



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) 2025**

PHYSICS



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EDUCATION EXAMINATION (CSEE) 2025

031 PHYSICS

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FOREWORD

The National Examinations Council of Tanzania (NECTA), is mandated to conduct and administer National Examinations in Tanzania. The examinations are conducted in accordance with the established standards and regulations to ensure transparency, accountability and continuous improvement in examinations.

The Certificate of Secondary Education Examination (CSEE) is among the examinations administered, which involves a summative evaluation after four years of study in secondary school level in various subjects. The physics examination aims at examining the competencies acquired by the candidates after four years of studying the Physics subject.

This Candidates' Item Response Analysis (CIRA) report on 2025 on Physics examination has been prepared to provide feedback to teachers, parents, education officers, and other education stakeholders about the item responses given by the candidates in the examination. It provides the basis for understanding and improving the observed performance of the candidates in the Physics subject.

Generally, the performance of candidates was good. However, some areas of weakness marked were due to failure to adequately elaborate key concepts, poor language use, improper application of theoretical and numerical methods and inadequate drawing skills. These weaknesses contributed to weak performance for some candidates.

The National Examinations Council of Tanzania extends its sincere appreciation to all who contributed to the successful preparation of this report.



Prof. Said Ally Mohamed

EXECUTIVE SECRETARY

1.0 INTRODUCTION

The Candidates' Item Response Analysis (CIRA) in 031 Physics on the year 2025 offers a detailed analysis on each question attempted by the candidates. It includes details on the specific demands of each question, charts and graphs summarising candidates' performance, selected extracts of responses indicating both the correct and incorrect responses, and recommendations for enhancing future examinations.

The 031 Physics had two examination papers, namely: 031/1 Physics 1, which was the theory and 031/2 Physics 2, the actual practical paper. The Physics examination was designed to assess the competences acquired by candidates after completing four years of study at the ordinary level.

The 031/1 Physics 1 examination paper consisted of three sections: section A, B and C, with a total of 11 questions. Section A comprised two (2) objective questions. The first question consisted of ten (10) multiple-choice items, each carrying one (1) mark. The second question had six (6) homogenous items for matching that carried a total of six (6) marks. Section B included six short-answer questions, each of which carried 9 marks. Section C contained three structured questions; each carried 15 marks. The candidates were required to answer all questions in sections A and B, and two questions from section C.

The theory paper comprised of the following topics: *Introduction to Physics, Introduction to Laboratory Practice, Measurements, Friction, Measurement of Thermal Energy, Structure and Properties of Matter, Work, Energy and Power, Temperature, Electromagnetism, Simple Machines, Light, Optical Instruments, Pressure, Forces in Equilibrium, Newton's Laws of Motion, Thermal Expansion, Waves, Radioactivity, Geophysics, Elementary Astronomy, Static Electricity, Current Electricity, Thermionic Emission and Electronics.*

The actual practical paper consisted of three alternative papers: 031/2 Physics 2A, 2B and 2C. Each paper contained two structured questions. The first question was constructed from the topic of *Measurement*. The second question was derived from the topic of *Light*. Each question carried 25 marks, making a total of 50 marks.

A total of 134,009 candidates sat for 031 Physics (CSEE) 2025, marking a slight increase of 11,979 candidates compared to the year 2024. The overall performance was good, as 84.04 per cent of the candidates passed the examination. Table 1 shows performance trends from 2023 to 2025, highlighting a steady improvement in candidates' performance.

Table 1: The Performance of Candidates in 031 Physics from the year 2023 to 2025

Year	Candidates who Sat	Candidates who Passed	
		Number	Percentage (%)
2023	122,102	87,402	71.85
2024	122,030	90,184	73.98
2025	134,009	112,309	84.04

In the analysis, the percentage distribution of scores is categorized into three ranges: 0–29 per cent (weak), 30–64 per cent (average), and 65–100 per cent (good). However, the report provides performance analysis in each topic and concludes with recommendations for future improvements in the examination process.

2.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH QUESTION IN 031/1 PHYSICS 1

This part reveals specific learning gaps, assesses the depth of conceptual understanding, and provides feedback to teachers and other stakeholders to improve future examination quality. Moreover, this analysis is supported by extracts of candidates' responses, which include both correct and incorrect responses as examples.

2.1 SECTION A: Objective Questions

This section consisted of two objective questions: Question 1 and Question 2. Question 1 was a multiple-choice question with ten (10) items. Each item carried one (1) mark, making a total of 10 marks. Question 2 was a matching items question. This question consisted of six (6) homogenous items. Each item carried one (1) 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 required to choose the correct answer from the five (5) given alternatives: A, B, C, D and E and write the corresponding letter next to the item number on the provided answer sheet. The items were constructed from the following topics: *Introduction to Physics, Introduction to Laboratory Practice, Measurement, Newton's Laws of motion, Structure and Properties of Matter, Pressure, Light, Static Electricity, Friction, Work, Energy and Power.*

The statistical analysis indicates that a total of 134,004 (100%) candidates attempted this question. Of these, 37,680 (28.12%) candidates scored from 0.0 to 2.0 marks, 88,982 (66.40%) candidates scored from 3.0 to 6.0 marks, and 7,342 (5.48%) candidates scored from 7.0 to 10.0 marks. In general, the performance was good, with 96,324 (71.88%) candidates scoring from 3.0 to 10.0 marks. Figure 1 summarizes the candidates' performance in question 1.

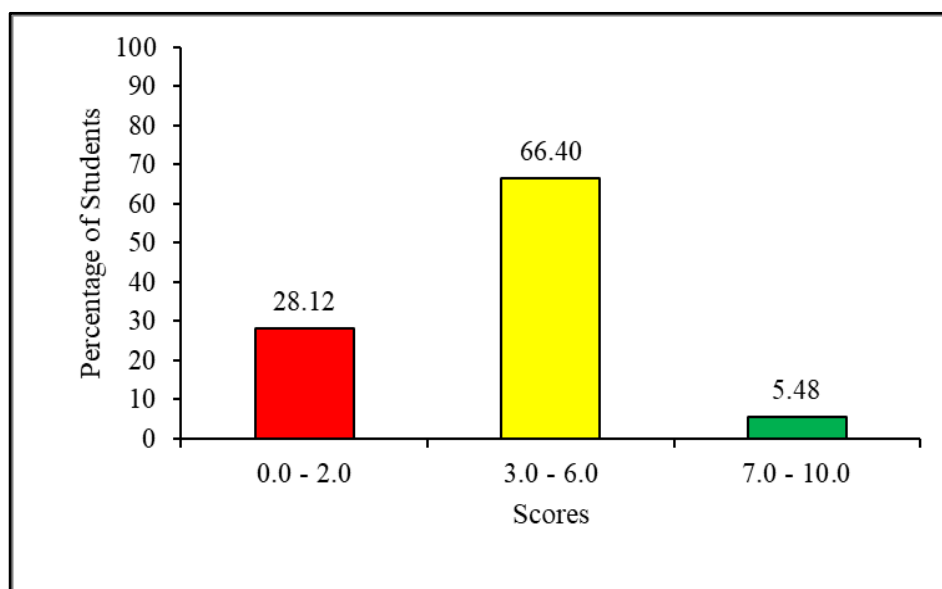


Figure 1: *The Candidates' Performance in Question 1*

Item (i) was derived from the topic of Introduction to Physics, intended to assess candidates' understanding of the concepts of physics, particularly applications of physics in communication. The candidates were required to

identify a method that allows a person to convey a message in the form of writing to another person in a nearby village.

The question stated as follows: *Which of the following ways, as applied in Physics, can be used by one person to convey the message to another person who is in the nearby village in the form of writings?* The given alternatives were:

- | | | |
|---------------------------------|-----------------------|---------------------|
| A <i>Electronic mails waves</i> | B <i>Fiber optics</i> | C <i>Headphones</i> |
| D <i>Radio</i> | E <i>Cables</i> | |

The correct answer was A (*Electronic mails*). The analysis shows that some of the candidates selected the correct answer. These candidates had the ability to identify a method that allows a person to convey a message in the form of writing to another person in a nearby village. The candidates in this category had sufficient knowledge and skills on the topic of *Introduction to Physics*. That is to say, they were able to identify and distinguish between output devices (headphones), communication media (*Optical fiber*), and communication services (method).

On the other hand, several candidates chose incorrect alternatives. For instance, some of the candidates chose an alternative B (*Optical fiber*). These candidates failed to know that optical fibres are a transmission medium used to carry signals as electromagnetic waves. Indeed, they are part of the infrastructure that supports internet communications, but a person cannot directly use optical fibre alone to write a message. Thus, optical fibre is not a communication method, but a medium for communication. Some of them chose option C (*Headphones*). These candidates failed to understand that headphones are output devices. These candidates were supposed to know that headphones are designed to receive and reproduce audio signals for listening purposes. They cannot transmit or send written messages. Looking at an alternative (headphones), it could be concluded that these candidates associated headphones with a mobile phone, assuming that since a phone can be used to compose and send messages, the headphone is a communication method. Other candidates chose alternative D (*Radio waves*). These candidates were supposed to know that radio waves are electromagnetic waves used to transmit signals. Thus, they cannot be used directly for a writing communication method. The analysis further revealed that some of the candidates chose an

alternative E (*Cables*). This was an incorrect alternative. The candidates in this category failed to realise that cables are used to carry signals in the communication systems. They are not a communication method.

Item (ii) was derived from the topic of *Introduction to Laboratory Practice*. The item was designed to assess candidates' understanding of the correct order of the procedure used to conduct scientific investigations. The question is stated as follows: *Carefully study logical steps 1 to 8 and then answer the question that follows:*

- 1 *Formulating a testable hypothesis*
- 2 *Data interpretation*
- 3 *Performing an experiment*
- 4 *Problem identification*
- 5 *Drawing a conclusion*
- 6 *Asking questions*
- 7 *Data presentation*
- 8 *Data collection and analysis*

Which steps show the best logical sequence for scientific investigation?

- A 8,7,6,5,4,3,2,1
- B 8,6,4,2,7,5,3,1
- C 4,6,1,3,7,8,2,5
- D 4,6,1,3,8,2,7,5
- E 6,4,1,3,8,2,7,5

The correct alternative was D (4, 6, 1, 3, 8, 2, 7, 5). Some candidates selected the correct response. Those who chose this response had sufficient knowledge and skills of the tested topic, particularly scientific investigation. They were able to identify the correct logical sequence of scientific investigation. The analysis further revealed that some of the candidates chose alternatives A (8, 7, 6, 5, 4, 3, 2, 1). Some of them selected an alternative B (8, 6, 4, 2, 7, 5, 3, 1). These were incorrect alternatives because they start with data collection before identifying the problem. This is not a logical flow of a scientific investigation.

Some candidates opted for *alternative C* (4,6,1,3,7,8,2,5), which was an incorrect response. This sequence places data presentation before proper analysis and interpretation. Some of them selected an alternative E (6, 4, 1, 3, 8, 2, 7, 5), which was an incorrect alternative. This alternative starts with

asking questions before identifying the problem (problem identification logically comes first). Thus, it can be said that those who selected the wrong alternatives had inadequate knowledge and skills on the subject matter.

Item (iii) was derived from the topic of *Measurements*. The item was designed to assess candidates' practical measurement skills, with specific emphasis on the accurate use and reading of a micrometre screw gauge.

The question asked: *Which precaution should be taken to avoid false readings before using micrometer screw gauge in measuring lengths?* The given alternatives were:

- A *The thimble and Ratchet should be correctly handled to get rid of the mismatch*
- B *The faces of the anvil and the spindle should be wiped clean to remove any dirty particles.*
- C *The sleeve and the thimble should be wiped clean to remove any dirty particles*
- D *The anvil and the Ratchet should be adjusted correctly to get rid of zero error*
- E *The sleeve and thimble should be held tight on their frame to get rid of parallax error*

The correct response was B (*The faces of the anvil and the spindle should be wiped clean to remove any dirty particles*). Some of the candidates chose this alternative. Candidates who selected this alternative demonstrated a good understanding of the necessary precautions to be observed before using a micrometre screw gauge. That is to say, they had a good practical experience, particularly in performing measurements using a micrometre screw gauge. They had the ability to identify the importance of cleaning the anvil and spindle before taking measurements, understanding that any dirt or particles present could increase the measured diameter of the object and lead to inaccurate results. Some of the candidates opted for an alternative A (*The thimble and Ratchet should be correctly handled to get rid of the mismatch*). This was an incorrect alternative. It could be assumed that those candidates failed to understand the working principles of a micrometre screw gauge. Moreover, they never used it to take a measurement. This is because the thimble and ratchet control rotation and

pressure on the sample to be measured. They do not directly remove the mismatch.

Some of the candidates chose an alternative C (*The sleeve and the thimble should be wiped clean to remove any dirty particles*), which was an incorrect response. These candidates were supposed to know that the sleeve and thimble contain the reading marking, dirt on them may affect readability and not the actual measurement. In principle, the false reading may be caused by dirt on the contact surface of the anvil and the spindle. Some of the candidates opted for alternative D (*The anvil and the Ratchet should be adjusted correctly to get rid of zero error*). This was also an incorrect response. The candidates in this category failed to realise that a zero error is checked by closing the micrometre without an object. Thus, zero error correction is a separate step from cleaning before measurement. This suggests that the candidates may lack practical experience with the device in the laboratory. The analysis further showed that some of the candidates chose alternative E (*the sleeve and thimble should be held tight on their frame to get rid of parallax error*). This was an incorrect choice. The candidates demonstrated insufficient understanding of the concept of parallax error. They were expected to recognize that parallax error is a slight deviation in measurement caused by the apparent relative movement of an object when the observer's eye position changes. Therefore, parallax error should be considered and minimized while taking the reading, not beforehand. Their responses also indicated limited knowledge of the proper use of the micrometer screw gauge.

Item (iv) was developed from the topic of *Newton's law of motion*. The item was designed to evaluate the candidates' ability in the applications of friction force and Newton's laws in daily life. The item read: *Why a person cannot push a car from inside when it is stuck in the mud or sand?* The candidates were provided with the following alternatives:

- A *Outside the car, the friction force between the legs and ground produces backward force*
- B *Inside the car, the friction force between legs and car produces less forward force*
- C *Inside the car, the friction force between the legs and car produces backward force*
- D *Outside the car, the friction force between the legs and ground produces forward force*
- E *Outside the car, the friction force between the legs and the car produces forward force*

The correct alternative was D (*Outside the car, the friction force between legs and ground produces forward force*). Candidates who selected this response were able to apply Newton's laws of motion to describe a physical problem. Some of the candidates selected an alternative A (*Outside the car, the friction force between the legs and ground produces backward force*), which was an incorrect response. The candidates in this category failed to apply Newton's laws of motion to a daily life experience. Based on this alternative, the candidates even failed to identify the directions of forces. As the person pushes the ground, the friction force must push forward and not backward. Some of them opted for an alternative B (*Inside the car, the friction force between legs and car produces less forward force*), which was an incorrect selection. These candidates failed to realise that when inside the car, the person and car become one system. Thus, from Newton's first law, a car can't move. Some of the candidates selected an alternative E (*Outside the car, the friction force between the legs and the car produces forward force*). This was also an incorrect response. These candidates failed to identify forces and their importance as per the subject context. They were supposed to know that the friction of the car opposes the motion, not acting forward. For a car to move, a person must overcome this friction. Thus, the essential friction is between feet and ground, not feet and car.

Item (v) structured from the topic of *Measurement* (density and relative density). The item was developed to assess the candidates' ability to interpret proportional relationship between variables in a formula. This holds particularly for the formula of density.

The item stated: *Which action will increase the density of a substance?* The alternatives were:

- A *Increasing the mass of the substance while increasing its volume*
- B *Increasing the volume of the substance while its mass is kept constant*
- C *Decreasing the mass of the substance while decreasing its volume*
- D *Increasing the mass of the substance while fixing its volume*
- E *Increasing the mass of the substance while decreasing its volume*

The correct alternative was E (*Increasing the mass of the substance while decreasing its volume*). Candidates who selected this alternative demonstrated mastery of the concept of density. They were able to apply mathematics skills to describe the dependence of density on mass and volume. Some of the candidates chose an alternative A (*Increasing the mass of the substance while increasing its volume*), which was an incorrect response. The candidates of this category failed to utilise mathematical skills to deduce the relationship between various physical quantities. The candidates were supposed to know that mathematically, density is given as $\frac{m}{V}$, thus, if both numerator and denominator increase, density may increase, decrease, or remain constant. Some of them selected option B (*Increasing the volume of the substance while its mass is kept constant*), which was an incorrect option. The candidates were supposed to know that when the denominator increases while the numerator remains constant, the density decreases.

The analysis further indicated that some of the candidates opted for an alternative C (*Decreasing the mass of the substance while decreasing its volume*). This was an incorrect response. These candidates were supposed to realise that when both the numerator and denominator are decreasing, the density may increase, decrease or not change. This depends on their relative changes. Moreover, some of the candidates selected an alternative D (*Increasing the mass of the substance while fixing its volume*). It should be noted that when the numerator increases while the denominator remains constant, the density is increasing. The increase in density is due to an increase in mass. This was the correct answer, but not the best answer.

Thus, it can be concluded that an alternative E guarantees the largest possible increase in density. Thus, an alternative E is more preferred in this context.

Item (vi) was set from the topic of *Structure and properties of matter*. The item was set to evaluate the ability of the candidates to apply the concepts of cohesive and adhesive to describe physical phenomena. The item presented candidates with an experimental scenario as follows: *A drop of water spreads on the surface of a smooth tiles while an equal sized drop of honey refuses spreading. Why are these wonders taking place?* The given alternatives were:

- A *Water has more cohesive force than honey*
- B *Water has more adhesive force than honey*
- C *Honey has more cohesive force than water*
- D *Honey has more adhesive force than water*
- E *Water has less adhesive force than honey*

The correct answer was alternative C (*Honey has more cohesive force than water*). Some of the candidates chose this response. This suggests that the candidates had enough knowledge and skills on the concepts and theories related to the structure and properties of matter. Some of the candidates opted for an alternative A (*Water has more cohesive force than honey*), which was an incorrect response. These candidates were supposed to realise that the viscosity is determined by the cohesive force (attraction between molecules of the same liquid). It implies that strong cohesion molecules resist moving past each other, this led to high viscosity. That is to say, honey is more viscous due to a stronger cohesive force. This property causes honey to resist spreading when poured onto tiles. Some of the candidates selected option B (*Water has more adhesive force than honey*). This was an incorrect response. Indeed, water more adhesive force than honey, thus, spreads on tile. It should be noted that, as per the context of the item, this was an incorrect response. The candidates were supposed to focus on what made the honey resist spreading on the tile. Some of them opted for an alternative D (*Honey has more adhesive force than water*), which was an incorrect response. The candidates failed to realise that honey has a more cohesive force than water. The analysis further revealed that some of the candidates chose an alternative E (*Water has less adhesive force than honey*). This was also not a correct response. It can be concluded

that those candidates who failed to choose a correct response had inadequate knowledge of the concepts and theories of structure and properties of matter, particularly regarding cohesion and adhesion forces.

Item (vii) was set from the topic of *Pressure*. The item was intended to assess the ability of the candidates to apply mathematical skills to explain a physical phenomenon. The item read: *When a sharp pencil 5 g is placed on your hand on its tip it will exert pressure on the hand. Calculate the maximum pressure the pencil will exert to you if it has dimensions shown in Figure 1.*

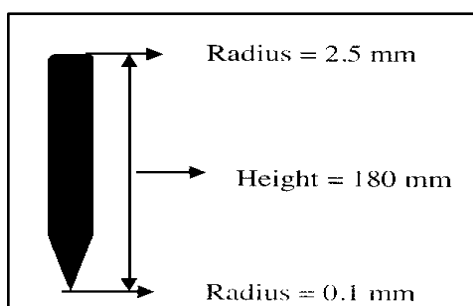


Figure 1

The alternatives were:

- A $1.59 \times 10^6 \text{ Pa}$
- B $1.59 \times 10^3 \text{ Pa}$
- C $2.55 \times 10^{-3} \text{ Pa}$
- D $2.55 \times 10^9 \text{ Pa}$
- E $2.55 \times 10^3 \text{ Pa}$

The correct answer was alternative A ($1.59 \times 10^6 \text{ Pa}$). The analysis showed that some of the candidates chose this response. These candidates had enough knowledge and skill on the topic of Pressure. It can be said that they applied the correct mathematical formula and performed the correct computation to obtain the needed physical quantity.

On the contrary, some candidates failed to select a correct response. For instance, some of them chose an alternative B ($1.59 \times 10^3 \text{ Pa}$). This was an incorrect alternative. The candidates in this category applied a correct formula, but failed to convert units. Note that the radius and mass are given

in millimetres (mm) and grams (g), respectively, while the final result is expressed in Pascals (Pa). Thus:

$$\text{Pressure} = \frac{\text{Normal force}}{\text{small surface area}} = \frac{mg}{\pi r^2}. \text{ Therefore,}$$

$$\text{Pressure} = \frac{mg}{\pi r^2} = \frac{5 \text{ g} \times 10 \frac{\text{N}}{\text{kg}}}{3.14 \times (0.1)^2 \text{ mm}^2} = 1.59 \times 10^3 \text{ Pa} . \text{ This calculation makes}$$

no sense from a physics perspective. For the candidates to get a correct answer, both mass and radius must be expressed in kilograms (kg) and metres (m), respectively.

Some of the candidates opted for an alternative C ($2.55 \times 10^{-3} \text{ Pa}$). This alternative was incorrect. Candidates in this category applied the correct formula and carried out the calculations correctly, but they used a large surface area. They were supposed to know that the large surface area led to the minimum pressure. Moreover, these candidates failed to perform unit conversion correctly. Thus:

$$\text{Pressure} = \frac{mg}{\pi r^2} = \frac{0.005 \text{ kg} \times 10 \frac{\text{N}}{\text{kg}}}{3.14 \times (2.5)^2 \text{ mm}^2} = 2.55 \times 10^{-3} \text{ Pa} .$$

Some of them selected an alternative D ($2.55 \times 10^9 \text{ Pa}$), which was an incorrect alternative. The candidates in this category failed to realise that the large surface area led to the minimum pressure. However, candidates applied the correct formula, performed unit conversion and carried out the calculations correctly. Thus:

$$\text{Pressure} = \frac{mg}{\pi r^2} = \frac{0.005 \text{ kg} \times 10 \frac{\text{N}}{\text{kg}}}{3.14 \times (0.0025)^2 \text{ mm}^2} = 2.55 \times 10^9 \text{ Pa} . \quad \text{Moreover, the}$$

analysis showed that some of the candidates selected an alternative E ($2.55 \times 10^3 \text{ Pa}$), which was incorrect. The candidates in this category failed to obtain the value of the normal force. It can be said that these candidates applied the incorrect formula. They applied the following formula

$$\text{Pressure} = \frac{\text{mass}}{\text{Area}} = \frac{5 \text{ g}}{\pi \times (0.0025)^2} = 2.55 \times 10^3 \text{ Pa} .$$

Generally, the candidates who failed to respond correctly had inadequate skills in the conversion of units.

Item (viii) was constructed from the topic of optics. It was intended to evaluate the ability of the candidates to apply concepts, theories and principles of optics to analyse the image formed by a concave mirror. The item read: *An object of 5cm is placed 25cm away from the concave mirror of radius of curvature 24cm. Deduce the position and characteristics of the image formed.*

- A 23.1 cm, real, inverted and diminished
- B 23.1 cm, real, inverted and magnified
- C 25.0 cm, real, upright and diminished
- D 25.0 cm, real, upright and magnified
- E 23.1 cm, virtual, inverted and diminished

The correct answer was A (23.1 cm, real, inverted, and diminished). Some of the candidates selected this option. This suggests that these candidates were able to apply concepts, theories and principles of optics to analyse the image formed by the concave mirror. They were able to realise that the object was placed beyond the radius of curvature, C. Moreover, they applied the correct formula to deduce the position of the image.

The analysis further showed that some of the candidates opted for an alternative B (23.1cm, real, inverted and magnified), which was an incorrect response. The candidates in this category were able to apply the correct formula to deduce the position of the image. However, they failed to apply concepts, theories and principles of optics to analyse the characteristics of the image formed by a concave mirror. They were supposed to realise that when the object is placed beyond the radius of curvature, the mirror will not magnify the image. Some of them selected options C (25.0 cm, real, upright and diminished) and D (25.0 cm, real, upright and magnified). These were incorrect responses. These candidates assumed that both the object and the image appear in the same position. This is true only when the object is placed at the radius of curvature of the mirror. Moreover, when the object is placed at a radius of curvature, the image will be real, inverted, and the same size as the object. Some of the candidates chose an alternative E (23.1 cm, virtual, inverted and diminished), which was an incorrect alternative. These candidates applied the correct formula to deduce the position of the image. However, they failed to analyse its characteristics. They were supposed to realise that when the object is beyond the radius of curvature, the image is always real

and diminished. A concave mirror formed virtual image only if the object is placed between the focal point and the vertex.

Item (ix) developed from the topic of Work, Energy, and Power. The item is intended to evaluate the ability of the candidates to apply mathematics to deduce the needed physical quantity. The question read: *Suppose an engine raises 200kg of water steadily through a height of 60 m in 20s. if the upward force used is equal to the weight of water raised, calculate the power in kW.* The given alternatives were:

A 4 kW B 5.88 kW C 3 kW D 5 kW E 7 kW

The correct alternative was B (5.88 kW). The analysis revealed that some of the candidates opted for this alternative. This suggests that the candidates applied the correct formula and performed unit conversion and numerical computation correctly. On the contrary, the analysis showed that some of the candidates chose an alternative A (4 kW), which was not a correct response. These candidates applied the incorrect formula. Thus:

$$power = \frac{mass \times time}{1000} = \frac{200 \text{ kg} \times 20 \text{ s}}{1000} = 4 \text{ kW} .$$

Some of the candidates chose an alternative C (3 kW). This was not a correct response. The candidates in this category applied the incorrect formula. It could be assumed that they used the following formula:

$$power = \frac{height}{time} = \frac{60 \text{ m}}{20 \text{ s}} = 3 \text{ kW} .$$

Moreover, the analysis showed that some of the candidates chose an alternative D (5 kW). This was also an incorrect response. These candidates also applied the incorrect formula. They probably used the following formula:

$$power = \frac{mass \times acceleration \text{ due to gravity} \times height}{time}$$

$$Power = \frac{200 \text{ kg} \times 10 \frac{\text{N}}{\text{kg}} \times 60 \text{ m}}{20 \text{ s}} = 5 \text{ kW} .$$

Some of them selected alternative E (7 kW), which was an incorrect alternative. It can be assumed that these candidates applied the incorrect formula. They probably use the following formula:

$$\text{power} = \frac{\text{mass} \times \text{time}}{\text{height}} = \frac{200 \text{ kg} \times 20 \text{ s}}{60 \text{ m}} \approx 7 \text{ kW.}$$

The candidates who were selected for alternatives A, C, D, and E failed to demonstrate their mastery of physics concepts, theories, principles and mathematics skills. That is to say that these candidates were incompetent in this topic.

Item (x) was constructed from the topic of *Static Electricity*. The item was intended to measure the candidate's ability to evaluate the dependence of capacitance of the variable parallel capacitor. The candidates were required to apply mathematics to analyse the relationship of various parameters in the capacitor. The question asked: *Which of the following alternatives will decrease the capacitance of the variable parallel capacitor in a radio receiver if the dielectric materials remain constant?* The given alternatives were:

- A *Decrease the separation and increase the area of the plate of the capacitor*
- B *Increase the separation and increase the area of the plates of a capacitor.*
- C *Increase the separation and decrease the area of the plates of a capacitor*
- D *Decrease the separation and decrease the area of the plates of a capacitor.*
- E *Decrease the separation and maintain the area of the plates of a capacitor*

The analysis showed that some of the candidates chose an alternative C (*Increase the separation and decrease the area of the plates of a capacitor*), which was a correct alternative. The candidates in this category were competent enough to understand the effect of the distance of separation in relation to the surface area of the capacitors' plates. Some of the candidates chose alternative A (*Decrease the separation and increase the area of the plate of the capacitor*), which was an incorrect response. Some of them chose alternative B (*Increase the separation and increase the area of the plates of a capacitor*). Moreover, some opted for an alternatives D (*Decrease the separation and decrease the area of the plates of a capacitor*) and E (*Decrease the separation and maintain the area of the plates of the capacitor*). These were incorrect alternatives. These candidates who chose incorrect alternatives failed to apply the mathematics

to evaluate the relationship between capacitance, plate separation distance and the area of the plates. They were supposed to know that the capacitance of a parallel plate capacitor is given as:

$$C = \frac{\epsilon A}{d}$$

That is to say that it is proportional to area and inversely

proportional to separation distance. Thus, the capacitance decreases as the area decreases. It also decreases as the distance is increased. The vice-versa is true. An extract 1.1 shows a sample of one of the candidate's incorrect responses to question 1.

QNS	i	ii	iii	iv	v	vi	vii	viii	ix	x
ANS	B	C	A	A	A	B	C	D	A	A

Extract 1.1: A sample of the candidate's incorrect responses to question 1

However, the candidates who provided an appropriate response to each item tested demonstrated mastery of basic concepts, theories, and principles of physics. Moreover, they demonstrated mastery in mathematics skills to evaluate various phenomena as well as logical thinking, as they managed to interpret correctly the demands of all the tested items in this question. An extract 1.2 shows a sample of a candidate who responded correctly in question 1.

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

Extract 1.2: A sample of candidate's correct responses to question 1

2.1.2 Question 2: Matching Items

This question consisted of six (6) homogeneous matching items derived from the topic of *Temperature*. Candidates were provided with the phrase of information in **List A** to be matched with the correct terminology from **List B**. The items and responses were:

List A	List B
(i) <i>The temperature of melting ice</i>	A <i>Upper fixed point</i>
(ii) <i>The temperature scale that is used in the SI system of units</i>	B <i>Thermodynamic scale</i>
(iii) <i>A measure of the average kinetic energy of the particles in a substance</i>	C <i>Fundamental interval</i>
(iv) <i>The temperature of boiling water</i>	D <i>Thermoelectric thermometer</i>
(v) <i>A temperature scale based on absolute scale</i>	E <i>Absolute zero</i>
(vi) <i>The point in which all molecular motion stops at -273.15°C.</i>	F <i>Lower fixed point</i>
	G <i>Temperature</i>
	H <i>Kelvin scale</i>
	I <i>Celsius scale</i>

A total of 134,004 (100%) candidates attempted this question. Out of these, 72,571 (54.16%) scored from 0.0 to 1.0 marks, 49,529 (36.96%) scored from 2.0 to 3.0 marks, and 11,904 (8.88%) scored from 4.0 to 6.0 marks. The general performance was average since 61,433 (45.84%) scored from 2.0 to 6.0 marks. Figure 2 summarises the candidates' performance in question 2.

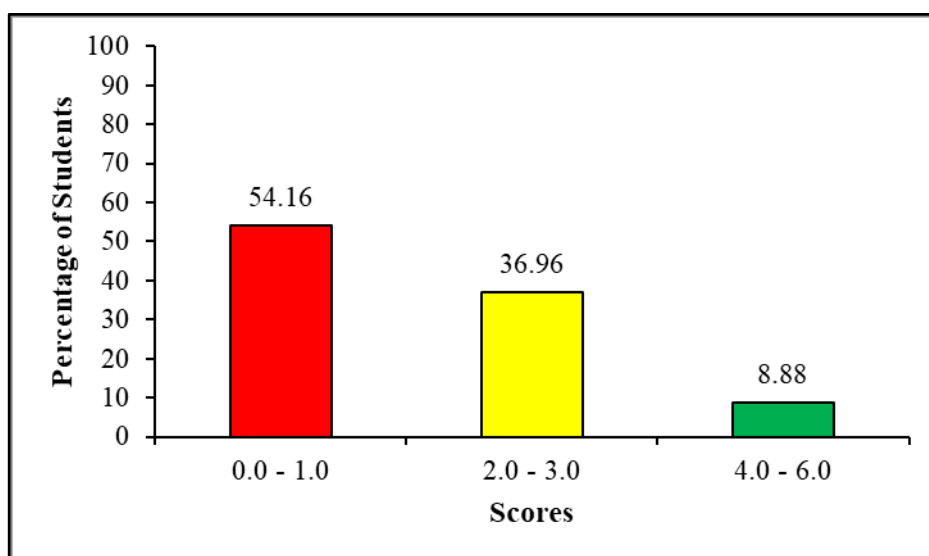


Figure 2: *The Candidates' Performance in Question 2*

In item (i), the candidates were required to identify the response that correctly matches the phrase, '*The temperature of melting ice*'. The analysis showed that most of the candidates opted for the correct response F (*Lower fixed point*). The candidates in this category were able to realise that the lower fixed point is the temperature of pure melting ice under standard atmospheric pressure (1 atm). It is important to note that it is called a lower fixed point because it remains constant while ice is melting. Thus, it provides a reliable reference temperature for calibrating thermometers. Some of the candidates selected an alternative A (*Upper fixed point*). This was an incorrect alternative. These candidates failed to realise that the upper fixed point is the temperature of steam above boiling water at standard atmospheric pressure (100 °C). Some of them selected an alternative E (*absolute zero*), which was an incorrect response. These candidates failed to understand the concept of absolute zero. From a temperature perspective, absolute zero is the lowest possible temperature where molecular motion theoretically stops. It is 0 K (-273 °C). Therefore, absolute zero is incorrect because melting ice occurs at 0 °C, not at -273 °C.

In item (ii), the candidates were required to identify the response that correctly matches the phrase, '*The temperature scale that is used in the SI system of units.*' The analysis revealed that some of the candidates selected alternative H (*Kelvin scale*), which was an incorrect response. Most of the

candidates chose the correct response B (*thermodynamic scale*). This was an incorrect response. These candidates were supposed to realise that the Kelvin scale is the practical name of the thermodynamic temperature scale used in SI. Some of them chose an alternative I (*Celsius scale*), which was an incorrect response. These candidates were supposed to know that the temperature scale that is used in the SI system of units is not the Celsius scale because it is not an SI unit of temperature.

In item (iii), the candidates were required to identify the response that correctly matches the phrase, '*a measure of the average kinetic energy of the particles in a substance.*' Some candidates chose the correct response G (*Temperature*). The candidates of this category were able to link the microscopic properties with measurable properties. That is to say, they were able to apply the kinetic theory of gases to describe the behaviour of matter in terms of measurable physical quantities. Some of the candidates opted for B (*Thermodynamic scale*). In this category, they were attracted by the term *dynamic* as it is closely related to *kinetic*.

In item (iv), the candidates were supposed to identify the phrase that matches '*the temperature of boiling water.*' Most of the candidates managed to identify the correct response A (*the upper fixed point*). The candidates in this category were able to distinguish it from the *lower fixed point*. On the contrary, some of the candidates opted for F (*lower fixed point*). These candidates were supposed to be aware that the upper fixed point is the temperature of steam from water boiling under standard atmospheric pressure of 760 mmHg. Additionally, it should be understood that the temperature of boiling water itself is not used as a fixed point for two reasons: i) Local overheating may occur, accompanied by bumping as water boils. ii) Any impurities that may be present will raise the boiling point. The candidates who chose the incorrect responses in this aspect had insufficient knowledge on identifying upper and lower fixed points of a thermometer.

In item (v), the candidates were supposed to identify the phrase that matches, '*a temperature scale based on an absolute scale.*' Most of the candidates were able to recognise the best response B (*Thermodynamic Scale*). Some of the candidates opted for either the *Celsius scale* or *Kelvin scale*, which are closely related terminologies, but they were not the best

options. The thermodynamic scale refers to the absolute theoretical basis of temperature measurement, while a Kelvin scale is the name used in SI.

In item (vi), the candidates were supposed to identify the phrase that matches, ‘*the point at which all molecular motion stops at -273.15 °C.*’ Most of the students recognised the correct response E (*Absolute zero*). These candidates were mindful that absolute zero is given the value 0 K. Also, they knew that the absolute zero on the Celsius scale is about – 273 °C. Furthermore, the temperature of 0 °C is 273 °C from the absolute zero, or 273 K; the temperature of 1000 °C is 373 K. Generally, $t^{\circ}\text{C} = (273 + t) \text{ K}$. In contrast, some candidates opted for F (*lower fixed point*). These were attracted by the term *point* as well as the *negative value*, which called for the concept of the term *lower*, leading to the decision of selecting this alternative. An extract 2.1 shows a candidate’s incorrect response to question 2.

Q2.	To match list A and list B.						
	LIST A	i	ii	iii	iv	v	vi
	LIST B	F	H	D	I	C	E

Extract 2.1: A sample of a candidate’s incorrect responses to question 2

The analysis further revealed that some of the candidates answered certain items correctly due to their high competence and mastery abilities in the topic of temperature. These candidates managed to answer all six given items in this question perfectly. An extract 2.2 displays one of the candidate’s correct responses to question 2.

2	i	ii	iii	iv	v	vi
	F	B	G	A	H	E

Extract 2.2: A sample of a candidate’s correct responses to question 2

2.2 SECTION B: Short Answer Questions

This section comprises six (6) short-answer questions, generated from various topics. Each question carried nine (9) marks, contributing to a total of 54 marks for the section. The topics covered in this section included *Optical Instruments, Light, Pressure, Forces in Equilibrium, Newton’s Laws of Motion, Thermal Expansion, Simple Machines, Measurement of*

Thermal Energy, Current Electricity, Elementary Astronomy and Geophysics. All questions were compulsory in this section.

2.2.1 Question 3: Optical Instruments and Light

This question was constructed from two topics, which are *Optical Instruments* and *Light*, consisting of two parts (a) and (b). Part (a) of this question was designed to assess candidates' ability to match a specific eye defect with the correct type of corrective lens.

Part (b) of this question was intended to evaluate the ability of the candidates to apply concepts and principles related to optics in daily life experience.

The question read as;

- (a) *Identify the type of lens which fits a person with;*
 - (i) *Short-sighted defect*
 - (ii) *Long-sighted defect.*
- (b) *Why concave mirrors used as shaving mirrors? Explain with an aid of a well labelled diagram.*

A total of 134,004 (100%) candidates attempted the question. Out of these, 60,406 (45.08%) scored from 0.0 to 2.5 marks, 62,942 (46.97%) scored from 3.0 to 5.5 marks, and 10,656 (7.95%) scored from 6.0 to 9.0 marks. The general performance was average, as 73,598 (54.92%) scored from 3.0 to 9.0 marks. Figure 3 summarizes the candidates' performance in question 3.

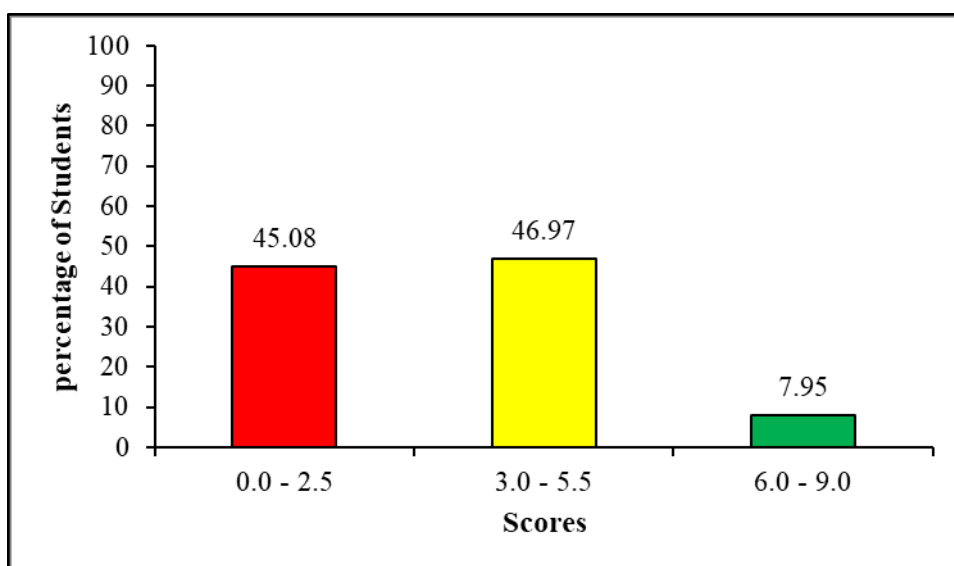


Figure 3: *The Candidates' Performance in Question 3*

In part (a)(i) and (ii), some candidates were unable to correctly identify the appropriate lenses used to correct short-sightedness and long-sightedness. For instance, in part (a)(i), one of the candidates wrote, “*a short-sighted defect can be fitted with a convex lens.*” Similarly, in part (a)(ii), wrote, “*a long-sighted defect can be fitted with a concave lens.*” This candidate erroneously interchanged the use of both convex and concave lenses. The candidates in this category presented that a converging (convex) lens is used to correct the short-sighted defect, instead of a diverging (concave) lens. Similarly, some candidates wrote that a *diverging (concave) lens* is used for correcting the *long-sightedness defect*, which was incorrect. This proves that they were unable to recognise the cause of both short-sighted defects and the long-sighted defects. Some of the candidates provided irrelevant responses. For instance, one candidate wrote “*optical lens and minimal lens.*” This statement makes no sense in a physics context.

In part (b), most of the candidates were unable to draw a well labelled sketch describe the characteristics of the images formed by the concave mirror. Some candidates were unable to explain why a concave mirror is suitable for use as a shaving mirror. This indicated a lack of understanding of the image properties formed by a concave mirror. Most of them provided incorrect responses. For example, one of the candidates wrote, “*a concave mirror is used as a shaving mirror because it produces an image with*

diminished size". This one was unaware of the meaning of the term diminished image. Another candidate wrote, "*a concave mirror is used as a shaving mirror because it tends to reflect light away at a large range*". These candidates were supposed to know that the characteristics of the image formed by a concave mirror depend on the position of the object. The characteristics of the images formed by a concave mirror are summarised as follows:

- Case I: The object is located at infinity. A single point at the Focal point (F). It implies that the position of the image, say q , is equal to the focal length (f) of the mirror.
- Case II: The object is located beyond the radius of curvature (C). The image is real, inverted, and smaller than the object, located between F and C.
- Case III: The object is located at C: The image is real, inverted, same size as the object, and located at C.
- Case IV: The object is located between C and F. The image is real, inverted, larger than the object, and located beyond C.
- Case V: The object is located at F: no image will be formed
- Case VI: The image closer than F (between F and Vertex): The image is virtual, erect, larger than the object, located behind the mirror.

When an object is placed between the focal point and the vertex of a concave mirror. That is to say that at this point, the image is enlarged, and an upright image makes it easier to see fine details of the face while shaving. An extract 3.1 shows a sample of the candidate's incorrect response to question 3.

03.	(a) i) Short sighted defect
	Can be fit to a person by using Convex lens.
	ii) Long-sighted defect
	Can be fit to a person by using Concave lens.
	(b) Concave mirrors are used as shaving mirrors because they form a real, inverted and diminished image making it useful due to its wide field of view.
	Consider the concave mirror below:

Extract 3.1: A sample of the candidate's incorrect response to question 3

In extract 3.1 the candidate demonstrated insufficient knowledge and skills related to the topic of optics. In part 3(a), a candidate failed to correctly identify the type of lens required to correct the specified eye defect. In part (b), the candidate was unable to describe how the characteristics of the image, depending on the position of the object, make a concave mirror suitable for use as a shaving mirror.

The analysis further revealed that some of the candidates scored higher marks (6.0 to 9.0). These candidates demonstrated their mastery of

concepts, theories and principles related to optics. They were able to correctly identify the type of lens required to correct the specified eye defect. Moreover, they were able to explain how the characteristics of the image, depending on the position of the object, make a concave mirror suitable for use as a shaving mirror. These candidates demonstrated their ability to translate the optics concepts, theories and principles in sketching a concave mirror as a shaving mirror. The object is correctly positioned such that the image becomes magnified and virtual. An extract 3.2 shows a sample of the candidate who answered question 3 correctly.

3.	a> i> Short-sighted defect- Concave lens. The lens help to diverge the light rays from a distant object so that the rays of light can intersect on the retina and not in front of the eye. ii> Long-sighted defect- Convex lens. The lens helps to converge the light rays from a nearby object so that the rays intersect at the retina and not behind it. b> Concave mirrors are used as shaving mirrors because they produce magnified and upright images that enhance the visibility of the shaved area. This happens because the object is placed between the pole of the mirror and the focal point hence giving a large image and upright image. b> <u>A DIAGRAM OF THE IMAGE FORMED</u>
----	--

Extract 3.2: A sample of a candidate's correct response to question 3

2.2.2 Question 4: Pressure and Forces in Equilibrium

This question consisted of two main parts: part (a) and part (b).

Part (a) was structured from the topic of *Pressure*. This part assessed the ability of the candidate to apply concepts and principles of atmospheric pressure in daily life. Part (b) measures the ability of the candidates to apply the principle of moments to solve real-world problems. The question stated;

- a) Draw a diagram of a simple mercury barometer showing clearly:
 - (i) The Torricellian vacuum
 - (ii) The atmospheric pressure and height of the mercury.
- b) Figure 2 shows rulers balanced at their centres of gravity in Cases I and II. Determine the difference in weight between A and B.

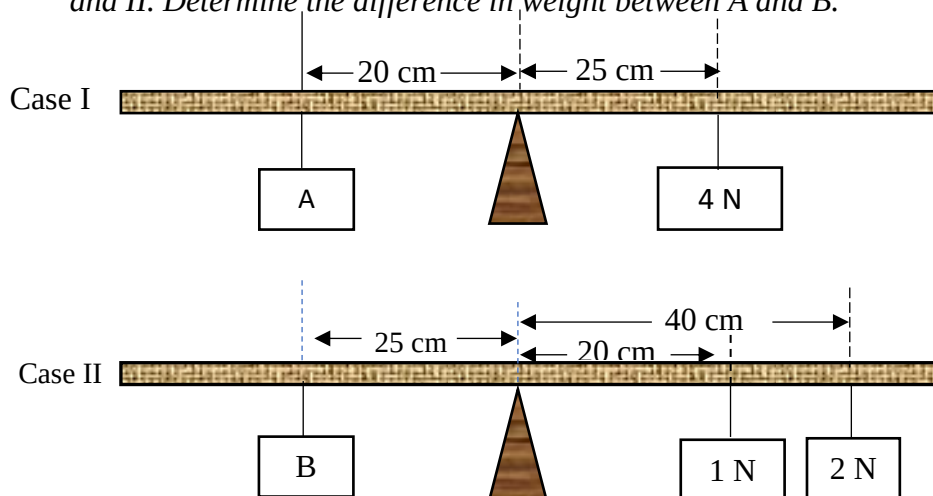


Figure 2

A total of 134,004 (100 %) candidates attempted this question. Out of these, 68,458 (51.09 %) candidates scored from 0.0 to 2.5 marks, 45,940 (34.28%) candidates scored from 3.0 to 5.5 marks, and 19,606 (14.63%) candidates scored from 6.0 to 9.0 marks. Generally, the performance in this question was average, as 65,546 (48.91%) of the candidates scored lower marks (0.0-2.5). Figure 4 summarises the candidates' performance in question 4.

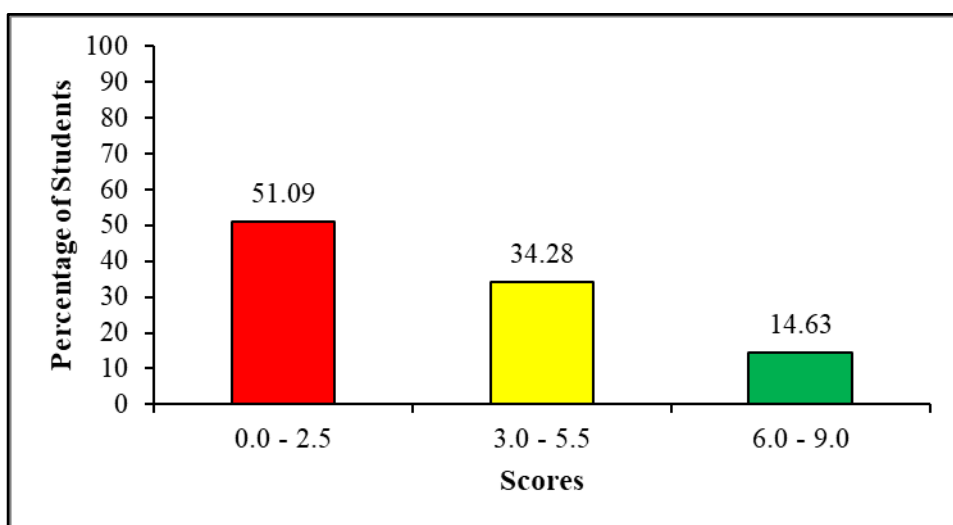


Figure 4: *The Candidates' Performance in Question 4*

The analysis revealed that 51.09% of the candidates who attempted this question scored lower marks (0.0-2.5). Most of them failed to provide a correct response in part (a) of this question. These candidates failed to provide a well-labelled sketch for a simple mercury barometer. Some of these candidates provided an incorrect sketch. For instance, some drew *Manometer*, *Hydrometer*, *Hydraulic press*, *Sixths thermometer* and *Wet and Dry Bulb Hygrometer*. These were incorrect drawings. These candidates failed to distinguish a simple mercury barometer from other measuring devices. Some of candidate drew a circuit diagram with a number of electric cells. Another candidate drew a diagram that proves that pressure in a liquid varies proportionally with depth. Looking at these responses, it is evident that these candidates never saw or used a simple barometer in the laboratory. Therefore, they failed to know that a simple barometer is used to measure the local atmospheric pressure. A mercury barometer consists of a glass tube that is sealed at the top and opens at the bottom. The open end is immersed in a shallow mercury reservoir, forming a small pool around the base of the tube. The height of the mercury column inside the tube adjusts according to the atmospheric pressure acting on the surface of the mercury in the reservoir. When atmospheric pressure increases, it pushes the mercury higher up the tube, but when the pressure decreases, the mercury level falls. The tube is calibrated with measurement markings, typically in atmospheres or bars, allowing observers to determine the air pressure by noting the height at which the mercury column comes to rest. Moreover, these responses revealed that these candidates were less

competent on this topic. Probably they failed to realise its application in daily life.

The analysis further revealed that most of the candidates who scored lower marks failed to provide a correct response in part (b) (Case II). Most of them correctly stated the principle of moment but failed to include all forces in the system. For instance, one candidate wrote

For instance, one of the candidates wrote:

Clockwise moment = anticlockwise moment.

$$F_1 d_1 = F_2 d_2$$

$$25 \times B = 3 \times 20$$

$$\frac{25}{25} B = \frac{60}{25}$$

$$\therefore B = 2.4 \text{ N}$$

The candidate failed to correctly state the principle of moments, which may have contributed to the overall failure in this question. The candidate's mathematical reasoning shows that the candidate was misled by the incorrectly stated principle. As a result, leading to errors in the calculations of needed physical quantities. Adding forces before the computation of the moment is wrong. The candidate was supposed to realise that the moment is given as:

Moment = force $\times$ perpendicular distance from pivot. This implies that the two forces act at different distances, so they produce different turning effects. The correct approach for the clockwise moment is:
Total clockwise moment = $(1 \text{ N} \times 20 \text{ cm}) + (2 \text{ N} \times 40 \text{ cm}) = 100 \text{ Ncm}$.

Another candidate wrote: *Clockwise moment = anticlockwise moment.*

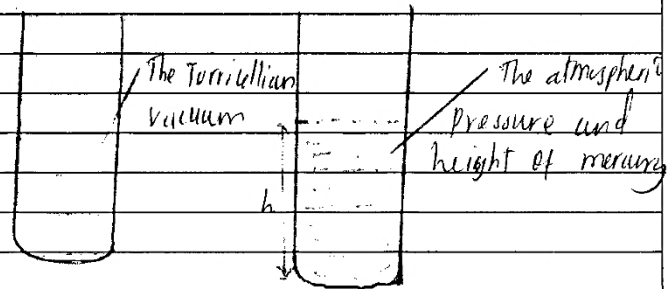
$$F_1 d_1 = F_2 d_2$$

$$25 \times B = 2 \times 40$$

$$\therefore B = 3.2 \text{ N}$$

This candidate ignored one force. The candidate assumed that only 2 N causes the turning effect. This is a completely wrong assumption. The candidates were supposed to know that the principle of moment states that a total (or sum of) clockwise moments is equal to the total (or sum of) anticlockwise moments. Extract 4.1 shows a sample of the incorrect responses to question 4 from one of the candidates.

4 (9) A DIAGRAM OF SIMPLE MERCURY BAROMETER SHOWING



(b)

solution

From for case I
Moment of clockwise = Moment of anticlockwise

$$0.3m \times A = 0.25m \times 0.4kg$$

$$0.3m \times A = 0.1mas/kg$$

$$0.3m \quad 0.3m$$

$$A = 0.33kg$$

Again

$$\text{weight} = \text{mass} \times \text{gravitational due to } g \quad \text{gravity}$$

$$= 0.33kg \times 9.8N/kg$$

$$\text{weight} = 3.266 \approx 3.3N$$

$$\text{weight in case I} = 3.3N$$

4	(b) in case 2
	From
	Melekuise = Mantelokuise
	$0.25m \times B = 0.3m \times 0.1kg + 0.1m \times 0.2kg$
	$0.25m/B = 0.4m/kg + 0.3m/kg \quad 0.02$
	$0.25m/B = 0.7m/kg$
	$0.25m \quad 0.25m$
	$B = 2.8kg$
	Then
	Weight =
	$0.25m/B = 0.3m \times 0.1kg + 0.1m \times 0.2kg$
	$0.25m/B = 0.03m/kg + 0.02m/kg$
	$0.25m/B = 0.05m/kg$
	$0.25m \quad 0.25m$
	$B = 0.2kg$
	weight = mg
	$= 0.2kg \times 9.8N/kg$
	weight = $1.96N \approx 2N$
	Then
	$= \text{Weight of case I} - \text{weight of case II}$
	$= 3.3N - 2N$
	$= 1.3N$
	$\therefore$ Difference in weight between A and B is $1.3N$

Extract 4.1: A sample of the candidate's incorrect responses to question 4

In extract 4.1, the candidate provided an incorrect response in both parts (a) and (b). This incorrect response indicates that the candidate lacked knowledge and skills of the tested concepts.

The analysis further displayed that some of the candidates (14.63%) scored higher marks (6.0 to 9.0). The candidates in this category demonstrated

their mastery of knowledge and skills on the topic of *Pressure* and *Force in equilibrium*. Most of these candidates provided a correct sketch of a simple barometer. Moreover, they applied the principles of moment to solve a practical problem correctly. For case I: From the principle of moment, *sum of clockwise moment = sum of anticlockwise moment*

$$F_1 d_1 = F_2 d_2$$

$$A \times 20 \text{ cm} = 4 \text{ N} \times 25 \text{ cm}$$

$$\therefore A = \frac{100 \text{ Ncm}}{20 \text{ cm}} = 5 \text{ N}$$

Case II:

sum of clockwise moment = sum of anticlockwise moment

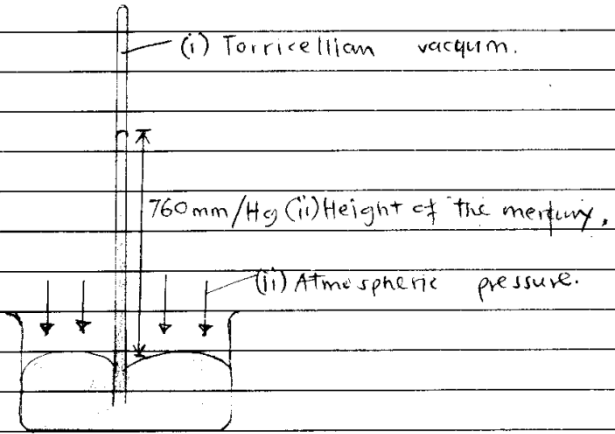
$$F_1 d_1 = F_2 d_2 + F_3 d_3$$

$$B \times 25 \text{ cm} = (1 \text{ N} \times 20 \text{ cm}) + (2 \text{ N} \times 40 \text{ cm})$$

$$B = \frac{20 \text{ Ncm} + 80 \text{ Ncm}}{25 \text{ cm}} = \frac{100 \text{ Ncm}}{25 \text{ cm}} = 4 \text{ N}$$

The difference in weight between A and B = $5 \text{ N} - 4 \text{ N} = 1 \text{ N}$

Conclusively, the candidates who responded to this question exhibited a higher degree of mastery in the application of the principle of moment in solving real-world problems. Extract 4.2 shows a sample of a correct response to question 4 from one of the candidates.

4	(9)
 DIAGRAM OF SIMPLE MERCURY BAROMETER.	
(b)	Solution CASE I By principle of moment, $\sum \text{Anticlockwise moment} = \sum \text{Clockwise moment}$ $20 \times A = 25 \times 4$ $20A = 100$ $A = \frac{100}{20}$ $\therefore A = 5 \text{ N}$ CASE II By principle of moment, $\sum \text{Anticlockwise moment} = \sum \text{clockwise moment}$ $25 \times B = (20 \times 1) + (40 \times 2)$ $25B = 20 + 80$ $25B = 100$ $B = \frac{100}{25}$ $\therefore B = 4 \text{ N}$
(b)	Difference in weight = $A - B$ $= 5 - 4$ $= 1 \text{ N}$ $\therefore$ The difference in weight between A and B is 1N

Extract 4.2: A sample of candidate's correct response to question 4

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

This question comprises two main parts: Part (a) was constructed from the topic of *Newton's laws of motion*, and Part (b) from the topic of *Simple Machines*. Part (a) consisted of part a(i) and part (a)(ii). Part (a)(i) was structured such that it assessed the ability of the candidate to apply the concept of impulse in real life, while part (a)(ii) tested the ability of the candidate to recall the law which supports the response provided in (a)(i) above. However, part (b) of the question tested the ability of the candidate to apply and evaluate the concept of a simple machine in real life. The question is stated as follows:

- (a) (i) *Why a person jumping from a high ground to the floor bends knees upon making contact?*
(ii) *State the law or principle that supports your answer in (a) (i) above.*
- (b) *A wooden plank is used to raise a heavy load from point A to point B as shown in Figure 3. Use Figure 3 to show that velocity ratio = $\frac{1}{\sin \theta}$*

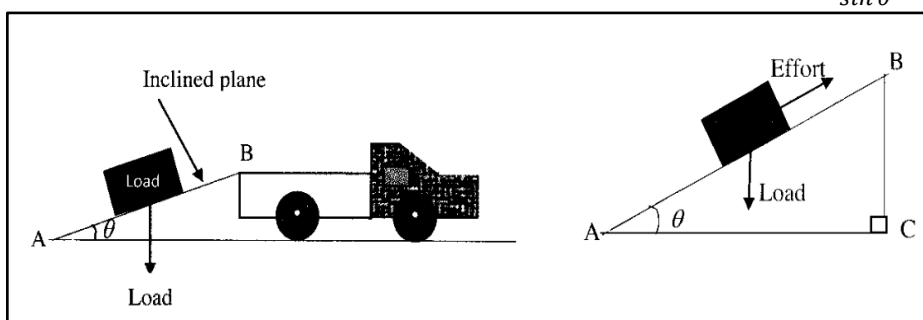


Figure 3

A total of 134,004 (100%) candidates attempted this question, and their scores were as follows: 94,923 (70.84%) candidates scored from 0.0 to 2.5 marks, 25,273 (18.86%) candidates scored from 3.0 to 5.5 marks, and 13,808 (10.30%) candidates scored from 6.0 to 9.0 marks. The general performance of this question was weak, as 39,081 (29.16%) scored from 3.0 to 9.0 marks. Figure 5 summarises the performance of the candidates in question 5.

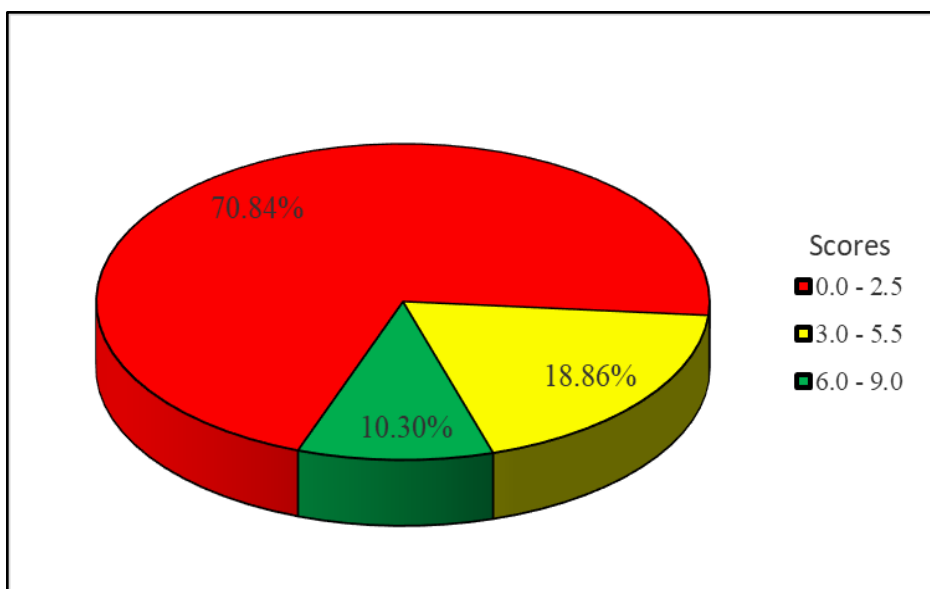


Figure 5: *The Candidates' Performance in Question 5*

The analysis showed that the majority of the candidates scored lower marks (0.0-2.5). This suggests that these candidates had inadequate knowledge and skills related to the tested topics. In part (a), they demonstrated a lack of conceptual understanding and reasoning skills, which led them to fail to relate the relevant physics principles to the action of bending the knees when landing from a high jump. For instance, one candidate provided the following description *"In order to reduce the friction on the ground that is why person bend the knees upon making contact with the floor from high jump"*. This response was incorrect. The candidate failed to realise the following:

- When a person lands vertically from a jump, the main force acting is the normal reaction force from the ground. Moreover, the friction acts parallel to the surface and is not the main force during vertical landing.
- Bending the knees does not significantly change the friction because it depends on: i) normal reaction force and ii) nature of the surfaces. It does not depend on the knee position.

Another candidate responded by writing *"that's because a person wants to reduce the force of impact by decreasing the moment of force"*. This was an incorrect response. The candidate failed to realise that landing from a jump is not a rotational problem about a fixed point. Thus, it is wrong to apply the principle of moment in this situation. They were supposed to recognise

that a person falling from a certain height builds up momentum, which must be brought to zero upon landing. The change in momentum (ΔP) is the product of the average force exerted during landing (F_{av}) and the time over which the force acts (Δt). According to Newton's second law: $\Delta P = F_{av} \times \Delta t$. Bending your knees extends the time of impact (Δt), allowing one to decelerate more gradually. Since the total change in momentum is constant, a longer time of impact means the average force F_{av} is smaller, resulting into more tolerable force on your body. In part (b), the candidates failed to show that $\text{velocity ratio} = \frac{1}{\sin \theta}$ because they had inadequate mathematical and analytical skills. They were supposed to start from the general concept of velocity ratio as follows:

$$\text{Velocity ratio} = \frac{\text{distance moved by the effort}}{\text{distance moved by the load}}$$

$$\text{Velocity ratio} = \frac{\text{Length of the plane}}{\text{Height of the plane}} = \frac{AB}{BC}$$

But

$$\sin \theta = \frac{\text{Height of the slope}}{\text{Length of the plane}} = \frac{BC}{AB}. \text{ Thus, it can be said that } \frac{1}{\sin \theta} = \frac{AB}{BC}$$

$$\text{Therefore, Velocity ratio} = \frac{1}{\sin \theta} = \frac{AB}{BC}.$$

Consider an Extract 5.1 of a candidate's incorrect response to question 5.

5	a) i) Because when a person jumping from a high ground to the floor bends knees in order to reduce the pressure, when without bending was cause to breaking the legs so pressure was inversely proportional to the area. ii) Pressure was inversely proportional to the area ($P \propto \frac{1}{A}$) and directly proportional to the force ($P \propto F$) so pressure is ($P = \frac{F}{A}$) but p = pressure, F = force then A = surface area so when increase the area the pressure was decrease so when bends knees in order to increase the surface area and to decrease the pressure. b) Data given angle $\theta = 25^\circ$ velocity ratio = Required From velocity ratio = $\frac{1}{\sin \theta}$
5	b) Velocity ratio = $\frac{1}{\sin 25}$ velocity ratio = $\frac{1}{0.4}$ velocity ratio = 2.5 The velocity ratio is 2.5

Extract 5.1: A sample of a candidate's incorrect response to question 5

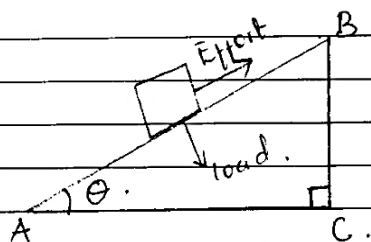
Extract 5.1 indicates that the candidate provided an incorrect response due to limited skills and abilities in understanding the question. In part (a), the candidate described pressure as the effect that should be minimised by bending the legs during a jump. This response was incorrect because the

question required an explanation of the effect of impulsive force, specifically how increasing the duration of impact reduces its effect on the body during landing. In part (b), the candidate showed insufficient knowledge and mathematical skills in deriving various equations in Physics. Nevertheless, some candidates scored high marks (6.0-9.0) on this question. This suggests that the candidate had enough knowledge and skill on the tested topics. They were able to apply concepts, theories, and principles of impulsive force to explain why it is necessary to bend the knees when landing from a high jump correctly. They also showed proficiency in mathematical and analytical skills in part (b) of the question. Extract 5.2 presents a sample of the best solution from a candidate who correctly answered the question.

5. a) i, This is because bending of knee increases time of impulse, thus the force of impact upon one jumping would be reduced thus avoiding injuries or dislocation of body parts.

ii, Newton's second law of motion states that, "the rate of change of momentum is directly proportional to the force applied and takes place in the direction of the force applied."

5. b)



$$\begin{aligned}\text{Velocity Ratio} &= \frac{\text{slanted height}}{\text{vertical height}} \\ &= \frac{\overline{AB}}{\overline{BC}}\end{aligned}$$

$$\text{But: } \sin \theta = \frac{\overline{BC}}{\overline{AB}}$$

$$\therefore \overline{AB} = \frac{\overline{BC}}{\sin \theta}$$

$$\text{Thus, velocity ratio} = \frac{\overline{BC}}{\sin \theta} \times \frac{1}{\overline{BC}}$$

$$\text{velocity ratio} = \frac{1}{\sin \theta}$$

$$\therefore \text{velocity ratio} = \frac{1}{\sin \theta}, \text{ hence shown.}$$

Extract 5.2: A sample of a candidate's correct responses to question 5

In extract 5.2, the candidate correctly explained in part (a) that a person should bend their knees when landing to reduce the effect of the impulsive force. The candidate also cited the relevant law supporting the answer in

part (a)(i) and demonstrated strong mastery of mathematical concepts and skills in deriving the solution in part (b).

2.2.4 Question 6: Thermal Expansion and Measurement of Thermal Energy

The question had two parts (a) and (b). Part (a) was derived from the topic of *Thermal expansion* and was intended to test the conceptual understanding and reasoning skills of the candidate. Part (b) of the question was structured from the topic of measurement of heat and tested the ability of the candidates to apply a mathematical formula to determine the steady temperature of the mixture. The question was as follows;

(a) (i) *How can a bimetallic strip be made? Briefly explain.*

(iii) *By using a simple diagram, show how a bimetallic strip made of iron and brass is formed when heated to the same temperature.*

(b) *Suppose 105 g of water at 75°C is added to 215 g of cold water at 15 °C, and the mixture is well stirred. Determine the final temperature of the mixture if the heat absorbed by the container is neglected.*

A total of 134,004 (100%) candidates attempted the question. The statistical analysis revealed that 64,008 (47.77%) of the candidates scored from 0.0 to 2.5 marks, 41,418 (30.91%) candidates scored from 3.0 to 5.5 marks and 28,578 (21.33%) candidates scored from 6.0 to 9.0 marks. Generally, the performance was average, as 69,996 (52.24%) scored from 3.0 to 9.0 marks. Figure 6 summarizes the performance of the candidates in question 6.

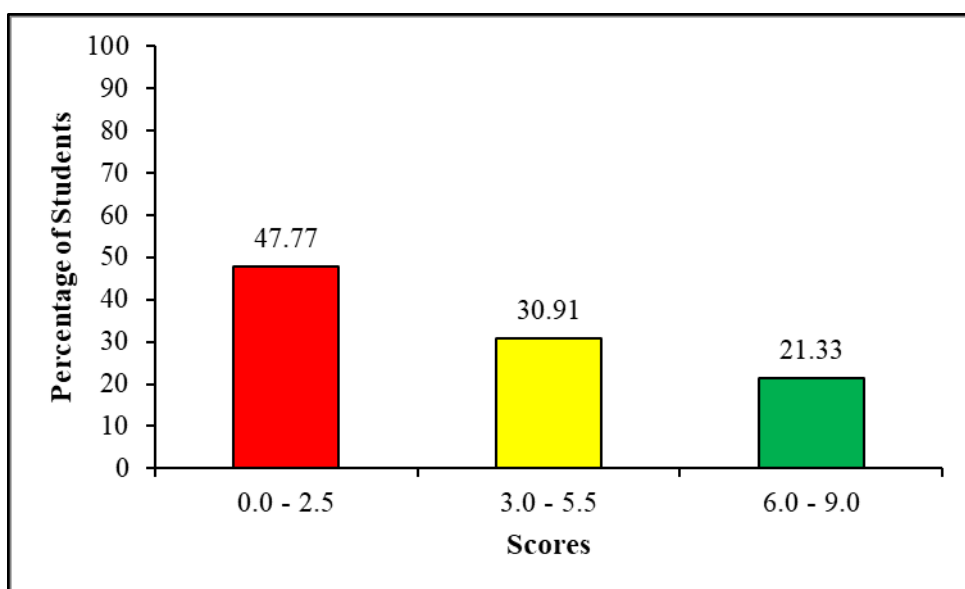
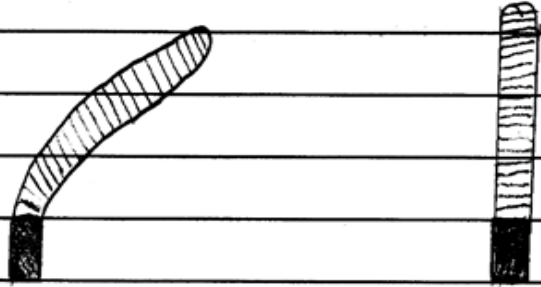


Figure 6: *The Candidates' Performance in Question 6*

The analysis showed that 47.77% of the candidates who attempted this question scored 0.0-2.5, which was a lower score. These candidates demonstrated insufficient knowledge and skills in thermal expansion and the measurement of thermal energy. They showed weaknesses in both conceptual understanding and reasoning skills, failing to provide correct responses across all parts of the question.

In part (a)(i), some candidates failed to provide a correct response because of a limited understanding of thermal expansion in solids. Several responses merely stated that a bimetallic strip is made by joining two metals, without providing essential details. Other candidates incorrectly stated that the metals must have the same thermal expansion, reflecting inadequate comprehension of the scientific principles underlying bimetallic strips. In part (a)(ii), while some candidates drew the bimetallic strip, their diagrams were incorrect due to interchanging the labels of iron and brass. This mislabelling indicates a gap in their understanding of thermal expansion. A correct response recognises that a bimetallic strip consists of two metals that expand at different rates when subjected to the same temperature change. For example, in a brass-iron bimetallic strip heated uniformly, the strip bends: the metal with the higher expansion rate (brass) forms the outer, convex side of the curve, while the metal with the lower expansion rate (iron) forms the inner, concave side.

In part (b), candidates in this category exhibited weaknesses in mathematical and computational skills, which were essential for providing a correct response. As a result, they were unable to calculate the final temperature of the mixture accurately. Extract 6.1 illustrates a sample of an incorrect response from one of the candidates in question.

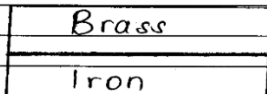
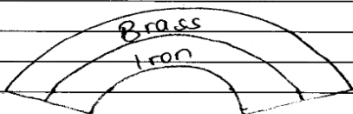
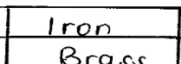
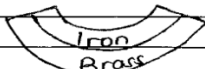
6a)	A bimetallic strip can be made either by heating an iron or plastic material until when it bends and become a bimetallic.
6b)	
	$\begin{aligned} \text{Final temperature} &= \frac{\text{Mass 1} \times \text{Temp 1} + \text{Mass 2} \times \text{Temp 2}}{\text{Mass 1} + \text{Mass 2}} \\ &= \frac{215 \text{ g} \times 75^\circ\text{C} + 105 \text{ g} \times 15^\circ\text{C}}{215 \text{ g} + 105 \text{ g}} \\ &= \frac{16125 + 1575}{320} \\ &= \frac{17700}{320} \\ &= 55.3125^\circ\text{C} \end{aligned}$
	$\therefore$ The final temperature is 5°C .

Extract 6.1: A sample of a candidate's incorrect response to question 6

In Extract 6.1, the candidate demonstrated insufficient mastery of the topic of *Thermal expansion*, particularly in applying the concept using a

bimetallic strip of iron and brass. The candidate failed to provide a correct sketch. In part (a), the candidate was expected to know that heating an iron increases its dimensions, length, width, and height, while heating a plastic material causes deformation. Thus, plastic cannot be a part of a bimetallic strip. The correct response should state that a bimetallic strip is made by placing two strips of different metals, each with different linear expansivities, welded side by side along their entire length. In part (b), the candidate also showed weakness in applying mathematical skills to solve physics problems, further reflecting inadequate competence in the topic. Extract 6.1 illustrates the correct responses from one of the candidates who performed well in question 6.

The analysis further showed that 21.33% of the candidates who attempted this question scored between 6.0 and 9.0 marks. This indicates that these candidates had enough knowledge and skills on the subject matter. They were able to correctly describe the formation of a bimetallic strip, showing understanding that it is formed by two metals expanding at different rates when subjected to the same temperature change. They also displayed good representation skills, which allowed them to present well-labelled diagrams of the bimetallic strip. Moreover, most of these candidates demonstrated strong mathematical and analytical skills. Extract 6.2 illustrates the correct responses from one of the candidates who performed well in question 6.

6 a.	i. A bimetallic strip is made by joining two metals of two different linear expansivities. They expand and contract differently when heated and cooled. Bimetallic strip is mostly used in fire detectors and in iron boxes.
	ii. Brass has a higher linear expansivity meaning that it expands more and faster when heated compare to iron which has a lower linear expansivity.
	 - before heating
	 - after heating OR
	 - before heating
	 - after heating
6.	b. $1 \text{ kg} = 1000 \text{ g}$ $\alpha = 105 \text{ g}$ $\alpha = \frac{105 \text{ g} \times 1 \text{ kg}}{1000 \text{ g}}$ $\alpha = 0.105 \text{ kg}$ $1 \text{ kg} = 1000 \text{ g}$ $\alpha = 215 \text{ g}$ $\alpha = \frac{215 \text{ g} \times 1 \text{ kg}}{1000 \text{ g}}$ $\alpha = 0.215 \text{ kg}$ Heat gained = Heat loss $0.215 \text{ kg} \times 4200 \text{ J/kg}^\circ\text{C} \times (\theta - 15)^\circ\text{C} = 0.105 \text{ kg} \times 4200 \text{ J/kg}^\circ\text{C} \times (75 - \theta)^\circ\text{C}$ $903 (\theta - 15) = 441 (75 - \theta)$ $903 \theta - 13,545 = 33,075 - 441 \theta$ $903 \theta + 441 \theta = 33,075 + 13,545$ $1344 \theta = 46,620$ $\theta = \frac{46,620}{1344}$ $\theta = 34.6875^\circ\text{C}$ $\therefore$ The final temperature is 34.6875°C

Extract 6.2: A sample of a candidate's correct responses to question 6

In Extract 6.2, the candidate responded correctly to both parts (a) and (b) of the question. This indicates that the candidate demonstrated strong competence in the topic of thermal expansion and the measurement of thermal energy. Additionally, the candidate applied mathematical skills to solve physics problems, reflecting the ability to use physics knowledge in practical situations.

2.2.5 Question 7: Current Electricity.

The question consisted of two parts, (a) and (b). Both parts were derived from the topic of current electricity. Part (a) assessed the candidate's understanding of the heating effect of electric current. They were required to identify the factors that influence the amount of heat produced. Part (b) evaluated the candidate's ability to apply experimental data and mathematical skills to determine both the internal resistance and the electromotive force (e.m.f) of the cell. The question was as follows.

- (a) *Briefly explain the three factors that determine the quantity of heat generated by an electric current.*
- (b) *In a certain experiment, the p.d across the terminals of the cell was 1.1 V when the current of 0.20 A was being drawn from the cell and the p.d across the terminals of the same cell was 1.30 V when the current drawn from the cell was 0.10 A. Calculate the:*
 - (i) *Internal resistance of the cell.*
 - (ii) *Electromotive force of the cell.*

A total of 134,004 (100%) candidates attempted this question. Out of these, 85,993 (64.17%) candidates scored from 0.0 to 2.5 marks, 30,970 (23.11%) candidates scored from 3.0 to 5.5 marks, and 17,041 (12.72%) candidates scored from 6.0 to 9.0 marks. Generally, the performance was average as 48,011 (35.83%) scored from 3.0 to 9.0 marks. Figure 7 summarises the candidates' performance in question 7.

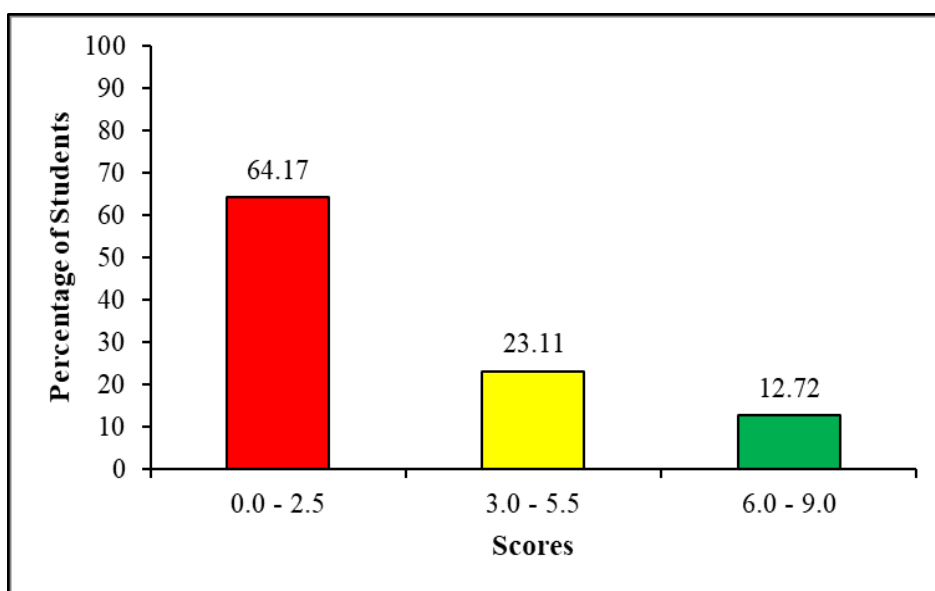


Figure 7: *The Candidates' Performance in Question 7*

The majority of the candidates (85,993 (64.17%)) who attempted this question scored between 0.0 and 2.5 marks. This indicates that these candidates had inadequate knowledge and skills on the topic of *Current Electricity*. In part (a), these candidates were unable to identify the correct factors that determine the amount of heat produced by an electric current. Most of them provide incorrect responses. For instance, one candidate wrote “*temperature, length of the conductor and cross-sectional area*”. This was an incorrect answer. The candidate mentioned the factors that affect the resistance of a conductor. They do not directly affect the heat generated by electric current. These candidates were supposed to realise that the quantity of heat generated by an electric current depends on the following:

- Current (I): The amount of heat generated is directly proportional to the square of the current flowing through the conductor. That is to say, a higher current causes more collisions between electrons and atoms in the conductor, producing more heat. Mathematically, $H \propto I^2$.
- Resistance (R): The conductor's resistance affects how much electrical energy is converted to heat. This is why thin wires or materials with poor conductivity heat up faster. It implies that a higher resistance means more energy is dissipated as heat. Mathematically, $H \propto R$.

- Time (t): The duration for which the current flows influence the heat generated. It should be noted that the heat generated by an electric current result from electrical energy being converted into thermal energy. This occurs as electrons collide with the atoms in the conductor. This implies that more time means more collisions occur, thus, more energy is transferred as heat. Mathematically $H \propto t$.

The combination of these factors gives Joule's heating law, mathematically given as $H = I^2 R t$.

Most of the candidates who failed to score higher marks in this question failed to score better marks in part (b) of this question. These candidates failed to apply the correct mathematical formula to deduce the EMF and internal resistance of the cells. That is to say, they failed to use the given experimental data and mathematical skills to determine both the internal resistance and the EMF of the cell. Most of them provided incorrect and irrelevant mathematical formulas. For instance, one candidate responded as follows:

$$R = IV$$

$$R = 1.30V \times 0.10 A$$

$$R = 0.13\Omega$$

This was an incorrect formula and makes no sense in Physics. The candidates of this category were supposed to know that a cell converts chemical energy into electrical energy. When some energy is supplied to the external circuit, some is dissipated as heat inside the cell due to internal resistance. It can be said that the total resistance (R_T) in the circuit is contributed to by internal resistance (r) and external resistance (R). Thus,

$R_T = R + r$. In this regard, using Ohm's law, one can obtain the following.

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

For part (b)(i), since each cell operated under different current conditions, the terminal voltages are not the same as stipulated in the question. Note that the terminal voltage measures the amount of voltage lost internally. Thus, it implies

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

where, V is the terminal voltage.

Thus, when 0.20 A is drawn from the cell, it implies that

$$E = 1.1 + 0.2r.$$

When 0.1 A is drawn for the cell, it implies that

$$E = 1.3 + 0.1r$$

Since the EMF of the cell is constant, it implies that:

$$1.3 + 0.1r = 1.1 + 0.2r \text{ . Thus:}$$

$$r = \frac{0.2}{0.1} = 2\Omega \text{ .}$$

The EMF can be computed by using $E = 1.3 + 0.1r$. Thus, the EMF of the cell is $E = 1.3 + (0.1 \times 2) = 1.3 + 0.2 = 1.5V$.

Extract 7.1 shows a sample of incorrect responses from one of the candidates in this question.

07a	<u>i) Length of the wire</u> → Another factor that may determine the quantity of heat generated by an electric circuit is the length of wire since when the length is long tends to increase friction that is ~~directly~~ directly proportional to the heat generated.
	<u>ii) Temperature of the surrounding</u> → Another factor is the temperature condition present within the surrounding of the circuit connection. If it's high then heat is high.
7a	<u>iii) Nature of the material (wire)</u> → Another factor determining the quantity of heat generated is the nature of the material used within the process in a circuit. Some materials have high and other low resistivities leading to variation of heat generation value.

07	b/ soln.	
	Data given:	Then
	Voltage (V_1) = 1.1V	From
	Current (I_1) = 0.20A	$R + r = 5.5 \dots i$
	Voltage (V_2) = 1.30V	$R + r = 13 \dots ii$
	Current (I_2) = 0.10A	To find r
	To find internal Resistance.	Substitute
	From	make a subject r in eqn i
	$V = IR$	$R + r = 5.5$
	But $R = (R + r)$	$r = 5.5 - R \dots iii$
	So	Then
	$\frac{V}{I} = \frac{I(R + r)}{I}$	Substitute into eqn ii
	$(R + r) = \frac{V}{I}$	$R + r = 13$
	Then	$R + (5.5 - R) = 13$
	$(R + r) = \frac{1.1V}{0.20A}$	$R - R + 5.5 = 13$
	$R + r = 5.5 \Omega \dots i$	$R - R = 13 - 5.5$
	Then	$R - R_1 = 7.5 \Omega$
	$(R + r) = \frac{1.3V}{0.10A}$	$\therefore$ Internal resistance = 7.5 Ω
	$R + r = 13 \Omega \dots ii$	
07b	ii To find Electromotive force (e)	
	From	
	$E = IR$	
	$E = I(R + r)$	
	$E = 0.20A \times 5.5 + 7.5 \Omega$	
	$E = 0.1A \times 13 \Omega$	
	$E = 1.3V$	
	$\therefore$ Electromotive force is 1.3V	

Extract 7.1: A sample of a candidate's incorrect responses to question 7

In Extract 7.1, the candidate demonstrated insufficient mastery of the topic of *Current electricity*. In part (a), the candidate identified and explained factors that determine the resistance of a conductor instead of the factors

that determine the quantity of heat generated by electric current. In part (b), the candidate failed to apply the correct mathematical expressions for calculating the internal resistance and the EMF of the cell.

The analysis showed that some of the candidates scored between 6.0 and 9.0, which was a good score. These candidates demonstrated their mastery skills on the topic of *Current electricity*. They were able to apply Joule's law to deduce the factors that determine the quantity of heat generated by electric current. Moreover, they applied Ohm's law to obtain the needed mathematical formula and used that formula to deduce the values of the internal resistance and the EMF of the cell. Extract 7.2 presents a sample of the correct responses from one of the candidates to question 7.

7.	a) i/ Current
	The larger the current used the more the heat generated therefore heat produced is directly proportional to current
	$H \propto I^2$
	ii/ Resistance
	The higher the resistance the more the heat generated since it changes electrons to internal heat therefore heat produced is directly proportional to the resistance of the wire
	$H \propto R$
	iii/ Time
	The longer the time is used to heat the more heat is produced unlike a short time therefore heat is directly proportional to time taken. $H \propto t$
	$\therefore H = I^2 R t$
	b) $E \cdot m \cdot f = ?$
	$r = ?$
	$V_1 = 1.1 \text{ V}$
	$I_1 = 0.2 \text{ A}$
	$V_2 = 1.3 \text{ V}$
	$I_2 = 0.1 \text{ A}$
	$E = I(R + r)$
	$E = IR + Ir$
	$E = V + Ir$

7 b)	$E = 1.1 + 0.2r$
	$E = 1.3 + 0.1r$
	$1.1 + 0.2r = 1.3 + 0.1r$
	$1.1 - 1.3 = 0.2r + 0.1r$
	$-0.2 = -0.1r$
	$\frac{-0.2}{-0.1} = \frac{-0.1}{-0.1}$
	$r = 2 \Omega$
	$E = 1.1 + (0.2 \times 2)$
	$E = 1.1 + 0.4$
	$E = 1.5 \text{ V}$
	$\therefore$ The internal resistance is 2Ω
	Electromotive force is 1.5 V

Extract 7.2: A sample of a candidate's correct responses to question 7

Extract 7.2 indicates that the candidate demonstrated adequate knowledge of electric current and the ability to apply mathematical skills in solving Physics problems.

2.2.6 Question 8: Elementary Astronomy and Geophysics

This question consisted of two parts: (a) and (b). Part (a) of the question was set up from the topic of *Elementary astronomy*, while part (b) was designed from the topic of *Geophysics*. Part (a) tested the ability of the candidates to recall the facts about the planets, while part (b) tested the ability of the candidates to identify the effects of volcanic activity on the Earth's surface. The question was structured as follows.

(a) *Why is Venus nicknamed as twin planet of the Earth?*

(b) *Briefly explain:*

- (i) *Two negative effects of volcanic activity on the earth's surface.*
- (ii) *Two positive effects of volcanic activity on the earth's surface.*

A total of 134,004 (100%) candidates attempted the question. Out of these, 7,890 (5.89%) candidates scored from 0.0 to 2.5 marks, 113,583 (84.76%) candidates scored from 3.0 to 5.5 marks, and 12,531 (9.35%) candidates scored from 6.0 to 9.0 marks. The general performance was good, as 126,114 (94.11%) scored from 3.0 to 9.0 marks. Figure 8 summarises the performance of the candidates in question 8.

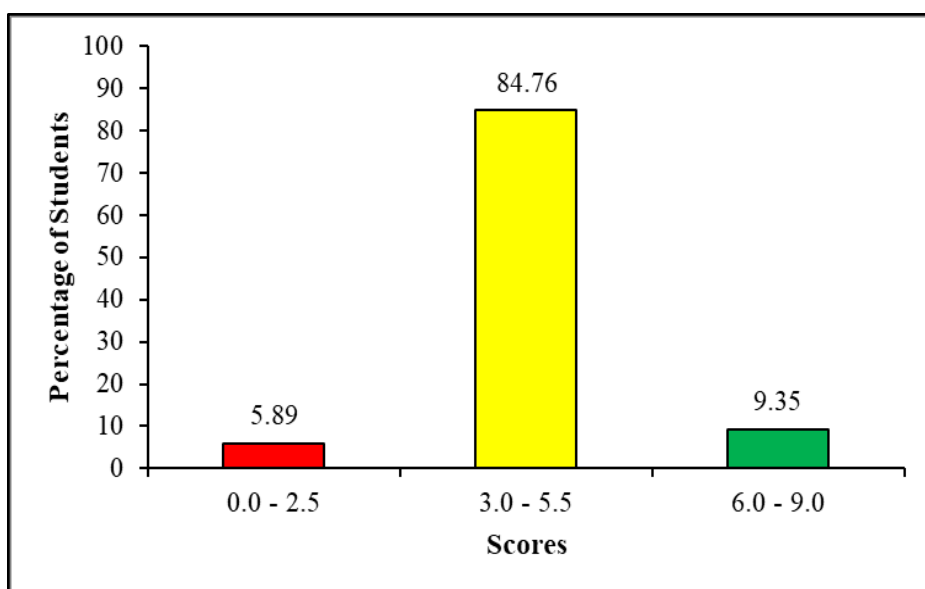


Figure 8: *The Candidates' Performance in Question 8*

The analysis showed that 5.89 per cent of the candidates scored from 0.0 and 2.5, which is poor performance. This suggests that the candidates had insufficient knowledge of the tested topics. These candidates demonstrated incompetence in conceptual understanding and reasoning skills that led them to present incorrect responses. For instance, in part (a), one candidate responded as *“it is because Venus is the only planet that can be viewed from the Earth, while other planets cannot be viewed from the Earth”*. Another Candidate wrote as *“Because its light appears on the Earth at morning and Evening”*. These two candidates wrote the wrong responses because they lacked knowledge of the solar system. They were supposed to recognise that Venus is almost as big as the Earth. Moreover, Venus has the same mass and density as the Earth. In part (b), some candidates failed to provide correct responses due to insufficient knowledge of geophysics, particularly volcanic activity. Extract 8.1 illustrates one candidate's incorrect response to question 8.

2a)	because Venus is the planet that have two names
	o It have natural and nicknamed name of the Earth.
b)	i) Two negative effects of Volcanic activities on the earth surface.
	Firstly i) Temperature, that means the temperature its the negative effect of Volcanic activities of the earth surface.
	ii) Concentration, that means its negative effect of Volcanic activities that it contract the activities of Volcanic of the earth surface.
	ii) Two positive effect of Volcanic activities on the Earth surface.
	i) Human activities
	That means It cause the Volcanic activities for example the activities in water and other It can be affected the Volcanic activities of the Earth.
	ii) pressure
	That means if pressure are high or low It cause the effect the Volcanic activities.

Extract 8.1: A sample of the candidate's incorrect response to question 8

Extract 8.1 indicates that the candidate demonstrated insufficient mastery of the topic of *Elementary Astronomy* and *Geophysics*. In part (a), the candidate failed to provide reasons why Venus is considered similar to Earth. In part (b), the candidate mentioned and explained factors such as temperature, pressure, and concentration as effects of volcanic activity. These were incorrect responses.

The analysis further revealed that some candidates (9.35%) scored between 6.0 and 9.0, which represents a higher performance range. These candidates had enough knowledge on the topics of *Geophysics* and *Elementary astronomy*. They were able to provide reasons why Venus is considered similar to Earth. Moreover, they were able to identify the positive and

negative effects of volcanic activities on the Earth's surface. Extract 8.2 demonstrates the candidates' correct response to question 8.

8.	a)	→ Because it's size is almost as big as the earth's size and hence the name twin planet of the earth.
	b)	i) negative effects
		1) Loss of lives
		People and animals might die due to volcanic eruptions, the magma might burn them to death
		2) Destruction of properties and landscape
		volcanic eruptions destroy people's properties
8	b) i) a) .. but	also destroys the landscape due to bombarding away of mountain tops or creation of new features and depressions.
	ii) positive effects	
		1) Source of energy
		Through geothermal energy, which is cause by volcanic activities. The energy can be harnessed and used
		2) Source of income (Tourism)
		Some volcanic features on the surface attract visitors for example hot springs and mountains attract tourists and did as source of income.

Extract 8.2: A sample of the candidate's correct response to question 8

2.3 SECTION C: Structured Questions

This section consisted of three questions derived from the topics of *Radioactivity*, *Thermionic emission*, *Waves*, *Electronics* and *Electromagnetism*. Each question carried 15 marks and the candidates supposed to answer any two questions in this section making a total of 30 marks.

2.3.1 Question 9: Radioactivity and Thermionic Emission

This question was made up of three parts: (a), (b), and (c) developed from two topics, which are *Radioactivity* and *Thermionic Emission*. Part (a) intended to evaluate the candidates' ability to explain the working principles of the cloud chamber as well as properties of alpha and beta particles. Part (b) was formulated such that it assessed the ability of the candidates to interpret scientific data and apply mathematical reasoning to determine the number of half-lives and their magnitude. Part (c) was designed to assess the candidate's ability to identify and correctly label the components of a cathode ray tube using a sketch. The question was as follows.

- (a) *The cloud chamber is used for detecting ionized nuclear radiation. Explain how you can use it to detect the alpha and beta particles.*
- (b) *One of the nuclear laboratory scientists recorded the information such that the mass of received sample X was 20 g and after 150 days was 0.652g.*
 - (i) *How many half-lives had elapsed for sample X to decay to 0.652 g?*
 - (ii) *Using information obtained in (b) (i) above, determine the half-life of sample X.*
- (c) *Draw a well labelled diagram to show the components of a cathode ray tube.*

A total of 112,105 (83.66 %) candidates attempted this question. Out of which 38,813 (34.62 %) candidates scored from 0.0 to 4.0 marks, 48,613 (43.36%) candidates scored from 4.5 to 9.5 marks and 24,679 (22.01%) candidates scored from 10.0 to 15.0 marks. The general performance was good, as 73,292 (65.37%) candidates scored from 4.5 to 15.0 marks. Figure 9 summarises the performance of the candidates in question 9.

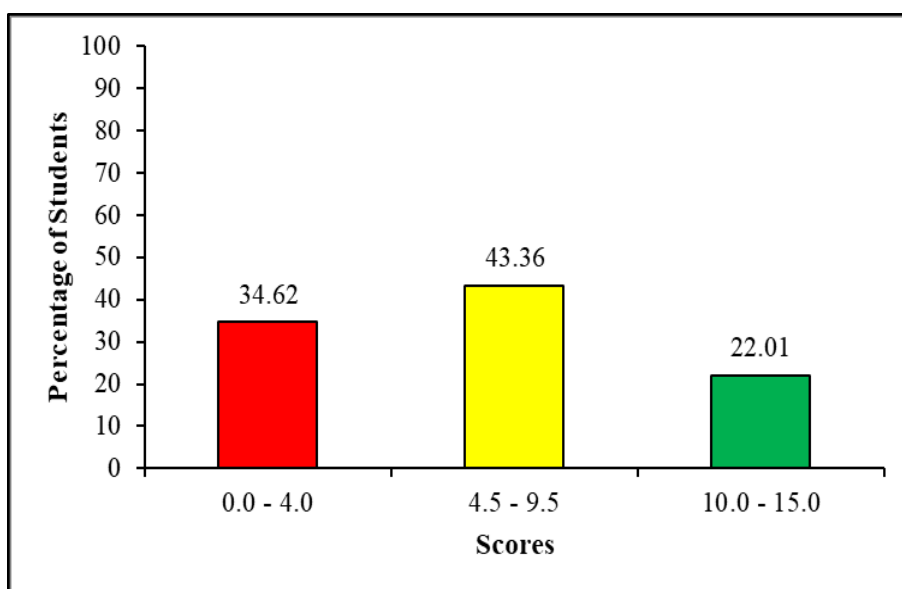


Figure 9: *The Candidates' Performance in Question 9*

Some of the candidates (34.62%) who attempted this question scored lower marks (0.0-4.0). These candidates failed to demonstrate adequate mastery of the concepts and skills related to the topics of *Radioactivity* and *Thermionic Emission*. Most of them provided incorrect responses. For instance, in part (a), these candidates failed to describe the use of a cloud chamber in detecting ionised nuclear radiation. One candidate responded as “*The cloud chamber can be used to detect alpha particles because alpha particles have low ionizing power so it can ionize easily while Beta particles have high ionising power compared to alpha particles therefore, it cannot ionize easily*”. This statement contains a major conceptual misunderstanding about the ionising power of alpha and beta particles. The candidate was expected to recognise that an alpha particle carries a double positive charge ($+2e$) and has a relatively high mass, which causes it to exert a strong electrostatic interaction on the electrons of nearby atoms. In contrast, a beta particle has a smaller charge ($-e$) and much lower mass, resulting in weaker electrostatic interactions with the electrons of atoms it passes by. Ionising ability depends on how strongly the particle attracts or repels electrons in atoms. Thus, alpha particles have higher ionisation power than beta particles. This shows that the candidate had little knowledge of radioactivity, particularly the concept of the detection of nuclear radiation. It could be assumed that the candidates of this type have never seen or used a cloud chamber in the laboratory.

In part (b), the candidates failed to calculate the number of half-lives and the corresponding half-life due to insufficient mathematical and analytical skills. Additionally, some candidates were unable to interpret the scientific data provided to determine the required half-life. These difficulties were largely attributed to a lack of understanding of radioactivity, particularly concepts of half-life. They were supposed to do as follows:

Given, $N_0 = 20\text{g}$ and $N_t = 0.652\text{g}$

$$\frac{N_t}{N_0} = \left(\frac{1}{2}\right)^n$$

$$\frac{0.652}{20} = \left(\frac{1}{2}\right)^n$$

$$n \log(0.5) = \log 0.0326$$

$$n = \frac{\log 0.0326}{\log 0.5} = \frac{-0.1488}{-0.3010}$$

$$n = 4.9 \approx 5$$

Therefore, 5 half-lives took place

Alternatively:

$$20 \xrightarrow{t_1} 10 \xrightarrow{t_2} 5 \xrightarrow{t_3} 2.5 \xrightarrow{t_4} 1.25 \xrightarrow{t_5} 0.625$$

The half-life can be obtained by applying the following steps.

$$n = \frac{t}{T} = \frac{150}{T}$$

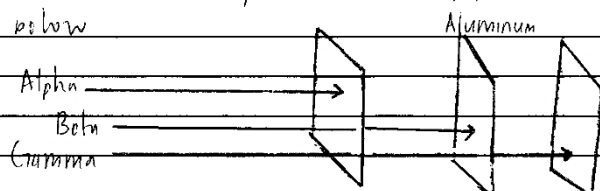
$$T = \frac{t}{n} = \frac{150}{5} = 30$$

$$T = 30 \text{ days}$$

Therefore, the half-life is 30 days

In part (c), these candidates failed to provide a correct sketch for a cathode ray tube. Extract 9.1 presents a sample of the candidate's incorrect responses to question 9.

09 a) The cloud chamber detecting ionized nuclear radiation of the alpha and beta particle through the use of different materials of which one of the particles pass through but other do not trap the materials example Aluminium, paper etc as it shown below



b) i) soln

$$\text{Half life} = \frac{0.652 \text{ g} \times 150 \text{ days}}{20 \text{ g}}$$

$$= 4.89 \text{ days}$$

∴ This is half

∴ Then if 4.89 half-life had elapsed for sample X to decay to 0.652g.

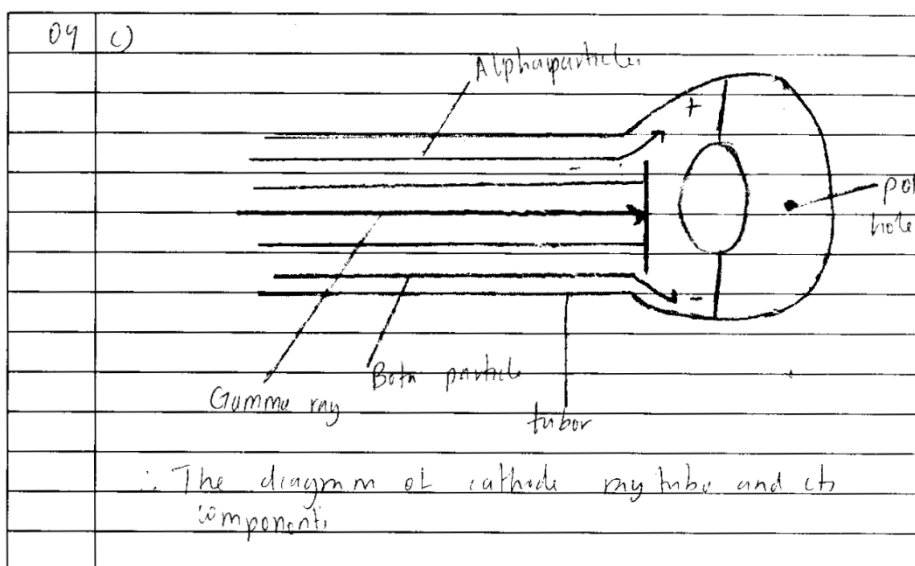
ii) soln

$$\text{Half life} = \frac{4.89 \text{ days} \times 0.652 \text{ g}}{20 \text{ g}}$$

$$= \frac{3.18828 \text{ days}}{20}$$

$$= 0.159 \text{ days}$$

The half life of sample Y is 0.159 days

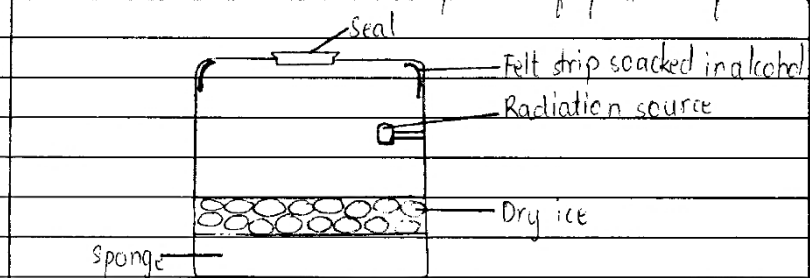


Extract 9.1: A sample of candidate's incorrect responses to question 9

In Extract 9.1, the candidate also failed to explain the use of a cloud chamber in detecting ionising radiation, reflecting a lack of conceptual understanding of radioactivity, particularly in radiation detection. Moreover, in part (b), the candidate demonstrated inadequate mathematical skills, resulting in the inability to determine the number of half-lives and the corresponding half-life. Furthermore, weaknesses in understanding the working principles of the cathode ray tube prevented the candidate from accurately drawing its diagram.

The analysis showed that some of the candidates (22.01%) scored from 10.0 and 15.0, which is considered a higher score. These candidates applied concepts, theories and principles related to radioactivity and thermionic emission correctly. Moreover, they demonstrated strong mathematical and analytical skills, which enabled them to correctly determine both the number of half-lives and their magnitude. Extract 9.2 presents a sample of correct responses from one of the candidates in question 9.

9. (a) Cloud chamber is an instrument used to detect the presence of a certain nuclear radiation, whether its an alpha, beta or gamma particle. The cloud chamber is composed of water vapour enclosed inside, a source of radiation and a camera to take the photo of patterns formed.



A diagram of the cloud chamber.

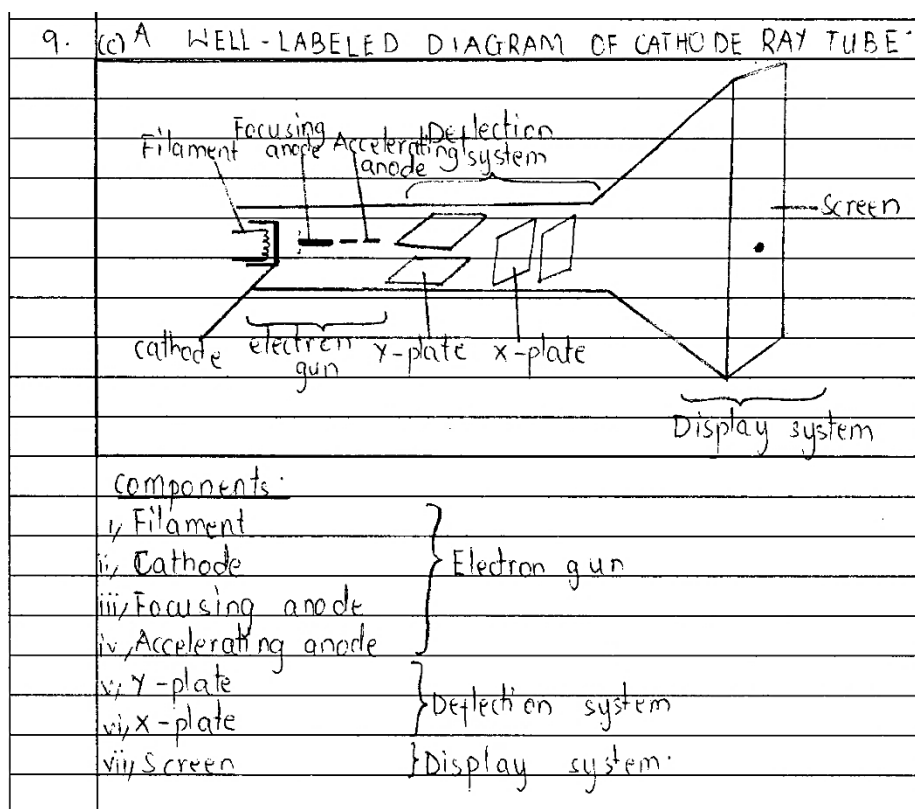
When alpha radiations are produced, since there is water vapour, the water vapour will accumulate on the ionised gases formed due to alpha radiations and form long strips captured by the camera.

alpha(α) =

When beta particles are produced they ionise the gas inside and the water vapour will accumulate around the beta particles thus forming wave-like patterns.

beta(β) =

9.	(b) (i) solution:
	$N = \frac{N_0}{2^n}$
	$0.652 = \frac{20}{2^n}$
	$2^n = \frac{20}{0.652}$
	$2^n = 30.6748 \dots$
	$2^n = 31$
	$\log_2 31 = n$
	$\frac{\log 31}{\log 2} = n$
	$n = 4.954 \dots \approx 4.5$
	$\therefore 5$ half-lives had elapsed.
	(ii) solution:
	$n = \frac{t}{t_{1/2}}$
	$5 = \frac{150}{t_{1/2}}$
	$t_{1/2} = \frac{150}{5}$
	$t_{1/2} = 30 \text{ days}$
	$\therefore$ The half-life of sample X is 30 days.



Extract 9.2: A sample of candidate's correct responses to question 9

2.3.2 Question 10: Waves and Electronics

The question consisted of three parts: (a), (b), and (c) designed from the topics of *Waves* and *Electronics*. Part (a) tested the ability of the candidates to identify the application of diffraction of waves. Part (b) was constructed to test the ability of the candidates to analyse scientific data and apply mathematical reasoning to relate the masses on the vibrating wire with its frequency. Part (c) tested the representing skills of the candidate to draw PNP and NPN transistor circuit symbols. The question was as follows:

- (a) Briefly explain three applications of diffraction of waves.
- (b) One scientist was investigating the impact of tension on the frequency of vibrating wire. The following data were recorded: Length of a stretched wire was 30 cm; tension of wire was 900 N and slotted masses of 3 g and 12 g. Use these data to show how the masses on the vibrating wire affects its frequency.

(c) Draw the PNP and NPN transistor circuit symbols and indicate their three layers of the transistors and direction of conventional current.

A total of 72,284 (53.94 %) candidates attempted this question. Out of these, 56,815 (78.60%) scored from 0.0 to 4.0 marks, 12,910 (17.86 %) scored from 4.5 to 9.5 marks and 2,559 (3.54 %) scored from 10.0 to 15.0 marks. The general performance was weak, as 15,469 (21.40%) scored from 4.5 to 15.0 marks. Figure 10 summarises the performance of the candidates in question 10.

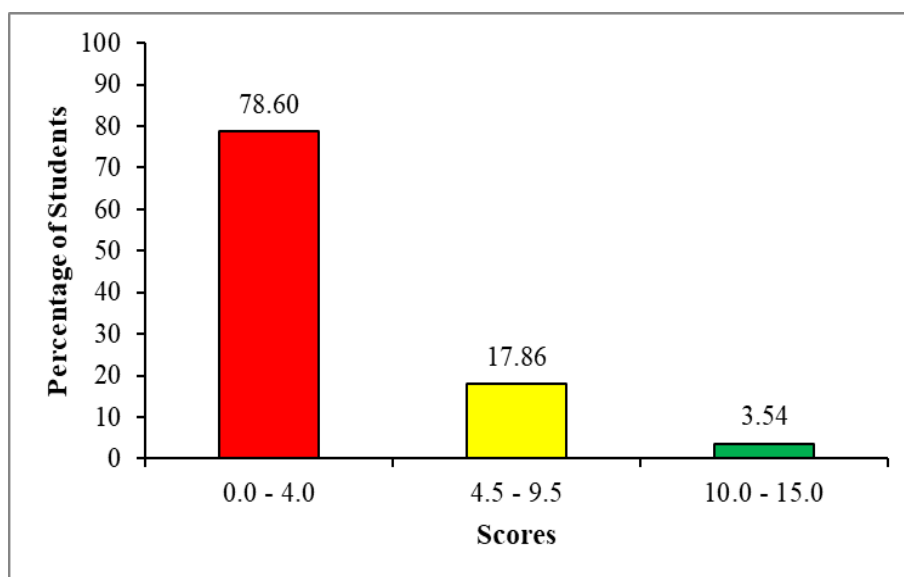


Figure 10: The Candidates' Performance in Question 10

The analysis showed that most of the candidates (78.60%) who attempted this question scored lower marks (0.0-4.5). These candidates demonstrated inadequate knowledge and skills on the topics of *Waves* and *Electronics*. In part (a), these candidates were unable to recognise or explain the practical application of wave diffraction. Most of them provided irrelevant responses. For instance, one of the candidates wrote:

- (i) *Diffraction of waves are applied in studios to defend the sound from outside to enter into the studio and interfere inside sound*
- (ii) *Diffraction of waves are applied on musical instruments for example, Headphones, Ear Pods.*

This candidate provided unclear responses. A lot of misconceptions are visible in these responses. For example, in response (i), the diffraction of

sound waves cannot be used to prevent noise in the studio. The candidate was supposed to know that the main principle for preventing outside noise is reflection and absorption, not diffraction. Diffraction actually spreads waves around obstacles. On the other hand, headphones and earphones do not use diffraction to transmit sound to our ears.

Another candidate responded to the same part as follows:

(i) *Used in making of mirrors*

(ii) *Used in musical sound*

(iii) *Used in hospital for diagnosis*

These responses mix the concepts of ray optics and wave optics. The candidates in this category were supposed to realise that the reflection of light by the mirror is ray optics and does not rely on the diffraction of the wave (wave optics). Part (ii) of the candidate's response was partially correct, as diffraction explains how musical sound spreads from a musical instrument or around obstacles. However, the candidate did not provide supporting reasoning, making the response ambiguous. A similar pattern is observed in response (iii). They were supposed to write in brief the following applications of diffraction of waves as follows:

(i) The process of diffraction is used in long-distance radio signal propagation. It helps radio waves to propagate a short distance that is why we have transmitters in different parts of the country.

(ii) Diffraction is used in a hologram to generate a three-dimensional impression of an image. Different versions of the image get diffracted and reach a lens from multiple sides, all together forming an interference pattern. This pattern is then made to fall on a holographic plate, providing a three-dimensional image.

(iii) Diffraction is used in measuring the coefficient of thermal expansion, crystalline size and thickness of thin films

(iv) X-ray diffraction is used to determine the distance between two consecutive atoms of a material. X-ray diffraction is crucial in the meteorological, pharmaceutical, chemical and other related industries because whenever researchers come across some unidentified materials, they need to figure out the details about their structure, starting with the alignment, distance and other characteristics of their atoms.

In part (b), these candidates failed to apply the correct formula to deduce the relationship between masses on the vibrating wire and frequency. It can be said that these candidates had inadequate knowledge and skills on the topic of *Waves*, as well as mathematical skills. Moreover, these candidates failed to interpret the given scientific data and use them to evaluate the relationship between the masses of a vibrating string and frequency. This is an indication of weak practical and reasoning skills. Thus, it can be said that these candidates have never seen or used this setup to verify the dependence of frequency on the tension of the string. They were supposed to know that the experimental setup to verify the relationship between the frequency (f) of a vibrating string and its tension (T) involves a sonometer. The candidates in this category were supposed to apply the following formula:

$$f = \frac{1}{2l} \sqrt{\frac{T}{\mu}}$$

where, f is the frequency in Hz, T is tension in N, l is length in m, and μ is mass density (mass per unit length) in kg/m. From the question, the masses (3 g and 12 g) are used to adjust the tension in the wire if it hangs vertically over a pulley (see any sonometer setup). As per the mathematical formula, it is clear that $f \propto \sqrt{T}$. Thus, as the mass increases, the tension increases, and the frequency also increases. Now, for 3 g, the tension is

$$0.003 \text{ kg} \times 9.8 \frac{\text{N}}{\text{kg}} = 0.0294 \text{ N.} \quad \text{For a 12 g, the tension is}$$

$$0.012 \text{ kg} \times 9.8 \frac{\text{N}}{\text{kg}} = 0.1176 \text{ N. Thus:}$$

$$\frac{f_2}{f_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{0.1176}{0.0294}} = 2. \text{ Based on this finding, it is evident that when the}$$

mass is increased from 3 g to 12 g, the tension increases 4 times, and the frequency doubles.

The analysis further showed that these candidates failed to score higher marks in part (c). The candidates failed to provide a correct circuit symbol for NPN and PNP transistors. They were supposed to realise that for an NPN transistor, the current flows out of the emitter when the transistor is forward biased, thus, the arrow on the emitter points away from the base (outward). For easy remembering, “NPN $\leftrightarrow$ Not Pointing iN” (arrow points

out). On the other hand, for a PNP transistor, the current flows into the emitter when forward-biased. Thus, the arrow on the emitter points inward (toward the base). For easy remembering, “PNP ↔ Pointing iN” (arrow points in). Extract 10.1 presents a sample of incorrect responses to question 10.

10a)	Application of diffraction of waves		
i.	It is used in Musical devices For Example is used In Studios to prevent and Organize Sound in the Studio Rooms.		
ii.	It is used in Designing musical Instruments like Piano, trumpets, Speakers and Extra.		
iii.	It is used by some Animals who they can't see For Example bats. They use to Fly while ~~Send~~ Sending an Echo and If the wave is diffracted they ~~know~~ they was an Alcohol.		
b)	Data given:		
	length is 30cm.		
	Tension of wire 900N.		
	Slotted mass: 3g and 12g		
	Formular: $f = \frac{1}{\lambda}$		
	Wave Length = $\frac{\text{Velocity}}{f}$		
	Mass = (12-3)g = 9g		
	Mass = 9g.		
	∴ The mass is 9g.		
c)	PNP Diagram:		
	P	N	P
	+++	- +	+++
	+++	+ -	+++
	+++	- +	+++
	NPN Diagram:		
	N	P	N
	- + -	++	- + -
	- + -	++	- + -

Extract 10.1: A sample of candidate's incorrect response to question 10

In Extract 10.1, the candidate demonstrated a poor conceptual understanding of the application of diffraction, which led to an incorrect response in part (a). The candidate also failed to analyse and interpret the scientific data to explain how the masses on the vibrating wire affect its frequency. Furthermore, the response in part (c) indicates a content knowledge gap, as the candidate was unable to provide circuit symbols of the PNP and NPN transistors.

Some of the candidates (3.54%) who attempted this question scored between 10.0 and 15.0, which is a higher score. These candidates had enough knowledge and skills on the topics of *Waves* and *Electronics*. They applied their practical and mathematical skills to evaluate the relationship between frequency and tension of the string. These candidates were able to differentiate between NPN and PNP transistors using their circuit symbol. Extract 10.2 illustrates the correct responses to question 10.

10.a)	Application of diffraction of waves
i)	Diffraction is used in holograms to create a three dimension display (3D display). Holograms are useful in presentations and give a visual imagination in various projects.
ii)	X-ray diffraction is an essential use and application of diffraction of waves. X-ray diffraction is useful in bringing about essentials in the medical field for diagnosis of various diseases.
iii)	Diffraction is applied in long-distance communication by making use of the earth's terrain and obstacles present. This enhances communication which is part and parcel of the human life.
b)	Data given.
	Length, $l = 80\text{cm}$
	Tension, $T = 900\text{N}$
	Masses, m_1 and $m_2 = 8\text{g}$ and 12g .
	Recall:
	Frequency = $\frac{1}{2l} \sqrt{\frac{T}{M}}$
	Where;
	$M = \text{Mass per unit length (kg/m)}$
	For 8g mass;
	First, 80cm to m
	$1\text{m} = 100\text{cm}$
	$\times \frac{80}{100}$
	$= 0.8\text{m}$

10. b)	$1\text{kg} = 1000\text{g}$
	$x = 3\text{g}$
	$= 0.003\text{kg}$
	$M = \text{Mass}$
	Length
	$M = 0.003\text{kg}$
	0.3m
	$M = 0.01\text{kg/m}$
	$f = \frac{1}{2 \times 0.3\text{m}} \sqrt{\frac{900\text{N}}{0.01\text{kg/m}}}$
	$f = \frac{1}{0.6\text{m}} \sqrt{90000}$
	$f = \frac{5 \times 300}{3}$
	$f = 500\text{Hz}$
	For the 12g mass;
	$1\text{kg} = 1000\text{g}$
	$x = 12\text{g}$
	$= 0.012\text{kg}$
	$f = \frac{1}{2 \times 0.3} \sqrt{\frac{900}{M}}$
	$M = 0.012\text{kg}$
	0.3m
	$M = 0.04\text{kg/m}$
	$f = \frac{5}{3} \sqrt{\frac{900}{0.04}}$
	$f = \frac{5}{3} \times 150$
	$f = 250\text{Hz}$

10. b)	From the calculations above; the higher the mass on vibrating wire the lower the frequency and the lower the mass on vibrating wire, the higher the frequency.
	$\therefore \text{Frequency} \propto \frac{1}{\text{Mass}}$
c)	
	NPN transistor PNP transistor

Extract 10.2: A sample of candidate's correct responses to question 10

In Extract 10.2, the candidate correctly answered the question by identifying the applications of wave diffraction and accurately applying mathematical skills to compute the relationship between the frequency and mass of a vibrating wire. The candidate also demonstrated sufficient knowledge in Electronics by correctly drawing the PNP and NPN transistor circuits with a high level of competence.

2.3.3 Question 11: Electromagnetism

This question comprised of three parts (a), (b) and (c). It was crafted from the topic of *Electromagnetism*. Part (a) tested the knowledge and representation skills where by the candidates were tasked to draw and describe mode of action of electric bell circuit. Part (b) tested the ability of the candidate to apply Fleming's left-hand rule to explain the direction of the force in a current carrying wire. Part (c) consisted of two sub parts where by in part (c) (i), the candidate was tested on the ability to identify the factors which affect the efficiency of the transformer while in part (c)

- (ii), to determine two factors which affect the magnitude of the induced e.m.f of the conductor. The question was as follows:
- Draw a well labelled electric bell circuit and explain how it works.*
 - Use the Fleming's left-hand rule to explain the direction of the force in a current carrying wire.*
- (c) (i) *What makes the efficiency of a transformer to be less than 100%. Briefly explain.*
- (ii) *With reference to Faraday's law of electromagnetic induction, determine two factors which affect the magnitude of the induced e.m.f of the conductor.*

A total of 83,613 (62.39%) candidates attempted this question. Out of these, 52,113 (62.33%) scored from 0.0 to 4.0 marks, 22,148 (26.49 %) scored from 4.5 to 9.5 marks, and 9,352 (11.18%) scored from 10.0 to 15.0 marks. Generally, the performance was average, as 31,500 (37.67%) candidates scored from 4.5 to 15.0 marks. Figure 11 summarizes the performance of the candidates in question 11.

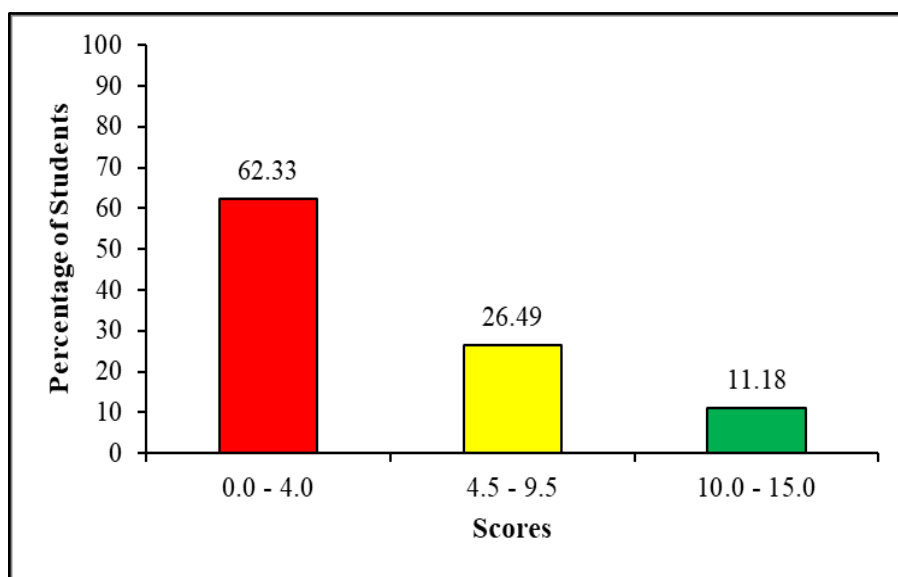


Figure 11: *The Candidates' Performance in Question 11*

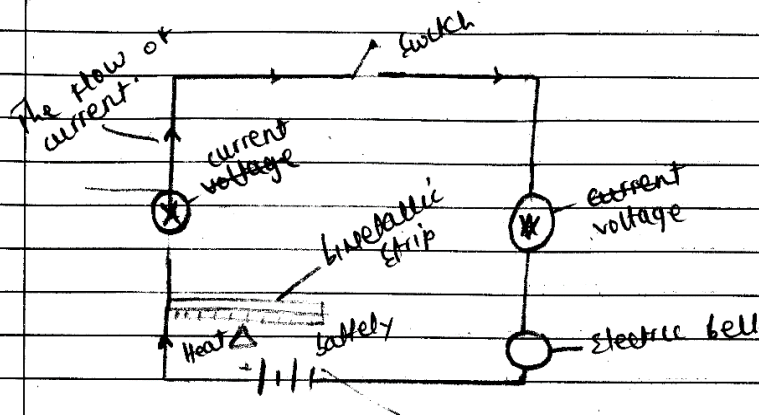
The analysis showed that most of the candidates who attempted this question scored from 0.0 to 4.5 marks, which is a low score. This suggests that the candidates lacked enough knowledge and skills on the topic of *Electromagnetism*. In part (a) of this question, candidates were unable to

distinguish between the electric bell and the fire alarm circuits, resulting in inaccurate diagrams and incorrect explanations of the electric bell's mode of operation. Some candidates were able to describe the correct mode of operation of an electric bell, but failed to provide an accurate sketch. It implies that these candidates have never seen an electrical bell (the circuit) in real-life. In part (b), these candidates failed to apply Fleming's left-hand rule to determine the direction of the current. Some candidates incorrectly applied the Grip (right-hand) rule instead of Fleming's left-hand rule. For instance, one candidate responded by stating the right-hand grip rule. The candidate responded as *"when the conductor is gripped by the right hand the fingers will curl showing the direction of magnetic field around the conductor and the fingers will point in the direction of current"*. The candidate's response was incorrect. The candidates of this category were supposed to know the right-hand grip rule used to deduce the direction of the magnetic field around a current-carrying conductor. Fleming's left-hand rule is used to deduce the direction of force (motion) on the current-carrying conductor in a magnetic field.

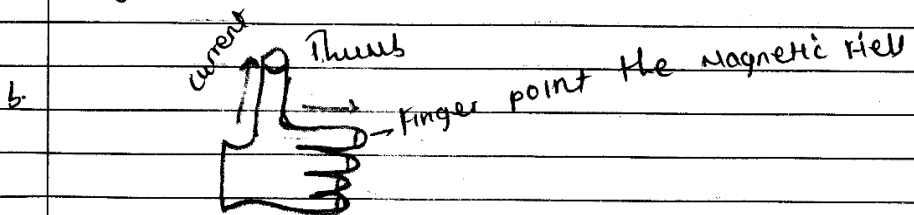
In part (c), these candidates failed to identify the factors that cause the efficiency of a transformer to be less than 100%. This indicates that these candidates had insufficient understanding of the transformer's operating mechanism. Furthermore, their inadequate knowledge of electromagnetic concepts prevented them from correctly explaining the factors that affect the magnitude of the induced electromotive force (e.m.f.) in a conductor. Extract 11.1 summarises the incorrect responses from one of the candidates in question 11.

11 a

AN ELECTRIC BELL CIRCUIT



When the bi-metallic strip are heated at a room temperature, and the temperature of the room are rises the bi-metallic strip can gain high amount of the heat produced which will cause the bi-metallic strip to bent due to high ~~are~~ heat energy produced. Then the ~~current~~ bi-metallic strip will continue to gain heat until it over heated then the bi-metallic strip will break up and cause the flow of electricity over the circuit and then the electricity produce may cause the bell to rung at the end of time.



Fleming's right hand rule" It state that if the fingers are pointing the direction of the magnetic field the thumb's will pointing the direction of the current carrying by the wire. So this

11 b.	Means that all the magnetic field will be held or will be pointing by the finger while the direction of the force current will be direction pointing on the direction of the force current carrying by the wire
c.i	The efficiency of transformer are less than 100% because of the friction force. This occurs when the the transformer has supply the electricity so not all current from the substation will be ending like starting pointing.
ii	The length of the conductor - Electromagnetic induction can be affected by the length of conductor simply because the electromagnetic induction can face obstacles when the conductor - has a high length while when its low the electromagnetic can not be affected.
	Amount of electromotive force carried by conductor - The higher electromotive force can affect the - electromagnetic induction simply because the amount of emf carried when is high might affect the electromagnetic induction.

Extract 11.1: A sample of a candidate's incorrect responses to question 11

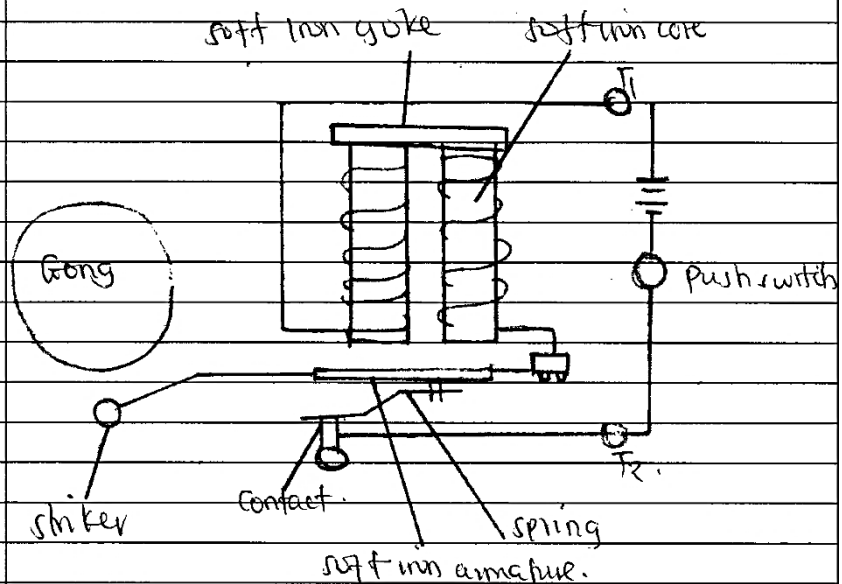
In Extract 11.1, the candidate demonstrated weak skills in the topic of *Electromagnetism*. In part (a), the candidate drew a diagram of a bimetallic strip; thus, the response was incorrect. In part (b), the candidate stated Fleming's right-hand rule, whereas the question required Fleming's left-hand rule. In part (c)(i), the candidate incorrectly identified frictional force as the reason for a transformer's efficiency being less than 100%. Friction is relevant to moving machine parts in the context of *Simple machines*, not transformers. In part (c)(ii), the candidate failed to interpret the question correctly and listed factors such as the length of the conductor and the

applied electromotive force, which are actually factors affecting the resistance of a conductor in the topic of *Current Electricity*, not the magnitude of the induced e.m.f.

The analysis further revealed that some of the candidates (11.18%) who attempted this question scored from 10.0 to 15.0 marks, which is a higher score. This suggests that these candidates had enough knowledge and skills on the topic of *Electromagnetism*. They demonstrated competence in conceptual understanding and reasoning skills, together with visualisation and representation skills, which led them to provide correct responses. They managed to correctly respond to the use of Fleming's left-hand rule in determining the direction of the force in a current-carrying a conductor. They were able to identify factors which affect the magnitude of the induced e.m.f of the conductor. Extract 11.2 shows a sample of a candidate's correct responses to question 11.

11. a) How the electric bell works?

Consider the diagram.



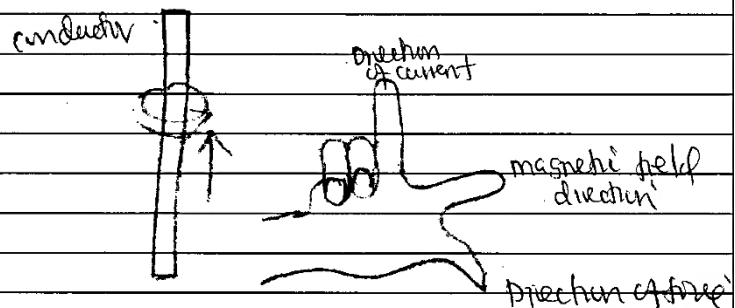
Mechanism -

When the switch is switched on current flows and the soft iron core becomes magnetised and generates a magnetic field that attracts the soft iron armature towards it. These attractions cause the striker to strike the gong and the contact is broken. This causes the soft iron core to lose its magnetism. The armature is returned to its position by the spring and the circuit becomes complete.

The cycle of events is repeated automatically and hence sound is produced by the electric bell.

b) Fleming's left hand rule states that "When you hold left hand so that the index finger, middle finger and the thumb are mutually perpendicular to each other then the index finger represents the direction of the magnetic field, the middle finger represents the direction of current and the thumb represents the direction of force."

from the stated rule: This means that:
The thumb represents the direction of force
That is dynamically



c) 1) What makes the efficiency of a transformer be less than 100%?

- Eddy currents

These are circulating loops of currents which normally cause loss of power in form of heat hence lowering the transformer efficiency.

	• Copper resistance The resistance of copper cause heating hence losing of power in form of heat thus lowering the transformer efficiency
	• Flux linkage This is due to the failure of the magnetic flux produced in the primary coil to link with the secondary coil. It can be minimised by winding the secondary with turns in the primary coil turn
	• Hysteresis loss This is the energy losses due to continuous magnetisation and demagnetization
	11) The factors which determine the magnitude of the induced emf: • The number of turns ∴ The larger the number of turns the larger induced emf of the conductor while the less number of turns the low/small amount of induced emf
	• Cross sectional area The larger the cross sectional area the larger the induced emf while the small the cross sectional area the small the induced emf.

Extract 11.2: A sample of candidate's correct response to question 11

In Extract 11.2, the candidate demonstrated strong mastery of the topic of Electromagnetism, particularly by accurately drawing and explaining the rules that govern the application of electromagnetic concepts.

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

The Physics practical paper was constructed with three alternative papers: 031/2A Physics 2A, 031/2B Physics 2B and 031/2C Physics 2C. Each alternative paper contained two questions, each of which carried 25 marks, making a total of 50 marks. The papers were designed to assess candidates' ability to conduct experiments in Physics, including setting up the apparatus, collecting data, presenting data, analysing results and drawing scientific conclusions.

In question 1, each alternative focused on the topic of *Measurements*. In paper 2A, 2B and 2C, candidates were required to determine the density and relative density of different materials, which are Steel metal, Korie oil and Cyprus wood, respectively.

In question 2, each alternative paper was based on the topic of *Light*. In papers 2A, 2B and 2C, candidates were required to perform an experiment to investigate the optical properties of a plane mirror, to determine the value of the critical angle as well as the refractive index of the rectangular glass block, respectively.

The candidates were required to answer both questions 1 and 2 in each alternative practical.

3.1 Question 1: Measurements

A total of 133,906 (100%) candidates attempted the question, and their scores were distributed as follows: 30,704 (22.93%) candidates scored from 0.0 to 7.0 marks; 57,447 (42.90%) candidates scored from 7.5 to 16.0 marks, and 45,755 (34.17%) candidates scored from 16.5 to 25.0 marks. This suggests that the candidates' performance was good as 103,202 (77.07 %) candidates scored from 7.5 to 25.0 marks. Figure 12 illustrates the candidates' performance on this question.

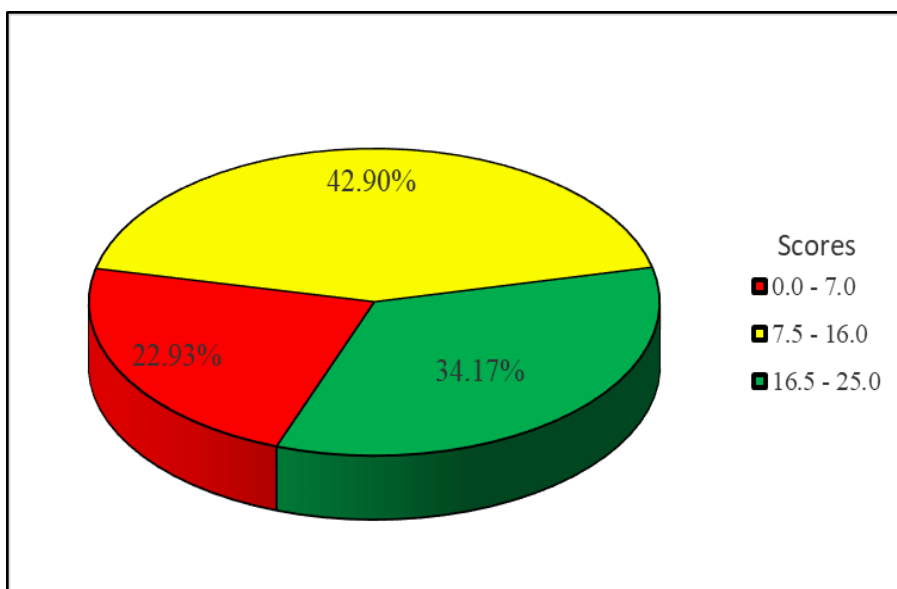


Figure 12: *The Candidates' Performance in Question 1 for Physics Paper 2*

3.1.1 031/2A Physics 2A

In Physics 2A question 1, the candidates were provided with the statement, “Density is one of the physical quantities that is used to differentiate materials with the same dimensions”. The candidates were required to quantify the statement by performing an experiment to determine the numerical value of the density of steel by using the following apparatus; plastic measuring cylinder of 250 cm^3 , six (6) steel slotted masses each of 50 g, and water filled in the beaker.

They were instructed to proceed as follows:

- Pour water into the measuring cylinder to the volume, $V_o = 100 \text{ cm}^3$
- Insert the slotted mass, m of 50 g, in the cylinder and record the corresponding new volume readings.
- Repeat procedure 1 (b) by adding another mass (m) of 50 g until you get a total of six (6) readings. Read and record the volume readings in each case.

Questions

- Record your results in tabular form as shown in Table 2.
Initial volume $V_o = 100 \text{ cm}^3$.

Mass, m (g)	$\frac{1}{m}$ (g ⁻¹)	Volume readings, V(cm ³)	V – V ₀ (cm ³)	$\frac{1}{V - V_0}$ cm ⁻³
50				
100				
150				
200				
250				
300				

Table 2

- (ii) Plot a graph of $\frac{1}{m}$ against $\frac{1}{V - V_0}$
- (iii) Determine the slope of the graph plotted in 1 (ii).
- (iv) What does the slope in 1 (iii) represent?
- (v) Determine the density and relative density of the material used to make the slotted masses of the steel.

Some of the candidates (42.90%) who attempted this question scored from 0.0 to 7.0, which is a low score. These candidates demonstrated unsatisfactory experimental skills in the topic of *Measurements*. Most of them failed to set up the experiment, collect data, analyse data, interpret findings, and provide a scientific conclusion. Based on their presented data, it could be assumed that most of them failed to use the measuring cylinder correctly to measure and record the volume of water. Most of them reported data which were out of the expected experimental range. As a result, they plotted an incorrect graph, which led to incorrect scientific conclusions.

The analysis further revealed that some candidates lacked computational skills. They failed to calculate the reciprocal of slotted masses and the volume of displaced liquids. Some of them reported mass as weight. Thus, they ended with an incorrect table of results, causing significant loss of marks across almost all parts of their experimental presentation.

Some of them were unable to obtain the slope of the graph correctly. For instance, one of them obtained a slope of the graph using the following expression:

$slope = \frac{M_2 - M_1}{V_2 - V_1}$. This was an incorrect expression of the slope. This is to say that the candidates plotted an incorrect graph. The candidates were supposed to plot a graph of $\frac{1}{m}$ against $\frac{1}{V - V_o}$. Thus, the slope of the

$$\text{graph is } \frac{\Delta\left(\frac{1}{m}\right)}{\Delta\left(\frac{1}{V - V_o}\right)}.$$

Moreover, most of these candidates failed to include important features on the graph, such as a title of the graph, properly labelled axes, appropriate scales, slope indication, and a best-fit line. Some of them were unable to transfer data points accurately, resulting in incorrect values for the quantities requested. Some candidates were unable to answer part (iv) correctly, which required them to explain the meaning of the slope. For instance, one of the candidates stated that *it represents the straight line of the graph*. Probably this candidate tried to state the nature of the graph, but it is not the correct answer. The candidates of this category were supposed to deduce the meaning of slope as follows:

$$density(\rho) = \frac{\text{mass of the substance}}{\text{volume of the substance}}.$$

As per the experiment, volume of the substance = $V - V_o$. It follows that

$$\rho = \frac{m}{V - V_o}. \text{ This implies that } \frac{1}{m} = \left(\frac{1}{\rho}\right) \frac{1}{V - V_o}. \text{ Thus, comparing it with}$$

the linear equation ($y = mx + c$), it implies that a slope of the graph of $\frac{1}{m}$

against $\frac{1}{V - V_o}$ is the $\frac{1}{\rho}$. Therefore; the slope of the graph represents the

reciprocal of density. Using the slope, the density of slotted mass could be determined. Extract 12.1, is a sample of the candidates' incorrect responses to this question.

i.	i.)	Mass, m (g)	ρ (g-1)	Volume	$(V-V_0) \text{ cm}^3$	$\frac{1}{V-V_0}$
			$\frac{m}{V}$	$\frac{\text{reading of } V \text{ (cm}^3\text{)}}{V-V_0}$	0.2	5
		50	0.02	100.20	0.30.2	-99.9
		100	0.01	100.30	0.3	-99.9
		150	6.67	100.40	0.4	-99.9
		200	5.03	100.50	0.5	-99.9
		250	4.03	100.60	0.6	-99.9
		300	3.3	100.80	0.8	-99.9

$$\text{iii) Slope} = \frac{\Delta x}{\Delta y}$$

$$\text{slope} = \frac{\Delta x_2 - \Delta x_1}{\Delta y_2 - \Delta y_1}$$

$$\text{Slope} = \frac{33 - 0.02}{-99.9 - 99.9} = \frac{3.28}{0} = 3.28$$

$$\therefore \text{Slope} = 3.28$$

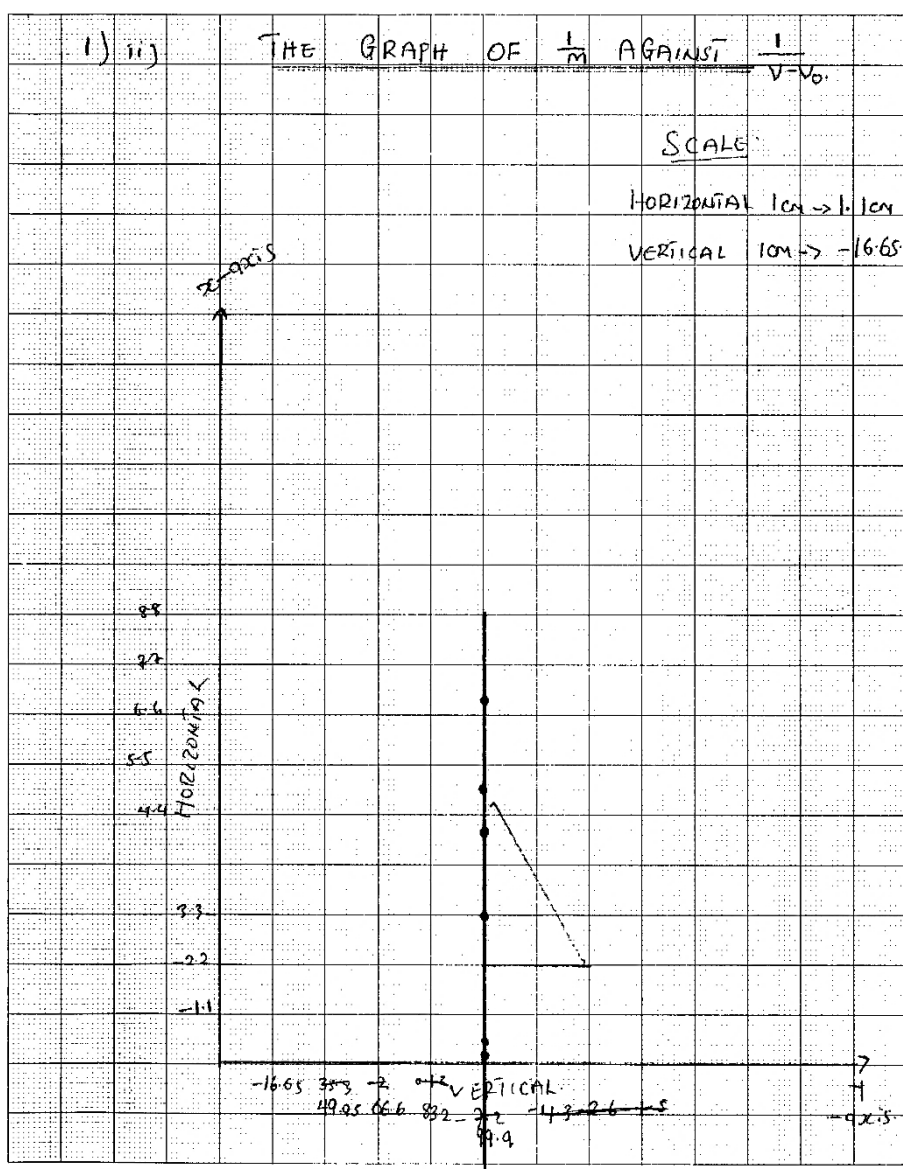
iv) The slope represent straight line of the graph.

$$\text{v) Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\rho = \frac{504}{\text{But } \frac{\text{Mass} = M_1 + M_2 + M_3 + M_4 + M_{\text{total}}}{\text{Volume} = V_1 + V_2 + V_3 + V_4 + V_5}}$$

$$\rho = \frac{300}{502.8} = 0.49 \approx 0.5$$

$\therefore$ The density of material used = 0.5



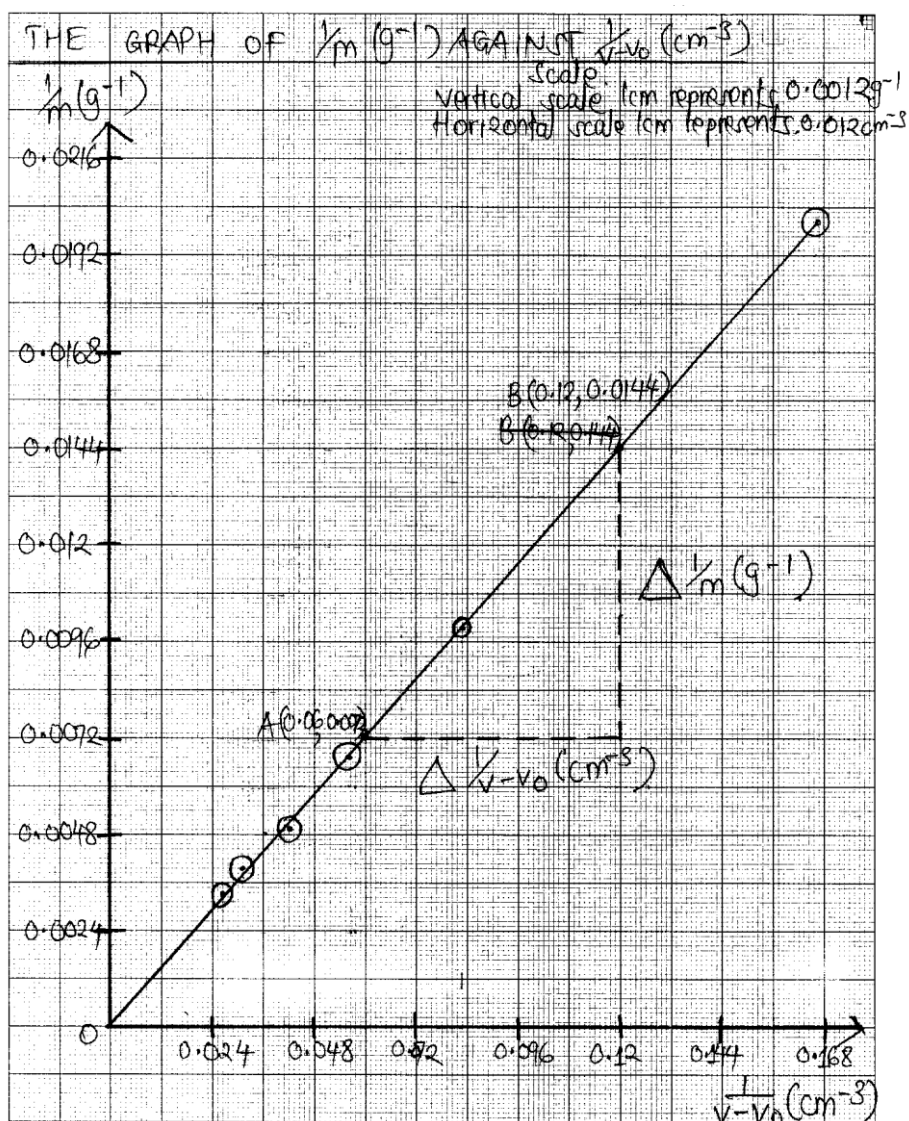
Extract 12.1: A sample of candidates' incorrect response to question 1 of Physics 2A

In extract 12.1, the candidate collected wrong data and failed to plot a graph. Since the data were incorrect, the candidate failed to make a correct scientific conclusion. In contrast, most of the candidates scored high marks in this question. These candidates demonstrated a comprehensive mastery of experimental skills in Physics, particularly in the topic of *Measurements*. These candidates were able to set up the apparatus, prepare a table of results with their respective units and give a clear graphical representation of the data. That is to say, they used appropriate scales for both the vertical

axis $\left(\frac{1}{m}\right)(g^{-1})$ and the horizontal axis $\left(\frac{1}{V-V_o}\right)cm^{-3}$, and transferred data correctly. They also included all essential features, which includes title of the graph, scales (vertical and horizontal), labelled axes, plotted points with a best-fit line and slope indication. Moreover, these candidates interpret and analyse experimental data correctly. That is to say that they computed a slope from the graph and used it to deduce the density of slotted mass. Extract 12.2 shows a candidate who followed the correct procedures, recorded the data, plotted the graph, used the graph for calculations and ultimately determined the correct value of density and relative density of the steel.

1	(a)(i) Table of results.					
	S/N	Mass m (g)	$\frac{1}{m}$ (g^{-1})	v (cm^3)	$v - v_0$ (cm^3)	$\frac{1}{v - v_0}$ (cm^{-3})
	1	50	0.02	106	6	0.167
	2	100	0.01	112	12	0.083
	3	150	0.0067	118	18	0.056
	4	200	0.005	124	24	0.0417
	5	250	0.004	132	32	0.0313
	6	300	0.0033	138	38	0.026
	(ii) The slope of the graph.					
	From points: A(0.0072, 0.06)					
	B(0.0144, 0.12)					
	Slope (M) = $\frac{\Delta \frac{1}{m} (g^{-1})}{\Delta v - v_0 (cm^3)}$					
	= $\frac{0.0144 - 0.0072}{0.12 - 0.06}$					
	= 0.12 g/cm^3					
	$\therefore$ The slope of the graph is 0.12 cm^3/g					
	(iv) The slope in 1(iii) represents the inverse of the density of steel as shown below.					
	From $\rho = \frac{M}{v - v_0}$					
	$M = \rho(v - v_0)$					
	$\frac{1}{M} = \frac{1}{\rho(v - v_0)}$					
	$\frac{1}{M} = \frac{1}{\rho} \left(\frac{1}{v - v_0} \right) + 0$					
	$y = mx + c$					
	Hence, shown					

	(iv) Density and relative density of the material.
	From slope (M) = $\frac{1}{\rho}$
	$0.12 = \frac{1}{\rho}$
	$\rho = 8.33 \text{ g/cm}^3$
	$\therefore$ The density of the material is 8.33 g/cm^3 .
	Relative density of the material.
	Relative density (RD) = $\frac{\text{Density of material}}{\text{Density of water}}$
	But Density of water = 1 g/cm^3
	$= \frac{8.33 \text{ g/cm}^3}{1 \text{ g/cm}^3}$
	$= 8.33$
	$\therefore$ The relative density of the material is 8.33



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

In Extract 12.2, the candidate correctly set up the experiment, accurately collected and recorded the data, and applied both theoretical and computational skills to determine the required physical quantities as specified in the question.

3.1.2 031/2B Physics 2B

In Physics 2B question 1, the candidates were required to determine the relative density of the given liquid (Korie oil) labelled L. The candidates

were provided with a 250 cm³ empty beaker, 200 cm³ measuring cylinder, water, liquid labelled **L** and a beam balance.

The candidates were required to proceed as follows:

- Measure and record the mass M_o of the empty glass beaker (in grams).
- Fill the beaker with 50 cm³ of water, measure and record a new mass M_w and then determine and record the mass m_w of the water.
- Repeat procedure 1 (b) using 75 cm³, 90 cm³, 120 cm³ and 150 cm³ of water. Determine the value of M_w and m_w in each case.
- Rinse the beaker thoroughly and then repeat procedures 1 (b) and (c) with the given liquid **L**. Record the new mass as M_L and mass of liquid as m_L .

Questions

(i) *Tabulate your results as shown in Table 3.*

Volume (cm³)	Mass of beaker filled with water (M_w) (g)	Mass of water used (m_w)(g)	Mass of beaker filled with liquid L (M_L)(g)	Mass of liquid L used (m_L)(g)
50				
75				
90				
120				
150				

(ii) *Plot a graph of mass m_L (g) against m_w (g).*

(iii) *Compute the slope of the graph in 1 (ii).*

(iv) *What is the physical meaning of the slope obtained in 1 (iii)?*

(v) *Determine the relative density of the given liquid L.*

(vi) *What is the aim of doing this experiment?*

The analysis showed that (22.93%) of the candidates who attempted this question scored a low mark (0.0-7.0). The candidates in this category demonstrated unsatisfactory experimental skills in the topic of *Measurements*. Most of them failed to set up the experiment, collect data, analyse data, interpret findings, and provide a scientific conclusion. Some candidates were unable to obtain correct data, possibly due to improper measurement and readings of the measuring apparatus, particularly the use

of the measuring cylinder and beam balance. This was observed in their data presentations, where the data recorded were not within the expected experimental range. As a result, they plotted an incorrect graph, which led to incorrect scientific conclusions. Some of the candidates plotted graphs using inappropriate variables. For instance, some of them plotted a graph of the mass of the beaker filled with liquid (M_L) against the mass of the beaker filled with water (M_w), which did not align with the requirements of the question. The question required them to plot the mass of the liquid (m_L) against the mass of the water (m_w). This indicates that the candidates failed to distinguish between the mass of the liquid and the mass of the container with its contents, leading to incorrect graphical representation. Some candidates failed to state the unit correctly. Most candidates in this category correctly determined the slope from the graph and expressed it in g/cm^3 without recognising that for a graph of mass of liquid, m_L (g), plotted against mass of water, m_w (g), the slope is dimensionless (unitless), since it represents a ratio of two quantities with the same unit. That is to say that a $\text{slope} = \frac{\Delta m_L(\text{g})}{\Delta m_w(\text{g})}$.

Some candidates were unable to state the correct physical meaning of the slope obtained. For example, one candidate interpreted the slope as the *density of the substance*. This was an incorrect conclusion. The candidates in this category were supposed to evaluate the slope of the graph as follows:

$$\text{Relative density (R.D)} = \frac{\text{mass of a given volume of a liquid}}{\text{mass of a given volume of water}}$$

Rearranging this expression (make m_L) as a subject of the formula gives: $m_L = \text{RD} \times m_w$. Compare this with a linear equation, i.e., $y = mx$. It implies that the slope of the graph is the RD density of liquid L. Extract 13.1 taken from the candidate's script, illustrates a sample of incorrect response to this question.

Volume cm ³	mass of beaker filled with water (m _w)	mass of can for used	mass of be aker filled liquid (m _L)	mass of liquid used mL (g)
50	114.3	11.2	6.2	3.9
75	7.2	4.9	7	4.7
90	7.6	5.3	7.3	5.0
120	8.6	6.3	8.3	6.0
150	9.7	7.4	9.2	6.9

v) Relative density = $\frac{\text{Density of substance}}{\text{Density of Water}}$

$$R.D = \frac{\rho_s}{\rho_w}$$

Where;

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$= \frac{26.5g}{485 \text{ cm}^3}$$

$$\text{Density} = 0.054g/\text{cm}^3$$

Then;

$$R.D = \frac{\rho_s}{\rho_w}$$

$$R.D = \frac{0.054g/\text{cm}^3}{1g/\text{cm}^3}$$

i) Relative density = 0.094 answer

$$\text{Slope} = \frac{\Delta \text{ mass (mL)}}{\Delta \text{ mass (m)}} \quad \text{mL}$$

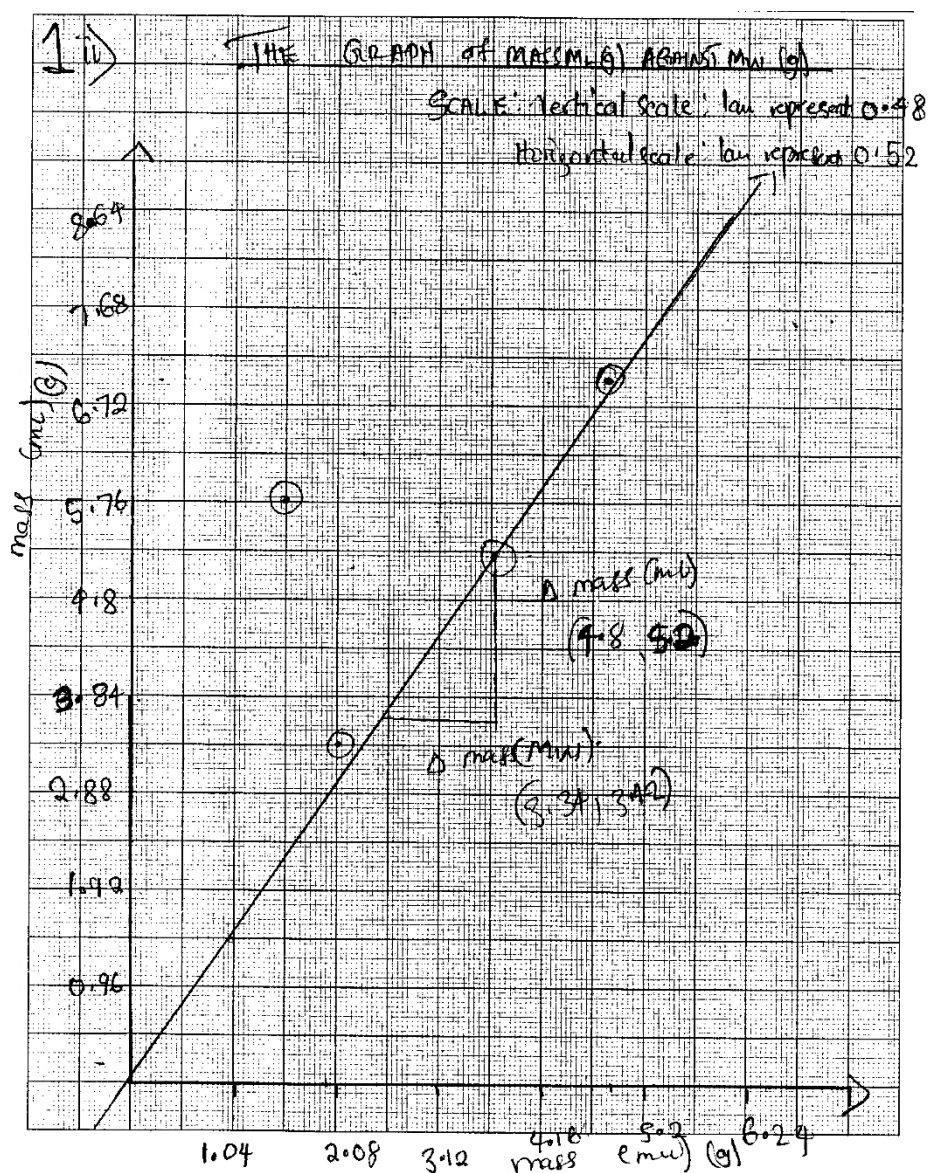
$$= \frac{4.8 - 5.2}{2.34 - 3.42}$$

$$= \frac{-0.4}{-0.08}$$

$$= 0.5$$
$$\approx 1 \text{ Answer}$$

ii) Because the slope is equal to the mass of liquid

iii) The aim of this experiment is to determine the mass of mL of a



Extract 13.1: A sample of a candidate's incorrect responses to question 1 of Physics 2B

In Extract 13.1, the candidate recorded the data values in the table. As a result, he/she failed to obtain correct results, which led to a wrong scientific conclusion.

The analysis also revealed that (31.17%) of the candidates who attempted this question scored between 16.5 and 25.0, which is a high score. This suggests that the candidates had adequate knowledge and skills in physics

experiments, particularly the topic of *Measurements*. That is to say that these candidates demonstrated accuracy in data collection and presentation in well-organised tables. They appropriately selected and applied suitable scales on both the vertical and horizontal axes. They correctly plotted the mass of liquid (m_L) on the vertical axis against the mass of water (m_w) on the horizontal axis, including the proper units. Their graphs incorporated essential features such as a clear title (with units), labelled axes, accurately plotted data points, a best-fit line, and a proper indication of the slope. Extract 13.2 shows a candidate who followed the correct procedures, recorded the data accurately, plotted the graph, and used the graph to perform the necessary calculations. Finally, the candidate successfully calculated the relative density of liquid L.

1 a) $M_0 = 99.6 \text{ g}$

i)

Volume (cm ³)	Mass of beaker filled with water $M_w(\text{g})$	Mass of water used $m_w(\text{g})$	Mass of beaker filled with liquid L $M_L(\text{g})$	Mass of liquid L used $m_L(\text{g})$	Mass of empty glass beaker $M_0(\text{g})$
50	151.6	52	144.3	44.7	99.6
75	176.2	76.6	166.7	67.1	99.6
90	189.6	90.0	180.8	81.2	99.6
120	218.2	118.6	205.4	105.8	99.6
150	247.8	146.2	231.9	132.3	99.6

iii)

$$\text{Slope, } M = \frac{\Delta M_L(\text{g})}{\Delta M_w(\text{g})}$$

$$= \frac{89.1 - 52(\text{g})}{100 - 61.2(\text{g})}$$

$$= \frac{35.1}{38.8}$$

$$= 0.9$$

iv) The physical meaning of slope is relative density of the liquid.

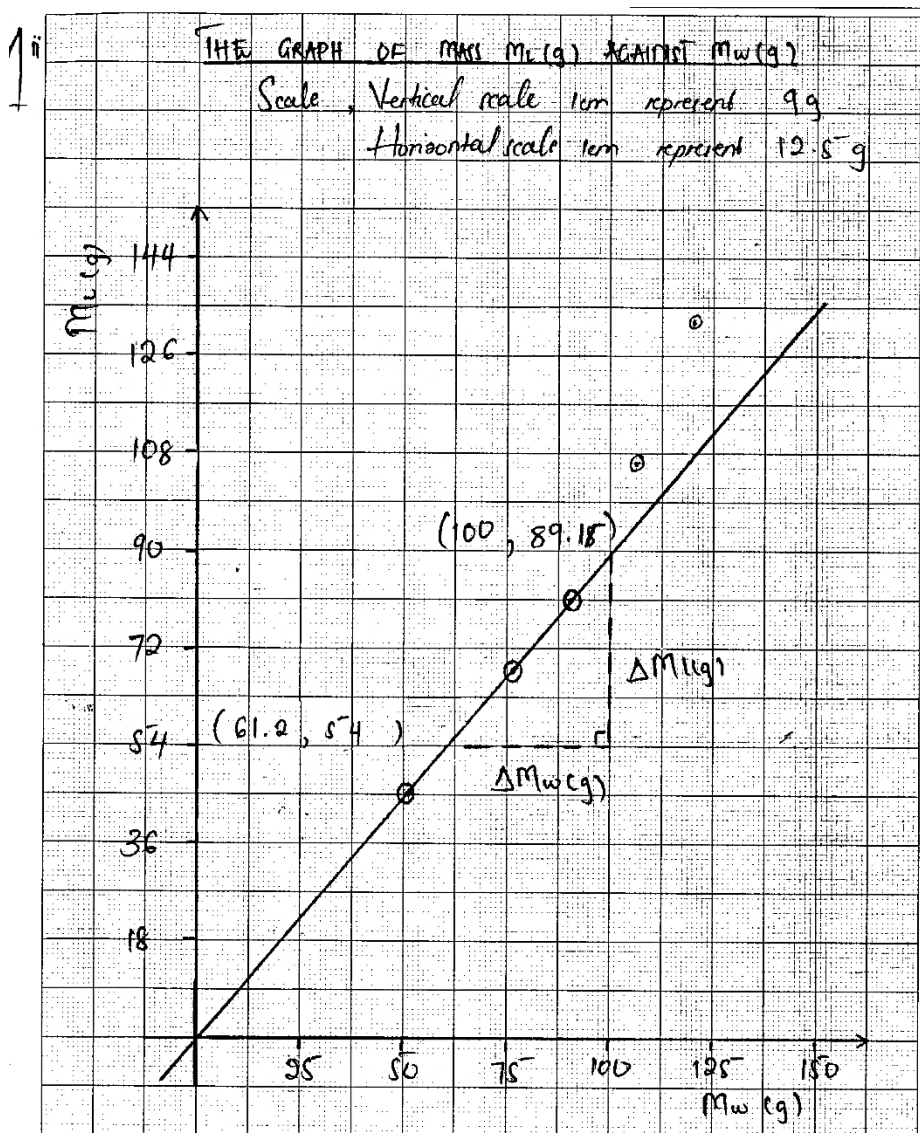
v) Relative density of liquid L.

$$R.D = \text{Slope, } M$$

$$R.D = 0.9.$$

$\therefore$ the relative density of liquid L is 0.9

vi) The aim of experiment is to determine the relative density of liquid L



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

In Extract 13.2, the candidate correctly set up the experiment, collected and recorded the data appropriately, and applied both theoretical and numerical skills to determine the required physical quantity.

3.1.3 031/2C Physics 2C

In physics 2C question 1, candidates were required to perform an experiment to determine the density of the given wooden material (Cyprus wood). The candidates were provided with beam balance, 30 cm plastic ruler and five wooden blocks labelled **B₁**, **B₂**, **B₃**, **B₄** and **B₅**.

They were supposed to proceed as follows;

- (a) Measure a block **B₁** and record its length *L*, width *w* and thickness *t* (in centimetres) then determine its volume (in cubic centimetres).
- (b) Determine the mass (in grams) of block **B₁**.
- (c) Repeat the same procedures at (a) and (b) for blocks **B₂**, **B₃**, **B₄** and **B₅**.
Recording their respective volume and mass.

Questions

- (i) Tabulate the results as shown in following table.

Block	Length <i>L</i> (cm)	Width <i>w</i> (cm)	Thickness <i>t</i> (cm)	Volume <i>V</i> (cm ³)	Mass <i>m</i> (g)
B ₁					
B ₂					
B ₃					
B ₄					
B ₅					

- (ii) Plot a graph of volume (cm³) against mass (g).
- (iii) Determine the slope *s* of the graph plotted in 1 (ii).
- (iv) What is the significant of the slope *s* in 1 (iii)?
- (v) Compute the density of a given wood.
- (vi) What is the aim of doing this experiment?

The analysis showed that 22.93% of the candidates who attempted this question scored low marks (0.0 to 7.0). This revealed that the candidates had inadequate skills in conducting experiments in physics, especially in the topic of *Measurement*. Most of them presented data which were not within the expected experimental range. It can be assumed that these candidates did not use the experimental apparatus properly when measuring the length, width, thickness, and mass of the wooden blocks.

However, some candidates were able to collect the experimental data accurately but made errors when transferring the points onto the graph. Consequently, they plotted an incorrect graph, which led to an inaccurate calculation of the wooden material's density. Some candidates failed to provide the physical meaning of the slope. For instance, one candidate incorrectly stated that it *represents density*, which was an incorrect response. The candidate was expected to use mathematical reasoning to deduce the correct physical meaning as follows:

$$\text{Density } (\rho) = \frac{\text{mass of a substance } (m)}{\text{volume of a substance } (V)}. \text{ Rearranging this equation, by}$$

making volume a function of the equation

$$\text{Volume of a substance} = \frac{\text{Mass of a substance}}{\text{Density of a substance}} = \frac{m}{\rho}. \text{ From a linear}$$

equation, i.e., $y = mx$, it implies that the slope of the graph is $\frac{1}{\rho}$.

Therefore, slope signifies the reciprocal of density.

Similarly, another candidate proposed an incorrect aim of the experiment. The candidate stated that *the experiment aims to determine length, width, thickness, volume and mass*. This was an incorrect response. In addition, some of the candidates used an incorrect formula to determine the value of the slope. For instance, one of the candidates applied the formula:

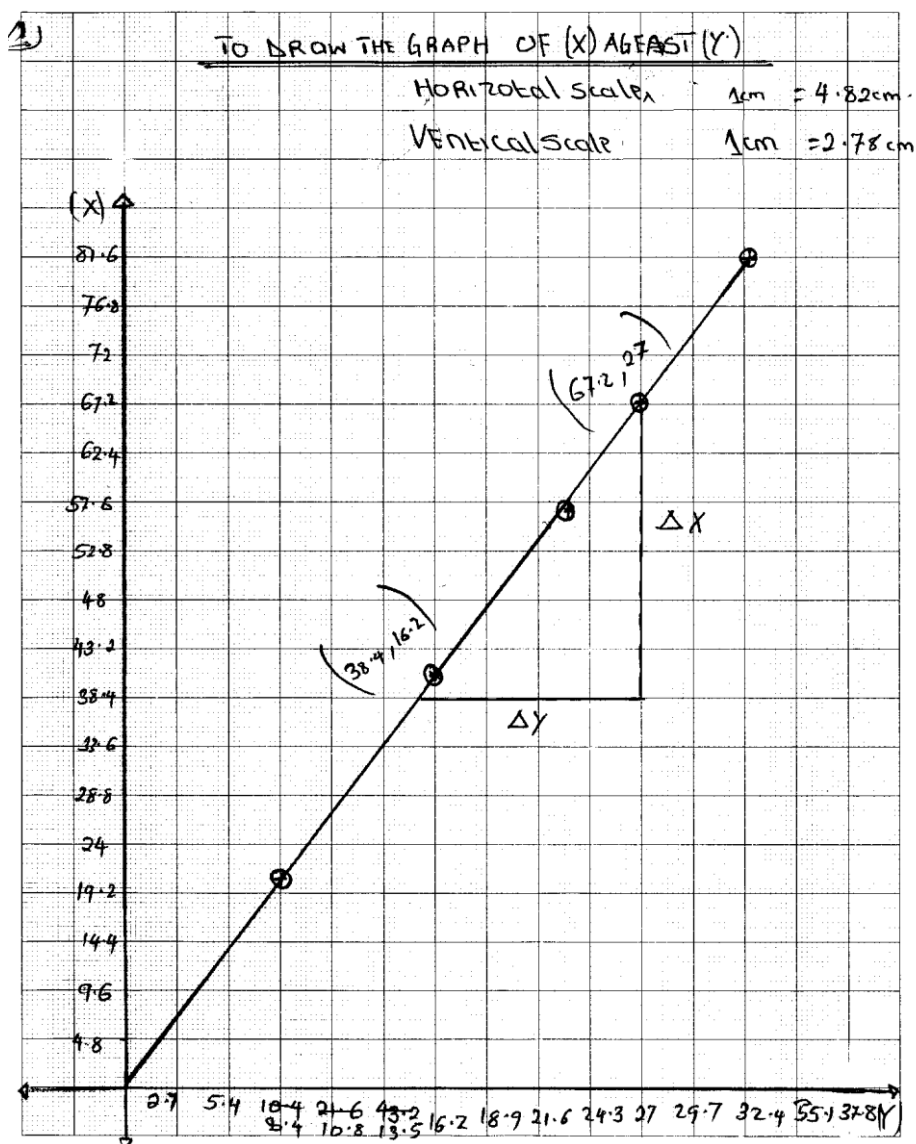
$$\text{slope} = \frac{\Delta y}{\Delta x}. \text{ This candidate had some understanding of how to determine}$$

the slope but failed to identify the appropriate physical quantities, mass (m) and volume (v), instead of using x and y . The correct formula for slope is given as:

$$\text{slope} = \frac{\Delta V (\text{cm}^3)}{\Delta m (\text{g})}. \text{ Extract 14.1 displays a sample from a candidate who}$$

did not provide the best responses to the entire question.

1	To Tabulate the result as shown in the table in the following					
	Block	Mass	Length L	Width (cm)	Thickness	Volume
	B ₁	4	21	10	6	1260
	B ₂	35	15	8	5	600
	B ₃	83	13	3	4	156
	B ₄	191	11	3	5	165
	B ₅	465	6	2	3	36
iii	Determine the slope of graph plotted from					
	Slope = $\frac{\Delta \text{Volume (cm}^3\text{)}}{\Delta \text{Mass (g)}}$					
	Slope = $\frac{(232.4 - 132.8)}{(815.1 - 592.8)}$					
	Slope = $\frac{99.6}{222.3}$					
	Slope = 0.8 cm					
iv	What is the significance of the slope is					
	ANS → The significance of the slope is to measure density of the block					
v	The density of given wood is because it is less dense than density of the block of water					
v	The aim of the experiment is to determine the density of liquid N					



Extract 14.1: A sample of a candidate's incorrect response to question 1 of Physics 2C

In Extract 14.1, a candidate incorrectly tabulated the results, plotted an incorrect graph, and ultimately performed incorrect calculations when determining the density of wooden material.

However, some of the candidates scored higher marks (16.5 to 25.0). That is to say that these candidates demonstrated competence in collecting data, plotting graphs, analysing the obtained data, and making scientific conclusions based on the experimental data.

The candidates measured the dimensions of the wooden block and presented systematically the mathematical solutions to parts of the question that involved basic operations. These candidates included all the essential features on their graphs, such as a title with units, clearly labelled axes, accurately plotted points, a best-fit line, and an indication of the slope. As a result, they were able to determine the correct slope and, consequently, the density of the given wooden material, fulfilling the requirements of the question. Extract 14.2 displays a sample from a candidate who provided the correct response to this question.

91. (D) TABLE OF RESULT						
Block	length L (cm)	width w (cm)	thickness t (cm)	Volume V (cm ³)	Mass m (g)	
B ₁	20	10	5	1000	545	
B ₂	14	7	4	392	222	
B ₃	12	5	3	180	92	
B ₄	10	4	2	80	40	
B ₅	5	2	1	10	5	
(ii) A graph of Volume (cm ³) against - mass (g) on a graph paper.						
(iii) Slope of the graph						
from						
Slope (m)						
$= \frac{\Delta y}{\Delta x}$						
$S = \frac{\Delta \text{Volume (cm}^3\text{)}}{\Delta \text{mass (g)}}$						
$= \frac{(687.5 - 250) \text{ cm}^3}{(377.1 - 138.2) \text{ g}}$						
$S = 1.898 \text{ cm}^3/\text{g}$						
$\therefore$ Slope of the graph is $1.898 \text{ cm}^3/\text{g}$						

-01- (iv) The slope signifies the inverse of the density of wood. $(\frac{1}{D}) = \text{slope}$

(v) Density of wood

From the graph

Density, D

$$D = \frac{m}{V}$$

$$V = \frac{m}{D}$$

$$V = \left(\frac{1}{D}\right)m + 0$$

$$\uparrow \quad \uparrow \quad \uparrow$$
$$y = mx + c$$

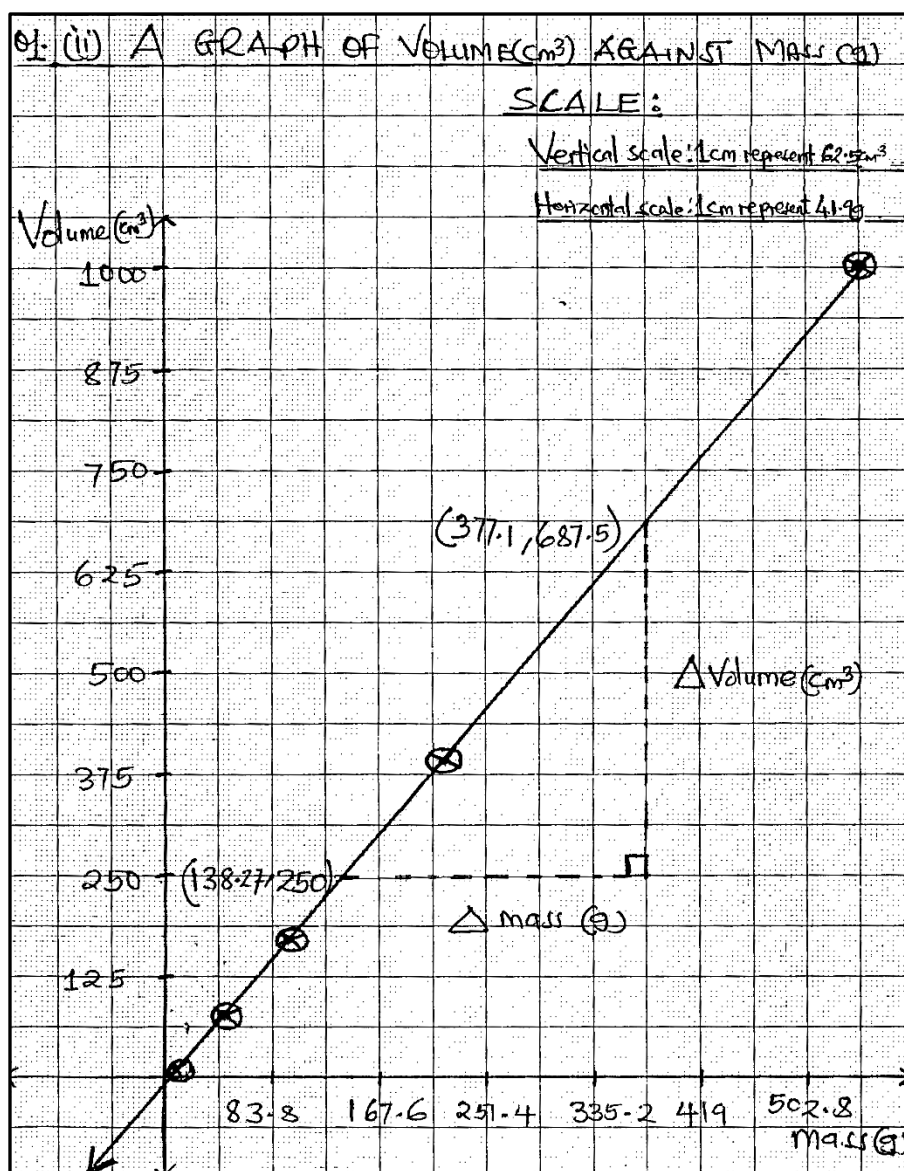
$$\text{slope} = \frac{1}{\text{Density}}$$

$$\text{Density} = \frac{1}{1.898 \text{ cm}^3/\text{g}}$$

$$= 0.539/\text{cm}^3$$

$\therefore$ The density is $0.539/\text{cm}^3$

(vi) The aim of doing this experiment is to determine the density of a wood.



Extract 14.2: A sample of a candidate's correct responses to question 1 of Physics 2C

In Extract 14.2, the candidate correctly set up the experiment, collected and recorded the data appropriately, and applied both theoretical and numerical skills to determine the required physical quantities.

3.2 Question 2: Light

A total of 133,906 (100%) candidates attempted the question, and their scores were distributed as follows: 40,595 (30.32%) candidates scored from

0.0 to 7.0 marks; 36,964 (27.60%) candidates scored from 7.5 to 16.0 marks; and 56,347 (42.08%) candidates scored from 16.5 to 25.0 marks. This suggests that candidates' performance was good, as 93,311 (69.68%) candidates scored from 7.5 to 25.0 marks. Figure 13 illustrates the candidates' performance in question 2 for Physics paper 2 (practical).

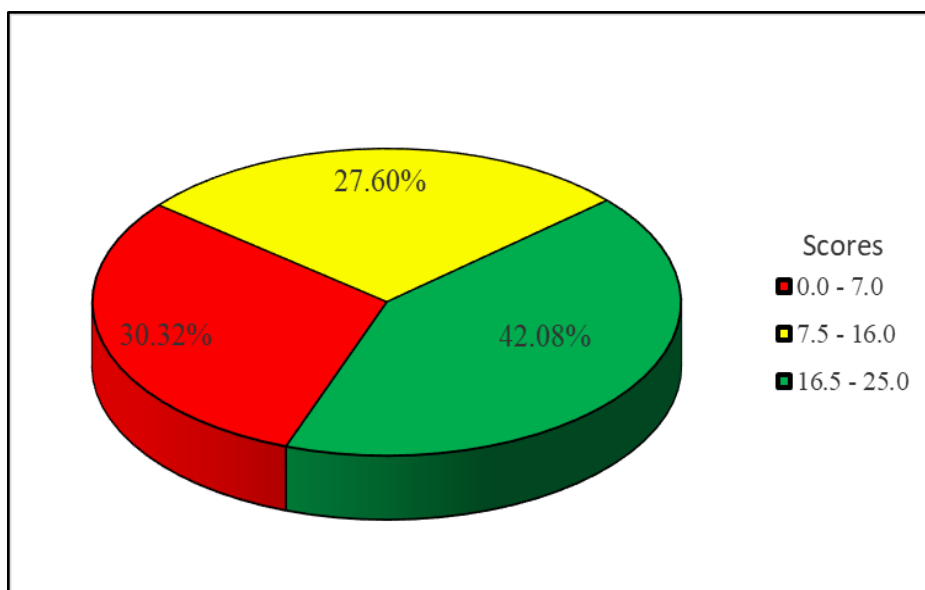


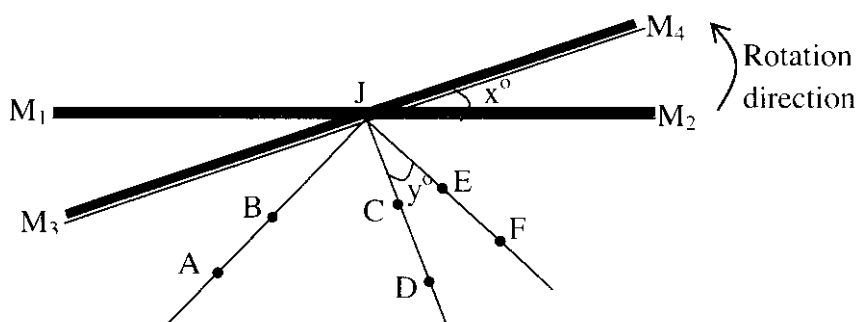
Figure 13: *The Candidates' Performance in Question 2 for Physics Paper 2*

3.2.1 031/2A Physics 2A

In Physics 2A question 2, candidates were required to perform an experiment to investigate the optical properties of a plane mirror. They were required to determine the relationship between the angle of rotation of the mirror (x°) and the corresponding angle of rotation of the image (y°). To perform this experiment, they were given a plane mirror glued on a wooden block, four optical pins, four thumb pins, white paper, a protractor and a drawing board.

They were required to follow the following procedures;

- (a) Pin the clean white paper on the drawing board, and then draw two straight lines M_1M_2 and M_3M_4 such that the angle between the lines x° is 10° as shown in the following Figure.



- (b) Draw a line through J to represent the incident ray, and then erect two pins A and B on this line as shown in the given figure. Place the reflecting surface of the mirror along M_1M_2 .
- (c) Erect pins C and D to appear in line with the images of A and B. Remove the pins C and D and then mark their position with a pencil. Draw the line JCD to represent the reflected ray.
- (d) Rotate the mirror such that it is a long line M_3M_4 . Erect the pins E and F to appear in line with the images of A and B. Remove the pins E and F then draw the line JEF to represent the new position of the reflected ray.
- (e) Remove the mirror and pins A and B then measure the angle y° as shown in the figure.
- (f) Repeat the procedures in 2 (a) to (e) for the value of $x = 15^\circ, 25^\circ, 35^\circ$ and 40° . Record the corresponding values of angle y° in each case.

Note: For each case, a new plain white paper must be used and attached with the answer booklet(s) for submission.

Questions;

- (i) Prepare a table for values of x° and y°
- (ii) Plot a graph of y° against x° .
- (iii) Calculate the slope of the graph plotted in 2 (ii).
- (iv) How is x° related to y° ?
- (v) What is the aim of doing this experiment?

Some of the candidates scored 0.0 to 7.0 marks. These candidates failed to demonstrate their mastery of basic experimental skills on the topic of *Light*. Some of them collected inappropriate data. Most of them presented incorrect experimental data. This failure is possibly due to the wrong setup of a plane mirror as per the instructions provided. Some of them presented

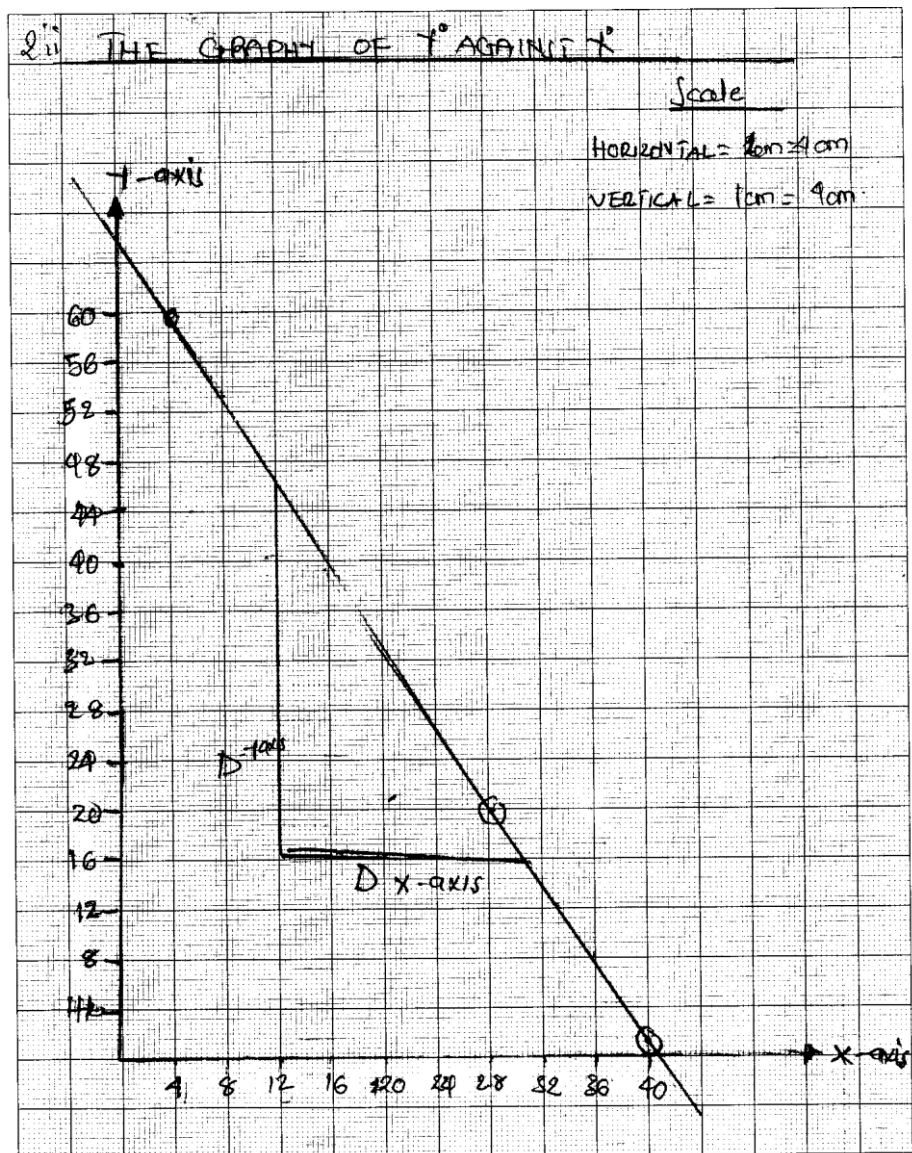
incorrect diagrams, which they used for data collection. This is because the sizes of the angles drawn did not correspond to their actual measured values, suggesting that the data may have been fabricated.

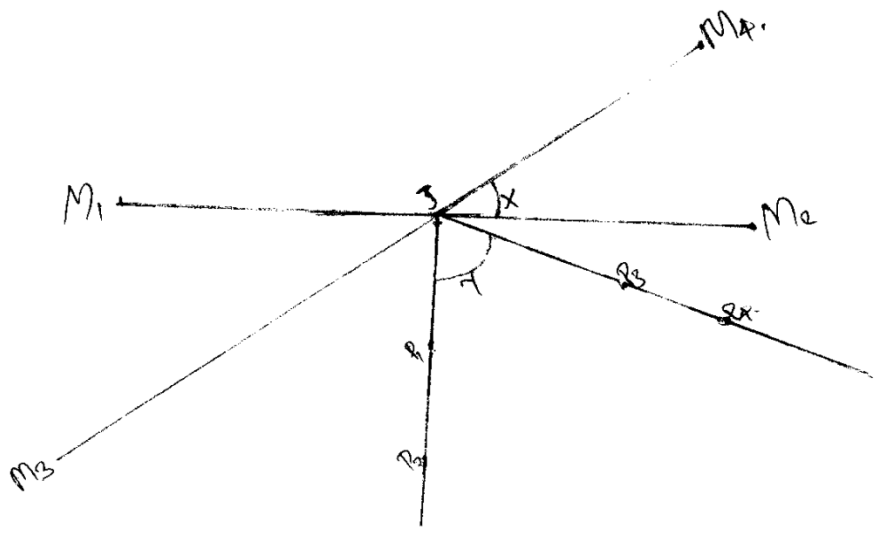
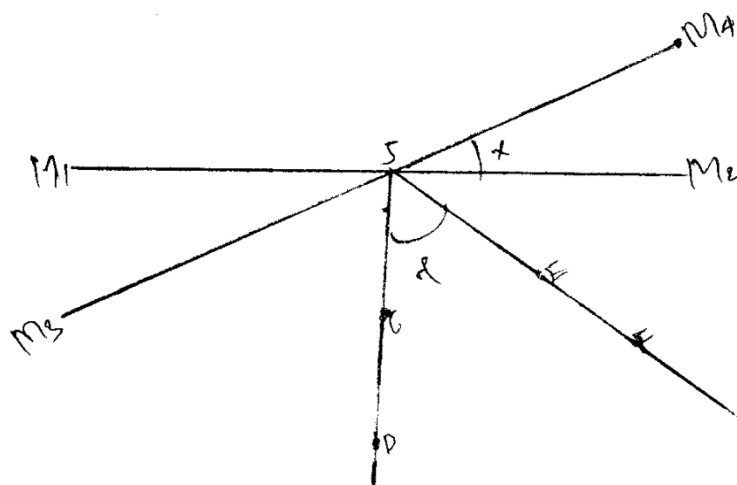
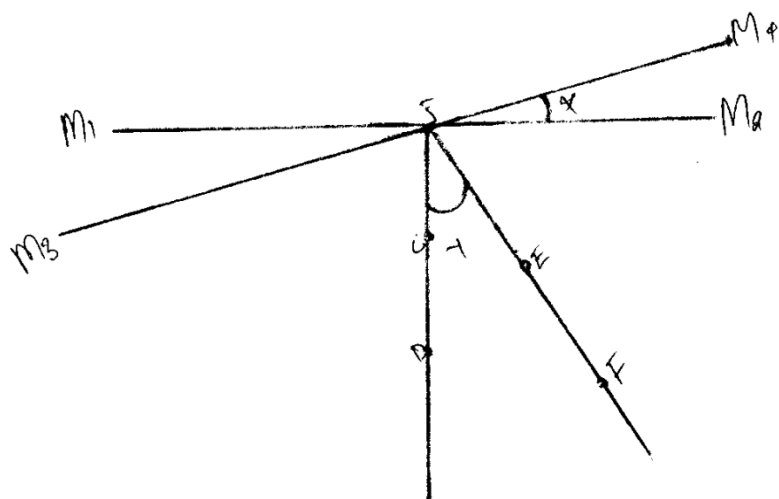
Some of the candidates demonstrated limited competence in data presentation and graph plotting. They presented incorrect values in the table of results, and they applied an inappropriate formula for calculating the slope and provided incorrect responses in almost all parts of the question. Some of them had correct data, but failed to correctly transfer data points onto the graph. As a result, they constructed inaccurate graphs and obtained an incorrect value of the slope. This indicates a lack of appropriate skills and understanding in interpreting graphical information.

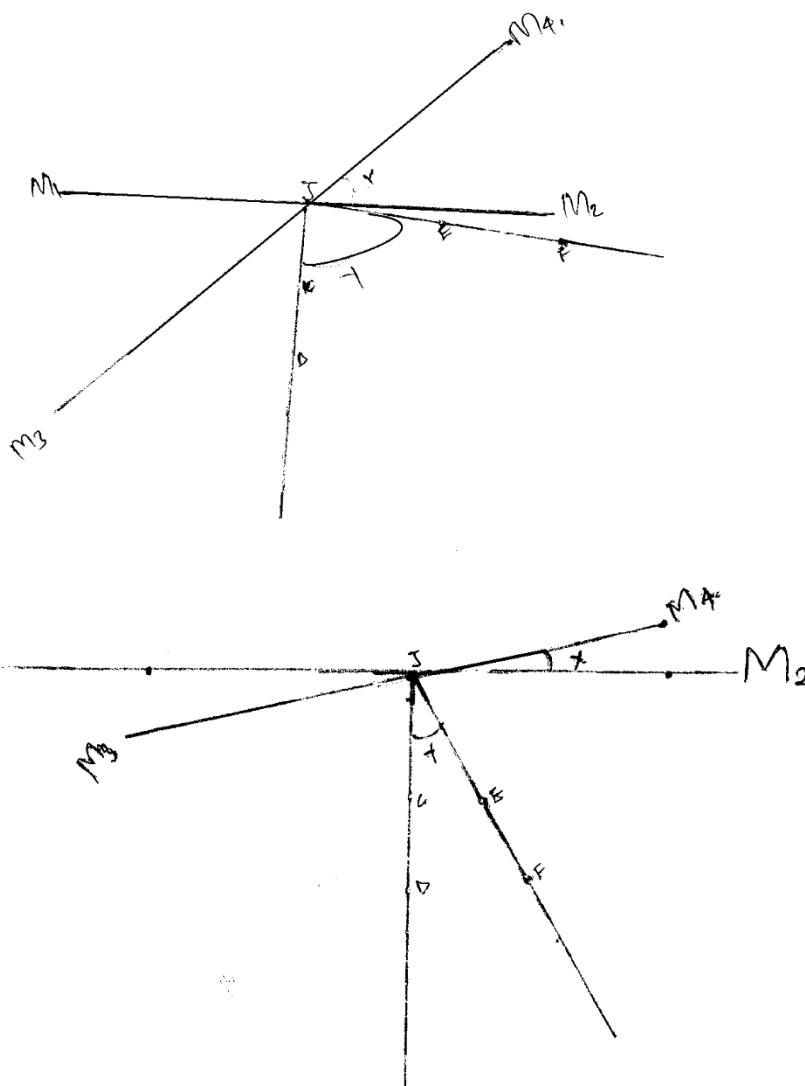
Moreover, some candidates misinterpreted the underlying theory of the question and consequently used an incorrect formula to relate x° and y° .

For instance, one candidate applied the expression $y = \frac{360^\circ}{x} - 1$, which is not relevant to the relationship being investigated. Some of them failed to propose the aim of the experiment. The candidates in this category stated incorrect and irrelevant statements. For instance, one of the candidates stated that the experiment aims to *determine the number of images in the plane mirror*. Overall, they failed to demonstrate mastery of the basic concepts, theories, and principles related to Light. Extract 15.1 presents a sample from one of the candidate's scripts illustrating incorrect responses.

Q2:	i	Table of Result.	
		X°	r°
		10°	60
		15°	55
		25°	35
		35°	20
		40°	5
	iii	Slope = $\frac{r_2 - r_1}{X_2 - X_1}$	
		Slope = $\frac{5 - 60}{40 - 10}$	
		Slope = $\frac{55}{30}$	
		Slope = 1.83	
	ii	X is the angle of $M_1 M_2$ and $M_3 M_4$ and r is represent angle CD and EF.	
	iv.	The aim of Experiment to determine the Reflective index.	







Extract 15.1: A sample of the candidate's incorrect responses to question 2 of Physics 2A

In Extract 15.1, the candidate inaccurately tabulated the results, plotted an inappropriate graph, and subsequently performed incorrect calculations. As a result, the candidate obtained incorrect answers in most parts of the question.

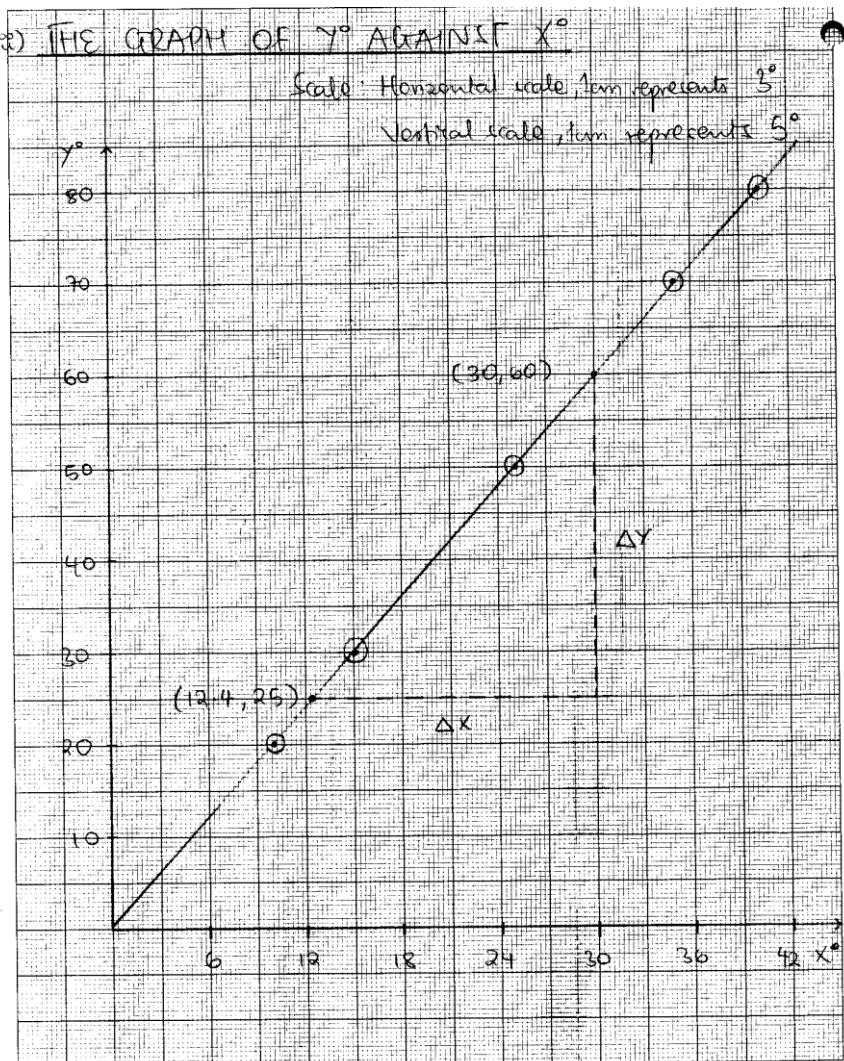
However, the observational analysis of the candidates' scripts revealed that some of the candidates, 93,311 (69.68%) scored high marks on this question. These candidates demonstrated a comprehensive mastery of

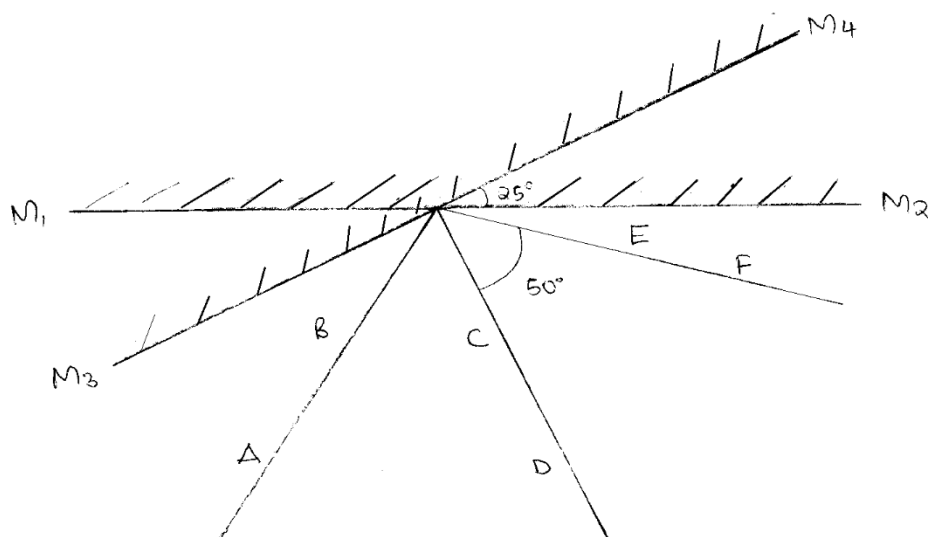
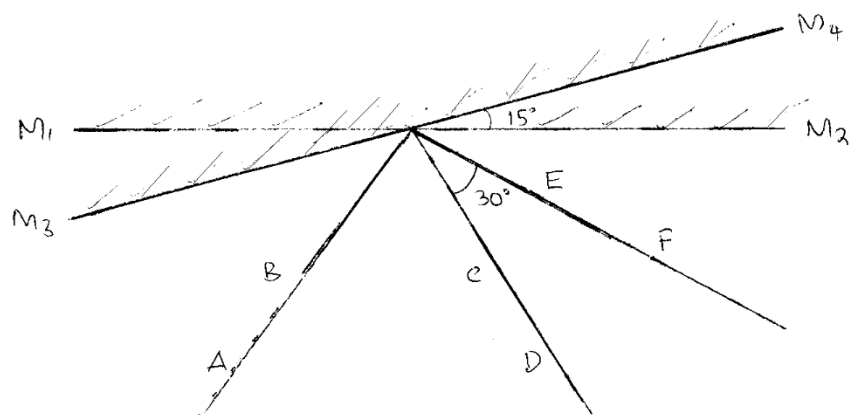
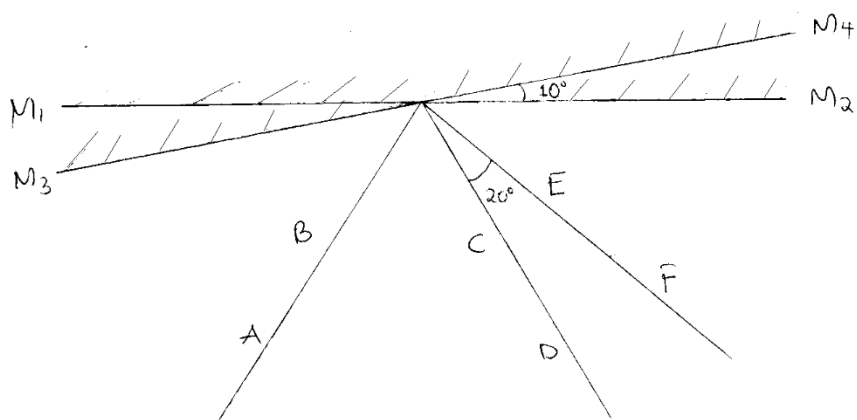
experimental skills in the topic of *Light*. Most of them had the ability to rotate the mirror as per instructions. They collected data and presented data in tabular form correctly. Moreover, they performed data analysis, interpretation, and drew scientific conclusions correctly. They were able to draw a good graph. That is to say, they used appropriate scales to plot the graph of y^0 on y-axis against x^0 on x-axis. These candidates included key features on their graphs, such as the title (with units), labelled axes, accurate plotting of points, a best-fit line, and the slope indication. They also demonstrated good mathematical skills in performing numerical calculations to obtain the correct value of slope. Extract 15.2 shows a sample of the candidate who performed correctly on question 2.

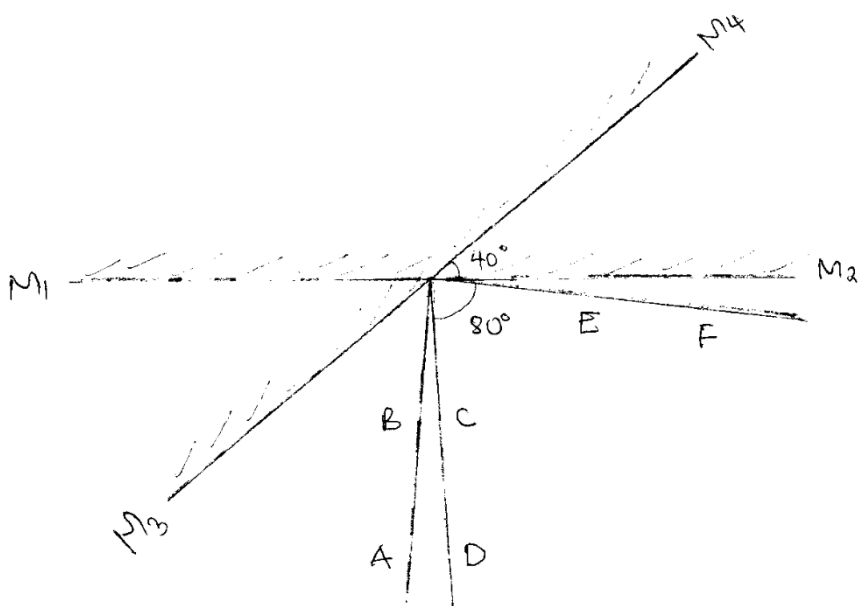
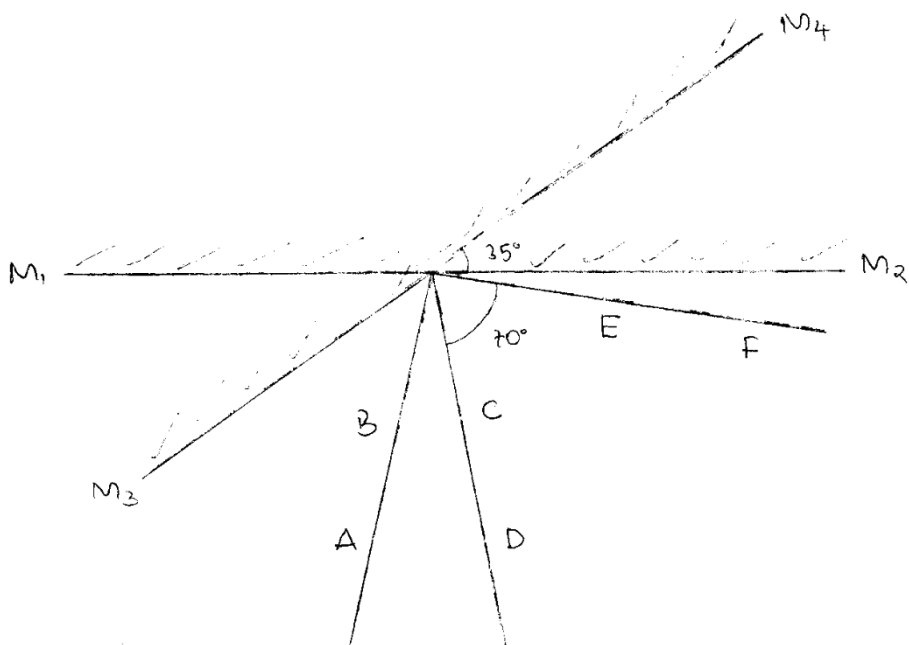
Q2	i)	TABLE OF RESULTS			
		S/No.	x°	y°	
		01	10	20	
		02	15	30	
		03	25	50	
		04	35	70	
		05	40	80	
Q2	ii)	From the slope plotted in a ii)			
		Slope, $M = \frac{\Delta y^\circ}{\Delta x^\circ}$			
		$M = \frac{60 - 25}{30 - 12.4}$			
		$M = \frac{35}{17.6}$			
		$M = 1.988$			
		$M \approx 2$			
		$\therefore$ the slope of the graph is 2			

02	iv) Relation between x° and y°
	From; $y = mx + c$
	where; y-intercept (c) = 0 slope (m) = 2
	Then; $y = (2)x + 0$
	$y = 2x$
	$2 \quad 2$
	$x = \frac{1}{2}y$
	iv) Since; $x^\circ = \frac{1}{2}y^\circ$
	$\therefore$ The value of x° is equal to a half of the value of y°
	v) The aim of this experiment is to determine the relationship between the angle of rotation of the mirrors (x°) and the angle of rotation of the reflected rays (y°)

02.3) THE GRAPH OF Y° AGAINST X°







Extract 15.2: A sample of a candidate's correct responses to question 2 of
Physics 2A

In Extract 15.2, the candidate demonstrated good experimental skills in the topic of *Light*. The candidate correctly prepared a table of results, plotted

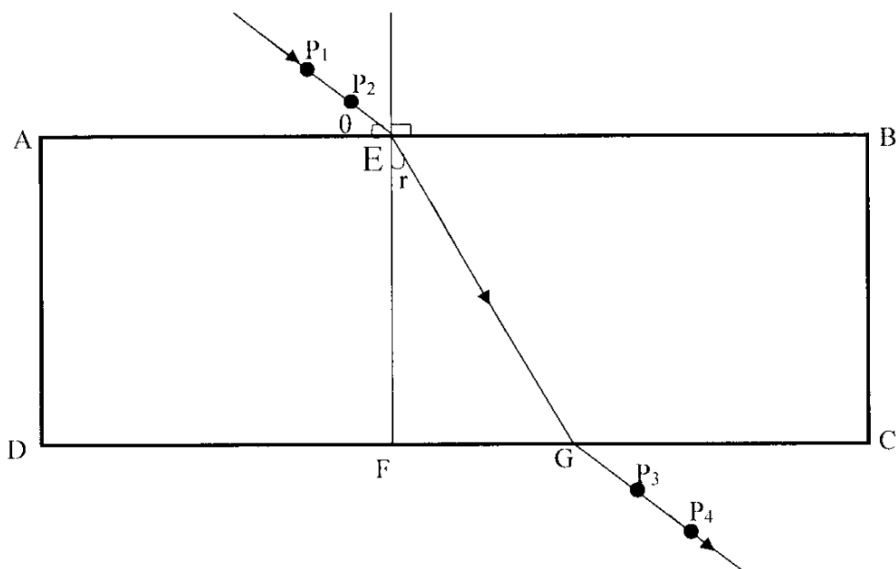
the correct graph and performed appropriate calculations in all parts of this question and managed to score high marks in this question.

3.2.2 031/2B Physics 2B

In Physics 2B, question 2, candidates were presented with the scenario: *You have been given a task to buy a rectangular glass block with the optical properties for either to reflect or to refract light when it passes optically through.* In order to determine the critical angle of that glass block, the candidate was required to experiment by using the apparatuses provided: a rectangular glass block, five sheets of drawing paper, four optical pins, four thumb pins, a protractor and a drawing board.

They were supposed to proceed as follows;

- (a) Use thumb pins to fix a plain piece of paper on the drawing board.
- (b) Place the rectangular glass block flat on the drawing plain paper fixed to the drawing board. Draw its outline ABCD with a sharp pencil. Remove the rectangular glass block and draw a line which cuts its largest sides normally at E and F as shown in the following Figure.



- (c) Draw a line making an angle of incident, $\theta = 35^\circ$ with the surface AB of the rectangular glass block. Stick two pins P₁ and P₂ on this line at a suitable distance and then place the rectangular glass block on the outlined ABCD.

- (d) Stick two more pins P_3 and P_4 on the other side of rectangular glass block so that they appear to be in the same straight line with the images of P_1 and P_2 as viewed through side CD of the rectangular glass block.
- (e) Remove the rectangular glass block and trace the straight path GP_3P_4 . Using a ruler, join G and E. use a protractor to measure the angle of refraction, r° .
- (f) Repeat the procedure in 2 (a) to (e) each time on fresh plain paper for angles of incident, $\theta = 45^\circ, 55^\circ, 65^\circ$ and 75° .

Questions

- (i) Tabulate your results including the values of θ° , r° , $\sin r^\circ$ and $\cos \theta^\circ$.
- (ii) Plot a graph of $\sin r^\circ$ against $\cos \theta^\circ$.
- (iii) Determine the slope of the graph in 2 (ii).
- (iv) What does the value obtained in 2 (iii) represent?
- (v) Calculate the value of the critical angle, C.
- (vi) Basing on the value calculated in 2 (v), deduce the phenomenon that occurs if the angle of incidence exceeds the critical angle, C

The analysis indicated that some of the candidates, 40,595 (30.32%) scored low marks (0.0-7.0). These candidates had demonstrated insufficient skills in conducting experiments in physics, particularly in the topic of *Light*. Most of them failed to appropriately set up an experiment as per the given instructions. As a result, they obtained wrong experimental results. Some of them managed to set an experiment, but failed to collect the data. The candidates in this category provided an incorrect table of results. The analysis revealed that these candidates failed to measure the angles. They measured an incident angle, θ from the incident ray to the normal line. Some candidates obtained good experimental data but failed to plot a good graph. They were unable to include key features on their graphs, such as the title (with units), labelled axes, accurate plotting of points, a best-fit line, and the slope indication. Some of the candidates failed to interpret the physical meaning of the slope. For instance, one of the candidates suggested that the value of the slope represents the *refractive index of the glass block*. Consequently, the candidate obtained an incorrect value of the refractive index and critical angle. This candidate had insufficient mathematical skills in the concepts of Snell's law. Some of them were unable to give the correct answer in part (iv), which required the candidate

to deduce the phenomena that occur if the angle of incidence exceeds the critical angle, C . For example, one of them wrote that *if the angle of incidence exceeds the critical angle, C , the angle of refraction will decrease*. This candidate exhibited inadequate knowledge of the process of refraction of light, as the candidate failed to state the phenomena that would occur. The candidate was supposed to know that when the angle of incidence is greater than the critical angle, all the light undergoes total internal reflection. So, the correct answer in part (iv) was the occurrence of the total internal reflection. These candidates failed to draw a good scientific conclusion from the experimental analysis. They failed to demonstrate their mastery of basic concepts, theories and principles related to *Light*. Extract 16.1 presents a sample of the candidate's incorrect responses.

2.7) TABLE RESULTS			
θ°	r°	$\sin r^\circ$	$\cos \theta^\circ$
35°	23.1	0.4	0.9
45°	30.1	0.5	0.8
55°	36.5	0.6	0.8
65°	43.2	0.7	0.7
75°	49.9	0.8	0.6
iii) $\text{slope}(m) = \frac{\Delta y}{\Delta x}$ $= \frac{0.7 - 0.6}{0.8 - 0.6}$ $= \frac{0.1}{0.2}$ $\text{slope}(m) = 0.5$			
$\therefore \text{slope}(m) \approx 1$			
iv) The value represent the slope of the graph $\sin r^\circ$ against $\cos \theta$.			
v) $\text{Index}(r) = \frac{y}{r}$			

$$2. \quad v) \quad 1.5 = \frac{\sin 90^\circ}{\sin r}$$

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

$$\underline{1.5 \sin r = 1}$$

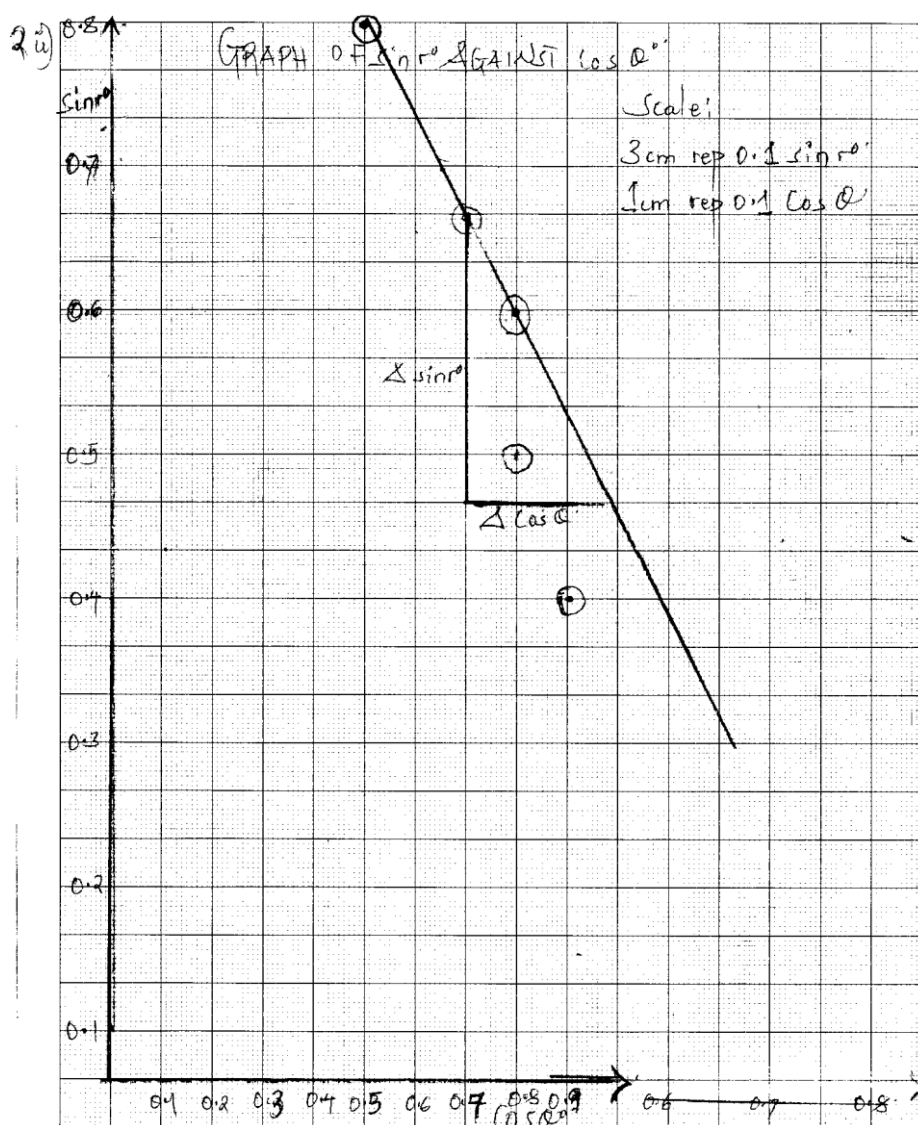
$$\frac{1.5}{1.5} \frac{\sin r}{1.5} = \frac{1}{1.5}$$

$$\sin r = 0.67$$

$$\sin^{-1} = 42.067^\circ$$

$$\therefore \text{Critical angle} = 42.07^\circ$$

vi) The phenomenon that occurs if the angle of incidence exceeds the critical angle (c) the reflection occurs.



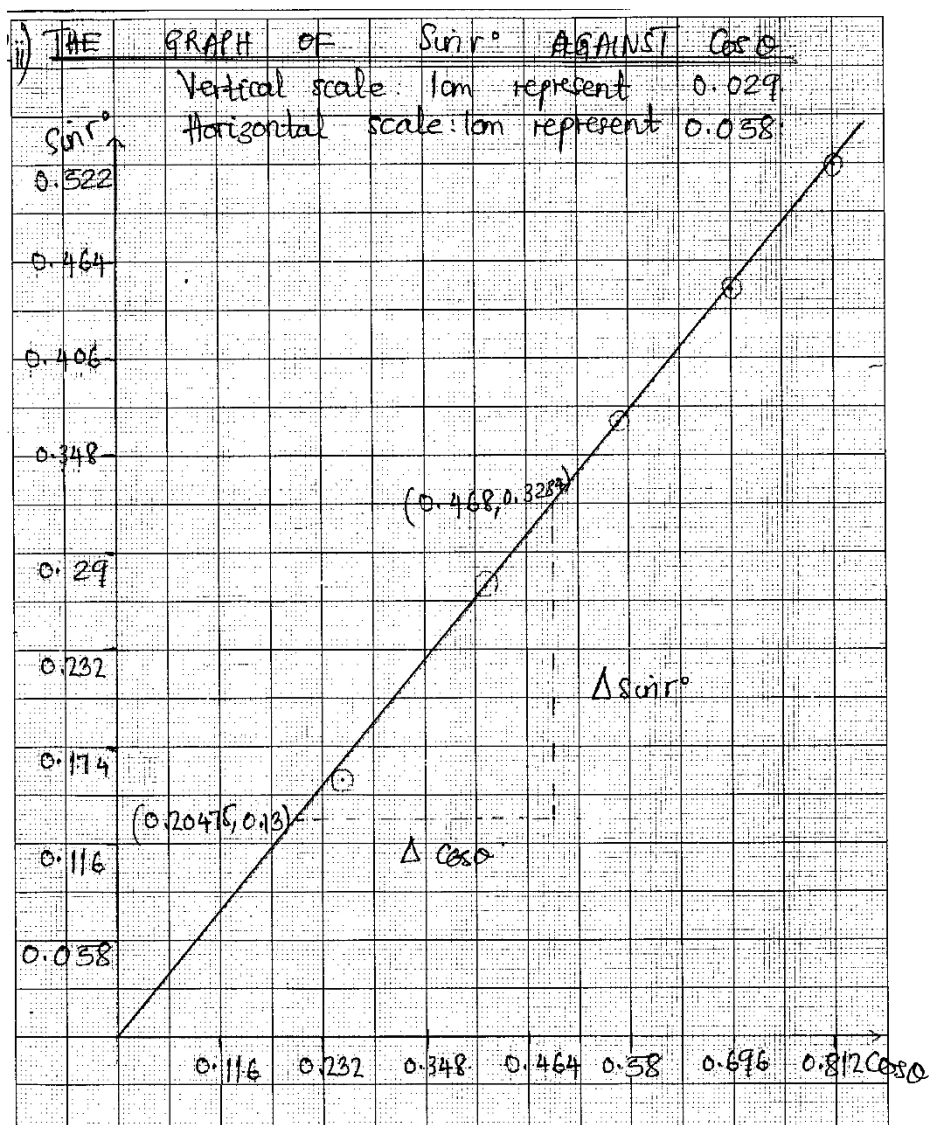
Extract 16.1: A sample of the candidate's incorrect responses to question 2 of Physics 2B

In Extract 16.1, the candidate had insufficient experimental skills. The candidate failed to present correct data. This candidate failed to design the experiment. This led to the wrong data and graph. The candidate failed to determine the required value of the critical angle.

However, most of the candidates scored high marks on this question. The candidates of this category were competent in analysing, evaluating, and applying mathematical skills systematically to obtain the correct answers. These candidates were able to interpret the diagram set up and managed to

collect the data within a reasonable range, as projected. They also managed to plot a graph of $\sin r^\circ$ against $\cos \theta^\circ$. Moreover, these candidates included key features on their graphs, such as the title (with units), labelled axes, accurate transfer of points, a best-fit line, and the slope indication. They also demonstrated good mathematical skills in performing numerical calculations to obtain the critical angle. An extract 16.2 summarises the correct responses given by one of the candidates in question 2 of Physics 2 B.

2 i)	θ°	r°	$\sin r^\circ$	$\cos \theta^\circ$
	35	32	0.5299	0.8191
	45	27	0.4539	0.7071
	55	22	0.3746	0.5735
	65	16	0.2756	0.4226
	75	9	0.1564	0.2588
iii	$\text{Slope} = \frac{\Delta \sin r^\circ}{\Delta \cos \theta}$ $= \frac{0.32 - 0.13}{0.5 - 0.205}$ $= 0.64$			
	<u>Slope = 0.64</u>			
iv)	The value in 2 / iii) Represents reciprocal of refractive index of rectangular glass block.			
v)	$\text{Slope} = \frac{1}{n}$			
	$\text{Slope} = \frac{1}{\sin c}$			
	$\text{Slope} = \sin c$			
	$c = \sin^{-1}(\text{Slope})$			
	$c = \sin^{-1}(0.64)$			
	$c = 40^\circ 5'$			
vi)	Total internal reflection.			



Extract 16.2: A sample of a candidate's good responses to question 2 of Physics 2B

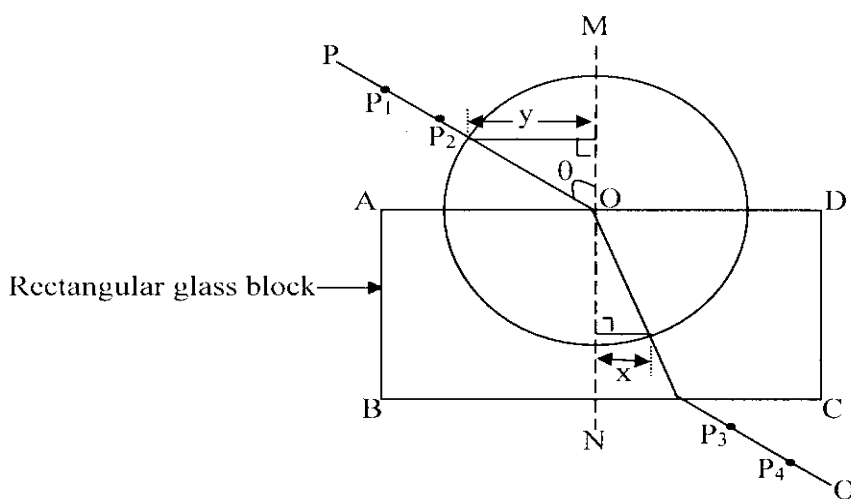
In Extract 16.2, the candidate successfully managed to set up an experiment as per the given instructions. The candidate was knowledgeable in tabulating and analysing experimental data. The candidate used mathematical skills to obtain the required critical angle.

3.2.3 031/2C Physics 2C

In Physics 2C question 2, candidates were provided with a rectangular glass block, optical pins, thumb pins, a soft board and white plain papers. They

were required to perform an experiment according to the following instructions:

- (a) Fix the sheet of white plain paper on a soft board by using the thumb pins provided. Place a rectangular glass block with its broader face resting on the plain white paper, and then trace its outline ABCD.
- (b) Remove the glass block; draw a normal MN to cut AD and BC at O and N, respectively. Draw the circle of radius 4 cm, point O being its centre. Draw another line PO, which makes an angle $\theta = 20^\circ$ to the normal line MN as shown in the following figure.



- (c) Erect optical pins at points P_1 and P_2 such that they are at least 2 cm apart. Replace the glass block on its outline ABCD, and then observe the pins at P_1 and P_2 through side BC. Erect pins at points P_3 and P_4 such that they appear to be in a straight line with images of pins at points P_1 and P_2 .
- (d) Remove the glass block and trace the refracted ray and emergent ray. Measure and record the distance x (mm) and y (mm), corresponding to its angle $\theta = 20^\circ$.
- (e) Using another plain white paper, repeat the procedures in 2 (a) to (d) for $\theta = 30^\circ, 40^\circ, 50^\circ$ and 60° .

Questions

- (i) Tabulate your results of θ , x and y .
- (ii) Plot a graph of y against x .
- (iii) Determine the slope of your graph.
- (iv) What is the significance of the slope in 2 (iii)?

The candidates who scored low marks (0.0 - 7.0) in this question had inadequate experimental skills in physics, mainly in the topic of *Light*. These candidates failed to demonstrate the skills in setting up the experiment, collecting data, interpreting and presenting graphically. They failed to measure the required angle of incidence θ^o and to draw the relevant circle to the given radius. As a result, they failed to obtain the correct table of results and graph, which led them to get the wrong final answers. Some of them managed to assemble the intended setup and obtained the correct results, but failed to analyse the data graphically. For instance, some of the candidates plotted *variable* x against *variable* y instead of y against x . Another candidate tabulated the results of *variable* x and *variable* y in centimetres (cm) instead of millimetres (mm) as per instruction. An incorrect unit led them to draw an incorrect graph, hence an unacceptable slope and final answer. Also, in part (iv), some candidates were incompetent to state the significance of the slope obtained. For example, one of the candidates wrote that the slope signifies *the density of the rectangular glass block*. This candidate was unable to distinguish *density* from the *refractive index* of the material. To understand this, the candidate was supposed to deduce the correct response as follows:

From Snell's law, $\eta = \frac{\sin i}{\sin r}$. All symbols carry their usual meaning. But as

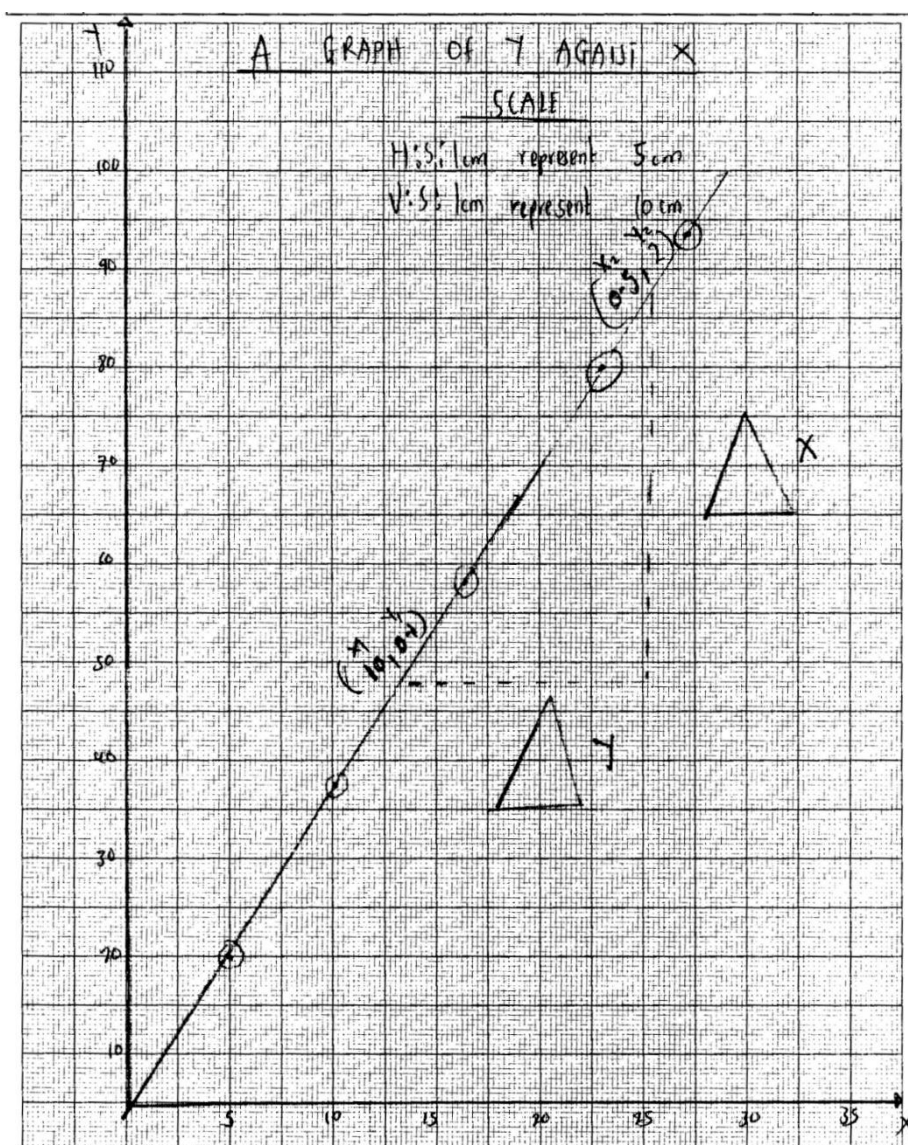
per the experimental setup, $\sin i = \frac{y}{R}$ and $\sin r = \frac{x}{R}$, where R is the radius of

the circle. It follows that $\eta = \frac{\frac{y}{R}}{\frac{x}{R}}$. Up on rearranging this expression, it

gives $y = \eta x$. This expression could be related to the linear equation i.e., $y = mx$. Thus, the slope of the graph is $m = \eta$. Therefore, the slope of the graph signifies the refractive index of the glass block.

Some of them plotted incomplete graphs as they failed to include all features of the graphs. These candidates were supposed to know that good graphs must have the following features: titles of the graph (the variables should have their respective units), scales (both vertical and horizontal scales), and slope indications. Some candidates managed to transfer data points and perform the best-fit line, but failed to complete the numerical calculations correctly. Extract 17.1 provides a sample of a candidate's incorrect responses to this question.

QUESTION NO 2			
2.1	TABLE OF RESULT		
	θ	x	y
	20°	1.3	3
	30°	2.5	3.2
	40°	3	3.5
	50°	3.2	4.5
	60°	3.5	4.7
ii	$\text{Slope} = \frac{\Delta x}{\Delta y}$ $\text{Slope} = \frac{x_2 - x_1}{y_2 - y_1}$ $\text{Slope} = \frac{0.5 - 2}{10 - 0.1}$ $\text{Slope} = \frac{-15}{9.9}$ $\text{Slope} = 0.6$		
	∴ Therefore the slope is ~~0.6~~ 0.6		
iv	The significance of the slope is It to determine the distance of the glass block.		



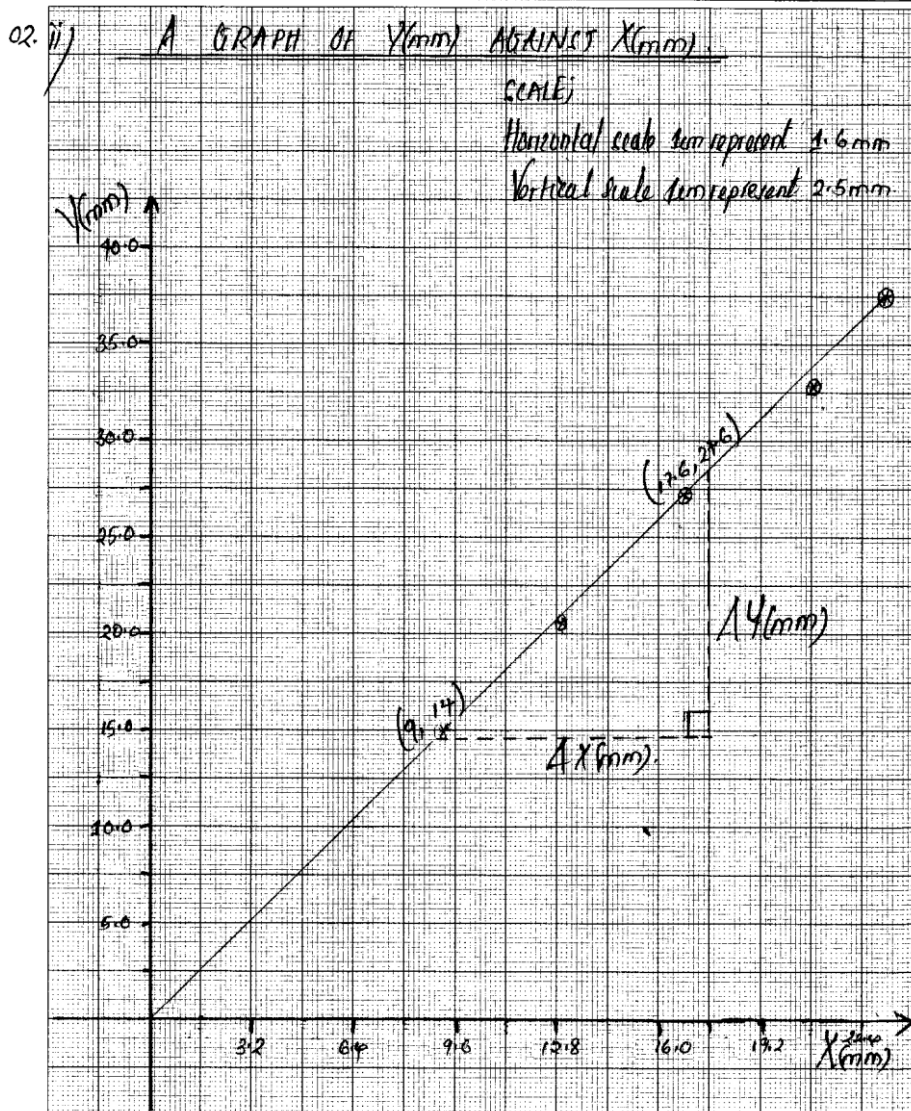
Extract 17.1: A sample of the candidate's incorrect responses to question 2 of Physics 2C

In extract 17.1, the candidate deduced inappropriate table of results with incorrect data and finally plotted an irrelevant graph resulting into wrong calculation of slope.

However, the candidates who scored high marks (7.5-25.0) on this question demonstrated ability in set up an experiment as per given instructions, collecting data, analysing them, interpreting and presenting the data

graphically. They managed to measure the correct angle of incidence θ° , distances x and y . Moreover, they managed to use those data to plot correct graphs by transferring the data points correctly. Likewise, they managed to include all features of the graphs which are; titles of the graph (with units), scales (both vertical and horizontal scales), and slope indications. These candidates had sufficient mathematical skills as they systematically performed numerical calculations in the parts of the question that involved basic operations. Consequently, they were able to make scientific conclusion. Extract 17.2 is an example of the best responses from one of the candidates for this question.

02.	i) Table of result.			
	θ°	$X(\text{mm})$	$Y(\text{mm})$	
	20	9	14	
	30	13	20	
	40	17	26	
	50	21	31	
	60	23	35	
	ii) The graph of $Y(\text{mm})$ against $X(\text{mm})$ has been plotted on a graph paper.			
	iii) The slope of graph $(9, 14)$ and $(23, 35)$ from			
	$\text{slope (s)} = \frac{\Delta Y(\text{mm})}{\Delta X(\text{mm})}$			
	$= \frac{(23 - 9) \text{ mm}}{(35 - 14) \text{ mm}}$			
	$\text{slope (s)} = 1.52$			
	<u>$\therefore$ The slope $s = 1.52$</u>			
	iv) The significance of the slope is Refractive index of the glass block.			



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

In Extract 17.2, the candidate was knowledgeable in collecting and tabulating the results correctly and plotted the graph appropriately, showing all necessary features. Also, the candidate used mathematical skills to obtain all asked quantities.

4.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH TOPIC

In the CSEE 2025 Physics examinations, a total of twenty-four (24) topics were tested. These topics included: *Introduction to Physics, Introduction to Laboratory Practice, Measurements, Friction, Measurement of Thermal Energy, Structure and Properties of Matter, Work, Energy and Power, Temperature, Electromagnetism, Simple Machines, Light, Optical Instruments, Pressure, Forces in Equilibrium, Newton's Laws of Motion, Thermal Expansion, Waves, Radioactivity, Geophysics, Elementary Astronomy, Static Electricity, Current Electricity, Thermionic Emission and Electronics.*

The analysis of performance in Physics Paper 1 revealed that several topics had good performance. For instance, the topic of *Elementary Astronomy and Geophysics* (94.11%) was assessed in Question 8. Meanwhile, the following topics were tested in Question 1: *Introduction to Physics, Introduction to laboratory practice, Measurements, Friction, Structure and Properties of Matter, Pressure, Light, Static Electricity, work, Energy and Power.* These topics had an overall performance of 71.88%. Also, the candidates' performance was good in the topic of *Radioactivity and Thermionic Emission* as (65.38%) performed well.

However, the candidates' performance was also good in the following topics: *Measurements* (77.07%) tested in question 1 of Paper 2, and *Light* (69.68%) tested in question 2 of Paper 2;

Furthermore, some of the candidates' performance was average in the following topics; *Light and Optical Instruments* (54.92%), tested in Question 3 paper 1; *Thermal Expansion and Measurements of thermal energy* (52.23%) this was assessed in Question 6 Paper 1; *Pressure and Forces in Equilibrium* (48.91%) this was assessed in Question 4 paper 1; *Temperature* (45.84%) this was assessed in Question 2 paper 1; *Electromagnetism* (37.67%) this was assessed in Question 11 paper 1; *Current Electricity* (35.83%) assessed in Question 7 paper 1.

Lastly; some of the topics had weak performance scores of less than 29% of the allocated marks. These involves; the topic of *Newton's Laws of Motion* which was assessed in question 5 (29.16%), and the topic of *Waves* and

Electronics (21.40%) being assessed in question 10. The weak performance in these topics was influenced by candidates' inadequate knowledge concerning the assessed topics, poor drawing skills, lack of proficiency in the English language, and improper use of formulae, which resulted from poor mathematical skills in attempting Physics problems.

The analysis of candidates' performance in each topic for Physics Paper 1 (Theory) is provided in Appendix I, while the analysis of Physics Paper 2 (Practical) is provided in Appendix II.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Generally, the candidates' performance in Physics subject in the CSEE 2025 was good as 84.04 per cent passed the examination. Those who performed well demonstrated sufficient knowledge and mastery of the concepts, theories, principles and laws governing the topics examined. The candidates' abilities facilitated them to recognise the demands of the questions and respond accordingly. However, some candidates performed poorly due to insufficient knowledge of the assessed topics and lack of proficiency in English language, which made the candidates to make grammatical errors in their responses. Incompetence in mathematical manipulation skills also lowered the performance of some candidates, particularly in the questions that required the use of data in attempting a Physics problem. Additionally, poor drawing skills contributed to low performance, as some candidates drew incorrect or irrelevant diagrams.

In the practical paper, although majority of the candidates scored high marks, some candidates came across some challenges. They unsuccessfully tabulated the tables of results, while others lacked the necessary skills to draw graphs which required data transfer from those tables. It was also observed that some candidates had problems in selecting suitable scales, labelling the axes, transferring points, indicating the slope and drawing the best-fit line.

5.2 Recommendations

From the candidates' response analysis report; teachers, education officers and other stake holders are recommended to adhere to the following;

- (a) To facilitate the students to use the curved mirrors to locate the images formed, by applying the respective rules. Additionally, guide the students to demonstrate how converging (convex) and diverging (concave) lenses are used to correct various types of eye defects in human eye.
- (b) To guide the students to practice how to measure atmospheric pressure using simple mercury barometer. Teachers should organize *study trips* to the nearby destinations such as *Airports*, where the students will learn a lot of relevant information about *atmospheric pressure* and the related concepts practically. Similarly, they will familiarize with different measuring devices including Simple mercury barometers, Fortin barometer and Aneroid barometer.
- (c) Teachers should guide the students to perform experiments related to the topic of *Forces in Equilibrium*. This should not only base on two masses but also multiple masses. Likewise, they should be aware on how to deal with multiple forces as well, hence become familiar on how to respond to such questions when asked. Additionally, it will help the candidates to know how to treat such questions when the fulcrum is either at the centre of gravity or not.
- (d) Teachers should facilitate the students to conduct group discussion, to share experience and improve their performance in different skills such as mathematical, practical and theoretical grounds. Also, in their discussions should focus on the use of the respective technical terms as per corresponding topics. This habit will help them improve their English-speaking proficiency as well as writing skills.
- (e) Assist the students to develop the attitude of discussing practical applications of various topics. Through which the students may answer properly real-world problems, such as the one related with Newton's laws of motion. Moreover, once teaching Newton's second law of motion, an emphasis should be on the relationship between the force of impulse and the time of impact and its application in real life situations.

- (f) Encourage the students to practice derivation of various formulae, such as the one related with simple machines including determination of velocity ratio and the efficiency of various types of simple machines like inclined plane.
- (g) Inspire the students to practice drawing various diagrams related to Physics subject in various topics. This will help them to remember the concepts easily as well as improving their drawing skills. Additionally, it should be recognised that drawings are part and parcel of the tested skills in examinations.
- (h) Assist the students in associating the learned knowledge with their real-life environments. This goes in hand by using the readily available materials in their learning environment to emphasize their understanding, rather than relying on industrially manufactured teaching aids.
- (i) Build the culture of teaching practically all the concepts which demand students' experimental experience such as verification of Ohm's law, various laws, rules and principles associated with *Electromagnetism, Ball and Ring Experiment as well Bimetallic strips (in thermal expansion)* and so forth.
- (j) Teachers should employ practical demonstrations and visual aids to enhance understanding of wave properties and various behaviours like diffraction of waves, reflections, and interference of waves.
- (k) Learners should be adequately trained and emphasized in the construction and use of correct circuit symbols. Example PNP and NPN transistor circuit symbols.

Appendix I

The Performance of Candidates in Each Topic in 031/1 Physics 1

S/N	Topic	Question Number	Percentage of Candidates who Scored an Average of 30 or above	Remarks
1.	Geophysics and Elementary Astronomy	8	94.11	Good
2.	Introduction to Physics, Introduction to Laboratory Practice, Measurements, Friction, Structure and Properties of Matter, pressure, Light, static Electricity, Work, Energy and Power	1	71.88	Good
3.	Radioactivity and Thermionic Emission	9	65.38	Good
4.	Light and Optical Instruments	3	54.92	Average
5.	Thermal Expansion and Measurement of thermal Energy	6	52.23	Average
6.	Pressure and Forces in Equilibrium	4	48.91	Average
7.	Temperature	2	45.84	Average
8.	Electromagnetism	11	37.67	Average
9.	Current Electricity	7	35.83	Average
10.	Newton's Laws of Motion and Simple Machine	5	29.16	Weak
11.	Waves and Electronics	10	21.40	Weak

Appendix II

The Performance of Candidates in Each Topic in 031/2 Physics 2

S/N	Topic	Question Number	Percentage of candidates who scored an Average of 30 or above	Remarks
1	Measurement	1	77.07	Good
2	Light	2	69.68	Good

