



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



**CANDIDATES' ITEM RESPONSE ANALYSIS  
REPORT ON THE CERTIFICATE OF SECONDARY  
EDUCATION EXAMINATION (CSEE) 2021**

**ENGINEERING SCIENCE**



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**035 ENGINEERING SCIENCE**

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## **FOREWORD**

The Certificate of Secondary Education Examination (CSEE) marks the end of four years of secondary education. This summative evaluation shows the effectiveness of the education system in general and the education delivery system in particular. The candidates' responses to the examination questions strongly indicate what the education system managed to offer to the students in their four years of secondary education.

The candidates' item response analysis report on the CSEE 2021 in Engineering Science subject has been prepared to give feedback to students, teachers, parents, policy makers and the public in general on how the candidates responded to the examination questions and how they were required to respond.

The analysis presented in this report will help various educational stakeholders to understand the reasons which led to the performance in the Engineering Science subject. It also points out factors which led the candidates fail to score high marks on the questions, including failure to identify the requirement of the questions, lack of drawing skills, lack of mathematical skills and poor knowledge of the topics. The views provided in this report will help educational administrators, school managers, teachers, and students to identify appropriate methods to improve the candidates' performance in future.

Finally, the Council would like to thank all examination officers, examiners and others who participated in preparing this report. The Council is also grateful to staff members who participated in processing the data used in this report.



Dr Charles E. Msonde  
**EXECUTIVE SECRETARY**

## 1.0 INTRODUCTION

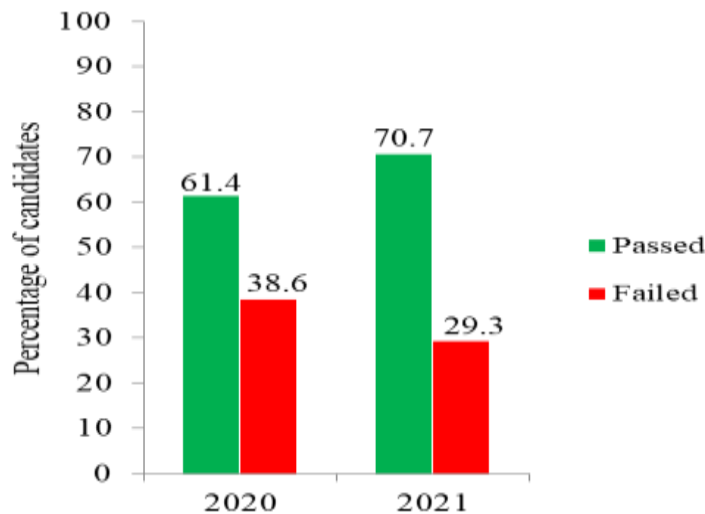
This report presents the candidates' performance on 2021 Certificate of Secondary Education Examination (CSEE) in the Engineering Science subject. The report focuses on the candidates' competences as per ordinary level secondary education syllabus for the Engineering Science subject. It analyses the candidates' performance and reveals on how the candidates performed on each question by identifying the candidates' strengths and weaknesses in each question attempted. The report further exposes the questions which were attempted by most candidates and those which were skipped.

The Engineering Science paper had 14 questions which were divided into three sections A, B, and C. Section A comprised of one (1) question consisting of ten (10) multiple choice items each carrying 1 mark. Section B consisted of nine (9) short answer questions each carrying ten (10) marks. Section C consisted of four (4) structured questions each carrying fifteen (15) marks. The candidates were required to answer all questions in sections A and B, and choose three questions from section C.

A total of 1407 candidates sat for the Engineering Science Examination, whereby 994 (70.7%) candidates passed while 413 (29.3%) failed. In 2020 the candidates who sat for the examination were 1312. Among them 805 (61.36%) candidates passed and 507 (38.64%) failed. Hence, the candidates' performance in the year 2021 increased by 9.34 per cent compared to that of 2020.

**Table 1: The Comparison of Candidates' Grade Scores in the Years 2020 and 2021**

Year	Candidates' Grade Scores					
	SAT	A	B	C	D	F
2020	1312	17	78	354	356	507
	100%	1.3%	5.9%	27.0%	27.1%	38.6%
2021	1407	134	180	407	273	412
	100%	9.5%	12.8%	28.9%	18.4%	29.3%



**Figure 1:** *Comparison of Candidates' Performance in 2020 and 2021*

The report also analyses the candidates' performance on each question. The analysis categorises the performance as weak, average, and good if the percentage of candidates' who scored from 30 percent and above are within the ranges of 0 – 29, 30 – 64, and 65 – 100, respectively. For emphasis, these ranges are represented by red, yellow and green colours respectively.

The analysis presents the requirements of each question, candidates' strengths and weaknesses in their responses. The percentage of candidates in each group of scores is presented using graphs. Finally, the report provides conclusion and recommendations.

## **2.0 ANALYSIS OF PERFORMANCE ON INDIVIDUAL QUESTIONS**

### **2.1 SECTION A: OBJECTIVE TYPE QUESTIONS**

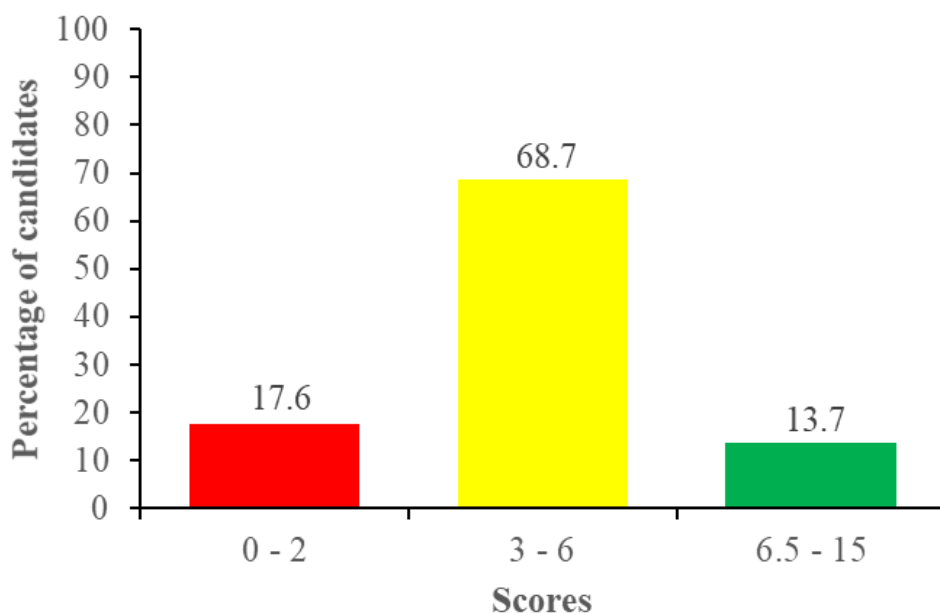
This section consisted of one objective question. The question consisted of ten (10) multiple choice items. Each item carried 1 mark, making a total of 10 marks.

#### **2.1.1 Question 1: Multiple Choice Question**

The question consisted of ten (10) multiple choice items. For each item, the candidates were required to choose the correct answer from the five given alternatives and write letter against the item number in the answer booklet provided. The items in this question were composed from nine (9) topics,

namely *Periodic Motion, Unit and Measurements, Light (Optics), Projectile Motion, Simple Machines, Strength of Materials, Turning Forces, Linear Motion and Friction.*

The analysis shows that 1407 (100%) candidates attempted this question. Further analysis shows that 247 (17.6 %) candidates who attempted the question scored from 0 to 2 marks; 967 (68.7 %) scored from 3 to 6 marks whereas 193 (13.7 %) scored from 7 to 10 marks. The analysis is summarized in Figure 2.



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

Data in Figure 2 shows that, most of the candidates (82.4%) scored 3 to 6 marks. These candidates provided the correct answers for 3 up to 6 items. Moreover, only 193 (13.7%) candidates were able to answer 6 up to 10 items correctly and out of these only 7 (0.5%) candidates scored 10 marks allocated to this question. These candidates had good understanding on the concepts tested.

Further analysis shows that the item which most of the candidates selected the correct responses was item number (ii). This item measured the concept on measurements. The results suggest that the candidates had appropriate knowledge necessary to read and write the reading from the micrometer



screw gauge. Item (i), (iii), (v), (vi), (vii), (viii), (ix), and (x) were moderately selected, suggesting that majority of the candidates had necessary knowledge in the relevant topics. The item which most of the candidates selected the wrong alternative was item number (iv). The analysis of candidates' responses in each item is presented as follows:

Item (i) was constructed from the topic *Periodic Motion*. It required the candidates to identify the true conditions about the acceleration of an object moving in periodic motion among the five given conditions. The question was:

*Which of the condition (1 – 5), are true about the acceleration of an object moving in a periodic motion?*

- (1) *Directed towards a fixed point in its path.*
  - (2) *Proportional to its distance from the fixed point*
  - (3) *Inversely proportional to its distance from the fixed point.*
  - (4) *Moving away from the force applied*
  - (5) *Having the same magnitude as the force applied*
- A (1) and (2)                      B (1) and (3)                      C (2) and (3)  
D (3) and (4)                      E (1) and (5)

Most of the candidates chose distractors instead of the correct response, which is option A (1) and (2), (1) *Directed towards a fixed point in its path* and (2) *Proportional to its distance from the fixed point*. Through the analysis of their choices, it was revealed that they failed to use the knowledge of a simple harmonic diagram for oscillating body to classify the focus and the direction of acceleration of a body.

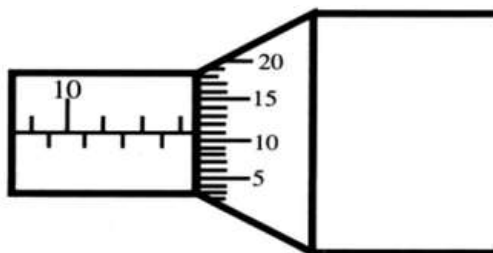
Furthermore, they did not realize that the acceleration of an object moving in a periodic motion encounters a restoring force which causes an object to move back toward its stable equilibrium position where the net force on it is zero and the direction of the acceleration is inwards.

Those who chose C confused that, the acceleration is not inversely proportional; it is directly proportional to its distance. Those who chose D and E did not understand that in a periodic motion when a body moves to and fro about a fixed mean position its acceleration is proportional to the displacement of object from the mean position and is always directed towards the mean position.

Item (ii) was set from the topic *Unit and Measurements*. The candidates were required to read the micrometer screw gauge and choose the correct response.

The question asked:

*What is the reading of the micrometer screw gauge shown in the Figure?*



- A 13.15      B 10.13      C 13.05      D 13.11      E 10.11

The correct response was D *13.11*. Most candidates had the knowledge of reading the micrometer screw gauge and therefore they chose the correct response. Few candidates were unable to choose the correct answer as most of them chose option E *11.13*. The candidates failed to demonstrate that, it could be seen that the marking on the main scale which is just on the left of the thimble was 13 mm. The half scale division displayed below the main scale, however, should not be neglected, and the reading on the main scale would continue to be 13.0 mm, as half scale was 0. For the auxiliary scale reading (Thimble), it should have been noted that the 11<sup>th</sup> division on the thimble scale matched with the main scale. Thus, the thimble scale reading would be 0.11 mm. The final reading would be the addition of these two readings that is,  $13.0 + 0.11$  and the micrometer reading thus could be 13.11 mm.

Item (iii) was constructed from the topic of *Light*. The candidates were required to identify the correct set of the nature of image formed by a convex mirror when the image is situated behind the mirror, between the principle focus and the pole.

The question asked:

*What will be the nature of the image formed by convex mirror when situated behind the mirror between principal focus and pole?*

- A *Virtual, erect and diminished*  
B *Real, inverted and diminished*  
C *Virtual, erect and magnified*

- D    *Real, inverted and magnified*  
E    *Virtual erect and the same size as the object*

The correct response was A *Virtual, erect and diminished*. Most of the candidates interpreted correctly the set containing the nature of the image formed in the mirror. This suggests that the candidates had knowledge about the properties of the image formed in curved mirrors especially convex mirror. They had the concept that, image formed by a convex mirror no matter where the object is placed the mirror produces virtual, upright, and smaller image than the object. Also as the object is moved closer to the mirror, the image approaches the size of the object. A few candidates chose among the wrong alternative B *Real, inverted and diminished*, C *Virtual, erect and magnified*, D *Real inverted and magnified* and E *Virtual erect and the same size as the object*. The candidates' weaknesses observed was their unawareness that, in convex mirror the image is virtual and not real and is diminished not magnified.

On the other hand, the candidates who failed to choose the correct answer lacked the knowledge and skills to draw a convex mirror which could demonstrate how an image is formed. Thus, they chose incorrect options by gambling on alternative of the question.

Item (iv) was constructed from the topic *Projectile Motion*. The candidates were required to determine whether the results would be similar if two balls held at the same level were thrown with the same speed at an angle of  $60^\circ$  and  $30^\circ$ .

The question asked:

*Which result will be the same, if two balls held at the same level are thrown with same speed at an angle of  $60^\circ$  and  $30^\circ$  respectively?*

- |                                     |                                 |
|-------------------------------------|---------------------------------|
| A <i>Their maximum height</i>       | B <i>Their landing velocity</i> |
| C <i>Their time of flight</i>       | D <i>Their range</i>            |
| E <i>Their landing acceleration</i> |                                 |

Most of the candidates chose an incorrect alternative C *Their time of flight*, instead of the correct one D *Their range*. The candidates did not understand that when an object is thrown at  $30^\circ$  angle, it travels laterally faster and spends less time in the air than when thrown at  $60^\circ$  angle. The object thrown at a  $60^\circ$  angle, on the other hand, remains in the air for a longer period of time

and goes horizontally slower than the object thrown at a  $30^\circ$  angle. These two impacts happen to be exactly equal for the angles of  $60^\circ$  and  $30^\circ$  degrees. They further failed to demonstrate that, from the 'range' formula given as  $s = \frac{u^2 \sin 2\theta}{g}$  it leads to the same response for the complement angles.

Therefore, for the two balls held at the same level and thrown with the same speed at an angle of  $30^\circ$  and  $60^\circ$ , their ranges are the same.

Item (v) was constructed from the topic *Simple Machines*. It required the candidates to choose the five given alternatives which represent '*the ratio of load to effort in simple machine*'.

The question asked:

*What does the ratio of load over effort in simple machine represents?*

- |   |                                |   |                             |
|---|--------------------------------|---|-----------------------------|
| A | <i>Movement ratio</i>          | B | <i>Mechanical advantage</i> |
| C | <i>Velocity ratio</i>          | D | <i>Force ratio</i>          |
| E | <i>Mechanical disadvantage</i> |   |                             |

Most of the candidates who attempted this item chose the correct response B *Mechanical Advantage*. Majority of the candidates who failed to choose correct answer chose option D *Force ratio*. These candidates confused the term force ratio because even load over effort is the force. They did not know that load over effort is a force ratio which is the mechanical advantage. They did not recognize that, not all force ratios is Mechanical advantage. Also effort over load is a force ratio, but mechanical advantage is only a ratio of load over effort. Therefore, option D was good distractor which led some of the candidates who were not knowledgeable to select it and thus failed. Others chose either option A *Movement ratio*, C *Velocity ratio* or E *Mechanical disadvantage*. Those who chose A did not understand that movement ratio is the distance moved by the effort to the distance moved by the load which is the velocity ratio, contrarily to the mechanical advantage. While those who chose C *Velocity ratio* failed to understand that the velocity ratio is the ratio of distance moved by effort over distance moved by load. Finally, some of the candidates chose option E *Mechanical disadvantage*. These candidates did not recognise that a lever is said to be at mechanical disadvantage when the load arm is longer than the effort arm.

Item (vi) was set from the topic 'Force'. The candidates were required to choose the option which explains what happens to the rubber belt fitted between two pulleys of a motor and milling machine which is in tension of the force applied.

The question asked:

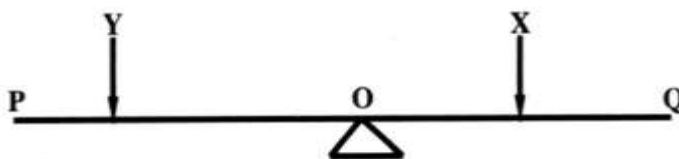
*What happens to the rubber belt fitted between the pulleys of a motor and milling machine which is in tension of the force applied?*

- A *It tends to be compressed*      B *It tends to be stretched*  
C *It tends to slide on one side*      D *It decreases in area*  
E *It increases in area*

Most of the candidates failed to choose the correct answer which was option B *It tends to be stretched*. Their responses indicate that they were knowledgeable about the acting force pulley belt. Those who chose option A *It tends to be compressed* were unaware that the force in the pulley belt is drawn towards the pulley and that is why there is tension in the belt. They could not differentiate between compressed force and tension force. Those who chose option C *It tends to slide on both sides*, did not know that this was a distractor that explains how the belt slides on both sides, but the force in the belt is stretched towards the pulley. Other candidates who selected option D *it decreases in area* and E *it increases in area* did not know that the belt between pulleys has no relationship with the belt areas but tension in the belt towards the opposite direction.

In item (vii) the question was:

*The figure shows a rod 'PQ' pivoted at its center of gravity 'O' and is in equilibrium with weight X and Y. If a weight of 2X is added to X; how will the rod be in equilibrium again?*



- A *By moving weight Y to O*  
B *By adding a weight 2X to Y*  
C *By moving the weight 2X and X away from O*  
D *By adding a weight of 2Y to Y*  
E *By adding a weight of Y to Y*

Most candidates chose the correct option, which was D *adding a weight of 2Y to Y*. They were able to use the principle of moment to find equilibrium after adding a weight of 2X to X. These candidates were also able to identify the concept of center O being in the middle of the 'PQ' rod because it is located at the center of gravity which is in the middle of the rod. Thus they were able to determine that the distance from center O to force Y is equal to the distance from center O to force X. By employing principle of moments, they discovered that in order for the rod to be balanced, a weight 2Y should be added to Y, and therefore they chose the proper option D. Some candidates could not use the principle of moment so they failed to choose the right answer, so they ended up gambling and choosing the wrong option.

In item (viii), the candidates were required to choose the graph which is suitable to represent the motion of a body moving in a straight line with a uniform acceleration.

The question asked:

*Which one is a suitable graph to represent motion of a body moving in a straight line with a uniform acceleration?*

- A    *Displacement against time graph*    B    *Acceleration against time graph*  
 C    *Velocity against time graph*            D    *Distance against time graph*  
 E    *Speed against time graph*

Majority of the candidates chose the correct response, which is C *Velocity against time graph*. These candidates were able to distinguish between the graphs in other alternatives. This shows that the candidates had the idea in mind that, velocity - time graph is the only one that involves acceleration that causes velocity to change from initial to final. They were able to recognize that the slope from velocity-time graph is an acceleration of a body, that is, slope which is equal to acceleration =  $\frac{\text{velocity}}{\text{time}}$ .

Those who chose distractors A *Displacement against time graph* did not realize that displacement-time graph shows how a body moves from one point to another in a specified direction with respect to time and finally gives velocity, that is, velocity =  $\frac{\text{displacement}}{\text{time}}$ . Those who opted for B did not understand that acceleration against time graph represents a graph with a

slope known as jerk, which is the rate at which an acceleration of object changes with respect to time. Those who chose option *D* and *E*, did not know that distance against time graph gives speed which is not uniform acceleration and speed against time represent a scalar quantity which is not uniform acceleration.

In item (ix), the question was:

*Which one is equivalent to the ratio of the distance moved by the ram piston to that moved by the pump piston in hydraulic system?*

- A Radius of ram piston dividing to radius of pump piston.*
- B Radius of pump piston dividing to area of pump piston*
- C Area of ram piston dividing to area of pump piston*
- D Velocity ratio dividing to radius of pump piston*
- E Area of pump piston dividing to area of ram piston*

This item was one of the poorly performed items, since most of the candidates failed to choose correct response. To identify the correct response, the candidates were supposed to go through the derivation of the equation to calculate the velocity ratio of the hydraulic press. However, the candidates failed to identify the correct answer, which was *E area of the pump piston dividing to area of ram piston*. They did not know that, the ratio of the distance moved by the ram piston to that moved by the pump piston in hydraulic system is the velocity ratio which is equivalent to the ratio of area of a ram piston to the area of pump piston. Those who chose *A Radius of ram piston dividing to radius of pump piston* failed to recognize that, this was the reciprocal of the correct answer. The candidates who chose *B, Radius of pump piston dividing to area of pump piston* did not understand that was the ratio of irrelevant quantity. Those who chose *C Area of ram piston dividing to area of pump piston* failed to understand that, it was also the reciprocal of the correct answer and those who chose *D Velocity ratio dividing to radius of pump piston* could not figure out that it was the ratio of irrelevant quantity.

This item (x) required the candidates to choose one factor from the given five alternatives that had a huge contribution to the friction between moving surfaces.

The question asked:

*Which of the following has huge contribution to the friction between moving surface?*

- A Smoothness of surface in contact*
- B Speed of moving surface*

- C Roughness of surface in contact      D Weight of surfaces in contact*  
*E Mass of the surface in contact*

This was one of the items which were moderately performed. The correct response to this item was alternative *C Roughness of surfaces in contact*. The candidates who correctly answered it were familiar with the methods of increasing or reducing friction. Those who chose *A Smoothness of surface in contact* were not aware that smoothness contributes to remove or eliminate friction instead of increasing it. Those who chose option *B Speed of moving surface* did not know that, speed has nothing to do with increase or decrease the friction and friction does not depend on the speed of surfaces in contact. Some of the candidates, who chose alternative *D Weight of surfaces in contact*, did not understand that weight can only have contribution if the surface is rough but for smooth surface weight has got no impact in friction. The candidates who chose option *E Mass of the surface in contact* lacked the idea that mass has nothing to do with increase in friction except when the surface in contact is rough.

## **2.2 SECTION B: SHORT ANSWER QUESTIONS**

### **2.2.1 Question 2: Work, Energy, and Power**

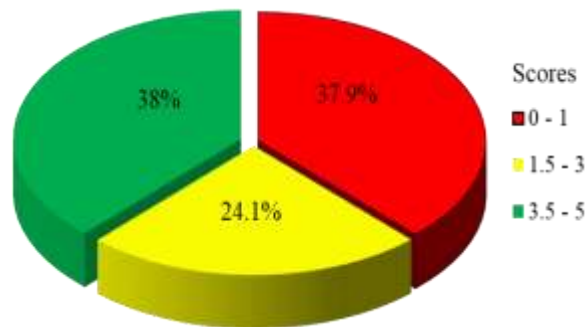
The question was as follows:

*A motor vehicle hauls a trailer at a speed of 72 km/h, when exerting a steady pull of 800N. Determine:*

- (a) The work done in MJ after 20 minutes.*
- (b) The required power.*

This question was attempted by 1407 (100%) candidates. Among them, 533 (37.9%) candidates scored from 0 to 1 mark of which 25.6 percent scored 0 marks; 24.1 per cent of the candidates scored from 1.5 to 3 marks and 38.0 per cent scored from 3.5 to 5 marks. This is one of the questions which were averagely performed. The graphical presentation of the groups of scores with respective percentage of candidates is shown in Figure 3.





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

The analysis shows that the average number of candidates (62.1%) scored average and above marks. Some of these candidates (27.4%) who scored all marks in part (a) were able to use the formula  $\text{Work done} = \text{Force} \times \text{distance}$  to calculate the distance. They were also able to write,  $\text{distance} = \text{average velocity} \times \text{time}$  to determine the work done and converted it correctly to the required unit. In part (b) they used the correct formula and substituted data correctly. Analysis further shows that, those who got average marks made small mistakes, so they could not get all the marks but they got a score range of 3.5 to 4.5 marks in this question. For example, there was one candidate who did not change the unit of work done into Mega Joule as such scored high but below 5 marks. Some candidates were able to write formulas in part (a) and (b) but either did not change the units of time from minutes to second or they failed to manipulate some portion of the question. Extract 2.1 is a sample of the good responses to Question 2.

2.	Soln.	
	Motor vehicle	
	$v = 72 \text{ km/hr}$	
	$F = 800 \text{ N}$	
	(a) Work done	
	$\text{w.d} = \text{Force} \times \text{distance}$	
	$t = 20 \text{ min}$	
	$72 \text{ km} = 1 \text{ hr} (60 \text{ min})$	
	$\therefore \frac{72}{60} \times 20 \text{ min}$	
	$d = 24 \text{ km} \rightarrow 24000 \text{ m}$	
	$\text{w.d} = 800 \text{ N} \times 24000 \text{ m} = 19200,000 \text{ Nm (J)}$	
	$M = 10^6$ $19.2 \text{ MJ}$ $\therefore \text{Work done is } 19.2 \text{ MJ}$	

**Extract 2.1:** A sample of the good responses on Question 2

In Extract 2.1, the candidate accurately calculated energy and power using the equations. Furthermore, the candidate converted the units of speed from kilometers per hour (km/h) to meters per second (m/s) and calculated the distance, which was then utilized to compute the work done.

There are those who scored between 0 and 1 mark. Most of these candidates were only able to write the formula in part (a) but failed to use it to find the distance by multiplying velocity with time. These candidates substituted the velocity instead of distance into the work done formula as a result they ended up scoring 1 mark. The analysis shows that others wrote only a formula for work done but did not continue to manipulate the question, thus had poor performance on this question. Extract 2.2 shows a sample of the poor responses.

2.	Data given	
	Speed = 72 km/hr	
	force = 800N	
	work done in 1J after 20 minutes = ?	
	required Power = ?	
	Wd = force X time	
	Speed	
	Wd = 8000 X 20 minutes	
	72 km/hr	
	Wd = 11.11 X 20	
	Wd = 222.2	
	required Power = force	
	Speed	
	= 8000 = 11.11	
	72	
	required Power = 11.11 J	

**Extract 2.2:** A sample of the poor responses on Question 2

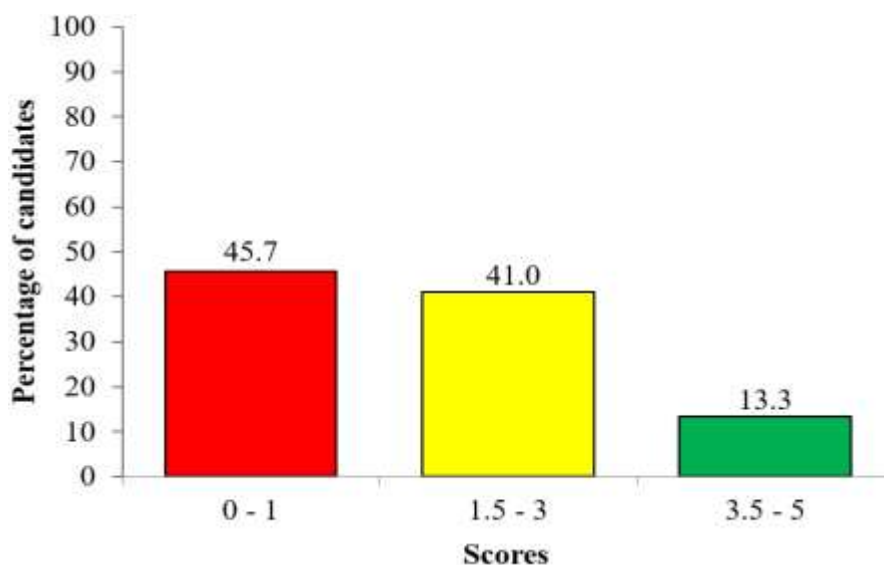
In Extract 2.2, the candidate could not recall the equations of calculating energy and power. The candidate also failed to convert the speed from kilometer per hour (km/h) to metre per second (m/s).

### 2.2.2 Question 3: Angular Motion

The question was as follows:

- (a) *What will be the effect to resistance of a metal wire as an electrical conductor when:*
- (i) *the length of the wire is increased.*
  - (ii) *the diameter of the wire is increased*
  - (iii) *the temperature of the wire is increased.*
  - (iv) *the length and diameter of the wire are doubled.*
- (b) *When does the potential difference across the terminals of a cell become equal to its e.m.f?*
- (c) *Briefly explain the fact that parallel arrangement of cells in an electric circuit is more advantageous than that of series arrangement.*

A total of 1407 (100%) candidates attempted this question. Out of these, 643 (45.7%) scored from 0 to 2 marks; 577 (41.0%) scored from 1.5 to 3 marks and 187 (13.3%) scored from 3.5 to 5 marks. Generally, the candidates' performance in this question was average. This analysis is summarized in Figure 4.



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

The data analysis shows that some of the candidates scored from 3.5 to 5.0 marks whereas 33 (2.2%) scored all the 5 marks. These candidates managed

to state the effect of length (L), diameter (D) and temperature (T) on the resistance (R) of the conductor in part (a). They knew that there is a relationship between resistance (R), length (L) and an area (A) of the conductor, that is,  $R = \frac{\rho L}{A}$  (where  $\rho$  is the resistivity of the material of the conductor. In part (b), these candidates correctly stated that, the potential difference across the terminal of the cell is equal to its *e.m.f* when the cell is not supplying a current in a circuit. They precisely explained the advantages of parallel arrangement of cells over series arrangement; that is, when cells are arranged in series. The combined resistance of the cells is maximized, thus offers greater resistance and hence reduces (minimize) the circuit current. They were aware that parallel arrangement minimizes the combined resistance of a cell, thus allowing huge amount of current to flow through the conductor.

The analysis reveals that most of the candidates who scored from 1.5 to 3.0 marks performed averagely in part (a) and (c). For example, some were merely able to write *the resistance will decrease* instead of writing *the resistance will decrease by 0.5 of the original resistance* in part (a) (iv). In part (c), some wrote about bulb as the disadvantages of arranging them in series on the circuit components instead of focusing cells. Some of them confused the arrangement in series and parallel resistors with that of cells as a result they ended up scoring average scores. Extract 3.1 is a sample response of well performed by the candidate on this question.

3	(a)	
	(i)	If the length of wire is increased the resistance of wire also increase i.e. $R \propto L$ .
	(ii)	If the diameter of wire is increased it cause the increase in cross sectional area therefore the resistance of wire decreased. $R \propto \frac{1}{A}$ .
	(iii)	If the temperature of a wire is increased the resistance of wire also increased $R \propto T$ .
	(iv)	If the length of wire is double the resistance of wire also doubled and if the diameter is doubled the resistance of wire halved.
	(b)	Potential difference across terminal of a battery become equal to its emf when no load connected.
	(c)	Parallel arrangement of cell in electric circuit is more advantageous than the series arrangement because parallel arrangement lead to low internal resistance and also voltage at each cell are equal compared to series arrangement.

**Extract 3.1:** An example of the good responses on Question 3

Extract 3.1 shows the responses of the candidate who managed to state the effect to resistance of a metal wire as an electrical conductor when the length, diameter, temperature of the wire is increased and both the length and diameter of the wire are doubled. He/she also explained the relationship between the potential differences across the terminals of a cell when become equal to its *e.m.f.* He/she further managed to explain briefly the fact that parallel arrangement of cells in an electric circuit is more advantageous than that of series arrangement.

Further analysis reveals that most of the candidates who scored from 0 to 1 mark had insufficient knowledge about electricity. Some of them wrote

correct responses only in part (a) (i) and (ii) but failed to answer correctly on the remaining items. From their responses it reveals that, most of these candidates provided irrelevant answers with regard to the question. For example, one candidate wrote in part (a) (i) *the current will increase* (ii) *power will be increased*. In part (b) the candidates were not able to understand the question as most of them skipped the item while some responded as *when are connected in parallel*. Extract 3.2 is a sample of poor responses to the question.

3	i/ The flow of electric current will become long.	
	ii/ The flow of electric current will become wider.	
	iii/ The rate of electric current will decrease.	
	c/ Because the flow of electric current goes in circular motion on a circuit.	

**Extract 3.2:** An example of the poor responses on Question 3

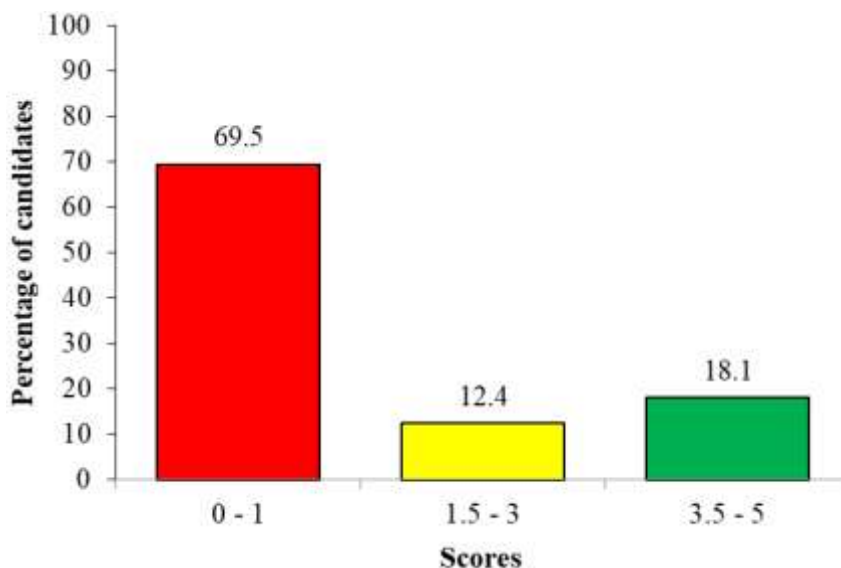
Extract 3.2 shows a poor response from the candidate who was not knowledgeable about the factors affecting the resistance of a conductor. He/she was not aware of the relationship between potential difference and electromotive force and the advantageous of parallel over series arrangement of resistors.

### 2.2.3 Question 4: Fluid Mechanics

The question was as follows:

*The mass of a density bottle is 18 g when empty, and 44 g when full of water. What will be the density of liquid when the bottle is replaced with another liquid and the mass is 39.84 g when full of the liquid.*

The analysis indicates that 1407 (100%) candidates attempted this question. Among them, 978 (69.5%) scored from 0 to 1 mark, of which 45.9 percent scored zero; 12.4 percent scored from 1.5 to 3 marks and 18.1 percent scored from 3.5 to 5 marks. The general performance of the candidates in this question was average. Figure 5 illustrates this performance.



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


The analysis reveals that the candidates, who scored 5 marks, calculated correctly the mass of liquid by subtracting the mass of an empty bottle from the mass of the bottle with the liquid. They also determined the mass of an equal volume of water by subtracting the mass of an empty bottle from the mass of the bottle with water. Then, they divided the quantity of mass of the liquid by the quantity of mass of an equal volume of water; therefore they obtained the relative density of the liquid.

Lastly, they used the value of the relative density to calculate the value of density using, the relationship that, the relative density is equal to the ratio of the mass of the substance to the mass of an equal volume of water. From the analysis of their responses, it is revealed that these candidates were knowledgeable about the subtopic of density and relative density of substances. Apart from those who scored all the 5 marks, others scored high marks but less than 5 marks. Some of these were able to cover a large part of the question but made minor mistakes in some parts of the question. For example, one candidate was able to write the correct formula of relative density and density but in calculation did not subtract the mass of an empty bottle, in determining the mass of an equal volume of water, thus scored less than 5 marks. Some of the candidates could not find the density of liquid as well as the relative density. These candidates could not figure out

that in order to get the density of the liquid they had to take the relative density of 0.84 multiplied by the density of an equal volume of water which is constant  $1 \text{ g/cm}^3$ . Hence, they could not score full marks although they got high marks.

Another group of candidates are those who performed averagely. Most of them remembered and wrote the equations for calculating relative density of a substance but failed to perform the subsequent computations. Extract 4.1 is a sample of the good responses to Question 4.



4.	$\rho_L = \frac{m_L \times \rho_w}{m_w}$	
	$m_w$	
	$\rho_L = 0.02184 \text{ kg} \times 1000 \text{ kg/m}^3$	
	$0.026 \text{ kg.}$	
	$\rho_L = 840 \text{ kg/m}^3.$	
	$\therefore \text{Density of liquid is } 840 \text{ kg/m}^3.$	
	liquid.	
	$\rho_{\text{liquid}} = ?$	
	bottle + m liquid = 39.84g.	
		
	mass of liquid = 21.84g.	
	$\rho \text{ of liquid} = \frac{\text{mass of liquid}}{\text{volume of liquid.}}$	
	$\rho \text{ of water} = \frac{\text{mass of water}}{\text{volume of water}}$	
	volume of water = volume of liquid.	
	$V_L = \frac{\text{mass}_L}{\rho_L}$	
	$V_w = \frac{m_w}{\rho_w}$	
	$V_L = V_w$	
	$\frac{m_L}{\rho_L} = \frac{m_w}{\rho_w}$	
	$\rho_w = 1000 \text{ kg/m}^3.$	
	$m_w = 26 \text{ g} \rightarrow 0.026 \text{ kg}$	
	$m_L = 21.84 \text{ g} \rightarrow 0.02184 \text{ kg.}$	

**Extract 4.1:** A sample of the good responses on Question 4

Extract 4.1 indicates that, the candidate succeeded to use the relation of ‘relative density = the ratio of the mass of the substance to the mass of an equal volume of water’ to find the relative density of the liquid and then its density.

From the analysis on this question, it is justified that, the candidates who demonstrated inadequate knowledge about the topic scored from 0 to 1 mark. Some of them failed even to write down the formula of calculating density and relative density and hence ended up scoring zero on this question. Others wrote only density formula but failed to manipulate the question. From their responses, it was revealing that the candidate demonstrates poor understanding of the density bottle and its usage. They failed to obtain the mass of water and liquid by using density bottle. Extract 4.2 is a sample of poor responses to the question.

4.	Data given	
	Empty bottle = 18g	
	Full bottle = 44g	
	Mass = 39.84g	
	Density = ?	
	$\rho = \frac{\text{Mass}}{\text{Volume}}$	
	$\rho = \frac{39.84g}{44}$	
	$\rho = 0.91 \times 18$	
	$= 16.38$	

**Extract 4.2:** An example of the poor responses on Question 5

Extract 4.2 is a sample response from the candidates who was not able to use density of bottle to calculate the relative density and density. The candidate wrote the equation  $\rho = \frac{\text{mass}}{\text{volume}}$  which was not useful for this question.

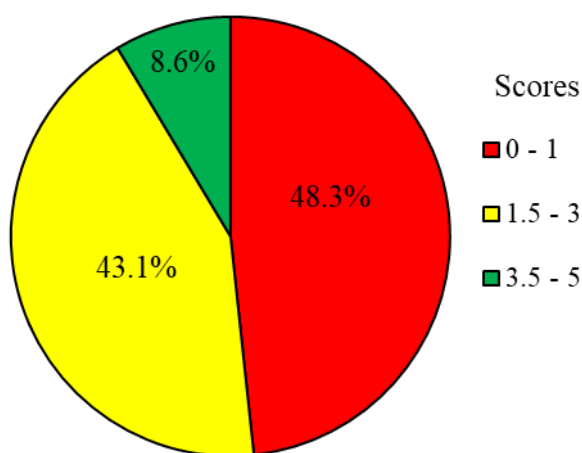
#### 2.2.4 Question 5: Linear Motion

Question 5 was as follows:

- (a) What happens to the speed of sound in air if:
- The air pressure rises
  - The air temperature rises
  - The air humidity rises

- (b) (i) *What is the relationship between the velocity, frequency and wavelength of a sound wave?*
- (ii) *In which state of matter does a sound wave travel faster?*
- (iii) *Why a sound wave does not pass through a vacuum?*

A total of 1407 (100%) candidates attempted this question, out of which 679 (48.3%) candidates scored from 0 to 1 mark, 607 (43.1%) scored from 1.5 to 3 marks and 121 (8.6%) scored from 3.5 to 5 marks. Generally, the candidates' performance in this question was average. Figure 6 presents scores with respect to the percentage of the candidates.



**Figure 6:** *The Candidates' Performance in Question 5*

The analysis shows that, Question 5 was averagely performed as 51.7 per cent of candidates scored average and above marks. Among these candidates, some scored from 3.5 to 5.0 marks. These candidates were able to explain the effects of temperature, humidity and air pressure on speed of sound in air as well as managed to state the relationship between velocity ( $v$ ), frequency ( $f$ ) and wave length ( $\lambda$ ) of sound as  $v = f\lambda$  in part (a) and (b) (i) respectively. In addition, the candidates were able to identify the state of solids as a state of matter in which sound travel faster. On top of that, they were able to explain reason for sound wave not to pass through a vacuum in part (b) (iii). Some of them provided response like *sound waves require particles that would oscillate or vibrate to propagate the sound waves from one point to another.*

Further analysis shows that most of these candidates who scored from 1.5 to 3.0 marks managed to give correct responses in part (b) but failed to explain what happens to the speed of sound in air if air temperature, air pressure and air humidity rise. These candidates were not familiar with the factors affecting the speed of sound in air. Extract 5.1 shows one of the best responses extracted from the script of a candidate.

05(a) i).	The rise in pressure there is no effect to sound because sound does not depend on pressure.	
ii)	Increase in temperature lead to increase in velocity of sound	
iii).	Air humidity rise lead to increase in sound velocity.	
5 (b) i)	Relationship of velocity, frequency and wavelength	
	Frequency = $\frac{1}{\text{Time}}$	
	Velocity = $\frac{\text{distance}}{\text{Time}}$	
	In wave distance = wavelength ( $\lambda$ )	
	velocity = $\frac{\text{wavelength } (\lambda)}{\text{Time } (T)}$	
	Frequency = $\frac{1}{T} = \frac{1}{\lambda \times F}$	
	$= \frac{1}{\lambda} \times \frac{v}{\lambda}$	
	Frequency = $\frac{\text{velocity}}{\text{wavelength}}$	
	Relationship v & F = $\frac{\text{velocity}}{\text{wavelength}}$	
	$F = \frac{v}{\lambda}$	
5 b	ii Sound travel faster in solid matter because are closely packed together.	
	iii). Sound do not pass in vacuum because sound require material medium to travel and in vacuum there is no material medium for sound to	

**Extract 5.1:** A sample of candidates' good responses on Question 5

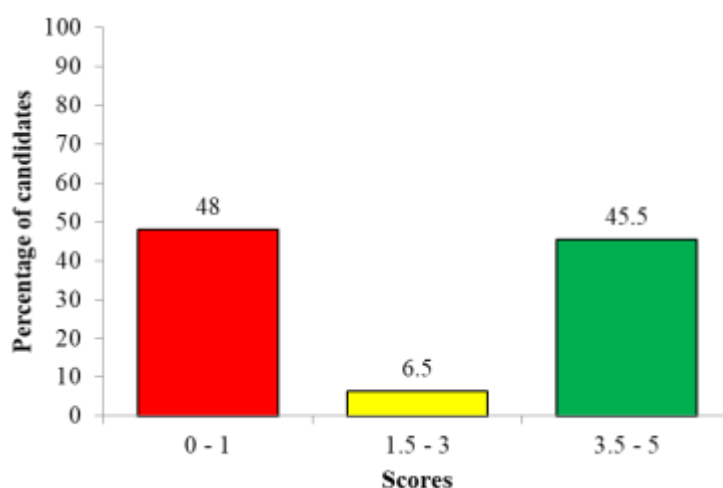
On other hand, some of the candidates who scored from 0 to 1 mark could neither not state any factor affecting the speed of sound in air nor the relationship between velocity, frequency, and wavelength in part (a) and (b). These candidates seemed to be unfamiliar with the topic of sound waves. They failed even to recall  $v = f\lambda$ , the relationship between velocity, frequency and wavelength.

### 2.2.5 Question 6: Angular Motion

The candidates were asked the following question:

- (a) *Briefly explain the term centripetal force.*
- (b) *If a body of mass 0.5 kg is rotating around a horizontal circular plane of radius 2m, at a constant speed of 10m/s, find the angular velocity of a body.*

The question was attempted by 1407 (100 %) candidates, out of which 675 (48%) candidates scored from 0 to 1 mark; 92 (6.5%) scored from 1.5 to 3 marks and 640 (45.8%) scored from 3.5 to 5 marks. The candidates' performance in this question was categorized as average because 52 per cent of the candidates scored average and above. The graphical presentation of performance of the candidates is summarized in Figure 7.



**Figure 7:** *The Candidates' Performance in Question 6*

After analysing the candidates' responses on this question it was discovered that, the average number of candidates 732 (52%) scored from 1.5 to 5

marks. Some of these 384 (27.3%) had the knowledge and skills related to centripetal force and the angular velocity of a body rotating around a horizontal circular plane. These candidates who scored all the 5 marks allotted to this question were able to explain that, the centripetal force is the force which causes a body to follow a curved path. They were also able to calculate the angular velocity of a body using the correct formula of  $\omega = \frac{v}{r}$ .

Some of those who scored high scores but less than 5 marks missed some small steps thus, ended up with good scores but less than 5 marks. From their responses, it reveals that these candidates had knowledge on angular motion as they demonstrated good presentation of knowledge on centripetal force and manipulation of parameters requested to be calculated.

Q6.	(a) Centripetal force.
	is the force towards the centre of the circle which keep the body moving in circular path.
	(b) Data given.
	$m = 0.5 \text{ kg}$
	$r = 2 \text{ m}$ .
	$v = 10 \text{ m/s}$ .
	$\omega = \frac{v}{r}$
	But also.
	$v = \omega r$ .
	$\omega = \frac{v}{r}$ .
	$\omega = \frac{10 \text{ m/s}}{2 \text{ m}}$
	$\omega = 5 \text{ rad/s}$ .
	$\therefore$ The angular velocity is $5 \text{ rad/s}$ .

**Extract 6.1:** A sample of the good responses on Question 6

Extract 6.1 shows a sample of the good responses as extracted from the script of a candidate. The candidate applied the correct formula,  $v = r\omega$  and obtained the required value of the angular velocity.

Further analysis reveals that some candidates only had partial understanding on subtopic *centripetal force* and *angular motion*, as demonstrated by their responses in a fraction of a question thus; they scored between 1.5 to 3 marks.

On the other hand, there were candidates who had poor knowledge and skills about centripetal force and angular motion. A few of them (11.5%) scored 1 mark as they managed only to describe the centripetal force as *a net force acting on an object in order to maintain it moving in a circular motion*. Others could neither describe the term centripetal force nor calculate the angular velocity of a body, thus they got 0 marks. Extract 6.2 shows a sample of poor responses to Question 6.

6	b/ Data given
	Mass of a body = 0.5 kg
	Radius of a body = 2 m
	Constant of a body speed = 10 m/s
	Angular Velocity = ?
	Angular Velocity = $\frac{\text{Mass} \times \text{length}}{\text{Speed}}$
	Angular Velocity = 0.5 kg
	10 m/s
	Angular Velocity = 0.05

**Extract 6.2:** A sample of the poor responses on Question 6

Extract 6.2 shows a sample of the poor responses as the candidate failed to explain the term centripetal force in part (a) and could not manage to find the angular velocity of a body because he/she was not able to apply the correct formula for angular velocity.

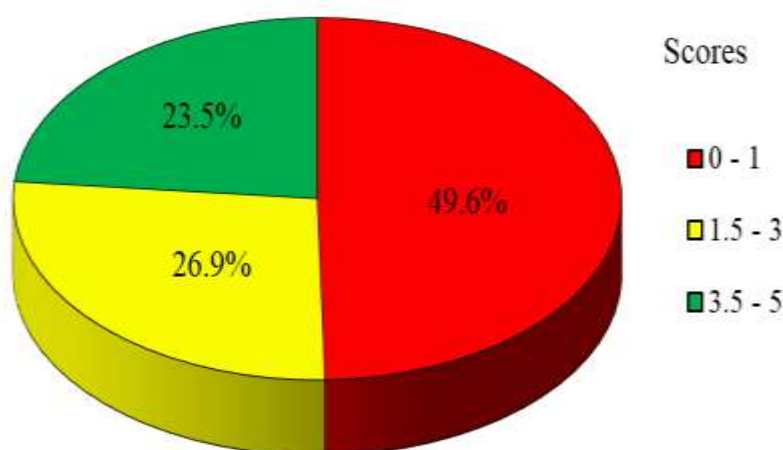
### 2.2.6 Question 7: Forces

Question 7 was as follows:

*An elephant is dragging a tree trunk along a surface by means of an attached rope which makes an angle of  $30^\circ$  with the horizontal. The tension in the trope is 4000 N.*

- (a) *With the aid of a sketch, calculate the horizontal and vertical forces exerted by the rope on the tree trunk*
- (b) *Apart from horizontal and vertical forces in a sketch name other forces acting on the tree trunk showing the directions in which they act.*

The question was attempted by 1407 (100%) candidates, out of which 698 (49.6%) candidates scored from 0 to 1 mark; 379 (26.9 %) scored from 1.5 to 3 marks; and 330 (23.5 %) scored from 3.5 to 5 marks. From the analysis it reveals that, 50.4 per cent of the candidates scored from 1.5 to 5 marks, thus, the general candidates' performance in this question was average. The candidates' performance in Question 7 is presented graphically in Figure 8.

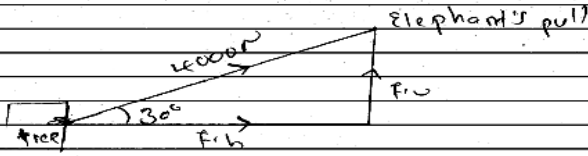
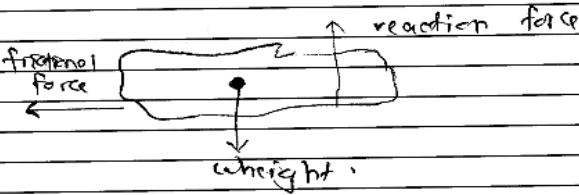


**Figure 8:** *The Candidates' Performance in Question 7*

It was observed that the candidates who scored 5 marks had the ability to sketch a truck of a tree being pulled by a rope at  $30^\circ$  from horizontal components. They also showed the tension of the rope which was regarded as the resultant force and then the horizontal and vertical forces were obtained by resolving the resultant force 4000 N into its vertical and horizontal components. The analysis conducted from the candidates' responses indicates that they had skill in resolving forces in vectors. These candidates were also able to name other forces acting on the trunk which were: *Weight (W) of the trunk which acts downwards the earth center, the normal reaction (R) acting downwards and the frictional forces ( $F_r$ ) which acts in the opposite direction to the movement of the trunk.* Good responses provided by these candidates justify their acquisition of enough skills in



resolution of forces. Most of the candidates, who scored high marks but less than 5 marks, sketched the diagram and calculated the horizontal and vertical components correctly, but did not write other forces on the trunk. Extract 7.1 shows a sample of a good response as extracted from the script of a candidate who performed well.

7	(a)	Soln. considers the diagram:
		
		<p>But</p> <p>Horizontal force (<math>F.h</math>) = Tension <math>\times \cos \theta</math> ..</p> <p><math>= 4000 \text{ N} \times \cos 30^\circ</math></p> <p><math>F.h = 4000 \text{ N} \times 0.866</math></p> <p><math>F.h = 3,464 \text{ N}</math></p> <p><math>\therefore 3,464 \text{ N}</math> was the horizontal force.</p> <p>but</p> <p>Vertical force (<math>F.v</math>) = Tension <math>\times \sin \theta</math></p> <p><math>= 4000 \text{ N} \times \sin 30^\circ</math></p> <p><math>= 4000 \times 0.5</math></p> <p>vertical force = <math>2000 \text{ N}</math></p> <p><math>\therefore 3,464 \text{ N}</math> was the horizontal force and <math>2000 \text{ N}</math> was the vertical force.</p>
7	(b)	other forces on tree trunk.
		Diagram of tree trunk
		
		<p>Other forces are</p> <p>i) The friction force which opposes trunk's motion</p> <p>ii) The weight of the trunk which acts downwards</p> <p>iii) The reaction force due to the weight of a trunk.</p>

**Extract 7.1:** A sample of good responses on Question 7

Extract 7.1 shows a sample of response from the candidate who managed to sketch a diagram of forces and calculate the horizontal and vertical forces exerted by the rope on the tree trunk. Furthermore, he/she managed to name the other forces acting on the tree trunk and showed correctly the directions in which those forces act.

Moderate responses in this question were due to partial knowledge and skills attained by these candidates. Failure to use appropriate equations to calculate vertical and horizontal component demonstrated their weaknesses. Most of these candidates interchanged the components as a result they scored average scores in this question. For example, one candidate sketched a truck of a tree being pulled by a rope at  $30^\circ$  and wrote the equation of vertical and horizontal components incorrectly as  $H.C = R\sin 30^\circ$  and  $V.C = R\cos 30^\circ$  for vertical and horizontal component respectively. The correct formulas are  *$H.C = R\cos 30^\circ$  for horizontal component and  $V.C = R\sin 30^\circ$  for vertical component.*

Poor responses in this question were due to lack of skill in resolving forces. They could not write the equation of vertical and horizontal components because they failed to draw a tree truck being pulled by a rope at  $30^\circ$ . They also failed completely to calculate the vertical and horizontal components, from the truck of a tree being pulled by a rope. These candidates demonstrated poor understanding on solving problems with respect to the forces acting at an angle which involves horizontal and vertical components by employing trigonometrical ratios. Extract 7.2 shows a sample of a poor response as extracted from the script of a candidate who performed poorly.

Solution:

Sum of force horizontal to the plane = 0

$$P \sin \theta + (-w \sin \theta) = 0$$

$$P - F - w \sin \theta = 0$$

$$F = P - w \sin \theta$$

where  $P = 4000 \text{ N}$

$$F = 4000 - w \sin 30$$

$$P = 4000 - w \sin 30$$

$$F = 4000 - 0.5 w \text{ N}$$

$\therefore$  The horizontal force is  $4000 - 0.5 w \text{ N}$

Sum of the force vertical to the plane = 0

$$R_N + (-w \cos \theta)$$

$$R_N = w \cos \theta$$

$$R_N = w \times \cos 30$$

$$R_N = 0.866 w \text{ N}$$

$\therefore$  The vertical force =  $0.866 w \text{ N}$

**Extract 7.2:** A sample of the poor responses on Question 7

In Extract 7.2, the candidate tried to resolve forces acting on a body resting on inclined plane. Its obvious, this candidate did not understand the demand of the question.

### 2.2.7 Question 8: Light (Optics)

Question 8 consisted of two parts, (a) and (b) whereby part (b) comprised of two sub parts, (i) and (ii). In part (a), the question required the candidates to write the mirror formula and then show that magnification is given by

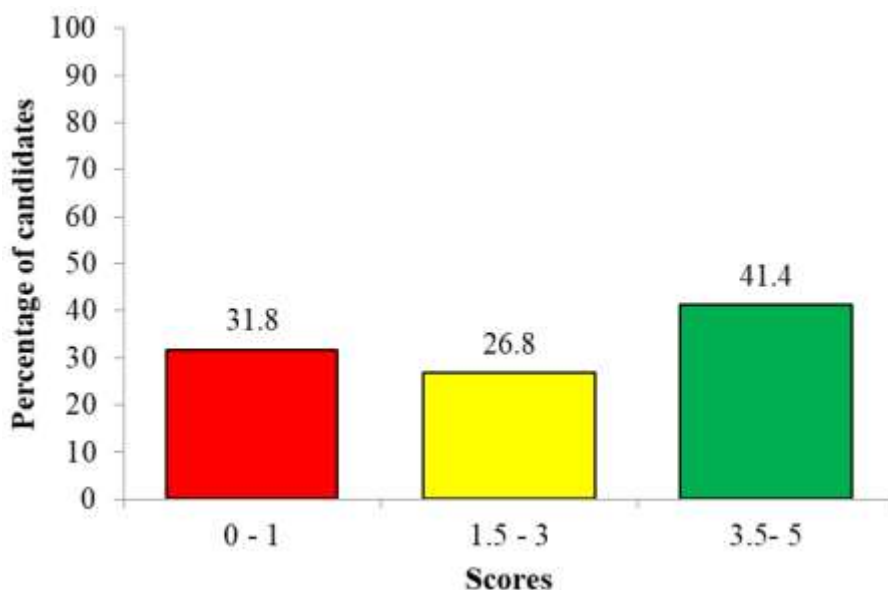
$$m = \frac{v}{f} - 1.$$

In part (b) the question was as follows:

*An object of 10 cm placed at 30 cm away from a concave mirror. A 2 cm high image is formed on the same side as the object. Determine;*

- (i) *the image distance from the mirror.*
- (ii) *the value of focal length.*

The number of candidates who attempted this question were 1407 (100%) of whom 447 (31.8%) candidates scored from 0 to 1 mark, 377 (26.8%) scored from 1.5 to 3.0 marks and 583 (41.4 %) scored from 3.5 to 5.0 marks. Generally, the question was averagely performed. Figure 9 shows the performance of the candidates in this question.



**Figure 9:** *The Candidates' Performance in Question 8*

This is one of the well performed questions as 68.2% of the candidates scored 1.5 marks and above. Most of the candidates had knowledge on the topic of light as revealed from their responses. For example there are those who scored all 5 marks as they managed to write the correct formula

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{in part (a) and used it to derive the magnification formula}$$

$m = \frac{v}{f} - 1$ . In part (b) they demonstrated good understanding by

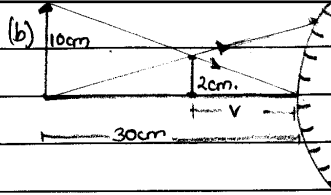
determining the image distance from the mirror and the value of focal

length. They then used correctly magnification formula  $m = \frac{h_i}{h_o}$  and  $m = \frac{v}{u}$

and ended up scoring all 5 marks. Some of the candidates scored high marks but less than 5 marks. These candidates answered large part of the question correctly but made some minor errors in some parts. For example, most of the candidates who scored 3.5 marks provided incorrect answers

only in part (b) (ii). Others 153 (10.9%), who scored 4 marks answered a large part of the question correctly but made some minor mistakes in a few areas. Extract 8.1 shows a sample of a good response as extracted from the script of a candidate.

8.	(a)	$m = \frac{v}{u}$	Prove $= \frac{v}{f} - 1$
		$\frac{v}{u}$	$\frac{v}{f}$
		$\frac{v}{u} = \frac{v}{f} - 1$	
		$\frac{v}{u} = \frac{v-f}{f}$	
		$\frac{v}{u} = \frac{v-f}{f}$	
		$\frac{v}{u} = \frac{v-f}{f}$	
		$\frac{v}{u} = \frac{v-f}{f}$	
		$\frac{v}{u} = \frac{v-f}{f}$	
		$vf = uv - uf$	
		$vf + uf = uv$	
		$f(v+u) = uv$	
		$\frac{f}{1} = \frac{uv}{v+u}$	
		Inverse	
		$\frac{1}{f} = \frac{v+u}{uv} = \frac{1}{u} + \frac{1}{v}$	
		Hence shown:	
		$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ to $m = \frac{v}{f} - 1$	
		using $m = \frac{v}{u}$	

8.	 <p>Concave mirror</p>	
	<p>i. Image distance,</p> $h_i = 2\text{cm}$ $h_o = 10\text{cm}$ $v = ?$ $u = 30\text{cm}$	
	$\frac{v}{u} = \frac{h_i}{h_o}$ $\frac{v}{30\text{cm}} = \frac{2\text{cm}}{10\text{cm}}$ $v \cdot 10\text{cm} = (30 \times 2)\text{cm}$ $v = 6\text{cm}$	
	<p><math>\therefore</math> Image distance is 6cm.</p>	
	<p>ii. Focal length.</p> <p>From:</p> <p>Mirror formulae</p> $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ $\frac{1}{6\text{cm}} + \frac{1}{30\text{cm}} = \frac{1}{f}$ $\frac{5+1}{30} = \frac{1}{f}$ $\frac{6}{30} = \frac{1}{f}$ $6f = 30$ $f = 5\text{cm}$	
	<p><math>\therefore</math> Focal length is 5cm.</p>	

**Extract 8.1:** A sample of the good responses on Question 8

In Extract 8.1 the candidate applied the correct concave mirror and managed to calculate the image distance and the focal length as instructed in the question.

Some of the candidates, however, scored average marks. These candidates only had partial information and skills on light topic especially concave mirror. They were only able to derive the magnification formula but did not do well on the other part of the question. It was clear from their responses that they lacked sufficient knowledge of the light topic.

Poor responses in this question were due to lack of skills on curved mirrors. Those candidates who could not provide the mirror formula or magnification formulae scored 0. Obviously, these candidates lacked knowledge on optics, particularly on spherical mirrors. Extract 8.2 is a sample of a poor response.

8.	b) Data given	
	length of the object = 10 cm	
	length from the concave mirror = 30 cm	
	length of the image = 2 cm	
	Required i/ Image distance	
	ii/ Focal length	
	Image distance = length of mirror - length of object	
	= 30 cm - 10 cm = 20 cm	
	$\therefore$ Image distance = 20 cm.	
	ii/ <del>for</del> Focal length	
	from focal length = $\frac{\text{length from the mirror}}{2}$	
	$\frac{30 \text{ cm}}{2} = 15 \text{ cm}$	
	$\therefore$ The value of focal length = 15 cm.	

**Extract 8.2:** A sample of the poor responses on Question 8

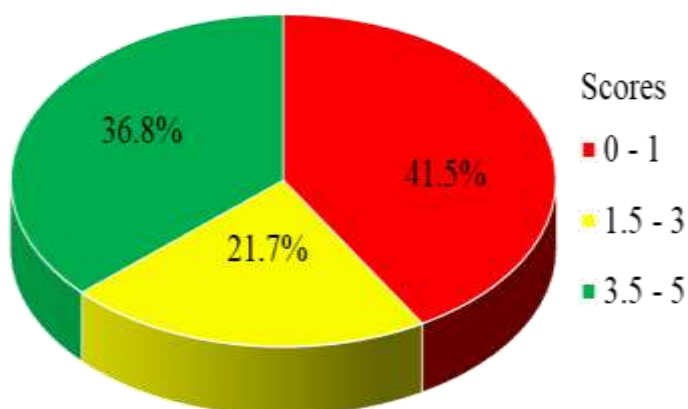
Extract 8.2 is a poor response from the candidate who could not provide the mirror formula or magnification formula. The candidate wrote incorrect optical formula particularly on spherical mirrors as a result they ended up providing wrong responses.

### 2.2.8 Question 9: Fluid Mechanics

Question 9 was as follows:

*A tank of water is rectangular and it measures  $3\text{ m} \times 2\text{ m}$ . It contains water to height of  $2\text{ m}$ . Compute the pressure and thrust on the base of the tank if the density of water in the tank is  $1000\text{ kg/m}^3$ .*

A total of 1407 (100%) candidates attempted this question and their scores were as follows: 584 (41.5%) scored from 0 to 1 mark, 305 (21.7 %) scored from 1.5 to 3 marks and 518 (36.8 %) scored from 3.5 to 5 marks. Generally, the performance in this question was average because 58.5 per cent of the candidates scored from 1.5 to 5 marks. Figure 10 summarizes the candidates' performance in this question.

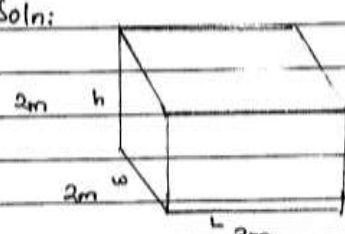


**Figure 10:** *The Candidates' Performance in Question 9*

Candidates who got all the 5 marks in this question knew how to calculate pressure in liquids and understood that thrust is equal to the force on the base in the context of the question. The majority of these candidates were able to determine liquid pressure by multiplying three parameters: density, height and gravity acceleration, resulting in the proper response. They were also able to determine that thrust equals to force on the base, thus allowing them to conceptualize that the force is calculated by using the formula



$P = \frac{F}{A}$ , where  $F = PA$ . They further wrote the correct formula for  $A$  which is  $A = l \times w$  and then obtained the correct thrust which is 120,000 N by multiplying the pressure and area. There are those who acquired high marks but less than 5 marks. Most of them did not understand that thrust is equal to force exerted at the base of the tank, as a result, they scored a zero marks allotted to this part which resulted their scores to be less than 5 marks. Extract 9.1 shows a sample of the good responses.

9.	<p>Soln:</p>  <p><math>h = 2\text{m}</math>  <math>w = 2\text{m}</math> and <math>L = 3\text{m}</math>.</p>
9.	<p><math>\rho = 1000\text{ kg/m}^3</math>.          Find pressure and thrust on base of tank.          From:  <math>\text{Pressure} = h \rho g</math>  <math>= 2\text{m} \times 1000\text{ kg/m}^3 \times 10\text{ N/kg}</math>  <math>= 2000 \times 10\text{ N/m}^2</math>  <math>\text{Pressure} = 20000\text{ N/m}^2</math></p> <p style="text-align: right;"><math>\therefore \text{Pressure is } 20000\text{ N/m}^2</math>          or <math>20000\text{ Pa}</math>.</p> <p><math>\text{Up thrust} = \text{upward force} =</math>  <math>\text{thrust} = \text{force}</math>  <math>\text{Volume} = 3\text{m} \times 2\text{m} \times 2\text{m}</math>  <math>\text{Volume} = 12\text{m}^3</math></p> <p><math>\rho = \text{mass}/\text{volume}</math>  <math>1000\text{ kg/m}^3 = \text{mass}/12\text{m}^3</math>  <math>\text{mass} = 12000\text{ kg}</math>  <math>\text{Force at base of tank} = m \times g</math>  <math>12000\text{ kg} \times 10\text{ N/kg}</math>  <math>= 120000\text{ N}</math></p> <p style="text-align: right;"><math>\therefore \text{Thrust at base of the tank}</math>          is <math>120,000\text{ N}</math>.</p>

**Extract 9.1:** A sample of the good responses on Question 9

Extract 9.1 shows that the candidate managed to use correct formula of pressure in liquid density and employed correctly the data from the rectangular tank to calculate the pressure and thrust on the tank.

Further analysis indicates that, most of the candidates who scored average marks in this question could not understand that thrust is equals to force exerted at the tank's base; as a result, they failed to calculate the force exerted at the tank's bottom by the water. Some of these candidates only managed to compute the pressure in liquid by applying a formula Pressure,  $P = \rho hg$ .

Analysis done on the scripts of candidates with poor performance reveals that, there were candidates who got below average marks. Some of them scored 0 as they had inadequate knowledge on the topic of pressure. They failed to use the data correctly because they did not remember to substitute acceleration due to gravity as a result they ended up with wrong responses. For example, one candidate wrote; *Pressure in liquid*  $= 1000 \text{ kg/m}^3 \times 2 \text{ m} \times 3 \text{ m} \times 2 \text{ m} = 12\ 000$ , and hence he/she scored 0 mark. Even for those who scored 1 mark, they were only able to write the formula  $P = \rho hg$  but in the calculation they applied wrong height parameters instead of using a height of 2 m. This suggests that they lacked knowledge on how to apply data to calculate the pressure in liquid when all the parameters of area and height of container are provided in the question. So, they scored only 1 mark of a formula. Extract 9.2 shows a sample of a poor response as extracted from the candidates' scripts.

9.	<u>Data given</u>
	Measures (Area) $= 3\text{m} \times 2\text{m} = 6\text{m}^2$
	$h = 2\text{m}$
	$\rho = ?$
	$\rho_{\text{water}} = 1000 \text{ kg/m}^3$
	from formulae,
	$P = \text{Force/Area}$
	also
	$P = \rho h$
	$P = 1000 \text{ kg/m}^3 \times 2\text{m} \times 6\text{m}^2$
	$P = 12000 \text{ N/m}^2$
	$\therefore$ Pressure is $12000 \text{ N/m}^2$

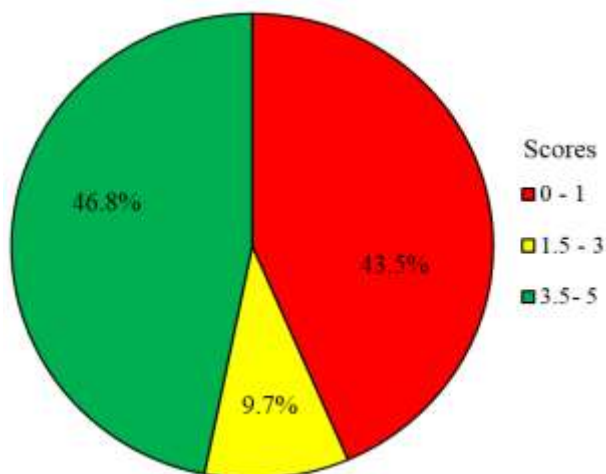
**Extract 9.2:** A sample of the good responses on Question 9

### 2.2.9 Question 10: Heat

The question was as follows:

*The coefficient of linear expansion of lead may be taken as  $0.000028/^{\circ}\text{C}$ . A length of the lead piping is measured at a temperature of  $15^{\circ}\text{C}$  and found to be 30m. After hot water has been flowing through the pipe for sometimes, the temperature of the pipe is found to have been raised to  $60^{\circ}\text{C}$ . Find the total length of the hot pipe.*

A total of 1407 (100%) candidates attempted this question with the following scores: 613 (43.5%) scored from 0 to 1.0 mark, 136 (9.7%) scored from 1.5 to 3.0 marks and 658 (46.8%) scored from 3.5 to 5.0 marks. In general, the question was averagely performed. The candidates' performance is presented in Figure 11.



**Figure 11:** The Candidates' Performance in Question 10

The performance analysis of this question indicates that average number of the candidates (56.4%) scored 2 marks and above, out of which 38.4 per cent scored all the 5 marks. These candidates managed to use the correct equation for calculating the total length of a pipe which is  $L_2 = L_1 + \alpha L_1(\theta_2 - \theta_1)$ . This implies that they were aware of the concept of linear expansion. As a result, they were able to calculate and obtain the proper answer for the length of a pipe after it had been heated. Further analysis reveals that the candidates had knowledge and competence to calculate and obtain the actual length of the hot pipe. However, some of the candidates made minor errors as a result; they

were unable to score all points, despite of getting good scores. Extract 6.1 shows a good response provided by a candidate.

10	Data
	$\alpha = 0.000028/^{\circ}\text{C}$
	$\theta_i = 15^{\circ}\text{C}$
	$l_0 = 30\text{m}$
	$\theta_f = 60^{\circ}\text{C}$
	$l_1 = ?$
	From:
	$\alpha = \frac{\Delta L}{l_0 (\Delta T)}$
	$0.000028/^{\circ}\text{C} = \frac{\Delta L}{30\text{m} (60^{\circ}\text{C} - 15^{\circ}\text{C})}$
	$0.000028/^{\circ}\text{C} \times 13.50\text{m} = \Delta L$
	$0.0378 = \Delta L$
	$\Delta L = l_1 - l_0 \Rightarrow l_1 - 30\text{m} = 0.0378\text{m}$
	$l_1 - 30\text{m} = 0.0378\text{m}$
	$l_1 = 30\text{m} + 0.0378\text{m}$
	$l_1 = 30.0378\text{m}$
	$\therefore \text{Total length of hot pipe is } 30.0378\text{m}$

**Extract 10.1:** A sample of candidates' good responses on Question 10

In Extract 10.1, the candidate used the correct formula of linear expansion and applied the data correctly to find the total length of the hot pipe.

A few (9.7%) candidates scored average marks in this question. Many of them were able to write the formula  $\alpha = \frac{l_2 - l_1}{l_1(\theta_2 - \theta_1)}$ , but they ended in substituting irrelevant data, so they ended up earning 2 marks only.

However poor responses were noted for some of the candidates who failed to use the proper formula and interpret the data from the question. These

candidates lacked skills on heat, particularly on linear expansion. Failure to provide the relevant formula, which is  $\alpha = \frac{l_2 - l_1}{l_1(\theta_2 - \theta_1)}$ , resulted in scoring zero for some of the candidates. On the other hand, some did not realize that the final length corresponded to the end length ( $L_2$ ) and initial length ( $L_1$ ) is 30 mm, with temperatures of  $L_2 = 60^\circ\text{C}$  and  $L_1 = 15^\circ\text{C}$ . Extract 10.2 shows a sample of poor responses.

10.	$= \frac{l_2 - l_1}{l_1(\theta_2 - \theta_1)}$
	Total length $\frac{(60 - 15)}{30}$
	$= 0.00022 \left( \frac{45}{30} \right)$
	$= 1.5 \times 0.00022/^\circ\text{C}$
	$0.000420/^\circ\text{C}$
	But required Total length
	$L_1 = 30\text{m}$
	$L_2 = 0.000420$
	Total length $= L_1 + L_2$
	$= 30\text{m} + 0.000420$
	$0.000450\text{m}/^\circ\text{C}$
	$\therefore$ Total length $= 0.000450\text{m}$

**Extract 10.2:** A sample response which portrays a weak response

The candidate wrote an incorrect formula to compute the coefficient of linear expansion and hence was unable to calculate the length of the hot pipe.

## 2.3 SECTION C: STRUCTURED QUESTIONS

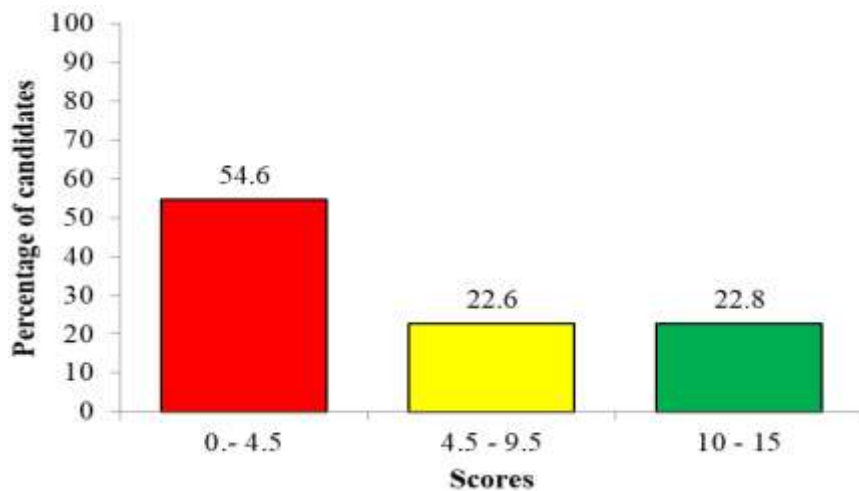
### 2.3.1 Question 11: Simple Machines

The candidates were asked the following question:

- (a) A belt-driven pulley has a diameter of 500 mm and its speed is 300 rev/min. The tensions in the two sides of the belt are 1800 N and 400 N respectively. Find the power transmitted by the belt.

- (b) The tensions in the tight and slack sides of a driving belt are 100 N and 460 N respectively. If the driving pulley has a diameter of 0.6 m and rotates at 5 rev/s, find:
- the driving torque.
  - the power transmitted
- (c) The lathe machine requires a force of 1.2 kN for cutting operation, the average diameter of work piece is 80 mm. If the work piece is revolving at 2 rev/sec, determine the following:
- work done per minute
  - power used in the cutting operation.

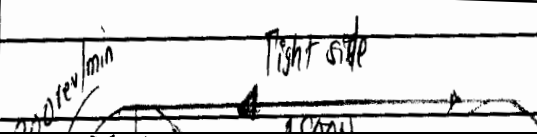
A total of 1058 (75.2%) candidates answered this question and the performance was as follows; 578 (54.6%) scored from 0 to 4 marks; 239 (22.6 %) scored from 4.5 to 9.5 marks and 241 (22.8%) scored from 10 to 15 marks. The question had average performance as 480 (45.4%) candidates scored from 4.5 to 15 marks. Figure 12 presents the candidates' performance in this question.



**Figure 12:** The Candidates' Performance in Question 11

This question had an average performance. The analysis conducted during the compilation of this report, shows that only 45.4 per cent of the candidates scored average or above. Those who scored all the 15 marks, were able to write the formula *Power transmitted = net force x linear speed of the belt* that is,  $P = F \times V$  and were able as well to find the net force in part (a). In part (b) they were able to calculate the driving torque and in part

(c) they calculated the work done per second by multiplying torque and angle turned through per second. It was observed that providing the correct formula and making accurate substitution led these candidates to score all the 15 marks allotted to the question. Extract 11.1 is a sample of the good responses provided by one of the candidates.

11.	
	$P = T\omega$
	$P = 108 \times 31.4$
	$P = 3,391.2 \text{ Watts}$
	$\therefore \text{The power transmitted is } \underline{3391.2 \text{ Watts.}}$
	$\text{slack side}$
	<p>Power transmitted by the belt</p>
	<p>from, Power = Torque X Angular speed</p>
	<p>Torque <math>T = F \times \text{radius}</math></p>
	<p>but <math>T = (F_1 r - F_2 r)</math></p>
	$T = (F_1 - F_2) r$
	$T = (1800 - 400) 0.25$
	$r = \frac{500}{2} = 250 \text{ mm} = 0.25 \text{ m}$

$$T = 1400 \times 0.25$$

$$T = 350 \text{ NM}$$

then, power Transmitted

$$P = T \times \omega$$

$$\omega = \frac{2\pi N}{60} \text{ rad/s} \quad \text{since } N \text{ rev/min} = \frac{2\pi N}{60}$$

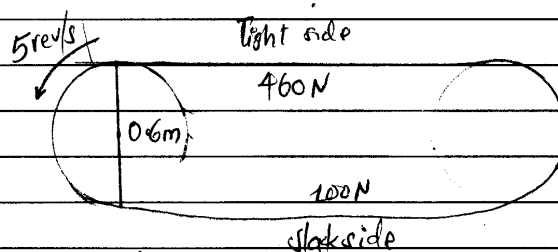
$$\omega = \frac{2 \times 3.14 \times 300}{60}$$

$$\omega = 31.4 \text{ rad/s}$$

$$P = 350 \times 31.4 \text{ rad/s}$$

$$P = 10,990 \text{ Watts}$$

$\therefore$  Power Transmitted by the belt is 10990 Watts.



Given

$$\begin{aligned} \text{Angular speed} &= 5 \text{ rev/s} = 2\pi N \text{ rad/s} \\ &= 2 \times 3.14 \times 5 \text{ rad/s} \\ &= 31.4 \text{ rad/s} \end{aligned}$$

then, driving Torque (T) =  $F_1 r - F_2 r$

$$T = (F_1 - F_2) r \quad \text{but } r = 0.6/2 = 0.3 \text{ m}$$

$$T = (460 - 100) 0.3$$

$$T = 360 \times 0.3$$

$$T = 108 \text{ NM}$$

$\therefore$  The driving torque is 108 NM

\* The power Transmitted (P)

**Extract 11.1:** A sample of the good responses on Question 11



Extract 11.1 is a sample response from the script of the candidate who calculated the effective force on belt and managed to write the correct equations for Torque and Power hence calculate the required Torque and Power transmitted.

Further analysis shows that there were those who scored average marks by attempting some parts of the question correctly while in other parts they failed. For example, one candidate managed to provide all the formula such as; Effective *force* =  $F_1 - F_2$ , Power transmitted =  $F \times v$  and Torque =  $F \times r$  but failed to substitute the correct data as a result he/she scored average marks on this question.

However, there were candidates who scored poor marks. Some of these scored 0 marks and were not able to provide any formula therefore could not carry out any necessary substitutions of the given data. This suggests that these candidates did not acquire the necessary skills and competences in Simple Machines. This was justified by their answers to this question, as some of them failed even to obtain effective belt force. There were those who provided appropriate formulae but failed to substitute the correct data as a result they scored poor marks. Extract 11.2 shows a poor response from the script of the candidates.

Data-
Diameter $\{D\} = 500 \text{ mm}$
Speed $\{s\} = 300 \text{ rev/min}$
belt $\{B\} = 1800 \text{ N}$
Tensions $\{T\} = 400 \text{ N}$
Power transmitted by the belt = ?
Velocity = Mass
Acceleration Volume.
$\frac{V}{A} = \frac{M}{V}$
$V = 500 \text{ mm} \times 300 \text{ rev/min}$
$A = 1800 \text{ N} + 400 \text{ N}$
$M = 500 + 300 = 800$
$V = 1800 + 400 = 2200$
$\text{Velocity} = \frac{800}{2200} = 3000$
Therefore power transmitted by the belt = 3000 mm
The tension in the tight and slack sides of a driving belt are 100N and 460N respectively. If the driving pulley has diameter of 0.6m and rotates at 5 rev/s.

**Extract 11.2:** A sample of the poor responses on Question 11

Extract 11.2 is a sample of responses from the script of a candidate who was not able to calculate the effective force on belt instead he/she wrote irrelevant formula to calculate the Torque and Power transmitted.

### 2.3.2 Question 12: Heat

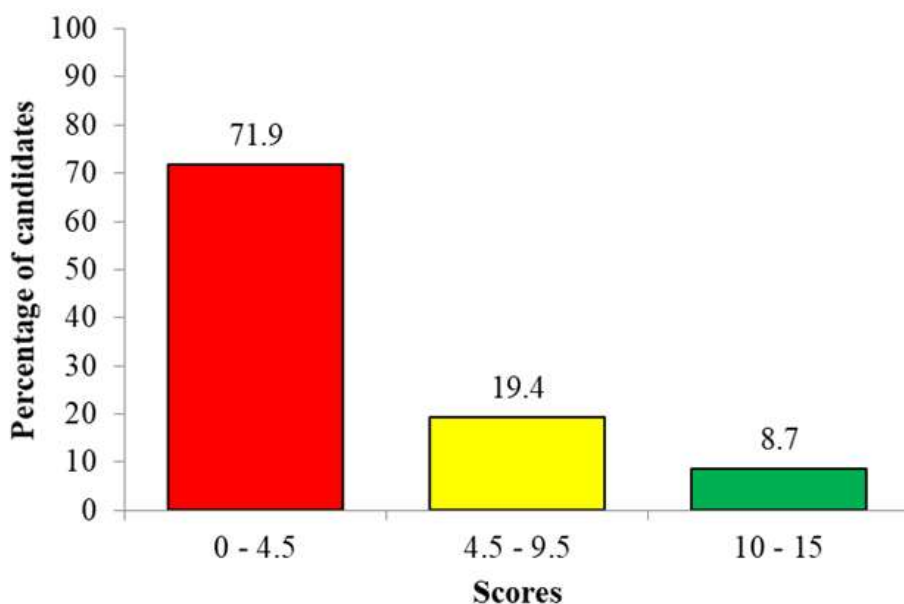
Question 12 was as follows:

- (a) A 60 W heating coil is totally immersed in 200 g of water contained in an insulated flask of negligible heat capacity.

- (i) If the temperature of the water is  $30^{\circ}\text{C}$  when the heater is switched on, how long would it take for the water to boil?
- (ii) After the water boiled for 20 minutes it was found that, the mass of water in the flask has decreased to 60 g. Assuming no external heat losses, calculate a value for the specific latent heat of vapourization of water.
- (b) Calculate the heat required to change 4 g of ice at  $-8^{\circ}\text{C}$  into steam at  $100^{\circ}\text{C}$  given that, specific heat capacity of ice =  $2100\text{ J/kgK}$ , specific heat capacity of water =  $4200\text{ J/kgK}$ , and specific latent heat of ice =  $336000\text{ J/Kg}$ .

This question was attempted by 861 (61.2%) candidates, of whom 619 (71.9%) candidates scored from 0 to 4 marks; 167 (19.4%) scored from 4.5 to 9.5 marks and the remaining 75 (8.7%) scored from 10 to 15 marks.

The candidates' performance in this question was poor because 614 (71.9%) candidates scored from 0 to 4.0 marks which implies that only 28.1 per cent of the candidates scored average and above. Figure 13 summarizes the candidates' performance on this question.



**Figure 13:** The Candidates' Performance in Question 12

The analysis reveals that, this was the question most skipped by most of the candidates. In fact, most of the candidates (71.9%) who attempted this question were not familiar with the topic of Heat. Some of the candidates did not understand the existing relationship between 60 W of heating coil, 200 g of water and insulated flask in part (a), as a result they failed to write the formula to calculate the time required to boil water. They also failed to calculate the specific latent heat of evaporation of water, as they failed to involve the change of the mass of boiled water from 200 g to 60 g. In addition they could not calculate the energy of boiling water for 20 minutes whereby the energy could be calculated by the formula ' $Q = mL$ ' which is used to calculate the latent heat of evaporation.

In part (b), these candidates failed to calculate the quantity of heat required to convert 4 g of ice at  $-8^{\circ}\text{C}$  to steam at  $100^{\circ}\text{C}$ . They had no idea that, to convert ice to steam requires two types of quantity of heat which are heat of converting temperature from  $-8^{\circ}\text{C}$  to  $0^{\circ}\text{C}$  and from  $0^{\circ}\text{C}$  to  $100^{\circ}\text{C}$  which converts ice state to water and water state to steam. They also failed to use the two formulae  $Q = mC(\theta_2 - \theta_1)$  and  $Q = mL$  for change of temperature and the one to convert from one state to another. Extract 12.1 portrays a sample of poor answers by a candidate.

Data	
Power (P) =	49
Energy (E) =	$8^{\circ}\text{C}$
Volume (v) =	$100^{\circ}\text{C}$
Capacity (c) =	2100 kg
Capacity water (c-w) =	4200 kg
heat (h) =	336000 kg
Velocity (v) =	?
Work done	= mass
Volume	Density
$\frac{W}{V} = \frac{M}{D}$	
$W = \frac{49 + 8 + 100}{2100} = 3670$	
$V = \frac{4200 + 336000}{2100} = 338100$	
$M = \frac{3670}{338100} = 341770$	
Therefore Velocity (v) =	341770 kg.

**Extract 12.2:** A sample of the poor responses on Question 12

Extract 12.2 shows the response of a candidate who scored 0 marks. The candidate could not remember any equation related to heat. He/she provided irrelevant formula and manipulated irrelevant calculation.

However, a few (28.1%) candidates who attempted this question managed to score average and high marks. Those who scored average (4.5 to 9.5) marks were able to correctly answer some parts of the question but were either unable to complete other parts of the question or miscalculated some parts of the question. For example, one candidate calculated part (a) correctly but in part (b) failed to calculate quantities of heat for; changing the temperature from  $-8^{\circ}\text{C}$  to  $0^{\circ}\text{C}$  and  $0^{\circ}\text{C}$  to  $100^{\circ}\text{C}$  and quantities of heat for changing the state of ice to water and water to steam. Some of the candidates incorrectly substituted the data to calculate the quantities of heat for changing the temperature from  $-8^{\circ}\text{C}$  to  $100^{\circ}\text{C}$  such as  $Q = mC(100 - (-8))$  and the heat to change the state of ice to steam as  $Q = mL$  as a result, they came up with the wrong answers.

On the other hand, some of the higher scorers (8.7%) wrote the correct formula such as  $Q = Pt$ ,  $Q = mc\Delta\theta$  and  $Q = mL$  and managed to substituted correctly the given data into the formula. They correctly wrote the formulae to find the time taken for water to boil, the quantity of heat gained and the value of specific latent heat of vaporization of water respectively. However, some they failed to substitute the given time to boil the water in part (a). Others did wrong manipulation on some parts of the question and therefore they scored high marks but less than 15.

Moreover, some of the candidates who scored all the 15 marks were able to apply formula correctly in part (a) and calculated correctly the quantity of heat gained and the time taken for water to boil in part (a) (i) and the value for the specific latent heat of vaporization of water in part (a) (ii). In part (b), they managed to establish the relationship that;  $Q_T = Q_1 + Q_2 + Q_3 + Q_4$ , which is;  $Q_T = MC_1\Delta\theta_1 + ML_1 + MC_2\Delta\theta_2 + ML_2$  and obtained the total amount of heat ( $Q_T$ ) required to change 4 g of ice at  $-8^{\circ}\text{C}$  into steam at  $100^{\circ}\text{C}$ . Analysis done to candidates' responses reveals that, the candidates understood the needs of the question and had adequate knowledge on the topic and demonstrate competence to perform calculation on how liquid condenses, expands and evaporates when heated. Extract 12.1 shows a sample of good responses from one of the candidates.

12	(a) i)	<u>Soln</u>
	<u>Data given</u>	
	power (P) = 60 W	
	mass of water (m) = 200 g $\rightarrow$ 0.2 kg	
	temperature of water = 30°C	
	then	
	$Q = mc\Delta\theta$	
	$Q = 0.2 \times 4200 \times (100 - 30)$	
	$Q = 58,800$	
	then	
	$t = \frac{Q}{P}$	
	$t = \frac{58,800}{60}$	
	$t = 980 \text{ min}$	
	$t = 16.3 \text{ hrs}$	
	$\therefore$ It will takes 16.3 hrs to boiled.	
	(ii)	<u>Soln</u>
	<u>Data given</u>	
	Time = 20 min	
	mass = 60 g	
	latent heat of vaporization?	
	from	
	$L_v = \frac{Q}{m}$	
	$Q = P \times t$	
	$= 60 \times 1200$	
	$Q = 72,000 \text{ J}$	
	but	
	$m = m_1 - m_2$	
	$= 200 \text{ g} - 60 \text{ g}$	

$$m = 140g$$

then

$$m = m \times \frac{1}{1000}$$

$$M = 140 \times \frac{1}{1000}$$

$$M = 0.14 \text{ kg}$$

$$l_v = \frac{Q}{M}$$

$$l_v = \frac{12,000}{0.14}$$

$$l_v = 514285.71 \text{ J/kg}$$

$\therefore$  The specific latent heat of vaporization is  $514285.71 \text{ J/kg}$ .

b)

soln

Data given

$$\text{mass of ice} = 0.004 \text{ kg}$$

$$\text{specific heat capacity of ice} = 2100 \text{ J/kgK}$$

$$\text{specific heat capacity of water} = 4200 \text{ J/kgK}$$

$$\text{specific latent heat of ice} = 336000 \text{ J/kg}$$

then

$$Q_1 = M c \Delta \theta$$

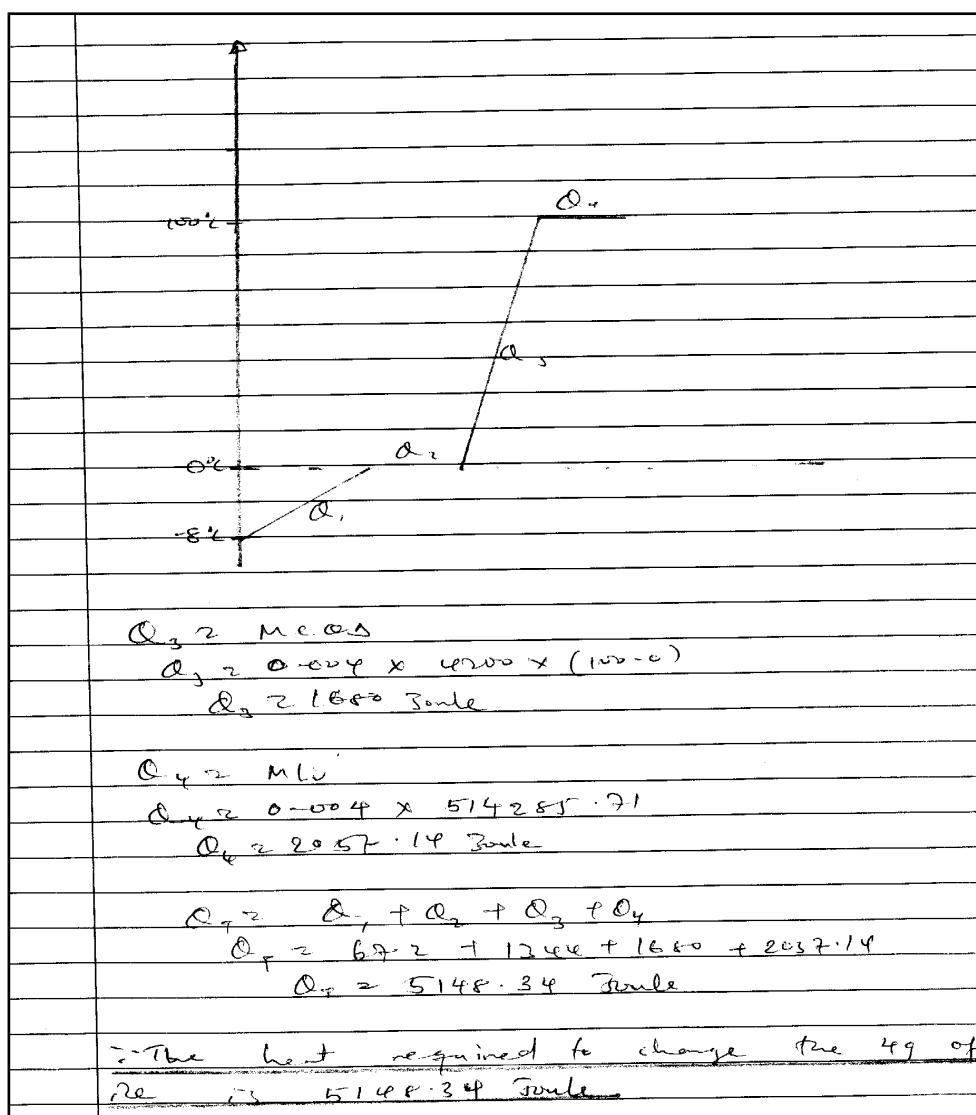
$$Q_1 = 0.004 \times 2100 \times (0 - -8)$$

$$Q_1 = 67.2 \text{ Joule}$$

$$Q_2 = M l_f$$

$$Q_2 = 0.004 \times 336000$$

$$Q_2 = 1344 \text{ Joule}$$



**Extract 12.1:** A sample of the good responses on Question 12

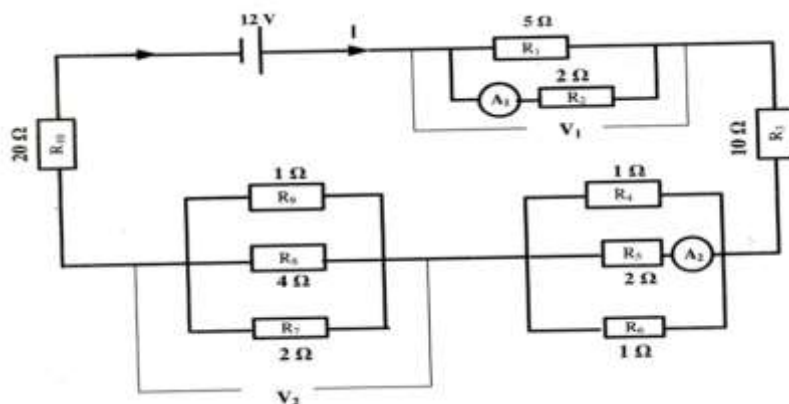
In Extract 12.1, the candidate was able to remember the concepts of heat which involve the change of the temperature from 30 °C to 100 °C, as a result he/she substituted correctly the data to calculate the specific latent heat of water as the mass decreased from 200 g to 60 g in part (a) (i) and (ii). In part (b), he/she was able to use the correct formula to calculate the heat required to change ice from -8 °C to 100 °C and change the state of ice to water and water to steam, thus scored all the 15 marks of the question.



### 2.3.3 Question 13: Electricity and Magnetism

The question was as follows:

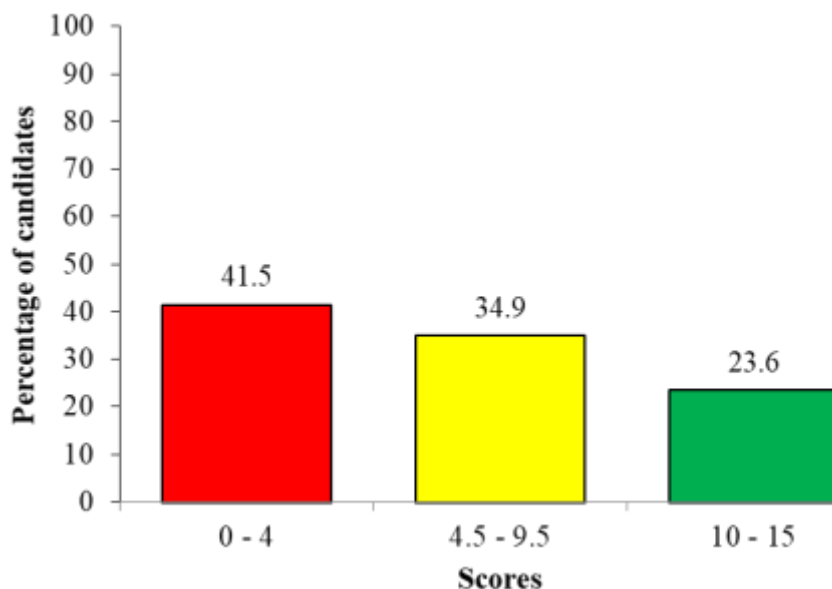
- (a) State the following law and rule with regards to electricity and magnetism.
- Ohm's law
  - Fleming's left hand rule.
- (b) Figure 3 shows an electric circuit. Study the diagram carefully and then answer the questions that follow.



Find:

- the total current of a circuit
- the voltage ( $v_1$ ) and ( $v_2$ )
- an electric current in ammeter  $A_1$  and  $A_2$

The question was attempted by 1165 (82.8%) candidates, of whom 483 (41.5%) scored from 0 to 4 marks; 407 (34.9%) scored from 4.5 to 9.5 marks and 275 (23.6%) scored from 10 to 15 marks. The overall performance in this question was average. Figure 14 summarizes the candidates' performance on this question.



**Figure 14:** *The Candidates' Performance in Question 13*

The good responses provided by the candidates who scored all the 15 marks were unveiled by their correctness of their answers. These candidates stated well the Ohm's Law and Fleming's Left Hand Rule and scored all the 3 marks in part (a). Also, these candidates performed well in part (b) by providing the required formula and forming the expressions for finding the resistances in series and parallel. In addition, they managed to find the combined resistance of the circuit and then, total current of the circuit by applying the formula  $V = IR$ . Furthermore, they successfully calculated the electric current in ammeters  $A_1$  and  $A_2$ . Moreover, they managed to calculate voltages  $V_1$  and  $V_2$  across the group resistors in parallel again by using the formula  $V = IR$ , after combining their respective resistance.

These candidates calculated the equivalent resistance of each group separately, then determined the overall resistance ( $R_T$ ) of the circuit using the equivalent resistance formula  $R_T = R_1 + R_2 + R_3 + R_4 + R_5$ .

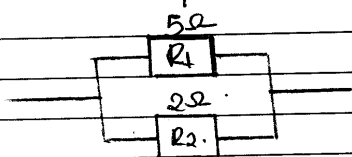
The analysis shows that there were candidates who scored high marks but less than 15 marks. These candidates had an understanding on Ohm's Law and Fleming's Left Hand Rule, as they were able to state the law and rule well. They also had the knowledge and skills to calculate the total current of

a circuit, the voltages ( $V_1$ ) and ( $V_2$ ) and also an electric current in ammeters  $A_1$  and  $A_2$ . Inability to manipulate all steps of calculation without committing small errors was found as main challenge to these candidates. Therefore, for those who inaccurately calculated the total current of a circuit in part (b) (i) or (ii) and (iii), failed to get all the 15 marks. Extract 13.1 shows a sample of the good response.

13 (i) Ohm's law state that.  
 "The voltage flowing through the circuit is directly proportional to the current flowing in that circuit other factor will be constant"  
 i.e.  
 $V \propto I$   
 constan  $R$  is introduced.  
 $V = IR$ .

(ii) Fleming's left hand rule state that.  
 "when the left hand is at right angle the THUMB represent motion of conductor first finger repres et flux and the middle fing represent direction of electric current."

(b) Total current.  
 find total resistor of parallel combination.



from:

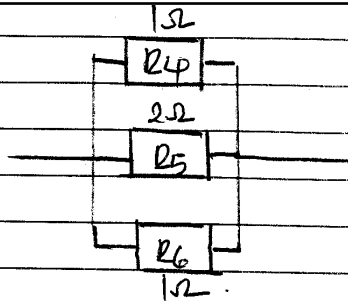
$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

$$R_T = \frac{5 \times 2}{5 + 2}$$

$$R_T = \frac{10}{7}$$

$$R_T = 1.43 \Omega$$

$\therefore R_T$  of  $R_1$  and  $R_2$  is  $1.43 \Omega$



From:

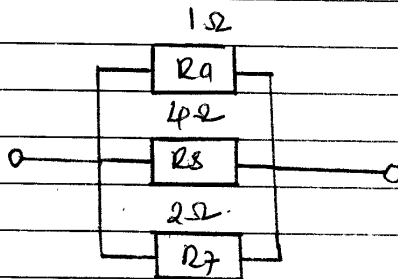
$$\frac{1}{R_T} = \frac{1}{R_4} + \frac{1}{R_5} + \frac{1}{R_6}$$

$$\frac{1}{R_T} = \frac{1}{2} + \frac{1}{2} + \frac{1}{1}$$

$$\frac{1}{R_T} = \frac{5}{2}$$

$$R_T = \frac{2}{5}$$

$\therefore$  RT of  $R_4$ ,  $R_5$  and  $R_6 = \frac{2}{5}\Omega = 0.4\Omega$ .



From:

$$\frac{1}{R_T} = \frac{1}{R_9} + \frac{1}{R_8} + \frac{1}{R_7}$$

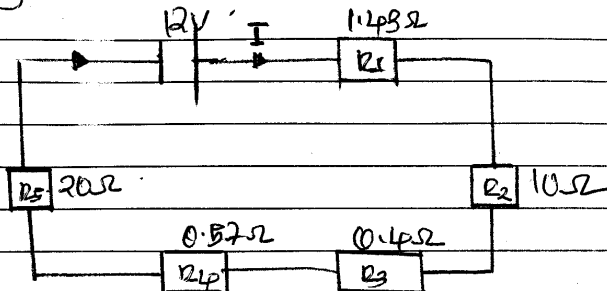
$$\frac{1}{R_T} = \frac{1}{4} + \frac{1}{2} + \frac{1}{1}$$

$$\frac{1}{R_T} = \frac{7}{4}$$

$$R_T = \frac{4}{7} = 0.57\Omega$$

$\therefore$  RT between  $R_9$ ,  $R_8$  and  $R_7$  is  $0.57\Omega$ .

Finally the circuit will be.



In series combination,

$$\begin{aligned} \therefore R_T &= R_1 + R_2 + R_3 + R_4 + R_5 \\ &= 1.43 + 10 + 0.4 + 0.57 + 20 \\ R_T &= 32.4 \Omega \end{aligned}$$

$\therefore$  Total resistance of the circuit is  $32.4 \Omega$ .  
Then:

From Ohm's law.

$$I = \frac{V}{R}$$

$$I = \frac{12}{32.4}$$

$$I = 0.37 \text{ A}$$

$\therefore$  Total current of the circuit is  $0.37 \text{ A}$

(ii)  $V_1$  and  $V_2$ .

$V_1$

Recall

$R_T$  of  $R_1$  and  $R_2$  is  $1.43 \Omega$ .

From:

$$V = IR$$

$$V = 0.37 \times 1.43 = 0.53 \text{ V}$$

$\therefore$  voltage ( $V_1$ ) is  $0.53 \text{ V}$ .

$V_R$  : since  $R_T$  of  $R_1$ ,  $R_3$  and  $R_2$  is  $0.57$ .

Then from:

$$V = IR.$$

$$V = 0.57 \times 0.37.$$

$$= 0.2109V.$$

$\therefore$  voltage  $V_R$  is  $0.211V$ .

(iii) A electric current in Ammeter  $A_1$  and  $A_2$ .  
Ammeter  $A_1$ .

since:

Total voltage passing in  $A_1$  is  $0.53V$ .

Resistance of  $A_1$  is  $2\Omega$ .

From:

$$I = \frac{V}{R}.$$

$$I = \frac{0.53}{2} = 0.265A.$$

$\therefore$  electric current passing Ammeter  $A_1$  is  $0.265A$ .

Ammeter  $A_2$ .

From:

Voltage of parallel combination is constant.

$$V = IR$$

$$V = 0.37 \times 0.4.$$

$$= 0.148V.$$

Then:

$$I = \frac{V}{R}.$$

$$I = \frac{0.148}{2} = 0.074A.$$

$\therefore$  electric current across Ammeter  $A_2$  is  $0.074A$ .

**Extract 13.1:** A sample of the good responses on Question 13

In Extract 13.1, the candidate correctly stated the Ohm's law and Fleming's Left Hand Rule. He/she further managed to minimise the resistors in sub-circuit and calculated the total equivalent resistance of the circuit which in turn substituted into the formula to calculate the current of the circuit. He/she also managed to calculate the voltage ( $V_1$ ) and ( $V_2$ ) and an electric current in ammeters  $A_1$  and  $A_2$  as the question instructed.

The analysis on the question reveals that, some of the average performers managed to state Ohm's law and Fleming's left hand rule in part (a) but in part (b) they attempted the question partially as a result they scored between 4.5 and 9.5 marks. Some of these candidates managed to calculate the total equivalent resistances in circuit but did not write the formula  $I = \frac{V}{R}$  so as to calculate the total current of a circuit which in turn could help to calculate the voltages ( $V_1$ ) and ( $V_2$ ) and sub current in ammeters  $A_1$  and  $A_2$ . It is concluded from their responses that the candidates had a problem in manipulating the obtained results of total equivalent resistance with the circuit's voltage, which resulted in an average performance on this question.

On the other hand, they managed to express Ohm's Law and Fleming's Left Hand Rule in part (a) but failed to undergo manipulation in part (b). The candidates' failure to complete computations in part (b) could be owing to lack of knowledge and skills in manipulating total equivalent resistance in series and parallel as a result they scored poor marks on this question.

However, there were some candidates who provided poor responses. Some of them scored zero because they lacked knowledge on the topic of electricity and magnetism. This was verified by their failure to state Ohm's law and Fleming's Left Hand Rule as well as to derive an electrical resistance formula to calculate the total equivalent resistance in series and parallel. Others managed only to state Ohm's law or Fleming's Left Hand Rule or both, therefore they scored between 1.5 and 3 marks. Extract 13.2 shows a sample of a weak response extracted from the scripts of two different candidates.

B (i) Ohm's law - That the state from the current of the ohms that the law from the current and formation from the voltage and community from second ohms and first Ohms

ii Fleming's left-hand rule - is the process of the hand from the ohms law and state that the current of the current.

(b) Solution.

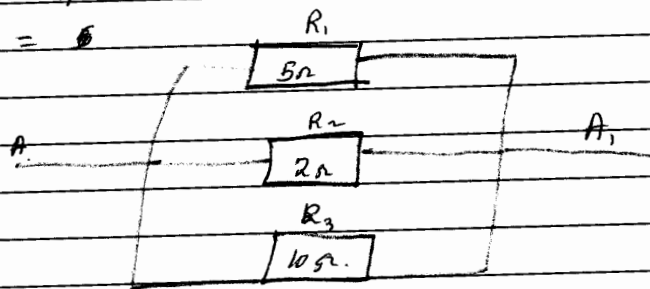
$$R_1 = R_1 + R_2 + R_3 \dots$$

$$R_1 = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

$$R_1 = R_1 + R_2 + R_3 \dots$$

$$R_1 = 5\Omega + 2\Omega + 10\Omega = 17\Omega.$$

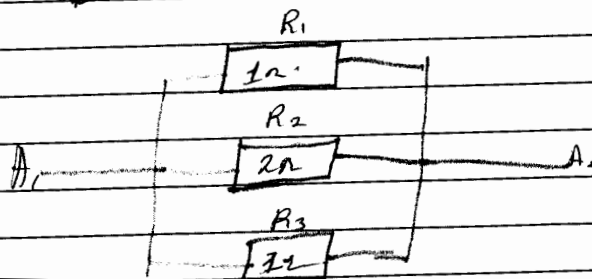
$$R_1 = 6$$



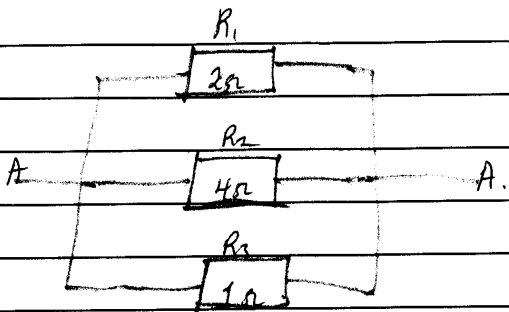
$$R_1 = R_1 + R_2 + R_3 \dots$$

$$R_1 = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \dots$$

$$R_2 = 1\Omega + 2\Omega + 1\Omega = 4\Omega$$





13	$R_3 = R_1 + R_2 + R_3$ . . . . .	
	$R_1 = \frac{7}{R_1} + \frac{3}{R_2} + \frac{9}{R_3}$ . . . . .	
	$R_1 = 2\Omega + 4\Omega + 1\Omega = 7\Omega$ .	
		
	$R_1 = R_1 + R_2 + R_3$ . . . . .	
	$R_1 = \frac{1}{R_1} + \frac{2}{R_2} + \frac{3}{R_3}$ . . . . .	
	$R_3 = R_1 + R_2 + R_3 + R_4 + R_5 + R_6 + R_7 + R_8 + R_9 + R_{10}$	
	$R_1 = 17\Omega + 4\Omega + 7\Omega + 20\Omega = 46\Omega$	
	$= 46\Omega$ .	
	$\therefore$ There the total current $= 46\Omega$ .	

**Extract 13.2:** A sample of the poor responses on Question 13

Extract 13.2 shows that the candidate failed even to state the Ohm's law and Fleming's Left Hand Rule. Additionally, he/she failed to find an equivalent resistance for any given group of resistance in the circuit as a result; he/she scored 0 marks.

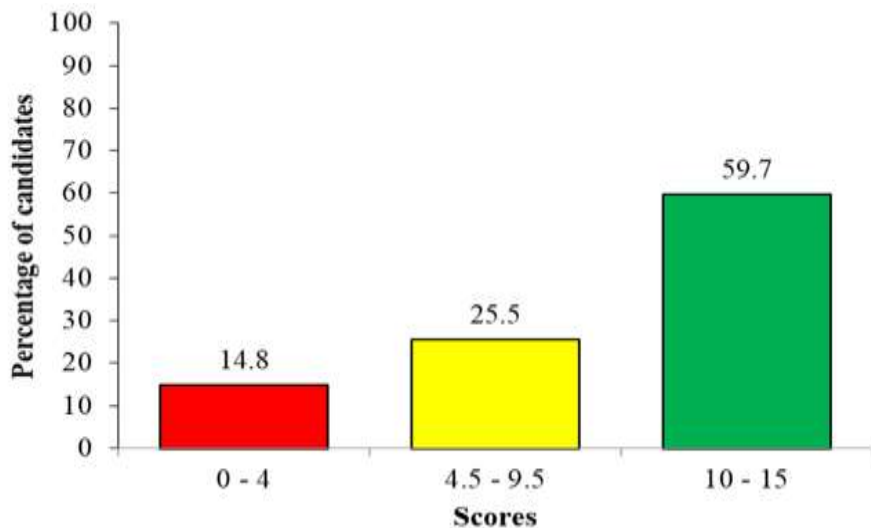
### 2.3.4 Question 14: Strength of Materials

Question 14 had two parts, (a) and (b). The question was as follows:

- (a) A wire of 3 m long and 3.15 mm diameter is extended by 0.9 mm when a tensile force of 200 N is applied to it. Calculate the young's Modulus of Elasticity for the material of the wire. Assuming that the elastic limit has not been exceeded.

(b) What will be the extension of a steel rod having a diameter of 11.28 mm and length of 20 mm when a tensile force of 10 kN is applied to it. ( $E$  for steel = 205 kN/mm<sup>2</sup>).

A total of 1136 (80.7 %) candidates opt this question. The candidates' scores were as follow: 168 (14.8%) scored from 0 to 4 marks; 290 (25.5%) scored from 4.5 to 9.5 marks and 678 (59.7 %) candidates scored from 10 to 15 marks. The general performance of candidates was good because 85.2 per cent of the candidates who attempted this question scored 4.5 to 15 marks. The summary of the candidates' performance on this question is indicated on Figure 15.



**Figure 15:** The Candidates' Performance in Question 14

The candidates' performance on this question indicates that, they had comparatively good understanding on the topic strength of materials. This is revealed from their adequate execution and manipulation of the requested Young's Modulus of Elasticity in part (a) and the extension of a steel rod in part (b).

In part (a), most of the candidates used correctly the required formula  $E = \frac{\text{Stress}}{\text{Strain}}$  to calculate the Young's Modulus of Elasticity for material of the wire. They managed to substitute correctly the given data and manipulated them to get the correct response. In part (b) they allied correctly the given data in determining the extension of the steel rod.

The majority of the candidates (59.7%) scored high marks, with few who got all the 15 points. Those who got 15 marks were able to recall formulae and substituted correct data, enabling them to manipulate and attain perfect solution. Other candidates in this group made minor errors, such as substituting wrong data to calculate extension in part (b) by using a formula  $\Delta L = \text{strain} \times \text{original length}$  which made them to score high marks but less than 15 marks.

Further analysis shows that, there were those who got average marks. These are the ones who did part (a) and failed part (b) or manipulated both part (a) and (b) but made an error in some of the calculation steps, thus scoring the average mark. For example, one candidate was able to recall the young modulus and extension formulas, but failed to calculate correctly the area of a wire and strain in part (a) thus scored an average mark in this question. Extract 14.1 is a sample of the candidate's response who performed well in this question.

14.	(a) A wire of length (L) = 3m
	diameter (d) = 3.15 mm
	Extension (X) = 0.9 mm
	Tensile force (F) = 200 N
	Required Young's modulus.
	from,
	Young's modulus = $\frac{\text{Stress}}{\text{Strain}}$ .
	But
	$\text{Stress} = \frac{\text{force}}{\text{Area}}$ .
	Also
	$\text{Area} = \frac{\pi d^2}{4}$
	$= \frac{3.14 \times (0.00315)^2}{4}$
	$A = 7.79 \times 10^{-6} \text{ m}^2$
	$\text{Stress} = \frac{200 \text{ N}}{7.79 \times 10^{-6} \text{ m}^2}$
	$\therefore \text{stress} = 25,676,701.44 \text{ N/m}^2$
	$\text{Strain} = \frac{X}{L}$
	$= \frac{0.9 \text{ mm}}{3000 \text{ mm}}$
	$\therefore \text{strain} = 3 \times 10^{-4}$

$$\begin{aligned}
 14 \text{ (a)} \quad \text{Young's modulus} &= \frac{\text{stress}}{\text{strain}} \\
 &= \frac{25,676,701.44 \text{ N/m}^2}{3 \times 10^{-4}} \\
 &= 8.559 \times 10^{10} \text{ N/m}^2 \\
 E &= 85.59 \text{ GPa}
 \end{aligned}$$

$\therefore$  The young's modulus is 85.59 GPa.

(b) Given:

$$\text{diameter (d)} = 11.28 \text{ mm}$$

$$\text{Length (L}_0\text{)} = 20 \text{ mm}$$

$$\text{Tensile force (F)} = 10 \text{ kN}$$

$$E = 205 \text{ kN/mm}^2$$

Required extension  $X$ .

from:

$$\text{strain} = \frac{\text{Extension (X)}}{\text{length initial (L}_0\text{)}}$$

But

$$\text{stress} = \frac{\text{force}}{\text{Area}}$$

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

$$= \frac{3.14 \times (11.28)^2}{4}$$

$$\underline{A = 99.88 \text{ mm}^2}$$

$$\text{Stress} = \frac{10000 \text{ N}}{99.88 \text{ mm}^2}$$

$$\therefore \text{stress} = 100.12 \text{ N/mm}^2$$

14.	(b) $E = \frac{\text{stress}}{\text{strain}}$	
	$\text{strain} = \frac{\text{stress}}{E}$	
	$= \frac{100.12 \text{ N/mm}^2}{205000 \text{ N/mm}^2}$	
	$\therefore \text{strain} = 4.88 \times 10^{-4}$	
	$\text{strain} = \frac{\text{Extension } x}{\text{Initial length } L}$	
	$x = \text{strain} \times \text{Initial length.}$	
	$= (4.88 \times 10^{-4}) \times 20 \text{ mm}$	
	$= 9.76 \times 10^{-3} \text{ mm}$	
	$\therefore \text{The extension is } 9.76 \times 10^{-3} \text{ mm.}$	

**Extract 14.1:** A sample of the good responses on Question 14

In Extract 14.1, the candidate showed correctly all the required steps in determining the young modulus of the wire and extension of the steel rod.

Despite the fact that many candidates performed well on this question, a few (14.8%) of them did poorly. These candidates were not conversant with the calculations involving the young modulus of elasticity and extension of a wire. Some of them were able to recall formula for stress, strain or young modulus but did not substitute any data, thus they ended up with weak scores. Others failed to recall the formula and carry meaningful calculation, hence they ended up with 0 score. From the analysis made on the candidates' responses, it is revealed that, these candidates lacked adequate knowledge on the concept of strength of materials, as they were unable to describe an elasticity, define and calculate tensile stress, tensile strain and young's modulus of elasticity. Extract 14.2 illustrates poor response from among the candidate who attempted this question.

14. a/. Data given

$$\text{wire} = 3 \text{ m}$$

$$\text{long} = 3.15$$

$$\text{diameter} = 0.9$$

$$\text{Force} = 200 \text{ N}$$

$$\text{Young's Modulus} = ?$$

Solution

$$\text{Young's Modulus} = \frac{\text{wire} + \text{diameter} + \text{long}}{\text{Force}}$$

$$\text{Young's Modulus} = \frac{3 + 3.15 + 0.9}{200}$$

$$\text{Young's Modulus} = \frac{1.05}{200}$$

$$\text{Young's Modulus} = 5.25 \times 10^{-3}$$

$\therefore$  The Young's Modulus for the material of the wire  $5.25 \times 10^{-3}$

b/. Data given.

$$\text{diameter} = 11.28 \text{ mm}$$

$$\text{length} = 20 \text{ mm}$$

$$\text{Force} = 10 \text{ kN}$$

$$\text{extension} = ?$$

$$E \text{ for steel} = 205 \text{ kN/mm}^2$$

14.	b/. Data given
	diameter = 11.28
	length = 20 mm
	Force = 10 kN
	extension = ?
	E for steel = 205 kN/mm <sup>2</sup>
	Solution
	power = 20 x length x Force
	power = length x Force
	power = 20 mm x 10 kN
	∴ power = 200 kN
	extension = power x diameter
	E for steel
	extension = $\frac{200 \times 11.28}{205}$
	extension = $\frac{2256}{205}$
	extension = $11.0048 \times 10^{-03}$
	∴ The extension of a steel rod having a diameter is $11.0048 \times 10^{-03}$

**Extract 14.2:** A sample of the poor responses on Question 14

In Extract 14.2, the candidate showed incorrect steps in determining the young modulus of the wire and extension of the steel rod. He/she provided the wrong formula for young modulus of elasticity and strain to calculate extension of the steel rod.

### 3.0 THE CANDIDATES' PERFORMANCE ON EACH TOPIC

The analysis of candidates' performance on the topics tested in the Engineering Science subject for the year 2021 indicates that, the candidates performed well in 3 topics, average in 7 topics. No topic was poorly performed.



The candidates demonstrated good performance on the topic of Strength of Materials, (85.2%) Electricity and Magnetism, Sound, Heat, Simple Machine, Light, Strength of Materials, Fluid Mechanics, Work, Energy and Power, Unit and Measurement, (82.4%) which was tested in multiple choice question and Light-Optics (68.2%).

The topics in which the candidates performed averagely were Electricity and Magnetism (56.4%), Work, Energy and Power (53.8%), Angular Motion (52.0%), Sound (51.7%), Force (50.4%), Fluid Mechanics (44.5%) and Heat (42.3%). This average performance suggests that the candidates had partial knowledge, skills, and competence in these topics.

The appendix summarises the candidates' performance on each topic whereby *green*, *yellow* and *red* colours represent *good*, *average* and *weak* performance grades respectively.

## **4.0 CONCLUSION AND RECOMMENDATIONS**

### **4.1 Conclusion**

The general performance of the candidates in Engineering Science subject in the year 2021 was good. Out of 1407 candidates who sat for the paper, 994 (70.7 %) candidates passed, while 413 (29.3 %) failed.

The analysis of the candidates' responses observed a few challenges the candidates faced when responding to the questions. These include the candidates' lack of knowledge on the concepts in responding to some of the questions, such as lack of sketching and computational skills particularly in the topic of Friction, Linear Motion and Angular Motion which were poorly performed. Another weakness observed was some candidates' failure to understand the requirement of the questions.

Therefore, it is recommended that, the weaknesses observed will be regarded as a reminder to teachers, students and other educational stakeholders for the purpose of improving learning and teaching practices for the future improvement of candidates' performance in Engineering Science subject.

## **4.2 Recommendations**

In order to improve the performance of the candidates, it is recommended that:

- (a) Teachers should guide the student to read and solve problems from different engineering science reference books so as to enable them to acquire different approaches in tackling engineering science problems.
- (b) Students should develop a self-reading behaviour by reading a variety of books which will enable them understand the requirements of the questions during examinations.
- (c) Teachers should guide the students to acquire mathematical skills by assigning them enough class exercises, which will help them to solve problems which involve calculations particularly in Heat, Fluid Mechanics, Work, Energy and Power and Force topics.
- (d) Students should be embarked with drawing skills which will help them to draw neat sketches or diagrams when solving different engineering science problems.

## Appendix

### Analysis of the Candidates' Performance Topic-wise in Engineering Science Subject

S/N	Topic	Performance for each Question		Average Performance for candidates who scored 30% and above	Remarks
		Number of Question	% of Performance per each Question (30% and Above)		
1.	Strength of Materials	14	85.21	85.2	Good
2.	Electricity and Magnetism, Sound, Heat, Simple Machine, Light, Strength of Materials, Fluid Mechanics, Work, Energy and Power, Unit and Measurement,	1	82.44	82.4	Good
3.	Light (Optics)	8	68.23	68.2	Good
4.	Electricity and Magnetism	3	54.3	56.4	Average
		13	58.5		
5.	Work, Energy and Power	2	62.1	53.8	Average
		11	45.4		
6.	Angular Motion	6	52.03	52.0	Average
7.	Sound	5	51.74	51.7	Average
8.	Force	7	50.37	50.4	Average
9.	Fluid Mechanics	4	30.5	44.5	Average
		9	58.5		
10.	Heat	10	56.4	42.3	Average
		12	28.1		

