THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR DIPLOMA IN TECHNICAL EDUCATION EXAMINATION (DTEE) 2019

781 ENGINEERING SCIENCE

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FOREWORD

This report on the Engineering Science subject for the 2019 Diploma in Technical Education Examination (DTEE) has been written to provide feedback to educational stakeholders on the performance of the candidates and the challenges they faced in attempting the examination questions.

The Diploma in Technical Education Examination marks the end of the Diploma in Technical Education course. This summative evaluation which indicates the effectiveness of the education system in general and the education delivery system in particular. The candidates' performance indicates what the education system was able or unable to offer to them in their two years of Diploma in Technical Education.

This analysis seeks to contribute towards understanding possible reasons behind the candidates' performance on Engineering Science. The report highlights the factors that made the candidates to perform differently on some questions. Such factors include the ability to identify the demand of the question, ability to follow instructions, and their knowledge about the subject matter. The report also highlights factors which made some of the candidates fail.

The National Examinations Council of Tanzania hopes that the feedback provided will help stakeholders in education to advice appropriate measures to be taken to improve candidates' performance in future.

Finally, the Council would like to thank the examiners and all the people who participated in analyzing the data used in this report, type setting the document, and reviewing the report.

Dr Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analysis the candidates' performance on the Diploma in Technical Education Examination (DTEE) for Engineering Science subject, which was done in May 2019. The examination paper consisted of questions which intended to measure the candidates' competences, knowledge and skills in the subject contents. The analysis revealed how they performed on each question. The report intended to identify the questions which were performed well, averagely and poorly. Furthermore, it highlights the questions which were attempted by most candidates and those which were not attempted.

The paper comprised 7 questions each carrying 20 marks. The candidates were instructed to answer 5 questions. The performance of the candidates on each question was categorized into three groups, which are weak, average and good if the percentage of the candidates' marks ranged from 0-39, 40-69 and 70-100 respectively. These categories are presented in charts using red, yellow and green colours in the report. Those who scored 0 – 39% are considered to have weak performance and represented by the red colour. Those who scored 40 – 69% are considered as average and their performance is represented by the yellow colour and those who scored 70 – 100% are good and their performance is represented by the green colour.

The general performance on the Engineering Science subject was average. Out of 113 candidates who sat the examination, 111 (98.23%) candidates passed while 2 (1.77%) failed.

The report provides feedback on the performance of the candidates. It shows what the candidates were required to do as well as their strengths and weaknesses based on their responses.
The analysis, observation, and recommendations contained in this report will help teachers, students, and other stakeholders in education. They will be able to identify areas that need special attention to improve teaching and learning Engineering Science in Tanzania.

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE ON EACH QUESTION

The paper comprised 7 questions each carrying 20 marks. The candidates were instructed to answer 5 questions. The performance of the candidates on each question was categorized into three groups which are weak, average and good if the percentage of the candidates' marks are in the range of 0-39, 40-69 and 70-100 respectively.

2.1 Question 1: Fluid Mechanics

This question had parts (a) and (b). Part (a) required the candidates to *differentiate between Archimedes' Principle and Torricelli's theorem as applied in fluid mechanics.* Part (b) started that *'Water is flowing through tapper pipe of length 150m with the slope of 1 in 20 at rate of 75litres/sec. If the diameters of that pipe are 600mm at the upper end and 200mm at the lower end; find the pressure at the lower end if the pressure at the higher end is 25N/cm^2. Support your answer with a neat sketch.'*

The question was attempted by 68 (60.18%) candidates. Among them 45 (66.18%) candidates scored from 0 to 7.5 marks; 23 (33.82%) candidates scored from 8 to 13.5 marks, but no candidates scored above it. The candidates' performance on this question was weak as shown in Table 1.

Table 1: Candidate' Performance on Question 1

Marks Scores	Percentage Range	Description	Candidates	
			Number	Percentage
0-7.5	0-39	Weak	45	66.18
8-13.5	40-69	Average	23	33.82
14-20	70-100	Good	0	0
TOTAL			**68**	**100**

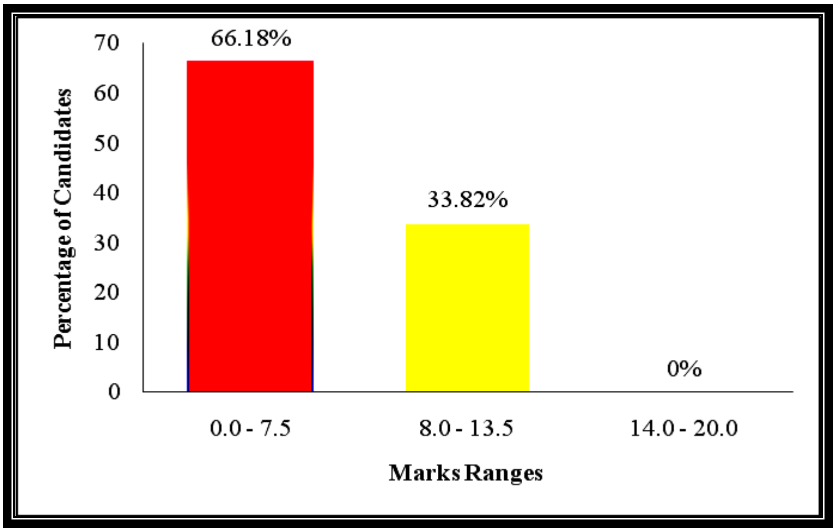


Figure 1: *Candidates' Performance on Question 1*

The candidates' performance on this question was poor. This performance was caused by candidates' failure to understand what the question required. These candidates failed to distinguish between Archimedes principle and Torricelli's theorem. Many candidates managed to state the Archimedes' principle which states that *" When a body is wholly or partially immersed in fluid it experiences an up thrust force which is equal to the weight of the fluid displaced*" but they failed to state Torricelli's Theorem which states that *"The velocity of efflux through an orifice at a depth h below the free surface of the liquid equal that acquired by a body falling freely from a height"*

In part (b) most candidates failed to apply Bernoulli's equation $\frac{P_1}{\rho g}+\frac{v_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{v_2^2}{2g}+Z_2$ to determine the pressure, (P_2) at the lower end of the pipe. Extract 1.1 is a sample of a poor response taken from the script of one candidate who failed to provide the correct answer.

1. (a) Archmedes Principle is the law states that, When a body is totaly or partially emersed in fluid its experienced on Upthrust which is equal to the total weight of the body displaces While Torricelli's theorem is the Theory states that The body tends to discrease Weight When immersed in fluid.

(b) soln

Data given

Length of Pipe (L) = 150 m

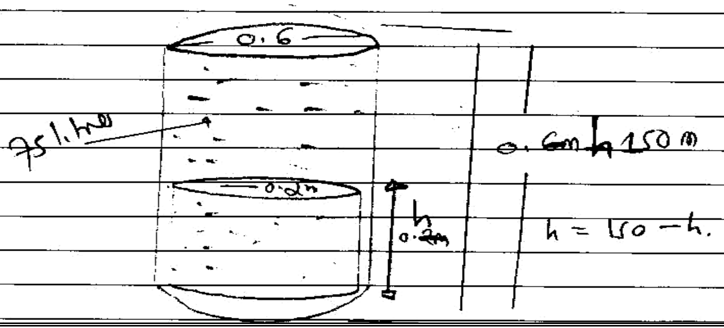
Mass of water (75 litres)

Uper Diameter of pipe 600mm = 0.6 m

low Diamet of the pipe 200mm = 0.2 m

pressure is required (P) = ?

(P) Pressure at highle is 25 N/m²



The pressure at lower end

$h_1 = H - h.$

$P = 75 \times$

Pressure at 25 of upper pipe

$P = \rho hg.$

$P = Mhg.$

$P = 75 \times 150 \times 9.8$

$P = 110,250$

P at higher pipe is 4410 N/m²

P at lower pipe

Extract 1.1 shows a sample of a poor response.

However, those who scored from 8 to 13.5 marks managed to define and apply Bernoulli’s equation but failed to indicate the correct units of the calculated values. Many of them comprehended partially. They provided incomplete responses while others faced much difficulty in calculating the value of pressure in part (b) or skipped some parts. The analysis of data reveals that none of the candidates scored from 14 to 20 marks. This indicates that they lacked knowledge of Fluid Mechanics particularly of the sub-topic of Laminar and Turbulent Flow. Extract 1.2 shows a sample of a good response extracted from the script of a candidate.

$d = \left(\frac{600}{1000}\right) m$

$d = 0.6\ m.$

Then.

$\text{Area} = \left(\frac{\pi \times 0.6^2}{4}\right) m^2$

$\text{Area} = 0.282 m^2.$

∴ The area at upper end $(A_1) = 0.282 m^2.$

Again, Area at a lower end

$\text{Area } (A_2) = \frac{\pi d^2}{4}$

$d = 200 mm = \left(\frac{200}{1000}\right) m.$

$d = 0.2 m.$

Then

$\text{Area } (A_2) = \left(\frac{\pi \times 0.2^2}{4}\right) m^2$

$\text{Area } (A_2) = 0.031 m^2.$

1 (5).

Bnd: The rate of wate to flow ($\dot{Q}$) = AV

where by

A = area of a pipe at one side

V = velocity of wate ~~to~~ flowing

Thus, given

$\dot{Q} = (75 \cancel{\times} 1000)\ m^3/sec$

$\dot{Q} = (75 \div 1000)\ m^3/sec$

$\dot{Q} = 0.075\ m^3/sec.$

For upper end the rate of wate to flow become.

$\dot{Q} = A_1V_1$

$0.075\ m^3/sec = 0.282 m^2\ V_1$

$V_1 = \frac{0.075\ m/s}{0.282}$

$V_1 = 0.266\ m/s.$

Again for lower end the rate of wate to flow is become.

$\dot{Q} = A_2V_2$

$0.075\ m^3/sec = 0.031 m^2\ V_2$

$V_2 = \cancel{24.194\ m/s}\ 2.4194\ m/s.$

Extract 1.2 is a sample of a good response extracted from the script of one of the candidates.

2.2 Question 2: Strength of Materials

The question had three parts: (a), (b), and (c) as follows:

(a) Briefly explain the term "stress" as used in engineering science.

(b) A piece of steel 10mm diameter is subjected to a load of 9kN which causes a length of 100mm to increase to 100.055mm. Calculate the:

(i) Stress

(ii) Strain and

(iii) Young's Modulus

(c) A sample of rectangular block rubber material of 300mm x 200mm x 20mm (length x height x width respectively) was firmly fastened to a vertical wall as shown in Figure 1. When the downward load of 48N applied to the free vertical-face, the vertical deflection of 2mm was obtained. Determine the modulus of rigidity of this block.

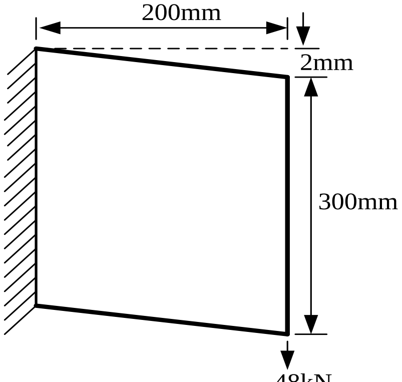


Figure 1

About ninety four (93.8%) percent, equivalent to 106 candidates, attempted this question. Their scores were as follows: 32 (30.19%) candidates' scored from 0 to 7.5 marks; 63 (59.43%) candidates scored from 8 to 13.5 marks; and 11 (10.38%) candidates scored from 14 to 20 marks. These data are presented in Table 2 and in Figure 2.

Table 2: Candidates' Scores on Question 2

Marks Scores	Percentage Range	Description	Candidates	
			Number	Percentage
0-7.5	0-39	Weak	32	30.19
8-13.5	40-69	Average	63	59.43
14-20	70-100	Good	11	10.38
TOTAL			**106**	**100**

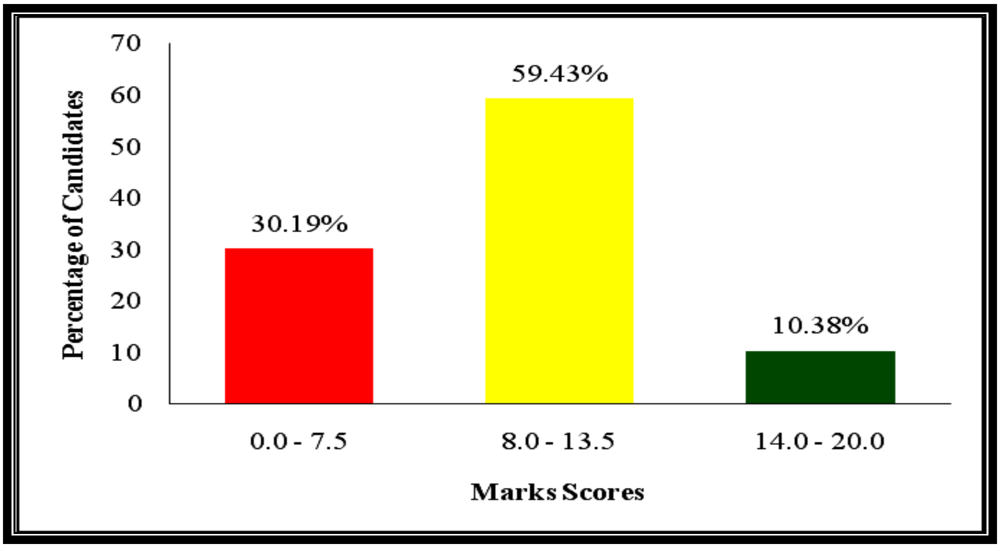


Figure 2: *Candidates' Performance on Question 2*

Their general performance on this question was good, since 69.81 percent of them scored above average. Most of them managed to explain the term stress, strain and Young Modulus but a few failed to calculate the Modulus of rigidity of rubber block. The candidates who scored from 8 to 13.5 marks managed to explain and compute stress, strain and Young's Modulus, but they made slight mistakes in calculating of Modulus of rigidity. However, those who scored from 14 to 20 marks managed to explain the term Stress as well as to use the formula for Young Modulus ($E = \frac{stress}{strain}$) and Modulus of rigidity ($G = \frac{Shear\ stress}{shear\ strain}$) to determine the required values. The good performance of the candidates implies that they had enough knowledge of the topic on the strength of materials. Extract 2.1 is a sample of a good response extracted from the script of one of the candidates.

2\. (a) Stress is the ratio of Applied force to the Area.
Mathematically

$$\text{Stress} = \frac{\text{Force or Load}}{\text{Area}}$$

$$\text{Stress} = \frac{(N)}{M^2}$$

Hence, the unit of force is N/M^2 Newton's per metre squared

b) Data given:-
Diameter of Steel = 10 mm
Load = 9 KN
Original Length = 100 mm
extension (change in Length) = 100.055 − 100
= 0.055 mm

Required to find,
(i) Stress

Recall, $\text{Stress} = \frac{\text{Force or Load (N)}}{\text{Area } (m^2)}$

Since $\text{Area} = \frac{\pi d^2}{4}$

where, d − diameter

2\. b)(i)

$$A = \frac{\pi d^2}{4}$$

$$A = \frac{\pi (10mm)^2}{4}$$

$$A = 78.54 \, mm^2$$

Thus, $\text{Stress} = \frac{9 \times 10^3 N}{78.54 \, mm^2}$

$\text{Stress} = 114.59 \, N/mm^2$

∴ Stress will be $114.59 \, N/mm^2$

ii) Strain, is given by,

$$\frac{\text{~~Original~~ Change in Length}}{\text{Original ~~extension~~ (Change in Length)}}$$

$\text{Strain} = \frac{\cancel{100 \, mm}}{\cancel{0.055 \, mm}} \quad \frac{0.055 \, mm}{100 \, mm}$

$= \cancel{1818.182}$

∴ Strain will be ~~1818.182~~ 5.5×10^{-4}

iii) Young's Modulus is given by,

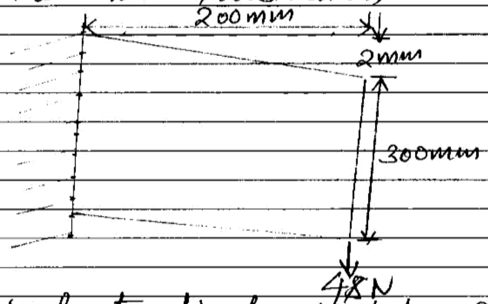
$$Y = \frac{\text{Stress}}{\text{Strain}}$$

$$Y = \frac{114.59 \, N/mm^2}{5.5 \times 10^{-4}}$$

$Y = 208.3 \times 10^3 \, \cancel{K} N/mm^2$

∴ Modulus will be $208.3 \, KN/mm^2$

2 (c) Data given:-
Rectangular block rubber dimensions
300mm x 200mm x 20mm (length x height x width)
Load of 48N
Consider the illustration below:-



Required to find Modulus of rigidity
Since Modulus of rigidity is given by $\gamma = \frac{\text{Stress}}{\text{strain}}$

$\text{Stress} = \frac{\text{Load (N)}}{\text{Area}}$

Area = 300 mm x 200mm
= 60,000 mm^2

Then, $\text{Stress} = \frac{48N}{60,000 mm^2}$
$= 8 \times 10^{-4} N/mm^2$

Extract 2.1 *is a response by one of the candidate who managed to calculate the required values.*

Despite the good performance on this question, 11(10%) candidates scored low(0 - 7.5) marks. Most of them failed to explain the term Stress and to use the correct formula to compute different parameters for strength of materials. For example, one candidate used the ultimate tensile strength formula to determine elongation, which had been provided in the question. Few candidates scored some marks by defining the term stress and finding the value of stress, strain and Young's modulus. However they but failed to find out the modulus of rigidity. Yet, the candidates who scored 0 to 1 mark managed to provide the formula for stress but they lacked knowledge and skills in the Strength of Materials since they failed to interpret the demand of the question. Extract 2.2 is a poor response extracted from the script of a candidate.

2. (a) This is ratio of factor safety and Ultimate Strength / force

i.e.

$$Stress = \frac{F.S}{Ultimate\ Strength}$$

(b) (i) Stress =

Given

force = 9kN

length = 100 × 100.055 MM

= 100.055 CM

$$stress = 9/100.055$$

Stress = 0.089 kN/m²

(ii) Strain

= 10mm = $\frac{1CM}{0.089}$

Strain = 11.235N

(iii) Yung Modulus

$$= \frac{Stress}{Strain}$$

$$Yung\ Modulus = \frac{0.089}{11.235}$$

Yung Modulus = 7.921×10^{-3}N

2 (c)

Given

Downward force = 48N

length = 300mm and 200mm.

Width = 20mm.

Deflection = 2mm.

Modulus = $\frac{48}{\text{Leng } 300 \times 20 \text{ CM}}$

Modulus = $\frac{48}{30 \times 20}$

Modulus = 0.08N

Extract 2.2 is a sample of a poor response from the script of a candidate who failed to calculate the required values.

2.3 Question 3: Fluid Mechanics

This question comprised two parts: (a) and (b). The question was as follows:

(a) *The surface tension of liquid depends upon three factors; that is, its nature, contamination and temperature. With one valid example, explain how these factors affect the surface tension.*

(b) *In hydraulic press the plunger is 30mm diameter and the ram 300mm diameter. (i) Determine the total force exerted by the ram when a force of 400N is applied to the plunger (Neglect all losses) (ii) Use a well labeled sketch to show the plunger, ram and direction of fluid flow.*

Data analysis reveals that 26 (23%) candidates attempted this question. Among them 9 (34.62%) candidates scored from 0 to 7.5 marks; 5 (19.23%) candidates scored from 8 to 13.5 marks; and 12 (42.15%) candidates scored from 14 to 20 marks. These scores portray good performance of the candidates because 65.38 percent of them scored (8-20) marks. Table 3 and Figure 3 are illustrative.

Table 3: Candidates' Scores on Question 3

Marks Scores	Percentage Range	Description	Candidates	
			Number	Percentage
0-7.5	0-39	Weak	9	34.62
8-13.5	40-69	Average	5	19.23
14-20	70-100	Good	12	46.15
TOTAL			26	100

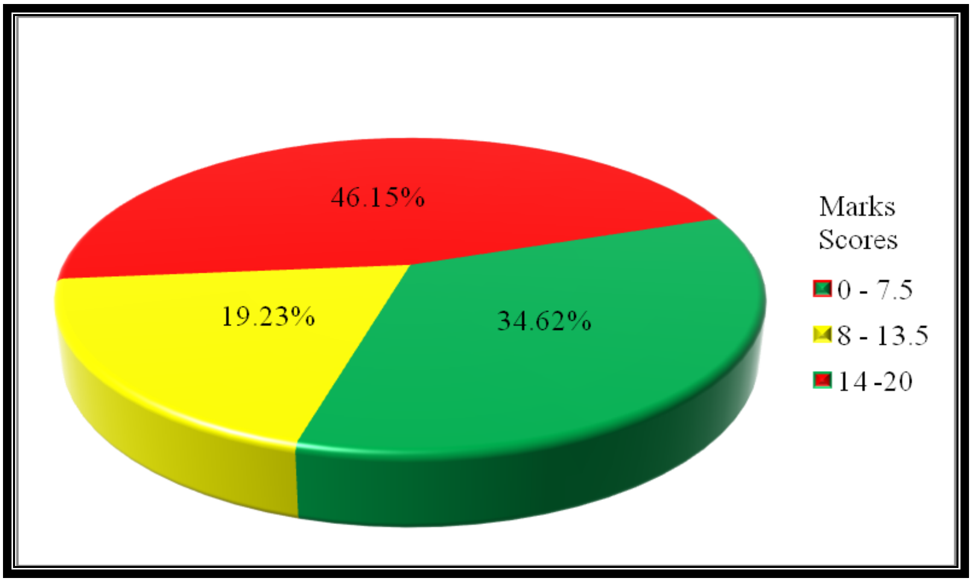


Figure 3: *Candidates' Performance on Question 3*

The analysis of candidates' responses shows that those who scored good (8-20)marks managed to recall factors affecting the surface tension and applied the knowledge of hydraulic press to calculate the force exerted on the ram when the effort of 400N is applied to the plunger. Most of the candidates who scored from 8 to 13.5 marks managed to explain how the type of liquids, impurities of the liquids and hotness or coldness influence the surface tension of the liquid. *Different liquids have different surface tension. For example, mercury has a very high surface tension of 55N/m while surface tension of water is 0.072N/m. In general, impurities in a liquid lower its surface tension.* It is because the addition of impurities results in liquid spreading out as a film which means the surface tension is lowered. *For example***,** *application of soap had ability to lower the surface tension of water as it decreases the forces of adhesion between small dust particles and the cloth.*

The surface tension of a liquid decreases with the increase in temperature. For example boiled water has lower surface tension than cold water. However, some of them failed to draw a correct sketch which shows plunger, ram and the direction of the fluid flow. A few of those who scored good marks (14-20) managed to answer correctly most parts of the question including using a well labeled sketch showing the plunger, ram and the direction of fluids.

Extract 3.1 shows a sample of good responses extracted from a candidate's script.

Extract 3.1

3 a/ Nature

The nature of the liquid affect the surface tension of that liquid, The liquid with higher density has high surface tension compeared to liquid - with lower densities, forexample Honey has higher surface tension - Compared to water

Contamination

The liquid which is contaminated or mixed with particle has lower - surface tension than Pure liquid, forexample an oiled water has - lower surface tension than pure water.

Temperature

The higher the temperature to the liquid, the lower the surface tension of that liquid, forexample Hot water has lower surface tension than - cold water.

3. (b). Data analysis.

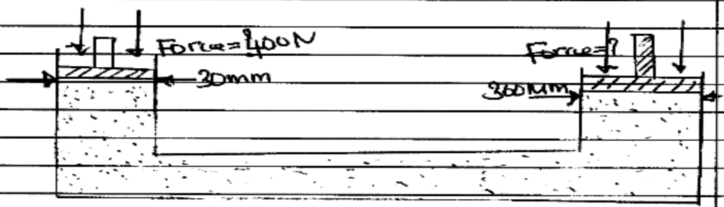
Diameter of plunger (d_1) = 30mm = 0.03 m.

(ii) Diameter of ram (d_2) = 300 mm = 0.3 m.

Force applied to the plunger = 400 N

Req: Force exterted to the ram = ?

Consider



From the hydraulic press

$$\frac{\text{force of plunger}}{\text{Area of plunger}} = \frac{\text{Force of ram}}{\text{Area of ram}}$$

But Area of plunger and ram is obtained from.

Area of plunger (A_p) $= \frac{\pi (d \text{ of plunger})^2}{4}$

$A_p = \frac{\pi (0.03)^2}{4}$

Area of ram $= \frac{\pi (d \text{ of ram})^2}{4}$

3. (b) $F_p/A_p = \frac{F_r}{A_{ram}}$

$= \frac{400N}{A_p} = F/A_r$

$F_r = \frac{400N\ A_{ram}}{A_p}$

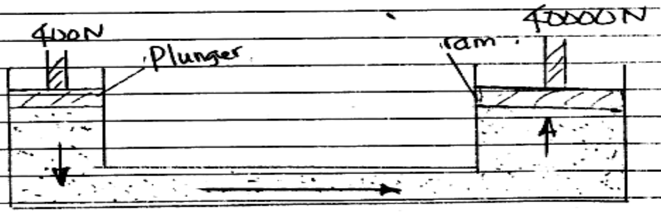
$F_{ram} = \frac{400N \times \pi(0.\cancel{0}3)^2}{\pi(0.03)^2}$

$F_{ram} = \frac{400N(0.3)^2}{(0.03)^2}$

$F_{ram} = 40.000N$

∴ Thee total force extrerted by the ram is 40000N.

(ii)



3. (b) $F_p/A_p = \frac{F_r}{A_{ram}}$

$= \frac{400N}{A_p} = F/A_r$

$F_r = \frac{400N\ A_{ram}}{A_p}$

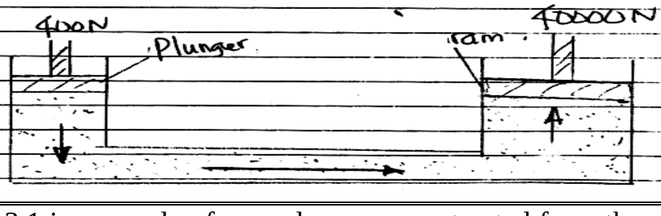
$F_{ram} = \frac{400N \times \pi(0.\cancel{0}3)^2}{\pi(0.03)^2}$

$F_{ram} = \frac{400N(0.3)^2}{(0.03)^2}$

$F_{ram} = 40.000N$

∴ Thee total force extrerted by the ram is 40000N.

(ii)



Extract 3.1 is a sample of a good response extracted from the script of a candidate.

Nonetheless, those who scored from 0 to 7.5 marks were noted to make various errors including providing of invalid examples. They failed to mention the factors affecting surface tension and determine the force exerted on the ram as well as to draw, a labeled sketch which indicates the direction of fluids. These candidates had exhibited different weakness in their responses. For example, some of them listed the factors affecting the surface tension without giving examples of each factor. Extract 3.2 shows an example of a poor response provided by one of the candidates.

3@ Nature; This is the factor which Surface tension depends. So Surface tension it depends on the nature of the materials Example contents detergents

3@ Temperature; This is also Surface tension depends on it Since it Increase in temperature Increase Surface tension.

Contamination; This is the factors through which Surface tension depends on it.

3ⓑ. Now:

$$\gamma = F/A.$$

$$\gamma_p = \frac{F_p}{A_p}$$

Where γ_p - Surface tension of the plunger.
F_p - force applied to the plunger.
A_p - Area of the plunger.

$$\gamma_p = \frac{400N}{7.065 \times 10^{-4}}$$

$\gamma_p = 566171.2668\ N/m^2.$
$\gamma_p = 566.17\ kJ.$

$$\gamma_p = \frac{F_R}{A_R}.$$

$$\gamma_R = \frac{400N}{0.0706m^2}$$

$\gamma_R = 5665.72\ N/m^2.$
$\gamma_R = 5.666\ kJ.$

Total force $= \gamma_p + \gamma_R.$
$= 566.17 + 5.666$
$= 571.8\ kJ.$

$\therefore$ The total force is $571.8\ kJ.$

Extract 3.2 shows a response by a candidate who failed to give relevant answers to both parts (a) and (b) of the question.

2.4 Question 4: Illumination

This question was divided into four parts: (a), (b), (c) and (d).

Part (a) required the candidates to *explain the term "coefficient of utilization" as applied in illumination.*

Part (b) required the candidates to mention *four factors of which the value of coefficient of utilization depends upon.*

Part (c) required them to apply the knowledge of lumen emitted to determine the value of coefficient of utilization for a *lecture room of 8m x 12m is lighted by 15 lamps to fairly uniform illumination of 100lm/m^2, given that the power output of the lamp is 1600lm*.

Part (d), required the candidates to *(i) differentiate luminous intensity from luminous flux and (ii) determine the luminous intensity of a lamp which will produce an illumination of 10lm/m^2 at a point 3m vertically below it.*

In part (a), the candidates were allowed to use the relationship of the lumens received by a particular surface to the total lumens emitted by a luminous source. Meanwhile, in part (b) the candidates were expected to summarize factors that the dissimilarity of ration of light depends upon These factors are types of mounting height of the fitting, colour and surface of the wall and ceiling, shape and dimensions of the room as well as direct or indirect type of lighting system.

The question was attempted by 110 (97.35%) candidates. Among them 11 (10%) candidates scored from 0 to 7.5; 59 (50.91%) candidates scored from 8 to 13.5 marks; and 43 (39.09%) candidate scored from 14 to 20. These scores imply that the general performance on this question was good. The following table and figure divulges the illustrate given above.

Table 4: Candidates' Scores on Question 4

Marks Scores	Percentage Range	Description	Candidates	
			Number	Percentage
0-7.5	0-39	Weak	10	10
8-13.5	40-69	Average	57	50.91
14-20	70-100	Good	43	39.09
TOTAL			**110**	**100**

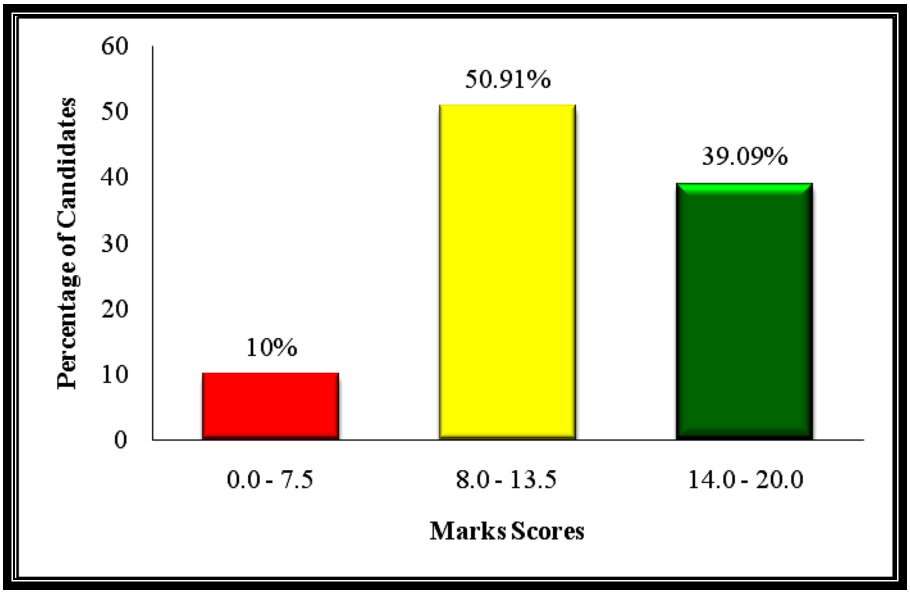


Figure 4: *Candidates' Performance on Question 4*

The analysis of the candidates' responses shows that those who scored higher marks (8-20) had sufficient knowledge of the concepts of Light and electricity. They managed to recall the factors on which the Coefficient of Utilization depends but also to give the correct responses to most parts of the question.

The candidates who scored from 8 to 13.5 marks managed to explain the term Coefficient of Utilization, outline the factors which affect the coefficient of utilization. However, they failed to determine the luminous intensity of a lamp and to differentiate it from luminous flux.

Although those who scored from 14 to 20 marks managed to answer part (a), (b), (c) and (d) they produced come slight mistakes in computation. Extract 4.1 is a sample of a good response extracted from the script of one of the candidates.

4.a Coefficient of utilization.
refer to the loss in current due to absorption of wall, ceilling, floor and the furniture and usually are 0.6.
is doneted by symbol η
by formula.

$$\eta = \frac{\text{lumens received on working plane}}{\text{lumens emitted by the lamp}}$$

also coefficient of utilization is a number without unit.

4 b. Four factors of which the value of variation of the coefficient of utilization depends on.

i, Size of the room.

ii, Types of reflector used.

iii, Coouring of wall, and ceilling

iv, Height of spacing and fitting

4d i

Luminous Intensity	luminous flux.
i, is a source of light	i, is a light emmited from the source of light
ii, It has S I unit which is candela	ii, It has S I unit which is lumen.
iii, It is denoted by symbol (I)	iii, It is denoted by symbol (Φ)

4d ii Data collection.
Ellumination (E) = $10\ lm/m^2$
distance from the source of light (d) = 3m.
required luminous intesity (I) = ?.

from formula.

$$E = \frac{I\,(cd)}{d^2 (m)}$$

$$E\ lm/m^2 = \frac{I (cd)}{d^2 (m)}$$

$$I (cd) = E\ lm/m^2 \times d^2 (m)$$

$$I_{cd} = 10\ lm/m^2 \times 3^2 m^2$$

$$I\ cd. = 90\ cd.$$

$\therefore$ ~~Illum~~ luminous intensity (I) = 90 candela

4 c. Data collection
Area = 8m x 12m = $96m^2$
Number of lamps (N) = 15
Illumination in (lm/m^2) = 100
Power output of lamp = 1600 lumens
required coefficient of utilization (η) = ?
from the formula.

$$\text{luminous flux} (\Phi) = \frac{\text{Area} (m^2) \times \text{Illumination required} (lm/m^2)}{\text{Coefficient of utilization} \times mf.}$$

Extract 4.1 is a sample of a good response extracted from the script of a candidate.

On the other hand, 10 percent of candidates who scored from 0 to 7.5 failed to explain the term coefficient of utilization, itemize factors that affects the coefficient of utilization and determine the luminous intensity of a lamp. Most of them failed to differentiate the luminous intensity from luminous flux. This shows that they lacked knowledge of the properties of light intensity. Extract 4.2 is illustrative

4 (a) This is the factor that is affected absorption light in the system.

(b) (i) Ageing
(ii) Light
(iii) Radiation
(iv) Dating

(c) Data
Area = 8 x 12m = 96m²
Lamp 15
Illuminaction 100cd
power output = 1600 lumen
C of utilization ?

From

$$\text{Illumination} = \frac{(\text{Area}(m^2) \times \text{lumen})}{\text{Maintanance factor} \times \text{coefficient factor ration}}$$

∴ Coefficient of utilization

= (Maintenance x Area x lumen)

$$= \frac{\text{Area} \times \text{lumen}}{\text{Maintanance factor} \times \text{Illumination}}$$

$$\text{C of utilization} = \frac{96 \times 1600\,\text{lumen}}{\cancel{0.8} \times 0.8 \times 100\,cd}$$

$$\text{C of utilization} = \frac{153600}{80}$$

C of utilization = 1920 lum/m².

Extract 4.2 is a sample of a poor response extracted from the script of a candidate.

2.5 Question 5: Applied Thermodynamics

This question had two parts: (a) and (b). Part (a) required the candidates to draw *T-S diagrams of heat transfer (Q) at constant volume, pressure and temperature to illustrate quantity of heat, absolute temperature, entropy and adiabatic process.* This part tested the candidates' ability to relate the change of materials properties when subjected to heat. The candidates were required to analyse the quantity of heat and entropy at the state when the volume, pressure and temperature parameters remain constant.

Part (b), required the candidates determine *(i) The pressure of the water on the base of the tank in kN/m^2, (ii) The total force on the base of the tank in kN and (iii) The total force on the side of the tank in kN for storage tank of 3m square contain water to a depth of 2m. If the base of the tank is horizontal and the density of water is 1000kg/m^3.*

The question was attempted by 66 (58.4%) candidates. They scored from 0 to 7.5 marks. Table 5 shows the scores of the candidates.

Table 5: Candidates' Scores on Question 5

Marks Scores	Percentage Range	Description	Candidates	
			Number	Percentage
0-7.5	0-39	Weak	66	100
8-13.5	40-69	Average	0	0
14-20	70-100	Good	0	0
TOTAL			**66**	**100**

The general performance of the candidates on this question was weak because all candidates scored from 0 to 7.5 marks. The majority (75.8%) who scored from 0 to 3 marks they failed to understand what the question asked them to do. They lacked knowledge about the subject matter. Figure 5 presents the candidates' performance on this question.

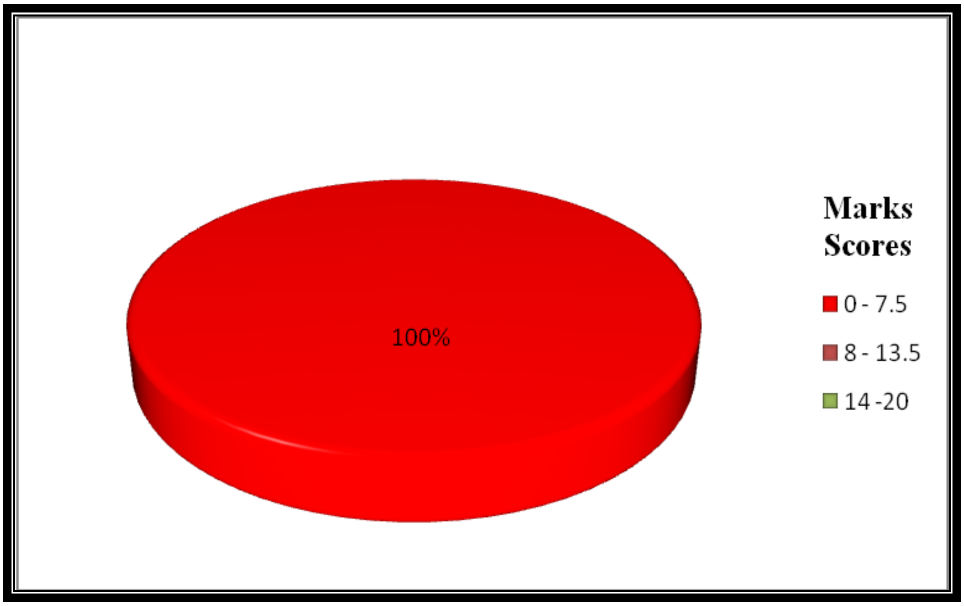
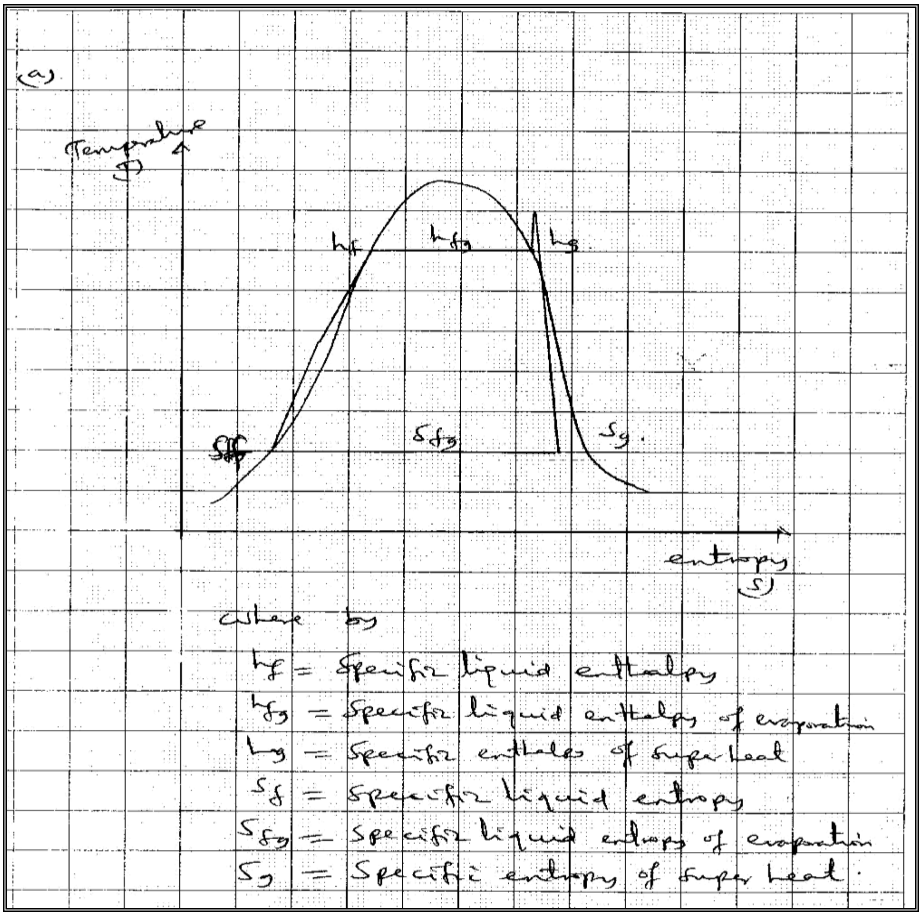


Figure 5: *Candidates' Performance on Question 5*

Moreover, the candidates who scored from 0 to 7.5 marks failed to draw a T–S diagram at constant volume, pressure and temperature to illustrate quantity of heat and entropy and to find the area of the base which was 3 x 3 = 9m^2. However, many of them(24.2%) managed to find the pressure of water on the base of the tank which is given by P = ρgh given that P = 1000 x 9.81 x 2 = 19.62kN/m^2. Extract 5.1 is a sample of a poor response extracted from the script of a candidate.



Extract 5.1 *shows a sample of a poor response extracted from the script of the candidate.*

2.6 Question 6: Applied Thermodynamics

The question had two parts, (a) and (b). In part (a) the candidates were required to *explain the importance of Coefficient of Performance (COP) in heat exchanger.*

In part (b) it was given that the results of a laboratory experiment in steam engine show that, the steam at the beginning of the expansion process is at 7 bar, dryness fraction is 0.98 and the expansion follow the law pv^{γ} = constant down to a pressure of 0.34 bar (where: γ =1.1).With the aid of a sketch, the candidates were required to find (i) *The volume rate (m^3/kg) of the engine.* (ii) *The work done in kilojoules during expansion and (iii)The heat flow to or from the cylinder walls during expansion. For a given pressure at the steam at the beginning of the expansion process as 7bar, dryness fraction is 0.98 and expansion follows the law pv^{γ} = constant down to a pressure of 0.34bar (where γ=1.1).*

The question was attempted by 68 (60.18%) candidates. Among them, 57 (83.82%) scored from 0 to 7.5 marks and 11 (16.18%) scored from 8 to 13.5 marks. This performance is summarized in Table 6 and Figure 6 as follows:

Table 6: Candidates' Scores on Question 6

Marks Scores	Percentage Range	Description	Candidates	
			Number	Percentage
0-7.5	0-39	Weak	57	83.83
8-13.5	40-69	Average	11	16.18
14-20	70-100	Good	0	0
TOTAL			**68**	**100**

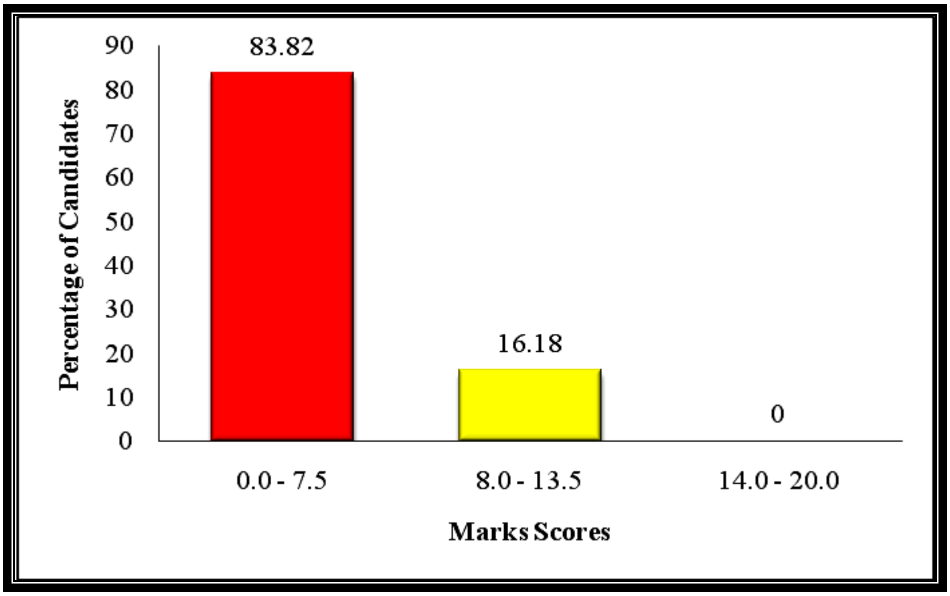


Figure 6: *Candidates' Performance on Question 6*

The candidates' performance on this question was weak because majority (45.6% out of 83.82%) failed to explain the importance of coefficient of performance (CPO), which is used to measure the effectiveness of refrigerator. Additionaly they failed to use the formula of the first law of thermodynamics, which is $Q = (U_1 - U_2) + W$ especially in the case of finding second dryness fraction (x_2), which is $x = 0.897$. Failure to obtain the correct value of x lead to incorrect value of second internal energy (U_2).

On the hand, the candidates who scored from 8 to 13.5 marks managed to explain the importance of coefficient of performance and to find the volume rate of the engine. Extract 6.1 is a sample of a good response extracted from the script of a candidate.

6. (a) coefficient of performance it is used to increase the efficiency of the boiler.

(b) Given

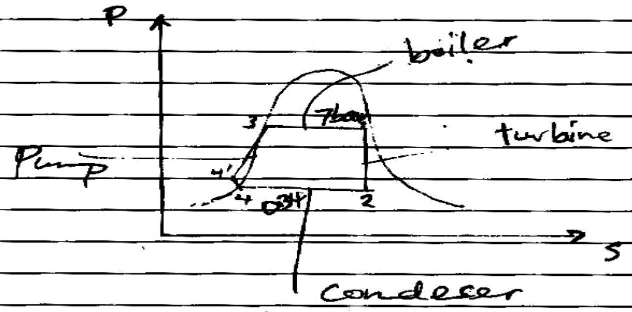
Pressure $(P_1) = 7$ bar

dryness fraction $(x) = 0.98$

$PV^{\gamma} =$ constant

Pressure $P_2 = 0.34$ bar

$\gamma = 1.1$



(i) volume rate of engine,

$V_1 = xV_{g1} = 0.98(0.2728)$

$V_1 = 0.267 \ m^3/kg$,

from,

$PV^{\gamma} = k$

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

6 (b) (i)

$$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{\gamma}$$

$$\frac{7}{0.34} = \left(\frac{V_2}{V_1}\right)^{\gamma}$$

$$20.59 = \left(\frac{V_2}{V_1}\right)^{1.1}$$

$$\ln(20.59) = 1.1 \ln\left(\frac{V_2}{V_1}\right)$$

$$2.7497 = \ln\left(\frac{V_2}{V_1}\right)$$

$$15.64 = \frac{V_2}{V_1}$$

$$V_2 = 15.64 V_1$$

$$V_2 = 15.64(0.267)$$

$$V_2 = 4.18 \ m^3/kg$$

∴ The volume rate of the engine is $4.18 \ m^3/kg$.

Extract 6.1 shows a sample of a good response extracted from the script of a candidate.

On the other hand, the candidates who scored from 0 to 7.5 marks failed to attempt part (a) and (b). A few of them managed to find the work done by the steam during the expansion process, which is given by the remarks $W = \frac{P_1 v_1 - P_2 V_2}{n-1}$. Therefore, $W = \frac{7x10^5 x0.267 - 0.34x10^5 x4.174}{1.1-1}$. These candidates lacked knowledge and clear understanding of the thermal dynamics topic, in particular of heat exchanger.

Extract 6.2 shows a sample of a poor response extracted from the script of a candidate.

6 (b) given
7 bar = 0.7 pressure
P_1 = pressure = 0.7 MN/m² = 700 kN/m²
x = 0.98.
P_2 = 0.34 bar = 3400 kN/m².
γ = 1.1.

$V_1 = x_1 V_{g_1}$.
V_1 = 0.98(2.264) = 2.21672 ≈ 2.217 m³/kg
Volume = 2.317 m³/kg.

From
$V_2 = x_2 V_{g2}$.
$P_2V_2 = MRT_2$.
~~at 0.34MN/m²~~ T_2 =
at 0.34 bar, T_2 = 72°C
$P_2V_2 = MRT_2$
$V_2 = \frac{MRT_2}{P_2}$ and $P_1V_1 = MRT_1$, T_1 = 90°C
$\frac{P_1V_1}{RT_1} = M$.
$\frac{700 \times 2.317}{0.289 \times (273+90)} = M$
M = ~~5612.11 kg~~ 15.46 kg
~~V_2 = 5612.11 × 0.~~
M_2 = 15.46 kg.
$V_2 = \frac{15.46 \times 0.289 \times (72+273)}{700}$
~~V_2 = 2.202 m³~~.

6 (ii) From
$$w = \frac{n}{n-1}(P_1V_1 - P_2V_2)$$
$$= \frac{1.1}{1.1-1}(700 \times 2.317 - 3400 \times V_2)$$

V_2 = ?

From
$PV^\gamma = k$.
$P_1V_1^\gamma = P_2V_2^\gamma$.
$V_2 = \left(\frac{P_1}{P_2}\right)^{1.1} V_1 = \left(\frac{700}{3400}\right)^{1.1} 2.317$ =
V_2 = ~~0.477 m³/kg~~ 0.4073.

$$\therefore w = \frac{1.1}{1.1-1}(700 \times 2.317 - 3400 \times 0.407)$$
w = 2619.1 kJ.

6 (b) (i) Volume rate (m³/kg) of the engine
V_1 = 2.317 m³/kg and V_2 = 0.4073 m³/kg

(ii) work done = (2619.1 kJ/kg × 15.46 kg)
work done = 40,491.286 kJ.

(iii) The heat flow to or from the cylinder walls during expansion.

$$H = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

$$H = \frac{700 \times 2.317 - 3400 \times 0.4073}{1.1 - 1}$$
H = 2,370.8 kJ/kg.
H = 2,370.8 kJ/kg × 15.46 kg.
H = 36,652.568 kJ.

Extract 6.2 is a sample of a poor response extracted from the script of a candidate.

2.7 Question 7: Applied Thermodynamics

The question had three parts: (a), (b) and (c). In part (a), the candidates were required to *explain the meaning of open system, closed system which adiabatically isolated system as applied in fluid system.*

The purpose of this item is to measure the ability of the candidates to apply the first law of thermodynamics, which states '*Whenever heat is added to a system, it transforms to an equal amount of some other form/forms of energy'*

In part (b), it was given that *The molecular weight of carbon dioxed (CO_2) is 44. In an experiment the value of γ for CO_2 was found to be 1.3. Assuming that CO_2 is a perfect gas, determine the: (i) Gas constant (R), (ii) Specific heat at constant pressure (Cp) and (iii)Specific heat at constant volume(C_v).*

In part (c) the question was: *A certain heat exchanger has $0.3m^3$ of air at a temperature of 45^oC and pressure of $1MN/m^2$ is allowed to expand according to the law $PV^{1.25}$ = constant. By considering C_p =1.006kJ/kgK and C_v = 0.717kJ/kgK, the candidates were required to calculate;(i)The work done,(ii)The internal energy change and (iii)The heat transfer.*

About ninety four percent (93.8%) of the candidates opted for this question; among them 96 (90.07%) scored from 0 to 7.5 marks and 10 (9.43%) candidates scored from 8 to 13.5 marks. The reasons for this poor performance include misconception about the open system, close system and adiabatically isolated system in relation to the requirements of the questions. *The **Open system** is a system that has boundaries that is permeable to matter such a system is usually permeable to energy but the energy that passes cannot in general be uniquely sorted into heat and work components.* In other words open system *boundaries may be either actually restrictive, or else non-restrictive*. In ***closed systems***, *boundaries are totally prohibitive for matter transfer* while, ***Adiabatically isolated system*** *is a system that energy can be transferred as work, but transfers of matter and of energy as heat are prohibited. It has only an isolating boundary sectors. Nothing can be transferred into or out of it.* Some of the candidates' responses explained isothermal and adiabatic processes by the consideration of constant temperature, volume and pressure. A summary of the candidates’ performance is indicated in Table 7 and Figure 7.

Table 7: Candidates' Scores on Question 7

Grade Ranges	Description	Candidates	
		Number	Percentage
0 - 7.5	Weak	96	90.57
8 - 13.5	Average	10	9.43
14 -20	Good	0	0
	TOTAL	**106**	**100**

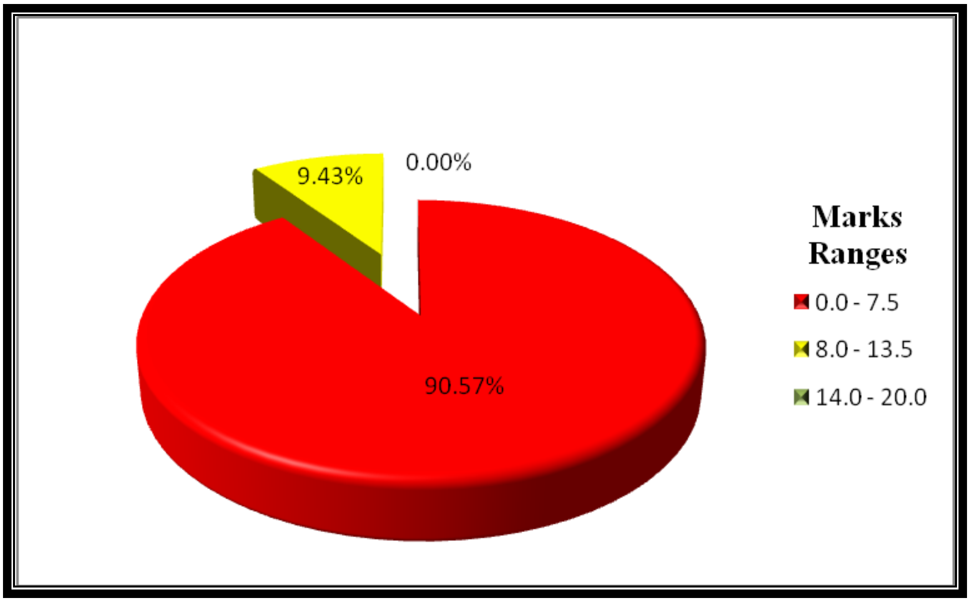


Figure 7: *Candidates' Performance on Question 7*

The candidates' performance on this question was weak. They failed to explain the meaning of open system and the closed system but they managed to explain the meaning of adiabatically the isolated system.

The candidates who scored from 0 to 7.5 marks failed to explain the open and closed systems. They also failed to determine the gas constant (R) and specific heats at constant volume and pressure. The analysis of the candidates' responses shows that those who scored lower marks (0 to 7.5) lacked knowledge and skill in the sub-topic of heat exchange. Extract 7.1 shows a sample of a poor response extracted from the script of one of the candidates.

7 (a) (i) Open System. Is the one in which Material are lost while temperature remains constant.

(ii) Closed System: Is the one in which temperature are lost while Material remain Constant.

(iii) Adiabatically Isolated System: Is the one in which no Material or temperature follows.

(c) Data given.

Volume $(V_1) = 0.3m^3$.

Temperature $(T_1) = 45°C + 273 = 318K$

Pressure $(P_1) = 1MN/M^2$

R

Solution

from

$P_1V_1^\gamma = nRT_1$

$$\frac{P_1V_1^\gamma}{RT_1} = n.$$

But $R = C_p/C_v$

$$R = \frac{1.006}{0.717}$$

$R = 1.4.$

$$n = \frac{P_1V_1^\gamma}{RT_1}$$

$$n = \frac{1 \times 0.3^{1.4}}{1.4 \times 318}$$

$n = 5 \times 10^{-4}$.

7 (c)

(i) Workdone $= \frac{(p_2v_2 - p_1v_1)}{n-1}$

Recall.

$PV^{1.27} = c.$

$P_1V_1^{\gamma} = P_2V_2^{1.27}$

But

$P_1V_1^{\gamma} = MRT_1$

$P_2V_2^{\gamma} = MRT_2$

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{\gamma}$

$\frac{P_1}{\left(\frac{V_2}{V_1}\right)^{\gamma}} = P_2.$

(b) (i) From $Cp = Cv + R$

$Cp - Cv = R$

$R = 1.006 - 0.717$

Gas constant $R = 0.289$ kJ/kg.

(ii) Internal energy $\Delta(U) = nCv\Delta T$

$\Delta U = nCv(T_2 - T_1)$

(iii) Heat transfer $\Delta(Q) = nCv\Delta T$

Extract 7.1 is a sample of a poor response extracted from the script of a candidate.

The candidates who scored from 8 to 13.5 marks managed to calculate the gas constant by using the formula $R = \frac{R_o}{M} = \frac{8314}{44x10^3} = 0.189kJ/kgK$, specific heat at constant pressure $C_p = \frac{\gamma R}{\gamma - 1}$ and specific heat at constant volume $C_v = \frac{R}{\gamma - 1}$. They failed to explain the meaning of close, open and adiabatically isolated systems. The variation of the candidates' scores depended on the extent to which they explained their points and evaluated correctly the parameters. Extract 7.2 is a sample of a good response extracted from the script of one of the candidates.

7(a) Open system → Is called Isothermal process whereby the heat is allowed to enter or leave the system; So heat is lost to the surroundings

Closed system – ~~No heat is allowed to~~ The – Is For lagged materials no heat entered the system but there is heat lost por ~~forme~~

Adiabatically Isolated system → No heat is allowed to enter or to leave the system ; since no heat loss of the system.

$dQ = \delta U + W$ · ΔU – Internal Energy W – work done, δQ, Energy supplied

(b) Data given.
Molecular Mass CO_2 (M) = 44.
γ = 1.3.
Required.
(i) Gas constant R = ?,

(ii) Specific heat at constant pressure C_p.
(iii) C_v = ?

From.
$PV^\gamma = K$.
$\frac{MRT}{V} V^\gamma = K$.
$MRTV^{\gamma-1} = \underline{K}$,

$R = \frac{\frac{M \times T V^{\gamma-1}}{V^\gamma}}{MT} = \frac{22.4^{1.3}}{44 \times 273}$.

(i) $R = \cancel{0.80092.\ KJ/kg}\,K.$

or

By another formula.

$$R = \frac{R_o}{\text{Molecular Mass}} = \frac{8.3144}{44}$$

$$R = 0.1889.$$

Then.

(ii) $C_p = C_v = R$

$R = C_p - C_v.$

from.

$$\gamma = \frac{C_p}{C_v}.$$

$$1.3 = \frac{C_p}{C_v}.$$

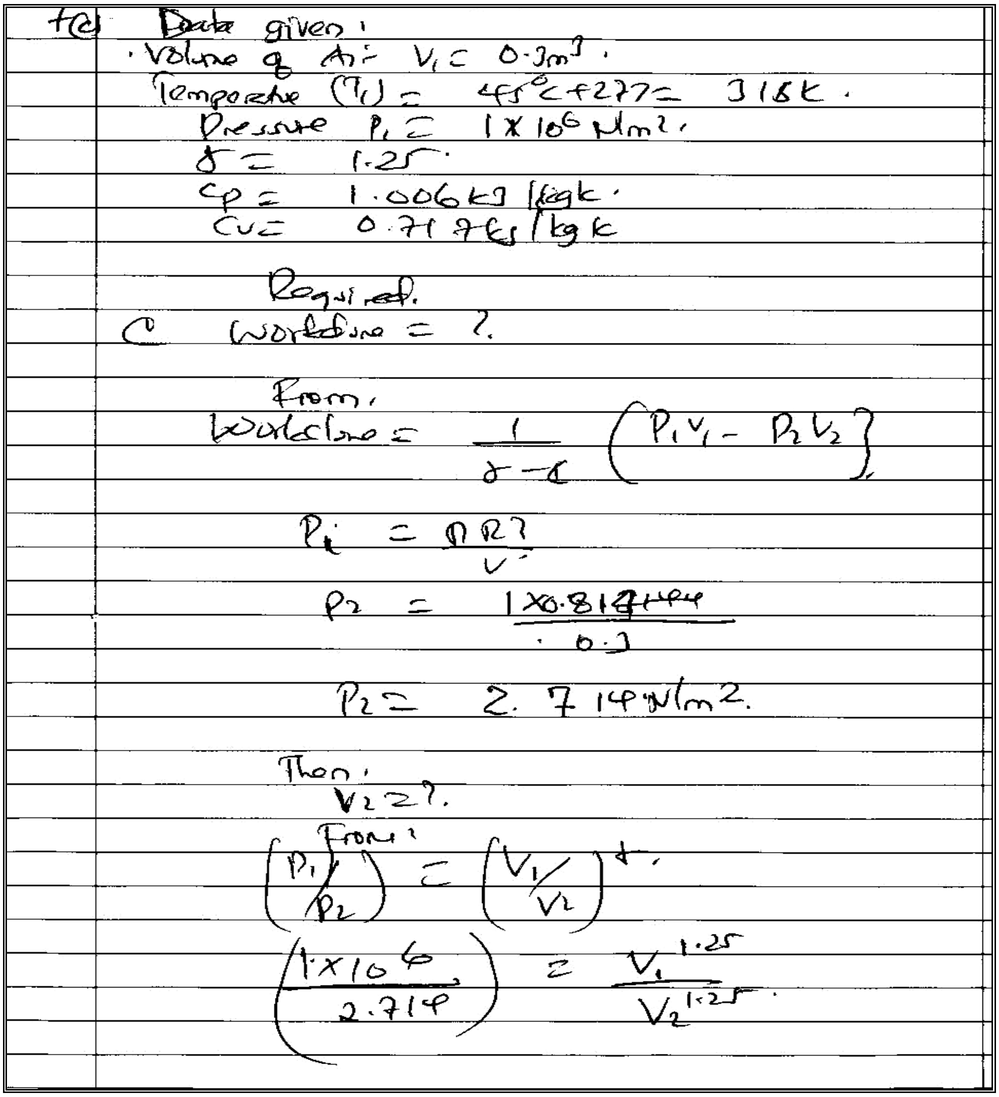
$$C_p = 1.3C_v.$$

$$R = C_p - C_v.$$
$$= 1.3C_v - C_v.$$
$$0.1889 = 0.3C_v.$$
$$C_v = \frac{0.1889}{0.3}.$$
$$C_v = 0.62.$$

Then $C_p = 1.3 \times C_v = 1.3 \times 0.62$

$$C_p = 0.818.$$

$\therefore\ C_v = 0.62$ and $C_p = 0.818.$



7(c) Data given:
· Volume of Air = $V_1 = 0.3m^3$.
Temperature (T_1) = $45^oC + 273$ = 318K.
Pressure $P_1 = 1 \times 10^6 N/m^2$.
$\gamma = 1.25$.
$C_p = 1.006 kJ/kgK$.
$C_v = 0.717 kJ/kgK$

Required.
C Workdone = ?.

From,
$$\text{Workdone} = \frac{1}{\gamma - 1}\left(P_1V_1 - P_2V_2\right)$$
$$P_1 = \frac{mRT}{V}$$
$$P_2 = \frac{1 \times 0.814}{0.3}$$
$$P_2 = 2.714 N/m^2.$$

Then,
$V_2 = ?$.
From:
$$\left(\frac{P_1}{P_2}\right) = \left(\frac{V_1}{V_2}\right)^{\gamma}$$
$$\left(\frac{1 \times 10^6}{2.714}\right) = \frac{V_1^{1.25}}{V_2^{1.25}}.$$

Extract 7.2 is a sample of a good response extracted from the script of one of the candidates.

3.0 THE ANALYSIS OF THE CANDIDATES' PERFORMANCE ON EACH TOPIC

The analysis of the candidates' performance on each topic is summarized in appendices I and II. The candidate demonstrated good performance on the topic of Illumination and average performance on the topic of Strength of materials. However, they demonstrated poor performance on the topics of Fluid Mechanics and Applied Thermodynamics.

Furthermore, the analysis shows that question 3 was the most avoided question by their candidates. Question 5 was the worst performed all candidates scored below average. The poor performance on this questions was due to the lack of knowledge about the specific content and insufficient practice on the computational skills required by the questions. The weakness shown by the candidates based on their responses include their inability to interpret the demand of the questions and to provide logical and clearly stated answers. Generally, the candidates exhibited very low level of knowledge and practical skills in answering the questions which involved calculations. The candidates showed greater weakness in formulating responses to questions requiring of higher order thinking.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The report analysed the candidates' performance and revealed the strengths and weaknesses shown by the candidates in answering the questions. The most notable strengths shown include candidates' ability to identify the requirements of the question and to recall some theories, formulae, principles and laws in the engineering science subject. Most of these candidates attained good performance on the topics of Strength of Materials in question 2 and Illumination in question 4. On one hand, the candidates' good English language proficiency, adequate knowledge of the subject matter as well as their ability to understand the demand of the questions helped them to demonstrate good performance.

However, some of the candidates performed poorly on other topics. This is due to lack of knowledge and skills in some of the topics, application of incorrect formulae in computations, and failure to explore the requirements of the questions. Therefore, they failed to apply scientific laws and formulae on answering the questions. The general performance of candidates in this subject was average. The analysis of the candidates' overall performance per topic is presented in Appendix II.

4.2 Recommendations

In order to improve performance on the Engineering Science subject, the following recommendations is important.

(a) Students should develop self-study behaviors by reading skills reference books. The activity will easier their understanding of the requirements of the questions when doing examinations.

(b) Teachers should give students enough class exercises which involving calculations and other mathematical model such as Fluid of Mechanics, Applied Thermodynamics, Strength of materials, Illumination and Source of energy. This will enable their students to be familiar with problems/question which involve calculations.

(c) Students should be involved in drawing activities that will help them to draw/sketch neatly labeled diagrams and graphs.

(d) Internal assessment questions should be set in line with the syllabus and the examination format to improve students' cognitive, psychomotor and effective domains.

(e) Students should be given enough exercises. This will enable them to have a long lasting memory on topic taught.

(f) There should be serious follow - up on the learning and teaching processes made by college academic masters and Administrative, Educational Quality Assurers and other Education stakeholders. More efforts should directed to identifying and re-addressing and /or eliminating the shortfalls mentioned in this report.

(g) Seminars and workshops should be organized so as to equip teachers with knowledge and new teaching skills. Indeed, using modern books, journal and other teaching and leading media so enabling teachers and leaner to greatly improve teaching and learning methods and methodologies.

Appendix I

Analysis of the Candidates' Performance Question-wise in the DTEE 2019 Engineering Science subject

S/N	Topics	Question Number	Percentage of candidates who scored 40 percent or more.	Recommendations
1	Fluid Mechanics	Q1	33.82	Weak
2	Strength of Materials	Q2	69.81	Average
3	Fluid Mechanics	Q3	65.39	Weak
4	Illumination	Q4	90.91	Good
5	Heat Transfer	Q5	0	Weak
6	Applied Thermodynamics	Q6	16.18	Weak
7	Applied Thermodynamics	Q7	9.43	Weak

Appendix II

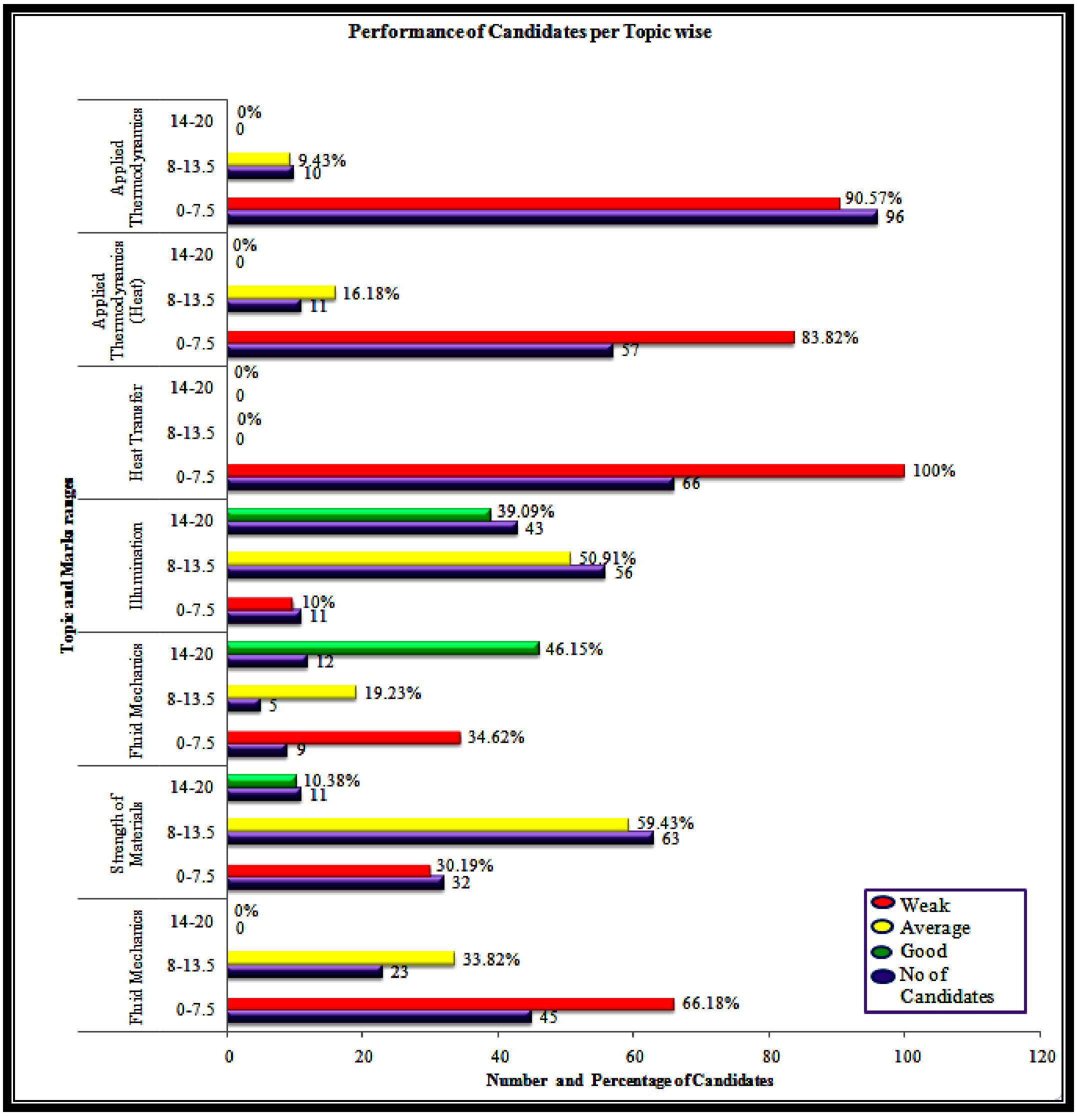


Figure 8: A summary of the performance of the candidates per topic.