THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT FOR THE CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (CSEE) 2018

035 ENGINEERING SCIENCE

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FOREWORD

The candidates' item response analysis report in Engineering Science subject for Certificate of Secondary Education Examination (CSEE) 2018 has been written in order to provide a feedback to the education stakeholders about the performance of the candidates and the challenges they faced in attempting examination questions.

The Certificate of Secondary Education Examination marks the end of four years of Ordinary Level Secondary Education. It is a summative evaluation which indicates the effectiveness of the education system in general and the education delivery system in particular. The candidates' performance is a strong indicator of what the education system was able or unable to offer to the students in their four years of Ordinary Secondary Education.

The analysis presented in this report is intended to contribute towards understanding of possible reasons behind the candidates' performance in Engineering Science subject. The report shows the factors that made the candidates to perform significantly different in some of the questions. Such factors include ability to identify the task of the question, ability to follow instructions and candidates' knowledge on the concepts related to the subject. The report also highlights factors which made some of the candidates fail.

The National Examinations Council of Tanzania expects that the feedback provided will make the education stakeholders to come up with proper measures of improving candidates' performance in future.

Finally, the Council would like to thank the Examiners and all people who participated in analysing the data used in this report, typesetting the document and reviewing the report.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents the analysis of the performance of candidates in Engineering Science who sat for CSEE in November 2018. The analysis revealed how the candidates performed each question. This report also focuses on identification of the questions which were performed well, averagely and poorly. Furthermore the report also exposes the questions which were attempted by most candidates and those which were mostly omitted.

The paper comprised 16 questions distributed in three sections: A, B and C. The candidates were instructed to answer all questions in sections A and B and choose three questions from Section C. Section A carried 10 marks, Section B carried 30 marks and section C carried 60 marks.

A total of 1392 candidates sat for the Engineering Science examination, whereby 955 (68.7%) candidates passed while 437 (31.3%) candidates failed. The candidates' performance in the year 2018 increased by 6.8 percent compared to that of 2017 where 1468 candidates sat for the examination of which 902 (61.1%) candidates passed and 566 (38.9%) candidates failed. Table1 shows the candidates' performance in Engineering Science in 2018 and 2017 respectively.

Table 1: Comparison of Candidates' Performance between 2018 and 2017 Respectively.

Year (2018)		**Year (2017)**	
Pass (%)	**Fail (%)**	**Pass (%)**	**Fail (%)**
68.7	31.3	61.1	38.9

The analysis presents the requirements of each question, candidates' strengths and weaknesses in their responses and the percentage of candidates in each score group accompanied with bar chats. Finally, it provides the conclusion, recommendations and attachments (Appendix I and II). The performance of the candidates was categorized into three main groups which were weak, average and good. The pass mark for each question was 30 percent or above. Therefore, if the question had the percentage of candidates who got 0 – 29% is considered to have weak

performance and represented by a red colour. Those who got 30 – 64% as an average is represented by a yellow colour and those who got 65 – 100% as good and is represented by a green colour. Generally, the performance in Engineering Science was average.

2.0 ANALYSIS OF PERFORMANCE FOR EACH QUESTION

2.1 SECTION A: Objective Type Questions

2.1.1 Question 1: Multiple Choice

This question consisted of ten items, (i) to (x), which were extracted from the topics of Angular motion, Simple machines, Work, Energy and Power, Turning forces, Measurements and units, Linear motion, Heat, Sound and Forces.

The question was attempted by 1392 (100%) candidates, of those 339 (24.4%) scored 0 to 2 marks; 999 (71.8%) scored 3 to 6 marks, and 54 (3.8%) scored 7 to 10 marks. This result is also shown by Figure 1 which shows the percentage of candidates' performance graphically.

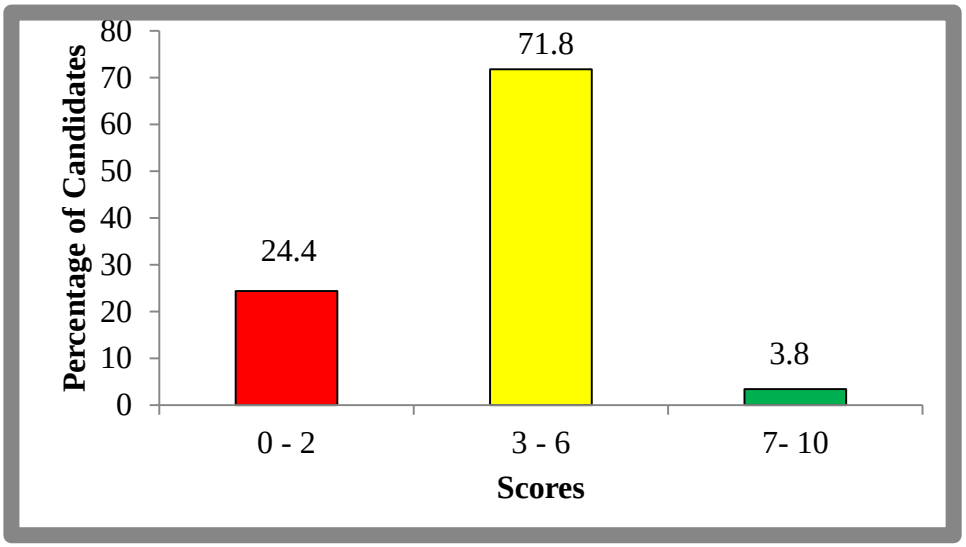


Figure 1: *Percentage of Candidates' Performance in Question1*

The general candidates' performance for this question was good because 75.6 percent passed. In this question, the item which was well performed was item (ix). Most of the candidates were able to distinguish between vector and scalar quantities; as such they correctly chose the alternative containing a set of vector quantities only. In the same light the item which was poorly performed was item (x). The reason for the poor performance was confusion on the definition of the angular velocity (the rate of change of angular displacement) with that of the angular speed (the rate of change in angle or the change in angle per second).

2.2 SECTION B: Short Answer Questions

2.3.1 Question 2: Simple Machines

In this question, the candidates were required to determine the velocity ratio (V.R) of a screw jack having 5 threads per centimeter and the turning lever (R) of length 20cm.

The question was attempted by 1336 (96%) candidates, out of those 753 (56.4%) scored 0 to 0.5 marks; 312 (23.3%) scored 1 to 1.5 marks; and 271 (20.3%) scored 2 to 3 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in Figure 2.

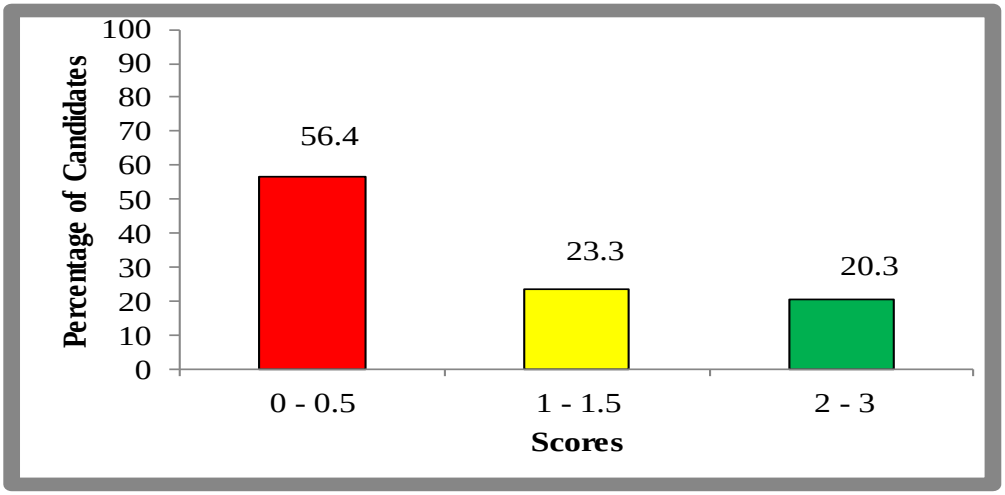


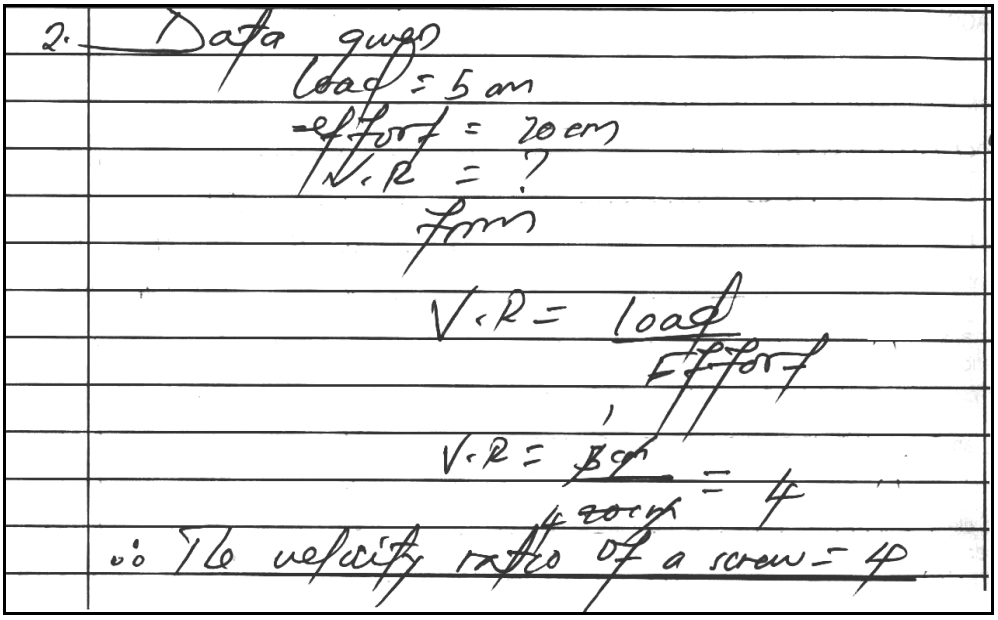
Figure 2*: Percentage of Candidates' Performance in Question 2*

The candidates' performance in this question was average, as only less than half of the candidates were above 30 percent. Majority of candidates failed

even to jot down data from the question. Also they failed to recall the proper formula for calculating the velocity ratio (V.R).

On the other hand, candidates who scored from 1 to 1.5 marks were able to state the formula $\left(V.R = \frac{2\Pi R}{P}\right)$ but substituted a wrong value of Pitch (P). These candidates regarded the value of Pitch (P) as 5. As such they made a wrong substitution and got a wrong answer. Others substituted the correct value of Pitch (P) into the equation but failed to get the correct value of the velocity ratio (V.R), for they lacked computation skills. Extract 2.1 indicates a poor response from the script of a candidate.

Extract 2.1

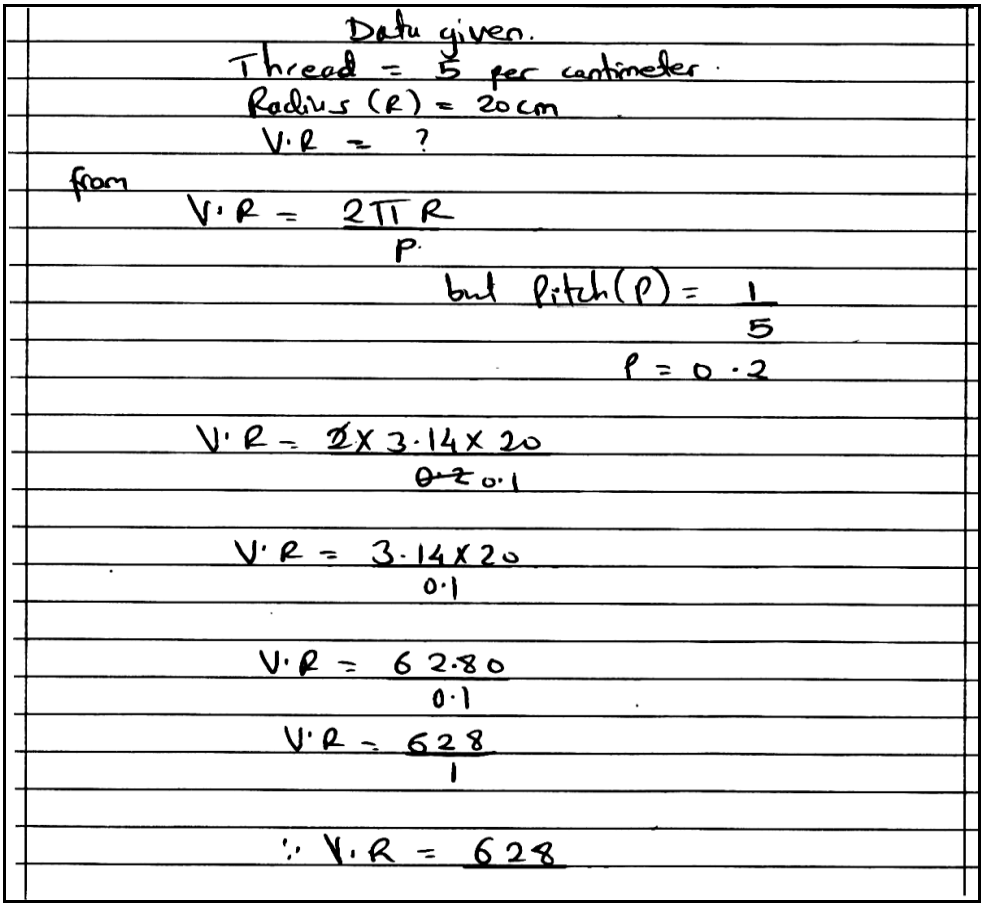


Extract 2.1 shows a poor response from the script of a candidate.

However, few candidates had competence to link threads on a screw jack and pitch, the pitch which was used to calculate velocity ratio using the formula $\left(V.R = \frac{2\Pi R}{P}\right)$. Some of the candidates managed to score all 3 marks allocated to this question. This category of the candidates understood well the question which required the formula $\left(V.R = \frac{2\Pi R}{P}\right)$ of which pitch (p) of the screw jack was to be calculated by dividing 1cm by 5 threads.

Thereafter values of P and R were substituted into equation $\left(V.R = \frac{2\Pi R}{P}\right)$ to obtain the value of the velocity ratio as 628. Extract 2.2 shows a good response from the script of a candidate who performed this question very well.

Extract 2.2



Extract 2.2 shows a good response provided by one candidate.

2.3.2 Question 3: Electricity and Magnetism

In this question, the candidates were required to identify the effects of an electric current which is the basis for the successful operation of the following devices: an electric iron; an electric motor; an electric bell; a filament lamp; and a fuse.

The question was attempted by1120 (80.5 %) candidates, out of those 650 (58%) scored from 0 to 0.5 marks; 260 (23.2%) scored 1 to 1.5 marks; and 210 (18.8%) scored 2 to 3 marks. Figure 3 is a summary of the graphical presentation of scores with respect to the percentage of candidates.

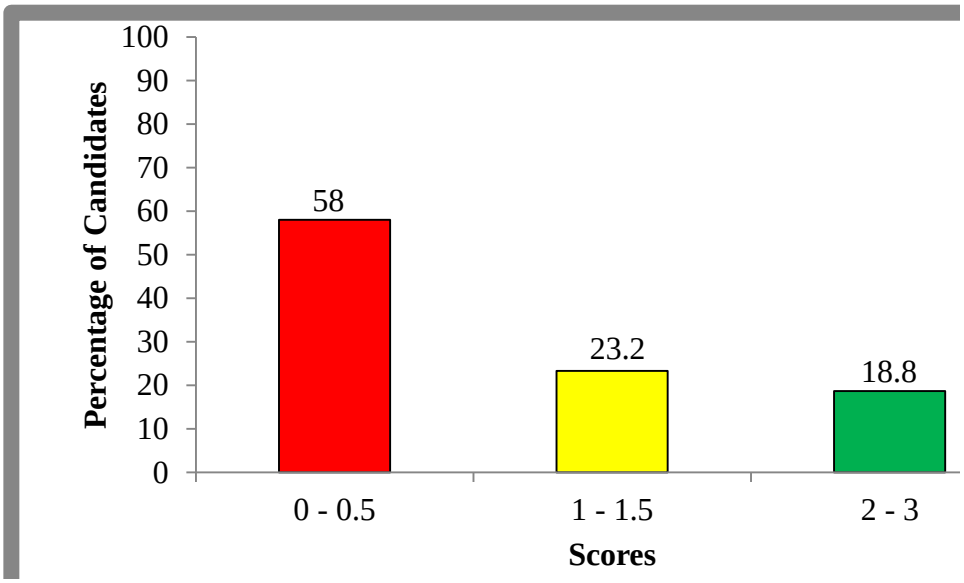
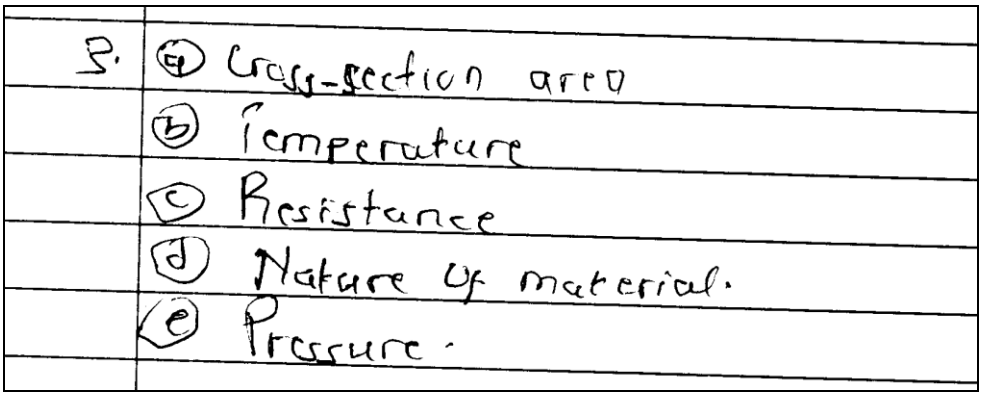


Figure 3: *Percentage of Candidates' Performance in Question 3*

The candidates' performance in this question was average. Most of the candidates could not correctly match the electrical devices given against the effects of electrical current. The candidates had confusion with the hazards that can be brought by an electric current such as fire, electric shock, or death. Some had confusion with the factors affecting resistance of a conductor. Extract 3.1 shows a sample of a poor response provided by one candidate.

Extract3.1

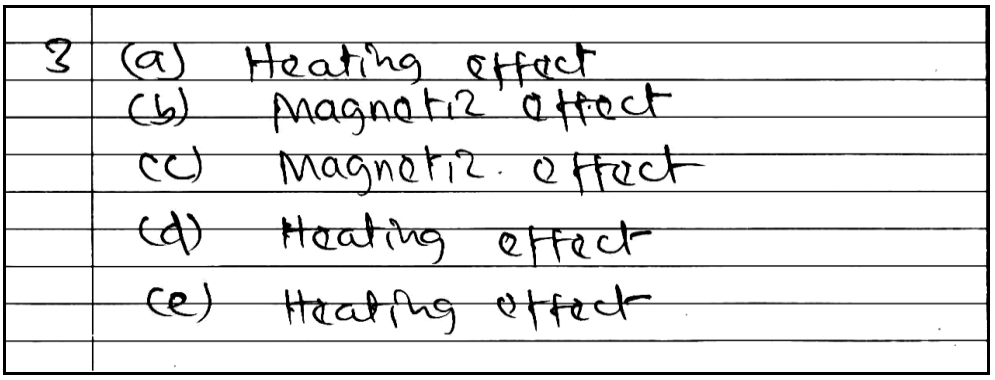


Extract 3.1 shows a sample of a poor response as extracted from the script of one candidate.

On the other hand, few candidates (18.7%) were able to link the effects of electric current with the respective electrical devices given. This indicates

that they had competence basing on mode of construction and operation of the appliances. As such they correctly matched the effects of electric current with the electrical devices given. Extract 3.2 shows a response of one of candidate who performed well this question.

Extract 3.2



Extract 3.2 shows a good response of one of the candidates.

2.3.3 Question 4: Measurements and Units

This question required the candidates to list any four (4) fundamental quantities and two (2) derived physical quantities and to mention the corresponding apparatus used to measure the quantities.

The question was attempted by 1311 (94.2%) candidates, out of those 502 (38.4%) scored between 0 and 0.5 mark; 226 (17.2%) scored 1 to 1.5 marks; and 583 (44.4%) scored between 2 and 3 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in Figure 4.

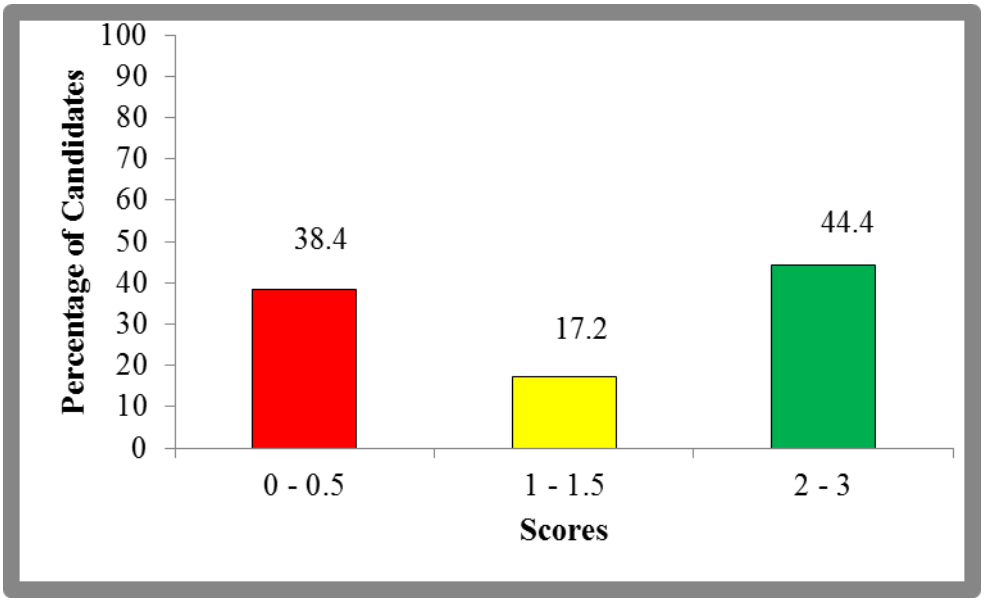


Figure 4: *Percentage of Candidates' Performance in Question 5.*

The candidates' performance in this question was average. Those candidates (18.3%) who scored all 3 marks were able to list four fundamental physical quantities and two derived physical quantities together with their corresponding measuring instruments. Extract 4.1 shows a sample of good response provided by one candidate for this question.

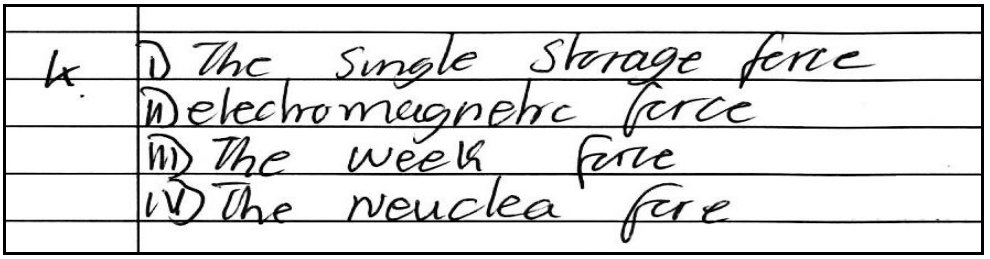
Extract 4.1

04.	Fundamental	apparatus
	(i) Mass	beam balance
	(ii) Time	stopwatch
	(iii) Volume	measuring cylinder
	(iv) Distance	metre rule
	Derived	apparatus
	(i) Weight	spring balance
	(ii) Relative density	Hydrometer

Extract 4.1 Portrays a sample of good response as extracted from the script of one candidate

Some of the candidates could list physical quantities without matching them with the corresponding measuring instruments. On the other hand, some candidates matched the physical quantities with incorrect measuring instruments, thus losing some marks. The candidates who scored 0 mark could not even name any physical quantity or any measuring instrument of a physical quantity. Failing to identify the measuring instruments showed that candidates were lacking knowledge on the concept measurements and units. Extract 4.2 portrays a sample of a poor response from the script of one candidate.

Extract 4.2



Extract 4.2 shows a response of a candidate who failed to list any physical quantity.

2.3.4 Question 5: Work, Energy and Power

In this question, candidates were required to differentiate work from energy. The question was attempted by 1364 (98%) candidates, out of those 320 (23.5%) scored 0 mark; 494 (36.2%) scored 1.5 marks; and 550 (40.3%) scored 3 marks. The Figure 5 illustrates the performance of candidates in relation to scores this question.

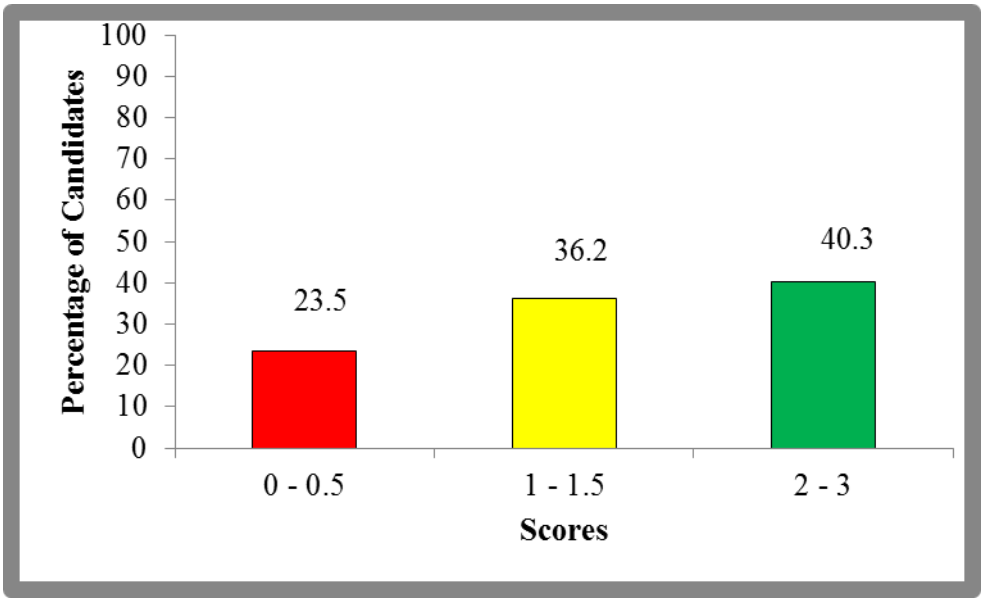
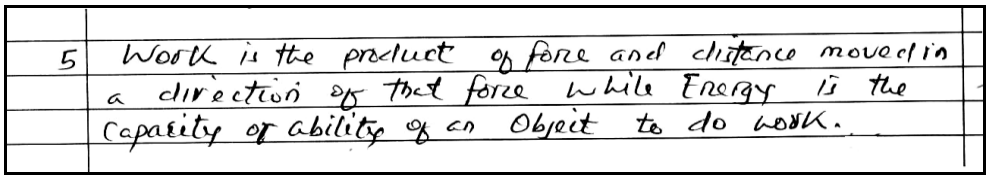


Figure 5: *Percentage of Candidates' Performance in question 5*

The candidates' performance in this question was good. Those candidates who scored all 3 marks allocated to this question provided proper definitions for work and energy. This shows that candidates had mastery of the content of the topic Work, Energy and Power particularly on the definitions of work and energy. The extract 5.1 depicts a sample of a good response extracted from the script of a candidate.

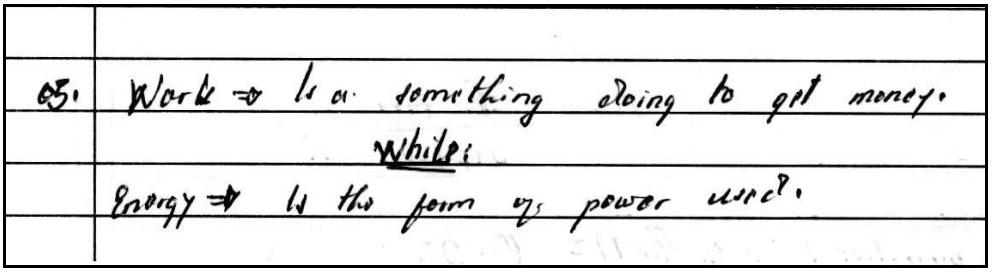
Extract 5.1


5 Work is the product of force and distance moved in a direction of that force while Energy is the capacity or ability of an Object to do work.

Extract 5.1 depicts the answer of a candidate who performed well in this question.

Some of candidates scored 1.5 marks because they managed to provide the definition of either terms. However, other candidates scored 0 mark, because they could not define any term. Most of the candidates confused work and energy to mean the same, because both have same unit, Joule. Extract 5.2 is a sample of poor response as extracted from the script of one candidate.

Extract 5.2



Extract 5.2 shows a response of a candidate who failed to differentiate work from energy.

2.3.5 Question 6: Angular motion

The question required candidates to calculate a torque which had to be applied to a flywheel of a moment of inertia 60 kgm^2 to give an angular acceleration of 0.5 rad/s^2.

The question was attempted by 1155 (83%) candidates, of those 667 (57.7%) scored 0 to 0.5 marks; 233 (20.2%) scored 1 to 1.5 marks; and 255 (20.5%) scored 2 to 3 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in Figure 6.

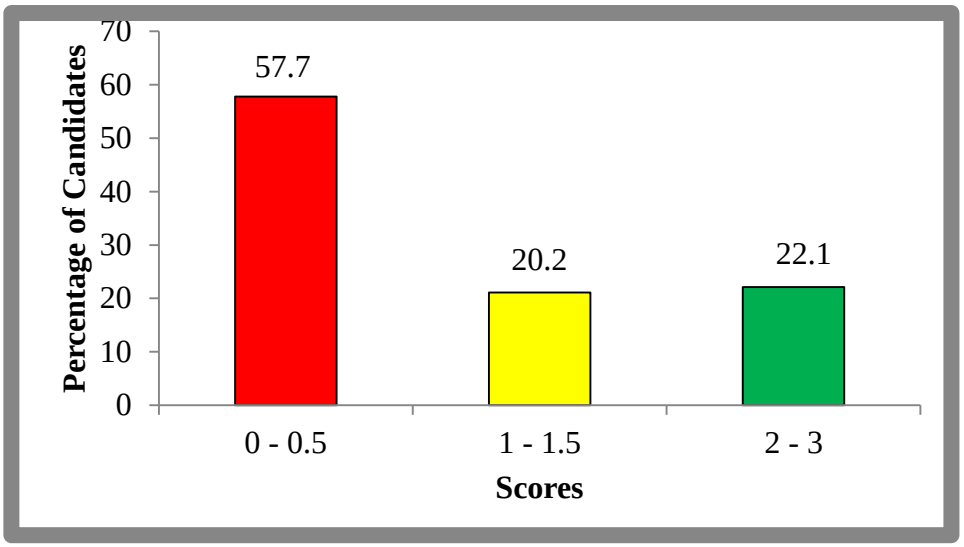
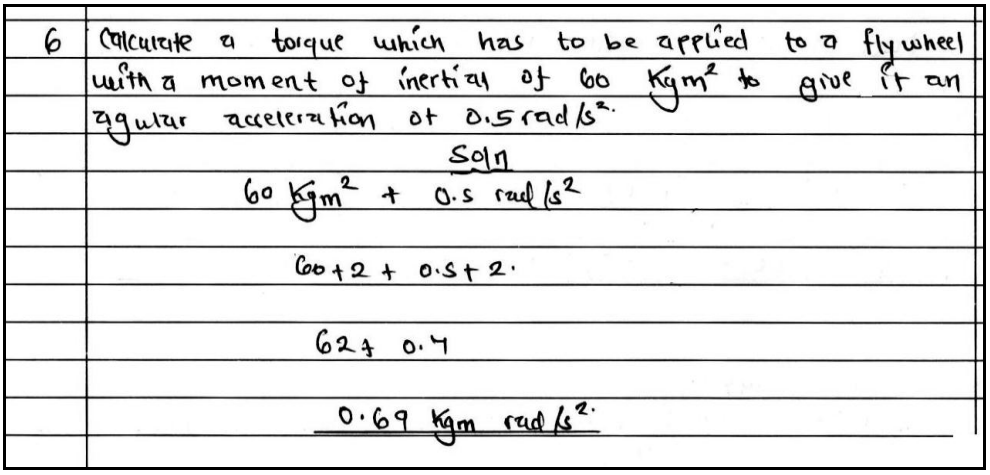


Figure 6: *Percentage of candidates' performance in question 6*

The candidates' performance in this question was average because more than half of candidates scored from 0 to 0.5 marks. These candidates were not conversant with the formula of torque ($T = I\alpha$). This shows that candidates did not acquire knowledge on concept of torque.

Those scored 0 mark failed to extract data from the question. This shows that they had no competence on application of formula found on the topic Angular Motion especially the formula for torque ($T = I\alpha$). Extract 6.1 is a sample of poor responses as extracted from a script of one candidate.

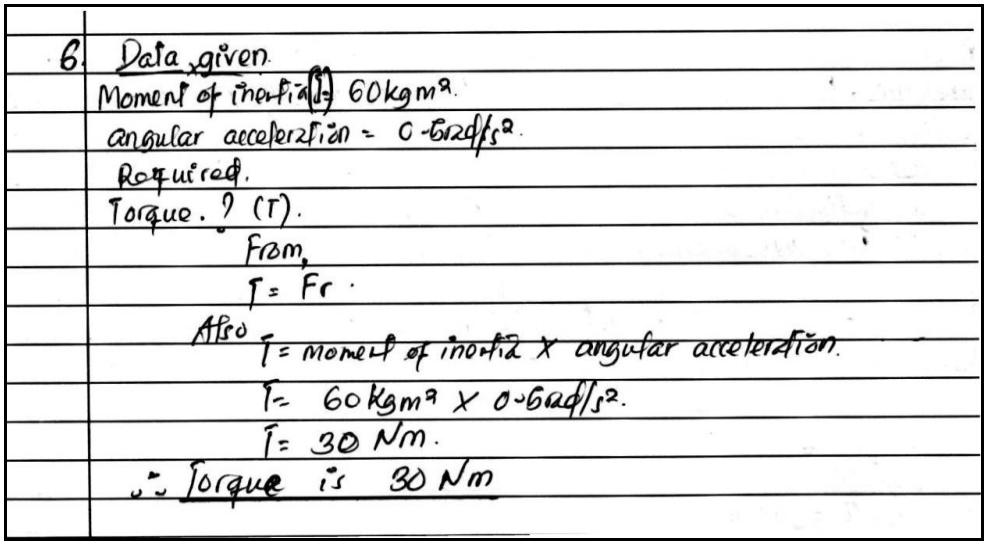
Extract 6.1



Extract 6.1 portrays a sample of poor response from a candidate.

Few candidates scored all 3 marks because they had competence and were able to apply successfully the formula to calculate the value of the Torque as 30 Nm. Extract 6.2 depicts the good answer as provided by one candidate who performed well this question.

Extract 6.2



Extract 6.2 shows the good provided by one candidate who performed well this question.

2.3.6 Question 7: Light (Optics)

In this question, the candidates were required to describe how solar and lunar eclipses occur. The question was attempted by 1237 (88.9%) candidates, out of those 559 (45.2%) scored 0 mark; 127 (10.3%) scored 1.5 marks and 551 (44.5%) scored 3 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in Figure 7.

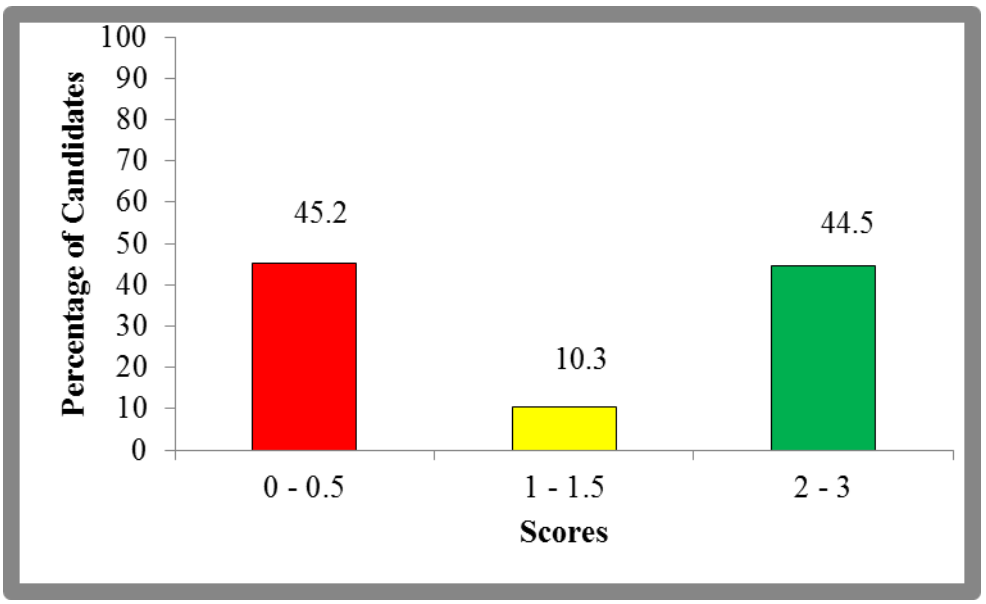
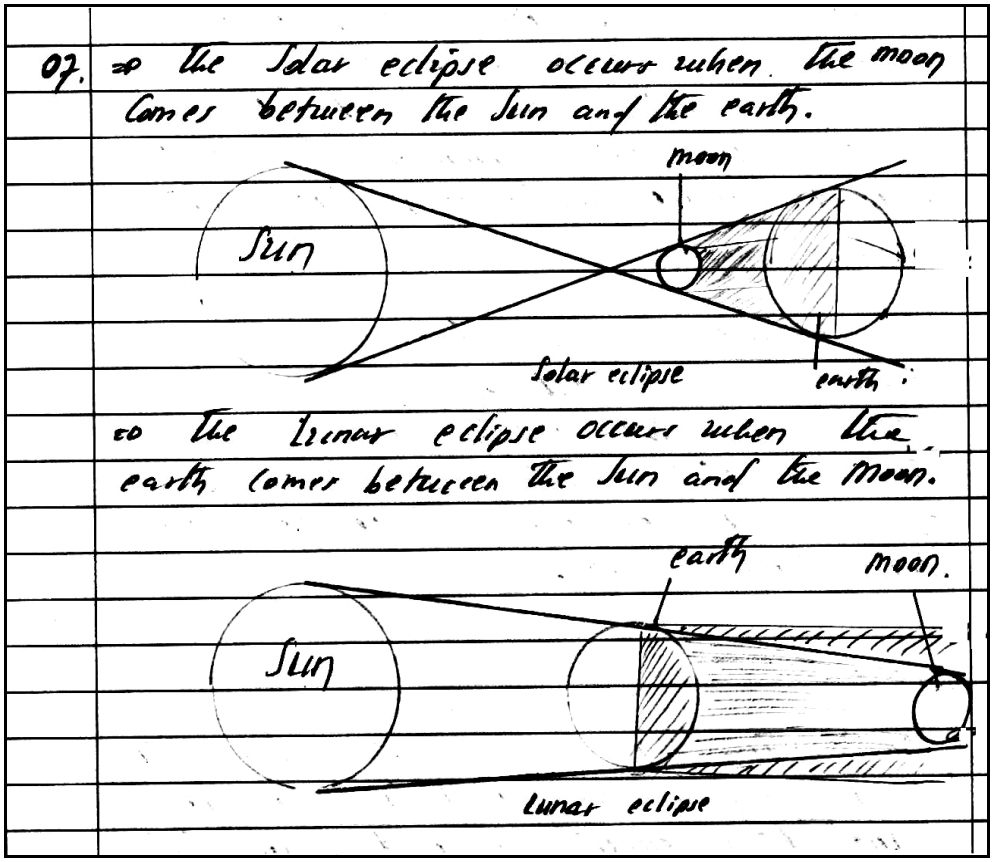


Figure 7: *Percentage of Candidates' Performance in Question 7*

Generally, candidates' performance on this question was average. The candidates managed to describe how solar and lunar eclipses occur. They also responded by either drawing a clearly well labelled diagram of each or by providing the explanation on how the two phenomena occur. Extract 7.1 shows a sample of a good response provided by a candidate who performed well.

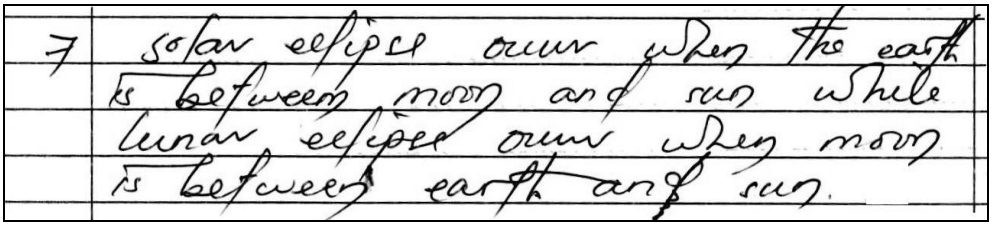
Extract 7.1



Extract 7.1 shows the answer of one candidate who performed well.

Those candidates who scored 1 to 1.5 marks were able to describe either solar or lunar eclipse correctly but not both. Candidates who scored 0 mark had no knowledge on concepts of solar and lunar eclipses. Half of the candidates had confusion on how the sun, moon and earth should be arranged in a straight line for solar eclipse and lunar eclipse to occur. Extract 7.2 shows a sample of a poor response from the script of a candidate who performed poorly.

Extract 7.2



Extract 7.2 shows a poor response as extracted from the script of a candidate who performed poorly.

2.3.7 Question 8: Fluid Mechanics

This question required the candidates to briefly explain why the volume of a bubble increases as it rises from the bottom of water to the surface. The question was attempted by 1083 (77.8%) candidates, out of those 807 (74.5%) scored 0 mark; and only 276 (25.5%) scored 3 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in Figure 8.

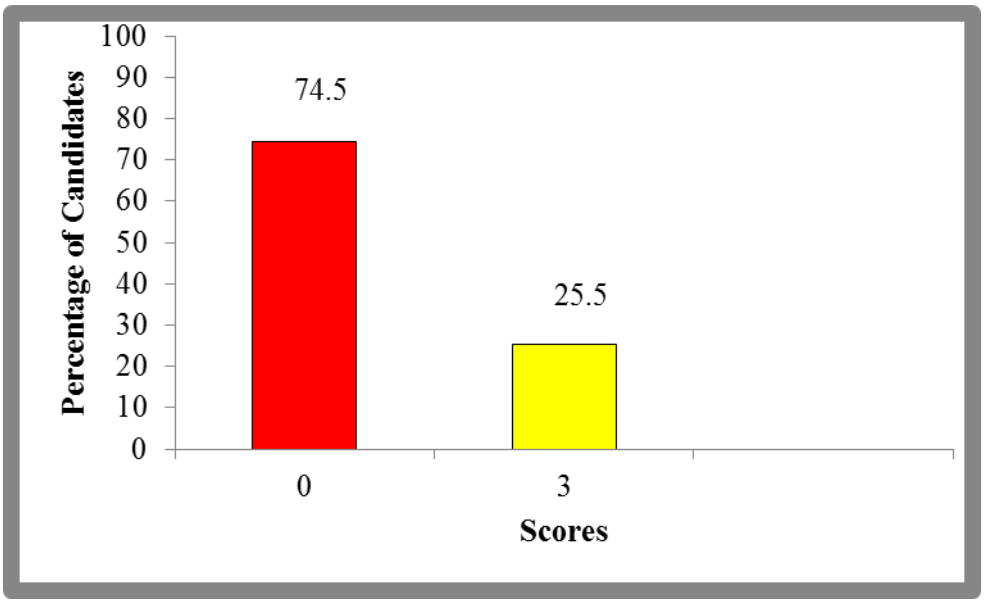
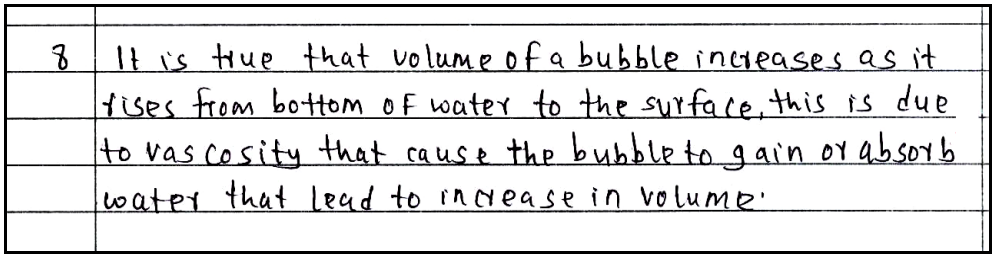


Figure 8: *Percentage of candidates' performance in question 8*

The candidates' performance in this question was generally weak. This indicates that these candidates did not acquire knowledge on the Boyle's law as learnt in fluid mechanics particularly on liquid pressure. Some of candidates provided wrong reasons on the concept of variations of pressure in relation to volume of a bubble. According to Boyle's law at constant temperature the pressure on a gas increases when its volume decreases. $P\alpha\frac{1}{V}$. Extract 8.1 shows a sample of a poor response as extracted from the script of a candidate.

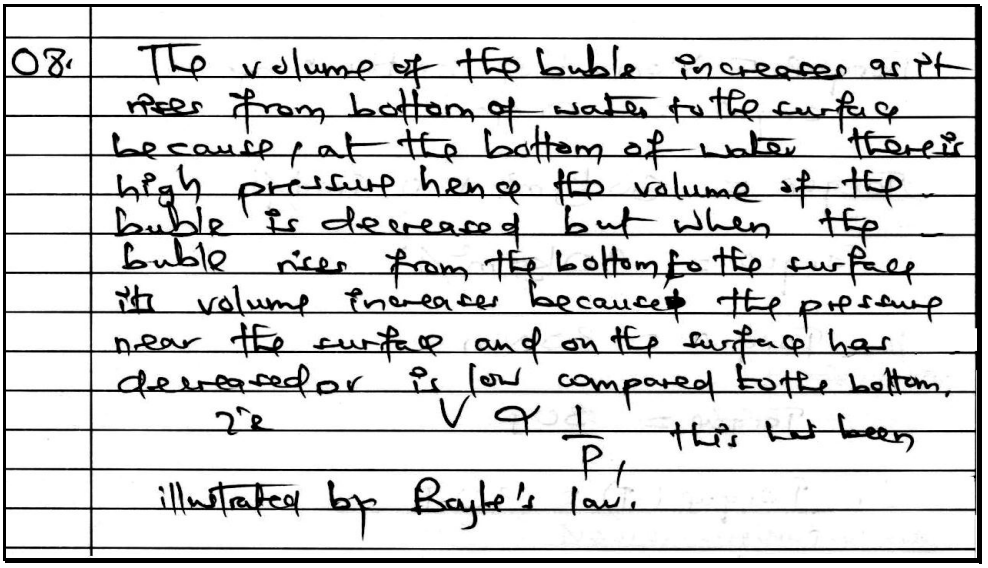
Extract 8.1


8 It is true that volume of a bubble increases as it rises from bottom of water to the surface, this is due to vascosity that cause the bubble to gain or absorb water that lead to increase in volume.

Extract 8.1 shows the response from the script of a candidate who performed poorly in this question.

Few candidates scored all 3 marks allocated for this question. Their correct explanations were based on; *Pressure on the top is less than at the bottom of water. As the bubble rises to the top, its volume increases because pressure decreases; this is according to Boyles's law*. The following extract 8.2 indicates the response of one candidate who performed well this question.

Extract 8.2


08. The volume of the buble increases as it rises from bottom of water to the surface because, at the bottom of water there is high pressure hence the volume of the buble is decreased but when the buble rises from the bottom to the surface its volume increases because the pressure near the surface and on the surface has decreased or is low compared to the bottom. i.e $V \propto \frac{1}{P}$ this has been illustrated by Bayle's law.

Extract 8.2 shows the response of a candidate who performed well.

2.3.8 Question 9: Simple Machines

In this question, the candidates were required to explain why the efficiency of car's screw jack is always smaller and less than 50%.

The question was attempted by 1220 (87.6%) candidates, out of those 704 (57.7%) scored 0 mark; 458 (37.5%) scored 1.5 marks; and 58 (4.8%)

scored 3 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in figure 9.

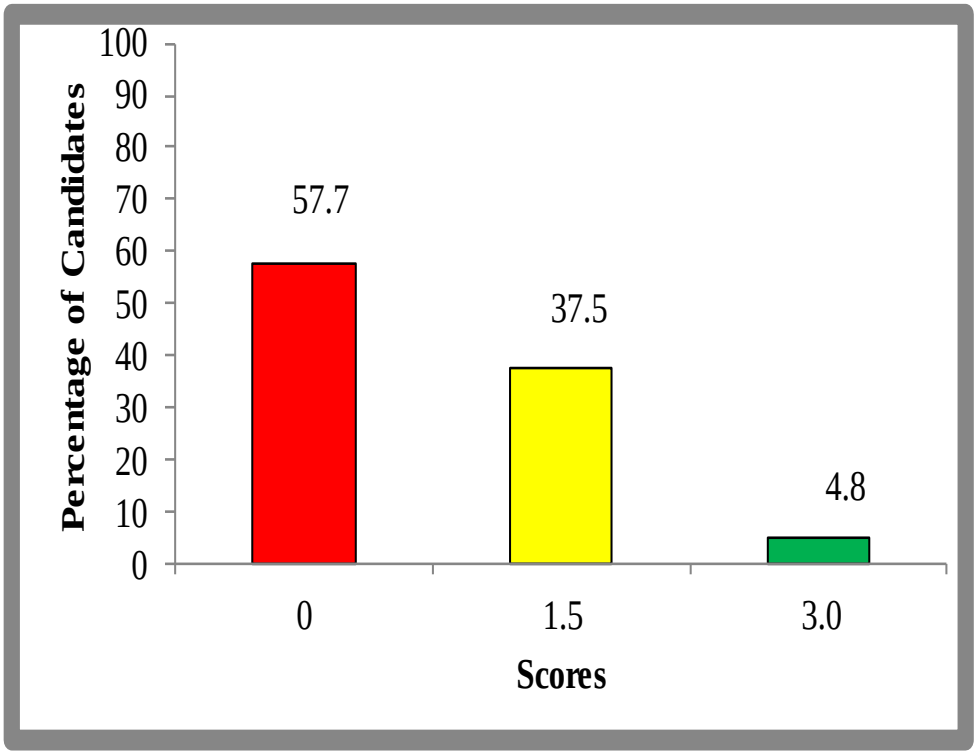
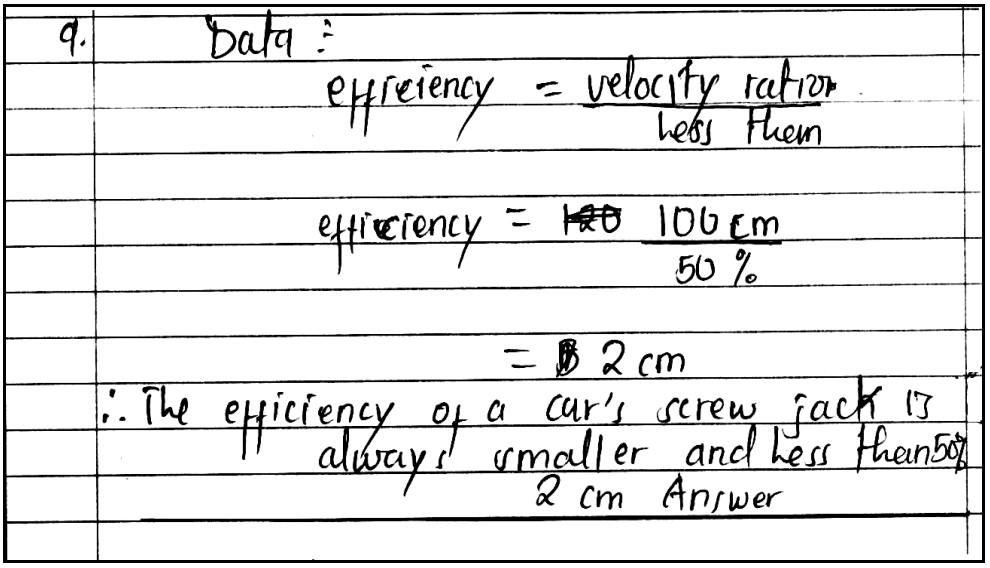


Figure 9: *Percentage of Candidates' Performance in Question 9*

The candidates' performance in this question was average. More than half of candidates were not able to associate energy loss in the operation of a car's screw jack due to lack of competence in describing the mode of operation of a screw jack. Very few candidates could only mention frictional force as one of the causes for a car's screw jack to have less than 50% efficiency. The majority of candidates failed to give any appropriate reason as to why the efficiency of the screw jack is always small and less than 50%. Extract 9.1 shows a sample of a poor response as extracted from a script of one candidate.

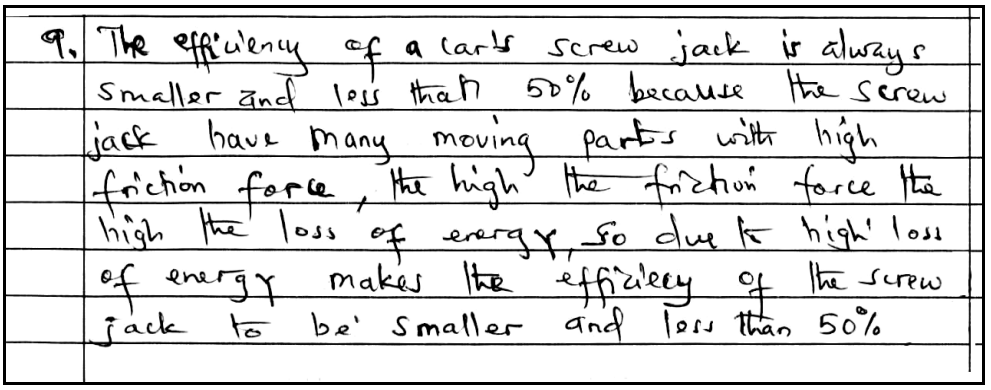
Extract 9.1


9. Data :
efficiency = velocity ratio / less than
efficiency = ~~120~~ 100 cm / 50 %
= 2 cm
∴ The efficiency of a car's screw jack is always smaller and less than 50%
2 cm Answer

Extract 9.1**:** Extract shows the response of a candidate who performed poorly.

Very few candidates managed to identify the energy losses occurring during operation of a car's screw jack. Few candidates had understanding that more than a half of the work done by effort on the jack is wasted into heat and sound energy in overcoming the frictional force. This frictional force is essential to ensure no back sliding of a jack when the effort is removed or released. Extract 9.1 shows a sample of a response of candidate who correctly answered this question.

Extract 9.2


9. The efficiency of a car's screw jack is always smaller and less than 50% because the screw jack have many moving parts with high friction force, the high the friction force the high the loss of energy, so due to high loss of energy makes the efficiency of the screw jack to be smaller and less than 50%

Extract 9.2 shows the response of a candidate with a good performance.

2.3.9 Question 10: Work, Energy and Power

This question required the candidates to explain (a) Chemical Energy, and (b) Nuclear Energy with regard to energy. The question was attempted by 1247 (89.6 %) candidates, out of those 723 (58%) scored 0 mark; 286 (22.9%) scored 1.5 marks; and 238 (19.1%) scored 3 marks. This performance is also elaborated by Figure 10 which shows the percentage of candidates' performance graphically.

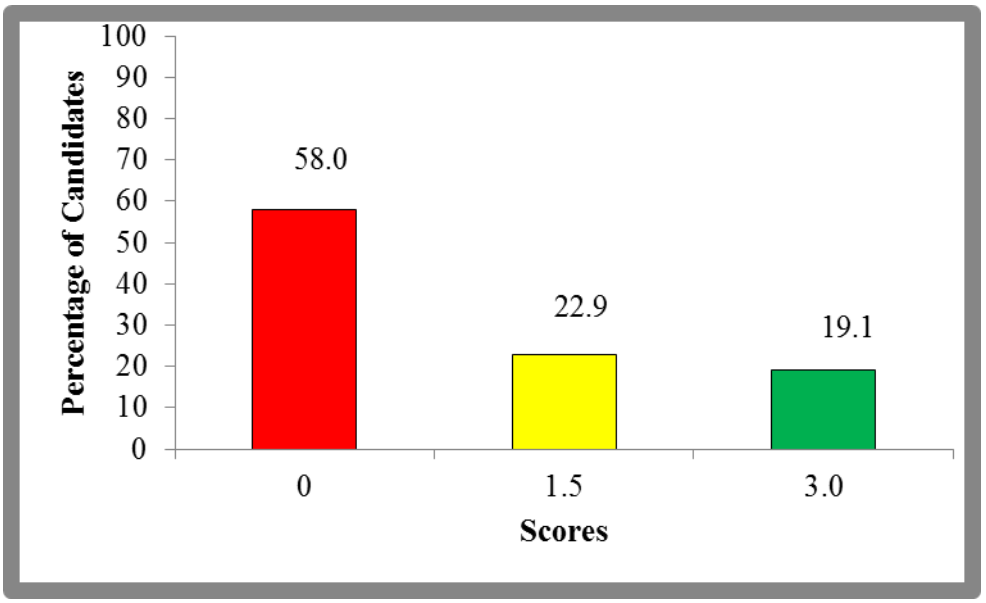
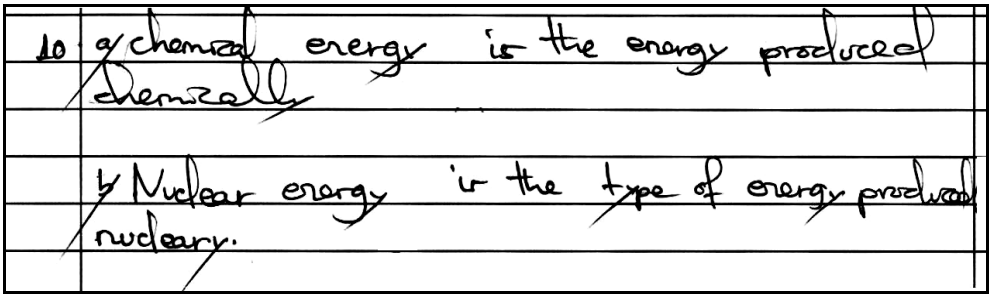


Figure 10: *Percentage of Candidates' Performance in Question 10*

The candidates' performance in this question was average. More than half of the candidates were unable to explain about chemical and nuclear energies. This indicates that lacked competence in identification of forms of energy.

The candidates who scored 1.5 marks could either explain correctly the terms chemical energy or nuclear energy correctly but not both. However, more than half of the candidates scored 0 mark, indicating that these candidates had no knowledge on concepts of chemical and nuclear energies. Extract 10.1 portrays a sample of a poor response as extracted from a script of a candidate.

Extract 10.1

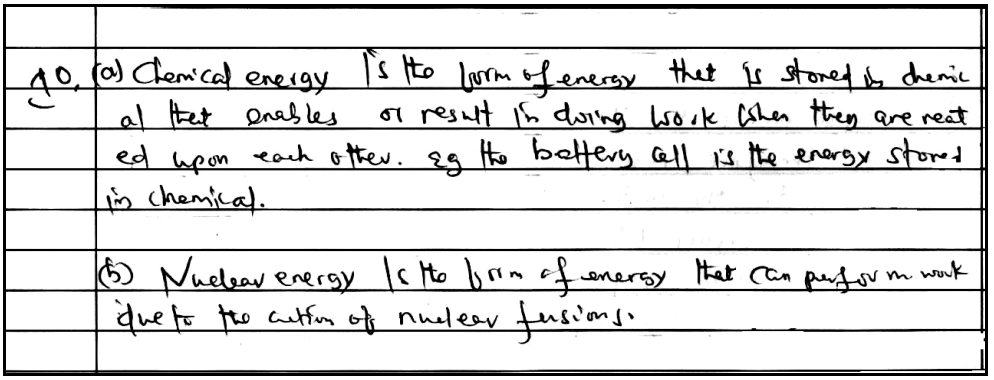

10 a/ chemical energy is the energy produced chemically

b/ Nuclear energy is the type of energy produced nuclearly.

Extract 10.1 portrays a sample of poor answer as extracted from the script of one candidate.

Few candidates managed to explain these terms correctly, hence scored all 3 marks allocated to this question. Extract 10.2 shows a sample of a good response as extracted from a candidate's script.

Extract 10.2


10. (a) Chemical energy is the form of energy that is stored in chemical that enables or result in doing work when they are reacted upon each other. eg the battery cell is the energy stored is chemical.

(b) Nuclear energy is the form of energy that can perform work due to the cutting of nuclear fusions.

Extract 10.2 shows a sample of a good response as extracted from the script of a candidate.

2.3.10 Question 11: Electricity and Magnetism

In this question, the candidates were required to explain why it is dangerous to replace an electric fuse with an iron nail. The question was attempted by 1243 (89.3%) candidates, out of those 939 (75.6%) scored 0 mark; 5 (0.4%) scored from1 to 1.5 marks; 299 (24.1%) scored from 2 to 3 marks. Figure 11 shows the percentage of candidates' performance graphically.

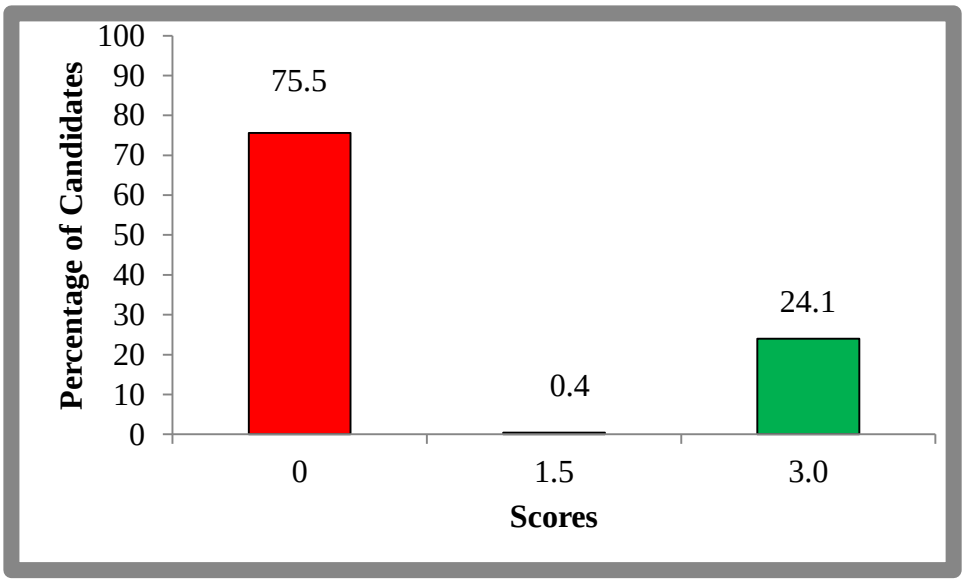
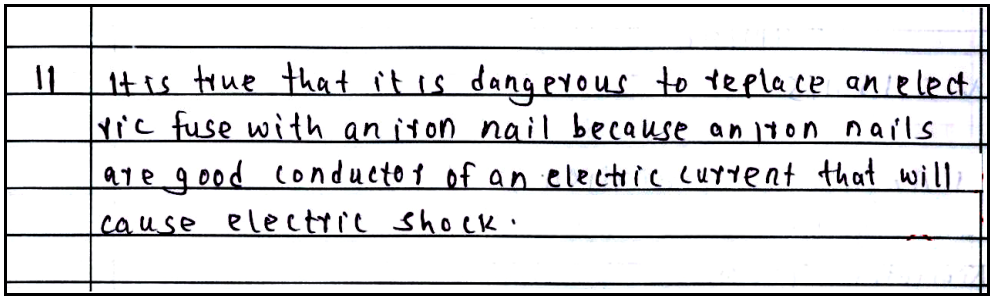


Figure 11: *Percentage of candidates' performance in question 11*

The candidates' performance in this question was weak. These candidates were not able to give comprehensive reasons as to why it is dangerous to replace an electric fuse with an iron nail. Majority of candidates failed to identify the effects of replacing an electric fuse with an iron nail. The necessary condition for fuse is to have a low melting point; this helps a sudden melting whenever there is any fluctuation of current. The property of melting protects electrical appliances from burning. Extract 11.1 depicts a sample of a poor response of one candidate.

Extract 11.1


11 It is true that it is dangerous to replace an electric fuse with an iron nail because an iron nails are good conductor of an electric current that will cause electric shock.

Extract 11.1 shows a sample of an illogical and unclear response as extracted from the candidate's script.

Only 24 percent responded correctly and scored all 3 marks. Extract 11.2 is a sample of a good response as extracted from a script of one candidate.

Extract11.2

11. It is dangerous to replace an electric fuse with an iron nail because fuse is made with small cross sectional area which allow the limited amount of electric current to pass while the nail will allow more electric current to pass which can cause electrical accidents such as fire or over heating of electrical equipment.

Extract 11.2 is a sample of a good response as extracted from the script of one candidate.

2.3 SECTION C: Structured Questions

2.3.1 Question 12:Light (Optics)

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

(a) A certain transparent liquid is poured in a measuring cylinder to a depth of 24cm. If a stone at the bottom of the cylinder appears to be raised 6cm as viewed by an observer from the top, determine the refractive index of the liquid. (Give the answer in two decimal places).

(b) A ray of light is incident on the air-glass boundary as shown in the Figure 2. If the refractive index of the glass is 1.5, determine the angle of incidence 'i'.

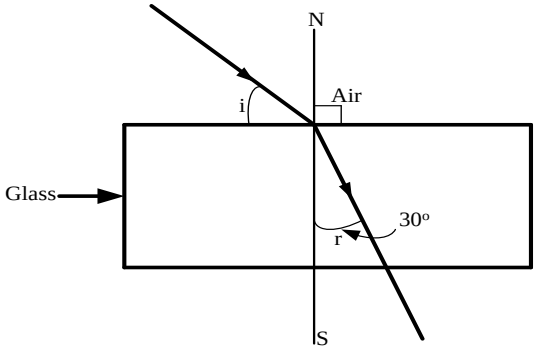


Figure 2

(c) An object is placed 10cm from a concave lens of focal length 15cm. Using the lens formula and 'real is positive' convention, determine: (i) The nature of the image (ii) The position of the image formed.

The question was attempted by 760 (54.6%) candidates, out of those 228 (30%) scored 0 to 5.5 marks; 356 (46.8%) scored from 6 to 12.5 marks; and 176 (23.2%) scored from 13 to 19 marks. The candidates' performance in this question was average. Figure 12 shows the percentage of candidates' performance graphically.

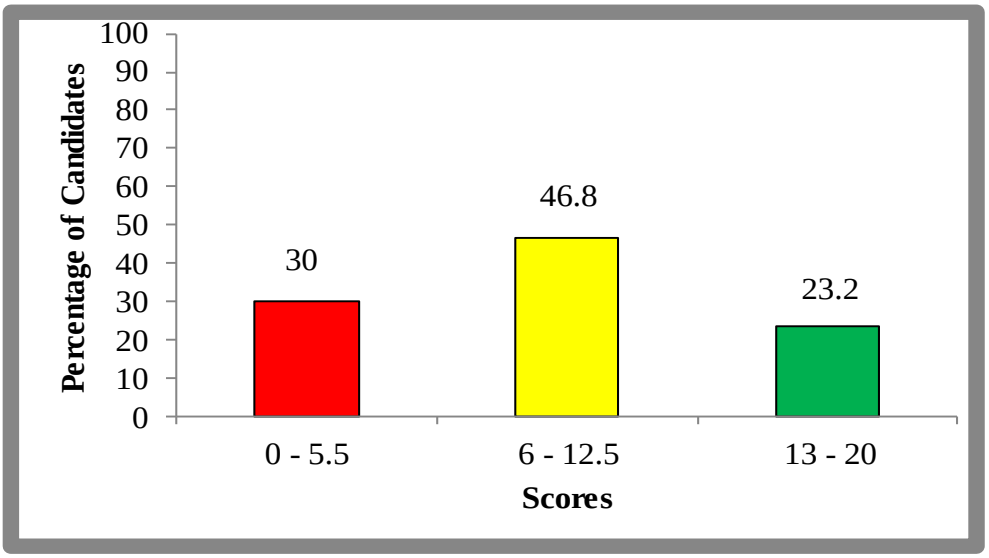


Figure 12: *Percentage of Candidates' Performance in Question 12.*

The candidates' performance in this question was good. Most candidates showed great understanding of the question's demand. These candidates did well in all parts of the question but they made slight mistakes in performing some calculations, particularly when simplifying the expressions into which the data had been correctly substituted. The candidates could calculate the apparent depth (h) and use it in the formula $\eta = \frac{Real\ depth}{Apparent depth}$ to get the refractive index of the liquid in part (a). In part (b), they used $\eta_g = \frac{\sin(90-i)}{\sin r}$ to get the value of the refractive index 'i'. In part (c), the candidates correctly applied the equation $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ to get value of the image distance (v). Also, they stated the nature of the image formed as virtual. Extract 12.1 shows a sample of a good performance as extracted from a candidate's script.

Extract 12.1

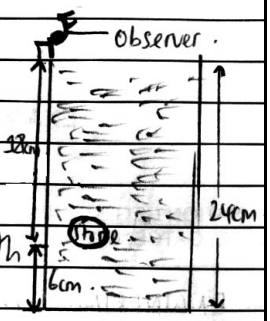
12 a Data.

Real depth = 24cm

Apparent depth = 24cm − 6cm.

= 18cm.

Refractive index = ?



$$\text{Refractive index} = \frac{\text{Real depth}}{\text{Apparent depth}}$$

$$= \frac{24\text{cm}}{18\text{cm}}$$

Refractive index = 4/3.

∴ Refractive index = 1·33.

12 b Data.

Refractive index = 1·5

Angle of refraction = 30°

Angle of incidence = x.

$$\text{Refractive index} = \frac{\sin i}{\sin r}$$

$$\frac{1 \cdot 5}{1} = \frac{\sin i}{\sin 30}$$

$$\sin i = \sin 30 \times 1 \cdot 5$$

$$\sin i = 0 \cdot 5 \times 1 \cdot 5$$

$$\sin i = 0 \cdot 75$$

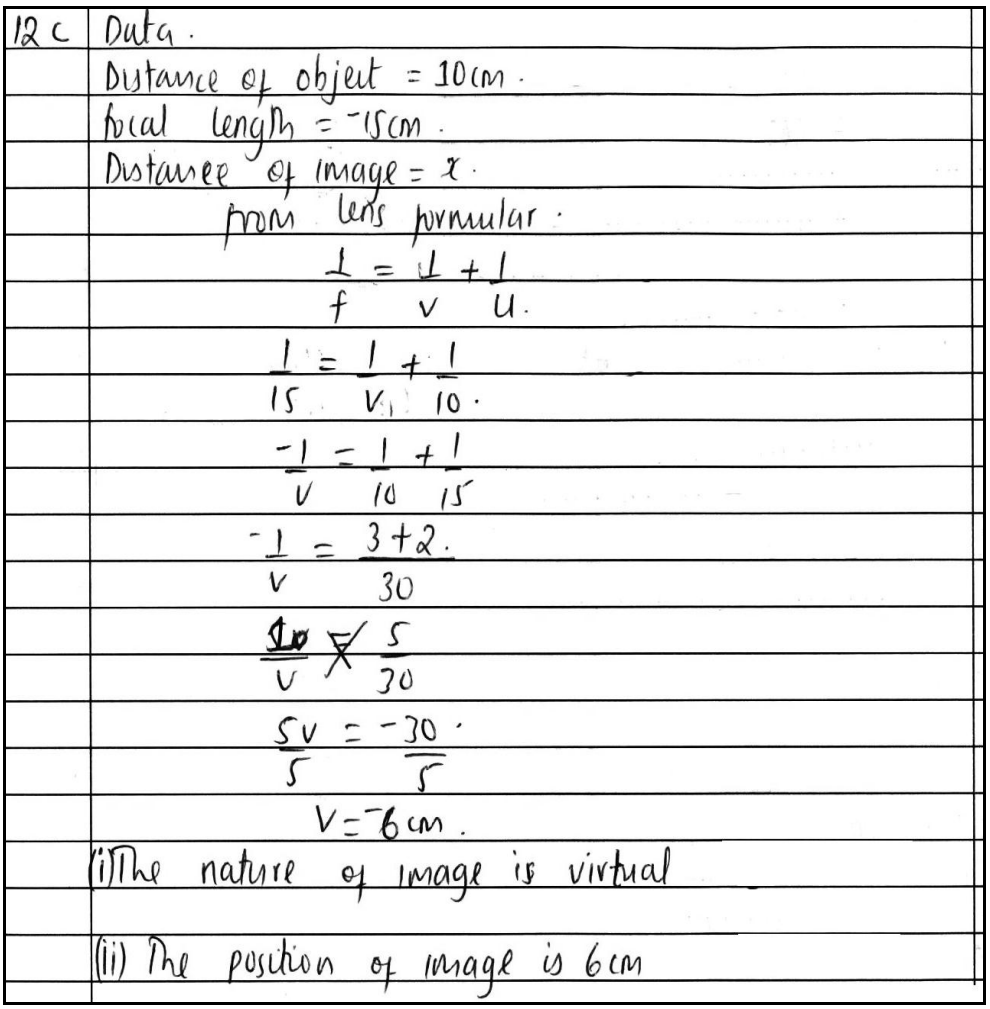
$$i = \sin^{-1} 0 \cdot 75$$

$$i = 48 \cdot 6°$$

$$i + i = 90°$$

$$48 \cdot 6 + i = 90°$$

$i = 41 \cdot 1$ ∴ The angle at $i = 41 \cdot 1°$



Extract 12.1 shows a sample of a good response as extracted from the script of a candidate.

Most of the candidates who scored from 6 marks to 12.5 marks could perform well in part (a) and part (c) but poorly in part (b). In part (b), most of these candidates wrongly calculated the angle of incidence 'i' using $\eta_g = \frac{\sin i}{\sin r}$ instead of $\eta_g = \frac{\sin(90-i)}{\sin r}$. Also, these candidates did not draw the sketch of ray diagram to show the position the object and focal point. Furthermore, they substituted a positive value of the length instead of a negative value (RP convention).

Most of the candidates who scored greater than 0 but less than 5.5 marks performed slightly well in part (c) but poorly in part (a) and part (b). These candidates could not associate the distance the stone appears to be raised with the apparent depth;

Apparent depth = 24 cm – 6 cm = 18 cm.

In part (b) the candidates did not realize that the angle which would be used to find the refractive index of glass η_g was to be $\theta^0 = (90 - i)^0$, and thus $\eta_g = \frac{\sin i}{\sin r}$ would had been modified to $\eta_g = \frac{\sin(90 - i)}{\sin r}$ which was the appropriate equation for determining the value of the angle of the incidence 'i'.

Those candidates who scored 0 mark lacked knowledge on the topic of Optics (Light) and refraction of light in particular. Extract 12.2 depicts a sample of a poor response extracted from a script of one candidate.

Extract 12.2

12. a) Give the answer in two decimal places).

Soln

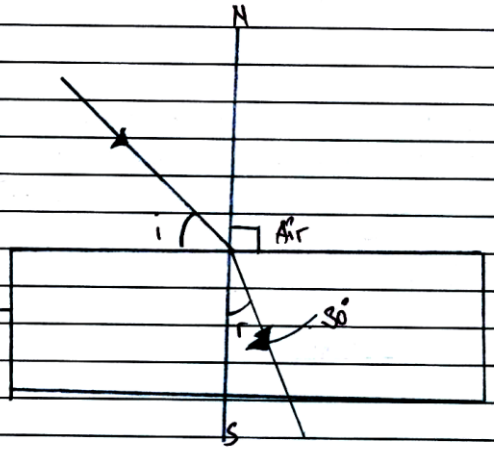
24 cm. 6 cm

24cm × 6 cm

24 × 6 = 144 cm

∴ Give the answer in two decimal places).

b) If the index of the glass is 1.5, determine the angle of incidence;



Soln

1.5 + 2 = 1.7

- Glass
- Air
- i
- N
- S

∴ 1.7

c) i) The nature of the image. 150 cm

ii) The position of the image formed. 150.

Extract 12.2 shows a sample of a poor response of one candidate.

2.3.2 Question 13: Angular Motion

This question had three parts, (a), (b), and (c). In part (a), the candidates were required to define: (i) constant angular velocity, and (ii) constant angular acceleration. In part (b), the candidates were required to determine the peripheral velocity of a point on the rim of a wheel of radius 200 mm when rotating at 3 rev/sec. and part (c) of the question was as follows:
The wheels of a car with a diameter 700 mm is rotating when the car moves along a horizontal road. If the rate of rotation increases from50 rev/min to 1100rev/min in 40 seconds, calculate:

(i) the angular acceleration of the wheels,

(ii) the linear acceleration of a point on the tyre thread.

The question was attempted by 1076 (77.3%) candidates, out of those 377 (35%) scored 0 to 5.5 marks; 240 (22.3%) scored 6 to 12.5 marks; and 459 (42.7%) scored 13 to 20 marks. Figure 13 shows the percentage of candidates' performance graphically.

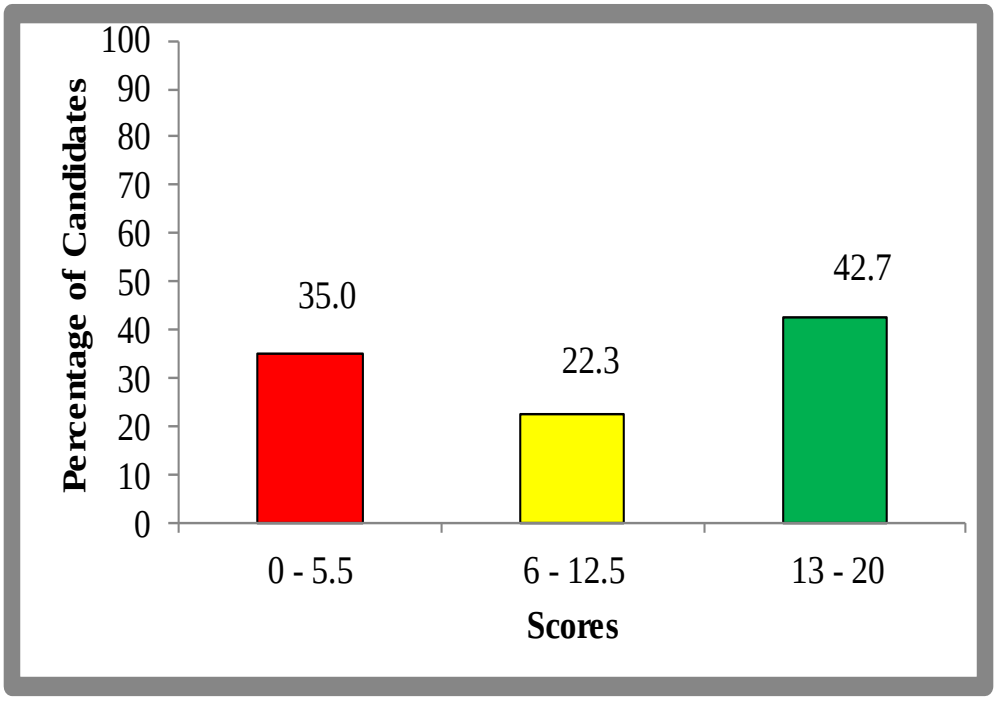


Figure 13: *Percentage of Candidates' Performance in Question 13*

The candidates' performance in this question was good. The candidates who passed were 65 percent. 42.7 percent of these candidates defined correctly the constant angular velocity and constant angular acceleration in part (a); apply $\omega = 2\pi N$ to get angular velocity in rad/s (in SI units); and then they applied $v = rw$ to calculate the peripheral linear velocity (v) of a point on the rim of a wheel, in part (b). In part (c), the candidates could correctly apply equation: $\omega = \frac{2\pi N}{60}$; $\omega_2 = \omega_1 + \alpha t$; and $a = r\alpha$ to calculate the angular velocity in radians per second, angular acceleration of the wheel and hence the linear acceleration of a point on the tyre thread. These candidates showed high understanding on the topic of Angular Motion. Extract 13.1 shows a sample of a good response extracted from a script of a candidate.

Extract 13.1

13 @(i) Constant angular velocity;
This is the constant rate of change of angular displacement

(ii) Constant angular acceleration;
-This is the constant rate of change of angular velocity.

(b) Data given:
Radius of wheel = 200mm
Angular velocity = 3 rev/sec
Required; peripheral velocity = ?
Soln
from; peripheral velocity = $2\pi rn$
= but r in m
= 2m 0.2m.
Then $V = 2\pi rn$
$= 2 \times 3.14 \times 0.2M \times 3\ rev/sec$
$V = 3.768\ rev/sec$
∴ peripheral velocity = 3.768 rev/sec.

(c) Data given.
diameter of wheel = 700mm
Rate of rotation ($w_1 = 50\ rev/min$, $w_2 = 1100\ rev/min$)

13 (c)(i) Time = 40 seconds.

Required: (i) Angular acceleration = ?

From

Angular acceleration = $\frac{\text{Rate change of rotation}}{\text{Time}}$.

$$\alpha = \frac{\omega_2 - \omega_1}{t}$$

but change rotation into rad/s.

From

1100 rev/min = $\frac{2\pi n}{60}$ rad/s.

$= \frac{2 \times 3.14 \times 1100}{60}$ rad/s.

$= 115.1 \simeq 115$ rad/s.

Also, 50 rev/min = $\frac{2\pi n}{60}$ rad/s

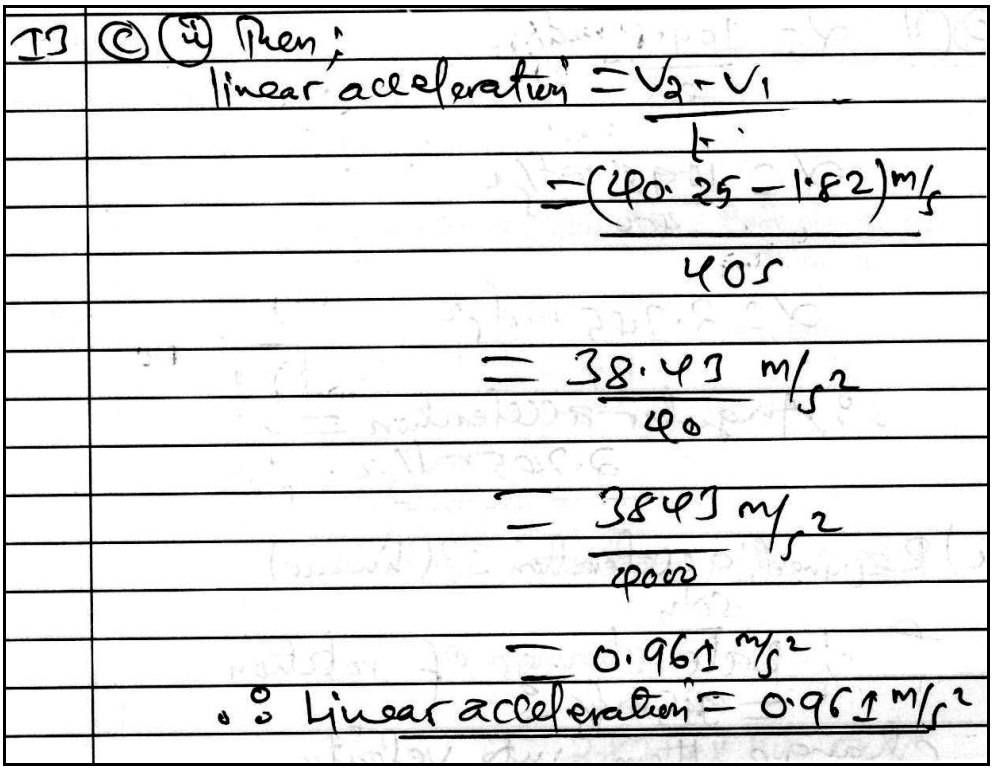
$= \frac{2 \times 3.14 \times 50 \text{ rev}}{60}$ rad/s

$= 5.23 \simeq 5.2$ rad/s.

Then,

$$\alpha = \frac{\omega_2 - \omega_1}{t}$$

$$\alpha = \frac{115 \text{ rad/s} - 5.2 \text{ rad/s}}{40s}$$



Extract 13.1 shows a sample of a good response as extracted from the script of a candidate.

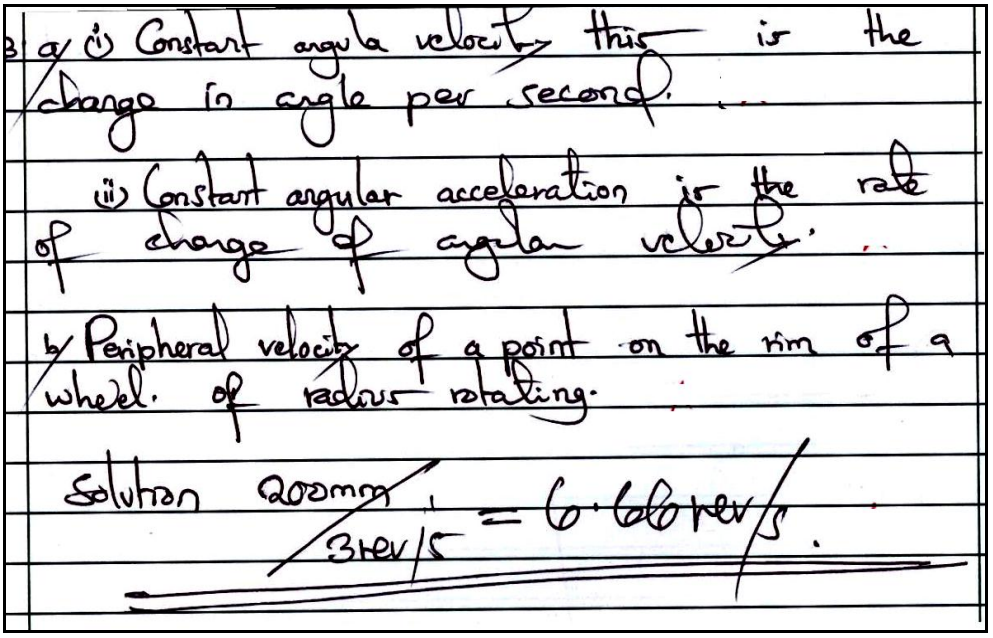
The major weaknesses noted on these candidates were on the definitions of constant angular velocity and constant angular acceleration. They falsely defined constant angular velocity as the '' *rate of change of angular displacement*'', and constant angular acceleration as the '*'rate of change of angular velocity*''. The correct definition for constant angular velocity should be '*'equal change of angular displacement per equal interval of time*''; and the correct definition for constant angular acceleration should be '*'equal change of angular velocity per equal interval of time*''. Most of the candidates who scored less than 13 marks but greater than 0mark were unable to apply the equation $w = \frac{2\Pi N}{60}$ to convert angular velocity from rev/s or rev/min to rad/s in part (b) and part (c). Hence they failed to compute the values of peripheral linear velocity (v) in part (b) and linear acceleration in part (c).

Most of the candidates who scored 0 mark failed to remember any of the useful formulae, $V = rw$; $w = \frac{2\Pi N}{60}$; $w_2 = w_1 + \alpha t$; and $a = r\alpha$, and they

did not even write down the data which were to be extracted from the question.

Extract 13.2 shows a sample of a poor response as extracted from a candidate's script.

Extract 13.2



Extract 13.2 shows a sample of a poor response extracted from the candidate's script.

2.3.3 Question 14: Simple Machine

This question had four parts: (a);(b); (c); and (d), and stated as follows: *A machine which consists of a wheel of 300 mm diameter and an axle of 75mm diameter has efficiency of 75% at a load of 120N. Determine: (a) the movement ratio of this machine (b) the effort required to raise the 120N load (c) the effort for this load if the machines efficiency was raised to 85% by lubrication of the bearings (d) the ideal effort for this load on this machine.*

The question was attempted by 1185 (85.1%) candidates, of those 274 (23.1%) scored 0 mark to 5.5 marks; 201 (17%) scored 6 marks to 12.5 marks; and 710 (59.9%) scored 13 to 20 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in Figure 14.

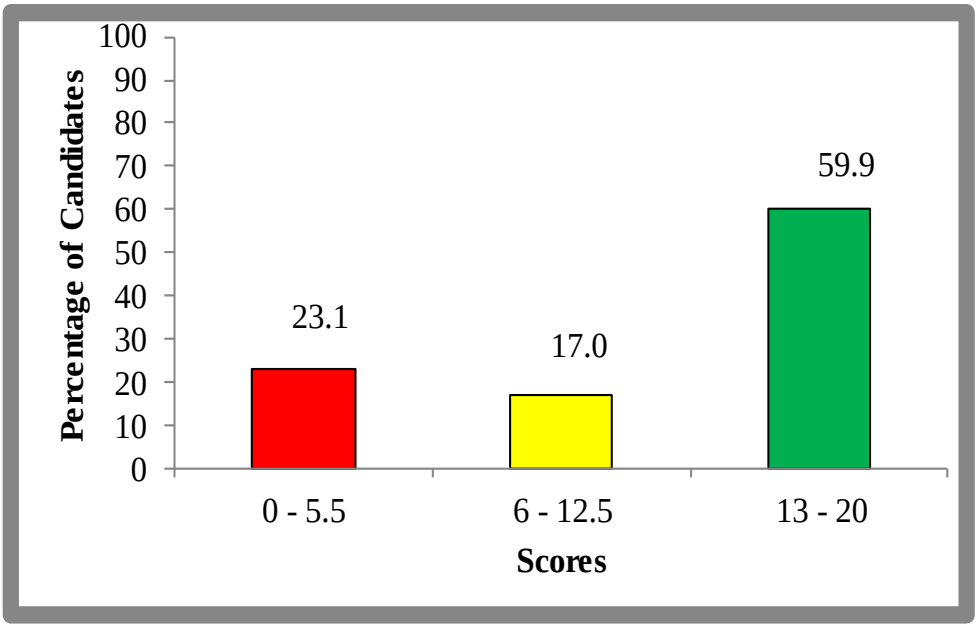


Figure 14: *Percentage of Candidates' Performance in Question 14.*

The candidates' performance in this question was good**.** These candidates applied their competences to recall and apply correctly the formula for the Movement Ratio (MR), Efficiency (η); Force Ratio (FR) and Ideal Effort, formulae, $V.R = \frac{wheeldiameter}{axlediameter} = \frac{wheelradius}{axleradius}$, in part (a); $\eta = \frac{FR}{MR} \times 100\%$; and $FR = \frac{Load}{Effort}$, in part (b) and part (c); and $F.R = M.R = \frac{Load}{IdealEffort}$. Extract 14.1 shows a sample of good responses from a candidate's script.

Extract 14.1

14. Data given

Wheel diameter = 300 mm

Axle diameter = 75 mm

Efficiency = 75%

Load = 120 N

Soln.

a) movement ratio.

$$\text{Movement ratio} = \frac{\text{Diameter of wheel}}{\text{diameter of axle}}$$

$$= \frac{300 \text{ mm}}{75 \text{ mm}}$$

$\therefore$ Movement ratio = 4.

14. b) The Effort required to raise the 120 N load.

Soln.

$$\text{Efficiency} = \frac{\text{Mechanical Advantage.}}{\text{Velocity ratio.}}$$

$$\text{Mechanical Advantage} = 75\% \times 4$$

$$= \frac{75}{100} \times 4$$

$$\text{MA.} = 3$$

Then;

$$\text{M.A} = \frac{\text{Load}}{\text{Effort}}$$

$$3 = \frac{120 \text{ N}}{\text{Effort}}$$

$$\text{Effort} = \frac{120 \text{ N}}{3}$$

$$= 40 \text{ N.}$$

$\therefore$ The effort required to raise the 120 N load = 40 N.

c) The effort required for this load if the machines efficiency was raised to 85% by lubrication of the bearings.

Soln

$$\text{Efficiency} = \frac{\text{M.A}}{\text{V.R}}$$

$$85\% = \frac{\text{MA}}{4}$$

$$\text{MA} = \frac{85}{100} \times 4$$

$$= \frac{85}{25}$$

$$= 3.4$$

$$\text{M.A} = 3.4$$

14.c) $\text{Mechanical Advantage} = \frac{\text{Load}}{\text{Effort}}$

$$\text{Effort} = \frac{\text{Load}}{\text{M.A}}$$

$$= \frac{120\text{N}}{3.4}$$

$$= 35.3\text{N}$$

∴ The Effort required = 35.3N.

d) The ideal effort for this load on this machine.

Soln.

$$\text{Ideal effort} = \frac{\text{Load}}{\text{Velocity Ratio}}$$

$$= \frac{120\text{N}}{4}$$

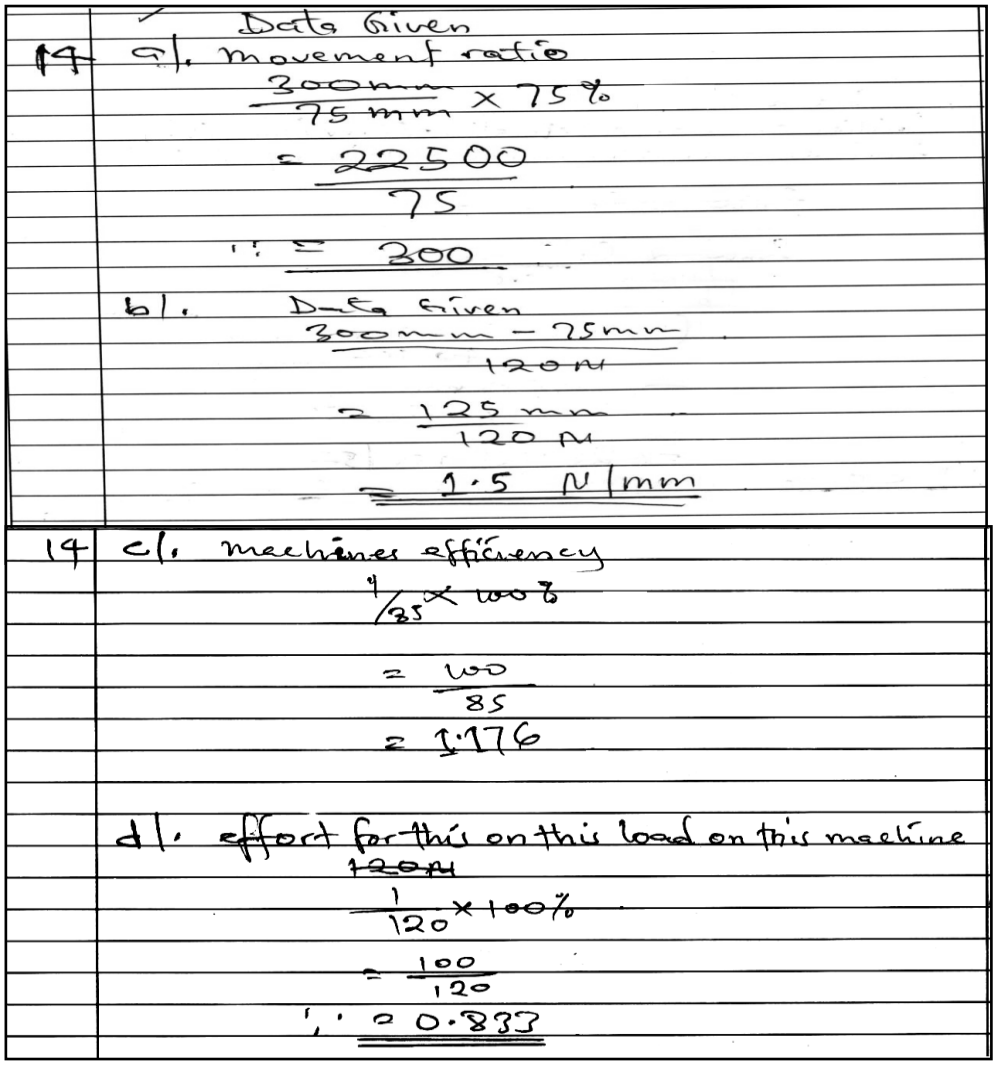
$$= 30\text{N}$$

∴ Ideal Effort = 30N

Extract 14.1 shows a sample of a good answer as extracted from the candidate's script.

Most of candidates performed well in part (a) and (b) but poorly in part (c) and (d). In part (d), most of the candidates were not able to apply the formula $M.R = \frac{Load}{IdealEffort}$ (the equation which could be used when a machine is assumed to have an efficient of 100%, thus making FR to be equal to MR. The candidates who scored 0 mark (3.6%) did not acquire knowledge in the topic of simple machine particularly on ideal effort. Extract 14.2 shows a sample of a poor response as extracted from a candidate's script.

Extract 14.2



Extract 14.2 shows a sample of a poor response from a script of the candidate who performed poorly in this question.

2.3.4 Question 15: Electricity and Magnetism

This question had three parts, (a); (b); and (c), and stated as follows:

(a) *A step-up transformer has 1000 turns in the secondary coil and 100 turns in the primary coil. An alternating current of 5.0 A flows in the primary circuit when connected to a 12.0 a.c supply.*

(i) *Calculate the voltage across the secondary coil*

(ii) *If the transformer has an efficiency of 90%, what is the current in the secondary coil?*

(b) *The heating element of a 250 v electric cooker has effective resistance between terminals of 10 Ω when the cooker is switched to maximum heat. If electrical energy costs 80 shillings per kWh how much does it cost to operate the cooker at maximum heat for half an hour?*

(c) *A generator supplies a load current of 20 A at a p.d of 200 V. Determine the power output of the generator.*

The question was attempted by 546 (39.2%) candidates, of those 170 (31.1%) scored 0 mark to 5.5 marks; 165 (30.3%) scored 6 marks to 12.5 marks; and 211 (38.6%) scored 13 marks to 20 marks. The graphical presentation of scores with respect to the percentage of candidates is summarized in Figure 15.

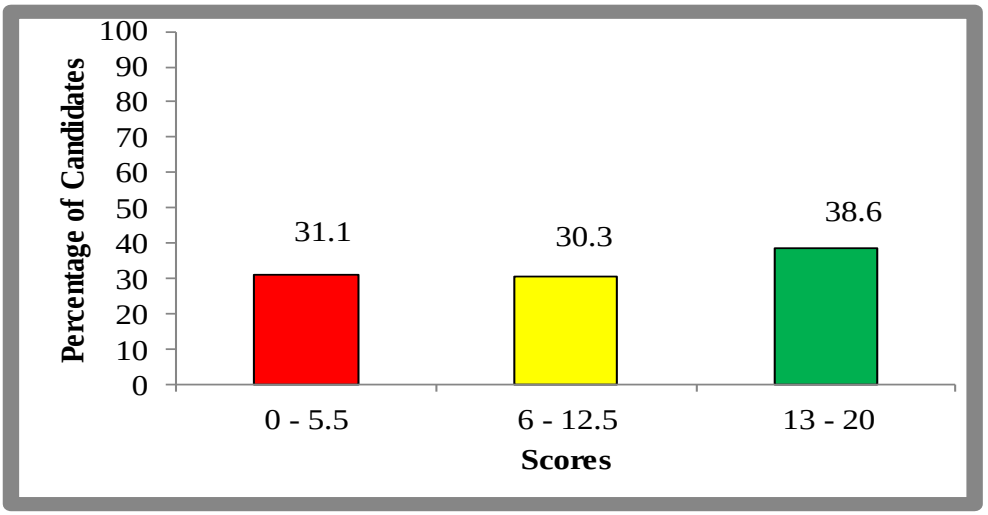


Figure 15: *Percentage of Candidates' Performance in Question 15.*

Generally, the candidates' performed for this question was good. This indicates that majority of candidates had acquired knowledge and relevant competences to meet the demands of the question.

Those candidates who scored all 20 marks allocated to this question, performed well in all three parts of the question. In part (c), they could apply the transformer equations, which were $\frac{N_s}{N_p}=\frac{V_s}{V_P}$; and $\frac{N_s}{N_p}=\frac{I_p}{I_s}$ Also, they correctly applied the equation of power, that is, $P_p = V_p \times I_p$ to get the value of power in the primary coil. They could also apply the equation for efficiency in transformer (which is $\eta = \frac{P_s}{P_p}\times 100\%$) to calculate the current in the secondary coil. They realized that the current in the secondary coil (I_s) could be obtained from $90\% = \frac{I_s V_s}{I_p V_P}\times 100\%$ (since the transformer was 90% efficient). In part (b), they managed to recall and apply correctly the equation for power (that is, $power = \frac{V^2}{R} = IR$. Also, they could remember and use appropriately the equation for cost of electrical energy (or cost of electricity) which is ''cost of electrical energy = energy in kWh x Rate". In part (c), they were able to apply the equation, power = VI to obtain the power output of the generator. Extract 15.1 shows a sample of a good answer from a script of one candidate.

Extract 15.1

15. @ Solution.

Data given:

$N_s = 1000$ where N = Number of turns.

$N_p = 100$ I = Current.

$I_p = 5.0A$ E = voltage.

$E_p = 12.0V$.

Required to find.

@① Voltage across the secondary coil (E_s)

From; $\frac{E_s}{E_p} = \frac{N_s}{N_p}$

Then; $E_s = \frac{E_p \times N_s}{N_p}$.

$E_s = \frac{12V \times 1000}{100}$.

$E_s = 120V$.

∴ The voltage across the secondary coil is 120V.

② If Efficiency (η) = 90%

Required to find;

Current in the secondary coil (I_s)

From;

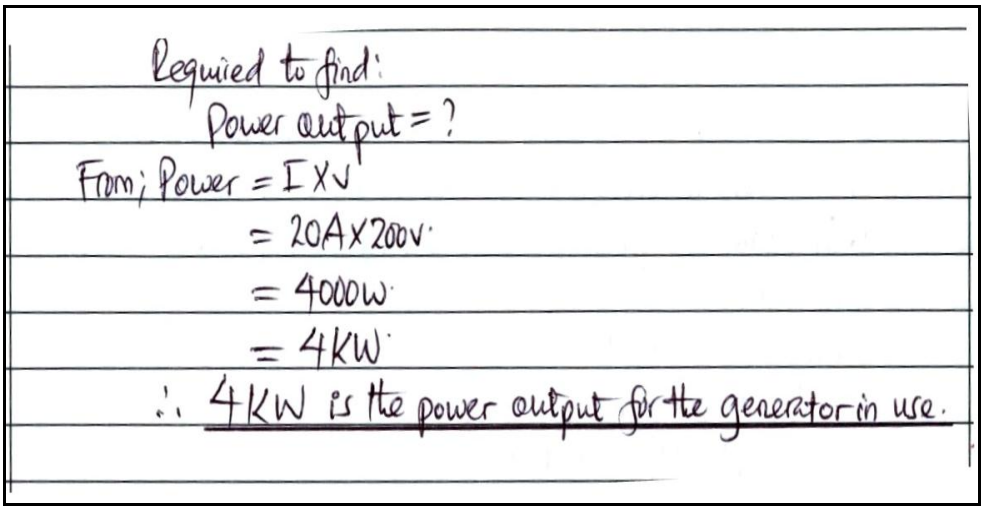
$\text{Efficiency} = \frac{\text{Power output}}{\text{Power Input}} \times 100\%$

but Power = I x E

$\text{Efficiency} = \frac{I_s \times E_s}{I_p \times E_p} \times 100\%$.

$I_s = \frac{\text{Efficiency} \times I_p \times E_p}{100\% \times E_s}$

$I_s = \frac{90\% \times 5A \times 12V}{100\% \times 120V} = \frac{9 \times 1}{20} = 0.45A$



Extract 15.1 shows the answer from the script of a candidate who performed well.

Most of the candidates who scored less than 20 marks but greater than 13 marks were able to remember most of the transformer formula of power but lacked skills on how to calculate the cost of electrical energy in part (c). In part (a), some of these candidates did not realize that in order to get the current in the secondary coil they had to equate 90% with $\frac{I_s V_s}{I_p V_p} \times 100\%$ (since the transformer had an efficiency of 90%). The candidates in this group were skipping relevant steps when presenting their answers. Those candidates who scored 0 mark could not even write down the data from the question. Extract 15.2 depicts a sample of a poor answer as extracted from a candidate's script.

Extract 15.2

15 a) i) calculate the voltage across the secondar coil

$F = BIT \times \sin\theta$

Sdh

$F = BIT \times \sin\theta$

$B = ?$

$I = 5.0A$

$T = 10$

$F = B \times 5.0A \times 10 \times 90^\circ$

$= 450.0$

$F = B\ 450.0$

Voltage of the ~~$B = 0.7$~~ secondar coil

$B = 0.7$

b) If the transformer has an efficiency of 90%, what is the current in the secondary coil.

Sdh

$F = BIT \times \sin\theta$

Sdh

$F = BIT \times \sin\theta$

$B = ?$

$I\ 5.0A$

$I = 1000$

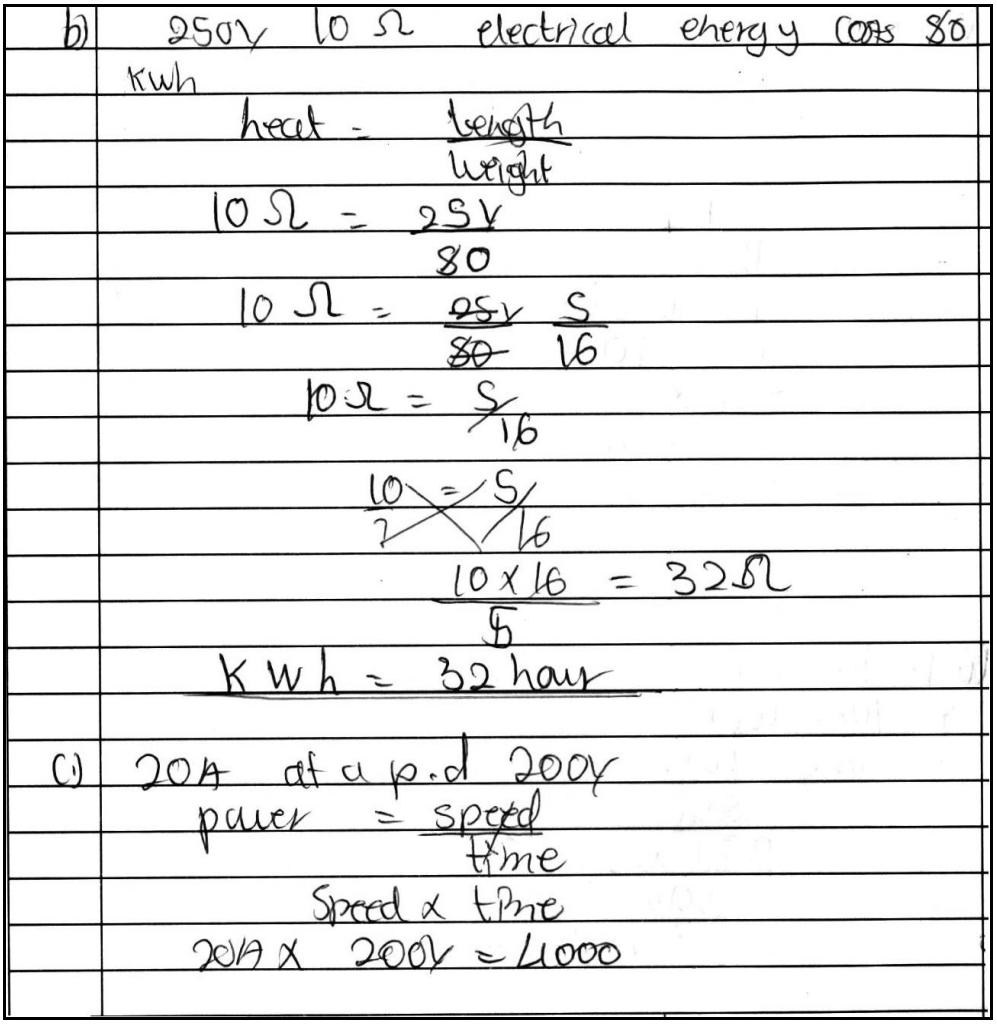
$B = IT \times \sin\theta$

$B = 5.0A \times 1000 \times 90^\circ$

$5000 \times 90^\circ = 4500$

∴ current of the ~~$= 0.71$~~ secondar is

0.71



Extract 15.2 shows the answer of a candidate with good performance in this question.

2.3.5 Question 16: Sound Wave

This question had three parts, (a), (b), and (c). In part (a) the candidates were required to define the following terms: (i) Echo (ii) Reverberation.

In part (b), the question was as follows: *A ship using an echo-sounding device receives an echo from a wreck 0.8 sec after the sound is transmitted. If the velocity of sound in sea water is 1500 m/sec, determine the depth of the wreck.*

Part (c) of the question was as follows: *A pipe open at both ends is dipped in water with one end open over the water. A radio producing the music of frequency 512 Hz is brought very close to the mouth of the pipe. If the radio and the pipe are then raised, find the length of the air column in the pipe*

for the first resonance, and when next resonance occurs. Note: End correction is neglected. Velocity of sound in air = 340 m/sec.

The question was opted for by 448 (32.2%) candidates, out of those 242 (54%) scored 0 to 5.5 marks; 114 (25.5%) scored 6 to 12.5 marks; and 92 (20.5%) scored 13 to 20 marks. This performance is also signposted by Figure 16 which shows the percentage of candidates' performance graphically.

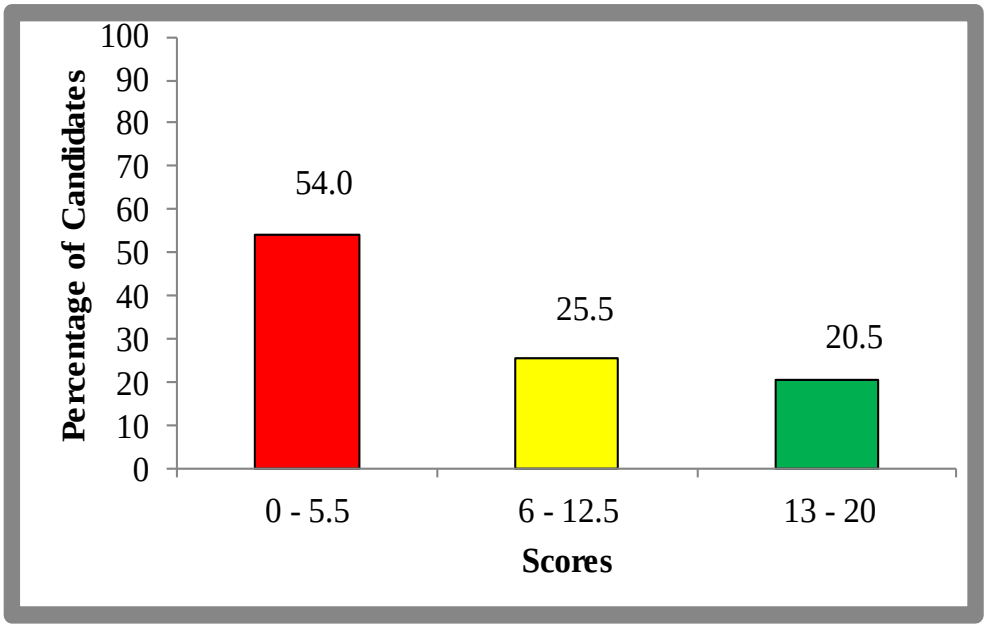


Figure16: *Percentage of Candidates' Performance in Question 16.*

The candidates' performance in this question was average. The candidates failed to define the term Echo and Reverberation. These candidates could not write down any relevant formula in part (b) and (c). These candidates failed even to write down the data from the question. Extract 16.1 shows a sample of a poor response extracted from a script of a candidate.

Extract 16.1

16 @. Define:

(i) Echo - Is the frequence of the wave to increase to velocity in machine.

(ii) Reverberation - Is the vibrale in the sound from the velocity frequence of one place to another place.

16 (b).

Data given.

Sounding 0.8 second

Velocity sound 1500 m/sec

Wreck?

solution

From

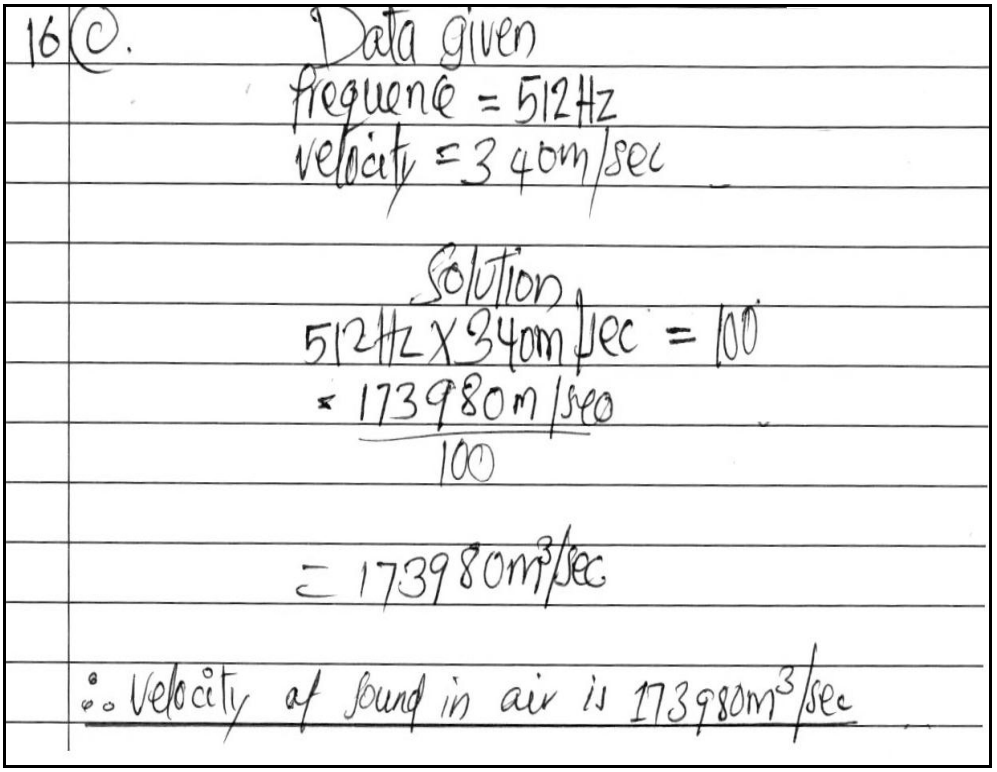
0.8 x 1500 m/sec = Wreck.

By formulae

$$\text{Mass} = \frac{\text{molar mass substance}}{\text{molar substance}}$$

$0.8 \times 1500 = 1200.0 \text{ m/sec}$

∴ Velocity of wreck is 1200.0 m/sec



Extract 16.1 depicts a sample of a poor answer as extracted from the candidate's script.

Most of the candidates who scored from 6 marks to 13 marks performed well in part (a) and (b) of the question but poorly in part (c). Some of the candidates managed to define well an echo and reverberation in part (a) but faced some difficulties in either part (b) or part (c). Several candidates were not able to form the equation for finding the depth (h) of the wreck, but managed to form relevant equations for calculating the lengths for the first and second resonance and hence being able to compute the corresponding values of the lengths in part (c). Few candidates managed to form the equation for calculating the depth (h) of the wreck $h = \frac{vt}{2}$ in part (b), but they failed to form the equation for the lengths for the first and second resonance in part (c).

Some candidates were able to score all 20 marks allocated to this question. These candidates managed to define the terms echo and reverberation, in part (a). Also, they managed to establish the equation for the velocity of sound in water, $v = \frac{2h}{t}$ from which they calculated the depth (h) of the sea,

in part (b). They presented their responses neatly and systematically, with diagrams to illustrate their answers. In part (c), they managed to form the relevant equations for calculating the lengths for the first and second resonance. The equations were: $L_0 = \frac{\lambda_0}{4}$; $V = f\lambda$; $L_0 = \frac{340}{4 \times 512}$; and for the $L_1 = \frac{3\lambda_1}{4}$; $L_1 = \frac{3 \times 340}{512 \times 4}$;

These candidates exhibited competence in the topic of Sound and mode of vibrations in pipes in particular. Extract 16.2 shows a sample of a good response as extracted from a script of a candidate.

Extract 16.2

16 a/ i/ Echo is a reflected sound

ii/ Reverberation is the multiple reflection of sound.

16. b/ Data given

time (t) = 0.8 sec

velocity (v) = 1500 m/sec

depth (d) = ?

From

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

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

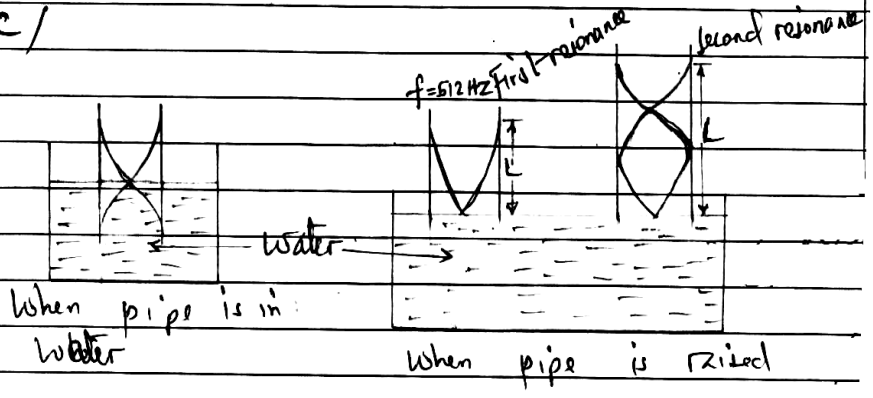
$$= \frac{1500 \times 0.8}{2}$$

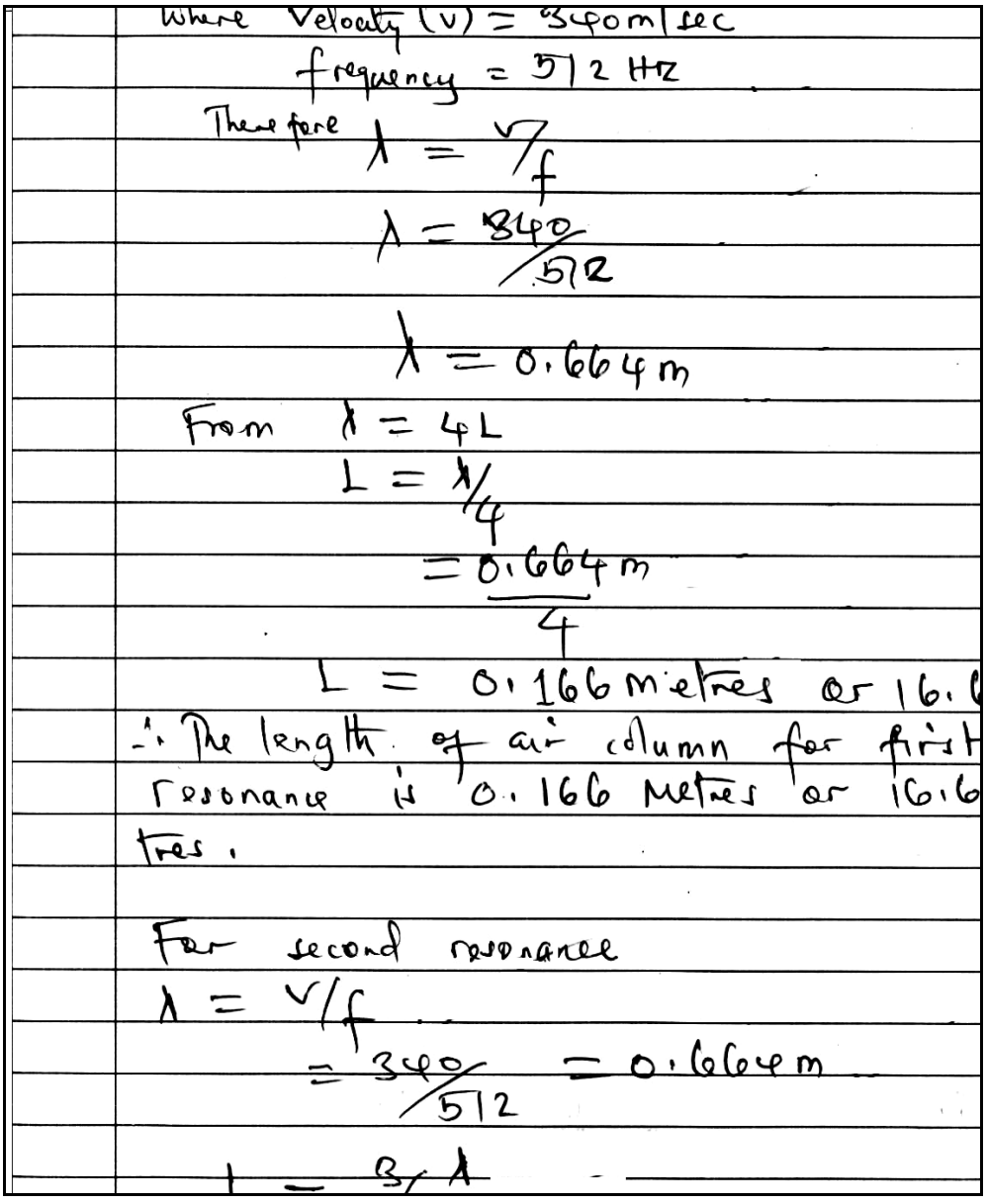
$$= 1500 \times 0.4$$

$$= 600 \text{ m}$$

∴ Depth of wreck is 600 Metres.

16. c/





Extract 16.2 shows a sample of good response extracted from a script of the candidate.

3.0 THE CANDIDATES' PERFORMANCE ON EACH TOPIC

A topic-wise analysis indicated that the performance of the candidates on the multiple choice questions from various topics was good, 75.7 % of the candidates were above average and the item (i) from the topic forces, sub-topic vector quantities was well performed, and the item (x) was poorly performed.

The topics which were performed well were Light (Optics); Work, Energy and Power, Simple Machines, Angular Motion, Electricity and Magnetism where by the topic of Fluid Mechanics was performed below the average.

Under short answer questions, question number 8 on Fluid Mechanics was performed below the average (25.5%). Candidates could not show competences derived from the objectives set on the topic of Fluid mechanics particularly on variations of pressure/ volume under Boyle's law.

On the structured questions, question 16 was the most skipped question by candidates and was the worst performed as 54% of the candidates scored below average. Poor candidate's performance was due to lack of knowledge on the specific content and insufficient practices on computational skills required on the questions under short answer and structured questions.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This report critically shows the candidates' performance of each question. It has revealed the strengths and weaknesses shown by the candidates in answering questions in the engineering science subject. The most notable strengths shown include candidates' competences to identify the requirements of the question and ability to recall some theories, formulae principles and laws in engineering science subject. However, some of the candidates performed poorly due to lack of knowledge and skills in some of the topics, using incorrect formulae in computations and failure to explore the requirements of the question. It is obvious that some candidates lacked knowledge of various engineering science concepts. Therefore, they failed to apply scientific laws and formulae in answering the questions. The general performance of candidates in this subject was average.

A slight improvement of candidates' performance has been noted in the CSEE 2018 for Engineering Science in comparison to CSEE 2017. The number of candidates who got grades A and C has increased while grade D and F has decreased. The analysis of the candidates' overall performance per topic in Engineering Science for 2018 is presented in Appendix I while the comparison of the candidates' grades between 2018 and 2017 is presented in Appendix II.

4.2 Recommendations

In order to improve the standard of performance in Engineering science subject the following recommendations should be observed:

(a) Students should be thoroughly taught the best use of numerals using Four Figures so as to equip them with skills necessary for mathematical tables/Four Figures computation.

(b) Students should develop self-study behaviors to acquire skills which will enable them understand the requirements of the questions when doing examinations.

(c) Teachers should guide students to acquire mathematical skills by giving them enough class exercises in the topics of Fluid of Mechanics, Measurements and Units, Electricity and Magnetism. This will enable the students to solve problems which involve calculations.

(d) Students should be guided to practise drawings that will help them acquire skills to draw/sketch neatly labeled diagrams and graphs.

Appendix I

Analysis of the Candidates' Performance Topic-wise in CSEE 2018 Engineering Science subject

S/N	Topics	Question Number	Percentage of candidates who scored 30 percent or more.	Recommendations
1	Multiple choice question from various topics	Q_1	75.7	Good
2	Light (Optics)	Q_7+Q_{12}	62.4	Average
3	Work, Energy and Power	Q_5+Q_{10}	59.3	Average
4	Angular Motion	Q_6+Q_{13}	53.7	Average
5	Measurement and units	Q_4+Q_{10}	48.8	Average
6	Sound	Q_{16}	46	Average
7	Electricity and Magnetism	Q_3,+ Q_{11},+ Q_{15}	45.1	Average
8	Simple Machine	Q_2+Q_9	43.5	Average
9	Fluid Mechanics	Q_8	25.5	Weak

Appendix II

The Comparison of the Candidates' Grades between 2018 And 2017

GRADES	**A**	**B**	**C**	**D**	**F**
YEAR (2018)	117	164	392	282	435
YEAR (2017)	68	170	380	284	555