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) 2020

PHYSICS

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031 PHYSICS

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FOREWORD

The Certificate of Secondary Education Examination (CSEE) is a summative evaluation after four years of study in secondary school level. The Examination intends to assess the candidates' performance and provide an overview of the efficiency of the education system, particularly the education delivery system. Basically, the candidates' responses to the examination questions are a strong indicator of what the education system was able or unable to offer to the candidates.

This candidates' items response analysis report in the Physics subject for CSEE 2020 aims to give feedback to candidates, teachers, parents, policy makers and the public in general on how the candidates responded to the examination questions.

The analysis presented in this report will help various stakeholders to understand the factors that influenced the candidates' performance in the Physics subject. The factors include failure to identify the requirement of the question, lack of mathematical skills, candidates' inadequate knowledge of various topics in Physics, lack of drawing skills and lack of proficiency in English. The recommendations given in the report intends to help education administrators, school managers, teachers and students to identify appropriate ways to improve the candidates' performance in future examinations administered by the Council.

Finally, the Council is indebted to all people who participated in the preparation of this report in various capacities, including data collection and analysis as well as printing of the report.

Dr. Charles E. Msonde

EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report analyses the performance of the candidates who sat for the Certificate of Secondary Education Examination (CSEE) 2020 in the Physics subject. The examination consisted of two papers namely, 031/1Physics 1 (Theory paper) and 031/2 Physics 2 (Actual Practical Paper). The examination was set according to the 2010 revised Physics Syllabus for secondary education and it intended to measure the competences achieved by the candidates after completing four years of study in ordinary level secondary school. The analysis reveals the strengths and weaknesses of the candidates' performance.

The Physics theory paper consisted of three sections, A, B and C. Section A comprised of two (2) objective questions. The first question had ten (10) multiple choice items constructed from ten (10) different topics. The second question contained five (5) homogeneous matching items. Section B had six (6) short answer questions constructed from nine (9) topics. Section C had three (3) optional questions constructed from four (4) topics. The candidates were required to answer all questions in sections A and B and two questions from section C.

The practical part had three alternative papers: 031/2A Physics 2A, 031/2B Physics 2B and 031/2C Physics 2C. Each alternative paper consisted of two questions, each carrying 25 marks, to make a total of 50 marks.

This report intends to provide detailed analysis of the candidates' performance in each question. It begins by indicating the question demand and then provides an analysis of the candidates' performance. It also highlights some misconceptions observed and it outlines some reasons behind the candidates' performance. The performance of the candidates is expressed in percentage. The percentage of performance in each question is divided into three categories, which are weak performance, ranging from 0 – 29 percent; average performance, ranging from 30 – 64 percent; and good performance, ranging from 65 – 100 percent. Apart from using percentages, different colours have been used to show the performance of the candidates, thus, red, yellow and green colours represent weak, average and good performance respectively. Additionally, different extracts representing samples of the candidates' responses have been inserted to reveal the reality of what the candidates wrote in the examination.

Comments on individual questions and extracts of candidates' answers have been thoroughly explained to illustrate the respective cases.

Moreover, this report provides some recommendations that may help to improve the candidates' performance in future examinations. Finally, the report presents appendices which indicate the performance in each topic and the difference in performance as compared to last year examination in terms of grades.

A total of 120,856 candidates sat for the CSEE 2020 for the Physics 1 paper, of which 58,808 (48.87%) candidates passed the examination with different grades as shown in Table 1.

Table 1: Candidates' Grades in CSEE 2020 in Physics

Grade	A	B	C	D	F
Number of candidates	153	1,326	15,977	41,352	61,534
% of candidates	0.13	1.10	13.22	34.22	50.92

Table 1 shows the percentage of candidates' grades for Physics in CSEE 2020

In the 2019 CSEE Physics Examination, 62,142 (48.38%) candidates passed, indicating a decrease of performance by 0.49 per cent, as shown in Table 2.

Table 2: Candidates' Grades in CSEE 2019 in Physics Examination

Grade	A	B	C	D	F
Number of candidates	436	1,713	16,220	43,773	66,302
% of candidates	0.38	1.33	12.55	33.86	51.29

Table 2 shows the percentage of candidates' grades for Physics in CSEE 2019

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION

This part describes the performance of the candidates in each question. The analysis part covers the sections, type of questions, topics from which the questions were constructed, demands of the questions as well as the performance of candidates in each question. The candidates' scores have been termed as weak, average or good according to the performance.

2.1 Section A: Objective Questions

This section comprised of two (2) questions (1 and 2) which covered different concepts from 11 topics. Question 1 had 10 multiple choice items which weighed 10 marks and question 2 was constructed from the topic of '*Thermionic emission*' and had 5 matching items which weighed 5 marks. The section had a total of 15 marks.

2.1.1 Question 1: Multiple Choice Items

This question comprised of ten (10) multiple choice items numbered (i) to (x). Candidates were required to choose the correct answer from among five (5) given alternatives and write its letter (A, B, C, D or E) against the item number in the answer booklet provided. The question items were constructed from ten topics of: *Measurement*; *Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Light;*, *Motion in a Straight Line; Temperature; Friction; Vapour and humidity, Transfer of Thermal Energy;* and *waves.*

This question was attempted by 120,763 (99.9%) candidates. The results show that 19,043 (15.8%) scored from 0 to 2 marks, 86,774 (71.8%) scored from 3 to 6 marks, and 14,946 (12.4%) scored from 7 to 10 marks. Generally, the performance of this question was good since 101,720 (84.2%) candidates scored from 3 to 10 marks. The overall candidates' performance in this question is summarized in Figure 1.

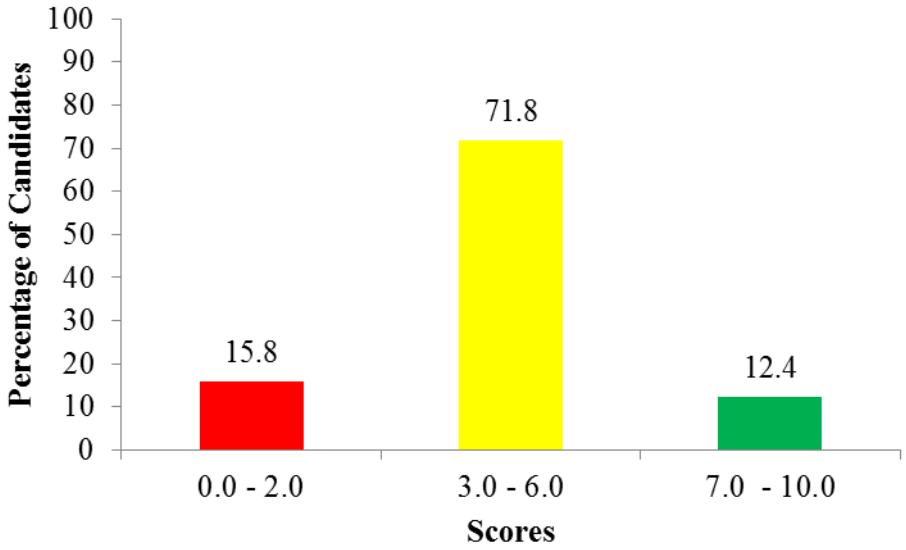


Figure 1: *Percentage of candidates' performance in question 1*

Item (i) asked "which pair of instruments is used for measuring lengths?"A. *a ruler and a measuring cylinder* B. *a micrometer screw gauge and a beam* balance C. *a vernier caliper and a micrometer screw gauge* D. *a pipette and a vernier caliper* and E. *a beam balance and a spring balance*. The correct alternative was 'C' *A vernier caliper and a micrometer screw gauge*. Majority of the candidates selected the correct answer, showing that the concept of measuring instruments was clear to most of them. However, other candidates chose the incorrect alternatives A, B, D and E. Those who selected alternative A. *a ruler and a measuring cylinder* did not understand that though a ruler is an instrument used to measure length, a measuring cylinder measures volume of liquids. The candidates who chose B. *a micrometer screw gauge and a beam balance* did not know that a micrometer screw gauge is used to measure the diameter (lengths) of the wires but a beam balance refers to an instrument used to measure the mass of objects. Similarly, the candidates who selected D. *a pipette* and *a vernier caliper* did not know that while a pipette is used to measure volume of liquids in millilitres (mL), a vernier caliper is the precise measuring device which is used to measure length including outside dimensions, inside dimensions and depth. The candidates who selected alternative E. *a beam balance* and a *spring balance*, failed to recall that the two instruments are used to measure mass and weight of objects respectively, although in some cases, spring balances are also calibrated to measure mass of objects. In

general, the candidates who chose incorrect answers had little knowledge of the uses of measuring instruments.

Item (ii) required the candidates to choose "the two factors that determine buoyancy". The alternatives were A. *Volume of fluid displaced and mass of the object;* B. *Weight and mass of the object;* C. *Density of the fluid and weight of the object;* D. *Volume of the fluid displaced and density of the fluid;* and E. *Mass of the object and density of the object*. The correct response was 'D' *Volume of the fluid displaced and the density of the fluid*. Most of the candidates who chose the distractors did not understand the term buoyancy and the factors which influence it. In order to get the correct alternative, the candidates were supposed to know that buoyancy is equal to the weight of the fluid displaced, and that it depends on density of the fluid and the volume of the fluid displaced. So, they could use the relation: the weight of the fluid displaced (buoyancy) = mass of the fluid × acceleration due to gravity, but not mass of the fluid = density of the fluid × volume of the fluid displaced. Since acceleration due to gravity is a constant physical quantity, then density of the fluid and the volume of the fluid displaced remain the only factors that determine the buoyancy. In general, the candidates who opted for incorrect options lacked understanding of the concept of Archimedes principle.

In item (iii), candidates were required to identify a physical phenomenon that is observed when a tea bag is dipped into a cup of hot water. The given alternatives were A. S*teaming;* B. D*iffusion;* C. O*smosis;* D. E*vaporation;* and E. B*oiling*. The correct response was 'B' *Diffusion*. Some candidates opted for C. *Osmosis* which is a wrong answer. This might be due to a close relationship that exists between osmosis and the phenomenon of diffusion. These candidates were supposed to know that osmosis is the movement of solvent particles across a semipermeable membrane from a dilute solution into a concentrated solution. The solvent moves to dilute the concentrated solution to balance the concentration on two sides of the membrane but diffusion is the movement of particles from an area of higher concentration to that of lower concentration. The overall effect is to equalize concentration throughout the medium. The candidates should have noted that in hot water, the molecules of tea bag have more energy and therefore, spread into the surrounding water quickly as they move or vibrate faster; hence a phenomenon called diffusion occurs. Other candidates opted for alternatives D and E. These candidates did not know

that evaporation is slower, occurs only from the surface of the liquid, does not produce bubbles, and results in cooling. Boiling is faster, can occur throughout the liquid, produces lots of bubbles, and does not result in cooling. In general, the candidates were supposed to realize that the mass of the solute, the temperature of the environment, the solvent density and the distance the molecules travelled are the key points which denote diffusion.

In item (iv), candidates were required to choose the type of material used in an experiment of light whose results showed that less light was transmitted and the image was distorted. The alternatives were A. *translucent material;* B. *opaque material;* C. *luminous material;* D. *transparent material;* and E. *non-luminous material*. The best alternative was A. *Translucent material*. Most candidates chose the correct answer A. *Translucent material*. However, some of the candidates were attracted by alternatives B. *opaque material* and D. *transparent material*. These candidates had some ideas about the concept of transmission of light but failed to recall their distinctive features. They had to recall that light transmission capacity varies from object to object. Transparent objects allow all the light to pass through them, translucent ones allow partial light to pass, whereas opaque ones allow no light to pass through. The amount of light that can pass through an object depends on its density of molecules. Opaque objects are the most dense; thus, do not allow light to pass through. Translucent objects have less density, whereas transparent objects are the least dense materials. The capacity of light penetration is what distinguishes objects or materials from each other. Few candidates who selected alternative C. *luminous material* and E. *non-luminous material* did not understand the concept of sources of light. Luminous materials refer to those materials or objects which emit light energy by themselves while non-luminous materials do not emit light energy by themselves. In this item, it is evident that some candidates had little knowledge of sources, propagation and transmission of light.

In item (v), candidates were required to choose the letter of the alternative which shows the value of the velocity of a stone dropped from the top of a building and hit the ground 4 seconds later. The given alternatives were A. *400 m/s;* B. *45 m/s;* C. *40 m/s;* D. *4.5 m/s;* and E. *0.4 m/s*. The correct response was 'C' *40 m/s*. Some candidates managed to get the right answer although majority did not get the correct answer. This might be partly due to insufficient knowledge of the concept of motion of bodies under gravity and partly due to lack of competence in doing questions which involve

calculations. In this case, the candidates were supposed to realize that when the body is released or dropped from the top of the building, its initial velocity is 0 m/s. however, it accelerates downwards with positive acceleration due to gravity (g = +10 m/s^2). Then, by applying the first equation of motion, v = u+gt, the candidates would find the value of the velocity of the stone when hitting the ground after 4 seconds.

In item (vi), candidates were required to choose the factor which explains why mercury is preferred in clinical thermometer as a thermometric liquid to water and alcohol. The alternatives were A. *it is denser than other liquids;* B. *it is opaque and does not need colouring*; C. *it is more sensitive to temperature;* D. *it is active and does not wet the glass; and* E. *it is a weak conductor of hea*t. The best alternative was 'B' *It is opaque and does not need colouring*. Most of the candidates got the appropriate answer as they had adequate knowledge of the concept of measurement of temperature. The candidates who opted for incorrect alternatives A, C, D or E had challenges on understanding the measurable physical properties of liquids such as water, alcohol and mercury that change with temperature. These candidates were supposed to recall that mercury is used as thermometric liquid because it has uniform contraction and expansion; it does not stick to the sides of the capillary tube; it is opaque and shining, thus it can be easily seen as a fine thread in the capillary tube; and it has high boiling point of 357^o C and a low freezing point of -39^o C.

Item (vii) asked, "A rectangular box of mass 10 kg resting on an inclined plane will begin to slide when the coefficients of static and dynamic frictions are 0.55 and 0.25 respectively. At what angle will the box begin to slide?" The given alternatives were, A. 14.8^o; B. 24.8^o; C. 28.8^o; D. 38.8^o; and E. 48.8^o. The correct alternative was C. 28.8^o. The candidates who failed to get the correct answer lacked the knowledge of the concept of friction, especially the applications of laws of friction in determining the coefficient of friction. They also lacked some computing skills to manipulate the appropriate formula so as to obtain the correct answer. These candidates were supposed to recall that the coefficient of static friction is equal to the tangent of the angle at which the objects just begin to slide. Therefore, they could use the statement, $\tan\theta = \mu_s$ where μ_s is coefficient of static friction. So, $\tan\theta = 0.55$, $\theta = \tan^{-1}(0.55) = 28.8^o$. Therefore, alternative C is the correct answer.

In item (viii), the candidates were required to choose the process which contributes to the heat loss in the thermos flask if the walls of the glass container were not coated with silver. The alternatives were A. *radiation;* B. *conduction;* C. *convection;* D. *absorption;* and E. *transmission*. The correct response was A. *Radiation*. Most of the candidates chose the correct answer, but some of them selected wrong alternatives B. *conduction*; C. *convection;* D. *absorption;* and E. *transmission*. These candidates had little content knowledge on transfer of thermal energy, especially the process which contributes to the heat loss in a thermos flask. The candidates who chose the incorrect alternatives were supposed to know that in a thermos flask, a thin layer of vacuum is provided between the two walls of flask to minimize heat losses by conduction. Also, the two walls are silvered to minimize heat loss by radiation, because a shiny surface is a bad absorber and bad emitter of radiation, but it is a good reflector of heat, thus prevents heat exchange between the content of flask and surrounding. Therefore, even if the walls of the glass container were not coated with silver, a vacuum would prevent heat loss by conduction; hence heat is transferred by radiation.

In item (ix) candidates were required to choose the correct answer from among the given alternatives about a proper day which a launderer would prefer most for washing and drying clothes. The alternatives were A. *dry day;* B. *hot day;* C. *windy day;* D. *still day;* and E. *cold day*. The correct alternative was C. *Windy day*. Most of the candidates supplied a wrong answer to this item as they opted for alternative B. *hot day*. This might be due to misconception that in a hot day, the sun provides much thermal energy that makes the clothes dry faster. Incredibly, the wind is more effective than the sun in drying clothes. It moves the particles of air, which collide with the water molecules of the fabric, speeding up its evaporation. The candidates were supposed to understand that, in wind drying, the energy for the movement of particles does not come from heat, but from the displacement of air to the wind, which is faster than heat. In this process, which is known as convection, the mass of air stirs and pushes the water molecules out of the fabric, drying the laundry.

In item (x) candidates were required to select the name of the process which is involved in producing reverberation. The given alternatives were A. *refraction*; B. *multiple reflection;* C. *interference;* D. *diffraction;* and E. *reflection*. The correct alternative was 'B' *multiple reflection*. Most

of the candidates chose the correct alternative B. *multiple reflection*. This item aimed at assessing the candidates' ability to understand and analyse various physical phenomena in waves, particularly the concept of echoes and reverberation. Some of the candidates opted for alternative E. *reflection*. These candidates were to some extent correct since reflection of sound waves off of surfaces can lead to one of two phenomena - an echo or a reverberation. However, they were supposed to know that echoes are different from reverberations in that, the former occur when a reflected sound wave reaches the ear more than 0.1 seconds after the original sound wave was heard, while the latter is caused by the reception of multiple reflections off of walls and ceilings within 0.1 seconds of each other. Few candidates who selected the incorrect alternatives A. *refraction*; C. *interference;* and D. *diffraction* did not understand that refraction of waves involves a change in the direction of waves as they pass from one medium to another. Refraction, or bending of the path of the waves, is accompanied by a change in speed and wavelength of the waves. Diffraction involves a change in direction of waves as they pass through an opening or around a barrier in their path. On the contrary, interference is a phenomenon in which two waves superpose to form a resultant wave of greater, lower, or the same amplitude.

2.1.2 Question 2: Matching Items

This question required the candidates to match the five (5) items on list A (phrases) with responses on list B by writing the letter of the correct response beside the item number. The items and the responses were constructed from the topic of T*hermionic emission*. In this question, each item carried one (1) mark making a total of five (5) marks. The premises and responses of the question are given in the following table.

List A	List B
(i) It produces fast moving electrons when heated at high temperature. (ii) Traces the direction of cathode rays in a cathode ray tube. (iii) Deflects the electron beam vertically. (iv) Deflects the electron beam horizontally. (v) Accelerates the ejected electrons to the screen.	A Perrin tube B X-plate C Anode D Cathode E Y-plate F Maltese cross tube G Vacuum

A total of 120,643 (99.8%) candidates attempted this question and their scores were as follows: 43,290 (35.9%) candidates scored from 0 to 1.0 mark, 51,842 (43.0%) scored from 2 to 3 marks, and 25,511 (21.1%) scored from 4 to 5 marks. These scores indicate that the candidates' performance was good as 77,353 (64.1%) scored from 2 to 5 out of 5 marks allotted to this question. Figure 2 summarizes the candidates' performance in this question.

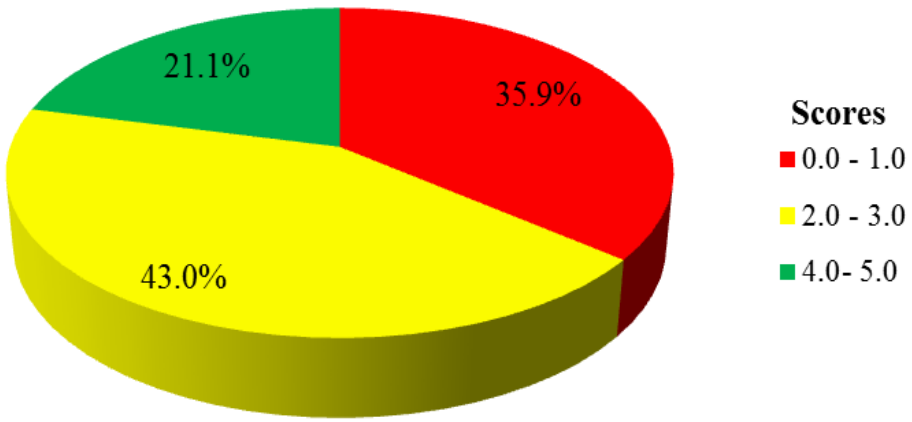


Figure 2: *Percentage of candidates' performance in question 2*

The analysis of the performance of the candidates in each of the items in this question is as follows:

In item (i), the candidates were required to provide a suitable response which matches correctly the statement "*it produces fast moving electrons when heated at high temperature"*. The right response was D which reads

cathode. Most of the candidates identified the appropriate answer in this item, showing that they had knowledge of the concept of thermionic emission, particularly the functions of the features of the cathode ray tube. Some candidates chose option C *Anode*. This is because both anode and cathode describe the direction of the flow of current. Conversely, these candidates failed to recall that cathode is the negatively charged electrode that attracts the cations or positive charge. Also, a cathode is the source of electrons or an electron donor that may accept the positive charge but anode is the positively charged electrode that attracts electrons or anions or negative charge. They may also be a source of positive charge or electron acceptor. Therefore, the candidates failed to differentiate anode from cathode. A cathode produces fast moving electrons while anode receives the electrons ejected from a cathode when subjected to high temperature.

In item (ii), the candidates were required to write the letter of the item which matched correctly the phrase "*Traces the direction of cathode rays in a cathode ray tube*". The appropriate response was F, which is *Maltese cross tube.* Most of the candidates chose incorrect responses, including A. *Perrin tube*. These candidates failed to discriminate the functions of each of the two electron tubes as they are applied in thermionic emission. They were supposed to know that Maltese cross tubes are highly evacuated electron tubes with divergent electron gun, fluorescent screen and Maltese cross for demonstrating straight line propagation of electrons in the absence of electric or magnetic fields. On the other hand, a Perrin tube is a highly evacuated electron tube with a focussing electron gun, fluorescent screen and faraday cage position on one side used for investigating the properties of electron beams.

Item (iii) required the candidates to identify the feature of the cathode ray tube which matched correctly the phrase, "*Deflects the electron beam vertically"*. The correct option was E, which is *Y-plate.* Most of the candidates managed to get the correct response in this part, showing that they had enough knowledge pertaining to the function of the Y-plate as applied in the cathode ray tube. Few candidates who failed to give the appropriate response matched it with *X-plate*. These candidates failed to express the role played by X-and Y-plates in the cathode ray tube. They were supposed to understand that X-plates are used to move the electron beam across the x-axis (horizontally) of the screen, while the Y-plate is

used to move the electron beam up and down the screen (vertically) along the y-axis of the screen.

Item (iv) required the candidates to identify the feature of the cathode ray tube which matched correctly the phrase, "*Deflects the electron beam horizontally"*. The appropriate response was B, which is *X-plate.* This item was attempted splendidly by most of the candidates, indicating that they had sufficient knowledge and good understanding of the functions of features of a cathode ray tube. However, few candidates treated *X-plate* and *Y-plate* interchangeably as they matched them in the opposite way. For example, in this item, some candidates matched it with Y-plate whose function is to deflect the electron beam vertically and not horizontally.

Item (v) required the candidates to give the feature of the cathode ray tube which matched correctly the phrase, "*accelerates the ejected electrons to the screen"*. The correct response was C which is *Anode.* The performance in this item was good as most candidates responded correctly; they knew that the function of an anode is to collect or accelerate electrons ejected from cathode and focus them in a fine energetic beam to the screen. As explained in item (i), some of the candidates confused the function of cathode with anode in a cathode ray tube, and therefore they ended up matching in the opposite way. Extract 2.1 shows a sample of responses from a candidate who matched all items of the question correctly.

2	LISTA	(i)	(ii)	(iii)	(iv)	(v).	
	LIST B	D	F	E	B	C	

Extract 2.1: A sample of the candidate's best response to question 2

Extract 2.2 shows a sample of responses from a candidate who matched incorrectly all items of the question.

2.	ans	i	ii	iii	iv	v
	ans	C	G	B	E	D

Extract 2.2: A sample of candidate's weak responses to question 2

Extract 2.2 portrays a sample of the answers from one of the candidates who matched the premises with their corresponding responses incorrectly.

2.2 Section B: Short Answer Questions

This section consisted of six (6) short answer questions. The questions required brief explanations and/or computations or drawing using well labelled diagrams. They were constructed from eleven topics namely; *Light, Optical instruments, Simple machines, Forces in equilibrium, Newton's laws of motion, Thermal expansion, Current Electricity, Radioactivity, Waves, Geophysics, and Electromagnetism*. Each question carries ten (10) marks, making a total of 60 marks.

2.2.1 Question 3: Light and Optical Instruments

In this question, the candidates were required to (a) draw the appropriate path of a ray and calculate the angle through which the ray is turned at each of the three reflections, from three plane mirrors arranged along three sides of a square, where a ray of light incident on the left side mirror at its midpoint with an angle of incidence of 40^{o} is afterwards reflected by other mirrors, and (b) explain two functions of the shutter in a camera.

This question was attempted by 112,074 (92.7%) candidates. The analysis of the candidates' performance shows that 95,479 (85.2%) candidates scored from 0 to 2.5 marks, 14,187 (12.7%) scored from 3.0 to 6.0 marks, and 2408 (2.1%) scored from 6.5 to 10 marks. This data indicates that the general performance was weak since only 14,521(14.8%) candidates scored from 3.0 to 10 marks. Figure 3 shows the graphical representation of the analysed data.

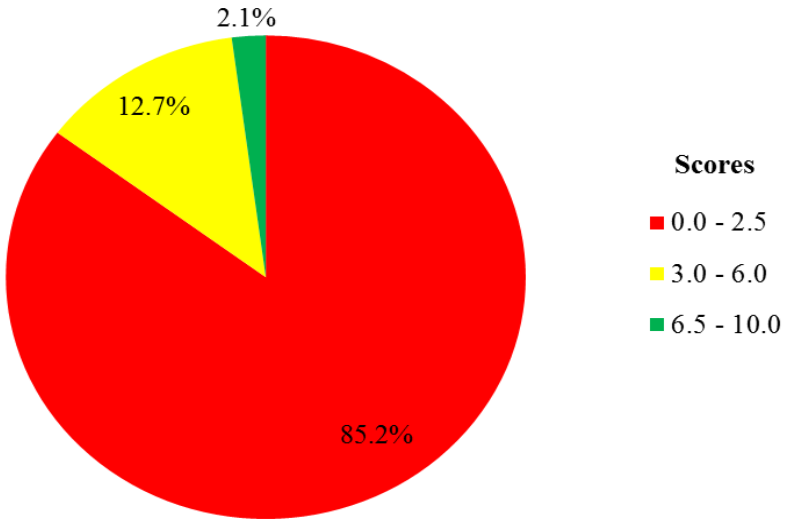


Figure 3: *Percentage of candidates' performance in question 3*

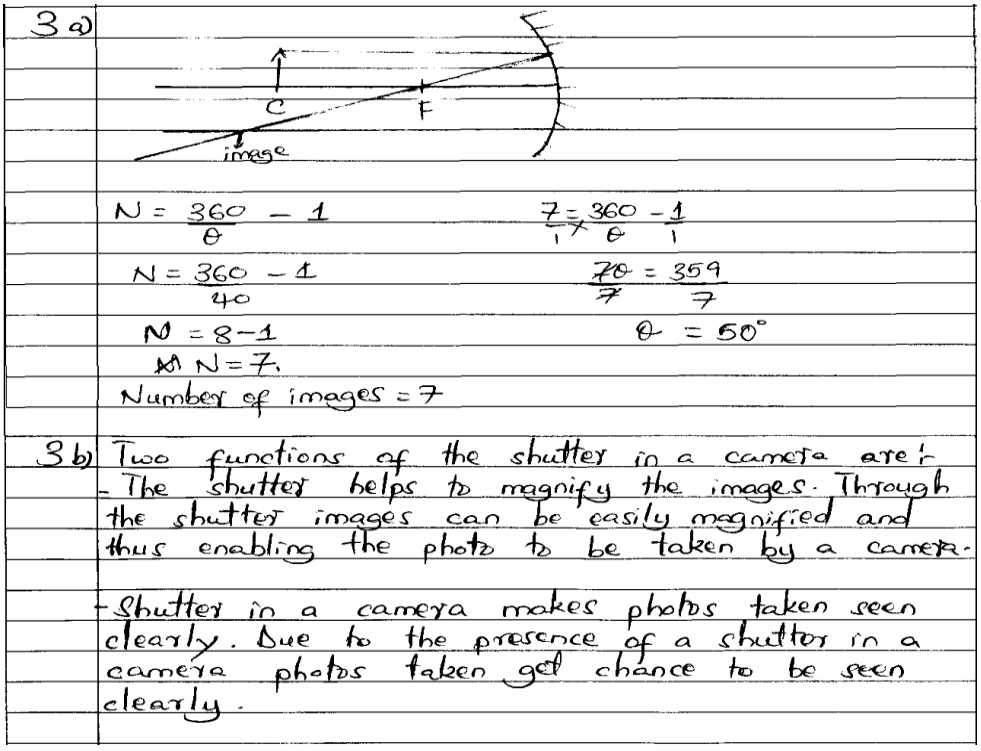
The weak performance in part (a) of the question was contributed by various factors such as language barrier, lack of drawing skills and lack of knowledge on the concept of light. Most candiates could not apply the laws of reflection of light which could help them trace the path of a ray of light through the three mirrors arranged along three sides of a square.
For example, one candidate drew three mirrors of different sizes which were vertically positioned and then indicated a ray incident on the first mirror which was refracted in the second mirror which eventually underwent divergence in the third one. This candidate either failed to follow the instructions or had little knowledge on the concept of multi reflections of light in plane mirrors. For simplicity, the candidate was supposed to draw the two plane mirrors placed vertically parallel to each other but at a distance equal to the length of the third mirror and then draw the third mirror laying at the top of the two. Finally, he/she could draw a ray of light that is incident on the left side mirror at its midpoint at an angle of incidence of 40^{o} and trace the path of reflections caused by the three plane mirrors.

In attempting to calculate the angle through which the ray is turned at each of the three reflections, some candidates applied Snell's law, as: $\mu = \frac{\sin i}{\sin r}$, $\mu = 1.5$ and $i = 40^{o}$ and found the angle of refraction r by taking the refractive index of a crown glass block $\mu = 1.5$. This concept is completely

irrelevant to the asked question as it involves the refraction of light and not the concept of reflection of light as per the requirement of the question. Other candidates used the mirror formula, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ to find the number of images formed in plane mirrors given by: $n = \frac{360}{\theta} - 1$.

Consequently, some candidates faced challenges in responding correctly to part (b) of the question because they were incompetent in the concept of optical instruments, particularly the functions of parts of the camera.

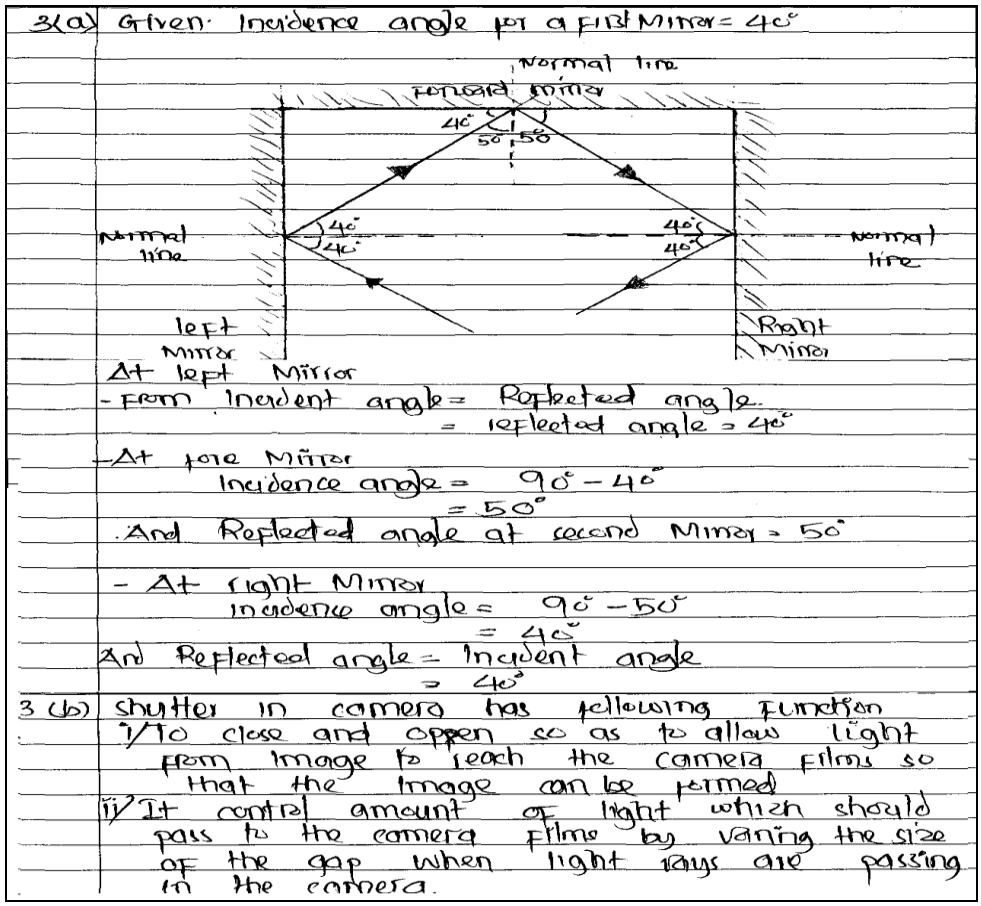
For example, one candidate listed two functions of the shutter in a camera (i) "*to cover the lenses in the camera for safety, and (ii) to adjust the lenses and film to reflect the objects' light"*. The candidates who failed this part of the question were supposed to write the functions of the shutter in a camera as: (i) to control the length of time that is permitted to pass through the lens to the image sensor and (ii) to allow light to fall on the film. Extract 3.1 is a sample of candidates' weak response.



Extract 3.1: A candidate's weak responses to question 3

Extract 3.1 shows that the candidate drew a ray diagram for images formed by a concave mirror and then applied the formula for determining the number of images formed in plane mirrors out of the demand of the question. He/she also stated incorrectly the functions of the shutter in a camera.

The candidates who scored high marks (6.5-10) in this question were able to draw the appropriate path of the ray through the three plane mirrors arranged along the three sides of a square. They used the knowledge of the laws of reflection of light on plane mirrors correctly. On top of that, they applied systematic procedures to calculate the angle through which the ray is turned at each of the three reflections. Moreover, they were able to use the knowledge of optical instruments to explain clearly the functions of a shutter of the camera. Extract 3.2 is a sample of candidate's good responses.



Extract 3.2: A candidate's good responses to question 3

In extract 3.2, the candidate managed to answer almost all parts of the question correctly as per the demand of the question.

2.2.2 Question 4: Pressure and Forces in Equilibrium

In this question, candidates were required to (a) use a well labelled diagram to explain the working principle of a hydraulic braking system; and (b) calculate the length of a pencil when the pencil AB weighing 40 g is balanced horizontally on a knife edge at 2 cm from end A when a mass of 60 g is hung from this end.

This question was attempted by 114,208 (94.5%) candidates. The analysis of data indicates that 94,080 (82.4%) scored from 0 to 2.5 marks, 17987 (15.7%) scored from 3.0 to 6.0 marks, and 2,141 (1.9%) scored from 6.5 to 10 marks. The general performance of candidates in this question was weak since only 20,128 (17.6%) candidates scored from 3.0 marks to 10 marks. Figure 4 shows the graphical representation of the data analysed.

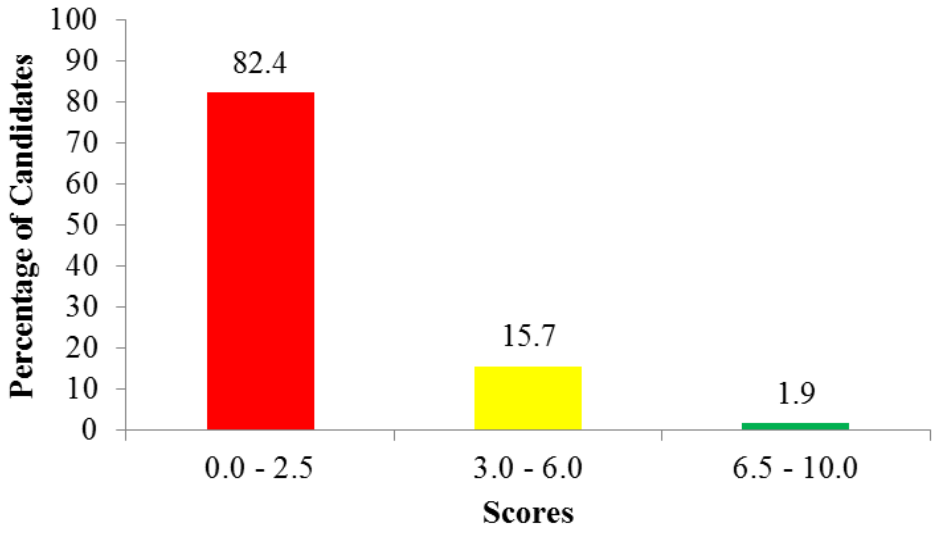


Figure 4: *Percentage of candidates' performance in question 4*

Candidates who scored low marks in this question lacked the knowledge of the concept of pressure, specifically the Pascal's principle of pressure transmission. These candidates failed to draw and explain the working principle of the hydraulic braking system. They also failed to apply the principle of moments, which could assist them to recall the formula and use it to calculate the length of a pencil.

Most of the candidates who scored low marks in this question lacked both content knowledge and computational skills. For example, one candidate in attempting to explain the working principle of hydraulic braking system wrote "*when the leg is pressed on the pedal or break then there is accompanied force in the hydraulic press which in turn it generates the force which acts as a breake"*.

Another candidate applied the concept of pressure equals to ratio of force to area and explained that *"Hydraulic brake is working under the principle that the higher the pressure the small the area. So if the driver compresses hydraulic fluid by high pressure the car will stop suddenly due to area to resist will be low"*.

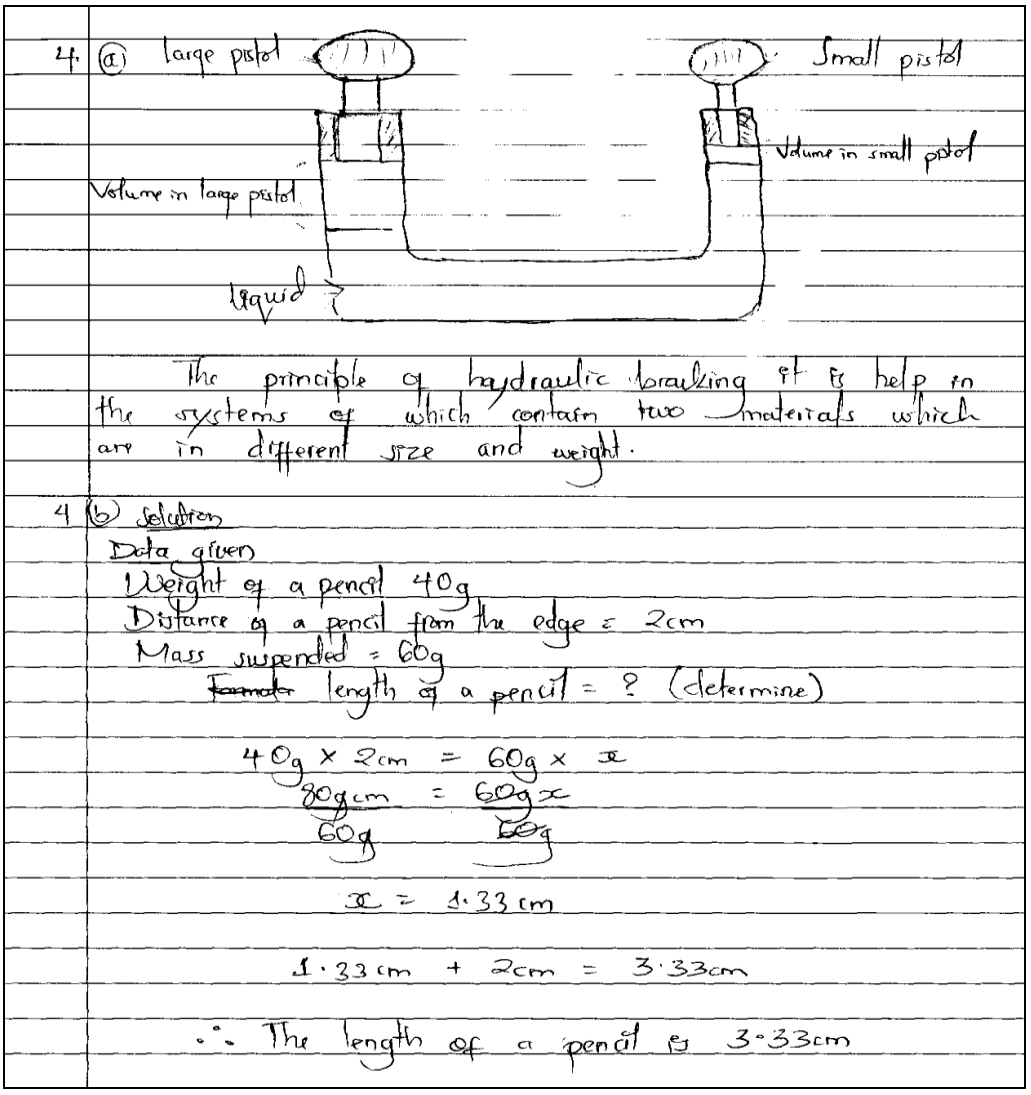
Apart from using poor English, these two candidates failed to explain appropriately the working principle of the hydraulic braking system. The candidates were supposed to explain as follows: when the brake pedal is pressed, a piston in the master cylinder forces the brake fluid through a linkage. As a result, pressure increases and gets transmitted to all pipes and all wheel cylinders, according to Pascal's law. Because of this pressure, both pistons move out and transmit the braking force on all wheels.

In part (b), most candidates failed to design a diagram based on the instructions given in a question item which could act as a guide to use the principle of moments correctly in formulating the relation, and hence, determine the appropriate value of the length of the pencil. Most of the candidates used irrelevant concepts which are not compatible with the requirement of the question. For example, one candidate calculated the length of the pencil as follows: $L = m\ h\ g$

Then, $L = \frac{60\ g \times 40\ g \times 10\ N}{2}$ =12000. This candidate used the formula for potential energy to calculate the length of the pencil whose units do not even match, showing that the candidate had no knowledge of the concept of units of various quantities.

Another one used the relation:

Length = mass × weight. This formula does not make sense in Physics, indicating that the candidate had limited content knowledge on the topic of Forces in equilibrium. Extract 4.1 is a sample of candidates' weak response to this question.



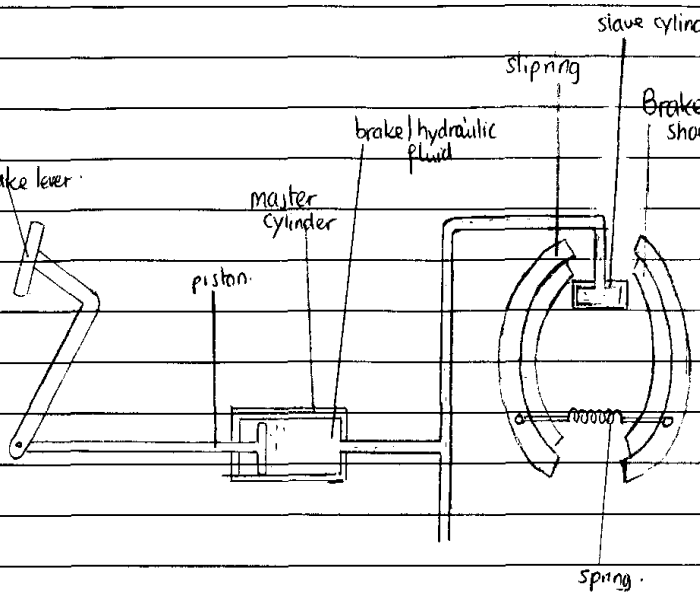
Extract 4.1: A sample of candidate's responses to question 4

In extract 4.1, the candidate failed to draw a suitable labelled diagram of the hydraulic braking system. Similarly, he/she failed to explain its working principle. The candidate also, failed to apply the principle of moment to calculate the length of the pencil.

On the other hand, the candidates who scored high marks in this question were able to draw the diagram of the hydraulic braking system and use it to explain how it operates. These candidates were knowledgeable enough as they managed to apply the Pascal's principle of pressure transmission in explaining the working principle of hydraulic braking system. They were

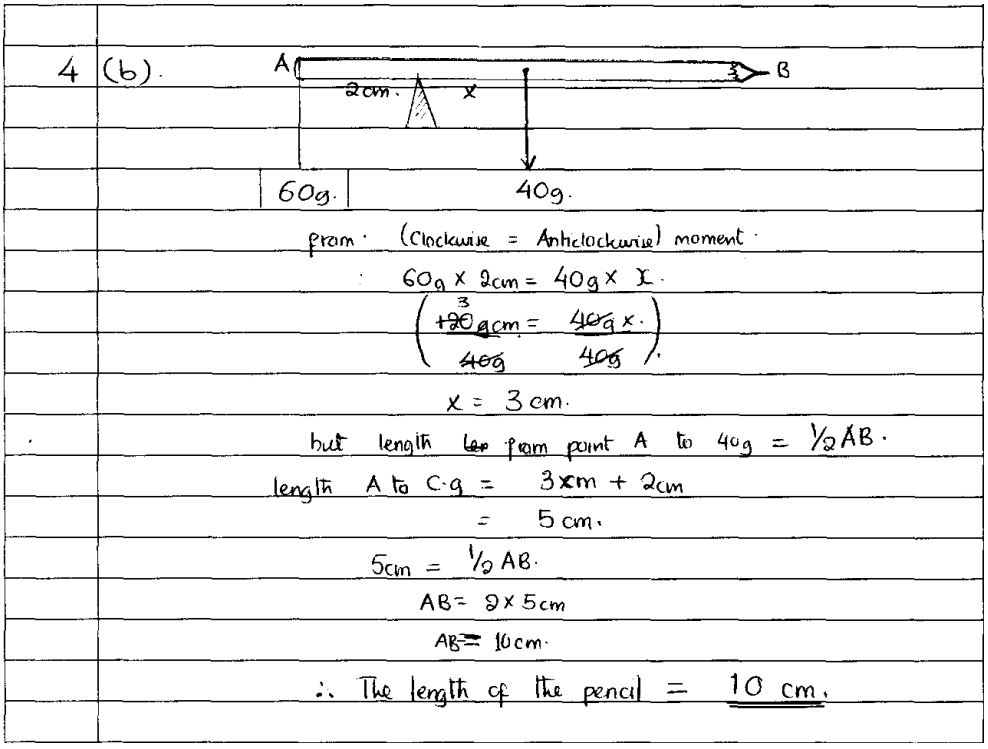
also competent in the concept of forces in equilibrium particularly the applications of the principle of moments to calculate the length of the pencil. Extract 4.2 is a sample of candidates' good responses to this question.

4 (a) HYDRAULIC BRAKING SYSTEM.



A labelled diagram showing hydraulic brake system

(a) When the ~~brea~~ brake lever is stepped on it moves the piston in the master cylinder forward creating pressure in the brake fluid forcing it into the pipe to the slave cylinders. The pressure of the slave cylinders make the spring holding the ~~stee~~ slip rings to extend making the brake shoe tightly attached to the car wheel and cause braking.



Extract 4.2: The sample of a candidate's good responses to question 4

In extract 4.2, the candidate managed to answer correctly almost all parts of the question.

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

This question comprised of two parts, namely (a) and (b). In part (a), the candidates were required to explain, by using the principle of conservation of linear momentum, why the recoil velocity of a gun is much less than the velocity of the bullet. In part (b), the candidates were required to use a well labelled cross-cross sectional diagram of a hydraulic press to determine the value of mechanical advantage if it is working with efficiency of 90 % when the hydraulic press consists of a pump, load and two cylinders in which the larger cylinder is eight (8) times the diameter of the smaller one.

This question was attempted by 109,078 (90.3%) candidates. The analysis of the data indicates that 95,829 (87.9%) scored from 0 to 2.5 marks, 12,734 (11.6%) scored from 3.0 to 6.0 marks and 515 (0.5%) scored from 6.5 to 10 marks. This data indicates that the general performance was weak

since only 12.1 percent scored from 3.0 to 10 marks. Figure 5 depicts the graphical representation of the analysed data.

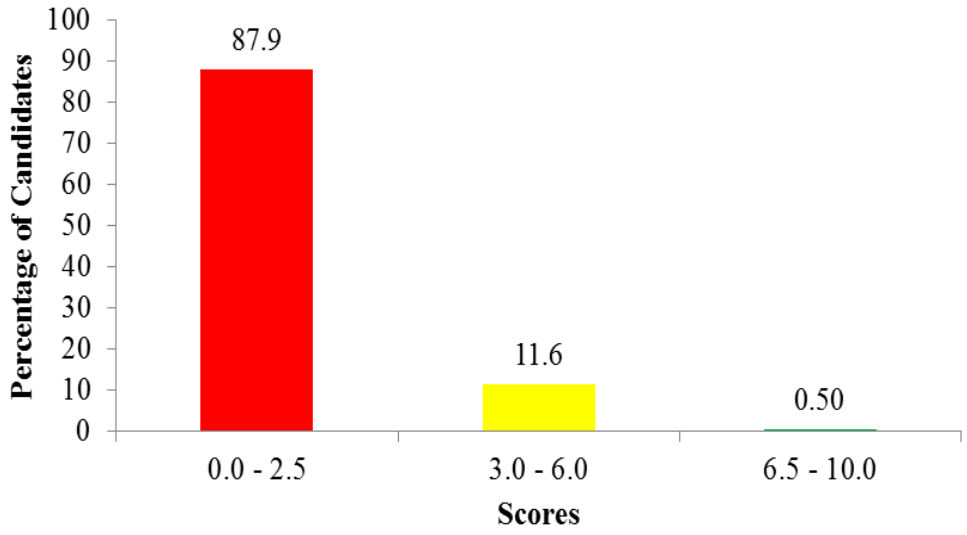


Figure 5: *Percentage of candidates' performance in question 5*

The candidates who performed below standard failed to recall the principle of conservation of linear momentum, which could help them to explain why the recoil velocity of a gun is less than the velocity of the bullet. Some of the candidates had some misconceptions that led them to scoring low marks. For example, some of the candidates used the concept of Newton's first law of motion despite being asked to use the principle of conservation of linear momentum. This is an indication that these candidates were not familiar with the principle of the conservation of linear momentum. For example, one of the candidates who misunderstood this part of the question wrote that *"the conservation of linear momentum states that the body at rest will remain at rest and that at motion will move at constant speed unless external force will be applied in the body that is why the recoil velocity of the gun is much less than velocity of the bullet because the velocity of bullet has been experienced with the external force".*

These candidates were supposed to realize that when a gun is fired, momentum is conserved, since the mass of the gun is much more than the mass of the bullet, its velocity is smaller than the velocity of the bullet. From the principle of conservation of linear momentum, the total momentum before collision must be equal to the total momentum after collision if there is no external force acting on a colliding system.

Momentum before collision = Momentum after collision

Momentum before collision = 0

Momentum after collision $= M_g V_g - M_b V_b$

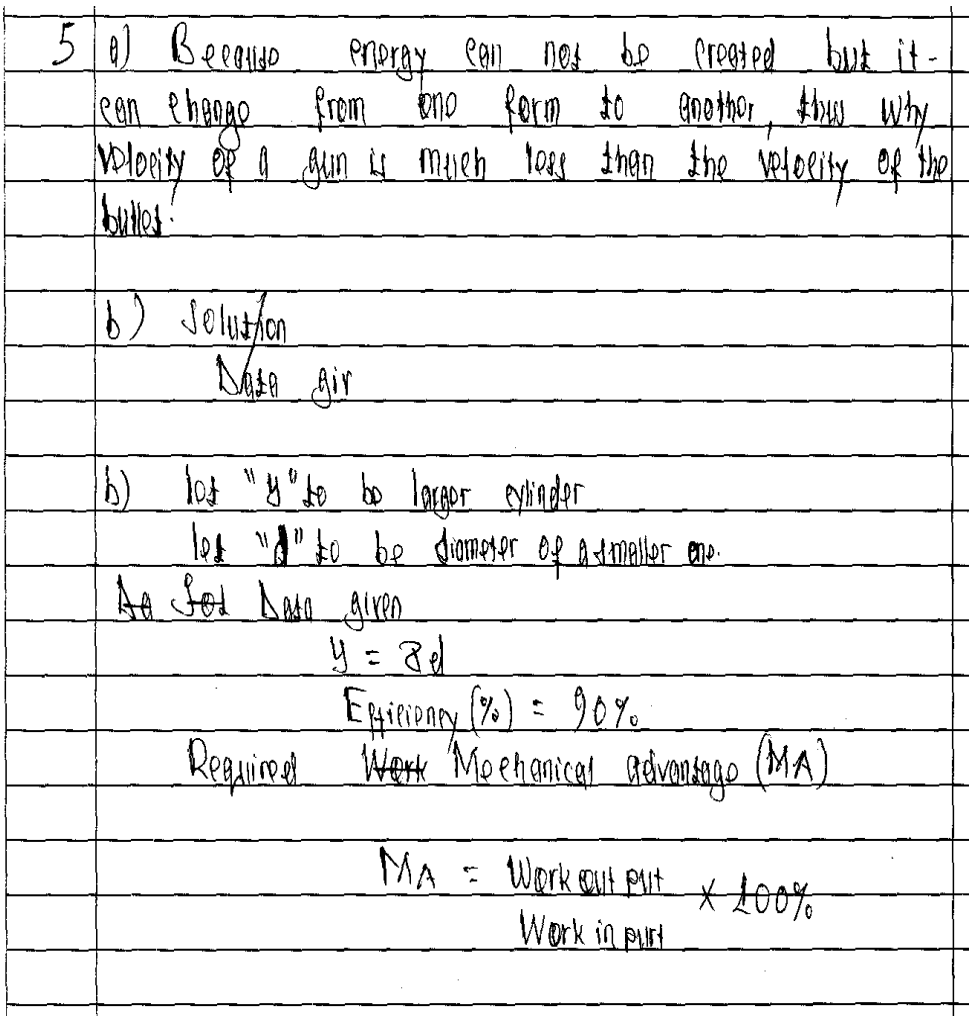
$M_g V_g - M_b V_b = 0$

$M_g V_g = M_b V_b$

$$\frac{V_g}{V_b} = \frac{M_b}{M_g}$$

From above equation the mass of the bullet is much less than that of the gun hence the recoil velocity of the gun V_g is also much less than the velocity of a bullet.

Likewise, in part (b), most candidates could not draw a proper diagram of a hydraulic press, and they failed to develop a formula for the velocity ratio of a hydraulic press, which could help them determine its mechanical advantage. For example, one candidate determined the mechanical advantage by using the relation: $\text{M.A} = \frac{\text{Pressure in large limbs}}{\text{Pressure in small limbs}}$ and another one used the equation: M.A = Efficiency × Velocity ratio. All these candidates demonstrated poor knowledge of simple machines, particularly hydraulic press. Extract 5.1 is a sample of responses from a candidate who did not perform this question well.



Extract 5.1: A sample of candidate's weak responses to question 5

Extract 5.1 shows answers from a candidate who failed to apply the principle of the conservation of linear momentum to explain why the recoil velocity of a gun is much less than the velocity of the bullet. It also shows how the candidate failed to develop a correct formula for determining the mechanical advantage of hydraulic press, and instead he/she applied the formula for finding the efficiency of the machine.

The candidates who performed well in this question had the required knowledge as they managed to state and use correctly the principle of conservation of linear momentum to explain why the recoil velocity of a gun is much less than the velocity of the bullet. Moreover, some of these candidates were able to draw a well labelled diagram of a hydraulic press

and clearly and systematically determine its mechanical advantage. Extract 5.2 is a clear sample of responses from a candidate who responded well.

5a. from the principle of conservation of linear momentum which states that "If there is no any external force acting on the ~~colliding~~ collision system the total momentum after collision is equal to total momentum after collision.

Momentum before collision = Momentum after collision.

Let, Mass of a gun = M_1

Mass of a bullet = M_2.

Velocity of a gun after impact (recoil velocity) = V_1 in opposite direction.

Velocity of a bullet = V_2.

Initial velocity = $U = 0$.

$(M_1 + M_2) \times 0\ m/s = M_1 \times V_1 + M_2 V_2$.

$0 = M_2 V_2 - M_1 V_1$.

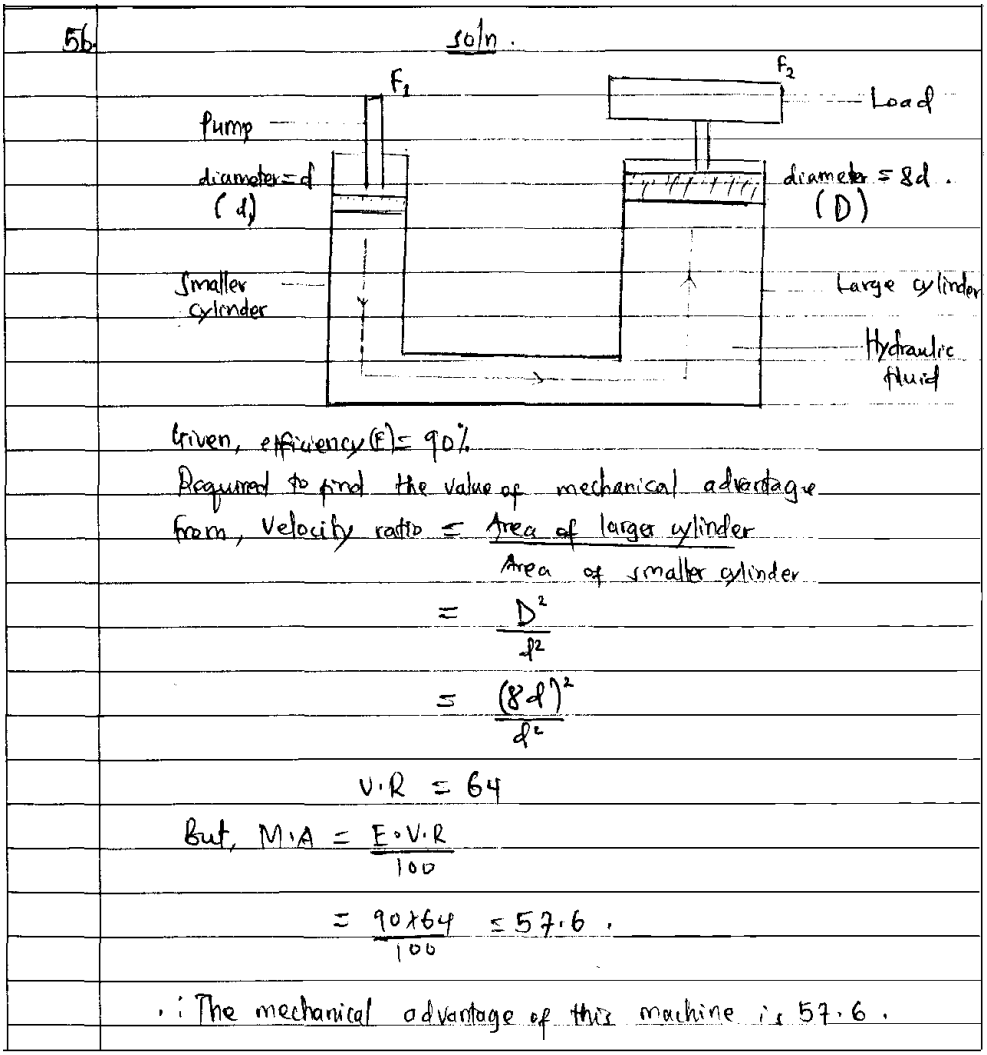
Let's make V_1 the subject also V_2 be the subject.

$M_1 V_1 = M_2 V_2$

$\overline{M_2}$

$V_1 < V_2$ since the gun has very large mass comparing to the mass of a bullet.

∴ The recoil velocity of a gun is much less than the velocity of a bullet because the gun has large mass than the mass of a bullet.



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

Extract 5.2 shows that the candidate had enough knowledge and mathematical skills on the concept of simple machines and the Newton's law of motion as he or she worked on the question with clear procedures and consequently arrived at correct answers.

2.2.4 Question 6: Thermal Expansion

In this question, candidates were required to (a) study Figure 1 and explain what will happen to the bulbs P and Q in relation to the water levels X and Y when the heater is turned on, and (b) explain how would the dimensions of a newly constructed Tanzania standard gauge rail line change during summer and winter days.

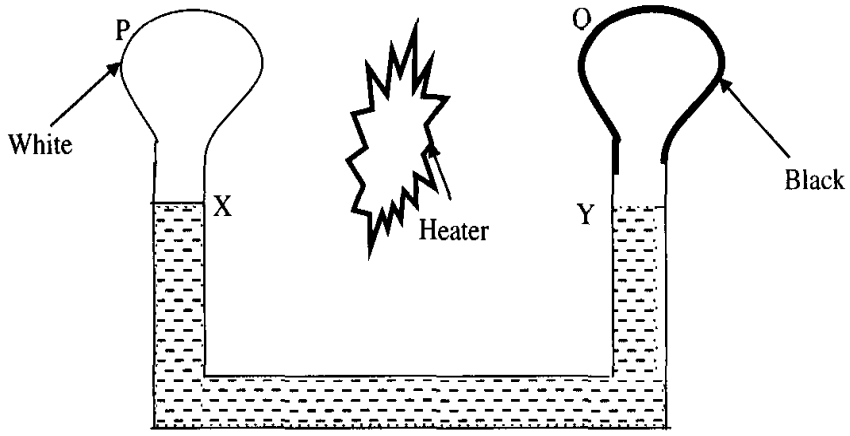


Figure 1

This question was attempted by 110, 529 (91.5%) candidates. The analysis of the data indicates that 70,918 (64.2%) percent scored from 0 to 2.5 marks, 30,094 (33.5%) scored from 3.0 to 6.0 marks, and 2,517 (2.3%) scored from 6.5 to 10 marks. This data indicates that the general performance was average as 35.8 percent scored from 3.0 to 10 marks.
Figure 6 shows the graphical representation of the analysed data.

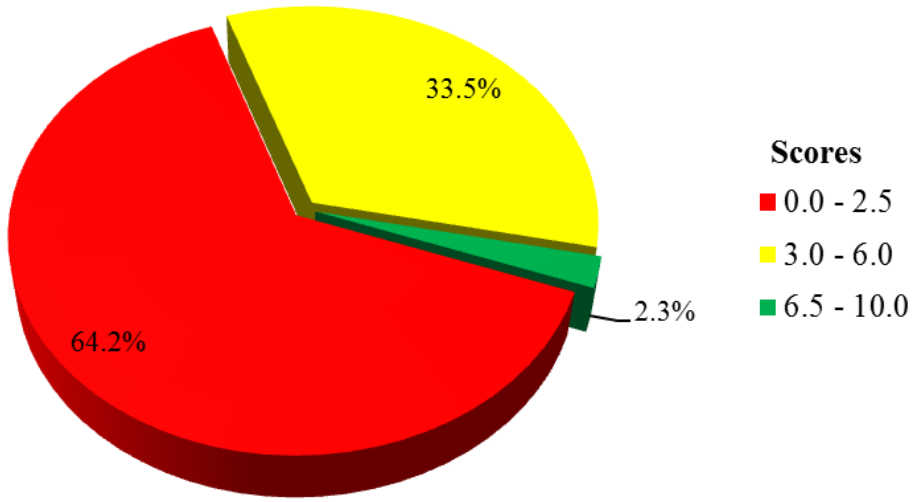


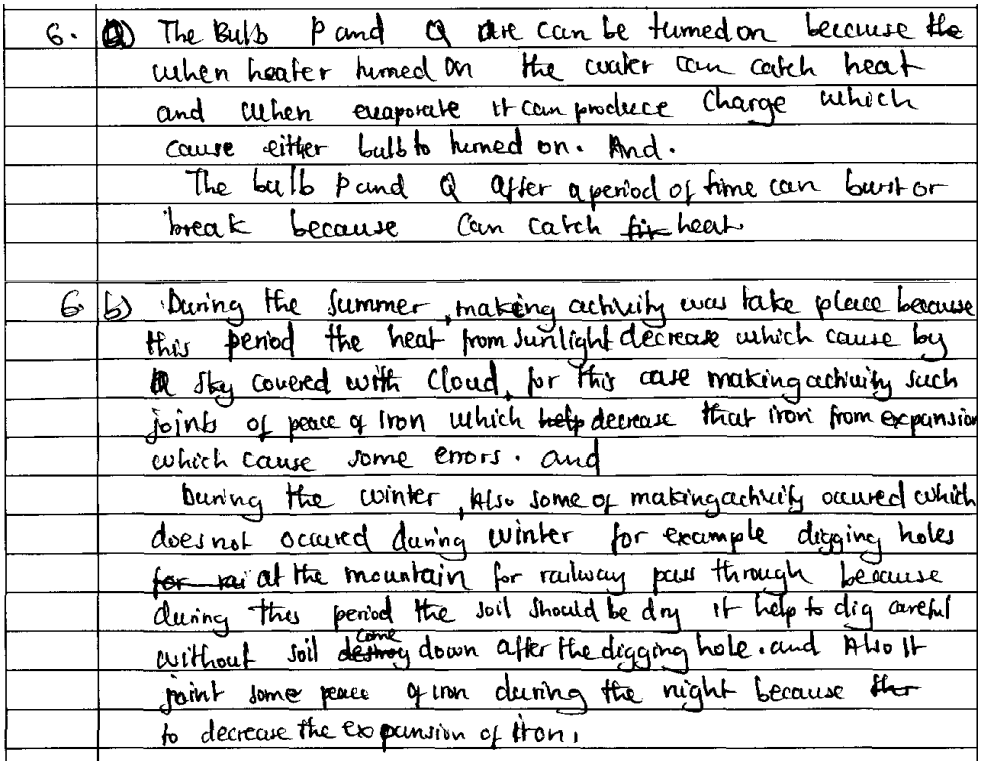
Figure 6: *The percentage of candidates' performance in question 6*

The analysis shows that candidates who scored below the pass mark (0-29 %) in this question had inadequate knowledge of the concept of thermal expansion, especially on volume expansivity when the two bulbs P (white) and Q (black) connected to two limbs of respective water tubes are subjected to heat. Most of the candidates failed to discover that when the heater is turned on, bulb Q painted black will absorb more heat and cause the air inside it to expand (increase in volume), and then push the water level Y downwards. When the water level Y goes down, it forces the water level X upwards. One candidate tried to respond to this part by writing, *"the bulb P will light and the level of the water will be cool while bulb Q will absorb heat and will not light and the level of the water will increase and will get hot compared to the bulb of the P and the level of water"*. This candidate misinterpreted the figure and then explained it in terms of lighting of the bulbs instead of considering absorption of heat by black bulb resulting in expansion of the bulbs and change of water levels.

In part (b), some candidates could not recall the concept of linear expansivity, which made them fail to explain the changes of dimensions of a standard gauge railway during summer and winter days. For example, one candidate stated that *"because during the winter period, much water are produced in different area and arrive to the standard gauge while during the summer period the water in different places is dry"*. Another candidate wrote, *"it does not affect the standard gauge rail lines because is built with*

the presence of gap between certain segment in order to allow expansion and relaxation during hot condition".

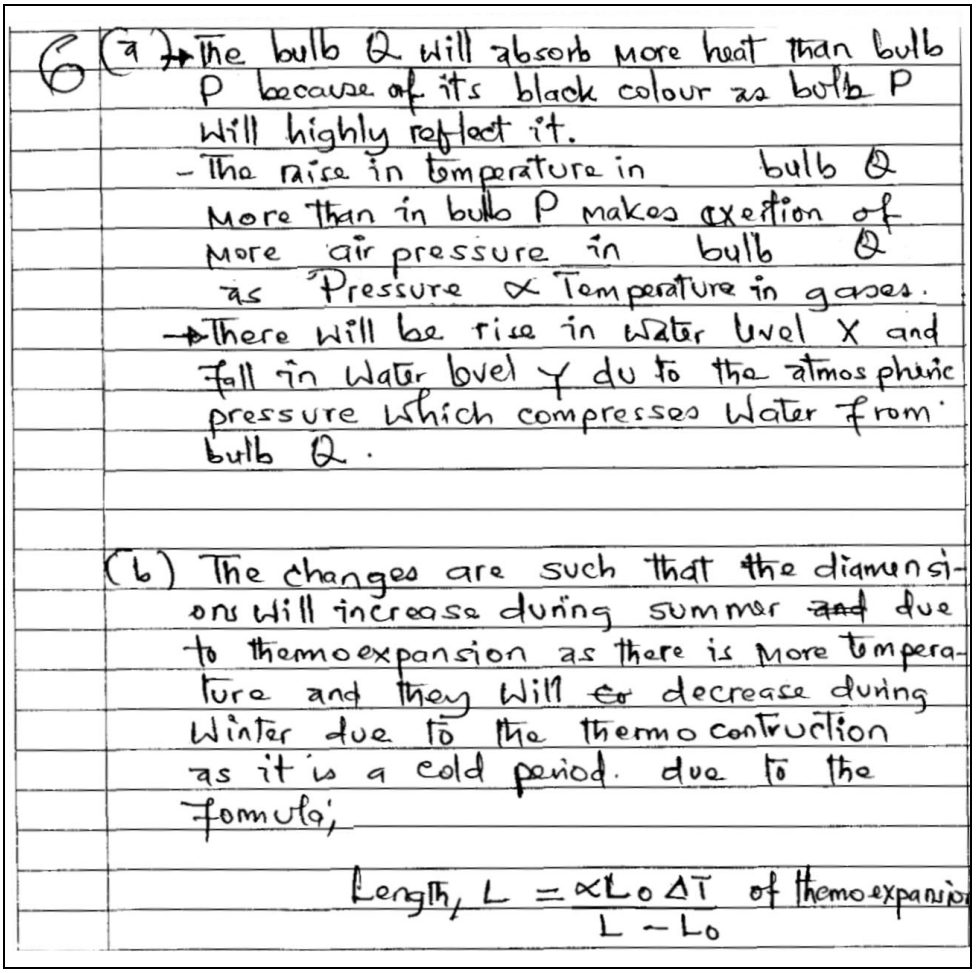
In the first case, the candidate considered the presence of water during winter and the absence of water during summer period as the key factors for the changes of dimensions of the rail lines. However, the candidate did not elaborate how they affect dimensions of the rail lines. In the second case, the candidate stated that the dimensions of the rail lines are not affected because of the gaps left during construction of rails. These candidates did not understand that changes due to climatic conditions result in alterations of the dimensions of the rail lines. They were supposed to know that during summer days rails are exposed to direct sunshine and become hotter than the air temperature, so they expand (increase in size) and cause extreme compression and buckling, which make the lines impassable. During winter days, the rail lines contract (decrease in size) due to the fall in temperature. Therefore, the change in temperature is the key factor towards the changes in dimensions of the rail lines. Extract 6.1 is a sample of responses of a candidate who scored low marks in this question.


6. (a) The Bulb P and Q are can be turned on because the when heater turned on the water can catch heat and when evaporate it can produce charge which cause either bulb to turned on. And.
The bulb P and Q after a period of time can burst or break because Can catch ~~fir~~ heat.

6 b) During the summer, making activity was take place because this period the heat from sunlight decrease which cause by sky covered with Cloud, for this case making activity such joints of peace of iron which ~~help~~ decrease that iron from expansion which cause some errors. and
During the winter, also some of making activity occured which does not occured during winter for example digging holes ~~for rai~~ at the mountain for railway pass through because during this period the soil should be dry it help to dig careful without soil ~~destroy~~ come down after the digging hole. and Also it joint some peace of iron during the night because ~~the~~ to decrease the expansion of iron.

Extract 6.1: A sample of candidates' weak responses to question 6

The candidates who performed well in this question had adequate knowledge of the concepts of thermal expansion. This enabled them to adeptly explain the rise and fall of water levels X and Y when the heater is turned on. Furthermore, they properly used the concept of linear expansivity to explain the changes in dimensions of the standard gauge railway line during summer and winter days. Extract 6.2 is a sample of correct responses from a candidate.


6 (a) → The bulb Q will absorb more heat than bulb P because of its black colour as bulb P will highly reflect it.
- The raise in temperature in bulb Q more than in bulb P makes exertion of more air pressure in bulb Q as Pressure ∝ Temperature in gases.
→ There will be rise in water level X and fall in water level Y du to the atmospheric pressure which compresses water from bulb Q.

(b) The changes are such that the diamensions will increase during summer ~~and~~ due to thermoexpansion as there is more temperature and they will ~~or~~ decrease during Winter due to the thermo contruction as it is a cold period. due to the fomula;

Length, $L = \frac{\propto L_o \Delta T}{L - L_o}$ of thermoexpansion

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

Extract 6.2 shows the answers of a candidate who did well in this question but with minor grammatical errors. For example, he/she wrote *thermo contruction* instead of *thermo contraction*. Also, he/she wrote the formula incorrectly.

2.2.5 Question 7: Current Electricity and Radioactivity

In part (a) of this question, the candidates were required to explain what will happen to bulbs A, B and D when bulb C blows off and the key K is closed as seen in Figure 2 with identical bulbs A, B, C and D connected in a circuit.

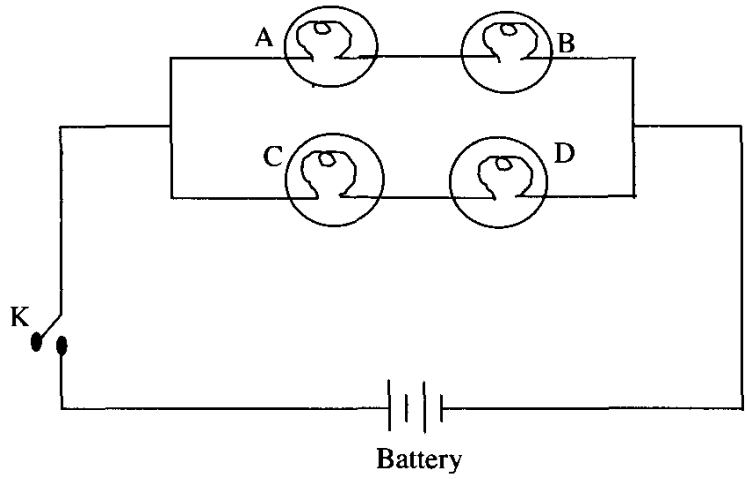


Figure 2

In part (b) the candidates were required to explain the possibility for a radioactive element to emit beta particles (electrons) from its nucleus when the Rutherford proton-neutron model shows that there are no electrons in the nucleus of an atom.

The question was attempted by 112,650 (93.2%) candidates whose scores were as follows: 87,425 (77.6%) scored from 0 to 2.5 marks, 24773 (22.0%) scored from 3.0 to 6.0 marks and 452 (0.4%) scored from 6.5 to10 marks. These scores indicate that the question was weakly done, since only 25,225 (22.4%) scored from 3.0 to 10 marks. Figure 7 summarizes the performance of candidates in this question.

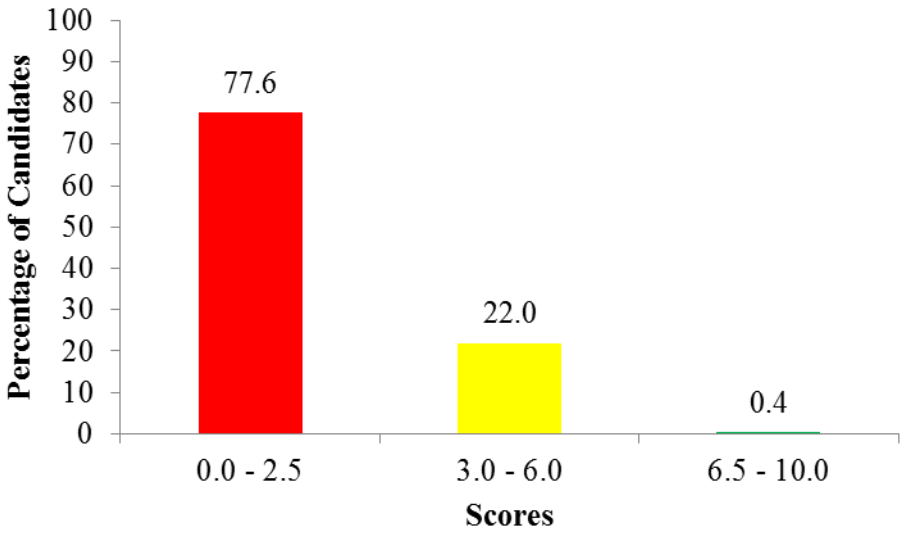
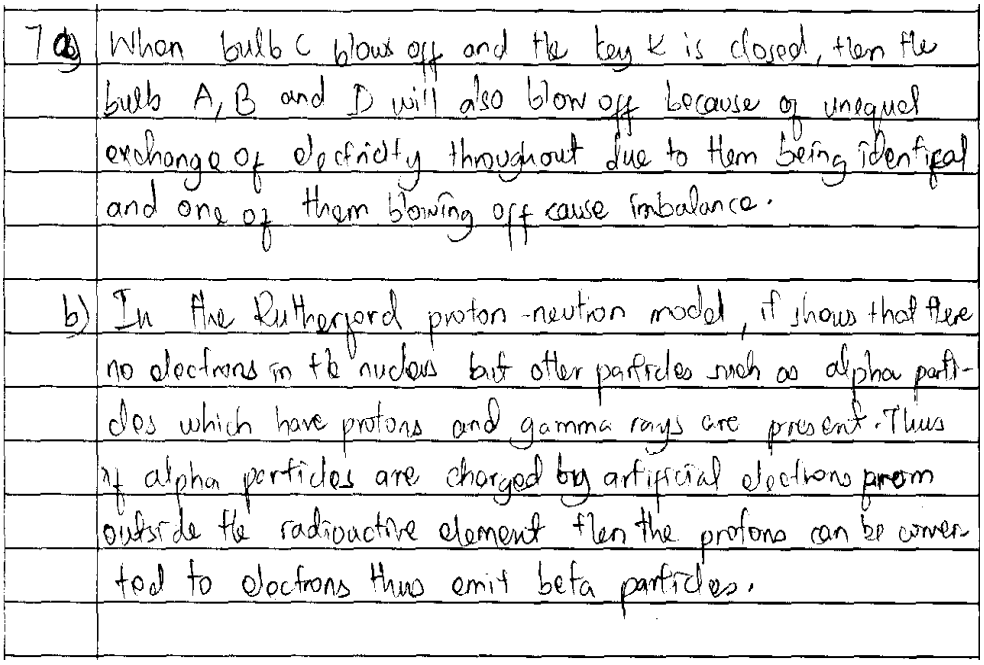


Figure 7: *The percentage of candidates' performance in question 7*

The candidates who performed weakly in this question lacked mastery of proper concepts on the topic of *Current electricity* from part (a) of the question. This made some of them fail to explain what will happen to bulbs A, B and D when bulb C blows off and the key, K is closed. In this part of the question, most of the candidates did not understand the concept of effect of resistance to electric current when electric components are connected to either in series or parallel in any electrical circuit. For example, one candidate seemed to have an idea of the answer but failed to present it, due to poor mastery of English and content of the subject. He/she stated that *"if key K is closed bulb A, B and D will continue to blow on because the circuit are connected in series in which if one bulb other will continue to blow on due to use different circuits"*. This candidate failed to integrate series and parallel connected components in a circuit. He/she was supposed to recognize that when the switch is closed the current flows up to the junction at which it divides into two parts, one current flow through bulbs A and B and the other one through Bulb C and D. Since bulb C is blown off, no current flows in bulb C and D. Therefore, bulbs A and B maintain the same brightness since the same current flows in each bulb as they are connected in series.

In part (b), some candidates failed to apply the concept of radioactivity, especially the nucleus of an atom to find out the possibility of a radioactive element to emit beta particles (electrons) from its nucleus. For example, a

candidate attempted to explain that "*radioactive element is unstable element that emits electrons". This is possible because the atom is made up of three charges which are electrons, protons and neutrons'*. This candidate and all others who failed to give the anticipated responses were supposed to understand that a beta particle is formed when a neutron changes into a proton and a high energy electron. The proton stays in the nucleus but the electron leaves the atom as a beta particle. When a beta particle is emitted from the nucleus, the mass number remains the same. Extract 7.1 is a sample of candidate's weak response to this question.


7 a) When bulb C blows off and the key K is closed, then the bulb A, B and D will also blow off because of unequal exchange of electricity throughout due to them being identical and one of them blowing off cause imbalance.

b) In the Rutherford proton-neutron model, it shows that there no electrons in the nucleus but other particles such as alpha particles which have protons and gamma rays are present. Thus if alpha particles are charged by artificial electrons from outside the radioactive element then the protons can be converted to electrons thus emit beta particles.

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

Those candidates who performed well in this question had adequate knowledge of both, the concept of Current electricity and Radioactivity. In part (a), the candidates were able to analyse the circuit and explained correctly what happens to the bulbs A, B and D when bulb C blows off if the key, K is closed. In part (b), the candidates managed to apply the knowledge of nucleus of an atom to explain how it is possible for a radioactive element to emit beta particles (electrons) from its nucleus. Extract 7.2 is the sample of answers from a candidate who performed well in this question.

7. (a) When key is closed and C blows off bulb A and B will light up (while produce light) because the path taken by current through bulb A and B is not blocken.

Bulb D will not light up this is because the circuit through bulb C and D is open by the blown bulb C.

(b) It is possible due to the fact that neutrons in the nucleus tend to disintegrate producing a proton and electron during radioactivity. As a result the electron(s) produced from the disintergrated neutron(s) will be the one which will be emitted as beta particle during radioactivity of the radioactive element

$^{0}_{1}n \longrightarrow {}^{+1}_{1}p + {}^{-1}_{0}e$

Hence the radioactive elecment will be able to emit $^{-1}_{0}e$ from the disintergrated neutron leaving a proton inside the nucleus.

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

Extract 7.2 shows how the candidate managed to answer all parts of the question correctly.

2.2.6 Question 8: Waves and Geophysics

This question required the candidates to (a) determine the wavelength from Figure 3 which shows the profile of a radio wave.

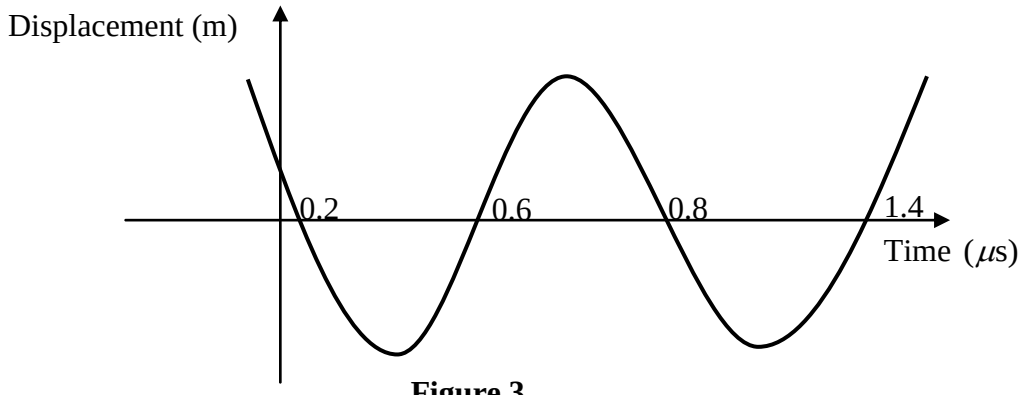


Figure 3

In part (b), the candidates were required to explain how earthquake occurs.

The question was attempted by 115,167 (95.3%) candidates whose scores were as follows: 92,887 (80.7%) scored from 0 to 2.5 marks, 21,406 (18.5%) scored from 3.0 to 6.0 marks and 874 (0.8%) scored from 6.5 to10 marks. This analysis shows that the candidates' performance was weak since only 22,280 (19.3%) scored from 3.0 to 10 marks. Figure 8 is a graphical representation of the performance of the candidates in this question.

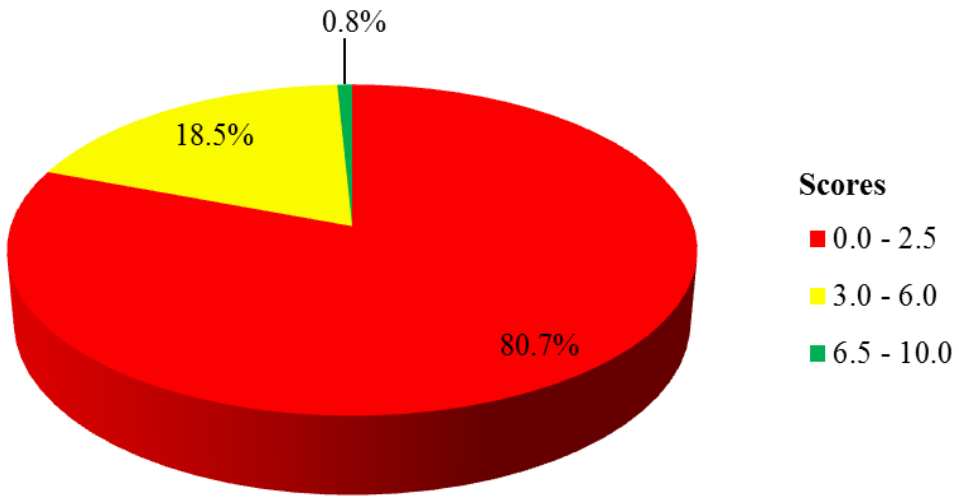
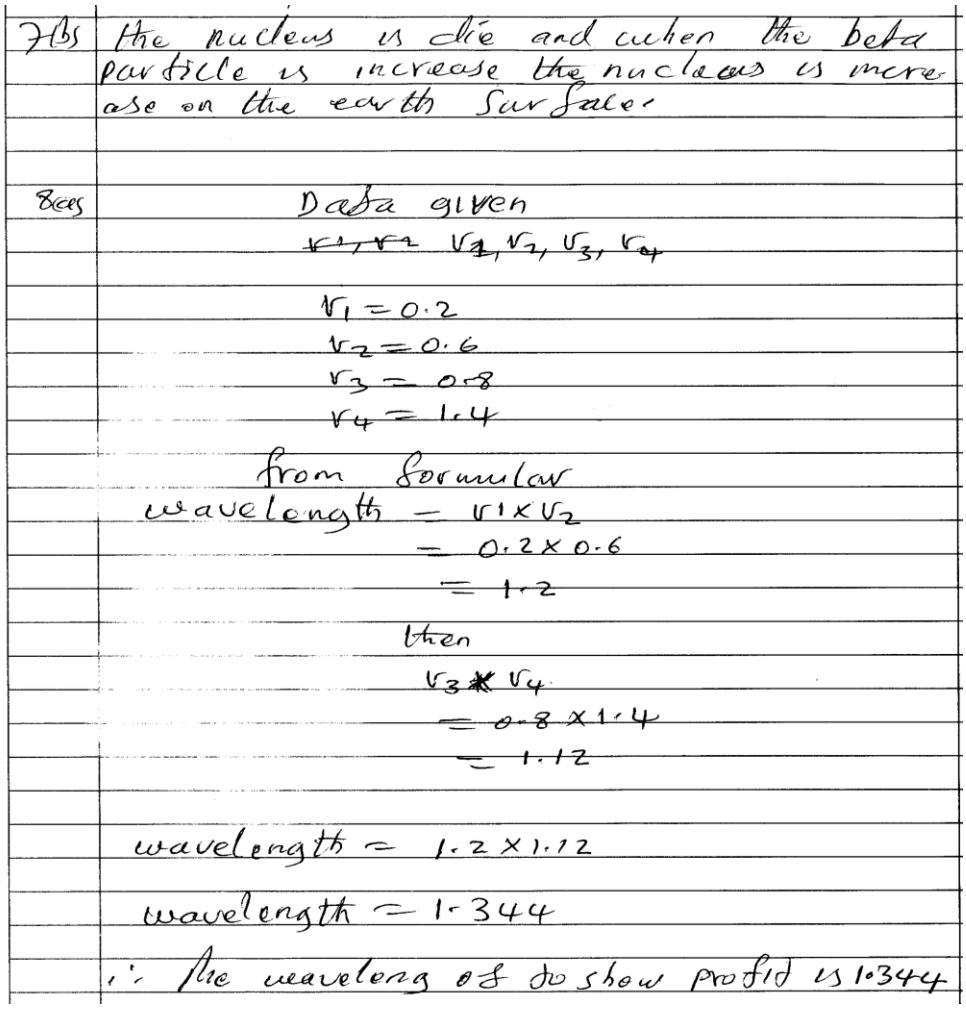


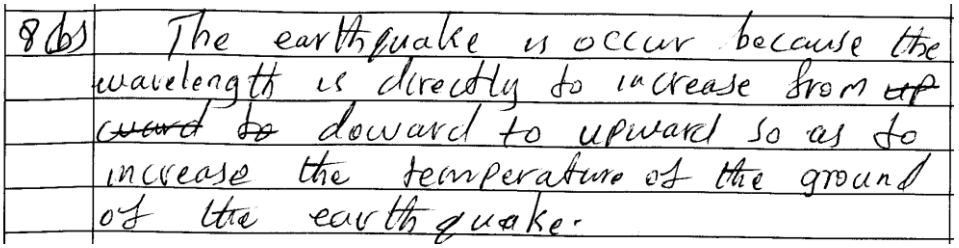
Figure 8: *Percentage of candidates' performance in question 8*

Most of the candidates who had weak performance in this question failed to interpret the radio wave profile given in Figure 3 of part (a) of the question and consequently failed to determine the wavelength. Moreover, in part (b), most of the candidates were not able to use the concept of Geophysics, particularly the origin of earthquake to explain how it occurs. In an attempt to respond to part (a) some of the candidates failed to deduce the wave equation and the relationship between frequency and the period of the wave. For example, one candidate wrote: ' $\text{Wavelength} = \frac{\text{Frequency}}{\text{Amplitude}}$, which does not make sense. This candidate was supposed to use the wave equation as: $\text{Velocity} = \text{Frequency} \times \text{Wavelength}$ so as to obtain the relation for a wavelength as: $\text{Wavelength} = \frac{\text{Velocity}}{\text{Frequency}}$. In order to get the

frequency of the wave, he/she would use the expression: $\text{Frequency} = \frac{1}{\text{Period}}$.

Another eminent drawback that led to unsatisfactory performance in this part of the question is that most of them failed to recognize that a radio wave is an electromagnetic wave in nature therefore it has the same characteristics as those of light. So, the velocity of the radio wave is the same as the velocity of light, which is 3.0×10^8 m/s. Extract 8.1 is a sample of a candidate's weak response.




8(b) The earthquake is occur because the wavelength is directly to increase from ~~up~~ ~~ward to~~ downward to upward so as to increase the temperature of the ground of the earthquake.

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

Extract 8.1 shows answers of a candidate who failed to interpret the radio wave profile to determine the wavelength of the wave by introducing non-existing formula. Consequently, he/she explained incorrectly the occurrence of an earthquake.

The candidates who did this question accurately demonstrated competence in the concept of waves, specifically propagation of electromagnetic waves that involve the determination of the relation between velocity, frequency and wavelength. They interpreted the given wave profile appropriately and they used computational skills to determine the wavelength of the wave. Some of them were able to explain in detail how the earthquake occurs in part (b) of this question. Extract 8.2 is a sample of candidate's correct answers.

8 (a) $T = (0.8 - 0.2)\,\mu s$

$= 0.6\,\mu s$

$1 s = 10^6\,\mu s$.

$? = 0.6\,\mu s$.

$\frac{0.6}{10^6}\ s$

$T = 6 \times 10^{-7}$ sec.

$\text{frequency} = \frac{1}{T}$

$F = \frac{1}{6 \times 10^{-7}}\ sec^{-1}$

Velocity of the wave $= 3 \times 10^8$ m/s

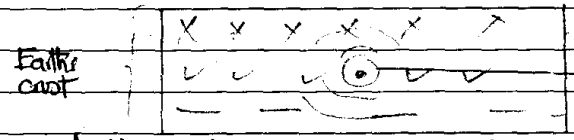
from $V = f\lambda$.

$3 \times 10^8 = \frac{\lambda}{6 \times 10^{-7}}$

$\lambda = 3 \times 10^8 \times 6 \times 10^{-7}$

$\lambda = 180$m.

(b) An earthquake is a shaking or tumbling of the earth's crust. The earthquake occurs as follows;



- Due to the isostatic adjustment of the earth crustal rocks the earth quake may develop from a point where the isostatic force is happening or acting this point where the earthquake begins is known as the focus after there it becomes spreaded at large areas as a form of disturbance.

Also movement of tectonic plates of the earth causes the earth quake to occur since it cause shaking of the earth's crustal rocks which results to an earth quake.

Extract 8.2: A sample of the candidate's good responses to question 8

Extract 8.2 shows how the candidate managed to construe a radio wave profile and correctly apply the wave equation to determine the wavelength

of the wave. Consequently, the candidate, to some extent, explained perfectly how an earthquake occurs.

2.3 Section C: Short Answer Questions

This section had three (3) questions extracted from the topics of *Waves, Electromagnetism, Current electricity and Electronics*. The candidates' were required to answer two (2) questions, each carrying twelve and a half ($12\,{}^{1}\!/_{2}$) marks, making a total of 25 marks.

2.3.1 Question 9: Waves and Electromagnetism

This question comprised of two parts (a) and (b). In part (a), the candidates were required to show clearly three ways in which a piano wire can be tuned to emit a note of the same frequency as a vibrating turning fork, given that the piano wire and turning fork are devices which produce sound. In part (b) the candidates were provided with a moving coil galvanometer of a coil of resistance 20 Ω which can carry a maximum current of 15 mA and they were required to design a galvanometer to register 10 mA full scale deflection.

The question was attempted by 35,080 (29.0%) candidates whose scores were as follows: 32,966 (94.0%) candidates scored from 0 to 3.5 marks, 1775 (5.0) scored from 4.0 to 7.5 marks and 339 (1.0%) scored from 8.0 to12.5 marks. This performance is generally weak as only 2,114 (6.0%) scored from 4.0 to 12.5 marks. Figure 9 graphically represents the candidates' performance in this question.

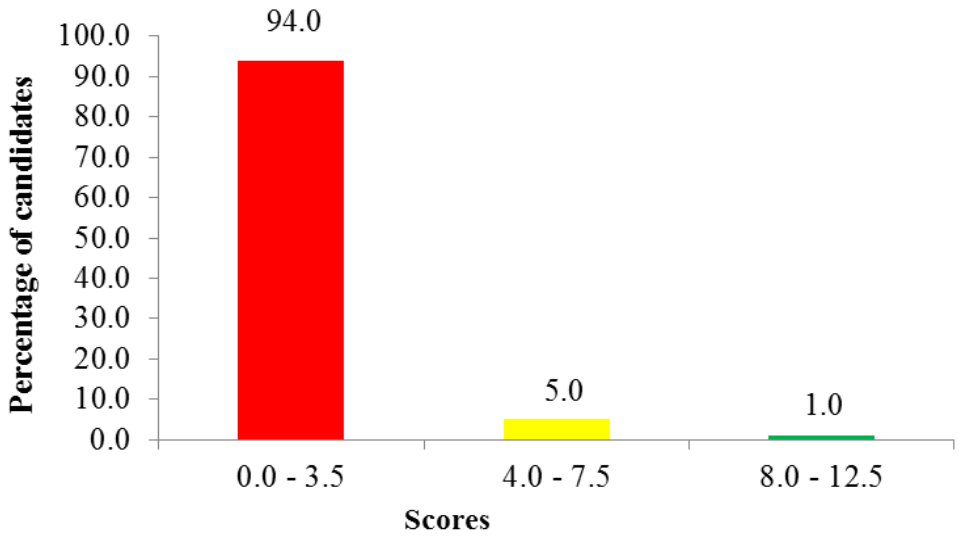


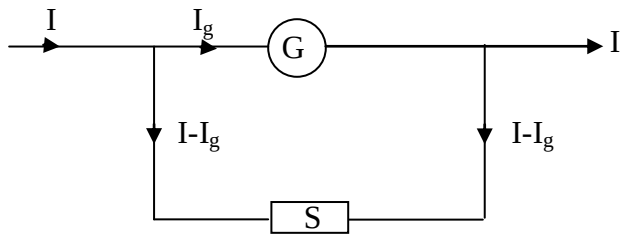
Figure 9: *Percentage of candidates' performance to question 9*

The candidates who got low marks in this question provided incorrect answers to almost all parts of the question. Most of the candidates (94%) scored below 4.0 out of 12.5 marks, indicating that they lacked knowledge on basic concepts of Waves especially music sound and Electromagnetism. They were also unable to use mathematical skills to calculate the value of the shunt resistor which could enable the galvanometer to give the full scale deflection, a current of 10 mA. Most of the candidates failed to show the ways in which a piano wire can be tuned to emit a note of the same frequency as a vibrating tuning fork. For example, one candidate stated the ways in which a piano wire can be tuned to emit a note of the same frequency as a vibrating tuning fork as follows:

'By keeping a piano near a vibrating fork; and through resonances'

This candidate did not understand that resonance describes a phenomenon of increased amplitude that occurs when the frequency of a periodically applied force is equal or close to the natural frequency of the system on which it acts. This is not a way in which a piano wire can be tuned to emit a note of the same frequency as a vibrating fork. The candidates were supposed to understand that for a piano wire to be tuned so that it can emit a note of the same frequency as a vibrating fork, the length, tension and the diameter of the wire should be varied. In attempting to answer part (b) of this question, one candidate wrote: *'by connecting the step down transformer with many primary coils than secondary coils'*. This candidate confused the concept of conversion of galvanometer into ammeters with

that of the functions of transformers in electromagnetic induction, so he/she introduced the concept which is not relevant to the question. The candidates were supposed to realize that a galvanometer can be converted into ammeter by connecting a low resistance called shunt parallel to the galvanometer. They were supposed to design a circuit to simplify the calculations as follows:



By using the relation: The p.d across the galvanometer = the p.d across the shunt. If the resistance of the galvanometer = G,
then, $I_gG = (I-I_g)\times S$

$S = \left(\frac{I_g}{I-I_g}\right)\times G$, the resistance of the shunt S, would be calculated.

Extract 9.1 is a sample of the responses from one of the candidates who got low marks in this question.

Q (a) Ways which piano can be tuned:

(i) By Stretching.

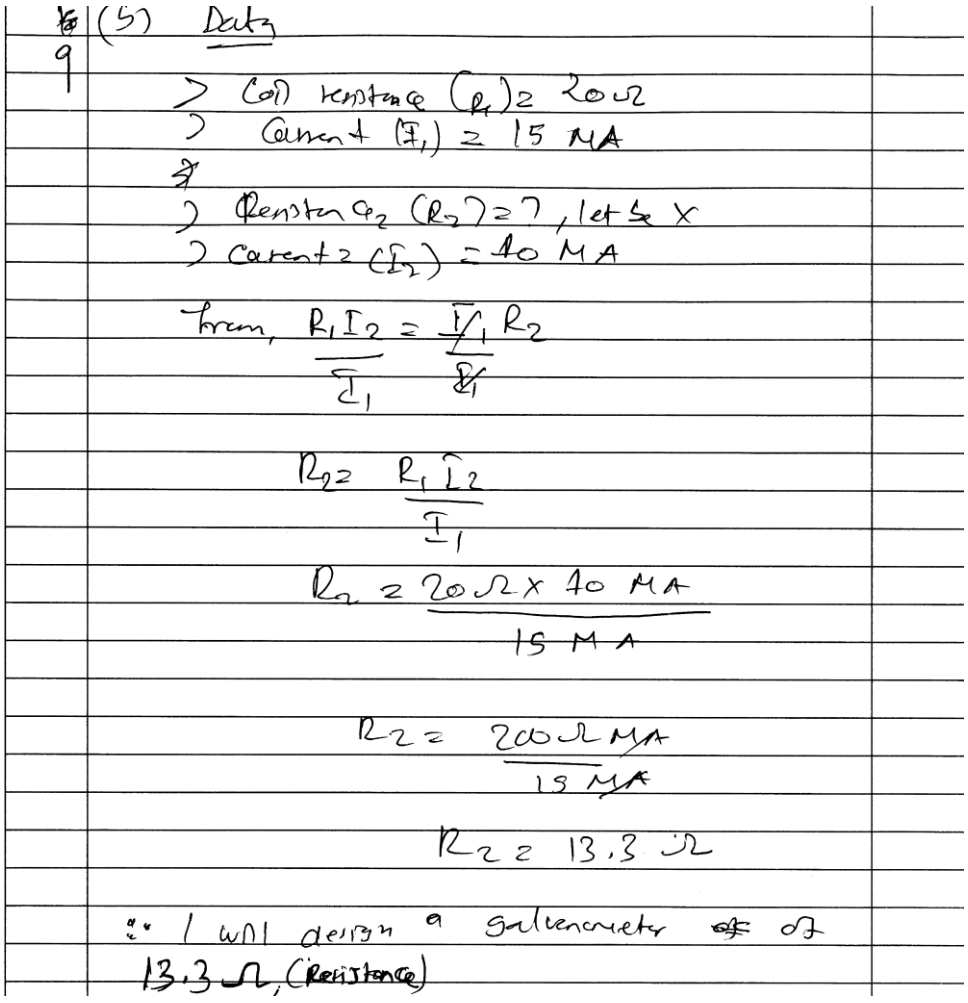
The piano emits a note of the same frequency when its wires are stretched. Thus by the stretching the sound may be produced by the piano, if same frequency of the vibrating tuning fork

(ii) through ~~Obscuration~~ Obscussion

- the here the piano wire is being struck, thus ~~n~~ked by tuning the wire of the piano. It will produce a sound of the same frequency as a vibrating tuning rack

(iii) by blowing wind.

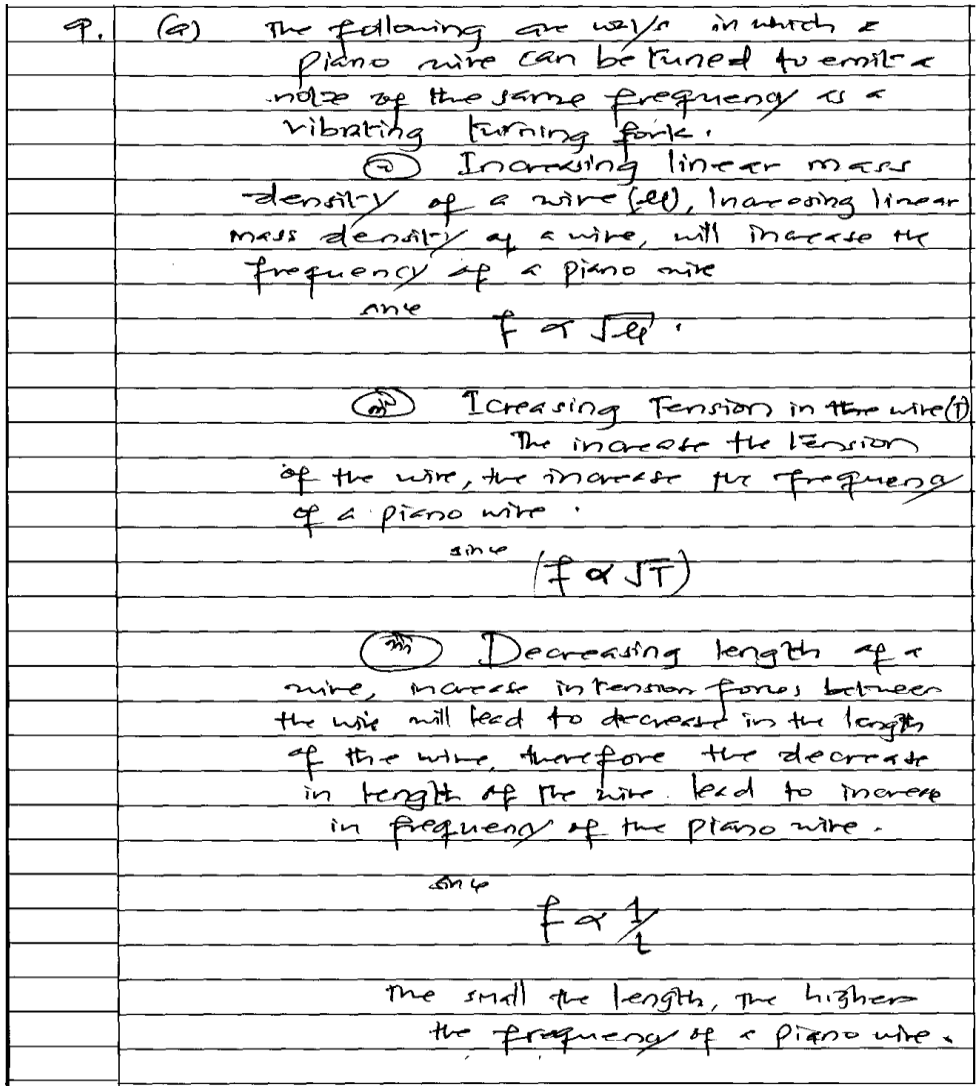
- The blowing wind affects the stationarity of a wire of a piano. so the effect of wind lead to the tunation and emition of a note of a piano of the same frequency as a vibrating tuning fork.



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

Extract 9.1 shows answers of a candidate who lacked clear understanding of the concept of music sound and thus provided incorrect responses to all parts of the question. However, he/she seemed to have little knowledge in part (b) but failed to present it precisely.

The candidates who performed this question well were highly knowledgeable of the concept of *Waves* and *Current electricity*. In part (a), some of these candidates managed to show and write clearly three ways in which a piano wire can be tuned to emit a note of the same frequency as a vibrating turning fork. In part (b), some of the candidates demonstrated clear mathematical skills by calculating the shunt resistor which could enable the galvanometer give full scale deflection a current of 10 mA. Extract 9.2 is a sample of the answers of the candidate who scored high marks in this question.



9. (b) Data Given.

Resistance in the galvanometer (R_g) = 20Ω

Maximum current (I) = 15mA.

1A = 1000mA

∴ = 15mA

$\frac{15mA \times 1A}{1000mA} = \frac{1000mA \times y}{1000mA}$

$y = \frac{15}{1000} A$

$y = 0.015A$.

Maximum current (I) = 15mA

= 0.015A.

Current registered by the galvanometer (I_g) = 10mA

$I_g = \frac{10mA}{1000mA \times A}$

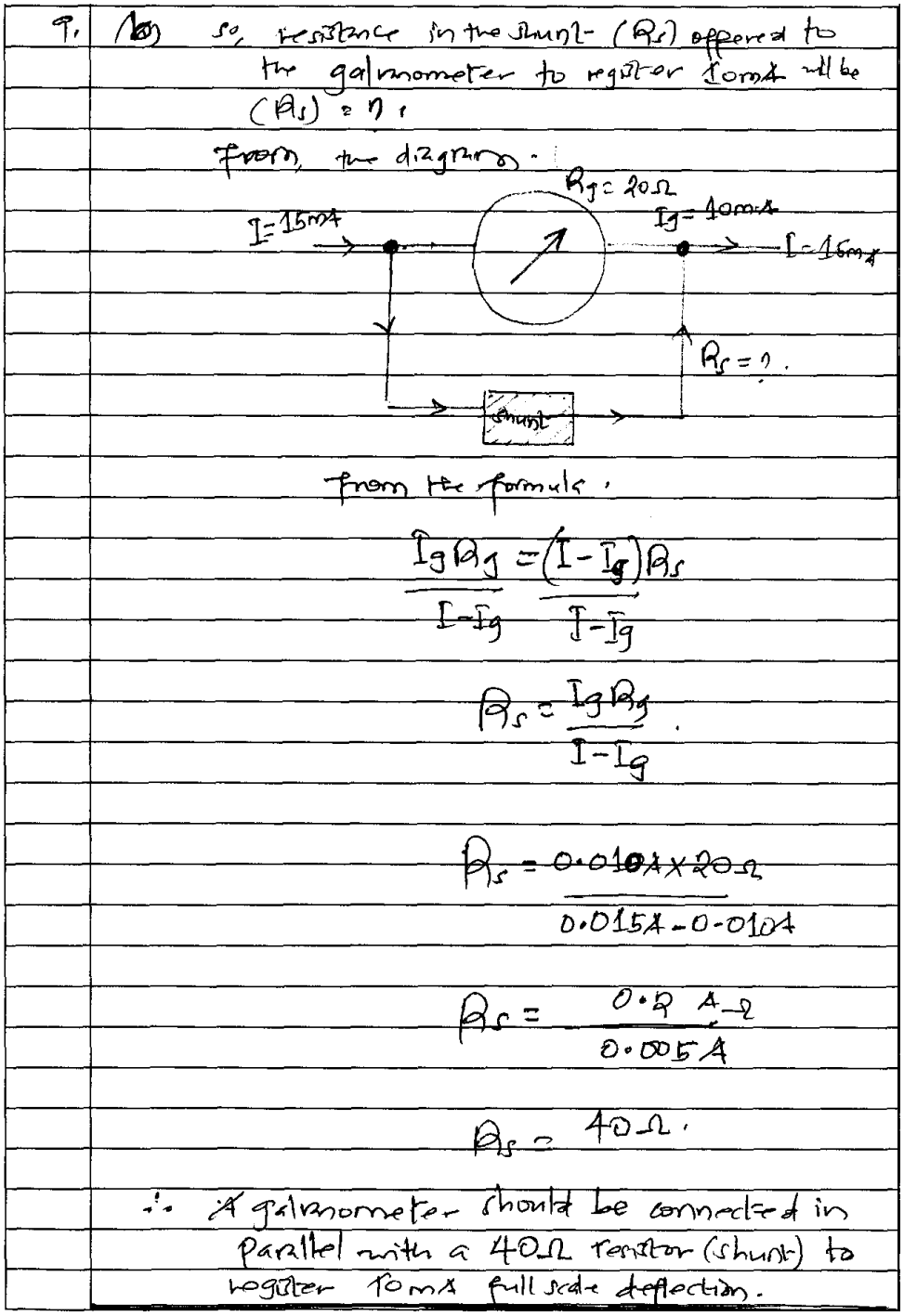
$I_g = 0.01A$.

How the galvanometer would be designed to register 10mA?

But;

A galvanometer can be designed to give an ammeter reading by connecting in parallel with a device called shunt.

A shunt is a low resistance resistor which connected Parallel to a galvanometer to make it function as an ammeter.



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

Extract 9.2 shows how a candidate was knowledgeable of the concept of music sound and how to convert galvanometer to work as an ammeter.

2.3.2 Question 10: Electronics and Current Electricity

The question had three parts (a), (b) and (c). Part (a) required the candidates to distinguish between the concepts of conductors, semiconductors and insulators in terms of their energy bands. In part (b), the candidates were required to calculate the value of current 'x' and resistance 'r' from the electric circuit shown in Figure 4. In part (c), the candidates were required to determine the effective resistance from part (b).

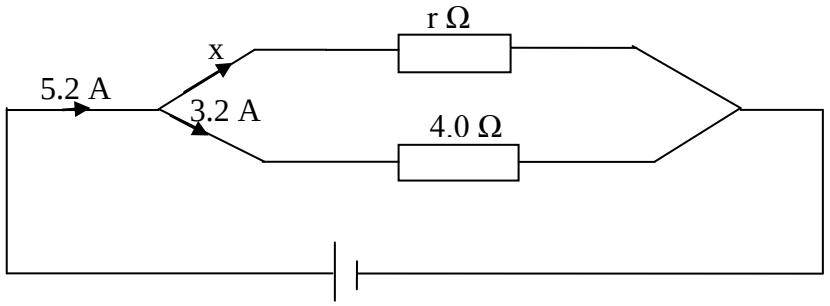


Figure 4

The question was attempted by 109,577 (90.7%) candidates whose scores were as follows: 69,430 (63.4%) scored from 0 to 3.5 marks, 26,918 (24.5%) scored from 4.0 to 7.5 marks and 13,229 (12.1%) candidates scored from 8.0 to12.5 marks. These scores signify that the candidates' performance in this question was average as only 40,147 (36.6%) candidates scored from 4.0 to 12.5 marks.

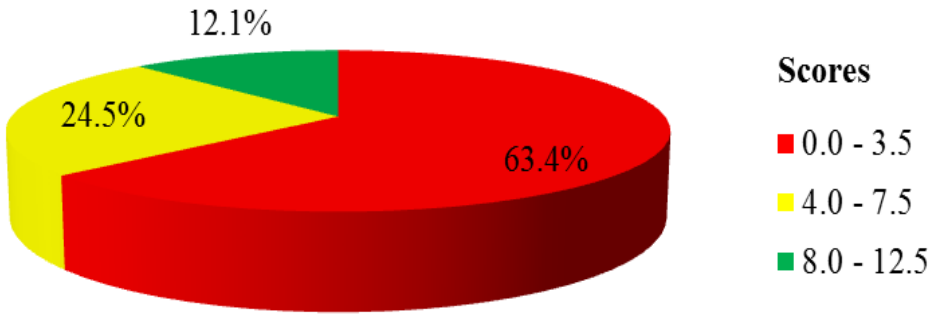
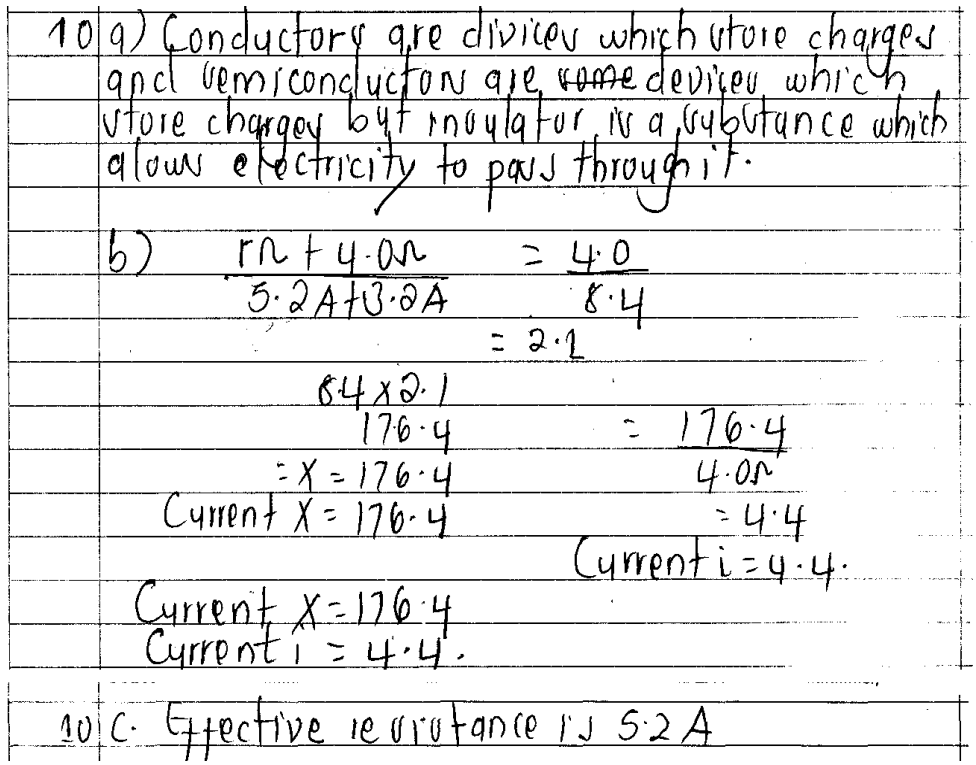


Figure10: *Percentage of candidates' performance in question 10*

In part (a), the candidates failed to distinguish between the concepts of conductors, semiconductors and insulators in terms of their energy bands. Some of the candidates confused the idea of conductivity with energy

bands in differentiating the given materials hence ended up giving wrong answers. They distinguished the materials referring to a measure of a material's ability to conduct electric current instead of giving their differences in terms of energy bands. For instance, one candidate explained that "*conductors are materials which allow the passage of electric current to pass through them, semiconductors are materials whose conductivities lie between those of conductors while insulators are the materials which do not allow the passage of electric current through them"*. This candidate was absolutely correct, but he/she did not observe the special requirement of the question which asked them to distinguish these materials with reference to their energy bands. In part (b), most of the candidates failed to apply the current law in electric circuit which state that *at any junction of the circuit, the main current distributes into two or more individual currents depending on the number of electric components connected in parallel*. For two resistors connected in parallel, the main current is the algebraic sum of the two currents, that is, $I = I_1 + I_2$. This could enable the candidates to calculate the value of current x and resistance r from the given circuit diagram.

Some of the reasons that contributed to poor performance in this part of the question were inability to identify the type of connected electric circuit and their corresponding formula for effective resistance; misuse of the SI units of quantities given as data to be used in computations; lack of mathematics skills; and inadequate general knowledge related to the concepts of simple circuits in current electricity. Furthermore, in part (c) other candidates failed to determine the effective resistance from the given circuit diagram. Extract 10.1 is a sample of answers from a candidate who scored low marks in this question.



Extract 10.1: A sample of a candidate's weak responses to question 10

Extract 10.1 showed that the candidate had confused the concepts as he/she introduced the concept of static electricity in place of electronics, and consequently failed to score any marks. Consequently, the candidate failed to develop the relation for the currents flowing in different electric components in the circuit. Finally, he/she failed to find the effective resistance in the circuit.

The higher achievers for this question provided the correct answers in almost all parts of the question. This shows that they had enough knowledge of the topic of Electronics, especially the concept of energy bands and Current electricity, especially the concept of parallel connection of resistors. These candidates were able to distinguish between conductors, semiconductors and insulators in terms of their energy bands. They also managed to calculate the current and unknown resistance, and finally determine equivalent resistance from the circuit. Extract 10.2 is a sample response from a candidate who scored full (12.5 out of 12.5) marks in this question.

10. @

CONDUCTORS	SEMICONDOCTORS	INSULATORS
→ Conductor have no forbidden gap and sometimes overlap the valence and the conduction band of the conductor do overlap	Semiconductors have moderate sized forbid gap compared to the valence band	Have a very large and wide forbbiden gap compared to that of insulators

Semi-conductors

DIAGRAMS

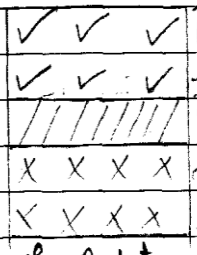


fig: Conductor energy bands.

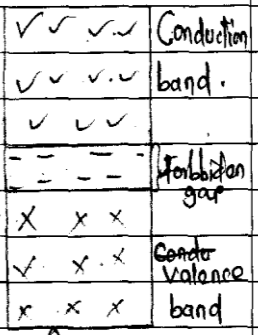


fig: Semiconductor energy band.

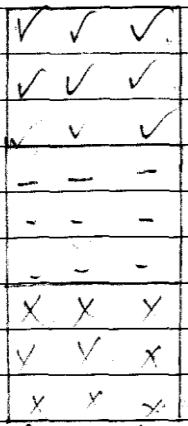


fig: Insulator energy bands.

10 (b) From.

$I_{total} = I_{R_1} + I_{R_2}$.

$I_T = 5.2A$

$I_{R_1} = X$

$I_{R_2} = 3.2A$.

$5.2A = 3.2A + X$.

$5.2A - 3.2A = X$

$X = 2A$

let $r\Omega = R_1$

$4.0\Omega = R_2$.

R_1 and R_2 share the same Voltage since they are in parallel

from $V = IR$.

$I = 3.2A$

$R = 4.0\Omega$.

$V = (3.2 \times 4.0)V$

$= 12.8V$

∴ Voltage across resistor is 12.8V.

$I_r = 12.8v$

$2Ar = 12.8V$

$r = \frac{12.8V}{2A}$

$r = 6.4\Omega$.

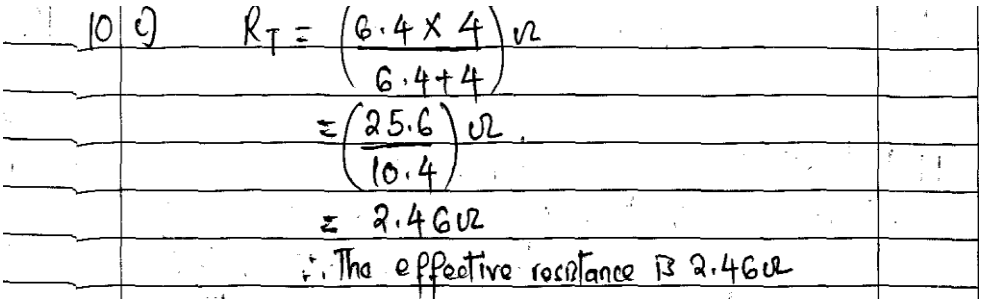
∴ $X = 2A$ and

$r = 6.4\Omega$

(c) from $R_T = \frac{R_1 R_2}{R_1 + R_2}$.

$R_1 = 6.4\Omega$

$R_2 = 4.0\Omega$



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

Extract 10.2 shows how a candidate managed to distinguish the conductors, semiconductors and insulators in terms of energy bands. The candidate used the current law in part (b) and systematically determined the unknown current x and resistance r. He/she applied the concept of parallel connection of resistances correctly to obtain the effective resistance of the circuit.

2.3.3 Question 11: Electronics and Waves

This question was comprised of three (3) parts, namely (a), (b) and (c). In part (a), the candidates were required to describe the mechanism of doping an intrinsic semiconductor to obtain a p-type semiconductor material. In part (b), the candidates were required to explain why most of the transistors in use are n-p-n transistors and in part (c) they were required to briefly explain how other students in the next room can hear form one students shouting in their classroom.

The question was attempted by 77,831 (64.4%) candidates whose scores were as follows: 67,559 (86.8%) scored from 0 to 3.5 marks, 9253 (11.9%) scored from 4.0 to 7.5 marks and 1019 (1.3%) scored from 8.0 to10 marks. These scores indicate that the candidates' performance was weak as only 10,272 (13.2%) candidates scored from 4.0 to 12.5 marks. Figure 11 is a graphic representation of the candidates' performance in this question.

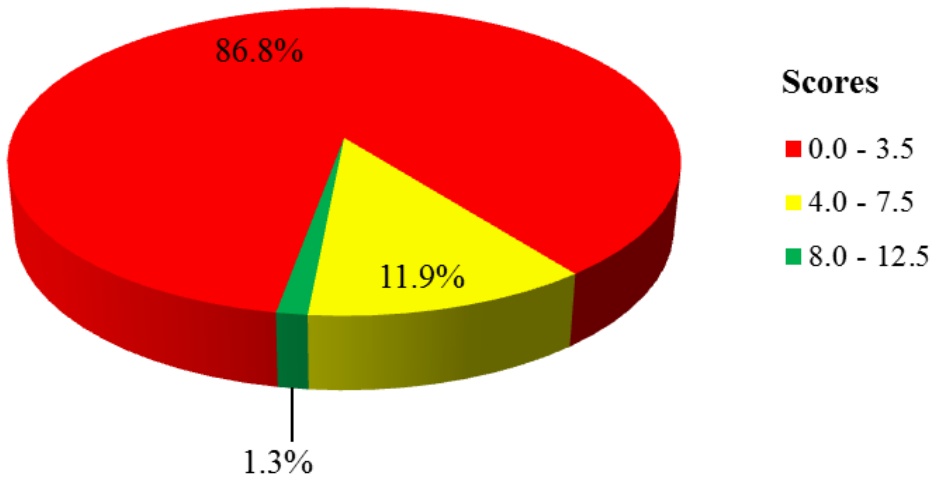


Figure 11: *The percentage of candidates' performance in question 11*

The candidates who achieved low marks in part (a) of the question had very little knowledge of the topic of Electronics especially of the concept of semiconductors. These candidates failed to describe the mechanism of doping an intrinsic semiconductor to obtain a p-type semiconductor material. For example, one candidate wrote:

Doping is done in the intrinsic semiconductor to obtain p-type doping simply to increase the conductivity in the semiconductor since doping induces impurities to increase the conductivity of the semiconductor hence p-type semiconductor is obtained.

This response is not only incorrect but also lacks logical flow. The candidates were supposed to know that in order to form P-type Semiconductor; there must be an addition of some trivalent impurities such as Boron, Aluminium or Gallium in intrinsic semiconductor. As trivalent impurity has three electrons in its valence shell, and when it creates bond with silicon (tetravalent) atom there will be deficiency of electron in valence shell which is called a hole. Therefore, the holes will be majority charge carriers and thus will form P-type semiconductor.

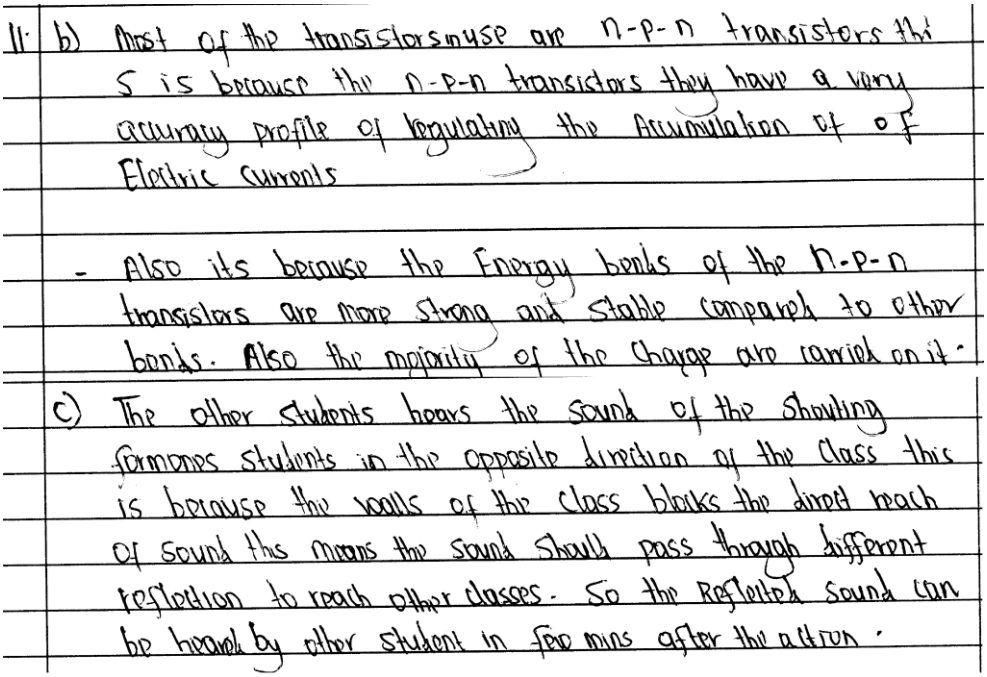
In part (b), the candidates failed to explain why most transistors in use are n-p-n transistors. Just like in part (a), some of the candidates did not understand which charges are plentifully found in n-p-n transistors as compared to other types of junction transistors, and why they are useful in such type of transistors. In attempting to respond to this part of the question, one candidate wrote "*Most of the transistors in use are n-p-n transistors because they have charges which are positive and negative charges"*. It is true that *n-p-n transistors* have positive and negative charges but why is it suitable for use in electronic components? The candidates were supposed to recall that n-p-n transistors are mostly used because their majority charge carriers are electrons whose mobility is higher than the mobility of holes, hence useful for amplifying and switching the signals.

In part (c), the candidates failed to explain how other students in the next room can hear the shouting of form one students in their classroom. Most of the candidates used the concept of reflection of sound waves to attempt to explain this scenario. For example, one of the candidates who used the concept of reflection of sound waves explained that:

Sound waves travel in a straight line and they are reflected, when being reflected some sound waves may return back while others are transmitted, therefore, when form one students were shouting in their classroom some sound waves were reflected back and some sound waves were transmitted hence making possible for other students in the next room to hear them shouting'.

These candidates were supposed to recall that reflection of sound waves off of surfaces can lead to one of two phenomena - an echo or a reverberation. It involves the change in direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated. Therefore, it is difficult for a reflected sound wave to be heard in the next rooms as they are thrown back to their original source. As such, the only possible means of the sound waves to be heard by other people in the next rooms is by diffraction of sound waves. Diffraction of sound waves is commonly noticed around corners or through door or window openings, allowing us to hear others who are speaking to us from adjacent rooms.

Another misconception was observed from a candidate who introduced the idea that "*sound waves travel directly through the vacuum and hence reach the students in the next rooms easily"***.** This candidate did not understand that sound waves are longitudinal mechanical waves which require material medium for their transmission, and thus they cannot travel through vacuum since they are not electromagnetic waves in nature. Extract 11.1 is a sample of responses from a candidate who scored low marks in this question.


11. b) Most of the transistors we use are n-p-n transistors this is because the n-p-n transistors they have a very accuracy profile of regulating the accumulation of of Electric currents

- Also its because the Energy bands of the n-p-n transistors are more strong and stable compared to other bands. Also the majority of the charge are carried on it.

c) The other students hears the sound of the shouting form one students in the opposite direction of the class this is because the walls of the class blocks the direct reach of sound this means the sound should pass through different reflection to reach other classes. So the Reflected sound can be heard by other student in few mins after the action.

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

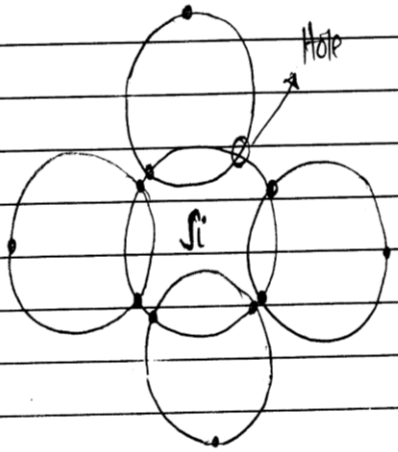
Extract 11.1 shows how a candidate used irrelevant concepts to go against the requirement of the question, and consequently failed to score any marks.

The higher achievers for this question provided correct answers in many parts of this question. This shows that they had enough knowledge of the concept of Electronics, especially of the effect of doping intrinsic semiconductors. Therefore, they were able to describe the mechanism of doping intrinsic semiconductor to obtain p-type semiconductor material. These candidates managed to explain why most of the transistors in use are n-p-n transistors. Finally, some candidates managed to briefly explain how other candidates can hear the shouting of form one students who are in the other (next) room. Extract 11.2 is a sample of responses from a candidate who scored higher marks on this question.

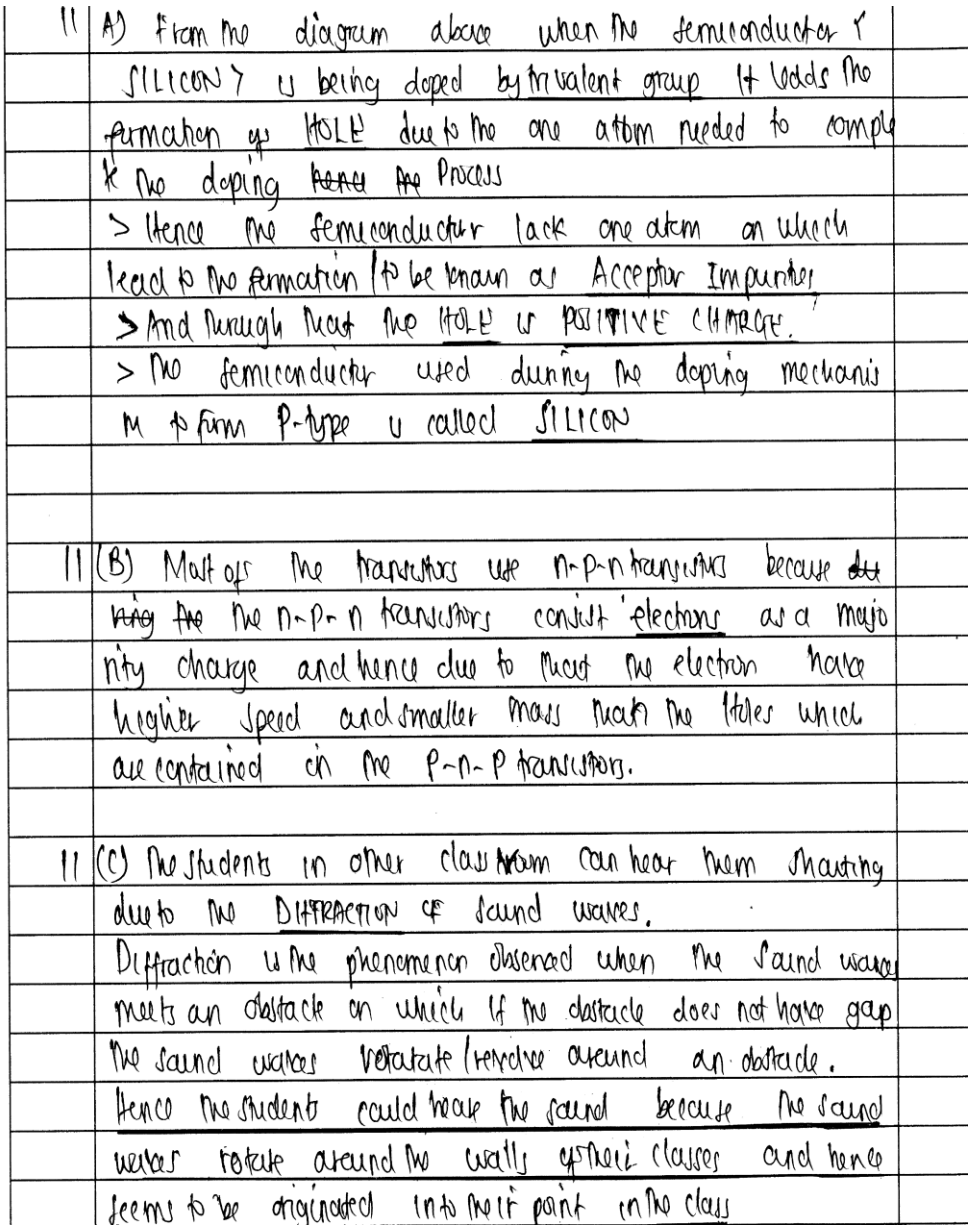
11 (A) Doping intrinsic semiconductor: refers to the process of adding impurities in a semiconductor in order to modify its conductivity

In the process of doping intrinsic semiconductor to get p-type semiconductor, the impurities ~~are~~ which are added are from ~~the~~ TRI VALENT GROUP

Consider the diagram below.



∴ P-type doping mechanism



Extract 11.2: A sample of candidate's good responses to question 11

Extract 11.2 shows that though the candidate did not attain all marks allotted to this question, he/she managed to a great extent to describe the mechanism of doping semiconductor to obtain the p-type semiconductor. The candidate tried to explain why the transistors in use are n-p-n transistors, and he/she applied the concept of diffraction of sound waves

correctly to explain how sound waves from one class can reach the next class.

3.0 ANALYSIS OF THE CANDIDATES PERFORMANCE IN EACH TOPIC IN 031/1 PHYSICS 1

In the subsequent section, the candidates' Performance was discussed on the basis of the topics tested. This analysis aims at appraising the teaching and learning progress so as to look for a better methodology to improve the candidates' performance in future Examinations.

In Physics Paper 1, a total of twenty two (22) topics were tested. The topics examined were *Measurement*; *Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Optical Instruments; Light; Motion in a Straight Line; Temperature; Friction; Transfer of Thermal Energy; Waves; Thermionic Emission; Radioactivity; Forces in Equilibrium; Simple Machines; Newton's Laws of Motion; Vapour and Humidity; Thermal Expansion; Transfer of Thermal Energy; Current Electricity; Geophysics; Electromagnetism;* and *Electronics*.

The analysis of candidates' performance revealed that good performance was observed in question 1 which was tested from various topics where a total of 101,720 (84.2%) candidates scored above 3 marks out of 10 marks. Another good performance (64.1%) was observed from the topic of Thermionic emission homogeneous matching items tested in question 2. The topic of Electronics and Current Electricity tested in question 10 was averagely performed at 36.6 per cent. The topic of Thermal expansion tested in question 6 was also performed at an average of 35.8 per cent. The candidates who had good and average performance seemed to have adequate content knowledge of some of the topics tested, ability to deal with questions demanding reasoning in providing detailed explanations, ability to interpret wave profile graphs, ability to apply computational and drawing skills, and competence in English.

Further analysis of the candidates' performance in each topic revealed that some topics had weak performance. These include *Current Electricity* and *Radioactivity* (22.4%) tested in question 7, *Waves* and *Geophysics* (19.3%) tested in question 8, *Pressure* and *Forces in Equilibrium* (17.6%) tested in question 4, *Light* and *Optical Instruments* (14.8%) tested in question 3, *Electronics* and *Waves* (13,2%) tested in question 11, *Newton's Laws of*

Motion and *Simple Machines* (12.1%) and *waves* and *Electromagnetism* (6.0%) tested in question 5 and 9 respectively. The detailed information on the candidates' performance is shown in Appendix 1.

4.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE IN EACH QUESTION IN PHYSICS PAPER 2

The Physics Practical Paper 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 carrying 25 marks each. The candidates were required to answer all the questions. Question 1 was set from the topic of Mechanics and question 2 from the topic of Current Electricity.

4.1 Question 1: Mechanics

4.1.1 031/2A Physics 2A

The question was attempted by 120,495 (99.9%) candidates whose scores were as follows: 62,963 (52.3%) scored from 0 to 7.0 marks, 39,944 (33.1%) scored from 7.5 to 16.0 marks and 17,588 (14.6%) scored from 16.5 to 25.0 marks. This indicates that the candidates' performance was average, as 57,532 (47.7%) scored from 7.5 to 25.0 marks. Figure 1 is a graphic representation of the candidates' performance in this question.

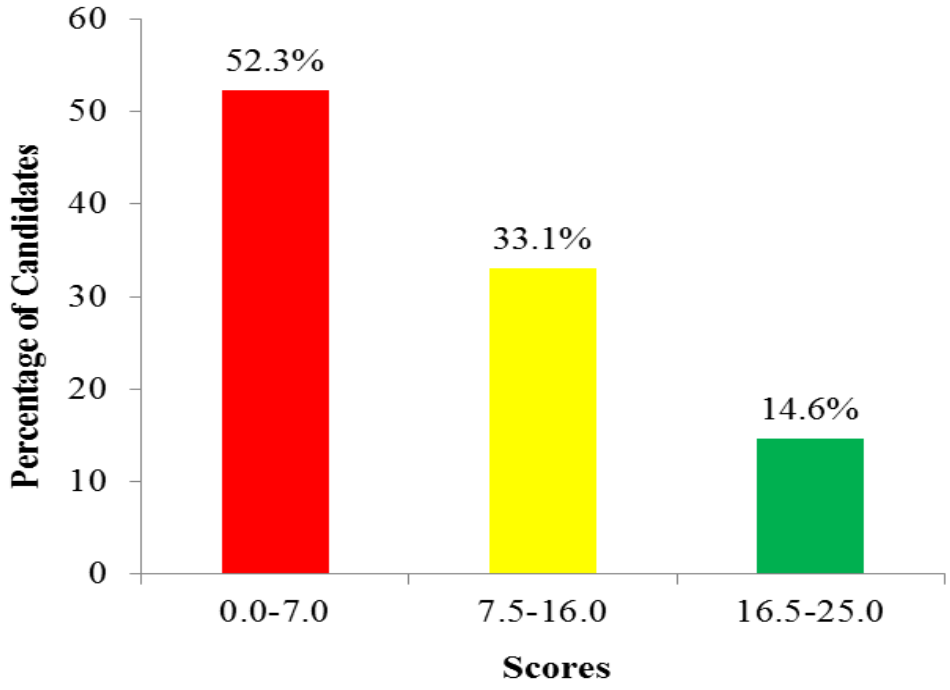


Figure 1: *Percentage of candidates' performance in question 1*

In this question the candidates were provided with a retort stand, a string of 110 cm, a stopwatch, 50 grams mass, cork pads and a metre rule.

The candidates were required to:

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

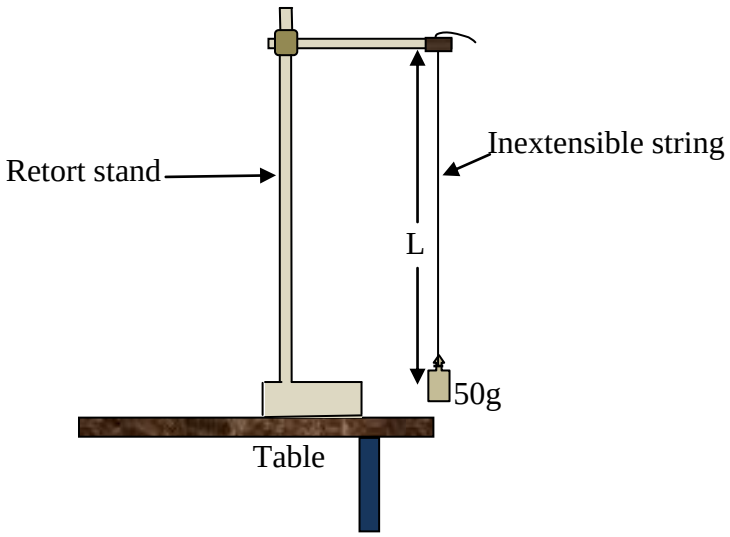


Figure 1

(b) Set the string at a length, L = 10 cm, displace the 50 g mass and release to make it oscillate and then determine the time, *t* taken for complete twenty oscillations (n = 20).

(c) Repeat the procedures in (b) for the values of L = 20 cm, 30 cm, 40 cm and 50 cm; and then:

(i) Tabulate their results including the value of t^2.

(ii) Plot a graph of t^2 (sec^2) against the length L (cm)

(iii) Find the slope of the graph,

(iv) Determine the value of 'Z' given that, $t^2 = \frac{4\pi^2 n^2 L}{Z} + c$

(v) State the significance of 'Z'.

(vi) State the aim of this experiment.

The candidates who scored high marks in this question were competent in analysing, evaluating and applying mathematical skills systematically to obtain the correct answer. These candidates managed to set the apparatus, prepare a table of results, and recorded the data correctly. These candidates collected the data at a reasonable range and then used a table of values to plot a graph of t^2 (sec^2) against the length L (cm) correctly.

In the graph, the candidates correctly indicated the following important aspects which are considered when marking the graph plotted: The title of the graph, including their units; the scale (vertical and horizontal scales) in a recommendable writing system, mainly in a statement form with their units; the axes (vertical and horizontal axes), with their respective SI units; transfer of points; best line or curve and slope indication. Moreover, the candidates used the points at the slope indication to find the slope of the graph by using the relation: $\text{Slope} = \frac{\Delta t^2 \ (sec^2)}{\Delta L \ (cm)}$. They also employed the equation of a line $y = m x + c$ to relate; $t^2 = \frac{4\pi^2 n^2 L}{Z} + c$ to determine the value of Z. Finally, the candidates stated correctly the significance of Z and the aim of the experiment. Extract 1.1 is a sample of responses from a candidate who scored high marks in this question.

1. i) TABLE OF RESULTS:

L (cm)	number of (n) oscillations	t (s)	t^2 (s^2)
10	20	14	196
20	20	19	361
30	20	23	529
40	20	26	676
50	20	29	841.

iii) From the graph;

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

$$S = \frac{(777.89 - 210.24) sec^2}{(46.2 - 11.165) cm}$$

$$S = \frac{567.65 sec^2}{35.035 cm} = 16.2 sec^2/cm$$

But where in sec^2/m, $1m = 100cm$

$$? = 35.035cm$$

$$S = 0.35035m$$

$$S = \frac{567.65 sec^2}{0.35035m}$$

$$S = 1620.2 sec^2/m$$

$$\text{Slope, } S = 16.2 sec^2/cm \text{ or } 1620.2 (sec^2/m)$$

iv) $t^2 = \frac{4\pi^2 n^2}{z} L + c$

$y = mx + c$

$m = \frac{4\pi^2 n^2}{z}$

1. (v) But when;

$$m = 1620.2 \text{ sec}^2/\text{m}$$

$$t^2 = \frac{4\Pi^2 n^2 l}{z} + c$$

$$y = mx + c$$

$$m = \frac{4\Pi^2 n^2}{z}$$

$$= \frac{4 \times (3.14)^2 \times 400}{1620.2}$$

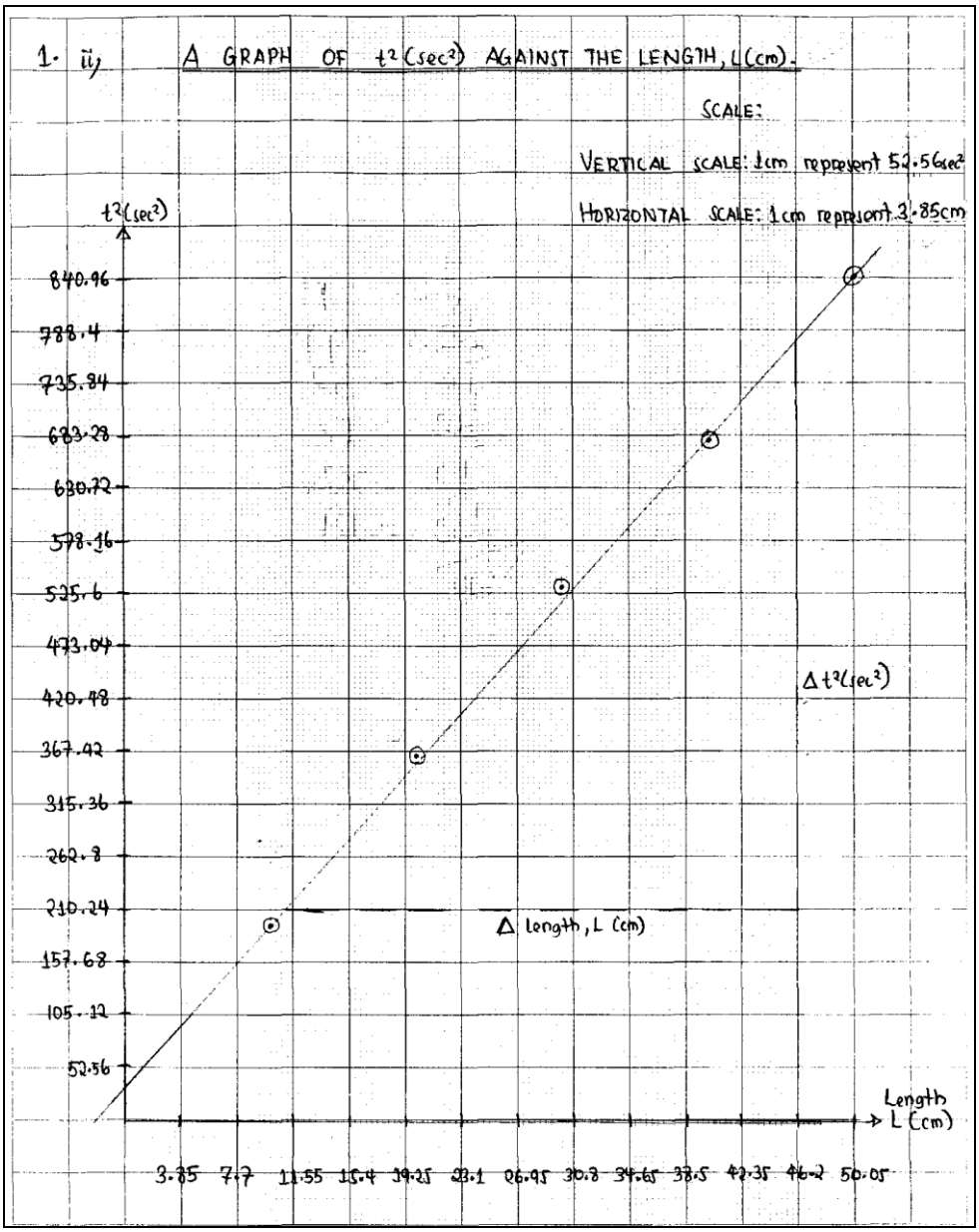
$$z = \frac{4 \times 9.8596 \times 400}{1620.2}$$

$$z = 9.737 \text{ m/s}^2$$

$$\therefore z = 9.737 \text{ m/s}^2$$

v) Z helps in attracting two objects together hence it holds us when on earth and helps the fruits to stay on trees.

vi) The aim of the experiment was to determine the acceleration due to gravity g



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

In extract 1.1, the candidate followed all the procedures correctly, recorded the data in a table form, plotted the graph and finally used it to perform the calculations appropriately. He/ she stated the significance of unknown Z and the aim of the experiment precisely.

The candidates who scored low marks in this question lacked knowledge of the concept of mechanics, specifically knowledge of simple pendulum. The

candidates who failed to set up the experiment correctly obviously failed to collect and record the data in the table of results. Some of the candidates drew the graphs without indicating the axes, title of the graph, the scale used, best line and slope indication. They also transferred the points incorrectly using the data which had been collected. These candidates had no knowledge of the choice of points for slope calculations, and thus failed to determine the rest of the items which depended on the previous variables.

Another remarkable shortcoming is that most of them confused the square of the time taken to complete 20 oscillations (t^2) and the square of time period of one oscillation (T^2); as a result they plotted a graph of T^2 against L instead of t^2 against L. They also lacked mathematical skills which made them end up with incorrect formula and answers. Others failed to state the significance of letter Z from the equation and the aim of the experiment. For example, one candidate explained that *the significance of Z is to determine the force constant*. This candidate did not understand that force constant is defined as the force required to produce unit extension or compression in the spring i.e., k=F/y. The SI unit of k is Nm^{-1}. If proper correlation of the formula given is done, the significance of Z is that it represents the acceleration due to gravity measured in m/s^2 or N/kg. They could also state the significance of Z as it helps to:

- fall towards the centre of the earth;
- determine the weight of an object; and
- measure the height (altitude) of mountains by using a barometer;

Extract 1.2 is a sample of candidate's weak responses observed in this question.

1. i) Soln

Length	Oscillation (20	t^2	$T^2(s^2)$
10		4.02	16.16
20		3.62	13.10
30		3.22	10.37
40		2.82	7.95
50		2.41	5.81

iii) Slope $\Rightarrow \frac{\Delta L}{\Delta T^2(s^2)}$

$\Rightarrow \frac{2.8 - 1.6}{60 - 30}$

$\Rightarrow \frac{1.2}{30}$

Slope $\Rightarrow$ 0.04 cm/s²

iv) Soln

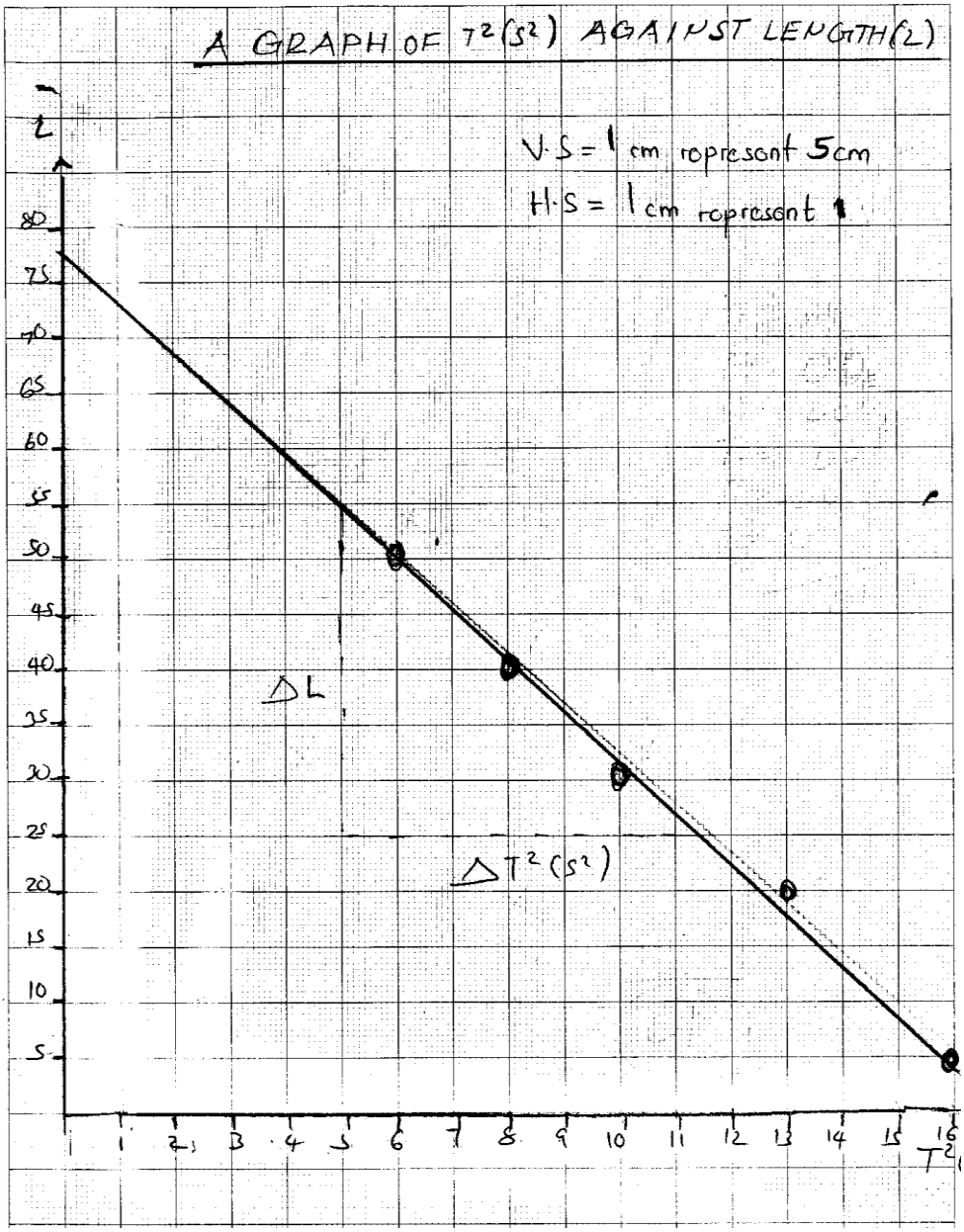
$\frac{t^2}{1} = \frac{4\pi^2 n^2 L}{2} + C$

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

$= \frac{1577.4}{288.881}$

54.61

$2 = 54.61$ Kns



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

Extract 1.2 shows that the candidate lacked content knowledge on the concept of simple pendulum as he/she failed to prepare the table of results by introducing irrelevant variables like T^2 instead of t^2. Also, the candidate drew a graph of L against T^2 instead of t^2 against L resulting in incorrect graph. Consequently, he/she failed to apply the linear equation $y = m x + c$ with the given one to perform the calculations.

4.1.2 031/2B Physics 2B

The candidates were provided with a retort stand with its accessories, two pieces of wood, a thread, pendulum bob, stop watch and a meter rule.

They were required to:

(a) Hang the pendulum bob on one end of a 90 cm length of thread and clamp the other end firmly between two small pieces of wood as shown in Figure 1.

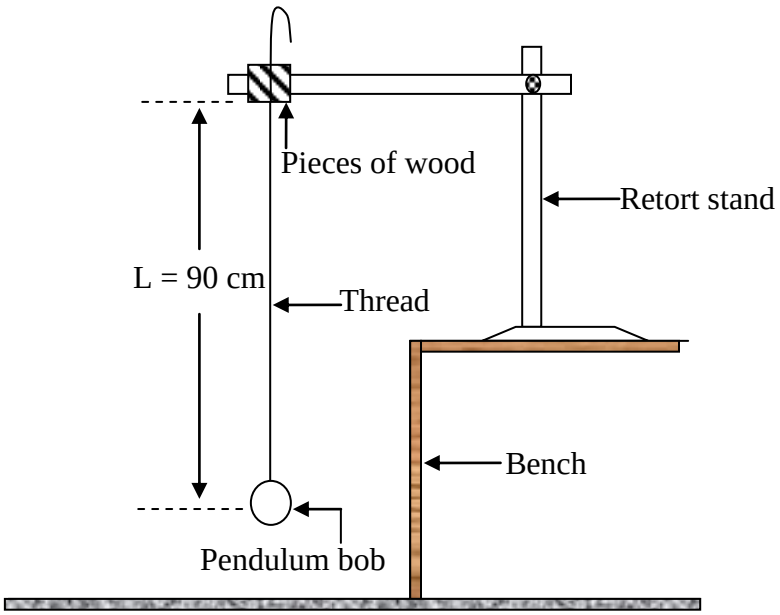


Figure 1

(b) Displace a pendulum bob to a small distance and release it such that,

It begins to swing to and fro motion. Determine the time *t* for twenty (20) complete oscillations and hence the corresponding periodic time, T.

(c) Repeat the procedures in 1 (b) for the values of L=70 cm, 50 cm, 30 cm and 10 cm.

Questions

(i) Construct a table of results that includes the values of T^2

(ii) Plot a graph of L (cm) against T^2 (sec^2)

(iii) From the graph determine the slope G

(iv) Find the value of the acceleration due to gravity, g.

(v) Give two importance of the value obtained in 1(iv) in daily life activities.

The candidates who had good scores of marks in this question were knowledgeable of the concept of mechanics, particularly in Simple pendulum, which aimed at determining the acceleration due to gravity. They managed to set the apparatuses as required, and to tabulate the results correctly. They also plotted correct graphs and use them to find the slope and acceleration due to gravity 'g'. Extract 2.1 shows a sample of good responses from one of the candidates who scored high marks in this question.

1. i) Table of results.

Length L (cm)	Time t for 20 oscillations (Sec)	Period time T (Sec)	T^2 (Sec^2)
90	38	1.9	3.6
70	32	1.6	2.6
50	28	1.4	2
30	22	1.1	1.2
10	12	0.6	0.4

ii) Soln.

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

$$= \frac{(90-10)\,cm}{(3.6-0.4)\,sec^2}$$

$$= \frac{80\,cm}{3.2\,sec^2}$$

$$\therefore \text{Slope } G = 25\,\frac{cm}{sec^2}$$

iv) Soln.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

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

1. (iv) $T^2 = \frac{4\pi^2 L}{g}$

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

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

but $\frac{L}{T^2}$ = Slope G

$g = 4\pi^2 \text{ Slope}$

$g = 4 \times 3.14 \times 3.14 \times 25 \text{ cm/sec}^2$

$g = 985.96 \text{ cm/sec}^2$

$g = 986 \text{ cm/sec}^2$

$\frac{986 \text{ cm/sec}^2}{100 \text{ m}}$

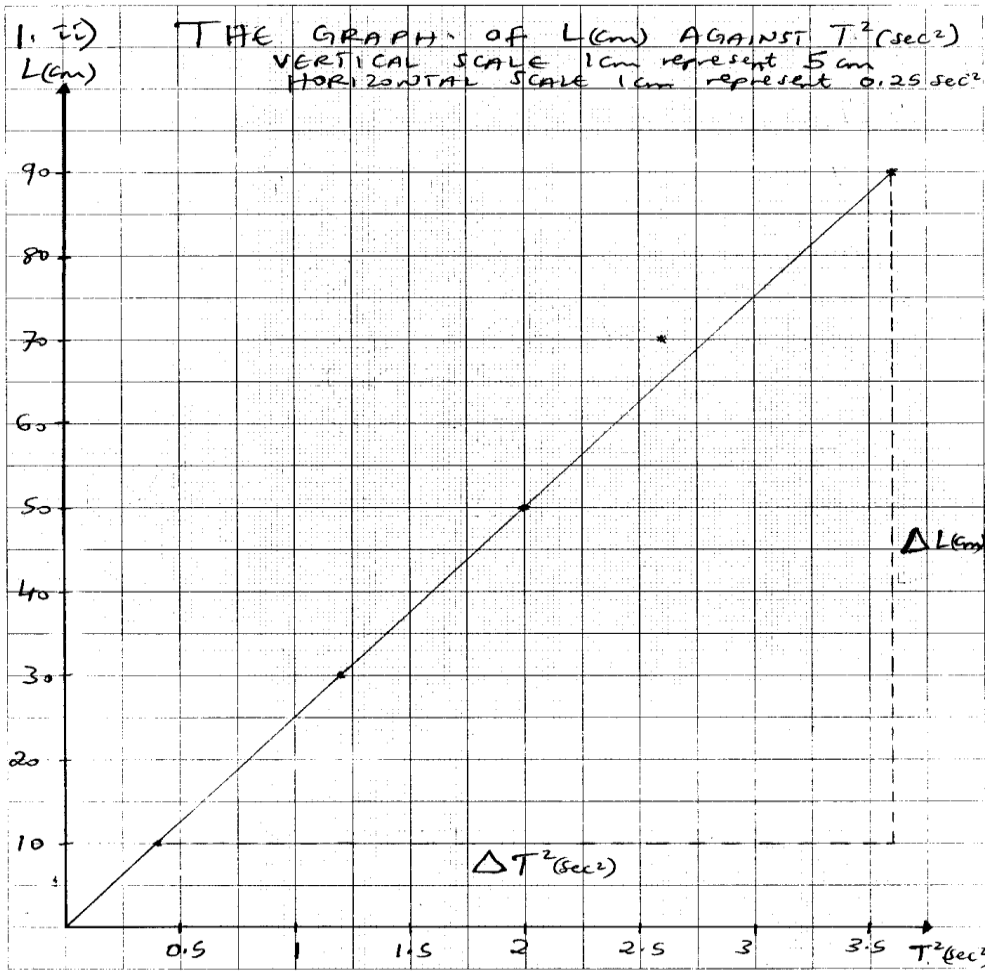
$\therefore \quad g = 9.86 \text{ m/sec}^2$

$\therefore$ Acceleration due to gravity is 9.86 m/sec^2

1. v) i) It helps to pull everythings toward the earth's surface. Without accelaleration due to gravity things can move and fly outward the earth's surface. So that the gravity control everything by pull towards the earth's surface.

ii) It helps people to walk possible. Without gravity people can't walk well and they can fly outward the earth's surface, so that people can lose their life.

1. ii)



Extract 2.1: A sample of candidate's good responses to question 1

In this extract, a candidate managed to provide correct data, draw a well labelled graph and use it to find the correct value of the acceleration due to gravity 'g'.

On the other hand, the candidates who performed below standard in this question had little knowledge of practical work especially knowledge of the concept of simple pendulum as part of the topic of mechanics. Some of these candidates provided concepts that were absolutely irrelevant to the given question. For example, one candidate drew a table of results mixed with the concepts of mechanics and light. This candidate inserted the length, time, the sine of an angle of incidence i and the angle of refraction r in the table as follows:

Qn 1.

(i)	length(cm)	Sin i	Sin r°	Time[-1]sec oscillation
	26cm	0.43	0.86	0.43
	24cm	0.40	0.8	0.40
	35cm	0.57	9.94	0.57
	40cm	0.64	0.01	0.64
	50cm	0.76	0.76.	0.76.

This is an indication that some of the candidates from different centres had mixed concepts, which consequently influenced their performance. Others failed even to prepare a table of values. Those who managed to tabulate the table of values collected and recorded incorrect data and because of wrong data, they failed to draw correct graphs. They also wrote incorrectly the important contents of the graph such as title, scale, axes and slope indication. For example, one of these candidates wrote T^2 (s^2) on vertical axis instead of L (cm) and L (cm) on horizontal axis instead of T^2 (s^2). Extract 2.2 shows a sample of weak responses in this question.

A TABLE OF RESULTS.

01 i)

values of (L)	Time for (T)	T^2	log(L)	log(T).
70	29	841	1·84509804	1·462397998
50	22	484	1·698970004	1·342422681
30	13	169	1·477121255	1·113943352
10	6	36	1	0·77815125

ii) From the graph slope is

$$\frac{\Delta L}{\Delta T} = \frac{70-1}{50}$$

$$= 3,505$$

∴ The slope of graph = 3505.

01 iv) From g)

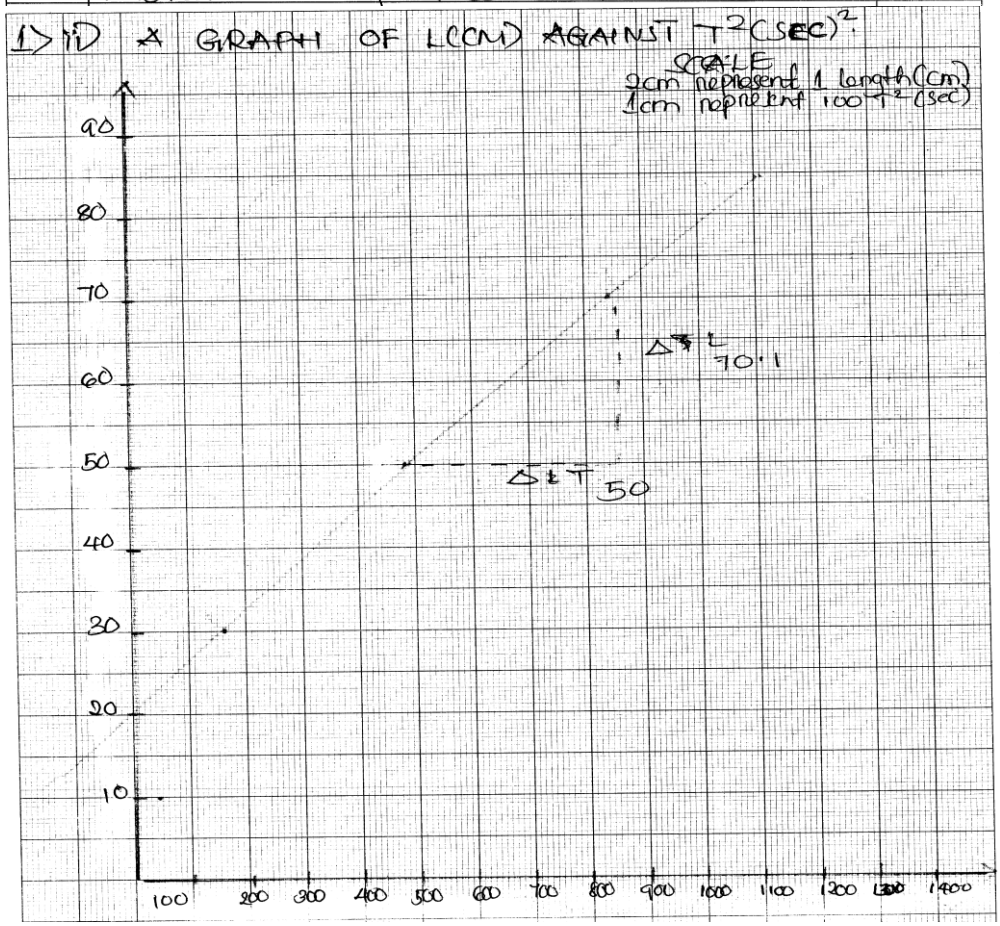
$= g = \left(\frac{T^2}{L}\right)$

$= g = \frac{3.14}{160}$

$g = 0.019625.$

v) a) It help in the force attraction.

b) It help in the rotation and movement of the earth.



Extract 2.2: A sample of candidate's weak responses to question 1

In extract 2.2, the candidate provided irrelevant data by including the log (L) and the log (T) in a table of results, which were not asked in the question. He/she failed to recall the formula for finding the period of the simple pendulum, and consequently made incorrect calculations. Also, the candidate only managed to write the title of the graph while writing wrong scale.

4.1.3 031/2C Physics 2C

In this question candidates were required to find the values of unknown masses m_1 and m_2. They were required to proceed as follows:

(a) Clamp a metre rule vertically with the zero mark uppermost. Suspend the spring as shown in Figure 1 using a plasticine. Attach an optical pin to its lower end so that its point will move over the vertical scale. Read and record the scale reading X_o.

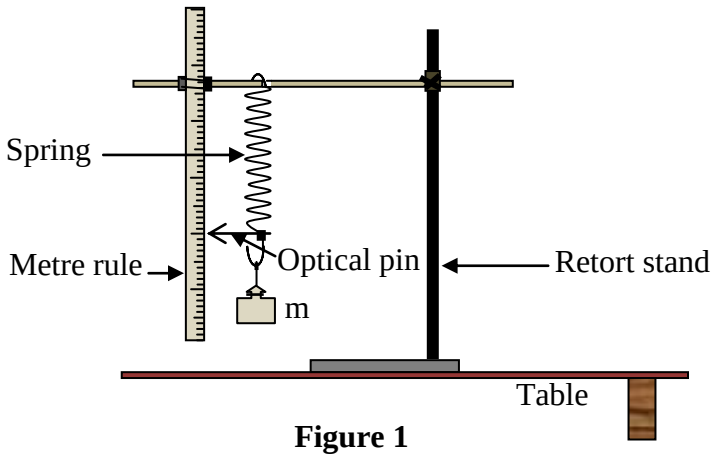


Figure 1

(b) Hang the mass = 50 g, to extend the spring. Read and record the new scale reading hence calculate the extension, $e = X_1 - X_o$

(c) Without removing the 50g mass and put the unknown mass m_1, repeat the procedures in 1(b) for the values of mass m =100 g, 150 g, 200 g and 250 g to obtain a total of five readings, and calculate the extension in each observation.

(d) Remove the last 250 g mass and put the unknown mass$_1$, record the new reading x_1 and the corresponding extension $e = X_1 - X_o$.

(e) Replace m_1 by m_2 and repeat the procedure 1(d), record the reading x_2 and the corresponding extension e_2

Questions

(i) Tabulate your results of m, x and e

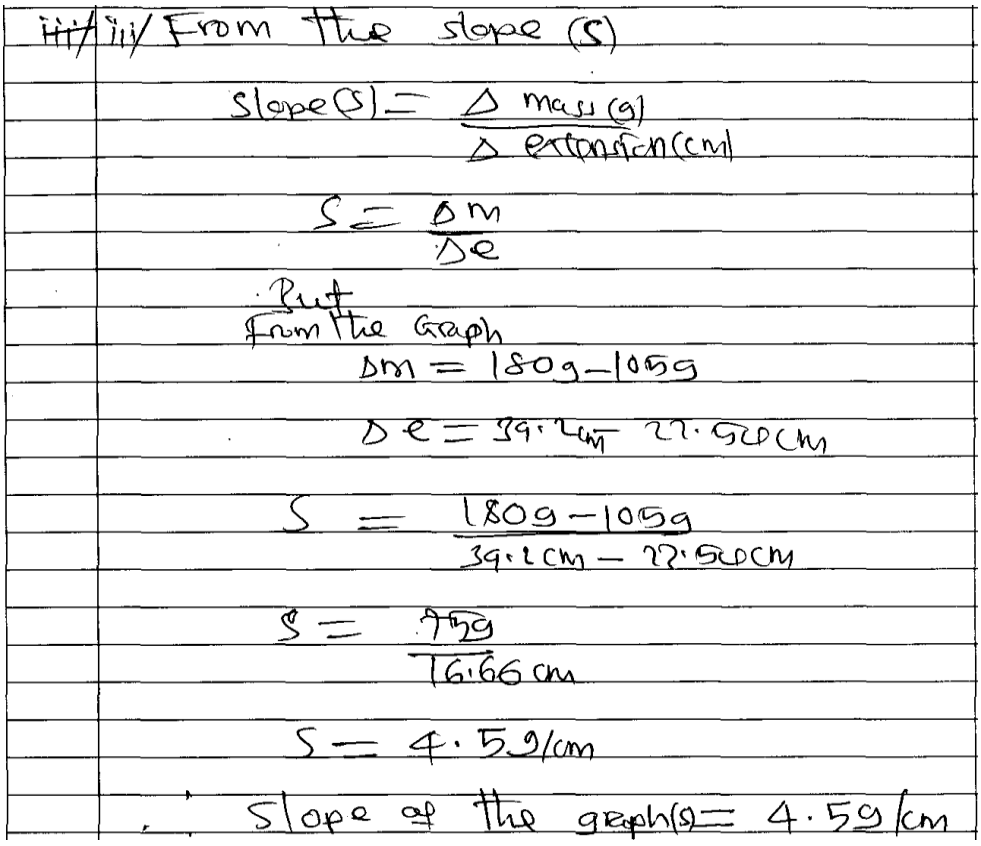
(ii) Plot a graph of mass (g) against extension e (cm).

(iii) Find the slope S of the graph

(iv) From the graph determine the unknown masses m_1 and m_2

(v) State the physical meaning of the slope S.

The candidates who scored higher marks in this question were knowledgeable of the concept of Hooke's law. They managed to assemble the apparatuses as required and set up the experiment correctly. Consequently, these candidates prepared a table of values correctly as per the instruction given by the question. Moreover, using the table of values, they plotted a well interpretable graph which finally assisted them to find the slope of the graph, determine the unknown masses m_1 and m_2, and state the physical meaning of the slope. Extract 3.1 presents a sample of the candidate's good responses to this question.



1 iv/ solution

From the table of result

M_1 produced extension of 16.9

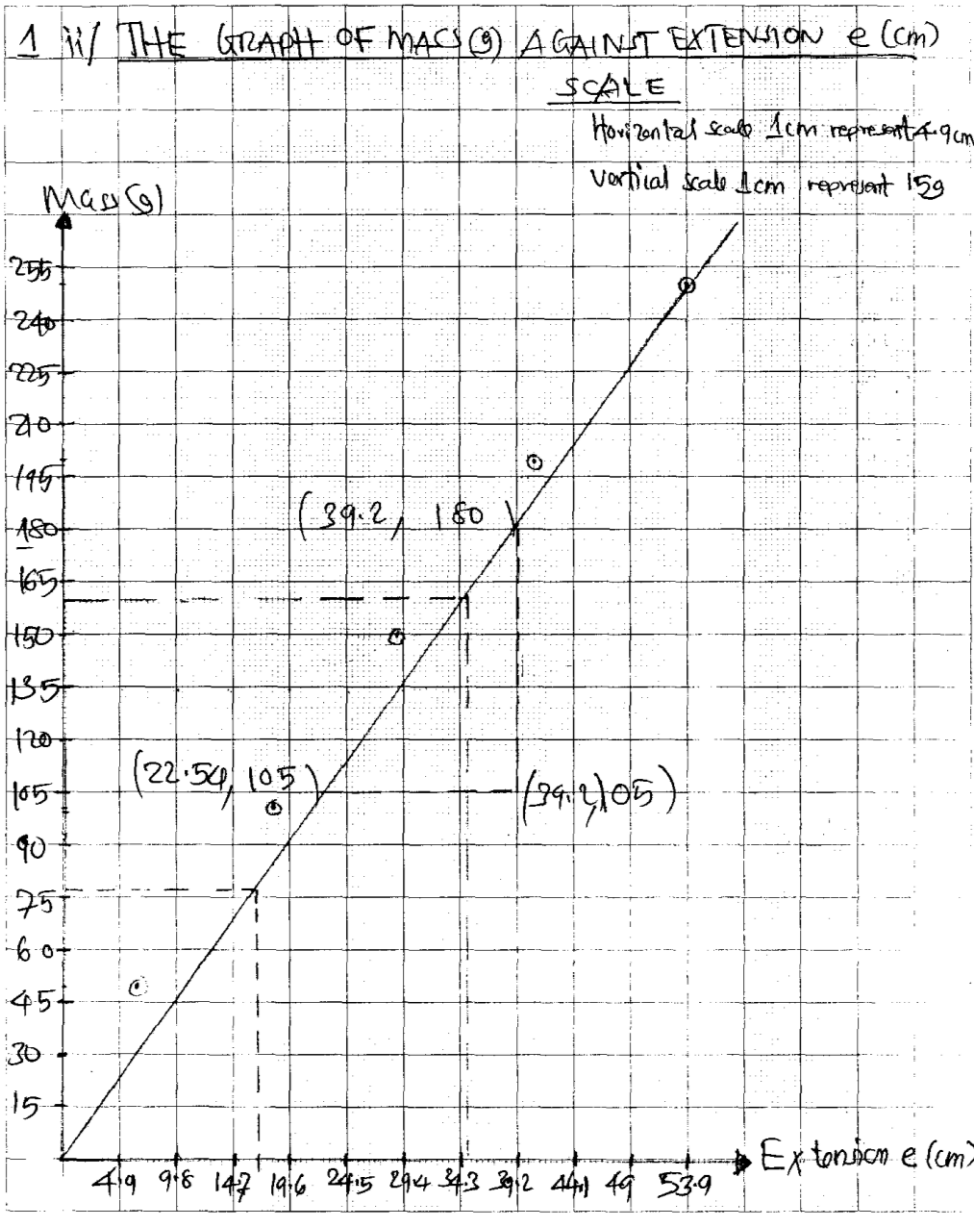
M_2 produced extension of 33.8

The extension is plotted on the graph paper

From the graph Mass of $M_1 = 76.5$

and Mass of $M_2 = 159g$

v/ Physical meaning of the slope is spring constant



Extract 3.1: A sample of candidate's good responses to question 1

In extract 3.1, the candidate answered almost all parts of the question correctly.

On the contrary, some of the candidates who attempted this question scored low marks because they had little knowledge of the concept of properties of matter, particularly Hooke's law. They seemed unfamiliar with the main idea in Hooke's law that whenever a stretching material such as a spring clamped at one end is stretched by an object attached at the other end, the force exerted is proportional to its extension provided the elastic limit is not exceeded. They were also supposed to know that extension is obtained by taking the difference between final length (when the spring is loaded) and the initial length of spring (when spring is not loaded). Some of the candidates failed to construct the required table of results. For example, one of these candidates included in a table of values the unknown masses m_1 and m_2 which were supposed to be found from the graph as follows:

	mass	m1	m2
	50	5	5
	100	10	25
	150	15	50
	200	20	75
	250	25	100
	300	30	125
	350	35	150

Extract 3.2: A sample of candidate's weak response in part of question 1

Extract 3.2 shows that the candidate lacked the knowledge of variation of force (weight) with extension (Hooke's law) for elastic materials.

The candidates were supposed to construct a table of results as follows:

m (g)	$x \pm 0.2$ cm	e (cm)
50	42.0	2.0
100	44.0	4.0
150	46.1	6.1
200	48.0	8.0
250	50.1	10.1

Another skill that the candidates lacked was drawing. Some of the candidates failed to plot a graph of mass (g) against extension (cm) correctly. The graphs they plotted lacked some important components such as title of the graph, axes, scales, slope indication, best line, and indication of transfer of points. Other candidates failed to do some calculations because of lack of mathematical skills. Extract 3.3 shows a sample of candidate's weak responses.

1. (a) Clamp a metre rule vertically with the zero mark uppermost. Suspend the spring as show in figure using a pratifine. Attach an optical pin to its lower end so that its point will move over the vertical scale. Read and record the scale reading X_0.

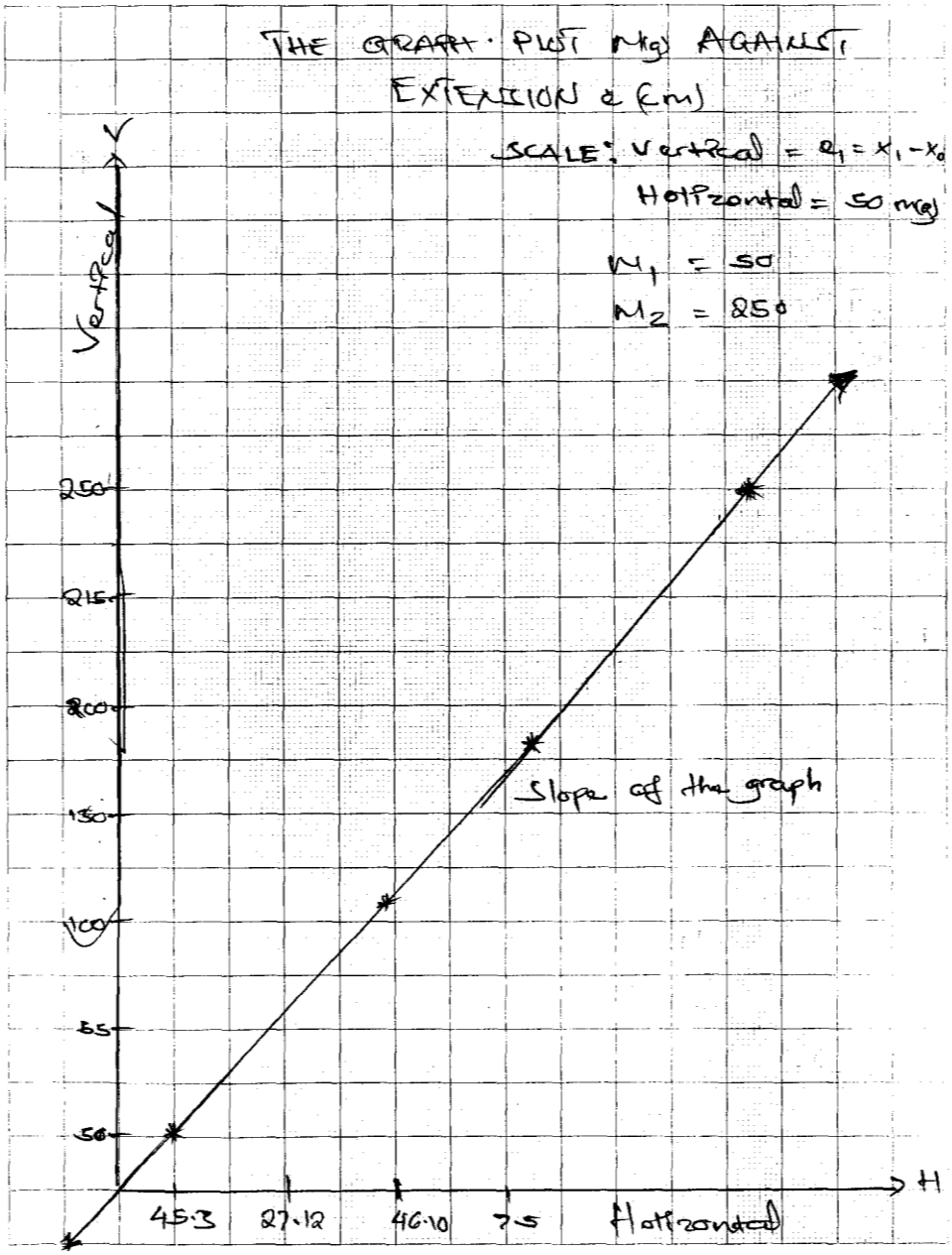
(b) Hang the mass, $m = 50g$ to extend the spring. Read and record the new scale reading x, hence calculate extension $e = x - x_0$.

Without removing the $M = 50g$ mass, represent procedure one (b) for the value of mass $m = 100g$, $m = 150g$, $200g$ and $250g$ obtain total five reading.

Removing the last 250g mass and put the unknown mass m_1, record the new reading x_1 and the corresponding, e in each observation. Represent M_1 by M_2 and repeat the procedure 1(b), record the x_2 and corresponding extension e_2.

(d) Tabulate result of m x and e

M	X	e	e
50g	453	13.09	9.06
100g	1309	18.05	13.09
150g	2712	23.05	18.08
200g	4610	28.05	23.05
250g	7.5	28.03	28.02



Extract 3.3: A sample of candidate's weak responses to question 1

Extract 3.3 shows the responses of a candidate who got low marks in this question. The candidate repeated to write the procedures given to set up the experiment instead of using them to record ad construct a table of values. In the graph, the candidate did not indicate correctly the axes, scale and slope indication.

4.2 Question 2: Current Electricity

4.2.1 031/2A Physics 2A

The question was attempted by119,918 (99.4%) candidates, of which 89,013 (74.2%) scored from 0 to 7.0 marks, 27,131 (22.7%) scored from 7.5 to 16.0 marks and 3,774 (3.1%) scored from 16.5 to 25.0 marks. These suggest that the candidates' performance was weak as only 25.8 percent scored from 7.5 to 25.0 marks. Figure 2 presents the candidates' performance in this question.

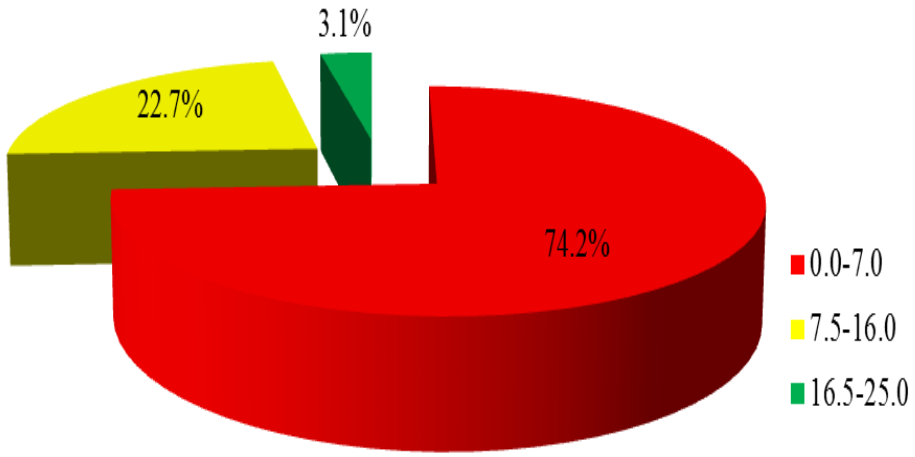


Figure 2: *Percentage of candidates' performance in question 2*

In this question the candidates were provided with 2 dry cells connected in series E, a resistance box R, a voltmeter V and a key K.

The candidates were then required to:

(a) Arrange the apparatus as shown in Figure 2.

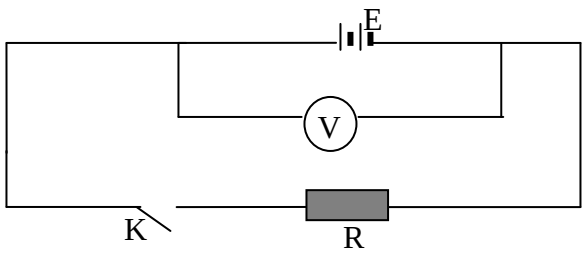


Figure 2

(b) Set R = 1 Ω in the resistance box, close the key K, read and record the value of V on the voltmeter.

(c) Repeat the procedure in (b) above for values of R = 2 Ω, 3 Ω, 4 Ω and 5 Ω, and record the values of the corresponding V in each case,
They were also required to:

(i) Tabulate their results including the values of $\frac{1}{V}$

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

(iii) Find the slope 'S' of the graph.

(iv) Record $\frac{1}{V}$ intercept as P and R intercept as Q.

(v) Determine the value of the ratio: $\frac{P}{Q}$, and lastly state how the value obtained is related to the slope, S of the graph.

The candidates who scored low marks in this question had little knowledge of the concept of current electricity. These candidates failed to recall and apply the necessary skills in assembling the circuit components as instructed in the question. They gathered and recorded incorrect data resulting in wrong table of values. Most of these candidates failed to prepare scales, transfer the points, label the axes, and indicate slope when drawing the graphs. For example, some of them wrote a scale as '*1cm to 1*Ω*"* instead of '*1cm represents 1*Ω*''*. Extract 4.1 is a sample of the responses of one of the candidates who scored low marks in this question.

2 (i) TABLE OF RESULT

Resistance (R)	Voltmeter (V)	1/V
1Ω	3.0	1/3.0 = 3.0
2Ω	3.2	1/3.2 = 3.2
3Ω	3.4	1/3.4 = 3.4
4Ω	3.6	1/3.6 = 3.6
5Ω	3.8	1/3.8 = 3.8

(ii) Slope = $\frac{\Delta 1/V}{\Delta R(\Omega)}$

Slope = $\frac{3.7 - 3.1}{4.5 - 2} = \frac{0.6}{2.5}$

Slope = 4 V/R(Ω)

(iii) $\frac{1}{V}$ = P and R intercept as Q

$\frac{1}{3.0}$ = 3.0

$\frac{1}{3.2}$ = 3.2

(iv) $\frac{1}{3.4}$ = 3.4

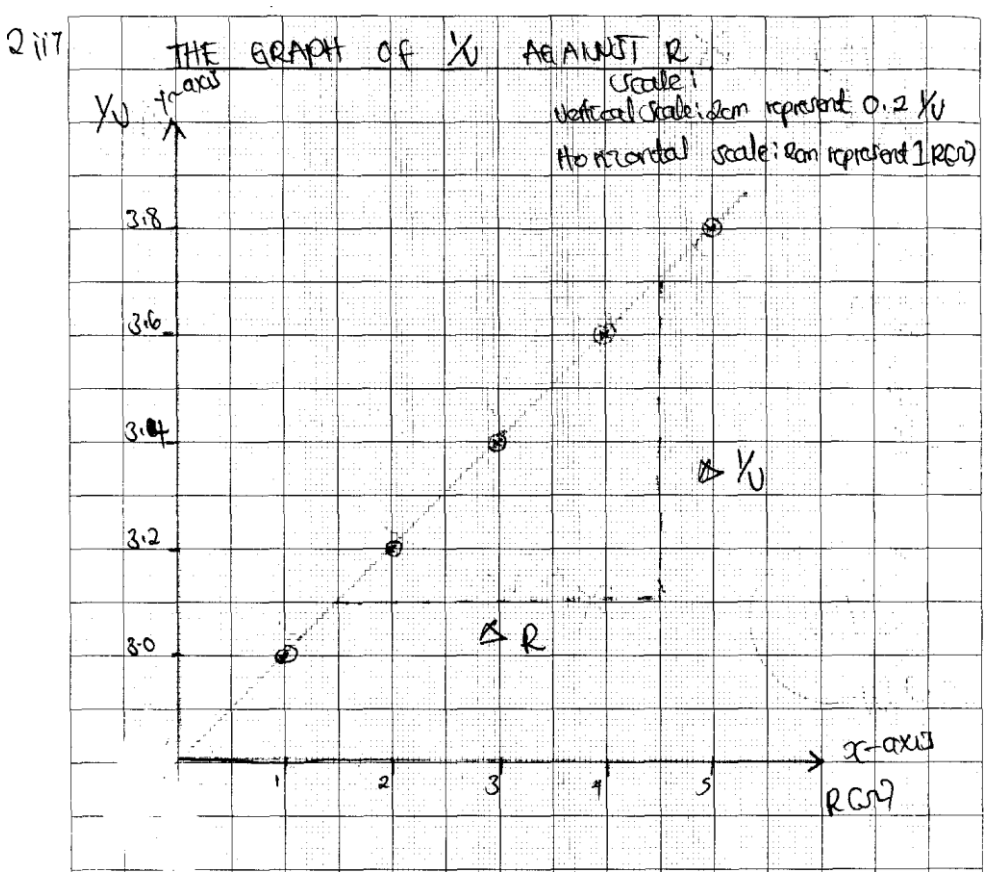
$\frac{1}{3.6}$ = 3.6

$\frac{1}{3.8}$ = 3.8

$\frac{1}{V}$ intercept = 0 as P and R intercept as Q

(v) $\frac{P}{Q} = \frac{1}{V} = R = 0$

The value obtained is related to slopes of the graph due to its intercept = 0 which is the ratio of $\frac{P}{Q}$



Extract 4.1: A sample of candidate's weak responses to question 2

In extract 4.1, the candidate provided incorrect responses to almost all parts of the question. Because of incorrect data collected, the candidate drew irrelevant graph with an incorrect scale.

Few candidates who scored higher marks in this question were knowledgeable of the concept of Current electricity. They were able to connect the circuit properly, which enabled them to tabulate the results of the data gathered correctly. These candidates had good skills in drawing the graph of $\frac{1}{V}$ against R and finding the intercepts of both R and $\frac{1}{V}$. They also demonstrated good computational skills as they managed to establish the relevant mathematical equations and correctly calculated the asked quantities. Extract 4.2 is a sample of candidates' correct responses to this question.

c.i Table of results including values of 1/V.

Resistance R(Ω)	Voltage(V)	1/V volt^{-1}
1	1.5	0.667
2	1.8	0.556
3	1.9	0.526
4	2	0.5
5	2.1	0.476

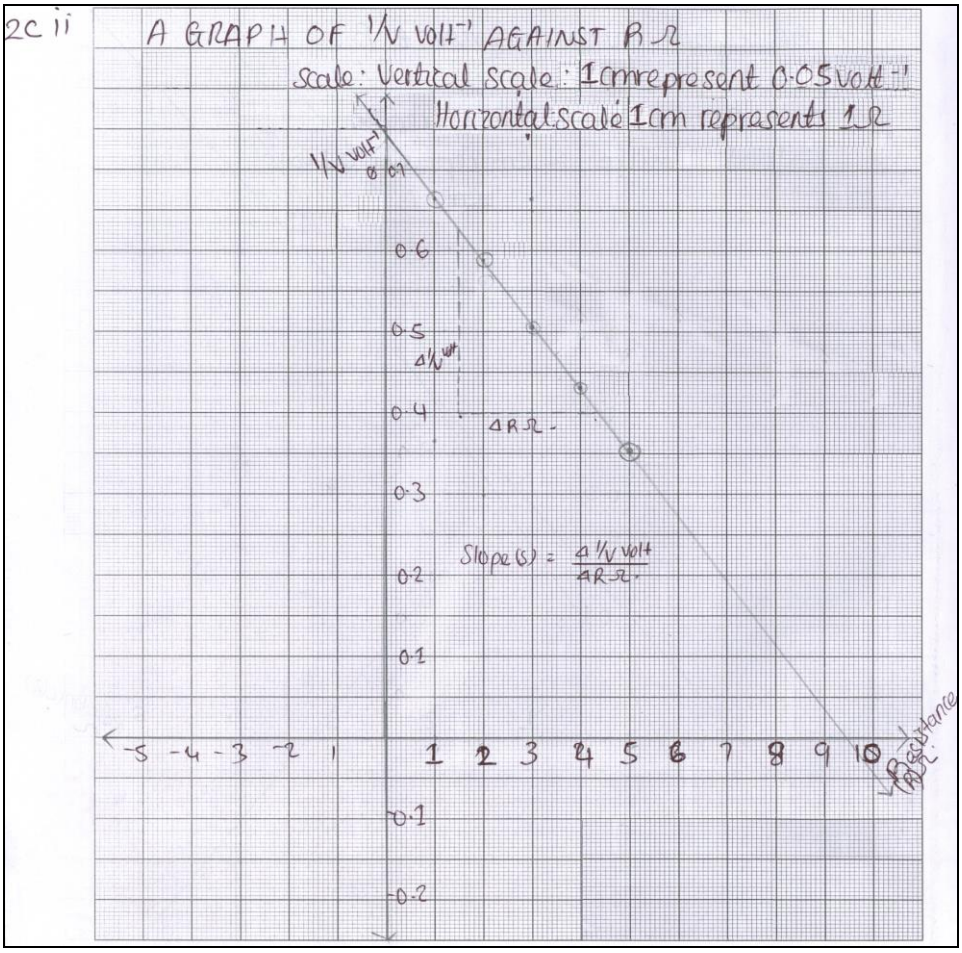
iii Slopes of the graph

$$\text{Slope (S)} = \frac{\Delta \text{ 1/V volts}^{-1}}{\Delta \text{R}\Omega}$$

$$\text{Slope (s)} = \frac{0.625 - 0.4 \text{ 1/V}}{1.5 - 4.3\ \Omega}$$

$$\text{Slope (s)} = \frac{0.225 \text{ 1/V}}{-2.8\ \Omega}$$

	Slope, $S = -0.08\ 1/V\Omega$
	∴ The slope S of the graph is $-0.08\ 1/V\Omega$.
iv	$1/V$ intercept as P is $-0.74\ 1/V$ and R intercept as Q is 9.4Ω
v.	Ratio between P/Q
	$= \frac{P}{Q} = \frac{-0.74\ 1/V}{9.4\Omega}$
	$= 0.078\ 1/V\Omega \approx 0.08$
	∴ The ratio of P/Q is $0.078\ 1/V\Omega \approx 0.08\ 1/V\Omega$.
	The value obtained is related to the slopes of the graph because they indicate the negative of each other.



Extract 4.2: A sample of candidate's good responses to question 2

Extract 4.2 shows that the candidate set the experiment and prepared a table of values correctly. He/she determined the slope of the graph and correctly read the intercepts from the graph. The candidate also drew a graph correctly with all the necessary points.

4.2.2 031/2B Physics 2B

In this question, the candidates were provided with a resistance box R, a dry cell E, a switch S, a jockey J and a centre- zero galvanometer. They were required to determine the value of the unknown resistance X by means of a metre bridge as follows:

(a) Set up the circuit as shown in Figure 2.

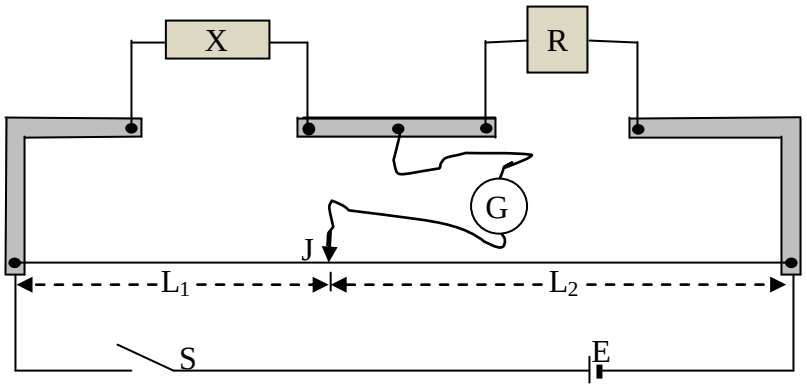


Figure 2

(b) Set R =1Ω, close the switch, slide the jockey over the metre bridge wire until the galvanometer reads zero. Read and record the length L_1.Also read and record the corresponding length L_2.

(c) Repeat the procedures in 2 (b) for values of R = 2Ω, 3Ω, 5Ω and 7Ω and record the values for L_1 and L_2 in each case. The candidates were also required to:

(i) Tabulate your results including the values of $\frac{L_2}{L_1}$

(ii) Plot a graph of R against $\frac{L_2}{L_1}$

(iii) Find the slope S of the graph

(iv) Determine the value of the unknown resistance X by showing clearly how you arrive at your answer.

The candidates who scored low marks in this question had little knowledge of the concept of Current electricity, particularly the metre bridge. The responses given by these candidates revealed that they failed to make proper connection of the circuit, and thus collected incorrect values of the required quantities. For example, the following is the table of values prepared by one of these candidates.

02.	Table value				
(i)	R	L_1	L_2	L_2/L_1	
	1	0.05	0.01	0.2	
	2	0.1	0.03	3.3	
	3	0.15	0.04	3.8	
	5	0.25	0.06	4.2	
	7	0.35	0.09	3.9	

Extract 5.1: Part of a candidate's weak response

This extract portrays that the candidate had little knowledge of the topic of current electricity since all the variables R, L_1 and L_2 have unknown measuring units such that one cannot understand what the variables represent. If Ls represent the length then the units should be shown as cm or m.

Most of the candidates failed to get the correct slope as their table of values and graphs were incorrect. The candidates were supposed to prepare a table of values as follows:

R (Ω)	($L_1 \pm 0.1$) cm	($L_2 \pm 0.1$) cm	$\frac{L_2}{L_1}$
1	80.0	20.0	0.25
2	66.7	33.3	0.50
3	57.1	42.9	0.75
5	44.4	55.6	1.25
7	36.4	63.6	1.75

From the table of values they could plot a graph of R against $\frac{L_2}{L_1}$ correctly.

To determine the value of X of the resistor of unknown resistance, the candidates were supposed to apply the metre bridge theory, $\frac{R}{x} = \frac{L_2}{L_1}$

Then, R = ($\frac{L_2}{L_1}$) X. By comparing this with linear equation;

$y = m x + c$, the slope of the graph is equal to the value of the unknown resistance X. Extract 5.2 shows a sample of response from a candidate who scored low marks in this question.

2 (i) Table of results

R (ohm)	h_1 (cm)	h_2 (cm)	h_2 / h_1
1 ohm	-284	384	-4.64
2 ohm	-92	192	-2.91
3 ohm	-28	128	-4.86
5 ohm	23.2	76.8	3.31
7 ohm	45.2	54.8	1.21

ii) Scales;
Horizontal Scale 1cm represents 0.5
Vertical Scale 1cm represents 1 ohm.

iv) $-R = -X$

$\frac{-4}{-} = \frac{-X}{-}$

$X = 4$ ohms.

From the graph.

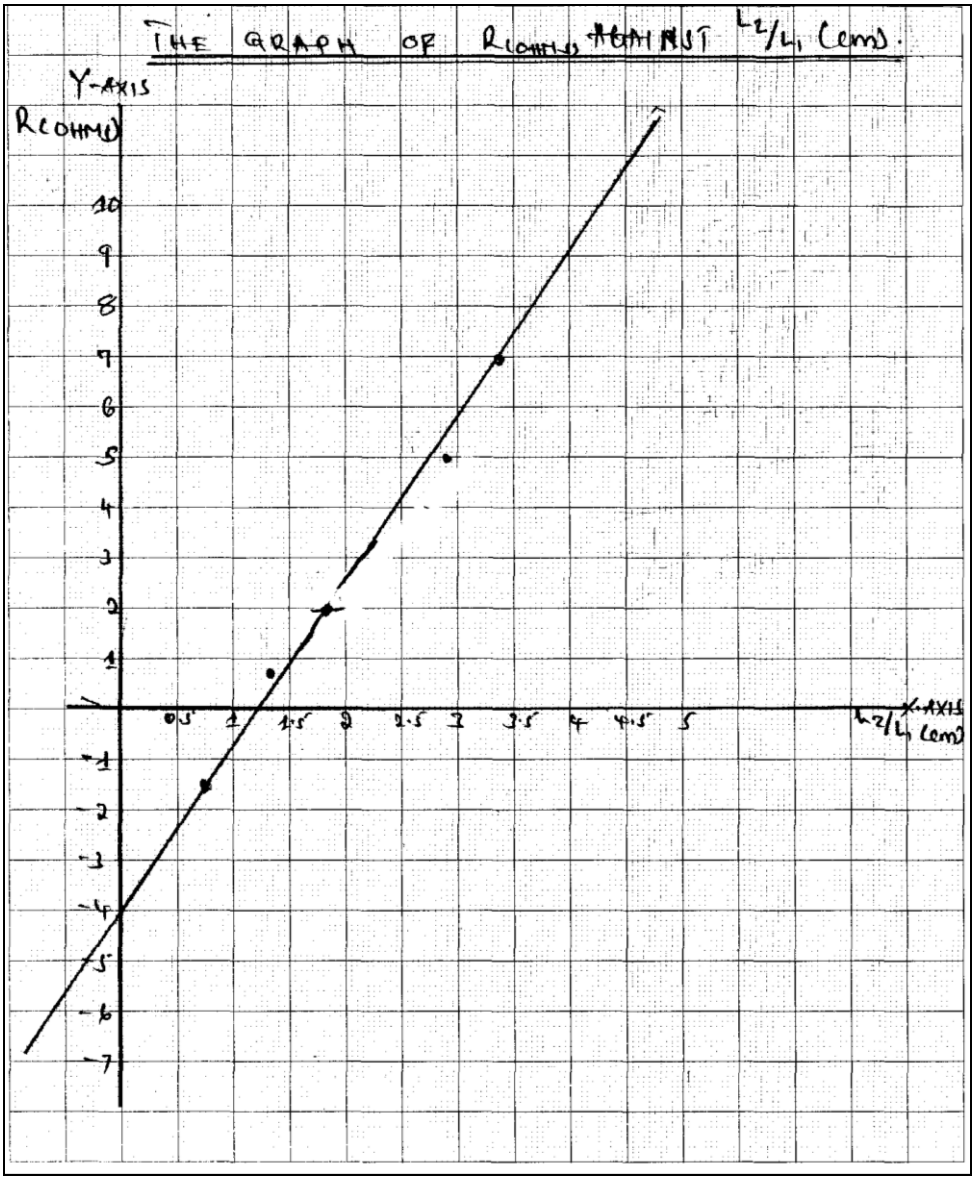
iii) Slope $= 100X$

but $X = 4$

Slope $= 100 \times 4$

Slope $= 400$ cm/ohm

$\therefore$ Slope is 400



Extract 5.2: A sample of candidate's weak responses to question 2

Extract 5.2 shows how the candidate failed to construct a table of values correctly. He/she plotted inappropriate graph which does not comply with the required one due to incorrect data values. The candidate lacked mathematical skills.

The candidates who scored high marks in this question were knowledgeable of the concept of current electricity, particularly the metre bridge theory. These candidates had the necessary skills in setting the apparatuses. They tabulated the data correctly and applied them in plotting the graph of R (Ω) against $\frac{L_2}{L_1}$ and performing the necessary calculations to find the unknown resistance X. Extract 5.3 provides an example of good responses from one of the candidates in this question.

2. (i) Table of result

R (Ω)	L_1 (cm)	L_2 (cm)	L_2/L_1
1	80	20	0.25
2	66.70	33.3	0.50
3	57.10	42.90	0.75
5	44.44	55.66	1.25
7	36.40	63.60	1.75

2. (ii) Required to plot graph of R against L_2/L_1

From

$$\frac{x}{L_1} = \frac{R}{L_2}$$

$$RL_1 = xL_2$$

$$R = x\frac{L_2}{L_1}$$

From

$$R = x\left(\frac{L_2}{L_1}\right)$$

$$y = mx$$

$m = x$, $y = R$, $x = L_2/L_1$

So nature of graph will pass through origin.

Vertical axis R (Ω)

1cm represent 0.5Ω

Horizontal axis (L_2/L_1)

1cm represent 0.125

2. (ii) To determine ~~acceleration~~ slope (S) of Graph.

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

$$\text{Slope} = \frac{\Delta R\ (\Omega)}{\Delta\ (L_2/L_1)}$$

$$\Delta R\ (\Omega) = (5-2)$$

$$\Delta\ (L_2/L_1) = (1.25 - 0.5)$$

$$\text{Slope(S)} = \frac{(5-2)\ \Omega}{1.25 - 0.5}$$

$$\text{Slope(S)} = \frac{3\ \Omega}{0.75}$$

$$\text{Slope(S)} = 4\ \Omega$$

∴ The Slope (S) of Graph is $4\ \Omega$

2 (iv) To determine Value of unknown resistance

From the equation.

$$R = x\frac{L_2}{L_1}$$

Compare to Nature of Graph

$$R = x\frac{L_2}{L_1}$$

$$y = m\ x$$

$y = R$, $m = x$, $x = L_2/L_1$

So

$$x = m$$

m = Slope.

Unknown resistance = Slope

but

Slope = $4\ \Omega$

So $x = 4\ \Omega$.

∴ The Value of unknown resistance is $4\ \Omega$

2. (iv) ~~Imagine~~ Or
imagine from table of result
when $R = 1\,\Omega$, $L_2/L_1 = 0.25$

but
equation
$R = x \frac{L_2}{L_1}$

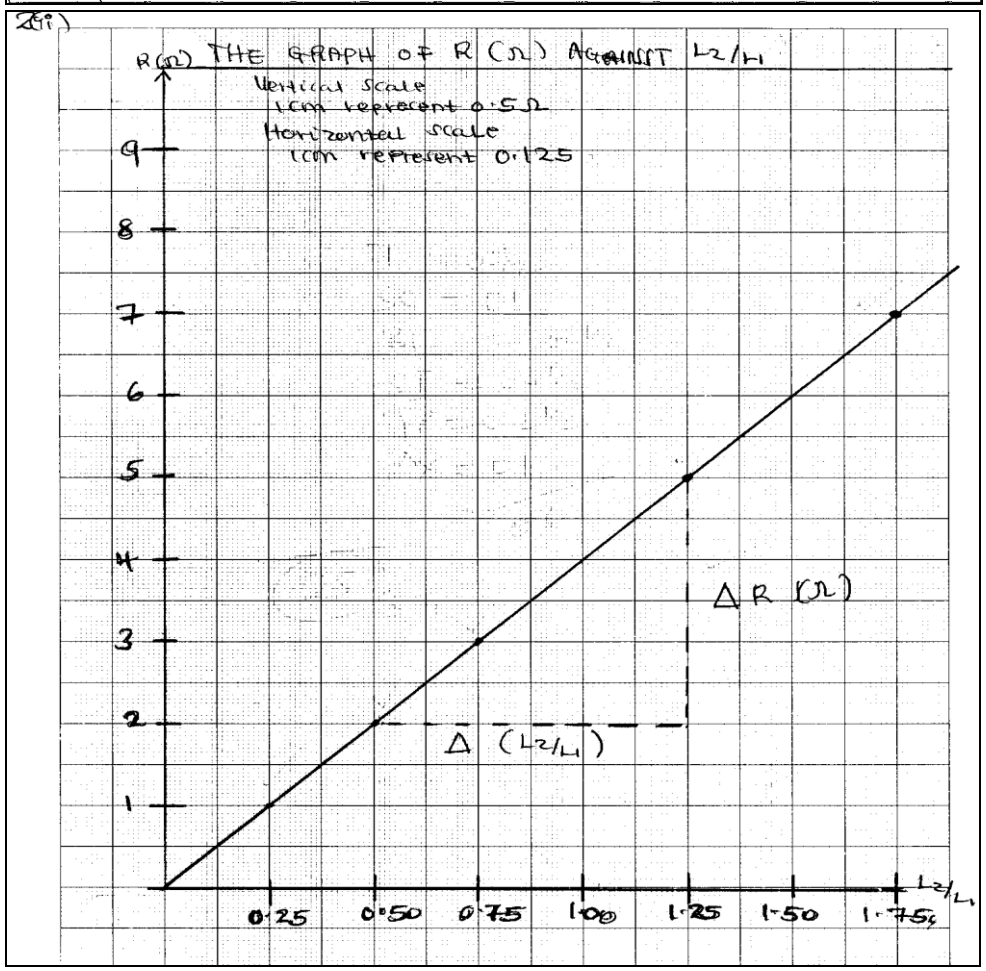
$1\,\Omega = x\ 0.25$

$x = \frac{1\,\Omega}{0.25}$

$x = 4\,\Omega$.

∴ The value of unknown resistance is $4\,\Omega$.

(i)



Extract 5.3: A sample of candidate's good responses to question 2

Extract 5.3 shows the responses of a candidate who managed to construct a table of values correctly and thus obtained an appropriate graph. He/she applied the correct graph to find the slope and the value for the unknown resistance X of the resistor.

4.2.3 031/2C Physics 2C

This question required the candidates to determine the resistance per unit length ρ of the wire provided through the following procedures:

(a) Set up the circuit as shown in the diagram below, where R is the resistance box, E is a dry cell, K is a key, G is a centre-zero galvanometer, J is a jockey and x is a wire of unknown resistance.

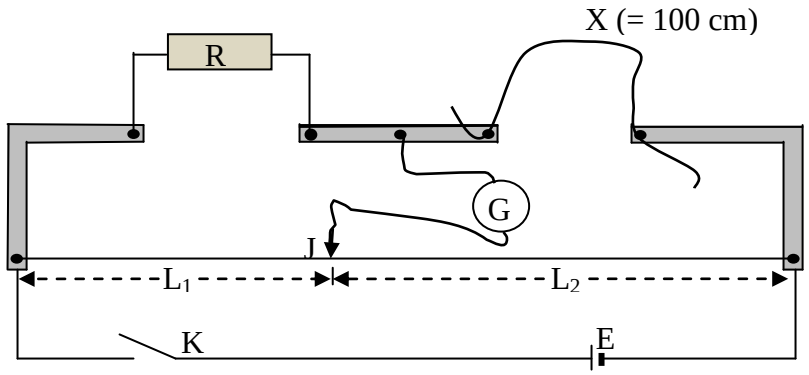


Figure 2

(b) Measure the length x of the wire provided equal to 100 cm, fit it to the metre bridge as shown in Figure 2 .Close the key and slide a jockey over the resistance wire of the metre bridge until the galvanometer reads zero. Read and record L_1 and its corresponding L_2

(c) Repeat the procedures in 2(b) without changing the length x, setting R=2 Ω, 3 Ω, 4 Ω and 5 Ω and record the values for L_1 and the corresponding values of L_2 in each case.

The candidates were required to:

(i) Tabulate your results including the values of $\frac{L_1}{L_2}$

(ii) Plot a graph of R against $\frac{L_1}{L_2}$

(iii) Compute the slope of the graph

(iv) Determine the value for the resistance per unit length ρ of the wire provided. Show clearly how you arrive to your answer.

The performance of the candidates in this question was generally weak. Most of the candidates who did this question repeated the instruction given in the question instead of answering it. Some of the candidates skipped the item which required them to construct a table of results. The failure to prepare the table of results contributed to low score of marks as other parts of the question depended on it. This is an indication that these candidates had little knowledge of the concept of the metre bridge theory in the topic of current electricity. Another competence that some candidates lacked was drawing and computational skills. For example, in an attempt to determine the resistance per unit length of the wire, one candidate wrote:

$\text{Resistance} = \frac{\text{Length per unit}}{\text{Potential difference}}$. This is not correct and does not make sense. The candidates were supposed to use the following relationship: $\text{Resistance per unit length} = \frac{R_w}{L}$; where R_w and L are the resistance and length of the wire respectively.

Besides, in some of the drawn graphs, the style of writing scale was incorrect. For example, some wrote the scales in the form of: $1cm \equiv 1\Omega,$ or $1cm = 1\Omega,$ or $1cm \rightarrow 1\Omega,$ instead of *1 cm represents 1* Ω. Extract 6.1 shows a sample of candidate's incorrect responses to this question.

2. i) TABLE OF RESULT

R (Ω)	L_1 (cm)	L_2 (cm)	L_1/L_2 cm
1	85.2	14.8	5.76
2	74.8	25.2	2.97
3	65.2	34.8	1.87
4	59.7	40.3	1.48
5	54.8	45.2	1.22

2. ii) Table of Value

R Ω	L_1/L_2 C
5	1.22
4	1.48
3	1.87
2	2.97
1	5.76

2. iii) From the graph

Slope S(s) $= \frac{5-1}{1.22-5.76}$

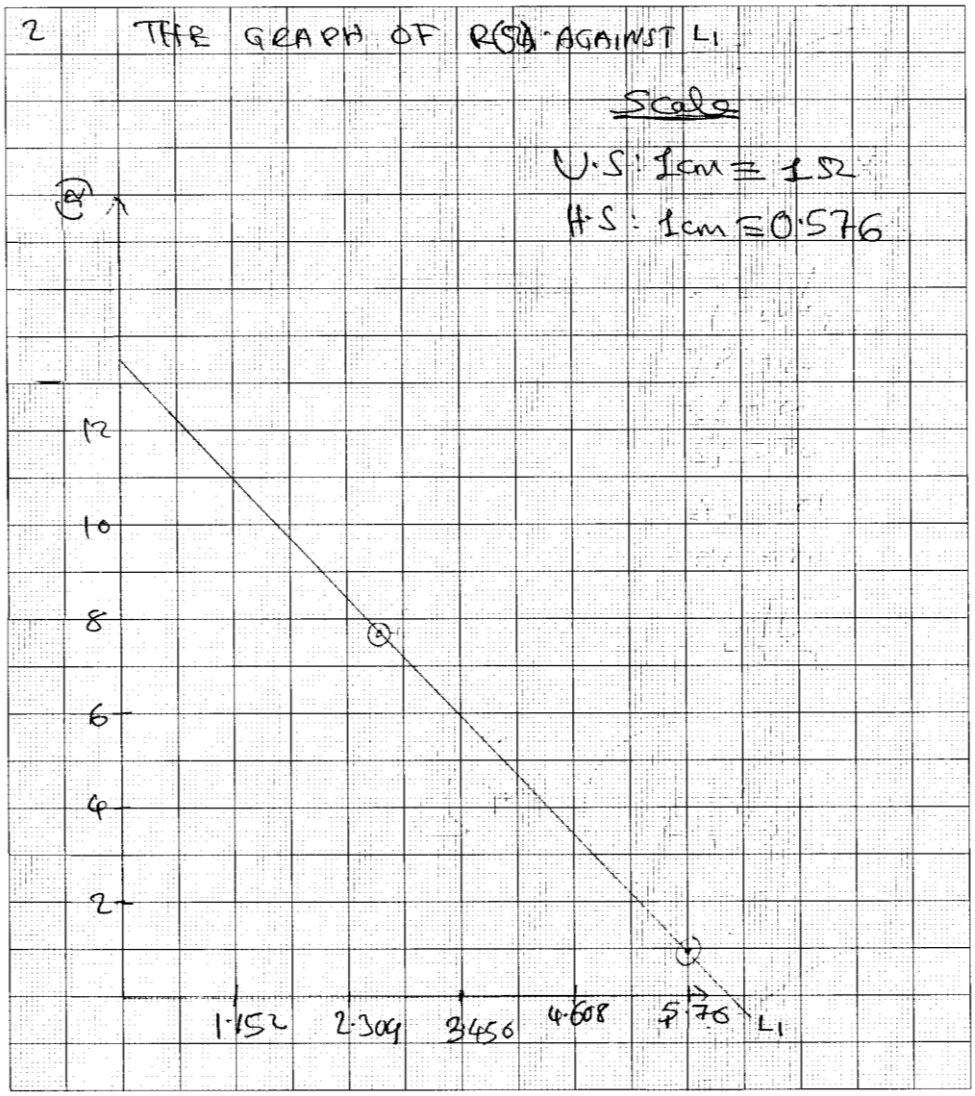
$= \frac{4}{-4.54} = -0.88\,\Omega$

2. (v) Solution

From

$$S = \frac{AR}{L}$$

$$= \frac{0.004 \times 0.88}{1}$$



Extract 6.1: A sample of candidate's weak responses to question 2

Extract 6.1, depicts the responses of a candidate who provided an incorrect table of values and applied irrelevant formula to perform calculations. In the graph, the candidate indicated the scale of the graph and other significant labels incorrectly.

However, other candidates had sufficient knowledge on the concept of the metre bridge theory in the topic of current electricity. These candidates managed to construct the required table of values, plot the graph and use it appropriately to determine the slope of the graph. They also established relevant expressions to obtain the resistance of the wire per unit length.

Extract 6.2 is a sample of the responses given by one of the candidates who answered this question.

2(i) TABLE OF RESULT.

R (Ω)	L_1 (cm)	L_2 (cm)	L_1/L_2
1Ω	20.8	79.2	0.36
2Ω	34.5	65.5	0.53
3Ω	44.8	55.2	0.79
4Ω	51.3	48.7	1.05
5Ω	56.8	43.2	1.31

2 (iii). From the above graph.

Recall from;

$$\text{Slope } (m) = \frac{\Delta R}{\Delta L_1/L_2}$$

But A (0.6026, 1.875)

B (1.048, 4).

Then;

$$\text{slope} = \frac{(4 - 1.875)\Omega}{1.048 - 0.6026}$$

$$\text{slope} = \frac{2.125}{0.4454}$$

$$\text{Slope} = 4.77\Omega.$$

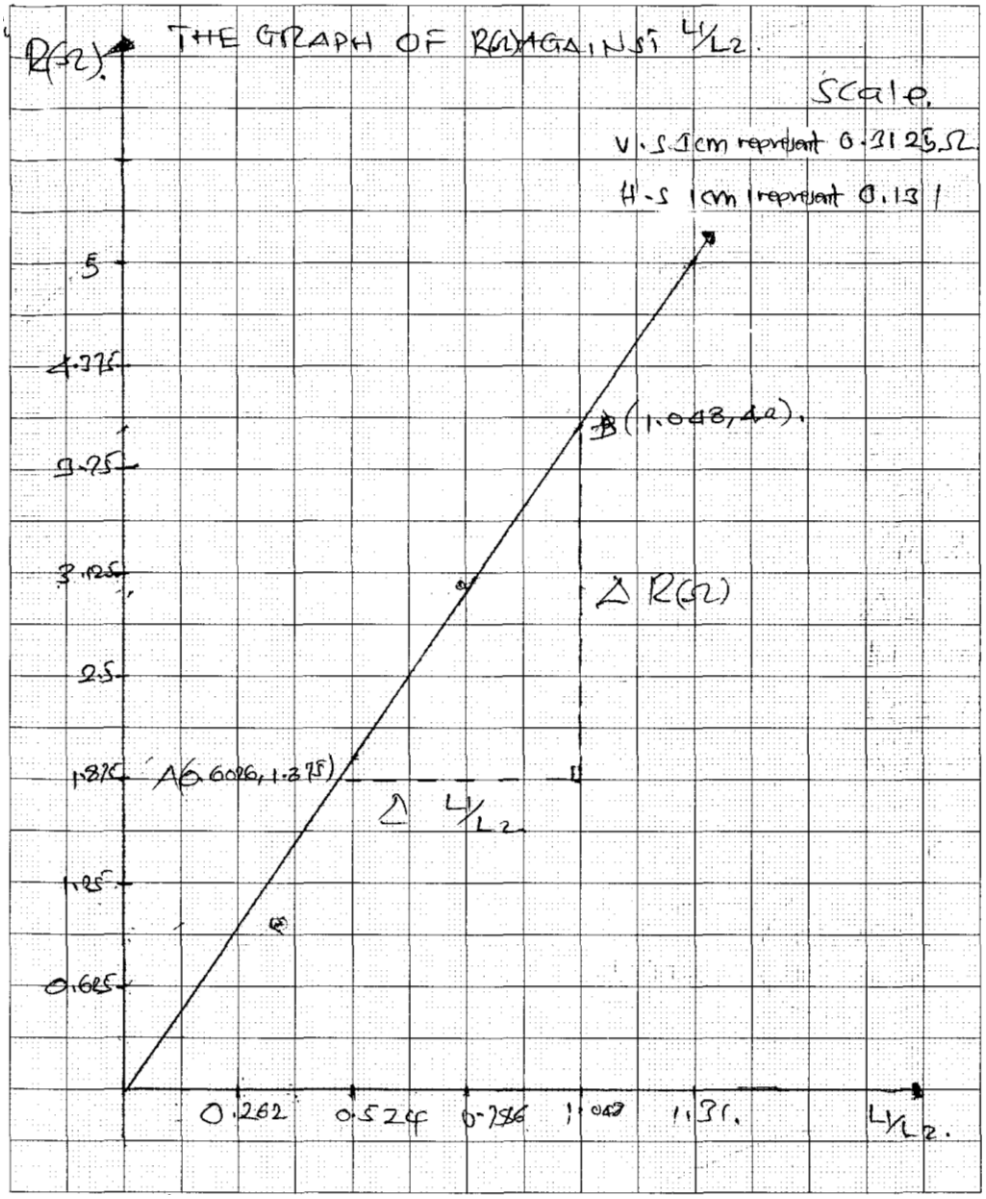
$\therefore$ Slope = 4.27Ω.

2(iv) Solution:

From the theory of an experiment.

$$\frac{R_1}{L_1} = \frac{R_2}{L_2}.$$

Make equation into $y = mx + c$.



Extract 6.2: A sample of candidate's good responses to question 2

In extract 6.2, the candidate provided appropriate responses to all parts of the question.

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The analysis of the candidates' performance revealed that the general performance of the candidates in this year has decreased by 0.49 percent as compared to the year 2019. In Physics 1 (Theory paper) the topics of *Measurement*; *Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Light; Magnetism; Motion in a Straight Line; Temperature; Friction; Vapour and Humidity; Transfer of Thermal Energy* and *waves* tested in question 1 (*Multiple Choice Items*) and the topic of *Thermionic Emission* tested in question 2 (Matching Items) had good performance. The topics which were performed at an average standard were *Electronics* and *Current Electricity;* and *Thermal Expansion*.

Further analysis showed that the candidates performance was weak in questions constructed from the topics of *Current Electricity* and *Radioactivity*; *Waves* and *Geophysics*; *Pressure* and *Forces in Equilibrium; Light* and *Optical Instruments*; *Electronics* and *Waves*; *Newton's Laws of Motion* and *Simple Machines*; and *waves* and *Electromagnetism*.

The responses given by the candidates showed that various challenges affected their performance in this theory paper. One of the major factors was poor knowledge of the concepts of various topics stipulated in the Physics Syllabus. Some of the candidates skipped most of the parts of the questions or provided inappropriate responses. This challenge was observed in question 5 where most of the candidates failed to apply the principle of conservation of linear momentum to explain why the recoil velocity of a gun is much less than the velocity of the bullet. The same challenge was observed in question 6 where the candidates failed to employ the concept of thermal expansion to explain how the dimensions of a newly constructed Tanzania standard gauge railway line would change during summer and winter days.

Another weakness observed was lack of proficiency in the English language, which posed challenges in understanding the demands of the questions and answering questions which required detailed or brief explanations. This factor negatively influenced the performance of some of the candidates as they failed to present their responses appropriately.

Further analysis revealed that lack of drawing and interpretation of a radio wave profile sketch played a vital part towards the performance of candidates. This challenge was observed in question 4 where the candidates failed to use a well labelled diagram to explain the working principle of a hydraulic braking system in the topic of pressure. The candidates also failed to interpret a radio wave profile sketch to determine the wavelength of the wave in question 8.

Lack of numerical skills affected greatly the performance of most of the candidates in items which involved calculations. Most of the candidates failed to deduce and use proper formula, for example, to determine the value of mechanical advantage of the hydraulic press machine working with efficiency of 90% in question 5. They also failed to apply the concept of parallel connection of resistors to calculate the value of the unknown resistance and current in an electric circuit and thus the effective resistance in question 10. Some of the candidates who managed to recall the formula failed to manipulate the data given and skipped very crucial steps, which led to loss of marks.

The analysis of results for Physics 2 (Actual practical paper) revealed that the candidates' performance in question 1 which tested the topic of *Mechanics* was average. However, question 2 which tested the topic of *Current electricity* had weak performance. The factors which contributed to weak performance are the same as those explained in the theory paper.

It is anticipated that the feedback and recommendations given in this report will enable stakeholders, candidates and teachers to take appropriate measures to improve performance in CSEE Physics examinations in future.

5.2 Recommendations

In order to improve the performance of candidates in future, it is recommended that teachers should:

(a) Guide students carry out an experiment to investigate the laws of reflection of light by using a plane mirror, a protractor, a ruler, soft board, optical pins, source of light and a plane paper. Discuss in groups the structure and functions of the parts of the lens camera by

using a camera and the diagram of the camera. This will help to develop their learning interest and improve understanding.

(b) Guide students use Think-Pair-Share technique to identify the applications of the atmospheric pressure by using hydraulic braking system of the car, and through investigation, apply the principle of moment to find the length of the pencil by using a metre rule, string two different masses, beam balance and a pencil.

(c) Use question and answer technique to:

(i) Determine the mechanical advantage, velocity ratio and efficiency of the hydraulic press by using model of hydraulic press and two strings of different sizes; and organize group discussion to identify the applications of the principle of the conservation of linear momentum by using model of a gun with bullets;

(ii) Determine the equivalent resistance of resistors or bulbs connected in series and parallel by using connecting wires, switch/key and a battery, and discuss the structure of the atom by using a chart and model of an atom.

(iii) Determine the relationship between frequency, wavelength and speed by using a chart showing the relationship between them, and brainstorm the concept of the earthquake by using a chart of earthquake;

(iv) Explain the concept of energy bands in solids and discuss the differences between conductors, semiconductors and insulators, galvanometer, battery and connecting wires; and discuss the structure and functions of types of transistors by using different types of transistors found in a radio and TV.

(d) Organize a gallery walk presentation about common applications of expansion of solids by using diagram of rails, and demonstrate the effect of heat on the density of liquids by using water, motor oil, beaker, heater and thermometer.

(e) Guide students to brainstorm the concept of conversion of galvanometers into ammeters and voltmeters by using a galvanometer, multiplier, shunt, cell, connecting wires and a switch.

(f) Encourage students to work hard to master mathematical skills so as to compute problems involving mathematical concepts.

(g) Emphasize the teaching of English by focusing on both speaking and writing skills through various techniques, including checking and correcting grammatical errors in their notebook during learning and teaching process.

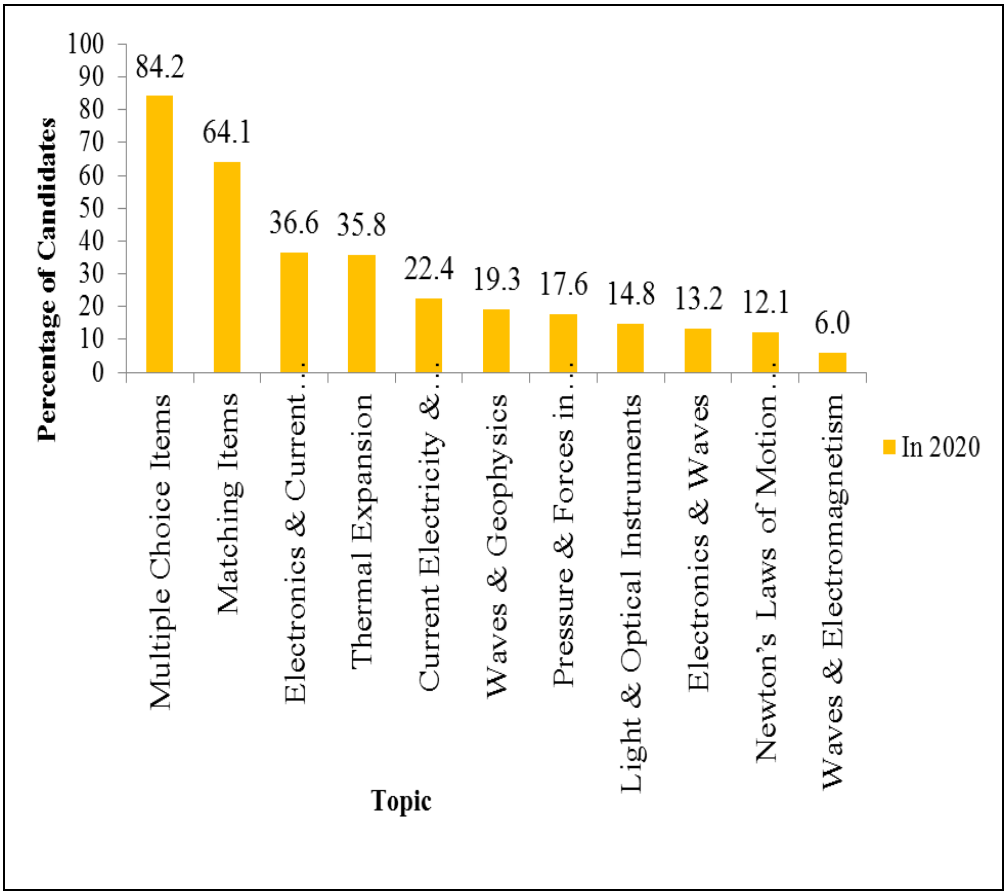
(h) Help students to master the art of drawing in order to be able to draw structures and diagrams of different circuits and devices.

Appendix 1

Summary of the Performance of Candidates in Each Topic for 031/1 Physics 1

S/N	Topic	Question Number	The % of Candidates Who Scored an Average of 30 % or Above	Remarks
1.	*Measurement; Archimedes Principle and the Law of Flotation; Structure and Properties of Matter; Light; Motion in a Straight Line; Temperature; Friction; Transfer of Thermal Energy; Waves and*	1	84.2	Good
2.	*Thermionic Emission*	2	64.1	Good
3.	*Electronics & Current Electricity*	10	36.6	Average
4.	Thermal Expansion	6	35.8	Average
5.	*Current Electricity & Radioactivity*	7	22.4	Weak
6.	*Waves & Geophysics*	8	19.3	Weak
7.	*Pressure & Forces in Equilibrium*	4	17.6	Weak
8.	*Light & Optical Instruments*	3	14.8	Weak
9.	*Electronics & Waves*	11	13.2	Weak
10	*Newton's Laws of Motion & Simple Machines*	5	12.1	Weak
11	*Waves & Electromagnetism*	9	6.0	Weak

(a)


Percentage of Candidates
100
90
80
70
60
50
40
30
20
10
0
84.2
64.1
36.6
35.8
22.4
19.3
17.6
14.8
13.2
12.1
6.0
Multiple Choice Items
Matching Items
Electronics & Current…
Thermal Expansion
Current Electricity &…
Waves & Geophysics
Pressure & Forces in…
Light & Optical Instruments
Electronics & Waves
Newton's Laws of Motion…
Waves & Electromagnetism
Topic
In 2020

(b)