic progression nor a geometric progression because it has neither a common difference nor a common ratio. In part (b), the candidates determined the common difference d from the formula $S_n = \frac{n}{2}[2A_1 + (n-1)d]$ and obtained $d=8$. They applied the formula for the n^{th} term to calculate the values of the fourth and ninth terms. That is, $A_4 = A_1 + 3d = 31$ and $A_9 = A_1 + 8d = 71$. Finally, they correctly computed the sum of the fourth and ninth terms of the progression to get the required answer. That is, $A_4 + A_9 = 31 + 71 = 102$. Extract 8.2 shows a sample of responses from a candidate who answered this question correctly.

08.	(a)	$n(2n-1)$
	First term ,	$n = 1$
		$1(2 \times 1 - 1)$
		$1(2 - 1)$
		$= 1$
	Second term ,	$n = 2$
		$2(2 \times 2 - 1)$
		$2(4 - 1)$
		$= 6$
	Third term ,	$n = 3$
		$3(3 \times 2 - 1)$
		$3(6 - 1)$
		$= 15$

08.	Fourth term, $n = 4$ $4(2 \times 4 - 1)$ $4(8 - 1)$ $= 28$ So the sequence is 1, 6, 15 and 28 It is neither an arithmetic progression nor geometric progression because it doesn't have a common difference or a common ratio.
8(b)	Sum of eleven terms = 517. $S_n = \frac{n}{2} [2A_1 + (n-1)d]$ $S_{11} = 517$ $517 = \frac{11}{2} [2A_1 + (11-1)d]$ but $A_1 = 7$. $\frac{2 \times 517}{11} = \frac{2 \times 11}{11 \times 2} [14 + 10d]$ $94 = 14 + 10d$ $\frac{10d}{10} = \frac{80}{10}$ $d = 8$ $A_4 = A_1 + 3d$ $= 7 + (3 \times 8)$ $A_4 = 7 + 24$ $A_4 = 31$ $A_9 = A_1 + 8d$ $A_9 = 7 + (8 \times 8)$ $A_9 = 7 + 64$ $A_9 = 71$ The sum = $A_4 + A_9$ $31 + 71$ 102 $\therefore$ The sum of fourth and ninth term is 102.

Extract 8.2: A sample of correct responses to question 8

In Extract 8.2, part (a), the candidate was able to determine the first four terms of the sequence. Thus, he/she provided a correct conclusion on the sequence. In part (b), the candidate was able to apply the correct formula for the sum of first n terms of an arithmetic progression. He/she determined the common difference and used it to find the values of the fourth and ninth terms. Finally, he/she computed correctly the sum of the fourth and ninth terms of the progression.

2.9 Question 9: Pythagoras' Theorem and Trigonometry

This question had two parts, (a) and (b). In part (a), candidates were examined whether or not they can determine the width of a rectangular plot of land, if it is 40 metres long and the length of its diagonal is 50 metres. In part (b)(i), candidates were required to find the value of $\tan A$ without using mathematical table, given that A is an acute angle for which $13\cos A - 5 = 0$. In part (b) (ii), they were required to determine the length of $\overline{BC}$ of a triangular pond ABC , given that $\overline{AB} = 8\text{m}$, $\overline{AC} = 5\text{m}$ and $\hat{BAC} = 60^\circ$.

The data analysis shows that 86,743 (16.4%) candidates passed this question, indicating a weak performance. It was further noted that 10,621 (2.0%) candidates scored all the allotted marks while 430,085 (81.3%) candidates scored zero. The summary of the candidates' performance on question 9 is presented in Figure 9.

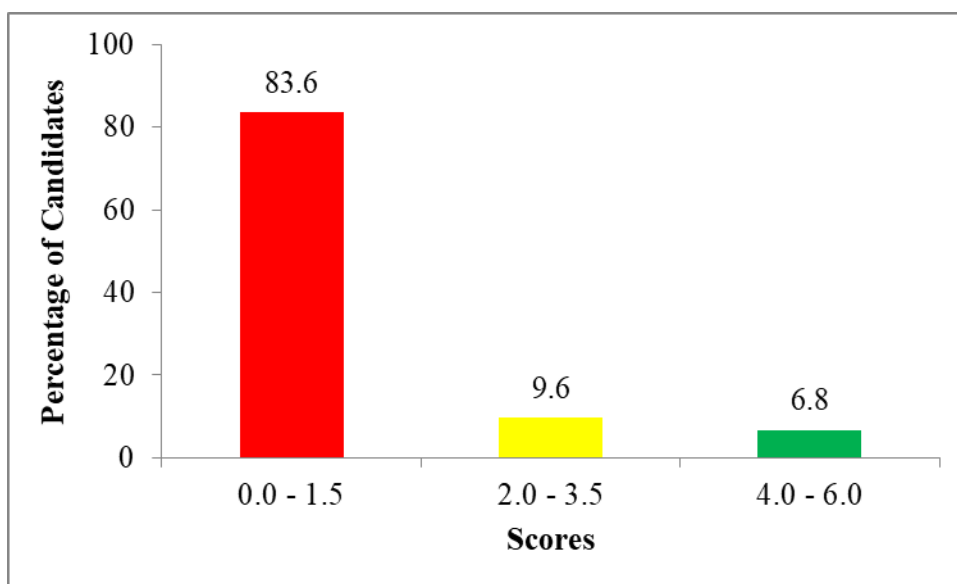


Figure 9: *Candidates' performance on question 9*

The analysis shows that majority of the candidates performed poorly on this question. The candidates failed to respond to the question correctly due to various reasons, including facing difficulties in interpreting the word problems and failure to recall the correct formulae. Mostly, they lacked competence on the applications of Pythagoras' theorem and the basic concepts of trigonometry. In part (a), they sketched a triangular plot instead of a rectangular plot as a result of failure to recognize the names of flat figures. There were candidates who managed to sketch a rectangular plot, but they failed to apply the Pythagoras' theorem. They wrongly calculated the width by multiplying the length of the rectangular plot by the length of its diagonal, that is $\text{width} = 40\text{ m} \times 50\text{ m} = 2000\text{ m}$, which is an incorrect answer. Some of the candidates added the given dimensions of the rectangular plot and ended up with incorrect answers such as $\text{width} = 40\text{ m} + 50\text{ m} = 90\text{ m}$. Furthermore, other candidates determined the width of the rectangular plot by applying wrongly the concept of trigonometric ratios. For instance, they used wrong formulae such as $\text{width} = \tan^{-1}\left(\frac{40}{50}\right)$ or $\text{width} = \sin^{-1}\left(\frac{40}{50}\right)$. This implies that they did not understand the requirement of the question.

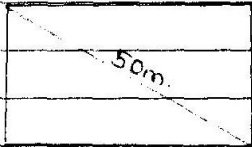
In part (b)(i), the candidates failed to find the value of $\tan A$ without using mathematical tables. They could not make $\cos A$ the subject of the

equation $13\cos A - 5 = 0$ to be able to identify the adjacent side, opposite side, and hypotenuse side of an angle A , instead they incorrectly multiplied by 13 throughout the equation, that is $\cos 13A - 65 = 0$. Some of candidates were able to rearrange the equation to get $\cos A = \frac{5}{13}$, but they failed to

determine the value of $\tan A$. Further analysis shows that most of the candidates computed the value of $\tan A$ by using non-programmable calculators and mathematical tables contrary to requirement of the question. In part (b) (ii), the candidates failed to interpret the word problem correctly. For instance, they sketched a rectangular pond instead of triangular pond. Moreover, the analysis shows that some of the candidates

applied the sine rule, $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$, which was not appropriate to

the question instead of applying the cosine rule. Furthermore, some of the candidates failed to note that the given triangular pond does not have a shape of a right-angled triangle. Thus, they wrongly applied the Pythagoras' theorem that led to incorrect answers. Also, there were candidates who could not recall correctly the cosine rule. They applied incorrect formulae such as $a^2 = b^2 + c^2 + 2bc \cos A$ or $a^2 = b^2 - c^2 - 2bc \cos A$ instead of $a^2 = b^2 + c^2 - 2bc \cos A$. Other candidates irrationally added the given dimensions of the triangular pond, that is $\overline{AB} + \overline{AC} = 8\text{m} + 5\text{m} = 13\text{m}$. These responses provide a highlight of candidates failure to attain the intended competences during the learning process. Extract 9.1 is a sample of responses from a candidate who answered this question incorrectly.

9a)	
	50m x 40m
	= 2000m
	∴ A wide of the plot is 2000m

b) Given that A is an acute angle for which $13\cos A - 5 = 0$, find the value of $\tan A$ without using mathematical table.

Soln

$$13\cos A - 5 = 0$$

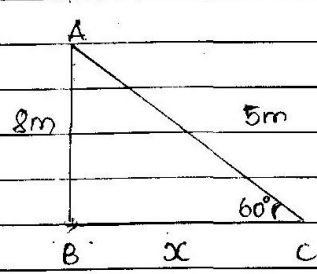
$$0.9744 A - 5 = 0$$

$$0.9744 - 5 = 0$$

$$-4.0256$$

$$\tan A = 0.070.$$

b) $\overline{AB} = 8\text{m}$, $\overline{AC} = 5\text{m}$ and $\angle BAC = 60^\circ$. Determine length of $\overline{BC}$



Soln

By pythagorus theorem

$$a^2 + b^2 = c^2$$

$$8\text{m}^2 + b^2 = 5\text{m}^2$$

$$64\text{m} + b^2 = 25\text{m}$$

$$64 + 25 = b^2$$

$$\sqrt{89} = \sqrt{b^2}$$

Length of $\overline{BC} = 9.43$

$\sin = \frac{\text{Opposite}}{\text{Hypotenuse}}$

$$= \frac{8}{60}$$

$$\sin = \frac{2}{15} \approx 0.13$$

Extract 9.1: A sample of incorrect responses to question 9

Extract 9.1 shows that, in part (a), the candidate failed to determine the width of rectangular plot. He/she just multiplied 50 m by 40 m, which is incorrect. In part (b)(i), the candidate demonstrated lack of knowledge and skills on trigonometric ratios. He/she failed to determine the value of

$\tan A$ from the given equation. In part (b)(ii), the candidate failed to determine the length of $\overline{BA}$. He/she used the Pythagoras' theorem which is not applicable on this item.

Although the performance was weak, there were candidates who managed to respond to this question correctly. The candidates had sufficient competence on the basic concepts of Pythagoras' theorem and trigonometry. In part (a), the candidates interpreted the given word problem geometrically by sketching a rectangular plot of land whose length is 40 m and diagonal is 50 m. They applied appropriately the Pythagoras' theorem using the sketched figure to determine the width of the plot. They were able to make relevant calculations to get a width of 30 metres, which is the correct answer.

In part (b)(i), the candidates were able to apply the trigonometric ratios to find the value of $\tan A$. They correctly re-arranged the equation $13\cos A - 5 = 0$ into $\cos A = \frac{5}{13}$. Since $\cos A = \frac{\text{adjacent side}}{\text{hypotenuse side}}$, they

sketched a right-angled triangle with adjacent side to angle A of length 5 units and a hypotenuse side of length 13 units. They calculated the length of the opposite side of angle A to get 12 units. Finally, they computed the

value of $\tan A$ from the relation $\tan A = \frac{\text{opposite side}}{\text{adjacent side}}$ to get $\tan A = \frac{12}{5}$,

which is the correct answer. Further analysis shows that, some of the candidates were able to find the value of $\tan A$ by using the trigonometric identity, $\cos^2 A + \sin^2 A = 1$. On substituting $\cos A = \frac{5}{13}$ in the identity,

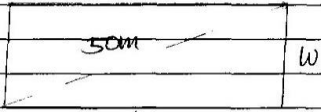
they obtained $\sin A = \frac{12}{13}$. Hence, they concluded

that $\tan A = \frac{\sin A}{\cos A} = \left(\frac{12}{13} \div \frac{5}{13} \right) = \frac{12}{5}$, which is the correct answer. In part

(b)(ii), the candidates were able to determine the length of $\overline{BC}$ by sketching the triangle ABC and applied the cosine rule, that is $a^2 = b^2 + c^2 - 2bc \cos A$. They substituted the given information such that $a = \overline{BC}$, $b = 8\text{ m}$, $c = 5\text{ m}$ and $A = 60^\circ$. They used their computation skills

to get $\overline{BC} = 7\text{m}$, which is the correct answer. Extract 9.2 shows a sample of responses from a candidate who answered this question correctly.

Q9 (a). Consider diagram.



From pythagoras theorem

$$w^2 + 40^2 = 50^2$$

$$w^2 = 50^2 - 40^2$$

$$\sqrt{w^2} = \sqrt{900}$$

$$w = 30\text{m}$$

$\therefore$ The plot is 30m wide

(b) (i). Given $13 \cos A - 5 = 0$

$$\cos A = \frac{5}{13}$$

from

$$\sin^2 A + \cos^2 A = 1$$

$$\sin^2 A + \left(\frac{5}{13}\right)^2 = 1$$

$$\sin^2 A + 25 = 169$$

$$\sin^2 A = 1 - \frac{25}{169}$$

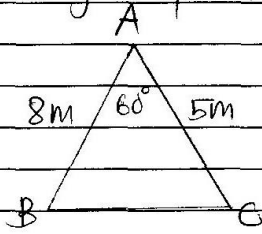
$$\sqrt{\sin^2 A} = \sqrt{\frac{144}{169}}$$

$$\sin A = \frac{12}{13}$$

$$\tan A = \frac{\sin A}{\cos A} = \frac{12}{13} \div \frac{5}{13}$$

$$= \frac{12}{5}$$

$\therefore \tan A = 12/5$

09	(b) (ii): Consider diagram of $\triangle ABC$
	
	From cosine rule
	$BC^2 = AB^2 + AC^2 - AB \cdot AC \cos A$
	$BC^2 = 8^2 + 5^2 - 5 \times 8 \cos 60^\circ$
	$\sqrt{BC^2} = \sqrt{49}$
	$BC = 7m$
	$\therefore$ The length BC is 7m.

Extract 9.2: A sample of correct responses to question 9

Extract 9.2 shows that, in part (a), the candidate applied correctly the Pythagoras' theorem to determine the width of a rectangular plot. In part (b)(i), the candidate applied the trigonometric identity $\cos^2 A + \sin^2 A = 1$ to determine the value of $\tan A$ without using mathematical tables. In part (b)(ii), the candidate applied appropriately the cosine rule to determine the length BC of the triangular pond.

2.10 Question 10: Quadratic Equations and Algebra

This question had two parts, (a) and (b). In part (a), candidates were required to determine the values of a , b and c , if $x = -3$ and $x = \frac{1}{3}$ are the solutions of the equation $ax^2 + bx + c = 0$, where a , b , and c are integers. In part (b), candidates were required to solve the inequality $10 - x \leq 3(x + 10)$, where x is an integer, and to state the first four values of x that satisfy the inequality.

The data analysis reveals that, 13,284 (2.5%) candidates passed this question. Generally, the candidates' performance on this question was weak. Further analysis reveals that, 534 (0.1%) candidates scored all the allotted marks while 488,830 (92.4%) candidates scored zero. The candidates' performance on question 10 is summarized in Figure 10.

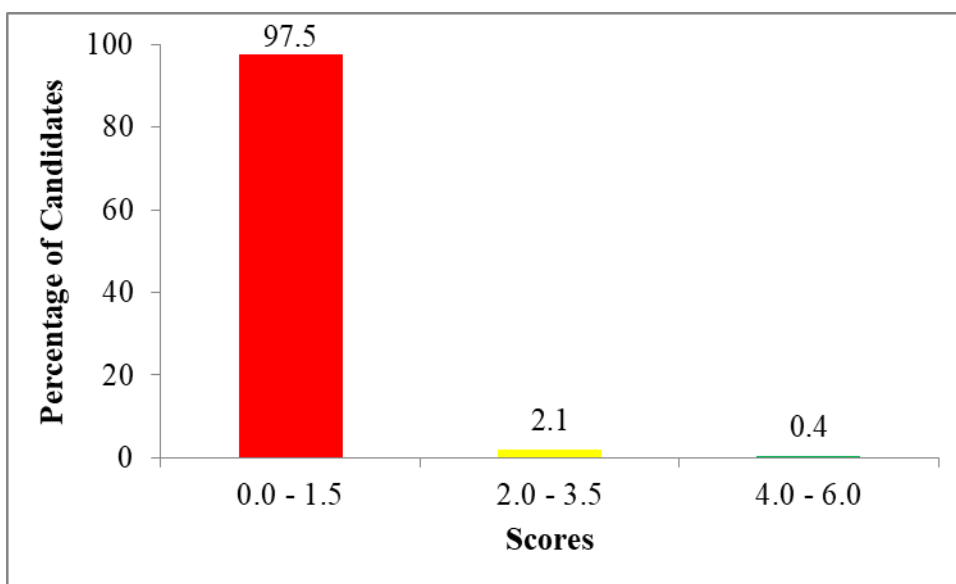


Figure 10: *Candidates' performance on question 10*

The analysis of responses shows that this question was poorly performed because majority of the candidates failed to provide the correct answers. They lacked competence on the basic concepts of quadratic equations and algebra. In part (a), the candidates failed to determine the quadratic equation using the solutions $x = -3$ and $x = \frac{1}{3}$. Other candidates substituted the given solutions in the general quadratic formula, $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ as $-3 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ which led to irrelevant calculations. Also, some of the candidates substituted simultaneously the solutions $x = -3$ and $x = \frac{1}{3}$ in the equation $ax^2 + bx + c = 0$ to get $-3^2 + \frac{1}{3} + c = 0$ which led to incorrect answers. Furthermore, the analysis shows that there were candidates who failed to expand $(x+3)\left(x-\frac{1}{3}\right) = 0$ since they lacked computation skills. They wrote $x^2 - \frac{1}{3}x + 3x - 1$ as $x^2 - \frac{8}{3}x - 1$ instead of $x^2 + \frac{8}{3}x - 1 = 0$. Most of the candidates performed

wrong calculations as the result of inadequate computation skills. Thus, they were not able to get the correct answers.

In part (b), the candidates demonstrated insufficient knowledge on how to solve problems that involve inequalities. They were unable to recognize that the inequality sign changes the direction if division by a negative number is done on both sides. They divided $-4x \leq 20$ by -4 on both sides without changing the direction of the inequality sign and got $x \leq -5$. This led them to obtain incorrect integer values of x such as $-6, -7, -8, -9$. Other candidates made errors in calculations to obtain $x \geq 5$ instead of $x \geq -5$. The responses from these candidates show that the intended learning outcomes on the concept of inequalities were not attained. Extract 10.1 shows a sample of responses from a candidate who answered this question incorrectly.

10a)	
	$x = -3 \text{ and } 1/3.$
	$ax^2 + bx + c = 0.$
	$a(-3)^2 + b(-3) + c = 0.$
	$9a + -3b + c = 0.$
	$9a + 9a - 3b + c = 0 \quad \text{--- (i)}$
	$a(1/3)^2 + b(1/3) + c = 0.$
	$a(1/9) + 1/3b + c = 0.$
	$1/9a + 1/3b + c = 0$
	$1/9a + 1/3b = -c$
	$\frac{a+3b}{9} = -c$
	$9+3b = -9c \quad \text{--- (ii)}$
	$\begin{array}{r l} 1 & 9a - 3b = -c \\ 9 & a + 3b = -9c \end{array}$
	$\begin{array}{r l} & 9a - 3b = -c \\ - & 9a + 27b = -81c \\ \hline & -30b = 80 \\ & \quad -30 \quad -30 \end{array}$
	$b = -2.6 \approx -3$
	Put $b = -3$ into eqn(i)
	$9a - 3(-3) = -c$
10b	$10 - x \leq 3(x + 10)$
	$10x - 3 + 10x$
	$10x - 10x = 3$
	$x = 3$

Extract 10.1: A sample of incorrect responses to question 10

In Extract 10.1, part (a), the candidate was not able to determine the values of a , b and c due to lack of knowledge and skills on quadratic equations.

In part (b), the candidate failed to solve the inequality due to lack of computation skills. He/she performed irrelevant calculations.

Nevertheless the performance on this question was weak, there were candidates who managed to respond to the question correctly. Those candidates had sufficient competence after learning the basic tenets of quadratic equations and algebra. In part (a), they were able to determine the values of a , b and c given that $x = -3$ and $x = \frac{1}{3}$ are the solutions of the

equation $ax^2 + bx + c = 0$. They were able to obtain a quadratic equation by taking the product of factors. That is, $(x+3)\left(x-\frac{1}{3}\right) = 0$, which implies that $3x^2 + 8x - 3 = 0$. They compared the terms of the quadratic equation with $ax^2 + bx + c = 0$ to get $a = 3$, $b = 8$ and $c = -3$. Also, the analysis shows that some of the candidates substituted $x = -3$ and $x = \frac{1}{3}$ in

$ax^2 + bx + c = 0$ to obtain $c = -9a + 3b$ and $c = -\frac{1}{9}a - \frac{1}{3}b$, respectively.

They equated the two equations to get $a = 3$, $b = 8$, and $c = -3$. Moreover, other candidates were able to recognize that, if the roots of the quadratic equation are given, then the equation has the form $x^2 - (\text{sum of roots})x + (\text{product of the roots}) = 0$. Hence, they obtained

$x^2 - \left(-3 + \frac{1}{3}\right)x + \left(-3 \times \frac{1}{3}\right) = 0$ implying that $3x^2 + 8x - 3 = 0$. Lastly, they

compared this equation with $ax^2 + bx + c = 0$ to get $a = 3$, $b = 8$ and $c = -3$. In part (b), the candidates were able to solve the inequality $10 - x \leq 3(x + 10)$ after applying relevant procedures to get $x \geq -5$. They correctly stated the first four values of x as $x = -5, -4, -3, -2$. Extract 10.2 shows a sample of responses from a candidate who answered this question correctly.

60 a	soln.
	$x = -3, x = \frac{1}{3}$
	but
	$(x+3)(x-\frac{1}{3}) = 0$.
	expand the equation.
	$x^2 - (\frac{1}{3} + 3x) - (\frac{1}{3} \times 3) = 0$.
	$x^2 - \frac{x+9x}{3} - 1 = 0$.
	$3x^2 + 8x - 3 = 0$.
	$3x^2 + 8x - 3 = 0$.
	compare the equation.
	$3x^2 + 8x - 3 = 0$.
	$ax^2 + bx + c = 0$.
	$a=3, b=8, c=-3$.
	$\therefore$ The value of $a, b, \text{ and } c$ are $3, 8, -3$ respectively.
10. b)	$10-x \leq 3(x+10)$
	$10-x \leq 3x+30$
	$10-30 \leq 3x+x$
	$-20 \leq 4x$
	$4 \quad 4$
	$x \geq -5$
	$\therefore x$ may be $-5, -4, -3, -2, -1, 0, 1, \dots$
	The first four values of x are $-5, -4, -3, -2$

Extract 10.2: A sample of correct responses to question 10

In Extract 10.2, part (a), the candidate was able to apply the knowledge and skills on the concepts of quadratic equations to determine the values of a, b and c . In part (b), the candidate solved the inequality correctly to obtain the correct integer values of the variable x .

2.11 Question 11: Statistics

This question consisted of three parts, (a), (b), and (c). Part (a) aimed at examining the candidates' ability to calculate the median score correct to

two decimal places from the following frequency distribution table that shows the scores of 30 students in a Mathematics test.

Class interval	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 - 99
Frequency	2	4	7	9	5	3

Part (b) examined the candidates' ability to find the mean score correct to four significant figures using the given frequency distribution table. Part (c) intended to examine whether candidates were able to draw a histogram to represent the given frequency distribution table and use it to estimate the mode.

The data analysis shows that 33,096 (6.3%) candidates scored all the allotted marks out of 216,197 (40.8%) candidates who passed this question. Generally, the analysis shows that the performance on this question was average. However, the analysis shows that 187,789 (35.5%) candidates scored zero. The summary of the candidates' performance on question 11 is presented in Figure 11.

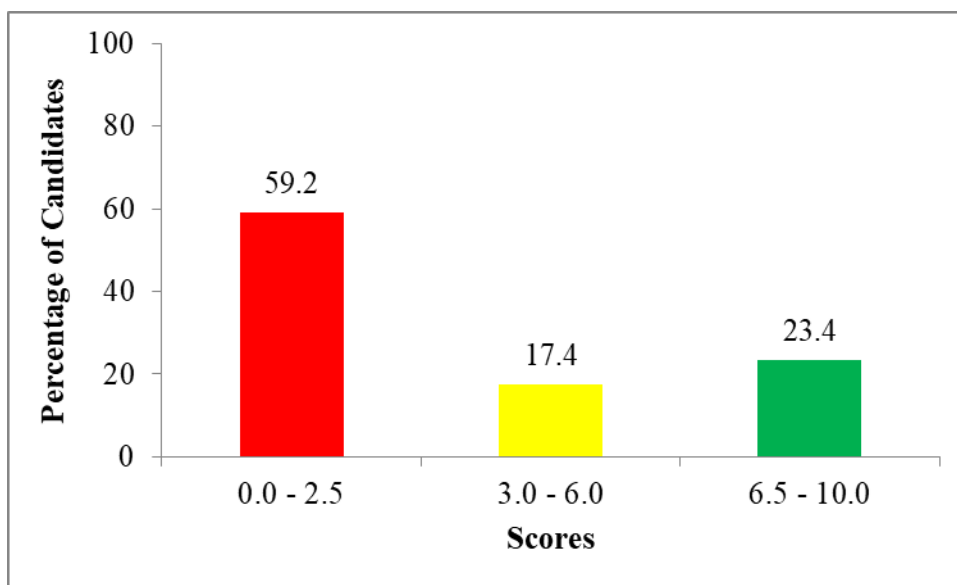


Figure 11: *Candidates' performance on question 11*

The analysis of responses shows that the candidates who performed well on this question demonstrated the assessed competence on statistical concepts of measures of central tendency. In part (a), the candidates applied appropriately the formula for computing the median of grouped data, that

is Median = $L + \left(\frac{\frac{N}{2} - n_b}{n_w} \right) i$. They substituted correct values in the formula

and performed relevant calculations to get median = 71.7222. Thereafter, they approximated the median score correct to two decimal places, that is median ≈ 71.72 , which is the correct answer.

In part (b), the candidates applied appropriately the formula,

Mean = $\frac{\sum f_i x_i}{\sum f_i}$ to calculate the mean score. They were able to tabulate the

frequency distribution table to include columns for class marks x_i and $f_i x_i$.

They performed correct computations to get $\sum f_i x_i = 2135$ and $\sum f_i = 30$.

These values were substituted in the formula to get mean = 71.1666. They approximated the answer to four significant figures to get mean ≈ 71.17 .

Further analysis shows that there were candidates who calculated the mean score by using the assumed mean method, that is $\bar{x} = A + \frac{\sum f_i d_i}{\sum f_i}$, where

A is the assumed mean and d_i are the deviations from the assumed mean.

They tabulated a frequency distribution table that includes the columns for x_i , d_i and $f_i d_i$, and calculated the mean to get $\bar{x} \approx 71.17$ as required. In

part (c), the candidates used the data in the frequency distribution table to draw a well labeled histogram. From the histogram, they estimated the mode score in the interval 70 – 79. Extract 11.1 shows a sample of responses from a candidate who answered this question correctly.

11 Frequency distribution table.

Class Interval	F	C.F	X	FX
40-49	2	2	44.5	89
50-59	4	6	54.5	218
60-69	7	13	64.5	451.5
70-79	9	22	74.5	670.5
80-89	5	27	84.5	422.5
90-99	3	30	94.5	283.5
	30			2135

11 a) solution;

Median class = 70-79.

$$\text{Median} = L + \left(\frac{N/2 - nb}{nw} \right) i$$

where by:

$$L = 69.5 \quad i = 10$$

$$N/2 = 15$$

$$nb = 13$$

$$nw = 9$$

$$\text{Median} = 69.5 + \left(\frac{15 - 13}{9} \right) \times 10$$

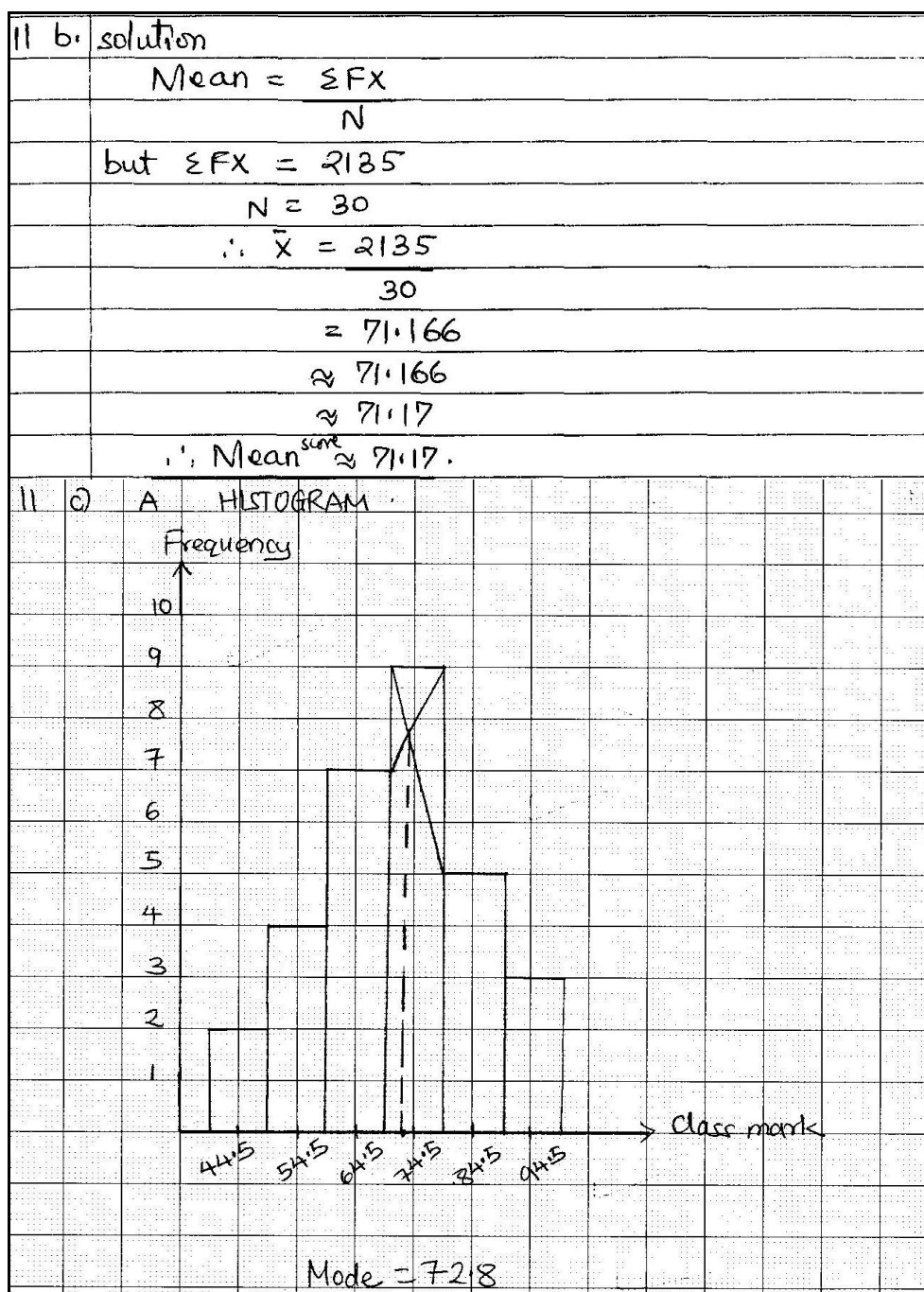
$$= 69.5 + \left(\frac{2}{9} \right) \times 10$$

$$= 69.5 + \frac{20}{9}$$

$$= 69.5 + 2.22$$

$$= 71.72$$

$$\therefore \text{Median} = 71.72$$



Extract 11.1: A sample of correct responses to question 11

Extract 11.1 shows that, in part (a), the candidate applied the formula for median to calculate the median score. He/she substituted relevant data in the formula to get the correct answer. In part (b), the candidate applied

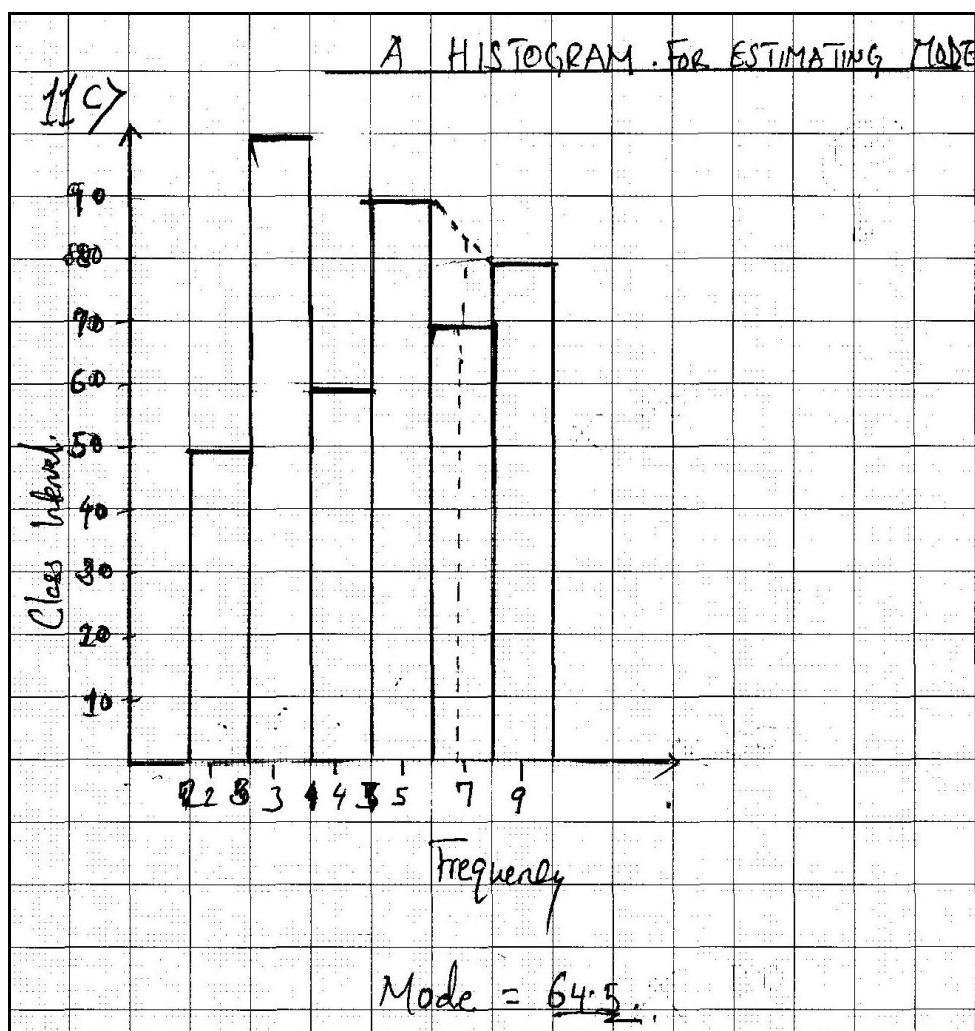
appropriate formula for finding mean and substituted the given values to get mean score = 71.17 which is the correct answer. In part (c), the candidate managed to draw the histogram and used it to estimate the mode.

On the contrary, the analysis of responses reveals that the candidates who performed poorly on this question have inadequate competence on statistical concepts of measures of central tendency. In part (a), the candidates could not identify the correct formula for calculating the median score of grouped data. Some of the candidates added the frequencies and divided the result by 5, that is $\frac{2+4+7+9+5+3}{5} = \frac{30}{5} = 6$. Other candidates wrongly applied the formula for mode to find the median score, that is $\text{Median} = L + \left(\frac{t_1}{t_1 + t_2} \right) c$. Furthermore, some candidates applied the correct formula but failed to perform relevant calculations.

In part (b), the candidates were not able to determine the correct entries for the $f_i x_i$ column. They multiplied the cumulative frequencies by the class marks instead of multiplying frequencies, f_i by the class marks, x_i . Thus, they could not get the correct value of $\sum f_i x_i$, hence they were not able to get the correct answer. Also, some of the candidates applied wrong formulae, such as $\bar{x} = \frac{\sum fd}{\sum f}$ instead of $\bar{x} = A + \frac{\sum f_i d_i}{\sum f_i}$.

In part (c), the candidates applied the formula for calculating the mode, that is $\text{Mode} = L + \left(\frac{t_1}{t_1 + t_2} \right) i$ which was contrary to requirements of the question. Other candidates drew histogram by plotting the frequencies against class intervals instead of frequencies against class marks. The responses from the candidates who failed to answer this question correctly provide a feedback that the learning process did not meet the intended outcomes. Extract 11.2 shows a sample of responses from a candidate who answered this question incorrectly.

11.	a) Calculate Median.
	Soln.
	$\text{Median} = L + N/2 \left(\frac{n_b}{n} \right)^{-1}$
	$= 7 + 4/2 \left(\frac{4}{9} \right)^{-1}$
	$= 7 + \frac{4}{2} \left(\frac{4}{9} \right)^{-1}$
	$= 7 + \frac{4}{2} (2.44)$
	$= 7 + 2 (2.44)$
	$= 7 + 4.44$
	$\text{Median} = 11.44$
b)	Mean score
	Soln
	$\text{Mean, } X = \frac{\sum f}{f}$
	$X =$

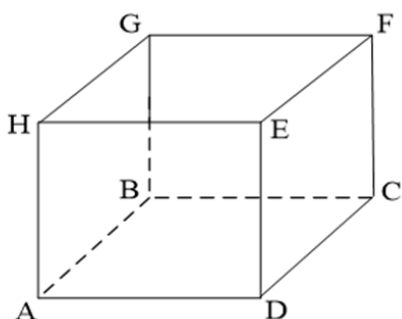


Extract 11.2: A sample of incorrect responses to question 11

Extract 11.2 shows that, in part (a), the candidate applied a wrong formula for calculating median and substituted irrelevant values which led to a wrong answer. In part (b), the candidates applied inappropriate formula for finding mean. In part (c), the candidate did not recognize the data to be used in drawing a histogram.

2.12 Question 12: The Earth as a Sphere and Three-Dimensional Figures

This question comprised two parts, (a) and (b). In part (a), candidates were given a square box ABCDEFGH whose sides are 8cm long as shown in the following figure.



They were required to; (i) determine the total surface area of the box and (ii) calculate the angle between the line segment $\overline{AF}$ and the plane ABCD, giving the answer to the nearest degree.

In part (b), candidates were given the information that “Boeing 787 Dream Liner flying at 500 km/h leaves Julius Nyerere International Airport in Tanzania ($7^{\circ}\text{S}, 45^{\circ}\text{E}$) at 8:00 am.”. They were required to find the time it will arrive at Addis Ababa in Ethiopia ($9^{\circ}\text{N}, 45^{\circ}\text{E}$) using the substitution

$$\text{of } \frac{2\pi R}{360^{\circ}} = 112.$$

The data analysis indicates that, 78,675 (14.9%) candidates passed, and among them 6,811 (1.3%) candidates scored all the marks allotted to this question. This indicates a weak performance on this question. It was further observed that 392,823 (74.2%) candidates scored zero on this question. The summary of the candidates’ performance on question 12 is displayed in Figure 12.

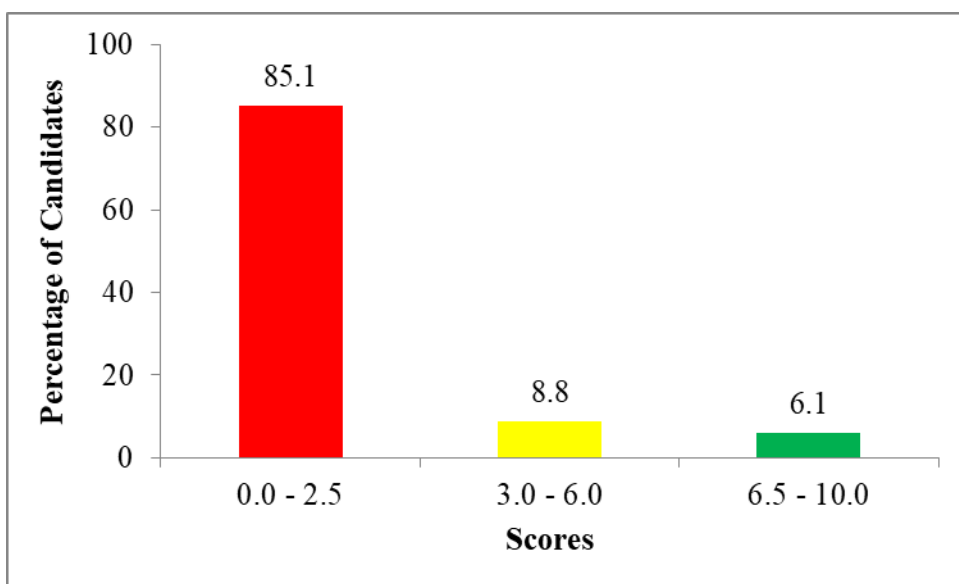


Figure 12: *Candidates' performance on question 12*

The analysis of responses shows that majority of the candidates who performed poorly on this question had insufficient knowledge and skills on the basic concepts of the Earth as a sphere and Three-dimensional figures. In part (a)(i), most of the candidates failed to apply the appropriate formula to determine the surface area of the cube. They performed illogical calculations such as $\text{surface area} = 8\text{cm} \times 8\text{cm} \times 8\text{cm} = 512\text{cm}$. Some of the candidates computed the surface area by multiplying 8cm by the total number of faces, that is $8\text{cm} \times 6 = 48\text{cm}$, which is a wrong procedure. Moreover, the analysis of responses shows that there were candidates who added the lengths of the three sides of the cube, that is $8\text{cm} + 8\text{cm} + 8\text{cm} = 18\text{cm}$. In part (a)(ii), the candidates failed to extract and construct the right-angled triangles from the square box. Hence, they could not determine the lengths of $\overline{AC}$ and $\overline{AF}$. It turned out that these candidates were not able to obtain the angle between the line segment $\overline{AF}$ and the plane $ABCD$.

In part (b), the candidates failed to find the angle between the two planes. They wrote $\theta = 9^\circ - 7^\circ = 2^\circ$, which is incorrect. Moreover, some of the candidates failed to write an appropriate formula for speed. For instance, they wrote $\text{Speed} = \frac{\text{time}}{\text{distance}}$, $\text{Time} = \frac{\text{speed}}{\text{distance}}$, $\text{Speed} = \text{distance} \times \text{time}$ or

Speed = distance – time instead of $\text{Speed} = \frac{\text{distance}}{\text{time}}$. Furthermore, some of the candidates applied wrong formulae for finding distance, such as $\text{Distance} = \frac{2\pi R \cos \theta}{360^\circ}$ which could not give a correct answer. Extract 12.1 shows a sample of responses from a candidate who answered this question incorrectly.

12. a) Total surface area
 $A = 1 \times 6$
 $A = 8 \times 6$
 Total surface area = 48 cm^2

b) From
 $\sin = \frac{\text{opp}}{\text{Adj}}$
 $\sin A = \frac{8}{8}$
 $\sin A = \frac{1}{1} = 90^\circ$
 Angle between the line segment = 90°

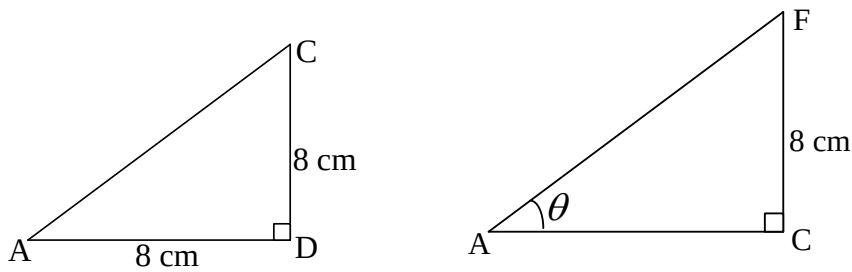
c) $\frac{2\pi R}{360} = 112$
 $2 \times 3.14 \times R = 112$
 $0.0174R = 112$
 0.0174×6436.7
 $R = 6436.7$
 From, $l = 17A$
 180
 $l = 3.14 \times 6436.7$
 180

12.	$l = 20211.4$
	$l = \frac{180}{1}$
	$l = 112.2$
	$length = 11.2 \cdot 2$
	$800 = 500$
	$897.6 = 500 \times x$
	$500 \quad 500$
	$x = 1.79$
	$2:19$
	Writ A H Anne adchis Ababa at
	2:19 PM

Extract 12.1: A sample of incorrect responses to question 12

Extract 12.1 shows that, in part (a)(i), the candidate failed to calculate the total surface area of a square box. He/she could not recognize the correct formula for the surface area of a cube. In part (a)(ii), the candidate failed to find the angle between the line segment $\overline{AF}$ and the plane ABCD. He/she performed irrelevant computations. In part (b), the candidate failed to calculate the arrival time. He/she lacked the knowledge of formulae to be applied.

However, the analysis of responses shows that the candidates who performed well on this question have sufficient knowledge and skills on Three-dimensional figures and the Earth as a sphere. In part (a)(i), the candidates were able to determine the total surface area of a square box ABCDEFGH. They recognized that a square box has a shape of a cube, that is it has 6 equal faces. They calculated the surface area of the box by applying the formula for surface area of a cube. That is surface area $= 6l^2 = 6 \times 8\text{cm} \times 8\text{cm} = 384\text{cm}^2$, which is the correct answer. In part (a)(ii), the candidates managed to calculate the angle between the line segment $\overline{AF}$ and the plane ABCD after finding the lengths of $\overline{AF}$ and $\overline{AC}$. They extracted the right-angled triangles ADC and ACF from the given figure as follows:



From the triangle ADC, they computed the length of $\overline{AC}$ by applying the Pythagoras' theorem, that is $\overline{AC}^2 = \overline{AD}^2 + \overline{DC}^2$ to get $\overline{AC} = \sqrt{128}$ cm. Similarly from the triangle ACF they applied the Pythagoras' theorem to determine the length of $\overline{AF}$, that is $\overline{AF}^2 = \overline{AC}^2 + \overline{CF}^2$ to obtain $\overline{AF} = 8\sqrt{3}$ cm. They were able to recognize the projection of $\overline{AF}$ on the plane ABCD as $\overline{AC}$ and angle θ . Thus, they applied the trigonometric ratio of either sine, cosine or tangent to find the measure of angle θ , that is $\sin \theta = \frac{\overline{CF}}{\overline{AF}} = \frac{8}{8\sqrt{3}} = 0.5773$ implying that $\theta = \sin^{-1}(0.5773) = 35^\circ$ to the nearest degree, which is the correct answer.

In part (b), the candidates were able to find the time for which Boeing 787 Dream Liner arrived at Addis Ababa in Ethiopia. They determined the angle between the two places, $\theta = 9^\circ + 7^\circ = 16^\circ$ and applied the appropriate formula for finding distance, that is $\text{Distance} = \frac{2\pi R}{360^\circ} \times \theta$. On substituting

$\frac{2\pi R}{360^\circ} = 112$ and $\theta = 16^\circ$ in the formula, they obtained $\text{distance} = 112 \times 16 = 1792$ km. Afterwards, they applied the formula, $\text{Speed} = \frac{\text{distance}}{\text{time}}$ to calculate the time taken, that is

$\text{time} = \frac{1792}{500} = 3.6$ hours = 3 hours and 36 minutes. Finally, they determined the arrival time as 8:00 am + 3 hours and 36 minutes to get 11:36 am as required. Extract 12.2 shows a sample of responses from a candidate who answered this question correctly.

12@ (i) Total surface area = $6l^2$

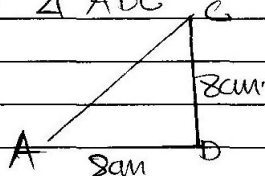
$$= 6 \times 8^2$$

$$= 6 \times 64$$

$$= 384 \text{ cm}^2$$

$\therefore$ The total surface area is 384 cm^2

(ii). Consider $\triangle ADC$

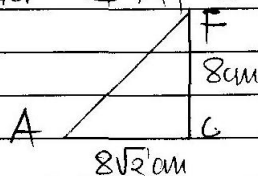


$$AC^2 = 8^2 + 8^2 \quad (\text{pythagoras theorem})$$

$$\sqrt{AC^2} = \sqrt{128}$$

$$AC = 8\sqrt{2}$$

Consider $\triangle AFG$



from pythagor trigonometry

$$\tan \angle FAC = \frac{8\text{cm}}{8\sqrt{2}\text{cm}}$$

$$\angle FAC = \tan^{-1}(8/8\sqrt{2})$$

$$\angle FAC \approx 35.3^\circ$$

$\therefore$ The angle between line AF and plane ABCD is 35.3°

12.	(b) Soln
	Given: Speed = 500km/h
	Tanzania ($7^{\circ}\text{S}, 45^{\circ}\text{E}$)
	Ethiopia ($9^{\circ}\text{N}, 45^{\circ}\text{E}$)
	Departure time = 8:00 a.m
	from,
	$d = \frac{\theta}{360^{\circ}} \times 2\pi R$
	$d = \left(\frac{2\pi R}{360^{\circ}}\right) \theta$
	$\theta = 7^{\circ} + 9^{\circ}$
	$= 16^{\circ}$
	$d = \left(\frac{2\pi R}{360^{\circ}}\right) \times 16^{\circ}$
	but $\frac{2\pi R}{360^{\circ}} = 112$
	$d = 112 \times 16^{\circ}$
	$= 1792 \text{ km.}$
	$t = \frac{d}{s}$
	$= \frac{1792 \text{ km}}{500 \text{ km/h}}$
	$= 3.6 \text{ hrs.}$
	$= 3 \text{ hrs } 36 \text{ min}$
	Arrival time = 0800hrs + 03 36
	$= 1136 \text{ hrs}$
	$\therefore \text{It will arrive at } 11:36 \text{ a.m.}$

Extract 12.2: A sample of correct responses to question 12

In Extract 12.2, part (a)(i), the candidate applied the correct formula and procedures to calculate the total surface area of a square box. In part (a)(ii), the candidate extracted the right-angled triangles correctly and used them to

determine the angle between the line $\overline{AF}$ and the plane ABCD. In part (b), the candidate was able to compute the distance between the two cities, the time taken to travel, and the arrival time.

2.13 Question 13: Matrices and Transformations

This question consisted of three parts, (a), (b), and (c). In part (a), candidates were required to find the values of x and y , given that

$$\begin{bmatrix} x & 4 \\ 3 & y \end{bmatrix} + \begin{bmatrix} 3x & 5 \\ -3 & 7 \end{bmatrix} = \begin{bmatrix} 8 & 9 \\ 0 & 9 \end{bmatrix}.$$

In part (b), candidates were given the information that “In a multiple choice test, 2 marks were awarded for each correct answer, 1 mark was deducted from each incorrect answer and 0 for not writing an answer. Anna answered 49 questions and scored 62 marks out of 100”. They were required to; (i) represent the information in matrix form by letting x be the number of correct answers and y be the number of incorrect answers and (ii) use the inverse matrix method to determine the number of questions that Anna answered correctly.

In part (c), the question stated that “A triangle has its vertices at the points A(1, 3), B(2, 5), and C(4, 1). If the triangle is rotated through 180° anticlockwise about the origin; (i) find the coordinates of the points A', B', and C' which are the images of A, B, and C, respectively, (ii) draw the triangles ABC and A'B'C' on the same set of axes”.

According to data analysis, 65,284 (12.3%) candidates passed this question, which indicates a weak performance. Further analysis shows that 2,160 (0.4%) candidates got full marks whereas 385,535 (72.8%) candidates scored zero on this question. Figure 13 shows a summary of the performance on question 13.

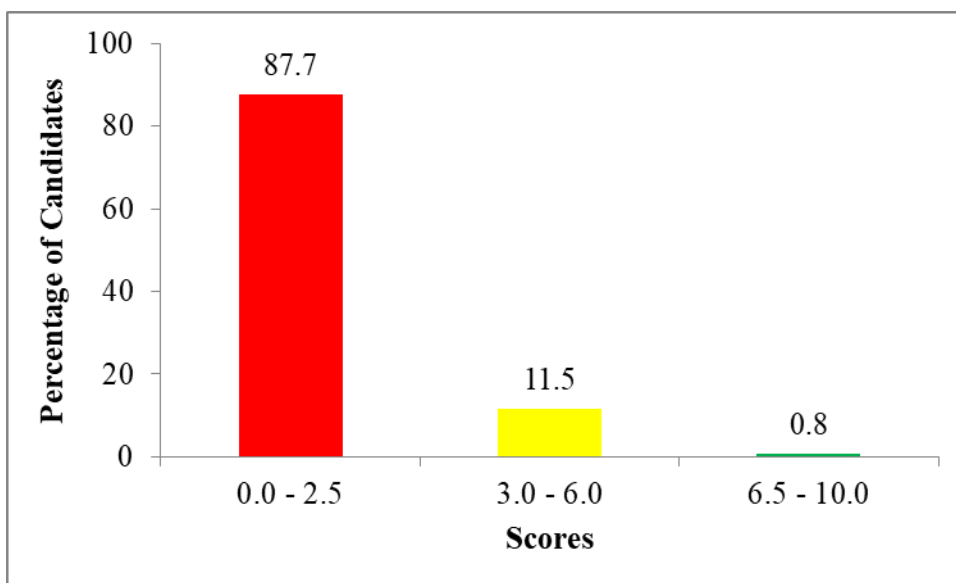


Figure 13: *Candidates' performance on question 13*

The analysis of responses shows that the candidates who performed poorly on this question lacked the competence on the basic concepts of Matrices and Transformations. In part (a), the candidates lacked the knowledge and skills on operations on matrices. They were not able to add the corresponding entries of the matrices in order to get the values of x and y . They performed irrelevant calculations that led to incorrect answers.

In part (b)(i), the candidates transformed the word problem into wrong simultaneous equations such as $\begin{cases} 2x + y = 100 \\ 49x + 13y = 62 \end{cases}$, whose matrix form is

$$\begin{pmatrix} 2 & 1 \\ 49 & 13 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 100 \\ 62 \end{pmatrix} \text{ instead of } \begin{pmatrix} 1 & 1 \\ 2 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 49 \\ 62 \end{pmatrix}.$$

In part (b)(ii), the candidates were unable to determine the number of questions that Anna answered correctly using inverse matrix method. This is the consequence of failure to answer (b)(i) correctly. In part (c)(i), the candidates applied a wrong formula for rotation matrix as well as incorrect image formulae such as $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \sin \theta & -\cos \theta \\ \sin \theta & \cos \theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$, instead of $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$. Upon substituting the given coordinates in a wrong formula, they obtained incorrect images.

Further analysis shows that, some of the candidates used the formula for reflection to find the coordinates of the images, which was a wrong procedure. For instance, they applied incorrect formulae such as $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \sin 2\theta & \cos 2\theta \\ \cos 2\theta & -\sin 2\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$, where $\theta = 360^\circ$ to get $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$. As a result, they got incorrect images of the points A(1,3), B(2,5), and C(4,1). Extract 13.1 shows a sample of responses from a candidate who answered this question incorrectly.

13	a) Soln.
	$\begin{bmatrix} x & y \end{bmatrix} \cdot \begin{pmatrix} 3x & 5 \\ -3 & 7 \end{pmatrix} = \begin{pmatrix} 8 & 9 \\ 0 & 9 \end{pmatrix}$
	$\begin{pmatrix} 3x^2+12 & 5x+28 \\ 9x+3y & 15+7y \end{pmatrix} = \begin{pmatrix} 8 & 9 \\ 0 & 9 \end{pmatrix}$
	$3x^2-12=8 \quad \dots (i)$
	$5x+28=9 \quad \dots (ii)$
	$9x-3y=0 \quad \dots (iii)$
	$15+7y=9 \quad \dots (iv)$
	$15+7y=9$
	$7y=9-15$
	$7y=\frac{6}{7}$
	$y=\frac{6}{7}$
	$5x+28=9$
	$5x=9-28$
	$\frac{5x}{5}=\frac{-19}{5}$
	$x=-3.8$
	$\therefore$ Value of $y = \frac{6}{7}$ and $x = -\frac{19}{5}$ or -3.8

Q 62 iii Then

$$|A| = (62 \times 2 - 49 \times 1)$$

$$|A| = 124 - 49$$

$$|A| = 75$$

Then

$$\frac{1}{|A|}$$

$$A^{-1} = \frac{1}{75} \begin{pmatrix} 62 & -1 \\ -49 & 2 \end{pmatrix}$$

$$A^{-1} = \begin{pmatrix} 62/75 & -1/75 \\ -49/75 & 2/75 \end{pmatrix}$$

Then

$$\begin{pmatrix} 2 & 1 \\ 49 & 62 \end{pmatrix} \begin{pmatrix} 62/75 & -1/75 \\ -49/75 & 2/75 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 62/75 & -1/75 \\ -49/75 & 2/75 \end{pmatrix} \begin{pmatrix} 100 \\ 100 \end{pmatrix}$$

Where by

$$A \times A^{-1} = I$$

$$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 82.67 + -1.333 \\ -65.33 + 2.666 \end{pmatrix}$$

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 81.3 \\ -62.6 \end{pmatrix}$$

Number of questions that Anna answered
correctly = 81.3

13 (C) (i) Rotations

$$A = \begin{pmatrix} \sin 180 & \cos 180 \\ -\cos 180 & \sin 180 \end{pmatrix} = \begin{pmatrix} 1 \\ 3 \end{pmatrix} = \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$A = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 3 \end{pmatrix} = \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$A = \begin{pmatrix} -1 \\ 3 \end{pmatrix} = \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$B = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 2 \\ 5 \end{pmatrix} = \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$B = \begin{pmatrix} -2 \\ 5 \end{pmatrix} = \begin{pmatrix} x' \\ y' \end{pmatrix}$$

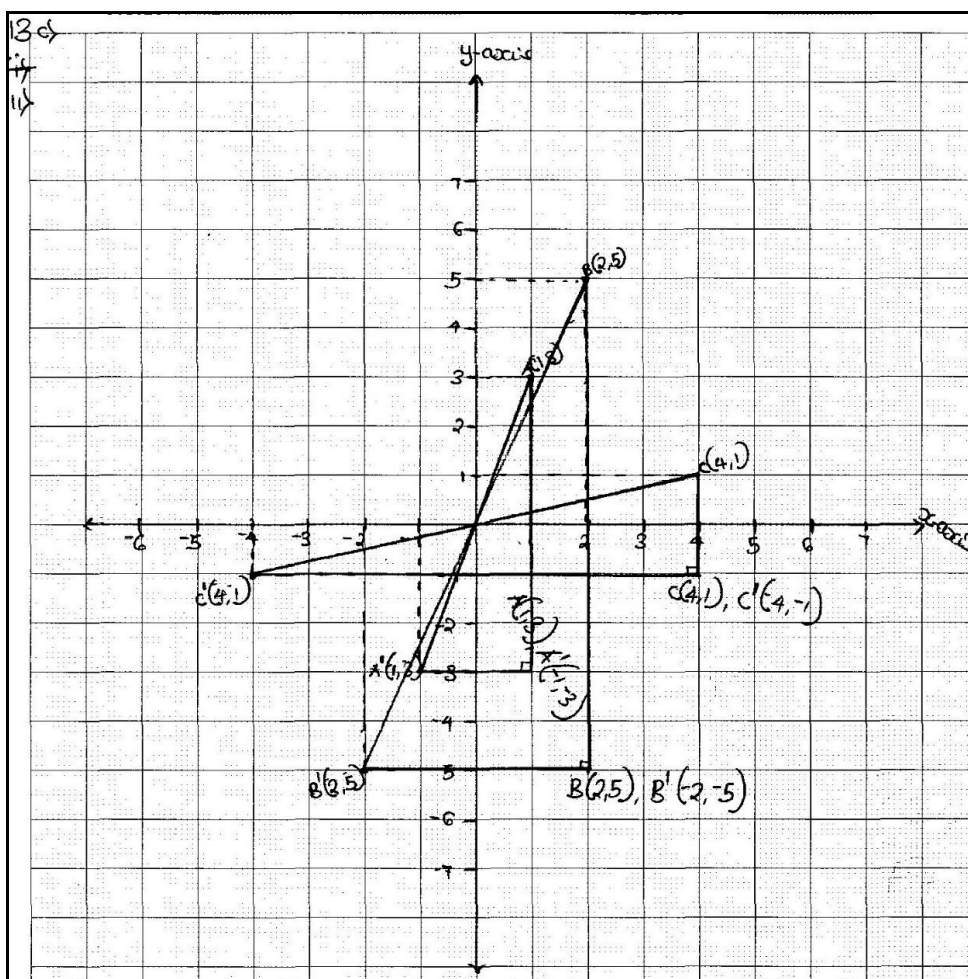
$$\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 4 \\ 1 \end{pmatrix} = \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$B = \begin{pmatrix} -4 \\ 1 \end{pmatrix} = \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$A'(-1, 3)$$

$$B'(-2, 5)$$

$$C'(-4, 1)$$



Extract 13.1: A sample of incorrect responses to question 13

Extract 13.1 shows that, in part (a), the candidate failed to add the matrices to be able to determine the values of x and y . In part (b)(i), the candidate was not able to interpret the word problem, thus he/she failed to present the information in matrix form. In part (b)(ii), the candidate could not solve the problem as a result of failure to represent it in matrix form. In part (c)(i), the candidate wrote a wrong formula for rotation matrix. In part (c)(ii), the candidate was not able to locate and join the coordinates of the given object and its images.

However, the analysis of responses shows that the candidates who performed well on this question showed to have gained the intended competence on the basic tenets of Matrices and Transformations. In part

(a), the candidates added the 2×2 matrices on the left hand side of the equation $\begin{pmatrix} x & 4 \\ 3 & y \end{pmatrix} + \begin{pmatrix} 3x & 5 \\ -3 & 7 \end{pmatrix} = \begin{pmatrix} 8 & 9 \\ 0 & 9 \end{pmatrix}$ to obtain $\begin{pmatrix} 4x & 9 \\ 0 & y+7 \end{pmatrix} = \begin{pmatrix} 8 & 9 \\ 0 & 9 \end{pmatrix}$. They compared the entries of the matrix equation to get $4x=8$ and $y+7=9$. They correctly solved for the values of x and y to get $x=2$ and $y=2$. In part (b)(i), the candidates were able to formulate the simultaneous equations $x+y=49$ and $2x-y=62$ and re-wrote them in the matrix form, that is $\begin{pmatrix} 1 & 1 \\ 2 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 49 \\ 62 \end{pmatrix}$. In part (b)(ii), the candidates used the inverse matrix method to solve the formulated system of simultaneous equations to get $x=37$ and $y=12$, which is the correct solution. In part (c)(i), the candidates applied the correct formula for rotation matrix, that is $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$, where θ is an angle rotated through anticlockwise about the origin. Thereafter, they substituted $\theta=180^\circ$ to get $R_{180^\circ} = \begin{pmatrix} \cos 180^\circ & -\sin 180^\circ \\ \sin 180^\circ & \cos 180^\circ \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix}$. They multiplied this matrix by each vertex of the object to get the images of the points A, B and C. That is, $A' = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 1 \\ 3 \end{pmatrix} = \begin{pmatrix} -1 \\ -3 \end{pmatrix}$, $B' = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 2 \\ 5 \end{pmatrix} = \begin{pmatrix} -2 \\ -5 \end{pmatrix}$ and $C' = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 4 \\ 1 \end{pmatrix} = \begin{pmatrix} -4 \\ -1 \end{pmatrix}$. In part (c)(ii), the candidates were able to draw the triangles ABC and A'B'C' on the same set of axes using the results obtained in (c)(i). Extract 13.2 is sample of responses from a candidate who answered this question correctly.

1307	$\begin{bmatrix} x & 4 \\ 3 & y \end{bmatrix} + \begin{bmatrix} 3x & 5 \\ -3 & 7 \end{bmatrix} = \begin{bmatrix} 8 & 9 \\ 0 & 9 \end{bmatrix}$
	$\begin{bmatrix} x+3x & 4+5 \\ 3-3 & y+7 \end{bmatrix} = \begin{bmatrix} 8 & 9 \\ 0 & 9 \end{bmatrix}$
	$x+3x=8$
	$4x=8$
	$4x=8 \quad x=2$
	4 4
	<u>$\therefore$ The value of x is 2</u>
	$y+7=9$
	$y=9-7$
	$y=2$
	<u>$\therefore$ The value of y is 2</u>

13b) Let the number of questions answered correctly be x
Let the number of questions answered incorrectly be y

$$\begin{aligned} \text{i) } x + y &= 49 \\ 2x - y &= 62 \end{aligned}$$

$$\begin{pmatrix} 1 & 1 \\ 2 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 49 \\ 62 \end{pmatrix}$$

ii) Let matrix $\begin{pmatrix} 1 & 1 \\ 2 & -1 \end{pmatrix}$ be A

$$|A| = (1 \times -1) - (1 \times 2)$$

$$|A| = -1 - 2 =$$

$$|A| = -1 - 2 = -3$$

$$|A| = -3$$

Adjoint of matrix $A \begin{pmatrix} -1 & -1 \\ -2 & 1 \end{pmatrix}$

To get A^{-1}

$$\frac{1}{|A|} \begin{pmatrix} -1 & -1 \\ -2 & 1 \end{pmatrix}$$

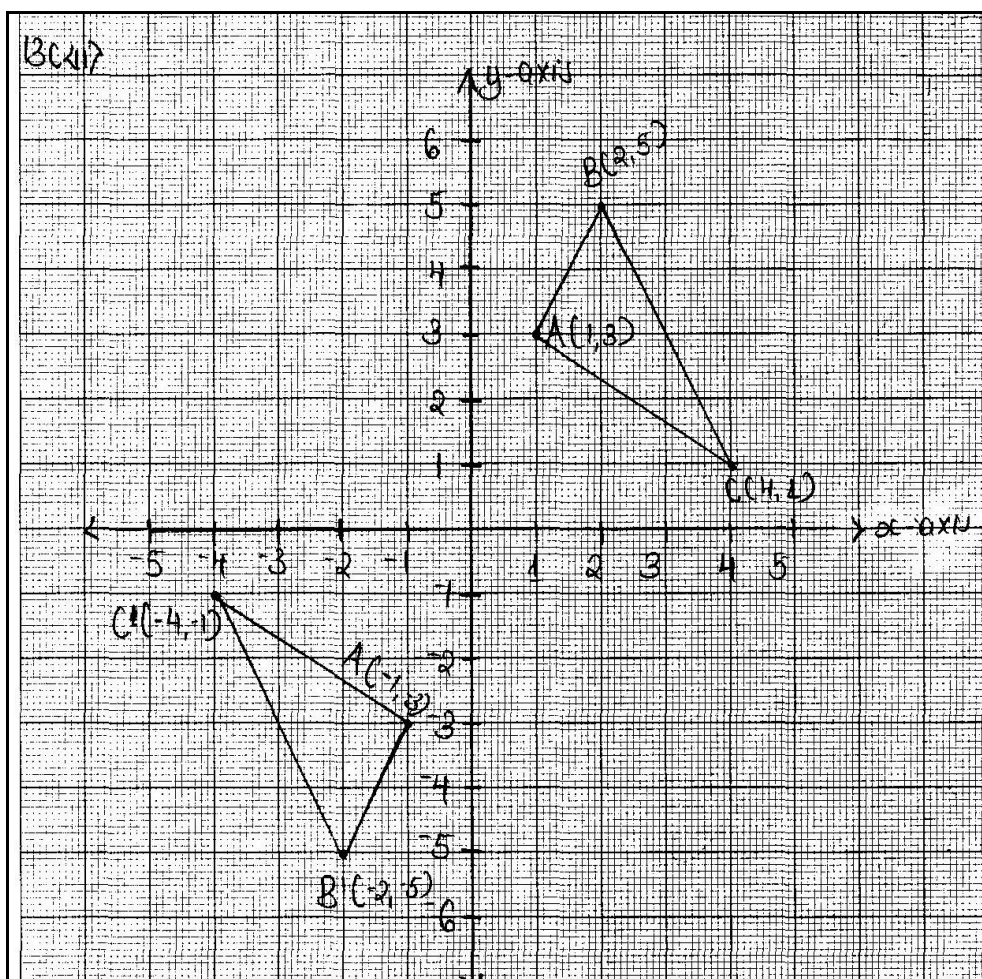
$$A^{-1} = \frac{1}{-3} \begin{pmatrix} -1 & -1 \\ -2 & 1 \end{pmatrix}$$

$$A^{-1} = \begin{pmatrix} 1/3 & 1/3 \\ 2/3 & -1/3 \end{pmatrix}$$

Then multiply by A^{-1} both sides

13b)	$\begin{pmatrix} 1/3 & 1/3 \\ 2/3 & -1/3 \end{pmatrix} \begin{pmatrix} 1 & 1 \\ 2 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1/3 & 1/3 \\ 2/3 & -1/3 \end{pmatrix} \begin{pmatrix} 49 \\ 62 \end{pmatrix}$
	$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 49/3 + 62/3 \\ 98/3 + -62/3 \end{pmatrix}$
	$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 111/3 \\ 36/3 \end{pmatrix}$
	$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 37 \\ 12 \end{pmatrix}$
	$x = 37, y = 12$
	<u>$\therefore$ The number of questions that Anna answered correctly is 37.</u>
13c)	A (1, 3) B (2, 5) C (4, 4)
17)	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$ $= \begin{pmatrix} \cos 180^\circ & -\sin 180^\circ \\ \sin 180^\circ & \cos 180^\circ \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$ $= \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$
	Rotation matrix = $\begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix}$

13c)	for A
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 1 \\ 3 \end{pmatrix}$
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 + 0 \\ 0 - 3 \end{pmatrix}$
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 \\ -3 \end{pmatrix}$
	$A' = (-1, -3)$
	for B
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 2 \\ 5 \end{pmatrix}$
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -2 + 0 \\ 0 - 5 \end{pmatrix}$
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -2 \\ -5 \end{pmatrix}$
	$B' = (-2, -5)$
	for C
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 4 \\ 1 \end{pmatrix}$
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -4 + 0 \\ 0 - 1 \end{pmatrix}$
	$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -4 \\ -1 \end{pmatrix}$
	$\therefore C' = (-4, -1)$



Extract 13.2: A sample of correct responses to question 13

Extract 13.2 shows that, in part (a), the candidate identified the corresponding elements, added and compared the entries in the matrix equation to get the values of x and y . In part (b), the candidate formulated the simultaneous equations from the word problem. He/she used the inverse matrix method to solve for the values of x and y . In part (c), the candidate applied the formula for rotation matrix correctly to find the images of the given vertices. Finally, he/she was able to draw the triangle ABC and its image $A'B'C'$ on the same set of axes.

2.14 Question 14: Functions and Linear Programming

This question comprised two parts, (a) and (b). In part (a), candidates were given a function $f(x)$ defined on the set of integers such that

$$f(x) = \begin{cases} -2 & \text{if } 0 < x \leq 5 \\ x+1 & \text{if } -6 \leq x < 0 \end{cases}.$$
 They were required to; (i) find the values of

$f(4)$ and $f(-5)$ and (ii) state the domain and range of $f(x)$. In part (b), candidates were provided with the information that “The Air Tanzania Company wants to buy two types of airplanes, A and B. Type A requires 6 dam² of parking space, type B requires 2 dam² of parking space while the company has 60 dam² of parking space available. Also the company has 480 billion shillings and the cost for buying airplanes of type A and type B are 20 billion shillings and 30 billion shillings, respectively”. They were required to find the greatest number of airplanes the company could buy.

From the data analysis, it was found that 71,397 (13.5%) candidates passed this question, which justifies a weak performance. It was also found that 928 (0.2%) candidates scored full marks while 405,050 (76.5%) candidates scored zero on this question. Figure 14 shows a summary of the candidates’ performance on question 14.

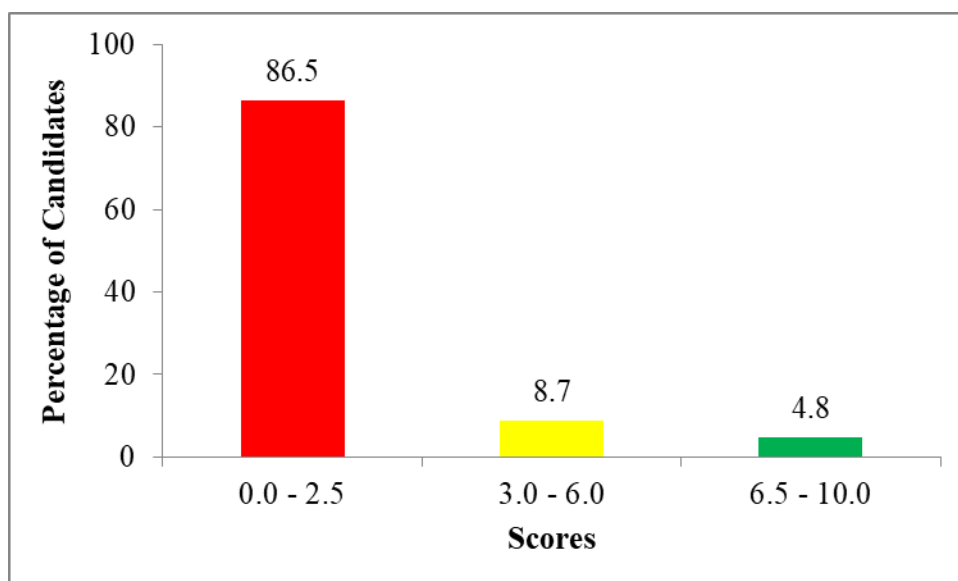


Figure 14: *Candidates’ performance on question 14*

The response analysis shows that the candidates who performed poorly on this question had inadequate knowledge and skills on the concepts of Functions and Linear programming. In part (a)(i), the candidates were not able to find the correct values of $f(4)$ and $f(-5)$. They could not identify the intervals containing the given points. They wrote $f(4)=5$ and $f(-5)=-2$ instead of $f(4)=-2$ and $f(-5)=-4$, respectively. In part (a)(ii), the candidates failed to state the domain and range of the integer function. They assumed wrongly that the function $f(x)$ is defined on the set of real numbers. For instance, they stated that Domain = {all real numbers}, which is an incorrect answer. Also, they stated that Range = $\{y: y = -2 \text{ or } y \geq -4\}$ instead of Range = $\{y: -5 \leq y < 1\}$.

In part (b), the candidates failed to formulate the required constraints of the linear programming problem. They could not recognize that the given linear programming problem is a maximization problem. Thus, they treated it as a minimization problem since they used inequalities such as $6x + 2y \geq 60$ and $20x + 30y \geq 480$ instead of $6x + 2y \leq 60$ and $20x + 30y \leq 480$. Furthermore, the analysis shows that the candidates failed to determine the objective function corresponding to the given linear programming problem. They defined the objective function as $f(x, y) = 60x + 480y$ or $f(x, y) = 480x + 60y$ instead of $f(x, y) = x + y$. The consequences of these mistakes caused the candidates' failure to solve the linear programming problem graphically. From the analysis, it can be deduced that the candidates lacked sufficient knowledge on the examined concepts. Extract 14.1 shows a sample of responses from a candidate who answered this question incorrectly.

14: as solution.

$$i) f(4) = x+1$$

$$4 = x+1,$$

$$4-1 = x$$

$$\therefore f(4) = 3.$$

$$f(-5) = x+1,$$

$$-5 = x+1$$

$$-5-1 = x,$$

$$\therefore f(-5) = -6.$$

Domains are 1 and -6.

Ranges are all real numbers.

b/ solution b/.

Let type A of air plane to be x
and type B of air plane to be y

	Type A	Type B	Total
No. Dm	$6x$	$2y$	60

Objective functions.

$$f(x) = 20x + 30y.$$

Con

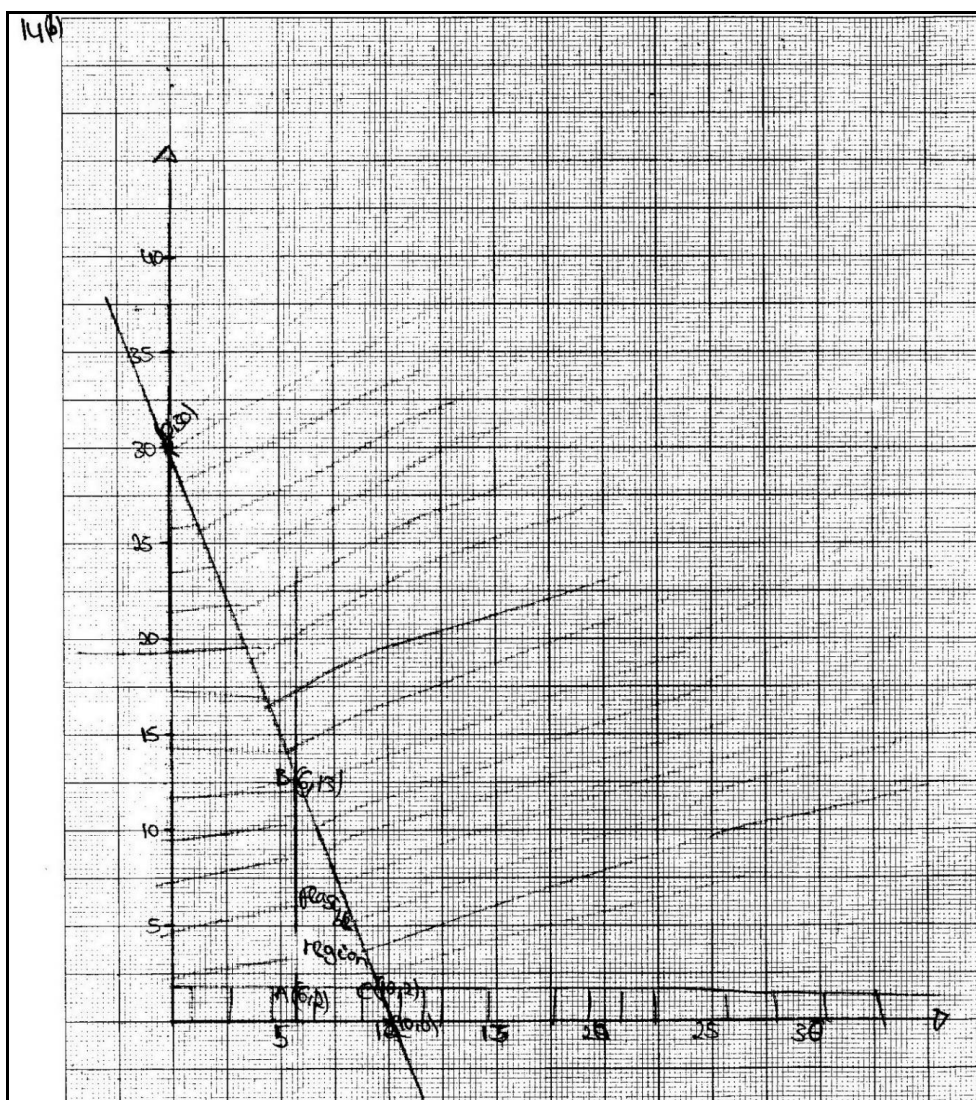
Equations.

$$6x + 2y = 60$$

Constant.

$$x \geq 0$$

$$y \leq 0$$



Extract 14.1: A sample of the incorrect responses to question 14

Extract 14.1 shows that, in part (a), the candidate failed to evaluate the values of $f(4)$ and $f(-5)$ from the given function. Similarly, he/she failed to state the domain and range of the function. In part (b), the candidate failed to extract the correct constraints of the linear programming problem. Hence, he/she was not able to solve the given linear programming problem.

On the other hand, the analysis of responses shows that the candidates who responded correctly to this question demonstrated the intended competences gained after learning the basic concepts of Functions and Linear programming. In part (a), the candidates were able to find the values of $f(4)$ and $f(-5)$, and state the domain and range of the integer function $f(x)$. They recognized that 4 lies in the interval $0 < x \leq 5$, while -5 lies in $-6 \leq x < 0$. Thus, they obtained $f(4) = -2$ and $f(-5) = -5 + 1 = -4$. They stated correctly the domain and range as Domain = $\{x : -6 \leq x \leq -1, 1 \leq x \leq 5\}$ and Range = $\{y : -5 \leq y \leq 0\}$ or Domain = $\{x : -6 \leq x < 0, 0 < x \leq 5\}$ and Range = $\{y : -5 \leq y < 1\}$. In part (b), the candidates interpreted the word problem correctly and defined the variables to be used by letting x and y be the number of type A and type B airplanes, respectively. They formulated the constraints of the linear programming problem, that is $6x + 2y \leq 60$, $20x + 30y \leq 480$, $x \geq 0$, $y \geq 0$. Also, they defined the objective function for the maximization problem such that $f(x, y) = x + y$. Thereafter, they used the inequalities to sketch the graph from which a feasible region defined by the corner points $(0, 0)$, $(0, 16)$, $(6, 12)$, and $(10, 0)$ was identified. The corner points were substituted in the objective function and $(6, 12)$ provided the optimal solution with an optimal value of 18. Finally, they concluded by stating that, the greatest number of airplanes the company could buy is 18. Extract 14.2 is a sample of responses from a candidate who answered the question correctly.

14.	a. Given;
	$f(x) = \begin{cases} -2 & \text{if } 0 < x \leq 5 \\ x+1 & \text{if } -6 \leq x < 0 \end{cases}$
	i. Solution
	$f(4) = -2$; $\therefore f(4) = -2$
	$f(-5) = -5 + 1 = -4$; $\therefore f(-5) = -4$
	iii. Domain of $f(x) = \{x : -6 \leq x < 0 \text{ and } 0 < x \leq 5\}$
	Range of $f(x) = \{y : -5 \leq y < 1\}$

14. b. let number of Air plane A be x
let number of Air plane B be y

$$6x + 2y \leq 60$$

$$6x + 2y = 60$$

$$3x + y = 30$$

x	0	10
y	30	0

$$20x + 30y \leq 480$$

$$20x + 30y = 480$$

$$2x + 3y = 48$$

x	0	24
y	16	0

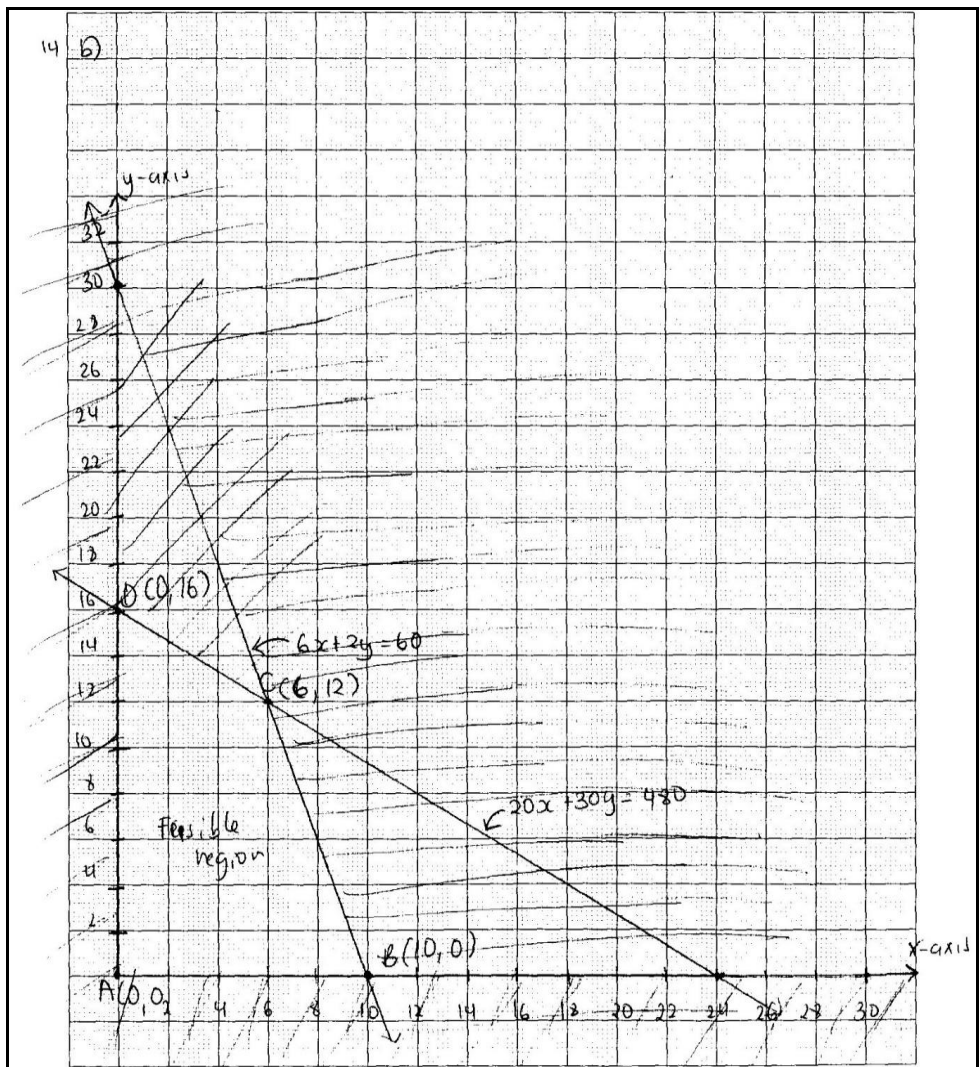
$$y \geq 0, x \geq 0$$

Objective function

$$f(x) = y + x$$

corner points	$f(x) = y + x$	number
A(0,16)	$0 + 16$	16
B(6,12)	$6 + 12$	18
C(10,0)	$10 + 0$	10
D(0,0)	$0 + 0$	0

$\therefore$ The greatest number is 18 at (6,12) where it can buy 6 type A airplane and 12 type B air planes



Extract 14.2: A sample of correct responses to question 14

Extract 14.2 shows that, in part (a), the candidate evaluated the function $f(x)$ at the given points and stated the domain and range correctly. In part (b), the candidate determined the inequalities and objective function correctly. He/she was able to solve the linear programming problem graphically to obtain the correct answer.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE ON EACH TOPIC

The data analysis reveals that, out of 25 topics which were examined in Basic Mathematics in CSEE 2023, only six (6) topics had an average performance. The topics were: *Numbers, Fractions, and Decimals and Percentages* (43.9%), *Statistics* (40.8%) and *Ratios, Profit and Loss, and Accounts* (34.9%). The rest of the topics had a weak performance. Those topics include: *Units and Rates and Variations* (29.5%), *Exponents and Radicals and Logarithms* (20.3%), *Pythagoras' Theorem and Trigonometry* (16.4%), *Geometry, Perimeters and Areas* (15.6%), *The Earth as a Sphere and Three-Dimensional Figures* (14.9%), *Functions and Linear Programming* (13.5%), *Matrices and Transformations* (12.3%), *Sets and Probability* (11.8%), *Coordinate Geometry and Vectors* (9.3%), *Sequences and Series* (7.8%), *Quadratic Equations and Algebra* (2.5%). The summary of the candidates' performance per topic is indicated in the Appendix provided on page 97.

4.0 CONCLUSION

The Basic Mathematics paper in CSEE 2023 had 14 questions and among them, only three (03) questions, that is questions 1, 11 and 7 had an average performance of 43.9, 40.8 and 34.9 per cent, respectively. The questions were set from the topics on *Numbers, Fractions, Decimals and Percentages, Statistics, Ratios, Profit and Loss and Accounts*.

Further analysis indicated that, the remaining 11 questions had weak performance ranging from 29.5 to 2.5 per cent. Those questions were set from the topics on: *Units, Rates and Variations, Exponents and Radicals, Logarithms, Pythagoras' Theorem, Trigonometry, Geometry, Perimeters and Areas, The Earth as a Sphere, Three-Dimensional Figures, Functions, Linear Programming, Matrices and Transformations, Sets, Probability, Coordinate Geometry, Vectors, Sequences and Series, Quadratic Equations and Algebra*.

The response analysis shows that, the main factors that contributed to weak performance were the candidates' inability to present mathematical information using graphs and figures; formulate inequalities, expressions and equations; apply correct formulae, rules, theorems, properties and

mathematical procedures to perform computations; and simplify and solve mathematical expressions, equations and inequalities.

5.0 RECOMMENDATIONS

In order to improve the candidates' performance in Basic Mathematics examinations in future, the Council recommends the following:

- (a) In the topic on *Quadratic equations*, teachers should guide students in groups through applying the substitution of variables in order to formulate quadratic equation and solve it using various methods.
- (b) In the topic on *Sequences and series*, teachers should use various teaching and learning resources like number cards, scientific pocket calculators and number patterns in ascending and descending order demonstrate to students the concepts of sequences and series, n^{th} term and sum of the first n terms by applying appropriate formulae and various techniques.
- (c) In the topic on *Coordinate geometry*, teachers should demonstrate to students in small groups on how to locate a pair of points on the xy -plane, read coordinate points and find the distance between two points and apply these concepts to discuss the properties of polygons using various teaching and learning resources like graph papers/board, squared papers, geoboard and rubber bands.
- (d) In the topic on *Vectors*, teachers should demonstrate to students on how to apply the knowledge on vectors in finding distance, direction, magnitude and location of objects and their properties using various teaching and learning resources like rulers, protractors, coloured chalks, magnetic compasses, squared papers, graph boards and graph papers.
- (e) In the topics on *Sets* and *Probability*, teachers should guide students through discussion on how to apply the knowledge on sets and probabilities in predicting, combining and making decision in real life situations, basing on the use of teaching and learning resources like Venn diagrams and real objects such as playing cards, dice, teams of players, real numbers and animals.
- (f) In the topic on *Matrices and transformations*, teachers should use participatory method and creativity techniques in teaching students

on how to solve matrices under addition, subtraction and multiplication operations. They should also guide students through solving simultaneous equations from word problems by applying the inverse matrix method, using teaching and learning resources like charts of inverses of matrices.

- (g) In the topic on *Linear programming*, teachers should use teaching and learning resources available in their surroundings to demonstrate to students the procedures of formulating the inequalities/equations and objective functions, drawing graphs, identify feasible regions and their corner points, and substitute the corner points in the objective functions to determine the maximum and minimum values using interactive teaching/learning methods.
- (h) In the topic on *The Earth as a sphere*, teachers should use participatory methods and variety of resources such as globe, atlas, graphs, protractor, non-programmable calculators, navigation compasses and gyroscope to demonstrate to students on how to use the latitudes and longitudes between two places on the Earth's surface to find distances between two places and time taken to cover the distances.
- (i) In the topic on *Three-dimensional figures*, teachers should use participatory techniques to lead students' discussion on how to calculate the lengths, angle formed between a line and a plane, angle formed between two planes and surface areas of three-dimensional figures using teaching and learning resources like wall charts, coloured chinks, three-dimensional models, mathematical instruments and scientific pocket calculators.
- (j) In the topic on *Perimeters and areas*, teachers should guide students in small groups through identifying and describing geometrical figures and their properties and applying them to find the areas of triangles and quadrilaterals using various teaching and learning resources like triangles, quadrilaterals, tape measure, ruler, Manila paper, marker pen and geoboard.
- (k) In the topics on *Trigonometry* and *Pythagoras' theorem*, teachers should demonstrate on how to use trigonometric ratios of sine, cosine and tangent of an angle, sine rule, cosine rule and Pythagoras' theorem to solve related problems in real life settings. Based on the

acquired knowledge and skills, they should demonstrate to students in small groups on how to calculate the heights and angles of real structures using various teaching and learning resources like graph paper, mathematical sets and calculators.

- (l) In the topics on *Exponents and radicals* and *Logarithms*, teachers should lead students' discussion on listing, verifying and applying the laws of exponents and logarithms in computations using resources like wall charts, number charts, mathematical tables and charts of exponential and logarithmic laws. They should also let students work in groups on problems involving exponential and logarithmic equations and conduct peer presentations.
- (m) In the topics of *Units* and *Rates and variation*, teachers should apply participatory methods and use various teaching and learning resources like tape measure, metre ruler and charts of units of length to demonstrate the computation and conversion of one metric unit of length into the other and then allow students in groups to perform computations on metric units of length using basic operations. They should also use physical objects to guide students in forming and solving equations related to direct variation.
- (n) In the topics on *Ratios, profit and loss* and *Accounts*, teachers should guide students through group discussion on how to divide a given quantity into its proportional parts using teaching and learning resources like money and other physical items. Teachers should also demonstrate how to construct a trial balance, post debit balances and credit balances, qualify a trial balance, and check the balances using cash accounts and resources like ledger books and samples of reposts on business transactions.
- (o) In the topic on *Statistics*, teachers should guide students to obtain statistical data from contemporary and cross-cutting issues, present the obtained data using frequency distribution tables and hence calculate the measures of central tendency, that is mean, median and mode. They should also demonstrate how to present data graphically and hence estimate the measures of central tendency using various teaching and learning resources like chart with different statistical data, graph paper, graph board, geoboard and coloured chalks.

- (p) In the topics of *Numbers, Fractions and Decimals and Percentages*, teachers should guide students through interactive methods on how to arrange fractions in ascending order using decimals and percentage techniques while making use of teaching and learning resources like real objects, pie charts and research reports. Teachers should also put more emphasis on determining the common multiples and factors of numbers as well as using the BODMAS rule to guide students through solving mathematical expressions involving mixed operations.

Appendix: The Candidates' Performance per Topic – CSEE 2023

S/N	Topics	Question Number	Percentage of Candidates who Passed	Remarks
1.	Numbers, Fractions, Decimals and Percentages	1	43.9	Average
2.	Statistics	11	40.8	Average
3.	Ratios, Profit and Loss, and Accounts	7	34.9	Average
4.	Units, Rates, and Variations	6	29.5	Weak
5.	Exponents, Radicals, and Logarithms	2	20.3	Weak
6.	Pythagoras' Theorem and Trigonometry	9	16.4	Weak
7.	Geometry, Perimeters, and Areas	5	15.6	Weak
8.	The Earth as a Sphere and Three-Dimensional Figures	12	14.9	Weak
9.	Functions and Linear Programming	14	13.5	Weak
10.	Matrices and Transformations	13	12.3	Weak
11.	Sets and Probability	3	11.8	Weak
12.	Coordinate Geometry and Vectors	4	9.3	Weak
13.	Sequence and Series	8	7.8	Weak
14.	Quadratic Equations and Algebra	10	2.5	Weak

