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 SECONDARY EDUCATION EXAMINATION (CSEE), 2023

MANUFACTURING ENGINEERING

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088 MANUFACTURING ENGINEERING

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FOREWORD

This report presents Candidates' Items Response Analysis (CIRA) on the Certificate of Secondary Education Examination (CSEE) in Manufacturing Engineering subject, which was conducted in November 2023. The report aims to provide feedback to all educational stakeholders on the candidates' performance in Manufacturing Engineering subject.

The Certificate of Secondary Education Examination (CSEE) is a summative evaluation, which intends to monitor candidates' learning and provide feedback that teachers, candidates and other educational stakeholders can use to improve teaching and learning processes. This report reveals that, candidates had good performance in the topics of Machine Tools I in question 5, Maintenance Practice in question 11 and Foundry Technology in question 2, 6 and 8. The candidates had average performance in topics such as Metal Forming and Heat Treatment in questions 3, 4 and 7 as well as Engineering Materials in question 9. However, the candidates had weak performance particularly in the topic of Machine Tools II in question 10. The given performance is well demonstrated in Appendices I-V.

The performance analysis shows that, the factors which contributed to the poor performance of the candidates are failure to understand the demands of the questions, inadequate knowledge and skills on some tested subject matters. Lack of enough knowledge in English language likewise affected the given performance. On the other hand, good performance of the candidates was contributed by ability to identify the demands of each question, adequate knowledge on the examined subject matter and proficiency in English language. The justification of the poor or good performance is well demonstrated in this report using extracts. In other words, the extract of good or poor performed question is well indicated in the report for reference.

The Council believes that, the report will be helpful to education stakeholders to improve the teaching and learning processes for attainment of required instructional objectives. The Council appreciates the efforts made by all who in one way or another contributed to the preparation of this report.

Dr. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the candidates' performance on the Certificate of Secondary Education Examination (CSEE) in Manufacturing Engineering subject, which was administered in November 2023. The report illustrates how the candidates had attained competences in accordance to Manufacturing Engineering Secondary Education Syllabus, which was issued in 2019.

The Manufacturing Engineering examination paper had three sections: A, B and C. The examination was comprised of 11 questions. Section A had two objective questions, 1 and 2. Question 1 consisted of ten multiple choice items constructed from eight topics. These topics are *Machine Tools I, Welding Technology, Maintenance Practice, Metal Forming and Heat Treatment, Foundry Technology, Engineering Materials, Workshop Tools and Equipment* and *Workshop Management and Safety Rules.* Each item carried one mark. Question 2 consisted of six homogeneous matching items constructed from the topic of *Foundry Technology.* Each item carried one mark, making 16 marks.

Section B had six short-answer questions 3, 4, 5, 6, 7 and 8. The given questions were constructed from three topics such as *Metal Forming and Heat Treatment, Machine Tools I* and *Foundry Technology,* each question carrying nine marks. Section C had three questions 9, 10 and 11 weighing 15 marks each. The candidates were required to answer only two questions from this section. The given questions were set from three topics such as *Engineering Materials, Machine Tools II and Maintenance Practice*.

There were 146 (100%) candidates sat for the CSEE of 2023 in Manufacturing Engineering subject. The performance analysis reveals that, 12 (8.22%) students scored marks from 0 to 29, while 134 (91.78%) candidates scored between 30 and 100 marks. Therefore, 91.78% of the candidates passed while 8.22% failed the assessment in Manufacturing Engineering subject. Generally, the performance of the Manufacturing Engineering subject was good.

The above general results were obtained from the performance of each question in the examination. The performance in each question depended on the responses given by the candidates in each question. The responses were awarded marks allocated to the respective response in each question. The allocated marks to responses in each question led to the conclusive performance in terms of good, average and weak. The given performance was illustrated using tables and graphs. The colours such as red, yellow and green were used to represent weak, average and good performance respectively. In addition, extracts from the candidates' scripts were used to provide vivid and practical examples of candidates who had good and poor response to the asked questions.

Additionally, the provided data presents the performance based on the gender of the candidates who participated in the examination, as outlined in Table 1. Concerning the performance of female candidates, Table 1 illustrates that 1 (4.35%) achieved grade A, 3 (13.04%) attained grade B, 14 (60.87%) scored grade C, 2 (8.70%) scored grade D, and 3 (13.04%) obtained grade F. The majority of female candidates (60.87%) scored grade C. On the contrary, the performance of male candidates in Table 1 indicates that, 11 (10.00%) scored grade A, 22 (20.00%) scored grade B, 53 (48.18%) scored grade C, 18 (16.36%) scored grade D, and 6 (5.45%) obtained grade F. The majority of male candidates (48.18%) scored grade C. Therefore, male candidates outperformed female candidates in the CSEE of 2023 in Manufacturing Engineering subject, with a difference of 3.79% for males compared to 0.26% for females.

Table 1: The Candidates' Performance According to Gender

Sex	**Grades**					**Passed**	
	A	**B**	**C**	**D**	**F**	**Number**	**Per cents**
M	11	22	53	18	6	104	94.55
F	1	3	14	2	3	20	86.96
Total	**12**	**25**	67	20	**9**	**124**	**93.23**

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH QUESTION

This part addresses the performance of the candidates based on the scores obtained in each question. It covers the type of questions, topics from which the questions were constructed, competencies test, the requirements of each question and the percentages of the candidates who had weak, average or good performance based on their responses in each question.

2.1 Section A: Objective Questions

This section is comprised of two questions carrying 16 marks. Question 1 consisted of 10 multiple-choice items constructed from various topics. Those topics include *Machine Tools I, Welding Technology, Maintenance Practice, Metal Forming and Heat Treatment, Foundry Technology, Engineering Materials, Workshop tools and Equipment* and *Workshop Management and Safety Rules.* Each item carried one mark. Question 2 included six matching items from the topic of *Foundry Technology,* each worth 1 mark.

2.1.1 Question 1: Multiple Choice Items

This question consisted of ten multiple-choice items (i-x). The candidates were instructed to choose the correct answer from among the given alternatives by writing its letter in the box provided. Each item carried one mark.

The question was attempted by 146 (100%) candidates whose scores were as follows: 10 (6.85%) candidates scored from 0 to 2 marks, 112 (76.71%) scored from 3 to 6 marks and 24 (16.44%) scored from 7 to 10 marks. Generally, the candidates' performance in this question was good since 136 (93.15%) candidates scored from 3 to 10 marks. This performance is summarized in Figure 1.

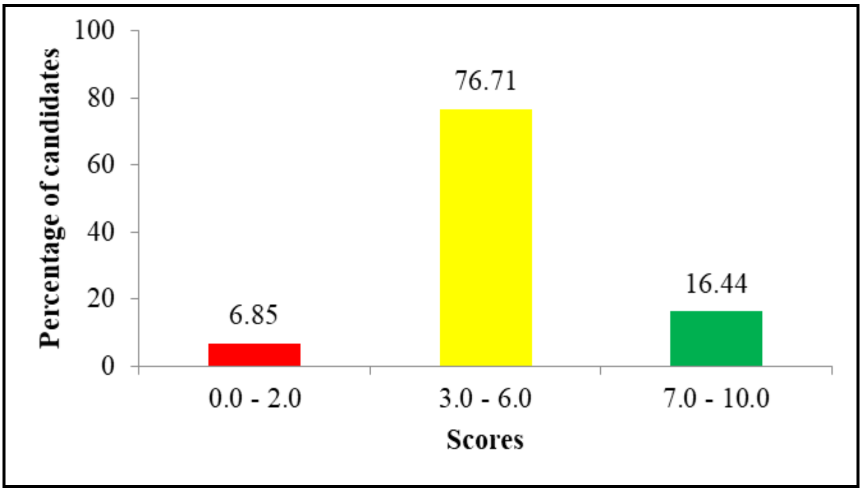


Figure 1: *The Candidates Performance in Question 1*

Despite of the candidates' good performance in this question, 10(6.85%) of the candidates performed poor due to number of reasons such as failure to understand the demands of the questions, inadequate knowledge and skills on some tested subject matters and lack of English language proficiency.

The following is the analysis of candidates' responses for each item:

Item (i) was set from the topic of *Machine Tools I*. The candidates were required to use knowledge acquired from Machine Tools I to identify the process of generating a hole with proper size and smooth finishing among the alternative given. The question was:

The process of generating a hole with proper size and smooth finishing after drilling called

A Drilling	*B Boring*	*C Reaming*
D Counter boring	*E Finishing*	

The correct response was *C: Reaming.* The candidates who opted the correct response had enough knowledge on hole drilling and surface finishing. The candidates understood that, reaming process is used to size and provide smooth finishing in a hole.

However, those who picked alternatives *A*, *Drilling* or *B, Boring D, Counter boring* and *E Finishing* lacked practical experience on Machine Tools specifically in surface finishing. They failed to relate the alternative A, *drilling* as an operation of making a circular hole by removing a volume of metal from the workpiece by cutting tool called drill. Likewise, alternative *B, boring* was not an answer because this is the process of enlarging a hole that has already been drilled or cast by means of a single-point cutting tool. Alternative *D, Counter Boring* operation basically enlarges a pre-drilled bore and *E, finishing* in machining refers to a manufacturing process that involves altering the surface of already fabricated parts or components for specific resolutions are explained in the topic of Machine Tools I.

This implies that, these candidates misunderstood, lacked knowledge, were overconfidence, involved guesswork, lacked attention to detail, had random selection and inadequate skills on the competencies tested in machining processes and operations.

Item (ii) was extracted from the topic of *Welding Technology*. It examined candidates' skills in identifying major function of filler rod in gas welding. The question was:

Filler metals are sometimes used in the welding process to obtain good quality of welded joints. Which one is a major function of filler rod in gas welding?
A Welding crack during welding B Parental metal during welding
C Welding gap before welding D Welding joint during welding
E Parent metals after welding

The correct response for this item was *D, Welding joint during welding.* The candidates who choose the correct response due to a good understanding of the welding process, good knowledge of the functions of filler metal, familiarity with welding terminology, and intensive study and preparation work on Welding Technology. They were able to understand that, filler rod is the material added on the welded joint to join metals during gas welding and typically, the weld rod is used to fill a single- or double V-groove or bevel T joints to form the weld.

The candidates who chose *B, Parental metal during welding* refers to the metal of components that are being welded by a molten filler metal while *E, Parent metals after welding* is the metal or steel that you are actually welding on and therefore failed to know that, parental metal is the welded material and not the function of filler rod. Those who opted for distractor *A, welding crack during welding* occurs when the welding operator stops welding prior to finishing a pass on a weld joint, leaving a wide, thin depression at the end.

In addition, those who chose *C, welding gap before welding* which denotes the distance between the plates failed to understand that, filler rod is not used in welding gap before welding as well as welding crack during welding as applied in welding technology processes. A candidate who chose the correct response likely did so because of good understanding of welding processes, good knowledge of filler metal function, being familiar with welding terminology and working hard in studying and preparations.

Overall, these alternatives suggest potential areas where candidates may need clarification or further study on the role of filler metals in gas welding processes.

Item (iii) was set from the topic of *Maintenance Practices*. It tested the candidates' knowledge on maintenance activities associated to schedule on time or meter to schedule equipment outages. The question was:

Which maintenance activity is associated with schedule on time or meter basis but is planned to coincide with schedule equipment outages?

A Routine maintenance	*B Maintenance testing*
C Diagnostic testing	*D Preventive maintenance*
E Predictive maintenance	

The correct response was *D, Preventive maintenance.* The candidates who chose the right answer were knowledgeable on maintenance practices. They understood that, *preventive maintenance* is the maintenance activity associated with scheduling or planning activity basis on time and meter. However, those who lacked enough background on Maintenance Practices had different choices. Those candidates who selected *A, Routine maintenance* failed to differentiate between routine and preventive maintenance. Routine is not basis on time and meter, it is the inspection performed daily to maintain the machine before preventive maintenance.

Moreover, the candidates who chose *B, Maintenance testing* failed to understand that, maintenance testing is the trial taken to a machine after equipment maintenance. The candidates who chose C, *Diagnostic testing* is an automatic partial test that uses built-in self-test features to detect faults. The candidates who opted *E, Predictive maintenance* did not understand that, *predictive maintenance* is the maintenance bases on maintaining the abnormal condition observed on the machine during break down. Hence, no time or running meter needed to planning or scheduling the activity to solve the abnormalities observed on the machine. There are several possible reasons why candidates chose the correct response in this question such as good understanding of maintenance concepts, good knowledge of maintenance strategies, attention to detail, experience or training and critical thinking skills on maintenance practices topic. Possible reasons why candidates chose each of the other alternatives are; misinterpretation, lack of familiarity, confusion with testing procedures, limited understanding, focus on troubleshooting, lack of clarity, misconception about timing and lack of differentiation of maintenance activities in Maintenance Practices.

Item (iv) tested the candidates' knowledge and skills for *Metal Forming and Heat Treatment*. The question was:

Sometimes steel being used in engineering works should have a hardened surface to resist wear and tear. What type of treatment would you apply in order to achieve a hardened surface?
A Temperature bath B Case hardening C Austempering
D Martempering E Hardenability

The correct answer was *B, Case hardening.* The candidates who chose the correct alternative understood that, *case hardening* is based on improving hardenability of steel surface to resist wear and tear on a surface of material. It changes properties of a surface of a steel to be hard to resist wear and tear and leaves the internal part be soft to allow flexibility as is greatly valued in modern engineering because it can withstand very high stress and fatigue. Candidates who chose the correct response because had Understanding of the concept, knowledge of pretreatment methods and clarity in question interpretation on Metal Forming and Heat Treatment.

For those candidates who chose *E, Hardenability* confused the properties of case hardening and hardenability whereby their difference lies to the depth to which steel is hardened after putting it through a heat treatment process. These candidates did not know that hardenability is the heat treatment process which is used to harden a steel uniformly so that it becomes hard and brittle in both internally and externally parts. Regardless of this hardship the hardened steel is not tough to withstand load subjected to it.

Moreover, those candidates who selected alternatives *A, Temperature bath,* failed to understand that temperature bath is a container or vessel filled with heated water and the temperature of water is maintained at a constant level as applied to incubate samples over a period at a constant temperature. For those who chose option *C,* failed to recognize that *Austempering* means to quench (steel) from above the transformation temperature in a bath between 350° and 600° F and hold at this temperature until transformation of austenite stops, for rendering it hard and tough. Some candidates opted *D, Martempering.* These candidates did not know that martempering is the process of quenching steel from above the transformation temperature in a bath at about 350° F and then cooling to room temperature after the temperature has become nearly uniform with the bath.

All of these options A, C, D and E as defined meant a heat treatment process other than case hardening to make the hardened surface wear and tear resistant. Candidates who selected incorrect option due to lack of understanding, confusion these terminologies and guesswork on metal forming and heat treatment.

Item (v) was set from the topic of Foundry Technology (*Introduction of Foundry and Operations)* and it tested candidates' knowledge on shrinkage allowance in material casting. The question was;

What shrinkage allowance is allowed on the wooden pattern if an aluminum pattern made from a wooden master pattern is to be used for grey iron casting?
A 10 mm/m B 16 mm/m C 20mm/m D 26 mm/m E 32mm/m

The correct answer was *D, 26 mm/m.* The candidates who selected the correct answer because of a deep grasp of the casting procedure, such as the connection between pattern materials, shrinkage allowances, and casting materials. This knowledge may result from extensive learning and hands-on involvement in manufacturing methods, casting techniques, and materials science, empowering the candidate to precisely evaluate the necessary shrinkage allowance for an aluminum pattern obtained from a wooden master pattern designed for grey iron casting.

Those candidates who opted for alternatives might have done so for several reasons. Option *[A] (10 mm/m)*: some candidates may have underestimated the shrinkage allowance required for the wooden pattern, potentially due to a lack of understanding of the casting process or incorrect assumptions about material properties. Candidates who opted for [B], 16 mm/m; failed to understand that the shrinkage allowance opted is smaller than the measurements required on the wooden pattern which should be 26 mm/m.

Option *[C] (20 mm/m)*: Candidates might have chosen this option if they overestimated the shrinkage allowance needed for the pattern, possibly due to confusion or incorrect interpretation of the question or the properties of the materials involved. Option *[E] (32 mm/m)*: Those who selected this option may have significantly overestimated the shrinkage allowance, possibly due to misunderstanding the casting process or making errors in calculation. Generally, these candidates had inadequate knowledge, skills and experience in pattern allowances and pattern material practices.

Item (vi) was drawn from the topic of *Engineering Materials.* It required the candidates to use knowledge to choose the percentage of copper and zinc contained in brass. The question was:

Red brass is an alloy of copper and zinc. What is the percentage of copper and zinc contained in it?

A *Cu = 65% and Zn = 35%* B *Cu = 70% and Zn = 30%*
C Cu = 75% and Zn = 25% *D Cu = 80% and Zn = 20%*
E Cu = 85% and Zn = 15%

The correct alternative was E, *Cu = 85% and Zn = 15%.* The candidates who chose the correct response understood that copper has 85% composition and Zn has 15% in red brass alloy. They understood that 'Red brasses', a family of alloys with high copper proportion and generally less than 15% zinc. These candidates proved that they had enough knowledge Engineering Materials. They were able to identify the proper percentage compositions of red brass alloy.

However, those candidates who chose A, *Cu = 65% and Zn = 35%* did not have enough knowledge on copper casting alloys that, the option has less copper than 85% composition and supplementary than required Zn of 15% in red brass alloy. Those candidates who chose *B, Cu = 70% and Zn = 30%* did not possess enough knowledge on copper casting alloys that, the option has less copper than 85% composition and extra Zinc in red brass alloy.

Candidates opted for *C, Cu = 75% and Zn = 25%* fell short of knowledge on copper casting alloys that, the option has less copper than 85% composition and Zinc is added in red brass alloy. For those chose alternative *D, Cu = 80% and Zn = 20%* had insufficient knowledge on copper casting alloys that, the option has less copper than 85% composition and more Zinc in red brass alloy.

Those candidates who chose incorrect alternatives lacked knowledge, misinterpreted, confused, guessed, lacked attention to detail and prioritized other options of the question on engineering materials.

Item (vii) was set from the topic of *Engineering Materials*. It tested candidates' ability of identifying various types of tool Materials. The question was:

A school storekeeper needs to order a new shaper-cutting tool for practical purposes. Which specification do you recommend for material of the tool?
A High speed steel *B Ceramic* *C High carbon steel*
D Medium carbon steel *E Diamond*

The correct alternative was *A, High speed steel*. The candidates who chose the correct response were familiarity with Industry Standards they had a solid understanding of industry norms and best practices for tool materials. High-speed steel is widely recognized and utilized in machining and cutting applications due to its excellent combination of hardness, wear resistance, and toughness.

Candidates had knowledge of Cutting Tool Requirements they recognized that shaper-cutting tools require materials with high hardness to withstand the abrasive forces encountered during shaping operations. High-speed steel is known for retaining its hardness at elevated temperatures, making it suitable for high-speed cutting applications like shaping. They had consideration of Performance Factors such as tool longevity, ease of sharpening, and overall performance. High-speed steel offers superior performance in terms of tool life and cutting efficiency compared to other materials like ceramics or carbon steels. Candidates who selected alternatives other than high-speed steel may have done so for several reasons on Engineering Materials.

B) Ceramic: Some candidates might have chosen ceramic due to its reputation for high hardness and resistance to wear. However, ceramics can be brittle and may not withstand the stresses and impacts encountered in shaping operations.

C) High carbon steel: This choice might have been made because high carbon steel is known for its toughness and ability to hold a sharp edge. However, it may not possess the necessary hardness and wear resistance required for prolonged use in shaping applications.

D) Medium carbon steel: Candidates could have opted for medium carbon steel believing it strikes a balance between hardness and toughness, making it suitable for cutting applications. However, it may not offer the high-speed performance required for efficient shaping operations.

E) Diamond: While diamond is incredibly hard and offers exceptional wear resistance, it is not commonly used as a material for shaper cutting tools due to its high cost and difficulty in machining.

Generally, candidates chose incorrect alternatives did not have enough of cutting tools properties and cutting tool materials selection based on sharper machine tool.

Item (viii) was extracted from the topic of *Workshop Management and Safety Rules*. It required the candidates to identify the term to be given great emphasis to increase morale and productivity in manufacturing engineering workshop. The question was:

What is to be given a great emphasis in order to have a better morale and increase productivity in mechanical engineering workshop?
A Safety *B Accident* *C First aid kit*
D Fire extinguishers *E Fire hydrant*

Candidates who selected 'Safety' as the correct response likely considered several factors as follows:

Awareness of Industry Standards: They may have a strong understanding of industry norms and regulations, recognizing that safety is a primary concern in any engineering workshop.
Prioritization of Employee Well-being: They might understand that ensuring a safe working environment is crucial for maintaining the physical and mental well-being of employees, which can directly impact morale and productivity.

Risk Management: They may have an appreciation for the importance of risk management in preventing accidents and minimizing disruptions to workflow, thereby enhancing productivity.

Legal Compliance: Recognizing that adherence to safety protocols and regulations is not only ethical but also legally required, they may have chosen safety as the priority to avoid legal liabilities and penalties.

Candidates who selected alternatives other than A may have done so for several reasons as follows:
[B] Accident Prevention

Focus on Reactive Measures: Some candidates may have believed that preventing accidents directly addresses the issue of safety, rather than emphasizing proactive measures.

Immediate Concern: Candidates might have prioritized preventing accidents over creating a comprehensive safety culture, viewing accident prevention as the most urgent need.

Misunderstanding: Some candidates may have confused accident prevention with overall safety, assuming they are synonymous.

[C] Availability of First Aid Kits

Immediate Response Capability: Candidates might have prioritized the availability of first aid kits as a crucial aspect of handling accidents or injuries promptly, assuming this directly impact safety.

Emergency Preparedness: Candidates may believe that having first aid kits readily available is essential for responding effectively to unforeseen incidents, without considering broader safety measures.

Limited Focus: Some candidates might perceive first aid kits as the primary means of addressing safety concerns, overlooking the importance of preventing accidents in the first place.

[D] Accessibility of Fire Extinguishers

Fire Safety Focus: Candidates may have prioritized fire safety due to its immediate threat to life and property, assuming that fire extinguishers play a central role in addressing safety concerns.

Specific Hazard Concern: Some candidates may have perceived fire hazards as the most significant risk in the workshop and prioritize measures to mitigate this specific threat.

Lack of Understanding: Candidates might have overemphasized fire safety measures due to a lack of awareness of broader safety considerations beyond fire hazards.

[E] Presence of Fire Hydrants

Fire Safety Emphasis: Candidates may have prioritized fire safety measures such as fire hydrants, assuming that addressing this specific hazard is paramount to overall safety.

Regulatory Compliance: Some candidates may have believed that the presence of fire hydrants is a legal requirement or industry standard, leading them to prioritize this aspect.

Limited Perspective: Candidates might have focused solely on fire-related risks and overlook other safety considerations present in the mechanical engineering workshop.

Item (ix) was set from the topic of *Workshop Tools and Equipment*. It tested the candidates' knowledge on measuring of length during bending process. The question asked:

How could you find the length of a material during the bending process of that material?

A By using meter rule and micrometer screw gauge

B By finding the length of the bend of the centre line

C By using Vernier caliper

D By using tape measure

E By using a rope and tape measure

The correct answer was alternative *B, By finding the length of the bend of the centre line.* The candidates possessed knowledge and skills in Workshop Tools and Equipment, particularly in bending practices. They understood that when a material is bent, its length along the centerline or neutral axis of the bend remains constant. Measuring the length of the bend along the centerline or neutral axis ensures an accurate measurement of the material's length after bending.

Those candidates who selected Option A, *utilizing a meter rule and micrometer screw gauge*, failed to grasp that the micrometer screw gauge is specifically intended for measuring the diameter of thin wires or the thickness of small sheets such as glass or plastics. A meter rule is utilized for measuring the length and distance of various objects and therefore cannot accurately measure the length of the bend along the centerline. Candidates who opted for

Alternative C, *employing a Vernier caliper*, failed to comprehend that a Vernier caliper is designed for measuring linear dimensions. It cannot ascertain the length of the bend along the centerline.

Those who chose Option D, *using a tape measure*, did not realize that a tape measure, being a strip of metal, plastic, or cloth primarily used for measuring, cannot accurately determine the length of the bend along the center line. Candidates selecting Option E, *employing a rope and tape measure*, misunderstood that a rope is a thick, strong cord primarily used for length measurement. Thus, it cannot be utilized to measure the length of the bend along the centerline. This indicates that candidates who chose incorrect alternatives lacked adequate knowledge, skills, and practical experience in Metal Forming and Heat Treatment.

Item (x) was set from the topic of *Welding Technology*. It required the candidates to identify the appropriate way to change the cylinder gas when the plant is required to change from MAG to MIG. The question was:

Metal Inert Gas (MIG) and Metal Argon Gas (MAG) are both modern Gas Metal Arc Welding (GMAW) technologies, which share the same plant but differ in gas cylinder. Suggest the appropriate way of changing a cylinder gas when the plant is required to change from MAG to MIG?

A Carbon dioxide cylinder to Inert gas cylinder
B Carbon monoxide cylinder to Carbon dioxide cylinder
C Inert gas cylinder to Oxygen cylinder
D Oxyacetylene cylinder to Oxygen cylinder
E Oxygen cylinder to Carbon dioxide cylinder

The correct answer was alternative *A carbon dioxide cylinder to Inert gas cylinder.* The candidates who chose the correct response had adequate practical knowledge and skills on MAG and MIG welding Technologies. They understood that since the MAG and MIG share the same plant but different shielding gas.

Therefore, these candidates understood the gases for MAG and

MIG. These candidates knew that, carbon dioxide cylinder is to be replaced with inert gas cylinder.

The candidate may possess a strong understanding of Gas Metal Arc Welding (GMAW) processes, including the differences between Metal Inert Gas (MIG) and Metal Argon Gas (MAG) welding.

Understanding of gas properties: The candidate may be aware that MIG welding typically utilizes carbon dioxide (CO_2) as the shielding gas, while MAG welding employs a mixture of argon and carbon dioxide.

Familiarity with cylinder types: The candidate might recognize that switching from MAG to MIG involves transitioning from an inert gas (such as argon) to carbon dioxide, which is commonly stored in its own dedicated cylinder.

Logical deduction: Even if the candidate is not deeply familiar with welding processes, they might use logical reasoning to deduce that changing from MAG to MIG would likely involve switching to a different type of gas that is suitable for MIG welding, such as carbon dioxide.

Candidates who chose alternatives other than the correct response [A] *Carbon dioxide cylinder to inert gas cylinder* may have done so for several reasons as follows:

Misunderstanding of GMAW processes: Candidates might lack a clear understanding of the differences between Metal Inert Gas (MIG) and Metal Argon Gas (MAG) welding techniques, leading them to select incorrect options.

Confusion about gas properties: Some candidates may be unclear about the specific gases used in MIG and MAG welding, leading them to choose options that do not align with the requirements of each process.
Lack of familiarity with cylinder types: Candidates may not be

well versed in the types of gases stored in different cylinders or the appropriate gases for specific welding processes, resulting in incorrect selections.

Misinterpretation of the question: Some candidates may have misunderstood the question or misinterpreted the terms 'MAG' and 'MIG,' leading them to select options based on incorrect assumptions.

Guessing or random selection: In some cases, candidates may have guessed or randomly chosen an option without a solid understanding of the subject matter.

2.1.2 Question 2: Matching Items

This question consisted of six matching items derived from the topic of *Foundry Technology.* This question required the candidates to match the descriptions in List A with their corresponding responses in List B by writing the letter of the correct response below the corresponding item number. The question was:

Match each moulding sand properties in List A with its terminology used in List B by writing a letter of the correct response beside the item number in the answer booklet provided.

List A	***List B***
(i) Ability of moulding sand mixture to bond with another body. *(ii) Ability of moulding sand mixture to decrease in volume.* *(iii) Ability of moulding sand mixture to take any desired shape easily.* *(iv) Ability of moulding sand mixture to withstand the heat*	*A Permeability* *B Collapsibility* *C Resistivity* *D Flow-ability* *E Cohesiveness* *F Adhesiveness* *G Refractiveness* H *Expansively*

List A	*List B*
of melt without showing any sign of softening or fusion. *(v) Ability of holding together of moulding sand grains.* *(vi) Ability of allowing gases to escape easily from the mould sand.*	

146 (100%) candidates attempted this question, and their scores are as follows: 36 (24.66%) candidates scored from 0 to 1 mark, 29 (19.86%) candidates scored from 2 to 3 marks, and 81 (55.48%) candidates scored from 4 to 5 marks. Overall, the candidates' performance in this question was satisfactory as 100 (68.5%) had average or above performance. Figure 2 depicts these results.

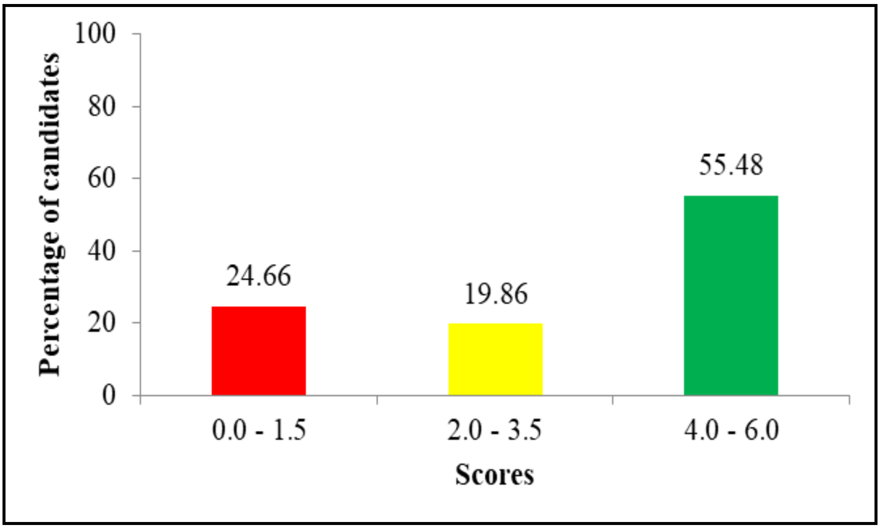


Figure 2: *The Candidates' Performance in Question 2*

Further analysis on the candidates' performance in each item is as follows:

Item (i) required the candidates to identify the appropriate molding sand property that corresponds to its ability to bond with another body. The correct answer was *F, Adhesiveness*. Those candidates who selected the correct response understood that adhesiveness refers to the property of a molding sand mixture to bond with another body during the casting process. However, some candidates incorrectly matched item (i) with distractor *E, Cohesiveness*, which denotes the ability of molding sand grains to hold together. This distinction indicates a lack of understanding among candidates regarding molding sand properties.

Item (ii) required candidates to match the correct molding sand property associated with a decrease in volume. The correct match was *B, Collapsibility*. Candidates who correctly matched this item recognized that collapsibility refers to the ability of molding sand to decrease in volume during the sand casting process. However, some candidates incorrectly matched item (ii) with distractor A, Permeability, which refers to the ability of molding sand to allow gases to escape easily. This mismatch suggests a partial understanding of molding sand properties among these candidates.

Item (iii) asked candidates to identify the molding sand property from list B that corresponds to its ability to take any desired shape easily. The correct answer was *D, Flow-ability*. Candidates who correctly compared this item understood that flow-ability is the property of molding sand that allows it to take any desired shape easily. However, candidates who matched (iii) with different alternatives provided in List B failed to do so accurately, indicating a partial understanding of Foundry Technology, specifically in molding sand properties.

Item (iv) instructed the candidates to match the correct molding sand property associated with the ability to withstand the heat of melt without softening or fusion. The correct answer was *G, Refractiveness*. Candidates who selected this item correctly understood that refractiveness refers to the ability of the molding sand mixture to withstand the heat of melt without softening or fusion. However, some candidates incorrectly matched item (iv) with distractor *C, Resistivity*, which refers to electrical resistance, indicating a lack of understanding of molding sand properties among these candidates.

Item (v) required candidates to match the correct molding sand property associated with the ability to hold together molding sand grains. The correct answer was *E, Cohesiveness*. Candidates who correctly paired this item understood that cohesiveness refers to the molding sand property that allows it to hold together molding sand grains. However, some candidates incorrectly matched item (v) with distractor *F, Adhesiveness*, which refers to the ability of a molding sand mixture to bond with another body, indicating a partial understanding of molding sand properties among these candidates.

Item (vi) required candidates to match the correct molding sand property associated with the ability to allow gases to escape easily from the molding sand. The correct answer was *A, Permeability*. Candidates who correctly matched this item understood that permeability refers to the molding sand property that allows gases to escape easily. However, some candidates incorrectly matched item (vi) with distractor *B, Collapsibility*, which refers to the ability of molding sand to decrease in volume during the sand casting process, indicating a partial understanding of molding sand properties among these candidates.

The candidates' overall performance in this question indicates that, they had adequate knowledge, skills, and practical experience in Foundry Technology, specifically in the properties of molding sand, which encompass a diverse range of characteristics affecting moldability, strength, surface finish, and other essential aspects of the casting process.

2.2 Section B: Short Answers Questions

This section comprised of six short answer questions. The questions were constructed from three topics, which are *Metal Forming and Heat Treatment, Machine Tools I and Foundry Technology.* Each question carried 9 marks, making a total of 54 marks for the whole section.

2.2.1 Question 3: Metal Forming and Heat Treatment

This question required the candidates to identify the characteristics of a treated steel of each defect, causes and measures for remedies on overheating, oxidation and insufficient hardness. The question was:

During heat treatment of steels specimen in the school workshop, the following principal defects were observed; Overheating, Oxidation and Insufficient hardness. Give the characteristics of each defect, causes and measures for remedies such defects.

The analysis reveals that, each of the 146 (100%) candidates attempted to the question. Among these, 83 (56.85%) scored marks from 0 to 2.5, while 47 (32.19%) scored marks between 3.0 and 5.5. Additionally, 16 (10.96%) candidates scored marks ranging from 6 to 9. These scores are presented in Figure 3, underline a noteworthy observation: The majority of candidates demonstrated poor performance. Specifically, (43.15%) of them scored from 3 to 9 marks, and (56.85%) candidates scored marks ranging from 0 to 2.

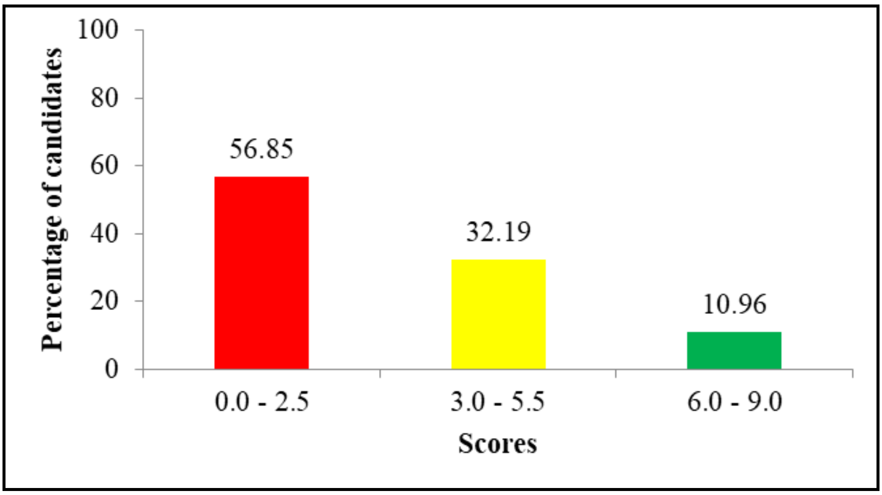


Figure 3: *The Candidates' Performance in Question 3*

The analysis demonstrates that, out of the candidates who scored low marks, ranging from 0 to 2.5, 83 (56.85%) candidates were unable to provide a clear explanation regarding the characteristics, causes, and constraints associated with defects stemming from overheating, oxidation, and insufficient hardness. These candidates were not aware of the followings:

Overheating characteristics are *i*. coarse grained microstructures and fractures and *ii.* reduced ductility and impact strength. *Overheating causes* are heating for longer periods at temperature considerably above the normal values and *Overheating remedies* are *i.* for slight overheating use normal annealing and normalizing and *ii.* for considerable overheating, use double annealing or normalizing. Example response from one of the script was, *"Incomplet penetration"*.

Oxidation characteristic is thick layer of scale on the surface of steel articles, *oxidation is caused* by oxidizing atmosphere in the heating furnace and *oxidation remedies* are; *i.* Heating in furnace with reducing, neutral or protective atmosphere, *ii*. Heat in boxes with used carburizing agent or cast iron chips and *iii*. Heat in molten salt baths. For example, one candidate response, *Two mood application of tool.*

Insufficient hardness causes are; *i. Hardening temperature is too low ii. Holding time is insufficient at the hardening temperature and iii. Cooling rate is too low.* Insufficient hardness *remedy is* the defects may be corrected by normalizing or annealing followed by hardening with the proper specified procedure.

The example of the response from script is *"Staying for long litre in the furnace"*.

These candidates missed knowledge on heat treatment defects explained with their characterics, causes and remedies. Most of the candidates provided irrelevant responses while others didn't provide responses in this question. Extract 3.1 shows the sample of weak performance from one of the candidates.

3. Characteristics of Over heating, Oxidation and Insufficient hard
i) Over heating
→ This is whereby when the metal or workpiece in the workshop it is been Increased the heat which causes defect to the workshop technicians.
ii) Oxidation
→ This is when the oxygen gas Increases and then that gas come and cause some defects in the workshop
iii) Insufficient hardness
→ This is whereby when the strength of hardness of a metal decreases in the metal which also can cause ~~some~~ accident in the workshop

Causes of the Overheating, Oxidation and Insufficient hard
i) Using large amount of heat when doing work in the workshop
ii) Lazyness when heating a metal or workpiece
iii) Other workshop technicians do not have enough education
iv) Not following ~~or~~ all rules and regulation in the workshop
v) Lack of ~~other~~ some equipment needed when conducting work in the workshop

Measures for the Overheating, Oxidation insufficient hardness
i) Maintaining the heat when doing the welding with the ~~r~~ workpiece.
ii) The workshop technicians should follow all rules and regulation for the workshop.
iii) Applying first Aid Kit in order to be used when there is any accident occur.

Extract 3.1: A sample of a candidate's weak responses to Question 3

In Extract 3.1, the candidate provided irrelevant response to this question. This candidate had weak performance due to inadequate knowledge, skills and practical experience on metal forming and heat treatment to predict characteristics, causes and control the outcomes defects accurately.

Moreover, 47 (32.19%) of the candidates who scored 3 to 5.5 marks were able to respond partially to the question. Most of these candidates managed to provide few correct responses. Also, some of them responded correctly in giving the characteristics or causes and measures for remedies of such defects.

Furthermore, 16 (10.96%) of the candidates who scored 6 to 9 marks understood the subject matter. They were able to respond perfectly by giving correct characteristics, causes and measures for remedies in overheating, oxidation and insufficient hardness after quenching. The candidates from this group had enough knowledge on heat treatment. Extract 3.2 is a sample of good responses from a script of one of the candidates.

3. Remedies of oxidation.
i) Balancing the amount oxygen gas with other gases like acetylene gas in gas treatment.
ii) Avoid exposing the metal specimen being treated to the atmospheric contamination.

Characteristics of Insufficient hardness.
i) Easy breaking of metal specimen.
ii) Brittle surface of metal specimen.
iii) Un uniform structure of the internal metal specimen.

Causes of insufficient hardness.
i) Improper quenching technique.
ii) Using incorrect quenching media like water
iii) Improper heating of the metal specimen.

Remedies of insufficient hardness.
i) Using proper quenching techniques.
ii) Using the appropriate quenching media
iii) Proper heating of the metal specimen to the required temperature below the recrystallization temperature of the metal specimen.

3. Characteristics of Overheating defect.
i) The microstructure of metal changes.
ii) Molten metal appears.

Causes of overheating.
i) Very high temperature application above recrystallization
ii) temperature of the metal specimen.
iii) Prolonged heating of the metal specimen.

Remedies to control overheating.
i) Avoiding heating of metal specimen for a long time
ii) Heating the metal specimen below the recrystallization temperature.

Characteristics of oxidation effect.
i) Appearance of oxide coating on the metal specimen
ii) Cutting of metal specimen being treated.

Causes of oxidation.
i) High amount of oxygen than other gas in gas heat treatment.
ii) Exposure of the weld/treated metal to the atmosphere

Extract 3.2: A sample of candidate's good responses to Question 3

Extract 3.2 shows a sample of the correct responses by a candidate who managed to address correctly both parties of this question. S/he was able to provide correct characteristics, causes and remedies of each defect provided in this part. The given sample indicates that, s/he further had adequate knowledge about metal forming and heat treatment.

2.2.2 Question 4: Metal Forming and Heat Treatment

This question was constructed from the topic of *Metal Forming and Heat Treatment*. The question had two parts (a) and (b). In part (a), the candidates were required to explain five reasons necessary to conduct heat treatment after producing metallic components before use. In part (b), the candidates were required to identify objective of conducting annealing of metals. The question was:

(a) *Why is it necessary to conduct heat treatment after producing metallic components before using it? Give five reasons.*

(b) *What are the four objectives of conducting annealing of metals?*

146 (100%) candidates attempted the question. Analysis indicates that, 9 (6.16%) candidates scored between 0 and 2.5 marks, 30 (20.55%) candidates scored between 3.0 and 5.5 marks, and 107 (73.29%) candidates scored between 6.0 and 9.0 marks. This analysis demonstrates a strong overall performance in which 137 (93.84%) scored between 3.0 and 9.0 marks. Figure 4 illustrates the candidates' performance on this question.

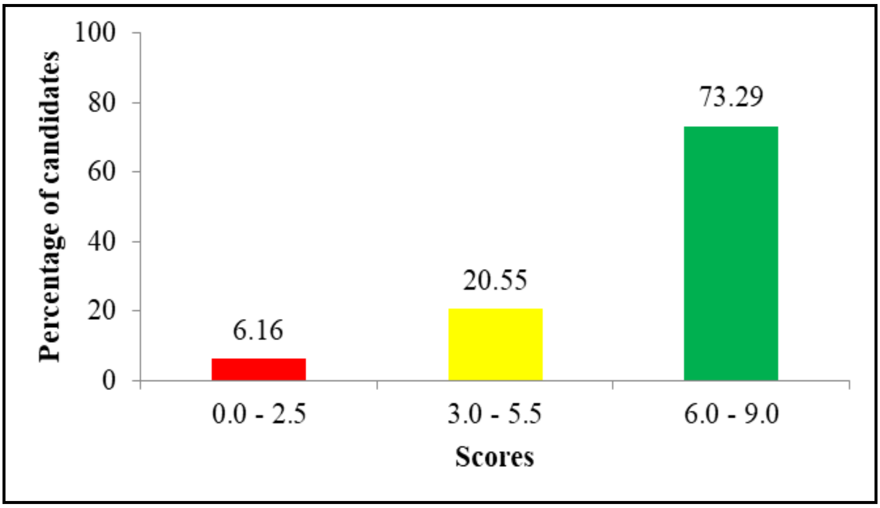


Figure 4: *The Candidates' Performance in Question 4*

The analysis depicted in Figure 4 indicates that, 107 (73.29%) candidates who performed well correctly identified the purposes of heat treatment in part (a). The candidates recognized that heat treatment aims to improve machinability, alter or refine grain size, relieve internal stress resulting from cold or hot work, and enhance mechanical properties.

Furthermore, these candidates understood that heat treatment processes can increase wear resistance, corrosion resistance, shock resistance, and can produce a hard surface or ductile interior.

In part (b), candidates in this category accurately identified the objectives of the annealing process. They understood that annealing is employed to soften metals, improve machinability, refine grain size, and reduce gaseous content. Furthermore, they recognized that annealing enhances mechanical properties, alters electrical and magnetic properties, and relieves internal stress during solidification, machining, forging, and welding. Extract 4.1 illustrates the responses given by one of the candidates who performed well in this question.

04. (a) The Following are the purposes of heat treatment:-

i/ To obtain fine grains and uniform structure; heat treatment is done on steels so as to obtain fine grain size of the steel and uniformity of the Component.

ii/ To improve the surface hardness of the material; The soft materials can be hardened on its surfaces through the process of heat treatment For example case hardening

iii/ To improve machinability of the metals; Some metal has to be heat treated so as they can be machined easily. For example annealing process improves machinability of the material.

iv/ To improve ductility of the material: heat treatment is important in improving ductility of materials since heat treated metals can be stretched into thin wires without breaking or fracture.

v/ To relieve internal stresses of the metal; some intern-
al stresses may occur when producing metals, thus heat treatm-
ent helps to minimize such stresses.

(b) Objectives of conducting annealing process:
i/ To improve softness of a metal which were previously hard
Annealing process has been more helpful in improving the soft
ness of metals.

ii/ To make the metals more ductile; Annealing impro-
ves the ability of a metal to be drawn into thin wire-
04 b/ ii/ - without breaking.

iii/ Annealing improves strength of the metal; The annea
led metals have high strength compared to other metals
which have not been annealed.

iv/ Annealing helps to remove the internal porosity of the
metals; some metals has the pores inside it thus annealing
process helps to relieve them.

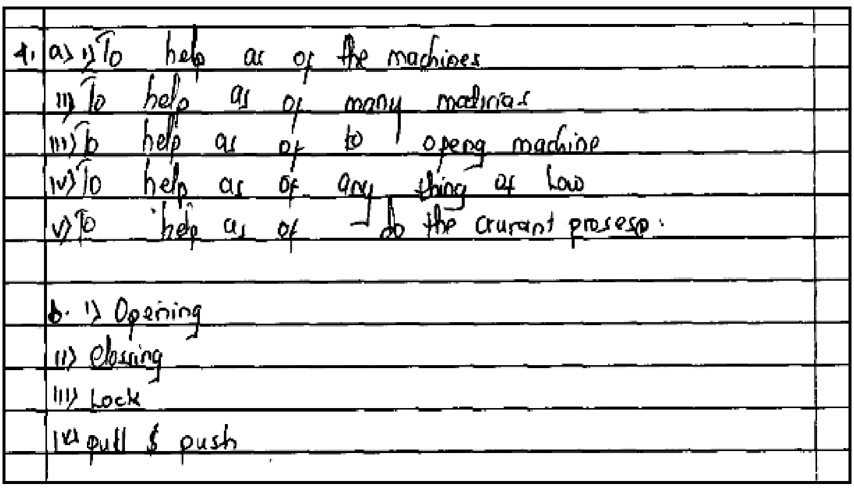
Extract 4.1: A sample of candidate's good responses to Question 4

In Extract 4.1, the candidate successfully provided accurate explanations for the purposes of heat treatment in part (a). Furthermore, the candidate successfully identified the goals of performing annealing on the metal. This indicates a good level of understanding of the topic being assessed in this question.

In addition, 30 (20.55%) candidates who scored between 3 to 5.5 marks, failed to respond correctly to all parts of the question. Some managed to list five reasons for conducting heat treatment (i.e. benefits of performing heat treatment on a material), including improving machinability, refining grain size, altering magnetic properties, relieving internal stresses, improving mechanical properties, and increasing resistance to wear, corrosion, and shock. However, they overlooked the required four objectives or targets, which involve softening metals, enhancing machinability, refining grain size, and reducing gaseous content in metals, among others. Also, the candidates from this group were able to provide few relevant responses regarding the question requirement in both parts and managed to score average marks.

Moreover, the analysis in Figure 4 highlights that, 9 (6.16%) candidates scored weakly from 0 to 2.5. These candidates demonstrated a lack of understanding of the question's demands, providing irrelevant answers and mixing responses intended for part (b) into part (a). Additionally, some mistakenly provided objectives of annealing instead of purposes of heat treatment, particularly in part (a).

In part (b), candidates struggled to provide correct responses due to misunderstanding the question's demands. While some managed to provide a few accurate responses, many scored low marks or mixed up their responses from part (a). This indicates a lack of awareness regarding the question's demands and a deficiency in knowledge, skills, and experience in Metal Forming and Heat Treatment. Extract 4.2 illustrates an incorrect response from a candidate who scored low marks, exemplifying the challenges faced by candidates in understanding the question's demands.



4. a) i) To help as of the machines
ii) To help as of many machines
iii) To help as of to openg machine
iv) To help as of any thing of low
v) To help as of do the curant prosesp.

b. i) Opening
ii) closing
iii) Lock
iv) pull & push

Extract 4.2: A sample of candidate's weak responses to Question 4

Extract 4.2 illustrates a sample answer from a candidate who did not give correct answers to all sections of this question. They offered irrelevant responses in both parts of the question. This suggests that the candidate lacked knowledge, skills, and experience in Metal Forming and Heat Treatment.

2.2.3 Question 5: Machine Tools I

This question was derived from the topic of *Machine Tools I*. It had two parts, (a) and (b). Part (a) required the candidates to explain the concept of cutting fluid. Part (b) required the candidates to analyze seven functions performed by cutting during operation process. The question was:

A newly employed technician was performing a cutting operation on a lathe machine without using any cutting fluids hence he experienced a rise of excessive heat in the cutting zone.

(a) Explain the concept ''cutting fluids''.

(b) What are the seven functions performed by cutting fluid in such process?

The question was attempted by 146 (100%) candidates from which 9 (6.16%) scored from 0 to 2.5 marks, 15 (10.27%) scored from 3.0 to 5.5 marks and 122 (83.56%) candidates scored from 6.0 to 9.0 marks. The majority candidates, 122 (83.56%) scored from 6.0 to 9.0 marks. Overall, the candidates performed well in this question because 137 (93.83%) candidates scored from 3.0 to 9.0 marks.

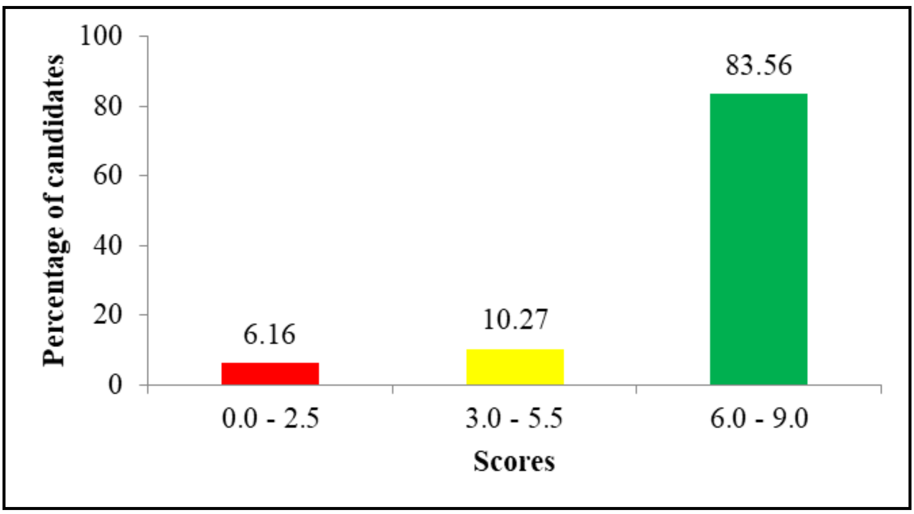


Figure 5: *The Candidates' Performance in Question 5*

Analysis of candidates' responses shows that, 119 (81.51%) demonstrated good performance by providing relevant answers that met the requirements of both parts (a) and (b). They accurately explained that cutting fluids, acting as coolants and lubricants, are applied to the tool-workpiece-chips zone (cutting zone) in metal cutting operations to facilitate machining. These candidates exhibited strong knowledge, skills, and experience with cutting fluids, evident in their comprehensive answers. In part (b), they correctly identified seven functions of cutting fluids, including increasing tool life, improving finishing, reducing heat generation, minimizing friction, and preventing temperature rise. They also recognized the roles of cutting fluids in reducing cutting force and power consumption, removing generated chips, and providing lubrication under high pressure.

Overall, these candidates demonstrated a thorough understanding of the topic and displayed proficiency in Machine Tools I. Extract 5.1 provides an example of well-performed responses.

5. (a) Cutting fluids - Are fluids used in lubricating cutting operation so as to reduce friction and they also known as lubricants example oil, grease and water.

5. (b) Functions of cutting fluids;

(i) To reduce friction between cutting tool and workpiece during an operation time.

(ii) To reduce tear and wear of the cutting tool.

(iii) To remove chips from the workpiece during an operation time.

(iv) To improve the quality of surface finish of work piece.

(v) To reduce the temperature of the cutting zone.

(vi) To reduce the cutting tool downtime.

Extract 5.1: A sample of candidate's good response to Question 5

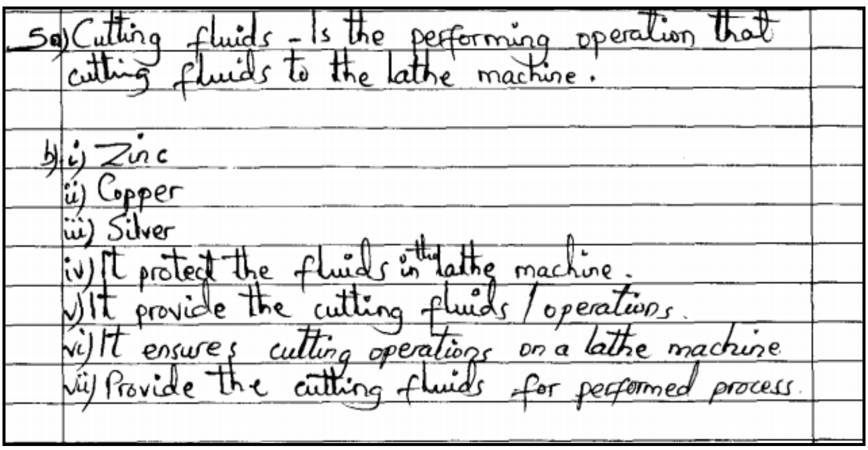
In Extract 5.1, the candidate effectively described the concept of cutting fluid in part (a) and correctly identified its functions. S/he demonstrated understanding of the question's requirements and provided accurate responses, showing proficiency in the machine tools topic.

On the other hand, 17 (11.64%) candidates managed to answer certain parts of the question correctly, either in part (a) or (b), or in both. For example, some candidates correctly answered part (a) but struggled with part (b), and vice versa. Additionally, some candidates within this group provided partially correct responses to both parts.

This analysis suggests that, these candidates lacked sufficient knowledge, skills, and experience regarding cutting fluids and their functions in metal cutting operations, a topic covered in Machine Tools I.

Similarly, 10 (6.85%) candidates demonstrated inadequate knowledge of cutting fluids. They either provided incorrect responses or failed to respond altogether. These candidates did not understand the concept that cutting fluids serve as coolants and lubricants applied to the tool-work piece-chip zone (cutting zone) during metal cutting operations to facilitate machining. These candidates also failed to understand the other functions of cutting fluids. These functions include increasing tool life and improving surface finish by dissipating heat generated during metalworking.

Additionally, the candidates under this category did not grasp the role of cutting fluids in reducing friction and preventing corrosion. Cutting fluids also provide a cushioning effect between the workpiece and tool and lubricate at high pressure, removing chips and dirt, and reducing cutting forces and power consumption. Some candidates provided irrelevant explanations of cutting fluids in part (a), while in part (b, most candidates in this group misunderstood the question requirements. Extract 5.2 serves as an example of a weak response from one candidate:


5a) Cutting fluids - Is the performing operation that cutting fluids to the lathe machine.

b) i) Zinc
ii) Copper
iii) Silver
iv) It protect the fluids in the lathe machine.
v) It provide the cutting fluids / operations.
vi) It ensures cutting operations on a lathe machine
vii) Provide the cutting fluids for performed process.

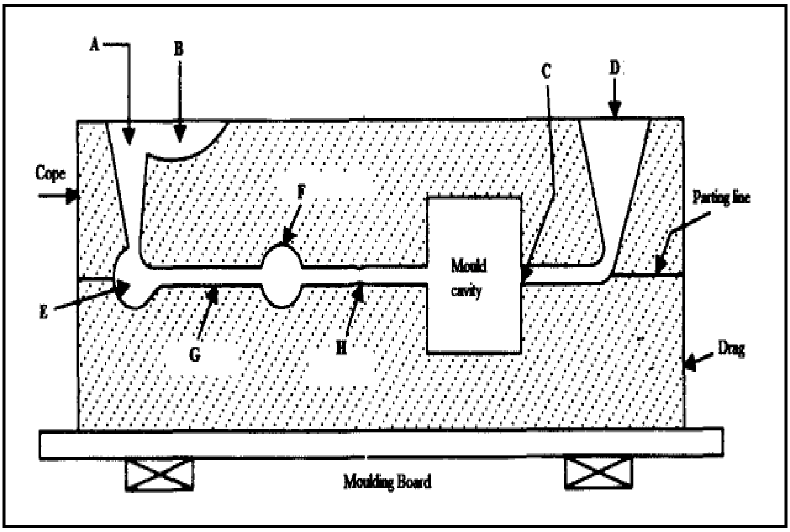
Extract 5.2: A sample of a weak candidate's responses to Question 5

In this extract, the candidate provided incorrect answers for both parts. In part (a), the candidate failed to explain cutting fluids and instead referred it wrongly as an operation performed on a lathe machine. In addition, this candidate mentioned alloying elements instead of describing the functions of cutting fluids. This indicates the candidate's insufficient knowledge, skills, and experience regarding Machine Tools I topics.

2.2.4 Question 6: Foundry Technology

This question was composed from the topic of *Foundry Technology*. It had two parts, (a), (b) and (c). Part (a) required the candidates to identify the labeled parts letters A–F. Part (b) required the candidates to give the function of parts labeled A, D and F. In part (c) the candidates were required to explain the outcomes when part labeled C and G are removed.
The question was:

Study the figure below and then answer the questions that follow:



(a) Mention the parts labeled with letters A-F.
(b) What are the functions of the parts labeled A, D and F.?
(c) What will happen to the process if parts C and G are removed?

The statistics indicate that, out of 146 candidates who attempted this question, 53 (36.30%) scored between 0 and 2.5 marks, 61 (41.78%) scored between 3.0 and 5.5 marks, and 32 (21.92%)

scored between 6.0 and 9.0 marks out of the total 9 marks allocated. Figure 6 illustrates the candidates' performance in this question.

Overall, the performance was average, with 93 (63.70%) candidates scoring from 3 to 10 marks. This analysis suggests that candidates had partial knowledge and experience in sand molding.

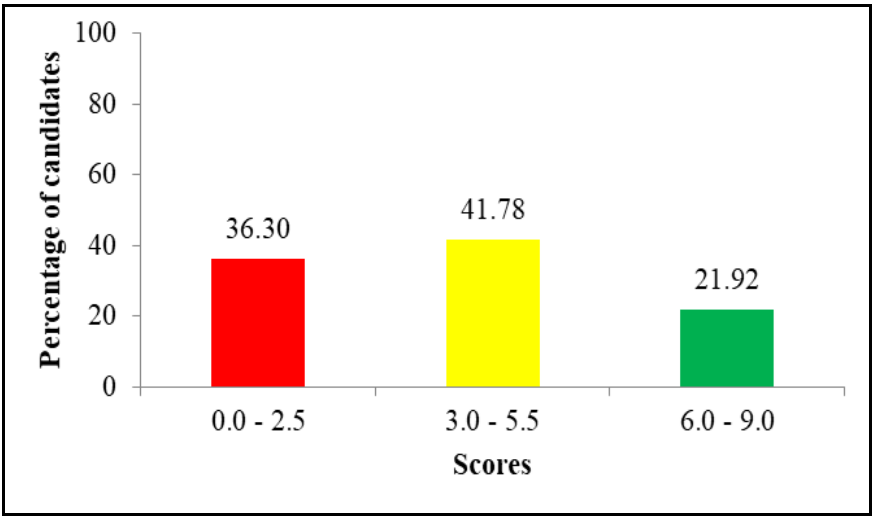


Figure 6: *The Candidates' Performance in Question 6*

The 53 (36.30%) candidates who performed poorly struggled to provide correct answers to both parts of the question. In part (a), candidates failed to correctly identify the labeled parts (A-F), which include sprue (A), pouring basin (B), In gate (C), riser (D), sprue base or well (E), and skim bob (F). Additionally, they were unable to provide the functions of parts A, D, and F. Specifically, sprue serves as the passageway for molten metal; riser allows molten metal to rise above the mold cavity, and skim bob prevents impurities from entering the mold cavity in part (b).

Furthermore, in part (c), candidates struggled to explain the consequences of removing parts labeled C and G. Removing In gate (C) would hinder molten metal flow to the mold cavity, resulting in a lack of product. Removing the runner (G) would prevent molten material from flowing to the sprue, potentially leading to issues like slags and air inclusion. Some candidates demonstrated a lack of knowledge in foundry technology, particularly in sand molding. Extract 6.1 is a sample of a weak response from one of the candidates.

6. (a) A - Tails stock.
B - Heading stock
C - Tail stock.
D - ~~Heading stock~~ base
E - Heat produced
F - cutting fluids

(b) A - Used to ~~rot~~ rotate and perform work.
D - Help to ensure the direction of metal ~~pro~~ cutting.
F - Help to proce the heat and cutting materials by rotating process.

(c) If part c and G are removed the Machine can not produce the head Source and can not operate the work to the other function.

Extract 6.1: A sample of candidate's incorrect responses to Question 6

Extract 6.1 illustrates a weak response from one candidate, who provided incorrect answers to all parts of the question. In part (a), the candidate erroneously identified lathe machine parts instead of the labeled mold box parts. In parts (b) and (c), irrelevant responses were provided, indicating a lack of understanding. This candidate exhibited inadequate knowledge, skills, and experience in Foundry Technology.

On the contrary, 63 (43.2%) candidates provided only a few correct responses in both parts. In part (a), they struggled to identify all labeled parts and could only describe the functions of parts A, D, and F to a limited extent. Most candidates failed to explain the consequences of removing parts C and G. Specifically, they did not grasp that removing part C would impede the flow of molten metal into the cavity, while removing part G would hinder the flow to the sprue, potentially leading to slags and air inclusion. This analysis indicates a lack of sufficient knowledge and practical experience in Foundry Technology among these candidates.

On the other hand, 30 (22.5%) candidates who scored from 6 to 9 marks correctly identified parts A to F and their functions. For example, they identified A as the sprue, D as the riser, and F as the skim bob. In part (b), these candidates accurately described the functions of parts A, D, and F. They understood that the sprue allows molten metal to flow into the mold cavity, the riser ensures the cavity is fully filled, and the skim bob prevents impurities from entering the cavity during pouring.

Furthermore, these candidates correctly explained the effects of removing parts C and G in part (c). They recognized that removing part C would disrupt the flow of molten metal toward the cavity, while removing part G could lead to issues like slags and air inclusion. This indicates a sufficient level of knowledge and practical experience in Foundry Technology. The overall responses of these candidates demonstrate a solid understanding of Foundry Technology, which is essential for producing metal products and components of various sizes and shapes.

The analysis shows that, these candidates had enough knowledge and practical experience on Foundry Technology, that it is used to create metal products and components in a variety of sizes and shapes. Extract 6.2 shows a sample of response from a candidate who provided relevant answer to this question.

6 (a). A - Sprue.
B - Pouring basin.
C - Gate.
D - Riser.
F - Well.
E - Runner.

(b). (i) Part A used to allow ~~the~~ pouring of molten or liquid metal to the mould cavity.

(ii) Part D used to prevent the shrinkage of the molten metal when cooled by providing an extra place for molten metal to rise

(iii) Part F to allow molten metal to move in different parts of the moulding cavity.

(c) There will be no directional movement of molten metal to the mould cavity; Hence molten metal will not be directed to the mould cavity.

Extract 6.2: A sample of a candidate's good responses to Question 6

Extract 6.2 describes a candidate's model response to Question 6. The candidate successfully identified labeled parts A-F in part (a), provided accurate functions for parts A, D, and F, and explained the impacts of removing parts C and G. This indicates a strong understanding of foundry technology.

2.2.5 Question 7: Metal Forming and Heat Treatment

This question had two parts (a) and (b). The candidates were required to use their knowledge of metal forming and heat treatment to respond to both two parties of this question. In part (a), the candidates were required to explain five most common defects that might occur due to heat treatment of metals. In part (b), the candidates wererequired to write the remedy of each defect mentioned in (a). The question was:

(a) When a metal or alloy fails to achieve the desired conditions and properties after heat treatment, the process is said to be defective. What are the five most common defects that might occur due to heat treatment of metals?

(b) Write the remedy of each defects mentioned in (a)

The question was attempted 146 (100%) candidates who sat for the assessment. Data analysis shows that, 45 (30.82%) candidates scored from 0 to 2.0 marks, 57 (39.04%) scored from 3 to 6.0 marks, and 44 (30.14%) scored from 7.0 to 10 marks. This performance is summarized in Figure 7, which shows that, the general performance was generally good. This is because 101 (69.18%) of the candidates achieved average and good performance.

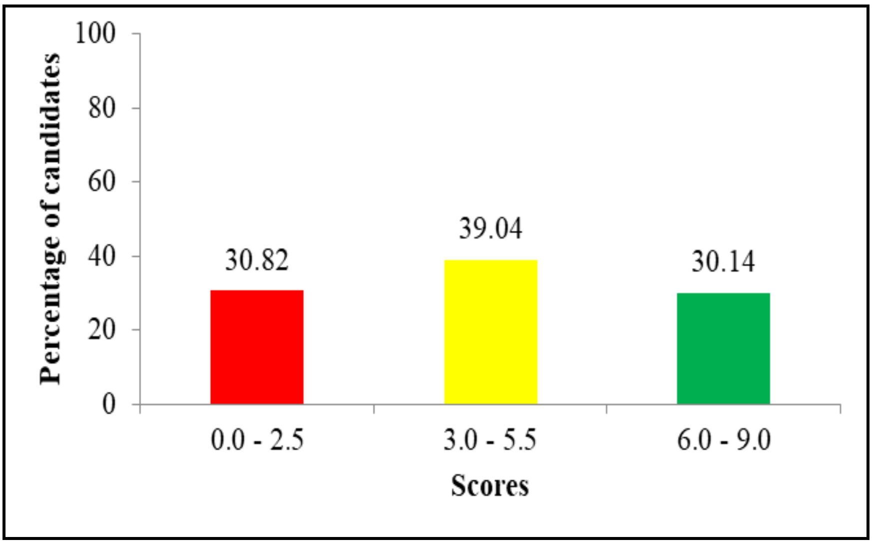


Figure 7: *The Candidates' Performance in Question 7*

The analysis indicates that, 45 (30.82%) of the candidates who scored 0 to 2.5 marks lacked knowledge on the subject matter and failed to address the demand of the question. The candidates were not able to give common defects that might occur due to heat treatment of metals, the defects are; wrong specifications of mechanical properties, soft spots quenching cracks, distortion and warping, overheating, burning corrosion and erosion, oxidation and decarburization and black fracture. These candidates provided irrelevant defects as the response to this part (a).

Candidate remedies for each of the defects listed in part (a) had to be written down in part (b). These remedies included slower cooling rates, lower austering temperatures and times, effective quenching, tampering right away after quenching, slow cooling in the martensitic range, homogenizing followed by double annealing, closely monitoring the flame heating and salt composition in salt baths, adhering to the proper heating temperatures and cooling rates, and heating the steel to a high temperature through forging.

The candidate in this group failed to identify the remedy in each defects mentioned. Most of the candidate failed to respond in part (a), as well as in part (b). The analysis indicates that; these candidates were not familiar with the question demand. They had inadequate knowledge as well. Extract 7.1 is a sample of the incorrect responses to this question.

7 (a)(i) The first directive is these product ~~was~~ does not flat surfaced.

(ii) The second directive is thes product was source of lose in marketing.

(iii) The third defective is there was source of losting the time in the ~~indust~~ Industry.

Extract 7.1: A sample of candidate's weak response to Question 7

Extract 7.1 demonstrates that, the candidate's responses to both parts were irrelevant since s/he failed to provide correct defect that might occurs due to heat treatment of metals in part (a). In part (b), this candidate was not able to analyze the remedy of each defect mentioned in (a). This candidate lacked knowledge on Metal Forming and Heat Treatment.

In contrast, 57(39.04%) of the candidates managed to score average as they provided incorrect response to part (a) of the question responded correctly in part (b). This indicates that, the candidates had moderate understanding on the topic of *Metal Forming and Heat Treatment*. Most of these candidates were able to respond correctly in part (a) while failed to respond in part (b). These candidates managed to provide relevant common defects that might occurs due to heat treatment but failed to respond correctly on the remedy of each defect mentioned in (a). The analysis shows that, candidates in this group lacked the complete knowledge and practical experience on the topic tested specifically in heat treatment processes.

Furthermore, the candidates who achieved good performance in this question managed to give perfect response that fulfilled the subject matter. In part (a), the candidates understood the question by showing enough knowledge, skills, and experience though their response. The candidates managed to give defects such as corrosion, burning, overheating, distortion, quenching cracks and soft spots. They understood that, warping, erosion, black fracture, incorrect hardness and wrong specifications of mechanical properties are the common types of defects to happen in heat treatment of a metal.

In part (b), 44 (30.14%) candidates were able to give the correct remedies to take on each mentioned defect. These candidates understood that, for better improvement on heat treatment process, defects are to be prohibited. These candidates wrote the remedy such as slower cooling rate, use of effective quenching, tempering immediately after tempering, cooling slow in the martensitic range and homogenizing are used to improve heat treatment defects.

Furthermore, these candidates also suggested additional correct remedy, provided other correct remedy such as regulatory the flame heat and adjusting the salt composition in the baths. These measures aim to address the mentioned defects in part (a) by ensuring precise heating temperatures at controlled cooling rates.

Extract 7.2 is an example of a response from a candidate who performed well.

7a Quenching ~~media~~ crack.
ii Carburizing
iii Overheating
iv Oxidaziong
v. insufficient hardness

7b. Quenching crack – use good quenching media
Carburizing – use proper atmosphere
Over heating – use temperature below it's melting point or below upper – critical point.
Oxidazing – use proper atmosphere
Insufficiend hardness – use carbon in order to improve hardness.

Extract 7.2: A sample of candidate's good responses to Question 7

Extract 7.2 shows the responses of a candidate who managed to analyze common defects occurred due to heat treatment in part (a). In part (b), s/he succeeded to identify the remedy of each defect mentioned in (a). The candidate really comprehended on Metal Forming and Heat Treatment and which contributed to scores 6 to 9 marks.

2.2.6 Question 8: Foundry Technology

This question had two parts (a) and (b). The candidates were required to use their knowledge of the *Foundry Technology* to give correct response to the subject matter. Part (a) required candidates to explain the four basic steps to accomplish casting of an engine part in foundry shop. Also, the candidates were required to provide three advantages and two limitations of the sand casting process.

The key objective of the question was to assess candidates' competence on steps to be followed during casting process. Moreover, the question intended to measure the candidates understanding in advantages of sand casting process and the limitations of the sand casting process. The question was:

(a) Suppose you are required to cast a certain engine part in the foundry shop. What are the four basic steps you will follow to accomplish the workpiece?

(b) Provide three advantages and two limitations of the sand casting process.

The question was attempted by 146 (100%) candidates. Among them, 21 (14.38%) scored from 0 to 2.5 marks, 47 (32.20%) scored from 3.0 to 5.5 marks and 78 (53.42%) scored from 6.0 to 9.0 marks. Figure 8 summarizes this performance. The general performance in this question was good since 125 (85.62%) candidates scored from 3.0 to 9.0. This signifies that, the candidates had adequate knowledge on foundry technology.

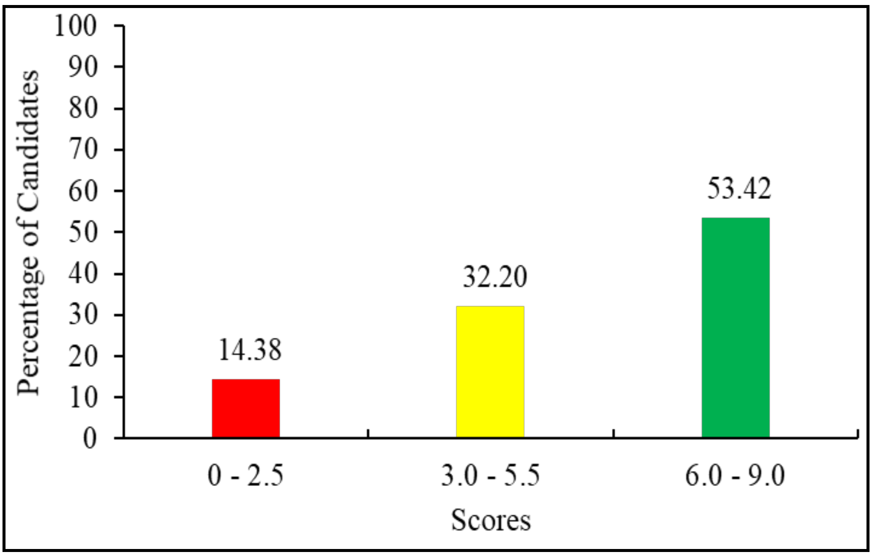


Figure 8: *The Candidates' Performance in Question 8*

The analysis reveals that, 77 (52.74%) candidates performed well in both parts (a) and (b) of this question. These candidates comprehended the question requirements and provided flawless responses, indicating their strong understanding and proficiency in the topic of foundry technology.

Adjacent to the above analysis, most of the candidates gave relevant response in part (a). Most of the candidates in this category offered the basic steps of casting process as; pattern making, mould and core making, melting and pouring as well as cleaning of the casting. They knew that, pattern making is the initial step followed by design of mould and core in the moulding box. These candidates understood that, metal melting and pouring the molten metal in a moulded box is the third step as well as cleaning of the casting is the last step.

However, the candidates outlined the advantages of the sand casting process in part (b). They highlighted its widespread use and cost-effectiveness, as well as its suitability for both ferrous and non-ferrous metals. Additionally, they noted its ability to produce castings of various sizes, thus accommodating a diverse range of products compared to other casting methods.

The Candidates also managed to provide the limitations such as limited to one or small number of moulding per box, metal ration is relative high and high level of waste is typically generated. These candidates in this category understood the question demand. In addition, they had enough knowledge and experience in the competence tested. Extract 8.1 is a sample of the correct responses of a candidate with good performance.

8 (a). (i) pattern making; this is the stape which involves in making the pattern with the desired shape of the Casting shape to be produced.

(ii). Mould preparation; this is the stape which involve filling moulding sand in a moulding box of flask with a pattern to achieve the moulding cavity with the required shape of the work.

(iii). Melting and Casting of metal; This involves melting the metal to molten state then pouring the molten metal in the mould box

(iv). Cooling and solidifing a metal; this is the stape which involve Cooling of molten metal in the mould box and left it to solidify so as to obtain the required metal Casting product.

8(b) Advantages of Sand Casting process.
(i) Is the Cheapest method of producing and Manufacturing Casting products
(ii). It produce products with ~~are~~ various Shape based on the shape of the moulding box.
(iii) large to Small Components Can be made by Considering the size of the moulding box.

Limitation of Sand Casting process
(i) It produces products with poor Surface finishing.
(ii) It requires skills for production of different equipments.

Extract 8.1: A sample of candidate's good responses to Question 8

Extract 8.1 shows a candidate's response in which s/he managed to analyze the four basic steps to accomplish casting engine part in the foundry workshop in part (a). In addition, s/he provided both advantages and limitations of sand casting process. This indicates that, s/he had adequate knowledge on Foundry Technology specifically in sand casting.

Nevertheless, 48 (32.88%) of the candidates had little understanding on the topic of *Foundry Technology*. Most of these candidates in this category were able to give correct response in part (a) but provided few correct responses in part (b). The analysis further shows that, the candidates were incompetent on the topic of Foundry Technology specifically in sand casting process.

On the other hand, 21 (14.38%) of candidates had weak performance. The given candidates were not able to respond correctly in both parts. In part (a), the candidates failed to explain the four basic steps to accomplish casting of a certain engine part in foundry shop. Some of the candidates did not understand the demand of the question as they provided irrelevant responses. They failed to know that, pattern making, mould and core making, melting and pouring as well as cleaning of the casting were the basic steps of casting process.

In part (b), the candidates lacked knowledge and practical experience on the competence tested. The candidates in this category failed to give advantages and limitations of sand casting process. Some of these candidates' misunderstood the item demand hence provided moulding sand properties as advantages of sand casting process.

The candidates overlooked the fact that sand casting offers several advantages, including its widespread usage and cost-effectiveness, as well as its ability to hold intricate details and resist deformation when heated. Furthermore, they failed to recognize that the limitations of sand casting include being typically restricted to one or a small number of molds per box, and having a relatively high sand-to-metal ratio. These oversights indicate a lack of understanding of the topic among the candidates.

The analysis shows that; candidates were not knowledgeable on Foundry Technology specifically in sand casting process. Extract 8.2 is a sample of a weak response from the script of one of the candidates.

8. (a) i) Wear the protective or safety equipment

ii) Check the effect of the engine before starting or switch one

iii) Switch to starting the our work after cheking the engine and satisfying our health and protective

iv) Switch off the engine after used or after fini shing of our work.

(b) Advantages of Sand casting process.

i) Sand casting is help to benefits of the casting process.

ii) It have used to cleaned the ~~[illegible]~~ liquids like water.

iii) It is help of the engineer to solve the casting process.

Limitations of the sand casting process.

i) It is holding together of moulding sand.

ii) It doesnt allowing gaseous to escape easily from the casting process.

Extract 8.2: A sample of candidate's poor responses to Question 8

In Extract 8.2, the candidate wrote responses that showed that s/he did not understand the requirements of the question in part (a). Instead of explaining the steps to accomplish the casting process in foundry workshop, s/he mentioned the workshop safety precautions. In part (b), s/he provided unmatched responses compared to the competence tested in this part. This candidate lacked knowledge, skills and experience on Foundry Technology.

2.3 Section C: Structured Questions

This section had three structured questions composed from the topics of *Engineering Materials, Machine Tools II and Maintenance Practice*. The section had 30 marks, each question with 15 marks. The candidates were required to attempt only two questions from this section.

2.3.1 Question 9: Engineering Materials

This question was derived from the topic of *Engineering Materials.* The candidates were required to use their knowledge of the Engineering Materials to give a correct response to the subject matter. In this question, the candidates were required to explain the physical and mechanical properties of Engineering Materials provided. The question was:

What does the following terms imply as far as physical and mechanical properties of engineering materials is concerned?

(a) Metals and its alloys (b) Organic materials (c) Organic polymers (d) Composites (e) Semi-conductors

The question examined the candidates' understanding abilities on Engineering Materials. The question was attempted by 112 (100%) candidates. The analysis of the candidates' performance shows that, 44 (38.94%) candidates scored from 0 to 4.0 marks, 49 (43.75%) scored from 4.5 to 9.5 marks and 20 (17.86%) scored from 10 to 15 marks. Figure 9 presents the performance of the candidates in question 9. The general performance in this question was average as 69 (61.61%) of the candidates performed average and above. This means that, majority of the candidates had adequate knowledge about the topic of Engineering Materials specifically in the properties of materials.

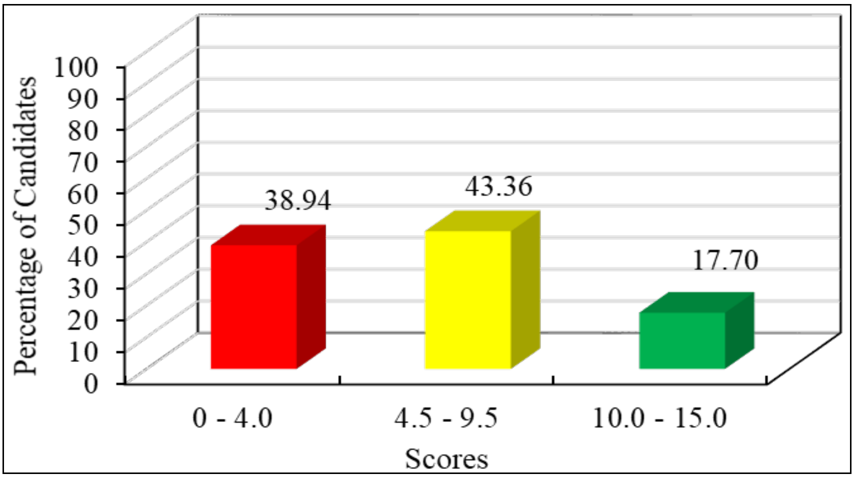


Figure 9: *The Candidates' Performance in Question 9*

The candidates' response analysis reveals that, 43 (38.39%) performed poorly in this question as they had inadequate knowledge on Engineering Materials specifically in physical and mechanical properties of Materials. Majority of the candidates in this category failed to respond correctly. The candidates in this category mixed up between physical and mechanical properties.

Some candidates did not understand the question and failed to attempt it. They were unaware of alloys being made by melting two or more metals and ceramics being non-metallic solids. They also did not know organic polymers consist of carbon combined with other elements. Additionally, they did not grasp composites being mixtures of materials like metals with ceramics. Lastly, they were unaware that semiconductors allow electrons to pass through them.

These candidates' had inadequate knowledge on the topic specifically in Materials properties. Extract 9.1 is a sample of weak responses from one of the candidates.

9. engineering materials are the materials used ina engineering. The following are the terms and their imply as far as physical and mechanical propertie of engineering materials

metals and its alloys: in this case we learning different metal example lead, Aluminium, copper and also it's alloy like alluminium alloy, copper alloy and so on.

Organic materials: this are those materials which is used ina organic example metal and non-metal

organic polymers: are those polymers which is used in a organic

composites: this are the substance which provide another substance example iron ore.

semi conductor are those material which allow the shortage pass of electricity

So all materials we used in a engineering have it's important we must protect them.

Extract 9.1: A sample of candidate's weak responses to Question 9

In Extract 9.1, the candidate wrote incorrect responses that showed that s/he did not understand the requirements of the question. This implies that, s/he lacked enough knowledge and skills in Engineering Materials specifically in the properties of Materials.

The performance of this question shows that, 49 (43.75%)

managed to score average in this question. Most of these candidates were capable to give few related answers on the subject matter of the question. These candidates knew that, the terms provided were examined from the topic of engineering materials hence managed to respond correctly on some of the terms. For instance, most of the candidate responded perfectly on semiconductor, metal and alloy and most failed to give relevant responses on composites, organic polymers and organic Materials. This implies that, the candidates had little understanding on the competence tested to this question.

In addition to above average performance, 20 (17.86%) of the candidates had good performance and they were able to respond correctly in the question. The candidates were competent to explain metals and it alloy organic Materials, organic polymers, composites and semi-conductors.

The candidates understood that, Metals are polycrystalline bodies consisting of a great number of fine crystals hence pure metals are of low strength and do not pass the required properties so alloys are produced by melting two or more metals.

They understood that, organic materials are referred to the large source of carbon-based compounds found within natural and engineered terrestrial and aquatic environment. They explained that composite materials consist of mixtures of various components, including metals and alloys, ceramics, as well as metals and organic polymers. These candidates as well explained perfectly on semi-conductors and organic polymers as solid material either non-metallic or compounds which allow electrons to pass through them and organic polymers usually consist of carbon chemically combine with hydrogen, oxygen or other non-metallic substances respectively.

These candidates were knowledgeable on Engineering Materials especially in Materials properties. Extract 9.2 is a sample of the correct responses of a candidate with good performance.

09. Metal and its alloy
Metals are the material with a commonity made up of metal. And usually ~~have~~ are very strong. eg Iron, Mecury etc.
Alloys. this is the mixture of two or more metalic compounds eg Al-Si-Cu
Usually are corrosive resistance and used in automobile parts.
But metals.
- Are slumy
- Malleable etc.

09 b) Organic materials.
Are the materials which are comming up from the organic compounds or made up of organic compound ~~e.g~~
e.g - Wood
- Rubber
Usually they are non-ductile, they are brittle and undergoes plastic deformation.

c) Organic polymers.
This are the material consisting of a long chain or networked carbon e.g High speed steels. and some of other steels.
Usually are hard as they can cut other material. and are mostly prepared to be used as tool cutter

d) Composite.
This are the material which are made up of two component of which one is metal and other are organic material s
Usually they are used to ~~make~~ ~~and~~ employed for corrosion resistances.

e) Semiconductors.
Are the material which tend to have the conduction and non conductivity property as they are made up of metal and non-metal components.
Usually have the characteristics of poor conduction of heat and electricity.

Extract 9.2: A sample of candidate's good responses to Question 9

In Extract 9.2, the candidate was able to explain the physical and mechanical properties of the provided engineering material in this question. This denotes that, the candidate had adequate understanding on engineering materials especially in materials properties.

2.3.2 Question 10: Machine Tools II

This question had two parts, (a) and (b). The candidates were required to explain the milling operations with the help of a simple sketch in part (a). For part (b), the candidates were required to calculate the cutting time using the data provided in the part in the question. The question was:

(a) *Milling is the process of removing the metal (chips) from a work piece by feeding it against a rotating multi-point cutting tool called milling cutter. With the help of simple sketch; explain how the following milling operations are done:*

   (i) Gang milling (ii) Angular milling (iii) Straddle Milling

(b) *A certain shaft was required to make a keyway of 150 mm long and depth of 4.2 mm. The available cutting tool and machine has the following specifications:*

   (i) High Speed Steel (HSS) end mill cutter with 20 mm diameter and four cutting teeth.

   (ii) Feed per tooth and cutting speed is 0.1 mm and 38 m/min respectively.

If the approach and over travel distance was half of the diameter of the cutter and depth of 4.2 mm can be cut in one pass, calculate the cutting time.

A total of 39 (100%) candidates attempted the question. The scores indicate that, 31 (79.49%) scored from 0 to 4.0 marks, 6 (15.38%) scored from 4.5 to 9.5 marks and 2 (5.13%) scored from 10 to 15 marks. Figure 10 shows that the candidates' overall scores in this question were low as 79.49% of the candidates scored 0 to 4.0.

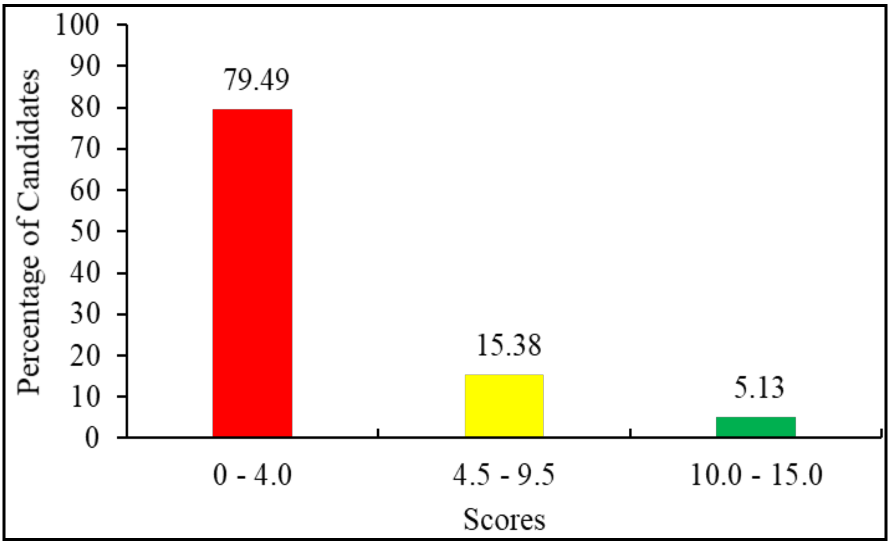


Figure 10: *The Candidates' Performance in Question 10*

The 31(79.49%) of candidates who scored low marks (0 to 4.0) had inadequate knowledge on Machine Tools II. Most of the candidates who scored these marks did not understand the question demand hence failed to provide correct responses. These candidates were not able to give the explanation on the gang milling, angular milling and straddle milling. They did not understand that; gang milling is the process that consists of reduction of plain flat surface along with slot at the center by special cutters. Also, angular milling is the operation which use cutter having helical teeth on the circumference and on end hence uses light operation such as profiling narrow surface, groove and recesses. They explained straddle milling as the operation of production of vertical surface on the opposite face of the workpiece. The candidates in this category were not able to provide a simple sketch on each milling operation in part (a). Most of them failed to give a relevant response to the question due to lack of knowledge on milling machine operations.

However, most of the candidates in this category failed to respond on this question in part (b). These candidates were required to calculate the cutting time from the data given in the question. The failure shows that the candidates were unaware of the question requirements and therefore did not provide the correct answer.

Some sample responses below from one of the candidate who misread the formula for calculating time in linear motion topic in engineering science and gave the wrong answer. Examples of incorrect responses from candidates in part (a) and (b) are;
Gang milling is among of the types of the milling operations which is used to remove the excess material from the workpiece or metal.

Angular milling *is the among of types of milling operations which are done in the workshop which this dials with milling cutter which this cuts the workpiece and make an angle which is used to shape well the workpiece or the metal.*

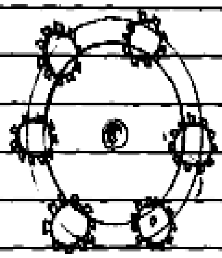
Straddle milling is among of the types of the milling operations which can be found in many workshop whereby this deals with feeding the workpiece against a rotating multi-point cutting tool.
Cutting time formula;

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{150 \text{ mm}}{38 \text{ m/min}} = 2.8$$

Extract 10.1 is a sample of weak responses from one of the candidates.

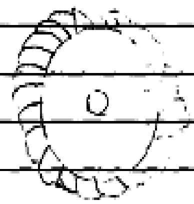
10.a

i. Gang milling cutter



can contain many cutter.

ii. Angular milling cutter



Is a milling in which can used to cut a metal at angle 60°

iii. Straddle milling cutter.

This milling cutter can cut a work piece at 45° angle.

10b	Data given
	Diameter of shaft = 150 mm
	Depth of cut = 4.2 mm
	Diameter of tool = 20mm
	Feed = 0.1 mm
	cutting speed = 38 m/min
	From:
	$VT^n = C$
	V = 38 m/min
	T = 4.2 mm
	n = 0.1
	C = 20
	$VT^n = C$
	$38 \times 4.2^{0.1} = 20$
	$38 \times 1.15 = 20$
	$43.86 = 20$
	$43.86 \div 20 =$
	2.19
	Time for cutting a bin is
	2 minutes

Extract 10.1: A sample of candidate's weak responses to Question 10

Extract 10.1 the candidate failed to explain the operations of gang milling, angular milling and straddle milling with the aid of the sketch. S/he gave incorrect explanations and poor sketches in part (a). On the other hand, because we were unable to introduce the correct calculation formula, we were unable to manipulate the required cutting time in part (b).

On the other hand, 5 (12.82%) of candidates scored average marks (4.5 to 9.5). Most of these candidates were able to respond correctly in part (a) and provided irrelevant responses in part (b).

Some candidates managed to provide few correct answers in (a) and abled to write formulars in (b) while failed to use the formular to get cutting time required. The analysis shows that, the candidates in this category had little knowledge in the subject matter specifically in part (b).

The 3 (7.69%) candidates who scored high marks (10 to 15) had adequate knowledge on Machine Tools II. Most of them gave relevant responses in both part (a) and (b). These candidates had knowledge on milling machine operations and thus understood the question demand. These candidates were able to give the explanation on the gang milling, angular milling and straddle milling. They understood that, gang milling is the process that consist of reduction of plain flat surface along with slot at the center by special cutters.

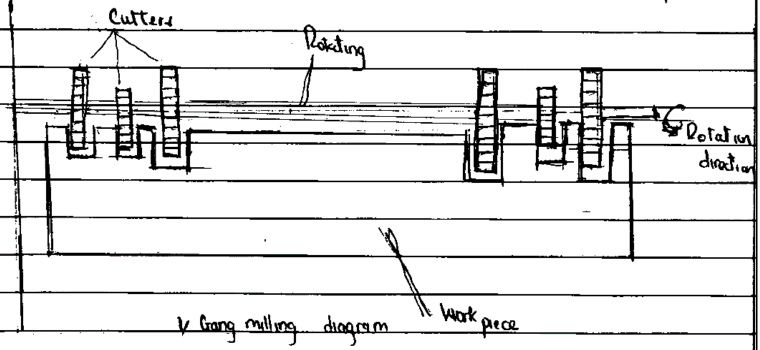
Also, angular milling is the operation which use cutter having helical teeth on the circumference and on end hence uses light operation such as profiling narrow surface, groove and recesses. They explained that, straddle milling is the operation of production of vertical surface on the opposite face of the workpiece.

Candidates in this category were able to provide a simple sketch to support their explanations of milling operations performed using a cutter with many teeth, rotating the cutter at high speed, or feeding the material slowly through the cutter. Most often it is a combination of these three approaches from part (a).

Despite the performance described in part (a), the candidates performed well in part (b). These candidates achieved higher scores by successfully calculating the cutting time. They utilized the provided data to approach the correct answer, demonstrating familiarity with the required formulas and applying them accurately. This indicates their understanding of the question's requirements, resulting in correct responses for part (b). Extract 10.2 illustrates one of the subjective responses given by a candidate in question 10.

10. a/

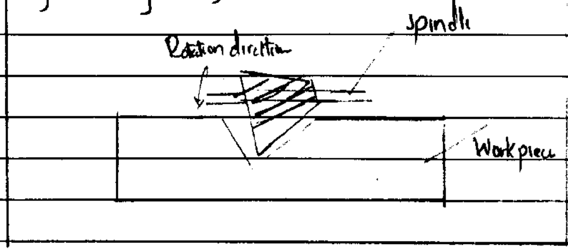
i/ Gang milling; Is an operation that involve using of more than one milling cutter for the purpose of creating required shape. All the cutters are mounted on the same spindle.



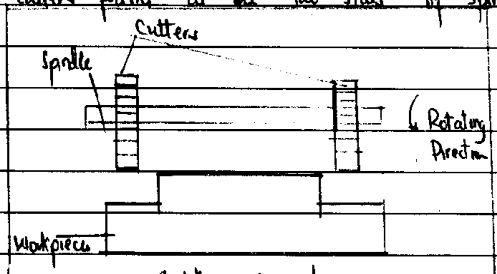
i/ Gang milling diagram

ii/ Angular milling; Is an operation of producing the bevelled or angular shape by employing the milling cutter that is in bevelled shape (angular shape).

10 a/ii/ Angular milling diagram.



iii/ Straddle milling; Is an operation of producing square or right angled surfaces on pieces of metal by employing two milling cutters found at the two sides of spindles.



Straddle milling diagram.

10 b/ Data given.

length of Key way = 150mm

Depth = 4.2mm

Diameter of cutter d = 20mm

Number of teeth = 4

Feed(f) = 0.1mm

Speed of cutting V = 38 m/min.

Approach and overall distance = $d/2$.

Number of passes = 1.

10b Formular

Time of cutting = $\frac{\text{length of tool travel}}{\text{feed} \times \text{Rev/min (N)}}$.

But Formular

$V = \frac{\pi D N}{1000}$.

$N = \frac{V \times 1000}{\pi \times D}$

$N = \frac{38m/min \times 1000}{3.14 \times 20mm}$

$N = 605.0955$ rev/min.

Recall

length of tool travel = length of Keyway + approach + over run.

length of tool travel = 150mm + approach + overrun.

But approach = $d/2$.

Approach = $20mm/2$

Approach = 10mm

and approach = Overrun.

length of tool travel = 150mm + 10mm + 10mm

length of tool travel = 170mm.

Therefore.

Time = $\frac{170mm}{0.1mm \times 605.095 \text{ rev/min}}$.

Time for one pass = 2.8 minutes

Therefore time for one pass = 2.8 minutes.

Extract 10.2: A sample of candidate's good responses to Question 10

Extract 10.2 demonstrates that the candidate successfully described the processes of gang milling, angular milling, and straddle milling with the help of a sketch. S/he provided accurate explanations and accompanying sketches in part (a). However, the candidate did not present the correct formula, resulting in her/his inability to manipulate the data to calculate the required cutting time in part (b).

2.3.3 Question 11: Maintenance Practice

This question had two parts, (a) and (b). In part (a), the candidates were required to explain five essential reasons of preventive maintenance in any operating system. For part (b), the candidates were required to elaborate the benefits of maintenance planning in the organization. The question was;

(a) Why preventive maintenance is essential in any operating system? Give five reasons.

(b) The following are considered to be the benefits of maintenance planning. How could the organization benefits from these factors?

(i) Reduction in time (ii) Staff development (iii) Resource utilization (iv) Machine life (v) Cost of improvising

140 (100%) candidates attempted the question. The scores indicate that, 14 (10.00%) candidates scored from 0 to 4.0 marks, 22 (15.71%) candidates scored from 4.5 to 9.5 marks and 104 (74.29%) candidates scored from 10 to 15 marks. The scores presented in Figure 11 shows that, the candidates' general performance in this question was good since 126 (90.00%) of the candidates scored 4. 5 to 15 marks.

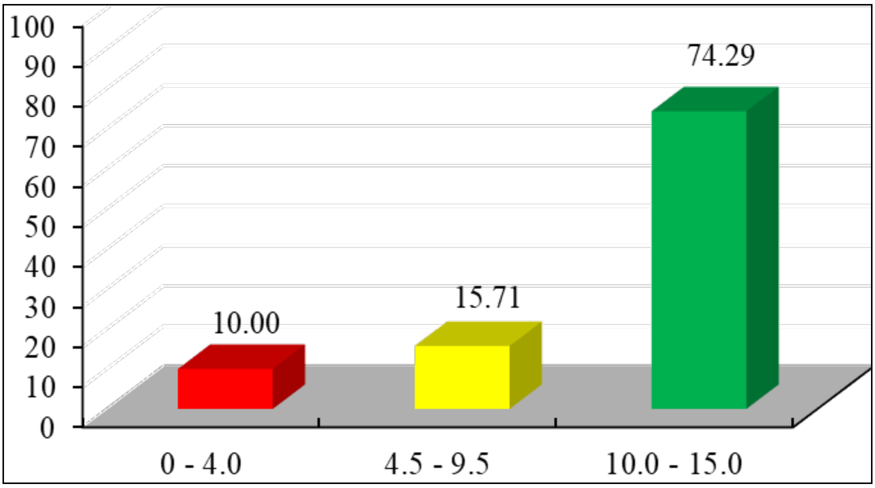


Figure 11: *The Candidates' Performance in Question 11*

The performance analysis reveals that 104 (74.29%) candidates had a good performance in this question. Most of these candidates knew that obtaining maximum availability of the plant, avoiding breakdown, reducing the shutdown periods to a maximum, to keep the machine in proper condition, minimizing the wear and tear, preserve the value of the plant, ensure for the safety of the workers and keeping the plant at the maximum production efficiency.

Besides, the candidates provided limited correct responses in (b) hence scored highly. Candidates knew that, easier scheduling of maintenance reduces downtime, reduces employee frustration, and improves workpiece satisfaction, which increases employee retention and increases productivity. They knew that, resource utilization is a true and accurate representation of all required resources, labor, materials, and tools.

They also knew that, machine life indicates how the machine is used and maintained, while improvisation costs indicate the availability of spare parts and special tools. This reduces downtime and increases ingenuity and creativity. These are the factors that lead to organizational superiority.

Therefore, the candidates scored higher marks as they were able to provide some correct response in both parts also the candidates in this category had enough understanding in the subject matter as well as good knowledge on Maintenance Practices specifically in preventive maintenance. Extract 11.1 presents one of the subjective responses provided by one of the candidates.

11 a) i/ It help to increase safety of the machine and personal during working

ii/ It help to reduce cost of damaged equipments or tools (assets).

iii/ It help to increase productivity of goods and product due to the early maintenance conducted.

iv/ It help to increase or improve life span of the equipment and tools or (assets).

v/ It help to improve quality of the goods and product through preventive maintenance of machine.

b). i/ Reduction in down time
It benefit from increase the long life span of the equipments or assets.

ii/ staff development → It help to reduce the repairing cost of damaged items from the staff.

iii/ Resource utilization → It help to increase the quality of goods and productivity.

iv/ Machine life :→ It help to prolong the life span of the machine

v/ cost of improvising → It help to reduce the cost of damaged equipment and tools.

Extract 11.1: A sample of candidate's good responses to Question 11

In Extract 11.1, the candidate was able to explain the importance of preventive maintenance in part (a). In part (b), s/he explained the benefits of maintenance planning in the organization regarding the factors such as reduction in down time, staff development, resource utilization, machine life and cost of improvement. This implies that, the candidate was knowledgeable on Maintenance Practices specifically in preventive maintenance.

Nevertheless, the 22 (15.71%) of candidates were able to provide some limited responses in both part (a) and (b). Most of these candidates responded correctly in part (a) while failed to give correct responses in (b). For example, one of the candidates provided few correct responses in part (a) hence scored few marks while provided irrelevant responses in (b). This implies that, most of the candidates had inadequate understanding on Maintenance Practices.

In spite of the above average performance, 14 (10.00%) of candidates who scored low marks, 0 to 4.0 had inadequate knowledge on Maintenance Practice. Most of them failed to give a relevant response to the question due to lack of knowledge on competence tested. Most of the candidates who scored these marks were not able to give five reasons on assured preventive maintenance to be essential in any operation system. These candidates were required to identify the importance of preventive maintenance. Some of the candidates provided few importance of preventive maintenance in part (a).

Moreover, in part (b), most of the candidates in this category were not able to respond; hence, others provided irrelevant answers. These candidates failed to explain the benefits of maintenance planning in the organization. They failed to understand that, promoting maintenance planning resulting to reduction in down time, staff development, resource utilization, machine life and cost of improvising brings benefits to the organization. Failures to understand the factors, the candidates were unable to explain the given factors in part (b).

Examples of incorrect responses provided by some of the candidates in part (a) are;

i. *because of the low of the thing*
ii. *Ii because of temperal of machine*
iii. *Because they know thy of use*
iv. *Because of the metal*
v. *Because of any people can change*

Some of the incorrect responses provided in part (b) are;

i. *And it reduce of the down time and athe used of the people and equlibriam*

ii. *And this staff development it to developme the amount of development of athe fraction and nuctias.*

iii. *Of the resource utilization and the ather used of many thing used of the people and the many people of resource utilization*

iv. *To help of ather life and of machine life of many machine in the society of the life machine*

Extract 11.2 is a sample of weak responses from one of the candidates.

11 (a) Maintenance is the repair the object of materials in a source of materia is in a process to the condition of people preventive maintenance of people the preventive:

Improves in quality: This is the materials in a person the quality of predicting full maintainance to repair the production manufacture.

Improves in a down time: To the down the time the process in a people to they is the main main the maintenance the protectivity in a person a people the activity

Improves in a cost of improving in a personal if the cost of the maintenance the people to containing the people in a source of material of the good in a person the predotive in sound.

Improves in a protective Activity: To improves the prefinter in a activity of the condition in a good maintain of process in a activity maintenance of personal a quantity activity.

Improves in a predective; To manage of process in a person a main the generated of the people in a condition the providing the society in a good of material of manure is the.

Generally; the conclusion is the preventetive maintenance to promote activity of social in a condition of person a maintenance.

Extract 11.2: A sample of candidate's weak response to Question 11

In Extract 11.2, the candidate provided the irrelevant responses. This shows that, s/he failed to understand the question demand in part (a). In part (b), the candidate was unable to provide the related responses. This implies that, the candidate had inadequate knowledge and experience on maintenance practices.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE ON EACH TOPIC

The Manufacturing Engineering CSEE subject comprises six topics: *Metal Forming and Heat Treatment, Machine Tools I, Foundry Technology, Engineering Materials, Machine Tools II* and *Maintenance Practices.* Candidates demonstrated strong performance across various topics, notably excelling in question 1 with a commendable score of 93.15%.

However, areas for improvement were identified, particularly in question 9 focusing on *Engineering Materials*, whose performance was average with 61.7%. Similarly, questions 3, 4, and 7, relating to the topics of *Metal Forming and Heat Treatmen*t, had average performance of 62.16%, these candidates exhibited strengths in understanding question requirements and applying their knowledge effectively.

Weak performance were particularly observed in question 10, from the topic of *Machine Tools II*, with a pass rate of 20.50%. This suggests a need for improvement on the subject matter knowledge and practical capabilities. Additionally, focus and resources should be allocated to topics with average or weak performance, *Engineering Materials and Metal Forming and Heat Treatment*. Also, targeted interventions are necessary to improve candidates' understanding on the topic of *Machine Tools II,* encompassing both theoretical concepts and practical applications.

Furthermore, interactive learning methods, practical demonstrations, and supplementary study materials should be employed to reinforce understanding across all topics and support candidates in identifying and addressing areas of weakness.

Continuous evaluation and adjustment of teaching methodologies are essential to ensure comprehensive coverage and effective learning outcomes, while ongoing professional development opportunities for educators will enhance the quality of instruction and student engagement. Through these measures, the overall effectiveness and outcomes of the Manufacturing Engineering CSEE subject can be significantly improved. A summary of the candidates' performance on each topic is presented in **Appendix I**.

4.0 CONCLUSION AND RECOMMENDATIONS

This section concludes the remarks and outlines the next steps following the analysis presented in the preceding sections. It summarizes the analysis of responses for each question and topic. While multiple stakeholders are involved in this analysis, the majority of recommendations are directed towards students and teachers for future improvement.

4.1 Conclusion

The overall performance in the Manufacturing Engineering subject in the CSEE November 2023 examination was good, as 71.38% of candidates scored average and above. However, the analysis reveals that certain weaknesses persisted among candidates, attributed by various factors as explained in the analysis of individual questions. The candidates faced difficulties in understanding the demands of questions, notably in questions 3 and 10, where incorrect responses were common. In addition, there was inadequate knowledge in certain subject areas, resulting in failure rates of 56.85% and 79.49% in questions 3 and 10 respectively. Furthermore, lack of knowledge in heat treatment experience and machining skills were observed in questions 3 and 10. Equally, the analysis underlines that, the candidates' proficiency in English language and poor understanding of question demands significantly contributed to their success.

4.2 Recommendations

4.2.1 Recommendations to Candidates

To improve the performance of candidates in the Manufacturing Engineering subject the candidates should:

(a) Engage in practical activities to bridge the gap between theoretical knowledge and practical skills, focusing on understanding machine operations such as gang, angular, and straddle milling.

(b) Actively participate in Manufacturing Engineering subject clubs to foster interest and deepen understanding.

(c) Improve English language proficiency through active involvement in debates, group discussions, and assignment presentations.

(d) Utilize drawing skills and knowledge acquired from related subjects (Engineering Drawing I-IV) to improve performance in Manufacturing Engineering, emphasizing neatness and accurate diagram labeling.

4.2.2 Recommendations to Teachers

Similarly, in improving the performance in the future, the teachers should:

(a) Create a supportive learning environment conducive to understanding question requirements and subject matter.

(b) Organize practical sessions on topics with practical applications, such as Metal Forming, Heat Treatment, and Machine Tools II, providing candidates with guidance during execution.

(c) Emphasize the importance of carefully reading questions before attempting them to ensure candidates understand the requirements.

4.2.3 Recommendations to Stakeholders

To ensure sustained improvement in Manufacturing Engineering subject, stakeholders including educational institutions, government bodies, and industry representatives, are encouraged to:

(a) Provide support and resources to facilitate the implementation of recommended strategies for candidates and teachers.

(b) Foster partnerships between educational institutions and industry to expose candidates to real-world applications and enhance practical skills.

(c) Conduct regular evaluations and assessments to monitor progress and identify areas for further improvement.

Appendix I

A Summary of Candidates' Performance (Topic-Wise & Question-wise)

S/N	**Topics**	**Percentage for each Topic**		**Remarks**
		Question Number	**Percentage of candidates who scored 30% or more**	
1	Machine Tools I, Welding Technology, Maintenance Practice, Metal Forming and Heat Treatment, Foundry Technology , Engineering Materials, Workshop Tools and Equipment & Workshop Management and Safety Rules.	1	93.15	Good
2	Machine Tools I	5	93.10	Good
3	Maintenance Practices	11	90.00	Good
4	Foundry Technology	2, 6 and 8	72.61	Good
5	Metal Forming and Heat Treatment	3, 4 and 7	68.72	Good
6	Engineering Materials	9	61.70	Average
7	Machine Tools II	10	20.50	Weak

Appendix II

The General Candidates' Performance in Manufacturing Engineering Subject

Grade	Percentage Range	Description	Number of candidates	Percentage
F	0 – 29	Weak	**9**	6.77
D & C	30 – 64	Average	**87**	65.41
B & A	65 – 100	Good	**37**	27.82
Total			**133**	**100.00**

Appendix III

The Distribution of Candidate' Performance in Each Question

Questions	1	2	3	4	5	6	7	8	9	10	11
Weak	10	46	83	9	10	53	45	21	43	31	14
	6.85%	31.51%	56.85%	6.16%	6.85%	36.30%	30.82%	14.38%	38.39%	79.49%	10.00%
Average	111	69	47	30	17	63	57	48	49	5	22
	76.03%	47.26%	32.19%	20.55%	11.64%	43.15%	39.04%	32.88%	43.75%	12.82%	15.71%
Good	25	31	16	107	119	30	44	77	20	3	104
	17.12%	21.23%	10.96%	73.29%	81.51%	20.55%	30.14%	52.74%	17.86%	7.69%	74.29%
Total	**146**	**146**	**146**	**146**	**146**	**146**	**146**	**146**	**112**	**39**	**140**

Appendix IV

The Overall Performance of Candidates Question Wise for Year 2023

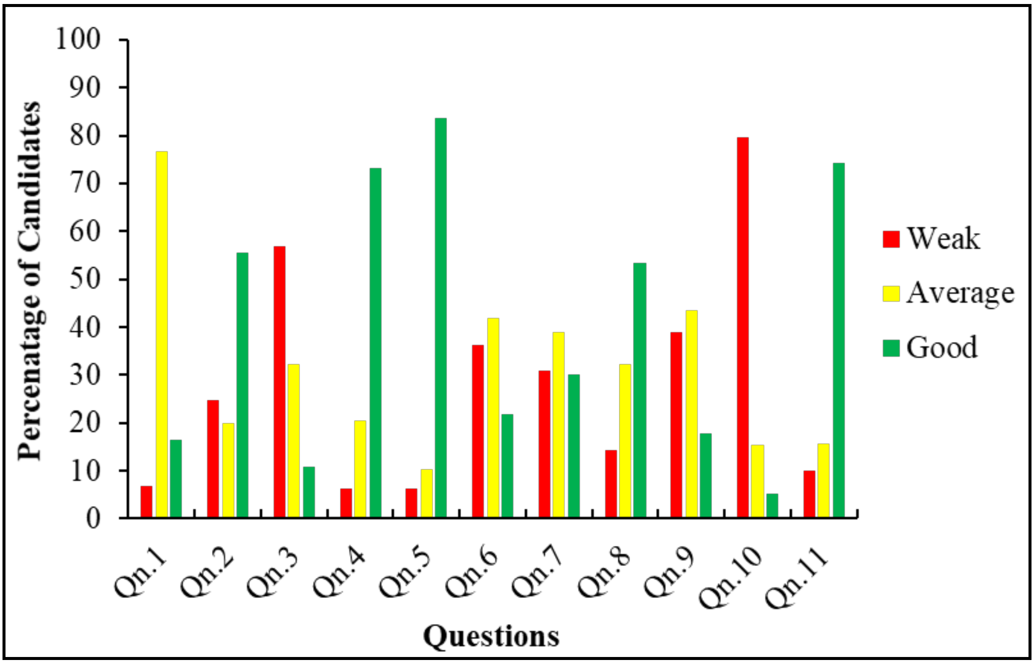


Figure 11: Overall performance of candidates questions wise for year 2023