THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

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

PHYSICS

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031 PHYSICS

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FOREWORD

The National Examinations Council of Tanzania (NECTA) is authorized to administer Assessments and Examinations at National level. The Certificate of Secondary Education Examination (CSEE) is a summative evaluation after four years of study in secondary school level. The CSEE aims at examining the competences acquired by the candidates as per curriculum for Secondary Education.

The Candidates' Item Response Analysis (CIRA) report on the Physics in CSEE 2023, has been prepared to provide feedback to education stakeholders about the responses given by the candidates in the examination items. It helps in understanding reasons for the observed performance of the candidates in the Physics subject.

Generally, the performance was good. However, few candidates had weak performance. The candidates who had good performance demonstrated adequate knowledge and mastery of the concepts, theories, principles and laws governing various concepts examined. Factors that contributed to the weak performance of some candidates include: inability to understand the questions' demand, poor English language proficiency, inadequate knowledge about the concepts assessed in a particular topic, insufficient skills in solving numerical problems, and poor drawing skills of various mechanical, thermal, electric, electronic structures or circuits.

The feedback about the candidates' performance will enable the policymakers, education administrators, school managers, teachers and candidates to identify proper measures to be taken to improve candidates' performance in future examinations.

The Council expresses its sincere appreciation to the examination officers, examiners and others who participated in the preparation of this report. The Council is also grateful to staff members who were involved in processing the statistical data that have been used in this report.

Dr. Said Ally Mohamed

EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of candidates who sat for the Certificate of Secondary Education Examination (CSEE) 2023 in Physics subject. The examination comprised two papers, namely; 031/1 Physics 1 (Theory paper) and 031/2 Physics 2 (Actual practical paper). The examination was set according to the 2022 Physics examination format which was based on the 2010 revised Physics syllabus for secondary education. The examination measured the competencies the candidates attained after completing four years of study in ordinary secondary school.

The Theory examiantion consisted of three (3) sections: A, B, and C. Section A comprised two (2) objective questions. Question 1 had ten (10) multiple-choice items constructed from ten (10) different topics, namely *Introduction to Physics; Introduction to Laboratory Practice; Measurements; Force; Archimedes' Principle and The Law of Floatation; Structure and Properties of Matter; Pressure; Work, Energy and Power; Magnetism; and Application of Vectors*. Each item carried one (1), making ten (10) marks. Question 2 had six (6) homogeneous matching items structured from the topic of *Simple machines*. Each item had one (1) mark, making six (6) marks. The whole section A was allocated with 16 marks.

Section B comprised six (6) short answer questions set from the topics: *Light; Optical Instruments; Pressure; Forces in Equilibrium; Newton's Laws of Motion; Simple Machines; Thermal Expansion; Transfer of Thermal Energy; Waves; Radioactivity; Geophysics;* and *Elementary Astronomy*. Each question carried nine (9) marks, making a total of fifty four (54) marks. Section C comprised three (3) questions set from the topics of S*tatic Electricity, Current Electricity, Thermionic Emissions, Electronics, Waves* and *Electromagnetism*. The candidates were required to answer any two (2) questions of their choice. Each question carried fifteen (15) marks, making a total of thirty (30) marks. The whole paper had 100 marks.

The practical examination had three alternative papers: 031/2A Physics 2A, 031/2B Physics 2B and 031/2C Physics 2C. Each alternative paper

consisted of two questions, each carrying 25 marks, to make a total of fifty (50) marks.

The number of candidates who sat for the Physics examination in the year 2023 was 122,102 out of which 71.85 per cent passed the examination and 28.15 per cent failed. In the year 2022, the per cent of the candidates who passed was 68.34. This indicates that the candidates` performance in Physics in the year 2023 has increased by 3.51 per cent. Performance of the candidates in Physics from the year 2021 to 2023 is summarized in Table 1.

Table 1: Performance of Candidates in Physics From 2021 to 2023

Year	Candidates who sat for the Paper	Candidates who Passed	
		Number	Percentage
2021	116,610	64,096	55.33
2022	114,472	78,009	68.34
2023	122,102	87,402	71.85

Table: 1 indicates that the performance of the candidates has improved from 55.33 per cent in the year 2021 to 71.85 per cent in the year 2023. However, the number of candidates who sat for the examination has been changing year after a year from 115,846 in 2021 to 122,102 in 2023.

This report provides a detail analysis of the performance of the candidates in each question. The analysis begins with description of the question demand followed by performance in the respective question. Graphs and charts are also used to summarize the candidates' performance in each question. Explanations about performance in specific questions and extracts of candidates' answers have been thoroughly clarified to exemplify a particular case.

The percentage of performance in each question is divided into three categories namely; weak, average, and good performance. The performance is considered to be weak if the marks of the candidates

range from 0 - 29 per cent. If the marks of the candidate range from 30 – 64 per cent, the performance is average. Good performance ranges from 65-100 per cent. Red, Yellow and Green colours have been used to specify weak, average and good, respectively.

The report also gives an analysis of the candidates' performance in different topics examined. Finally, the report draws conclusion and gives recommendations that may help to improve the candidates' performance in future examinations

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH QUESTION IN PHYSICS 1

This section presents the performance of candidates in each question. It describes the types of questions, topics from which the question was constructed, the learning outcome assessed and the candidate's performance for each question. The sample of the candidates' performance extracts are incorporated in this report.

2.1 Section A: Objective Questions

This section comprised two objective questions: Question 1 and Question 2. Question 1 was a multiple-choice question with ten (10) items. Each item in this question carried one (1) mark, making a total of 10 marks. Question 2 was a matching item type of question. This question consisted of six (6) items. Each item carried one mark, making a total of 6 marks.

2.1.1 Question 1: Multiple Choice Items

This question consisted of ten (10) multiple-choice items numbered (i) to (x). Candidates were supposed to choose the most correct answer among the five (5) given alternatives: A, B, C, D, and E. They were required to select the correct answer among the five given alternatives and write the correct letter beside the corresponding item number in the answer sheet provided. The items were constructed from different topics stipulated in the Physics Syllabus 2010. These topics were: *Introduction to Physics; Introduction to Laboratory Practice; Measurement; Force; Archimedes' Principle and the Law of Floatatio;*

Structure and Properties of Matter; Pressure; Work, Energy and Power; Magnetism; and Application of vectors.

The analysis shows that the question was attempted by a total of 122,102 (100%) candidates, out of whom 12,595 (10.32%) scored from 0 to 2.0 marks, 72,234 (59.15%) scored from 3.0 to 6.0 marks and 37,234 (30.53%) scored from 7.0 to 10 marks. These scores indicate that candidates' performance in this question was good as 109,507 (89.68 %) scored from 3.0 to 10.0 marks out of 10 marks allocated to this question. Figure 1 summarizes the performance of the candidates in Question 1.

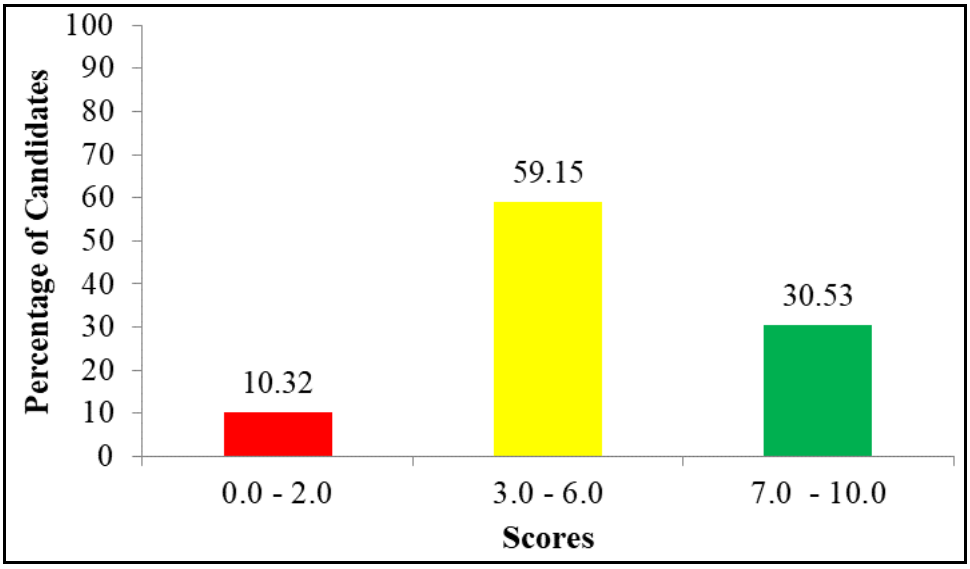


Figure 1: The performance of the candidates in Question 1.

Item (i) was set from the topic of *Introduction to Physics,* intended to assess candidates' understanding of the concepts of physics, particularly the branches of physics. In order for the candidates to correctly respond to the question, they should be able to identify and describe various branches of physics and their importance. The item stated, "*A study that deals with constellation, solar system and cosmos is referred to as."* The alternatives were: A. *Electromagnetism.*, B. *Structure and properties of matter.* C. *Light.* D. *Astronomy* and E. *Geophysics.* The correct alternative was D (*Astronomy*). Most of the candidates chose the correct alternative. This suggests that those candidates had enough

knowledge of physics, particularly the branches of physics. Some candidates chose alternative E (*Geophysics*), which was an incorrect response. These candidates failed to realize that Geophysics is a branch of physics that deals with the physics of the earth (the physical process of the Earth) and its surroundings. They were supposed to know that astronomy is the branch of physics that deals with the study of the physical universe and its objects that are beyond the Earth's atmosphere. Few others opted for other incorrect alternatives: A (*Electromagnetism*), B (*Structure and properties of matter*) and C (*Light*). Those candidates could not differentiate the various branches of Physics in the world. They were supposed to remember the meaning of each branch of physics.

Item (ii) was derived from the topic of *Introduction to Laboratory Practice*. The item aimed at assessing candidates' skills in firefighting. The item stated, "*Which of the following burning medium requires a carbon dioxide extinguisher*?" The given alternatives were: A. *Organic solid*. B. *Flammable liquid and greases.* C. *Flammable gases*. D. *Combustible metals,* E. *Electrical hazards.* The correct alternative was B (*Flammable liquid and greases*). Few candidates selected alternative B, which was a correct response. Those who chose this response had sufficient knowledge and skills in identifying and describing the classes of fire and the devices that are used to extinguish the fire. Most of the candidates chose alternative E (*Electrical hazards*). This was an incorrect response. These candidates in this category failed to identify the classes of fire. They were supposed to realize that fire extinguishers do not extinguish electric hazards; they extinguish fire. Moreover, they were supposed to know that an electric hazard is any potential cause of harm, whether through an electric shock hazard or thermal hazard.

Those candidates who failed to choose the correct response were supposed to realise that there are six classes of fire, namely:

- **Class A:** It caused by combustible carbon-based solids (organic solids). It can be extinguished by pressurized water, foam spray, and ABC powder.

- **Class B:** It is caused by flammable liquids and greases (paraffin, petrol, diesel, or oil) but not cooking oil. This fire class is extinguished using CO_2, dry powder and foam spray.
- **Class C:** It is caused by flammable gases (methane or LPG). It can be extinguished using dry powder.
- **Class D:** It is caused by burning metals such as aluminium. It can be extinguished using dry powder.
- **Class E:** it is caused by electric fire (short-circuiting equipment). This class of fire is extinguished using CO_2.
- **Class F:** it is caused by fats and cooking oils. Wet chemicals can extinguish it.

Item (iii) was constructed from the topic of *Measurement*. The question assessed candidates' ability to apply mathematics skills to determine the volume of liquid dispensed from the burette. The item stated, "*The initial volume of a liquid in a burette was* 50 cm^3. *If X* cm^3 *of the liquid was poured out of the burette and the final volume of the liquid remaining was 23* cm^3, *calculate the value of X."* The item was provided with the following alternatives: A. $80\ cm^3$, B. $50\ cm^3$ C. $34\ cm^3$ D. $46\ cm^3$ E. $-46\ cm^3$. The correct response was C (34 cm^3). Most of the candidates chose alternative C, which was the correct response. Those candidates were able to formulate the correct mathematical formula which is used to determine the volume of liquid dispensed out of the burette. Some candidates failed to select correct responses, suggesting they had insufficient mathematics skills. Those candidates were supposed to realize that the burette measures the volume of the liquid dispensed, not the volume it contained. Unlike other volumetric apparatus, the zero-mark scale on the burette is written at the top. However, in item (iii), the remaining liquid was 23 cm^3. Moreover, the value of 57 cm^3 was not an initial volume reading. It was the volume of the liquid contained in the burette. That is to say that they indicate the initial and final volumes of liquid in the burette. Therefore, the volume of liquid dispensed can be calculated based on the amount of liquid in the burette as follows:

$$V_{\text{liquid dispensed}} = V_{\substack{\text{initial volume of}\\ \text{liquid in burette}}} - V_{\substack{\text{final volume of}\\ \text{liquid in burette}}}$$

It follows that , $V_{\text{liquid dispensed}} = 57\ \text{cm}^3 - 23\ \text{cm}^3 = 34\ \text{cm}^3$

Item (iv) was constructed from the topic of *Force*. Candidates were supposed to identify the effect of force exerted on an object to respond to this item. The item stated, "*Classify the force experienced when a metal solid or a hard object is twisted."* The alternatives were: A. *Compression* B. *stretching* C. *Restoring* D. *Torsion* E. *Friction.* The correct alternative was D (*Torsion*). Some candidates opted for the correct alternative, which was D. These candidates in this category demonstrate mastery of concepts of force, particularly the effect of force. Some of the candidates failed to provide the correct response. Some of them chose response A (*compression*), which was an incorrect response. Those candidates failed to comprehend that compression force reduces the size of an object and does not twist the object.

Item (v) was developed from the topic of Archimedes' principle and the Law of flotation. The item assessed the ability of the candidates to demonstrate mastery of the basic concepts, theories, and principles of physics. This holds particularly to the density and Archimedes' principles. The candidates were required to use an appropriate mathematics expression to determine an object's relative density. The item stated, *"Calculate the relative density of an object that weighs 3.5 N when in air and 2.8 N when fully immersed in water."* The item was provided with the following alternatives: A. *0.8 B. 6.4* C. *5.0* D. *0.22* E. *3.5.* The correct alternative was C (5.0). Some of the candidates selected alternative C (5.0), which was the correct response. Most of the candidates failed to choose the correct response. This suggests that those candidates failed to apply Archimedes' principle to determine an object's relative density. They were supposed to know that the relative density of an object is calculated using the following equation

$$RD = \frac{\text{weight of an object in air}}{\text{upthrust}}.$$

$$\text{Upthrust} = \text{weight of an object in air} - \text{wight of an object in water.}$$

That is to say that:

$$RD = \frac{\text{weight of an object in air}}{\text{weight of an object in air} - \text{weight of an object in water}}.$$

It follows that

$$RD = \frac{3.5N}{3.5N - 2.8N} = \frac{3.5N}{0.7N} = 5.0.$$

Item (vi) was set from the topic of *Structure and properties of matter*. The item was constructed to assess candidates' knowledge of the concepts of surface tension. The candidates were supposed to provide a scientific reason for why the pond skater and water strider walk on the water's surface without sinking. The statement stated, *"Why can water striders and pond skaters walk on water without sinking?"* The given alternatives for this item were: A. *Because of the process of osmosis* B. *Because of property of capillarity C. Because of the presence of impurities in water* D. *Because of force of surface tension* E. *Because of the force of cohesion and adhesion.* The correct alternative for this item was D (*Because of force of surface tension*). Some candidates selected the correct alternative, signifying that they had sufficient knowledge of surface tension. They had ability to integrate the concepts of surface tension to real-life stuations. Some candidates opted for incorrect alternatives A, B, C and E, indicating that they had insufficient knowledge of the properties of matter.

Item (vii) was derived from the topic of *Pressure*. The item was designed to test candidates' ability to state Pascal's principle of transmission of pressure. The item stated: "*Identify the statement that describes the Pascal's Principle of transmission of pressure in fluids*". The item was provided with the following alternatives: A. *Pressure is equally transmitted in liquid.* B. *Pressure is the ratio of force to area.* C. *Pressure depends on the height of the liquid column.* D. *Pressure is affected by the force of gravity.* E. *Pressure produces up thrust.* As per the item, the correct answer was alternative A (*Pressure is equally transmitted in liquid*). Some of the candidates selected the correct response, which was A, suggesting that they demonstrated mastery of pressure in liquids especially Pascal's principle, which states that when pressure is applied at any point on the surface of a fluid contained in a container, it is transmitted undiminished to all parts of the fluid and the walls of the container. Some candidates were distracted with alternative B (*Pressure is the force ratio to the area*). This was an incorrect

alternative because it was describing the truth about pressure in solid. But the item's context was about Pascal's principle, which is studied in pressure in liquid. Others opted for alternative C (*Pressure depends on the height of the liquid column*). This was incorrect because, though it gives out information about pressure, it functions even for non-enclosed liquids, while Pascal's principle operates only for enclosed liquids. Some candidates who opted for alternative D (*Pressure depends on the force of gravity*) did not understand how Pascal's principle is stated. Few who opted for alternative E (*Pressure produces upthrust*) failed to realize that upthrust is not concerned with pressure under this context.

Item (viii) was structured from the topic of *Work*, *Energy* and *Power*. The item assessed candidates' skills in applying the mathematical formula to compute the value of power. In addition, the item aimed to evaluate the ability of candidates to convert physics units. The item stated, "*Suppose an engine rises 200 kg of water steadily through a height of 60 m in 20 seconds. The upward force used is equal to the weight of water raised. Calculate the power in kW."* The item was provided with the following alternatives: A. *6* kW, *B. 3* kW, B. *5* kW, D. *7* kW, E. *4* kW. The correct alternative was A (*6 kW*). Most of the candidates selected the response A, which was the correct answer. These candidates used the right mathematical expressions to relate physical principles and phenomena. They were able to use the correct formula and convert watt (W) to a kilowatt (kW). Candidates who opted for incorrect alternatives *B (3* kW), C *(5* kW), D *(7* kW), *and E (4 kW)* failed to apply an appropriate mathematical formula to describe physical phenomena. They were supposed to know that power is defined as $\frac{\text{work done}}{\text{time}} = \frac{mgh}{t}$.

On substituting the given data, $\text{power} = \frac{200 \times 10 \times 60}{20} = 6000\,\text{W}.$

But 1 kW is equivalent to 1000 W. Thus, the calculated power is 6 kW.

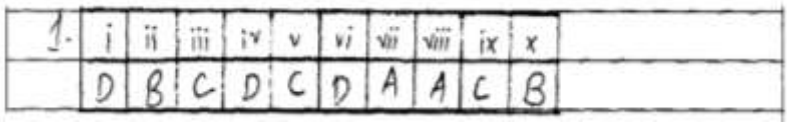
Item (ix) was constructed from the topic of *Magnetism*. In this item, the candidates were assessed for their ability to identify the properties of the magnetic lines of force among the given alternatives. The item stated, "*The following statements about magnetic line of force are correct* ***except****."* The item was equipped with the following alternatives:

A. *Always forms close loop* B. *Start at North pole and end at the north-pole C. Cross one another* D. *Stronger where the lines are closer together* E. *Pass through all materials, both magnetic and non-magnetic.* The correct alternative was C (*Cross one another).* Some of the candidates selected response C, which was a correct answer. These candidates correctly identified the properties of the magnetic lines of force. Some of them failed to select the correct response. Some of the candidates chose alternatives A *(Always forms close loop)* B *(Start at North pole and end at the north-pole)* D *(Stronger where the lines are closer together)*r E *(Pass through all materials, both magnetic and non-magnetic),* which were incorrect responses. Candidates failed to realize that they were asked to identify the wrong property of magnetic field lines among the given alternatives. They were supposed to recognise that the magnetic lines never intersect. This implies that if two or more lines intersect at any point in the space, the lines have two directions at that point, indicating that the lines are pointing in more than one direction, which is impossible.

Item (x) was developed from the topic of the *Application of Vectors*. The item required the candidates to have the ability to distinguish between distance (scalar quantity) and displacement (vector quantity). For the candidates to select the correct alternative, they were supposed to be able to use the laws of vector addition to calculate the displacement covered by an athlete. The item stated, "*What is the distance and displacement covered by an athlete who runs 100 m to the North, 70 m to the East, 100 m to the South and 70 m to the West to complete the race*. The given alternatives were: A. *Distance is 0 m and displacement is 340 m B. Distance is 340 m and displacement is 0 m* C. *Distance is 340 m and displacement is 340 m* D. *Distance is 0 m and displacement is 0 m* E. *Distance is 700 m and displacement is 700 m.* The correct alternative was B (*Distance is 340 m and displacement is 0 m*). Some candidates chose the correct response, which was B. These candidates in this category demonstrated the ability to distinguish vector and scalar and apply the vector and scalar laws to calculate the displacement and distance, respectively. Some candidates opted for alternatives A (*Distance is 0 m and displacement is 340 m*), C (*Distance is 340 m and displacement is 340 m*), D (*Distance is 0 m and*

displacement is 0 m), E (*Distance is 700 m and displacement is 700 m*) because they failed to apply the concept of vector and scalar to find total displacement and total distance travelled by an athlete, respectively. They were supposed to realize that distance is a scalar quantity. The total distance is the same as the magnitude of the total length covered. On the other hand, displacement is a vector quantity, and its sum can be obtained by summing the given magnitudes with respect to their distance.

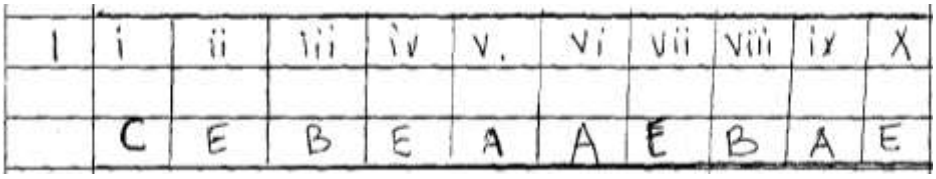
Generally, the analysis revealed that a few candidates scored high marks in this question. Most of the candidates scored high marks in this question which signifies mastery of concepts from various topics. E**xtract 1.1**. portrays a sample of correct responses from one the candidates who scored all marks in this question.



1.	i	ii	iii	iv	v	vi	vii	viii	ix	x
	D	B	C	D	C	D	A	A	C	B

Extract 1.1: A sample of the candidate's correct responses in Question 1.

On the other hand, some of the candidates scored low marks in this question because of inadequate knowledge pertaining to concepts and facts of different topics.. Extract 1.2 represents a sample of one of the candidate's incorrect answers who did this question.



1	i	ii	iii	iv	v.	vi	vii	viii	ix	X
	C	E	B	E	A	A	E	B	A	E

Extract 1.2: A sample of the candidate's incorrect responses in Question 1.

2.1.2 Question 2: Matching Items

This question was constructed with six (6) homogeneous items (i) to (vi) in **List A** to be matched with eight responses (A) to (H) in **List B** derived from the topic of *Simple Machines.* Candidates were required to match the properties or functions of the simple machines in List A with

their corresponding names in **List B** by writing the letter of the correct response beside the item number in the answer booklet provided.

List A	List B
(i) Is useful in drawing water from a borehole.	A Wheelbarrow
(ii) Applies the principle of first class lever.	B Wheel and axle
(iii) Its velocity ratio increases by increasing the length of the ramp.	C Hydraulic press
(iv) The effort is between the load and fulcrum.	D Tong
(v) Operates based on the principle of transmission of pressure in fluids.	E Claw hammer
(vi) Carries objects from one point to another horizontally.	F Inclined plane
	G Pulley
	H Windmill
	I Screw jack

A total of 122,102 (100%) candidates attempted the question, and their scores were as follows: 50,082 (41.02%) candidates scored from 0 to 1.0 mark, 59,893 (49.05%) scored from 2.0 to 3.0 marks and 12,127 (9.93%) scored from 4.0 to 6.0 marks. These scores indicate that candidates' performance in this question was average as 72,020 (58.98 %) scored from 2.0 to 6.0 marks out of 6.0 marks allocated to this question. Figure 2 depicts the performance of the candidates in Question 2.

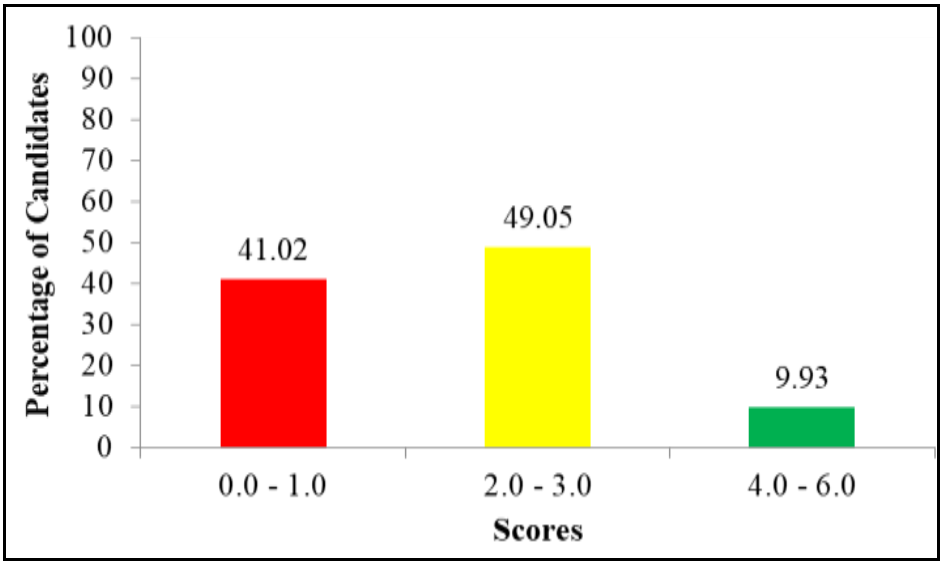


Figure 2: *The performance of the candidates in Question 2.*

In item (i**)**, the candidates were required to provide a response which matched the phrase: "*Is useful in drawing water from borehole*." The item was constructed to assess the ability of the candidates to demonstrate their mastery skills in the concepts, theories and applications of *Simple machines*. The correct response for this item was H (*wind mill*). The item was matched correctly with some of the candidates. Most of them failed to choose the correct response. Some candidates selected response B (*Wheel and axle*), which was incorrect. Those candidates failed to realize that a windmill is a wheel and axle comprising many wind turbines, thus transferring a high moment of force. Therefore, this type of wheel and axle can lift water from a more than 60 m borehole. In addition, they were supposed to know that there are various types of wheels and axles (such as wheelbarrows, car tires, and electric fans).

Item (ii) required the candidates to respond correctly by matching the statement "*Applies the principle of the first class lever*." The item assessed the candidates' ability to identify different levers. The correct response for this item was E (*claw harmer*). Some of the candidates chose the correct response, which was E. These candidates in this category demonstrated the ability to identify classes of lever specifically the first class lever. Some candidates matched the description with

response D, which was incorrect. Those who failed to match the description with the correct response revealed insufficient knowledge and skills in identifying the classes of lever. The candidates in this category were supposed to know that there are three classes of lever, namely:

- First-class lever: In this class of lever, the effort moves over a long distance to move the load at a smaller distance, and the fulcrum is between load and effort. It can be represented as effort-fulcrum-load.
- Second class lever: In this class, the effort moves over a long distance to move the load, which is located between the fulcrum and effort. It can be represented as fulcrum-load-effort.
- Third class lever: The effort moves a short distance to move a load over a long distance, and effort is between the load and fulcrum. It can be represented as load-effort-fulcrum.

Those who selected response D failed to integrate that a tong has a load-effort-fulcrum configuration. Therefore, it is a third-class level.

In item (iii), candidates were required to match the statement that states: "*Its velocity ratio increases by increasing the length of the ramp*." This item aimed to measure the competence of candidates to use mathematics skills to describe the velocity ratio of simple machines. The candidates were required to identify various mathematical formulas for different simple machines. For a given item, the correct response was F (*Inclined plane*). Some of the candidates matched this description correctly. This is because they used correct mathematical formulas to evaluate the physical phenomena. Some of the candidates selected incorrect responses to match with a given description. Few candidates matched the description with response B (Wheel and Axle), which was incorrect. These candidates in this category failed to realize that the velocity ratio of wheel and axle is defined as

$\text{Velecity ratio, } VR = \frac{\text{Circumference of the wheel}}{\text{Circumference of the axle}} = \frac{2\pi R}{2\pi r}$. Some of the candidates chose response C (*Hydraulic press*), which was an incorrect response.

The velocity ratio of the hydraulic press is expressed as $\text{Velecity ratio, } VR = \frac{\text{distance moved by effort}}{\text{distanced moved by laod}} = \frac{R^2}{r^2}$. there were few candidates who selected response G (*Pulley*). This was an incorrect response. Those candidates were supposed to realize that the velocity ratio for the pulley is defined as $\text{Velecity ratio, } VR = \frac{\text{distance moved by effort}}{\text{distanced moved by laod}}$. Few candidates chose response I (*Screw Jack*) which was an incorrect response. Those candidates were supposed to know that the velocity ratio for a Screw jack is defined as $\text{Velecity ratio, } VR = \frac{\text{Circumference of the circle made by the turning arm}}{\text{Pitch of the screw}} = \frac{2\pi R}{Pitch}$. Looking at these responses is evidence that these candidates did not comprehend that velocity ratio of an inclined plane is governed by the length of the plane. These candidates were supposed to realize that the velocity ratio for the inclined plane is defined as $\text{Velecity ratio, } VR = \frac{\text{Slanted length}}{\text{Vertical height}}$. Thus, it can be said that it is only an inclined plane whose velocity ratio increases with the increase in the length of the ramp or plane.

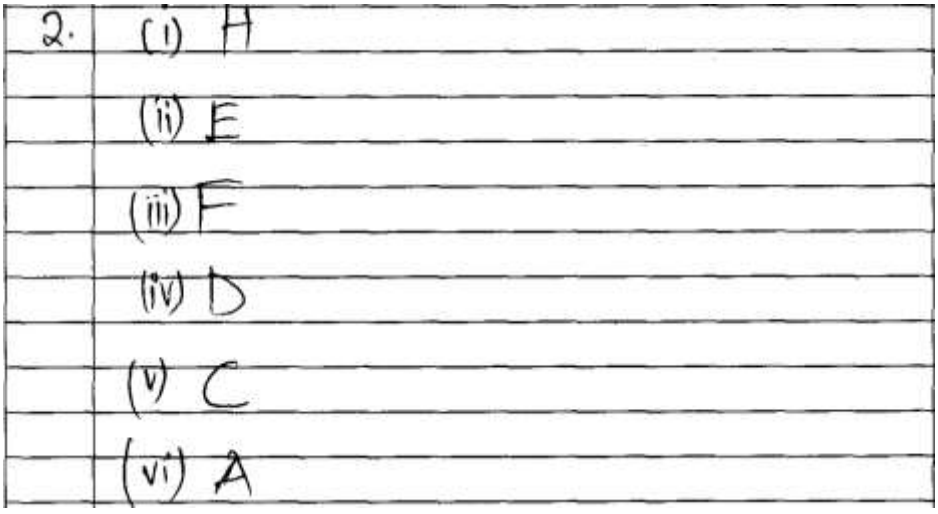
Item (iv) was constructed to assess the candidates' ability to identify the examples of the classes of levers. The item stated, "*The effort is between the load and fulcrum."* The correct response was D (*Tong*). Some candidates responded correctly. Those candidates in this category were able to differentiate the three classes of levers and ther basic examples. Those who chose the correct response had plenty of knowledge about simple machines, specifically the classes of levers. The candidates who failed to select the correct response had little knowledge about positions of effort, load and fulcrum in simple machines.

Item (v) was designed to assess candidates' ability to identify an instrument that operates based on the principle of pressure transmission in fluid. The correct response was C (*Hydraulic press*). Most of the candidates chose response C, suggesting that they were able to integrate the concepts of simple machines and the principle of transmission of

pressure in fluid. Few candidates failed to select the correct response because of a low understanding of the hydraulic press's concept structure and mode of operation. They confused the hydraulic press with other simple machines. Some of them opted for response F (*inclined plane)*, and others opted for response I (*screw Jack*). Generally, the candidates were supposed to understand that a hydraulic press is the only best option since it is the simple machine that works with liquid enclosed to produce large force from small force.

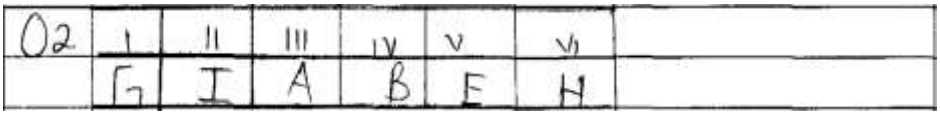
In Item (vi), the candidates were required to identify a device that carries an object horizontally from one point to another. The correct response was A (*Wheelbarrow*). Most of the candidates matched the description with the correct response. This indicates that they had sufficient knowledge of simple machines, particularly the the function of the wheelbarrow. Few candidates failed to opt for the correct response because they were not able to identify the simple machine that carries objects from one point to another in a horizontal direction. Most of those who failed to respond correctly chose response D (*Tong*). Tong is among the levers given in List A**,** but it was not a correct response. Some of the candidates opted for response H (*Windmill*) and I (*Screw Jack*). They failed to differentiate between levers and other simple machines.

In summary, smost of the candiadtes (58.98%) matched the items correctly. Extract 2.1 shows the responses of one of the candidates who scored all marks in this question.



Extract 2.1: A sample of the candidate's correct responses in Question 2.

Conversely, some candidates scored zero marks in question 2. This shows that the topic of S*imple Machines* particularly their examples was not well understood to some of them. Extract 2.2 shows a sample of incorrect responses from one of the candidates who scored zero marks in this question.



Extract 2.2: A sample of a candidate's incorrect responses in Question 2.

2.2 Section B: Short Answer Questions

This section comprised six (6) short answer questions derived from eleven (11) topics stipulated in the 2010 Physics syllabus. *These topics include Light; Optical Instruments; Pressure; Force in Equilibrium; Simple Machines; Newton's Laws of Motion; Thermal Expansion; Transfer of Thermal Energy; Waves; Radioactivity; Geophysics;* and *Elementary Astronomy;* Each question weighted nine (9) marks, making a total of fifty four (54) marks. The candidates were required to attempt all the questions. The candidates were required to use physics concepts, theories, and principles, draw diagrams and pply mathematics skills to determine the various physical phenomena.

2.2.1 Question 3: Light and Optical Instruments

The question consisted of two parts, namely; part (a) and (b). Part (a) of this question was a conceptual question constructed from the topic of *Light*. This part aimed to assess the candidates' ability to describe the application of the curved mirrors. It required the candidates to justify the statement that a convex mirror is often used as the wing mirror of a car instead of plane mirror. Part (b) of this question was a numerical question developed form the topic of *Optical Instruments*. The item was designed to assess candidates' ability to construct the camera and use mathematics skills to determine the focal length of the camera lens and the height of the image formed on the film, if a camera is used to take a close up picture of an object 3 cm tall, when the object is positioned 24 cm in front of the lens which is focused on the film 12 cm behind the lens.

Looking at the nature of part (b), the candidates can either (i) do mathematical manipulation directly to obtain those physical quantities or (ii) use graphical method to determine the focal length and the height of the image formed on the film.

The statistical analysis shows that the question was attempted by a total of 122,102(100 %) candidates, out of whom 49,999 (40.95%) scored from 0.0 to 2.5 marks, 33,160 (27.16%) scored from 3.0 to 5.5 marks and 38,943 (31.98%) scored from 6.0 to 9.0 marks. These scores indicate that candidates' performance in this question was average as 72,103 (59.05 %) scored from 3.0. to 9.0 mark out of 9.0 marks allocated to this question. Figure 3 summarizes the performance of the candidates in Question 3.

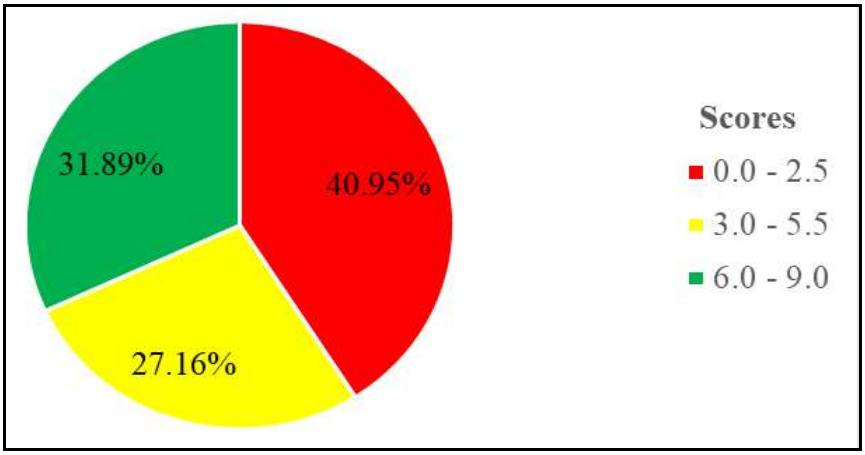


Figure 3: *The performance of the candidates in Question 3.*

The analysis reveals that most candidates scored higher marks in part (a) than in part (b). This is to say that these candidates had good skills in providing scientific reasoning in the field of light, particularly curved and plane mirrors. However, the candidates who scored high marks in part (b), were competent in formulating the lens and magnification formula to determine the focal length of the camera lens and the height of the image formed on the film. Extract 3.1 shows the correct responses from one of the candidates who scored high in question 3.

3. a) Because a convex mirror has a wide range of view compared to the plane mirror that help the driver to see the wide range behind the car.

b) Data given.

Object height = 3cm.

Objat distance = 24cm.

Image distace = 12cm.

focal length f = ?

height of image = ?

from;

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}.$$

$$\frac{1}{f} = \frac{1}{12} + \frac{1}{24}$$

$$= \frac{2+1}{24}$$

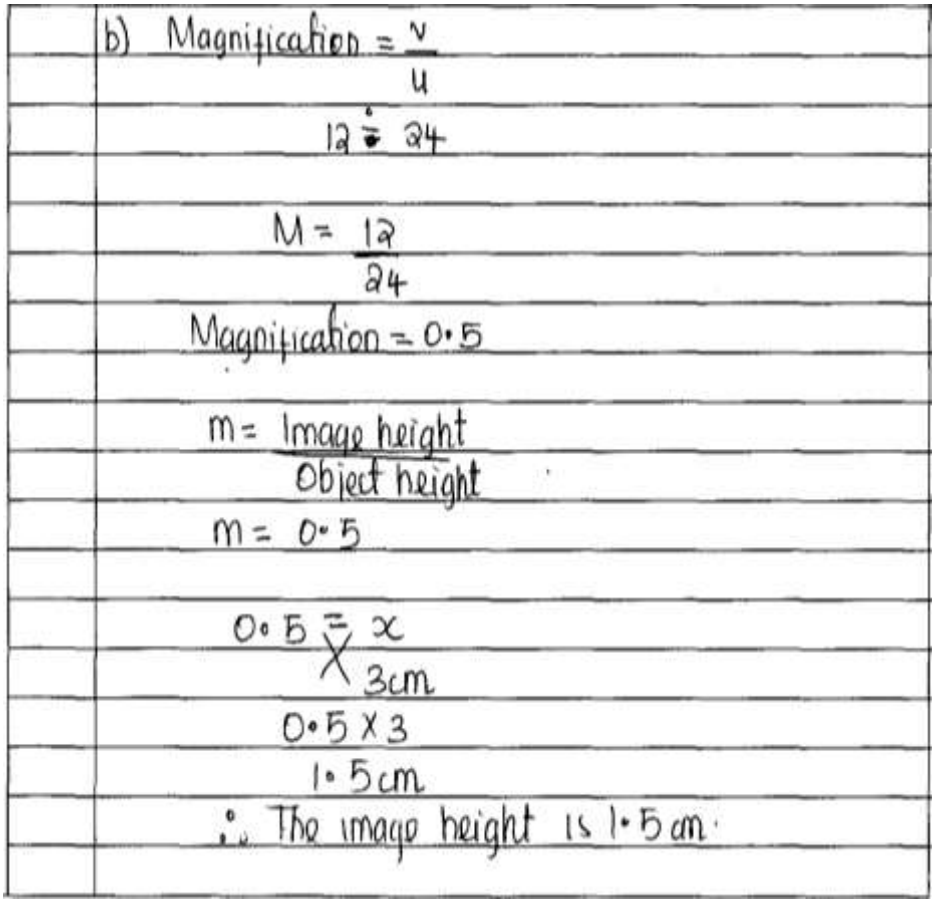
$$\frac{1}{f} = \frac{3}{24}$$

$$f \times 3 = 24$$

$$\frac{3f}{3} = \frac{24}{3}$$

$$f = 8cm$$

∴ The focal length is 8cm



Extract 3.1: A sample of a candidate's correct responses in Question 3.

In extract 3.1, the candidate managed to give reasons to why a convex mirror is often used as the wing mirror of a car instead of plane mirror. He/she determined the focal length of the camera lens and the height of the image formed on the film correctly.

On the other hand, due to poor English language writing skills, lack of mathematical and graphical skills, and inadequate knowledge regarding to the subject content, some candidates scored low marks. These candidates failed to demonstrate mastery of the concepts, theories, and physical principles related to *Light* and *Optical Instruments*.

Concerning to candidates' performance in part (a), some failed to provide correct responses. For instance, one of the candidates responded, "*Because a convex mirror makes an image magnified, upright and near to the object*." This incorrect response suggests that

the candidate had insufficient knowledge of the subject matter. The candidate was required to realize that a convex mirror produces a diminished image regardless of the object's position. He/she was supposed to know the features of the images formed by convex mirror as:

- Virtual image
- Upright image
- Reduced in size (smaller than the object regardless of the position of the object).

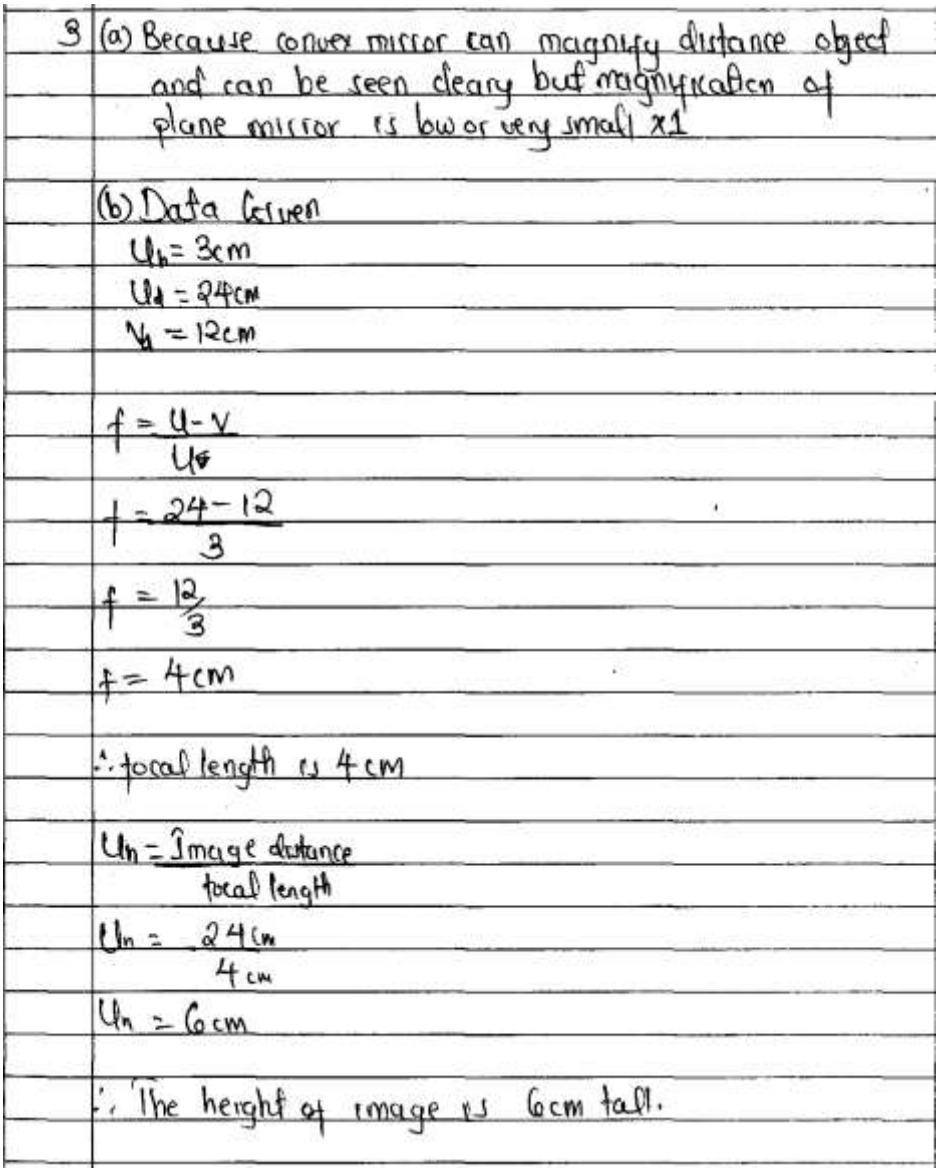
However, as per the candidate response, it is evident that candidates failed to integrate the concept of the size of the image with respect to the field view of vision Another candidate wrote, "*Because the image formed is virtual and small in size*". This candidate had some insight on the characteristics of the images formed by convex mirrors but failed to integrate these characteristics with respect to the wide view. The candidates was supposed to realize that the diminished image formed by the convex mirrors provides a wider view of the road to the driver. In addition, they were supposed to know that a plane mirror has a narrow range of view, making it impossible to use as a wing mirror.

Looking at part (b), the candidates who scored low marks failed to provide correct answers. These candidates failed to apply the correct mathematical formula to evaluate the focal length and size of the image formed. For instance, one of the candidates used the following formula $\frac{1}{f}=\frac{1}{u}-\frac{1}{v}$. This was an incorrect formula. Some candidates used correct mathematical formulas but failed to manipulate that formulas. For example, one of the candidates defined the correctly the lens equation $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$, then defined focal length as f = u+v which was an incorrect formula. It can be said that the candidate lacks mathematics skills to effectively manipualate the data and lens formula to be applied.

The candidates in this category, failed to use mathematics or graphical skills to determine the focal length and nature of the image formed by the camera lens. The candidates who had inappropriate mathematics knowledge failed to establish the relation between focal length, image

distance and the object distance. In addition to this, these candidates did not understand how magnification of the lens camera is related to the height of object and height of image formed on the film. The candidate was supposed to know that based on mathematics manipulation, focal length is defined as $f = \frac{uv}{v+u}$. Some of the formulas were irrelevant. For instance, one candidate defined magnification as $\frac{1}{h} = \frac{1}{h_o} + \frac{1}{h_i}$. Another candidate wrote $Magnification = \frac{position\ of\ object}{focal\ length}$. Another one wrote $m = H_i - H_O$. These were incorrect formulas and they had no meaning in Physics.

Further analysis shows that there was no candidate who managed to apply a graphical approach to determine the focal length and size of the image formed on the film. Thus, this suggests that they are seldomly familiar in using graphical drawing technique when determining the focal length and size in terms of heigt of image and object of the lens camera. Extract 3.2 shows the incorrect responses from one of the candidates in question 3.



Extract 3.2:A sample of a candidate's incorrect responses in Question 3.

In extract 3.2, the candidate failed to write both the lens camera and magnification formula by writing $f = \frac{u - v}{u}$ and

$u_n = \frac{\text{Image distance}}{\text{focal length}}$ instead of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, and

$\textit{Magnification} = \frac{\text{Height of image}}{\text{Height of object}}$ respectively.

2.2.2 Question 4: Pressure and Forces in Equilibrium

This question consisted of two parts, namely parts (a) and (b). Part (a) of this question was a conceptual question composed on the topic of *Pressure*. It was set to assess candidates' ability to identify suitable liquid for barometric application. The candidates were required to scientifically give a reason as to why water is practically not used to make a barometer instead mercury is used. Part (b) was constructed from the topic of *Forces in Equilibrium*. Part (b) measured the ability of the candidates to apply the concepts of Forces in equilibrium to loosen the car tire nuts. The candidates were required to apply the principle of the moment to determine wheither the 30 cm long spanner with a force of 150 N or the 20 cm long spanner with a force of 200 N would separately effectively used to loosen the right and left front car tire nuts res[ectively.

The statistical analysis shows that the question was attempted by a total of 122,102 (100%) candidates, out of whom 79,375 (65.01%) scored from 0.0 to 2.5 marks, 30,897 (25.30 %) scored from 3.0 to 5.5 marks and 11,830 (9.69%) scored from 6.0 to 9 marks. These scores indicate that candidates' performance in this question was average as 42,727 (34.99%) scored from 3.0 to 9.0 marks out of 9.0 marks allocated to this question. Figure 4 recapitulates the performance of the candidates in Question 4.

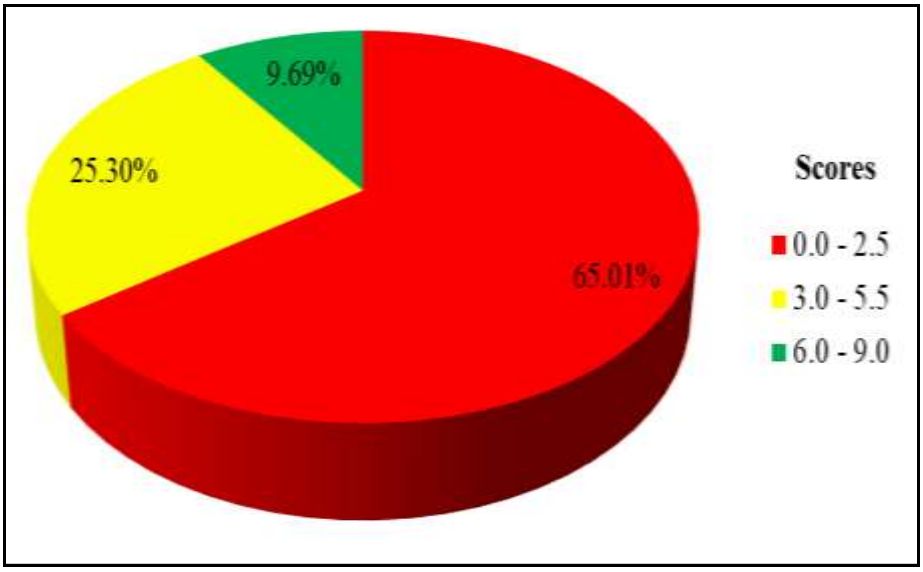
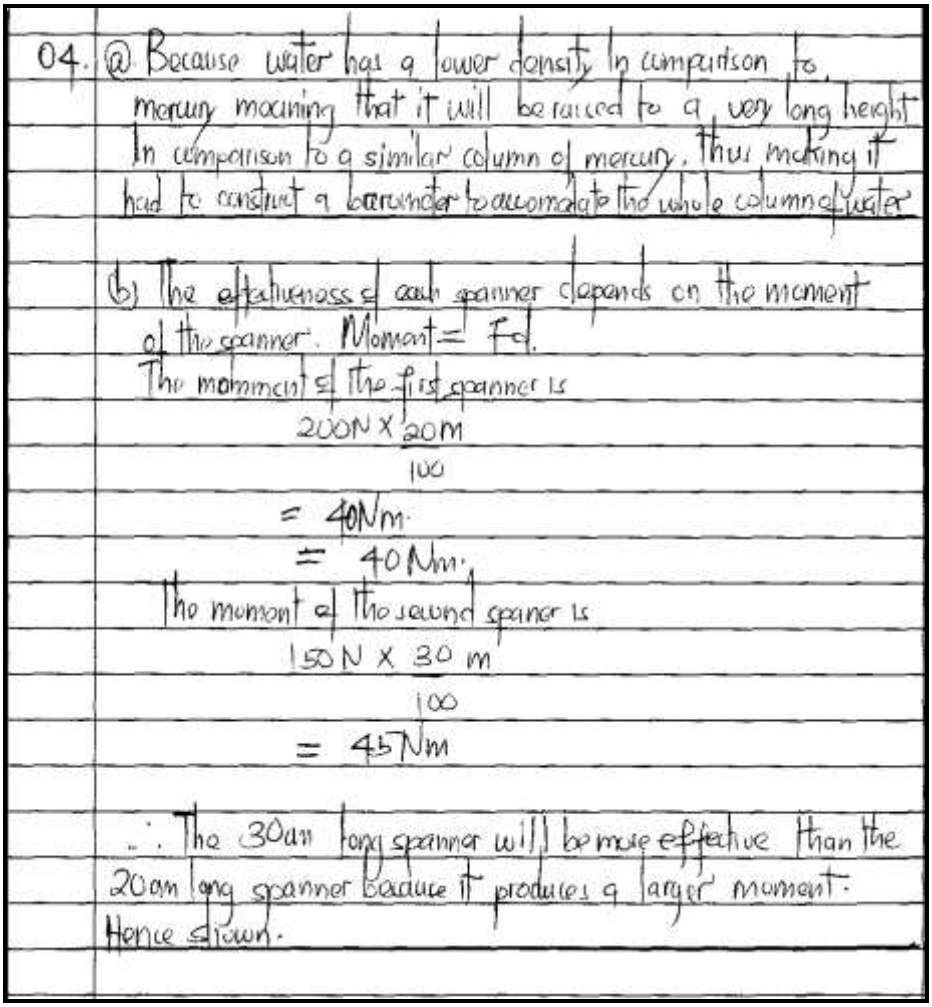


Figure 4: *The performance of the candidates in Question 4.*

The analysis shows that some of the candidates scored high marks (from 6.0 to 9.0). Those who scored high marks proved to have adequate knowledge of the concepts, theories and physical principles which relates to *Pressure* and *Force in equilibrium.* In part (a), they stated correctly that a barometer uses mercury instead of water because a water barometer would require a tall stem of glass about 10 m high than a short stem for mercury barometer. Hence, water is not practically used to make a barometer as it has high vapour pressure and wets glass which gives inaccuracy readings. In part (b), these candidates had also the ability to apply mathematical skills to identify the spanner that can effectively loosen the tire nuts. They applied the correct formula for the moment of force which enabled them identify the spanner to be used to loosen the car tire nuts. Extract 4.1 shows the sample of correct responses in Question 4.


04. (a) Because water has a lower density in comparison to mercury meaning that it will be raised to a very long height in comparison to a similar column of mercury, thus making it hard to construct a barometer to accomodate the whole column of water

(b) The effectiveness of each spanner depends on the moment of the spanner. Moment = Fd.

The moment of the first spanner is

$$\frac{200N \times 20m}{100}$$

$$= 40Nm$$

$$= 40Nm.$$

The moment of the second spanner is

$$\frac{150N \times 30m}{100}$$

$$= 45Nm$$

∴ The 30cm long spanner will be more effective than the 20cm long spanner because it produces a larger moment. Hence shown.

Extract 4.1: The sample of correct responses in Question 4.

On the other hand, the candidates who scored low marks failed to demonstrate mastery of the concepts, theories, and physical principles related to *Pressure and Forces in equilibrium*. The analysis further reveals that some of the candidates attempted only one part of either (a) or (b)) of the question.

In part (a), some of the candidates failed to provide the correct response. These candidates failed to comprehend the meaning of barometer, and thus provided incorrect responses. Some of them perceived a barometer as a device for measuring temperature. For instance, one candidate wrote, "*because mercury is sensitive to pressure*

and temperature change, it helps people to know the temperature of the place." Another candidate stated, "Because water has higher *linear expansivity than mercury*." These candidates probably assumed that liquids with good thermometric properties could be used in barometric applications. Some of them responded using concepts of *Current electricity and Measurement of thermal energy*. For example, one of the candidates wrote, "*Because water is a good conductor of heat and electricity and also have high melting point while mercury have low melting point and it is not good conductor of heat and electricity."* Another candidate wrote, *"Mercury cannot stick on the slope of glass."* This was an incorrect response. Some of the candidates provided irrelevant responses. For instance, one of the candidates responded, "*Because barometers are slightly soluble in water*." This was an irrelevant response and made no sense in physics, particularly *Pressure.* Looking at those responses, it is evident that candidates lacked knowledge of *Pressure in liquids*. This holds particularly true for the concepts of measurement of atmospheric pressure.

These incorrect responses suggest that some candidates faced problems in writing the correct concepts that relates to *pressure* especially, the significance of mercury over water in making a barometer.

The candidates were supposed to realize that the barometer is an instrument used to measure atmospheric pressure. Commonly, mercury is used instead of water because of the following:

- Mercury has high density; thus, less tube height is needed. Mathematically, the equation to find the atmospheric pressure by using a barometer is given as $p_{\text{atm}} = \rho_{\text{liquid}} \times g \times h.$ Thus, the height of the tube can then be estimated as $h = \frac{p_{\text{atm}}}{\rho g}$, it implies that $h \alpha \frac{1}{\rho}$. That is to say that the higher the density, the lower the height of the tube to be used in the barometer.

- Mercury has low vapour pressure compared to water. This is to say that mercury cannot evaporate easily into the evacuated portion of the tube. This gives high accuracy in measuring the atmospheric pressure.

- Mercury does not wet glass, thus giving accuracy in taking readings.

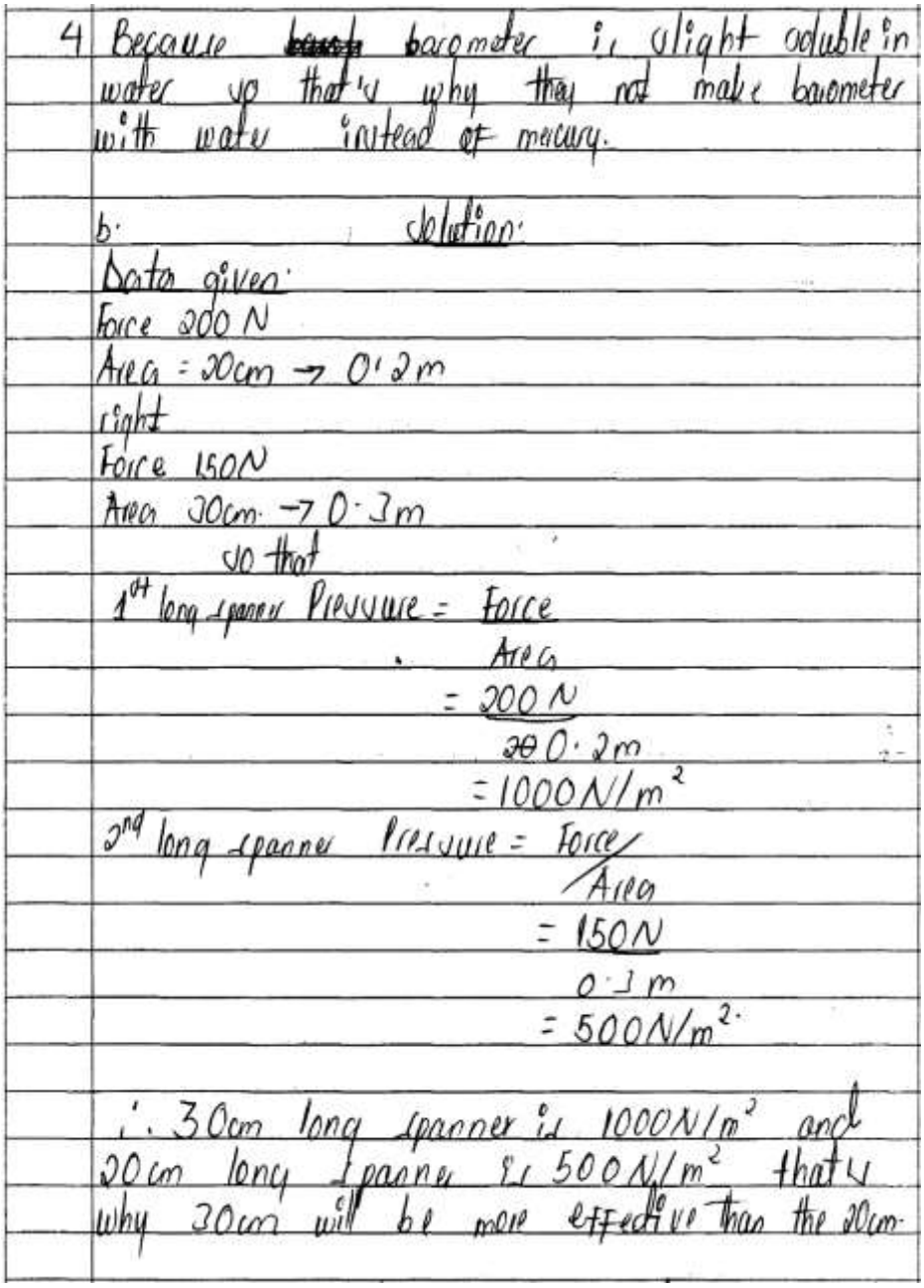
In part (b), candidates who responded incorrectly failed to compare the turning effect of two spanners with different lengths when different forces were applied to them. Some related the question to momentum, while others related it to work. One candidate responded with the formula, "Work = Force × Distance instead of Moment = Force × perpendicular distance for the case of moment of force or turning effect of applied force. Another candidate used the formula "$\frac{F_1}{A_1} = \frac{F_2}{A_2}$." This candidate confused the concept of comparing pressure in the arms of a hydraulic press with a moment of force produced on the spanner.

These candidates were supposed to realize that the turning effect of the force on the tire nut is defined by the moment of a force. The moment of a force depends on the magnitude of the force and the perpendicular distance from the axis of rotation. The magnitude of a moment of a force is defined as $M = Fd$, where F is the applied force, and d is the distance between the force's line of action and axis of rotation. The moment of a force for each spanner can be calculated as:

For 20 cm long spanner: $M = 200\,\text{N} \times 20\,\text{cm} = 4000\,\text{Ncm} = 40\,\text{Nm}.$

For 30 cm long spanner: $M = 150\,\text{N} \times 30\,\text{cm} = 4500\,\text{Ncm} = 45\,\text{Nm}.$

As per the calculation above, a 30-cm long spanner has a larger moment of force value than a 20-cm long spanner. Therefore, a 30-cm spanner is more effective because less force (150 N) is needed to generate a moment of force (40 Nm) compared to the spanner with a 20-cm long handle. Extract 4.2 shows a sample of incorrect responses from one of the candidates in question 4.


4 Because barometer is slight soluble in water so that's why they not make barometer with water instead of mercury.

b. Solution:

Data given:

Force 200 N

Area = 20cm → 0.2m

right

Force 150N

Area 30cm → 0.3m

so that

1st long spanner Pressure = Force / Area

= 200 N / 0.2m

= 1000 N/m²

2nd long spanner Pressure = Force / Area

= 150N / 0.3m

= 500N/m².

∴ 30cm long spanner is 1000N/m² and 20cm long spanner is 500 N/m² that's why 30cm will be more effective than the 20cm.

Extract 4.2: A sample of incorrect responses in Question 4.

In extract 4.2, the candidate used the formula for pressure in solids in part (b) to determine which spanner will be more effective than the orher instead of using the formula for the moment of force.

2.2.3 Question 5: Newton's Laws of Motion and Simple Machines

The question consisted of parts (a) and (b). Part (a) was set from a topic of *Newton's Laws of Motion*. This item aimed to assess the ability of the candidates to apply Newton's third law to describe the motion of a swimmer. The item required the candidates to give a reason as to why while swimming, the swimmer pushes the water backward with his hands. Part (b) was designed on the topic of *Simple Machines*. The candidates were provided with two simple machines, A and B, with the same efficiency. The candidates were required to use a mathematical formula to justify that a simple machine A requires minimum effort to raise a load of 5000 N.

The analysis shows that the question was attempted by a total of 122,102 (100%) candidates, out of whom 94,768 (77.61%) scored from 0.0 to 2.5 marks, 19,939 (16.33%) scored from 3.0 to 5.5 marks and 7,395 (6.06 %) scored from 6.0 to 9.0 marks. These scores indicate that candidates' performance in this question was weak as majority, 94,768 (77.61%) scored the lowest range of marks from 0.0 to 2.5 marks out of 9.0 marks allocated to this question. Figure 5 summarizes the performance of the candidates in Question 5.

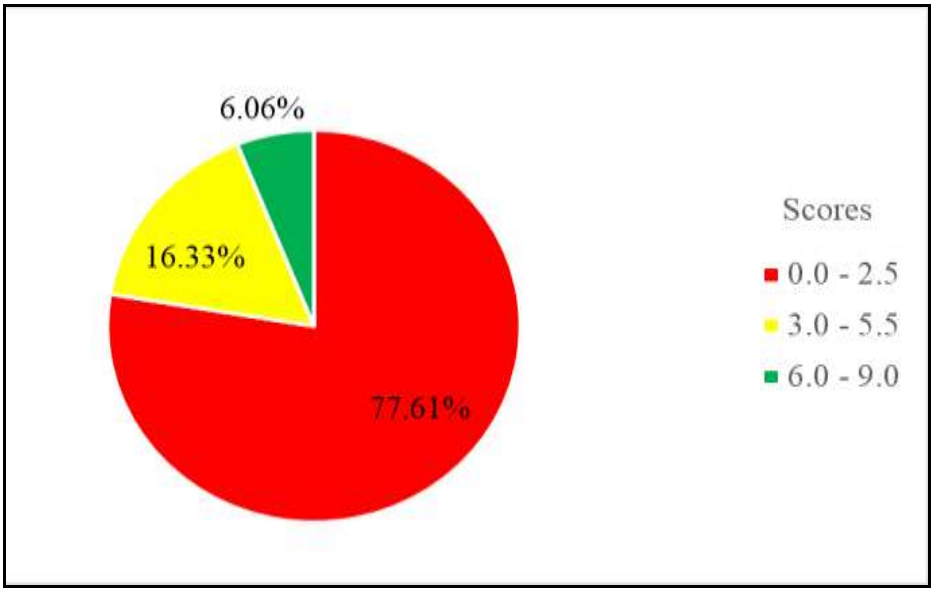
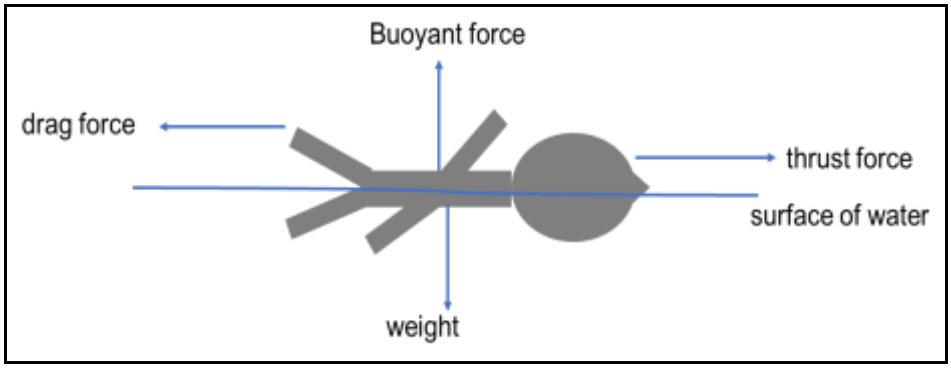


Figure 5: *The performance of the candidates in Question 5.*

Further analysis shows that most of the candidates attempted either part (a) or part (b) of the question The majority of the candidates (77.61%) scored low marks (0.0 to 2.5) which indicates that they had insufficient knowledge and skills in the topics of Newton's *Laws of Motion and Simple Machines*. In part (a) of the question, most of the candidates who responded incorrectly provided responses that were out of the context of the question. For instance, one candidate responded: *"In order to reduce water pressure."* This was an incorrect response because the pressure in water (liquid) does not depend on the features on its surface. The candidate failed to relate motion and force and pressure. The candidate was supposed to know that force is the cause of motion. Other candidates lacked the basic knowledge of Newton;s third law of motion as they failed to integrate the concepts of Newton's laws of motion into the swimmer's motion. For example, one of the candidates stated, "*To increase frictional force and normal force for swimmer to move forward*." The candidate failed to comprehend forces acting on the swimmer, as shown in the following diagram.



The forces exerted on the swimmer.

As shown in the diagram, it is evident that thrust and drag force describe the swimmer's forward motion. Buoyant force and weight describe the floating state of the swimmer. Looking at the candidate's responses, it is clear that the candidates failed to understand which forces are responsible for forward motion. Those candidates were supposed to realize that according to Newton's third law, when the swimmer pushes water backward (action) during swimming, water offers a reaction force, making the swimmer move forward.

Further analysis reveals that those who scored low marks in part (b) failed to apply the appropriate mathematical formula to determine the minimum effort required to raise a load of 5000 N. This suggests that most of those candidates were unable to identify names or types of the simple machines A and B as a result, they used wrong formula. Some of the candidates regarded the given simple machines as levers. Others used incorrect formulas to find the velocity ratio of wheel and axle as $VR = \frac{R^2}{r^2}$. This was the wrong formula and does not provide any physical meaning in physics. The candidate was supposed to realise that the correct formula for the velocity ratio for the wheel and axle is $VR = \frac{R}{r}$.

They were also supposed to understand that simple machines A was a wheel and axle while B is a compound pulley system. Likewise, they were supposed to comprehend that velocity ratio for a wheel and axle is defined as $VR = \frac{R}{r} = \frac{50}{10} = 5$. The velocity ratio for compound pulley system is given as $VR = \text{number of pulleys} = n = 4$. The efficiency of simple machine is expressed as $Efficiency = \frac{M.A}{V.R} \times 100\%$. Since both simple machines have the same efficiency then, $\left(\frac{MA}{VR}\right)_A = \left(\frac{MA}{VR}\right)_B$. By substituting the values of velocity ratios and performing manipulation, it can be found that $(MA)_A = 1.25(MA)_B$. This implies that the mechanical advantage of simple machine A is greater than that of B. The mechanical advantage is given as $MA = \frac{\text{Load}}{\text{Effort}}$. This means that $\text{Effort} = \frac{\text{Load}}{MA}$. For A constant a load, $\text{Effort } \alpha \ \frac{1}{MA}$. Based on this analysis it can be concluded that simple machine A requires minimum effort. Extract 5.1 is the sample of the incorrect responses from one of the candidates who scored low marks in Question 5.

5a) To overcome the resistant or opposing force caused by water ~~~~ due to surface tension of the liquid.

b) Data.

$\pi = 3.14$

$R = 10cm$

$P = 10/1$

$P = 10$

$L = 1000N$

Sol.

$E_1 = E_2$

$V = \frac{2\pi R}{P}$

$= \frac{2 \times 3.14 \times 10}{10}$

$V = 31.4$

5b) $\xi = \frac{M.A}{V.R} \times 100\%$.

$\xi = \frac{1000/E}{31.4} \times 100\% = \frac{5000/E}{4} \times 25 \times 100\%$.

$\frac{100000}{E} : \frac{125000}{E}$

$\frac{100000}{31.4} = \frac{125000}{E}$

$\frac{100000}{31.4E} = \frac{125000}{E}$

$\frac{3200000}{31.4} = \frac{31.4E}{31.4}$

$E = 11942.6 \cdot 11942.6$

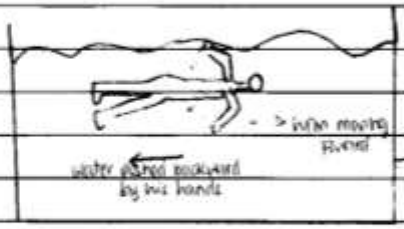
Minimum effort required to raise a load of 1000N is 11942.6N.

Extract 5.1: The sample of incorrect responses in Question 5.

In extract 5.1, the candidate utilized the concept of surface tension to explain the assertion why the swimmer pushes the water backward with his hands instead of the concept of Newton's third law of motion. Consequently, the candidate failed to establish a relationship that helps to justify that simple machine A requires minimum effort to raise a load of 5000 N.

Conversely, some of the candidates scored high marks (7.0 to 9.0). Those candidates were able to apply Newton's third law of motion to describe the motion of a swimmer. This is to say that they demonstrated their ability to identify forces acting on the person during swimming. Moreover, those candidates demonstrated mastery of concepts, theories, and mathematics. The candidates were able to apply the correct mathematics formula to evaluate which simple machines requires minimum effort to raise a load of 5,000 N. Extract 5.2 is a sample of the correct responses in Question 5.

5a) The swimmer pushes the water backward to propel him forward this can be explained by Newton's third law of motion that states "To every action there is an equal but opposite reaction". In the action is pushing water backward and the reaction is his body moving forward.



b) Data given

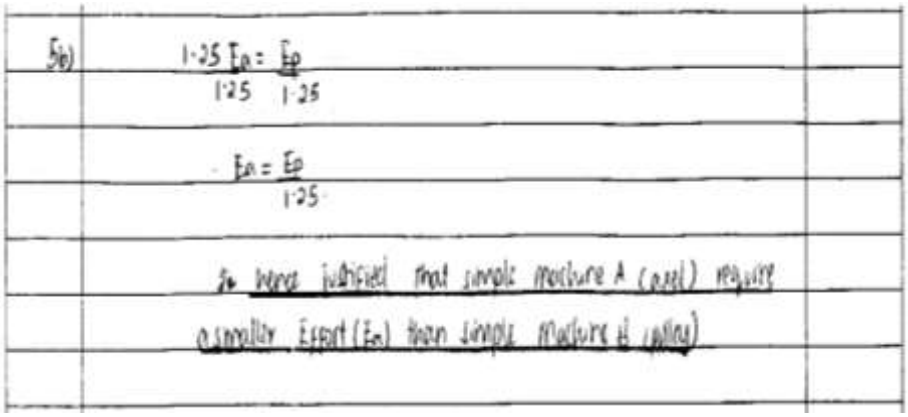
Machine A (pulley)	Machine B (pulley)
$VR = \frac{R}{r}$	$VR = 4$
$= \frac{(50cm)^2}{(10cm)^2}$	$\eta = \frac{MA}{VR} \times 100\%$
$VR = \frac{R}{r}$	$\eta = \frac{MA_B}{4} \times 100\%$
$= \frac{50cm}{10cm}$	$\frac{MA_B}{4} \times 100\% = \frac{MA_A}{5} \times 100\%$
$VR = 5$	$\frac{MA_B}{4} = \frac{MA_A}{5}$
$\eta = \frac{MA}{VR} \times 100\%$	$\frac{5MA_B}{4} = \frac{4MA_A}{4}$
$\eta = \frac{MA_A}{5} \times 100\%$	$MA_B = 1.25\, MA_B$

Recall

$$MA = \frac{L}{E}$$

$$\frac{L}{E_A} = 1.25 \frac{L}{E_B}$$

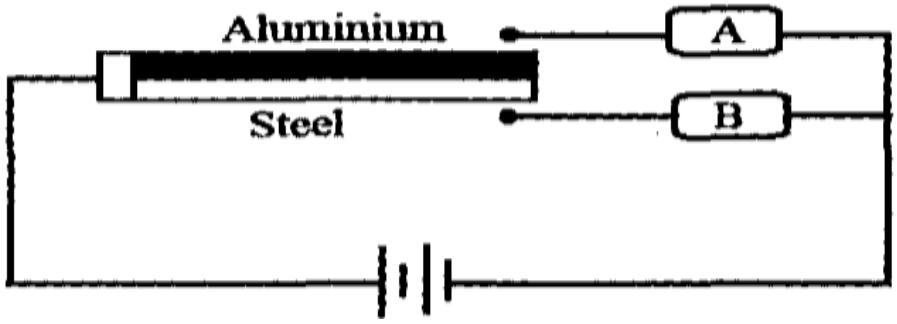
$$\frac{1}{E_A} = 1.25 \frac{1}{E_B}$$



Extract 5.2: The sample of correct responses in Question 5.

2.2.4 Question 6: Thermal Expansion and Transfer of Thermal Energy

This question comprised of parts (a) and (b). Both items were conceptual questions. Part (a) of this question was constructed from the topic of *Thermal Expansion*. In this part, the candidates were given a diagram showing a bimetallic thermostat strip used to regulate the room temperature using the devices labelled A and B. The candidates were required to identify which device, either device A or device B, acted as a heater, and they were supposed to provide a scientific rationale for their choice. Part (b) was set from the topic of *Transfer of thermal energy*. The item aimed to assess candidates' ability to apply the concepts of thermal transfer of energy to demonstrate heat transfer by convection in water.



The analysis shows that the question was attempted by a total of 122,102 (100%) candidates, out of whom 80,668 (66.07%) scored from 0.0 to 2.5 marks, 25,679 (21.03%) scored from 3.0 to 5.5 marks and 15,755 (12.90 %) scored from 6.0 to 9.0 marks. These scores indicate that

candidates' performance in this question was average as 41,434 (33.93 %) scored from 3.0 to 9.0 marks out of 9.0 marks allocated to this question. Figure 6 summarizes the performance of the candidates in Question 6.

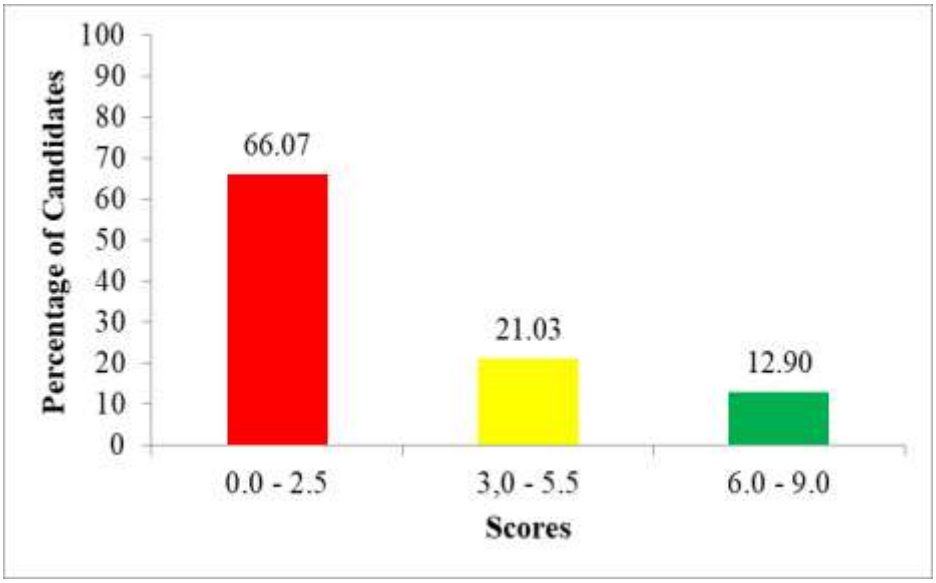


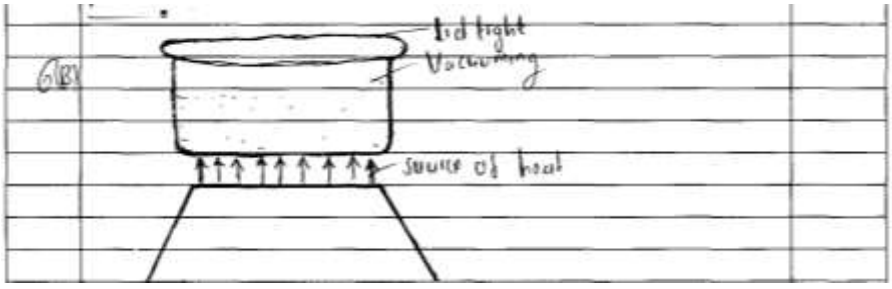
Figure 6: *The performance of the candidates in Question 6.*

The analysis further revealed that 66.07% of the candidates performed poorly on this question. They scored from 0.0 to 2.5 marks, suggesting that they had inadequate cknowledge in the topic of *Thermal expansion* and Transfer *of thermal energy*. In part (a), most of the candidates failed to score all marks allocated. This indicates that they failed to apply the concepts and principles related to thermal expansion to identify a heating element in the given thermal circuit. Some candidates were able to identify the correct device but provided incorrect scientific justification. For instance, some candidates wrote, "*Device A is a heater."* That is to say, they were guessing the choice. On the contrary, some candidates identified the correct device but provided an incorrect scientific reasoning. Those candidates lacked adequate reasoning skills or had less knowledge of the concepts and theories related to linear expansivity and the bimetallic strip. For example, the candidates wrote, "*Device B has small linear expansivity so it expands faster than device A, hence B is a heater."* Another candidate stated, "*B is a heater because once it heats*

up the bimetallic thermometer bend towards aluminum." Looking at those responses, it is evident that those candidates lacked a basic understanding of linear expansivity.

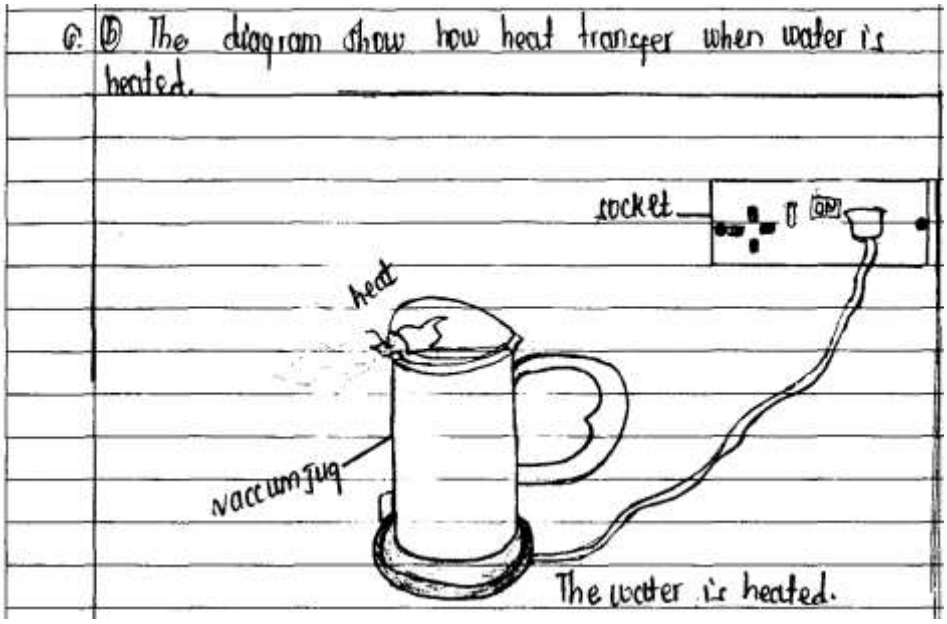
That is to say, most of the candidates who scored low marks in this part failed to integrate the concepts of linear expansivity in real-life situations. The candidates were supposed to know that linear expansivity is an intrinsic property of the material which describes the measure of an increase in the length of a body per unit of original length when its temperature increases by 1 K. That is to say that $\text{linear expansivity, } \alpha = \frac{\text{increase in length}}{\text{original length} \times \text{rise in temperature}} = \frac{\Delta l}{l_0 \Delta \theta}$. As per item (a), the bimetallic strip consisted of aluminium (with linear thermal expansivity of 0.00003 $^{\circ}C^{-1}$) and steel (with linear thermal expansivity of 0.00001 $^{\circ}C^{-1}$). When the metals are heated, aluminium expands faster than steel. As a result, the aluminium curves are in a convex shape, and consequently, the bimetallic curves move toward device B. On the other hand, at low temperatures (below room temperature), aluminium contracts faster than steel; consequently, the bimetallic curves toward device A make contact with A. The circuit turns on, and the heating starts. This implies that device A is a heater.

In part (b) of this question, those who scored low marks failed to provide the correct response. This indicates that candidates had inadequate knowledge to demonstrate heat transfer. They lacked skills and understanding of heat transfer, especially by convection. Some drew diagrams showing the containing vessel with water on the source of heat without indicating convection currents.



Extract 6.1: A sample of incorrect response in question 6 (b)

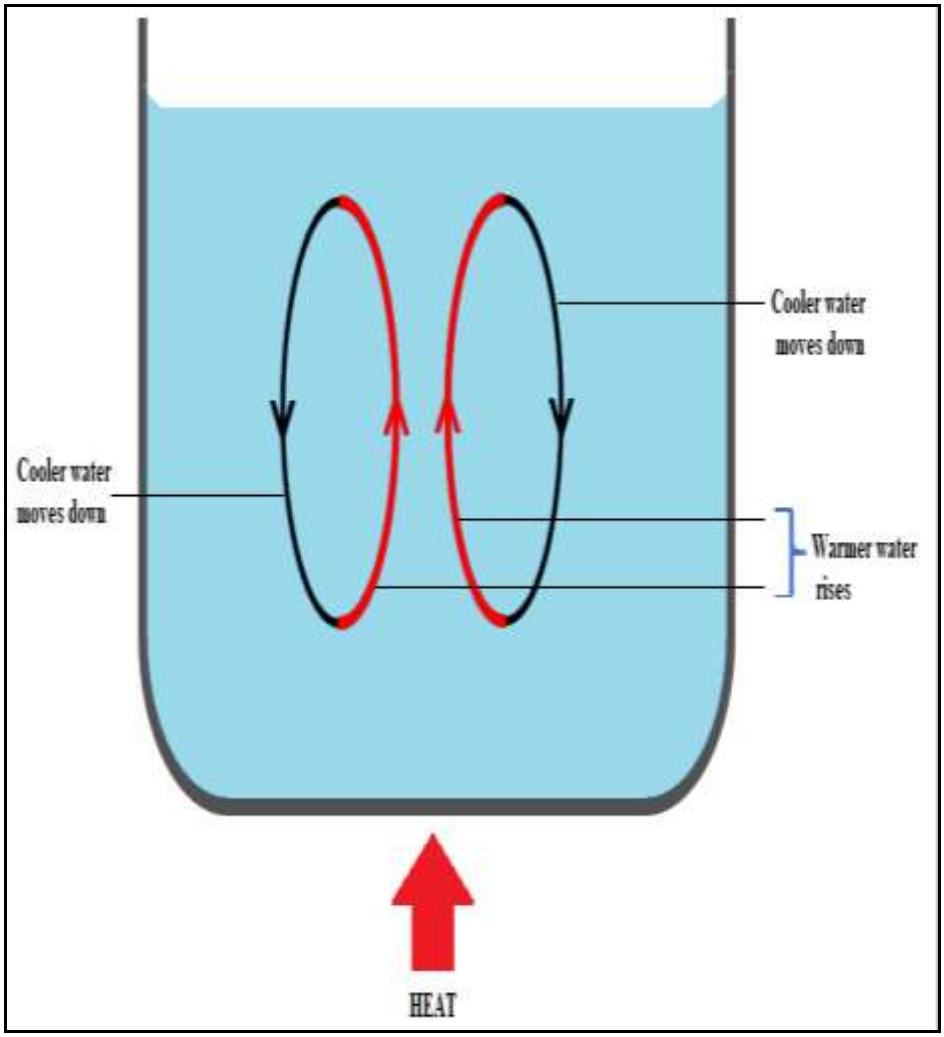
Some candidates demonstrated anomalous behaviour of water to indicate density variation with temperature change. Some of them had a concept that when water is heated, convection currents start, but they failed to present the sketch with convectional currents. For example one candidate responded as, "*Convection is the process whereby particles of matter move from high concentration to the low concentration due to change in temperature through the medium"* Another candidate tried to sketch the diagram indicating a sketch of electric cattle plugged to an electric socket to boil water as shown in extract 6.2.



Extract 6.2: A sample of incorrect response in question 6 (b)

Also, some candidates drew a sketch of the domestic hot water supply. These candidates demonstrated poor understanding since they failed to differentiate the mechanism and applications of convection of heat. Candidates were supposed to understand that the system of hot water supply of a house is one of the application of convection. They were supposed to draw a simple sketch indicating an arrow diagrams showing how water molecules circulate when heated. In fact, when water is heated, water molecules at the bottom near the heat source gain temperature and become less denser. This will make warm molecules to move upward, whereas the cooler molecules from the surface move downward since they are denser than warmer molecules. This exchange

in the position of particles proceed continuously as long as water is supplied with heat as shown in the following diagram.



Convection Currents of Water

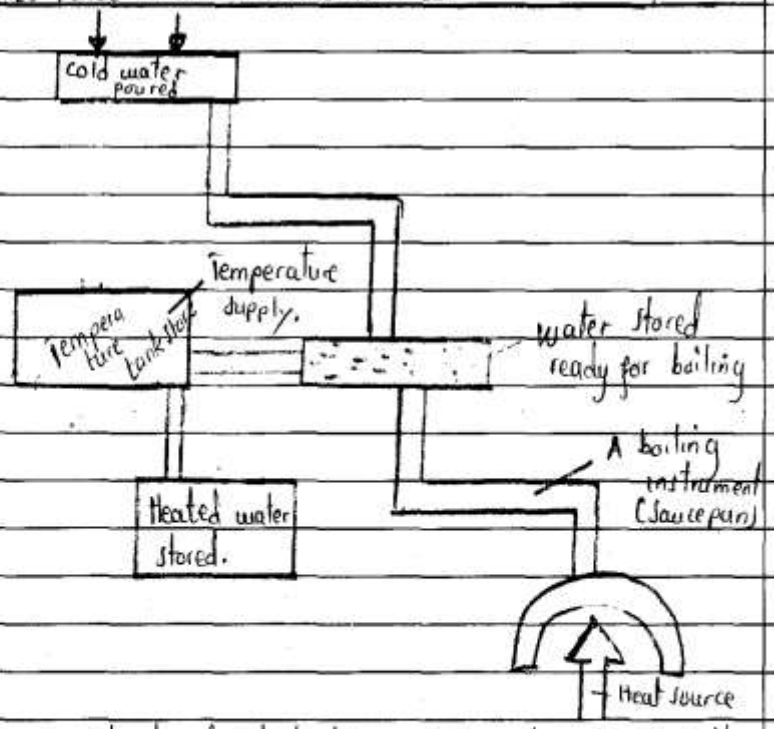
The diagram indicates how convectional currents circulate when water is heated. It shows that hotter particles rise due to low density after being heated, and the downward movement of particles indicates that cooler particles have high density. Extract 6.3 is a sample of incorrect responses from one of the candidates in question 6.

6. a) From a diagram that shows a bimetallic thermostat strip used to regulate the temperature of the room by using a heater and cooler.

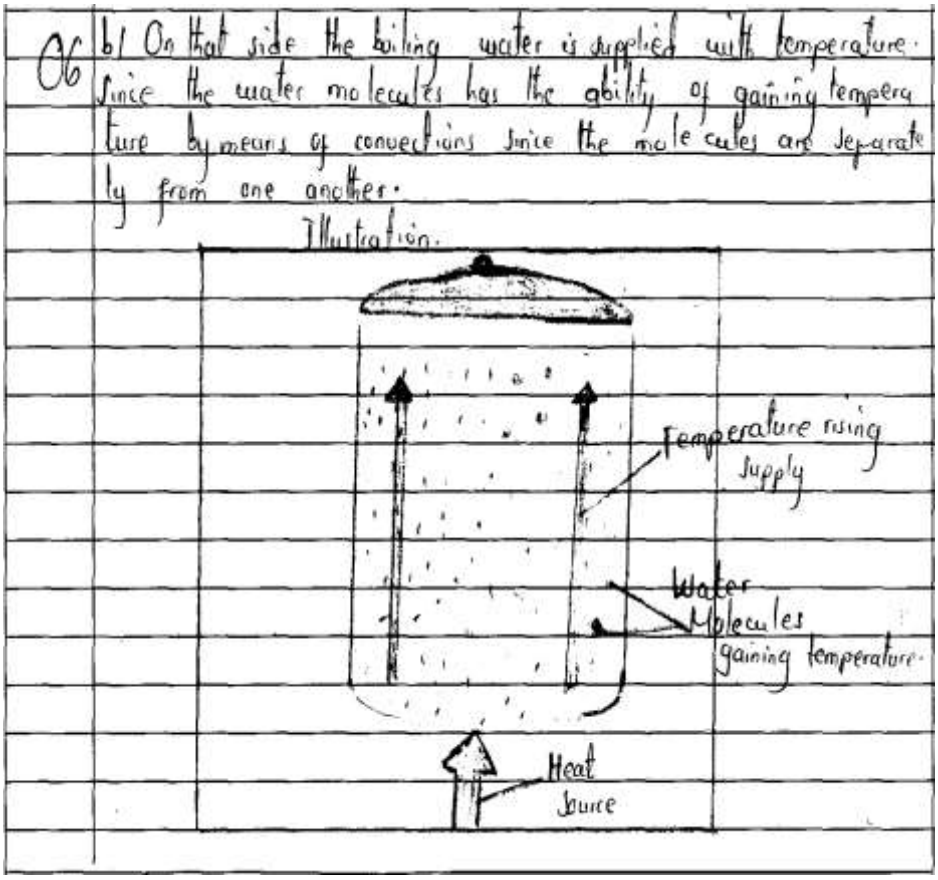
A device which is a heater is device B

This is because device B is a heater since it is the one where by it produces heat where by the heat when is produced cause into the expansion of aluminium and steel and then device A acts as the cooler where by when temperature is increased and cause into expansion of steel and aluminium are then cooled so as to return to their orginal and normal condition Due to that device B is a heater.

6. b) A DIAGRAM SHOWING HOW HEAT TRANSFER BY CONVECTION TAKES PLACE WHEN WATER IS HEATED.



Water is introduced into heating machine and sent to the boiling instrument where by when heat is supplied it gains temperature and then the temperature is supplied to the other side



Extract 6.3: A sample of the incorrect responses in Question 6

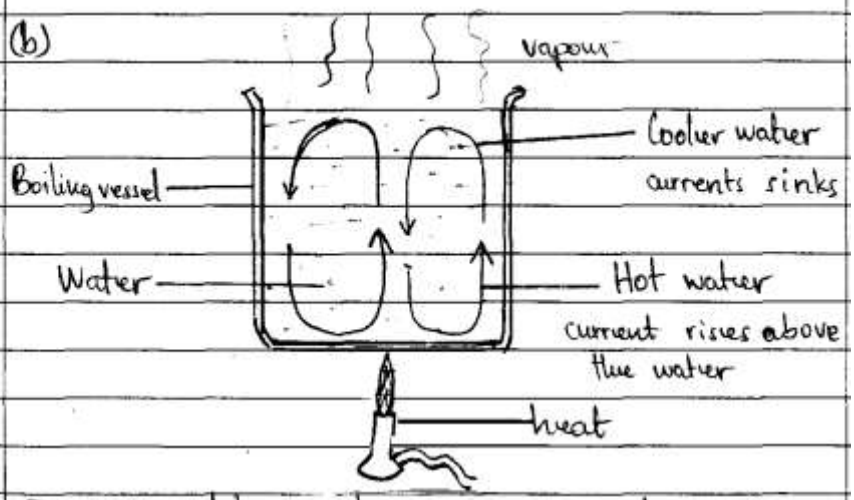
In extract 6.3, the candidate lacked the concepts of linear expansivity and meachanism of heat transfer by convection in liquids hence failed to provide the appropriate explanations.

On the contrary, the candidates who scored high marks in this question, had adequate knowledge in the topics of *Thermal expansion* and *Transfer of thermal energy* especially linear expansion of metals and heat transfer by convection in liquids. The candidates were able to assimilate the concepts, theories and principles related to thermal expansion of metals in conjuction to their respective linear expansivities to identify that device A is a heater. Theoretically, they were able to recognize that the metal or alloy whose linear expansivity is large is a heater and the one with small value of linear expansivity is a cooler.

For this case, aluminium a heater and steel is a cooler. Moreover, these candidates demonstrated the ability to apply the concepts of transfer of thermal energy to illustrate heat transfer by convection in water. They were able to show that when water is heated, warm water from the bottom of the container rises to the surface water and the cold water moves down to take the place of the rising warm water resulting into circulating convettional current through the water. Interestingly, some candidates responded by applying the concepts of the kinetic theory of matter. Those candidates had the ability to relate the energy and motion of the water molecules. For example one candidate responded as, *"When heat is applied on the water, water molecule or atoms gain the kinetic energy, then move more vigorous and lose their binding energy from liquid state to gas state through heat transfer by convection take place."*Extract 6.4 exposes the responses of one of the candidates who correctly answered question 6.

6. (a) Device A is a heater, because aluminium expands more than steel, so when the temperature at the room increases aluminium will expand faster than steel causing the bimetalic strip to curve toward device B so as to regulate the temperature. Also aluminium contracts faster than steel, so when the temperature become cooler the metal strip will curve toward device A which is a heater to regulate the temperature.

(b)



From the diagram above, the convenction occurs through alternately rising and falling of water currents depending on their temperatures. The hotter water has low density than the cool water hence it rises on the upper part of the boiler then the cooler water from top part falls to under part of the boiler due to its higher density, this currents ocurs repeatingly causing convection and tranfer of heat throughout the water.

Extract 6.4: A sample of the correct responses to Question 6.

2.2.5 Question 7: Waves and Radioactivity

This question comprises two parts namely: part (a) and (b). Part (a) was set from the topic of *Waves*. The item was constructed to assess candidates' ability to compare the effect of frequency and amplitude to musical sound. Part (b) was constructed from the topic of *Radioactivity*. The candidates were required to use a diagram to compare the penetrating ability of the three types of radiations on a piece of paper, aluminium sheet and lead block.

The number of candidates who attempted this question was 122,102 (100%), out of whom 78,954 (64.66%) scored from 0.0 to 2.5 marks, 36,545 (29.93%) scored from 3.0 to 5.5 marks and 6,603 (5.41%) scored from 6.0 to 9.0 marks. These scores indicate that candidates' performance in this question was average as 43,148 (35.34%) candidates scored from 3.0 to 9.0 marks out of 9 marks allocated to this question. Figure 7 summarizes the performance of the candidates in Question 7.

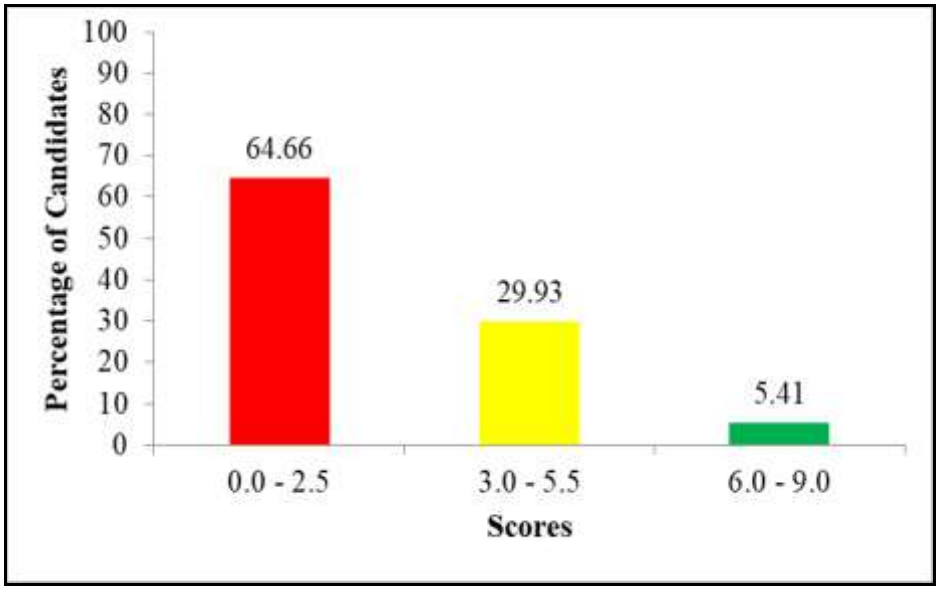


Figure 7: *The performance of the candidates in Question 7.*

The analysis shows that most of the candidates who scored low marks failed to give the correct responses to part (a). This suggests that these candidates had inadequate knowledge of the concepts of musical sound. They failed to show the relationship between pitch and loudness with amplitude and frequency. Most of them provided wrong responses. For

example, one of the candidates wrote that, "*when frequency increase the loudness of the musical sound increase*." This was an incorrect response. The candidate failed to understand that the loudness of a sound is a measure of the amplitude of the sound wave. That is to say, the greater the amplitude of the sound waves, the louder the sound. The frequency of the sound waves determines the pitch of the sound. It can be said that the higher the frequency of sound waves, the higher the pitch of the sound. One of the candidates responded, "*When the frequency is increased the wavelength of musical sound decrease*". Another candidate wrote, "*Wavelength changes the rate of hearing the musical sound."* Those were incorrect responses. Those candidates in this respect failed to realize that musical sound is a wave that travels at a certain speed in a medium. It can be defined as $v = f \times \lambda$. It implies that the speed of sound waves in air is almost constant. However, the speed of the sound depends on the medium's compressibility. It should be noted that the speed of sound is higher in water than in air. However, as per the item, it could be assumed that the sound wave was propagating in the air. For a fixed distance, the rate of change of hearing the musical sound is almost constant. The candidates were supposed to relate the frequency and amplitude of the musical sounds with respect to the pitch, loudness, timber and intensity.

Further analysis revealed that few candidates scored low marks in part (b). These candidates failed to describe the interaction of nuclear radiation with matter correctly. Most of the candidates failed to differentiate the properties of nuclear radiations. Moreover, it also observed that most candidates who scored low marks in this part failed to identify the types of nuclear radiations. As a result, they failed to describe their properties, particularly their penetrating power in different media. They were supposed to know that there are three nuclear radiations, namely alpha $\alpha-$radiation, beta, $\beta-$radiation, and $\gamma-$radiation. These radiations behave differently in different materials. Therefore, they can be differentiated based on their penetrating power in the materials. It has been proven that $\alpha-$radiation has lower penetration power, and it can be stopped by a thin sheet of paper. $\beta-$radiation has

moderate penetration power and can penetrate a sheet of paper but can be stopped by a thin aluminium sheet.

On the other hand, γ – radiations have higher penetration power as they can penetrate a thin aluminum sheet but can be stopped by a lead sheet of several centimetres. The candidates were required to provide a systematic sketch describing the aforementioned properties. Some of the candidates provided irrelevant responses. **Extract 7.1** is a sample of incorrect responses from a candidate who provided irrelevant responses.

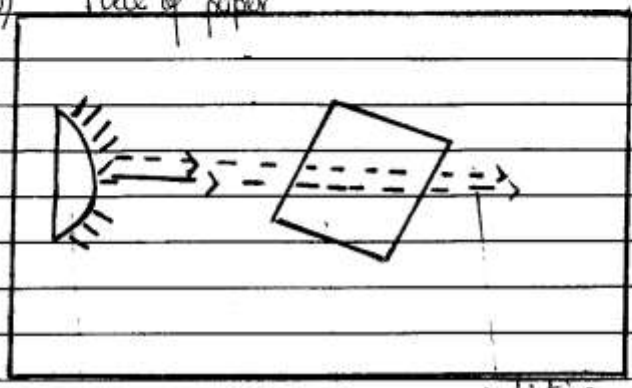
7. a) FREQUENCY

- The frequency that will be generated will be much and of high due to amount of crest formed will be of huge amount lead to produce high sound

AMPLITUDE

- amplitude will be generated into highest stage which lead to produce high sound

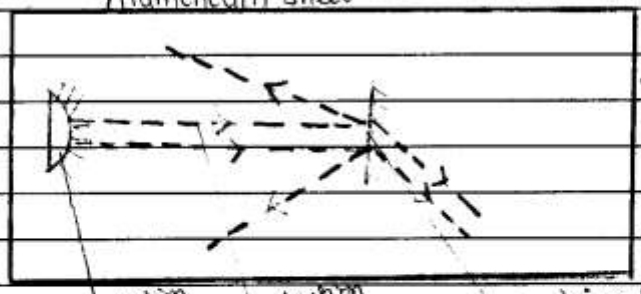
7. b) Piece of paper



- Easy to penetrate since material is transparent

Source of radiation — Piece of Paper — radiation

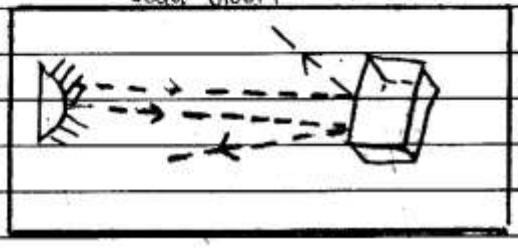
Aluminium sheet



- It allows little amount of radiation

Source of radiation — Radiation — aluminium sheet

Lead block



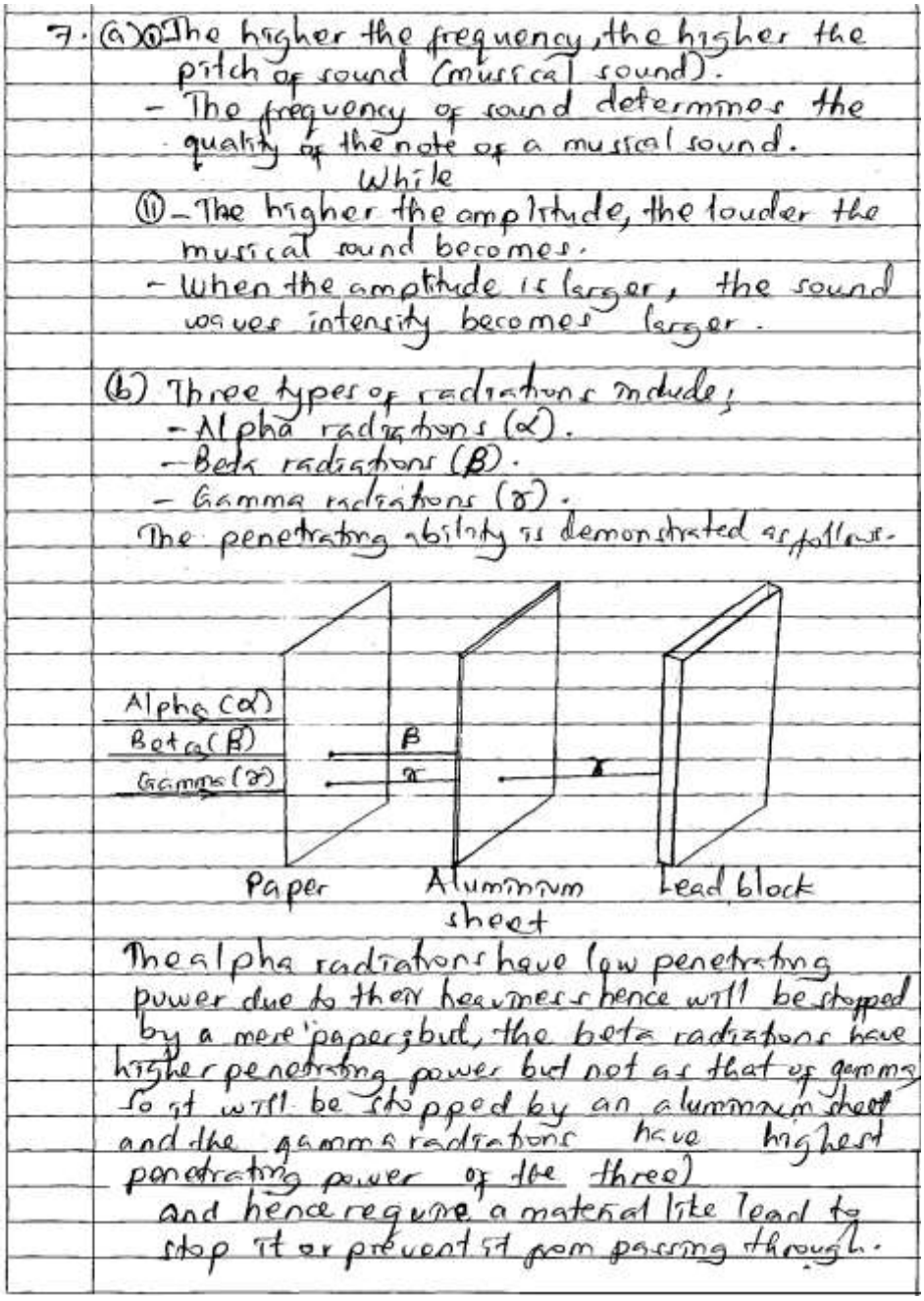
- Difficult to penetrate since material is opaque

Extract 7.1: A sample of the incorrect responses to Question 7.

In extract 7.1, the candidate failed to arrange and show how the three types of nuclear radiations can pass through the piece of paper, aluminium sheet and lead block depending on their penetration power.

On the contrary, candidates who scored high marks in this question were able to relate frequency and amplitude with respect to the pitch, loudness, timber and intensity. This indicates that they had enough competence of the musical sounds. These candidates were also able to identify the three types of nuclear radiations and correctly show their penetration power on the piece of paper, aluminium sheet and lead block

The candidates described the penetrating power of $\alpha-$radiation, $\beta-$radiation, $\gamma-$radiation, correctly. In addition, these candidates demonstrated effectively the penetration power of the nuclear radiations in different materials. **Extract 7.2** is a sample of responses from one of the candidates who provided the answers correctly in question 7.



Extract 7.2: A sample of the correct responses to Question 7

2.2.6 Question 8: Geophysics and Astronomy

This question consisted of parts (a) and (b). Part (a) was developed from the topic of *Geophysics*. The part (a) was a conceptual question. In this

question, the candidates were required to apply the concepts and theories of seismic waves to describe why surface waves are more dangerous than primary waves. On the contrary, part (b) was constructed from the topic of *Astronomy*. The item aimed at assessing the candidate's ability to describe the uses of constellations.

The statistical data analysis shows that the question was attempted by a total of 122,102 (100%) candidates, out of whom 65,547 (53.68%) scored from 0.0 to 2.5 marks, 24,322 (19.92%) scored from 3.0 to 5.5 marks and 32,233 (26.40%) scored from 6.0 to 9.0 marks. These scores indicate that candidates' performance in this question was average as 56,555 (46.32%) scored from 3.0 to 9.0 marks out of 9.0 marks allocated to this question. Figure 8 summarizes the performance of the candidates in Question 8.

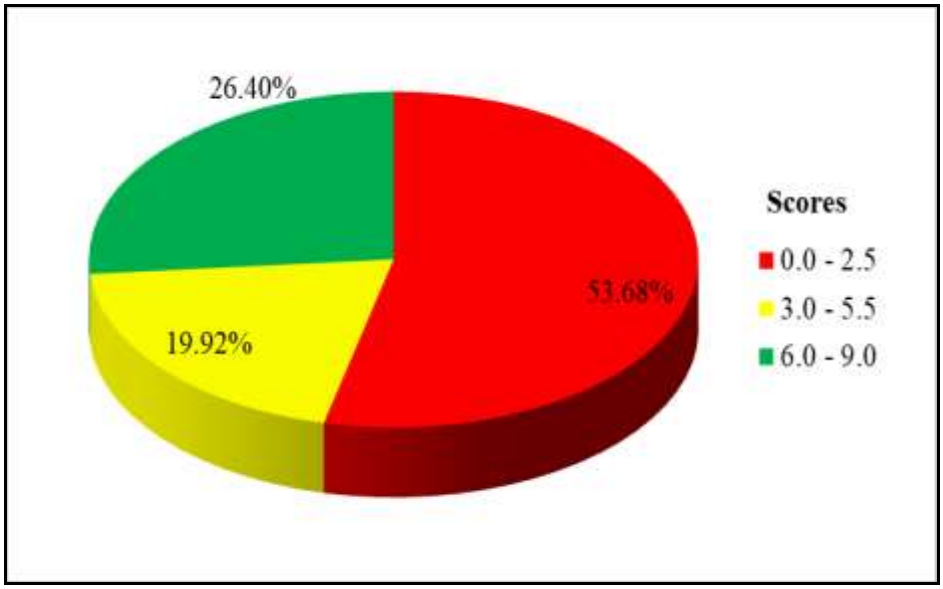


Figure 8: *The performance of the candidates in Question 8.*

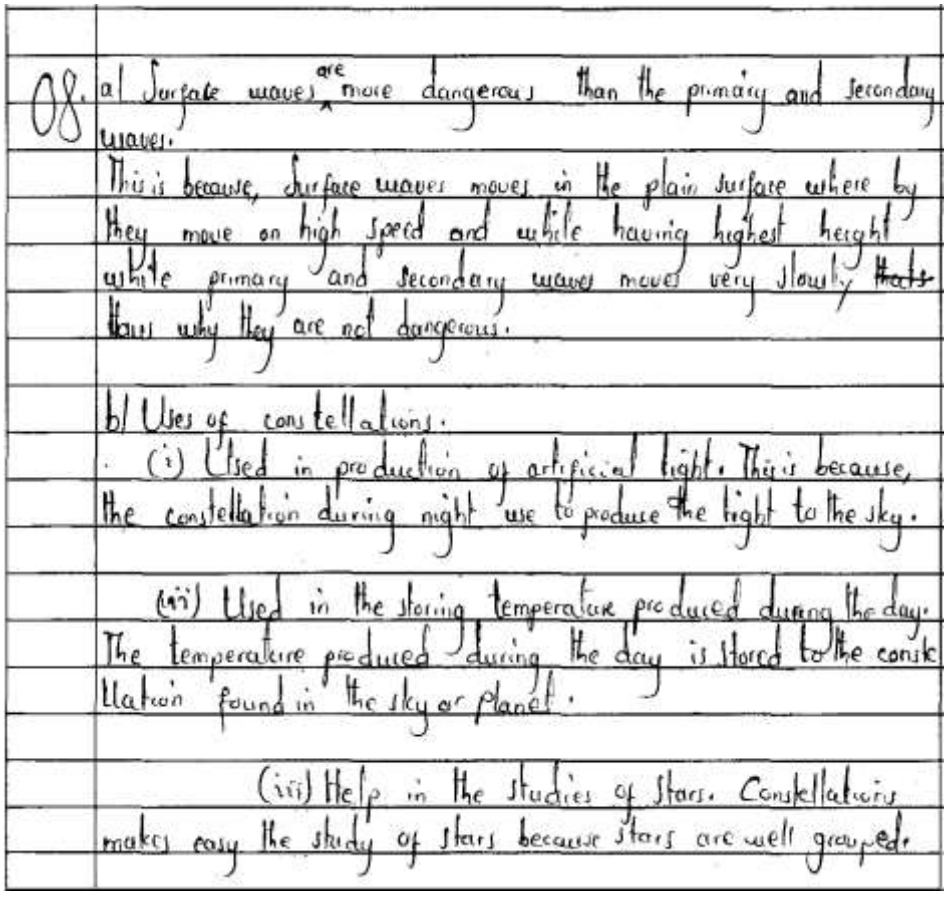
The candidates who scored low marks in this question had poor knowledge of *Geophysics* specifically, on the concept of properties of seismic waves and the topic of *Elementary Astronomy* particularly, on the uses of contellations.The analysis shows that most of them scored higher marks in part (b) than part (a). This suggests that the candidates had more poor knowledge about surface and body (primary and secondary) waves. Most of the candidates who failed part (a) provided

incorrect responses per the item's context. One of the candidates wrote, "*Because surface waves has high frequency and are violent while primary and secondary waves have low frequency and are non-violent."* This was an incorrect response. The candidate realised that the energy released during an earthquake is transmitted in the form of waves. However, the he/she failed to realise that the measure of that transmitted energy is amplitude. Thus, it is wrong to relate the impact of the surface wave with the frequency. Another candidate wrote, "*Because they travel in circular motion on the earth's surface, hence having more fatal impacts like loss of life and destruction of features*." This candidate failed to realise that the energy of the earthquakes originates from the hypocenter (focus) and is transmitted as a wave from that point to the epicentre. Those candidates were supposed to know that energy is the one that causes fatal impacts. Looking at those responses, it is evident that those candidates failed to distinguish between surface, primary and secondary waves. They were required to know that surface waves move along the surface of the Earth while primary waves move through the interior of the Earth with a speed greater tha secondary waves. Surface waves are normally generated when the source of the earthquake is very close to the surface of the Earth. They are characterized by higher amplitude than the primary waves and secondary waves. It is worth noting that the amplitude of the surface waves diminishes less rapidly with distance than that of the primary waves. Therefore, surface waves produce more ground movement as they have high amplitude. Moreover, it takes longer to pass as it travels more slowly than the primary waves.

Some of the candidates provided irrelevant responses as per item context. For instance, one of the candidates wrote, "B*ecause surface waves have high magnitude than primary and secondary waves*." This was an irrelevant response. Another candidate responded, "*Because it leads to flooding and high cost of repairing the destructed features*." This was an incorrect and irrelevant response. Not all flooding is caused by earthquakes. Earthquakes can sometimes cause tsunamis. However, not all tsunamis are caused by earthquakes. Following the statistical analysis and candidates' responses, they clearly lack sufficient competence to distinguish types of seismic waves and their impacts.

The candidates who scored low marks in part (b), lacked adequate knowledge about the uses of constellations in different life situations. Those candidates failed to understand the meaning of constellations. This could be a reason for the observed incorrect responses. For example, one of the candidates responded, "*They are used to determine galaxy."* This kind of candidate failed to understand the difference between constellation and Galaxy. They failed to know that a Galaxy is a big group of stars, but a constellation is a group of stars that forms a pattern of features known from the Earth. Therefore, constellations cannot be used to determine the Galaxy.

Candidates who failed to present correct response failed also to remember the uses of constellations and tried to respond with the uses of other features in the universe. This means that they lacked ability to differentiate celestial bodies. For example one candidate responded that, "*used to differentiate different things since they form different structures*." this was not correct because constellations do not help us to differentiate things but having an awareness of things from the earth can help us to study and understand constellations. Others wrote, "*It is used to gain knowledge*" and "*to predict the characteristics of people's personalities*." This one was totally out of track because constellations cannot give characteristics of people. Another candidate responded, "*Constellations are used for studying in the school*", and another one stated, " They are u*sed to store temperature, and production of artificial light*." Candidates were supposed to respond as follows (i) Constellations are used in religious (ii) They are used to forecast weather (iii) they are also used in agriculture (iv) Are used in developing calendars (v) They are used in predicting time or season and (vi) Constellations are used in navigation. **Extract 8.1** is a sample of incorrect responses in question 8.

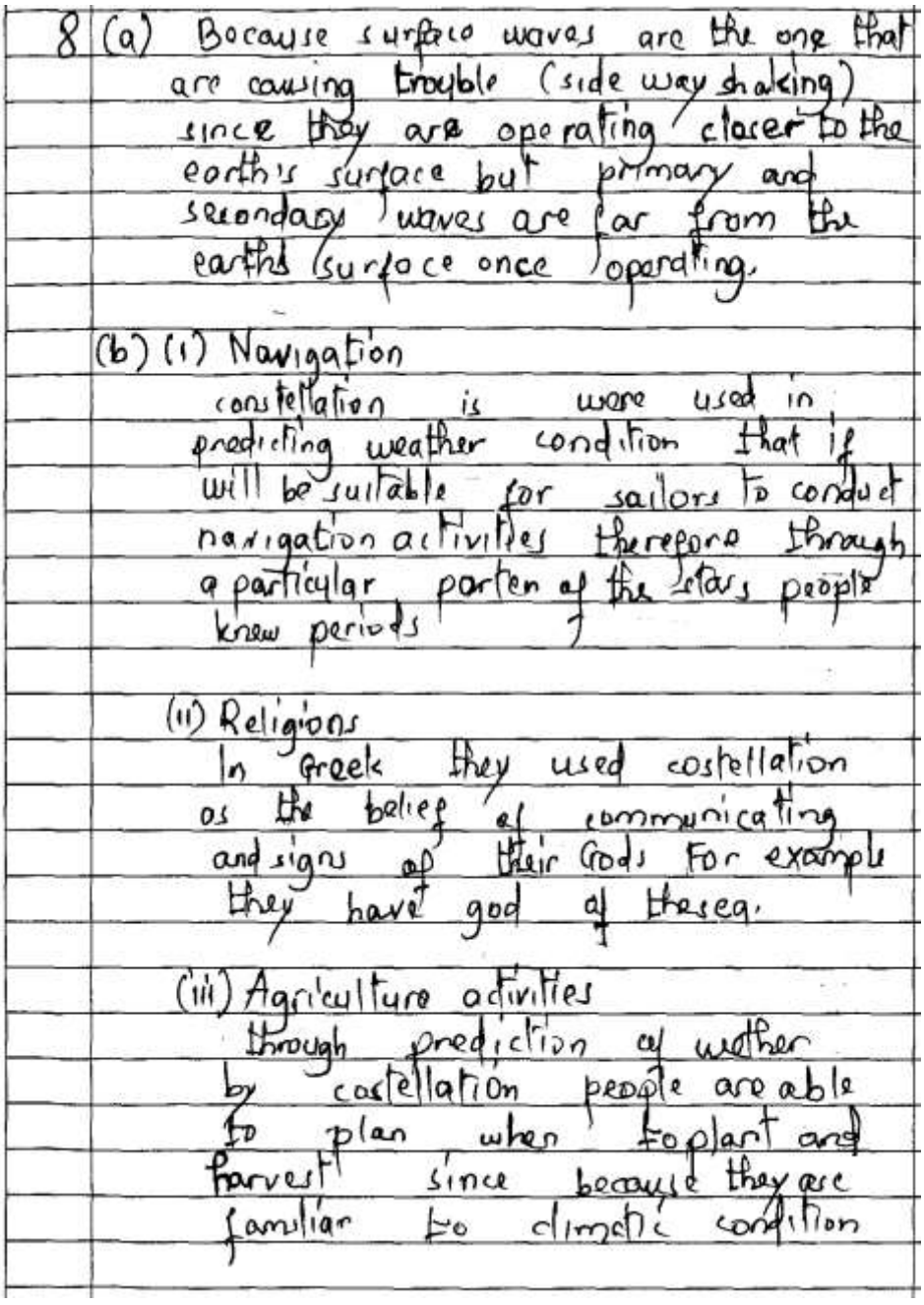


Extract 8.1: A sample of the incorrect responses to Question 8

In extract 8.1, the candidate had inadequate knowledge concerning to seismic waves as well as the concepts of constellations as a result he/she ended up with loosing all the marks.

On the contrary, some of the candidates scored high marks on this question because they demonstrated the ability to differentiate surface waves from primary and secondary waves with respect to their amplitudes of vibrations. The candidates who scored high marks in part (a) realised that surface waves have high amplitudes, which vanish less rapidly with the distance and travel very slowly compared to the primary and secondary waves. Furthermore, they were able to relate their respective features with the energy transmitted. The analysis also reveals that most candidates who scored high marks could describe the uses of constellations. This suggests that those candidates had enough

competence in the topic of *Elementary astronomy asc well as in Geophysics*. Extract 8.2 is a sample of correct responses from one of the candidates in question 8.


8 (a) Because surface waves are the one that are causing trouble (side way shaking) since they are operating closer to the earth's surface but primary and secondary waves are far from the earths surface once operating.

(b) (i) Navigation
constellation is were used in predicting weather condition that if will be suitable for sailors to conduct navigation activities therefore through a particular parten of the stars people knew periods

(ii) Religions
In Greek they used costellation as the belief of communicating and signs of their Gods For example they have god of theseq.

(iii) Agriculture activities
through prediction of wether by costellation people are able to plan when to plant and harvest since because they are familiar to climatic condition

Extract 8.2: A sample of the correct responses to Question 8.

2.3 Section C: Structured Questions

This section consisted of three (3) structured questions. The questions were constructed from six (6) topics stipulated in the physics syllabus 2010. These topics include: *Static Electricity, Current Electricity, Thermionic Emission, Electronics, Waves and Electromagnetism*. Each question weighted fifteen (15) marks, making a total of thirty (30) marks. The candidates were required to attempt only two questions. The candidates were required to use physics concepts, theories, and principles to describe various physical phenomena. Moreover, the candidates were required to demonstrate mastery of basic measurement symbols and drawing of circuit drawings used in physics, particularly static electricity and electronics.

The statistics analysis showed that Question 9 was attempted by 82,177 (67.30%) candidates. Question 10 was attempted by 86,858 (71.14%) candidates, while Question 11 was attempted by 75,167 (61.56%). The analysis revealed that most of the candidates attempted Question 10. On the contrary, Question 11 was the least chosen by candidates. It could be assumed that most candidates were somewhat weak in the topics of *Waves and Electromagnetism*.

2.3.1 Question 9: Static Electricity and Current Electricity

This question consisted of three (3) parts, namely parts (a), (b) and (c). Part (a) of this question was constructed from the topic of *Static electricity*. The item assessed the candidates' ability to design and draw electric circuits for charging and discharging the capacitors. The candidates were required to use the provided electric components of a cell E, a voltmeter V, a switch **S**, a capacitor C, a resistor R and connecting wires.

Part (b) of this question was designed from the topic of C*urrent Electricity*. The item measured the ability of the candidate to use mathematical skills to comment on the amount of current flowing between the wires A and B, if these two wires are of the same material and length, whose cross-sectional area are in the ratio of 2:1 and the same potential difference is applied across each wire.

Part (c) was also set from the topic of *Current Electricity*. The item was designed to assess the candidates' ability to use an appropriate formula to explain why a low voltage supply should have a low internal resistance.

The analysis shows that the question was attempted by a total of 82,177 (67.30%) candidates, out of whom 80,252 (97.66%) scored from 0.0 to 4.0 marks, 1,832 (2.23%) scored from 4.5 to 9.5 marks and 94 (0.11 %) scored from 10.0 to 15.0 marks. These scores indicate that candidates' performance in this question was very weak as 80,252 (97.66%) scored from 0.0 to 4.0 marks out of 15.0 marks allocated to this question. Figure 9 summarizes the performance of the candidates in Question 9.

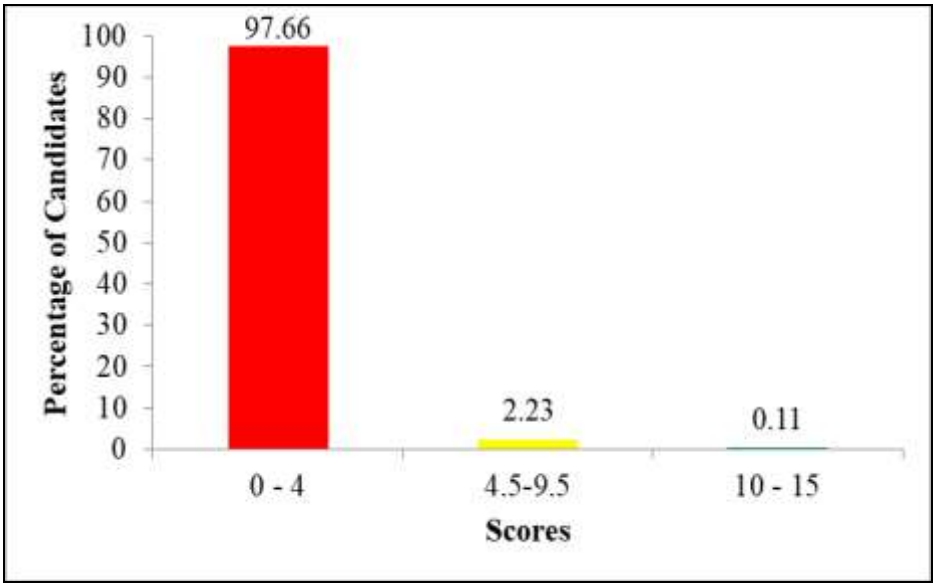
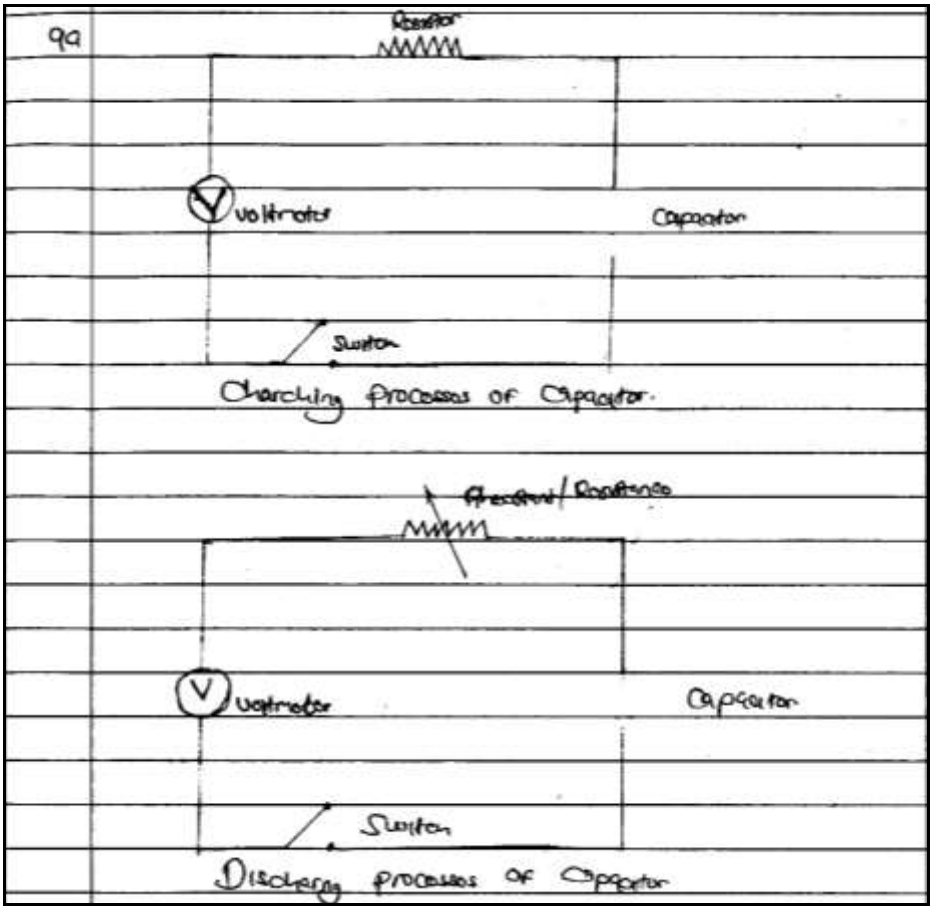


Figure 9: *The performance of the candidates in Question 9.*

The analysis shows that the candidates performed poorly in this question. Their marks ranged from 0.0 to 4.0 because they lacked adequate knowledge and skill on the topic of *Static* and *Current Electricity*.

In part (a) of the question, most of the candidates failed to design and draw an electric circuit for charging and discharging the capacitor. This suggests that they had improper knowledge of the process of charging and discharging of capacitors. Some candidates provided incorrect

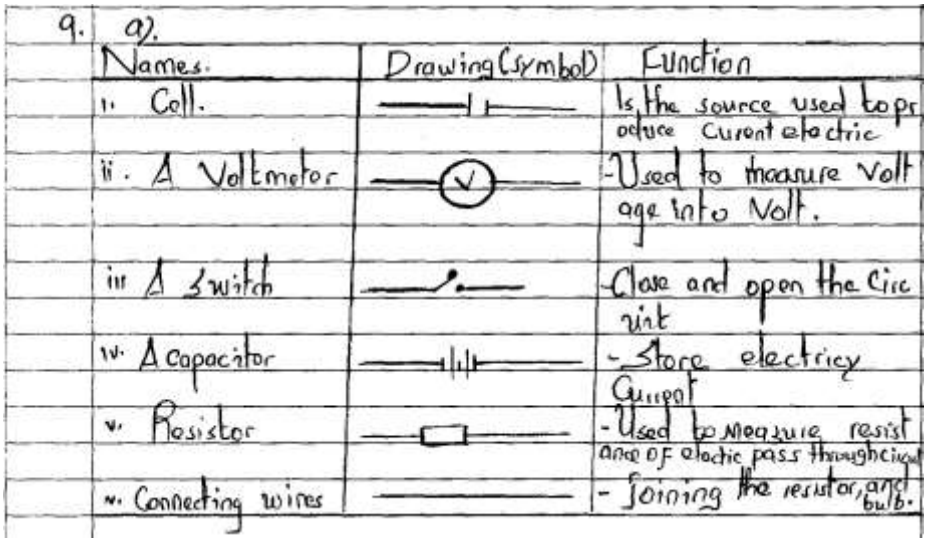
circuit for charging and discharging the capacitor. For instance, one candidate drew a circuit with a voltmeter connected in series with other electric components. This candidate lacked the basic principles of how the the voltmeter is connected in the electric circuit. The candidate was supposed to understand that a voltmeter is a device for measuring the potential difference between two points in the electric circuit. It has very high resistance and, thus, should be connected parallel to the devices whose potential difference is determined. If it is connected in series, it will prevent the flow of current. Therefore, the capacitor will not be charged. see Extract 9.1.



Extract 9.1: A sample of incorrect response in question 9 (a)

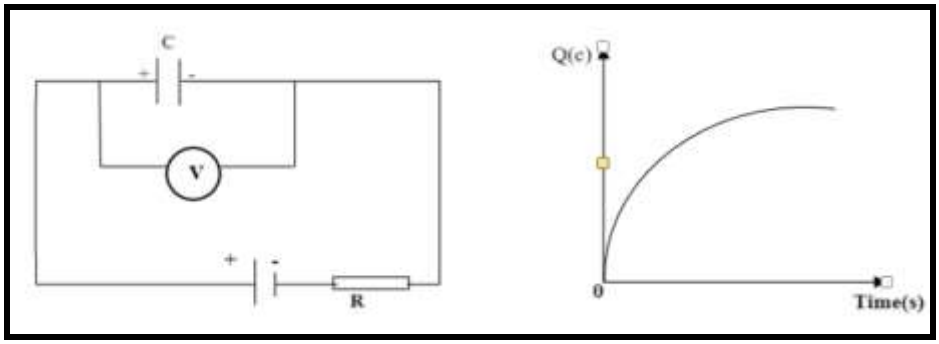
Further analysis shows that most of the candidates did not have content knowledge and drawing skills pertaining to the process of charging and discharging of a capacitor. For instance, one of the candidates used the

electric components provided in part (a) of the question to draw their electric symbols and gave their functions. See extract 9.2.



Extract 9.2: A sample of incorrect responses in question 9 (a)

Some of the candidates wrote the mathematical formula for the capacitor. They stated $\text{capacitor} = \frac{\text{quantity charge}}{\text{voltage}}$. This was an inappropriate response as per the item requirement. These candidates were supposed to know that an RC circuit is used for charging or discharging the capacitor. In this circuit, the capacitor and resistor are connected in series. That is to say, when charging an uncharged capacitor, its plates are connected to the power source terminal and the voltmeter is connected in parallel with the capacitor. The current will flow through the capacitor until the potential difference across the capacitor equals the potential difference of the power source. It can be said that the voltmeter is connected parallel to the capacitor to measure its potential difference. However, when the charged capacitor is connected to a load (resistor), as shown in the following illustration, the charge will flow from the capacitor. That is to say, the capacitor discharges through the resistor.

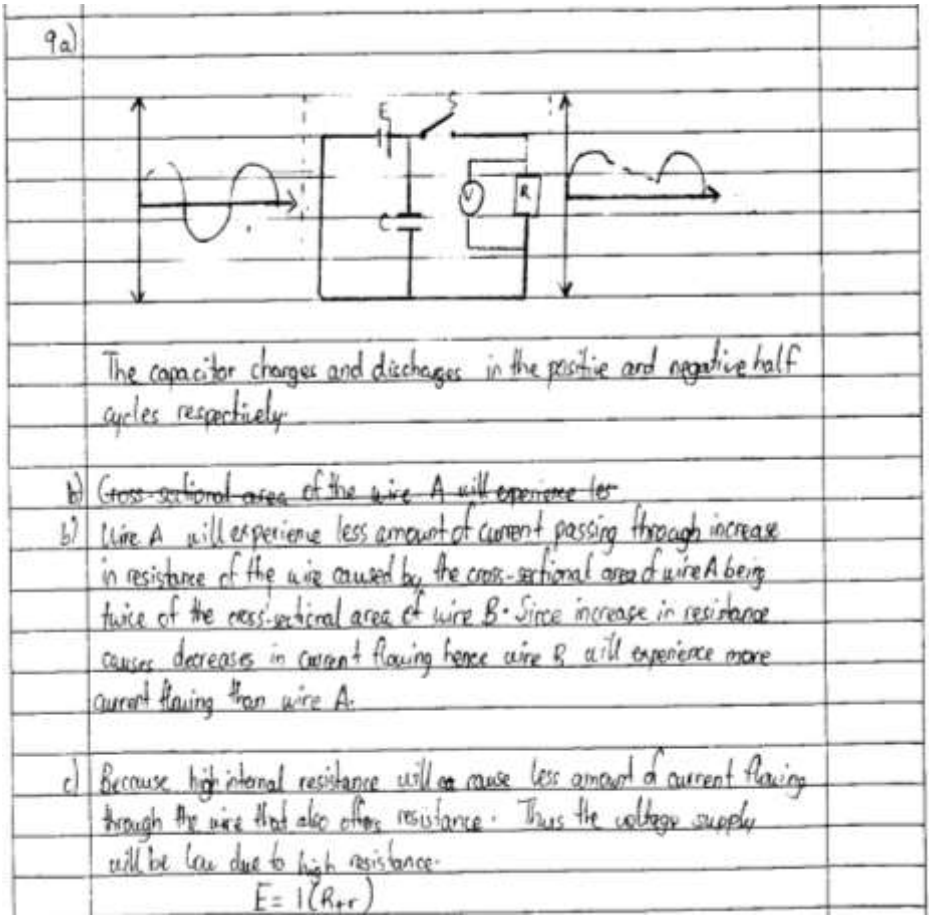


(a) Charging a capacitor (b) A graph of charging of a capacitor

In part (b), the candidates failed to apply the factors affecting the resistance of the material or conductor and the Ohm's law to establish the relationship between the ratios of resistances of the wires A and B with their respective ratios of cross-sectional areas. They also failed to show that the resistance of a conductor or material varies inversely proportional to both cross-sectional area and the current flowing through it. Hence, failed to comment appropriately on the amount of current flowing between the wires A and B. Some evident examples which support these statements are hereunder articulated by the following some samples of responses of the candidates: One candidate wrote "*the current flow in wire A will be slower compared to wire B because it has a larger cross-sectional area hence making the flow of current faster in wire B because it has a smaller cross sectional area*". If you look at this quotation, the candidate focused on the speed of the flow of current instead of the magnitude or amount of the current that flow in the wires. The candidate's explanation also reveals that he/she lacked the mathematical skills that could help the candidate to merge the relations which involves the resistances, currents and the cross–sectional areas of the two wires A and B. Another candidate wrote *"Since increase in cross – section, increases resitance which is inversely proportional to current , therefore increase in resistance decreases current thus more current will flow in wire B compared to wire A"*. The candidate was only right when writes that resistance is inversely proportional to current, and that increase in resistance decreases current, but wrong when states that increase in cross–section

increases resistance and thus more current will flow in wire B compared to wire A. This candidate had some knowledge regarding to variations of resistance with current but failed to combine that knowledge correctly with how cross – section area changes with the change of resistance. In fact, he/she lacked some skills of mathematics of how to solve the question.

In part (c), some candidates managed to write an appropriate formula, $E = I(R + r)$ but failed to explain why a low voltage should have a low internal resistance. These candidates were supposed to reliaze that the maximum current which can be drawn from a supply is $I = \frac{E}{r}$, hence to obtain a higher current from a low voltage supply, the internal resistance r should be as small as possible. Extract 9.3 is a sample of incorrect responses from one of the candidates who attempted all parts of the question.



Extract 9.3: A sample of incorrect responses in Question 9.

In extract 9.3, a candidate failed part (a) and (b) due to poor drawind, and sketching and mathematical skills but managed to write an appropriate formula for the equation that relates e.m.f of the cell, E, current I, External resistance R and an Internal resistance r in part (c).

2.3.2 Question 10: Thermionic Emission and Electronics

The question contained parts (a), (b) and (c). Part (a) and (b) were set from the topic of *Thermionic emission.* In part (a), the candidates were required to explain the way the penetrating power of X-rays is affected when the wavelength is reduced and voltage across the X-ray tube increased. Part (b) of this question is designed to evaluate candidates' ability to apply the concepts, theories, and principles related to thermionic emission to analyse how the presence of a speaker near to a

Television (TV) operating using cathode ray tube affects the quality of the picture on the screen but when taken away the picture becomes normal.

Part (c) was developed from the topic of *Electronics*. This part evaluated candidates' ability to design and draw a NPN transistor circuit for the common base, common emitter and common collector configuration modes including the input and output circuits.

The analysis shows that the question was attempted by a total of 86,858 (71.14%) candidates, out of whom 74,962 (86.30%) scored from 0 to 4.0 marks, 9,684 (11.15 %) scored from 4.5 to 9.5 marks and 2,212 (2.55%) scored from 10.0 to 15.0 marks. These scores indicate that candidates' performance in this question was weak as 74,962 (86.30%) scored from 0.0 to 4.0 marks out of 15.0 marks allocated to this question. Figure 10 summarizes the performance of the candidates in Question 10.

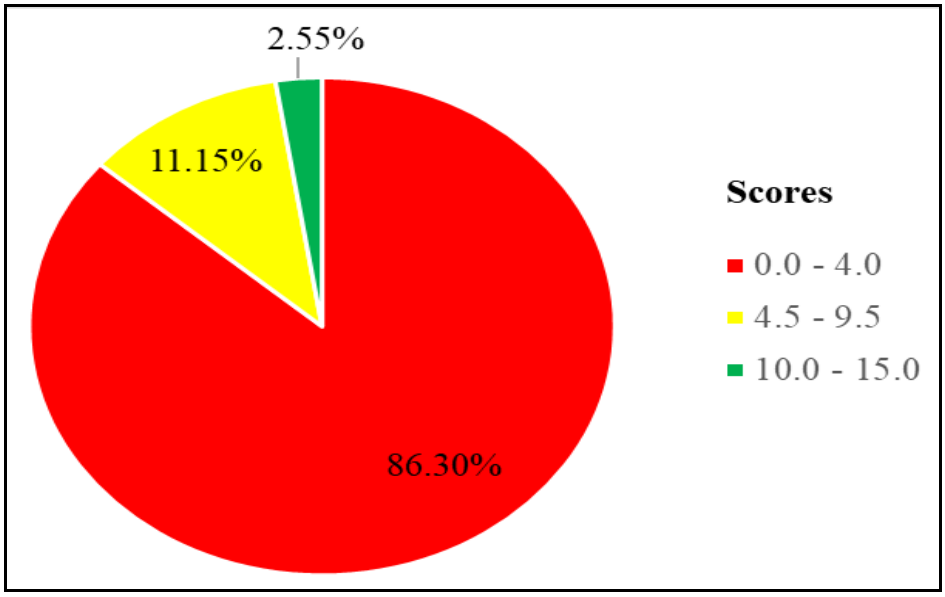


Figure 10: *The performance of the candidates in Question 10.*

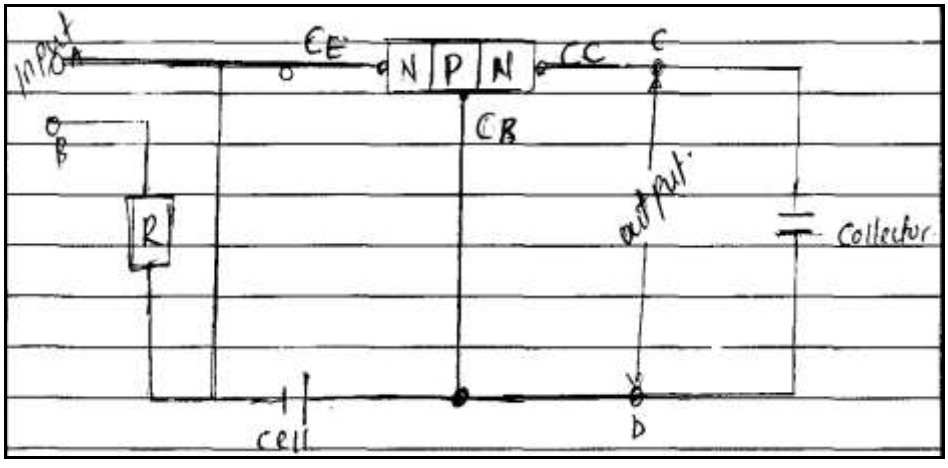
Most of the candidates performed poorly because they lacked adequate knowledge and skills on the topic of *Thermoelectric emission* and *electronics*, particularly on cathode and x-rays and NPN transistor configuration modes respectively. In part (a), most of the candidates failed to correctly explain the dependence of the penetrating power of X-

rays on their wavelength and voltage across the X-ray tube. These candidates deemed to lack the basic concepts of X-ray and Cathode ray tubes. For instance, one of the candidates wrote, "*When wavelength increase it causes the speed of X-rays to be decreased causing X-rays to have a low penetration power*." The candidate failed to realize that X-rays are electromagnetic waves like light but with much shorter wavelengths and travel in a straight line with the speed of 3×10^8 m/s. Since the speed of an X-ray in a vacuum is constant, then it is possible to say that $\lambda = \frac{c}{f}$, where, λ is the wavelength of X-rays, *c* speed of X-ray, and *f*, the frequency of the X-ray. Thus, changing the wavelength of an X-ray affects its frequency. This implies that reducing the wavelength of the X-ray increases its frequency, consequently increasing its energy and, hence, its penetration power. This means that by decreasing the wavelength of X-rays, corresponds to increase in their frequency, leading to higher energy of X-rays and increasing their penetrating power. Looking at the candidates' responses, it is evident that the candidates failed to integrate the relationship between wavelength, frequency, speed and energy of the X-rays. Another candidate responded, "*When voltage across an X-ray tube is increased, it will produce harder X-rays."* Indeed, X-rays can be categorized as soft or hard X-rays depending on the voltage applied between the anode and the X-ray tube cathode. The candidate was supposed to realise that as the voltage across the X-ray increases, the amount of X-rays coming out of the tube and the average energy. As a result, it increases the penetration power. Some of the candidates provided an irrelevant and unclear response. For example, one of the candidates wrote that "*The wavelength of an X-ray is very important since the distance between the successive points will be reduced."* This revealed that those candidates lacked adequate knowledge of the concepts of X-ray penetration power.

The candidates who scored low marks on part (b) failed to evaluate how the presence of a speaker near a Television (TV) affects the quality of the produced image. This revealed that those candidates failed to integrate concepts and theories related to thermionic emission in real-life situations. Most candidates provided unclear responses that made no sense per item context. For example, the candidate wrote, "*Because light*

travels faster than sound so when speaker is brought near the TV it affect the picture because people will see event then the sound heard." This was an irrelevant response, and it made no sense. Some candidates failed to explicitly deduce a speaker's effect on the quality of the image. For example, one of the candidates wrote, "*Because the speaker will affect the electron beam that make to give picture with low efficiency*." The candidate failed. Those candidates in this category had knowledge related to the speaker and electron beam interaction. They should know that cathode rays travel in straight lines. They are deflected by either the magnetic field or an electric field. The candidates were required to understand that the speaker comprises a magnet, which produces a magnetic field. The speaker near the TV deflects the beam of electrons on the screen. As a result, it impacts the quality of the image produced. When the speaker is removed, no magnetic field is available to deflect the beam of electrons from the screen.

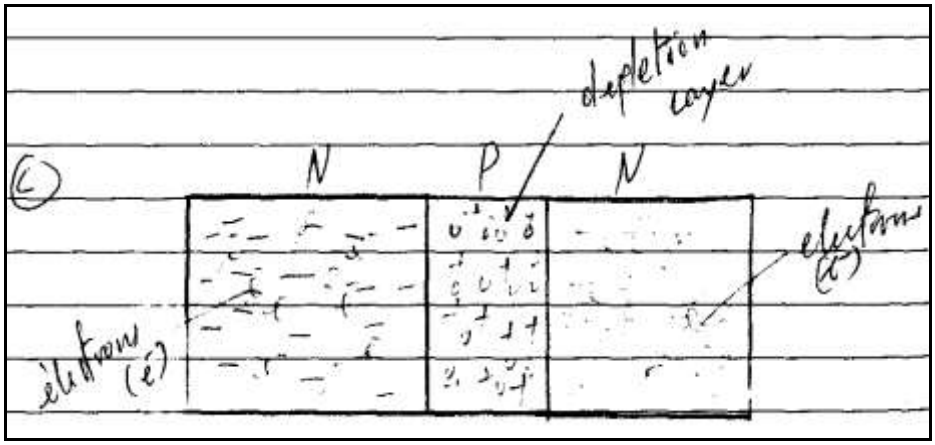
In part (c), some of the candidates failed to score high marks because they had insufficient knowledge of the transistor concepts. Most of the candidates who scored low marks provided the incorrect transistor circuit diagram. The candidates failed to employ the correct transistor circuit symbols for NPN transistor, their input and output terminals and indication of direction of conventional currents in the circuit. For instance, one candidate drew the incorrect transistor circuit as shown in extract 10.1.



Extract 10.1: Sample of incorrect response in question 10 (c).

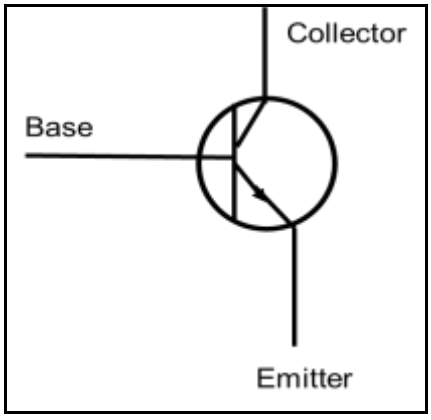
In extract 10.1, the candidate used the N and P junction diodes instead of using the three leads of emitter, base and collector in a correct transistor circuit.

Another candidate drew the NPN transistor circuit as shown in extract 10.2.



Extract 10.2: Sample of incorrect response in question 10 (c).

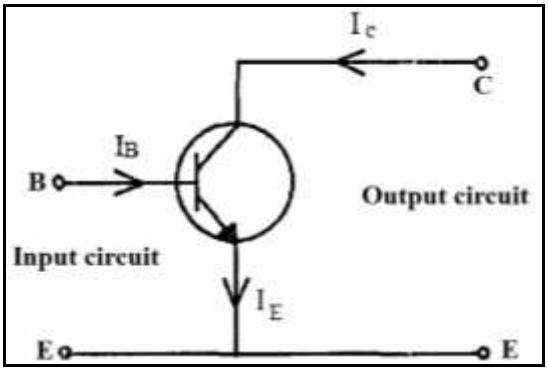
Looking at extracts 10.1 and 10.2, it is evident that those candidates lacked basic knowledge of the transistor circuits and their modes of configuration. They were supposed to know that a transistor is an electronic component with three terminals: emitter, collector, and base. The transistor symbol can be represented as shown in following drawing:



A symbol of transistor.

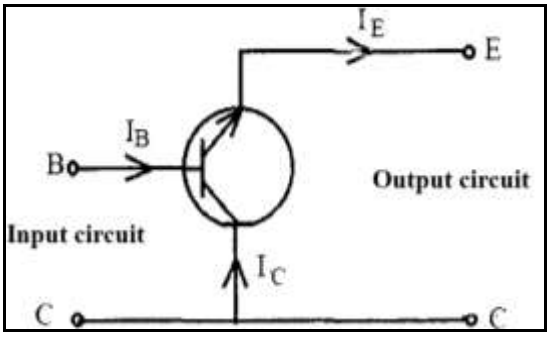
Moreover, the candidates were supposed to know that the transistor configuration depends on the connection of transistor terminals. Thus, there are three transistor configurations, namely:

- Common-emitter transistor configuration: In this configuration, the emitter is connected between the collector and base. This implies that it is common to collector and base. This is to say that the input signal and output signal share the same point (emitter) as shown in the following circuit.



Common- emitter connection of transistor.

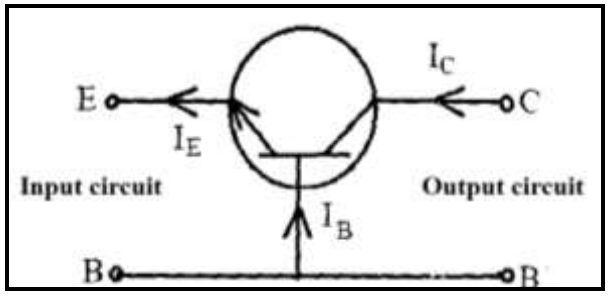
- Common-collector transistor configuration: In this configuration, the collector terminal is connected between the input and output terminals. This is to say that the collector terminal is common to the input and output terminals as shown in the following circuit.



Common - collector connection of transistor.

- Common-base transistor configuration: In this configuration, the base terminal of the transistor is common to both input and output

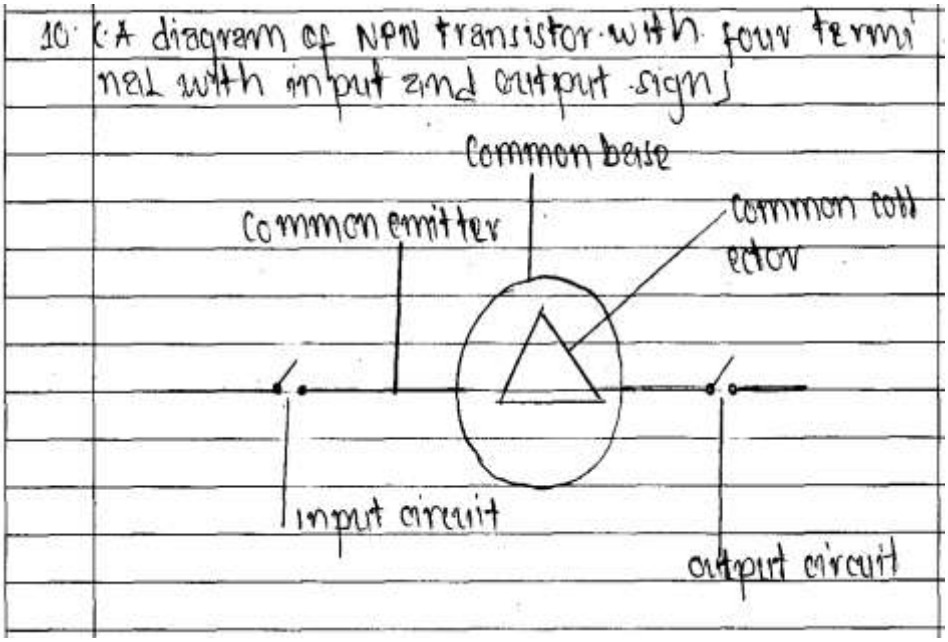
terminals. Thus, the base terminal is connected between the input and output terminals, as shown in the following circuit.



Common base connection of transistor.

Generally, the candidates failed to demonstrate mastery of transistor circuit drawing and hence scored low or no marks in this part of the question. Extract 10.3 depicts the incorrect resonses for all parts of question 10 from one of the candidates who scored low marks.

10	a·i·when wavelength reduced also penetratin
	g power of x ray will reduced because, the
	x-rays will not travell on far distance, th
	e wavelong is go directly proportional to t
	he penetrating power
	ii·When voltage increased also reduce pen
	etrating power of a x-rays, because a volt
	age resist a ~~current~~ particles to move fro
	m to another distance
	b·In order to reduce this problem a catho
	de ray tube should evacuated before taking
	into electrical equipment like Television,
	when cathode ray is evacuated, it help a
	~~material~~ to reduce power loose on a mate
	rial, so cathode ray tube should evacuated
	before taking into Television and picture
	will become normal



Extract 10.3: Sample of a candidate's incorrect responses in question 10.

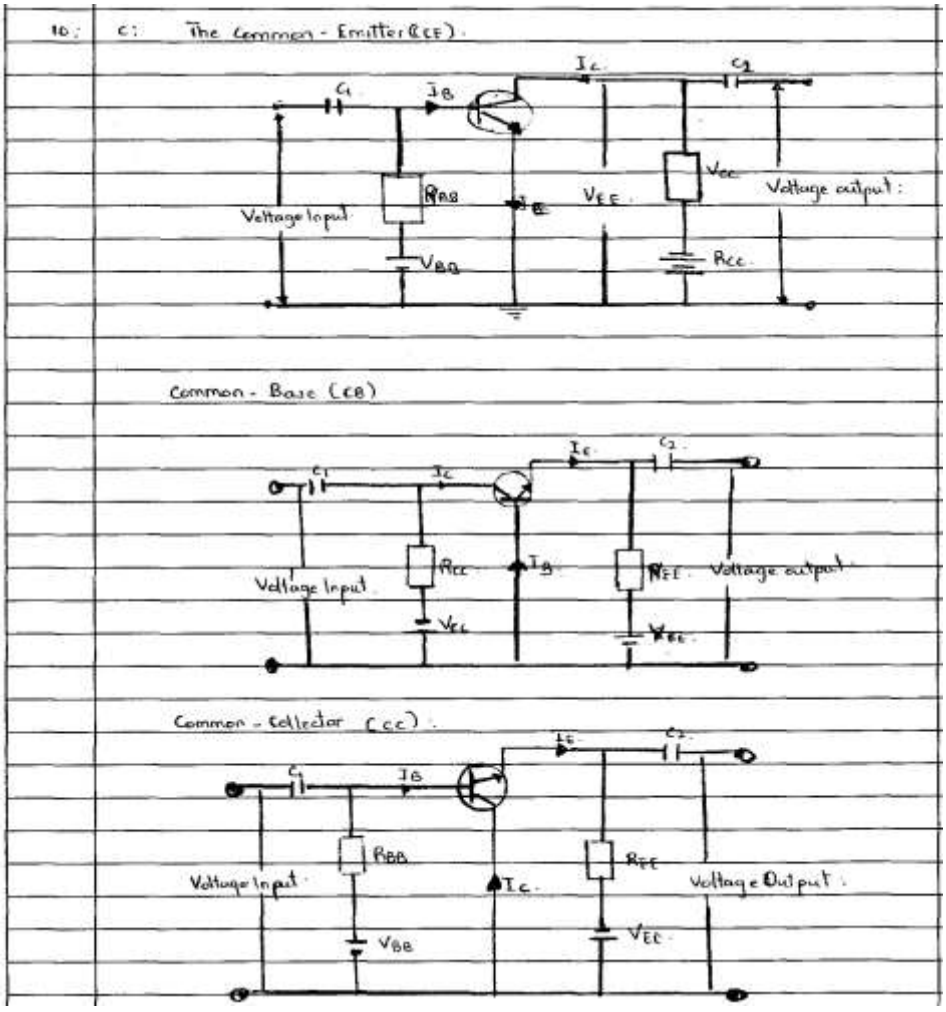
In extract 10.3, the candidate failed to show the effect of reducing wavelength and increasing voltage on peneratining power of X-rays. He/she stated incorrectly the effect of a speaker placed near to a TV operating using a cathode ray tube. Finally, the candidate drew an irrelevant diagram of the NPN transistor circuit modes.

Despite the poor performance of majority of candidates in this question, a few number of candidates scored high marks (10.0 to 15.0). Those candidates correctly described the dependence of the penetrating power of X-rays on their wavelength and voltage across the X-ray tube. They demonstrated the ability to apply the concepts, theories, and principles related to thermionic emission to analyse how the presence of a speaker near a Television (TV) affects the quality of the picture produced on the screen. Moreover, they managed to design and draw the transistor circuit diagram for all three transistor configuration modes. That is to say they had adequate knowledge and skills on the topic of *Thermionic emission* and *Electronics*. Extract 10.4, represents a sample of correct responses from one of candidates who scored high marks in question 10.

10: a: i: The penetrating power of x-rays will be increased when the wavelength is reduced this is because The decrease of wavelength increases the frequency and making the x-rays hard which penetrate easily.

ii: The penetrating power of x-rays will be increased also when the Voltage is high this is because the high voltage leads to the production of hard x-rays which penetrate easily through materials.

b: When the speaker is brought Near a Television it causes the Internal cathode rays of the Television to get deflected toward the magnetic field produced by the speaker hence due to this the picture on the screen is affected. and when Taken away the Television shows a Normal picture because of the removal of a magnetic field from the Television.

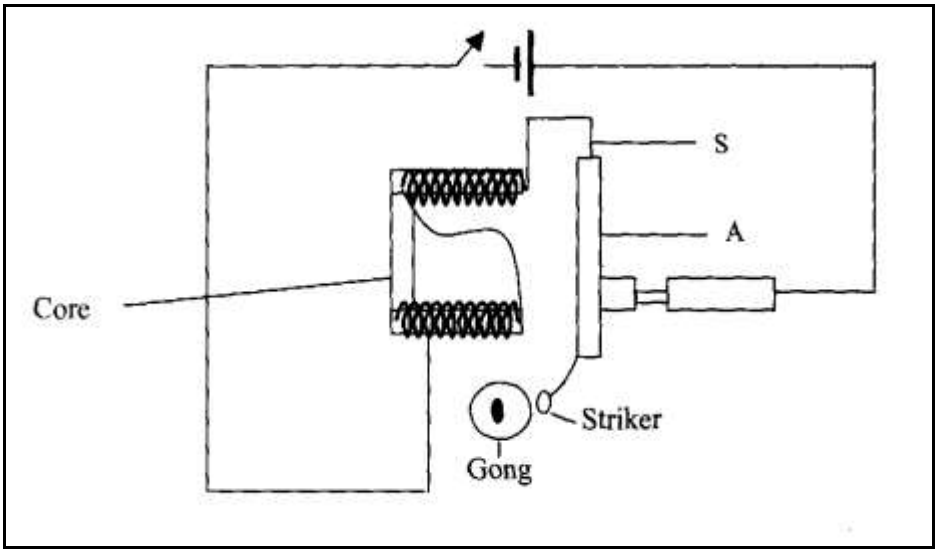


Extract 10.4: A Sample of the candidate's correct responses in question 10.

2.3.3 Question 11: Waves and Electromagnetism

This question comprised of three (3) parts, namely (a), (b) and (c). Part (a) of this question was constructed from the topic of *Waves*. The candidates were required to calculate the shortest length of the column of air which resonates in similar conditions to a note of frequency 800 Hz, if the shortest length of air column in a resonance tube with one end closed and other end open which resonates to a note of frequency 500 Hz is found to be 160 mm. Part (b) and (c) were set from the topic of *Electromagnetism*. Part (b) aimed at assessing the ability of the candidates to show the relationship between Lenz's law and the principle of conservation energy.

Part (c) required the candidates to use the following diagram of the electric bell to describe the function of steel strip S. in practice, the candidates were required to describe what happened to S when the switch was closed.



Structure of electric bell

The data analysis shows that the question was attempted by a total of 75,167 (61.57%) candidates, out of whom 55,220 (73.46%) scored from 0.0 to 4.0 marks, 17,874 (23.78%) scored from 4.5 to 9.5 marks and 2,073 (2.76 %) scored from 10.0 to 15.0 marks. These scores indicate that candidates' performance in this question was weak as 55,220 (73.46 %) scored from 0.0 to 4.0 marks out of 15.0 marks allocated to this question. Figure 11 summarizes the performance of the candidates in Question 11.

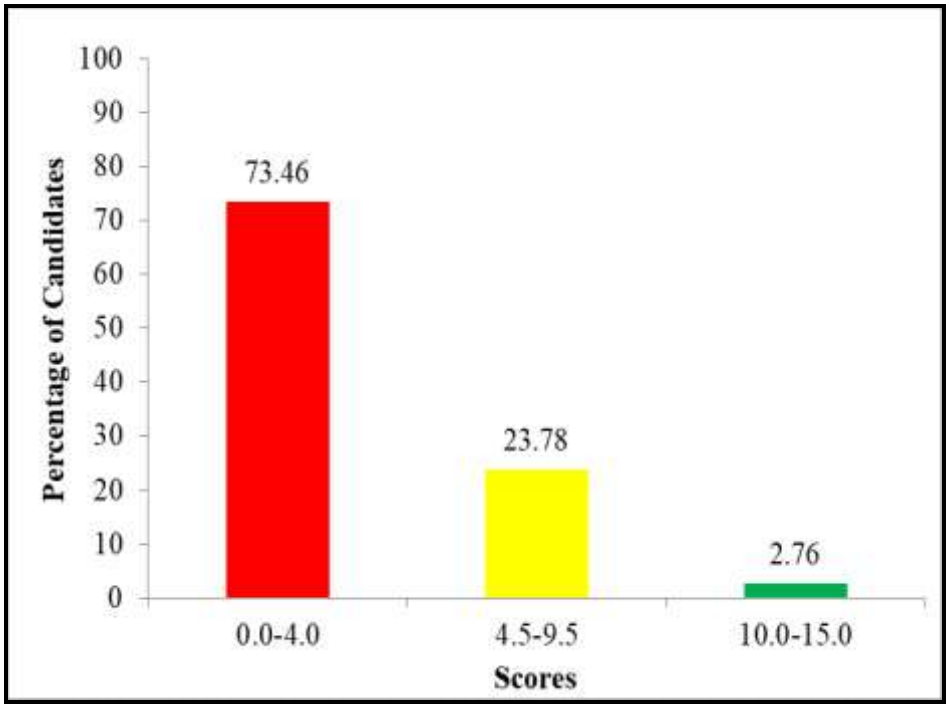


Figure 11: *The performance of the candidates in Question 11.*

As per statistical analysis, it is evident that most of the candidates scored low marks. This suggest that they had inadequate knowledge of waves particularly, in musical sounds and e*lectromagnetism*. The analysis further showed that those who failed part (a) of this question failed to apply mathematical formulas to describe the resonance in the air column tube. The analysis revealed that most of the candidates who scored low marks failed to use an appropriate mathematical formula to evaluate the problem. For instance, one of the candidates wrote $v = \lambda f$. This was correct mathematical formula describing the speed of the wave. However, the candidate was supposed to realise that the wavelength depends on the length of the air column in the tube. Theywere also supposed to know that the condition for standing wave to occur is that the wave must fit within the provided segment. It can be said that the boundary conditions must be observed. As per the question, the boundary conditions are met when a quarter of the wavelength is equal to the length of the tube. This is to say that $v = 4fl$. The candidates were then required to compare the expressions for the given two tubes.

Thus, it is possible to say that $(4f_1l_1)_{\text{first pipe}} = (4f_2l_2)_{\text{second pipe}}$. On mathematics manipulation, $l_2 = \frac{f_1l_1}{f_2}$. Thus,

$l_2 = \frac{160\,\text{mm} \times 500\,\text{Hz}}{800\,\text{Hz}} = 100\,\text{mm}$. Therefore, the shortest length is 100 mm.

Some of the candidates used the formula $v = 2(l_2 - l_1)f$. Those candidates were supposed to understand that it was impossible to apply this formula as there were two unknowns to be determined.

In part (b), some candidates scored low marks allocated to this item because they failed to show the relationship between Lenz's law and the principle of conservation of energy. This suggests that they were not able to state Lenz's law of electromagnetic induction. Some of the candidates provided irrelevant and unclear responses. For example, one of the candidates responded, "*Lenz's law adapt the energy can be created or destroyed but can be transferred from one form to another form by the induction of magnetic field direction of energy*." This was an irrelevant response. However, the candidate had knowledge of the principle of the conservation of energy in mechanics but lacked adequate knowledge of electromagnetic induction.

Another candidate responded, "*Lenz's law is a special case of law of conservation of energy because it explain the concept of the conservation of energy deeply and wisely*." This was also an irrelevant response, and it had no logical implication in Physics. There was a candidate who wrote "*the direction of induced current is to oppose the change causing it*." This response was not clear and irrelevant as per the context of the question. The candidates in this category failed to understand Lenz's law, which states that the polarity of the induced emf is in such a way that it tends to produce a current which opposes the change in the magnetic flux that produces it. The candidates were supposed to understand that Lenz's law is an application of the law of energy conservation. Energy is expended when the induced current flows and the source of this energy is the work done resulting from the

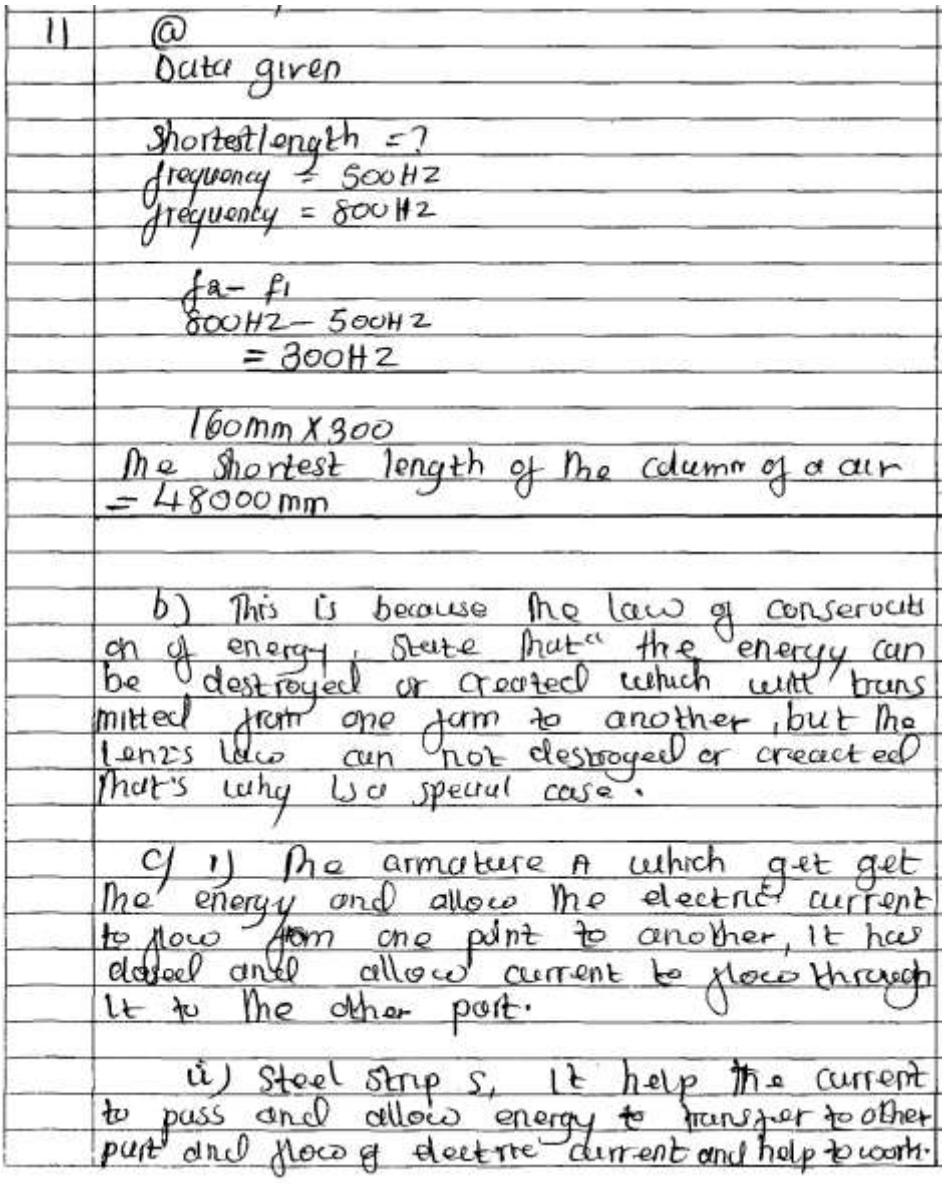
motion of the magnet. Hence, if work is to be done when the magnet moves with respect to the coil, it must experience an opposing force.

In part (c), candidates who scored low marks failed to construe the structure of the electric bell. These candidates were supposed to understand the main parts of an electric bell which are electromagnet, armature, spring, armature rod, hammer and a gong and their respective key functions. Consequently, they were also ought to know practically step-by-step the process of the working of the electric bell.

Most of the candidates provided the wrong responses. For instance, one of the candidates responded, "*When switch is closed the armature A would not conduct striking of the gong in the bell and also would not conduct flowing of electrons towards the strike*." Another candidate wrote "*When armature A is closed the current will not allowed to pass through thus bell wont rings*." These were incorrect responses. Those candidates were supposed to realise that when the switch is closed, the current will flow through the circuit, powering the electromagnet. The electromagnets will produce a magnetic field, pulling the armature A toward it. As a result, armature A will strike the gong, giving out the sound. Some of the candidates provided irrelevant responses. For example, one of the candidates wrote, "*When switch is closed the armature will expand after expansion we see that the contraction of this mark the strikes to move on the gong and then create the sound*." This was the irrelevant response. The candidate was supposed to realise that the current will not produce enough heat to cause the expansion of an armature.

The analysis indicated that most of the candidates who scored low marks in part (c) (i) also scored low marks in part (c) (ii). That is evidence that those candidates failed to comprehend the concepts, theories and principles related to the electric bell. As per part (c) (ii), most of the candidates failed to identify S and its physical application to the electric bell. The candidate was supposed to know that the electric bell came from the battery. Another candidate responded, "*Steel strip is transfer the voltage to the armature in the form of temperature for the aim of the armature to expand and contracting and fulfill the process and the end electric bell to outlet the sound*." That was an incorrect response. Those

candidates were supposed to know that the battery is the energy source in that circuit. They were required to understand that the electric bell operates under the principles of electromagnetism. As per the given circuit, the steel strip acts as a spring which returns an armature to its original position when pulled toward the gong. Extract 11.1 is a sample of incorrect responses in question 11.


11 @
Data given

Shortest length = ?
frequency = 500Hz
frequency = 800Hz

fa − f1
800Hz − 500Hz
= 300Hz

160mm X 300
The shortest length of the column of a air
= 48000mm

b) This is because the law of conservation of energy, State that the energy can be destroyed or created which will transmitted from one form to another, but the Lenz's law can not destroyed or created that's why is special case.

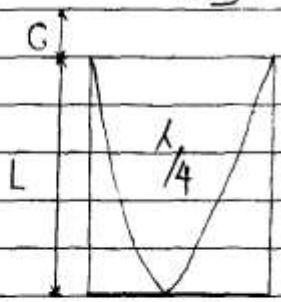
c) i) The armature A which get get the energy and allow the electric current to flow from one point to another, it has closed and allow current to flow through it to the other port.

ii) Steel strip S, it help the current to pass and allow energy to transfer to other part and flow of electric current and help to work.

Extract 11.1: A sample of incorrect responses in question 11.

Despite the poor performance observed in this question, a few of them scored high marks. These candidates demonstrated mastery of the concepts, theories, and principles of the *Waves* and *Electromagnetism*. They used appropriate mathematical formulas to solve numerical problems related to closed organ pipes in standing waves. They also managed to state Lenz's law and to some extent showed that Lenz's law is a special case of the law of conservation of energy. Moreover, they were able to analyse main parts of the electric bell and their functions. Extract 11.2 is a sample of the correct response in question 11.

11 a. Soln.



$C + L = \lambda/4$

$4(L+C) = \lambda$

But $\lambda = V/f$

$4(L+C) = V/f$

let $f_0 = f$

$f_0 = V/4(L+C)$

from the question.

Data given

$f_0 = 500Hz.$

$L = 160mm = 16cm.$

$500 = V/4 \times 16$

$500 = \frac{V}{64}$

$V = 32000$

from

$$\lambda = \frac{v}{f}$$

$$\lambda = \frac{32000}{800} = 40\,cm$$

But:

$$L = \frac{1}{4}\lambda$$

$$L = \frac{1}{4} \times 40 = 10cm = 100mm$$

∴ short length is 100mm

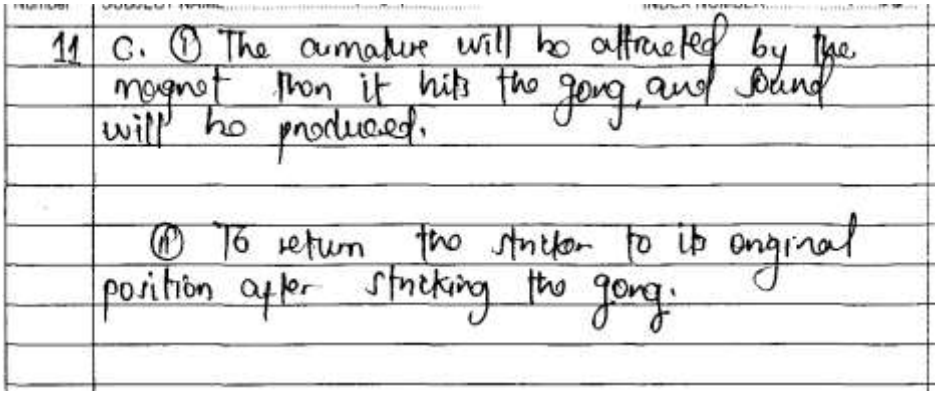
11 b. Lenz' law:

"The induced E.M.F is such kind to oppose the effect producing it"

Law of conservation of energy

"Energy can neither be created nor destroyed but transformed from one form to another"

Now when the opposed charge from lenz's law are taken in opposite direction, the energy is transmitted to another form.



Extract 11.2: A sample of correct responses in question 11.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE ON EACH QUESTION IN 031 PHYSICS 2

The practical paper comprised three alternative papers, namely, 031/2A Physics 2A, 031/2B Physics 2B, and 031/2C Physics 2C. Each alternative paper consisted of two questions, each carrying 25 marks, making a total of 50 marks. The alternative papers measured candidates' ability to perform experiments in Physics, data presentation and analysis, and made scientific conclusions. Question 1 in each alternative was set from the topic of *Mechanics*. The candidates were required to perform experimental work following the given procedure to determine the acceleration value due to gravity and other experimental parameters. Question 2 in each alternative paper was developed on the topic of c*urrent electricity*. The candidates were required to answer all the questions in either alternative.

3.1 Question 1: Mechanics

The data analysis reveals that 121,970 (99.89%) candidates attempted Question 1, out of which 38,252 (31.36%) scored from 0.0 to 7.0 marks, 47,704 (39.11 %) scored from 7.5 to 16.0 marks, and 36,014 (29.53%) scored from 16.5 to 25.0 marks. The analysis shows that the candidates' performance was good because 83,718 (68.64%) scored from 7.5 to 25 marks.

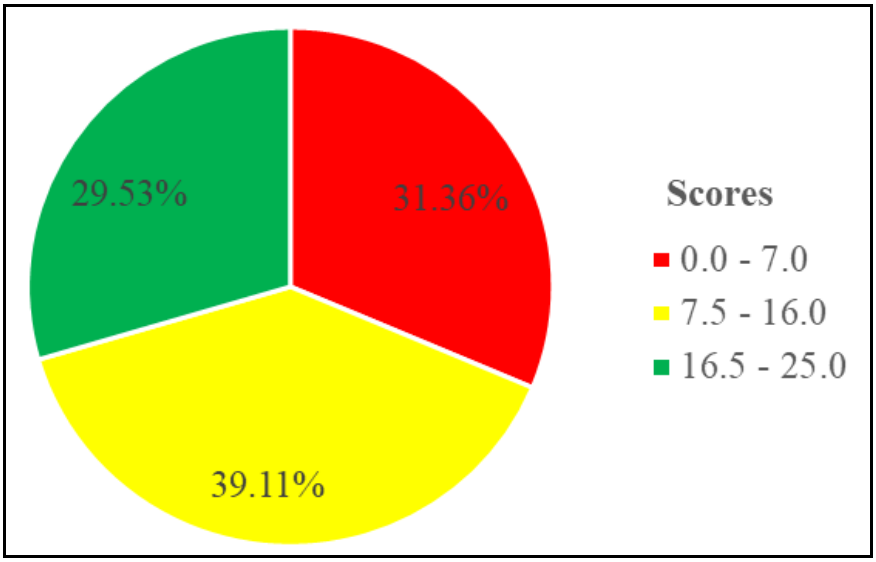
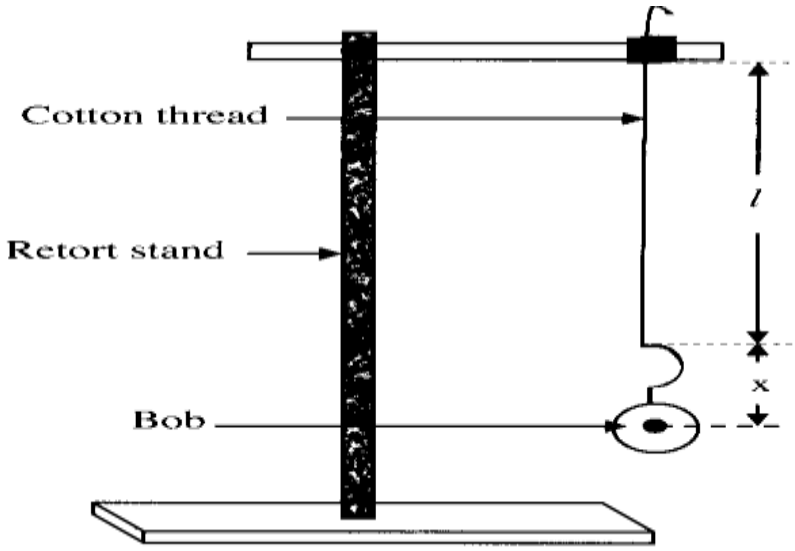


Figure 12: *The performance of candidates in Question 1 of paper 2*

3.1.1 031/2A Physics 2A

In this question, the candidates were asked as follows: A Form Four student was walking to school and saw the kids swinging to and fro motion. The student related the motion of the swings with the oscillations of the simple pendulum discussed at the school. With curiosity the next day, the student decided to design an experiment using the following apparatus; cotton thread, retort stand, pendulum bob, meter rule and stopwatch. The candidates were required to perform an experiment using those apparatuses and then to give the answers to the questions that followed. They were also required to proceed as follows:

(a) Set up the apparatus as seen in subsequent diagram.



(b) Adjust the length (l) of the cotton thread so that l = 90 cm. Displace the pendulum bob through a small angle and then release it to oscillate. Record the time t for 20 complete oscillations.

(c) Repeat the procedures in 1 (b) for the values of $l = 80\,\text{cm}, 70\,\text{cm}, 60\,\text{cm}, 50\,\text{cm}$ and $40\,\text{cm}$ then:

(i) Tabulate the results of l, t and t^2.

(ii) Plot the graph of l against t^2.

(iii) Determine the slope of the graph in 1 (ii).

(iv) The graph of l against t^2 is related by the equation $t^2 = \frac{4\pi^2 n^2 l}{g} + \frac{4\pi^2 n^2 x}{g}$, where x is the distance from the centre of the mass of the pendulum bob to the point at which it is tied to the cotton thread, and n is the number of oscillations. Using this equation and the slope obtained in 1 (iii), estimate the acceleration due to gravity, g (cm/s^2)

(v) From your graph, determine the l-intercept in cm

(vi) What does the value obtained in 1 (v) signify?

Many candidates (68.64%) scored high marks ranging from 7.5 to 25 marks. These candidates demonstrated their mastery of experimental skills in Physics. They had sufficient skills in data collection, presentation, and analysis. They were also able to plot the graph of l against t^2 correctly. In the plotted graph, the candidates indicated the

appropriate important features for the graphs, such as the title of the graph including units; the scales (both vertical and horizontal); labelled axes (vertical and horizontal); transfer of points with best fit of line; and slope indication. They had good mathematical skills as they systematically obtained the correct answers. Furthermore, the candidates managed to relate the experimental results with theories. Extract 12.1 shows the candidate who followed appropriate procedures, recorded the data, plotted the graph, used the graph to perform the calculations accordingly and finally calculated the value of g correctly.

TABLE OF RESULTS.

01. (i)

L cm	t (sec.)	t^2 (s^2)
90	37.94	1439.44
80	35.77	1279.49
70	33.46	1140.41
60	30.98	959.76
50	28.25	798.06
40	25.30	640.00

ii. Plot the graph of L against t^2
- slope is plotted in the graph paper.

iii. Determine the slope of the graph.

$$\text{Slope} = \frac{\text{Change in } L\,(cm)}{\text{Change in } t^2\,(s^2)}$$

$$\text{Slope} = \frac{42 - 11\,(cm)}{700 - 200\,(s^2)}$$

$$\text{Slope} = \left(\frac{31}{500}\right) cm/s^2.$$

$$\text{Slope} = 0.062\ cm/s^2$$

∴ Slope of the graph is $0.062\ cm/s^2$

Q1. iv. $t^2 = \frac{4\pi^2 n^2}{g} L + \frac{4\pi^2 n^2 x}{g}$

but, in 1.(ii) to draw the graph of L against t^2, therefore

$t^2 = \frac{4\pi^2 n^2 L}{g} + \frac{4\pi^2 n^2 x}{g}$.

$\frac{4\pi^2 n^2 L}{g} = t^2 - \frac{4\pi^2 n^2 x}{g}$.

$4\pi^2 n^2 L = t^2 g - 4\pi^2 n^2 x$.

$\frac{4\pi^2 n^2 L}{4\pi^2 n^2} = \frac{t^2 g}{4\pi^2 n^2} - \frac{4\pi^2 n^2 x}{4\pi^2 n^2}$

$L = \frac{t^2 g}{4\pi^2 n^2} - \frac{4\pi^2 n^2 x}{4\pi^2 n^2}$

$$L = \left(\frac{g}{4\pi^2 n^2}\right) t^2 - x$$

$$y = mx - c$$

So,

slope $= g / 4\pi^2 n^2$.

but, slope from the graph = 0.062

n = number of oscillation = 20

$\pi = 3.14$.

g = acceleration due to gravity.

therefore.

$m = g / 4\pi^2 n^2$.

$0.062 = g / 4 \times (3.14)^2 \times (20)^2$.

Q1. iv. $0.062 = \frac{g}{4\times(3.14)^2\times(20)^2}$

$g = 4\times(3.14)^2\times 20\times 20\times 0.062$

$g = (15775.36\times 0.062)\ cm/s^2$

$g = 978.07\ cm/s^2 \approx 978.\ cm/s$

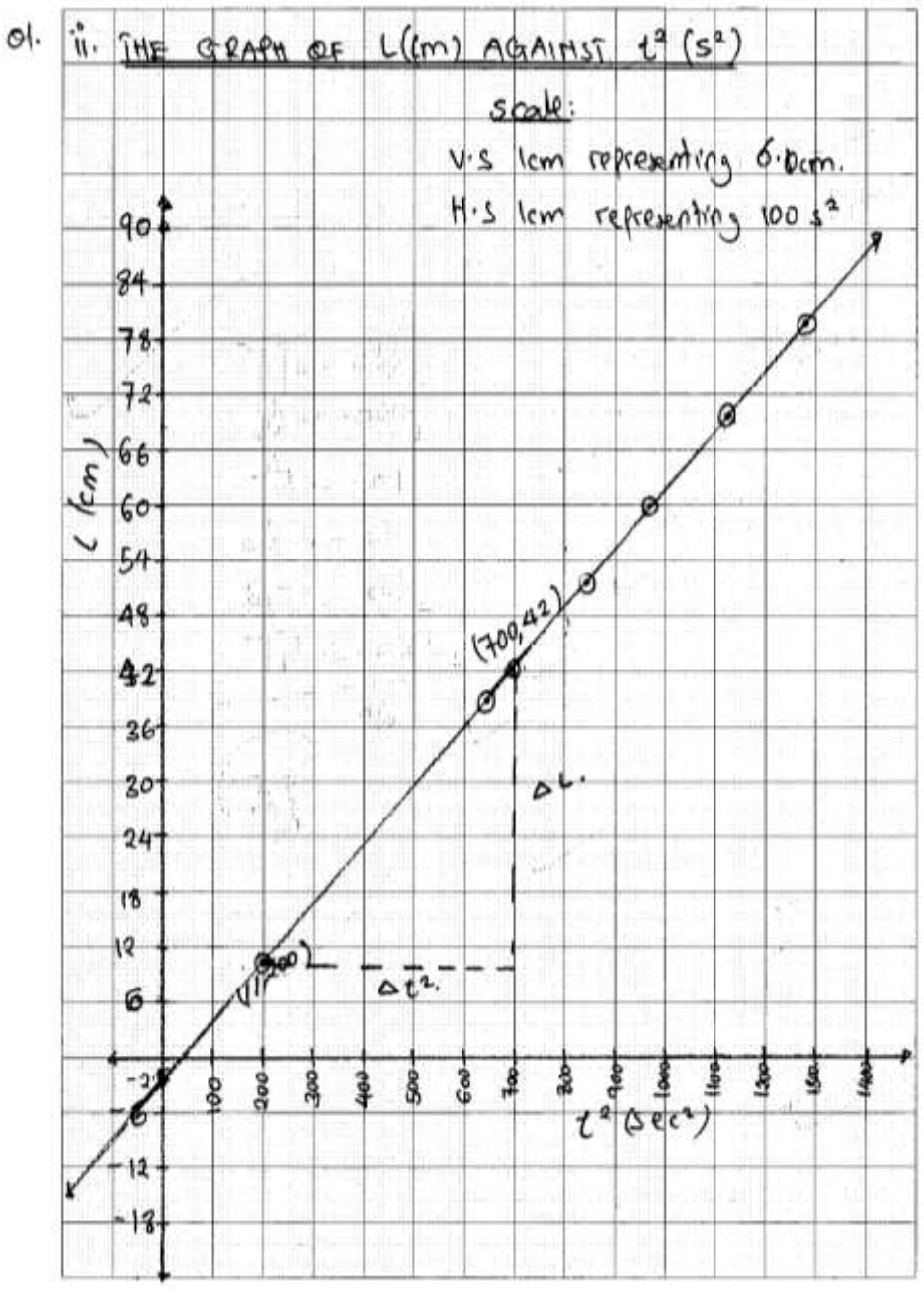
∴ Acceleration due to gravity 978 cm/s^2

v. From the graph determine L-intercept in cm.

> From the graph L-intercept is -2.5 cm

vi. What does the value obtained signify?

- The value obtained signify the distance from the centre of pendulum bob to the point of fixing, which is 2.5 cm.



Extract 12.1: A sample of a candidate's good responses to question 1 of Physics 2A.

The candidates who scored 0.0 to 7.0 marks failed to demonstrate their mastery of basic experimental skills on the topic of *Mechanics especially the simple pendulum*. some of the candidates failed to collect,

present and analyse experimental data as their experimental table of values are incorrect. For the candidates to get a correct value of acceleration due to gravity, they were supposed to plot the graph of l against t^2. Thus, the candidates were supposed to measure the length, l of thread and determine the time, t in seconds. Then tabulate the results of l (cm), t (seconds), and t^2 (seconds)^2. Few candidates failed to present their experimental data correctly. For example, some candidates failed to indicate the proper units of the measured experimental variables while others failed to indicate important features such as the title of the graph, labelled axes (vertical and horizontal axis), reasonable scale (vertical and horizontal scales), slope indication, and best line. Also, some of them failed to transfer points correctly.

Moreover, they were incompetent in the use of mathematics skills to relate the linear equation $y = mx + c$ with $t^2 = \frac{4\pi^2 n^2 l}{g} + \frac{4\pi^2 n^2 x}{g}$. These candidates failed to make l as a subject of the formula in order to determine the value for the slope and equation which gives the l-intercept.

In fact, the candidates were supposed to first make l the subject of the formula from the equation $t^2 = \frac{4\pi^2 n^2 l}{g} + \frac{4\pi^2 n^2 x}{g}$, thus, $l = \frac{gt^2}{4\pi^2 n^2} - x$.

As per the given equation, the plot of l against t^2, yields a straight line with a slope = $\frac{g}{4\pi^2 n^2}$ and the l-intercept as – x.

Some of the candidates obtained the correct value of the slope but failed to include the unit. As a result, they failed to score all marks allocated in item (v). Most of the candidates failed to find the slope and thus, failed to determine the value of acceleration due to gravity. Others provided inappropriate physical meaning of the slope of the graph. For instance, one of the candidates wrote, "*the slope is amount of voltage coming from the cell in the circuit*". This statement was incorrect and holds only for concepts relating to current electricity and not mechanics. Some candidates used the wrong data to draw the graph or failed to transfer the data points to the graph correctly. Those candidates in this

category failed to obtain the correct values of slope and *l*-intercept. Some of the them plotted the graph correctly but failed to interpret the physical meaning of the slope and *l*-intercept.

The candidates were supposed to compare equation $l = \frac{gt^2}{4\pi^2 n^2} - x$ with $y = mx + c$. Therefore, the value of *x* signifies the distance from the centre of mass of the pendulum bob to the point at which it is tied to the thread. Some candidates obtained the correct slope value but failed to use it to determine the value of acceleration due to gravity. These candidates used one of the tabulated data to determine the acceleration due to gravity. As a result, they obtained the wrong slope and other experimental parameters. That is to say, the candidates lacked adequate knowledge and skills to conduct such an experiment. Exptract 12.2 shows incorrect responses from one of the candidates who scored low marks in this question.

1.	L	20t	t^2
	90	120	14400
	80	113	12800
	70	105	11200
	60	97	9600
	50	89	8000
	40	80	6400

III. B. The slope of the graph in 1(ii)

Formula

$$S = \frac{L_2 - L_1}{t^2 - t_1}$$

$$S = \frac{90 - 40}{144 - 80} = \frac{26}{60}$$

$$S = 0.4$$

∴ slope of the graph = $0.4 cm/s^2$

IV. $t^2 = 4\pi^2 n^2 L + 4\pi^2 n^2 x$

solution.

Data given.

$n = 3.14$ n = number of oscillation

$x =$ 20

$$t^2 = \frac{4\pi^2 n^2 L}{g} + \frac{4\pi^2 n^2 x}{g}$$

$$t^2 = \frac{4 \times 3.14 \times 20 \times 90}{g} + \frac{4 \times 3.14 \times 20 \times 2.5}{g}$$

$$144^2 = 4 \times 3.14 \times 20 \times 90 + 4 \times 3.4 \times 20 \times 2.5$$

$$g144^2 = 4 \times 3.14 \times 20 \times 90 + 4 \times 3.4 \times 20.25$$

$$g = \frac{9.8652 \text{ cm/s}^2}{10000}$$

$$g = 9.8 \text{ N/cm/s}^2 \text{ or } 10g(\text{cm/s}^2)$$

∴ Acceleration due to gravity = 9.8N or 10g(cm/s²)

v. The L-intercept in cm

1m = 100cm

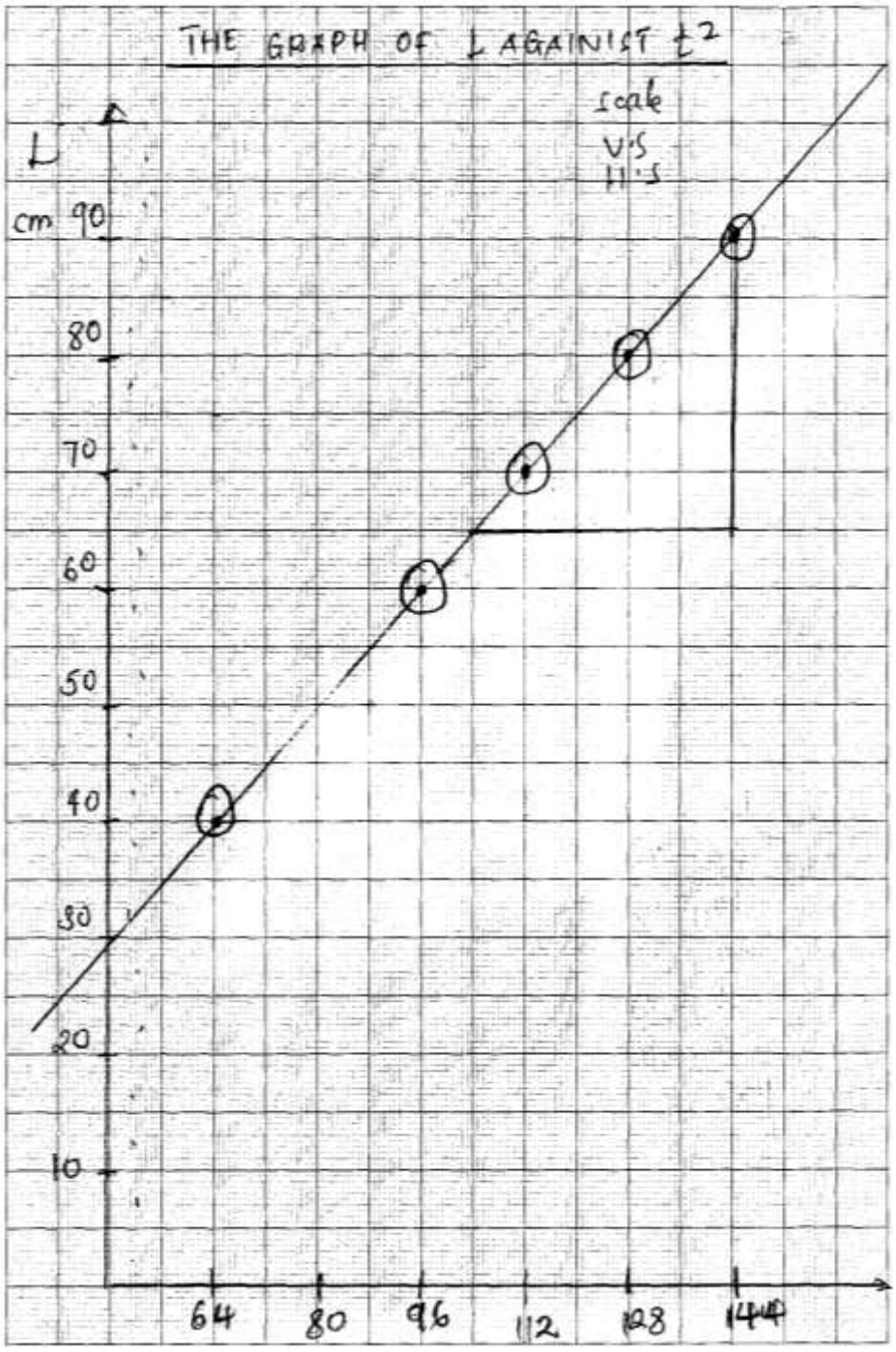
40m x

= 40 × 100

= 4000

L-intercept = 4000cm.

vi. The value obtained in 1(v) signify the Intercept in cm which obtained from the graph.



Extract 12.2: A sample of a candidate's weak responses to question 1 of Physics 2A.

Extract 12.2, shows that the candidate lacked the knoeledge of data collection, data presentation, data analysis and showed poor graphical and mathematical skills in determining the acceleration due to gravity in simple pendulum. He/she failed also to relate the linear equation with the one provided hence, failed to determine the slope and inter-cept of the graph.

3.1.2 031/2B Physics 2B

In this question, the candidates were provided with a pendulum bob, meter rule, retort stand, stopwatch, clamp, cork pads and cotton thread and were required to proceed as follows:

(a) Set up the apparatus as shown in the following Figure.

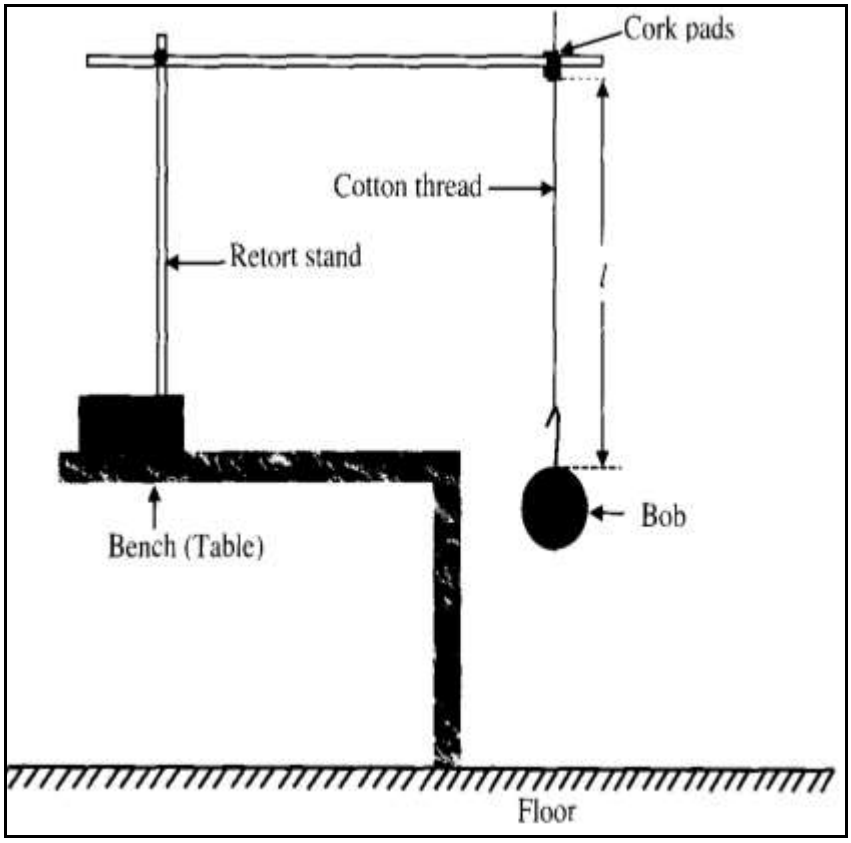


Figure 13.1:

(b) Adjust the length, *l* of the pendulum to 20 cm.

(c) Displace the pendulum bob at a small angle on one side and release it to oscillate to and fro motion. Using the stopwatch, read and record the time, *t* for 10 complete oscillations and determine its periodic time, *T* (sec).

(d) Repeat the procedures in 1 (c) for *l* = 40 cm, 60 cm, 80 cm, and 100 cm.

The candidates were supposed to answer the following questions:

(i) Tabulate the results, including the values of T^2 (sec^2) as shown in the following table:

Length *l* (cm)	**Time, *t* for 10 oscillations (sec)**	**Periodic time, T (sec)**	**T^2 (sec^2)**
20			
40			
60			
80			
100			

(ii) Plot the graph of T^2 (sec^2) against *l* (cm).

(iii) Determine the slope of the graph plotted in 1 (ii).

(iv) Use equation, $l = g\left(\frac{T}{2\pi}\right)^2$ determine the value of acceleration due to gravity, *g*.

(v) Why it is not possible to obtain the exact value of acceleration due to gravity? Give a reason.

The candidates who scored low marks (0.0 to 7.0) marks failed to demonstrate their mastery of basic experimental skills about the topic of *Mechanics*. Most of the candidates failed to collect the correct data. This resulted into a tabulation of incorrect values of periodic time.

Some of the candidates demonstrated their mastery of data collection skills but failed to perform scientific data interpretation. These candidates failed to use a given formula to determine the slope of the graph. They were also required to plot the graph of T^2 (sec^2) against l (cm). in order to solve the problem, candidates were supposed to know that the best line fit yields the slope of the graph. From the relation $l = g\left(\frac{T}{2\pi}\right)^2$; this equation yields $T^2 = \frac{4\pi^2}{g}l$. Using $y = mx + c$, it can be shown that the slope of the graph is $\frac{4\pi^2}{g}$.

Further analysis reveals that some of the candidates calculated correctly the value of the slope but failed to use it to determine the acceleration due to gravity. Some candidates failed to indicate important features of the graph. Those features include: the title of the graph, labelled axes (vertical and horizontal axes), reasonable scale (vertical and horizontal scales), slope indication, and best line. Some of the candidates failed to transfer points correctly, implying that they had poor data presentation and graph interpretation skills. Most of the candidates failed to plot the best line of the graph. They forced the best line to start from the origin, hence ended up with improper graph.

Some of the candidates failed to provide the correct reasons as to "*why it is not possible to obtain exact value of acceleration due to gravity*." in item (v). For instance, one of the candidates wrote, "*It not possible to obtain the value of acceleration due to gravity because of the rotation of the Earth*". The response was incorrect, suggesting that the candidate had insufficient knowledge and skills in the topic of *Mechanics*, specifically the simple pendulum. It is worth noting that the influence of Earth's rotation on the acceleration due to gravity is out of scope as per the Physics syllabus of 2010. Some of the candidates provided unclear and irrelevant responses. Looking at the question, candidates were supposed to apply the formula of the periodic time ($T^2 = \frac{4\pi^2}{g}l$). As per the periodic formula, the period of oscillation depends on the length of the thread. However, as per the experimental set-up, the length of the thread was measured from the point of suspension in the cork pads to

the upper end of the bob. The proper formula to describe the dynamics of the bob was supposed to be $T^2 = \frac{4\pi^2}{g}(l + x)$. This shows that the graph was not a straight line from the origin. Therefore, ignoring *x* induced an experimental error. That is to say that, as per the experimental setup, it was impossible to obtain the exact value of the acceleration due to gravity. Some of the candidates responded to this item (v) by associating the obtained experimental result with experimental error without giving a scientific reasoningt. Indeed, the experimental error is the main problem, but they were supposed to give a detailed description of the source error explicitly. This suggests that most of the candidates had inadequate reasoning skills. Extract 13.1 shows a sample of a candidate's incorrectresponses to Question 1 in Physics 2B.

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	length l cm	Time, t for 10 oscillations	periodic time T sec	T^2 (sec^2)
	20	12	120	14400
	40	8	~~320~~ 80	6400
	60	6	~~360~~ 60	3600
	80	4	~~320~~ 40	1600
	100	2	20	400

iv) plot the graph of T^2 (sec^2) against l (cm).

Soln

The grap of on paper in graph

(iii) Determine the slope of the graph plotted in 1 (ii)

Soln.

$\frac{\Delta (20, 400}{\Delta (40, 1600)}$

$\frac{\Delta\ 20 \times 400}{\Delta\ 40 \times 100}$

$\frac{\Delta\ 8000}{\Delta\ 64000}$

$\frac{\Delta\ 8^1}{\Delta 64_8}$

∴ Slope in the graph is $\Delta\ 8$

iv) $L = g\left(\frac{T}{2\pi}\right)^2$

soln

$$L = g\left(\frac{T}{2\pi}\right)^2$$

$L = 20cm$

$g = ?$

$T^2 = 400$

$2\pi = \frac{22}{7}$

iv) $L = 20cm$

$g = ?$

$T^2 = 400$

$2\pi = \frac{22}{7}$

$$L = g\left(\frac{T}{2\pi}\right)^2$$

$$20 = g\left(\frac{120}{\frac{22}{7}}\right)^2$$

$$20 = g\left(\frac{14400}{\frac{484}{49}}\right)$$

$$20 = 9\left(\frac{29.8}{49}\right)$$

$$20 = 9(0.6)$$

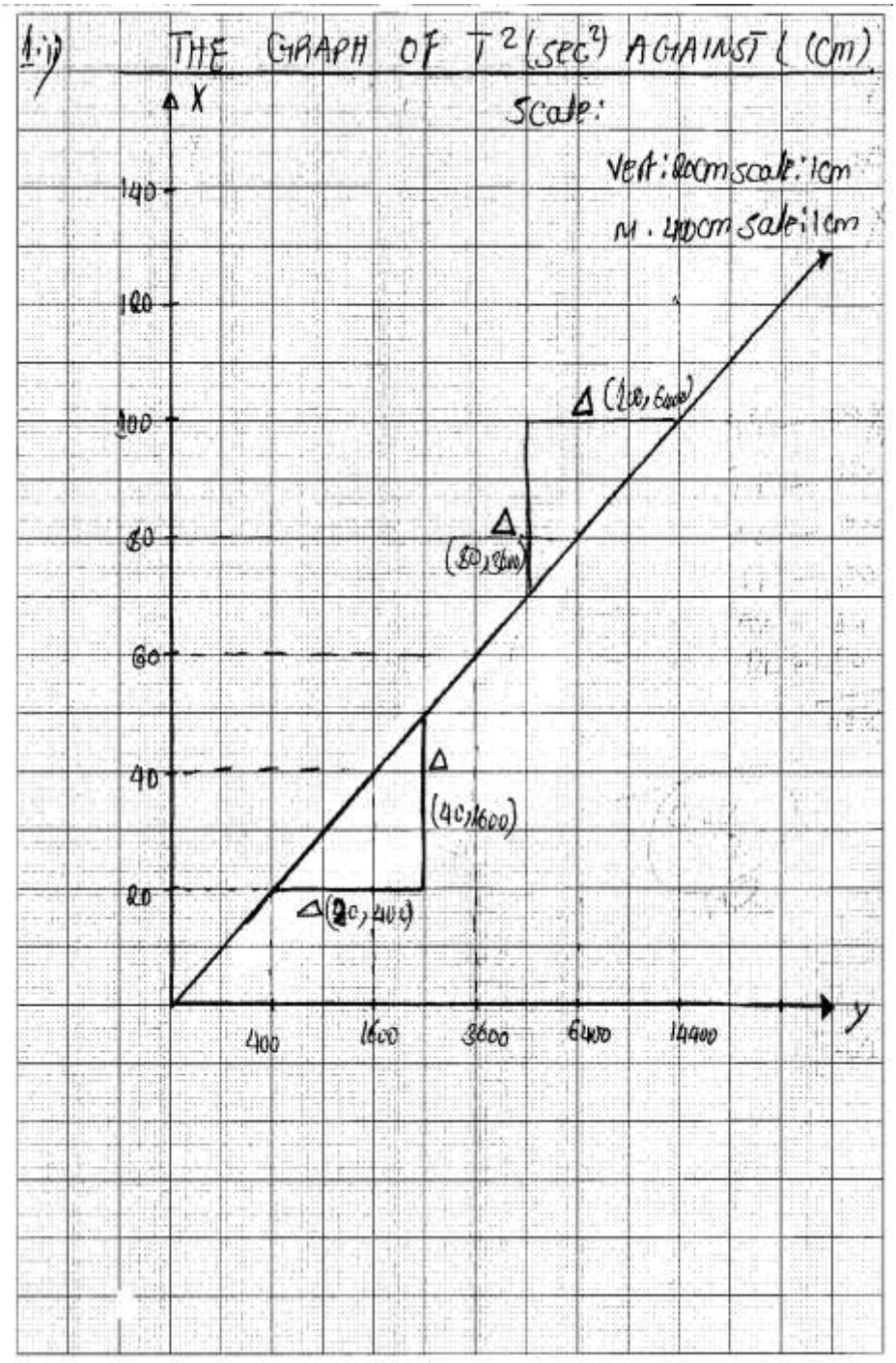
$$20 = 9(0.6)$$

$$\frac{20}{0.6} = \frac{0.6g}{0.6}$$

$$g = 33.$$

∴ The gravity, $g = 33$.

v) i) It help to control time
ii) It help to reduce material
iii) It use in the equation.



Extract 13.1: A sample of a candidate's weak response to question 1 in Physics 2B

In extract 13.1, the candidate obtained the periodic time by multiplying the time taken to make 10 oscillations by 10 for each entry in the respective entry column contrary to the method to be applied. He/she failed to write the correct formula for the determination of the slope and ploted an incorrect graph.

The statistical analysis shows that most of the candidates who scored high marks in this question, were good in setting the experiment, collection of data, analysis of data and had mathematical skills. These candidates were able to present data in tabular form and indicated all the variables with their corresponding units correctly. They demonstrated competence in plotting the graphs, particularly on data transfer, including all important features for a suitable graph. The important parts of the graph included: the title of the graph with appropriate units of the variables, the scale (both vertical and horizontal scale), the labelled axis (*vertical* and horizontal axis) including units, best line and the slope indication.

Consequently, they were also capable of finding the slope of the graph and the *l*-intercept. This reveals that they really did the xperiment and used the collected experimental data to determine the acceleration due to gravity. Similarly, they managed to provide a reason for a small deviation of the value of acceleration due to gravity. Most of them stated that the deviation is mainly due to experimental errors such as air resistance and recording length of the string. However, no detailed scientific description related to the source of experimental error with respect to the nature of the graphs was discussed. Extract 13.2 shows a sample of a candidate's good responses in Question 1 in Physics 2B.

Q1. (i)

Length, L(cm)	time for 10 oscillations t(sec)	Periodic Time T(sec)	$T^2(sec^2)$
20	8.90	0.89	0.80
40	12.63	1.26	1.60
60	15.54	1.55	2.41
80	18.06	1.81	3.26
100	20.08	2.01	4.03

(iii) from,

$$\text{Slope} = \frac{\Delta T^2 (sec^2)}{\Delta L (cm)}$$

$$\text{Slope} = \frac{T_1^2 - T_2^2}{L_1 - L_2}\left(\frac{s^2}{cm}\right) = \frac{(3.6 - 1.5)s^2}{(90 - 38)cm}$$

$$\text{Slope} = \frac{2.1}{52}\frac{s^2}{cm} = 0.045\,s^2/cm$$

∴ Slope of the graph is $0.045\,s^2/cm$

(iv) from

$$L = g\left(\frac{T}{2\pi}\right)^2$$

$$\frac{L}{1} = \frac{gT^2}{4\pi^2}$$

$$\frac{gT^2}{g} = \frac{4\pi^2 L}{g}$$

$$T^2 = \frac{4\pi^2}{g} \cdot L$$

$$y = m \cdot x$$

Gf. $\therefore \quad m = \frac{4\pi^2}{g}$

$$g = \frac{4\pi^2}{m}$$

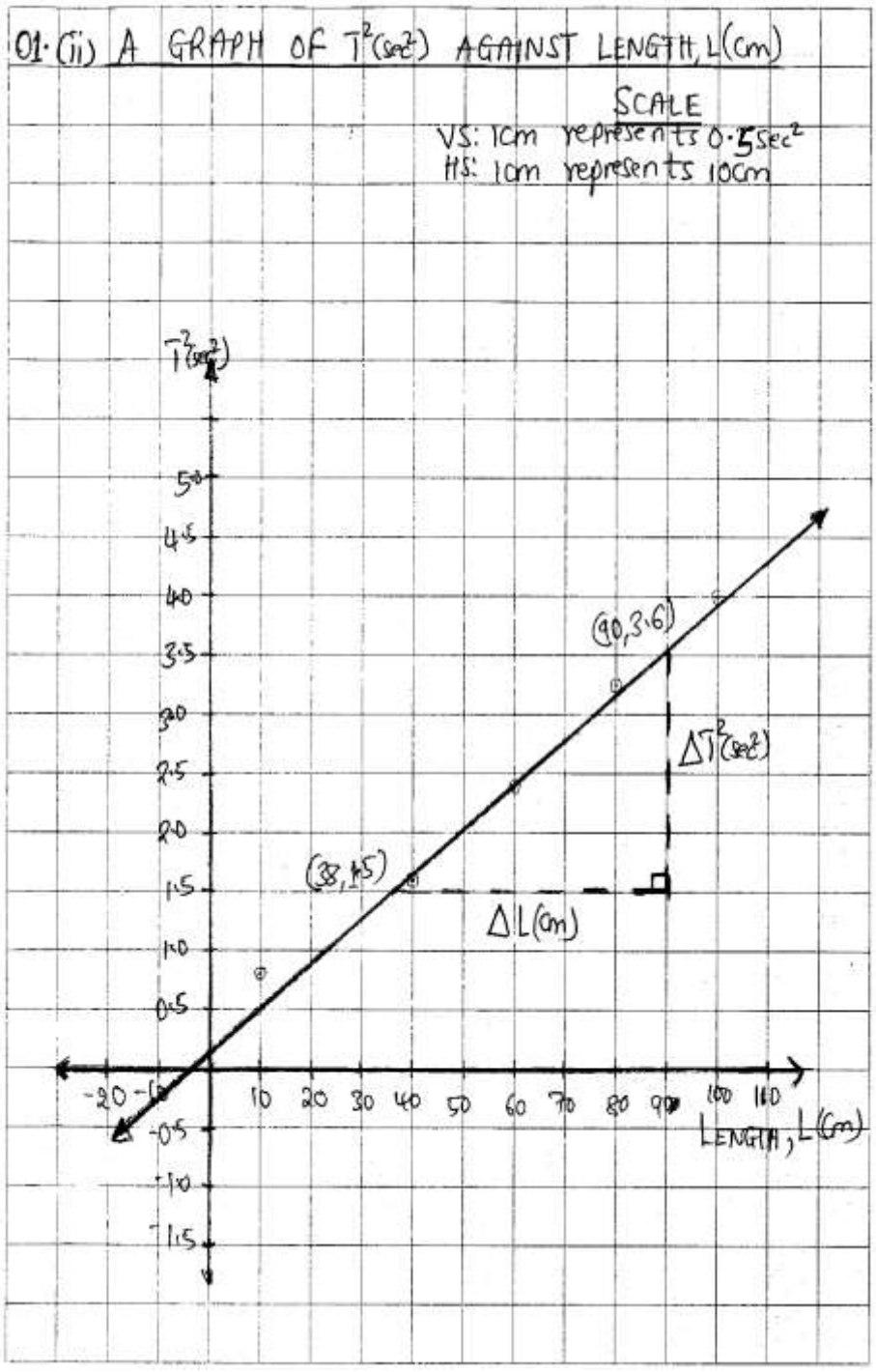
$$g = \frac{4 \times (3.14)^2}{0.04 \, s^2/cm}$$

$$g = \frac{985.98 \, cm/s^2}{100}$$

$$g = 9.8 \, m/s^2$$

$\therefore$ Acceleration due to gravity is $9.8 \, m/s^2$

(v) It is not possible to obtain exact value of acceleration due to gravity because of some sources of error like air resistance and time delay.



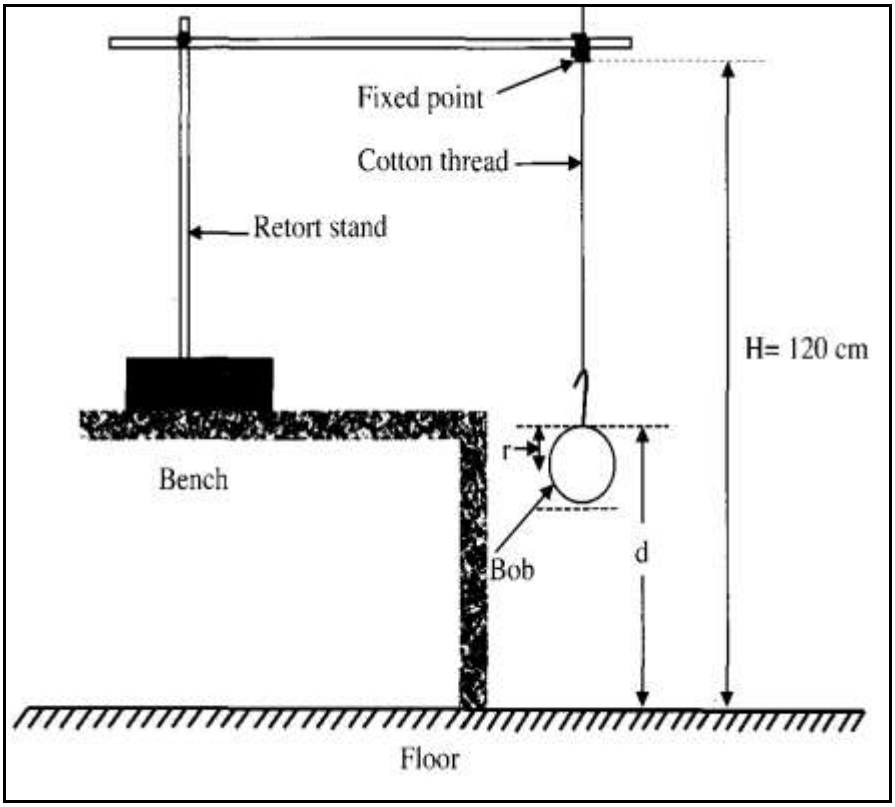
Extract 13.2: A sample of a candidate's good responses to question 1 in Physics 2B

In extract 13.2, the candidate collected appropriate values of the parameters in the table of results and then appropriately drew a suitable graph. He/she calculated the slope of graph correctly and then used it to determine the acceleration due to gravity, g.

3.1.3 031/2C Physics 2C

In this question, the candidates were required to conduct an experiment to verify acceleration due to gravity (g) from to and fro motion of natural and man-made occurrence swinging objects. They were provided with cotton thread, retort stand, pendulum bob, meter rule and stopwatch. They were required to perform the experiment by using the following procedures:

(a) Set up the apparatus as shown in Figure 1



(b) Measure the height = 120 cm above the floor to the fixed point. Suspend the pendulum bob from the fixed point using the retort stand such that the value of distance, *d* from the floor, is 10 cm.

(c) Displace the pendulum bob through a small angle to one side and release it to oscillate. Record the time, t for 10 complete oscillations and determine its periodic time, T (sec).

(d) Repeat the procedure in 1 (c) for values of d = 20cm, 30 cm, 40 cm and 50 cm and then:

(i) Record your results including the values of $T^2(s^2)$

(ii) Plot the graph of T^2 against d (cm) ,for which T and d, are related by the equation, $T^2 = \frac{4\pi^2 d}{g} + \frac{4\pi^2}{g}(H + r)$

(iii) Determine the slope of the graph in 1 (ii)

(iv) Use the equation in 1 (ii) and the slope obtained in 1 (iii) to determine the acceleration due to gravity. Compare the value obtained and the theoretical value of g at the earth's surface.

(v) Using your graph, determine the T^2 intercept and use it to determine the value of r and, hence determine the diameter of the bob in cm.

(vi) Using the Vernier caliper given, measure the diameter of the bob in cm

(vii) Comment on the values obtained in parts (v) and (vi)

The analysis indicates that most of the candidates scored high marks from 16.5 to 25.0 marks. Those candidates demonstrated the ability to perform experiments in Physics. They adhered to experimental procedures, including setting the experiment collecting and analyzing data. The candidates were able to present experimental data excellently. The analysis more reveals that those candidates in this category demonstrated the ability to plot graphs. In the graph, they indicated all the necessary important features such as the title of the graph, which includes units of the measured variables, the scale (both vertical and horizontal scale), labelled axes (horizontal and vertical axis) including units, data transfer, best line fit and slope indication. Also, the candidates had the ability to use mathematics to determine the value of the acceleration due to gravity and other experimental parameters. Likewise,

they were able to use a vernier calliper to measure the diameter of the bob. Extract 14.1 shows a sample of a candidate's good responses to Question 1 in Physics 2C.

01 (i) TABLE OF RESULTS

d (cm)	t (s)	T (s)	T^2 (s^2)
10	20.97	2.09	4.37
20	20.00	2.00	4.00
30	18.97	1.89	3.57
40	17.89	1.79	3.20
50	16.73	1.67	2.79

(iii) Solution.

From the graph;

$$\text{slope (m)} = \frac{\text{change in } T^2 (s^2)}{\text{change in d (cm)}}$$

$$\text{slope (m)} = \frac{\Delta T^2 (s^2)}{\Delta d (cm)}$$

$$\text{slope (m)} = \frac{2.79 - 4.38 (s^2)}{49.68 (cm) - 9.72 (cm)}$$

$$\text{slope} = \frac{-1.59 (s^2)}{39.96 (cm)}$$

$$= -0.04 s^2/cm$$

∴ The slope of the graph is $-0.04 s^2/cm$

(iv) Solution.

From the equation.

$$\frac{T^2}{g} + \frac{4\pi^2 d}{g} = \frac{4\pi^2 (H+r)}{g}$$

$$\frac{T^2}{g} = \frac{4\pi^2 (H+r)}{g} - \frac{4\pi^2 d}{g}$$

$$\frac{T^2}{g} = \frac{-4\pi^2 d}{g} + \frac{4\pi^2 (H+r)}{g}$$

But

$$\text{slope } (m) = \frac{-4\pi^2}{g}$$

$$\frac{m}{1} = \frac{-4\pi^2}{g}$$

$$\frac{-4\pi^2}{m} = \frac{m \times g}{m}$$

$$g = \frac{-4\pi^2}{m}$$

$$g = \frac{-4 \times (3.14)^2}{-0.04\ s^2/cm}$$

$$g = 985.96 \sim 986\ cm/s^2$$

∴ The acceleration due to gravity (g) is $986\ cm/s^2$

(v) From the graph.

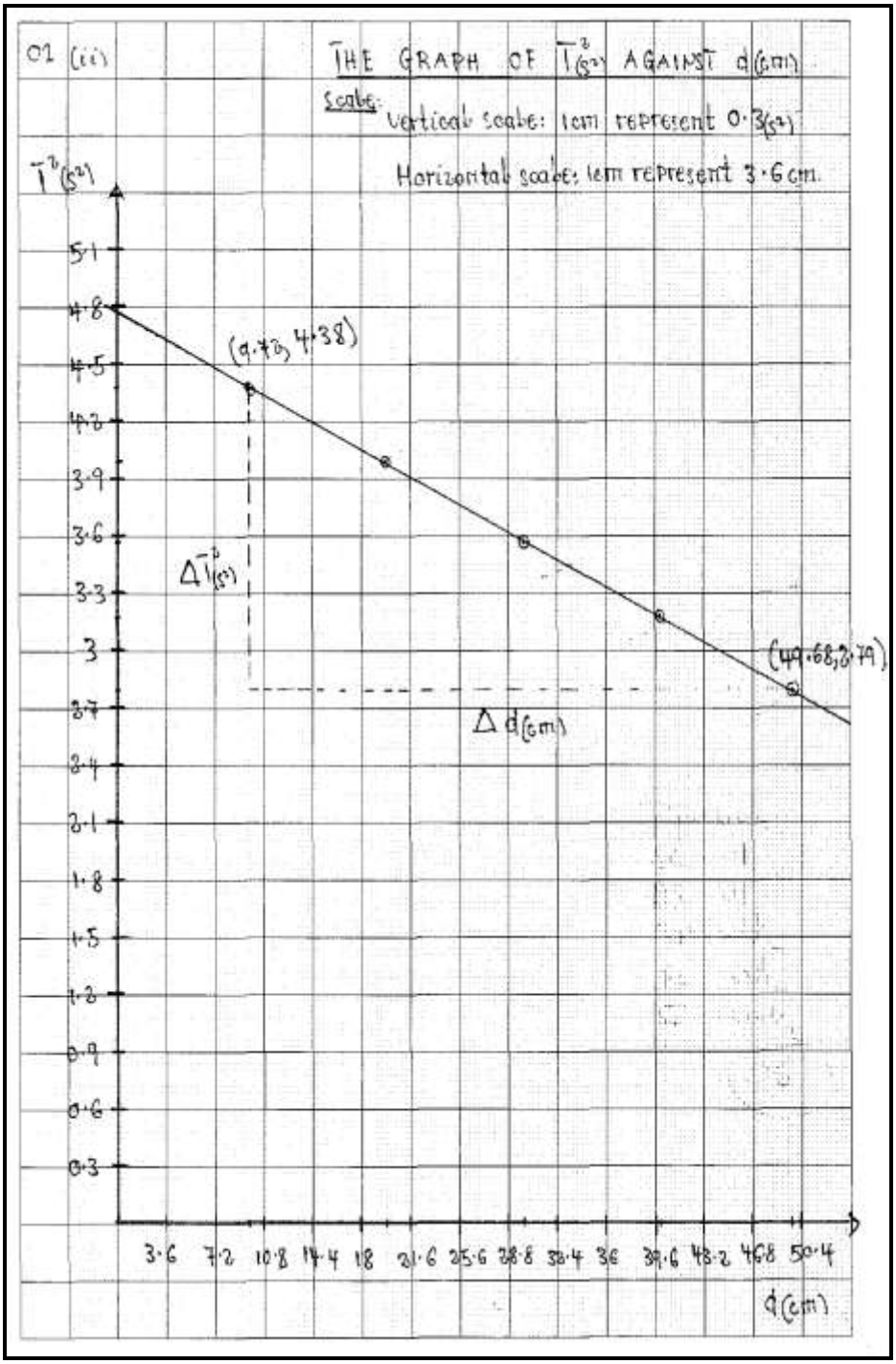
(a) The T^2 intercept is $4.77(s^2)$

(b) The value of r is 0.97cm.

(c) The diameter of the bob is 1.94cm.

(vi) The diameter of the bob is 1.94cm.

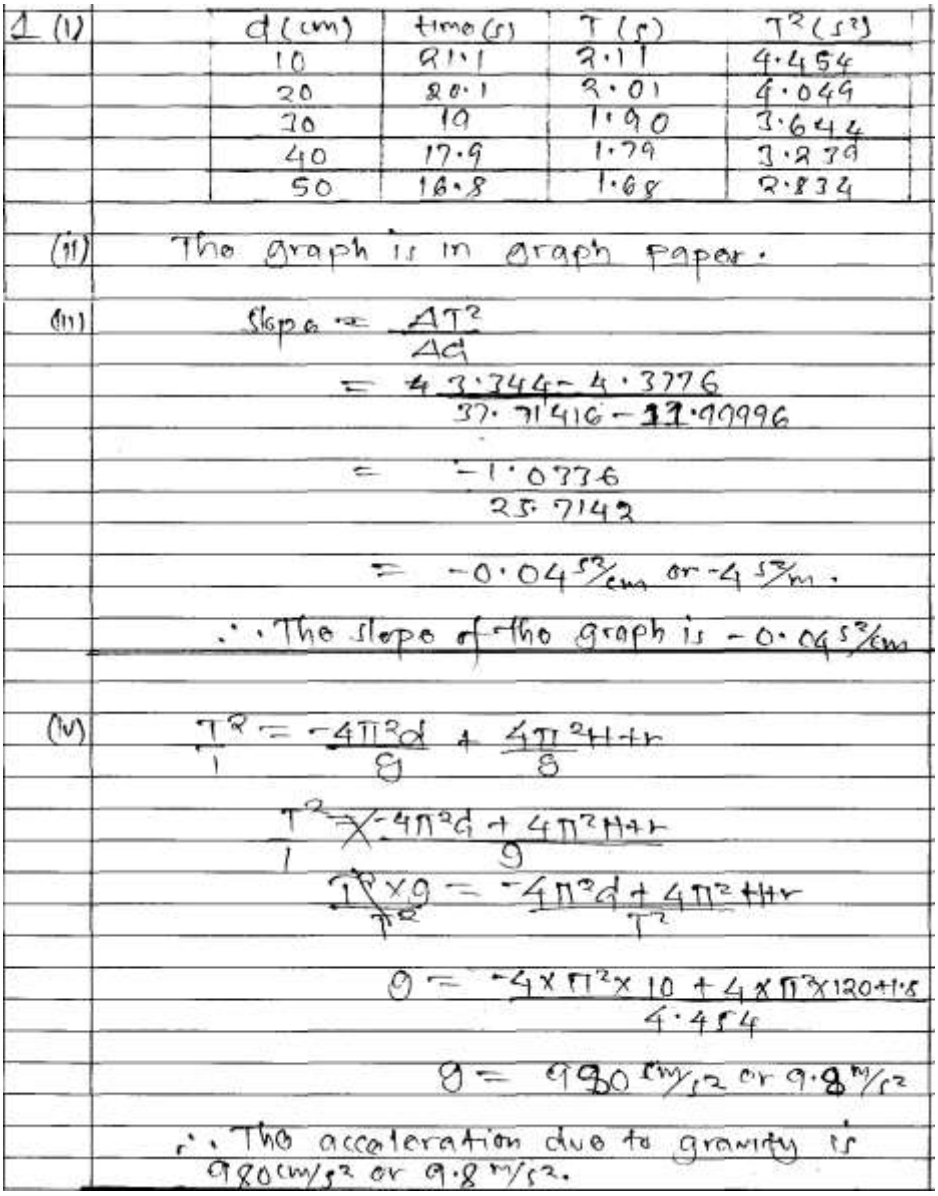
(vii) The values obtained in parts (v) and (vi) is the same, such as diameter of bob.



Extract 14.1: A sample of a candidate's good responses in Question 1 in Physics 2C.

In extract, 14.1, the candidate did well most parts of the question. However, he/she failed to indicate the SI units of the calculated value of the acceleration due to gravity g.

The majority of the candidates who scored low marks in this question lacked the knowledge of Mechanics particularly simple pendulum. These candidates failed to set up the experiment correctly which led them to end up with wrong data in the table of results. Some of the candidates failed to indicate important features such as the title of the graph, labelled axes (vertical and horizontal axis), reasonable scale (vertical and horizontal scales), slope indication, and best line. Others managed to plot the correct graph but failed to score full marks because they lacked mathematical skills to compute the slope and the acceleration due to gravity. For example, one candidate evaluated the slope using the formula; $\text{slope, s} = \frac{\Delta L(cm)}{\Delta t(s)}$ which is contrary to the question demand. For the candidates to have the value of acceleration due to gravity, they were supposed to plot the graph of T^2 (s^2) against d (cm). Then, use the following formula to determine the slope: $\text{slope, s} = \frac{\Delta T^2(s^2)}{\Delta d\,(cm)}$. Few candidates managed to obtain the correct value of the slope but they employed incorrect approach to determine the acceleration due to gravity due to lack of mathematical skills, see extract 14.2.



Extract 14.2: A sample of a candidate's partial responses in question 1 for Physics 2C.

In extract 14.2, the candidate managed to calcultate correctly the value of the slope but employed incorrect way of finding the value of acceleration due to g.

Some of the candidates obtained incorrect answer of g when comparing the acceleration due to gravity from the experimental data and the

theoretical value of that experienced at the earth's surface. It is noted that the value of g obtained from experimental data and the theoretical value, are approximately equal. Furthermore, some of the candidates failed to get correct value of T^2 intercept as a result they failed to determine the value of r. Since, they got incorrect value of T^2 –intercept (s^2) and r, they therefore, ended with incorrect diameter of the bob in cm.

These category of candidates were supposed to calculate the diameter of the bob by comparing the equation $T^2 = \frac{4\pi^2 d}{g} + \frac{4\pi^2}{g}(H + r)$ with the linear equation $y = mx + c$ which gives the T^2-intercept as $\frac{4\pi^2}{g}(H + r)$. The value of r will be obtained by the using the relation: diameter of the bob ($d = 2r$).

Some of the candidates didn't manage to score marks in an item (vi) due to poor knowledge about the use of vernier calipers in the measurement of diameters of different regular shaped bodies. Consequently, they provided incorrect answer in item (vii) where they were required to compare the value of diameter d obtained from direct measurement using the Vernier caliper and that from the calculations. They were supposed to comment that the values are approximately equal. Extract 14.3 is a sample of a candidate's weak responses to question 1 in Physics 2C

1. Table Results

cm	T	T^2
10	24	2.4
20	37	7.4
30	52	14.9
40	66	62.4
50	72	3.6

(ii) $m = \frac{y_1 - y_2}{x_1 - x_2}$

$y_1 = 10.4$

$y_2 = 52.0$

$x_1 = 24.0$

$x_2 = 2.4$

$m = \frac{y_1 - y_2}{x_1 - x_2}$

$m = \frac{10.4 - 52.0}{24.0 - 2.4}$

(ii) (m) Gradient $= \frac{10.4 - 52.0}{24.0 - 2.4}$

$m = \frac{-41.86}{21.6} = -1.93$

∴ The Gradient is -1.93

$\Delta\ m = \bar{i}_1 + \bar{i}_2$

$m = \frac{y_1 - y_2}{x_1 - x_2}$

$y_1 = 10.14$

$y_2 = 52.$

$x_1 = 24$

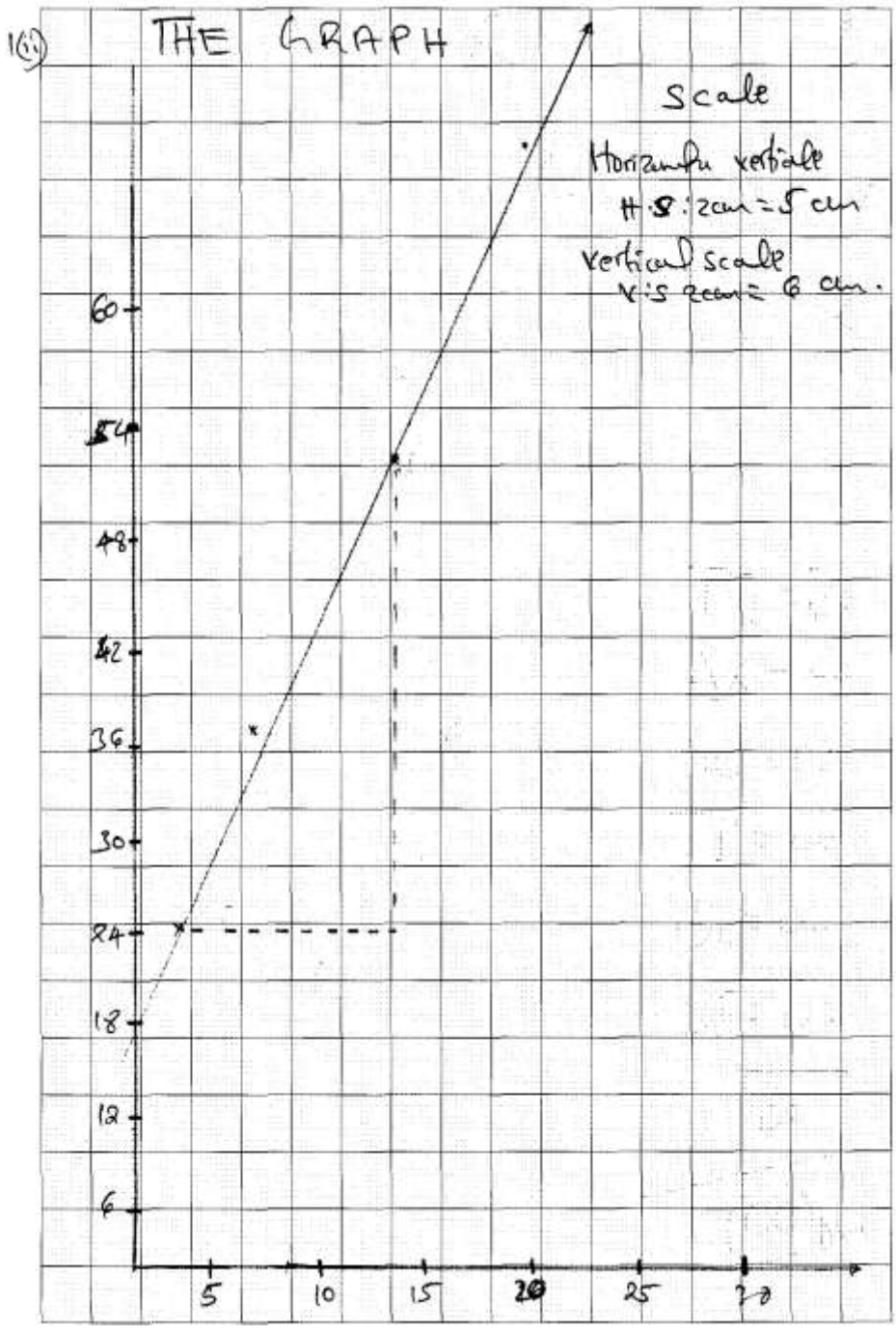
$x_2 = 2.4$

$m = \frac{y_1 - y_2}{x_1 - x_2}$

$m = \frac{10.14 - 52.0}{24.0 - 2.4}$

$m = \frac{-41.86}{21.6}$

$m = -1.93$



Extract 14.3: A sample of a candidates' weak responses to question 1 in Physics 2C

In extract 14.3, the candidate provided incorrect answers to all parts of the question.

3.2 Question 2: Current Electricity

Question 2 in each alternative paper was developed on the topic of c*urrent electricity*. The questions were developed to assess the candidates' ability to construct the simple electric circuit using the provided electrical components. The candidates were required to use the constructed circuit to collect and analyse data and determine the experimental parameters according to given experimental instructions.

The data portrays that 121,970 (99.89%) candidates attempted question 2, out of which 43,257 (35.47%) scored from 0.0 to 7.0 marks, 45,025 (36.91%) scored from 7.5 to 16.0 marks, and 33,688 (27.62 %) scored from 16.5 to 25.0 marks. As can be seen in Figure 13, the candidates' performance was average since 78,713 (64.53 %) scored from 7.5 to 25.0 marks out of 25 marks.

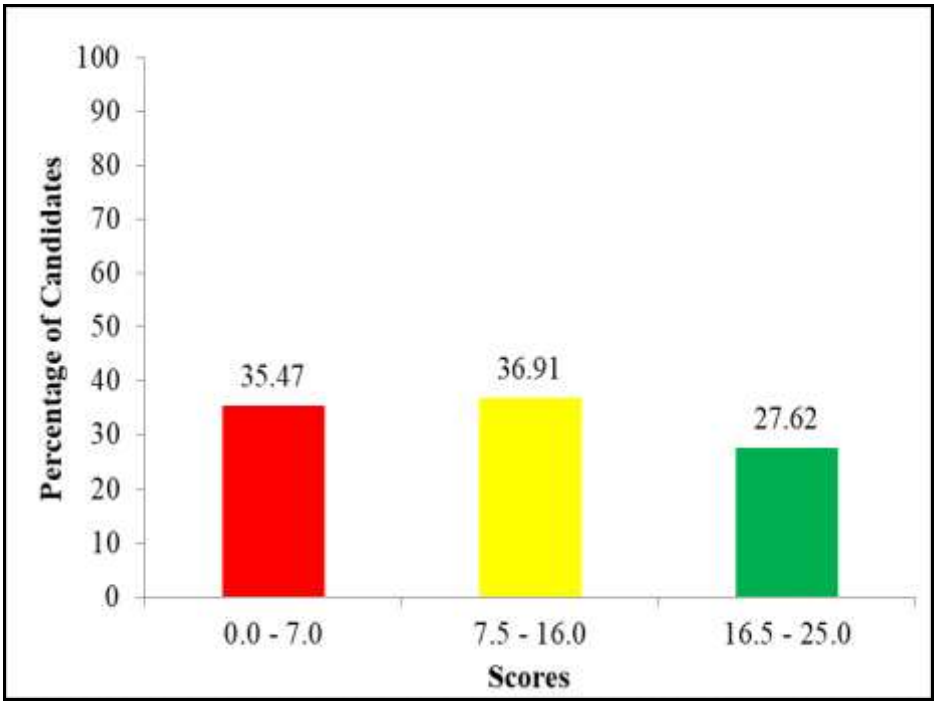


Figure 13: *The performance of candidates in Question 2 for Physics paper 2*

3.2.1 031/2A Physics 2A

In this question the candidates were provided with a cell E, the key K, resistance box R, Ammeter, A and the Voltmeter, V.
The candidates were required to proceed as follows:

(a) Set up the circuit as shown in the following Figure.

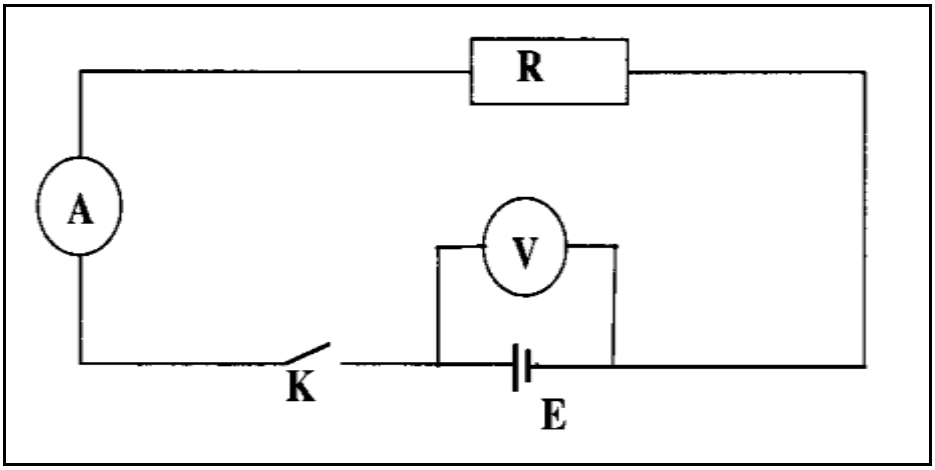


Figure 15.2

(b) Observe and record the reading *E* on the voltmeter when the key open

(c) Set the resistance *R* equal to 7 Ω, close the key and then record the reading of the current *I* flowing through the circuit and the potential difference *V* across the cell.

(d) Repeat the procedure in 2 (c) with *R* = 5 Ω, 4 Ω, 2 Ω and 1 Ω. For each case, record the corresponding values of *I* and *V*.

(i) Prepare a table of values including *I* (A), *V*(V) and (*E*-*V*)

(ii) Plot a graph of (*E*-*V*) in volts against *I* in amperes.

(iii) Compute the slope of the graph plotted in 2 (ii).

(iv) What is the physical meaning of the slope in 2 (iii)?

(v) If a house alarm is rated 3 Ω is connected in the circuit, determine the current that must flow through the circuit alarm to operate it.

In Question 2 of the Physics 2A, the candidates were required to construct a simple electric circuit as per the given Figure. Moreover, they were required to measure two electrical parameters. This includes; the voltage of the battery and current flowing in the circuit when the resistor value changes. The question measured the ability of the candidates to determine the value of internal resistance, r of a cell E.

Some of the candidates scored from 16.5 to 25.0. These candidates demonstrated the ability to construct simple electric circuits and measure electrical parameters using a voltmeter and an ammeter. This suggests that they adhered to the experiment procedures, including setting the experiment and collecting and analyzing experimental data. The analysis further reveals that candidates were able to present the data and plot the graph effectively. That is to say, they plotted a graph containing all important features such as the title of the graph, which includes units of the measured variables, the scale (both vertical and horizontal scale), labelled axis (vertical and horizontal axis) including units, data transfer, best line fit and slope indication. It was further noted that the candidates described the slope's physical meaning correctly. This suggest that they had sufficient knowledge and skills of the concepts of internal resistance of the cell and the application of Ohm’s law. Another notable competence is that they possessed good mathematics skills. Further, those candidates provided the correct response to item (v). consequently, these candidates described the physical meaning of the experimental results and associated it with real-life situations. Extract 15.1 shows a sample of a candidate’s good responses to Question 2 in Physics 2A.

2 (b) The reading E = 1.5 V

(d) (i) TABLE OF RESULTS.

R (Ω)	I (A)	V (V)	E − V (V)
7	0.20	1.40	0.10
5	0.28	1.36	0.14
4	0.30	1.34	0.16
2	0.60	1.20	0.30
1	1.0	1.0	0.50

(iii) slope = $\frac{\Delta (E-V)\ (V)}{\Delta I\ (A)}$

$= \frac{(0.45 - 0.25)\ V}{(0.9 - 0.5)\ A}$

$= \frac{0.2\ V}{0.4\ A}$

$= 0.5\ \Omega$

∴ slope of the graph = 0.5 Ω

(iv) The physical meaning of the slope is the internal resistance of the cell.

2 (d) (v) Data given

Resistance of a house alarm, $R = 3\Omega$

from, $E = I(R + r)$

$$I = \frac{E}{R + r}$$

but, $E = 1.5\,V$

$R = 3\Omega$

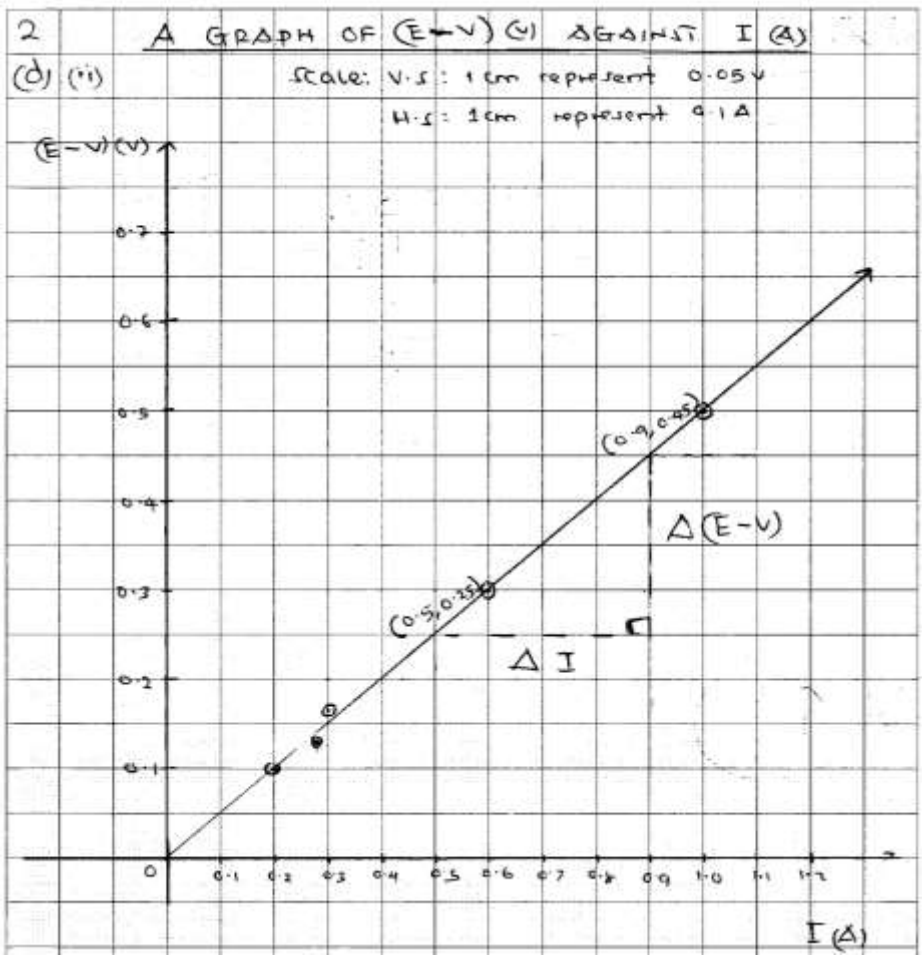
$r = 0.5\Omega$

$$I = \frac{1.5\,V}{3\Omega + 0.5\Omega}$$

$$= \frac{1.5V}{3.5\Omega}$$

$$= 0.43A$$

∴ The current that must flow through is $0.43\,A$



Extract 15.1: A sample of the candidate's good responses to question 2 in Physics2A.

Extract 15.1 shows that the candidate was good in setting and preparing a correct table of values and used it to plot a suitable graph. Likewise, he/she demonstrated both drawing and mathematical skills and hence, managed to compute the slope of the graph and the current that flows in the circuit when a house alarm of 3 **Ω** is connected in the circuit.

On the contrary, the candidates who scored 0.0 to 7.0 marks failed to demonstrate their mastery of basic experimental skills about the topic of *Current Electricity*.

Some of them collected inappropriate data. In connection to this, they failed to construct a table that involves all the necessary variables and

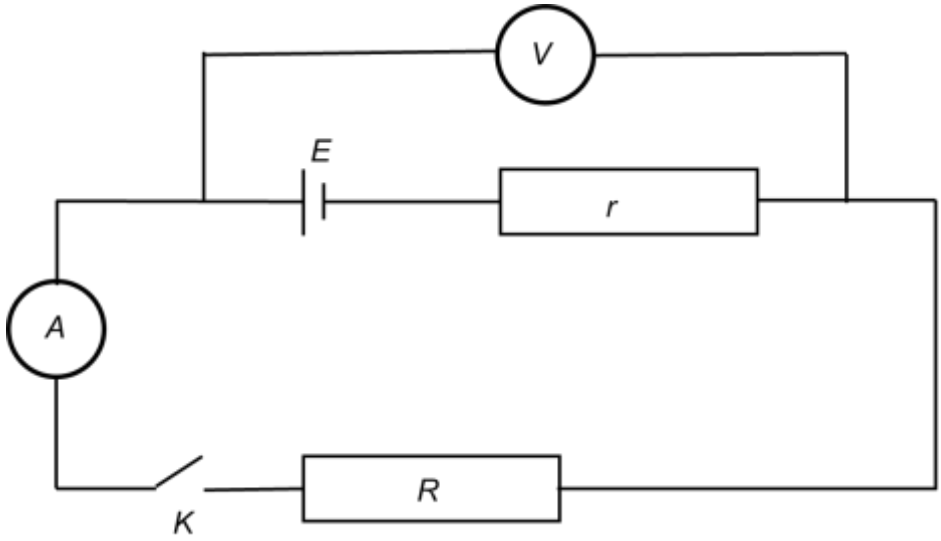
their anticipated units. This is an indication that these candidates lacked some important concepts, theories, principles and experimental setting skills. They were supposed to understand that for a given electric circuit, an ammeter is always connected in series while the voltmeter is connected parallel to the cell E or a conductor such as a resistor.

Furthermore, the analysis shows that some candidates had insufficient knowledge of some of the electric symbols used in the electric circuit provided. Others failed to identify what do the symbols V, A and R represents. Few of them were able to collect data, but failed to plot graphs, implying inadequate knowledge of data handling and analysis. Few candidates plotted correct graphs but failed to compute the slope of the graph. This revealed that they had inadequate mathematics skills. Few candidates obtained the correct slope value but failed to provide the physical meaning of that value. For instance, one of the candidates wrote, "*slope of the graph represents the current of the battery*", which was an incorrect response. Another candidate stated that "*the slope of the graph represents the amount of voltage coming from the cell in the circuit*". This was an incorrect response. These responses show that the candidates had insufficient knowledge and skills of integrating theories with experimental results. They were supposed to realise that Ohm's law would deduce the physical meaning of the slope.

In addition, the candidates were required to know that the total voltage in the circuit is the sum of the voltage drop across the resistor R and the internal resistance of the cell E. Therefore, this is to say that $E = I\left(R + r\right).$ This implies that $E = IR + Ir,$ where E is the emf of the cell, I current flowing in the circuit, R resistance and r an internal resistance. From Ohm's law, it can be deduced that $E = V + Ir.$ It follows that $E - V = Ir.$ This mathematical formula demonstrated that the best line fit of the graph is a straight line which passes through the origin with the slope r as the internal resistance. Therefore, the slope of the graph represents the internal resistance of the cell E.

Conversely, some of the candidates failed to appropriately use Ohm's law to determine the current that flows through the circuit when an alarm of 3 Ω was connected to the circuit. These candidates failed to realize that any cell has an internal resistance that offers resistance to

the current flow. To analytically evaluate this phenomenon, the candidates were supposed to realize that the internal resistance of a cell acts as a resistor connected in series with the source. Thus, it is possible to measure the voltage drop across that resistor as shown in the following Figure:



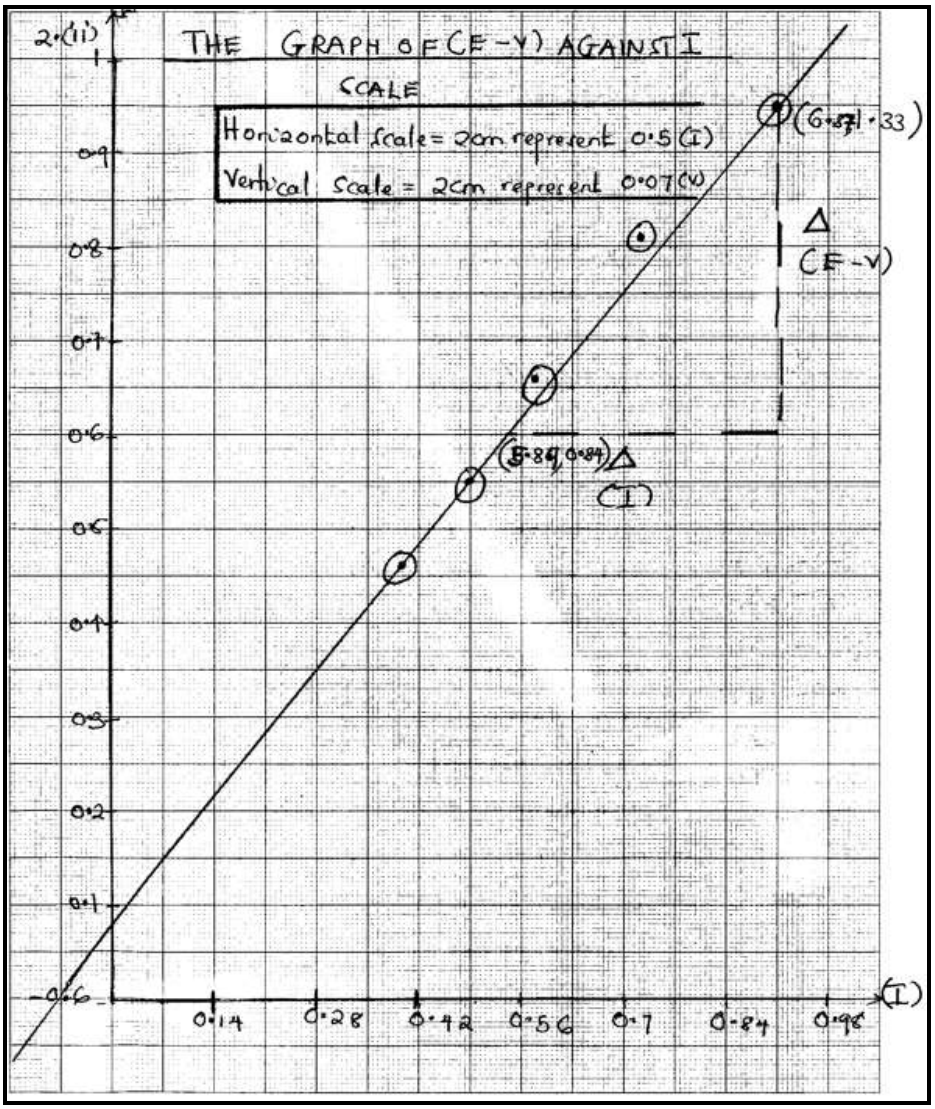
From the Figure, the candidates were supposed to evaluate the current flow to the circuit when an alarm of 3 Ω connected in the circuit as follows:

- Use the expression for the total voltage in the circuit, which is the sum of the voltage drop of a resistor 3 Ω and the internal resistance of the cell E. That is $E = IR + Ir$.
- Make I the subject of the formula and compute its value. That is $I = \frac{E}{R+r}$. $I = \frac{E}{3\Omega + r}$. From the experimental value of $r = 0.5\Omega$ and by using the e.m.f of the cell $E = 1.5$ V. Then, the current flowing through the alarm is $\mathrm{I} = \frac{1.5}{3+0.5} = 0.43\,\mathrm{A}$. Extract 15.2, shows the incorrect responses from one of the candidates who scored low marks in this question.

2(v) $I = \frac{2}{3}$

$I = 0.6$

=> The current flow through the circuit alam to operate it is 0.6 A



Extract 15.2: A sample of the candidate's weak responses to question 2 in Physics 2A.

In extract, 15.2, the candidate prepared no table of results but came up with a graph which is obviously incorrect. He/she deduced the value of the current passing through the alarm without introducing the formula.

3.2.2 031/2B Physics 2B

The question stated that, a laboratory physics technician was interested to observe light brightness of a torch using a dry cell with electromotive force (e.m.f) that lies between 1.3 V and 1.6V. Then the candidates were assigned to carry out an experiment to check whether or not a torch would produce the brightest light by using the apparatuses: a dry cell E, an ammeter A, a switch K and resistance box R. They were required to proceed as follows:

(a) Connect the given components in series

(b) With the tapping key closed, note and record the current I in the circuit when $R = 2\Omega$.

(c) Repeat the procedure in 2 (b) for values of $R = 4\ \Omega$, $6\ \Omega$, $8\ \Omega$,$10\ \Omega$ and $12\ \Omega$.

(i) Draw an electric circuit diagram of the connected components in 2 (a)

(ii) Tabulate your results including the column of $\frac{1}{I}$.

(iii) Plot a graph of R against $\frac{1}{I}$.

(iv) Determine the slope of the graph plotted in 2 (iii)

(v) Use the graph plotted in 2 (iii) and the equation governing the circuit, calculate the e.m.f. of a dry cell

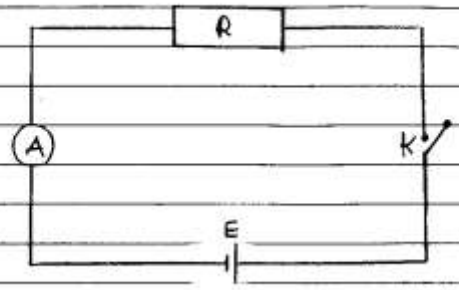
(vi) Use the value obtained from 2 (v), to ascertain whether or not the torch will produce the brightest light

(vii) What might be a reason for the slight deviation of the value obtained in 2 (v) from the expected theoretical value?

In question 2 of Physics 2B, the candidates were supposed to design and construct a simple electric circuit according to given instructions. Moreover, they were required to measure the current flowing in a circuit when the resistor value changed. The question was developed to measure the candidates' ability to test the torch's brightness when electromotive force lies between 1.3 V and 1.6 V.

The statistical analysis reveals that some candidates scored from 16.5 to 25.0. Those candidates demonstrated their ability to design and construct simple electric circuits to determine the E.m.f of a given cell and to ascertain whether the torch will produce the brightest light or not. Those candidates managed to draw the correct electric circuit. They were also able to set the experiment, collect and analyse experimental data. Consequently, they were able to plot the graph correctly. Due to possession of good mathematics skills they calculated the value of the slope of the graph appropriately. Extract 16.1 shows a sample of a candidate’s good responses in Question 2 Physics 2B.

2 (i)



where

A - Ammeter

E - A dry cell

K - A switch

R - Resistance box

(ii) Table of results

Resistance (Ω)	Current I (A)	$\frac{1}{I}$ (A^{-1})
0	0.60	1.670
4	0.32	3.125
6	0.22	4.545
8	0.16	6.250
10	0.14	7.143
12	0.12	8.333

Nature of equation

from

$$E = IR_T$$

But,

$$R_T = R + r$$

$$E = (R + r)I$$

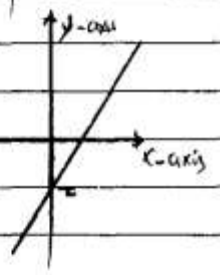
$$R + r = \frac{E}{I}$$

$$R = \frac{E}{I} - r$$

$$R = E \cdot \frac{1}{I} - r$$

$$y = m \cdot x - c$$

∴ The graph passes through the negative y-intercept with a positive slope



(iv) $\text{Slope}(m) = \frac{\Delta R(\Omega)}{\Delta 1/I(A^{-1})}$

$$= \frac{11.5\Omega - 2.5\Omega}{8A^{-1} - 2A^{-1}}$$

$\text{Slope}(m) = 1.5V$

(v) Circuit governing circuit

$E = IR_T$

from ohm's law as

$V = IR$

but, $R_T = R + r$

where, R - resistance mean

r - battery's internal resistance

as, $E = I(R + r)$

$$R = \frac{E}{I} - r$$

R =

$R = E \cdot \frac{1}{I} - r$

$y = mx - c$

In such,

$E = y$ and

m = slope

hence,

$E = 1.5V$

∴ The electromotive force, e.m.f of dry cell is 1.5V

(vi) The torch will produce brightest light because the battery have an electromotive force of 1.5V which is enable to light a torch according to the range interval of electromotive force ~~of~~ to light of which is from 1.9V to 1.6V.

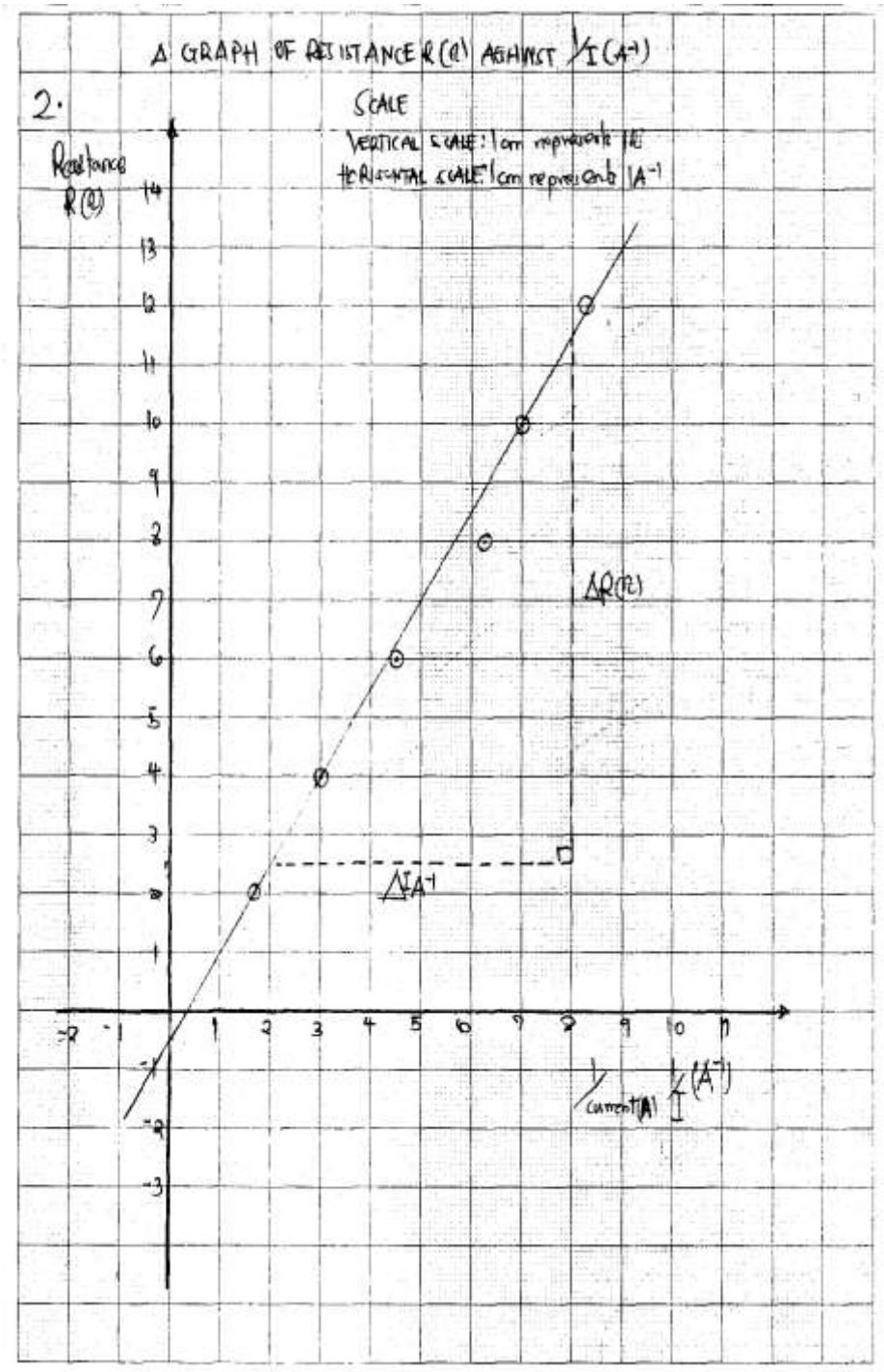
(vii) The reason for the slight deviation which may occur on the value of electromotive force of a battery can ~~could~~ be

(i) loose connection

- The connection can be located as when equipments are not tighted well especially resistance box as flow of unrequired charges in proportion, and

(ii) Parallax error

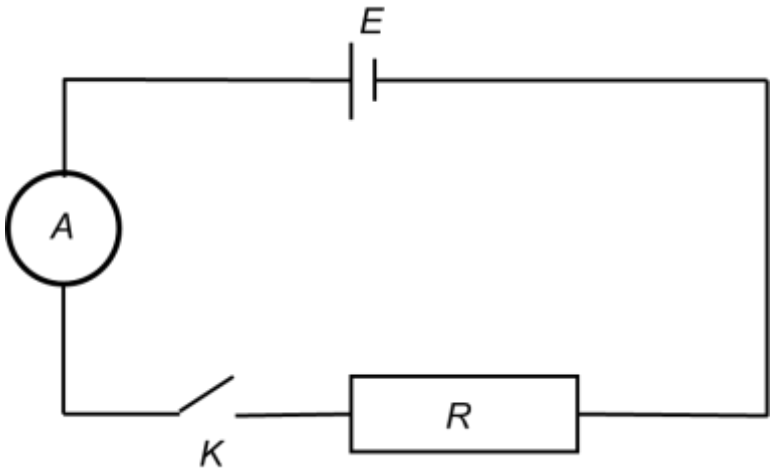
- Also this can cause to deviations as occurred when eyes are not perpendicular to the scale readings of ammeter as ∴ wrong current value.



Extract 16.1: A sample of a candidate's good responses to question 2 in Physics 2B

In extract 16.1, the candidate drew a correct electric circuit, tabulated the results correctly and finally plotted a suitable graph. Also, this candidate managed to use a graph to determine the slope and prepared the appropriate equation governing the circuit.

Other candidates scored 0.0 to 7.0 marks suggesting that they demonstrated poor mastery of basic experimental skills of the topic of *Current electricity*. Those candidates failed to design and construct the electrical circuit. This indicated that the candidates had little knowledge pertaining to electric circuit experimental set up. They drew incorrect circuits, suggesting they had insufficient designing skills. As a result, they obtained incorrect data. These candidates were supposed to design the following correct electric circuit so as to tabulate the correct data:

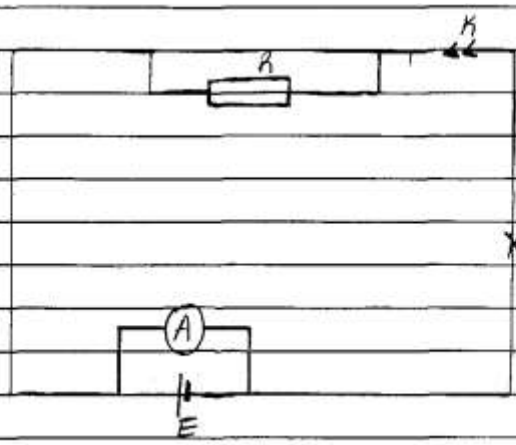


In practice, some of the candidates managed to design the required circuit but failed to collect the expected data values. They drew the required electric circuit and presented incorrect experimental data. This suggests that they had insufficient skills of handling electric measuring instruments. Some of the candidates managed to obtain experimental data but failed to present them correctly. Moreover, the candidates plotted the graph, which lacked the following features: the title of the graph, including units, practical scales (vertical and horizontal axes) with their respective units, transfer of points, best line, and slope indication. The analysis further reveals that most of the candidates failed to compute the slope of the graph. This suggested that the

candidates did not understand the mathematical formula which governed the designed circuit.

Generally, those candidates were supposed to realise that the mathematical equation governing the experiment is defined as $E = I\left(R + r\right)$. Upon mathematics manipulation, it can be shown that $R = E\frac{1}{I} - r$. That is to say, the slope of the graph is $\frac{\Delta R}{\Delta \frac{1}{I}}$. The candidates were supposed to recognize that the slope of the graph is the e.m.f. of the cell provided. Moreover, other candidates failed to respond correctly to item (vi), suggesting that they had inadequate knowledge and skills on the topic of c*urrent electricity* when some electrical components are connected in a circuit. Some of the candidates provided incorrect responses. For instance, one of the candidates responded, "*The torch will produce a bright light simply because there is an electromotive force which cause the flow of electric current in the torch*". This was an incorrect response. Those candidates were supposed to realise the importance of measuring the emf and internal resistance. It is important to determine the emf and internal resistance of the cells to find the cell that will produce the maximum power to the circuit. Thus, the candidates were supposed to know that any electromotive force between 1.3 V to 1.5 V produces the brightest light. Extract 16.2 shows a sample of the candidate's weak responses to question 2 in Physics 2B.

2. ii)



iii) Tabulate your results including the column of $\frac{1}{I}$.

(A) Ampear	Current Axis	$\frac{1}{I}$	Colum
1.5	1	1.5	0.6
1.4	2	2.8	0.3
1.6	3	4.8	0.2
1.7	4	6.8	0.1

iii) The graph in on paper in graph.

iv) Determine the slope of the graph plotted in 2 (iii)

soln.

$$\frac{\Delta\ 6.8, 0.1}{\Delta\ 2.8, 0.6} = \frac{\Delta\ 0.68}{\Delta\ 1.68}$$

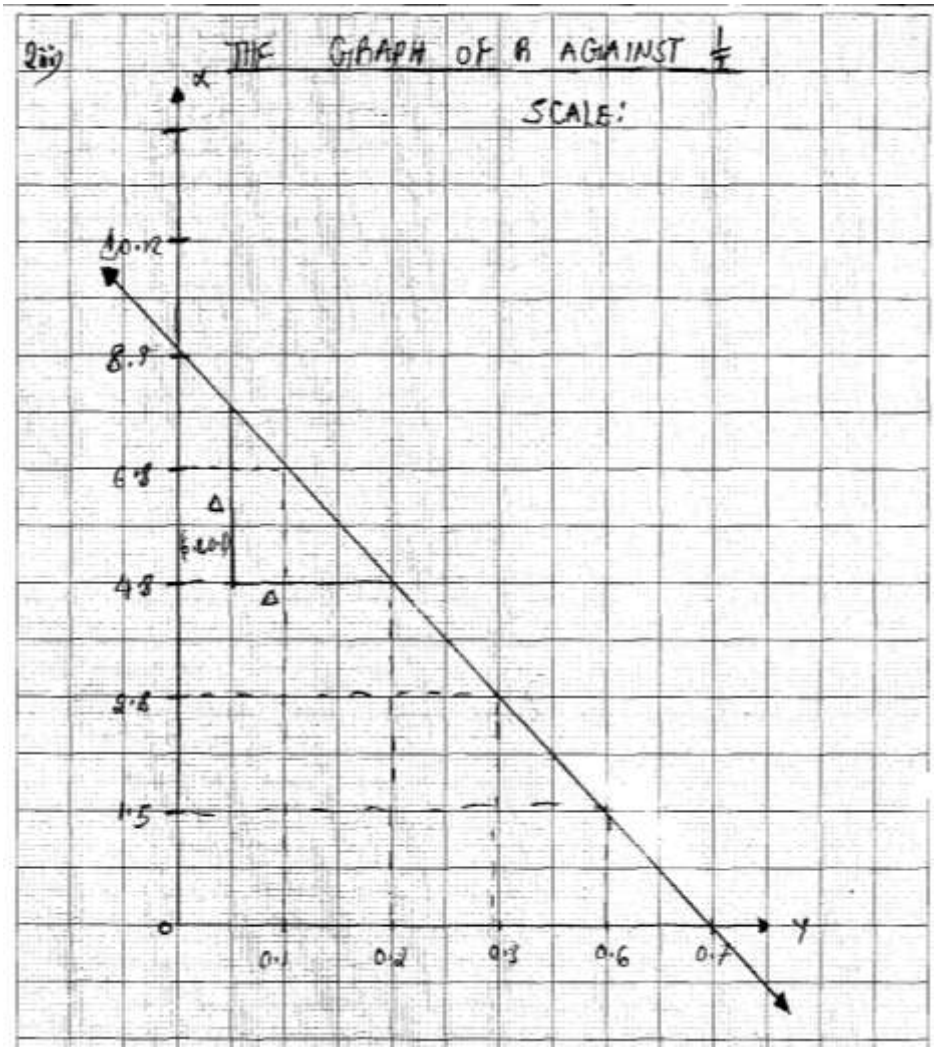
$$= \frac{\Delta\ 0.68}{\Delta\ 1.6.8} = \Delta\ 0.4$$

∴ The slope in the graph is $\Delta 0.4$

2. vii) i) It reduced in Chage.
ii) It Control in motion in Chage
iii) It decrease material in current
iv) It produce in value of resislance

vii) Use the value obtained from 2 v, to ascertain whether or not the torch will produce the brightest light.
i) It used to Control Chage
ii) It used to reduce Current

v) Are graph in against in the resistance box n in the Current.



Extract 16.2: A sample of the candidate's weak responses to question 2 of Physics 2B.

In extract 16.2, the candidate recorded incorrect data and hence drew an irrelevant graph. The candidate, also calculated incorrect slope and therefore failed to get the required e.m.f of the cell.

3.2.3 031/2C Physics 2C

In this question, the following information was given; Baraka wanted to know the electromotive force (e.m.f.) and internal resistance (*r*) of his dry cell he bought. The candidates were assigned to conduct an experiment to help Baraka to know the values of e.m.f. and *r*. Given the

following apparatuses; a dry cell E, an ammeter A, a switch K and a resistance box R. The candidates were required to proceed as follows:

(a) Connect the circuit of the given apparatuses.

(b) With the switch closed, read and record the current *I* passing through the circuit when *R* is set to 4 Ω.

(c) Repeat the procedure in 2 (b) for values of *R*= 6 Ω, 8 Ω, 10 Ω, 12 Ω and 15 Ω

Questions

(i) Draw an electric circuit diagram you connected

(ii) Tabulate your results including the column for $\frac{1}{\mathrm{I}}$

(iii) Plot a graph of $\frac{1}{I}$ against *R*

(iv) Compute the slope of the graph in 2 (iii).

(v) What does the slope obtained in 2 (iv) represent?

(vi) Calculate the e.m.f of the cell and give a comment on the answer obtained.

(vii) Use the graph plotted in 2 (iii) and the equation governing the circuit to determine the internal resistance of the dry cell.

Looking at Question 2 of Physics 2C, the candidates were supposed to design and construct a simple electric circuit as per the given instructions. Moreover, they were also required to measure the current flowing in a circuit when the resistor value changed from 6 Ω to 15 Ω. The question measured the ability of the candidate to design, construct and perform an experiment to determine the e.m.f. and internal resistance of the given dry cell.

As per analysis, some of the candidates scored low marks in this question, suggesting that they had inadequate experimental skills on the topic of *Current electricity*. The analysis further revealed that most of the candidates who scored low marks provided an incorrect circuit

diagram. This suggests that those candidates failed to design, construct and drew an appropriate circuit. Some of the candidates provided correct circuit diagrams but tabulated incorrect experimental data. Those candidates failed to to follow procedures as instructed. There were some candidates who obtained correct experimental data but failed to analyse those data. As a result, they made the wrong scientific conclusion. Few candidates obtained correct experimental data but failed to plot a graph correctly. It is observed that these candidates failed to realise the important features of a good graph. They were supposed to know that a good graph must have the following features: the graph's title, including units, reasonable scale (vertical and horizontal axes) with their respective units, transfer of points, best line and slope indication. Some candidates in this category failed to provide the correct title for the graph. For example, one of the candidates wrote the title of the graph as, "*the graph of r against* $\frac{1}{I}$ " which was incorrect. As per item (iii), the candidates were supposed to plot the graph $\frac{1}{I}$ against *R*. It is worth noting that as per item (iii), $\frac{1}{I}$ should appear in the vertical axis and R in horizontal axis. Some of the candidates failed to compute the slope of the graph. Those candidates failed to use mathematical skills to evaluate the slope of the graph. Others failed to provide the physical meaning. These candidates were supposed to know that the slope of the graph can be analytically evaluated as follows: The e.m.f. of the dry cell is given as $E = I\left(R + r\right)$. The expression can be documented as $\frac{1}{I} = \frac{1}{E}R + \frac{r}{E}$. It implies that the plot $\frac{1}{I}$ against *R* yields a straight line graph with a slope equal to $\frac{\Delta\frac{1}{I}}{\Delta R} = \frac{1}{E}$ and $\frac{1}{I}$- intercept as $\frac{r}{E}$. This is to say that the reciprocal of the slope of the graph and $\frac{1}{I}$-intercept represent the e.m.f. and internal resistance of the dry cell, respectively. Extract 17.1 shows a sample of the candidate's weak responses to question 2 of Physics 2C.

Q. i) Practical representing currents

Experiment

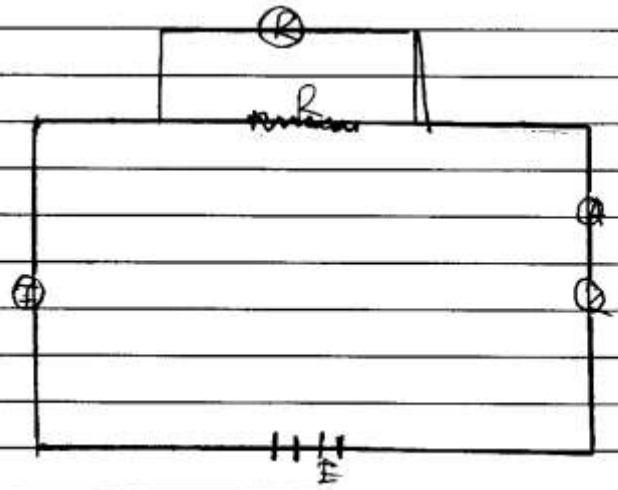
Apparatus

E. dry cell

Ammeter A

Switch K

resistance Box



ii) Table of result

R_2	I (A)	A^{-1}
0.33	4	3.03
0.23	6	4.15
0.18	8	3.60
0.14	10	7.14
0.12	12	8.33
0.10	14	10.47
~~0.8~~		

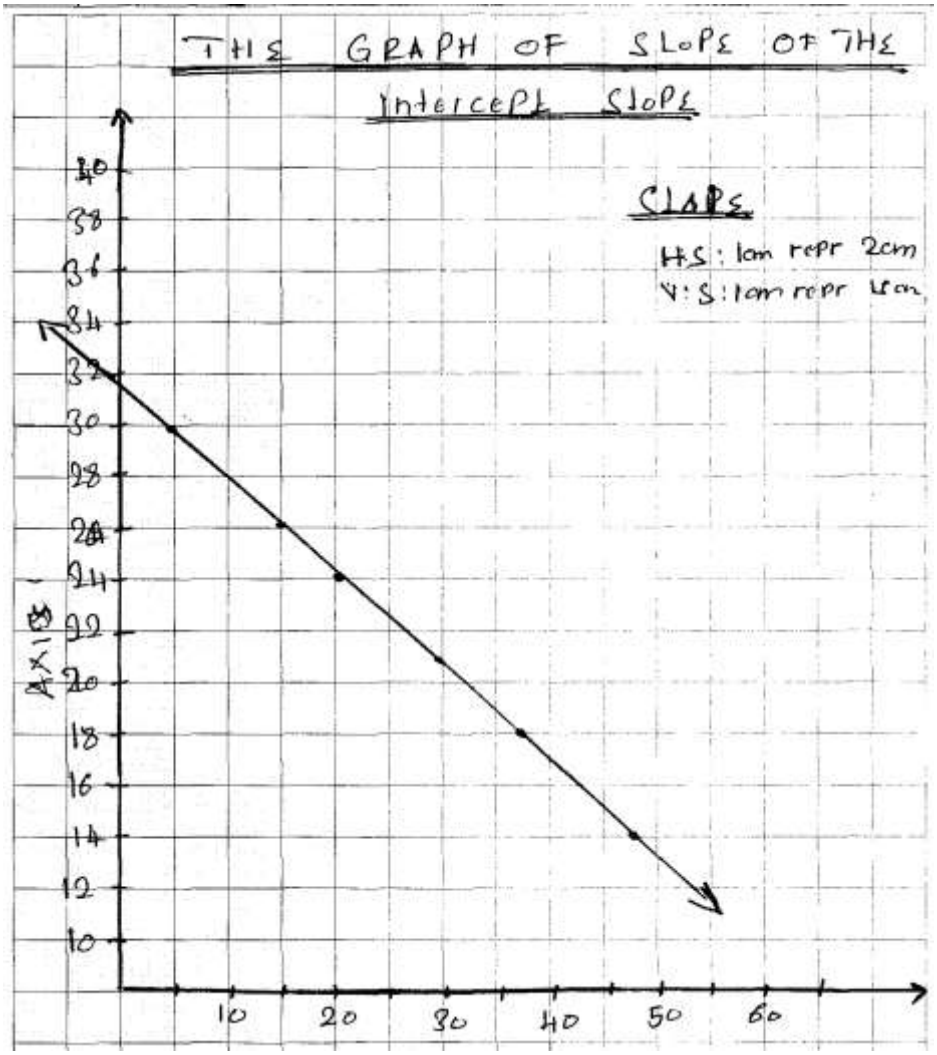
Scale

From Scale High transport
low transport

For verticle Scale
Scale ('A (A)
Verticle Scale HD
SR

Verticle Scale 10.43 = 0'7A^{-1}
~~7cm represent~~ 0.7

1 0.7cm represent 0.7

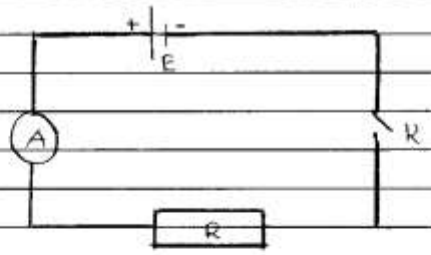


Extract 17.1: A sample of the candidate's weak responses to question 2 of Physics 2C.

The statistical analysis further reveals that some of the candidates scored high marks. This suggests that candidates who scored high marks had sufficient knowledge and skills in designing and constructing a simple electric circuit that can be used to determine the cell's emf and internal resistance. The candidates in this category connected and drew the correct electric circuit. That is to say, those candidates were able to set the experiment, collect and analyse experimental data and drew a scientific conclusion. The analysis further reveals that candidates in this category were able to present the required experimental data and plotted

the suitable graph. These candidates demonstrated their mastery of mathematics to calculate the slope value of the graph, the emf and internal resistance of a given dry cell. This indicates that those candidates had the ability to use the experimental values to determine the required physical quantities. Extract 17.2 shows a sample of a candidate's good responses in Question 2 in alternative Physics 2C.

2 i/ ELECTRIC CIRCUIT DIAGRAM.



ii/ TABLE OF RESULT.

R (Ω)	I (A)	$^1/_I$ (A^{-1})
4	0·33	3·03
6	0·23	4·35
8	0·18	5·56
10	0·14	7·14
12	0·12	8·33
15	0·10	10

Nature of the graph

From

$$E = I(R+r)$$

$$\frac{E}{I} = R+r$$

$$\frac{1}{I}\left(\frac{E}{E}\right) = \frac{R+r}{E}$$

$$\frac{1}{I} = \frac{R+r}{E}$$

2 iii) But:

$$\frac{1}{I} = \frac{R+r}{E}$$

$$\frac{1}{I} = \frac{R}{E} + \frac{r}{E}$$

$$\frac{1}{I} = \left(\frac{1}{E}\right)R + \frac{r}{E}$$

Then

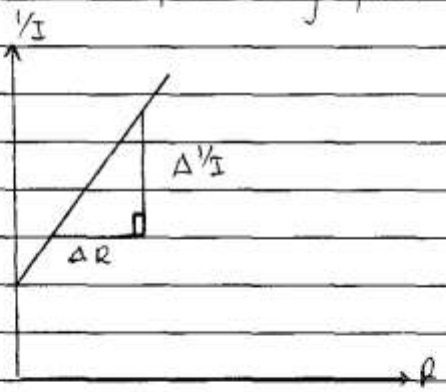
$$\frac{1}{I} = \frac{1}{E}(R) + \frac{r}{E}$$

$$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$

$$y = mx + c$$

Then

Nature of the graph



iv) $\text{Slope} = \frac{\Delta \frac{1}{I} (A^{-1})}{\Delta R\ (\Omega)}$

$$= \frac{6.5 - 4\ (A^{-1})}{10.8 - 7\ (\Omega} = \frac{2.5}{3.8}$$

$$= 0.657 \approx 0.667$$

∴ The slope of the graph is $0.667 A^{-1} R^{-1}$

2 v/ What does slope represent

From

The equation of nature of graph.

$$\frac{1}{I} = \frac{1}{E}(R) + \frac{r}{E}$$

$$y = mx + c$$

$$\frac{1}{E} = m$$

Then

Slope represent resaiprocal of e.m.f.

∴ The slope represent $\frac{1}{E}$ (resiprocal of e.m.f)

vi/ Calculate e.m.f of the cell

From

Equation

$$\frac{1}{E} = m$$

But

$$m = \text{Slope} = 0.67$$

$$\frac{1}{E} = \frac{0.67}{1}$$

$$0.67E = 1$$

$$\frac{0.67}{0.67} \quad \frac{1}{0.67} \qquad E = 1.49 \approx 1.5$$

∴ The e.m.f of the cell is 1.5 in which

2 vi/. The resiprocal of e.m.f is the slope

vii/. From

Equation:

$$\frac{1}{I} = \frac{1}{E}(R) + \frac{r}{E}$$

$$\downarrow \quad \downarrow$$

$$y = mx + c$$

Then

y-intercept $= r/E$.

But:

$E = 1.5$

Then

c from the graph is $= 0.33$.

But

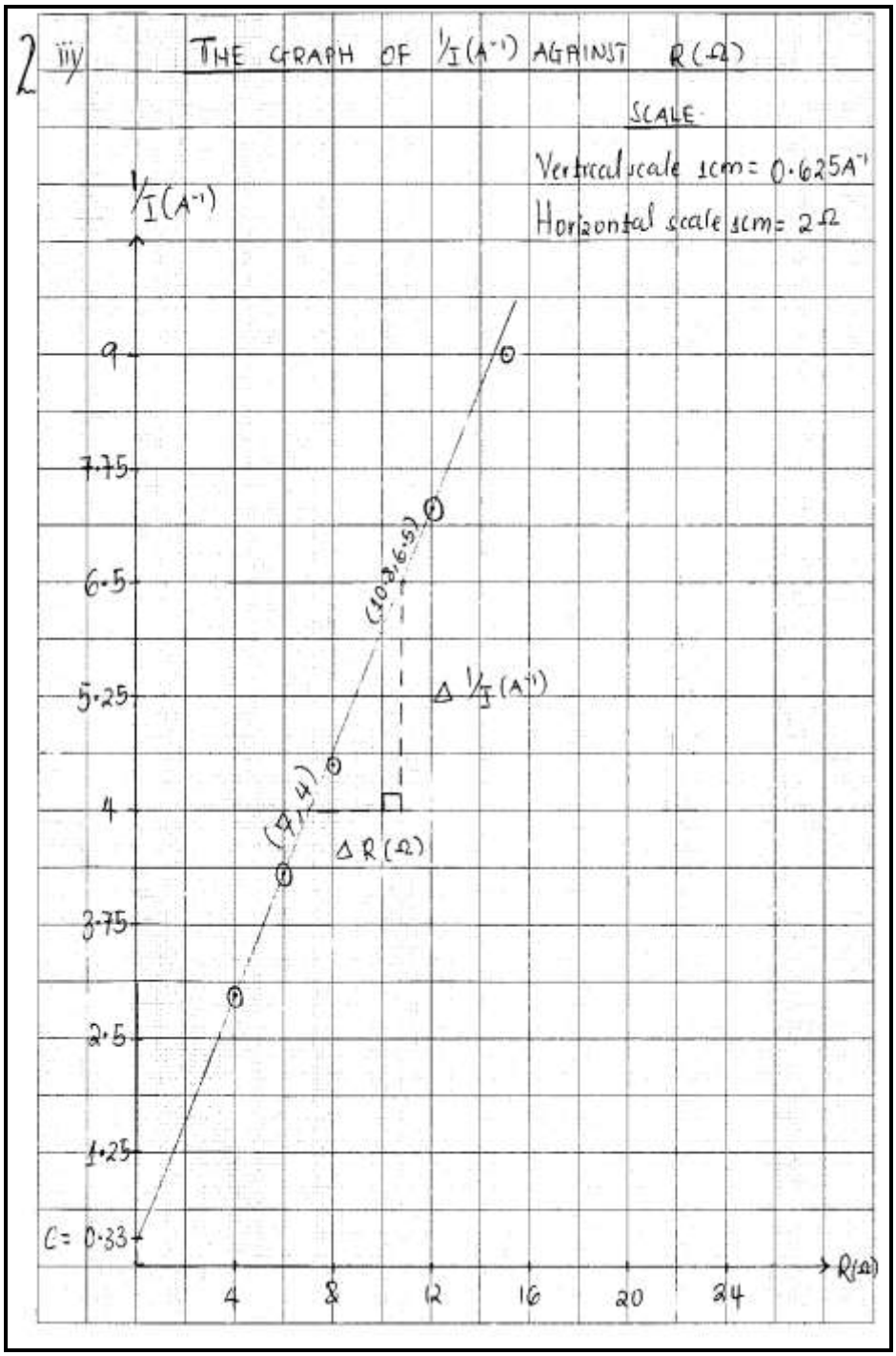
$$c = \frac{r}{E}$$

$$\frac{0.33}{1} = \frac{r}{1.5}$$

$$r = 0.33 \times 1.5$$

$$r = 0.5$$

∴ The internal resistance of the dry cell is 0.5.



Extract 17.2: A sample of the candidate's good responses to question 2 in Physics 2C.

In extract 17.2, the candidate performed correctly almost all parts of the question.

4.0 ANALYSIS OF THE CANDIDATES' PERFOMANCE IN EACH TOPIC

In 2023 Physics examination, twenty six (26) topics were tested. These were; *Introduction to Physics; Introduction to Laboratory Practice; Measurement; Force; Archimedes' Principle and The Law of Floatation; Structure and Properties of Matter; Pressure; Work, Energy and Power; Magnetism; Motion in a Straight Line; Simple Machines*; *Light; Optical Instruments; Forces in Equilibrium; Newton's Laws of Motion; Thermal Expansion; Thermal Transfer of Energy; Waves; Radioactivity; Geophysics; Elementary Astronomy*; *Static Electricity; Current Electricty; Thermionic Emission; Electronics*; and *Electromagnetism.*

The analysis of performance in Physics paper 1 reveals that question 1, a multiple choice item set from various topics had good performance (89.68%). This question had different topics namely: *Introduction to Physics; Introduction to Laboratory Practice; Measurement; Force; Archimedes' Principle and The Law of Floatation; Structure and Properties of Matter; Pressure; Work, Energy and Power; Magnetism;* and *Motion in a Straight Line;* Most of the candidates in this question opted for correct answers in each item of the question.

The candidates had average performance on topics of *Light* and *Optical Instruments* (59.05%) tested in Question 3; *Simple Machines* (58.98%) tested in Question 2; *Geophysics* and *Elementary Astronomy* (46.32%) tested in Question 8. Other topics with average performance were: *Waves* and *Radioactivity* (35.34%); *Pressure* and *Forces in Equilibrium* (34.99%); and *Thermal Expansion* and *Transfer of Thermal Energy* (33.93%) which were tested in Questions 7, 4 and 6 respectively. The average performance was due to the fact that, some of the candidates attempted only parts of the questions because of having inadequate knowledge regarding to the concepts of the topics while others was due to unsatisfactory mathematical skills in performing calculations.

Further analysis shows that, the performance was weak in the topics of *Waves and Electromagnetism* (26.54%) tested in Question 11; *Newton's Laws of Motion and Simple Machines* (22.39%) tested in Question 5; *Thermionic Emission and Electronics* (13.70%) tested in Question 10; and *Static and Current Electricity* (2.34%) tested in Question 9. The weak performance in these topics were influenced by the candidates' poor drawing skills, inadequate knowledge about the topics tested, lack of English language proficiency, inappropriate use of formulae due to both unsatisfactory knowledge and poor mathematical skills, and the candidates' poor English language understanding.

The analysis of candidates' performance in each topic for Physics paper 1 (Theory paper) is indicated in Appendix I. On the other hand, the analysis of Physics 2 (Actual Practical Paper) denotes that the topic of Mechanics had good performance of 68.64 per cent tested in Question 1 while the topic of Current Electricity had an average performance of 64.53 per cent. This shows that candidates performed better in Physics practical paper than in theory paper specifically in the topic of Mechanics (see Appendix II).

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The candidates' general performance in the Physics subject in the CSEE 2023 was good (71.85%). The candidates who had good performance demonstrated adequate knowledge and mastery of the concepts, theories, principles and laws governing the various concepts examined. Their knowledge enabled them to identify the requirements of the questions and respond accordingly. On the contrary, some candidates performed poorly due to unsatisfactory knowledge of the tested topics and poor mastery of language of instruction. Hence, they provided grammatical incorrect responses. Lack of mathematical manipulation skills was also a challenge on the performance of some of the candidates particularly the questions which required the candidates to manipulate the data and make calculations. Likewise, lack of drawing skills made some candidates' performance low as they drew poor or unrelated diagrams.

In practical paper, some candidates failed to tabulate the results correctly. Others lacked drawing skills of the graphs which required transfer of data from the table of results. It was also observed that some of the candidates had weakness on selecting suitable scales, transfer of points, labelling of the axes, slope indication and drawing the best line.

5.2 Recommendations

For future improvement of candidates' performance, it is recommended that teachers should:

(a) guide students on the effects of the density of liquid on the construction of simple barometer. He/She should demonstrate construction of a simple mercury barometer using thick walled glass tube about 1 m long sealed at one end, mercury and glass trough.

(b) lead students to demonstrate the application of Newton's third law of motion in daily life. For instance, recoil of the gun, rocket propulsion, a person throwing a package out of a boat and in swimming.

(c) guide students to apply the concept of velocity ratio (V.R), mechanical advantage (M.A) and efficiency to identify the simple machines which operates with minimum effort.

(d) encourage students to master both subject content as well as drawing skills specifically in the following areas:

(i) drawing circuit diagram of charging and discharging of capacitor;

(ii) drawing circuit diagram of NPN transistor in different modes;

(iii) drawing diagram that compares the penetrating ability of three (3) types of radiations through a piece of paper, aluminium sheet and lead block.

(e) guide students to demonstrate the factors affecting loudness, pitch and quality of a musical sound by using instruments such as drum, guitar, microphone and cathode ray oscilloscope.

(f) lead students to use bar magnet and coil/solenoid to show that Lenz's law of electromagnetic induction is a special case of the law of conservation of energy.

(g) put emphasize on developing mathematical skills so as to improve their computational skills.

(h) motivate students to use English as a medium of communication in their day to day activities so as to improve both writing and speaking of English language.

(i) encourage students to conduct variety of practical works as instructed in the syllabus in each level in order to grasp and understand the knowledge of different topics.

(j) assist the students to associate the learned knowledge with their real life environments.

(k) provide students with sufficient exercises, assignments, quizzes, tests and internal examinations with close supervision to equip them with knowledge of understanding the demands of questions.

Appendix I: The Performance of Candidates in Each Topic in 031 Physics 1

S/N	Topic	The Performance of Candidates in Each Question		
		Question Number	% of Candidates who Scored an Average of 30% or Above	Remarks
1	Introduction to Physics, Introduction to Laboratory Practices, Measurements, Force, Archimedes' Principle and The Law of Floatation, Structure and Properties of Matter, Pressure, Work, Energy and Power, Magnetism and Motion in a Straight Line	1	89.68	Good
2	Light and Optical Instruments,	3	59.05	Average
3	Simple Machines	2	58.98	Average
4	Geophysics and Elementary Astronomy.	8	46.32	Average
5	Waves and Radioactivity	7	35.34	Average
6	Pressure and Forces in Equilibrium,	4	34.99	Average
7	Thermal Expansion and Thermal Transfer of Energy	6	33.93	Average
8	Waves and Electromagnetism	11	26.54	Weak
9	Newton's Laws of Motion and Simple Machines	5	22.39	Weak
10	Thermionic Emissions and Electronics	10	13.70	

				Weak
11	Static Electricity and Current Electricity,	9	2.34	Weak

Appendix II: The Summary of the Candidates' Performance in each Topic in 031 Physics 2

S/N	Topic	The Performance of Candidates in Each Question		
		Question Number	% of Candidates who Scored an Average of 30% or Above	Remarks
1	Mechanics (Simple Pendulum)	1	68.64	Good
2	Current Electricity,	3	64.53	Average