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) 2022

PHYSICS

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031 PHYSICS

Published by
The National Examinations Council of Tanzania,
P. O. Box 2624,
Dar es Salaam, Tanzania.

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FOREWORD

The National Examinations Council of Tanzania (NECTA) among other things is mandated to administer Examinations at National level. The Certificate of Secondary Education Examination (CSEE) is a summative evaluation after four years of study in secondary school level. The CSEE aims at examining the competences acquired by the candidates after four years of study as per the 2010 Physics Syllabus for Secondary.

This Candidates Item Response Analysis (CIRA) report for the 2022 Physics subject Form Four National Examination (CSEE), has been prepared to provide feedback to education stakeholders about the responses given by the candidates in the examination items. It helps in understanding reasons for the observed performance of the candidates in the Physics subject.

The report highlights factors that contributed to the candidates' performance, including: failure to follow instructions, inability to understand the demand of the questions, poor English Language proficiency, inadequate knowledge about the concepts examined, lack of drawing skills and inability to solve numerical problems. It is expected that the recommendations provided in this report will enable the policy makers, education administrators, school managers, teachers and candidates to identify proper measures to be taken in order to improve candidates' performance in future examinations administered by the Council.

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

Dr. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report presents an analysis of the candidates' Items Responses in the 2022 Physics Certificate of Secondary Education Examination (CSEE). The examination consisted of two papers namely, 031/1 Physics1 (Theory Paper) and 031/2 Physics 2 (Actual Practical Paper). The Examination intended to assess competences achieved by the candidates based on the 2010 Physics Syllabus for Secondary Education. The competences tested included the ability of a candidate to: apply Physics knowledge, principles and concepts in daily life; apply scientific methods in solving problems in daily life; apply technological skills in conservation and sustainable use of environment; manage simple technological appliances; and design and implement simple electronic circuits in daily life.

The Physics 1 examination paper consisted of three sections, namely; A, B and C with a total of eleven (11) questions. The candidates were required to answer a total of 10 questions which weighed 100 marks. Section A consisted of two (2) questions, one with multiple choice items and the other matching items. The candidates were required to answer all the questions. Each item in both multiple choice and matching items weighed one (01) mark making a total of 15 marks.

Question 1 had ten multiple choice items which were constructed from nine (9) topics. The topics included; *Measurement; Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Light; Motion in a Straight Line, Measurement of Thermal Energy, Vapour and Humidity; Temperature; Thermionic Emission; Elementary Astronomy;* Question 2 had five (5) homogeneous items for matching which were set from the topic of *Waves*. Section B consisted of six (6) short answer questions set from the topics of *Light; Optical Instrument; Pressure; Forces in Equilibrium; Newton`s Laws of Motion; Simple Machines; Thermal Expansion; Measurement of Thermal Energy; Current Electricity; Radioactivity; Geophysics; and Waves.* Each question carried ten (10) marks making a total of 60 marks. Section C had three (3) short answer questions aimed to assess the candidates' skills in managing the application of Physics and other technological devices in daily life. The questions were constructed from four (4) topics. The topics included: *Waves,* *Electromagnetism*, *Current electricity* and *Electronics*. The candidates were required to answer two questions from this section. Each question carried 12.5 marks, making a total of 25 marks.

The practical part of the examination, Physics 2, had three option papers. The papers were 031/2A Physics 2A, 031/2B Physics 2B, and 031/2C Physics 2C. Each alternative paper consisted of two questions. In each alternative, the candidates were required to answer all the questions. Each question carried 25 marks, making a total of 50 marks.

The number of candidates who sat for the Physics examination was 114,472 out of which 78,009 (68.34%) passed the examination and 36,463 (31.66%) failed. In the Year 2021, the candidates who sat for Physics examination were 116,610 out of which 64,096 (55.33%) passed and 52,514 (44.67%) failed. In the Year 2020, 120,856 candidates sat for Physics examination of out of which 58,808(48.87%) passed and 62,048 (51.13%) candidates failed. This indicates that the candidates` performance in Physics for the Year 2022 has increased by 13.01% compared to the Year 2021. Table shows the performance of the candidates from the Year 2020 to 2022 in Physics.

Table 1: **The Physics Candidates Performance from 2020 to 2022 in Physics**

Year	Candidates who Sat for the Paper	Candidates who Passed	
		Number	Percentage
2020	120,342	58,808	48.87
2021	115,846	64,096	55.33
2022	114,472	78,009	68.34

Table: 1 indicates that the performance of the candidates has increased by 19.47% from 2020 to 2022. However, the number of candidates enrolled has been gradually decreasing from 120,342 in 2020 to 114,472 in 2022.

This report provides a comprehensive analysis of the performance of the candidates in each question. The analysis begins with description of what the candidates were supposed to do and how they responded to each question. Thereafter it summarizes the reasons behind the candidates` performance in a particular question. Extracts representing samples of the candidates' good and weak responses are presented to show clearly what the candidates did.

The percentage of performance in each question is divided into three categories namely; weak, average, and good performance. The performance is considered to be weak if the marks of the candidate range from 0-29 per cent. If the marks of the candidate range from 30-64 per cent the performance is average. Good performance ranges from 65-100 per cent. Red, Yellow and Green colours have been used to indicate weak, average and good, respectively. The report comprises of Appendix I which indicates the general performance in each topic while Appendix II shows the comparison of candidates' performance between CSEE 2021 and 2022 topic-wise.

The samples of candidates' responses are presented as extract to indicate good and weak cases. Graphs and charts are used to summarize the candidates' performance in each question. Clarifications on specific questions and extracts of candidates' answers have been thoroughly explained to illustrate a particular case.

Finally, the report draws conclusion and gives recommendations that may help to improve candidates' performance in future examinations.

2.0 THE CANDIDATES' PERFORMANCE ANALYSIS PER QUESTION IN PHYSICS PAPER 1

This section describes the performance of the candidates in each question. It covers types of the questions, topics from which the questions were set as well as the performance of the candidates in each question. The candidates' scores have been analysed as weak, average and good according to the performance.

2.1 Section A: Objective Questions

This section consisted of two objective questions (1 and 2). Question One consisted of 10 items and Question Two had 5 items each item carrying 1 mark.

2.1.1 Question 1: Multiple Choice Items

This question comprised of ten (10) multiple choice items numbered (i) to (x). The question items were constructed from nine (9) topics which are: *Measurements*, *Archimedes Principle and the Law of Floatation*, *Structure and Properties of Matter*, *Light*, *Motion in a Straight Line*, *Measurement of Thermal Energy*, *Temperature*, *Thermionic Emission*, and *Elementary Astronomy*. The candidates were required to choose the correct answer from the five (5) (A, B, C, D or E) alternatives and write its letter against the item number in the answer booklet provided. Each item weighed 1 mark making a total of 10 marks for the question.

The question was attempted by 114,472 (100 %) candidates out of which 43,296 (37.82%) candidates scored from 0.0 to 2.0 marks; 63,574 (55.54%) scored from 3.0 to 6.0 marks and 7,602 (6.40%) scored from 7.0 to 10.0 marks. Thus the general performance of this question was average as 71,176 (62.18%) candidates scored from 3.0 to 10.0 marks. Figure 2 shows the candidates' performance in this question.

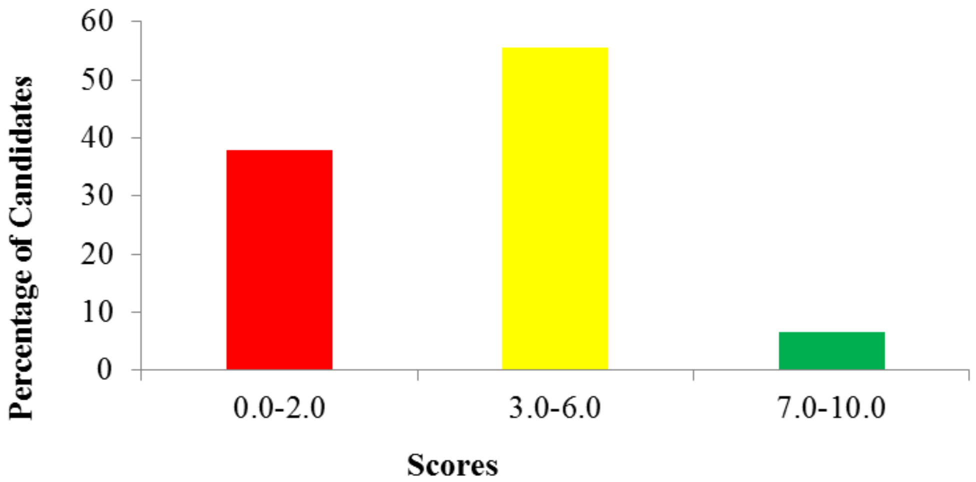


Figure 2: *Candidates' Performance in Question 1*

Item (i) was constructed from the topic of *Measurement*. The candidates were required to identify the set which represents fundamental quantities with their SI units. The given alternatives were; *A. Length (km), mass (kg), temperature (^{0}C), amount of substance (mol) and electric current (A), B. Length (m), mass (kg), force (N), temperature (K), time (s), amount of* *substance (mol) and energy (J), C. Length (m), mass (kg), time (s) electric current (A), temperature (^{0}C) and amount of substance (mol) D .Length (m), mass (kg), time (s), temperature (K), electric current (A) and luminous intensity (Cd)* and *E. Length (km), mass (g), time(s), temperature (K), electric current (A)* and *amount of substance (mol).* The correct alternative was D. *Length (m), mass (kg), time (s), temperature (K), electric current (A) and luminous intensity (Cd)*. Most of the candidates managed to choose the correct answer, showing that the concept of Measurement was well understood by the candidates. However, a few candidates chose incorrect alternatives A or B or C or E because they failed to identify a set of the fundamental quantities with their corresponding SI units. Those who opted for *A. Length (km), mass (kg), temperature (^{0}C), amount of substance (mol) and electric current (A*) lacked the knowledge that the SI unit of length and temperature are metre (m) and kelvin (K), respectively. Similarly, those who chose alternative B. *Length (m), mass (kg), force (N), temperature (K), time (s), amount of substance (mol) and energy (J)* failed to differentiate the fundamental from derived quantities. The force (N) and energy (J) in this alternative are derived quantities. For those who opted for C. *Length (m), mass (kg), time (s) electric current (A), temperature (^{0}C) and amount of substance (mol),* failed to identify the unit for temperature. A few candidates opted for *E. Length (km), mass (g), time(s), temperature (K), electric current (A)* and *amount of substance (mol)*. These candidates did not know the SI unit for length and mass hence, opted a wrong option.

Item (ii) was set from the topic of *Archimedes Principle and the Law of Floatation*. The candidates were required to identify a condition that could be satisfied for a body to float. The given alternatives were: *A. Apparent weight is equal to the difference between real weight of the body and its upthrust, B. Upthrust equals to the weight of the fluid displaces, C. Real weight of the body equals to its upthrust, D. Apparent weight is equal to the product of real weight of a body and its upthrust and E. Density of a body is equal to the density of surrounding fluid.* The correct alternative was *C. Real weight of the body equals to its upthrust*. The alternative is among of the conditions for a body to float. The conditions are:

(i) The volume of submerged part of the object must be large to displace a large volume of water.

(ii) Density of the object must be less than the density of the surrounding water.

(iii) The upthrust due to water must be equal the weight of the object.

Most of the candidates opted for *B. Upthrust equals to the weight of the fluid displaces,* indicating that they failed to distinguish between conditions for a body to float and the Archimedes' Principle. Others opted for *D. Apparent weight is equal to the product of real weight of a body and its upthrust.* These candidates had inadequate knowledge about the conditions for a body to float.

Item (iii) was constructed from the topic of *Structure and properties of matter*. The candidates were required to choose the correct statement about the properties of gaseous state of matter among the given alternatives. The alternatives were: *A. Particles vibrate in fixed positions, B. The shape is indefinite with definite volume, C. Particles are closely packed together, D. Both shape and volume are definite and E. The inter-particle distance is large*. The correct alternative was *E. The inter-particle distance is large,* since it is one of the properties of gaseous state of matter. Others opted for *B. The shape is indefinite with definite volume;* the term indefinite shape distracted them but failed to recognize that gas has no definite volume, since it always occupies the volume of the containing vessel.

In item (iv**),** the candidates were required to identify the position which the object will be placed for a concave mirror to form virtual, magnified and erect image behind the mirror. The item was constructed from the topic of Light. The given alternatives were; *A. Between the principle focus (F) and the pole (P) in front of the mirror*, *B. Between the principle focus (F) and pole (P) behind the mirror, C. Between the centre of curvature (C) and principle focus (F) in front of the mirror, D. Between the centre of curvature (C) and principle focus (F) behind the mirror and E. Between the centre of curvature (C) and the pole (P) in front of the mirror.* The correct choice was *A. Between the principle focus (F) and the pole (P) in front of the mirror*. The candidates should be able to remember the rules of locating the images formed in a curved mirror, which are:

(i) Rays passing through the centre of curvature are reflected back along their own path

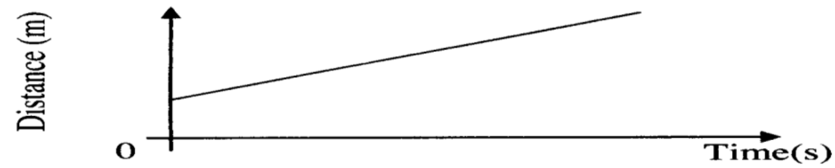
(ii) Rays parallel to the principal axis are reflected through the principal focus.

(iii) Rays through the principal focus are reflected parallel to the principal to the principal axis

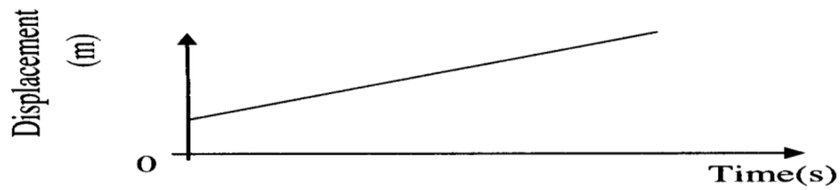
Most of the candidates responded incorrectly by opting *C. Between the centre of curvature (C) and principle focus*, the image will be real, inverted and beyond centre of curvature. However, a few candidates opted for alternative *B. Between the principle focus (F) and pole (P) behind the mirror*, candidates had inadequate knowledge on images formed by concave mirrors as "no object placed behind the mirror".

Item (v) was constructed from the topic of Motion in a Straight Line. The candidates were required to identify the uniform motion graphs which represent velocity. The given alternatives were:

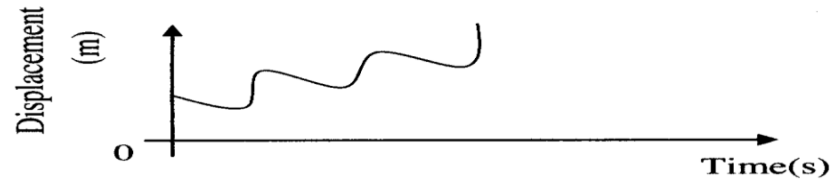
A



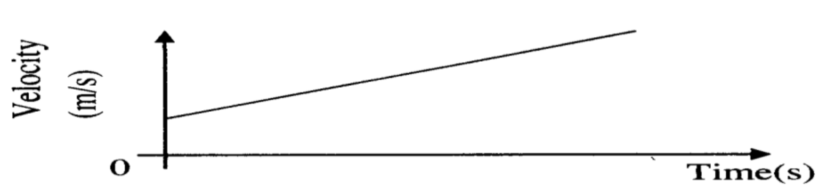
B



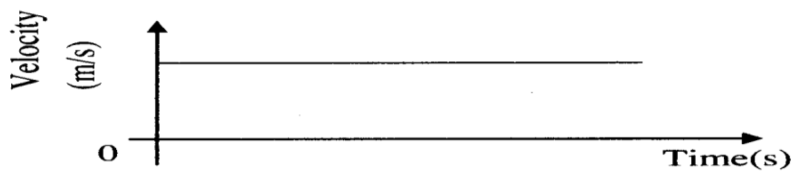
C



D



E



The correct alternative was *B,* which is the displacement time graph. Most of the candidates opted for *E,* which was incorrect response. They were attracted by the constant velocity represented in velocity time graph, which shows that they had the knowledge but failed to interpret the alternative given. Those who opted for *A,* were not able to differentiate between distance and displacement.

In item (vi), the candidates were assessed in the topic of *Measurement of Thermal Energy*. The candidates were required to choose a correct response for combination statements that explained the observation when two objects X and Y were supplied by equal quantities of thermal energy and observed that the temperature increase of object X is greater than the temperature increase of object Y. The given alternatives were as follows: *A. X has a lower melting point than Y, B. X has lower density than Y, C. X has lower thermal capacity than Y, D. X is a better thermal conductor than Y and E. X is heavier than Y*. The correct response was *C. X has lower thermal capacity than Y.* Most of the candidates who opted for response D. *X is a better thermal conductor than Y,* failed to differentiate thermal conductor from thermal capacity. The candidates were supposed to understand that heat capacity is the amount of heat required to raise the temperature of the object by 1K or 1^oC, while thermal conductor refers to the material which allows heat energy to pass through it easily.

Item (vii) was set from the topic of *Vapour and Humidity*. The candidates were required to select the correct response which explains what happens to the mass and weight of the water in the cup while " hot water in a cup undergoes evaporation in an open air" from the given alternatives. The alternatives were as follow: *A. Both mass and weight decrease, B. Mass decreases while weight stay the same, C. Both mass and weight stay the same,* D. Mass *increases while weight decreases and E. Mass stays the same while weight decreases.* The correct response was A. *Both mass and weight decrease.* Most of the candidates responded correctly showing that they properly understood that evaporation takes place when water molecules escape from the surface to the air. As water molecules continue to escape, their mass and weight on the container/surface is reduced. A few candidates opted for alternative *B. Mass decreases while weight stays the same.* Others opted for *D. Mass increases while weight decreases*. This suggests that the candidates opted randomly, which indicates that the candidates did not understand the effect of evaporation on mass and weight.

Item (viii) was constructed from the topic of *Temperature*. The candidates were provided with the scenario in which a candidate wished to check the upper and lower fixed points on Celcius scale thermometer. The candidates had four beakers, namely P, Q, R and S. Beaker P contained a mixture of ice and salt; Q contained a mixture of ice and water; R contained a mixture of boiling salt solution and S contained boiling water. The candidates were required to choose the pair of beaker that was to be used to check the fixed points. The given alternatives were: *A. P and Q, B. P and S, C. Q and S, D. Q and R and E. S and R*. The correct response was *C. Q and S*. The candidates who failed this question chose *E, S and R* indicating that they had knowledge of how to check upper fixed point using boiling water but didn't know how to check for lower fixed point.

In item (ix), the candidates were assessed in a topic of Thermionic emission. They were required to identify one statement which is not a property of cathode rays from the following ones: *A. They are stream of fast moving protons, B. They travel in straight line, C. They are deflected by electric fields, D. They are deflected by magnetic fields and E. They produce x-rays when stopped suddenly*. The correct response was *A. They are stream of fast moving protons.* Alternatives B, C, D and E were properties of cathode rays. Majority of the candidates picked option *E. They produce x-rays when stopped suddenly* and a few chose option *D. They are deflected by magnetic fields* implying their lack of knowledge about properties of x-rays.

In item (x), the candidates were required to identify the response which gives the meaning of the term Milky Way. The given alternatives were: *A. A vast collection of asteroids, B. One of the galaxies of the universe, C. A group of stars that form a pattern in the sky, D. One of the meteoroids and E. One of the solar systems*. The correct response was *B. One of the galaxies of the universe*. Most of the candidates responded correctly. Those who failed opted for *C. A group of stars that form a pattern in the sky.* These candidates were distracted by the definition of constellations which was not the requirement of the question. Others opted for responses *E* or *D* or *A* suggesting their lack of knowledge about the elementary astronomy.

2.1.2 Question 2: Matching Items

This question comprised of five (5) items constructed from the topic of Waves. The candidates were required to match each of function in **List A** with the corresponding electromagnetic radiations in **List B**. The question was as follows:

Match the applications of parts of the electromagnetic spectrum in **List A** with the corresponding parts of electromagnetic spectrum in **List B** by writing the letter of the correct response beside the item number in the answer booklet provided. **(5 marks)**

List A	List B
(i) Can be used to sterilize fruits and vegetables.	A Visible light
(ii) Stimulates the production of vitamin D in the human skin.	B X-rays
(iii) Stimulates the sensitive cells in the retina.	C Microwaves
(iv) Emitted by a remote control.	D Alpha particles
(v) Used for rapid cooking in an oven.	E Gamma rays
	F Infra-red rays
	G Radio waves
	H Ultra-violet rays

A total of 114,472 (100%) candidates attempted the question and their scores were as follows: 36,317 (31.73%) scored from 0 to 1 mark, 58,029 (50.69%) scored from 2.0 to 3.0 marks; and 20,126 (17.58%) scored from 4.0 to 5.0 marks. The scores indicate that the candidates' performance was good as 78,155 (68.27%) scored from 2.0 to 5.0 marks out of 5 marks. Figure 2 summarizes the candidates' performance in Question 2.

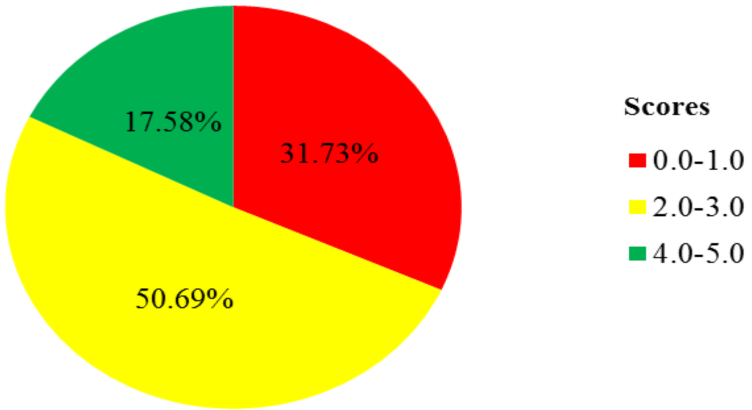


Figure 2: The *Candidates' Performance in Question 2*

In item (i), the candidates were required to provide a suitable response which matches correctly with the statement *"can be used to sterilize fruits and vegetables"*. The correct response was *E. gamma rays*. Most of the candidates identified the appropriate answer in this item, showing that they had knowledge about the concept of waves, particularly the various electromagnetic radiations contained in the electromagnetic spectrum and their uses. Some of the candidates were distracted by alternative *B. x-rays*. This is because x-rays and gamma rays have the same properties. However, the two rays differ in their practical applications. For instance, while gamma rays are used in the sterilization of medical equipment and food, x-rays are used in the treatment of cancer diseases.

Item (ii) required the candidates to write the letter of the item which matched correctly the phrase *"stimulates the production of vitamin D in the human skin"*. The appropriate response was *H. ultra-violet rays.* Most of the candidates chose the correct response, implying that the candidates were knowledgeable on the functions of ultraviolet rays. However, a few candidates opted for response *F. Infra-red rays.* These candidates had no insight on the functions of x- rays. They were supposed to learn that the functions of infrared are remote control operation and strengthening of the human and animal heat patterns.

Item (iii), required the candidates to give the radiation which matched correctly with the statement *"stimulates the sensitive cells in the retina"*. The correct option was *A. visible light,* whereby visible light is used to stimulate the sensitive cells in the retina. Most of the candidates chose the correct response, showing that they knew the uses of visible light. A few candidates opted for other responses B, C, D, E, F, G, or H which indicates that these candidates had poor knowledge about the general uses of electromagnetic radiations.

In item (iv), the candidates were required to provide a suitable response which matched correctly with the statement *"emitted by a remote control".* The appropriate response was *F. infra-red rays*. This item was wrongly matched by most of the candidates. Most of them opted for *G. radio waves* which was an incorrect response. These candidates were supposed to know that radio waves are used for radio and television communication, but not in remote control.

In item (v), the candidates were required to give the electromagnetic radiation which matched correctly the statement *"used for rapid cooking in an oven".* The correct response was *C. microwaves.* Most of the candidates opted for the correct answer. This implied that they were familiar with the uses of microwaves. A few candidates failed to match the correct response which alludes that they had insufficient knowledge about the concept and the uses of the electromagnetic radiations. These candidates were supposed to understand that some of the uses of micro waves include: cooking and reheating food, disinfecting kitchen items, proofing yeast, and heating beauty products. Extract 2.1 shows a sample of responses from a candidate who matched all items of the question correctly while Extract 2.2 shows a sample of incorrect responses given by one of the candidates in this question.

2.	LIST A	i	ii	iii	iv	v.		
	LIST B	E	H	A	F	C		

Extract 2.1: A sample of correct responses in Question 2

In extract 2.1, the candidate matched all the items of the question correctly and scored full marks.

2 i	C
ii	B
iii	F
iv	A
v.	H

Extract 2.2: A sample of incorrect responses in Question 2

In extract 2.2, the candidate showed to have insufficient knowledge about the uses of electromagnetic radiations of the electromagnetic spectrum from the topic of Waves.

2.2 Section B: Short Answer Questions

This section comprised of six Short Answer Questions which had six (6) items set from twelve (12) topics. The topics included *Light; Optical instruments; Pressure; Forces in Equilibrium; Newton`s Laws of Motion; Simple Machines; Thermal Expansion; Vapour and Humidity; Current Electricity; Radioactivity; Geophysics and Waves.* Each question carried 10 marks.

2.2.1 Question 3: Light and Optical Instruments

The question had two parts, namely (a) and (b). In part (a), the candidates were required to use a well labelled diagram to show how an upright and enlarged image can be formed in a concave mirror. In part (b), the candidates were required to use a diagram to describe three ways in which a human eye can be compared to a photographic camera.

The question was attempted by 114,472 (100%) candidates out of whom 90,702 (79.24%) scored from 0 to 1.0 mark, 18,928 (16.54%) scored from 2.0 to 3.0 marks and 4,842 (4.22%) scored from 4.0 to 5.0. The performance of the candidates in this question was weak as 90,702 (79.24%) candidates scored 0.0 to 1.0 mark. Figure 3 summarizes the performance of the candidates in Question 3.

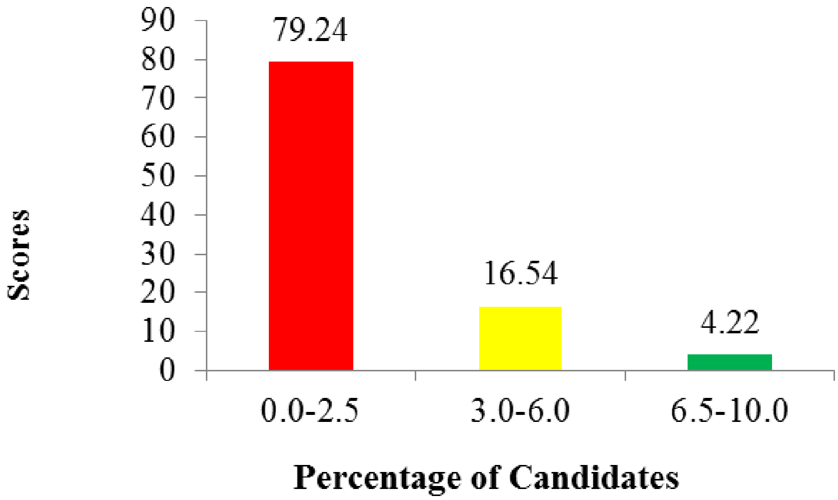
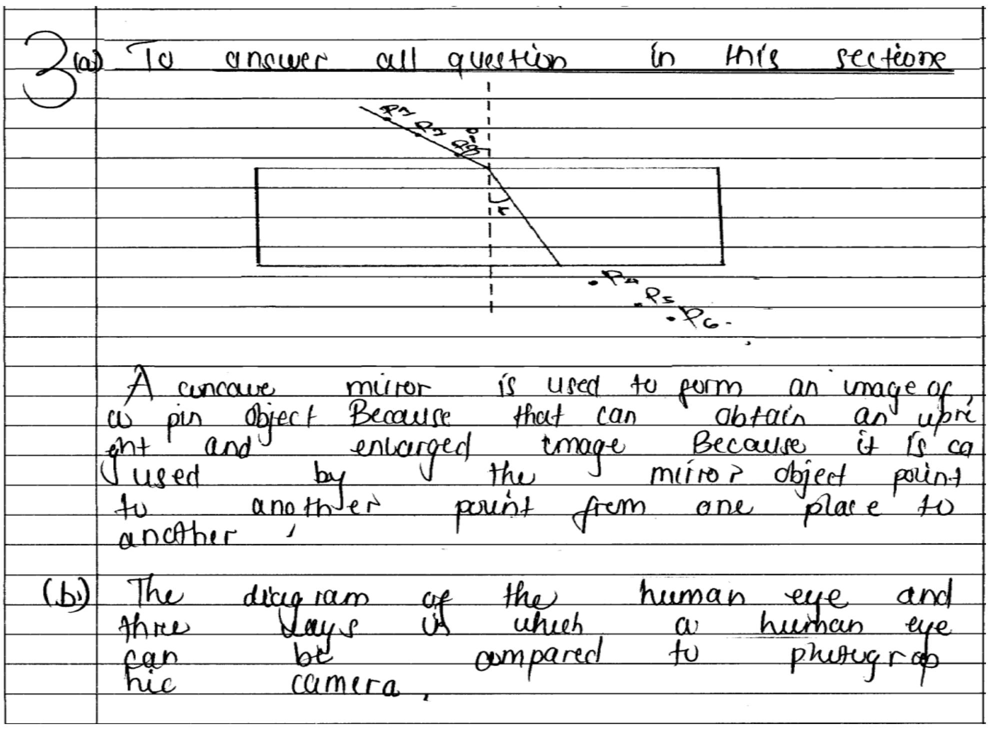


Figure 3: *The Candidates' Performance in Question 3*

The candidates who scored low marks (0.0 to 1.0) had inadequate knowledge and poor drawing skills in the topic of *Light*. In part (a), most of the candidates who responded incorrectly used the concept of refraction of light by concave lens, glass block or triangular glass prism instead of using the concept of reflection of light in a concave mirror. This shows that they had inadequate knowledge about the rules and ways of the construction of ray diagrams in the reflection of light for curved surfaces.

Other candidates were able to draw the concave mirror diagram but failed to indicate on it the position of the pin object, principal focus, centre of curvature and the pole of the mirror. For instance, one of the candidates stated that "*the upright and magnified image is obtained by placing the object between the centre of curvature and the principal focus of the concave mirror.*" This candidate was supposed to realize that although the image formed is enlarged upon placing the object between the centre of curvature and the principal focus, the image is real and inverted. Some of the candidates drew a convex mirror instead of the concave mirror. In order to be able to draw a correct diagram, the candidates were supposed to know that the outer side of the curved mirror is silvered such that the inner becomes reflective, hence a concave mirror. If the inner part is silvered and the outer becomes reflective the mirror is convex. They were also supposed to understand that, upright and enlarged image in a concave mirror is formed whenever the object is placed between the principal focus and the pole, and that the image is formed behind the mirror.

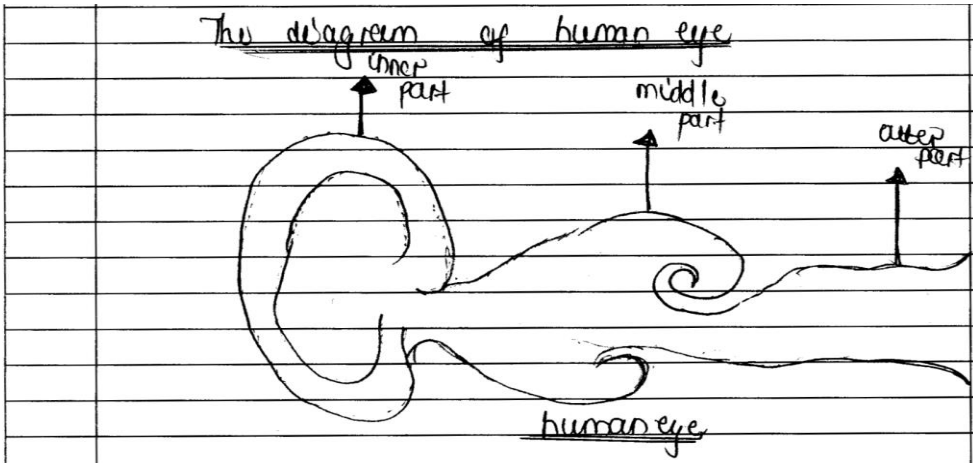
In part (b), the candidates who scored unsatisfactory marks had inappropriate skills in drawing the diagrams of the human eye and that of the photographic camera. These candidates had also, insufficient knowledge pertaining to the features or parts of the human eye and those of the photographic camera. A few candidates managed to draw and indicate properly some parts of the photographic camera but drew incorrect diagram of the human eye The candidates were supposed to use the concepts of *optical instruments* to draw a well labelled diagram of both the human eye and photographic camera and hence, compared distinctive features as follows: *both have convex lens system to focus the image; the amount of light entering is controlled by variable aperture called iris in the eye and diaphragm in the camera; both have surfaces in which the image is formed; film in the camera and retina in the eye; and while the camera has shutter, the eye has a pupil both meant for controlling light.* Extract 3.1 is a sample of the incorrect responses from one of the candidates who scored low marks in this question.



3(a) To answer all question in this sectione

A concave mirror is used to form an image of a pin object Because that can obtain an upright and enlarged image Because it is ca used by the miror object point to another point from one place to another

(b) The diagram of the human eye and three ways in which a human eye can be compared to photographic camera,



* It i's used for earing
* human eye it i's used sens organ is the bo dy'
* Human eye it i's used for transfer anyth ing from one place to another,

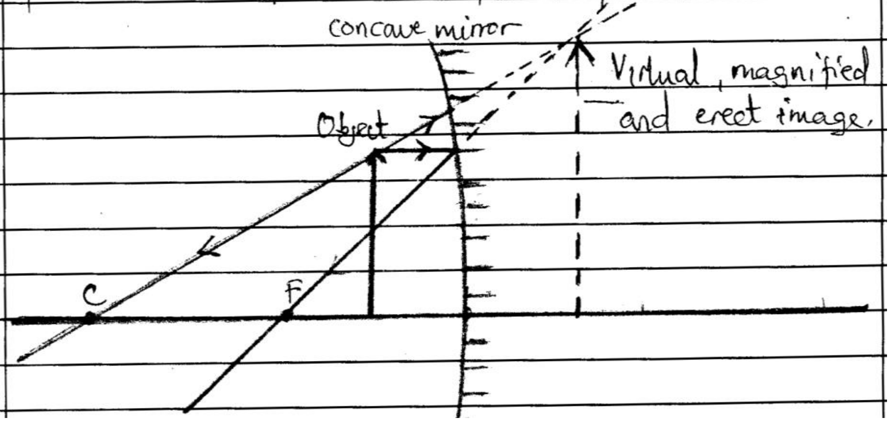
Extract 3.1: A sample of incorrect responses in Question 3

In extract 3.1, the candidate drew a diagram of the glass block which is usually for demonstrating the laws of refraction of light, specifically the Snell's law instead of the diagram of a concave mirror for the formation of images in curved surfaces. She/he also drew the diagram of an ear instead of drawing the diagram of the eye.

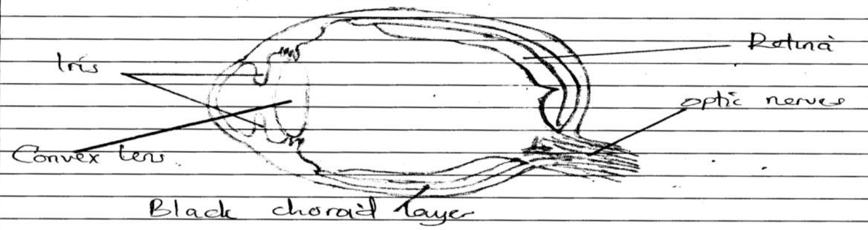
Statistics show that, the highest score in this question was 5.0 marks out of 10.0. The candidates who scored relatively good marks in part (a) had sufficient knowledge about the concept of reflection of light, especially the rules of constructing ray diagrams in the location of images in a concave mirror. They also used the rules to draw the correct ray diagrams by placing the object in a correct position along the principal axis. Thus, they produced an upright and enlarged image formed by a concave mirror behind the mirror.

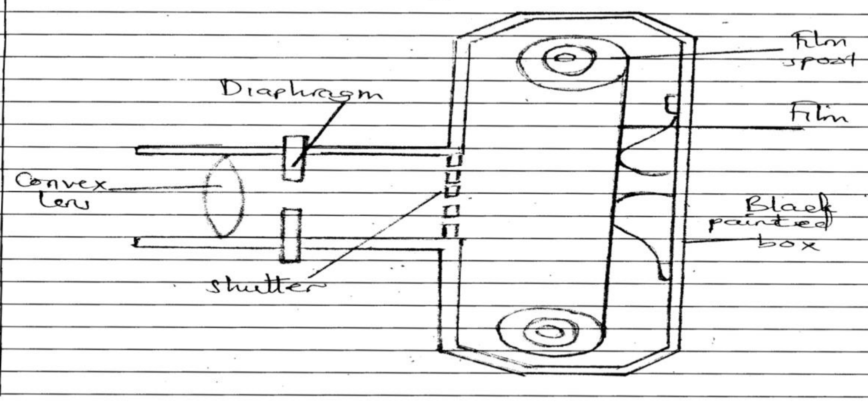
In part (b), the candidates had good performance in the concepts of optical instruments, specifically, on the photographic camera. These candidates drew well labelled diagrams of both the human eye and photographic camera. Likewise, they managed to describe the different ways in which a human eye could be compared to a photographic camera. Generally, their responses suggest that they had understood the topics of *Light* and *Optical Instruments*. Extract 3.2 shows a sample of one of the candidates who performed well in this question.

Q3a) A concave mirror forms an upright and enlarged image when the object is placed between principal focus (F) and pole (P) infront of the mirror.



3b)





3b) Similarities

i) Both have a convex lens system which forms a real, diminished and inverted image

ii) Both have image forming surfaces (light sensitive surfaces) that is retina on eye and film on the Camera

iii) Both controls among of light entering. This is through a diaphragm in a camera and iris in human eye.

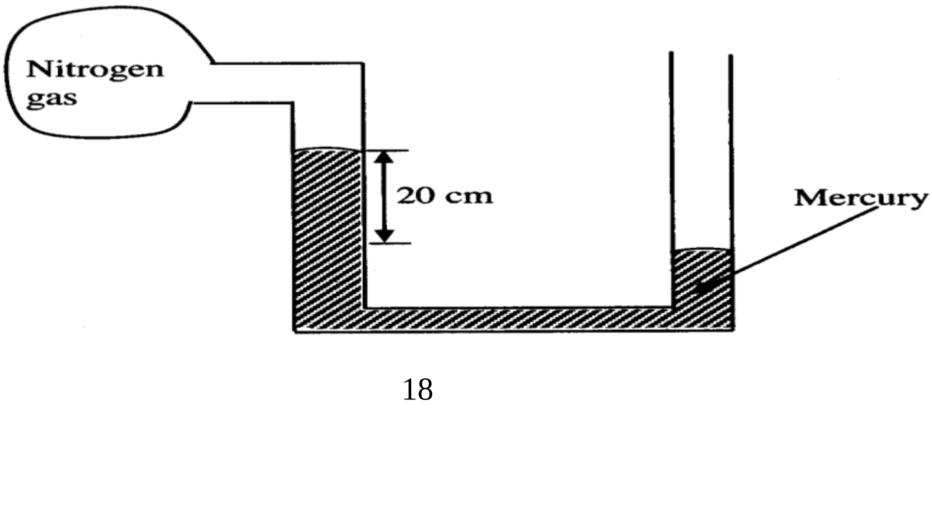
iv) Both are blackened inside to reduce /prevent internal unwanted reflections. Camera is painted black inside while human eye has a black choroid layer.

Extract 3.2: A sample of correct responses in Question 3

In extract 3.2, the candidate provided correct responses to all parts of the question.

2.2.2 Question 4: Pressure and Forces in Equilibrium

This question comprised of parts (a) and (b). Part (a) required the candidates to study the following Figure carefully and determine the pressure of the gas when the atmospheric pressure was $102{,}000\,Pa$ and density of mercury was $13.6\,g/cm^3$. In part (b), the candidates were required to give reason as why a ship cannot overturn when hit by a strong wave on one side.



The question was attempted by 114,472 (100%) candidates out of whom 110,068 (96.15%) scored from 0 to 2.5 marks; 3,964 (3.46%) scored from 3.0 to 6.0 marks; and 440 (0.39%) scored from 6.5 to 10 marks. These scores suggest that the performance of the candidates in this question was generally weak, since 110,068 (96.15%) candidates scored below the pass mark range (from 0.0 to 2.5 marks). Figure 4 shows the performance of the candidates in Question 4.

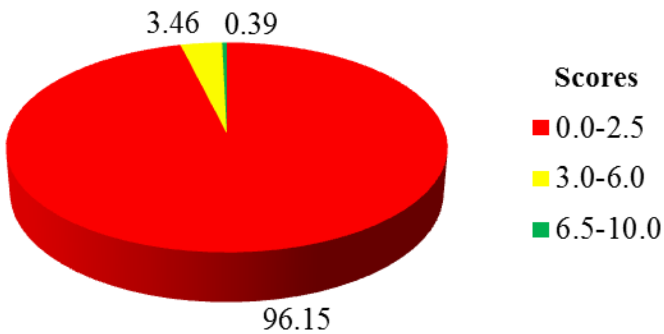


Figure 4: *The Candidates' Performance in Question 4*

In this question, 96.15 per cent of the candidates scored the lowest mark. In part (a), they failed to determine the pressure of the gas enclosed in a U-tube partially filled with a liquid (mercury). Most of them scored low marks in this question due to lack of both the content knowledge and computational skills. Some of the candidates applied incorrect formula to determine the pressure of the gas. For instance, some of the candidates determined the pressure of the gas by using the equation; $\text{Pressure} = \dfrac{\text{Volume}}{\text{Density}}$ which bears no meaningful scientific implication. Others, employed the concept of current electricity to determine the pressure of the gas by using the parameters of length, resistivity and cross-sectional area to calculate the resistance of the material by using the formula; $\text{Resistance} = \dfrac{\text{Length} \times \text{Resistivity}}{\text{Cross sectional area}}$. This indicates that they had poor knowledge about the pressure of the gas by failing to differentiate the concept of pressure from those of current electricity. These candidates were supposed to know that the atmospheric pressure pushes the liquid in the U-tube causing the level in the two limbs of the tube to be different. The level of mercury was higher in the limb of the manometer that is connected to the nitrogen gas than that which was open to the atmosphere. The difference in height of the liquids shows that atmospheric pressure is greater than the pressure of the gas (Nitrogen gas).

$$P_{atm} = P_{gas} + \rho gh$$

$$P_{atm} = P_{gas} + \rho gh$$

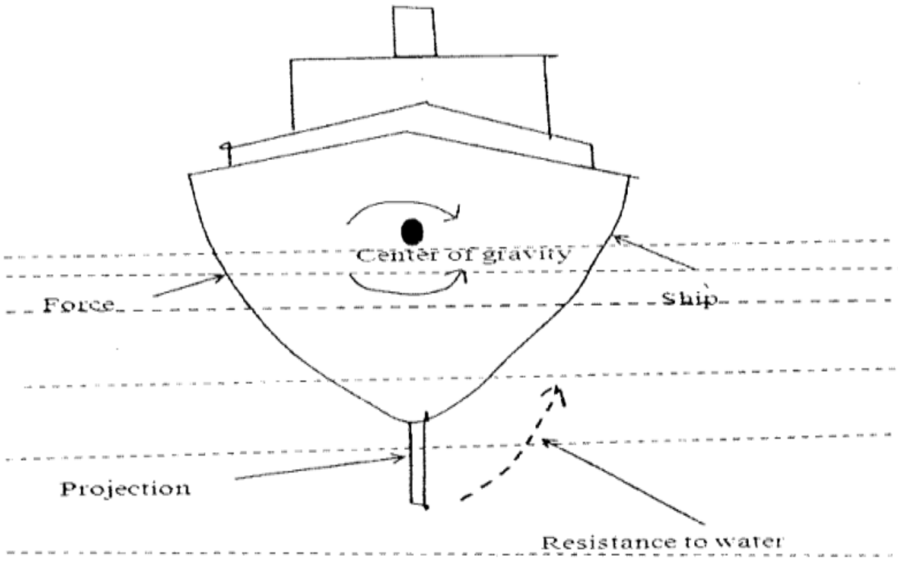
$$P_{gas} = P_{atm} - \rho gh$$

$$p_{atm} = 102,000 \text{ Pa}, \ \rho = 13600 \text{ kg/m}^3 \ and \ h = 0.2 \text{ m}$$

$$P_{gas} = 102000 \ \ Pa - 13600 \times 10 \times 0 \cdot 2 \ pa$$

$$P_{gas} = 74800 \ \ Pa$$

In part (b), most of the candidates failed to explain why a ship cannot overturn when hit by a strong wave on one side. For instance; one of the candidates responded that: *"Because the surface of the bottom of ship is flat and detects resistance of sea water, therefore it will be difficult to move and to overturn when hit by strong wave"*. Another candidate responded that, *"Ship cannot overturn when hit by strong wave on one side because, when the ship moves with the transverse wave so it is very difficult to overturn because it moves with the speed of transverse wave motion"*. These candidates confused the concepts of forces in equilibrium and those of waves. They failed to conceptualize the idea of stability of a ship as it moves on water. The candidates were supposed to realize that a ship has long and wide projecting plates extending from their bases into the water to increase stability as shown hereunder.



When a strong wave hits the ship on one side, it tends to overturn. The projection then meets a lot of resistance as it tends to sweep the large mass of water in contact with it. The resistance due to water causes an opposing moment about the centre of gravity. Thus, the ship is saved from overturning. Extract 4.1 shows a sample of incorrect responses from one of the candidates who performed this question.

04. a) soln

Data given.

Atmospheric pressure = 102,000 Pa

density of mercury = 13.6 g/cm^3

required = pressure of gas.

$$\text{pressure} = \frac{\text{volume}}{\text{density}}$$

$$\text{Pressure} = \frac{102{,}000\ \text{Pa}}{13.6\text{g}/\text{cm}^3 \times 20\text{cm}}$$

$$\text{Pressure} = \frac{102{,}000\ \text{Pa}}{13.6\text{g}/\text{cm}^3 \times 20\text{cm}}$$

$$\text{Pressure} = \frac{102{,}000\ \text{Pa}}{272\ \text{g}/\text{cm}^3}$$

$$\text{Pressure} = 375\ \text{g}/\text{cm}^3$$

∴ The pressure of the gas is 375 g/cm^3.

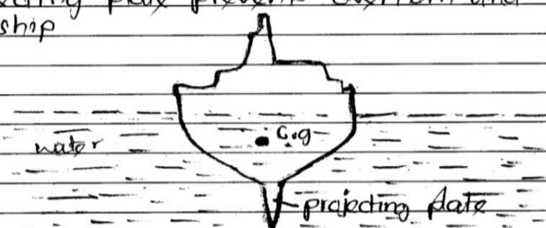
b) ship can not over-turn when hit by strong wave on one side because. when the ship move move with the transverse wave so it is very difficult to over-turn because it moves with the speed of transverse wave motion.

Extract 4.1: A sample of incorrect responses in Question 4

On the other hand, the analysis of the candidates' responses shows that the candidates (0.39%) who scored high (6.5-10.0) marks in this question were able to use the correct formula and computed correctly the pressure of nitrogen gas in a U-tube filled partially with mercury. These candidates had adequate knowledge about the pressure and the concept of equilibrium (stability). They applied the appropriate formula to determine the pressure of the gas and correctly explained the stability of a ship when it was hit by strong wave. Extract 4.2 shows a sample of good responses from one of the candidates who performed this question.

Data given
Mercury height column, $h = 20cm = 0.2m$
Density of mercury, $\rho = 13.6g/cm^3 = 13600 kg/m^3$
Atmospheric pressure Atm $= 102,000 Pa$
From
Pressure of the gas, $p = \rho gh + $ Atmospheric pressure $- \rho gh$
$P = Atm - \rho gh$
$P = 102{,}000 Pa - (13600 kg/m^3 \times 10 m/s^2 \times 0.2m)$
$P = 102000 N/m^2 - (13600 Kg/m^2 \times 2 m/s^2)$
$P = 102000 N/m^2 - (27{,}200 kg\,m s^{-2}/m^2)$
$P = 102000 N/m^2 - 27{,}200 N/m^2$
$P = (102000 - 27{,}200) N/m^2$
$P = 74{,}800 N/m^2$
$\therefore$ Pressure of the gas $= 74800 Pa$

4. (b) A ship can not overturn when hit by a strong wave on one side, due to the presence of a plate projecting into water at the bottom of a ship which lowers the centre of gravity and increases the stability where by when hit on one side, a projecting plate prevents overturn and brings back a ship

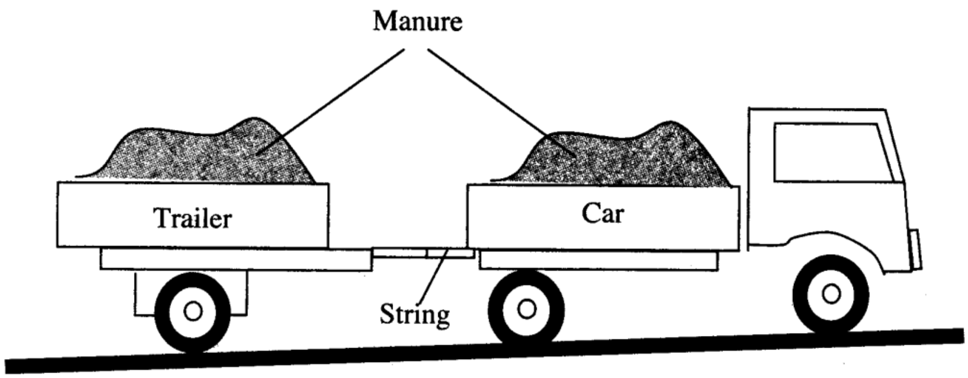


A projecting plate lowers centre of gravity and increases stability.

Extract 4.2: A sample of correct responses in Question 4

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

This question consisted of two parts, namely (a) and (b). In part (a), the candidates were provided with a Figure showing a car that was moving to the farm. The candidates were required to identify four pairs of action/reaction forces taking place and describe their effects.



In part (b), the candidates were required to sketch a well labelled diagram of the machine that is made up of four (4) pulleys and determine the effort required to raise two bags of maize each weighing 100 kg, if the pulley system has efficiency of 75 per cent.

The question was attempted by 114,472 (100%) candidates out of whom 83,991 (73.37%) scored from 0 to 2.5 marks; 29,427 (25.71%) scored from 3.0 to 6.0 marks; and 1,054 (0.92%) scored from 6.5 to 10 marks. The general performance in this question was weak, since 83,991 (73.37%) candidates scored from 0.0 to 2.5 marks. Figure 5 shows a summary of the candidates' performance in Question 5.

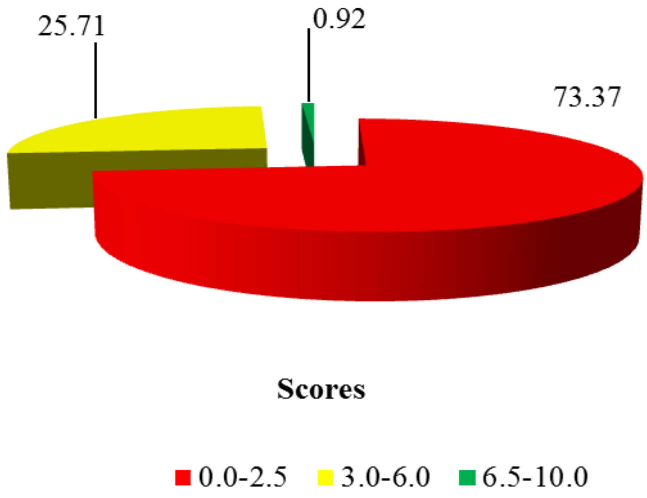


Figure 5: *The Candidates' Performance to Question 5*

In part (a) of this question, most of the candidates failed to identify pairs of action and reaction forces in a given diagram, instead they mentioned different types of forces such as *Friction force, gravitational force, compression force, upthrust force, spring force, fundamental force* and t*ensional force* as expressed in the topic of *Force*. These candidates failed to differentiate the facts of Newton's Law of Motion from different types of forces. Others copied the labelling worlds shown in the Figure such as *Manure, Trailer*, *string* and *car*. This indicates that, these candidates had insufficient knowledge on the concept of Newton's third law of motion which states that "*to every action there is equal and opposite reaction*". They were supposed to give the correct pairs of action and reaction forces for the question as follows; (i) *Action* of tyres pushing the road backward, road produces *reaction* force which pushes the car forward. (ii) *Action* force of total weight of trailer and manure, the ground produces *reaction*. (iii) *Action force* of total weight of car and manure, the ground produces *reaction*. (iv) *Action* produced by car to the trailer, the trailer produces the *reaction* forces to the car. (v) *Action* force of weight of manure on trailer, the *reaction* force of trailer to the manure. (vi) *Action* force of weight of manure on car, the *reaction* force of car to the manure.

In part (b), the candidates who scored low marks, failed to sketch a well labelled diagram of four (4) pulley systems of machines. Some of the candidates sketched the diagrams of pulleys but failed to interpret that the four pulley system is a combination of compound pulleys which comprises of fixed and movable pulleys. Others sketched four (4) pulleys with improper rope connection. Some of the diagrams by these candidates had overlapping rope or last terminal (effort) pointed up. These candidates also failed to calculate the effort required to raise the two bags of maize of 100 kg each. They used weight of one bag (1000 N) as a load in calculating the effort instead of the weight of two bags (2000 N). Essentially, in the four pulley system, one end of the rope is fixed while the other end is left for a person to pull thereby lifting a movable pulley and the load. Most of candidates demonstrated poor drawing and computational skills. In addition, the candidates had to know that velocity ratio is equal to a number of pulleys. Then, they had to do as follows:

$$Efficiency = \frac{M \cdot A}{V \cdot R} \times 100\%$$

$$M \cdot A = \frac{Efficiency}{100\%} \times V \cdot R$$

If V.R = 4, and efficiency = 75%

Then $M \cdot A = \frac{75\%}{100\%} \times 4$

$$M \cdot A = 3$$

Load = 2 x mass of a single bag x acceleration due to gravity

$$Load = 2 \times m \times g$$

$$Load = 2 \times 100\ kg \times 10\ N/kg$$

Load = 2000 N

From $M \cdot A = \frac{L}{E}$

$$E = \frac{L}{M \cdot A}$$

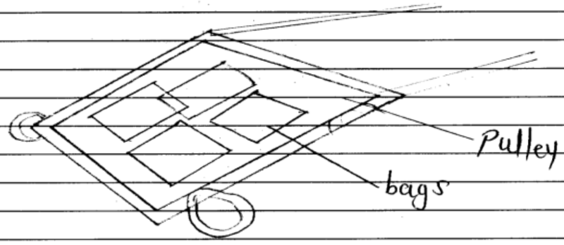
$$E = \frac{2000}{3} = 666.7\ N$$

The effort required to raise two bags of maize by four pulley system was 666.7 N.

Extract 5.1 is a sample of incorrect responses from one of the candidates who scored low marks in this question.

5(a) - Upthrust force.
- To push or pull the object of high mases
- Spring forces.
- Fundamentel forces.

5(b)



5 b. From

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

$E = \frac{100kg}{75}$

$E = \frac{100}{75}$

$E = 1.4$

$\therefore$ Effort $= 1.4N$

$= 1.4N$

Extract 5.1: A sample of the incorrect responses in Question 5

In extract 5.1, the candidate drew a wheelbarrow instead of pulley system. This candidate confused between a pulley system and a lever. A wheelbarrow is an example of second class lever which cannot lift a load vertically.

On the other hand, a few candidates who performed well in this question had adequate knowledge on the topics of *Newton's Laws of Motion* and *Simple Machines*. They managed to identify four pairs of action/reaction forces taking place and describing their effects. Moreover, some of the candidates correctly sketched a well labelled diagram of four pulley systems and determined its effort used to raise the two bags of maize. Extract 5.2 shows a sample of good responses from one of the candidates who attempted this question.

5(a) (i) Action and reaction force between ~~car A and car B. In this car~~ a car and a trailor. In this a trailor provides ~~an~~ action force (pulling force) to the car and the car in turn produces an equal ~~but~~ ~~oppo~~ opposite pulling force to the trailor.

Due to these action and reaction forces the car can pull the trailor and enable it move with it.

(ii) Action and reaction force between the car and the ground. In this case the car produces ~~an~~ an action force (pushing force) to the ground and the ground in turn produces an equal but opposite reaction force to the car which makes the car move forward.

These action and reaction forces enable a car to move forward. In absence of these forces the car would not

5(a) move forward.

(iii) action and reaction forces between the manure and the car ~~and a trailer~~. In this case the manure provides an action force ~~at~~ to a car due to its weight and the car in turn produces a reaction force of equal ~~mag~~ magnitude but opposite in direction to the manure.

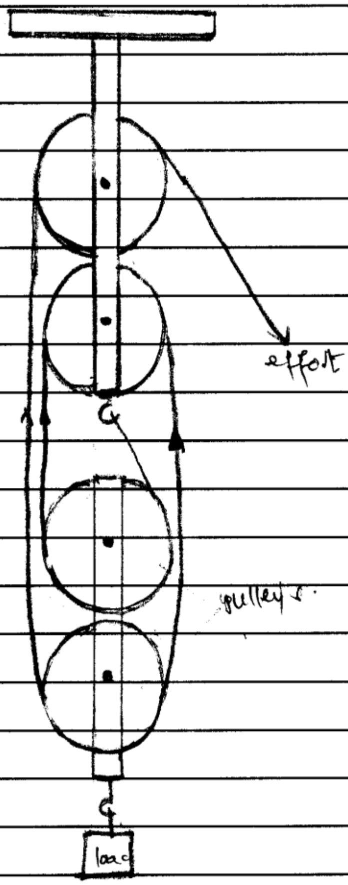
These forces enables the manure to be supported by a car and hence ~~avoid~~ avoid falling of manure.

(iv) Action ~~for~~ and reaction forces between the trailer and the ground. In this case the trailer provides an action force on the ground due to its weight and the ~~grou~~ ground provides and equal but opposite force to the trailor.

These forces enables the trailer to be supported on the ground and avoid sinking of the trailer.

5(b) Given:

number of pulleys = 4 pulleys.



soln:

Given:

velocity ratio (V.R) = number of pulleys = 4.

efficiency (e) = 75%

Load (L) = (100kg) 2. = 200kg.

effort (E) = ?

from:

$e = \frac{\text{Mechanical advantage (M.A)}}{\text{V.R}} \times 100\%$

Mechanical advantage (M.A) $= \frac{\text{Load}}{\text{Effort}}$

$e = \frac{\frac{\text{Load}}{\text{effort}}}{V.R} \times 100\%$

$e = \frac{\text{Load}}{\text{effort} \times V.R} \times 100\%$

$75\% = \frac{\text{Load}}{E \times V.R} \times 100\%$

$0.75 = \frac{200\text{kg}}{E \times 4} \cancel{\times \frac{100}{100}}$

$(0.75)\, E \times 4 = 200\text{kg}$

$E = \frac{200\text{kg}}{0.75 \times 4}$

$E = 66.67\text{kg}$

$E = 666.7\text{N}$

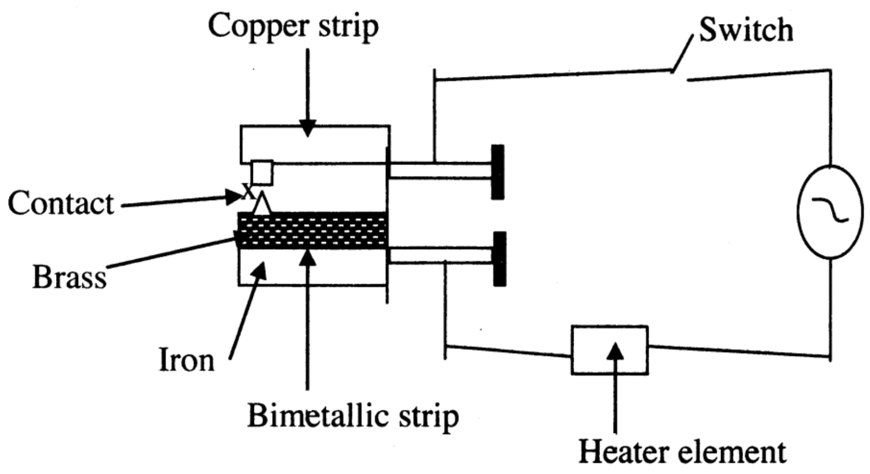
$\therefore$ The effort required to raise the mass of 200kg is 666.7N.

Extract 5.2: A sample of the correct responses in Question 5

In extract 5.2, the candidate performed correctly all parts of the question.

2.2.4 Question 6: Thermal Expansion and Vapour and Humidity

This question had two parts, namely (a) and (b). In part (a), the candidates were required to study a circuit diagram for controlling the temperature of the sitting room. Then they were required to describe how a circuit controls the temperature when the switch is closed.



In part (b), the candidates were required to give reasons on why it takes less time to boil vegetables in a cooking pot with a lid on than one without a lid.

A total of 114,472 (100%) candidates attempted this question. Out of these candidates, 88,255 (77.10%) scored from 0 to 2.5 marks; 21,864 (19.10 %) scored from 3.0 to 6.0 marks; and 4,353 (3.80%) scored from 6.5 to 10 marks. The general performance in this question was weak, since 88,255 (77.10%) of the candidates scored from 0.0 to 2.5 marks. Figure 6 shows a summary of the candidates' performance in Question 6.

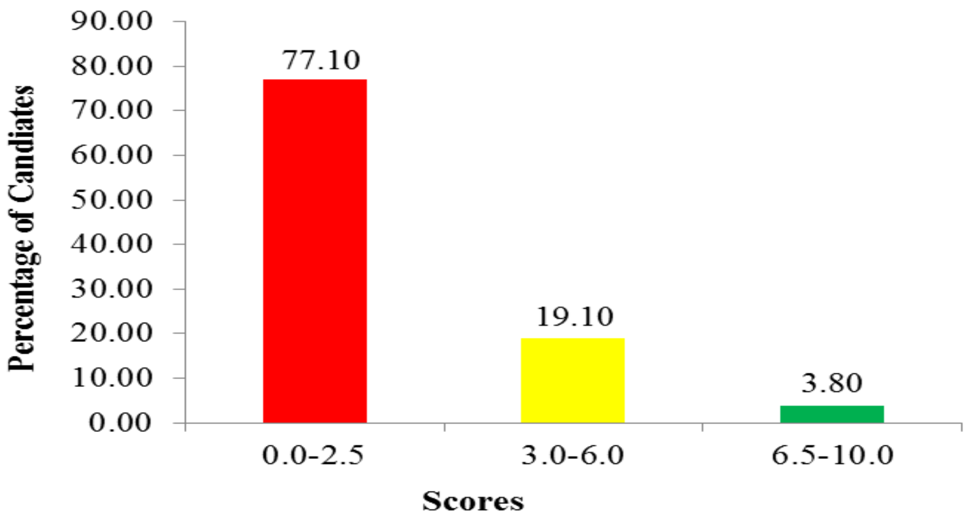


Figure 6: *The Candidates' Performance in Question 6*

The candidates who scored low marks in part (a) had insufficient knowledge about the concept of thermal expansion. Consequently, they were not able to describe how the circuit controls the temperature of the sitting room. One of the candidates explained that "*when the circuit is closed, the bimetallic strip will bend towards the copper strip to connect the contact x".* Another candidate stated that "*when the switch is closed the brass relax and iron contract".* These candidates were supposed to know that, the strips are bounded together throughout their lengths. The brass expands faster than iron, therefore it bends towards an iron. In cooling, iron cools slower than brass, therefore it bends towards brass.

The candidates who provided the correct responses demonstrated competences on the application of expansion and contraction of solid materials. They were able to tell that the bimetallic strips bend towards the iron because the linear expansivity of brass is greater than that of an iron. Also they were able to make proper interpretation of the circuit diagram that when the switch is closed, the current will flow through the brass strip and the bimetallic strip will gain heat in contact with copper strip at x. When the temperature rises, the bimetallic strip expands. The brass in the bimetallic strip expands more than the iron causing it to curve away from the copper strip and bend towards iron and at one stage the contact at x is not in contact with the bimetallic strip. There will be no flow of current in the strip, the strip cools and turn back in contact with copper strip at x where the temperature rise again to cause the process to repeat.

In part (b), majority of the candidates failed to briefly explain the phenomenon behind putting a lid on cooking pot. They did not understand the factors which cause the liquid within the container to boil faster. Some candidates who responded incorrectly explained that "*to boil vegetable in the cooking pot with lid, takes short time than one with no lid because the lid is contactor material".* This signifies insufficient knowledge on the concept of vapour and humidity. The candidates were supposed to understand that when you put a lid on, the heat stays in the pot. This helps to cook the food faster. This is because when a lid is put on a boiling pot, the water vapour will be prevented from going out and hence speeds up the cooking time. This will increase the pressure inside the boiling pot and will keep the steam inside the pot. However, when the lid is off the pot, water vapour escapes from the cooking pot to the surrounding air, and hence cools the content instead of boiling. Extract 6.1 is a sample of incorrect responses from one of the candidates who scored low marks in this question.

6a) A circuit refers to as the electric flow of charge of the electricity when switch is closed, the static cuiraunit will be high due to the conductivity of the wire which will allow the electrical of circuit to pass through and even the temperature to be at a constant. hence circuit has a high voltage when switched is closed up.

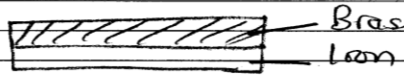
b) Because the cooking pot it contain the change of electricity into radio waves which help the vegetables to take less time when boiled than lid.

Extract 6.1: A sample of incorrect responses in Question 6

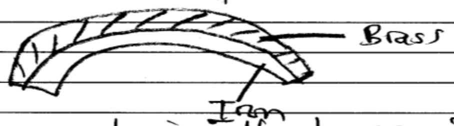
In extract 6.1, the candidate employed the concepts of electricity and waves to explain why a cooking pot with a lid on takes less time to cook vegetables instead of using the concepts of vapour and humidity due to the process of boiling and evaporation.

Those who responded correctly, were able to explain that lid on the cooking pot reduces heat loss by evaporation. Since the vapour has higher temperature than liquid, the overall temperature inside the cooking pot will rise. Also the vapour collected over the liquid will increase the vapour pressure. Thus the vegetable will take short time to boil in a cooking pot with lid than that with no lid. Extract 6.2 shows a sample of correct responses from one of the candidates who performed the question well.

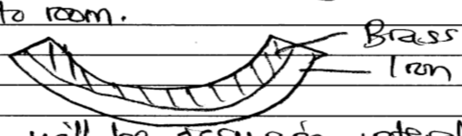
06. (a) When a circuit is closed the current flows through the heat element and it becomes hotter and the room temperature is higher. At this point the bimetallic strip is in contact with the copper strip as shown below



But when more current flows in a circuit and the room is has high temperature, the brass expands more and hence to bend toward the iron, this will disconnect the circuit since it will be far apart from copper contact hence the temperature of room will fall down.



After some time, the brass will become more colder than iron, hence the bimetallic strip will bent again toward the ~~copper~~ brass curving in to copper. This will connect the circuit again hence to heat the element to room.



These events will be occurring interchangeably cooling and heating the room.

06. (b) This is because the pot lid returns back the vapour which has latent heat of vapourization. This latent heat of vapourazation has high heat conten.
But cooking without a lid, the latent heat of vapourazation escapes hence it needs more time for such heat to cook the food. But it takes a short time for pot with lid since there is high heat content.

Extract 6.2: A sample of correct responses in Question 6

2.2.5 Question 7: Current Electricity and Radioactivity

This question comprised of two parts, namely (a) and (b). In part (a), the candidates were provided with electric cattle containing two heating coils A and B such that coil A takes 10 minutes and coil B takes 20 minutes to boil the same amount of water. The candidates were required to determine the time that would be taken to boil the water if the two coils were joined in series. In part (b), the candidates were required to determine the number of undecayed atoms left after 690 days, if a sample of the substance has 1.6 x 10^{11} undecayed atoms at the beginning with half-life of a radioactive substance of 138 days.

This question was attempted by 114,472 (100%) candidates out of which 71,308 (62.29%) scored from 0 to 2.5 marks; 42,538 (37.16%) scored from 3.0 to 6.0 marks; and 626 (0.55%) scored from 6.5 to 10 marks. Generally, the candidates' performance in this question was average as 43,164 (37.71%) scored from 3.0 to 10.0 marks. Figure 7 summarizes the performance of candidates in this question.

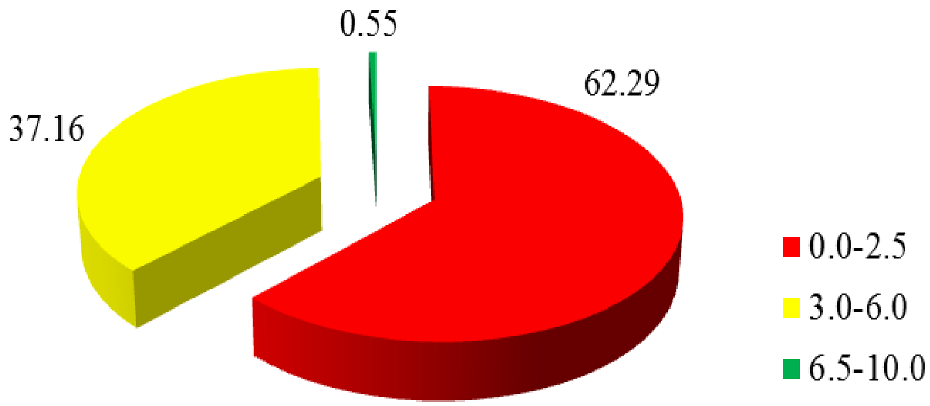


Figure 7: *The Candidates' Performance in Question 7*

The candidates who scored low marks failed to interpret the question and applied incorrect formulae as a result they provided wrong responses. In part (a), they lacked knowledge on the concept of electrical energy. This led to incorrect interpretation of the requirement of the question which resulted into incorrect responses. The candidates were supposed to understand that the voltage is the same in either case. For coils in series the power dissipated must be maintained and therefore the consumption will be the same. They were supposed to use the following formula:

For coil A: $H = (\frac{V^2}{R_A})t_A$

For coil B: $H = (\frac{V^2}{R_B})t_B$

$$H_T = (\frac{V^2}{R_T})t_S$$

Where H = Heat consumed, V = voltage, t_A = time taken by coil A to heat water,
t_B = time taken by coil B to heat water and t_S = time taken by coil A and B to heat water.
But $R_T = R_1 + R_2$ (For series connection);

$$H = (\frac{V^2}{R_1 + R_2})t_S$$

$$H = (\frac{V^2}{\frac{V^2}{H}t_A + \frac{V^2}{H}t_2})t_S$$

$$H = \frac{V^2.t_s}{\frac{V^2}{H}(t_A + t_B)}$$

$$t_S = t_A + t_B$$

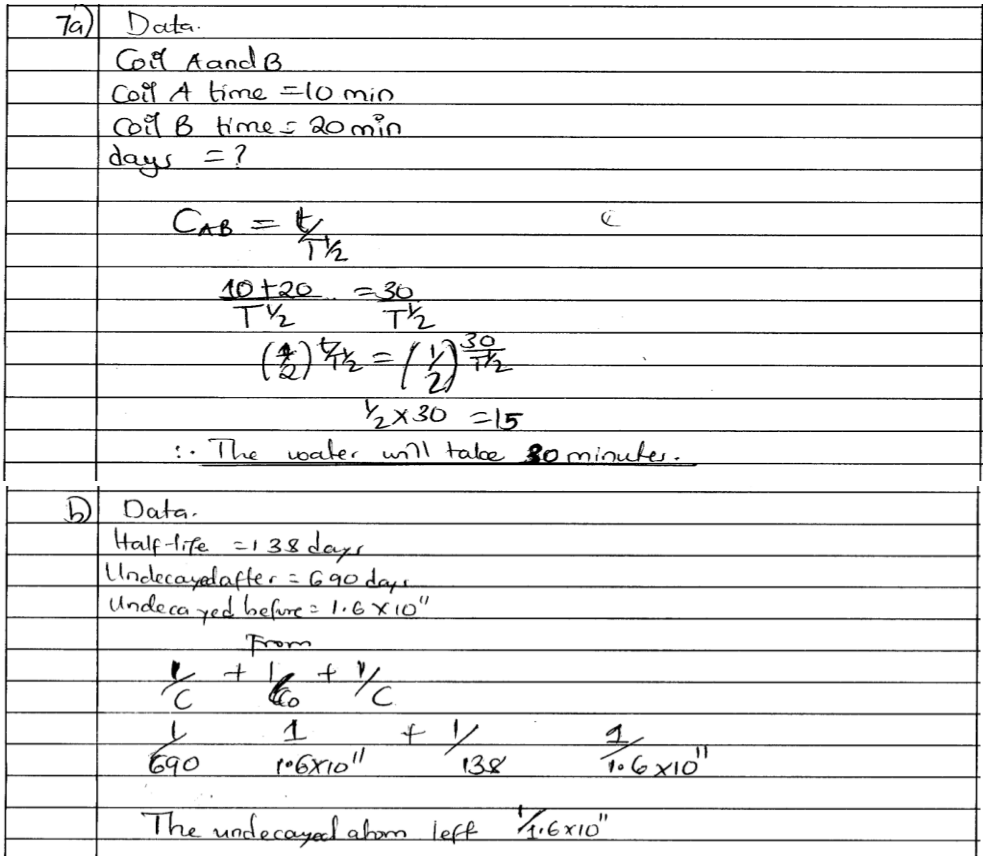
Some candidates swapped the arrangement of the coils. They considered parallel connection instead of series connection. In so doing the time for heating the same amount of water decreased.

Part (b) of the question, was correctly done by most of the candidates although a few failed to use the concept of half-life in radioactivity that is, "*half-life is the time taken for an atom to decay to its a half*". Insufficient knowledge and use of wrong formula in connection to poor mathematical computation skills led them to score low marks. For example, some candidates calculated the half-life by using the wrong formula $\frac{N}{N_0} = \frac{t}{t_{\frac{1}{2}}}$

instead of $\frac{N_i}{N_f} = 2^n$ and $\frac{t}{t_{\frac{1}{2}}} = n$ to obtain a number of undecayed atoms.

Where N_i = initial number of atoms, N_f = number of atoms left, t = time taken for an atom to decay, $t_{\frac{1}{2}}$ = half-life and n = number of half-life.

Extract 7.1 is a sample answer of one of the candidates who provided incorrect responses to this question.


7a) Data.

Coil A and B

Coil A time = 10 min

Coil B time = 20 min

days = ?

$C_{AB} = \frac{t}{T_{1/2}}$

$\frac{10+20}{T_{1/2}} = \frac{30}{T_{1/2}}$

$\left(\frac{1}{2}\right)^{t/T_{1/2}} = \left(\frac{1}{2}\right)^{30/T_{1/2}}$

$\frac{1}{2} \times 30 = 15$

∴ The water will take 30 minutes.

b) Data.

Half-life = 138 days

Undecayed after = 690 days

Undecayed before = 1.6×10^{11}

From

$\frac{1}{C} + \frac{1}{C_o} + \frac{1}{C}$

$\frac{1}{690}$ $\frac{1}{1.6 \times 10^{11}}$ + $\frac{1}{138}$ $\frac{1}{1.6 \times 10^{11}}$

The undecayed atom left $\frac{1}{1.6 \times 10^{11}}$

Extract 7.1: A sample of incorrect responses in Question 7

In extract 7.1, the candidate applied the incorrect concept of capacitances instead of one relating to radioactivity.

The candidates who scored high marks in part (a) and (b) demonstrated knowledge on two topics of *Current Electricity* and *Radioactivity* that were tested in this question. They demonstrated their computational skills on current electricity and radioactivity. Most of these candidates were able to find time taken for the water to boil and determine the number of undecayed atoms by using appropriate formula. Extract 7.2 shows a sample of the correct responses from one of the candidates who scored high marks in this question.

7. a) When two ~~heat~~ heating coils are connected in series current passing through them is the same.

From

$P = \frac{H}{t}$

$H = IVt$

Total heat liberated will be:

$H_T = H_1 + H_2$.

$IV(t_T) = IV(t_1) + IVt_2$.

$IVt_T = IVt_1 + IVt_2$.

$IVt_T = IV(t_1 + t_2)$.

$\frac{IVt_T}{IV} = \frac{IV(t_1 + t_2)}{IV}$

$t_T = t_1 + t_2$.

$= 10min + 20min$

$= 30$ minutes,

∴ It will take 30 minutes to boil water.

b) Soln

Data given

Half life $(T_{1/2}) = 138$ days;

Initial mass $(M_o) = 1.6 \times 10^{11}$

Time for decay $(T) = 690$ days;

required:

Final mass $(M_f) = ?$

From

$M_f = \frac{M_o}{2^n}$

but

7. b) $n = t/T_{1/2}$

$= \frac{690\ \text{days}}{169}$

$= \frac{690\ \text{days}}{138\ \text{days}}$

$= 5$

$\therefore n = 5$

From:

$M_f = \frac{M_o}{2^n}$

$= \frac{1.6 \times 10^{11}}{2^5}$

$= \frac{1.6 \times 10^{11}}{32}$

$= 5 \times 10^9$ or $5,000,000,000$

$\therefore$ Undeceayed atoms that remained undecayed after 690 days are 5×10^9.

Extract 7.2: A sample of correct responses in Question 7

2.2.6 Question 8: Geophysics and Waves

This question comprised of two parts, namely (a) and (b). Part (a) required the candidates to analyse five (5) effects of volcanoes eruption on the Earth's surface. In part (b), the candidates were required to determine the wavelength of tuning fork when it produces resonances in a tube at 40 cm and 85 cm, respectively for part (a) and (b).

The question was attempted by 114,472 (100%) candidates out of whom 40,551 (35.42%) scored from 0.0 to 2.5 marks; 60,671 (53.01%) scored from 3.0 to 6.0 marks; and 13,250 (11.57%) scored from 6.5 to 10.0 marks. Generally the candidates' performance in this question was average as 73, 921 (64.58%) candidates scored from 3.0 to 10.0 marks. Figure 8 summarizes the candidates' performance in Question 8.

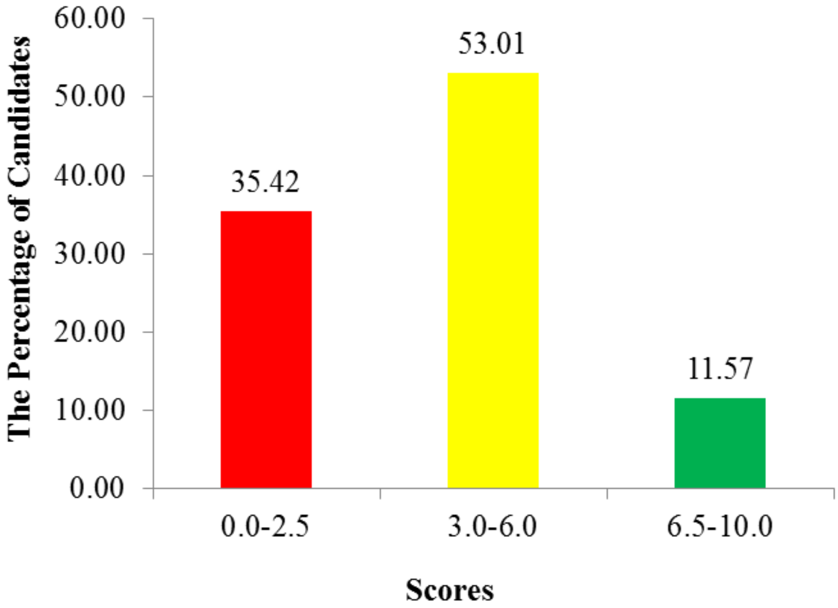


Figure 8: *The Candidates' performance in Question 8*

Most of the candidates who scored high marks were able to use the concept of geophysics in analysing the effects of volcanoes eruption on the earth's surface. They also demonstrated good computational and derivational skills on the determination of the wavelength of the tuning fork. This indicates that they were competent on music sounds especially production of resonances in closed tubes. Extract 8.1 shows a sample of correct responses from a candidate who scored high marks in this question.

8. @ i) Cause earthquake due to the volcanoes eruption earthquake occurs when the movement of the material which lead to earthquake.

ii) May lead to death due to the volcanoes eruption on the earth's surface, may lead to death due to hot magma which emited

iii) Land degradation, this is effect which caused by the volcanoes eruption on the earth's surface due to the movement which lead to damage land.

iv) Formation of other features like crater this is due to the volcanoes eruption

v) Lead to discover of the minerals from the area where volcanoes taken place.

b)

Data given

Length, $L_1 = 40cm = 0.4m$

Length, $L_2 = 85cm = 0.85m$

Wavelength = ?

$l_1 + c = \frac{1}{4}\lambda$

$l_2 + c = \frac{3}{4}\lambda$

$0.4 + c = \frac{1}{4}\lambda$

$0.85 + c = \frac{3}{4}\lambda$

$0.85 - 0.4 = \frac{3}{4}\lambda - \frac{1}{4}\lambda$

$2 \times 0.45m = \frac{1}{2}\lambda \times 2$

$\lambda = 0.9m$

$\therefore$ The wavelength is 0.9m

Extract 8.1: A sample of correct responses in Question 8

In the extract 8.1, the candidate analysed correctly the effects of volcanoes eruption on the Earth's surface. He/she also, utilized the correct formula for the calculation of the wavelength of the turning fork which produced resonances at two different levels of a closed tube.

The candidates who scored low marks (from 0.0 to 2.5) in part (a), failed to analyse five (5) effects of volcanoes eruption on the Earth's surface, This was contributed by inadequate knowledge on geophysics. For example, one of the candidates responded incorrectly that *"the effects of volcanoes include global warming, green house, communicable and non-communicable diseases."* This indicates that the candidate had inadequate idea on volcanoes and their effects on the earth's surface. The candidates were supposed to understand that volcanoes spew hot, dangerous gases, ash, lava, and rock that are powerfully destructive. They can cause death due to volcanic blasts. Volcanic eruptions can result in additional threats to health, such as floods, mudslides, power outages, drinking water contamination, and wildfires. In general, the eruption of volcanoes can result in good and detrimental effects such as:

- Destruction of properties and life; many volcanoes erupt violently, hurling hot lava and ash, poisonous gas and rocks into the atmosphere, destroying life and damaging property.
- Volcanic activity is responsible for many features on the ground including mountains, hills and plains of volcanic rocks
- Eruptions emit gases such as hydrogen chloride, carbon dioxide and hydrogen fluoride and sulphur dioxide, which are harmful to the environment
- Volcanic activity brings up useful commercial minerals from the deep part of the crust to the upper surface of the crust.

In part (b), the question tested the ability of the candidates to determine the wavelength of the tuning fork which produced resonances in a tube. Majority of the candidates failed to deduce the wave equation for resonance in accordance with their respective number of harmonics and overtones. For instance, one of the candidates used unrelated formula by writing; the relation: $w\text{avelength} = \frac{2\pi L}{L}$ to determine the wavelength. Another candidate determined the wavelength by using the formula; wavelength = $L_1 \times L_2$. Others determined the wavelength by just adding the two lengths were the resonance is produced $\left(\lambda = L_1 + L_2\right)$. All these formulae were incorrect. The correct formula to be used by the candidates in determining the positions at which the resonance occurs are related to frequency f and the velocity of sound v by equation $\text{v} = 2\text{ f }\left(\text{L}_2\text{-L}_1\right)$.

$$f = \frac{v}{2\left(L_2 - L_1\right)}$$

$$L_1 = 40\ cm/0.4\ m,\ L_2 = 85\ cm/0.85\ m,\ v = 340\ m/s$$

$$f = \frac{340\ \text{m/s}}{2\ (0.85\ \text{m} - 0.4\ \text{m})} = 377.8\ \text{Hz}$$

The wavelength, λ is given by $\lambda = \frac{V}{f} = \frac{340}{377.8} = 0.9$ m. Extract 8.2 shows a sample of incorrect responses from one of the candidates who attempted this question.

8. a) i) climate change
where by to change the season of the year
it include the period of rainfall and sun.

ii) environmental degradation
it's leads to the cause of environmental
problem

iii) it's cause the pets and disease such as
communicable and non-communicable disease.

iv) global warming
according to the volcanoes eruption can cause
the global warming

v) green house
it's take place when volcanoes appear on
the earth surface

8. (b) Solution

Data given.
lengths of turning fork 40cm and 85cm.
pie = 3.14
To find wave length.
from the formular.

$$\text{wave length} = \frac{2\pi}{L}$$

but,

length = 85 − 40 = 45m.

$$\text{wave length} = \frac{2 \times 3.14 \cancel{\times 45}}{45}$$

$$\text{wave length} = \frac{6.28}{45}$$

wave length = 0.14m.

∴ The wave length of turning fork is 0.14m.

Extract 8.2: A sample of incorrect responses in Question 8

2.3 Section C: Structured Questions

2.3.1 Question 9: Waves and Electromagnetism

This question comprised two parts namely, (a) and (b). In part (a), the candidates were required to calculate a frequency of the first and second harmonics, when a stretched taut string of length 40 cm and mass 2×10^{-3} kg is pulled with tension of 100 N is plucked at its middle. Part (b) required the candidates to find the potential difference across the secondary circuit if a current of 0.15 A flows in secondary circuit of a transformer while a potential difference of 60 V and current of 3.7 A flows across the primary circuit of a transformer when the efficiency was 95%.

The question was attempted by 79,656 (69.6%) candidates out of which 44,771 (56.21%) candidates scored from 0 to 3.5 marks, 21,124 (26.52%) scored from 4.0 to 8.0 marks and 13,761 (17.28%) scored from 8.5 to 12.5 marks. The overall candidates' performance in this question was average as 34,885 (43.80%) scored from 4.0 to 12.5 marks. Figure 9 shows the performance of the candidates in this question.

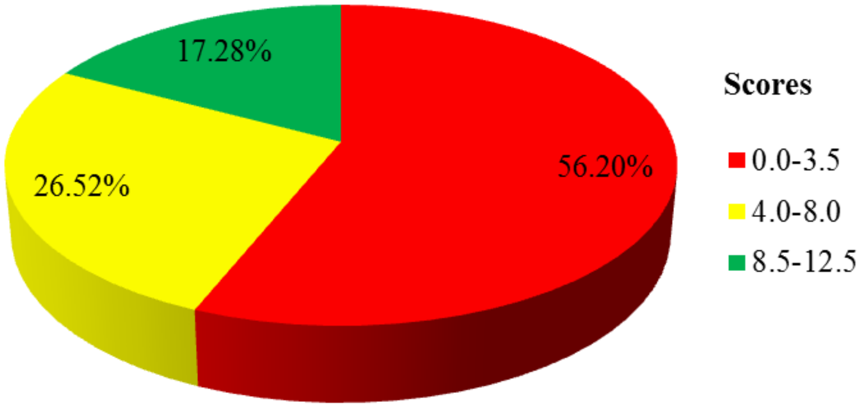


Figure 9: *The Candidates' Performance in Question 9*

The candidates who performed well in this question had a good understanding of the concepts tested. Most of the candidates were able to use correct formula and mathematical skills to answer part (a) and (b). They correctly substituted values and converted the unit well. Extract 9.1 shows sample of responses from a candidate who scored the higher marks on this question.

09	(a) Data given;-
	length (l) = 40 cm (0.4 m)
	mass (m) = 2×10^{-3} kg
	Tension (T) = 100N
	$f_1 = ?$
	from,
	$f_n = \frac{n}{2l}\sqrt{\frac{Tl}{m}}$
	$f_1 = \frac{1}{2\times0.4}\sqrt{\frac{100\times0.4}{2\times10^{-3}}}$
	$f_1 = \frac{1}{0.8}\sqrt{\frac{40}{2\times10^{-3}}}$
	$f_1 = 1.25\sqrt{20\times10^{3}}$
	$f_1 = 176.78\,Hz$
	∴ The frequency of first harmonic is 176.78 Hz
	For 2nd harmonic;-
	since,
	$f_n = nf_0$ (for strings)
	$f_2 = 2f_0$
	$= 2\times176.78$
	$= 353.55\,Hz$
	∴ Second harmonic is 353.55 Hz

09 (b) Data given;-

$V_p = 60V$

$I_p = 3.7A$

$V_s = ?$

$I_s = 0.15$

$E = 95\%$

From the formula;

$$E = \frac{\text{power output}}{\text{Power input}} \times 100$$

$$E = \frac{I_s V_s}{I_p V_p} \times 100$$

Hence,

$$\frac{95}{100} = \frac{0.15 \times V_s}{3.7 \times 60}$$

$$0.95 = \frac{0.15 V_s}{222}$$

$$0.15 V_s = 0.95 \times 222$$

$$V_s = \frac{0.95 \times 222}{0.15}$$

$$V_s = 1406v$$

$\therefore$ Potential difference at sec. coil is $\underline{1406V}$

Extract 9.1: A sample of correct responses in Question 9

The candidates who demonstrated weak performance lacked understanding of some specific concepts from the topics of both *Waves* and *Current Electricity*. They also lacked mathematical skills. Some candidates applied incorrect formula $f_n = (n+1) f_0$ to find the frequency at n harmonics, f_n where f_0 is the fundamental frequency. It should be noted that the formula is correct only if n represent the number of overtones. Other candidates used the length of the string, 40 cm without changing to metre (m) while others applied an incorrect formula to find the fundamental frequency by writing $f_0 = \frac{1}{2l}\sqrt{\frac{Tm}{l}}$ instead of: $f_0 = \frac{1}{2l}\sqrt{\frac{Tl}{m}} = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$, as a result they got the inappropriate answers. The candidates were supposed to perform the calculations as follows:

Frequency of the first harmonic, $f_1 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

$$f_1 = \frac{1}{2\times 0.4}\sqrt{\frac{100}{5.0\times 10^{-3}}}Hz$$

$$f_1 = 176.8HzHz$$

For the second harmonic frequency, $f_2 = 2f_0$

$$f_2 = 2\times 176.8Hz$$

$$f_2 = 353.6Hz$$

Thus, the frequency of the first harmonic was 176.8 Hz and that of second harmonic was 353.6 Hz.

In part (b), some of the candidates applied incorrect formula for the efficiency of the transformer by writing,

$Effenciency = \frac{power\ \ input}{power\ \ output}\times 100\%$, instead of

$\text{Effenciency} = \frac{\text{power output}}{\text{power input}}\times 100\%$. Others treated the transformer as an ideal one (100% efficiency) by applying the equation $I_p \times V_p = I_s \times V_s$ which led to incorrect computations. These candidates were supposed to determine the potential difference across the secondary circuit by using the correct formula for efficiency of transformer as follows:

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

$$\text{Efficiency} = \frac{I_s \times V_s}{\text{Power input}}\times 100\%$$

$$V_s = \frac{95 \times 3.7 \times 60}{100 \times 0.15} V$$

$$V_s = 140V$$

The voltage across the secondary coil was 140 V.

Extract 9.2 shows a sample of incorrect responses from a candidate who scored low marks on this question.

9. a) Data

Length = 40cm

Mass = 2×10^{-3}kg

F = 100N

Frequency of 1 harmonics : ?

2 harmonics ?

From

1^{st} frequency harmonics $= \sqrt{\pi L g}$

$- \pi = 3.14$ $L = 40$ cm $m = 2 \times 10^{-3} = 0.0002$

$1^{st} \sqrt{3.14 \times 40} = \frac{71}{0.0002} \times 10$

$= 71 \times 10 = 710\lambda$

$\therefore$ frequence of 1^{st} harmonic $= 710\lambda$

$- 2^{nd}$ frequency $= \frac{\sqrt{\pi L}}{m} = \frac{\sqrt{3.14 \times 40}}{2} = \frac{70}{2} = 35\lambda$

$\therefore$ Frequency of 2^{nd} harmonic $= 35\lambda$

9. b) Data

Pd = 60V Pc.

I = 3.7A

P.d = ?: Sc.

I = 0.15A

Efficiency =

Solution

$\frac{n(\text{Pd in Pd})}{n(\text{P.d Pds})} = \frac{n(I\,P)}{n(I\,s)}$

n(Pd in Pc = 60V

n.of Primary I = 3.7

n(P.d in Sec = ?

n sec I = 0.15

$\frac{n(P_{pd})}{n(s\ pd)} = \frac{n(I_p)}{n\,I_s}$

$\frac{60V}{s\text{-}pd} = \frac{3.7A}{0.15}$

$\frac{60V \times 0.5}{3.7} = \frac{3.7\,s\,Pd}{3.2}$

$sPd = \frac{9}{3.7} = 2.4\,V$

Potential difference in Secondary circuit = 2.4V

∴ The potential difference on secondary circuit = 2.4 V

Extract 9.2: A sample of incorrect responses in Question 9

In extract 9.2, the candidate demonstrated extreme poor knowledge about the factors which affect the frequency of a note produced by a stretched string and hence, failed to establish a relation that would help to determine the frequency of first and second harmonics. Moreover, this candidate failed to find the output voltage across the secondary circuit of a non-ideal transformer.

2.3.2 Question 10: Current Electricity and Electronics

This question had three parts; (a), (b) and (c). In part (a), the candidates were required to explain four factors that affect the resistance of a conductor. In part (b), they were required to draw the circuit diagram and find the current flowing through a $5\ \Omega$ resistor when the parallel combination of $2\ \Omega$ and $5\ \Omega$ resistors are connected across the external resistor of $3\ \Omega$ through the supply of 4 V. Part (c) required the candidates to use a common-emitter amplifier circuit to explain why n-p-n transistor was named so.

The question was attempted by 107,895 (94.3%) candidates out of which 40,516 (37.55%) scored from 0 to 3.5 marks; 59,682 (55.31%) scored from 4.0 to 8.0 marks; and 7,697 (7.14%) scored from 8.5 to 12.5 marks. This suggests that the general performance was average as 67,379 (62.45%) candidates scored from. 4.0 to 12.5 marks. Figure 10 shows the candidates' performance in this question.

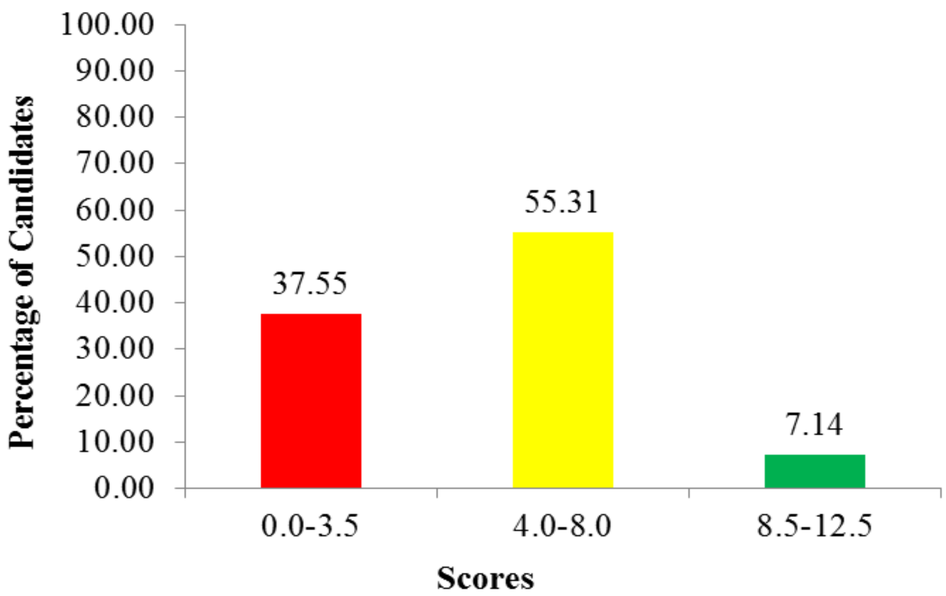


Figure 10: *The Candidates' Performance in Question 10*

The candidates who scored high marks in this question had satisfactory knowledge of the factors affecting the resistance of the conductor. They also showed to have skills in drawing electric circuit diagram used to calculate the current passing through a resistor of $3\ \Omega$. This implies that they had acquired enough knowledge from both electricity and electronics. Consequently, they managed to draw an appropriate common-emitter amplifier circuit and explain correctly why n-p-n transistor is named so. Extract 10.1 shows a sample of correct responses from one of the candidates who did it correctly.

10 (a) Factors affecting resistance of a conductor;-

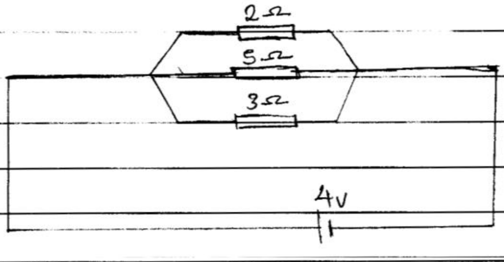
i/. Temperature; The temperature increase causes the conductor to increase its resistance since, high temperature increase the kinetic energy of atoms in a conductor of which, will interfere and block the flow/convectional flow of electrons in a conductor.

ii/ Length of the conductor; Increase in length also, cause increase in resistence. This is because on increasing length is like to increase the resistors in series.

iii/. Cross sectional area of conductor; Increase in cross sectional area of conductor is like to arrange resistors in parallel. As a results, the resistence of conductor will decrease and vice versa.

iv). Nature of the conductor;- There are conductors with high resistivity and others with low resistivity. The more the resistivity, the more resistence and the less the resistivity the less the resistance of conductor.

(b) Consider the following;-



For parallel connection

p.d is common

10 (b) then,

I across 5Ω;-

$V = IR$

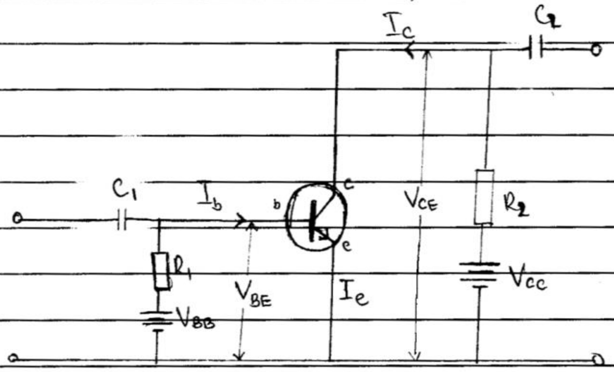
$I = \frac{V}{R}$

$I = \frac{4}{5}$

$= 0.8A$

$\therefore$ Current across 5Ω resistor is $0.8A$

(c) Consider the circuit below;-



n-p-n transistor is named so because the base terminal serve as input and collector terminal serves as output while the emitter terminal is common in both base terminal and collector terminal circuits

Extract 10.1: A sample of the correct responses in Question 10

On the other hand, the candidates who scored low marks, in part (a), were not able to explain the factors affecting the resistance of the conductor clearly. Some candidates managed to mention the factors correctly but with wrong explanations in relation to resistance of the conductor. For example, one of the candidates wrote "*when temperature increases the resistance of the conductor decreases*". This candidate lacked the knowledge that when temperature increases in a conductor the collision among electrons increases which in turn limits their flow. Some candidates listed the factors like conduction, forbidden gap, valence band and semiconductor. These candidates failed to distinguish the concept of current electricity and those from electronics, particularly the energy band theory. They were supposed to explain the following factors:

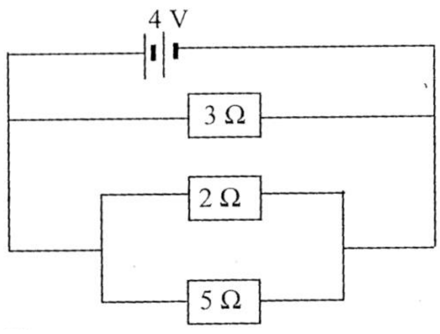
(i) Temperature, for most metals and metal alloys: The resistance of the conductor increases with increase in temperature.

(ii) Length of the conductor: The resistance of a conductor which is made of the same material and thickness increase with the increase of the length of conductor. The long the conductor, the resistance of the conductor becomes high.

(iii) Cross sectional area of the conductor: When the cross sectional area increases and other factors held constant, the resistance decreases. Therefore, a thin conductor has high resistance than a thick conductor.

(iv) Nature of the material: Resistance of the conductor depends on the type of material making it. For example, steel wire has higher resistance than copper wire of identical dimension at the same temperature.

In part (b), the candidates who failed had inadequate knowledge on drawing the electric circuit and solving the electric circuit problems. Some candidates used the relation, $RD = \frac{Atm}{cn}$. Others connected the two parallel resistors ($2\,\Omega$ and $5\,\Omega$) in series with the 3 Ω resistor, hence ended up with incorrect answer. The correct circuit diagram was supposed to be as shown below:



Where the correct formula was supposed to be: From Ohm's law $I = \frac{V}{R}$

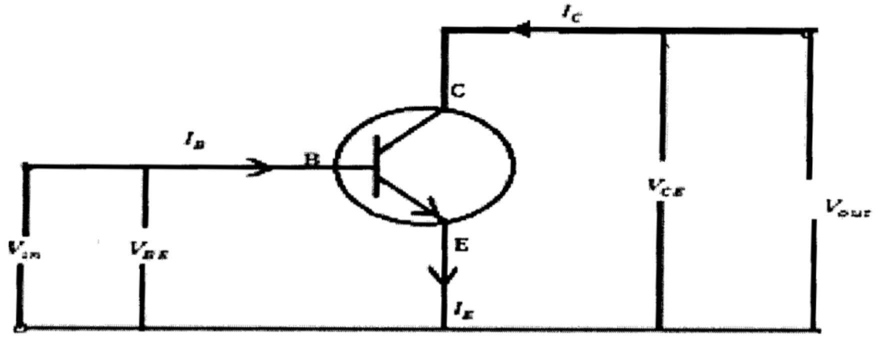
Since $2\,\Omega$, $5\,\Omega$ and $3\,\Omega$ are connected in parallel the voltage is the same.

$$I = \frac{4\ V}{5\ \Omega} = 0.8\ A$$

Thus, the current passing through $5\,\Omega$ resistor was 0.8A

In part (c), the candidates who scored low marks had inadequate knowledge on the topic of *Electronics* especially, the common emitter transistor circuit. Some of the candidates failed to draw and to explain with the aid of common emitter amplifier, why the n-p-n transistor is named so. One of the candidates stated that "*it is named so because diodes help the transistor to direct the current in one direction*". Despite the fact that the candidate responded contrary to the need of the question, he/she did not understand how the diode and transistor differ in terms of their configurations and operations. The candidates were supposed to understand that a diode is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but severely restricts the current from flowing in the opposite direction. On the contrary, a transistor is a miniature semiconductor that regulates or controls the current or voltage flow in addition amplifying and generating these electrical signals and acting as a switch/gate for them. As n-p-n transistor, the current flows from the collector (C) to the Emitter (E). A common n-p-n transistor is called so because both the signal source (input) and the load (output) share the emitter lead as the common connection point i.e Emitter is common to both Base and Collector.

The candidates were expected to draw the common emitter amplifier using n-p-n transistor as shown in the following diagram.

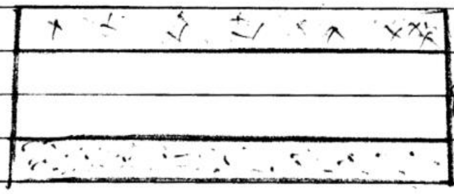


Extract 10.2 shows a sample of incorrect responses from a candidate who scored low marks on this question.

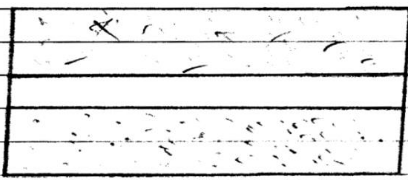
10a Four factor that affect the resistance of a conductor are :

Conduction: This are resistance that pass through and have all electron in the resistance

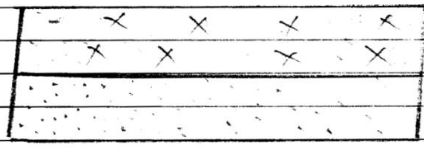
Folbided gap: This is the large gap which lay between semi - conductor band and Valency band.



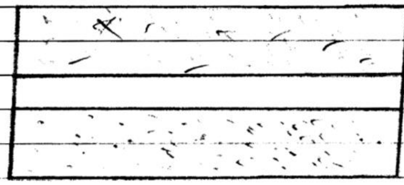
10 a Valency band: These are conduction which there is a small forbidded gap between semi conductor band and Valency band.



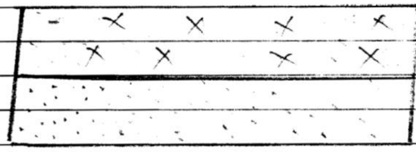
Semi conductor: These are conductor where there is no forbidded gap between semi conductor band and valency band



10 a Valency band: These are conduction whiche there is a small forbidded gap between semi conductor band and Valency band.



Semi conductor: These are conductor where there is no forbidded gap between semi conductor band and valency band



10b $RD = \frac{Atm}{Cn}$

Solution

$RD = \frac{Atm}{Cn}$

$RD = \frac{2 \times 5 \times 3}{4 \times 5}$

$RD = \frac{30}{20}$

$RD = 1.5$ Ans

∴ The current that flow through the

10b $RD = \frac{Atm}{Cn}$

Solution

$RD = \frac{Atm}{Cn}$

$RD = \frac{2 \times 5 \times 3}{4 \times 5}$

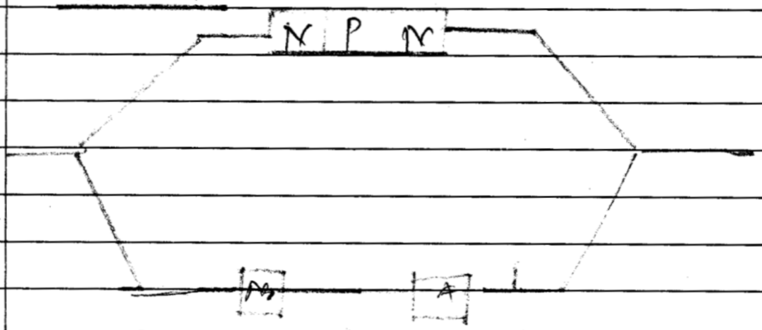
$RD = \frac{30}{20}$

$RD = 1.5$ Ans

∴ The current that flow through the

10b Presistor is 1.5 Ans

10c Solution



The NPN mean that ~~to~~ the two conductor are open and the resistance pass through the two conductor.

Extract 10.2: A sample of incorrect responses in Question 10

In Extract 10.2, a candidate drew the diagram of energy bands in semiconductor to explain factors affecting resistance in a conductor. She/he also failed to draw the common emitter amplifier using n-p-n transistor. This implies that the candidate had poor knowledge about the concepts of current electricity and electronics.

2.3.3 Question 11: Waves

This question comprised of three parts, namely, (a), (b) and (c). In part (a), the candidates were required to briefly explain how sound from the disco hall can be transmitted into the other room. In part (b), they were required to explain how microwaves are used in cooking and part (c) required them to describe how destructive interference is used in noise reduction system.

This question was attempted by 41,358 (36.1%) candidates whose scores were as follows: 31,301 (75.68%) scored from 0 to 3.5 marks, 8,029 (19.42%) scored from 4.0 to 8.0 marks and 2,028 (4.90%) scored from 8.5 to 12.5 marks. The data shows that the candidates' performance was weak as majority of the candidates (75.68%) scored below the marks. Figure 11 shows the performance of the candidates in this question.

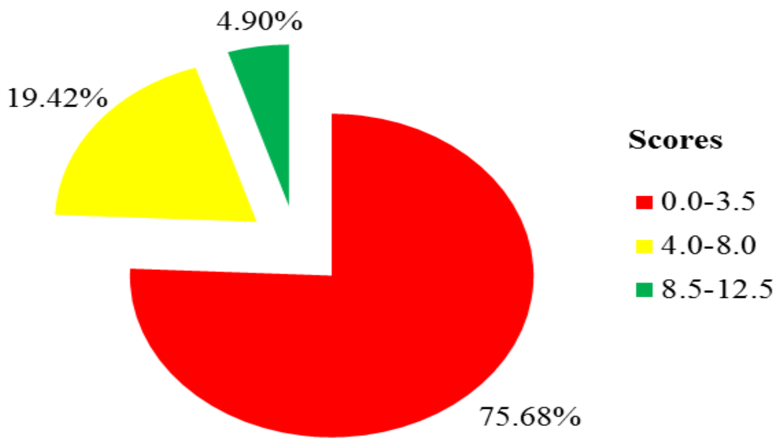


Figure 11: *The Candidates' Performance to Question 11*

Majority of the candidates (75.68%) scored low marks (0.0-3.5) because they had insufficient knowledge about the behaviours of waves specifically, the applications of reflection and diffraction of waves in daily life. Also, they had poor knowledge about the propagation of sound waves in part (a) of this question. For instance, one of the candidate's responses in this part wrote that "*trivalent element is doped in intrinsic semiconductor*". This response from the candidate indicates that he/she failed to understand the topic from which the question is set. The explanation provided by the candidate was absolutely contrary to the anticipated responses. The response was from the topic of *Electronics* particularly, the concept of mechanism of doping impurities in intrinsic semiconductors instead of waves. The candidates were supposed to understand that a noise source in one room sends air pressure waves which induce vibration to one side of a wall or element of structure setting it moving such that the other face of the wall vibrates in an adjacent room.

In part (b), most of the candidates appeared to have insufficient knowledge about the mode of action of the microwaves in cooking. For example, one of the candidates wrote that "*microwaves used for cooking through the use of solar and wind which travel from one place to another.*" The kinds of responses indicate that some of the candidates were not familiar with the functions of microwaves oven used in cooking. The candidates were supposed to realize that microwaves of certain frequencies pass through the food and get absorbed by the food molecules. The absorbed energy causes the molecules to rapidly vibrate producing the heat that heats or cooks the food.

The candidates who scored low marks in part (c) had little knowledge about the destructive interference of waves. For instance, a response of one candidate in this part was written as *“because there is presence of different sound so the system is reduced*”. Another one wrote that *“because of produce the sound transmit to the ear drum while the reflection was transfer the sound from one area to another position.”* Apart from possession of inadequate knowledge in the concept of waves especially, the importance of destructive interference of waves in noise reduction system, they had poor English Language writing skills which played as an obstacle for them to clearly present their responses. The candidates were supposed to know that destructive interference occurs at any location along the medium where interfering waves have a displacement in opposite direction. The destructive interference cancel out unwanted sound by creating an opposing sound wave that copycats the noise you want to get rid of, but just 180° out of phase. Extract 11.1 is a sample of a candidate’s incorrect responses in this question.

11a When trivalent element is doped in intrinsic semi conductor. The hole produced that is responsible to Conducting electricity. Majority carrier is Hole and Mainority is Electron. So the sound of disco hall inside it Contain electron which is mainority, so they Colide ~~to Cothe~~ to form sound that transmitted into the room.

b The micro waves used in cooking as a source of heat like Solar. So the microwave used in a Cooking fore drying food.

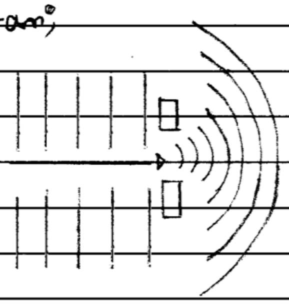
c Because there is a presence of different sound so the system is reduced and lead us understandable ~~of~~ from one person to another.

Extract 11.1: A sample of incorrect responses in Question 11

In extract 11.1, the candidate applied the knowledge of electronics in the production of p-type semiconductor in a place which required the concept of waves.

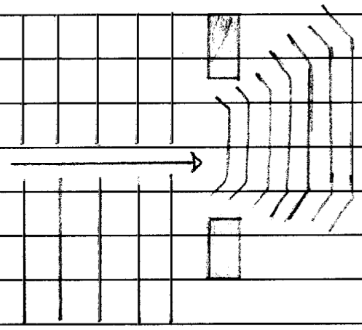
The data indicates that 4.90 per cent of the candidates did well in this question. The candidates who scored high marks in this question were able to describe how sound waves travel from a disco hall to nearby rooms, how microwave oven works and how destructive interference is used in noise reduction system. Some candidates used drawings to illustrate the propagation of sound waves. The candidates also managed to describe the working mechanism of microwave ovens. Extract 11.2 is a sample of correct responses from one of the candidates in this question.

11c, a) Sound from the disco hall are transmitted into my room through diffraction of waves.
Diffraction is the spreading of sound waves through an obstacle. Obstacles in the disco hall are windows and so sound waves pass through them whereby when the gap is small the sound waves form nearly circular wave fronts
Diagram;



And due to the formation of the circular wave from the sound will be heard in my room.
Also;
When the gap is large the sound waves from the

11. a) disco hall to my room will be heard since the waves will form a nearly parallel wave fronts
Diagram;



And due to the formation of the nearly parallel wave fronts the sound will be heard in my room from the disco hall.

b) Microwaves are used in cooking through the microwave oven. When food is kept in the microwave oven and switched on the microwave produces radio waves and and the radio waves are absorbed by the food And so the food getting warmer leaving the plate in the microwave cooler.

c) Destructive interference helps in the noise reduction system because it helps to make different sound waves meet and produce a smaller amplitude therefore leading to the reduction of noise.

Extract 11.2: A sample of the candidate's good responses in Question 11

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

The Physics Practical comprised of three alternative papers namely, 031/2A Physics 2A, 031/2B Physics 2B and 031/2C Physics 2C. Each alternative paper consisted of two questions each carrying 25 marks. The candidates were required to answer all the questions. Question 1 was set from the topic of *Forces in Equilibrium* and question 2 from the topic of *Current Electricity*.

3.1 Question 1: Forces in Equilibrium

The question was attempted by 114,472 (100%) candidates whose scores were as follows: 61,349 (53.59 %) scored from 0 to 7.0 marks; 33,305 (29.09%) scored from 7.5 to 16.0 marks; and 19,818 (17.31 %) scored from 16.5 to 25.0 marks. This indicates that the candidates' performance was average as 53,123 (46.41%) scored from 7.5 to 25.0 marks. Figure 12 shows the candidates' performance in this question.

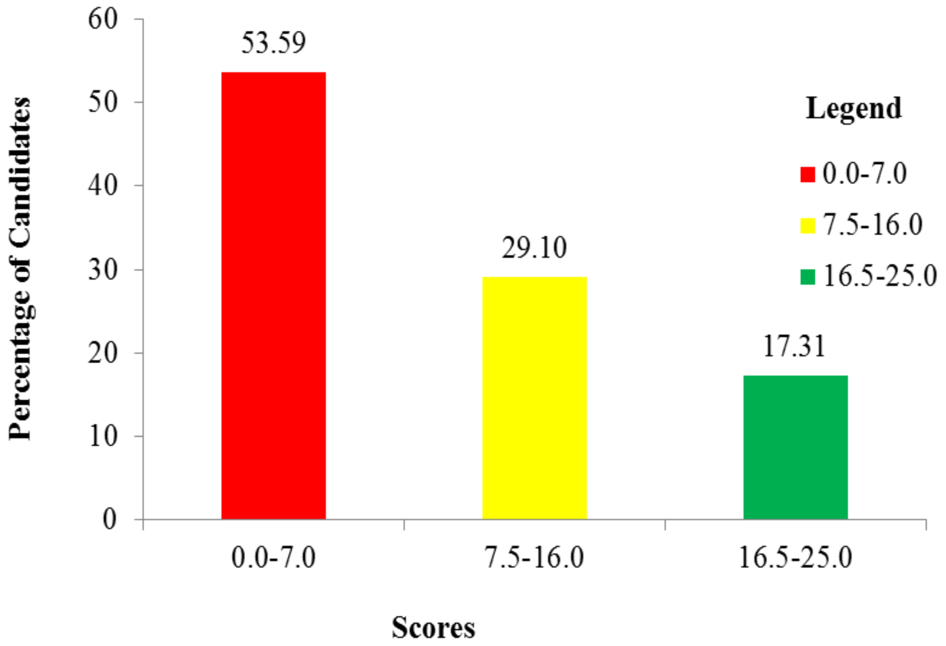


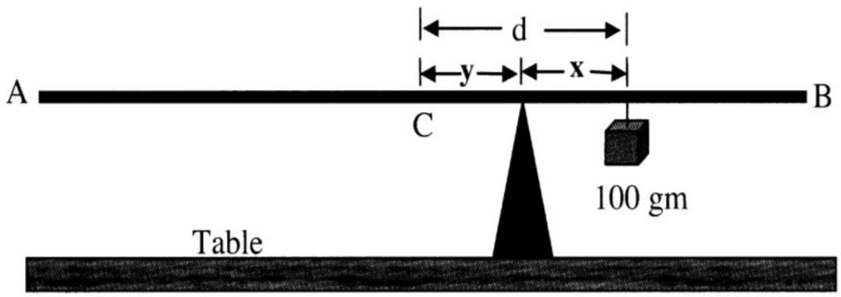
Figure 12: *The Candidates' Performance to Question 1 of Physics 2*

3.1.1 031/2A Physics 2A

The aim of the experiment was to determine the density of a metre rule. The candidates were required to follow the following procedure:

(a) Locate the centre of gravity C of the metre rule AB by balancing it freely on the knife edge.

(b) Suspend 100 g mass on the ruler with distance d =10 cm from C, adjust the position of the knife edge to get a balance as shown in the following Figure.



(c) Record the distance **y** from the centre of gravity to a knife edge and distance x from knife edge to the known mass of 100 g.

(d) Repeat the procedures in 1(b) and (c) by increasing the distance of 100 g to d =15 cm, 20 cm, 25 cm and 30 cm.

They were then required to answer the following questions:

(i) Tabulate the results in a suitable table showing the values of d, x and y.

(ii) Plot a graph of y (cm) against x (cm).

(iii) Determine the slope of the graph.

(iv) Describe how the slope obtained from the graph is related to the mass of the metre rule provided and hence determine the mass of a rule.

(v) Measure and record the length, width and the thickness of the metre rule provided

(vi) Determine the density of a metre rule.

Most of the candidates who scored high marks in this question were competent in analyzing, evaluating, and applying mathematical skills systematically to obtain the correct answers. These candidates managed to set apparatuses, prepare a table of results and record the data correctly. They also collected the data at a reasonable range and then used them to plot a graph of y (cm) against x (cm) correctly.

The candidates correctly indicated important features to be considered when plotting the graph such as the title of the graph including units; the scales (both vertical and horizontal); labelled axes (vertical and horizontal); transfer of points with best fit of line; and slope indication. Also they managed to measure and record the length, width, and thickness of the metre rule provided from which its volume was determined. Finally, the candidates were able to calculate the density of the metre rule by using the value of the slope obtained. Extract 12.1 shows a sample of correct responses from one of the candidates who did well this question.

1 i/

d (cm)	y (cm)	x cm
10	5	5
15	7.3	7.7
20	10	10
25	12.3	12.7
30	14.8	15.2

The center of gravity = 50.4 cm

ii/ The graph of $y \propto x$

iii/ Slope $= \frac{\Delta y}{\Delta x}$

$= \frac{8.7 - 6}{9 - 6.3}$

$= \frac{2.7}{2.7}$

$= 1$

Slope = 1

iv/ let the mass of ruler be M
from principles of moment
Sum of clockwise moment = sum of anticlockwise moment for a system to be a rotational balance
Thus

$M \times y = \cancel{X} x \times 100$

$My = 100x$

1 $\frac{My}{M} = \frac{100x}{M}$

$y = \frac{100}{M} x$

$y = Mx + C$

$M = \text{slope}$

$\text{slope} = \frac{100}{M}$

$1 = \frac{100}{M}$

$M = 100g$

The mass of the ruler is 100g

v/ length = 100cm
Width = 2·95cm
thicknes = 0·67cm

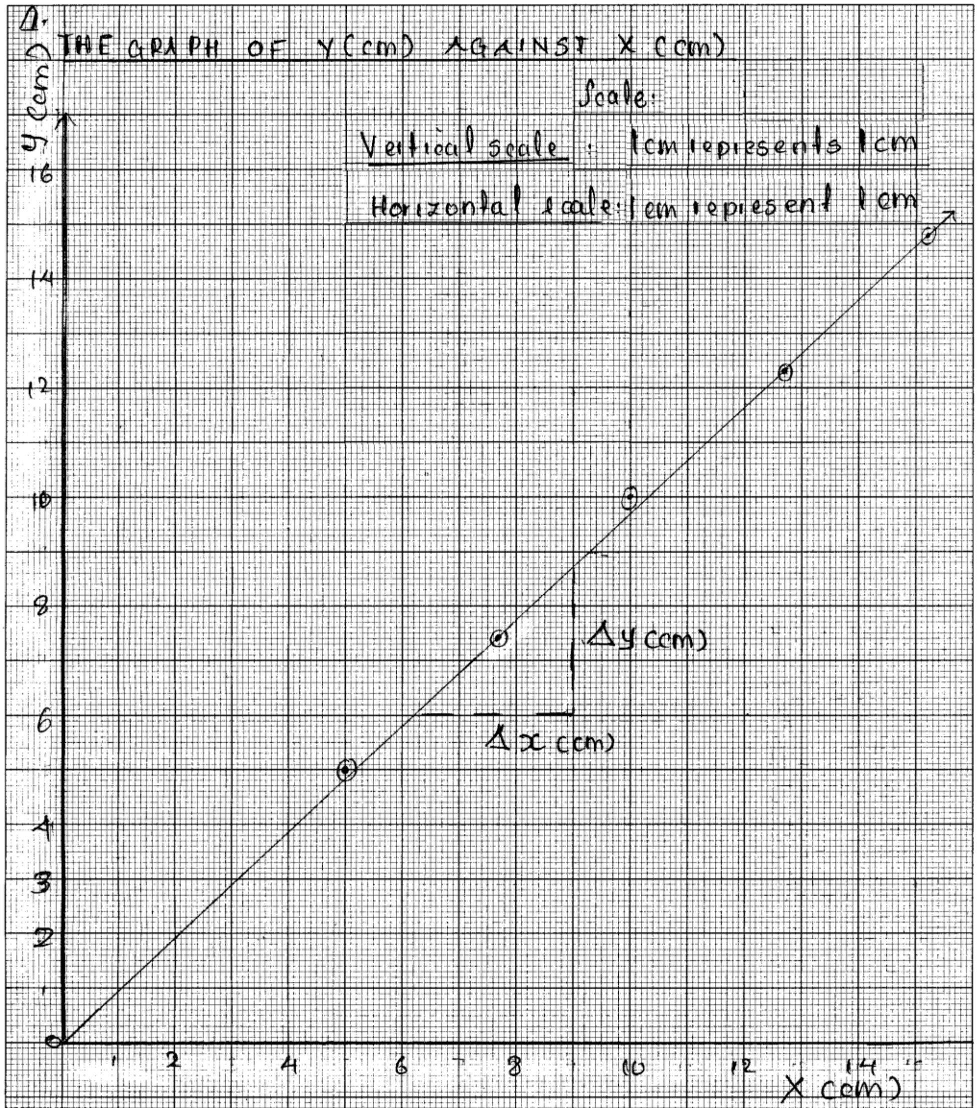
vi/ Density of ruler = $\frac{\text{Mass of ruler}}{\text{Volume of ruler}}$

$\rho = \frac{M}{V}$

Volume = length x width x thickness
= 100 x 2·95 x 0·67
= 197·65 cm^3

Density = $\frac{100g}{197.65}$
= 0·51 g/cm^3 / 0·506 g/cm^3

The density of the ruler is 0·506 g/cm^3



Extract 12.1: A sample of a candidate's good responses in Question 1 of Physics 2A

In extract 12.1, the candidate followed correctly all the required procedures; recorded the data in a table of results and plotted the graph with well labelled features. Finally, he/she calculated the value of the slope and applied it to perform the calculations appropriately. The candidate used correctly the principle of moment to determine the mass of a meter rule and used it to calculate the density of the metre rule provided.

On the other hand, the candidates who scored low marks in this question did not have the knowledge of the concept of forces in equilibrium. The candidates who failed to set up the experiment correctly; collected and recorded incorrect data in the table of results. Others drew the graphs without indicating the axes, title of the graph, the scale to be used, best line and the slope indication. They also transferred the points incorrectly from table of results to the graph. These candidates had inadequate knowledge of the choice of points for the calculation of the slope, and thus failed to determine the mass and density of the metre rule provided.

Other candidates failed to measure the length; width; and the thickness of the metre rule; as a result, they failed to determine the necessary volume for the determination of density of a metre rule. Others did not use the standard mass (100 g) while some of them were found using the rulers having mass greater or smaller than 100 g according to the values they obtained.

The candidates were supposed to use the correct points of the slope indication to find the slope of the graph by using the relation: $slope = \frac{\Delta y\,(cm)}{\Delta x(cm)}$. Also candidates were required to apply the principle of moment to obtain the mass of the ruler by using the relation: $my = 100x$, $y = \frac{100x}{m}$ and relating the slope obtained from the graph with that of the equation, to obtain: $slope = \frac{100}{m}$, m = $\frac{100}{\text{Slope}}$

In the graph, the candidates were supposed to indicate the following aspects when plotting the graph; the title of the graph including its units, (a graph of y (cm) against x (cm), the scale (vertical and horizontal) in a recommended way, example; horizontal scale: 1 cm represent 1cm, labelling of axes (both vertical and horizontal), with their respective SI units, transfer of points, best line and slope indication. Extract 12.2 shows a sample of candidates' weak responses in Question 1.

solution.

01. Table of result.

Distance (cm).	y (cm)	X (cm)
10	40	20
15	35	30
20	30	40
25	25	50
30.	20	60.

iii) slope.

since

$$slope = \frac{\Delta y(cm)}{\Delta X(cm)}.$$

$$slope = \frac{(43.56 - 29.7)\,\cancel{cm}}{(31.75 - 20)\,\cancel{cm}}$$

$$= \frac{13.86}{11.75}$$

$$= 1.18.$$

$\therefore$ slope of the graph = 1.18.

iv) From the graph.

Weight = mass x Gravitational.

W = mg.

W = (100g x 0.01N)

W. = 10N.

From.

Force = mass x gravitationa.

F = gm.

y = m x

g = slope.

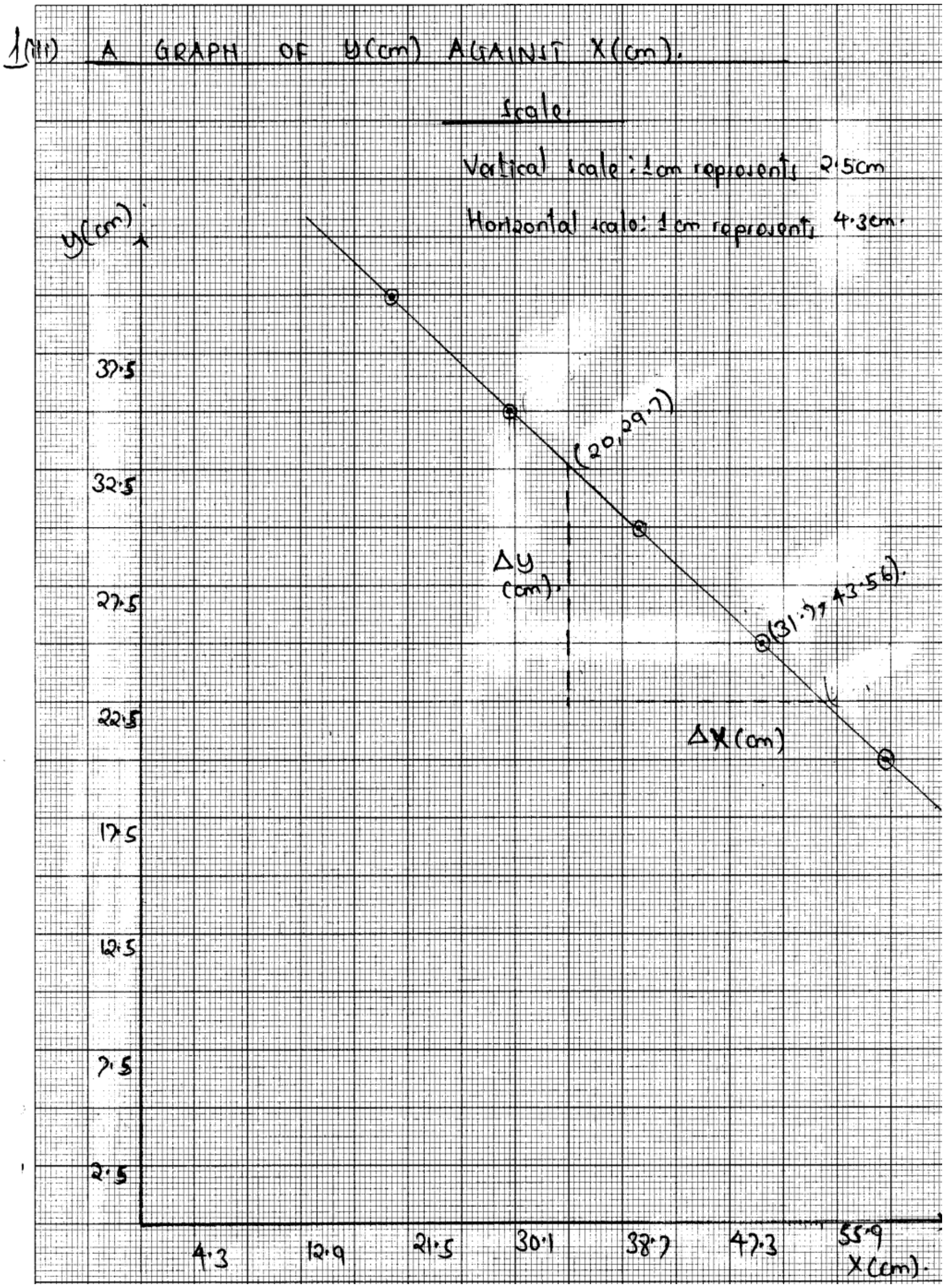
so.

F = gm.

$$\frac{10}{1.18} = \frac{1.\cancel{18} \times m}{1.\cancel{18}}.$$

m = 8.47g.

$\therefore$ Mass of the ruler = 8.47g.



Extract 12.2: A sample of incorrect responses in Question 1 of Physics 2A

3.1.2 031/2B Physics 2B

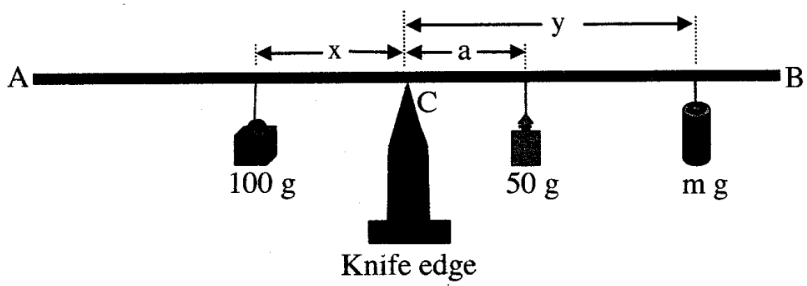
In this question the candidates were provided with unknown mass "m", a knife edge, 50 g mass, 100 g mass, and a metre rule. The candidates were required to perform experiment through the following procedure:

(a) Find and mark the centre of gravity C of the metre rule AB by balancing it freely on a knife edge.

(b) Place a metre rule on a knife edge at its centre of gravity C.

(c) Suspend the 100 g mass at point x=10 cm from the centre of gravity of a metre rule. Suspend 50 g mass at distance a =5 cm from C on the other side of C.

(d) Suspend the mass m to the side of 50 g mass and adjust it until the metre rule balances horizontally as shown in the following Figure.



(e) Repeat the procedure in 1 (d) when x =15 cm, 25 cm and 30 cm. Find the corresponding value of y (cm) in each experiment.
The candidates were then required to answer the following questions

(i) Tabulate the results of x (cm) and y (cm).
(ii) Plot a graph of x (cm) against y (cm).
(iii) Calculate the slope of the graph.
(iv) Formulate the equation of the graph.
(v) Determine the unknown mass m.

The candidates who had good scores in this question were knowledgeable in the concept of forces in equilibrium, particularly the principle of moments. They managed to set the apparatuses as required, tabulate the results, good transfer of points, and plot a graph of x (cm) against y (cm). They drew the best line and indicated the points for the determination of the slope and correctly used it to get the unknown mass 'm'. Extract 13.1 shows a sample of good responses from one of the candidates who scored high marks in this question.

1. The aim of this experiment is to determine the unknown mass m.

(i) Table of results

x (cm)	y (cm)
10	9.5
15	15.5
20	20.5
25	26.0
30	32.0

(ii) Graph of x (cm) against y (cm) drawn on the graph paper.

(iii) Slope of the graph;

From:

$$\text{Slope} = \frac{\Delta x\,(cm)}{\Delta y\,(cm)}$$

$$= \frac{27.5cm - 12.5cm}{29.0cm - 11.5cm}$$

$$= \frac{15\cancel{cm}}{17.5\cancel{cm}}$$

$$= 0.85$$

$\therefore$ slope of the graph is 0.85

1. (iv) The equation of the graph;

From Principle of Moments

Σ clockwise = Σ anticlockwise.

$$100g\,x = 50g(a) + my.$$

$$\frac{\cancel{100}x}{\cancel{100}} = \frac{50a + my}{100}.$$

$$x = \frac{my}{100} + \frac{50a}{100}$$

but: $a = 5$

$$x = \frac{my}{100} + \frac{50(5)}{100}$$

$$x = \frac{my}{100} + \frac{250}{100}$$

$$x = \frac{m}{100}\cdot y + 2.5$$

$$y = mx + c$$

Thus:

The equation of the graph is

$$x = \frac{m}{100}\cdot y + 2.5$$

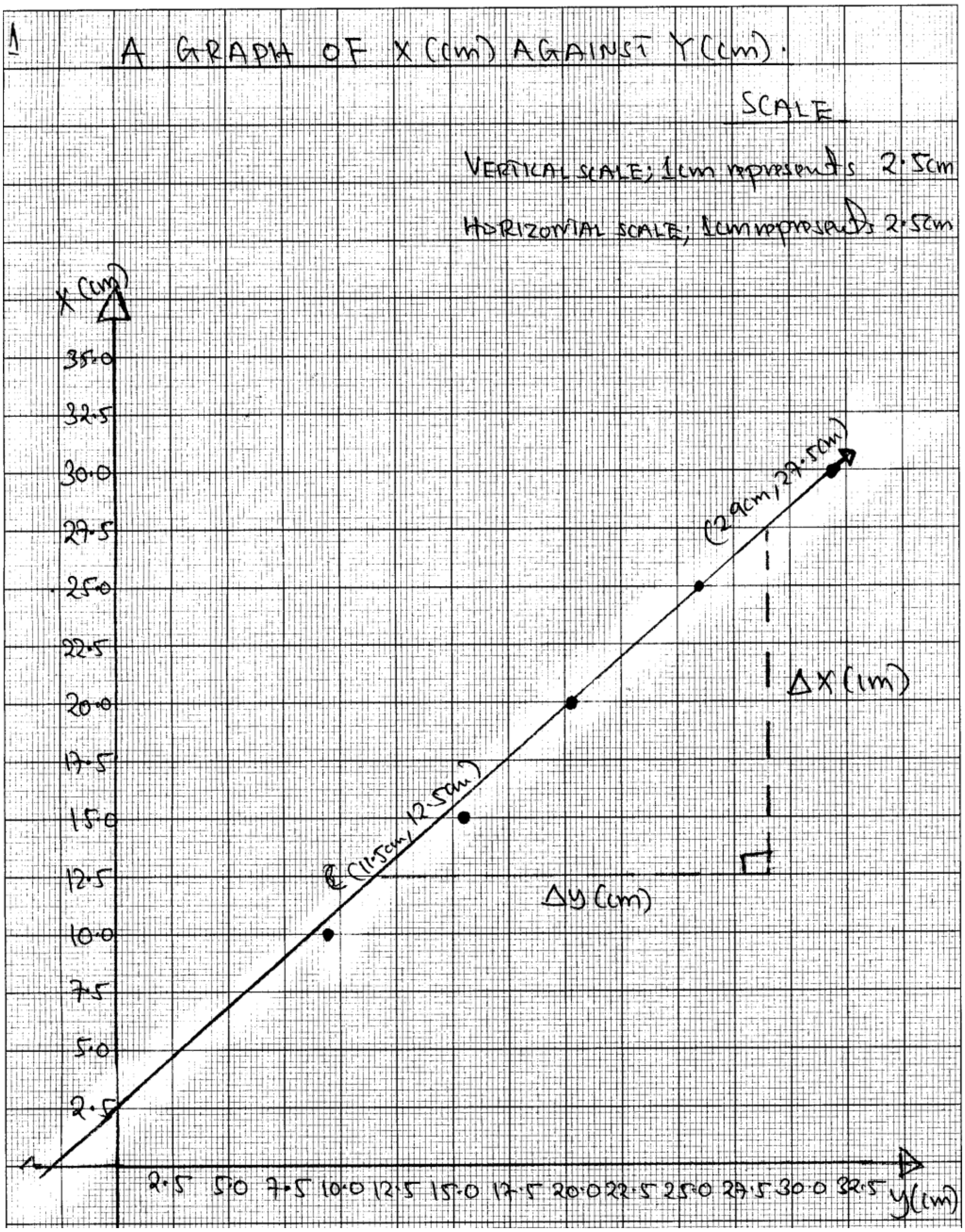
(v) Since slope, $m = 0.85$

$$\text{slope} = \frac{m}{100} = 0.85$$

$$m = 0.85 \times 100g$$

$$m = 85g$$

$\therefore$ The Unknown mass m is 85g.



Extract 13.1: A sample of correct responses in Question 1 in Physics 2B

In extract 13.1, the candidate collected and recorded the correct data, drew a well labelled graph and in it he/she indicated all the necessary parts or features. Finally, the candidate correctly calculated the slope and used it to find the correct value of unknown mass ‘m’.

On the other hand, the candidates who performed weakly in this question had little knowledge on practical work especially, the concept of principle of moments. Some of the candidates provided the concepts which were irrelevant to the demands of the question. For instance, one of the candidates performed wrong mathematical operations to obtain different values of y. This could have been caused by poor experimental set up and therefore, recorded improper data of values in the table of results. She/he drew a non-linear graph and hence, obtained an incorrect slope. It was also observed that some of the candidates used directly the data recorded in the table of results to find the slope (mathematical approach) instead of selecting the points along the drawn best line and use them to calculate the slope. Other candidates applied an incorrect scale and used it to draw the graph. Extract 13.2 shows a sample of responses from one of the candidates who scored low marks in this question.

I When X = 30cm

$100 \times 30 = 50(5+y) + 50(5)$

$3000 = 250 + 50y + 250$

$3000 = 500 + 50y$

$\frac{2500}{50} = \frac{50y}{50}$

$y = 50$cm

1/I/

X(cm)	Y cm
10	10
15	20
20	30
25	40
30	50

III/ $\text{Slope} = \frac{\Delta y}{\Delta x}$

$\text{Slope} = \frac{Y_2 - Y_1}{X_2 - X_1}$

$\text{Slope} = \frac{40-20}{25-15} = \frac{20}{10}$

$\text{Slope} = 2$

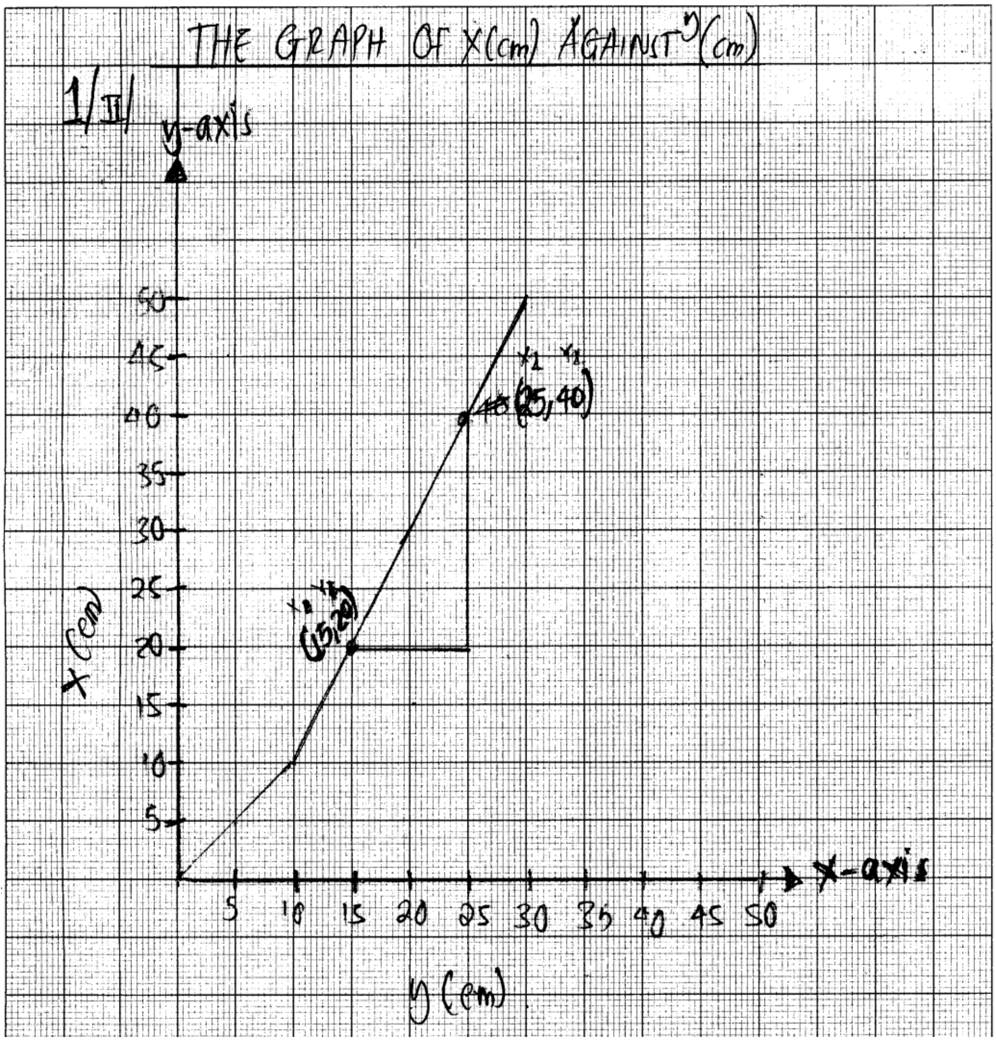
IV/ $y = m(x - x_1) + y_1$

$y = 2(x - 15) + 20$

$y = 2x - 30 + 20$

$y = 2x - 10$

V/ th Unknown Mass Is 50g.



Extract 13.2: A sample of incorrect responses in Question 1 in Physics 2B

In extract 13.2, the candidate provided incorrect table of results and hence, failed to plot and interpret the graph for doing the calculations.

3.1.3 031/2C Physics 2C

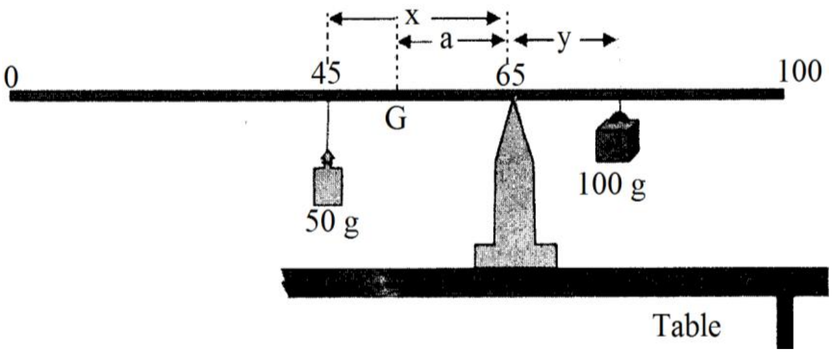
The candidates were provided with a knife edge, metre rule, two strings of 20 cm, each 50 g and 100 g masses. They were required to perform experiment following procedures (a) to (e).

(a) Balance a metre rule on a knife edge, mark the balancing point, write letter G at the balancing point using a pencil.

(b) Use a Vernier calliper to determine the thickness, t and the width, w of the metre rule.

(c) Place the metre rule on a knife edge so that the knife edge is at 65 cm mark. Suspend the given 100 g mass at a point which balances the metre rule. Record the distance between the knife edge and G as **a** cm, and between the knife edge and the position of 100 g mass as **y.**

(d) Suspend the mass of 50 g on the left hand side of the knife edge at the position 45 cm and the adjust the position of 100 g mass to balance the metre rule as shown in Figure 21**.** Record the new value of y and then record the distance between the 50 g mass and the knife edge as x.



(e) Repeat the procedures in 1 (d) by changing the position of 50 g to 40 cm, 35 cm, 30 cm and 25 cm.
The candidates were then required to answer the following questions:
(i) Tabulate the results of **x** (in cm) and **y** (in cm).
(ii) Plot a graph of **y** against **x.**
(iii) Determine the slope of the graph.
(iv) Calculate the value of z from your experimental results given that, $y = Sx + \frac{z+a}{100}$.
(v) State the physical significance of z.
(vi) State the aim of doing this experiment.

The candidates who scored higher marks in this question had sufficient knowledge on the concept of f*orces in equilibrium*. They managed to assemble the apparatuses and set up the experiment correctly. Consequently, these candidates tabulated the results correctly as per instruction given in the question. Moreover, they were able to write the tittle of the graph, design the scale, label the axes, transfer the points, draw the best line and indicate the slope correctly. Also the candidates were able to apply mathematical skills to calculate the slope and the value of z from the given equation. Likewise, by using the table of values, they correctly plotted well interpretable graph which helped them to find the value of z. Moreover, the candidates chose the points in the graph along the best line to find the slope of the graph by using the relation: $\text{Slope} = \dfrac{\Delta y(\text{cm})}{\Delta x(\text{cm})}$.

Furthermore, they were able to state the physical meaning of the value of z and gave the suitable aim of the experiment. Extract 14.1 shows a sample of correct responses from one of the candidates who attempted Question 1 of Physics 2C.

1. i) Table of results:

X (cm)	Y (cm)
20	25
25	27.5
30	30
35	32.5
40	35

- The distance between G and knife edge = 15cm
- The distance between the knife edge and mass of 100g = 15cm

ii) From the principle of moment:
Sum of clockwise moment = Sum of anticlockwise moment.

$$(50g \times x) + (G \times a) = 100g \times y$$

$$50x + Ga = 100y$$

$$\frac{\cancel{100}y}{\cancel{100}} = \frac{50x}{100} + \frac{Ga}{100}$$

$$y = \frac{50}{100}x + \frac{Ga}{100}$$

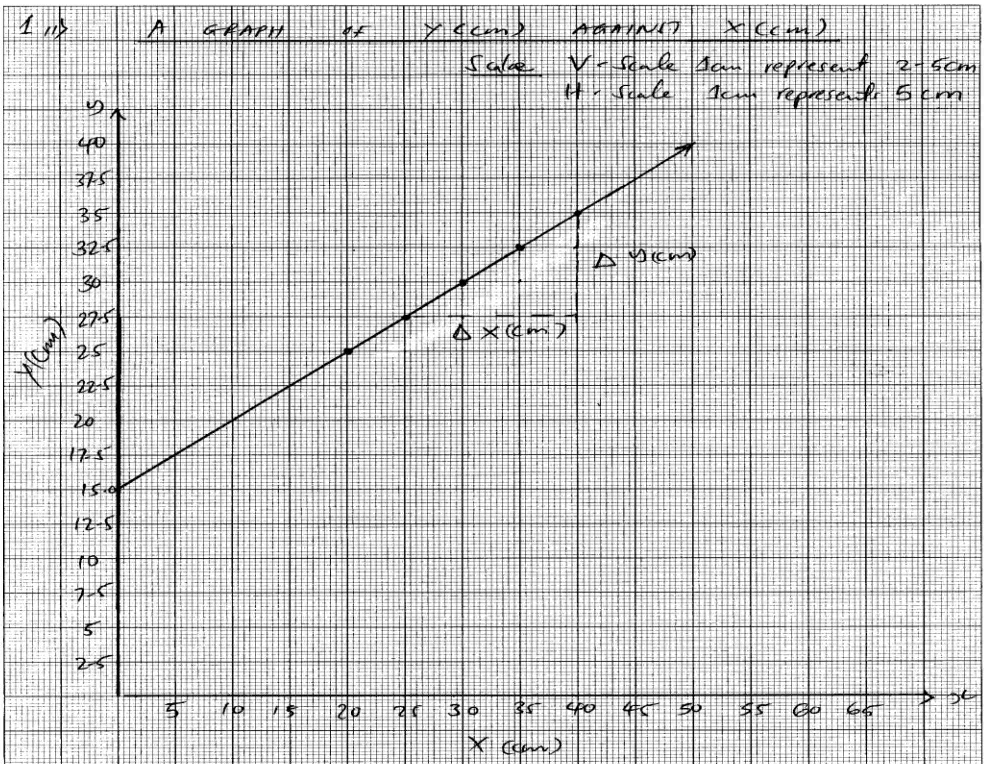
$$y = mx + c$$

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

$$= \frac{(35 - 27.5)\cancel{\text{cm}}}{40 - 25\ (\cancel{\text{cm}})}$$

$$= \frac{7.5}{15} = \frac{7.5}{15}$$

1	iii) Slope $= \frac{7.5}{15} = 0.5$
	∴ The Slope of the graph $= 0.5$
	iv) $y = Sx + \frac{Z \times a}{100}$
	but
	$y = 15 =$ y-intercept
	Slope $(S) = 0.5$
	The value of $a = 15$ cm
	$x = 0$
	$15 = 0.5 \times 0 + \frac{Z \times 15}{100}$
	$15 = 0 + \frac{15Z}{100}$
	$100 \times 15 = \frac{15Z}{\cancel{100}} \times \cancel{100}$
	$\cancel{1500 = 15Z}$
	$\frac{1500}{15} = \frac{15Z}{15}$
	$100 = Z$
	$Z = 100g$
	∴ The Value of $Z = 100g$.
1	v) The physical Significance of Z is the weight of the meter rule.
1	v) The physical Significance of Z is the mass of the metre rule.
	vi) The aim of the experiment is to determine the mass of the metre rule.
1	b) - The thickness (t) of the metre rule = 0.5cm
	- The width (w) of the metre rule = 1.5cm



Extract 14.1: A sample of correct responses in Question 1 of Physics 2C

However, some of the candidates who attempted this question scored low marks because they had poor knowledge of the concept of *forces in equilibrium* especially in the principle of moments. One of the most observed and a measureable challenge to most of candidates faced in this topic was failure in locating the centre of gravity of the metre rule. Another challenge was the use of Vernier calliper as a measuring instrument to determine the thickness and width of the metre rule. Most of them failed to use it to find the thickness and width of the metre rule.

They also failed to recall the statement for the principle of moments that "sum of clockwise moment is equal to sum of anti-clockwise moment". Some of the candidates failed to obtain the required table of results. For example, one candidate was copying the given data and substituting into equation; $y = S \times + \frac{z+a}{100}$. Other candidates used a free hand in drawing the graph which made it difficult to determine the slope because of a rough line. The candidates were supposed to use the points of the slope indication to determine the slope of the graph by using the relation: Slope $= \frac{\Delta y \text{ (cm)}}{\Delta x \text{ (cm)}}$. The data obtained from the graph had to be related with the equation $y = S \times + \frac{z+a}{100}$ to obtain the value of z. They were also required to relate the given equation with the equation of the straight line $y = mx + c$.

By comparing, $c = \frac{z+a}{100}$ which equals to the y-intercept, the candidates would be able to state correctly the physical significance of z and the aim of doing an experiment. Extract 14.2 shows a sample of incorrect responses from one of the candidates who attempted Question 1.

1. Experimental table of results.

a cm	X (cm)	Y (cm)	L (cm)
16	22	15	45
15	21	20	40
15	26	28	35
15	31	31	30
15	35	37	25

ii) To plot the graph of y against X

solution.

y – located at y – axis

X → located at X – axis.

1 iii) To determine slope of the graph

solution

data given

X points = (   )

y - points = (   )

from:

$$slope = \frac{\Delta y}{\Delta x}$$

$$slope = \left(\frac{y_1 - y_2}{x_1 - x_2}\right)$$

slope =

iv) To calculate the value of z

solution

$$y = \left(5x + \frac{z \times a}{100}\right)$$

$$y - 5x = \frac{za}{100}$$

$$\frac{100(y-5x)}{a} = \frac{z\cancel{a}}{\cancel{a}}$$

1 iv)

$$\frac{100(y-5x)}{a} = z$$

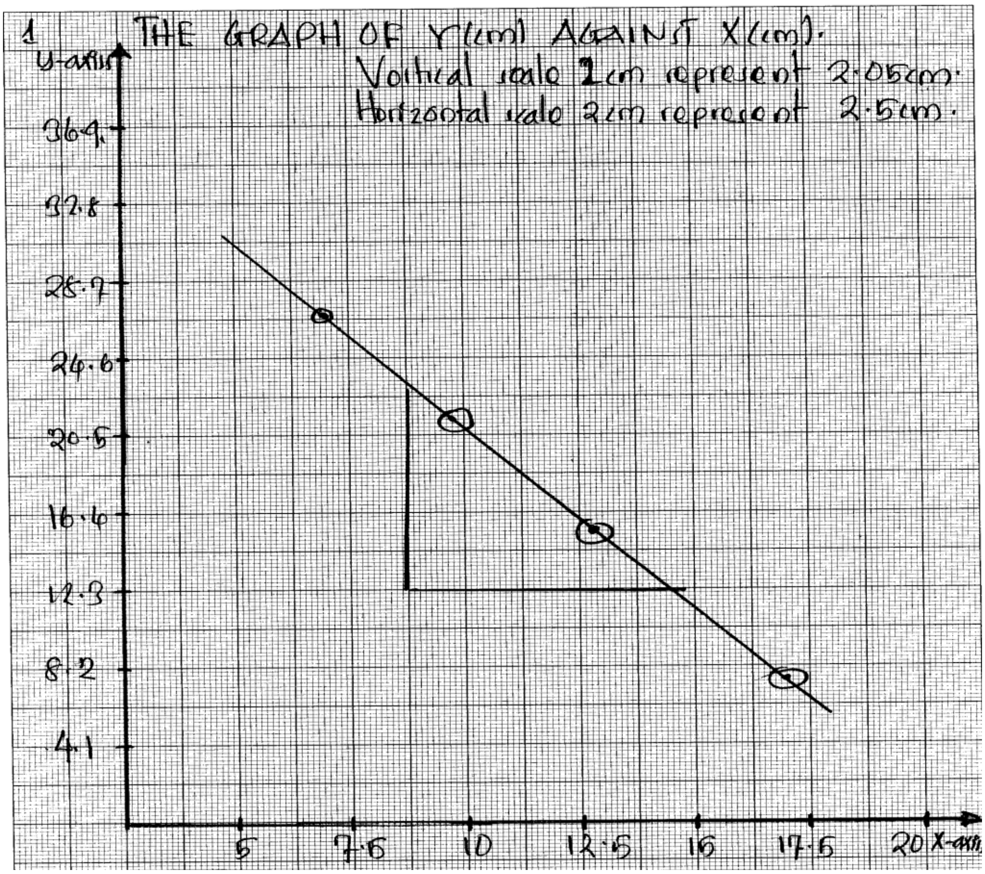
$$z = \frac{100(y-5x)}{a}$$

$$z = 100($$

v) physical significant of z It help to determine the unknown mass of a given substance

vi) Aim of doing this experiment is to determine ~~un known~~ mass of a substance.

position



Extract 14.2: A sample of incorrect responses in Question 1 of Physics 2C

In extract 14.2, the candidate prepared an incorrect table of results which led to his/her failure to the rest parts of the question.

3.2 Question 2: Current Electricity

The question was attempted by 114,472 (100%) candidates and the scores were as follows: 25,883 (22. 61 %) scored 0 to 7.0 marks; 51,568 (45.05 %) scored from 7.5 to 16.0 marks; and 37,021 (32.34 %) scored from 16.5 to 25 marks. This indicates that the candidates' performance was good as 88,539 (77.39%) scored from 7.5 to 25.0 marks. Figure 15 summarizes the performance of the candidates in this question.

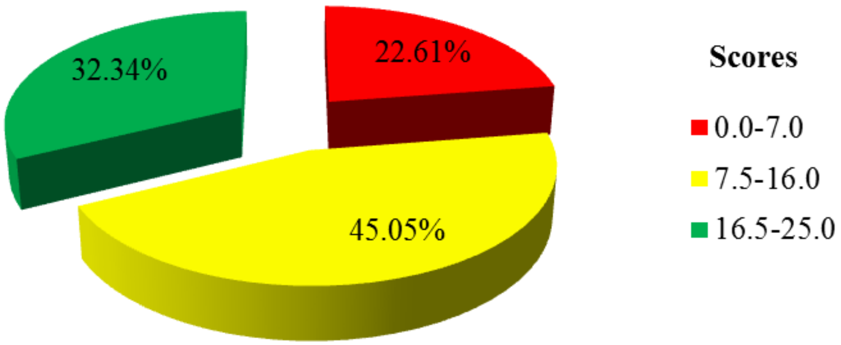


Figure 15: *The Candidates' Performance in Question.2 of Physics 2*

3.2.1 031/2A Physics 2A

In this question, the candidates were provided with a dry cell, resistance box, switch, an ammeter, and a set of connecting wires. They were required to perform experiment through the following procedures:

(a) Connect the given electrical components in series with a switch open. Thereafter, draw and label clearly the circuit.

(b) Set the resistance $R = 1\ \Omega$, and then close the switch. Thereafter, read and record the ammeter reading. Open the switch immediately after taking the readings.

(c) Repeat the procedures in 2 (b), setting the value of R = 2 Ω, 3 Ω, 4 Ω and 5 Ω. The candidates were also required to answer the following questions;

(i) Tabulate the results including the values of $\frac{1}{\mathrm{I}}$.

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

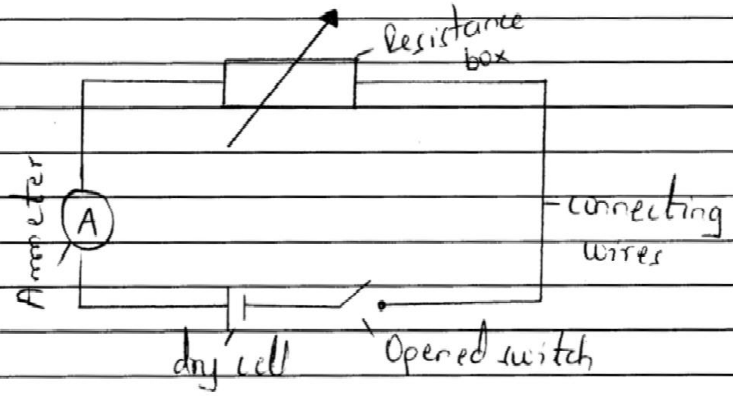
(iii) From the graph, determine the slope and the vertical intercept.

(iv) Use the results obtained in 2 (iii) to determine the internal resistance and e.m.f of a given dry cell.

(v) State the aim of doing this experiment.

The candidates who scored high marks managed to correctly connect the circuit which helped them to get the correct data from the ammeter readings. These candidates plotted the graph correctly and applied appropriate relation to get the slope. They were competent in applying mathematical skills to derive the equation which relates the electromotive force (e.m.f) of the cell 'E', internal resistance of the cell 'r' and resistance due to resistance box 'R'. The candidates obtained the value and units of e.m.f and internal resistance of the cell correctly. Extract 15.1 shows a sample of the correct responses from one of the candidates in this question.

2. a) A LABELLED DIAGRAM OF THE CIRCUIT



2. i)

Resistance(Ω)	Current(A)	1/I (1/A)
1 Ω	1 A	1 amp^{-1}
2 Ω	0·6 A	1.6667 amp^{-1}
3 Ω	0·4 A	2·5 amp^{-1}
4 Ω	0·3 A	3·3333 A^{-1}
5 Ω	0·3 A	3·3333 A^{-1}

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

$(2.025\ A^{-1},\ 2.5\ \Omega)\ (3\ A^{-1},\ 3.95\ \Omega)$

$\text{Slope} = \frac{3.95\Omega - 2.5\Omega}{3\ A^{-1} - 2.025\ A^{-1}}$

$= \frac{1.45\ \Omega}{0.975\ A^{-1}}$

$= 1.487\ \Omega A \approx 1.5\ \Omega A.$

$\therefore$ The slope is $1.487\ \Omega A \approx 1.5\ \Omega A$

2. iii) The vertical intercept is $-0.5\ \Omega$.

2. iv) From equation

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

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

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

$y = mx + c.$

$m = E.$

$\therefore$ The slope is electromotive force.

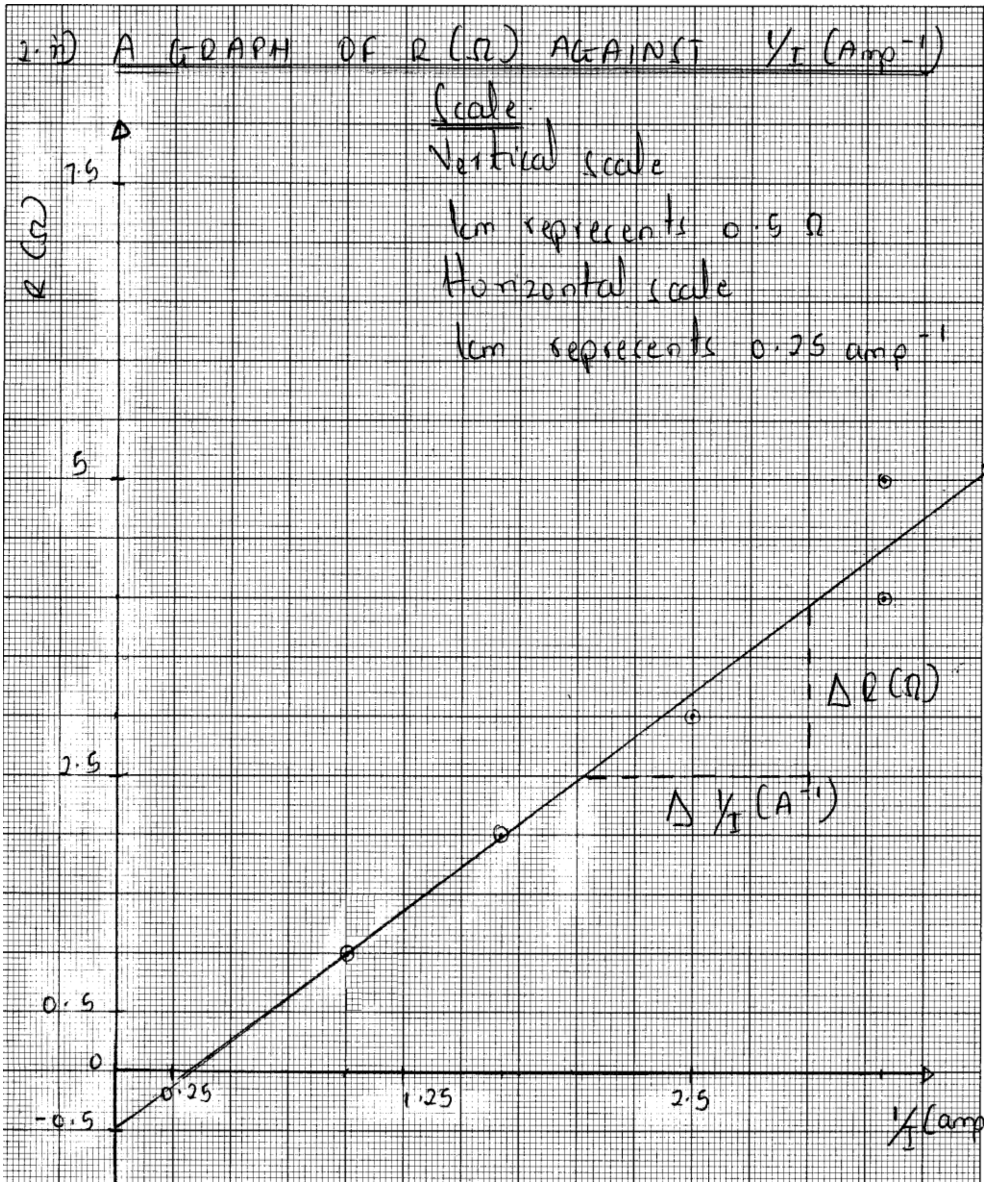
$y\text{-intercept} = -r.$

$\frac{-0.5\Omega}{-1} = \frac{-r}{-1}$

$r = 0.5\ \Omega.$

$\therefore$ The internal resistance is $0.5\ \Omega$ and electromotive force is 1.487 volts

2. v) The aim of an experiment is to determine electromotive force and the internal resistance of the cell.



Extract 15.1: A sample of correct responses in Question 2 of Physics 2A

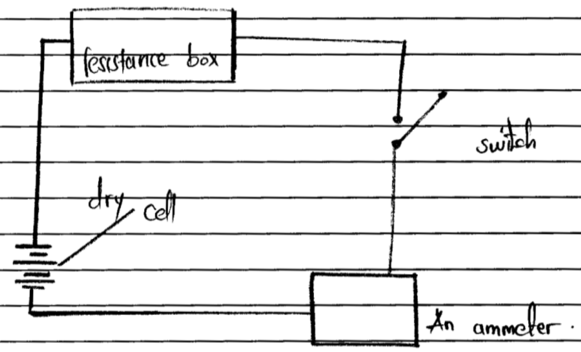
The candidates who scored low marks in this question had inappropriate knowledge of how the e.m.f of the cell was related to both internal and external resistance in the circuit. Most of them failed to make proper connection of some of the electrical components, specifically the ammeter. For instance, some candidates connected the ammeter in parallel or across the resistance box instead of setting it in series as per the principles of connecting an ammeter in any electric circuit or as per question instruction.

This poor knowledge of connection led to incorrect data recording. A few candidates included a voltmeter in the electric circuit they drew, an instrument which was not mentioned anywhere in the question. This indicates that some candidates were not familiar with the electrical components and how they are connected in the circuit.

Another problem observed was the candidates' incorrect reading of the ammeter scale. For example, some of them read and wrote the ammeter reading as *current,* $I = 3A$ *instead of* $I = 0.3\,A$ when the resistance, R was 4 **Ω**. Some candidates wrote incorrect scale such as *2 cm represents 1*A^{-1} instead of *1cm represents 0.5* A^{-1}. Also, they failed to indicate some essential parts of the graph used for drawing the graph. For example one of the candidates drew the graph without naming the vertical and horizontal axes. Some candidates wrote a graph of y against x instead of R against $\frac{1}{I}$.

Others wrote incorrect formula for the equation which relates an e.m.f of the cell, internal resistance, current and external resistance. For instance, one of the candidates wrote "*E = IR"* instead of "*E = I(R+r)"*. Extract 15.2 shows a sample of incorrect responses from one of the candidates who scored low marks in this question.

2. (a) circuit



(b) resistance R = 1 Ω the an ammeter read to 2·5A
So the resistance =

$R = \frac{1\Omega}{2{\cdot}5A}$

R = ~~1.5~~

R = 1.5A

(c) R= 2Ω, 3Ω, 4Ω, and 5Ω

Soln.

$R = 2\Omega = \frac{2\Omega}{2.5A}$

$= 12.5A.$

$R = 3\Omega = \frac{3\Omega}{2.5A}$

$= 7.1A.$

(iii) $Slope = \frac{X_2 - X_1}{Y_2 - Y_1}$

$Slope = X_1 = 4.5.$

$Y_1 = 6.5.$

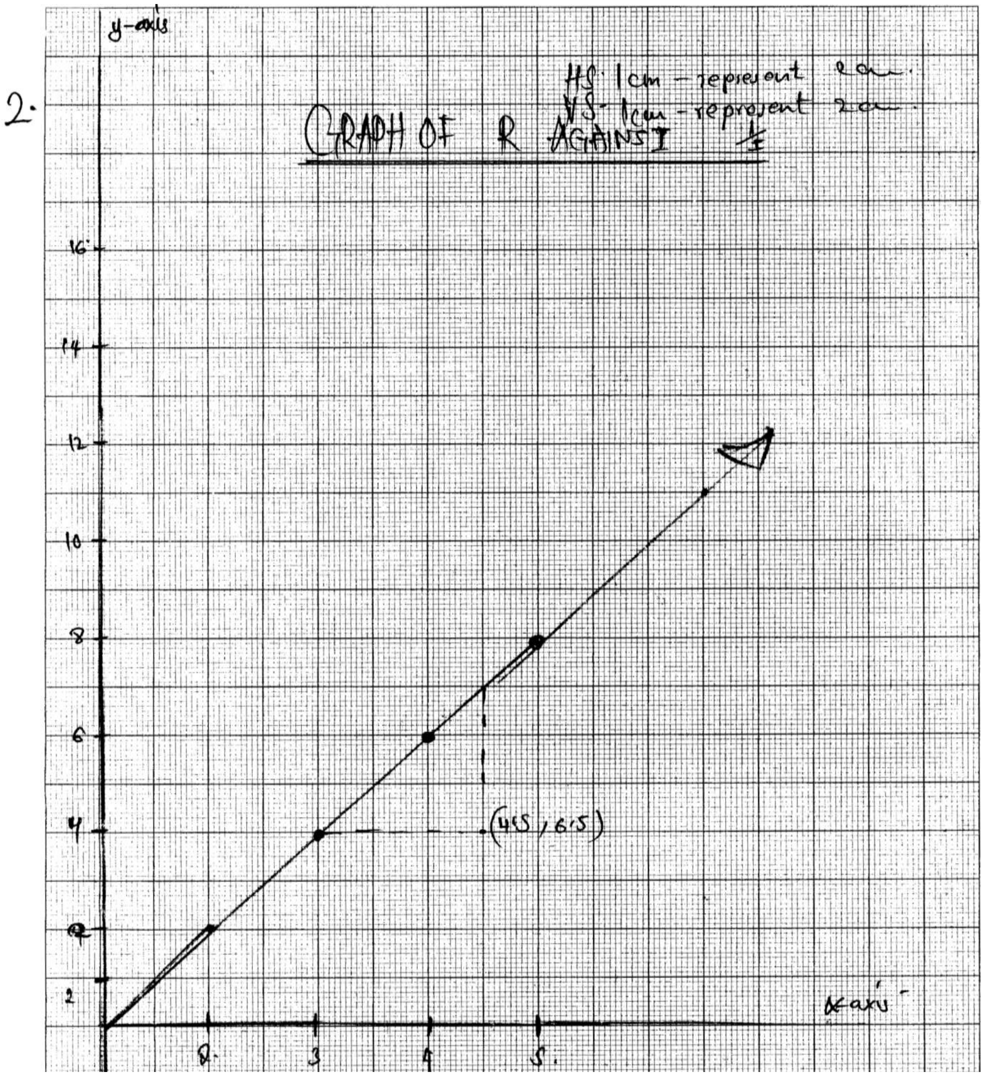
$Slope = \frac{X_2 - 6.5}{Y_2 - 4.5}.$

$Slope = 1.8.$

(iv) The internal resistance of emf of a dry cell $= 2\Omega$.

(i) results including the value of $\frac{1}{I}$

Value.	$\frac{1}{I}$
2Ω	12.5A
3Ω	7.1A
4Ω	4.1A
5Ω	5A.



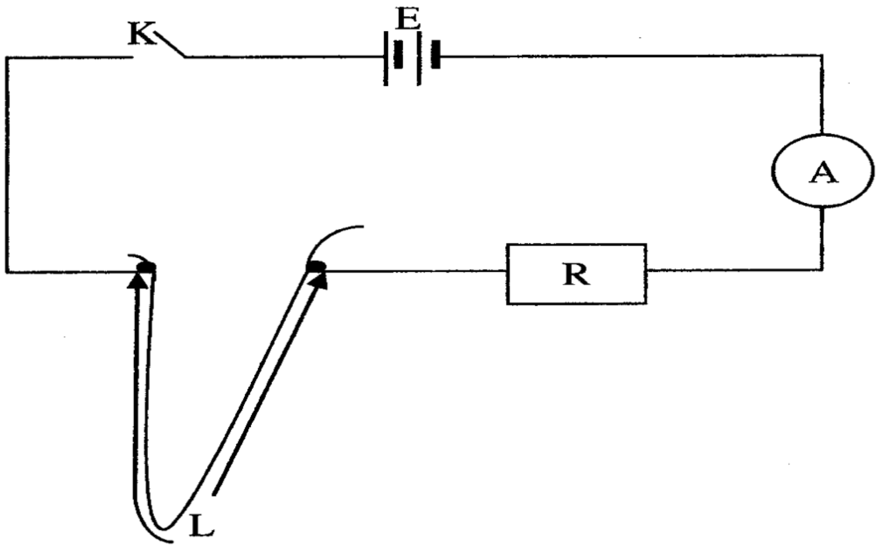
Extract 15.2: A sample of incorrect responses in Question 2 of Physics 2A

In extract 15.2, the candidate drew a circuit diagram with an electric symbol of the battery, but wrote it as a dry cell and ammeter instead of resistance box. Consequently, he/she utilized an incorrect formula to determine the slope of the graph by writing the ratio of horizontal increase to the vertical increase instead of ratio of change in Resistance to change in reciprocal of current.

3.2.2 031/2B Physics 2B

In this question, the candidates were required to determine the e.m.f of the cell and the resistance of a given piece of wire through the following procedures:

(a) Connect the circuit diagram as shown below in which E is a battery, K is a key, L is the length of the wire, R is the resistance box and A is an ammeter.



(b) With L = 12 cm and R set at $1\,\Omega$, record the ammeter reading I (A).

(c) Without altering the value of L, repeat the procedure in 2 (b) with R = 2 Ω, 3 Ω, 4 Ω and 5 Ω. Record the corresponding values of ammeter reading in each case.

The candidates were then required to answer the following questions:

(i) Tabulate the results of R, I and $\frac{1}{I}$.

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

(iii) Calculate the slope S of the graph.

(iv) Find the value of I for which R = 0.

(v) Determine the e.m.f and resistance of the wire L given that, the internal resistance of the cell was 1.0 Ω. They were also asked to show clearly how they arrived to their answers.

The candidates who scored high marks had adequate knowledge and competence about the topic of *Current Electricity*. They managed to connect the electric circuit and recorded the ammeter correctly. They also drew the appropriate graph correctly. Moreover, they possessed computational skills, as they managed to derive the correct equation which connects the electromotive force of the cell, internal resistance of the cell, resistance of the wire and the resistance due to resistance box. This equation helped them to get the correct numerical value of e.m.f of the cell and resistance of the wire. Extract 16.1 shows a sample of correct responses from one of the candidates in this question.

2 (i) Table of results

R (Ω)	I (A)	$\frac{1}{I}$ (A^{-1})
1	1.25	0.8
2	0.8	1.2 ~~1.3~~
3	0.7	1.4
4	0.6	1.7
5	0.5	2

2 (iii) Chosen points (1, 0.8) and (3, 1.4)

From Slope (m) $= \frac{\Delta \frac{1}{I}}{\Delta R}$

$= \frac{(1.4 - 0.8)\,A^{-1}}{(3 - 1)\,\Omega}$

$= \frac{0.6\,A^{-1}}{2\,\Omega}$

$= 0.3\,A^{-1}/\Omega$

2 (iv) From

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

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

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

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

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

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

$$y = m x + c$$

when $R = 0$

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

But $\left(\frac{R_w + r}{E}\right) = \frac{1}{I}$ intercept which is 0.5

$$\frac{1}{I} = \left(\frac{1}{2}\right)A^{-1} \longrightarrow I = 2\,A$$

$$\therefore \quad I = 2\,A$$

2 (v) From

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

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

2 (v) $\frac{1}{I} \cdot \frac{E}{E} = \frac{R}{E} + \frac{R_w + r}{E}$

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

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

$$y = m x + C$$

from Slope(m) $= \frac{1}{E}$

But Slope(m) $= 0.3$

$$0.3 = \frac{1}{E}$$

$$\frac{\cancel{0.3}E}{\cancel{0.3}} = \frac{1}{0.3}$$

$$E = 3.3 \approx 3V$$

∴ The e.m.f of the wire is 3V

From

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

$$y \quad m x + c$$

But c - intercept $= 0.5$

$$\frac{0.5}{1} = \frac{R_w + 1.0\Omega}{\cancel{E}\ 3V}$$

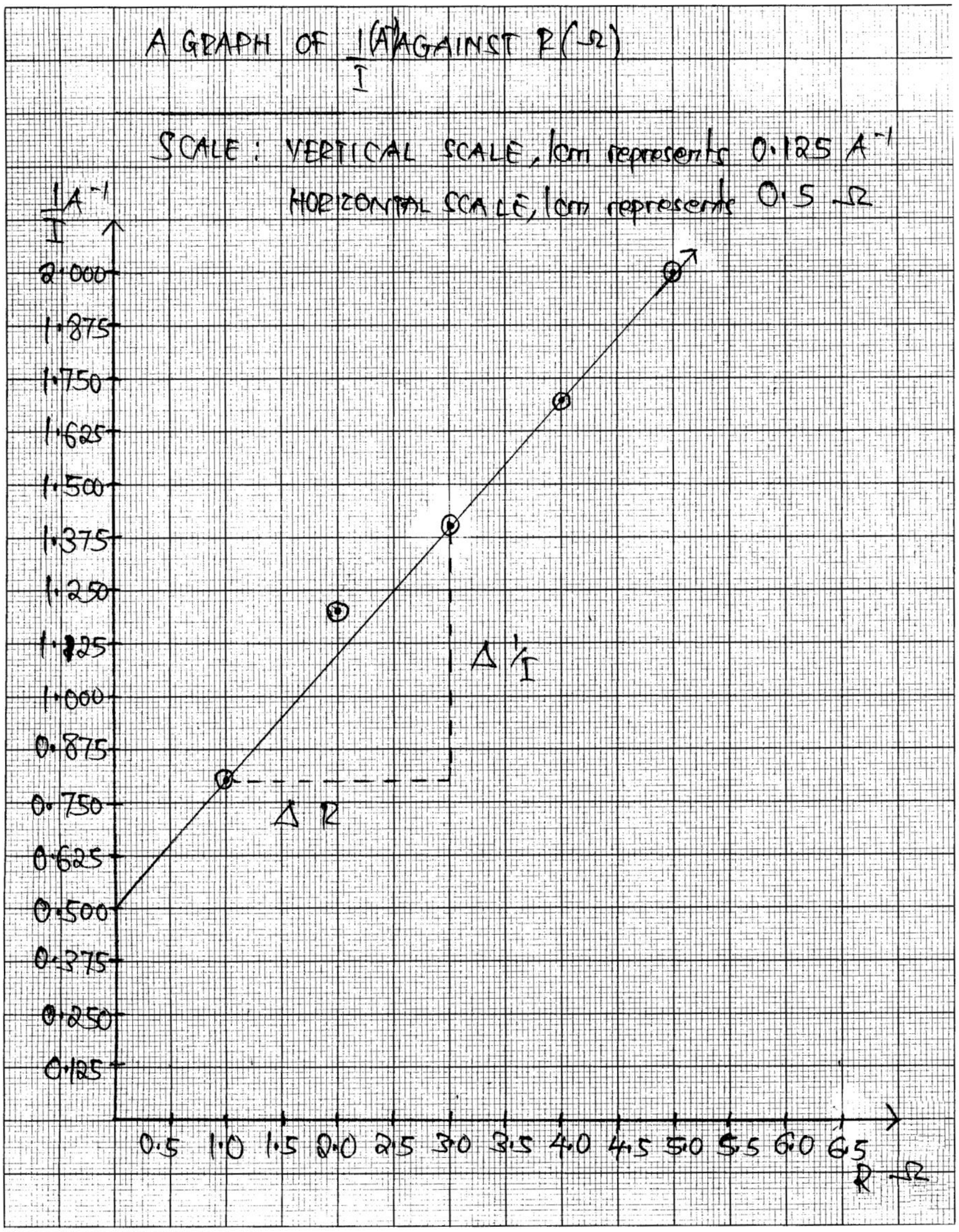
$$1.5 = R_w + 1.0$$

$$R_w = 1.5 - 1.0$$

2 (v) $R_w = 1.5 - 1.0$

$$R_w = 0.5\Omega$$

∴ Resistance of the wire is 0.5Ω.



Extract 16.1: A sample of correct responses in Question 2 of Physics 2B

On the other hand, the candidates who scored low marks had inadequate knowledge about the topic of *Current Electricity*. These candidates faced the challenges in setting the experiment, as a result they ended up with incorrect value. Some of them were unable to read the ammeter scale which led them gather incorrect data. For example, one candidate obtained a current, I = 1.7 A at a resistance, $R = 1\ \Omega$ instead of $I = 1.19\ A$. Some candidates prepared a complex scale to draw the graph which led to their failure in reading the graph. For example, one candidate prepared the scale of 1cm represents $0.0997A^{-1}$ instead of 1cm represents $0.1\ A^{-1}$. Other candidates who did wrongly exposed his/her poor mathematical skills. For this reason, they failed to show the relationship between electromotive force of the cell; internal resistance of the cell; resistance of the wire; and resistance. For instance, one candidate wrote *"E = I(R+r)"* which was not correct, as a result they calculated incorrect value of the e.m.f of the cell and resistance of the wire. The correct formula was $E = I\left(R + r + R_w\right)$ where R_w is the resistance of the wire. Extract 16.2 shows a sample of incorrect responses in this question.

Table of result

R	I	1/I
1Ω	3	0.33
2Ω	1.5	0.66
3Ω	1	1
4Ω	1.3	0.76
5Ω	1.6	0.62

iv. The value of I for which R = 0
from

$V = IR$

$V = 3\ V$
$I = ?$
$R = 0$

$\cancel{3} = I = V/R$

$I = 3/0$

$I = 0$

v. E.m.f
from

$V = IR$

But $I = \left(\frac{E.m.f}{R + r}\right) R$

$V = \left(\frac{E.m.f}{R + r}\right) R)$

$V = 1.5 \times 2 = 3$
$R = 1$
$R = 1$

$3 = \left(\frac{E.m.f}{1 + 1}\right) 1$

$$3 = \left(\frac{E.m.f}{2}\right)\frac{1}{}$$

$$3 = \frac{1\,E.m.f}{2}$$

$$E.m.f = \frac{3 \times 2}{1}$$

$$E.m.f = 6V$$

Resistance of the wire
from

$$E.m.f = I(R + r)$$

$$E.m.f = I(R + r)$$

$$E.m.f = IR + Ir$$

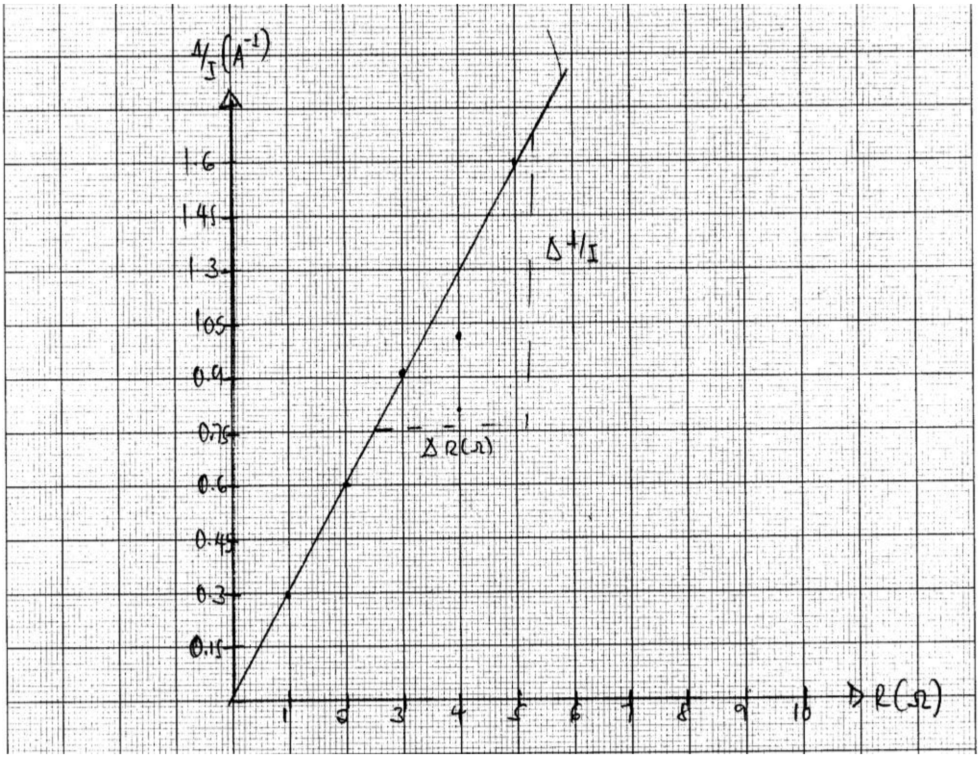
$E.m.f = 6v$
$R = ?$
$r = 1$
$I = 1$

$$6v = R + (I \times 1)$$

$$6 = 1R$$

$$R = 6\Omega$$

Resistance of the wire $= 6\Omega$



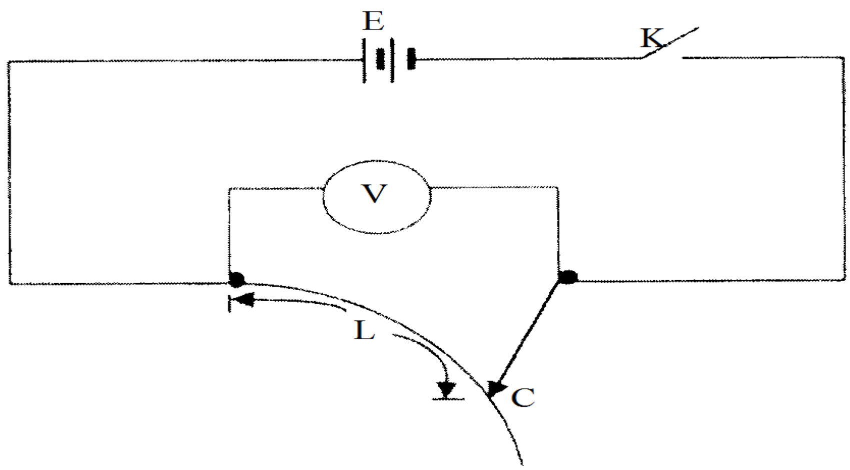
Extract 16.2: A sample of incorrect responses in Question 2 of Physics 2B.

In extract 16.2, the candidate prepared an inappropriate table of values and hence plotted incorrect graph. Similarly, he/she applied a formula which excluded the resistance of the wire, thus ended up with wrong value of the e.m.f of the cell.

3.2.3 031/2C Physics 2C

In this question the candidates were required to determine the resistivity of the material of the wire provided from the following procedures:

(a) Use the micrometre screw gauge to determine the diameter of the given wire and hence find its cross section area in m^2. Connect the circuit as shown in Figure 26 where C is a crocodile clip. Measure the length of wire $L = 100$ cm and clip it so that the current flows across the wire. Record the voltmeter reading V.



(b) Repeat the procedures in 2 (a) with crocodile clip at $L = 80\ cm$, $60\ \text{cm}$, $40\ \text{cm}$ and $20\ \text{cm}$. Record the corresponding voltmeter reading in each case.

The candidates were then required to:

(i) Tabulate the values of L, V, $\frac{1}{L}$ and $\frac{1}{V}$. (The length L should be in metres).

(ii) Plot a graph of $\frac{1}{V}(v^{-1})$ against $\frac{1}{L}(m^{-1})$.

(iii) Determine the slope S.

(iv) Find the value of V for which $\frac{1}{L} = 0$ and state its physical meaning.

(v) Determine the value of resistivity of the wire given that, $\frac{1}{\text{V}} = \frac{\text{A}}{\rho\text{E}}\frac{1}{\text{L}} + \frac{1}{\text{E}}$.

The candidates who scored higher marks in this question were competent in applying the concept of current electricity. They managed to assemble the apparatuses as required and set up the experiment correctly. These candidates performed proper measurement and recorded the results appropriately. They also plotted the appropriate graph of which they used to determine the slope of the graph. Consequently, they found the value of V when $\frac{1}{\text{L}} = 0$ and stated its physical meaning correctly. Likewise, they determined the value of resistivity of the wire using the formula $\frac{1}{V} = \frac{A}{\rho E}\frac{1}{L} + \frac{1}{E}$. Extract 17.1 shows a sample of candidates' good responses to this question.

2(a) (i) Diameter of the wire = 0·00038m

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

$= \frac{3{\cdot}14 \times 0{\cdot}00038 \times 0{\cdot}00038}{4}$

$= 1{\cdot}3354 \times 10^{-7}\ m^2$

(ii) TABLE of RESULTS

L(m)	V(v)	1/L (m⁻¹)	1/V (V⁻¹)
1	2·4	1	0·41
0·8	2·3	1·25	0·44
0·6	2·2	1·77	0·45
0·4	1·9	2·5	0·53
0·2	1·2	5	0·7

(iii) Plot the graph

$1/V\ (V^{-1})$	0·41	0·44	0·45	0·53	0·7
$1/L\ (m^{-1})$	1	1·25	1·77	2·5	5

VS: HR = $\frac{HD}{SB}$

~~(iii) Slope~~

$= \frac{0{\cdot}7}{0{\cdot}1} = 7$

∴ 1cm represent 0·1 V^{-1}

HS ÷ HR = $\frac{HD}{SB}$

	$MR = \frac{5}{0.5}$
	$= 10$
	$\therefore$ 1cm represent $0.5m^{-1}$
2 (III)	Slope
	$= \frac{\Delta 1/v}{\Delta 1/L}$
	$= \frac{0.23}{3.5}$
	$= 0.066$
	$\therefore$ slope of the graph $= 0.066 v^{-1}/m^{-1}$
(iv)	Value of V
	From
	$\frac{1}{L} = 0$
	$\frac{1}{v} = \frac{A}{PE} \cdot \frac{1}{L} + \frac{1}{E}$
	$\frac{1}{v} = \frac{1.13 \times 10^{-7}}{4.8 \times 10^{-7}} + \frac{1}{3}$
	$\frac{1}{v} = \frac{1}{3}$
	$\frac{v}{1} = \frac{3}{1}$
	$v = 3$
	$\therefore$ Value of $v = 3V$

V To determine resistivity

From

$$\frac{1}{V} = \frac{A}{\rho E} \cdot \frac{1}{L} + \frac{1}{E}$$

compare with linear equation

$$\frac{1}{V} = \frac{A}{\rho E} \cdot \frac{A}{L} + \frac{1}{E}$$

$$y = mx + C$$

$$M = \frac{A}{\rho E}$$

but

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

$$= \frac{3.14 \times 0.00038 \times 0.00038}{4}$$

$$= 1.3354 \times 10^{-7}$$

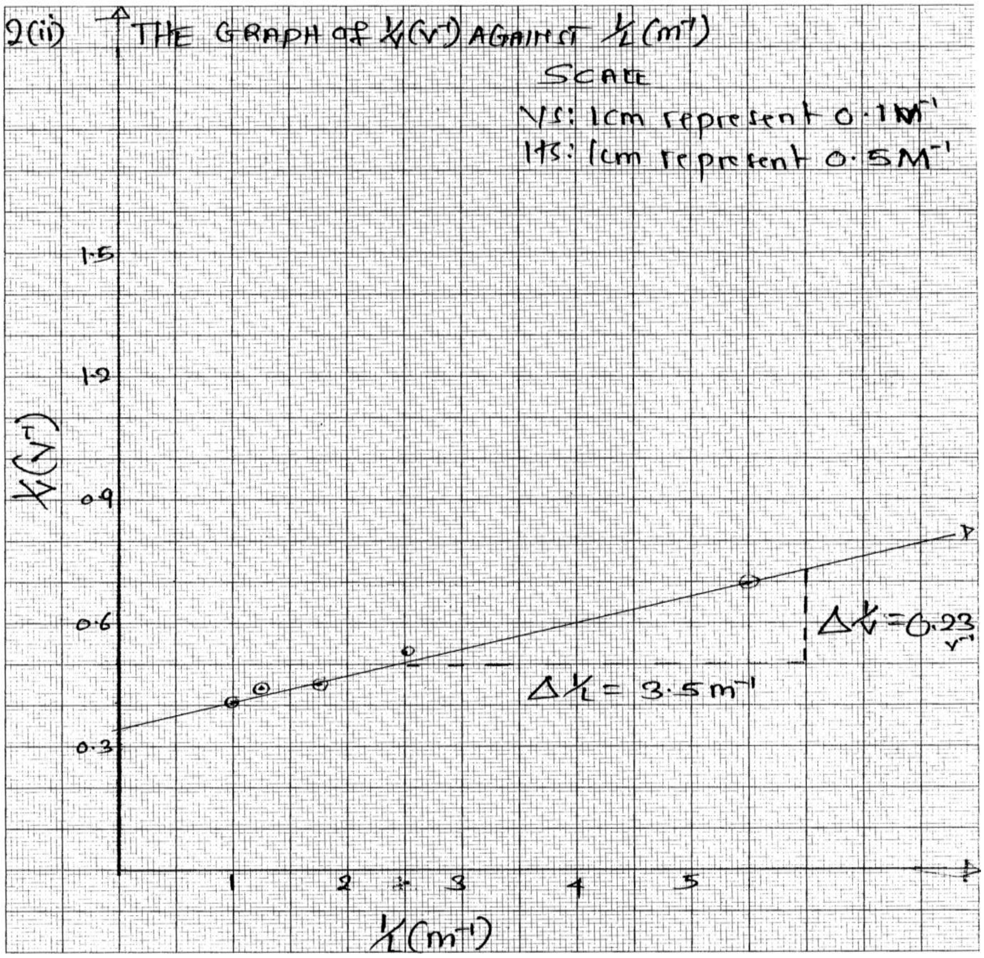
$$\rho = \frac{A}{mE}$$

$$\rho = 1.13354 \times 10^{-4}$$

$$\rho = 0.136 \times 10^{-3}$$

$$\rho = 4.8 \times 10^{-7}$$

$\therefore$ Resistivity of wire is $4.8 \times 10^{-7}\,\Omega$



Extract 17.1: A sample of correct responses in Question 2 of Physics 2C

In extract 17.1, the candidate responded correctly to all parts of the question.

The candidates who scored low marks on the other hand, had little knowledge of the concept of current electricity, particularly experimental determination of resistivity of the material. A few candidates (22.61%) had low standard of performance. These candidates could not set up the experiment as per instruction, as a result they recorded and tabulated incorrect values of L, V, $\frac{1}{L}$ and $\frac{1}{V}$. The candidates in this category lacked the skills of simple electric circuits, basic electric components and symbols. One can tell that, these candidates did not understand the main function of the crocodile clip as a result they failed to clip the required value of the length of the wire. Similarly, they failed to read precisely the value of the voltage across the wire. These candidates were supposed to know that crocodile clips are principally used to create flexible, temporary or experimental electrical connections of electrical conductors in laboratories. For example, this could be between two wires or between an electrical lead or between the entrance and exit points of an electrical current. Therefore, when a voltmeter is connected across the wire such that the circuit is made complete by connecting the battery and a key, the resistance or resistivity of the wire can be determined.

Another challenge shown by these candidates was inability to transfer and use the data for plotting the graph. In the graph, a few candidates failed to prepare the scales, transfer of data points, labelling of the axes and slope indication. For example, one candidate wrote a scale as *"2 cm represents 0.01''*, instead of *"1cm represents 0.01V^{-1}''*. Moreover, some of the candidates who managed to obtain the slope failed to indicate the S.I unit. Those who managed to draw the graph they wrongly interpreted it as a result, they failed to state the physical meaning of V when $\frac{1}{\mathrm{L}} = 0$. These candidates were supposed to apply the mathematical concept of coordinate geometry that, when a graph of $\frac{1}{V}(\mathrm{V}^{-1})$ against $\frac{1}{L}(m^{-1})$ is plotted, letting one variable as zero gives the intercept of the other variable and vice versa. In connection to this, some candidates exposed their little knowledge of applying mathematical abilities and hence, failed to determine the value of resistivity of the wire.

The formula could help them to determine the value of resistivity of the wire by first, finding the e.m.f of the battery from the intercept of $\frac{1}{\mathrm{V}}$ and second, measure the diameter of the wire by using a micrometer screw jack. Finally, use the diameter of the wire to obtain the cross-sectional area A. Extract 17.2 indicates a sample of incorrect responses from one of the candidates in this question.

2. (i) To tabulate the value of L, v, $\frac{1}{L}$ and $\frac{1}{V}$. length L should be in metre

From

$L = 100$

$V = 2.5$

$\frac{1}{L} = \frac{1}{10}$

$\frac{1}{V} = \frac{1}{2}$

From

$L \times V \times \frac{1}{L} = \frac{1}{V}$

$100 \times 2 \times \frac{1}{10} = \frac{1}{2}$

$\cancel{10}\ 200 = \frac{1}{10} = \frac{1}{2}$

$\frac{200}{10} = \frac{1}{2}$

$\cancel{20}^{10} = \frac{1}{\cancel{2}_1}$

$\frac{1}{\cancel{2}_1} = \frac{20}{10} = 10$

$= 10$

The length is $L = 10$.

∴ The value of L, V, $\frac{1}{L}$ and $\frac{1}{V}$. Leng L = 1 0 in metres $L = 10m^2$.

(iii) To determine the slope S thus as area $2m^2$.

(iv) To Find the value of V For $\frac{1}{L} = 0$

Given that

$V = 0.1$

$\frac{1}{L} = 0$

Solution

From

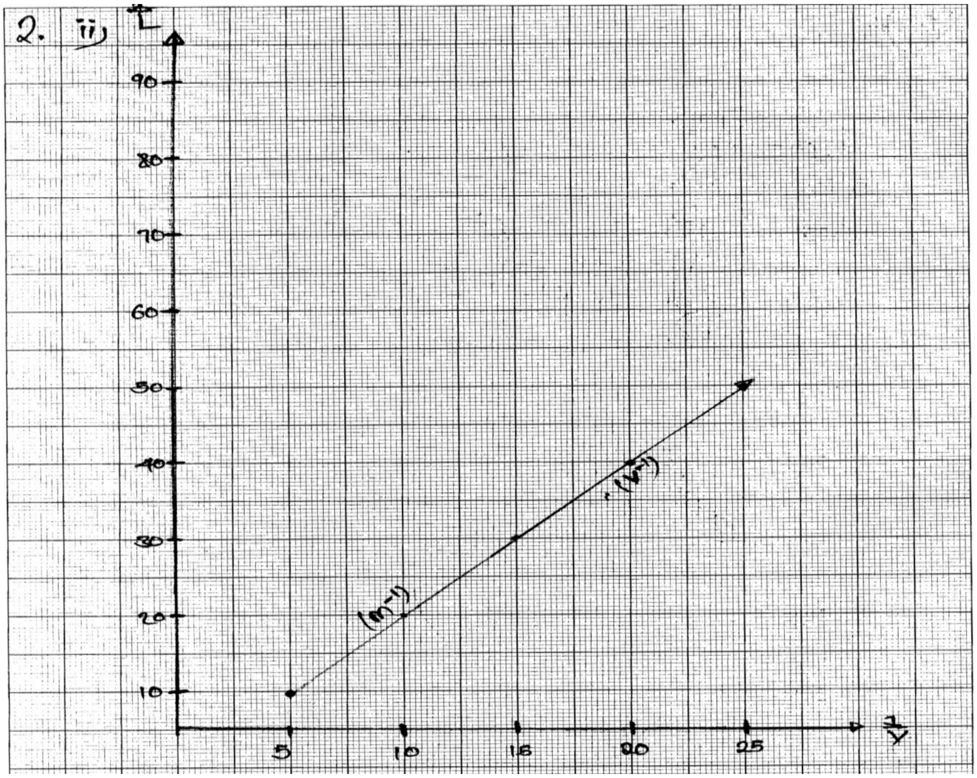
$V = \cancel{0.1 = 0}$

$V = 1.$

$\therefore$ The value of $V = 1$ · For $\frac{1}{L} = 0$·

Phisical state·

① The voltemete to change the point durting the connect the string wire·



Extract 17.2: A sample of incorrect responses in Question 2 of Physics 2C

In extract 17.2, the candidate failed to prepare table of results and hence, provided incorrect responses to the rest parts of the question.

4.0 THE CANDIDATES' PERFORMANCE ANALYSIS IN EACH TOPIC IN PHYSICS PAPER 1&2

A total of 22 topics were examined in the Physics examination papers. The topics examined were *Measurement; Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Pressure; Light; Simple Machines; Newton's Laws of Motion; Motion in a Straight Line; Forces in Equilibrium; Current Electricity; Temperature; Vapour and Humidity; Measurement of Thermal Energy; Thermionic Emission; Elementary Astronomy; Optical Instruments; Thermal Expansion; Radioactivity; Geophysics; Waves; Electromagnetism; and Electronics.*

The analysis of performance in Physics paper 1 reveals that sixteen (16) topics had average performance. The topics are *Geophysics and Waves* (64.57%) which were examined in Question 8; *Current Electricity and Electronics* (62.44%) set in Question 10; *Measurement; Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Light; Motion in a Straight Line, Measurement of Thermal Energy, Vapour and Humidity; Temperature; Thermionic Emission;* and *Elementary Astronomy* (62.18%), all examined in Question 1 which was a multiple choice items.

Other topics with average performance include: *Waves* (46.29%) which was examined in Questions 2 & 11; *Waves and Electromagnetism* (43.80%) examined in Question 9; and *Current Electricity* and *Radioactivity* (37.71%) examined in Question 7. The average performance was due to the fact that, some of the candidates attempted only parts of the questions and skipped other parts especially those who had poor mathematical skills in performing calculations.

Further analysis shows that, the performance was weak in the topics of *Newton's Laws of Motion* and *Simple Machines* (26.63%) examined in Question 5; *Thermal Expansion* and *Vapour and Humidity* (22.90%) examined in Question 6; *Light and Optical Instruments* (20.77%) examined in Question 3; and *Pressure* and *Forces in equilibrium (3.84%)* examined in Question 4. The weak performance in these topics were influenced by the candidates' poor drawing skills, inadequate knowledge about the topics examined, lack of English language proficiency, failure to understand the requirement of some questions and inappropriate use of formulae due to both unsatisfactory knowledge and poor mathematical skills, and the candidates' poor English language command. The analysis of candidates' performance in each topic for Physics paper 1 is summarized in Appendix I.

On the other hand, the analysis of Physics 2 (Actual Practical Paper) revealed that the topic of *Current Electricity* had good performance of 77.39 per cent while the topic of *Forces in Equilibrium* had an average performance of 46.41 per cent. This indicates that candidates had better understanding in practical paper than in theory paper especially in the topic of *Current Electricity* (see Appendix II).

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In general, the performance of candidates in the 2022 Physics was good as 78,009 (68.34%) of the candidates passed the examination and only 36,463 (31.66%) failed. The good performance was due to the candidates' ability to understand the requirements of the questions set, correct application of the principles in interpreting scientific observation, candidates' good knowledge and mathematical skills about the subject matter and candidates' possession of drawing skills.

However, some candidates faced difficulties in understanding the content and requirements of the questions. Weak performance of some candidates was due to;

(a) Lack of knowledge about various concepts, hence providing incorrect responses and poor mastering of the subject matter.

(b) Poor background of mathematical skills. Most of the candidates who scored low marks in questions which required calculations, failed to analyse and manipulate the given data through correct procedures and appropriate calculations.

(c) Application of inappropriate formulae. Some candidates used incorrect formulae to perform calculations. Others applied the formulae interchangeably.

(d) Poor communication skills. The candidates provided responses with grammatical errors. In some cases, candidates with problems in English language communication skills failed to give detailed responses required in the questions.

(e) Lack of drawing skills. Some of the candidates failed to draw the image formed in a concave mirror, diagram of human eye, photographic camera, combinational pulley systems, simple electric circuits and common emitter amplifier circuit which were required for one of the questions in CSEE 2022.

5.2 Recommendations

(a) Based on the observations made through the Candidates' Item Response Analysis, the following recommendations should be adhered to in order to improve future performance of the candidates in the Physics subject:

   (i) Teachers and students are advised to read the Candidates' Item Response Analysis report (CIRA) each year. This will help them to scrutinize the major factors which affect candidates' responses and take appropriate actions during classroom teaching and learning in order to improve the candidates' performance.

   (ii) Teachers and students are urged to use English Language when discussing various topics in the class and in other extracurricular activities. This will improve students' writing skills and assist them to understand what is taught in the classrooms and what is asked in the question paper.

   (iii) Students should be urged to do experimentation, demonstrations and drawing activities in order to acquire competence in drawing diagrams from various topics.

(iv) Students should continue learning and practising computation skills that are required in solving different questions involving calculations.

(b) Based on the teaching and learning strategies, teachers are advised to adhere to the Physics syllabus for better students' acquisition of knowledge and competences in the unsatisfactory performed topics as follows:

(i) Guide students to use stiff spiral spring, block of wood or book, a table and a retort stand to demonstrate the action and reaction forces by showing their relationship in the topic of *Newton's Law of Motion*. They should also guide students to use block and tackle pulley system through gallery walk presentations to determine the effort required to raise two bags of manure in the topic of *Simple Machines*.

(ii) Lead students to demonstrate the expansion and contraction of solids by using brass, iron and copper strips, switch and source of heat in the topic of *Thermal Expansion*. Likewise, they should lead students to brainstorm the factors affecting evaporation of the liquid by using a cooking pot with or without a lid, hot water and source of heat in the topic of *Vapour* and *Humidity*.

(iii) Guide students to demonstrate on how to locate the images formed in a concave mirror by using tools such as a graph paper, a plane paper, a transparent ruler of 30 cm and a concave mirror by placing the object at different positions from the centre of curvature to the pole. Also, they should guide students to draw the structure of the human eye and that of photographic camera by using models of the human eye and photographic camera.

(iv) Lead students by using Think-Pair-Share technique to measure the pressure of the liquid and the atmospheric pressure with the help of flushing tanks, syringes, water, siphon and bicycle pump. Similarly, teachers should lead students' group discussion to identify the three states of stability in daily life by using a model of a bus or ship and solid objects of various shapes.

Appendix I: The Summary of the Topic-wise Candidates' Performance in Physics 1

S/N	Topic	Question Number	The % of the Candidates who scored an Average of 30% or Above	Remarks
1	Geophysics and Waves	8	64.57	Average
2	Current Electricity and Electronics	10	62.44	Average
3	Multiple Choice Items	1	62.18	Average
4	Waves	2 & 11	46.29	Average
5	Waves and Electromagnetism	9	43.80	Average
6	Current Electricity and Radioactivity	7	37.71	Average
7	Newton's Laws of Motion and Simple Machines	5	26.63	Weak
8	Thermal Expansion and Vapour and Humidity	6	22.90	Weak
9	Light and Optical Instruments	3	20.77	Weak
10	Pressure and Forces in Equilibrium	4	3.84	Weak

Appendix II: The Summary of the Topic-wise Candidates' Performance in Physics 2

S/N	Topic	Question number	The % of candidates who scored an average of 30% or above	Remarks
1	Current Electricity	2	77.39	Good
2	Forces in Equilibrium	1	46.41	Average