THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT ON THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2025

131 PHYSICS

Published by:

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

Table of Contents

FOREWORD v

1.0 INTRODUCTION 1

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN 131/1 PHYSICS 1 3

2.1 Question 1: Measurement (Physical quantities and Errors) 3
2.2 Question 2: Mechanics (Uniform Circular Motion) 12
2.3 Question 3: Mechanics (Simple Harmonic Motion) 20
2.4 Question 4: Mechanics (Rotation of Rigid Bodies) 26
2.5 Question 5: Heat (Heat Transfers and First Law of Thermodynamics) 31
2.6 Question 6: Heat (Heat Transfer; Thermal Radiation) 36
2.7 Question 7: Environmental Physics (Earthquake, Environmental Pollution and Geophysics) 42
2.8 Question 8: Current Electricity (Alternating Current, electrical networks and Kirchhoff's laws) 48
2.9 Question 9: Electronics (Diode, Transistor and Operational Amplifier) 66
2.10 Question 10: Electronics (Logic Gates, Transistors and Operational Amplifiers) 73

3.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN 131/2 PHYSICS 2 82

3.1 Question 1: Fluid Dynamics 82
3.2 Question 2: Vibrations and Waves 90
3.3 Question 3: Properties of Matter 102
3.4 Question 4: Electrostatics 113
3.5 Question 5: Electromagnetism 121
3.6 Question 6: Atomic Physics 128

4.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION 131/3 PHYSICS 3 135

4.1 Question 1: Mechanics 136
4.1.1 Physics 3A 136
4.1.2 Physics 3B 146
4.1.3 Physics 3C 156
4.2 Question 2: Heat 162
4.2.1 Physics 3A 162
4.2.2 Physics 3B 168

4.2.3 Physics 3C 174
4.3 Question 3: Current Electricity 181
4.3.1 Physics 3A 182
4.3.2 Physics 3B 189
4.3.3 Physics 3C 198
5.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH TOPIC . 205
6.0 CONCLUSION AND RECOMMENDATIONS 206
6.1 Conclusion 206
6.2 Recommendations 207
Appendix I: The Candidates' Performance in Each Topic in Physics 1 & 2 in ACSEE 2025 209
Appendix II: The Candidates' Performance in Each Topic in Actual Practical Papers 3A, 3B and 3C in ACSEE 2025 210

FOREWORD

The National Examinations Council of Tanzania (NECTA) is pleased to issue the Candidates' Item Response Analysis report on the Advanced Certificate of Secondary Education Examination (ACSEE) in Physics subject. This report provides feedback to students, teachers, policy makers and the public in general about the performance of the candidates. Basically, the candidates' responses to the examination questions indicate what the education system was able/ unable to offer to students in their Advanced Certificate of Secondary Education level.

The general performance of the candidates in Physics subject was good. The report shows factors which contributed to the candidates' ability to answer the examination questions correctly and score high marks. The factors include, ability to identify the task of the questions, good knowledge of the subject matter, good mathematical skills and correct application of principles and theories in interpreting scientific observation to real-life situations. However, the candidates with low marks lacked such qualities.

It is hoped that the suggestions and recommendations provided in this report will enable various education stakeholders to take proper teaching and learning measures so as to enable the students to master the required skills and knowledge hence improve performance in the future examinations administered by the Council.

Lastly, the Council is grateful to all examination officers, examiners and all other staff members who participated in the preparation of this report.

Prof. Said Ally Mohamed
EXECUTIVE SECRETARY

1.0 INTRODUCTION

The Physics examination adhered to the 2019 Physics Subject Examination Format, which is based on the 2010 Physics Syllabus. The examination consisted of three papers: 131/1 Physics 1 (Theory), 131/2 Physics 2 (Theory), and 131/3 Physics 3 (Practical).

Paper 1 (131/1) comprised sections A and B, with a total of ten (10) questions. Section A included seven (7) short-answer questions, each carrying 10 marks. Section B contained three (3) structured questions, each carried 15 marks. Candidates were required to answer all questions in section A and two (2) questions from section B. Paper 2 (131/2) included six (6) structured questions, out of which candidates were required to answer five (5). Each question carried 20 marks. Paper 3 (131/3) comprised three alternatives: 131/3A Physics 3A, 131/3B Physics 3B and 131/3C Physics 3C. Each paper contained three questions: Question 1 carried 20 marks, and Questions 2 and 3 each had 15 marks. Candidates were required to sit for one alternative paper and answer all questions within it.

A total of 29,604 candidates sat for the Physics examination in 2025. Among them, 28,819 (97.48%) candidates passed while 744 (2.52%) failed. The candidates' performance this year has declined by 0.28% compared to 2024, in which 97.76% of the candidates passed. This slight decrease in performance was influenced by the varying levels of candidates' understanding across topics. Notable performance improvement was observed in the topics of *Environmental Physics* and *Atomic Physics,* which have improved from an average performance in 2024 to good performance in 2025. Table 1 presents the topics with improved performance in 2025 compared to 2024.

Table 1: Candidates' Improved Performance in 2 Topics in ACSEE 2025 Compared to 2024

S/n	Topic	ACSEE 2024			ACSEE 2025		
		Number of Questions	Percentage of Candidates who scored 35 % or above	Remarks	Number of Questions	Percentage of Candidates who scored 35 % or above	Remarks
1.	Environmental Physics	1	57.34	Average	1	97.03	Good
2.	Atomic Physics	1	58.03	Average	1	72.06	Good

In addition, Figure 1 illustrates the candidates' performance according to grades for two consecutive years, 2024 and 2025.

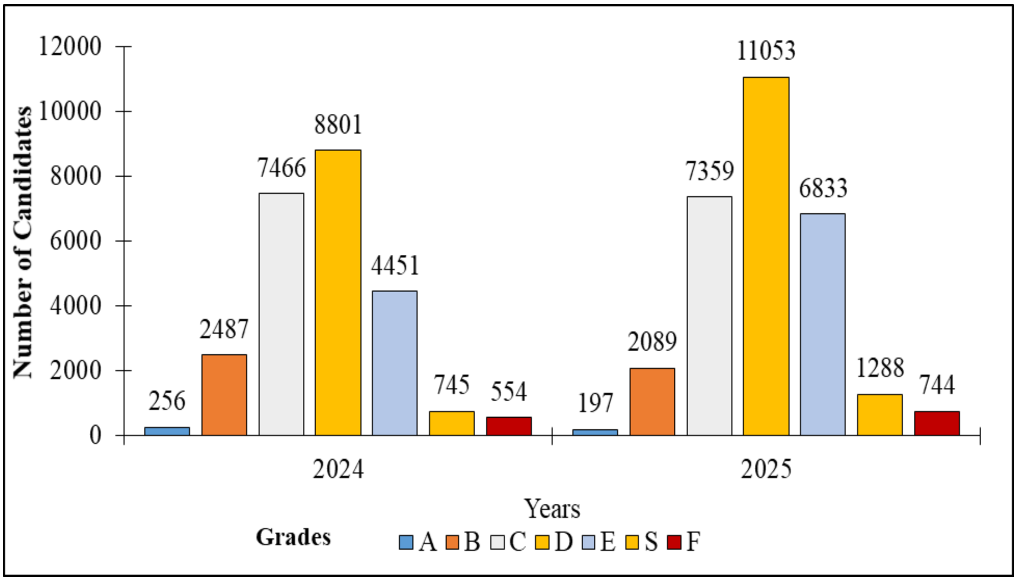


Figure 1: *Candidates' performance according to grades*

Figure 1 shows a decrease in the number of candidates who scored grades A, B, and C in 2025 compared to 2024. It further shows that there is a significant increase in candidates who scored grades D, E, S and F in 2025 compared to 2024.

The subsequent part of this report shows the analysis of the candidates' performance on each question in 131/1 Physics 1, 131/2 Physics 2, and 131/3 Physics 3. The analysis shows what the candidates were required to do, as well as the strengths and weaknesses of their responses. Samples of the candidates' answers have been extracted from their scripts to illustrate their responses. Figures and tables have been used to illustrate the respective cases. The performance is ranked as weak, average or good if the performance of candidates lies in the range of 0 to 34, 35 to 59 or 60 to 100 per cent, respectively. The colours, green, yellow and red, have been used to represent good, average and weak performances, respectively. The report also contains Appendices I and II, showing the candidates' performance in different topics. Finally, it provides a conclusion and recommendations that may help to improve teaching and learning of the Physics subject.

2.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN 131/1 PHYSICS 1

This paper consisted of a total of 10 questions in sections A and B. Section A consisted of seven (7) short-answer questions, each carrying 10 marks. Candidates were required to answer all questions. Section B consisted of three (3) structured questions, two to be chosen while each consisting of 15 marks. Six (6) topics which were tested are: *Measurement (Physical Quantities and errors), Mechanics (Uniform Circular Motion, Newton's Laws of Motion, Rotation of Rigid Bodies and Simple Harmonic Motion), Heat (Heat Transfer and First law of Thermodynamics and thermal radiation), Environmental Physics (Environmental Pollution, Earthquakes and Geophysics) Current Electricity (Alternating Current, electrical networks and Kirchhoff's laws)* and *Electronics (The p-n junction, Transistors, Logic gates and Operational amplifier)*. The following is a detailed description of candidates' item responses:

2.1 Question 1: Measurement (Physical quantities and Errors)

This question consisted of parts (a) and (b). In part (a), candidates were required to (i) explain why every measuring instrument has its limit of precision and (ii) determine the dimensional formula of torque τ and apply it to obtain the dimension of viscosity using the equation $\tau = \frac{\pi \eta r^4 \theta}{2l}$, where other symbols carry their usual meaning. In part (b), they were required to find the maximum percentage error in the measurement of specific gravity given that a stone weigh (5.0 ± 0.1) kg in air and (4.0 ± 0.1) kg when totally immersed in water.

The analysis shows that the question was attempted by 29,604 (100%) candidates, out of whom 7,966 (49.38%) scored 0.0 to 3.0 marks, 6,984 (23.59%) scored from 3.5 to 5.5 marks, and 8,002 (27.03%) scored from 6.0 to 10.0 marks. These scores indicate that candidates' performance in this question was average, as 14,986 (50.62%) candidates scored from 3.5 to 10.0 marks. Figure 2 depicts the candidates' performance in Question 1.

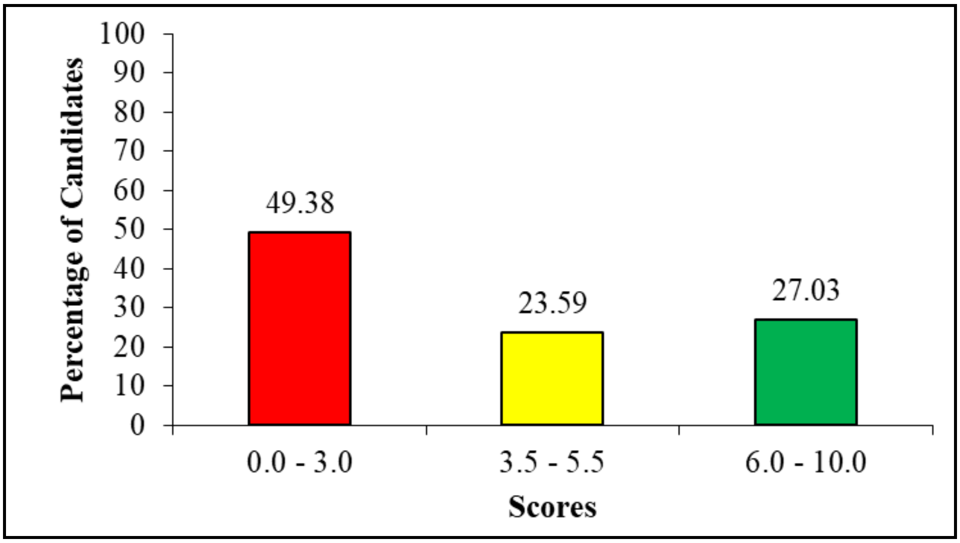


Figure 2: *Candidates' performance in question 1 of paper 1*

Statistical data reveal that 27.03% of the candidates scored higher marks (6.0 to 10). This suggests that those candidates had enough knowledge of the concept of measurement. In part (a) (i), they explained the reason an instrument has a limit of precision. They demonstrated the ability to identify the limitations of scientific measuring instruments. In part (a) (ii), they showed adequate knowledge of dimensional analysis. Most of the candidates who scored high marks in this section applied the principle of dimensional analysis to determine the dimensions of viscosity. These candidates demonstrated adequate mathematical skills. In part (b), the candidates were able to write a correct formula for specific gravity. Moreover, these candidates correctly apply error analysis techniques to determine the maximum percentage error for specific gravity. This level of accuracy and understanding is illustrated in Extract 1.1.

1. (a)	(i) This is because limit of precision increases accuracy of the measuring instrunment. This is also because each measuring instrunment has least count which increases accuracy.
	(ii) Solution.
	from: $\tau = FR$.
	$[\tau] = [F][R]$.
	$[\tau] = MLT^{-2} \times L$.
	$[\tau] = ML^{2}T^{-2}$.
	from: $\tau = \frac{\pi \eta r^4 \theta}{2L}$.
	$\tau \times 2L = \pi \eta r^4 \theta$.
	$\eta = \frac{2\tau L}{\pi r^4 \theta}$.

$$\therefore [\eta] = \frac{2[T][L]}{\pi [r]^4 [\theta]}.$$

But; $[T] = ML^2T^{-2}$.

$[L] = L$.

$[r] = L$.

$[\theta] = M^0L^0T^0$

$$\therefore [\eta] = \frac{ML^2T^{-2} \times L}{L^4}$$

$$[\eta] = \frac{ML^3T^{-2}}{L^4}$$

$[\eta] = ML^{-1}T^{-2}$.

$\therefore \quad [\eta] = ML^{-1}T^{-2}$

1. (b) Solution.

Specific gravity (Δ) = $\frac{\text{Weight in air } (W_1)}{\text{Upthrust in water } (u)}$

$$\Delta = \frac{W_1}{u}$$

But; $u = W_1 - W_2$ (Weight in water).

$$\therefore \quad \Delta = \frac{W_1}{W_1 - W_2}.$$

Introduce natural logarithim.

$$\ln \Delta = \ln \left(\frac{W_1}{W_1 - W_2} \right)$$

$$\ln \Delta = \ln W_1 + \ln (W_1 - W_2).$$

Differentiating each term:

$$\frac{\Delta \Delta}{\Delta} = \frac{\Delta W_1}{W_1} + \frac{\Delta W_1 + \Delta W_2}{W_1 - W_2}.$$

$$\frac{\Delta \Delta}{\Delta} = \frac{0.1}{5} + \frac{0.1 + 0.1}{5 - 4}.$$

$$\frac{\Delta \Delta}{\Delta} = \frac{11}{50}.$$

$$\frac{\Delta \Delta}{\Delta} \times 100\% = \frac{11}{50} \times 100\%$$

$$\frac{\Delta \Delta}{\Delta} = 22\%$$

$\therefore$ Maximum percentage error = 22%.

Extract 1.1: A sample of correct responses to question 1 of paper 1

In Extract 1.1, the candidate provided correct responses related to measurement (physical quantities and errors). The candidate applied the correct dimensions of each physical quantity in the provided mathematical formula and successfully determined the dimension of viscosity. Moreover, the candidate correctly applied the error analysis technique to determine the maximum percentage error of the specific gravity of a stone. It can be said that the candidate had adequate mathematical skills.

On the other hand, 23.59% of the candidates scored average marks (3.5 - 5.5) and demonstrated adequate skills in dimensional analysis and error analysis. Most of these candidates failed to determine the maximum percentage error of the specific gravity. Most of the candidates in this category failed to correctly substitute data in the derived formula.

The analysis of candidates' performance revealed that 40.38% of those who scored low marks (0.0–3.0) demonstrated inadequate knowledge and understanding of measurement concepts. In part (a)(i), most of the candidates failed to provide a scientific explanation for why the measuring instruments have a limit of precision. Most of them provided incorrect responses. For example, one candidate wrote: *"Every instrument has its limit of precision due to calibration made during preparation of the instrument."* This was an incorrect response. The candidate was supposed to understand that calibration is a process of evaluating and adjusting the measuring instrument to ensure its measurements are accurate and reliable. It can be concluded that the calibration of any measuring instrument improves the accuracy, but it cannot alter the precision of the instruments. Another candidate responded: *"Every measuring instrument has its limit of precision in order to avoid least count."* The candidate was supposed to realise that the least count is the smallest value that a measuring instrument can detect or read. It defines the instrument's resolution. A smaller least count means higher precision of the measuring instrument. It can be said that every measuring instrument has a limit of precision because of physical and practical constraints, not to avoid the least count. The candidates in this category were supposed to realise that the instruments have a limit of precision because of their design, scale and other imperfections. For instance, a vernier calliper (least count 0.02 mm) is more precise than a ruler (least count 1 mm).

Moreover, in part (a) (ii), most of the candidates failed to correctly apply the principle of dimension analysis to obtain the dimensions of physical values. Some of the candidates provided irrelevant approaches as per the question. For instance, one candidate responded to this section as follows:

$$\tau = \frac{\pi\eta r^4\theta}{2l}$$

Then,

$$\ln\tau = \ln\pi + \ln\eta + \ln r^4 + \ln\theta = \ln 2l$$

But η is constant, π is constant, θ is constant

$$\tau = \frac{r^4}{2l}.$$

This response suggests that the candidate lacked adequate knowledge and skills in the concepts of dimension analysis.

Similarly, in item (b), most of the candidates failed to provide the correct response. Most of the candidates apply the incorrect formula for specific gravity. For instance, some of the candidates wrote:

$$g = \frac{weight\,in\,air,\,W_1}{weight\,in\,water,\,W_2}.$$

They further evaluate the expression as:

$$\frac{\Delta g}{g} = \frac{\Delta w_1}{w_1} + \frac{\Delta w_2}{w_2}$$

Then

$$\frac{\Delta g}{g} = \frac{0.1}{5} + \frac{0.1}{4}$$
$$= 0.045 \times 100\%$$
$$= 4.5\%$$

This was an incorrect approach. The candidate failed to apply mathematical concepts to explain a physical phenomenon. Some of the candidates wrote: $\text{specific gravity} = \text{upthrust} = \text{weight in air} - \text{weight in water}$. This is an incorrect expression of the specific gravity. This revealed that these candidates lacked knowledge and skills in the concepts of measurements. It could be assumed that they failed to understand the meaning of specific gravity. They were supposed to realise that specific gravity is a ratio of the density of a substance to the density of a reference substance (commonly water). Thus, it can be said that specific gravity is a special case of relative density. As per the item context, the candidates were supposed to apply Archimedes' principles. Thus, the specific gravity of a stone can be calculated as:

$$\text{specific gravity} = \frac{\text{weight of stone in air}}{\text{Loss of weight in water}} = \frac{W_{air}}{W_{air} - W_{water}}.$$

The candidates were supposed to use this expression to determine the maximum percentage error of the specific gravity of a stone. Extract 1.2 shows incorrect responses of one of the candidates.

1. a).

i). This is because precision is the closeness of several measurement of same quantity to each other. As the result every measuring instrument has its limit of precision.

ii) soln

Given

$I = \frac{\pi \eta r^4 Q}{2L}$

Required the dimension formula

From

1. a). ii) $I = \frac{\pi \eta r^4 Q}{2L}$

But $[r] = [L]$

$[L] = [L]$

Now

$I = \frac{[L^4] \times [ML^{-1}T^{-1}]}{[L]}$ ~~…~~ $\frac{[L^4]}{[L]}$

~~$[= ML^{-1}$~~ $[L^3]$

$\therefore \quad I = \frac{[L^4]}{[L]}$

$I = L^3$

∴ Dimension formula is not correct

iii). From dimensional of viscosity, η

From

$I = \frac{\pi \eta r^4 Q}{2L}$

$MLT^{-1} = \frac{\eta [L^4]}{[L]}$

$MLT = \eta [L^4]$

$\eta = \frac{MLT}{L^4}$

$\eta = ML^{-3}T$

∴ The dimension of viscosity, $\eta = ML^{-3}T$

b). soln

Given $w_1 = (5.0 \pm 0.1)$ kg

$w_2 = (4.0 \pm 0.1)$ kg

Required percentage error

	iii. From dimensional of viscosity, η
	From
	$I = \frac{\pi n r^4 \theta}{2L}$
	$MLT^{-1} = \frac{\eta [L^4]}{[L]}$
	$MLT = \eta [L^4]$
	$\eta = \frac{MLT}{L^4}$
	$\eta = ML^{-3}T$
	∴ The dimension of viscosity, $\eta = ML^{-3}T$
	b) soln
	Given $w_1 = (5.0 \pm 0.1)$ kg
	$w_2 = (4.0 \pm 0.1)$ kg
	Required percentage error

1.	a). iii $I = \frac{\pi n r^4 \theta}{2L}$
	But $[r] = [L]$
	$[L] = [L]$
	Now
	$I = \frac{[L^4]}{[L]} \times$ ~~[MLT^{-1}]~~ $\frac{[L^4]}{[L]}$
	~~I = MLT^{-1}~~ $[L^3]$
	∴ $I = \frac{[L^4]}{[L]}$
	$I = L^3$
	∴ Dimension formula is not correct

1.	b). From
	$\left(\frac{\Delta g}{g}\right)\% = \left(\frac{\Delta kg}{kg} + \frac{\Delta kg}{kg}\right) \times 100\%$ But (5.0 ± 0.1) kg
	$\frac{\Delta g}{g} = \left(\frac{0.1}{5} + \frac{0.1}{4}\right) \times 100\%$ But (4.0 ± 0.1) kg
	$\frac{\Delta g}{g} =$ ~~0.02 + 0.025~~ $\times 100\%$ $0.12 \times 100\%$
	$\Delta g/g =$ ~~4.5%~~ $0.12 \times 100\%$
	∴ The percentage error = ~~4.5%~~ 12%

Extract 1.2: A sample of an incorrect response to question 1 of paper 1

In Extract 1.2, the candidate defined the term precision instead of providing a scientific explanation for why the measuring instruments have a limit of precision. Moreover, the candidate failed to verify the given formula dimensionally. In addition, the candidate failed to apply concepts, theories and principles related to error analysis to calculate the percentage error of specific gravity. This overall response indicates inadequate knowledge in both dimensional and error analysis.

2.2 Question 2: Mechanics (Uniform Circular Motion)

This question had two parts: (a) and (b). Part (a) consisted of two items: part (a) (i) and (ii). In part (a) (i), candidates were required to explain the origins of tangential and centripetal acceleration in the motion of an object along a circular path. Part (ii) required candidates to apply mathematical skills to determine the magnitude and direction of the net acceleration of a cyclist moving at a speed of 72 km/h, decelerating at a rate of 5 m/s² along a 100-m-radius circular path. Part (b) of this question demanded the application of mathematical skills to deduce the aircraft's speed. The aircraft was horizontally flying at a height of 4,500 m above the ground and subtended an angle of 60° on the ground at two positions that were 10 s apart.

This question was attempted by 29,604 (100%) candidates. The analysis reveals that 18,515 (62.54%) candidates scored from 0.0 to 3.0 marks. 14,180 (29.95%) scored from 3.5 to 5.5 marks, and 2,224 (7.51%) scored from 6.0 to 10.0 marks. Generally, the performance of the candidates was average, as 16,404 (37.46.54%) candidates scored from 3.5 to 10.0. Figure 3 shows the candidates' performance in this question.

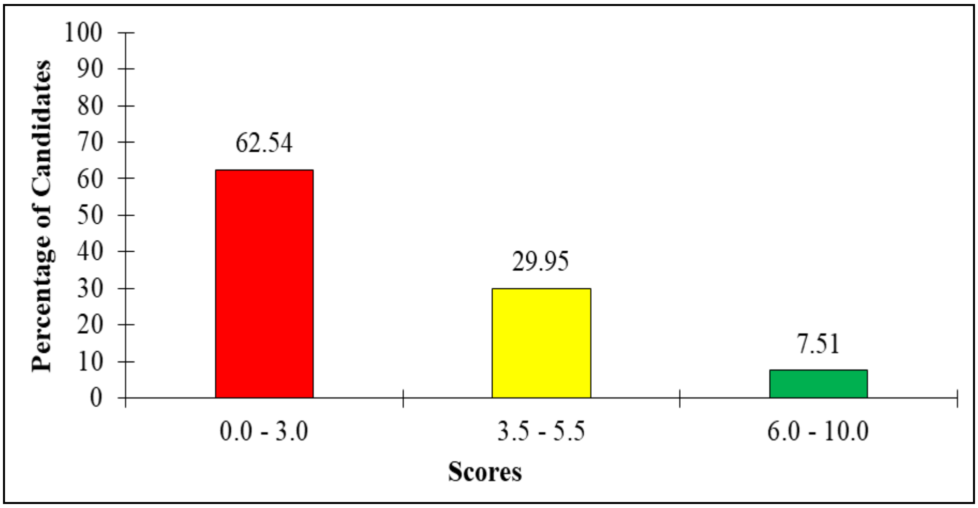


Figure 3: *Candidates' performance in question 2 of paper 1*

Statistical data shows that very few candidates (7.51%) scored higher marks (6.0 to 10.0). The analysis further revealed that the candidates in this category provided correct responses, particularly in part (a) (i). They were identifying the origins of tangential and centripetal acceleration for an object moving along a circular path correctly. This suggests that they had adequate knowledge and skills on the concepts of tangential and centripetal acceleration of an object moving along a circular path.

In part (a) (ii), those candidates correctly applied an appropriate mathematical formula to determine the direction and magnitude of centripetal acceleration for a cyclist moving along a circular road. The candidates of this category had adequate mathematics skills and knowledge of the concepts of circular motion. In part (b), the candidates were able to provide an appropriate sketch describing the motion of the aircraft. Those candidates used the sketch and mathematics formula to deduce the speed of an aircraft. Extract 2.1 illustrates the correct responses from one of the candidates in this question.

2 (a) (i) • Centripetal acceleration arises from the centripetal force that pulls the object towards the centre

• Tangential acceleration arises due to the centrifugal force that tends to move the object away from the circle, away from the centre.

(ii) Solution

Data given

Speed of cyclist (v) = 72km/h

Radius (r) = 100 m

Acceleration (a) = 5m/s²

~~Req~~ Required

• Magnitude of net acceleration

from

$a_{net} = \sqrt{a_c^2 + a_t^2}$

But $a_c = \frac{v^2}{r}$ and $a_t = 5ms^{-2}$

2(a) (ii)

$$a_c = \frac{v^2}{r}$$

Where

$V = 72 km/h$

$= 20 m/s$

$r = 100 m$

$$a_c = \frac{(20)^2}{100}$$

$$a_c = 4 ms^{-2}$$

from $a_{net} = \sqrt{4^2 + 5^2}$

$$a_{net} = 6.4 ms^{-2}$$

∴ The magnitude of the net acceleration is $6.4 m/s^2$

• The direction of net acceleratio

~~- The direction of the net acceleration is~~

$\tan\theta =$

2(b) Solution

Data given

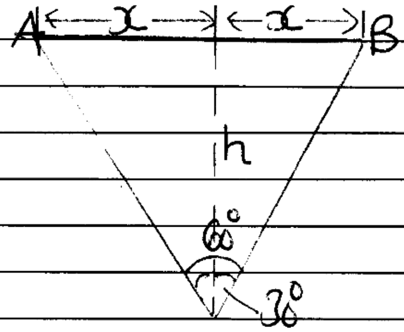
Height (h) = 4500 m

Angle (θ) = 60°

Time interval (t) = 10 s

Required speed.

Consider the diagram below

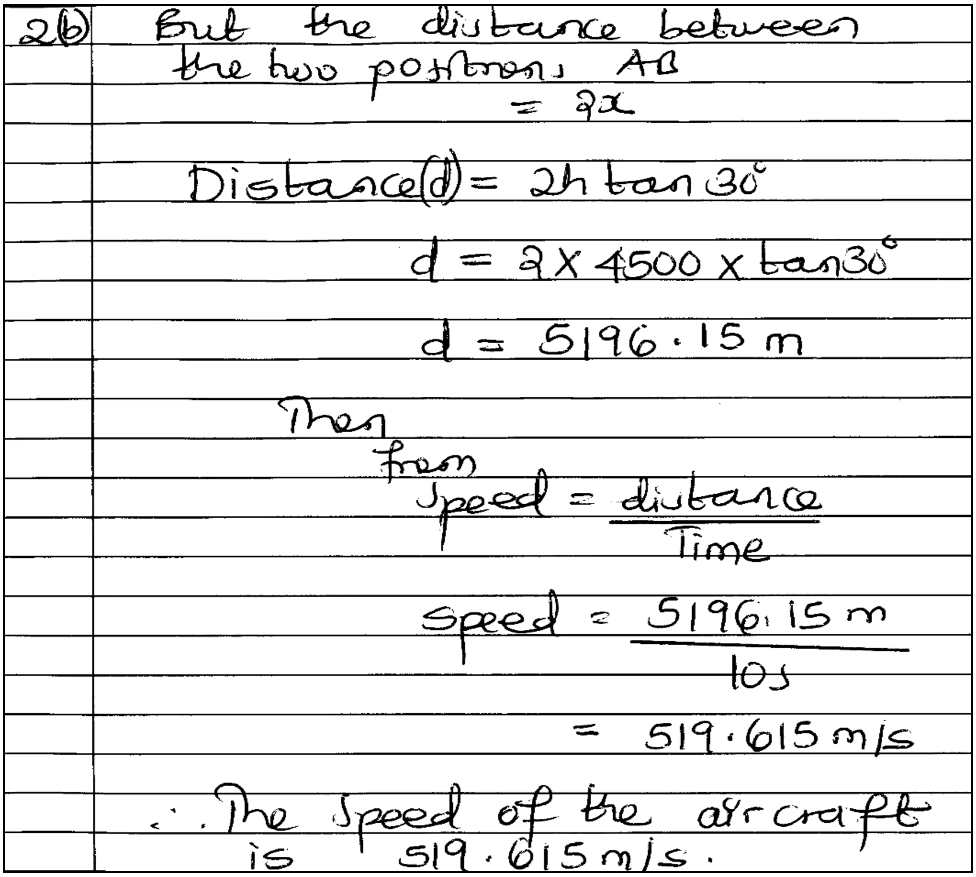


from

$\tan 30° = \frac{x}{h}$

$\tan 30° = \frac{x}{h}$

$x = h \tan 30°$



2(b) But the distance between the two positions AB
= 2x

Distance(d) = 2h tan 30°

d = 2 X 4500 x tan30°

d = 5196.15 m

Then from

Speed = distance / Time

Speed = 5196.15 m / 10s

= 519.615 m/s

∴ The speed of the aircraft is 519.615 m/s.

Extract 2.1: A sample of correct responses in question 2 of paper 1

In Extract 2.1, the candidate correctly explained the origins of tangential and centripetal acceleration of an object moving along a circular path. This candidate demonstrated mastery of mathematics skills as they applied the correct formula to deduce the needed physical quantities.

Nevertheless, 29.95% of the candidates demonstrated competence in some parts of the question, resulting in average scores ranging from 3.5 to 5.5 marks, which were categorised as average marks. These candidates were able to correctly determine the magnitude and direction of the net acceleration of the cyclist, and skipped some steps of determining the speed of the aircraft flying horizontally above the ground.

On the other hand, it was observed that 62.54% of the candidates scored between 0.0 and 3.0 marks. Those candidates provided incorrect responses. For instance, these candidates failed to identify the origins of tangential and centripetal acceleration for an object moving along a circular path. One of the candidates wrote, "*tangential and centripetal accelerations arise due to* *changes in centripetal force and the presence of centrifugal force*". This was an incorrect response. The candidate was supposed to know that centrifugal force is a fictitious or pseudo force due to inertia when observing an object from a rotating frame. Thus, it cannot cause tangential and centripetal acceleration for an object moving along a circular path. Centripetal acceleration originates from the continuous change in the velocity direction and is caused by the centripetal force directed towards the centre of the circular path. Tangential acceleration originates from changes in the object's velocity caused by a net tangential force. In part (b), most of the candidates failed to develop a correct sketch that described the motion of the aircraft as per the item context. For instance, one candidate developed and sketched an irrelevant diagram (see Diagram 1).

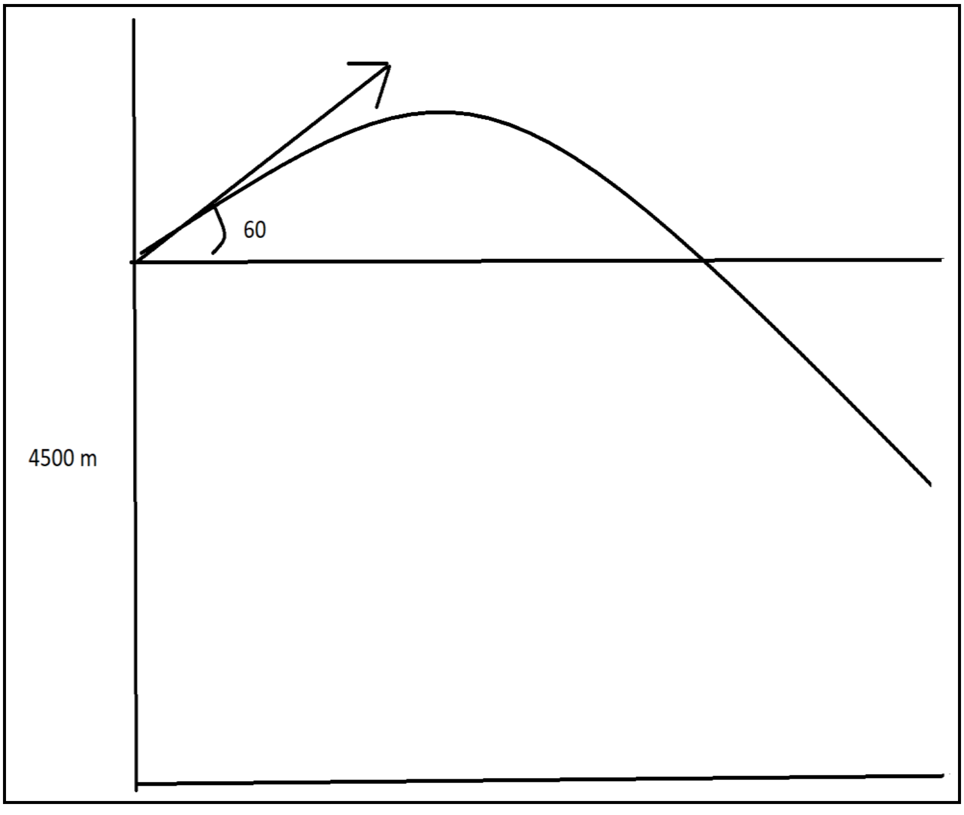


Diagram 1

Moreover, the candidate used an incorrect formula to deduce the speed of the aircraft. This candidate wrote:

$$H = ut + \frac{1}{2}gt^2$$

The candidate analysed the equation for *H* and obtained

$$h = u\cos\theta_c + \frac{1}{2}gt^2$$

Upon performing mathematics, the candidate wrote:

$$u\cos\theta_c = \frac{H - \frac{1}{2}gt^2}{\cos}$$

$$u = \frac{H - \frac{1}{2}gt^2}{\cos\theta_c}$$

This is an indication that the candidate lacked mathematics skills. The expression $u\cos\theta_c = \frac{H - \frac{1}{2}gt^2}{\cos}$ makes no sense in Physics and is dimensionally incorrect. It is important to note that the provided sketch and the mathematical formulas used are related to the topic of projectile motion. This is to say that the candidate failed to understand the scenario of the question. As per the item context, the aircraft was flying horizontally in a straight line and not projected. When observing the aircraft from a point on the ground, it looks to move across the sky. This movement across the sky from one point to another makes an angle 60^o after 10 seconds. Thus, the correct sketch as per the scenario is shown in Diagram 2.

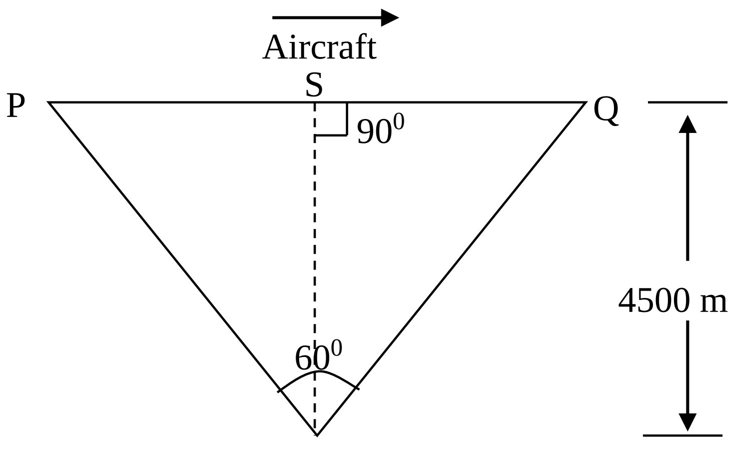


Diagram 2

Using triangle SQO in which $\angle SQO = 60^o$ and $OS = 4500$ m

$$\tan 60^o = \frac{OS}{SQ}.$$

It follows:

$$SQ = \frac{OS}{\tan 60^o} = \frac{4500}{\tan 60^o} = 2598.08 \text{ m}$$

Thus:

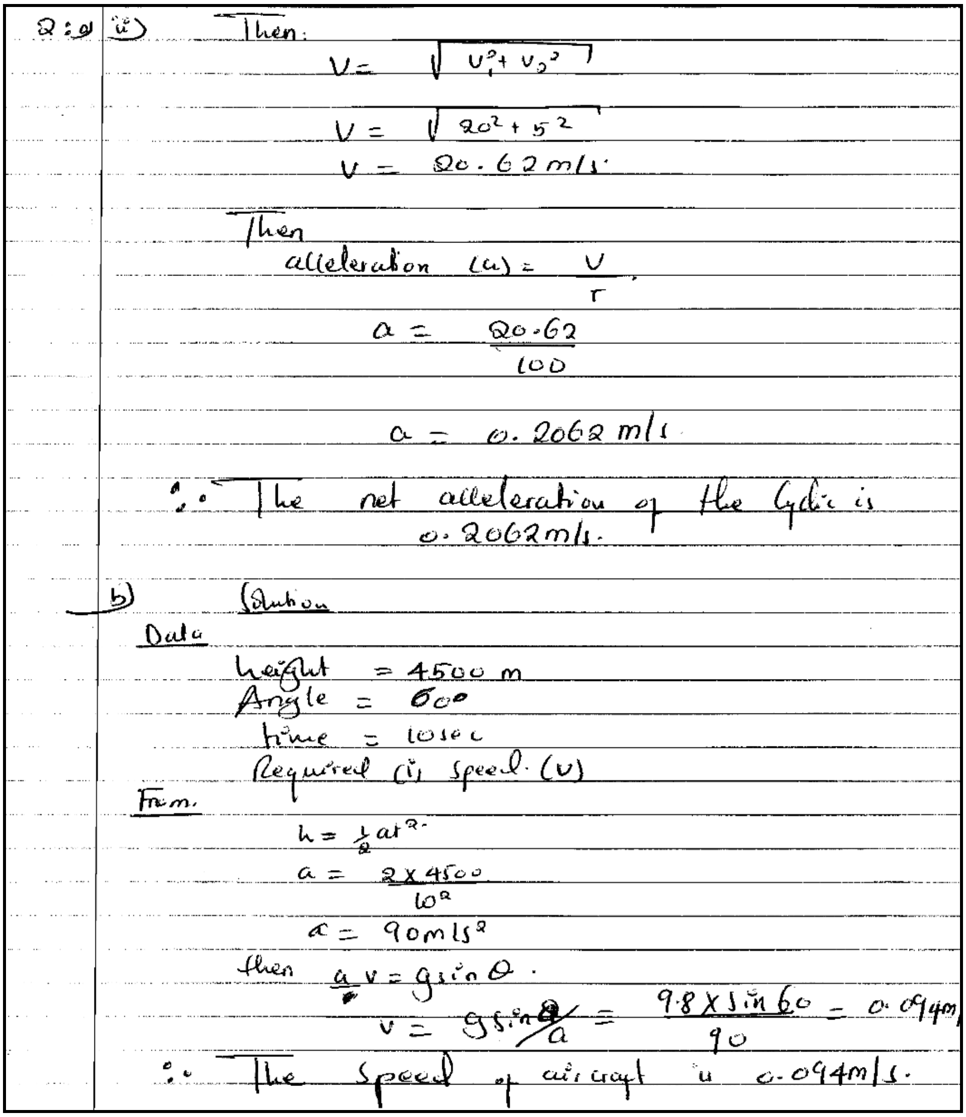
$$PQ = 2SQ = 2 \times 2598.08 \text{ m} = 5196.15 \text{ m}$$

As per diagram 2, velocity, $v = \frac{PQ}{\text{time taken}}$. Then after substituting data,

$$v = \frac{5196.15 \text{ m}}{10 \text{ s}} = 519.62 \text{ m/s}.$$

Most of the candidates who failed to provide a correct response to this item had inadequate knowledge and skills on the concept of circular motion. They failed to link the trigonometric concepts to solve the given physical problem. Extract 2.2 shows the incorrect responses of one of the candidates in this question.

2:	a) i) ~~Because~~ Tangential and Centripetal accele ration arises along the circular path of the circle during its motion in the circle
	ii) Solution
	Data
	Speed (v_1) = 72 km/hr (20 m/s).
	speed (v_2) = 5 m/s².
	radius (r) = 100m
	Required (i) Magnitude and direction of acceleration


Q:2 (ii) Then:
$V = \sqrt{V_1^2 + V_2^2}$
$V = \sqrt{20^2 + 5^2}$
$V = 20.62 m/s$
Then
acceleration $(a) = \frac{V}{r}$
$a = \frac{20.62}{100}$
$a = 0.2062 m/s$
∴ The net acceleration of the cyclic is $0.2062 m/s$.

b) Solution
Data
height = 4500 m
Angle = 60°
time = 10sec
Required (i) speed (v)
From.
$h = \frac{1}{2}at^2$
$a = \frac{2 \times 4500}{10^2}$
$a = 90 m/s^2$
then $a v = g \sin\theta$.
$v = \frac{g \sin\theta}{a} = \frac{9.8 \times \sin 60}{90} = 0.094 m/s$
∴ The speed of aircraft is $0.094 m/s$.

Extract 2.2: A sample of an incorrect response to question 2 of paper 1

In Extract 2.2, the candidate failed to identify the origins of centripetal and tangential acceleration and was unable to determine the net acceleration of a cyclist. Moreover, the candidates failed to understand the scenario of the items, thus, provided incorrect sketches and mathematical formulas to deduce the speed of the aircraft.

2.3 Question 3: Mechanics (Simple Harmonic Motion)

The question consisted of two parts (a) and (b). In part (a), the candidates were required to (i) identify and explain the factors affecting the motion of oscillating systems in Simple Harmonic Motion (SHM), and (ii) write an expression for the displacement equation of an object executing SHM with an amplitude of 0.12 m and a period of 0.5 seconds. In part (b), the candidates were required to use an appropriate sketch to describe the relationship between mechanical energy (kinetic and potential energy) with displacement.

This question was attempted by 29,604 (100%) candidates. The analysis reveals that 8,543 (28.86%) candidates scored from 0.0 to 3.0 marks. 7,345 (24.81%) scored from 3.5 to 5.5 marks, and 13,716 (46.33%) scored 6.0 to 10.0 marks. Generally, the candidates' performance was good, as 21,061 (71.14%) scored from 3.5 to 10.0 marks. Figure 4 displays the candidates' performance in this question.

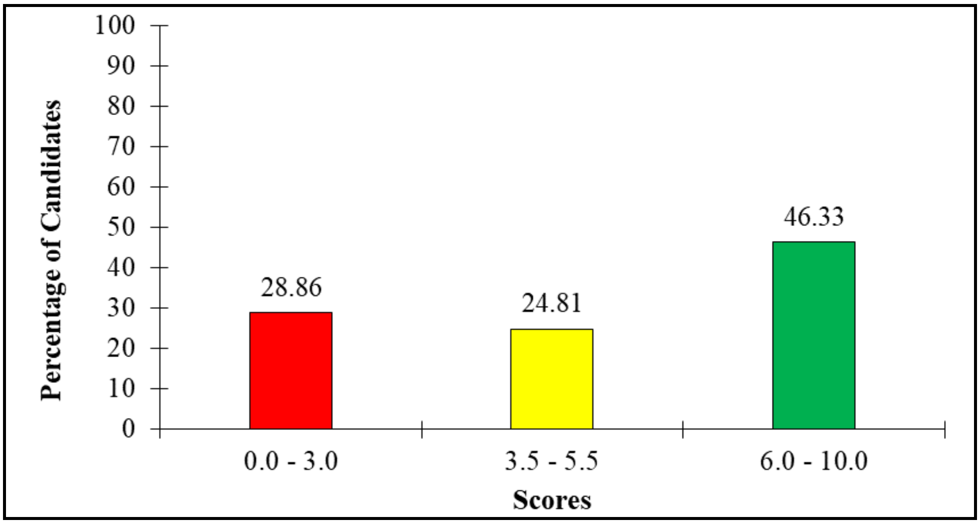
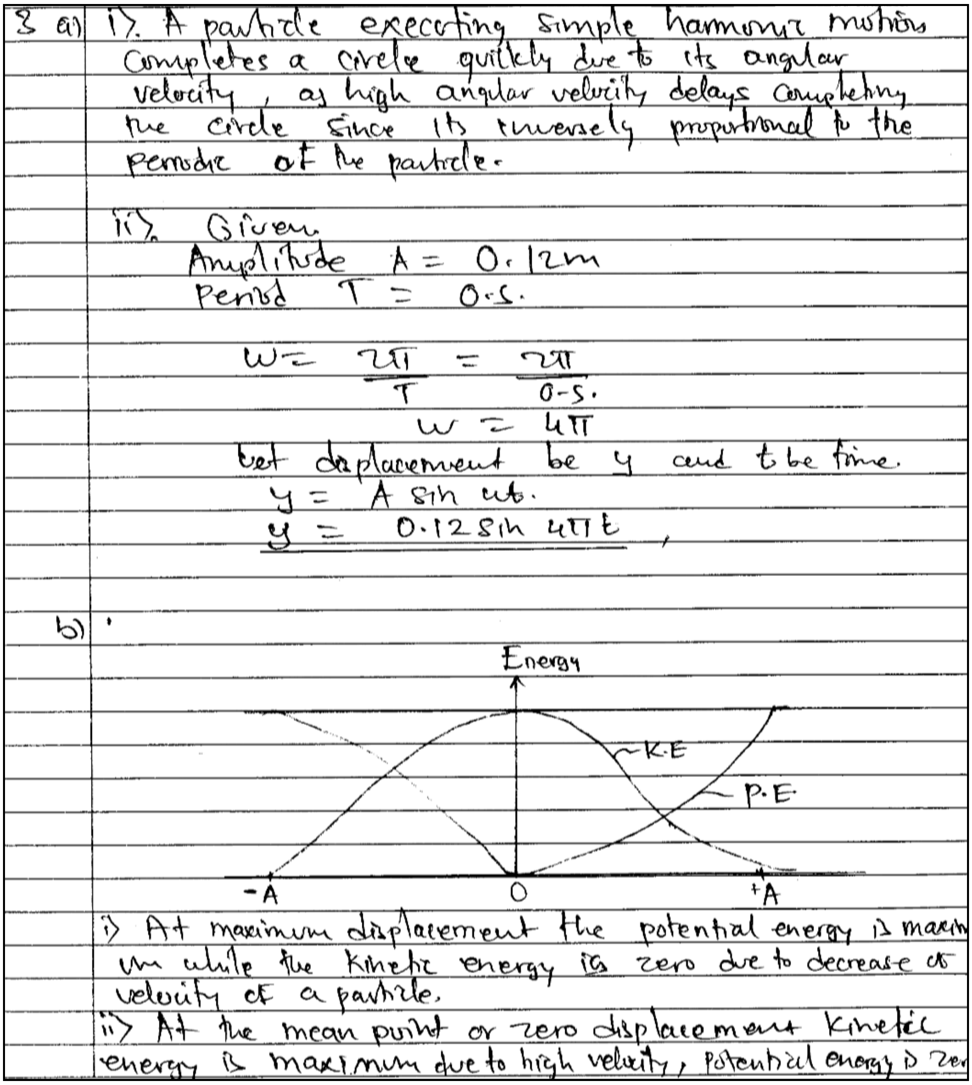


Figure 4: *Candidates' performance in question 3 of paper 1*

Most of the candidates (46.33%) scored higher marks (6.0 – 10.0). These candidates demonstrated mastery of concepts, theories and principles related to the SHM. In part (a) (i), the candidates were able to identify the key factors affecting the motion of a particle in Simple Harmonic Motion (SHM). Moreover, they provided a correct mathematical formula that describes the displacement of the motion of a particle executing SHM. In part (b), these candidates correctly sketched a well-labelled graph that illustrates how the kinetic and potential energies of a particle executing simple harmonic motion (SHM) vary with displacement. Extract 3.1 illustrates a sample of correct responses from one of the candidates who scored higher marks in question 3.



3 a) i) A particle executing simple harmonic motion completes a circle quickly due to its angular velocity, as high angular velocity delays completing the circle since its inversely proportional to the periodic of the particle.

ii) Given
Amplitude A = 0.12m
Period T = 0.5.

$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.5}$

$\omega = 4\pi$

Let displacement be y and t be time.

$y = A \sin \omega t$.

$y = 0.12 \sin 4\pi t$

b)

i) At maximum displacement the potential energy is maximum while the kinetic energy is zero due to decrease of velocity of a particle.

ii) At the mean point or zero displacement kinetic energy is maximum due to high velocity, potential energy is zer

Extract 3.1: A sample of correct responses to question 3 of paper 1

Extract 3.1 illustrates how the candidates applied the correct concepts, theories to obtain the correct response about SHM.

For the case of the mean scored group, the analysis shows that 24.81% of the candidates scored from 3.5 to 5.5 marks. These candidates were able to identify some of the factors affecting the motion of a particle in SHM; however, they were unable to analyse how these factors influence the frequency and period of SHM. In part (b), these candidates provided a correct sketch describing the relationship between mechanical energy and displacement. However, they failed to analyse how the changes in displacement influence the mechanical energy (kinetic and potential energy).

Conversely, the analysis reveals that 28.86% of the candidates scored low marks (0.0 to 3.0). These candidates lacked enough knowledge and skills on the topic of Simple Harmonic Motion. The candidates were unable to identify and analyse key factors affecting the frequency and period of the particle executing SHM. Most of them provided irrelevant responses. For instance, one candidate responded: *"The displacement from the equilibrium position to the maximum position makes the particle execute simple harmonic motion quickly to complete the cycle."* This was an incorrect argument. The candidate was supposed to know that the maximum displacement is the amplitude. The amplitude of an oscillatory system does not affect how quickly the particle completes a cycle. This suggests that the candidate lacked adequate knowledge of the factors that affect the motion of SHM. Another candidate gave the following incorrect statement: *"Acceleration makes a particle executing simple harmonic motion quickly complete a cycle."* This candidate was supposed to know that the acceleration of the particle executing SHM affects the motion, but it is not the cause of the timing of the oscillation cycles.

The candidates were supposed to realise that the time to complete one cycle in SHM is given as:

i) For simple pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$, where T is the period of oscillation, l is the length of the pendulum, and g is the acceleration due to gravity.

ii) For a spring-mass system: $T = 2\pi\sqrt{\frac{m}{k}}$, where T is the period, m is the mass, and k is the spring constant.

In the two simple systems, the period is independent of both amplitude and acceleration. It is important to note that for a non-ideal oscillatory system (if the friction is considered or for large-angle pendulums), the amplitude can slightly affect the period. However, this is beyond the scope of this. These candidates were supposed to know that the period of an SHM system depends on: i) the length of the pendulum, ii) the restoring force, and inertia. For a system to oscillate faster requires a higher restoring force, lower inertia (smaller mass), or shorter system length (for a simple pendulum system).

Furthermore, in part (a) (ii), these candidates were unable to present the correct mathematical formula for the displacement of the particle executing SHM. Most of the candidates used the equation of acceleration to deduce the displacement of SHM. For instance, one candidate wrote:

$a \alpha - y$

$a = -\omega^2 y$

$y = \frac{a}{\omega^2}$

Upon substituting the expression of angular frequency, the candidate obtained the following relation:

$y = \frac{T^2}{4\pi^2} a$

These candidates were supposed to realise that in SHM, the particle moves back and forth about its equilibrium position. That is to say that they repeat periodically. Mathematically, sine or cosine is the function used to describe any repeating oscillatory system. Therefore, the candidates were required to use either the sine or cosine function to deduce the displacement equation for SHM. Thus:

$y(t) = A\sin(\omega t + \phi)$, where y is the displacement at time *t*, A is the amplitude, ω is angular frequency and ϕ is the phase constant. Then, upon substituting the given data, the displacement can be written as:

$y = 0.12\sin(4\pi t)$.

Moreover, these candidates failed to provide a correct sketch describing the relationship between the mechanical energy (kinetic and potential energy) with displacement. Extract 3.2 shows the incorrect answers from one of the candidates who scored low marks in this question.

3. a) i) ~~The~~ Because due to the presence of the velocity that enables the body to move freely

ii) Solution

Given:

Amplitude = 0.12m

Period, T = 0.5sec

~~$A = \omega^2 y$~~ To show expression for the ~~displace~~ displacement equation

~~a =~~ $A = \omega^2 y$

$y = \frac{A}{\omega^2}$

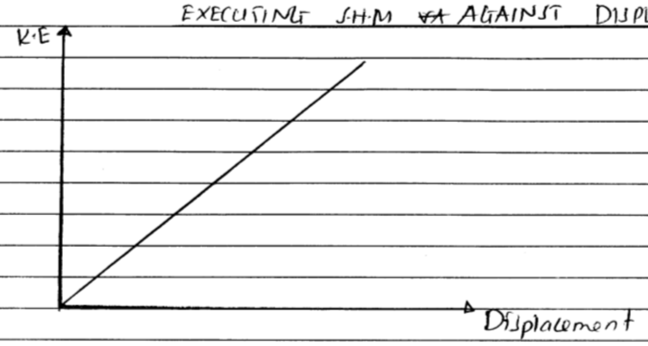
$y = \frac{0.12}{\omega^2}$

but, $\omega = \left(\frac{2\pi}{T}\right)^2$

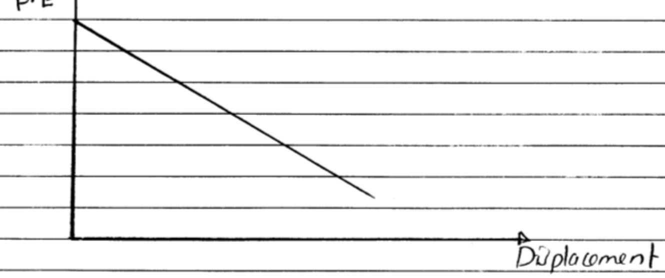
$y = A \times \frac{T^2}{4\pi^2}$

$\therefore y = \frac{A \times T^2}{4\pi^2} = \frac{0.12 \times 0.5^2}{4\pi^2} = 7.6 \times 10^{[illegible]}$

3. b) A GRAPH FOR KINETIC ENERGY OF A PARTICLE EXECUTING S.H.M ~~VA~~ AGAINST DISPLACEMENT



A GRAPH OF POTENTIAL ENERGY OF A PARTICLE EXECUTING S.H.M AGAINST DISPLACEMENT



The particle moving when displacement is increased the kinetic energy also increase while the potential energy decrease but ~~when~~ also, when displacement decrease kinetic energy also decrease while potential energy increase.

Extract 3.2: A sample of correct responses to question 3 of paper 1

In extract 3.2, a candidate failed to apply the correct concepts and theories to analyse the system executing SHM. Moreover, the candidate failed to use mathematics skills to deduce the displacement of a particle executing SHM.

2.4 Question 4: Mechanics (Rotation of Rigid Bodies)

This question had two parts: part (a) and part (b). Part (a) required candidates to (i) apply the concepts and principles of rotational motion to describe the behaviour of rigid bodies in the absence of external torque, and (ii) use mathematics to derive the work done by torque. In part (b) (i), the candidates were supposed to provide the physical meaning of the radius of gyration, while in part (b) (ii), the candidates were required to use mathematics skills to determine the angular acceleration of a disc which is rotating freely about an axis through its centre.

This question was attempted by 29,604 (100%) candidates. Of these, 15,663 (52.91%) candidates scored from 0.0 to 3.0 marks. 6,774 (22.88%) scored from 3.5 to 5.5 marks, and 7,167 (24.21%) scored 6.0 to 10.0 marks. Generally, the candidates' performance was average, as 13,941 (47.09%) scored from 3.5 to 10.0 marks. Figure 5 presents the candidates' performance in this question.

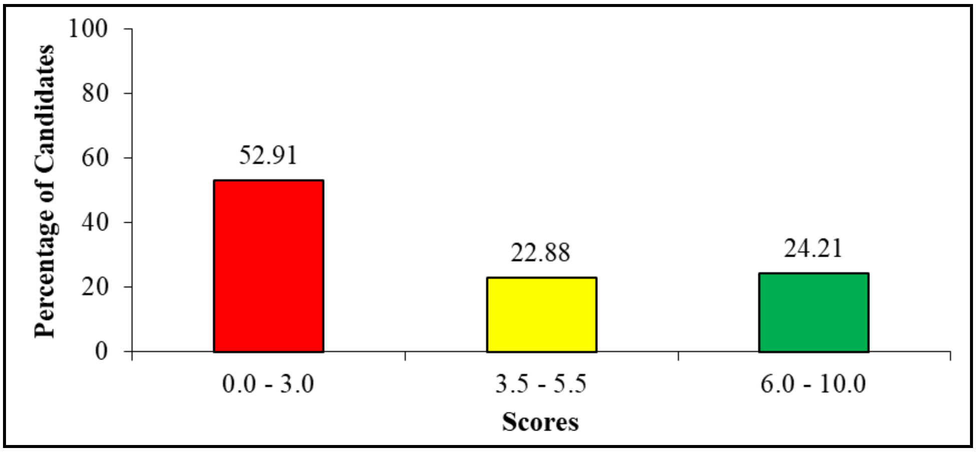


Figure 5: *Candidates' performance in question 4 of paper 1*

Statistical data indicates that 24.21% of the candidates scored higher marks, ranging from 6.0 to 10.0. These candidates demonstrate their mastery of basic concepts and principles of the motion of a rigid body. Moreover, they demonstrate the use of mathematics to compute the value of a physical quantity. For instance, in part (a) (i), these candidates were able to apply concepts and principles of rotational motion to describe the dynamics of a fan after switching it off. They understand that the rigid body will continue in its state of rest or uniform rotational motion unless acted upon by an external torque. These candidates were able to apply mathematics to derive the work done by the torque. In part (b) (i), the candidates demonstrated a clear understanding of the physical meaning of the radius of gyration, which is a measure of the distribution of a body's mass relative to a given axis of rotation.

Furthermore, in part (b) (ii), the candidates were able to apply correct mathematical formulas to calculate the angular acceleration of the disc. Extract 4.1 shows the correct responses from one of the candidates who scored almost all parts of the question.

4 (a) i. The fan continue to rotate after some time due to the rotational inertia, such that when the fan was rotating and suddenly switched off will continue in its rotational motion. Hence rotational inertia plays a role to make it continue rotating.

(a) ii) Required to show relationship between Workdone by torque and its relation to angle of rotational.

now, consider

Workdone by torque (W·d) = F x S

F = Force

S = Linear displacement

W·d = FS

but S = θr

W·d = Fθr

W·d = Frθ

but Torque = Fr

W·d = τθ Hence derived

where W·d = workdone

τ = Torque

θ = Angle of rotation.

(b) (i) The physical meaning of radius of gyration simply the distance to which the mass of the particles distributed from the axis of rotation.

4 (b) ii. Solution

Data given

Force $(F) = 50N$

mass of disc $(M) = 2kg$

radius of disc $(r) = 20cm = 0.2m$

Required angular acceleration $(\alpha) = ?$

From

Torque $(\tau) = Fr$

$\tau = 50N \times 0.2m$

$\tau = 10Nm$

but from

$\tau = Fr$, $F = ma$

$\tau = mar$, but $a = \alpha r$

$\tau = m \cdot r \cdot r \alpha$

$\tau = mr^2\alpha$ but $mr^2 = I$

$\tau = I\alpha$

$$\alpha = \frac{\tau}{I}$$

but I, for disc

$$I = \frac{1}{2}mr^2$$

$$I = \frac{1}{2} \times 2kg \times (0.2m)^2$$

$I = 0.04\,kgm^2$

then $\alpha = \dfrac{10Nm}{0.04\,kgm^2}$

$\alpha = 250\,rad/sec^2$

Hence the angular acceleration $= 250\,rad/s^2$

Extract 4.1: A sample of correct responses to question 4 of paper 1

In Extract 4.1, the candidate correctly explained why the blades of a fan continue to rotate for some time after it is switched off and appropriately derived an expression showing the relationship between the work done by a torque and the angle of rotation. Similarly, the candidate accurately stated the meaning of the radius of gyration, and well calculated the angular acceleration of the disc.

Conversely, the analysis further reveals that most of the candidates (52.91%) scored lower marks (0.0 to 3.0). These candidates lacked adequate skills in the concepts and principles of the topic of the rotation of rigid bodies. These candidates failed to apply mathematics to determine the angular acceleration of a rotating disc. Most of them provided incorrect responses. For example, one candidate misunderstood the concept in part (a) (i), by stating: *"This is due to external speed which causes the blade to continue rotating for some time."* This response was not a correct one. First, the term external speed is not a valid term to describe the motion of a rigid body. The candidate was supposed to know that speed is not an external or an internal; it measures how fast an object moves. It can be said that the candidate failed to demonstrate their mastery of basic terminologies in Physics. Secondly, the candidate failed to identify the basic principle governing the motion of a rigid body. In part (a) (ii), one of the candidates' responses was as follows:

$\tau = Fd$

$w = Fd$

But, $w = mg\cos\theta$

For a small angle, $\cos\theta \approx \theta$

$w = \tau\theta$

$\tau = \frac{w}{\theta}$.

This approach was not correct. The candidates were supposed to know that torque is the measure of how much a force causes an object to rotate about an axis. Thus, it is given as:

$\tau = r \times F = rF\sin\theta$, where τ is a torque, r is the distance from the axis of rotation to the point where the force is applied, F is the applied force, and θ is the angular displacement due to the applied force.

In a rotational motion, torque does work. Work done by a torque in rotational motion can be derived as follows:

$dw = F.ds$, where ds is the displacement in the direction of force, and other symbols carry their usual meaning. It is important to note that the applied force is tangential to a rotating body. Thus, it causes a rigid body to move through a small arc length, ds. In angular displacement, the arc length is defined as:

$ds = r.d\theta$

Thus:

$dw = F.ds = Frd\theta$

It is known that $\tau = rF$

Therefore, $dw = \tau d\theta$

Suppose the torque is constant over the angular displacement; the total work done by the torque is:

$$w = \int dw = \int_{\theta_1}^{\theta_2} \tau d\theta$$

Hence:

$$w = \int_{\theta_1}^{\theta_2} \tau d\theta = \tau\Delta\theta$$

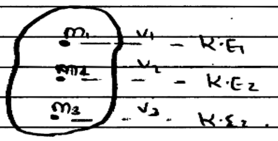
Assume $\Delta\theta$ is a total angular displacement, θ, the total work done by a torque can be documented as:

$$w = \tau\theta$$

Moreover, most of the candidates who scored lower marks failed to provide the physical meaning of the radius of gyration. Most of them defined the radius of gyration, instead of its physical meaning. Moreover, these candidates failed to apply their mathematics skills to compute the angular acceleration of a rotating disc. They used the wrong mathematical expression. This is an indication of inadequate mathematical skills. Extract 4.2 shows a sample of incorrect responses from one of the candidates in this question.

4. a) (i) Due to torque which help the body to rotate and also increase in kinetic energy. because is directly proportion. ✗

(ii) Consider.



From

$K.E = \frac{1}{2} mv^2$.

$K.E_1 = \frac{1}{2} m_1 V_1^2$

$K.E = \frac{1}{2} m_2 V_2^2$

$K.E = \frac{1}{2} m_3 V_3^2$.

But.

$K.E_T = K.E_1 + K.E_2 + K.E_3 + \dots + K.E_n$

$K.E_T = \frac{1}{2} m (V_1^2 + V_2^2 + V_3^2 + \dots + V_n^2)$ $\quad m_1 = m_2 = m_n$

But $v = \omega r$

$K.E_T = \frac{1}{2} m (\omega^2 r_1^2 + \omega^2 r_2^2 + \omega^2 r_3^2 + \dots + \omega^2 r_n^2)$

4. a) (ii)

$K.E_T = \frac{1}{2} m\omega^2 (r_1^2 + r_2^2 + r_3^2 + \dots + r_n^2)$

$K.E = \frac{1}{2} I\omega^2$.

Hence shown.

b) (i) Radius of gyration; is the turning point in the rotating body.

(ii) Data.

$F = 50N$

$m = 2Kg$

$r = 20cm$

From.

$F = m\frac{v^2}{r}$

$V = \sqrt{\frac{rF}{m}}$

$V = \sqrt{\frac{20\times10^{-2} \times 50}{2}}$

$v = 2.236 ms^{-1} = \sqrt{5}$

But.

$a_c = \frac{v^2}{r} = \frac{(\sqrt{5})^2}{20\times10^{-2}} = 25 ms^{-2}$.

$\therefore$ Angular acceleration $= 25 ms^{-2}$

Extract 4.2: A sample of an incorrect response to question 4 of paper 1

In Extract 4.2, the candidate derived an expression for the rotational kinetic energy of rigid bodies, instead of the correct expression relating work done by a torque. The candidate applied incorrect concepts and mathematical formulas to calculate the angular acceleration of the disc.

2.5 Question 5: Heat (Heat Transfers and First Law of Thermodynamics)

This question consisted of two parts (a) and (b). In part (a), the candidates were required to explain briefly the following observations: (i) Thermos flasks are designed to maintain the temperature of their contents for a long time, and (ii) Chairs made of metallic materials appear colder than wooden chairs during the cold season, and (iii) Transformers are always kept in a tank containing oil. In part (b), they were required to calculate the new volume of the gas if an ideal gas of volume 500 cm^3 at 300 K expands adiabatically and its temperature falls to 270 K when the ratio of their heat capacities $\gamma = \left(\frac{C_P}{C_V}\right)$ is 1.4.

This question was attempted by 29,604 (100%) candidates, of whom 6,019 (20.33%) candidates scored from 0.0 to 3.0 marks. 5,481 (18.52%) scored from 3.5 to 5.5 marks, and 18,104 (61.15%) scored 6.0 to 10.0 marks. In general, the candidates' performance was good, as 23,585 (79.67%) scored from 3.5 to 10.0 marks. Figure 6 presents the candidates' performance in this question.

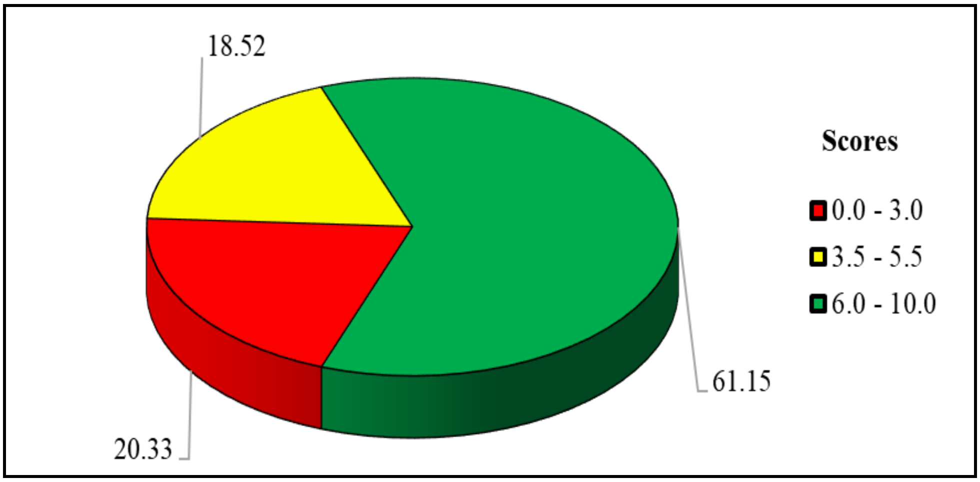


Figure 6: *Candidates' performance in Question 5 of Paper 1*

The statistical data reveals that most of the candidates (61.15%) scored higher marks in this question. In part (a) (i), candidates showed their ability to apply the method of heat transfer in our daily life. They were able to apply concepts and theories of heat transfer to describe thermal insulation. Moreover, in part (a)(ii), the candidates were able to identify materials based on their thermal conductivity. The candidates correctly describe why chairs made of metallic materials appear colder than wooden chairs during the cold season, attributing it to their thermal conductivity. In part (a)(iii), these candidates correctly explained that transformers are always kept in a tank containing oil to facilitate cooling and electrical insulation, thereby ensuring safe and efficient operation.

In part (b), the candidates demonstrated their mastery of basic concepts and principles of thermodynamics to evaluate a physical problem. These candidates use mathematics to explain the physical problem. They were able to apply appropriate mathematical formulas and compute the needed physical quantity. They correctly wrote the formula expressing the relationship between temperature and volume under adiabatic conditions, and made proper substitutions using the given data, which ultimately led to the correct response. Extract 5.1 portrays the correct responses from one of the candidates in this question

5 A) (i) Thermos flask contain a vacuum which prevent heat loss by convection, also it's inner walls are silvered to prevent heat loss by radiation and it's made of plastic stopper which is poor conductor of heat hence prevent heat loss by conduction; these features make

5 A) a thermos flask to store / maintain the temperature for a long period of time

(ii) - Chairs made by metallic materials appear colder because metals are good conductor of heat hence they tend to extract heat from your body making a person feel colder
- on other hand wooden chairs are not more colder because woods are poor heat conductor hence don't cause much heat loss from person in conduct.

(iii) Transformers are always kept in a tank containing oil because the oil tend to cool the transformer by convection means whereby hot oil rises and the cold one move down due to difference in density

5 B) Data

$V_1 = 500cm^3$

$T_1 = 300k$

$T_2 = 270k$

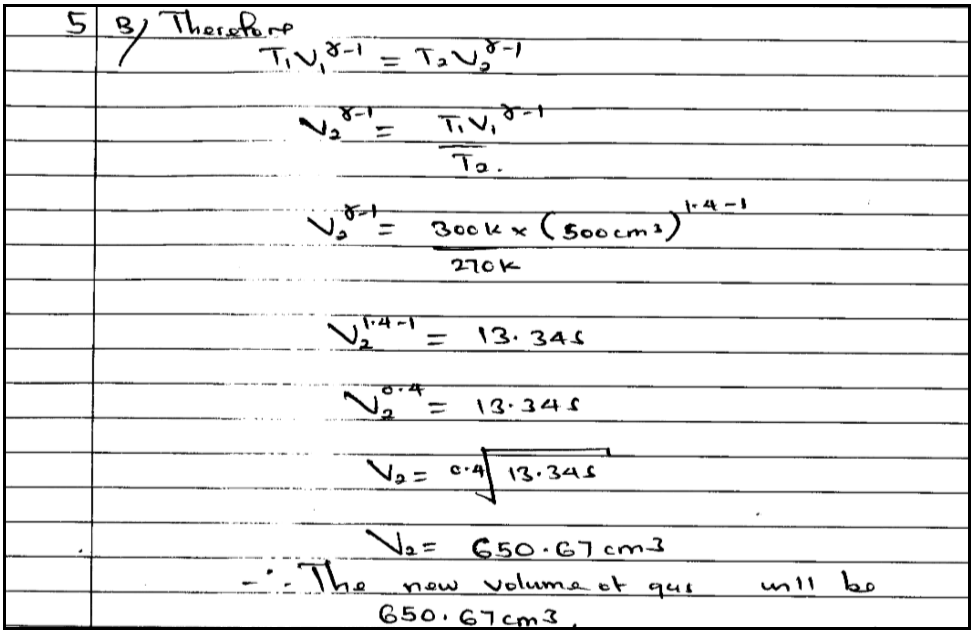
$\gamma = 1.4$

$V_2 = ?$

Since it's adiabatic expansion

hence

$TV^{\gamma-1} = k.$



5 b) Therefore

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$V_2^{\gamma-1} = \frac{T_1V_1^{\gamma-1}}{T_2}.$

$V_2^{\gamma-1} = \frac{300k \times (500cm^3)^{1.4-1}}{270k}$

$V_2^{1.4-1} = 13.345$

$V_2^{0.4} = 13.345$

$V_2 = \sqrt[0.4]{13.345}$

$V_2 = 650.67 cm3$

∴ The new volume of gas will be 650.67cm3.

Extract 5.1: A sample of correct responses to question 5 of paper 1

Extract 5.1 shows a response from a candidate who had enough knowledge and skills on the topic of heat transfer. The candidate was able to apply the first law of thermodynamics in solving the given problem.

The analysis shows that 18.52% of the candidates scored between 3.5 to 5.5 marks, which is the average score. These candidates demonstrated competence in applying methods of heat transfer to real-life situations. However, they failed to apply the first law of thermodynamics in solving the given problem. Some of the candidates applied the first law of thermodynamics but failed to identify the thermodynamic process. For instance, some of the candidates assume that the process was isothermal, which was incorrect.

The statistical data shows that some of the candidates (20.33%) scored between 0.0 to 3.0, which is a lower score. Most of these candidates demonstrated an inability to apply concepts and theories of heat transfer and thermal conductivity in daily life situations. Most of them provided incorrect responses. For instance, one of the candidates in part (a)(ii) responded: *"Because metallic materials are made up of low specific heat capacities as compared to chairs."* This statement was not correct. The candidate was supposed to know that the specific heat capacity describes how much thermal energy a material can store, and not how quickly the material can transfer thermal energy. Thus, metals feel colder than wood because they transfer thermal energy more quickly and not because they store more thermal energy (specific heat capacity).

In part (b), most of the candidates who scored lower marks failed to apply the first law of thermodynamics to compute the needed physical quantity. Most of them applied the incorrect and irrelevant mathematical formula. For example, one candidate wrote: $T_1V_1^{\gamma} = T_2V_2^{\gamma}$ Upon mathematical manipulation, the candidate wrote $V_2 = V_2\left(\frac{T_1}{T_2}\right)^{\gamma}$. This was a wrong expression. The candidates were supposed to apply the following expression $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$, after mathematical manipulation, they were supposed to write $V_2 = V_1\left(\frac{T_1}{T_2}\right)^{\frac{1}{\gamma-1}}$. Extract 5.2 depicts the incorrect responses from one of the candidates in question 5.

03 (b)(ii) $\tau = I\alpha$.

But

$\tau = 50N$

$50N = 0.08kgm^2 \alpha$.

$\alpha = \frac{50N}{0.08kgm^2}$

$\alpha = 625 \ rad/s^2$.

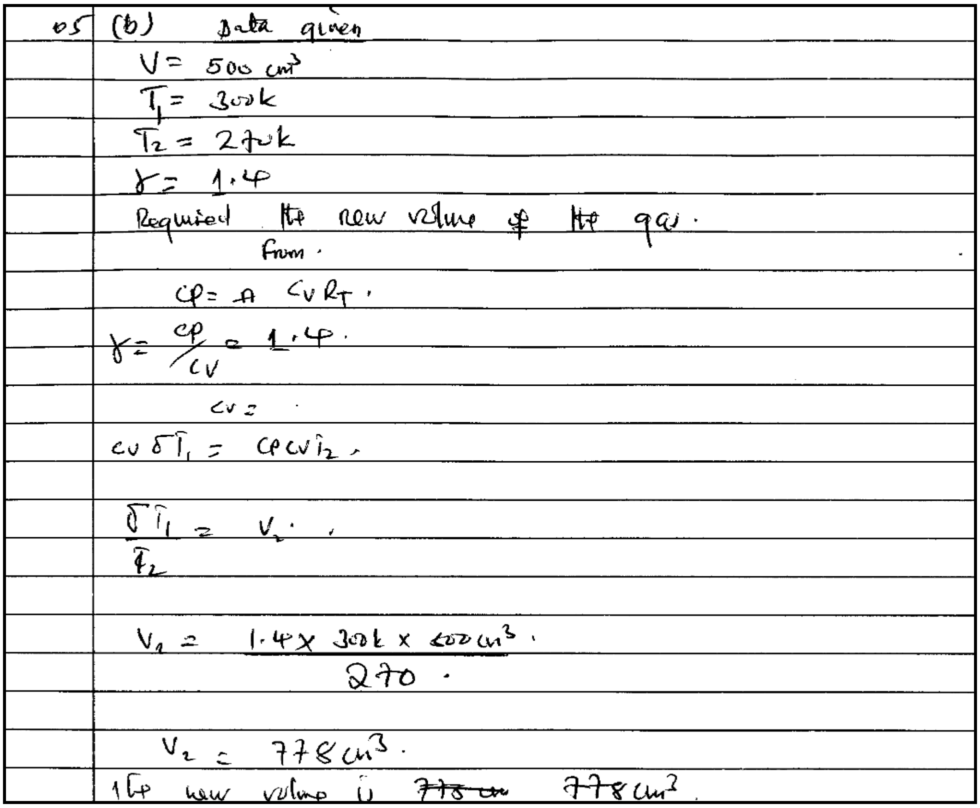
∴ The angular acceleration is 625 rad/s².

~~05. (a)(i) This Thermos maintain its own temperature.~~

05. (a)(i) Because thermos flasks made up of the iron which help to maintain heat for long time.

(ii) During colding season the heat is low and this made iron to appear as low when while wooden chair does not appear like this because do not depend on heat.

(iii) Transformers are always kept in a tank containing oil due to reduce heat ~~bb~~ between the tank and the iron.



05 (b) Data given
V = 500 cm³
T₁ = 300k
T₂ = 270k
γ = 1.4
Required the new volume of the gas.
From.
cp = A cv RT.
γ = cp/cv = 1.4.
cv =
cv γT₁ = cp cv T₂.
γT₁/T₂ = V₂.
V₂ = 1.4 x 300k x 500 cm³ / 270.
V₂ = 778 cm³.
the new volume is ~~778 cm~~ 778 cm³

Extract 5.2: A sample of an incorrect response to Question 5 of paper 1

In Extract 5.2, the candidate demonstrated an unsatisfactory understanding of heat transfer mechanisms, conduction, convection, and radiation and therefore failed to explain the corresponding observations in items (a) (i), (ii), and (iii). Furthermore, the candidate applied an irrelevant formula to calculate the volume of a gas under adiabatic conditions in thermodynamics.

2.6 Question 6: Heat (Heat Transfer; Thermal Radiation)

The question had two parts (a) and (b). In part (a), the question asked *(i) Why does a good absorber of radiant energy appear black? (ii) Give four information obtained from the curves regarding black body radiation*. In part (b), the candidates were required to calculate the energy radiated in one minute by a black body of surface area 200 cm^2 maintained at 127 °C.

The question was attempted by 29,604 (100%) candidates. Of these, 8,702 (29.39%) candidates scored from 0.0 to 3.0 marks, 9,839 (33.24%) scored from 3.5 to 5.5 marks, and 11,063 (37.37%) scored 6.0 to 10.0 marks.

Generally, the candidates' performance was good, as 20,902 (70.61%) scored from 3.5 to 10.0 marks. Figure 7 presents the candidates' performance in Question 6.

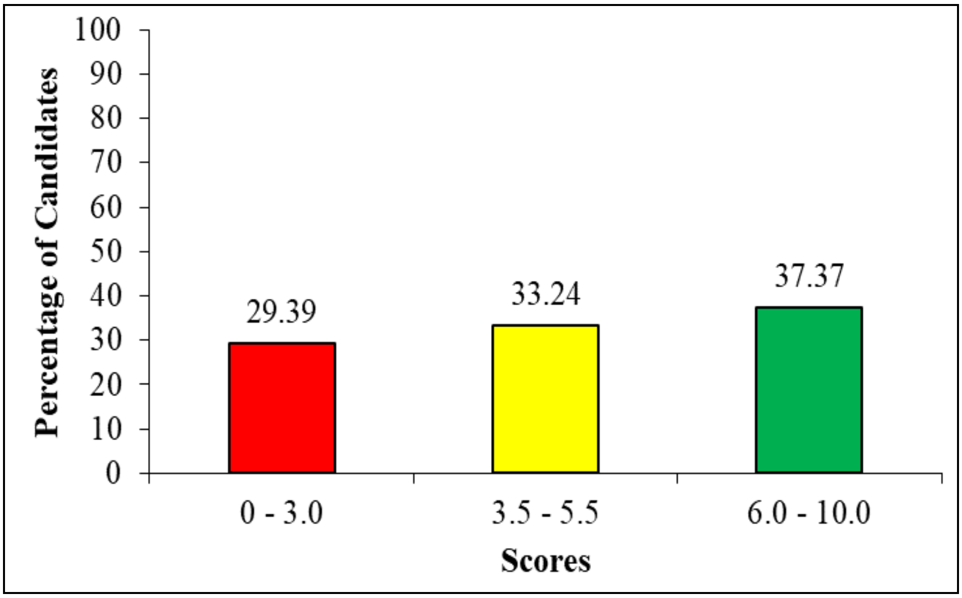


Figure 7: *Candidates' performance in question 6 of paper 1*

"The analysis shows that 37.37% of the candidates who scored higher marks (6.0 to 10.0) demonstrated sufficient knowledge and understanding of the concepts, theories, and principles governing heat transfer by radiation. In part (a) (i), these candidates were able to apply Kirchhoff's law of thermal radiation to describe the appearance of a blackbody. In part (a) (ii), candidates were able to identify key characteristic features of blackbody spectra as stipulated by the Stefan-Boltzmann law and Wien's displacement law.

In part (b), the candidates applied appropriate mathematical skills and used a suitable formula to calculate the energy radiated by a blackbody in one minute. Extract 6.1 is a sample of correct responses from one of the candidates in this question.

6(a)(i) Good absorber of radiant energy appear black because it tend to absorb all light of visible frequency and emitts non of them, thus why appear black.

6.
(a)(iii) The followings are the Information obtained from the curves of black body radiation.

- The energy emitted by a black body in each curve is directly protional to the area of the curves
- The energy emitted by black body in each curve is directly proportional to temperature.
- The black body emitts radiation and absorbs radiation at an equall amounts.
- The blackbody absorbs all radiation of visible frequency and emitts non of it.

6(b) Solution.

Data provided.

time (t) = 1 mins (60 sec)

Surface area (A) = 200 cm^2

Temperature of surface (T) = 127°C (400 K)

Required; energy (E) = ?

Recall from stefan's law.

$P = eA\sigma T^4$

$P = e\sigma AT^4$.

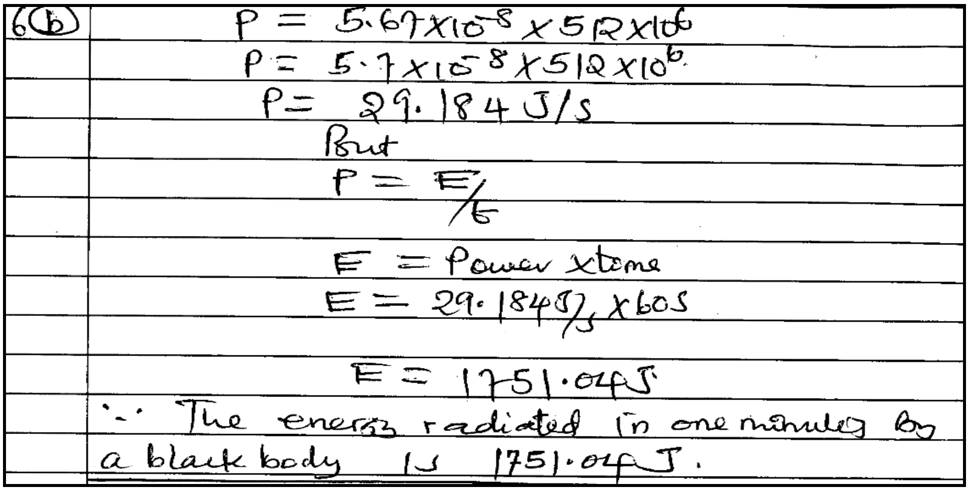
But $200 cm^2 = 0.02 m^2$

$P = 1 \times 5.67 \times 10^{-8} \times 0.02 \times (400)^4$

$P = 1 \times 5.67 \times 10^{-8} \times 0.02 \times 2.56 \times 10^{10}$

$P = 5.67 \times 10^{-8} \times 512 \times 10^{+6}$

$P = 5.67 \times 10^{-8} \times 512 \times 10^{6}$



6(b) P = 5.67×10⁻⁸ × 512×10⁶
P = 5.7×10⁻⁸ × 512×10⁶
P = 29.184 J/s
But
P = E/t
E = Power × time
E = 29.184 J/s × 60s
E = 1751.04 J
∴ The energy radiated in one minute by a black body is 1751.04 J.

Extract 6.1: A sample of correct responses to Question 6 of paper 1

In Extract 6.1, the candidate demonstrated a good understanding of the concepts, theories and principles related to thermal radiation. The candidate applied the correct mathematical formula to evaluate the radiation energy emitted by a blackbody for one minute.

The statistical analysis further indicates that some of the candidates (33.24%) scored average marks (3.5 - 5.5). Most of these candidates failed to score higher marks in part (a) of the question. The candidates in this category failed to use concepts, theories and principles related to thermal radiation to describe real-life situations. The analysis of statistical data shows that most of these candidates scored higher marks in part (b) of the questions. The candidates applied the correct mathematical formula to evaluate the energy emitted by the blackbody for one minute.

In contrast, the statistical data shows that some candidates (29.39%) scored lower marks (0.0 – 3.0). Some of them were unable to provide clear responses, though they had basic understanding of thermal radiation. For instance, in part (a) (i), one of the candidates responded: *"Because black has an emissivity of 1, that's why a black body is a good absorber."* This response was not very clear. The candidate was supposed to know that not all black materials have an emissivity of 1. Black materials appear black but may not absorb all radiation. Thus, their emissivity can be higher than 1. A blackbody is an ideal object with an emissivity of 1. It is a perfect absorber and emitter of radiation across all wavelengths. To correctly respond to this item, the candidates were supposed to use Kirchhoff's law of thermal radiation, which states as "*For a body in thermal equilibrium, the emissivity of a surface is equal to its absorptivity for radiation of the* *same wavelength*". Based on Kirchhoff's law, a blackbody is a perfect absorber and perfect emitter. At room temperature, a blackbody absorbs all visible light and emits none or very little in the visible region. Thus, with no or very little visible light reaching our eyes, the body appears black. This means that at room temperature, the blackbody absorbs all visible light and emits in longer wavelengths (heat).

In part (a) (ii), candidates in this category failed to apply both the Stephan-Boltzmann and Win's displacement law to identify key characteristic features of a blackbody spectrum. Most of them provided incorrect and irrelevant responses. For instance, one candidate wrote:

(i) *it indicates the transfer of heat from one system to another*

(ii) *it tells anything about the condition under which heat can be converted heat mechanical energy to other form*

(iii) *it tells about the condition of first law of thermodynamics which facilitate the rate of heat lost to enter and leave the system*

(iv) *the heat energy supplied in a system should be equal to the heat energy supplied to a system to enter and leave the system of exchangeable*.

These responses are irrelevant with respect to the characteristics of the blackbody spectrum. The candidate was supposed to realise that blackbody curves show a relationship between intensities of emitted radiation and wavelengths at a given temperature. Thus, the following are key features of the blackbody curves.

i) The curve's intensity: it increases with an increase in temperature. Based on the Stefan-Boltzmann law, the total energy emitted by a blackbody is proportional to T^4.

ii) The peak wavelength of emitted radiation exhibits a blue shift (shifting to the shorter wavelength) with an increase in temperature. From Wein's displacement law, i.e., $\lambda_{max} = \frac{b}{T}$ (all symbols carry their usual meaning). It implies that the emitted peak wavelength is inversely proportional to the temperature.

iii) Broadness of the blackbody curves. The broadness of the curves decreases with an increase in temperature.

Some of the candidates sketched the blackbody spectrum but failed to identify and describe key characteristic features of the spectrum. Extract 6.2 shows a sample of incorrect responses from one of the candidates in question 6.

6. a i) The good absorbor of radiant energy appears black
=> Blacks Because the black colour has the ability
to absorb energy than other colour like White Thus why
the good absorbor tend to appear black.

ii) The Information That regar obtained from the curve of black
body radiation.
a. Should produce large size
b. It is rigid
c. absorb the heat energy
d. does not radiate

b. Given data.
time 1 minutes → 60sec
$A = 200cm^2$
$\Delta\theta = 127°C \rightarrow 400k$

from,
~~$Q = \frac{KA(\Delta\theta}{x}$~~

~~$Q = 5.7 \times 10^{-8} x$~~

$\frac{Q}{t} = \frac{KA\Delta\theta}{t}$

$\frac{Q}{60} = 5.7 \times 10^{-8} \times \frac{200cm^2 \times 400k}{1}$

$Q = 60 \times 5.7 \times 10^{-8} \times 200cm^2 \times 400$

$Q = 0.2736 kJ$

∴ The amount of energy radiated in 1 minutes is 0.2736 kJ.

Extract 6.2: A sample of an incorrect response to Question 6 of paper 1

In Extract 6.2, the candidate failed to identify key information from the blackbody radiation curves and thus provided irrelevant responses. Moreover, the candidate applied the incorrect mathematical formula to deduce the energy emitted by a blackbody. He/she used mathematical formula related to the rate of heat loss from Newton's law of cooling, instead of the Stephan-Boltzmann law of thermal radiation, to compute the energy emitted by a blackbody at a given temperature.

2.7 Question 7: Environmental Physics (Earthquake, Environmental Pollution and Geophysics)

The question consisted of parts (a) and (b). In part (a), the candidates were required to (i) distinguish between greenhouse effect and global warming and (ii) enumerate four human activities which contribute to global warming. Part (b) required candidates to (i) identify and analyse two warning signs which predict the occurrence of an earthquake and (ii) identify one key importance of the troposphere and stratosphere to humankind.

The question was attempted by 29,604 (100%) candidates. Of these, 879 (2.97%) candidates scored from 0.0 to 3.0 marks. 3,501 (11.83%) scored from 3.5 to 5.5 marks, and 25,224 (85.20%) scored 6.0 to 10.0 marks. This analysis indicates that the candidates' performance was good, as 28,725 (97.03%) scored from 3.5 to 10.0 marks. Figure 8 summarises the candidates' performance in Question 7.

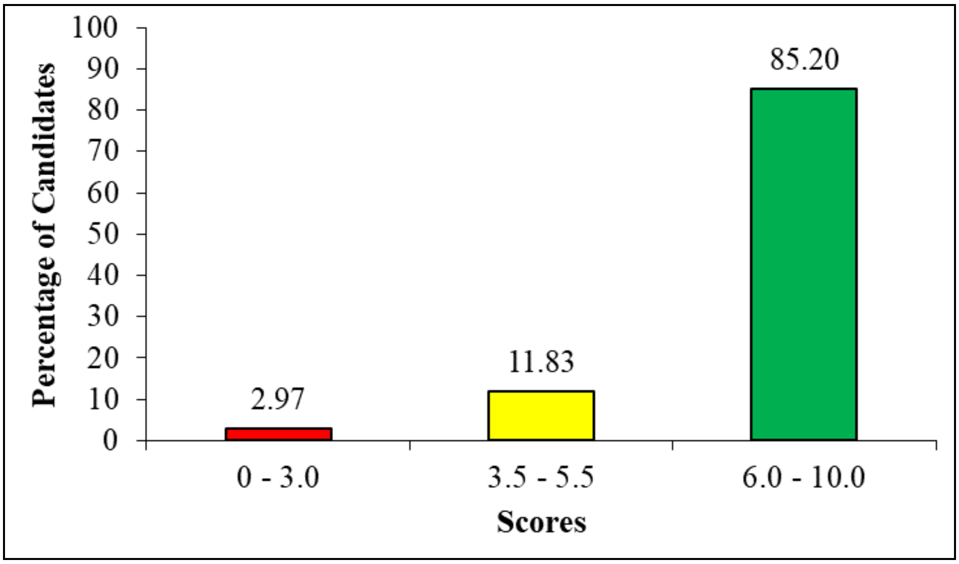


Figure 8: *Candidates' performance in question 7 of paper 1*

The data reveals that 85.20% of the candidates scored higher marks, ranging from 6.0 to 10.0. These candidates provided correct responses which are in line with the question's requirements. In part (a) (i), candidates successfully distinguished between the greenhouse effect and global warming. In (a) (ii), candidates were able to identify and explain four human activities which contribute to global warming.

The statistical data further reveals that most of the candidates in this category were able to identify and describe warning signs which can be used to predict the occurrence of an earthquake. Moreover, these candidates describe the role of the troposphere and the stratosphere correctly. Extract 7.1 shows a sample of correct responses from one of the candidates to this question.

7 (a)(i) → Greenhouse effect is the phenomenon where the radiant energy emitted by the earth are trapped by the atmospheric gases and dust and then the radiant energy is reflected back to the earth's surface.
Examples of gases causing greenhouse effect are Carbondioxide, CO_2 hence increasing the earth's temperature

WHILE

→ Global warming is the rapid increase in the overall temperature of the earth's surface.
→ Global warming is caused by various factors such as the increase in the concentration of greenhouse gases.

(ii) Human activities which contribute to global warming:
1. Large scale industries which tend to produce more greenhouse gases which ultimately lead to global warming.
Industries produce gases such as CO_2, NO_2 and SO_2 which largely contribute to global warming

2. Energy (fuel) production activities such as Nuclear bombs.
→ The influx of nuclear activities has led to global warming —

7 (a)(ii) 2. because more gases such as CO_2 are produced which contribut to global warming.

3. Deforestation activities
→ cutting trees expose the sand to direct sun radiations causing more heating of the earth's surface and since the earth's surface is strongly heated the overal temperature of the earth will increase.

4. Transportation activities using cars, and ships.
→ These transport vehicles produce more CO_2 gases and increasing its concentration in atmosphere and thus leading to the rapid increase in the earths temperature and hence global warming.

(b)(i) Warning signs predicting the occurrence of earthquake:
1. Rapid decrease in the water level base in the water bodies
→ The rapid decrease in the water level base can indicate the sign for earthquake occurrence.
2. Random movement of large groups of animals such as warthogs also indicate the preparation for

(ii) → Importance of troposphere:
1. It controls all weather conditions in the earth's surface and hence acts as source of rainfall.
2. It contains useful gases for the survival of living organisms such as Oxygen gas.

→ Importance of stratosphere
1. It helps the aircraft to fly through it since it has streams of strong winds

Extract 7.1: A sample of correct responses to question 7 of paper 1

In Extract 7.1, the candidate provided correct responses to all parts of the question.

Furthermore, the statistical data shows that 11.83% scored average marks (3.5 to 5.5). Most of these candidates failed to score higher marks in part (a)(ii) of the question. They only mention the activities that contribute to global warming without a scientific justification. This lowers their performance.

The statistical data shows that only 2.97% of the candidates scored lower marks. The scores of these candidates range from 0.0 to 3.0 marks. They failed to demonstrate their mastery of the concepts related to the topic of Environmental Physics. Most of them provided irrelevant responses. For example, in part (a)(i), one candidate wrote: *"Greenhouse effect is a situation whereby the weather condition is maintained, while global warming is the increase in the atmospheric temperature causing abnormal conditions in the environment."* This response is not clear and makes no sense in Physics. The candidate was supposed to know that the greenhouse effect is a natural process (not a weather condition) in which certain gases in the atmosphere trap heat, helping to keep the planet warm enough to support life. Moreover, the candidate was supposed to realise that global warming is an increase in the average global atmospheric temperature due to increased concentrations of greenhouse gases. This results in climate change, such as extreme weather events (drought or heavy rains), shifts in weather patterns and rising sea levels.

In part (b)(i), these candidates failed to identify two key warning signs that can be used to predict the occurrence of an earthquake. Some candidates stated that "*unusual animal behaviour, minor tremors, or ground deformation*" as the warning signs that can be used to predict the occurrence of an earthquake. Most of the responses were not correct. The candidates were supposed to know that the key signs included:

(i) Thermal indicator:
The average temperature of an area keeps increasing. During earthquake days, the temperature of a particular area is about 5 – 9 degrees Celsius above the average normal temperature.

(ii) Water indicator.
There exist sudden rises or falls in water levels in wells; the rise can be as high as one meter.

(iii) Seismo-electromagnetic indicator.
Rise in temperature reduces the geomagnetic field; the reduction in the geomagnetic field adversely affects the propagation of EM-waves. This is noted in Radio, TV and Telephone.

(iv) Animal indicator:
The entire animal kingdom becomes highly disturbed and restless. They move in a directionless manner and in fear. Birds do not perch on trees but move about at a low height, emitting a shrill noise.

The analysis reveals that candidates who scored lower marks also failed to provide correct responses in part (b)(ii) of this question. For instance, one candidate wrote: *"Since the stratosphere is the one in which the ozone layer is formed, it supports life because oxygen is found in this layer."* This response is wrong. In principle, the stratosphere contains oxygen, but most of the breathable oxygen is in the troposphere. The stratosphere contains the ozone layer. This layer absorbs all the harmful ultraviolet (UV) rays from the sun, thereby protecting living organisms on the Earth. Extract 7.2 presents a sample of incorrect responses from one of the candidates who scored low marks in question 7.

7. (a)(i) Greenhouse effect is the space around the earth's surface which contd the earth temperature due to presence of green house gases.

While.

Global warming is the increase in earth temperature due to depletion of ozone layer caused by the green house gases

(ii) (a) Burning of bushes for agriculture
(b) Transportation by using motor vehicles
(c) Industries which produce more gases.
(d) Live stock keeping

7. (b)(i) High movement of magma in the earth crust

(ii) High rate of ~~vottcat~~ volcano eruption

(c) Troposphere act as the centre of communication due to present of radio wave which enable communication.

Stratosphere enable formation of water to take place hence lead to association of rain which is more useful.

Extract 7.2: A sample of an incorrect response to Question 7 of paper 1

Extract 7.2 shows that the candidate failed to distinguish greenhouse effect and global warming. Additionally, the candidate provided a partial and inaccurate explanation of the human activities that contribute to global warming.

2.8 Question 8: Current Electricity (Alternating Current, electrical networks and Kirchhoff's laws)

This question was a structured question with three parts: part (a), (b) and (c). In part (a), the question asked: *A load resistor of 25 Ω is connected in series with an inductor of inductance 0.4 H and internal resistance of 5 Ω. If the pair is then connected across a 200 V r.m.s supply alternating at* $\frac{50}{2\pi}\,Hz$;,

(i) Draw a well-labelled circuit diagram for the connection and

(ii) *calculate the r.m.s current value.*

Part (b) of this question, the candidates were provided with a circuit diagram as shown in Diagram 3.

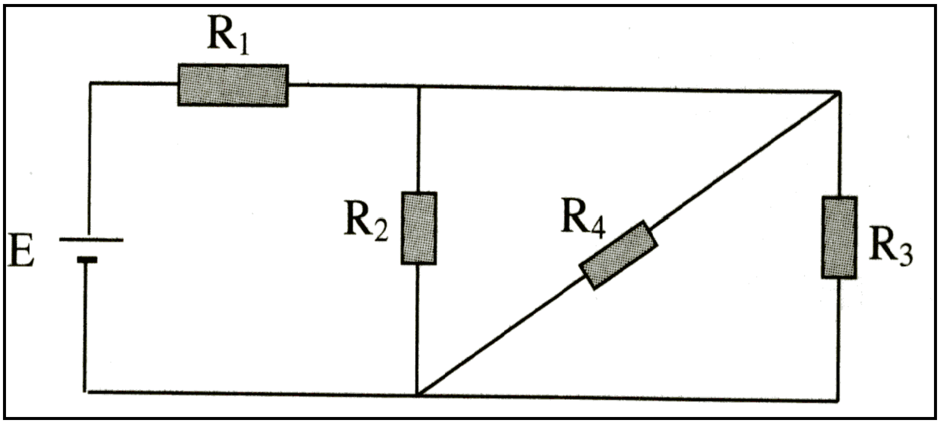


Diagram 3

Using the circuit diagram, the candidates were required to calculate:

(i) The equivalent resistance of the network and

(ii) *The current passing through* $R_2 = 50\,\Omega$.

Part (c) required the candidates to study the circuit diagram 4 and to answer the questions that follow:

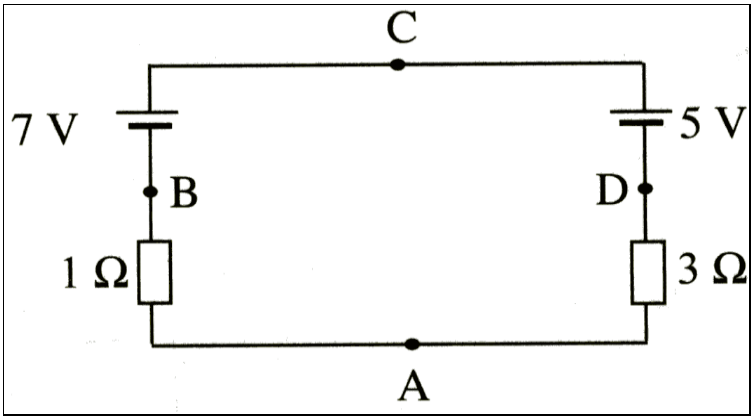


Diagram 4

(i) *Apply Kirchhoff's laws to find the potential difference between A and C.*
(ii) *Why does the potential decreases from point A to B?*

The question was an optional one with a total of 15 marks and was attempted by 7,478 (25.3%) candidates. Of these, 4,242 (56.73%) candidates scored from 0.0 to 5.0 marks, 1,685 (22.53%) scored from 5.5 to 8.5 marks, and 1,551 (20.74%) scored from 9.0 to 15.0 marks. The analysis points out that the candidates' performance was average, as 3,236 (43.27%) of the candidates who attempted this question scored 5.5 to 15.0 marks. Figure 9 summarises the candidates' performance in question 8.

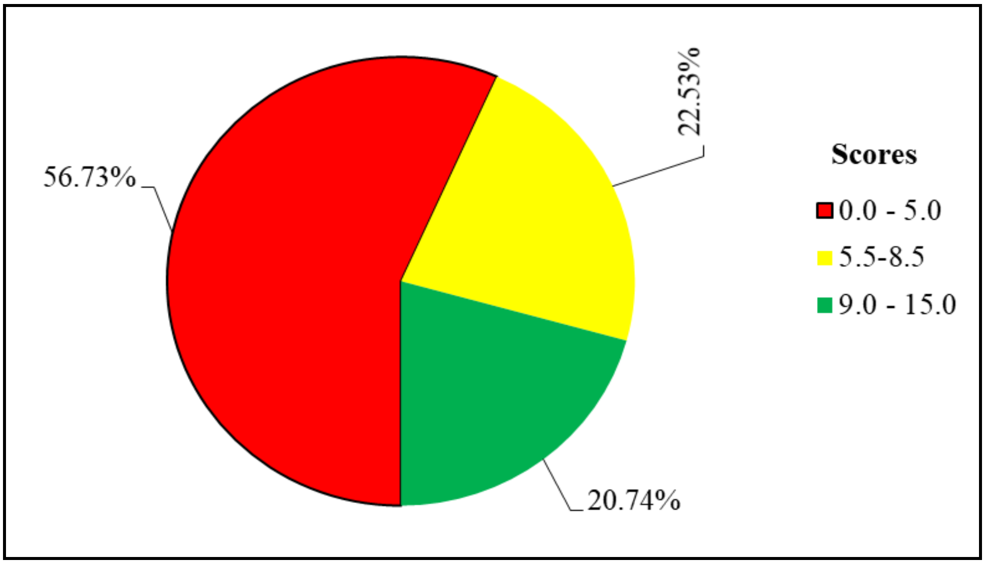


Figure 9: *Candidates' performance in Question 8 of paper 1*

The statistical analysis reveals that 20.74% of the candidates scored higher marks (9.0 to 15.0). These candidates demonstrate their mastery of basic symbols as well as experimental skills as they design and evaluate various electrical circuits. For instance, in part (a)(i), these candidates designed and sketched a well-labelled circuit diagram involving a series connection of a load resistor, an inductor with internal resistance, and an AC power supply. In part (a)(ii), the candidates use mathematics to determine the rms current value.

In part (b), the candidates showed the ability to interpret a circuit diagram, use appropriate concepts and principles related to current electricity to determine the value of effective resistance and current flowing in one of the resistors. These candidates showed the ability to use mathematical reasoning to solve problems related to the current electricity. In part (c) (i), they demonstrated the ability to apply Kirchhoff's laws (current law and voltage law) to analyse a complex electric circuit and determine they potential differences across the components. That is to say that they had adequate mathematical reasoning skills. Moreover, the candidates provided a correct scientific argument related to the current flowing in the circuit. Extract 8.1 shows the correct responses from one of the candidates who scored high marks in question 8.

8. (a) Given

Resistance of a resistor, $R = 25\Omega$

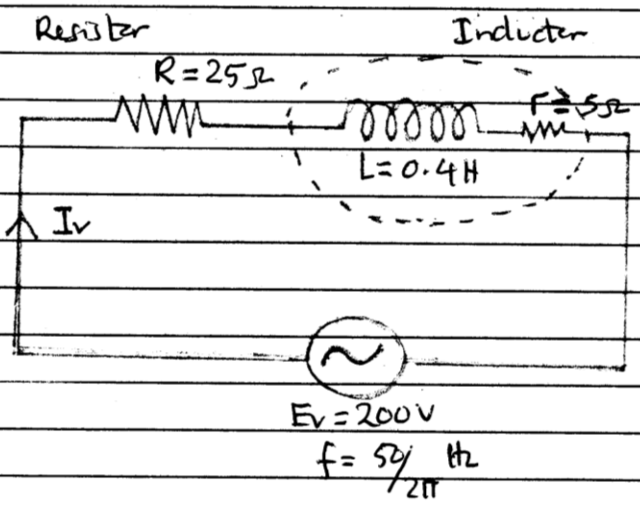
Inductance, $L = 0.4H$ } INDUCTOR

Internal resistance, $r = 5\Omega$ }

voltage of supply $(E_v) = 200$ V

frequency, $f = \frac{50}{2\pi}$ Hz.

(i) Circuit diagram for the connection



(ii) Root mean square current value, I_v

$$I_v = \frac{E_v}{Z} \quad \text{where } Z \Rightarrow \text{Impedance.}$$

$$Z = \sqrt{R^2 + X_L^2}$$

But $R_T = R + r$

$R_T = 25\Omega + 5\Omega$

$R_T = 30\Omega$

8. (a) (ii)

$$X_L = 2\pi f L$$

But $f = \frac{50}{2\pi}$ Hz

$L = 0.4H.$

$$X_L = 2\pi \times \frac{50}{2\pi} \times 0.4 H$$

$X_L = 20\Omega.$

Therefore,

$$Z = \sqrt{R^2 + X_L^2}$$

$$= \sqrt{(30\Omega)^2 + (20\Omega)^2}$$

$$= \sqrt{900\Omega^2 + 400\Omega^2}$$

$$= \sqrt{1300\Omega^2}$$

$$= 36.056\Omega.$$

$\therefore Z = 36.056\Omega$

So,

$$I_v = \frac{E_v}{Z}$$

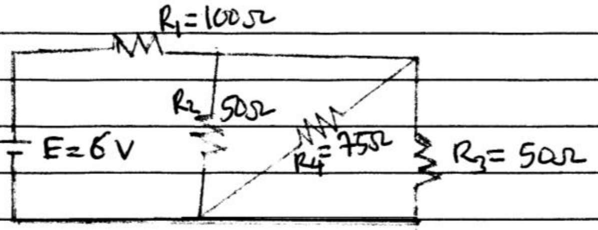
$$= \frac{200\,V}{36.056\,\Omega}$$

$$= 5.547\,A$$

$\therefore$ Root mean square current value is

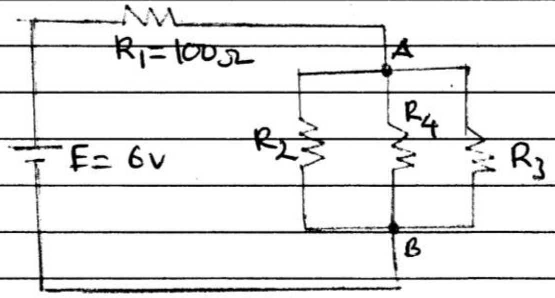
$I_v = 5.547\,A$

8 (b) Given the figure



(i) Equivalent resistance of the network.

Resistor, R_4 and R_3 are parallel with R_2



Let r be an equivalent resistance between A and B

$$\frac{1}{r} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}.$$

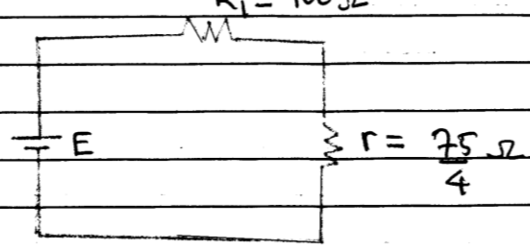
$$\frac{1}{r} = \frac{1}{50\Omega} + \frac{1}{50\Omega} + \frac{1}{75\Omega}$$

$$\frac{1}{r} = \frac{4}{75\Omega}$$

$$\therefore r = \frac{75}{4}\Omega$$

Therefore,

8 (b) (i)



$$R_T = R_1 + r$$

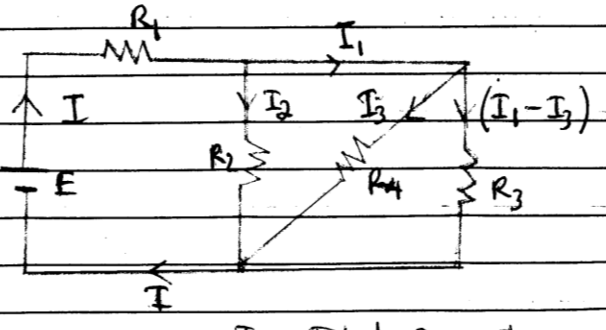
$$R_T = 100\Omega + \frac{75}{4}\Omega$$

$$R_T = \frac{475}{4}\Omega$$

$$R_T = 118.75\Omega$$

∴ Equivalent resistance is 118.75Ω.

(ii) Current passing through R_2.



But since I = Total current

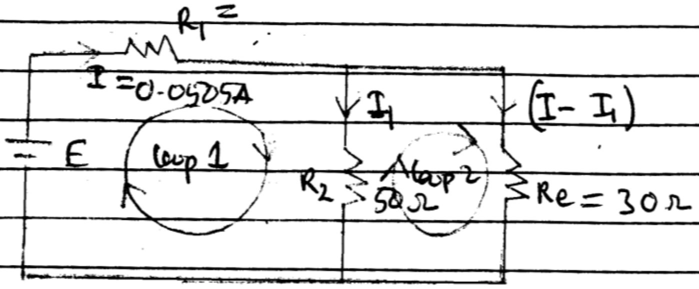
$I = \frac{E}{R_T}$ $E = 6V$

$R_T = 118.75\Omega$

$$I = \frac{6V}{118.75\Omega}$$

$$\therefore I = 0.0505\,A$$

8 (b) (ii) Consider



But $Re = \frac{R_3 R_4}{R_3 + R_4}$

$Re = \frac{50\Omega \times 75\Omega}{50\Omega + 75\Omega}$

$\therefore Re = 30\Omega.$

Using KVL in loop 1

$E - IR_1 - I_1R_2 = 0.$

$E = IR_1 + I_1R_2.$

$6 = (0.0505 \times 100) + I_1 \times 50$

$6 - (0.0505 \times 100) = 50 I_1$

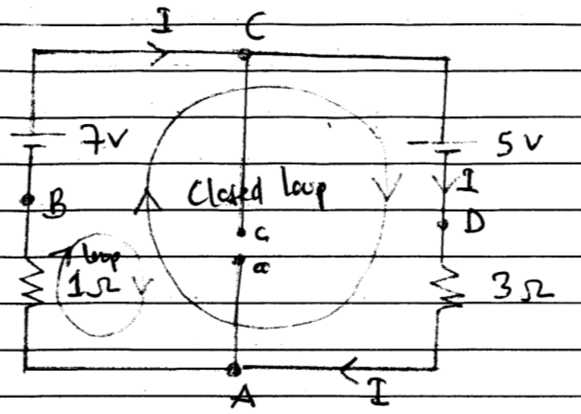
$0.95 = 50 I_1$

$\frac{50 I_1}{50} = \frac{0.95}{50}$

$I_1 = 0.019A$

$\therefore$ Current through R_2 is 0.019A

8 (c) Given



(i) By using Kirchoff's voltage law KVL

$7V - 5V - 3I - I = 0$

$\frac{2V}{4} = \frac{4I}{4}$

$\therefore I = 0.5A$

~~Using KVL for small loop.~~

$V_{ac} - I + 7 = 0$

$V_{AC} - 0.5 + 7 = 0$

$V_{AC} = 6.5V$

∴ Potential difference between A and C is 6.5 volts

8 (c) (ii) Potential decrease from A to B because, some of it drops across 1Ω resister.

potential drop = IR

$= 0.5A \times 1\Omega$

$= 0.5V.$

∴ 0.5V drops at 1Ω resister

Extract 8.1: A sample of correct responses to Question 8 of paper 1

In extract 8.1, a candidate managed to use mathematics and appropriate laws and principles to calculate the value of the needed physical quantity.

The statistical data shows that 22.53% of the candidates scored between 5.5 and 8.5 marks, which is the average score. The analysis reveals that these candidates did not perform well in parts (b) and (c). In part (a), the candidates successfully designed and sketched a well-labelled circuit diagram. They used the circuit diagram and the principles of AC to deduce the r.m.s value. In part (b) (i), the candidates correctly applied the concepts and theories related to current electricity to determine the effective resistance of the network. However, most of them failed to calculate the current passing through R_2. In part (c) (i), these candidates applied Kirchhoff's laws to determine the potential difference between points A and B in the circuit. The analysis revealed that they were unable to provide a scientific explanation for the decrease in potential from point A to B.

The data also shows that most of the candidates (56.73%) scored lower marks (0.0 – 5.0). Further analysis of statistical data showed that 1,301 (4.87%) of these candidates scored zero marks. This suggests that the candidates lacked adequate knowledge and skills on the topics of AC theory and current electricity. The analysis reveals that most of these candidates failed to score higher marks in part (a). Most of them failed to design and sketch a well-labelled circuit diagram, that is the candidates provided wrong circuit diagrams. For instance, one of the candidates drew and used the following circuit diagram (see Diagram 5) to deduce the r.m.s value. Moreover, the candidate failed to apply the correct formula for calculating the r.m.s value of the current. It suggests the lack of basic understanding of the concepts, theories and principles related to AC circuits.

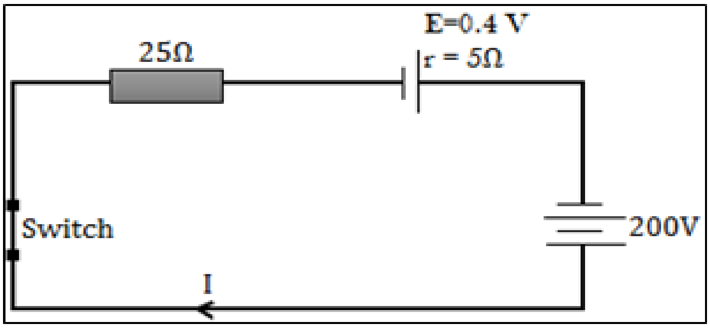


Diagram 5

This is an incorrect circuit diagram which indicates that the candidate failed to master basic symbols in Physics. The candidate was supposed to recognize that the circuit must contain an AC power source, an inductor and resistors. It can be said that these candidates failed to distinguish circuit symbols for a DC and an AC power source. It can be concluded that most of the candidates in this category failed to design and sketch a correct circuit diagram, and thus were unable to calculate the r.m.s value. The candidates in this category were required to design and sketch the circuit diagram shown in Diagram 6.

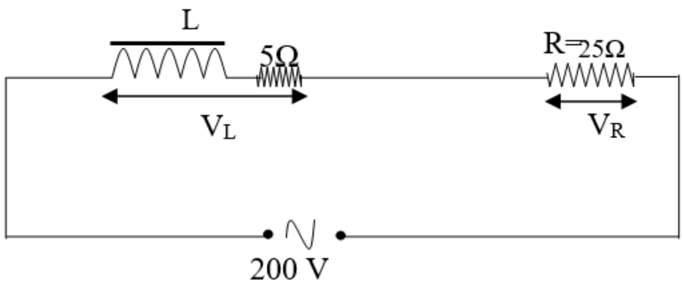


Diagram 6

The analysis of statistical data revealed that some of the candidates designed and sketched a well-labelled circuit diagram, but failed to analyse it. They failed to apply Ohm's law to calculate the r.m.s current value. Most of them were unable to determine the total impedance of the circuit. They ignored the effect of inductive load in the circuit. For instance, some of them calculated the r.m.s current value as follows:

$$V = I\,R$$

$$I = \frac{V}{R}, \text{but } R_T = R_1 + R_2$$

$$I = \frac{V}{R_1 + R_2},$$

$$I = \frac{200}{25\,\Omega + 5\,\Omega}$$

$$I = 6.67\,A$$

This was an incorrect response. These candidates were supposed to realise that in this circuit, the current through the resistor and inductor is the same. Thus, the total impedance, Z, is given as:

$Z = \sqrt{R^2 + X_L{}^2}$, where R and L are respectively a resistor and an inductor connected in series. Knowing the total impedance, Ohm's law can be applied to calculate the r.m.s current value as:

$$I_{\text{r.m.s}} = \frac{V_{\text{r.m.s}}}{Z} = \frac{V_{\text{r.m.s}}}{\sqrt{R^2 + X_L^2}}.$$

X_L is given as:

$$X_L = \omega L = 2\pi fL = 2\pi \times \left(\frac{50}{\pi}\right) \times 0.4 = 40\ \Omega$$

Thus:

$$I_{\text{r.m.s}} = \frac{V_{\text{r.m.s}}}{\sqrt{R^2 + X_L^2}} = \frac{50V}{\sqrt{30^2 + 40^2}} = 4\,\text{A}.$$

Moreover, these candidates failed to analyse and solve problems involving resistor configurations as per the electric circuit in part (b)(i) of the question. It implies that the candidates lack adequate knowledge and skills related to current electricity. Most of them failed to understand the resistor configuration in the circuit. Thus, failed to determine the equivalent resistor stepwise. For instance, one candidate assumed that R_3 and R_4 are serially connected. As a result, this candidate reduced the given circuit to the circuit shown in Diagram 7:

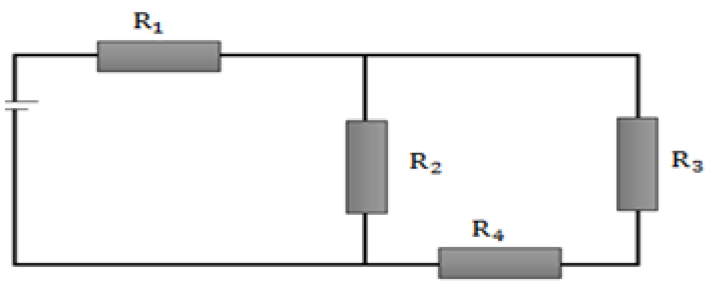


Diagram 7

Thus, the candidate used the following mathematical equation:

$R_T = R_1 + \frac{(R_3 + R_4) \times R_2}{R_2 + R_4 + R_3}$. Upon substituting data, the candidate wrote:

$R_T = 100 + \frac{(50+75) \times 50}{50+75+50}$ =135.71 Ω.

This was an incorrect response. The candidate was supposed to realise that resistors R_2, R_3 and R_4 are connected in parallel. The equivalent resistor for parallel network of R_2, R_3 and R_4 is given as:

$$\frac{1}{R_p} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4},$$

where R_p is an equivalent resistor for a parallel network in the circuit.
Thus,

$$R_p = \frac{R_2 R_3 R_4}{R_3 R_4 + R_2 R_4 + R_2 R_3}$$

This implies that the equivalent resistor is in a serial connection with R_1. Therefore, for this configuration, the equivalent resistor is:

$$R_{eq} = R_1 + R_p = R_1 + \frac{R_2 R_3 R_4}{R_3 R_4 + R_2 R_4 + R_2 R_3}.$$

Hence,

$$R_{eq} = 100\ \Omega + \frac{50\Omega \times 50\Omega \times 75\Omega}{50\Omega \times 75\Omega + 50\Omega \times 75\Omega + 50\Omega \times 50\Omega} = 118.75\ \Omega.$$

In fact, the candidate was supposed to use Ohm's law to determine the current passing through R_2. The total current:

$$I_T = \frac{E}{R_{eq}} = \frac{6}{18.75} = 0.0505\ \text{A}.$$

Then the potential difference across R1 is given as:

$$E_1 = I_T \times R_1$$

Thus,

$$E_1 = 0.0505\ \text{A} \times 100\ \Omega = 5.05\ \text{V}$$

Also, the potential difference across R2 is given as:

$$E_2 = E - E_1 = E - (I_T \times R_1)$$

Thus,

$$E_2 = 6.0\ \text{V} - 5.05\text{V} = 0.95\ \text{V}$$

Using Ohm's law, the current through R2 can be calculated as follows:

$$I_{R2} = \frac{pd\ \text{accross}\ R_2}{R_2}.$$

where I_{R2} is the current through R2.

Therefore:

$$I_{R2} = \frac{pd \text{ accross } R_2}{R_2} = \frac{0.95 \text{ V}}{50 \ \Omega} = 0.019 \text{ A} .$$

In part (c) (i), some of the candidates failed to apply Kirchhoff's voltage law in analysing the circuit. The analysis further showed that some candidates applied Kirchhoff's voltage law but failed to perform mathematical computation correctly. These candidates failed to follow appropriate steps. Some computed the current instead of the potential difference between A and C. For instance, one candidate wrote:

$$IR - V = 0$$

$$Ir = V$$

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

$$I = 7A$$

Moreover, in part (c) (ii), the candidates failed to provide a scientific explanation for the decrease in potential difference from point A to B. Most of them provided irrelevant responses. For instance, one candidate wrote: "*the potential decreases from point A to B because they are arranged in Series"*. This statement is also incorrect. The candidate was supposed to know that the potential does not decrease just because components are in series. According to Ohm's law, the decrease occurs due to current flow and the presence of resistance. Extract 8.2 is a sample of the incorrect responses from one of the candidates who scored zero marks in this question.

8 (a) Given that.

Load resistor = 25Ω.

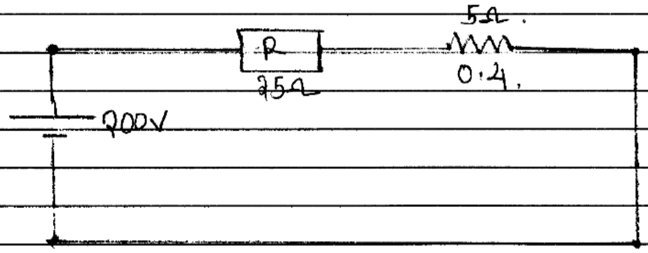
Inductance = 0.4H.

Internal resistance = 5Ω

Volts = 200V.

frequency = $\frac{50}{2\pi}$ Hz. = 7.958 Hz.

(i) A diagram for circuit.



(ii). from

$E = I(R+r)$

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

$I = \frac{200V}{(25+5)}$

$I = 6.67A$

8(b	Given that.
	$R_1 = 100\Omega$,
	$R_2 = 50\Omega$. ,
	$R_3 = 50\Omega$,
	$R_4 = 75\Omega$. , $E = 6.0$.
	Required.
	(i) Equivalent resistance of the network
	(ii) The current passing through R_2.
	from.
	$R_T = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$.
	$R_T^{-1} = \frac{1}{100} + \frac{1}{50} + \frac{1}{50} + \frac{1}{75}$.
	$R_T^{-1} = \frac{19}{300}$
	$\frac{1}{R_T} = \frac{19}{300}$, $19 R_T = 300$
	$R_T = 15.789\Omega$.
	∴ The equivalent resistence is 15.789Ω.

8(b)	(ii)
	from
	$E = I(R+r)$.
	$I = \frac{E}{(R+r)}$.
	~~$I = \left(\frac{6.0}{50+0.05}\right)$.~~
	~~$I = 2.916$ A~~
	∴ The
	$I = \left(\frac{6.0}{50+15.789}\right)$
	$I = 0.09$ A
	∴ The current passing through R_2 is 0.09A.

8(c) (i) Given that:

Volts$_1$ = 7V

Resistence$_1$ = 1Ω.

Volts$_2$ = 5V

Resistence$_2$ = 3Ω.

Required

potentioal difference =?

From

Kirchhoff's law

$V = (I_1R_1 + I_2R_2) - (I_2R_1 + I_1R_2)$

$V = ((7\times1) + (5\times3)) - ((5\times1) + (7\times3))$

$V = 22 - 16$

$V = 6V$

∴ The potential difference between A and C is 6V

(ii) The potention from A to C decrease because the electromotive force and the current provided is different.

Extract 8.2: A sample of an incorrect response to question 8 of paper 1

Extract 8.2 demonstrates that the candidate lacked fundamental knowledge of alternating current (AC) theory and skills in Kirchhoff's Voltage Law (KVL) in electrical networks. As a result, the candidate was unable to correctly determine the equivalent resistance, current, and potential difference within the circuit.

2.9 Question 9: Electronics (Diode, Transistor and Operational Amplifier)

This question was divided into three parts: part (a), part (b) and part (c). Part (a) required the candidates to (i) give the necessary condition for a transistor to act as an open switch, (ii) study the given electronic circuit and find the voltage across the capacitor, C. In part (b), the candidates were required to (i) identify two characteristics of an op-amp, and (ii) evaluate the output voltage V_o in a given electronic circuit. In part (c), the candidates were asked to (i) give two advantages of using integrated circuits in electronic devices (ii) briefly explain the mode of operation of a p-n junction.

The question was optional and was attempted by 26,707 (90.20%) candidates. Among them, 8,465 (31.70%) candidates scored 0.0-5.0 marks, 9,614 (35.99%) candidates scored 5.5-8.5 marks, and 8,628 (32.31%) candidates scored 9.0-15.0 marks. The analysis indicates that the overall performance was good, as 18,242 (68.30%) candidates scored 5.5-15.0 marks. Figure 10 summarises the candidates' performance in Question 9.

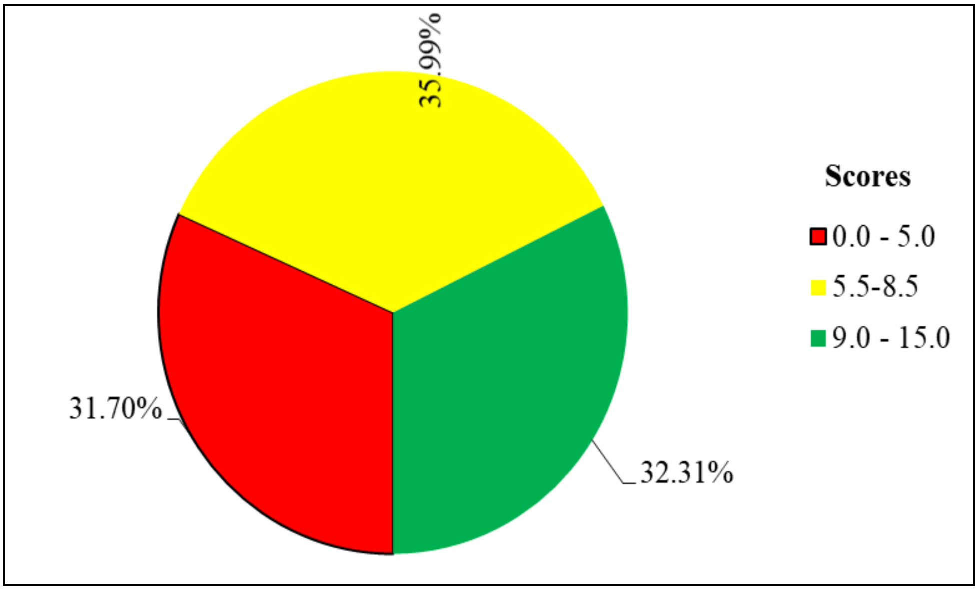


Figure 10: *Candidates' performance in question 9 of paper 1*

Statistical data shows that higher achievers (32.31%) demonstrated knowledge and skills of diode, transistor and op-amp. For example, in part (a) (i), they accurately stated the necessary condition for a transistor to function as an open switch, as when both the collector and emitter are reverse-bias. The analysis revealed that the candidates were able to apply appropriate concepts, theories, and principles governing the half-wave rectifier to deduce the voltage value across the capacitor. Moreover, the candidates were able to identify key characteristic features of op-amps as per part (b) (i) in this question. These candidates applied the appropriate concepts, theories and principles governing op-amps to deduce the V_o as per the given circuit. In part (c) (i), these candidates explained several key advantages of using integrated circuits (ICs) in electronic devices effectively. Extract 9.1 presents a sample of a candidate's correct response, demonstrating good competency and mastery in this area.

9 (a)

(i) Necessary condition for a transistor to act as an open switch is at cut off point.

(ii) Solution.

From:

$$V_{r.m.s} = \frac{V_{max}}{\sqrt{2}}$$

$$V_c = \sqrt{2} \times V_{r.m.s}$$

$$V_{r.m.s} = 240V$$

$$V_c = \sqrt{2} \times 240V$$

$$V_c = 339.41V$$

Hence;

The voltage Across the Capacitor is 339.41V.

(b)

(i) Characteristics of an op-amp.

- It has high input impedance.
- It has low output impedance.

(ii) Solution:

Since, Figure 4 acts a summing Amplifier

Then,

$$V_o = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$$

9. (ii) $V_0 = -8\Omega\left(\frac{4V}{5\Omega} + \frac{-3V}{4\Omega}\right)$.

$V_0 = -8\Omega\left(\frac{4V}{5\Omega} - \frac{3V}{4\Omega}\right)$.

$V_0 = -8\Omega \times \frac{1\,V}{20\Omega}$.

$V_0 = -0.4V$.

Hence;

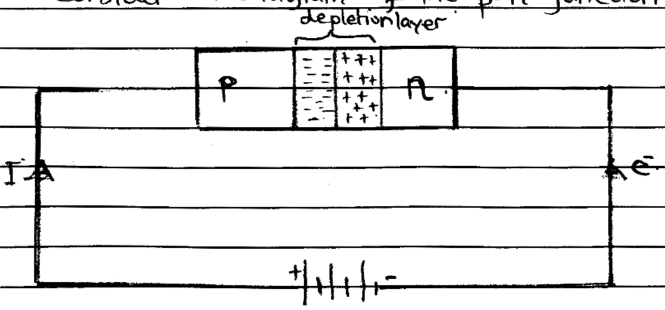
The output voltage $V_0 = -0.4V$.

(c)

(i) Advantages of using intergrated circuits

- It helps in working multi-function as one circuit could not.
- It reduces cost of buying digital circuit for amplify

(ii) Consider a diagram of the p-n junction below.



9 (c) (ii) When the switch is closed the electrons move from the n-type material leaving the holes and the holes are appears to the part of n-type in the depletion layer when the exchange of electrons with holes continues the depletion layer increases causing a voltage drop accross the depletion layer that is knee voltage.

Extract 9.1: A sample of correct responses to question 9 of paper 1

In Extract 9.1, the candidate provided well-articulated responses on several key aspects. These included a clear explanation of the conditions under which a transistor operates as an open switch, accurate calculations of the voltage across the capacitor, a correct description of the characteristics of an operational amplifier, and a well-stated account of the advantages of using integrated circuits in electronic devices.

The analysis further reveals that some candidates scored between 5.5 and 8.5 marks, which is considered an average score. It was revealed that the candidates performed better in parts (b) and (c), where they scored relatively higher marks. However, most of the candidates failed to obtain higher marks in part (a) due to insufficient knowledge and skills related to diodes and transistors. Moreover, the analysis indicated that most of them were unable to analyse the given circuit and compute the voltage across the capacitor. This could be due to their limited understanding of the concepts, theories and principles related to the diodes and half-wave rectifiers.

On the other hand, the analysis indicates that 31.70% of the candidates who attempted this question scored lower marks (0.0–5.0). These candidates failed to demonstrate their mastery of the basic concepts, theory and principles related to transistors, diodes and ICs. In part (a), most of them provided incorrect and irrelevant responses. For example, in part (a)(i), some of them failed to provide the necessary condition for a transistor to act as an open switch. One of the candidates responded as: "*the necessary for transistor to act as open switch is due to the absence of the feedback resistance on the op-amps"*. Looking at this response, the candidate incorrectly associates the operation of a transistor as an open switch with the absence of the feedback resistance in an op-amp system. This suggests that the candidate failed to distinguish electronic components and their respective functions and configurations (transistor and op-amp). The candidate was supposed to know that a transistor has three operating regions, named: (i) the cut-off region (open switch), (ii) the active region (amplification), and (iii) the saturation region (closed switch). These operation modes depend on the biasing conditions. For a transistor to act as the open switch, there must be no current flowing through the collector-emitter junction. This could be possible only if the base-emitter junction (for npn) is reverse biased. Another candidate responded as "when *there is a parallel arrangement of both inductor, capacitor and resistor, it acts as an open switch"*. This is an irrelevant response.

In part (a)(ii), most of the candidates failed to analyse the given circuit and calculate the voltage value across the capacitor. Most of them provide irrelevant responses. This has been revealed to several candidates. For instance, one of the candidates responded to this part as follows:

$$V_{in} = V_e + V_c$$
$$but$$
$$V_{in} = V_c$$
$$V_c = 240V$$

Therefore, a voltage across the capacitor is 240 V. The approach is not clear and makes no sense as per the question. Some of the candidates applied Kirchhoff's law to deduce the voltage across the capacitor. For instance, one candidate wrote:

By Kirchhoff's law

Since; $V_D = 0.7\,\text{V}$

$$V_{ac} = V_D + V_C$$
$$V_C = V_{ac} - V_D$$
$$V_C = 240 - 0.7 = 233\,\text{V}$$

The approach was not correct. The candidate was supposed to know that by using KVL, the loop will be source, diode, capacitor and then return to the source. Thus, by KVL

$$V_{source}(t) - V_D - V_C(t) = 0$$

It implies that:

$$V_C(t) = V_{source}(t) - V_D$$

Moreover, the candidates were supposed to realise that the source is an AC supply. Thus, the peak voltage can be calculated as:

$$V_{peak} = \sqrt{2} \times V_{RMS} = \sqrt{2} \times 240\,\text{V} = 339.4\,\text{V}$$

It follows that:

$$V_C(t) = V_{source}(t) - V_D = (339.4 - 0.7)\text{V} = 338.7\,\text{V}$$

In part (b), most of the candidates failed to provide key features of the op-amp. Some of them provided the application instead of the features of the op-amp. For instance, one candidate wrote: *It performs mathematical operations like addition, subtraction, differentiation and integration.* This was an incorrect response. These candidates had insufficient knowledge about the characteristics of op-amps. Furthermore, inadequate knowledge and understanding were observed in part (c)(ii). For example, one of the candidates described the function of a capacitor instead of the importance of ICs. The candidate wrote: *It Helps in storing charge in the circuit also used in electrical appliance.* This suggests that the candidate failed to identify various electronic components and their application in the circuits. Extract 9.2 presents a sample of a candidate's incorrect response, demonstrating poor competence on the topic.

9. a.) i) The necessary condition for a transistor to act as a ~~schich~~ switch is to connect the p-type with positive terminal of the battery (forward biased).

9. a)ii) By Kirchhoff's law

Since; $V_D = 0.7V$

$V_{ac} = V_D + V_c$

$V_c = V_{ac} - V_D$

$V_c = 240 - 0.7$

$V_c = 233 V$

∴ The voltage across the capacitor is 233 V.

9 b.) i) – It reduce noise
– It simplify work.

ii) from; –

$A_{CL} = V_o / V_{in} = R_f / R_{in}$

~~$V_o / 4+5 = 8 / 5+4$~~

$A_{CL} = \frac{8}{5+4}$

$A_{CL} = 8/9$

$A_{CL} = 0.8889$

$A_{CL} = V_o / V_{in}$

$0.7889 = V_o / (4+3)$

$0.7889 = V_o / 7$

$V_o = 7(0.8889)$

$V_o = 6.2222V$

∴ The output voltage is 6·2222V ·

9·(c·)i)i) It store charge due to the presence of capacitor

ii) It reduce noise.

ii) When the p-type semiconductor and n-type semiconductor are joined the charge start to diffuse from their semiconductor and cause the ~~conductor~~ pn-junction to occur. When connected to n or p-type semiconductor to form transistor

Extract 9.2: A sample of incorrect responses to question 9 of paper 1

In Extract 9.2, the candidate incorrectly applied Kirchhoff's Law in part (a)(ii) when calculating the voltage across the capacitor. Furthermore, the candidate failed to provide correct responses in other parts of the question.

2.10 Question 10: Electronics (Logic Gates, Transistors and Operational Amplifiers)

This question had three parts: parts (a), (b) and (c). Part (a) of the question asked: *In each of the following diagrams, find the truth table and mention which single gate it represents.*

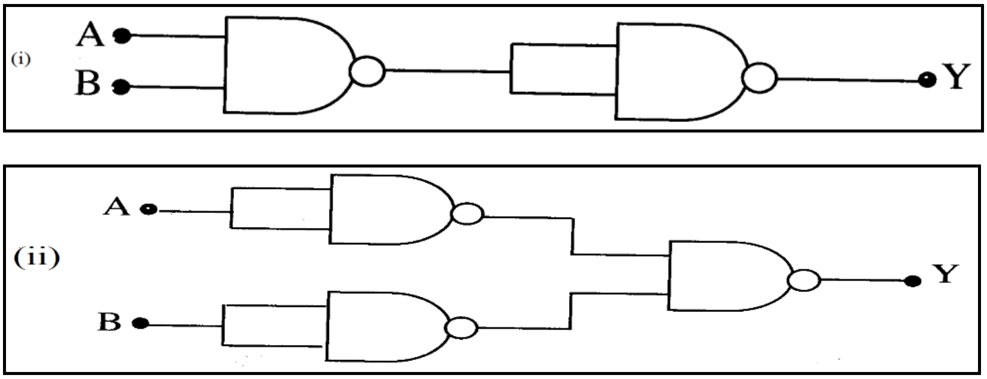


Diagram 8

In part (b), the question asked

(i) *What is meant by the voltage follower? Give one importance of it.*

(ii) *Point out three factors to consider when designing a voltage amplifier.*

In part (c) the candidates were required to (i) sketch the labelled graphs of input and output characteristics of a common base transistor connection, (ii) determine the base current in an n-p-n transistor of collector current 10 mA if 90% of electrons emitted from the emitter reach the collector.

This was an optional question, attempted by 25,023 (84.5%) candidates. The score distribution was as follows: 8,053 (32.18%) candidates scored between 0.0 and 5.0 marks; 10,637 (42.51%) candidates scored between 5.5 and 8.5 marks; and 6,333 (25.31%) candidates scored between 9.0 and 15.0 marks. The analysis indicates that overall performance was good, with 16,970 (67.82%) candidates scoring between 5.5 and 15.0 marks. Figure 11 illustrates the candidates' performance in Question 10.

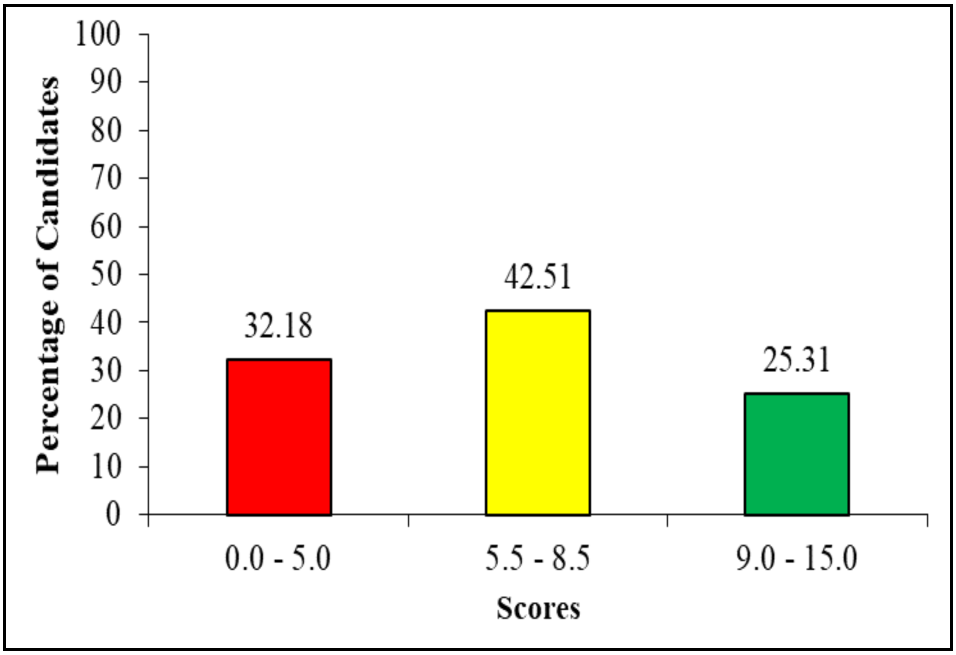
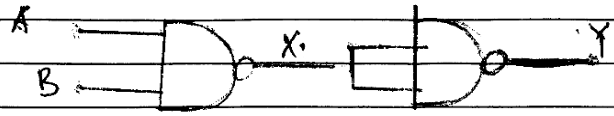


Figure 11: *Candidates' performance in question 10 of paper 1*

Statistical analysis indicates that overall performance on this question was good, with 67.82% of candidates achieving higher marks (5.5-5.0). In parts (a) (i) and (ii), candidates demonstrated familiarity with Boolean algebra, particularly with the fundamental rules governing logic operations. They applied these rules effectively to construct truth tables and identified the resulting logic gates. In part (b) (i), candidates demonstrated a good understanding of the concept of a voltage follower. Some were able to illustrate the circuit and clearly explain its significance. In part (b) (ii), candidates were able to identify key factors to consider when designing a voltage amplifier. Furthermore, in part (c), candidates effectively applied computational skills and correctly interpreted the input and output characteristic graphs of a common-base transistor configuration, resulting in accurate responses. Extract 10.1 shows the correct responses of one of the candidates who answered question 10 appropriately.

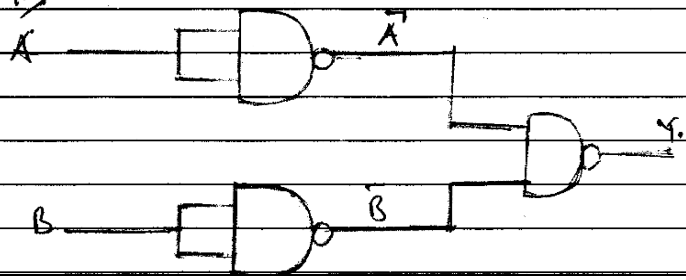
10. a) i) Truth table for tho crcuit below.



Inputs		Outputs	
A	B	X	Y.
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1

The tho single gate represented is AND gate.

ii)



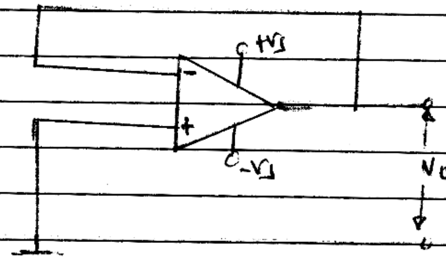
10(a) (ii)

Inputs		Outputs		
A	B	$\bar{A}$	$\bar{B}$	Y.
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1.

The single gate represented is OR gate.

b (i) A voltage follower is an operational amplifire in which all the output signal is feedbacked to the input signal

diagramatically



Importance of voltage follower.

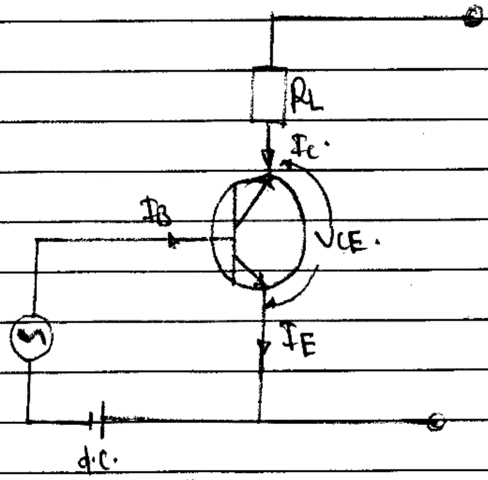
i) It is used as coulombmeter to determine charge and smallest current.

10 (b) (i) Factors to consider when voltage amplifier.

(i) The load resistor (R_L) should be connected to the collector terminal so that it gives output voltage.

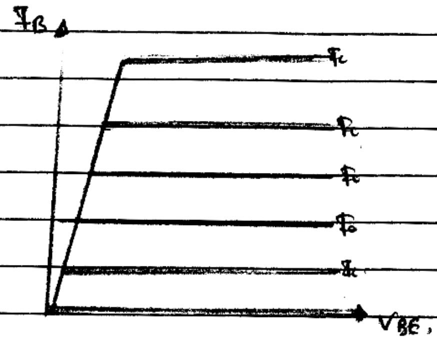
(ii) An alternating input signal either voltage or current should be applied to the p input base region

(iii) Base emitter circuit should be forward biased by application of small d.c source.

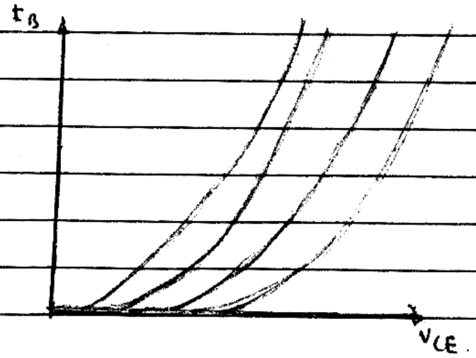


A diagram of voltage amplifier.

C (i) Input characteristics



(ii) Output characteristics



(iii) Given $I_C = 10mA$.

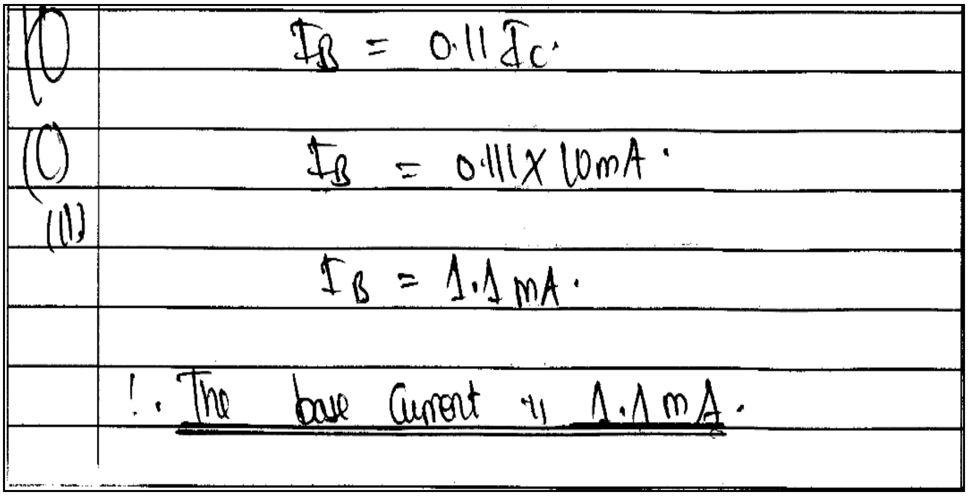
From
$$I_E = I_C + I_B.$$

But
$$I_C = \frac{90}{100} I_E.$$

$$I_E = 1.11 I_C$$

How

$$1.11 I_C = I_C + I_B.$$
$$1.11 I_C - I_C = I_B.$$


10 (c) (ii)

$I_B = 0.11 I_C$.

$I_B = 0.11 \times 10mA$.

$I_B = 1.1 mA$.

∴ The base current is 1.1 mA.

Extract 10.1: A sample of correct responses to question 10 of paper 1

In Extract 10.1, the candidate successfully applied relevant electronic concepts, theories, and principles to solve the given problems.

The analysis further illustrates that 10,637 (42.51%) of the candidates who attempted this question scored between 5.5 and 8.5 marks, which is considered an average score. It was revealed that the candidates performed better in parts (a) and (b) (i), where they scored higher marks. However, most of the candidates failed to obtain higher marks in part (b) (ii) and (c) due to insufficient knowledge and skills related to transistors. These candidates failed to apply the correct formula to calculate the base current as per the given conditions.

Nonetheless, a total of 32.18% of the candidates who attempted this question scored lower marks. The scores were poor in almost every part of the question. This suggests that they lacked enough knowledge and skills on the topic of electronics. In parts (a)(i) and (ii), most of them failed to correctly interpret the output of the provided logic gate, which led to incorrect responses. On the other hand, these candidates failed to provide the meaning of the term voltage follower. Most of them provided incorrect and irrelevant meanings. For example, one candidate defined the voltage follower as *"the path which provides more volt energy due to input energy provided,"*. This statement is scientifically incorrect because:

(i) The words "*provides more volt energy*" are ambiguous and incorrect. The candidate was supposed to know that voltage itself is not energy. The energy must involve both voltage and current over time.

(ii) A voltage follower does not provide more voltage than the input. It means that no amplification of voltage. The input voltage is always equal to the output voltage.

In a voltage follower, the op-amp maintains an output voltage equal to the input voltage. It provides current to the load from its power supply, not from the input signal, making it useful for impedance matching and buffering without amplifying voltage.

Moreover, in Part (b) (ii), some candidates were unable to identify the factors to be considered when designing a voltage amplifier. Instead, they provided irrelevant information. For instance, one candidate responded as follows: "*Summing: voltage amplifier can be summing for adding the current*". "*Subtractor: is the difference in output voltage an input voltage*" and "*Comparator: comparison of voltage amplifier*". These responses indicate that the candidates did not understand the question. Instead of addressing the design considerations for a voltage amplifier, they listed applications of an operational amplifier. This reflects the candidates' inability to comprehend and respond appropriately to the question's requirements.

Additionally, the analysis reveals that most of the candidates who are in this category failed to score higher marks in part (c). They failed to provide the correct labelled diagram for the input and output characteristic curves of a common-base transistor connection. Extract 10.2 shows the incorrect responses from one of the candidates who scored low marks in this question.

10 (a) (i) Truth table

Inputs		output
A	B	Y
0	1	0
0	1	1
1	0	1
1	0	1
0	1	0
0	1	0
1	0	0
1	0	1

The single gate is NAND gate

(ii)

inputs		outputs
A	B	Y
1	0	1
1	0	0
1	0	0
1	0	0
0	1	1
0	1	1
0	1	1
0	1	0
		1

The single gate is NOR Gate

10 (b) (i) voltage follower is the device that controls the use of voltage toa certain equipment.

Important

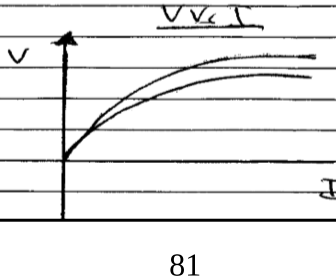
(i) It helps to reduce the risk of burning of equipments like fuses and computors.

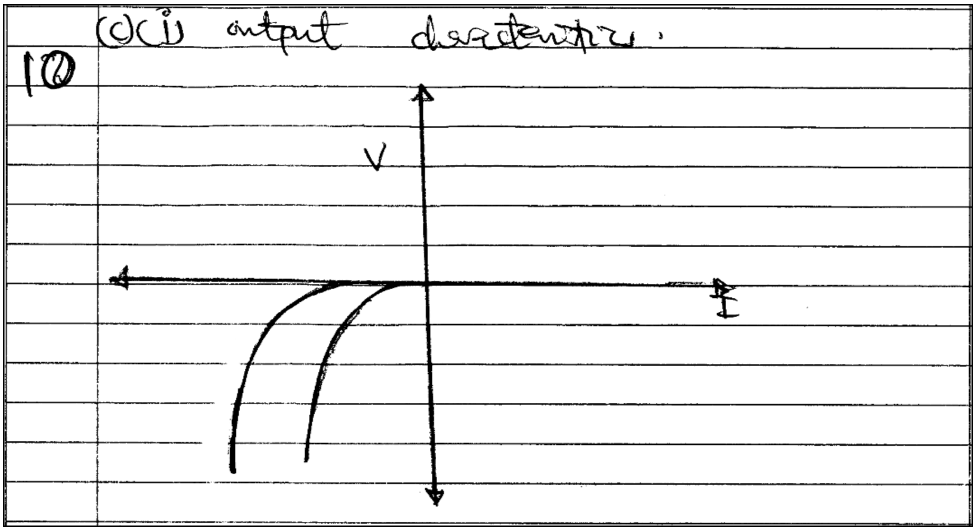
(ii) Also reduces the fire outbreak when the potential difference increases the rated one.

(ii) (a) ~~Able to~~ low current consuming.
(b) Can operate reversible as a voltmeter.
(c)

(c) (i)
Input graph of common base transistor

V vs I





Extract 10.2: A sample of incorrect responses to question 10 of paper 1

In Extract 10.2, the candidate failed to identify the number of inputs for the logic gate. As a result, the candidate constructed an incorrect logic gate and its corresponding truth tables. Additionally, the candidate provided an irrelevant explanation of the voltage follower and its importance. Similarly, the response included incorrect factors to consider when designing a voltage amplifier.

3.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN 131/2 PHYSICS 2

This paper was derived from six topics, namely: *Fluid Dynamics, Vibrations and Waves, Properties of Matter, Electrostatics, Electromagnetism* and *Atomic Physics*. Each topic contributed one question carrying 20 marks. The candidates were required to attempt five questions. The analysis of each question is as follows:

3.1 Question 1: Fluid Dynamics

This question had parts (a), (b) and (c). In Part (a), the question asked:

(i) *Account for a suction effect phenomenon based on Bernoulli's Theorem.*

(ii) *A raindrop of radius 2 mm falls from a height of 500 m above the ground with decreasing acceleration to half its original height. If it attains its maximum terminal speed and moves with uniform speed*

thereafter, determine the work done by the gravitational force on the drop in the first and second of its journey.

In part (b), the question asked:

(i) *Distinguish between static pressure and dynamic pressure as applied in laminar fluid flow.*

(ii) *Water is flowing steadily through a horizontal pipe of uniform cross-sectional area. If the velocity and pressure at a point where cross section area is 0.02* m^2 *are 2 m/s and* 4×10^4 Nm^{-2}*, respectively, calculate the pressure at a point where the cross-sectional area is reduced to 0.01* m^2*.*

In part (c), the question asked: *Determine the rate of flow of glycerine of density* 1.25×10^3 kgm^3 *through the cross section of a pipe if the radii at its ends and the pressure of a drop across its length are 0.1 m, 0.04 m and 10* N/m^2*, respectively.*

A total of 28,446 (96.09%) candidates attempted the question. Among them, 7,702 (27.08%) scored from 0.0 to 6.5 marks, 13,436 (47.23%) scored from 7 to 11.5 marks, and 7,308 (25.69%) scored from 12.0 to 20.0 marks. The data shows good candidates' performance in this question, since 20,744 (72.92%) scored from 7.0 to 20.0 marks. Figure 12 illustrates the overall performance of this question.

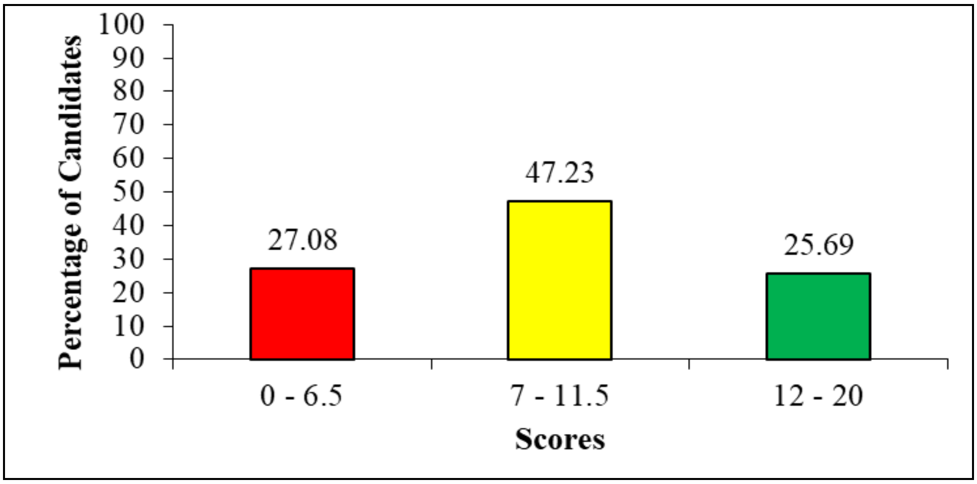


Figure 12: *Candidates' performance in question 1 of paper 2*

The analysis reveals that the candidates who scored higher marks (12.0 – 20.0) correctly explained a suction effect phenomenon based on Bernoulli's Theorem. They were aware that the pressure difference creates a net force that pushes the person towards the objects. It can be said that these candidates applied Bernoulli's principle to interpret and explain practical phenomena.

Moreover, they managed to distinguish static pressure and dynamic pressure as applied in laminar fluid flow. They also applied the correct formula to determine the work done by the gravitational force of a raindrop. Consequently, their computational skills enabled them to obtain the correct values of the work done by the gravitational force. Moreover, some of them used the concept of Bernoulli's Theorem to determine the pressure of water at a point where cross section area is reduced to 0.01 m^2. In addition, these candidates applied the Continuity equation to solve a numerical problem. This is an indication of mastery of basic concepts, theories and principles related to the dynamics of fluid flow as well as mathematics skills. Extract 11.1 shows the correct responses to this question.

1. (a) (i) SUCTION EFFECT

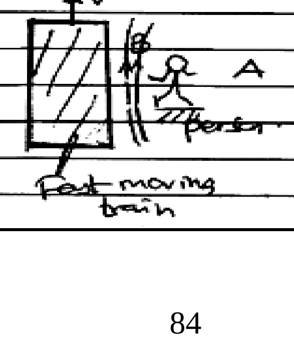
Suction effect is the phenomena which occurs when two moving objects get attracted to each other or a stationary object standing closer to a rapid moving train get attracted by the train.

According to Bernoulli's Theorem

$$P + \frac{1}{2}\rho V^2 + \rho g h = \text{Constant}$$

The Theory implies that, when velocity of fluid at a point increase, then pressure decrease.

Occurrence of suction effect



- Since the train is moving fast, air at point B also moves faster than that of position A.
- According to Bernoulli's theorem, the pressure at B becomes less than that at A

$P_B < P_A$

Therefore, a person is pushed toward the train by an outward pressure P_A.

---- This is how suction effect occurs.

1. (a) (ii) Mass of a rain drop

$\rho = \text{mass}/\text{volume}$

and $\rho = 10^3 \text{ kg/m}^3$

$V = 3.35 \times 10^{-8} \text{ m}^3$

$m = \rho V$

$m = 10^3 \text{ kg/m}^3 \times 3.35 \times 10^{-8} \text{ m}^3$

$\therefore m = 3.35 \times 10^{-5} \text{ kg}$

$\therefore$ Gravitation force on the drop $= mg$

$F = (3.35 \times 10^{-5} \text{ kg} \times 9.8 \text{ N/kg})$

$F = 3.28 \times 10^{-4} \text{ N}$

- Work done by gravitational force in first and second of its journey

~~W = Force × distance~~

$W = 3.28 \times 10^{-4} \text{ N} \times 250 \text{ m}$

$W = 0.0821 \text{ J}$

$\therefore$ Work done by gravitational force is equal to $W = 0.0821 \text{ J}$.

1 (b) (i) Static pressure

- Is the pressure of a liquid due to its elevation at a point

For example, In Bernoulli's equation

static pressure, $P_s = P + \rho gh$.

While

Dynamic pressure - Is the pressure of liquid (fluid) at a point due to its motion. This is not the actual pressure but has a dimension of pressure

Dynamic pressure, $P_d = \frac{1}{2}\rho v^2$.

(ii) Given

Cross section area, $A_1 = 0.02\ m^2$

Velocity at the point, $V_1 = 2\ m/s$.

Pressure at a point, $P_1 = 4 \times 10^4\ Nm^{-2}$

At another point,

Cross section area, $A_2 = 0.01\ m^2$

velocity of water, $V_2 = V$

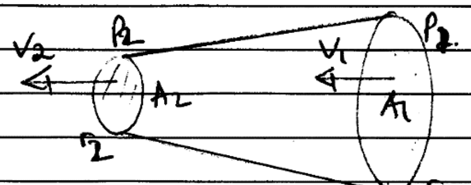
Pressure at a point, $P_2 = P$.

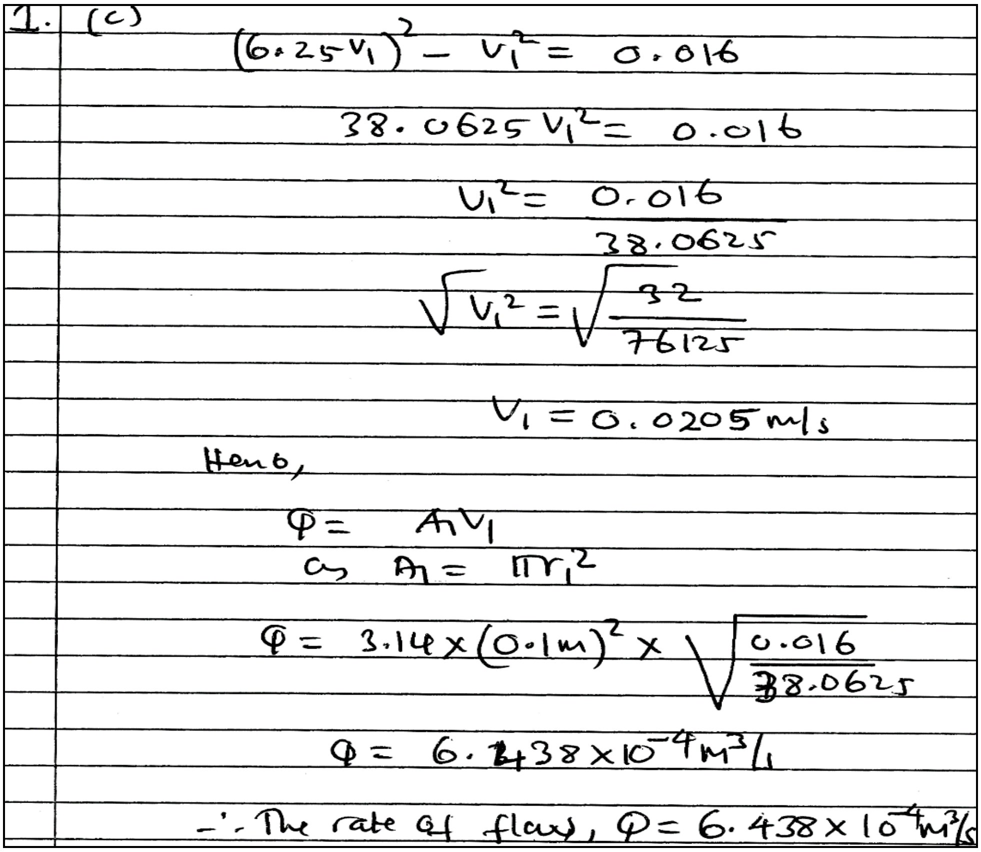
From the equation of continuity,

$A_1V_1 = A_2V_2$.

$0.02\ m^2 \times 2\ m/s = 0.01\ m^2 \times V$

$V = \frac{0.02\ m^2 \times 2\ m/s}{0.01\ m^2}$

1	(b) (ii) Hence, $\rho = 10^3 kg/m^3$
	New velocity, $V = 4 m/s$
	Bernoulli's equation
	$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$
	$4 \times 10^4 Nm^{-2} + \frac{1}{2} \times 10^3 kg/m^3 \times (2 m/s)^2 = P_2 + (\frac{1}{2} \times 10^3 kg/m^3 \times (4 m/s)^2)$
	$P_2 = [4 \times 10^4 + (500 \times 4)] - (500 \times 4^2)$
	$P_2 = 34000 Nm^{-2}$
	$\therefore$ The new pressure, $P_2 = 3.4 \times 10^4 Nm^{-2}$
1	(c) Given
	Density of glycerine, $\rho = 1.25 \times 10^3 kgm^{-3}$
	
	$r_1 = 0.1 m$ $r_2 = 0.04 m$
	$P_1 - P_2 = 10 N/m^2$ — ①
	~~But~~ Rate of flow, $\varphi = A_1V_1 = A_2V_2$



1. (c)

$$(6.25V_1)^2 - V_1^2 = 0.016$$

$$38.0625V_1^2 = 0.016$$

$$V_1^2 = \frac{0.016}{38.0625}$$

$$\sqrt{V_1^2} = \sqrt{\frac{32}{76125}}$$

$$V_1 = 0.0205 \, m/s$$

Hence,

$$\varphi = A_1V_1$$

as $A_1 = \pi r_1^2$

$$\varphi = 3.14 \times (0.1m)^2 \times \sqrt{\frac{0.016}{38.0625}}$$

$$\varphi = 6.438 \times 10^{-4} m^3/s$$

∴ The rate of flow, $\varphi = 6.438 \times 10^{-4} m^3/s$

Extract 11.1: A sample of correct responses to question 1 of paper 2

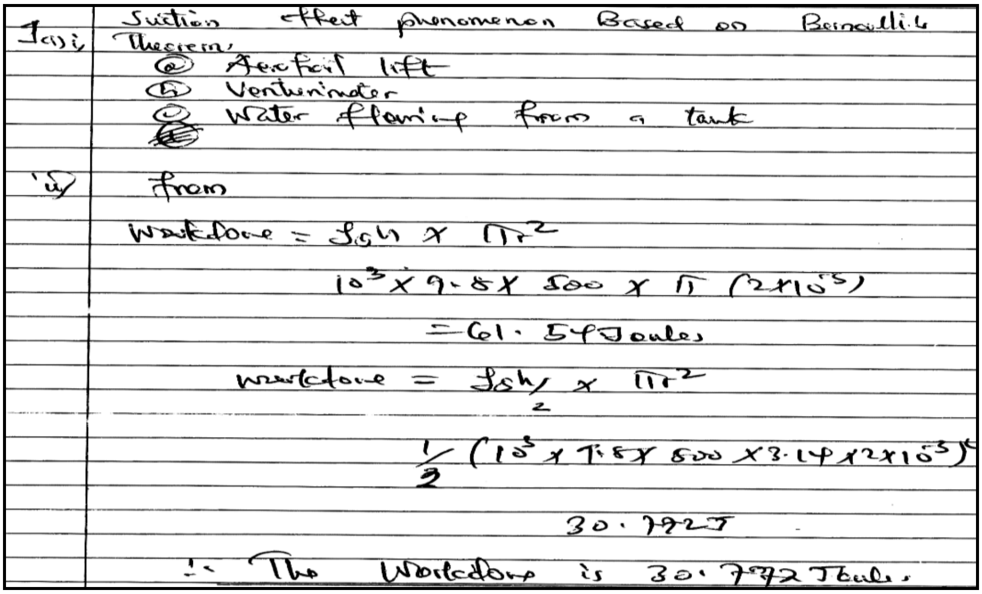
In Extract 11.1, the candidate demonstrated competence in fluid dynamics. The candidate applied conceptual understanding and critical thinking to explain the suction effect and Bernoulli's principle. Moreover, the candidate used mathematical skills to calculate the work done by the gravitational force as well as the pressure of the flowing fluid in a reduced area.

Further analysis shows that some of the candidates (47.23%) scored average marks (7.0 - 11.5). Most of these candidates scored higher marks in parts (a) and (b). However, most of them failed to score good marks in part (c). Looking at their responses, it is evident that they lacked adequate knowledge and skills related to the Continuity equation. These candidates applied the incorrect formula to calculate the rate of fluid flow. Some of them applied Bernoulli's principle, which was incorrect as per the item.

On the other hand, analysis reveals that 7,702 (27.08%) of the candidates who attempted this question scored lower marks (0 – 6.5). These candidates failed to apply concepts, theories and principles related to fluid dynamics to real-world contexts. Most of them provided incorrect or irrelevant responses. In part (a), one of the candidates stated as; *suction effect is a phenomenon caused by pressure difference between the large tube and a small tube of a syringe which causes the increase of velocity of the fluid sucked from a bath to a syringe* and *Energy can neither be created nor destroyed but can be transformed from one form to another.* This response is vague and lacks a clear logical flow. The candidate stated that the pressure difference is caused by the increased velocity, which is incorrect. The candidate was supposed to know that, as per Bernoulli's principle, it is the high fluid speed that causes the lower pressure in a region and not vice versa. Moreover, the candidate applied the principle of conservation of energy in the wrong contexts.

Additionally, the candidates described the suction effect in terms of a pressure gradient, stating that: "*the suction effect occurs when someone sucks a liquid using one end of the tube, creating the pressure gradient and hence the liquid is pulled by a force", which was given as:* $F = \frac{1}{2}\rho\left(V_2^{\ 2} - V_1^{\ 2}\right)$. This was an incorrect response. The mathematical formula used was dimensionally incorrect. Other candidates applied the formula for the terminal velocity of a smooth object falling through a fluid. They wrote: $\mathrm{V_T} = \frac{2}{9}r^2\left(\frac{\rho - \delta}{\eta}\right)g$. This was an incorrect response as per the context of the item. The candidates in this category were supposed to know that terminal velocity and suction effect are not related phenomena. Terminal velocity is due to the balance of forces on a falling object, while the Suction effect is due to the pressure-induced movement of fluid. Some of the candidates responded to part (a) (ii) by writing $\sqrt{2gh}$. This was an incorrect formula. The candidates were supposed to know that the gravitational work done is defined as: $W = mgh$, where m is the mass of a raindrop and other symbols carry their usual meaning. Mass of a raindrop, $m = \rho V$. Assuming that a raindrop is spherical, its volume is defined as $\frac{4}{3}\pi r^3$. It follows that: $W = \frac{4}{3}\pi r^3 \rho g h$.

In part (c), some candidates failed to establish the relationship between the concepts of velocity, cross-sectional area of a pipe, pressure and density of glycerine to which is crucial for determining the rate of flow of glycerine. Most of them applied the incorrect formula as per the context of the item. For example, one of the candidates wrote that the *flow rate of glycerine is determined by applied Poiseuille's formula* $Q = \frac{\pi P a^4}{8\eta l}$. Some of them wrote irrelevant expressions. For instance, one candidate wrote: *rate of flow of glycerine* $Q = (\Delta p \times v_2)$. The expression is dimensionally incorrect. The candidate was supposed to use the Continuity equation, which is given as $Q = A_1 v_1 = A_2 v_2$, where all symbols carry their usual meaning. Extract 11.2 illustrates a sample of incorrect responses.


1 (a) i) Suction effect phenomenon Based on Bernoulli's Theorem;
(a) Aerofoil lift
(b) Venturimeter
(c) Water flowing from a tank
ii) from
Workdone = ρgh x πr²
10³ x 9.8 x 500 x π (2x10⁻⁵)
= 61.54 Joules
workdone = ρgh/2 x πr²
1/2 (10³ x 9.8 x 500 x 3.14 x 2x10⁻⁵)
30.772J
∴ The Workdone is 30.772 Joules.

Extract 11.2: A sample of incorrect responses to question 1 of paper 2

In extract 11.2, the candidate outlined the concepts of aerofoil lift, the Venturi meter, and water flow in a tank, examples that represent applications of Bernoulli's Theorem, instead of explaining the suction effect, as the question demands. Moreover, the candidate used an incorrect formula to calculate the work done by the gravitational force.

3.2 Question 2: Vibrations and Waves

This question was derived from the topic of vibration and waves. It comprises parts (a), (b) and (c). Part (a) consisted of two parts, named part (a) (i) and part (a) (ii). In each part, a candidate was supposed to apply mathematics skills to obtain the physical quantities. In part (a) (i), the candidates were required to (i) determine the number of beats per second heard by the observer (assuming there was no wind), when a whistle gave a sound of frequency of 500 Hz moving away with the velocity of $1.5\,\text{m/s}$ from a stationary observer in a direction towards and perpendicular to a flat wall. In part (a) (ii), determine the width of the central maximum on a screen placed at a distance of 1 m from the slit, if the given slit width was 0.1 mm, and the slit was illuminated with a monochromatic light of wavelength of $5{,}000\,\overset{o}{\text{A}}$.

Moreover, part (b) of this question was also a numerical question. The candidates were examined to (i) calculate the frequency of the note when a wire of length 140 cm and mass was stretched by means of a load of 16 kg, and (ii) estimate the positions where two bridges were to be placed to divide the wire into three segments whose fundamental frequencies were in the ratio of 1:2:3. Part (c) of this question was conceptual. The candidates were asked to (i) identify the necessary conditions for interference of light to occur and (ii) explain briefly when Fraunhofer's diffraction takes place.

A total of 25,424 (85.89%) candidates attempted this question. Their scores were distributed as follows: 9,461 (37.21%) candidates scored between 0.0 and 6.5 marks, 10,466 (41.17%) candidates scored between 7.0 and 11.5 marks, and 5,497 (21.62%) candidates scored between 12.0 and 20.0 marks. Overall, the candidates' performance was good, as 15,963 (62.79%) candidates scored between 7.0 and 20.0 marks. Figure 13 illustrates the performance distribution for this question.

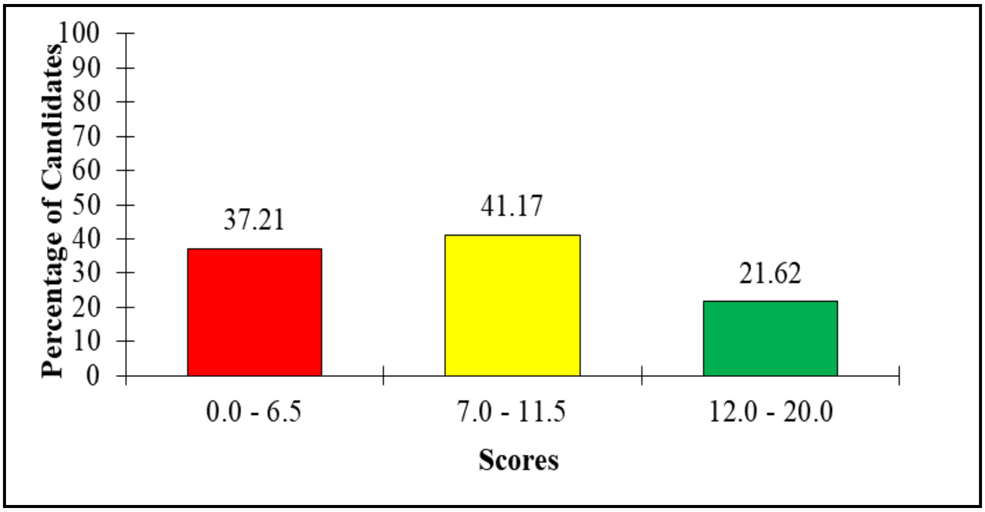


Figure 13: *Candidates' performance in question 2 of paper 2*

The data shows that 21.62% of the candidates scored higher marks (12.0 – 20.0). These candidates demonstrated their mastery in basic concepts and principles related to the Doppler effect and beat frequency. These candidates were able to evaluate the changes in sound frequency due to the relative motion of the source and observer. Moreover, they were able to use an appropriate formula to determine the beat frequency value. Furthermore, candidates applied the concepts and principles related to wave optics to determine the width of the central maximum.

In part (b), the candidates demonstrated their mathematical skills by correctly calculating the frequency of the note. These candidates also correctly determined the positions of the bridges. Likewise, in part (c), they accurately identified the necessary conditions for the occurrence of light interference and applied appropriate sketches to effectively illustrate Fraunhofer diffraction. Extract 12.1 is a sample of a candidate's correct responses.

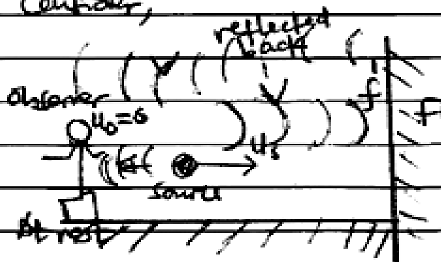
2. (a) (i) Given

Original frequency of whistle sound, f = 500Hz

speed of source, U_s = 1.5m/s

Consider,

$V = 336m/s$



Let F be the apparent frequency heard by an observer when whistle is moving away

f' be the frequency heard by an observer after reflection from the wall.

Apparent frequency = Relative velocity btn sound and observer × f / Vrel between sound and source

$$F = \frac{Vf}{V+u_s}$$

as $V = 336 m/s$ $f = 500 Hz$ $u_s = 1.5 m/s$.

$$F = \frac{336 m/s \times 500 Hz}{336 m/s + 1.5 m/s}$$

$\therefore F = 497.78 Hz$

Then, frequency reflected by wall --- observer is wall

$$f' = \frac{Vf}{V-u_s}$$

$$f' = \frac{336 m/s \times 500 Hz}{336 m/s - 1.5 m/s}$$

2 (a) (i) $f' = 502.24 Hz$

Since wall and observer are not moving --- No relative motion between hence f' will also reach an observer

Therefore,

Beat frequency to an observer $= f' - F$

$\Delta f = 502.24 Hz - 497.78 Hz$

$\Delta f = 4.46 Hz$

$\therefore$ Number of beats heard per second

i.e $\Delta f = 4.46 Hz$. or 4.46 beat per sec.

(ii) Given

width of a slit, $d = 0.1 mm$

or $d = 0.1 \times 10^{-3} m$

wavelength, $\lambda = 5000 A^o$

as $1A^o = 10^{-10} m$

$\therefore \lambda = 5000 \times 10^{-10} m$

$D = 1 M$

as

width of central maximum, $2x = \frac{2\lambda D}{d}$.

$$\text{width, } B = \frac{2\lambda D}{d}$$

$$= \frac{2 \times 5000 \times 10^{-10} m \times 1 M}{0.1 \times 10^{-3} m}$$

$\beta = 0.01 m$

$\therefore$ width of central maximum, $B = 10 mm$

2	(b) (i) Given
	length of a wire, $l = 140cm$ or $1.4m$
	mass of a wire, $m = 0.52 \times 10^{-3} kg$
	mass attached, $M = 16kg$.
	Required, note frequency i.e f
	From,
	$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$
	But tension, $T = Mg$.
	$T = 16kg \times 9.8 m/s^2$
	$\therefore$ Tension, $T = 156.8N$
	Linear mass density, $\mu = \frac{\text{mass of wire}}{\text{Length}}$
	$\mu = \frac{0.52 \times 10^{-3} kg}{1.4M}$
	$\therefore \mu = 3.714 \times 10^{-4} kg/m$
	Therefore,
	$f = \frac{1}{2 \times 1.4m} \times \sqrt{\frac{156.8N}{3.714 \times 10^{-4} kg/m}}$
	$f = \frac{5}{14}\sqrt{\frac{156.8}{3.714 \times 10^{-4}}}$
	$f = 232.057 Hz$
	$\therefore$ Frequency of the note, $f = 232.057 Hz$

2 (b) (ii) Given

length of sonometer wire, $L = 110cm$.

Let the respective length for three segments be l_1, l_2 and l_3.

Since, $f \propto 1/l$.

$f_1 l_1 = f_2 l_2 = f_3 l_3$.

where f_1, f_2 and f_3 are fundamental frequency for l_1, l_2 and l_3 respectively.

as

$l_1 + l_2 + l_3 = 110cm$ — (i).

Also, $f_1 : f_2 : f_3 = 1 : 2 : 3$

$f_1 : f_2 = 1 : 2$

$f_1/f_2 = 1/2$

$\therefore f_2 = 2f_1$ — (ii)

$f_2 : f_3 = 2 : 3$

$f_2/f_3 = 2/3$

$3f_2 = 2f_3$

$\therefore f_2 = 2/3 f_3$ — (iii).

$f_1 : f_3 = 1 : 3$

$f_1/f_3 = 1/3 \Rightarrow \therefore f_3 = 3f_1$ — (iv).

2 (b) (ii) as

$l_1 + l_2 + l_3 = 110\text{cm}$

and.

$f_1 l_1 = f_2 l_2 = f_3 l_3.$

$f_1 l_1 = f_2 l_2.$

$l_1/l_2 = f_2/f_1$

as $f_2/f_1 = 2$

$l_1/l_2 = 2.$

$\therefore l_1 = 2l_2$

$f_2 l_2 = f_3 l_3$

$l_2/l_3 = f_3/f_2$

as $f_3/f_2 = 3/2$

$l_2/l_3 = 3/2.$

$\therefore l_3 = \frac{2l_2}{3}.$

Hence

$2l_2 + l_2 + \frac{2l_2}{3} = 110\text{cm}.$

$\frac{11}{3} l_2 = 110\text{cm}$

$l_2 = \frac{110\text{cm}}{11} \times 3$

$\therefore l_2 = 30\text{cm}$

2	(b) (ii)
	$l_1 = 2l_2$
	$l_1 = 2 \times 30cm$
	$l_1 = 60cm$
	$l_3 = \frac{2l_2}{3}$
	$l_3 = \frac{2}{3} \times 30cm$
	$l_3 = 20cm$
	First bridge should be at $l = 60cm$
	second bridge at $l = 90cm$.
	∴ The bridges should be placed at $l = 60cm$ and second at $l = 90cm$.
2	(c) (i) Necessary conditions for interference of light to occur
	• Sources must be coherent
	• Sources should give monochromatic light
	• Sources of light should be narrow to give a narrow beam of light.

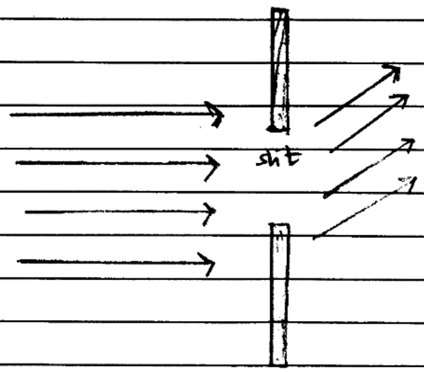
2 (c) (ii) • Fraunhoffer's diffraction takes place when parallel beams of light rays reach an obstacle or aperture.

• Usually this takes place when source and screen or obstacle are at an infinite distance from each other.

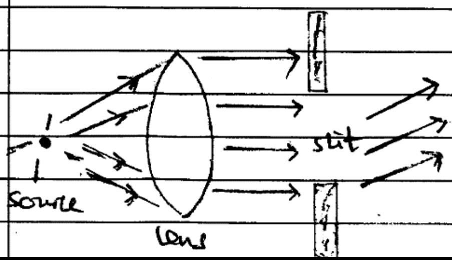
• For sources near the obstacle, a lens may be used to create parallel rays of light.

Diagrams

• For an infinite source



• ~~for nearby source of monochromatic light~~



Extract 12.1: A sample of correct responses to question 2 of paper 2

In Extract 12.1, the candidate applied the concept of the Doppler effect to determine the number of beats per second as heard by the stationary observer. He/she was capable of calculating the central maximum using the formula $\frac{2D\lambda}{d}$ as applied in physical optics. Also, the candidate correctly calculated the fundamental note using an appropriate formula.

Moreover, it was observed that 41.17% of the candidates who attempted this question scored between 7.0-11.5 marks, which is an average score. Most of these candidates only attempted a few parts of this question. As a result, they only score a lower mark.

An analysis further reveals that 28.61% of the candidates who attempted this question scored lower marks (0.0-6.5). They failed to demonstrate their mastery in basic concepts, theories and principles of vibration and waves. Most of them provided irrelevant responses. For instance, in part (a)(i), one candidate wrote: $f' = \left(\frac{V - U_S}{V + U_S}\right) f$. Indeed, the expression is correct as per the Doppler effect context. However, the candidate was supposed to further simplify the expression, as it involves a stationary observer and reflection (echo). The frequency of sound directly from the source (source moving away) is given as:

$f' = f\left(\frac{v}{v + v_s}\right)$. The reflected sound acts like a source moving towards the observer (with speed 1.5 m/s) is given as $f'' = f\left(\frac{v}{v - v_s}\right)$.

Thus, the beat frequency is given as:

$f_{beat} = \left| f'' - f' \right|$. Upon substituting data, the beat frequency is 4.4 Hz. Extract 12.2 is a sample of incorrect responses to this question.

2. (a) (i) Solution:

Data: Sound frequency = 500 Hz

velocity = 1.5 m/s

velocity of sound = 336 m/s:

Number of beats = ?

(No wind):

From ∓ Beats = $\frac{\text{Sound frequency} \times \text{Velocity of sound}}{\text{frequency velocity}}$

$= \left(\frac{500 \times 336}{1.5}\right)$ Beats/second.

= 112000 Beats/second.

∴ There 112000 Beats/psecond being heard.

(ii) Solution:

Data: Width = 0.1 mm = 0.0001 m:

Wave length = 5000 Å = 5×10^{-7} m

Distance apart = 1 m

Width of Central maximum

$= \frac{5 \times 10^{-7} m \times 1 m}{0.0001 m}$

$= 5 \times 10^{-3}$ m

= 50000000 Å

∴ The wake width of central maximum on a screen = 5×10^{-3} m

2. (b) (i) Solution:

Data; Mass of wire = 0.52×10^{-3} kg.
length of wire = 0.14 m
Mass of load = 16 kg.
frequency of the note = ?

from; $\frac{1}{f} = 2\pi\sqrt{\frac{L}{g}}$.

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{301538.46 m^2/s^2}{0.14 m}}.$$

$$f = 233.69/s$$

∴ The frequency of the note = 233.69/sec

(ii) Solution:

Data: length = 110 cm.
fundamental frequences = ?
Ratio = 1:2:3

from: $\frac{1}{f} = 2\pi\sqrt{\frac{L}{g}}$.

$$\frac{1}{f} = \frac{2\pi\sqrt{L}}{\sqrt{g}} ; \quad \frac{2\pi}{\sqrt{g}} = K$$

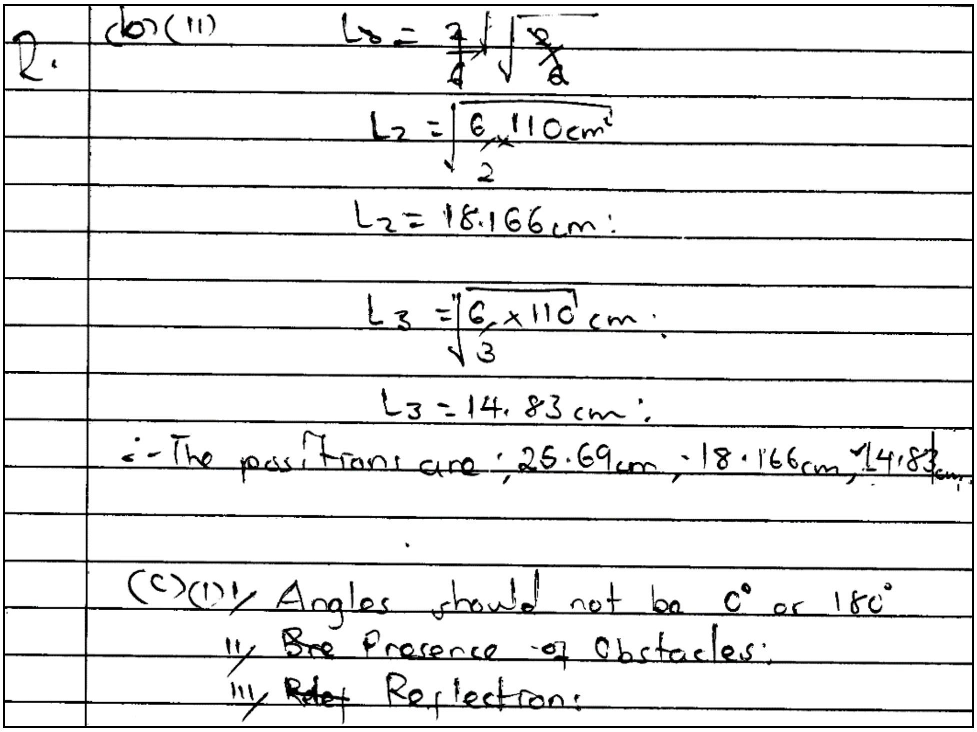
$$f\sqrt{L} = K$$

$$f_1\sqrt{L_1} = f_2\sqrt{L_2} = f_3\sqrt{L_3}$$

$$\sqrt{L_1} = 2\sqrt{L_2} = 3\sqrt{L_3}$$

$$L_1 = \sqrt{110 cm \times 6}.$$

$$L_1 = 25.69 cm.$$



2. (b)(ii) $L_2 = \frac{3}{4}\sqrt{\frac{x}{2}}$

$L_2 = \sqrt{\frac{6 \times 110 cm^2}{2}}$

$L_2 = 18.166 cm$

$L_3 = \sqrt{\frac{6 \times 110}{3}} cm$

$L_3 = 14.83 cm$

∴ The positions are; 25.69 cm, 18.166 cm, 14.83 cm.

(c)(i) Angles should not be 0° or 180°

ii) ~~Bre~~ Presence of Obstacles.

iii) ~~Rdef~~ Reflection.

Extract 12.2: A sample of incorrect responses to question 2 of paper 2

In Extract 12.2, the candidate applied irrelevant formulas to calculate the number of beats per second and the frequency of the fundamental note in parts (a) and (b), respectively. In part (c), the candidate incorrectly stated conditions for diffraction instead of identifying the correct conditions required for the interference of light to occur.

3.3 Question 3: Properties of Matter

This question was divided into three parts: (a), (b), and (c). In part (a), candidates were required to:(i) explain why reducing the volume of a gas at constant temperature leads to an increase in pressure, and (ii) deduce Avogadro's law in terms of the kinetic theory of gases.

In part (b), the candidates were asked to: (i) *explain the terms root mean square speed and mean speed of gas molecules, and (ii) determine the root mean square speed of a hydrogen molecule at a given temperature of 27^o C, using the Boltzmann constant ($K = 1.38 \times 10^{-23}$ J/K). In part (c), the question asked candidates to state six assumptions that form the basic postulates of the kinetic theory of gases*.

A total of 28,682 (96.89%) candidates attempted this question, and their scores were as follows: 8,207 (28.61%) scored from 0.0 to 6.5 marks, 12,448 (43.40%) scored from 7.0 to 11.5 marks, and 8,027 (27.99%) scored from 12.0 to 20.0 marks. These scores indicate that the candidates' performance in this question was good, as 20,475 (71.39%) of them scored from 7.0 to 20.0 marks. Figure 14 presents a summary of the candidate's performance.

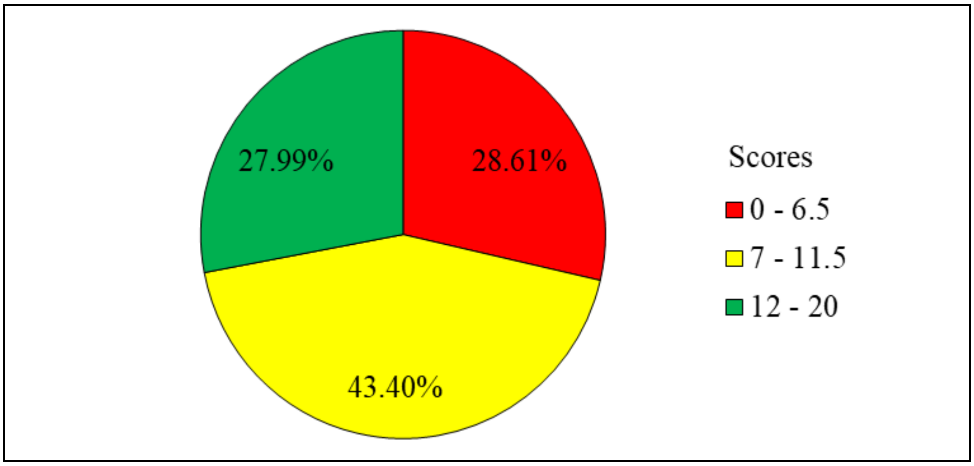


Figure 14: *Candidates' performance in question 3 of paper 2*

The data analysis reveals that 27.99% of the candidates scored higher marks (12.0-20.0). The candidates in this category scored higher on most parts of the question. They were able to apply Boyle's law and the kinetic theory of gases to scientifically explain the cause of an increase in pressure when volume is reduced at constant temperature. Moreover, the candidates correctly applied the kinetic theory of gases to deduce Avogadro's law. Furthermore, these candidates applied a correct formula to determine the root mean square speed of a hydrogen molecule. This suggests that the candidates had adequate knowledge and skills on the topic of properties of matter. Extract 13.1 presents an example of correct responses from one of these candidates.

02. (a)

(i) This is because, reducing the volume of a gas at constant temperature leads to the increase in the number of moles of a gas per unit volume which leads to the increase in frequency of collision. The increase in the frequency of collision per unit area of container results into increase in pressure.

(ii) From kinetic theory of gases;

$$PV = \frac{1}{3} N m \bar{c}^2$$

but

$$N = n \cdot L_A$$

then

$$PV = \frac{1}{3} n L_A m \bar{c}^2$$

$$PV = \frac{2}{3} n L_A \left[\frac{1}{2} m \bar{c}^2 \right]$$

2	(a) (ii)
	but $\frac{1}{2}m\bar{c}^2 = K.E$
	And $K.E \propto T$
	Then
	$\frac{1}{2}m\bar{c}^2 \propto T$
	Then
	$PV = \frac{2}{3} nLA \cdot T$
	$V = \left(\frac{2nLA}{P}\right) T$
	$V = \left(\frac{2LAT}{P}\right) n$
	Since pressure (P) and Temperature is constant [Avogadro law]
	Then
	$\frac{2LAT}{P} = \text{constant} = c$
	$V = cn$
	$V \propto n$
	$\frac{V_1}{n_1} = \frac{V_2}{n_2}$
	but $V_1 = V_2$ [Avogadro law]
	Then $n_1 = n_2$

3.	∴ Avogadro's law is $n_1 = n_2$
	It states that " Equal volume of all gases at constant
	temperature and pressure contains equal amount of
	gases ".
03.	(b) (i) - Root mean square speed of a gas refers to
	the root of the average of square velocities of the
	gas molecules at a given temperature.
	- Mean speed of gas molecules refers to the
	average of the speeds of individual gas molecules
	at a given temperature.
	- Root mean square speed is given by $\sqrt{\frac{3RT}{M}}$ while
	mean speed is given by $\sqrt{\frac{8RT}{\pi M}}$.
	(ii) Data
	Temperature, $T = 27°C$
	$= 300K$
	$K = 1.38 \times 10^{-23}$ J/K
	$M = 1.674 \times 10^{-27}$ kg
	from
	$U_{rms} = \sqrt{\frac{3KT}{m}}$

03 (b) (ii)

$$u = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 300}{2 \times 1.674 \times 10^{-27}}}$$

$u_{rms} = 1926.0529$ m/s

∴ Root mean square speed = 1926.052 m/s

03 (c) Assumptions

(i) Gases are made up of molecules which are in the state of uniform random motion

(ii) The random motion of gas molecules results in collisions between themselves and collisions with the walls of the container

(iii) The collisions between the molecules of gases and with the walls of container are perfectly elastic

(iv) The kinetic energy of gas molecules depends on the absolute temperature of a gas

(v) The force of interaction between the gas molecules is negligible.

(vi) The size of the gas molecules is negligible compared to the size or volume of a container. This causes the effect of gravity on gas molecules to be negligible

Extract 13.1: A sample of correct responses to question 3 of paper 2

In Extract 13.1, the candidate correctly stated the relationship between the volume of a gas and its pressure at constant temperature. This candidate was able to deduce Avogadro's law from the kinetic theory of gases. Moreover, the candidate applied the appropriate formula to determine the root mean square speed of hydrogen molecules. Furthermore, the candidate accurately listed the six assumptions of the kinetic theory of gases, as required by the question.

The analysis further shows that 43.40% of the candidates scored average marks (7.0-11.5). Most of these candidates failed to score higher marks in parts (b) and (c) of this question. In part (b) (i), these candidates failed to clearly define the root mean square speed and mean speed of the gas molecules. On the other hand, most of them provided a correct mathematical formula but failed to substitute the values of temperature and mass of the H_2 when calculating the root mean square speed of H_2.

The statistical data shows that (37.21%) of the candidates scored lower marks (0.0– 6.5). Most of them provided incorrect responses in most parts of this question. They failed to apply concepts, theories and principles related to the kinetic theory of gases to describe various physical phenomena. In part (a) (i), these candidates failed to provide a scientific reason on the cause of the increase in pressure when the volume of a gas is reduced at constant temperature. Most of them provided incorrect responses. For instance, one candidate wrote; "*upon reducing the volume the number of molecules that collide is decreased hence pressure increases*" This was an incorrect statement. The candidate failed to realise that the pressure of gas comes from molecules colliding with the walls, not molecules crowding. In this regard, it can be concluded that reducing the volume results in: (i) molecules having less space to move, and (ii) an increased rate of collisions between the molecules and the container walls. As a result, the pressure of the gas increases at constant temperature. Some of the candidates provided irrelevant responses. For instance, one candidate argued that, "*number of molecules per unit volume decreases when volume of a gas is deduced.*" This statement makes no sense as per the question.

In part (a)(ii), these candidates failed to apply the kinetic theory of gases to deduce Avogadro's law. For example, some candidates incorrectly wrote Avogadro's equation as $\frac{1}{2}PV = K$ while others wrote $NM = \frac{1}{2}Mv^2$. These formulas make no sense in physics. The candidates in this category failed to understand that macroscopic quantities (pressure and volume) are related to microscopic properties (speed, energy and collision). The kinetic theory of gases establishes a connection between the two properties.

Thus, according to the kinetic theory of gases, the pressure of the gas is given as:

$P = \frac{1}{3}\frac{Nm\langle c^2 \rangle}{V}$. The mean speed defines the average kinetic energy of the molecules. As per the kinetic theory of gases, the average kinetic energy per molecule is related to temperature by:

$\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$.

Thus:

$m\langle c^2 \rangle = 3kT$.

From the equation of the pressure, one can write

$PV = \frac{1}{3}N.(3kT) = NkT$. This is the ideal gas equation. Since Avogadro's number (number of molecules per mole) is given as: $N_A = \frac{N}{n}$ and $k = \frac{R}{N_A}$.

It follows that:

$PV = nRT$. This is an ideal gas equation in terms of moles. For constant pressure and temperature, the pressure equation becomes:

$V = Kn$. Note $\frac{RT}{P} = K, \text{ constant}$.

Thus, it can be said that at constant temperature and pressure, the volume of a gas is directly proportional to the number of molecules (or moles) of the gas.

Moreover, in the determination of the root mean square speed in part (b), some candidates applied the wrong formula. For instance, one candidate wrote: $KE = \frac{3}{2}k_BT$. This was an incorrect expression as per the question's demand. This equation describes the average kinetic energy of the molecules. The candidate was supposed to know that the root mean square speed of hydrogen molecules is defined as: $v_{rms} = \sqrt{\frac{3kT}{m}}$.

Some candidates failed to substitute the correct value of the mass of hydrogen. For example, one candidate used 2 kg as the mass of hydrogen. This was incorrect data and makes no sense in Physics. The mass of a hydrogen atom (1.674×10^{-27} kg) was provided in the examination paper. Thus, the mass of hydrogen molecules (H_2) is $2 \times 1.674 \times 10^{-27} kg = 3.348 \times 10^{-27} kg$. In addition, some of the candidates calculated the mass of hydrogen gas as the product of the number of molecules, N and the mass of an electron, i.e., $N \times m_e$. This calculation makes no sense in Physics. Extract 13.2 represents a sample of an incorrect responses to this question.

3.	a) i) The Volume of the gas decrease while its pressure increased because the gas is compressible molecule and when the pressure increased, the Volume decrease.
	Consider mathematically expression
	From Boyle's law
	$P \alpha \frac{1}{V}$
	Means the increase in pressure lead to the decrease in Volume.
	ii) To deduce the Avogadro's law in terms of the kinetic theory of gases.
	Solution
	From
	$\frac{1}{3} Nm^{-1} c$
	But
	$n \alpha V$
	Where
	n = number of moles
	V = Volume
	Thus
	$\frac{1}{3} Nm^{-1} c$

$$\frac{1}{3} \frac{Nmc^{-2}}{n \times V}$$

$$\frac{1}{3} = \frac{P}{n \times V}$$

Thus

~~nx~~

$n \propto V$

$n = kV$

Where

k = Constant physical quantity

$P = n \propto V$

b) i) Mean square speed; Is the speed of the gas molecules move around the container holding it. While mean speed of the gas molecules is the average of the speed of gas molecule in air.

ii) Given

Temperature = 27°c

Boltzmann's constant $k = 1.38 \times 10^{-23} JK$

Required root mean square speed.

From

27° + 273 = 300k

But

~~giv~~ given

Boltzman Constant, k

1.38×10^{-23} J/k

Thus

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2/c^2$

$\frac{300k \times 1.38 \times 10^{-23} J/K}{9.0 \times 10^9 Nm^2/c^2}$

3.9×10^{-21}

$\frac{9 \times 10^9 Nm^2/c^2}{300K \times 1.38 \times 10^{-23} J/k}$

$\frac{9.0 \times 10^9 Nm^2/c^2}{4.14 \times 10^{-21}}$

2.174×10^{-12} m/s.

3. c, Assumptions which represent the basic postulates of the kinetic theory of gases

i, The gas is made up by small particles called molecules.

ii, The gas in its Container move at Constant Speed.

iii, The gas is compressible in its Container at high pressure.

iv, The gas possess small collision in its Container.

Extract 13.2: A sample of incorrect responses to question 3 of paper 2

In Extract 13.2, the candidate provided incorrect responses on all part of this question.

3.4 Question 4: Electrostatics

The question consisted of parts (a), (b) and (c). The question asked: (a)

(i) *How is the direction of the field strength is specified?*

(ii) Two point charge +2q should be placed between two-point charges A and B of $+2q$*) and* $-4q$ *respectively are situated 90 mm apart. Where should a point charge of -2q be placed so that it experiences no resultant electrostatic force?*

(b) (i) What are the common properties of electric field lines?

(ii) In demonstrating the motion of a charged particle, students considered an electron projected with an initial velocity of $10^7\,\mathrm{m/s}$ *into a uniform electric field between two parallel plates of length* $2\,\mathrm{cm}$ *being at a distance of* $1\,\mathrm{cm}$ *apart. If the direction of the field was vertically downwards when the electron just missed the upper plate as it emerges from the field, evaluate the magnitude of electric field.*

(c) If a spherical conductor of radius $12\,\mathrm{cm}$ *has a charge of* $1.6\times10^{-7}\,\mathrm{C}$ *distributed uniformly on its surface; calculate the electric field:*

(i) Inside the sphere.

(ii) At a point $18\,\mathrm{cm}$ *from the sphere.*

This question was attempted by 20,098 (67.89%) of the candidates, of which 12,327 (61.33%) candidates scored from 0.0 to 6.5 marks, 6,183 (30.77 %) scored from 7.0 to 11.5 marks, while 1,588 (7.90%) scored from 12.0 to 20.0 marks. These scores show that 7,771 (38.67%) candidates scored from 7.0 marks and above, which indicates average performance. Figure 15 summarizes the candidates' performance in this question.

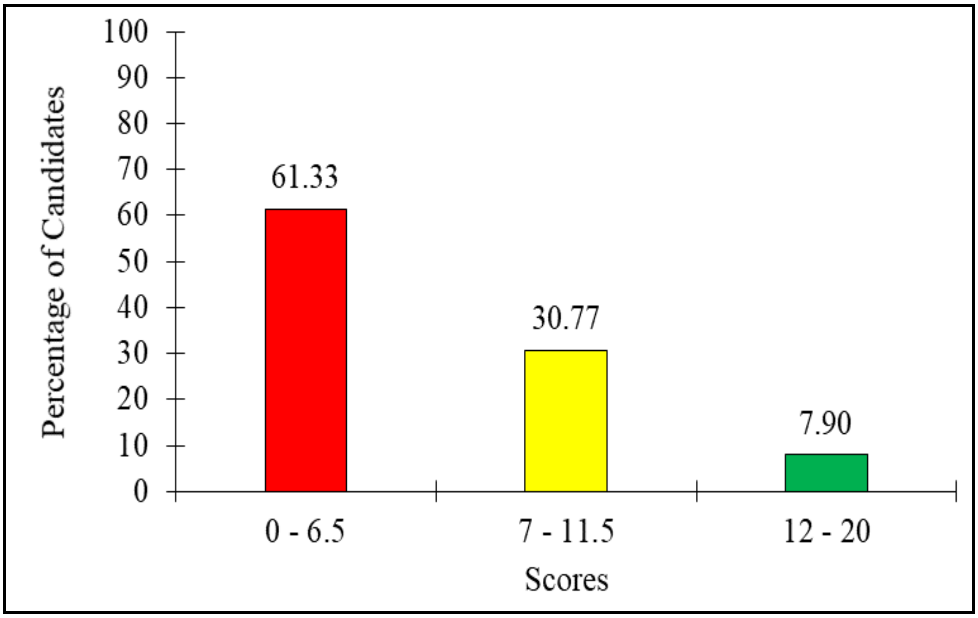
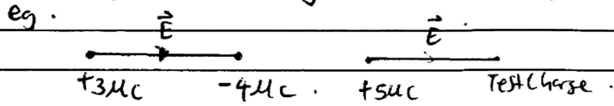


Figure 15: *Candidates' performance in question 4 of paper 2*

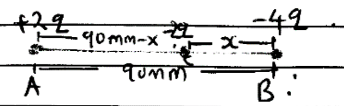
Further analysis of data reveals that among 20,098 (67.89%) candidates who attempted this question, 38.67% scored above 6.5 marks. The candidates had sufficient knowledge on the topic of electrostatics. In part (a), most of them applied the positive test charge rule to describe the direction of the field strength. Moreover, these candidates applied Coulomb's law to determine the neutral point between point charges A and B. Regarding part (b), the candidates were able to identify two common properties of electric field lines. Looking at their responses, it can be concluded that their understanding of these properties enabled them to evaluate, analyse, and manipulate expressions to determine the magnitude of electric fields at different points between two parallel plates. In part (c), they were able to apply the appropriate formula to calculate the electric field both inside the sphere and at a point 18 cm from its centre. Extract 14.1 presents a sample of correct responses provided by one of these candidates.

4. (a) (i) Direction of electric field is from a positive charge to a negative charge or from a more positive charge to a less positive charge

eg.



4 (a) (ii)



$$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

$$F_{CA} = \frac{9\times10^9 \times 2q \times 2q}{(90-x)^2}$$

$$F_{CB} = \frac{9\times10^9 \times 2q \times 4q}{x^2}$$

$$F_{CA} = F_{CB}$$

$$\frac{9\times10^9 \times 4q^2}{(90-x)^2} = \frac{9\times10^9 \times 8q^2}{x^2}$$

$$\frac{4}{(90-x)^2} = \frac{8}{x^2}$$

$$\frac{1}{(90-x)^2} = \frac{2}{x^2}$$

$$x^2 = 2(8100 + x^2 - 180x)$$

$$x^2 = 16200 + 2x^2 - 360x$$

$$x^2 - 360x + 16200 = 0$$

$x = 52.72$ mm or $x = 307.28$ mm

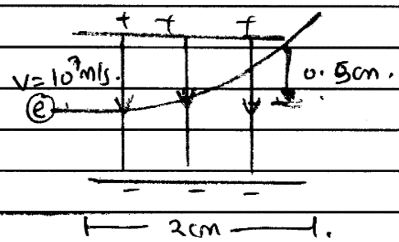
4. (a) ∴ It should be 307.28 mm from −4q and at the same time 217.28 mm from +2q charge.

or 52.72 mm from −4q and 32.78 mm from +2

(b) (i) – They never cross each other

– They come from positive charge directed to a negative charge.

(ii)



$F = eE$

$ma = Ee$

$a = \frac{Ee}{m}$

$S_y = u_y t + \frac{1}{2}at^2$

$S_y = 0 + \frac{1}{2}\frac{Ee}{m}t^2$

$y = \frac{Eet^2}{2m}$

$S_x = u_x t + \frac{1}{2}a_x t$

$S_x = Vt$

$t = \frac{x}{v}$

$$y = \frac{Ee\,t^2}{2m}.$$

$$y = \frac{Ee}{2m}\left(\frac{x}{v}\right)^2.$$

$$y = \frac{Eex^2}{2mv^2}.$$

$$E = \frac{2mv^2y}{x^2e}.$$

$$E = \frac{2 \times 9.11 \times 10^{-31}\,kg \times (10^7 m/s^2)^2 (0.5 \times 10^{-2})m}{(2 \times 10^{-2})^2 \times 1.6 \times 10^{-19}\,c}.$$

$$E = 14234.375\ N/c.$$

∴ The magnitude of electric field is 14234.375 N/C.

ⓒ. $r = 12cm.$

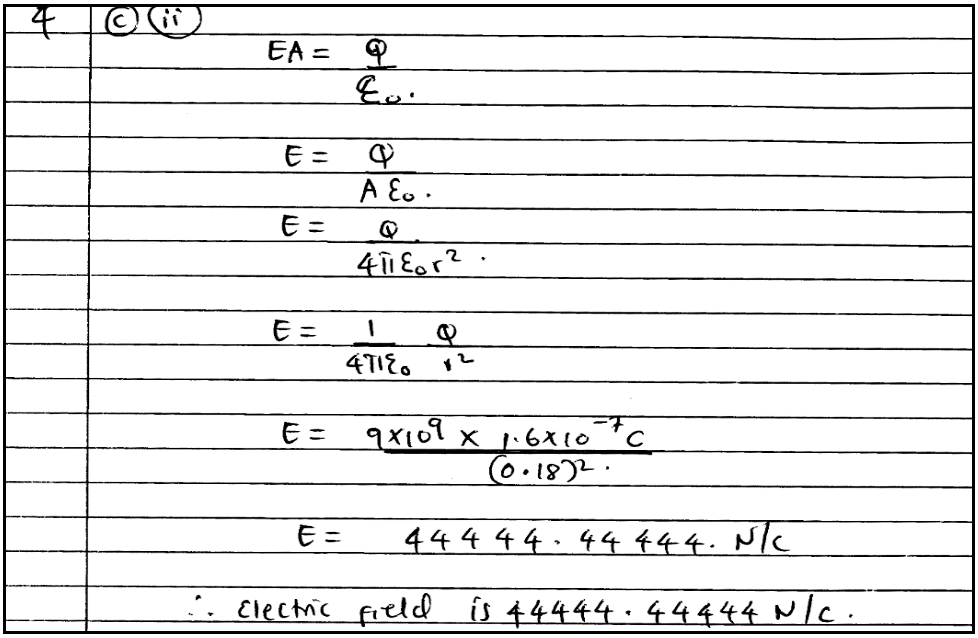
$Q = 1.6 \times 10^{-7} C.$

(i). Electric field inside a conducting sphere is zero.

From $E = \frac{Q}{A\varepsilon_0}$

inside a sphere $Q=0$.

$$E = 0/A\varepsilon_0 = 0.$$


4 (c)(ii)

$$EA = \frac{Q}{\varepsilon_o}.$$

$$E = \frac{Q}{A\varepsilon_o}.$$

$$E = \frac{Q}{4\pi\varepsilon_o r^2}.$$

$$E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$$

$$E = \frac{9\times10^9 \times 1.6\times10^{-7}C}{(0.18)^2}.$$

$$E = 44444.44444.\ N/C$$

∴ Electric field is 44444.44444 N/c.

Extract 14.1: A sample of correct responses to question 4 of paper 2

In Extract 14.1, the candidate correctly managed to specify the direction of the electric field strength, identify the common properties of electric field lines, and evaluate the magnitude of the electric field of a sphere.

On the other hand, 61.33% who attempted this question scored lower marks (0.0–6.5). Most of them scored a lower mark in each part of this question. In part (a), some candidates failed to specify the direction of electric strength. For example, one candidate wrote, "*The direction of field strength can be specified through the magnetic field.*" This response is not true as per the question. Magnetic and electric fields are connected when dealing with either moving charges (changing fields) or electromagnetic waves. For the static conditions, the direction of the field can be specified by using a positive test charge (the law of positive test charge). Thus, it depends on the configuration and polarity of the source charges. Another candidate wrote: *"The direction of field strength can be specified by lines which pass from one pole to another."* This was also an incorrect response. This response has some misconceptions. The candidate misused the word pole. A pole is always used for a magnetic field (the north and south poles of a magnet). In static electricity, positive and negative charges are used instead of poles. In this regard, the electric lines do not pass from one pole to another. These field lines originate from positive charges and end at negative charges.

Furthermore, in part (a) (ii), most of the candidates in this category applied an incorrect formula to determine the neutral point between point charges A and B. This demonstrated a lack of mathematical skills. For example, one of the candidates incorrectly wrote: *position of a neutral point is determined by* $R_m = \left(\frac{V - V_o}{4}\right)A$ instead of computing $F_{CA} + F_{CB} = 0$ and $\frac{Q_C Q_A}{4\pi\varepsilon_O x^2} = \frac{Q_C Q_B}{4\pi\varepsilon_O (90 + x)^2}$.

In part (b), most of the candidates provided irrelevant responses. For instance, one of the candidates outlined common properties of electric field lines as: "*flow of electric charge or electrons in a conductor* and flow of *current from positive terminal to negative terminal.*" Moreover, these candidates failed to apply an appropriate mathematical equation to evaluate the magnitude of the electric field. For example, one candidate used $B = \frac{mv}{qr}$ instead of manipulating $y = \frac{1}{2}at^2$, $a = \frac{Ee}{m_e}$ and $y = \frac{1}{2}\left(\frac{Ee}{m_e}\right)t^2$. They also applied incorrect formulas to calculate the electric field both inside the sphere and at a point 18 cm from its centre. For example, one candidate incorrectly calculated the surface area of the sphere using the formula $A = \pi r^2$ instead of the correct formula $A = 4\pi r^2$. Another candidate applied an incorrect formula to determine the electric field strength at a point 18 cm from the centre of the sphere as $E = kq\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$, instead of $\mathrm{E} = \frac{\mathrm{q}}{4\pi\pi_o \mathrm{r}^2}$ which led to an incorrect result. Extract 14.2 is a sample of incorrect responses of one of the candidates to this question.

9 b) gravity = 9.8 ~~g/n~~ g/s

$B = \frac{M_o I}{2\pi r}$

$B = M_o n I$

c)

i) Data given.

Soln.

Radius = 12cm = ~~0.012 mm~~ 0.12 m

Charge = 1.6×10^{-7}

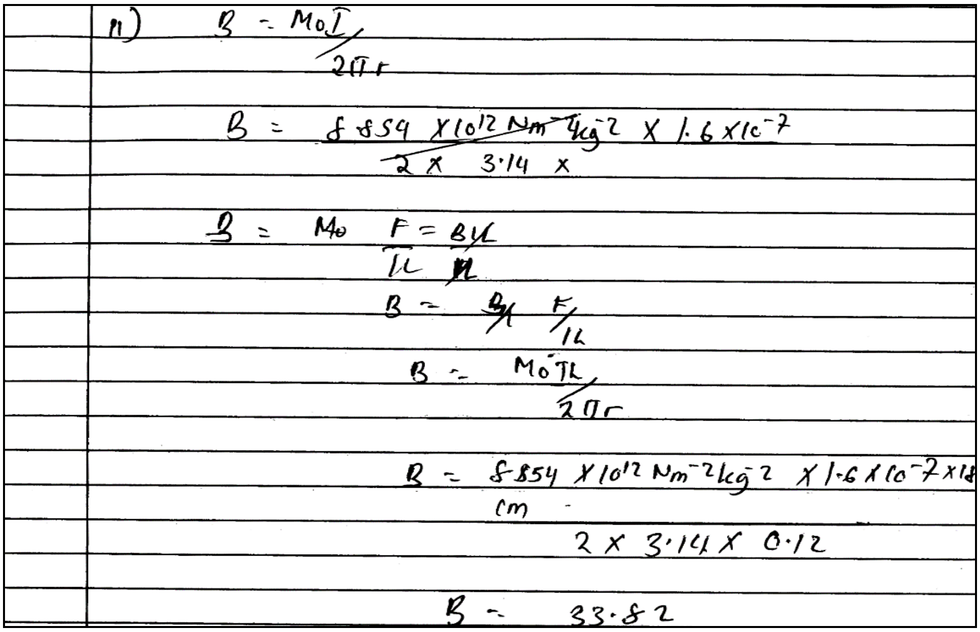
M_o = $8.854 \times 10^{12} Nm^{-2}kg^{-2}$

$B = \frac{M_o I}{2\pi r}$

$B = \frac{8.854 \times 10^{12} Nm^{-2}kg^{-2} \times 1.6 \times 10^{-7} C}{2 \times 3.14 \times 0.12 m}$

$B = 1.87 \times 10^{18} m$

∴ Inside the Sphere electric field is $1.87 \times 10^{18} m$



n) $B = \frac{M_0 I}{2\pi r}$

$B = \frac{8.854 \times 10^{12} Nm^{-2} kg^{-2} \times 1.6 \times 10^{-7}}{2 \times 3.14 \times}$

$B = \frac{M_0}{IL}$ $F = BIL$

$B = \frac{F}{IL}$

$B = \frac{M_0 IL}{2\pi r}$

$B = \frac{8.854 \times 10^{12} Nm^{-2} kg^{-2} \times 1.6 \times 10^{-7} \times 18 \ cm}{2 \times 3.14 \times 0.12}$

$B = 33.82$

Extract 14.2: A sample of incorrect responses to question 4 of Paper 2

In Extract 14.2, the candidate applied an incorrect formula to determine the physical quantities.

3.5 Question 5: Electromagnetism

This question consisted of three parts: (a), (b) and (c). Part (a) required the candidates to justify the following statements;

(i) *Permanent magnets are made of steel while the core of a transformer is made of soft iron.*

(ii) *Like poles of nearly magnets repel each other while unlike poles attract.*

(iii) *Above Curie temperature ferromagnetic material becomes paramagnetic.*

Part (b) required the candidates to (i) distinguish between diamagnetic materials and ferromagnetic materials with one example in each case and (ii) describe the hysteresis loop for soft and hard steel with the aid of labelled sketches. Part (c) required the candidates to; (i) calculate the force on the conductor carrying current of 5 A passing through it, when a vertical straight conductor of length 0.6 m is situated in a horizontal uniform magnetic field of 0.1 tesla and (ii) determine the angle through which the conductor must be substituted in the vertical plane so that the force on the conductor is halved.

The analysis reveals that 23,208 (78.40%) of the candidates attempted this question. Among them, 4,459 (19.22%) scored from 0.0 to 6.5 marks, 10,152 (43.75%) scored from 7.0 to 11.5 marks, and 8,593 (37.03%) scored from 12.0 to 20.0 marks. The general candidates' performance in this question was good, as 80.78% of the candidates who attempted this question scored above 7.0 marks. Figure 16 represents these scores. The distribution of their scores is shown in Figure 16.

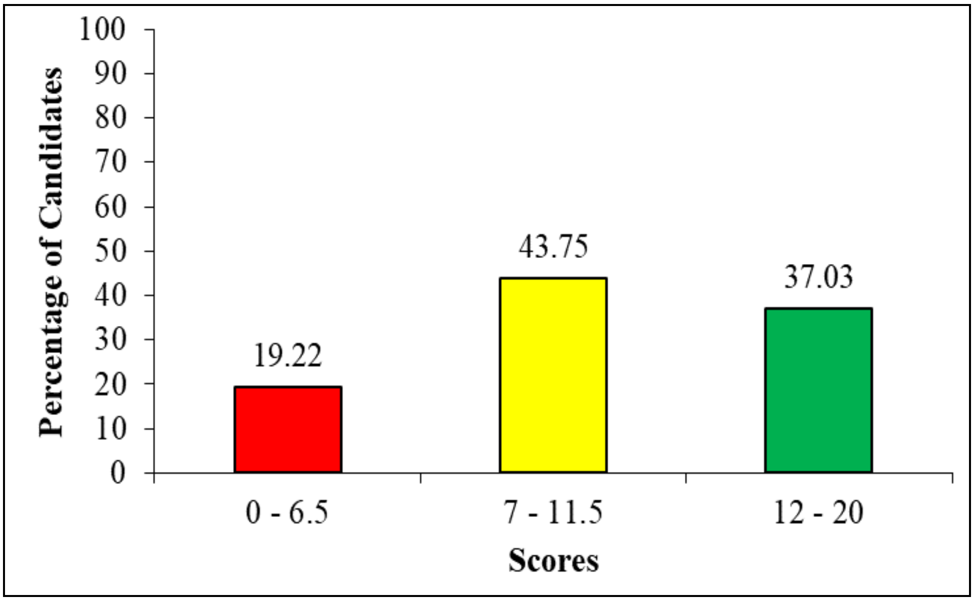


Figure 16: *Candidates' performance in question 5 of paper 2*

The candidates (37.03%) who scored between 12.0 and 20.0 marks demonstrated a good understanding of the concept of electromagnetism. They showed competence by correctly explaining the principles related to permanent magnets, the core of a transformer, the repulsion between like poles, the attraction between unlike poles, and the behaviour of ferromagnetic materials above the Curie temperature. Most of them also provided comprehensive descriptions and relevant examples of both diamagnetic and ferromagnetic materials.

The statistical data shows that 37.03% of candidates scored between 12.0 and 20.0 marks. These candidates demonstrated their mastery of the basic concepts, theories and principles related to electromagnetism. They applied the correct mathematical formula to determine the values of the needed physical quantities. These candidates presented well-labelled sketches and a broad description of hysteresis loops for soft and hard steel.

Extract 15.1 represents a sample of correct responses from one of the candidates.

5 (a) (i) Permanent magnets are made of steel because steel have high value of retentivity and coercivity hence can retain the magnetism and cannot be easily demagnetized.

On other hand core of tranformers are made of soft iron because the soft iron:
- first have small area of hysteresis loop hence the loss of energy due to hysteresis is minimum.
- secondly have low value of coercivity and retentivity hence can be easily magnetized and demagnetized.

(ii) Like poles of magnets are like two parallel conductors moving in the same direction whose current are in opposite direction hence repulsion results.

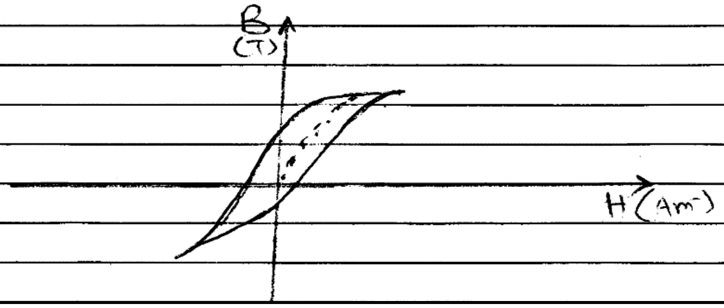
On other hand unlike poles are like two parallel conductors in the same direction whose current are in the same direction hence attraction results.

(iii) In ferromagnetic materials the domains are aligned in proper orientation, the alignment of the domains is due to presence of forces which holds these domain in the alignment. Above curie temperature these forces disappear hence the domains are not alligned again hence material become paramagnetic

5 (b) (i) Diamagnetic materials are these material which when the external magnetic field is applied, they are weakly repelled in the direction opposite to the direction of external magnetic field
Example: Water and Bismuth.
WHILE
Ferromagnetic material are these materials which when the external magnetic field is applied, they are strongly attracted in the direction of the field.
Example: Iron and Nickel.

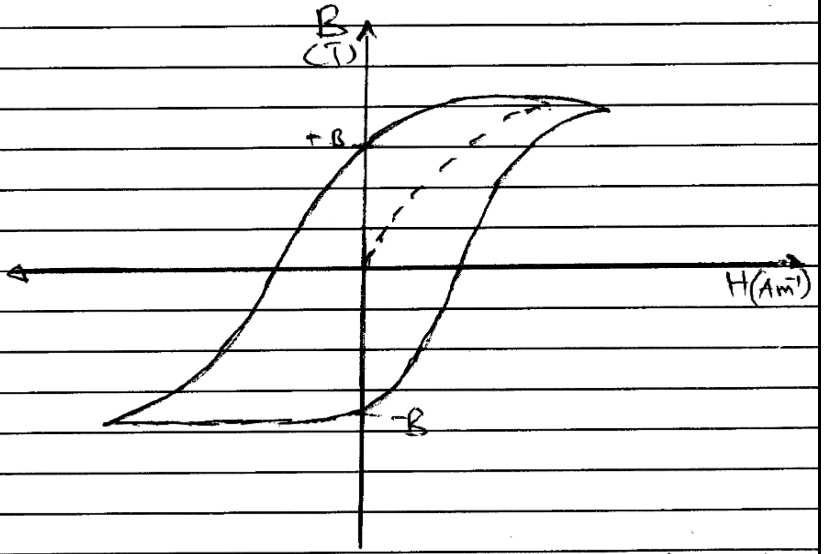
(ii) - Hysteresis loop for soft steel.
- Soft steels have hysteresis loop with very small area.
- Thus they have small values of retentivity and coercivity.
- Even the loss of energy due to hysteresis in them is very small.

Sketch for hysteresis of soft steel



5 (b) ii. hysteresis loop for hard steels.

- Hard steels have hysteresis loop with very large area.
- Thus they have large value of retentivity and coercivity.
- Thus even the loss of energy in them due to hysteresis is large.



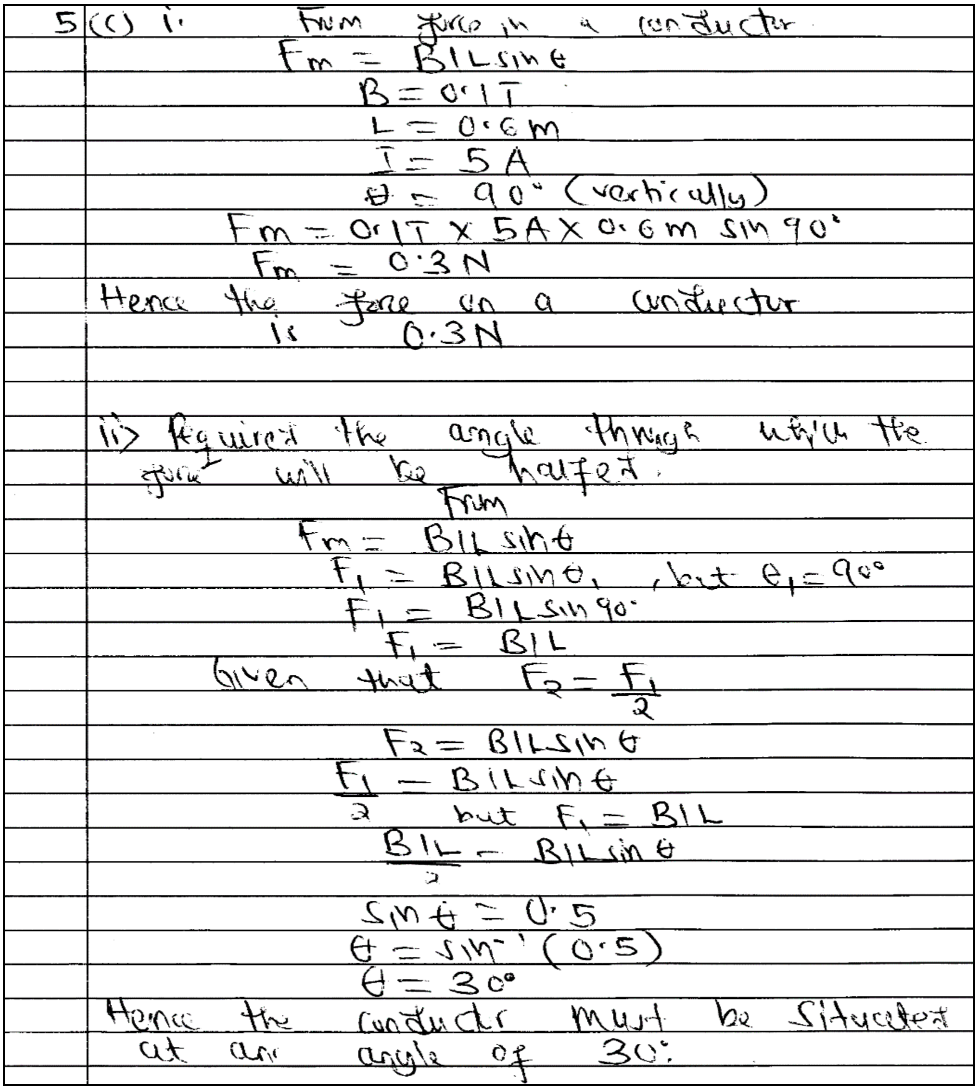
Sketch for hysteresis loop for hard steel

5 (c) Data given Solution

Length of the conductor (L) = 0.6m

Magnetic field (B) = 0.1 T

<i> Required force on a conductor when a current of 5A is passed into it.



5 (c) i. From force in a conductor
$F_m = BIL\sin\theta$
$B = 0.1T$
$L = 0.6m$
$I = 5A$
$\theta = 90°$ (vertically)
$F_m = 0.1T \times 5A \times 0.6m \sin 90°$
$F_m = 0.3N$
Hence the force on a conductor is 0.3N

ii) Required the angle through which the force will be halfed.
From
$F_m = BIL\sin\theta$
$F_1 = BIL\sin\theta_1$, but $\theta_1 = 90°$
$F_1 = BIL\sin 90°$
$F_1 = BIL$
Given that $F_2 = \frac{F_1}{2}$
$F_2 = BIL\sin\theta$
$\frac{F_1}{2} = BIL\sin\theta$
but $F_1 = BIL$
$\frac{BIL}{2} = BIL\sin\theta$
$\sin\theta = 0.5$
$\theta = \sin^{-1}(0.5)$
$\theta = 30°$
Hence the conductor must be situated at an angle of 30°.

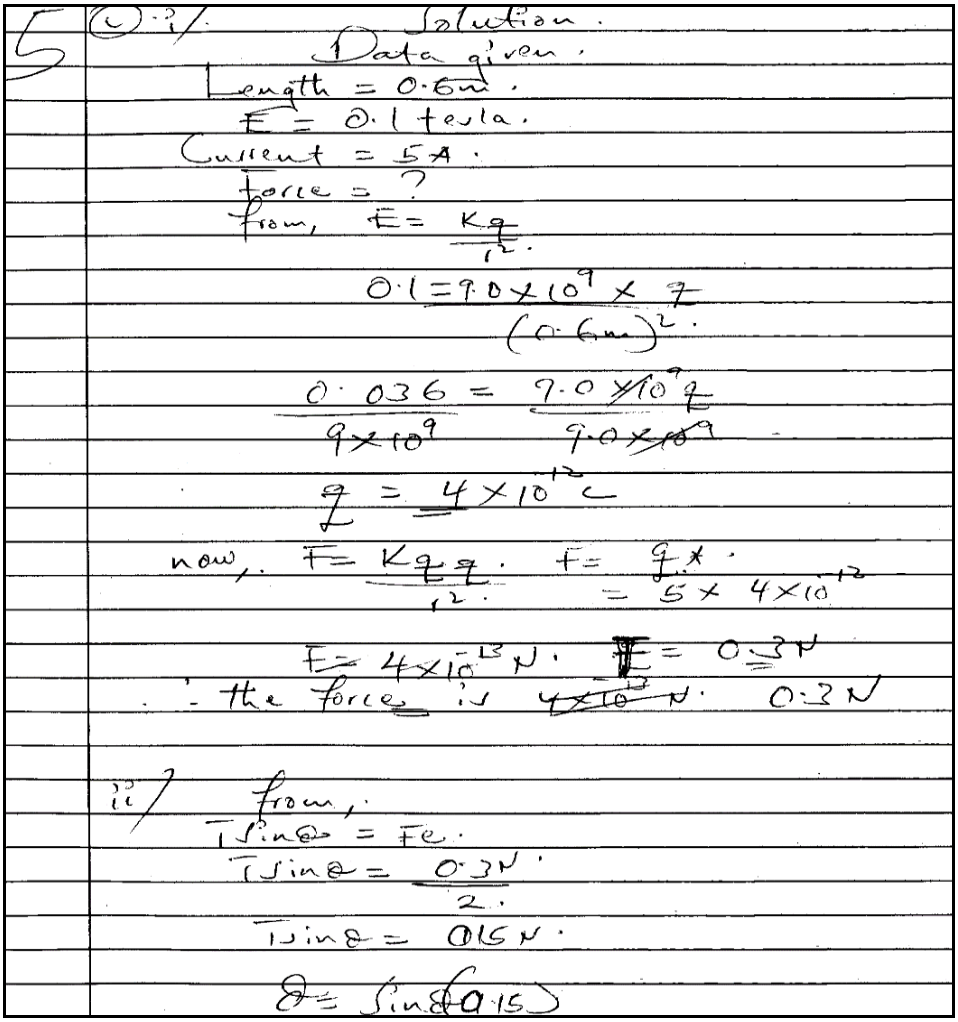
Extract 15.1: A sample of correct responses to question 5 of paper 2

In Extract 15.1, the candidate correctly explained the concepts related to magnetic materials. The candidate accurately sketched the hysteresis loops for both soft and hard steel. Moreover, the candidate applied the relevant formulas and followed appropriate procedures to calculate the force on a conductor.

On the other hand, 43.75% of the candidates who attempted this question scored average marks (7.0 - 11.5). Most of them scored higher marks in part (a) and (b). They failed to score a higher mark in part (c). Most of them failed to provide the correct formula. This suggests that they lacked adequate knowledge and skills related to current carrying conductors.

The statistical data further shows that a small proportion of candidates (19.22%) who attempted this question scored between 0.0 and 6.5 marks. Most of them scored very low marks in each part of the question. Their responses had a lot of misconceptions. For instance, one candidate responded part (a) (i) as: *Because the coil of a transformer must have high magnetic strength in order to attract the coil to rotate and cause the electric field.* Looking at this response, it is evident that the candidate confused a transformer with a motor. The coil rotation due to magnetic attraction is characteristic of an electric motor, not a transformer. The candidate was supposed to realise that transformers have no rotating parts. They are operating based on the principles of electromagnetic induction between coils (stationary). In addition, the candidate is supposed to know that high magnetic permeability does not necessarily mean high magnetic strength. The candidate was supposed to understand that a material with high permeability is good at allowing magnetic flux. It does not produce a strong magnetic field. Thus, the core of a transformer should have high magnetic permeability to allow the induction process. Another candidate stated: *Because steel has low permittivity as compared to iron.* This was not a correct response. The core of a transformer must have high permittivity and low retentivity (lose magnetism faster). Thus, a soft iron core is more ideal for a transformer.

Moreover, some of them failed to distinguish the diamagnetic materials and ferromagnetic materials. They provided incorrect or irrelevant responses. For instance, one of the candidates wrote: *diamagnetic materials are materials which have magnetic properties, example is steel while ferromagnetic materials are the materials which have no magnetic properties, example is wood.* The candidates were supposed to understand that diamagnetic materials are materials which are weakly repelled by a strong magnet and have negative magnetic susceptibility, for example, copper, zinc, bismuth, while ferromagnetic materials are materials which are strongly attracted by a magnet and have positive magnetic susceptibility, for example, iron, nickel, cobalt. In addition, some candidates provided incorrect descriptions and sketches of the hysteresis loops for soft and hard steels. Extract 15.2 represents a sample of incorrect responses to this question.


5 (c) i/ Solution.
Data given.
Length = 0.6m.
E = 0.1 tesla.
Current = 5A.
Force = ?
from, $E = \frac{Kq}{r^2}$.
$0.1 = \frac{9.0 \times 10^9 \times q}{(0.6m)^2}$.
$\frac{0.036}{9 \times 10^9} = \frac{9.0 \times 10^9 q}{9.0 \times 10^9}$
$q = 4 \times 10^{-12} C$
now, $F = \frac{Kqq}{r^2}$. $F = qI$. $= 5 \times 4 \times 10^{-12}$
$F = 4 \times 10^{-13} N$. $F = 0.3N$
∴ the force is ~~$4 \times 10^{-13} N$~~. $0.3N$
ii/ from,
$T\sin\theta = Fe$.
$T\sin\theta = \frac{0.3N}{2}$.
$T\sin\theta = 0.15N$.
$\theta = \sin^{-1}(0.15)$

Extract 15.2: A sample of incorrect responses to question 5 of paper 2

In Extract 15.2, there is an example of a candidate who applied an incorrect formula to calculate the force of a conductor carrying current. The candidate applied of electric field $E = \frac{kq}{r^2}$ and electrostatic force $F = \frac{kq_1q_2}{r^2}$ instead of a magnetic force $F = BIL\sin\theta$ to calculate the force on a conductor.

3.6 Question 6: Atomic Physics

This question was divided into three parts: (a), (b), and (c). Part (a) required candidates to (i) explain a line spectrum based on the transition of electrons between energy levels and (ii) calculate the ionisation energy of an element, when the energy of the convergence limit line of that element is -

1.6 eV and that of the first energy level is -10.4 eV. Part (b) required the candidates to (i) evaluate the kinetic energy gained by electrons in the X-ray tube, when the potential difference across its ends is 40 kV and (ii) determine the electric current flowing in the tube, when 0.5% of the energy obtained in 6 (b) (i) is transformed into X-rays and 600 W was produced. In part (c) the question asked: *A beam of α -particles is directed normally at a thin metal foil in an α -scattering experiment. Briefly explain why;*

(i) most α -particles pass straight through the foil?

(ii) some α -particles are deflected through angles of more than 90^o ?

(iii) multiple scattering of an individual α -particle is unlikely?

A total of 22,156 (74.84 %) candidates attempted this question, and their scores were as follows: 6,191 (27.94%) scored from 0.0 to 6.5 marks, 8,315 (37.53%) scored from 7 to 11.5 marks and 7,650%) scored from 12.0 to 20.0 marks. The general candidates' performance in this question was good, as 15,965 (72.06%) of the candidates who attempted this question scored from 7.0 to 20.0 marks. Figure 17 summarizes the candidates' performance in this question.

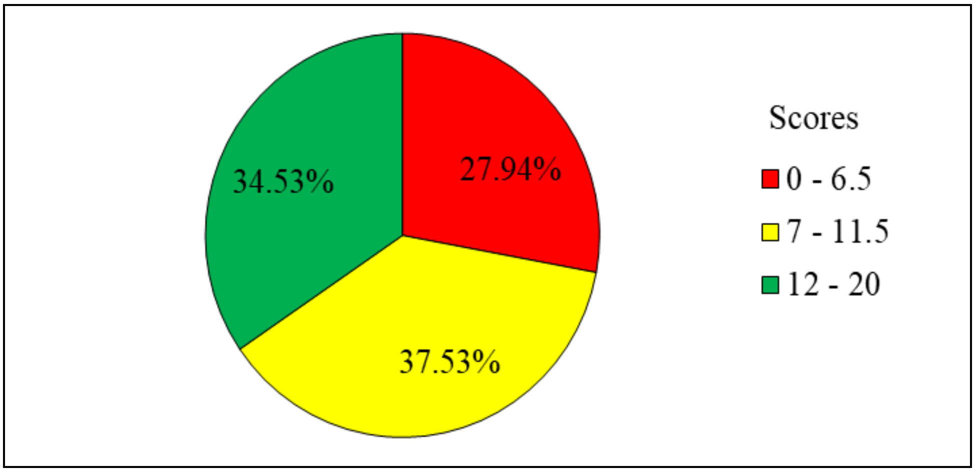
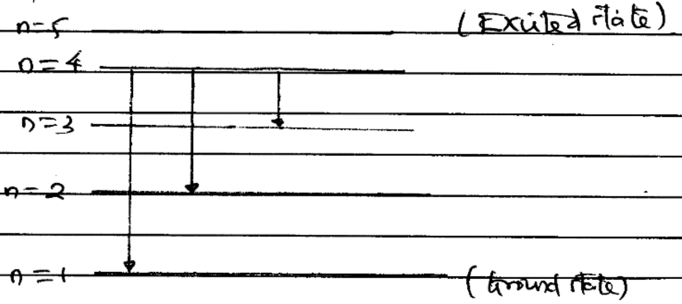


Figure 17: *Candidates' scores in question 6 of paper 2*

The analysis reveals that 34.53% of the candidates scored higher marks (12.0–20.0). These candidates demonstrated a good understanding of the topic of Atomic Physics. These candidates correctly explained the concept of line spectra based on electron transitions between energy levels. They understood that specific amounts of energy (quanta) are absorbed or emitted, corresponding to the differences between these levels. Furthermore, the candidates accurately described the behaviour of alpha (α) particles based on experimental observations of their scattering when a beam is incident perpendicularly on a metal foil. In addition, most of these candidates effectively applied relevant formulas to calculate the ionisation energy of an atom, determine the kinetic energy gained by electrons during X-ray production, and compute the electric current flowing through the tube. Extract 16.1 provides a sample of correct responses to this question.

06: (a) : (i) : - The line spectrum is a type of spectrum that is formed by lines of different wavelengths on transition of electrons
- It's usually formed after the electrons at ground state absorb much energy of different wavelength and get excited to higher energy levels
- On de-excitation, the electrons at high energy levels release out the energy it absorbed at different wavelength.
- Hence, the released radiations of different wavelength forms the line spectrum at different energy levels

Example



(ii) ; Given data :
Energy of convergent limit = −1.6ev
First energy level (n_1) = −10.4ev
Ionization energy = ?

Recall

06: Ionization energy $= E_\infty - E_1$
$= -1.6ev - ^{-}10.4ev$
$= 8.8ev$
∴ The ionization energy is $8.8ev$.

(b) : (i) : Given data.
Potential difference (PD) $= 40kV$
$= 40 \times 10^3 V$.
From:
$KE = eV_0$.
But $e = 1.6 \times 10^{-19} C$
Now.
$KE = 1.6 \times 10^{-19} \times 40 \times 10^3$
$= 6.4 \times 10^{-15} J$

∴ The Kinetic energy is $6.4 \times 10^{-15} J$.

(ii) Given data
$E_{xrays} = 0.5\%\ KE$
Power $= 600W$.
Current (I) $= ?$
From:
Initial $KE = 6.4 \times 10^{-15} J$
Energy of Xrays $= \frac{0.5 \times 6.4 \times 10^{-15}}{100}$
$E_{xrays} = 3.2 \times 10^{-17} J$
Now:
$E_{heat} = E_{ff} - E_{xrays}$
$= 6.4 \times 10^{-15} - 3.2 \times 10^{-17}$
$= ~~3~~\ 6.368 \times 10^{-15} J$

06: Now:

$KE\ (\text{Heat flow}) = 6.368 \times 10^{-15}\ J$

Then, from:

$Power = \frac{KE}{T}$. If 0.5% → x

$Power\ (P) = VI$

$\text{Total power} = 3.015 + 600$

$= 603.015W$

Now

$P = VI$

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

$I = \frac{603.015}{40 \times 10^3}$

$I = 0.015A$

∴ The current is 0.015A

06: (c): (i) :- Most of the α-particles pass straight through the foil because most of the space in the metal foil atom is an empty space.

- But only a very small central part is concentrated (Contains the nucleus) that is positively charged
- Thus, on passing the α-particles, they pass freely without being deflected.

(ii) : - Some of the α-particles are deflected at an angle more than 90° because they pass very close to the nucleus at the centre of the atoms

- Hence, due to repulsion between the α-particles and the nucleus at a very strong level, there happens that are deflected at more than 90°

(iii) :- Multiple scattering of an individual
α-particle is unlikely because
the it's only the nucleus of the
atom that is required to cause the
scattering, found only at centre position of atom
- Since, it's centrally located, and not
uniformly found all over the element's
atoms, there wont be multiple scattering
- Hence, due to absence of random spreading
or arrangement of the nucleus in the
atoms, there can't happen a multiple
scattering of α-particle.

Extract 16.1: A sample of correct responses to question 6 of paper 2

In Extract 16.1, the candidate correctly explained the line spectrum based on the transitions of electrons between energy levels, as well as the behaviour of alpha (α) particles when directed at a thin metal foil. The candidate also demonstrated outstanding mathematical skills in solving problems related to the ionisation energy of an atom and the electric current flowing through the tube.

Nevertheless, 37.53% of the candidates who attempted this question scored average marks (7.0-11.5). These candidates scored higher marks in part (a) (i) and (c). They scored lower marks in part (a) (ii) and (b). In part (b), most of them provided irrelevant responses. It can be said that they failed to demonstrate their mathematics skills in describing physical phenomena.

On the other hand, 27.94% of the candidates who attempted this question scored lower marks (0.0-6.5). These candidates failed to correctly explain the concept of the line spectrum based on electron transitions between energy levels. For example, one candidate wrote, "*An electron releases energy and jumps to a higher energy level.*" Others stated that *"An excited electron absorbs energy as a photon of light."* These responses indicate a lack of adequate knowledge on the concept, theories and principles of atomic transitions. The candidates were supposed to understand that an electron absorbs energy to jump from a lower energy level to a higher one. When the excited electron falls back to a lower energy level, it releases the excess energy in the form of a photon of light.

In addition, some of them lacked mathematical skills as they encountered challenges in calculating the ionization energy of the atom, evaluating the kinetic energy gained by electrons and determining the electric current flowing in a tube. For example, in responding to part (b) (i), one candidate evaluated the kinetic energy gained by the electron in the x-ray tube by applied the formula to determine energy stored in the capacitor as $E = \frac{1}{2}CV^2$ instead of $Ke = \frac{1}{2}mv^2$. Other candidates applied the $P = I^2R$ and $H = I^2Rt$ instead of $P = IV$ and $P_{Total} = P_{heat} + P_{x-rays}$ to determine the electric current flowing in a tube. Extract 16.2 represents a sample of incorrect responses to this question.

6. a) i) Line Spectrum the lines are not closed packed together in which they allow the transition of electrons between Energy-level with Small amount of Energy.

ii) Solution

Data given

Energy = 1.6eV

Energy of the first Energy level = -10.4eV

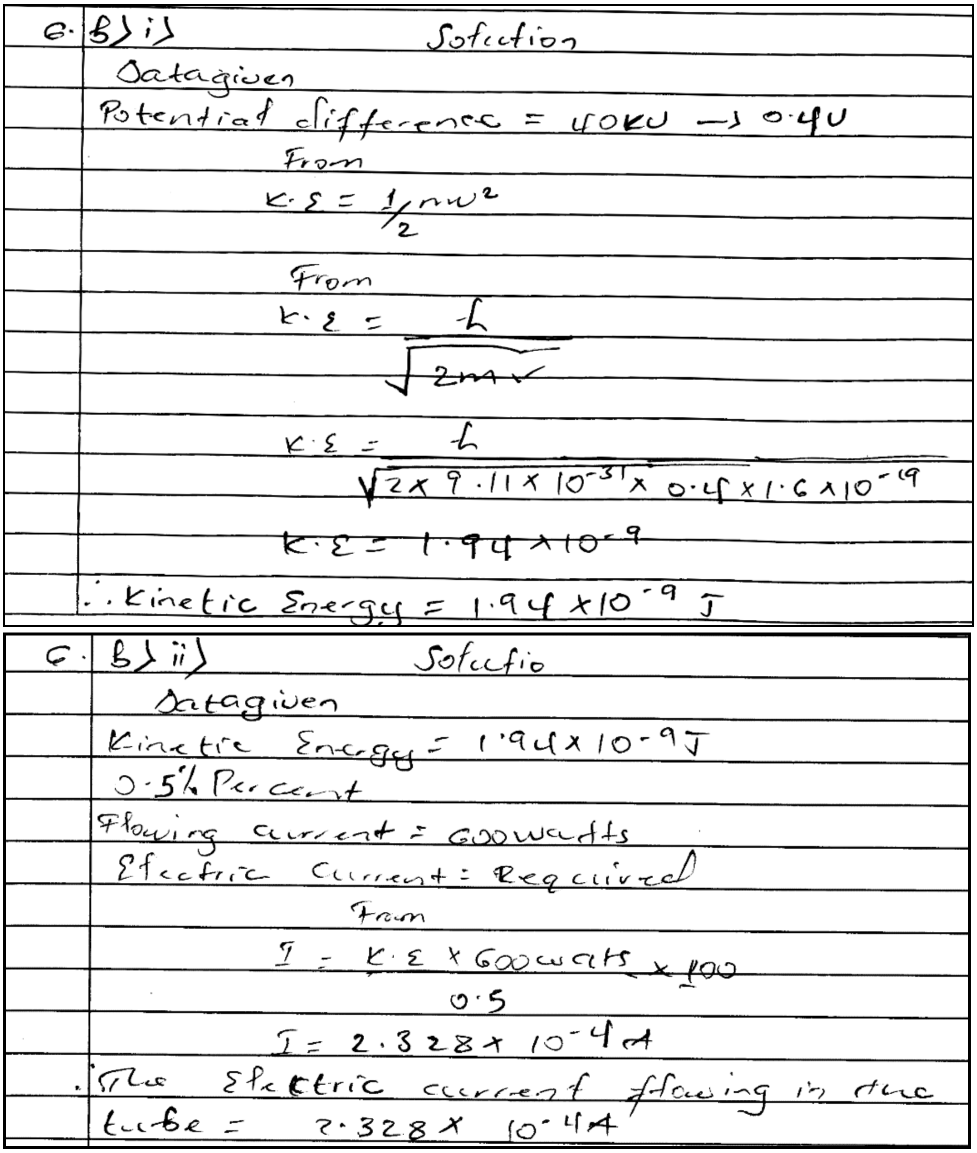
Ionization Energy = Required

from

$$I.E = \frac{1.6 \times 1.6 \times 10^{-19}}{-10.4 \times 1}$$

$I.E = -2.46 \times 10^{-20}$

∴ Ionization Energy = -2.46×10^{-20} J



6. b) i) Solution
Datagiven
Potential difference = 40KV → 0.4V
From
$K \cdot E = \frac{1}{2} mv^2$
From
$K \cdot E = \frac{h}{\sqrt{2mv}}$
$K \cdot E = \frac{h}{\sqrt{2 \times 9.11 \times 10^{-31} \times 0.4 \times 1.6 \times 10^{-19}}}$
~~$K \cdot E = 1.94 \times 10^{-9}$~~
∴ Kinetic Energy = 1.94×10^{-9} J

6. b) ii) Solution
Datagiven
Kinetic Energy = 1.94×10^{-9} J
0.5% Percent
Flowing current = 600watts
Electric Current = Required
From
$I = \frac{K \cdot E \times 600\text{watts}}{0.5} \times 100$
$I = 2.328 \times 10^{-4}$ A
∴ The Electric current flowing in the tube = 2.328×10^{-4} A

Extract 16.2: A sample of incorrect responses to question 6 of paper 2

In Extract 16.2, the candidate provided an incorrect explanation of the line spectrum based on electron transitions and applied incorrect formulas when calculating kinetic energy and ionisation energy.

4.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION 131/3 PHYSICS 3

Physics paper 3 had three alternatives of Actual Practical Papers, which are 131/3A Physics 3A, 131/3B Physics 3B and 131/3C Physics 3C. Each alternative paper consisted of three questions. Question 1 carried 20 marks while questions 2 and 3 carried 15 marks each. Question 1 was set from the topic of Mechanics, question 2 from Heat and question 3 was from Current Electricity. The candidates' response analysis for each question is as follows:

4.1 Question 1: Mechanics

This part consisted of three questions derived from the topic of Mechanics. It is a collection of questions from all alternative papers: Physics 3A, 3B and 3C. The analysis of these questions is as follows:

These questions were attempted by all 29,604 (100%) candidates, of which 22.04% scored from 0.0 to 6.5 marks, 17.01% scored from 7.0 to 11.5 marks, and 60.95% scored from 12.0 to 20.0 marks. The analysis reveals that the candidates' general performance in these questions was good, as 77.96% of the candidates scored 7.0 marks or above. Figure 18 summarizes candidates' performance.

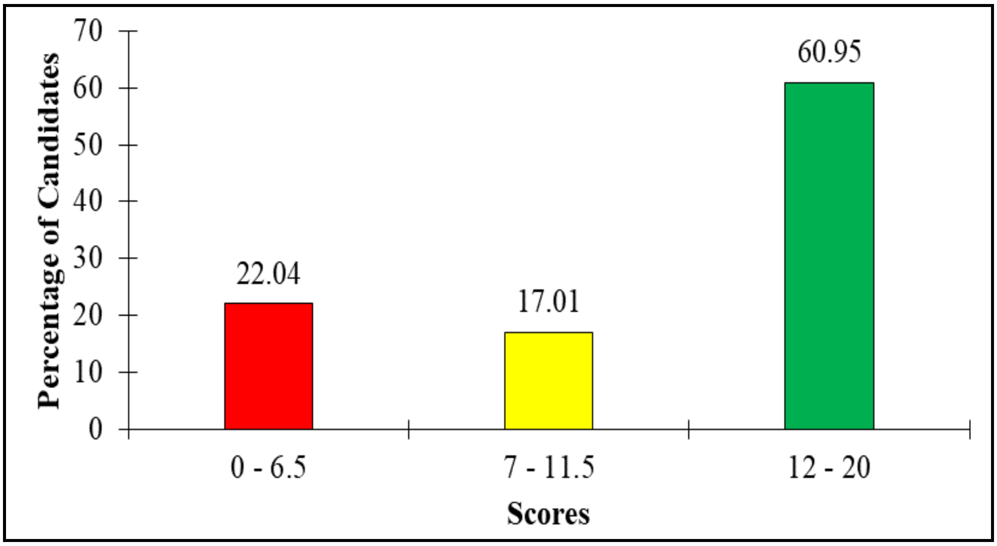


Figure 18: *Candidates' performance in question 1 of paper 3*

4.1.1 Physics 3A

The candidates were provided with the plastic ruler (30 cm), metre rule, retort stand with its accessories, mass, **M**, thread, masking tape, micro meter screw gauge and weighing balance. They were required to proceed as follows:

(a) By using cork pads on the retort stand, clamp the given 30 cm ruler so that its flat side is horizontal and the protruding length, $l = 27$cm.Using a masking tape, fix the thread with length L = 110 cm at the end of the ruler and the mass, **M** hanging at the bottom as shown in Diagram 9.

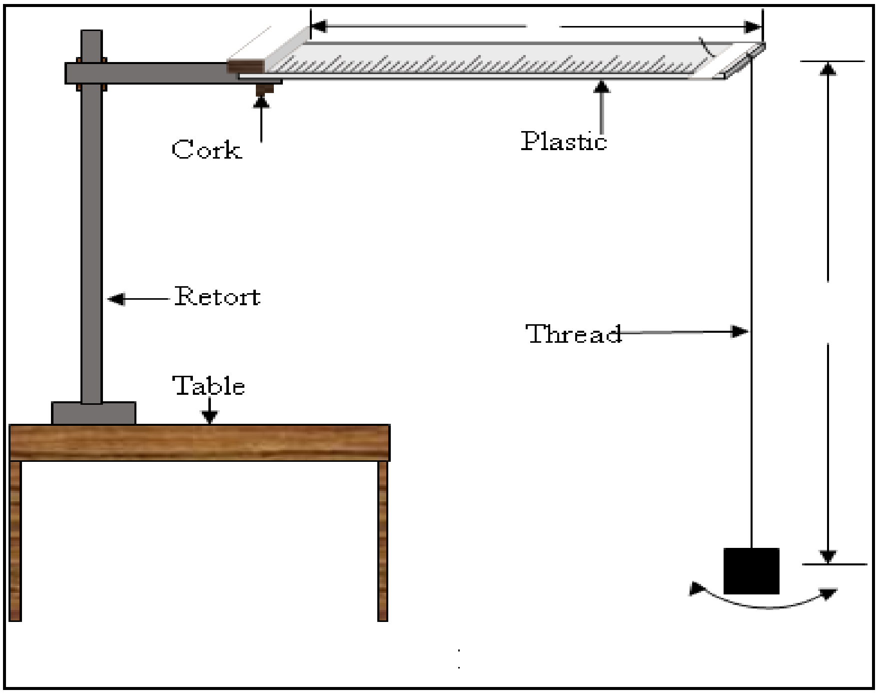


Diagram 9

(b) Displace the mass, **M** a small distance from its equilibrium and release it so that it executes oscillations in a plane parallel to the ruler. Measure and record the time, t_{10} for ten oscillations and hence compute its periodic time T.

(c) Repeat the procedures in 1 (b) when the lengths of the thread is L= 90 cm, 70 cm ,50 cm and 30 cm

Questions

(i) Tabulate your results including the values of L (m), t_{10} (s), T(s) and $T^2(s^2)$

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

(iii) If T and L are related by: $T^2 = 4.03L + T_c^2$, what is the value of, T_c^2 ?

(iv) State the physical meaning of, T_c .

(v) Measure and record the mass of the solid, **M** and the breadth, b and thickness, t of the ruler.

(vi) Compare the Young's modulus E of the plastic ruler in SI, given that $E=\frac{16\pi^2 M}{bT_c}\left(\frac{l}{t}\right)^3$.

Analysis reveals that 60.95% of the candidates scored from 12.0 to 20.0. These candidates demonstrated the ability to set up an experiment and collect data, present data on the length (*L*) of the thread and time (*t*) for 10 oscillations period as per the given procedure. They further apply mathematical skills and provide correct responses to all items. This suggests that the candidates adhered to the experimental procedures, including setting up the experiment, collecting and analysing experimental data. Furthermore, they displayed skill in plotting graphs. Using appropriate scales for both the vertical and horizontal axes, they plotted variable T^2 (s^2) against L (cm). In addition to the correct scales and axes, candidates included all essential graph features, such as the title (with units), labelled axes, plotted points with a best-fit line, and slope indication.

Moreover, they manipulated the formula $E=\frac{16\pi^2 M}{bT_c}\left(\frac{l}{t}\right)^3$ to compute Young's modulus (*E*) of a plastic ruler with correct units. Also, they correctly determined the value T_c^2 using equation $T^2 = 4.03L + T_c^2$ and stated its physical meaning. Extract 17.1 shows the correct responses from one of the candidates.

1(i) Table of Results:

L (m)	t_{40} (sec)	T (sec)	T^2 (sec^2)
1·1	20·80	2·08	4·34
0·9	18·72	1·87	3·50
0·7	16·76	1·68	2·81
0·5	14·20	1·42	2·02
0·3	11·00	1·10	1·21.

(ii) A graph of T^2 (s^2) against L (m).

(ii) From the Relation

$T^2 = 4{\cdot}03L + T_c^2$,

Relate with the graph.

$T^2 = 4{\cdot}03L + T_c^2$.

$y = m\ x + c$.

So, T^2 – intercept $= T_c^2$.

T^2 – intercept $= 0{\cdot}067 sec^2$.

Hence; $T^2_c = 0{\cdot}067 sec^2$.

1.

(iv) physical meaning of T_c^2 is the periodic time of oscillation of the plastic ruler sets to oscillates when the L = 0 cm or mass removed.

T_c is periodic time of oscillating plastic ruler.

(V) To Measure and Record

- Mass of solid M.

M = 100g.

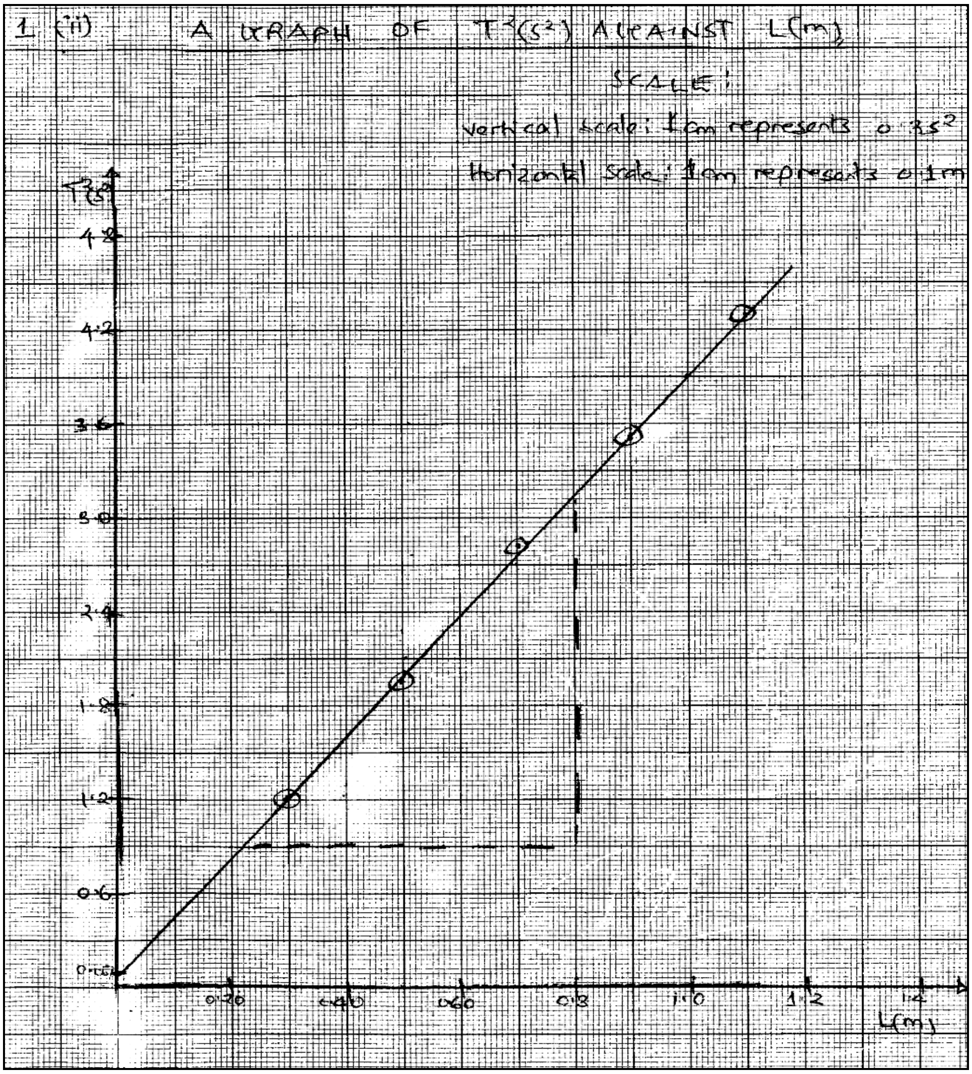
- Breadth b, of Ruler.

b = 3.1 cm.
b = 0.031m

- thickness t.

t = 0.24cm
t = 2.4×10^{-3}m

1	(vi)
	To compute. young's modulus.
	From: $E = \frac{16\pi^2 M}{bT_c}\left(\frac{l}{t}\right)^3$
	$T_c = \sqrt{T^2}$
	$T_c = \sqrt{T^2 - \text{intercept}}$
	$T_c = \sqrt{0.0675ec^2} \Rightarrow 0.259\,sec$
	$b = 0.031m$ $l = 27cm$ $t = 0.24cm$ $M = 0.1Kg$
	Hence:
	$E = \frac{16\pi^2 \times 0.1Kg}{0.031m \times 0.259sec} \times \left(\frac{0.27m}{}\right)^3$
	$E = 1964.79609 \times \left(\frac{0.27m}{2.4 \times 10^{-3}m}\right)^3$ (Kgm/sec)
	$E = 2797531933$
	$E = 2.798 \times 10^9\,N/m.$
	youngs modulus of plastic ruler is $2.798 \times 10^9\,N/m.$



Extract 17.1: A sample of correct responses to question 1 of paper 3A

In Extract 17.1, the candidate collected the correct data in the table of results and used it to plot the graph of $T^2 (s^2)$ against $L(m)$. Then, applied the given equations to obtain the value of T_c and Young's modulus (E) of the ruler.

The analysis of statistical data shows that 22.04% of the candidates scored between 0.0 and 6.5 marks. These candidates failed to demonstrate mastery of basic experimental skills related to the topic of mechanics. Other candidates collected incorrect data, which led to incorrect presentation and analysis of their experimental results. For example, some candidates neglected to include proper units for the measured experimental variables, while others failed to include important graph features such as the title (with units), labelled axes (both vertical and horizontal), slope indication, and the best-fit line. Additionally, some candidates failed to transfer the collected data points to the graph correctly. Some of these candidates failed to set appropriate scales (vertical and horizontal). For instance, one of the candidates wrote: "*2 cm represents 10 cm*". Another wrote "*1 cm: 2.7cm*". The other candidate wrote: "$1\,\text{cm} \equiv 2.7\,\text{cm}$. These candidates were supposed to write the scale as 1 cm represents 5 cm, or 1 cm represents 2.7 cm, or 1 cm represents 0.5 s".

Moreover, most of the candidates in this category failed to determine the value, and lacked the mathematical skills to determine the value of T_c^2 using equation $T^2 = 4.03L + T_c^2$. They failed to state the physical meaning of T_c^2. Most of them provided irrelevant responses. For instance, one of the candidates wrote the physical meaning of T_c^2 as $\left(\frac{l}{g}\right)^2$, which is incorrect. The candidate was supposed to recognise that when the length of the thread (L) is zero, it implies that:

$T^2 = 4.03 \times 0 + T_c^2$. Meaning that $T^2 = T_c^2$. In this condition, only the plastic ruler will be oscillating. Therefore, value could be read from the graph as the intercept of the axis, and its physical meaning is the period of vertical oscillation of the clamped ruler.

They also failed to manipulate the equation $E = \frac{16\pi^2 M}{bT_c}\left(\frac{l}{t}\right)^3$ to obtain the value of Young's modulus. Extract 17.2 is a sample of a candidates' candidate's incorrect responses to question 1 of paper 3A.

1 (ii) TABLE OF RESULTS

L(cm)	t_{10} (s)	T(s)	T^2 (s^2)
110	6.92	0.692	0.478
90	5.12	0.512	0.262
70	3.51	0.351	0.123
50	2.12	0.212	0.045
30	0.98	0.098	0.009

(ii) The graph of T^2 (s^2) against L cm

but

$T^2 = 4.03 L + T_0^2$

From the graph

A (70, 0.15)

B (110, 0.36)

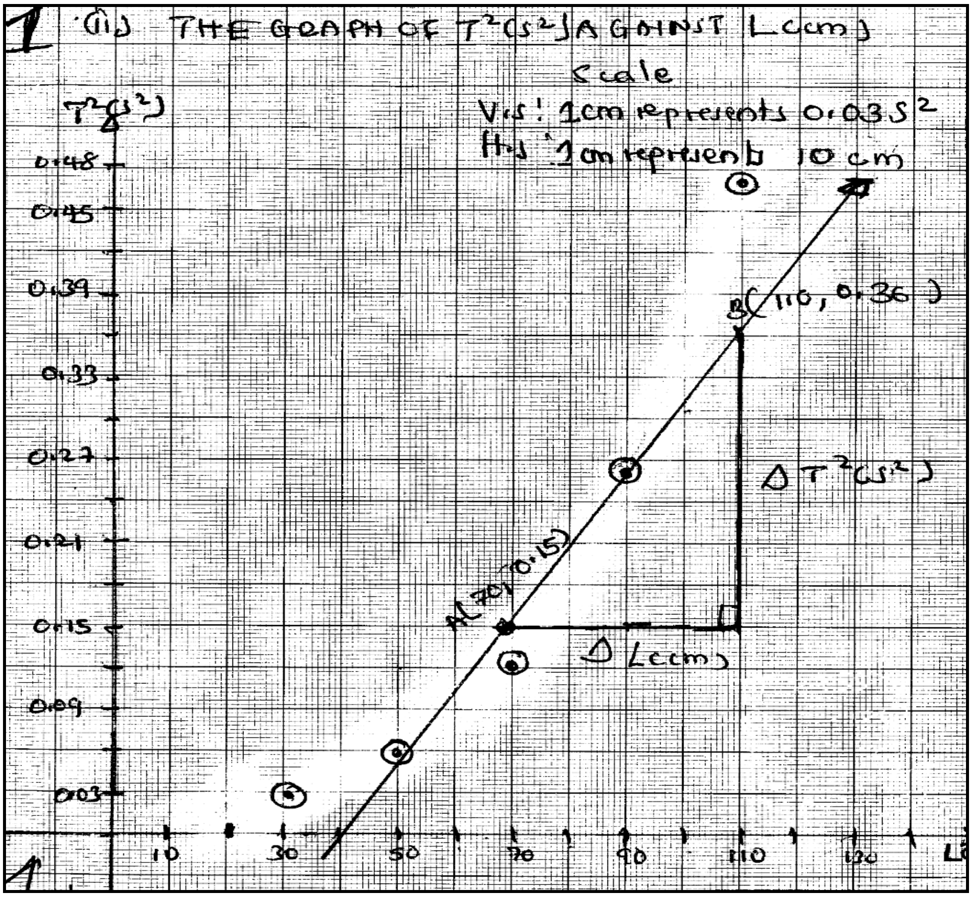
$$Slope = \frac{\Delta T^2 (s^2)}{\Delta L (cm)}$$

$$M = \frac{(0.36 - 0.15)\ s^2}{(110 - 70)\ cm^2}$$

$Slope = 5.25 \times 10^{-3}\ s^2 cm^{-1}$

1	(iii) From $T^2 = 4.03L + T_c^2$ $y = m\,x + c$ $T_c^2 = C$ - intercept C = L-intercept. $C = 40\,cm$ Value of $T_c^2 = 40\,cm$ $T_c = \sqrt{40}\,cm$ $T_c = 6.325\,cm$ ∴ Value of T_c^2 is 40 cm
	(iv) The physical meaning of T_c is the intercept which is L-intercept which mean the length which the mass will be suspended from the floor to fixed point
	(v) Mass $M = 100\,g$ Breadth of solid (b) $= 2.5\times10^{-2}\,m^2$ Thickness (t) of rule $= 5.8\times10^{-3}\,m$.

1	(vi) From $E = \frac{16\pi^2 M}{bT_c}\left(\frac{L}{t}\right)^3$ $T_c = \sqrt{40}\,cm$ $T_c = 6.325\,cm$ $T_c = 0.06325\,m$ $L = 27\,cm = 0.27\,m$ $t = 5.8\times10^{-3}\,m$ $b = 2.5\times10^{-2}\,m$ $M = 100\,g = 0.1\,kg$ $E = ?$ From $E = \frac{16(3.14)^2\times0.1}{2.5\times10^{-2}\times0.06325}\left(\frac{0.27}{5.8\times10^{-3}}\right)^3$ $E = \frac{16(3.14)^2\times0.1\times(0.27)^3}{2.5\times10^{-2}\times0.06325\times(5.8\times10^{-3})^3}$ $E = 1.01\times10^9\,N/m^2$ ∴ Young modulus of the plastic ruler is $E = 1.01\times10^9\,N/m^2$



Extract 17.2: A sample of incorrect responses to question 1 of paper 3A

In Extract 17.2, the candidate collected incorrect data, plotted an incorrect graph and failed to indicate T^2 intercept, which would help to obtain the value of T_c and Young's modulus of the plastic ruler.

4.1.2 Physics 3B

The candidates were provided with the statement that Rectangular wooden bars are used for making floors of pedestrian bridges. They were required to investigate the suitability of the wooden bar provided. They were required to proceed as follows:

(a) Locate the centre of gravity G of the given bar.

(b) Firmly clamp the metre rule at its centre on the retort stand so that its flat side is vertical. Note that the retort stand has to be clamped on the bench.

(c) Pass the bar through the two loops made on the ends of the two lengths of cotton threads.

(d) Arrange the threads so that they are at a distance of d = 90cm apart. Adjust the length of the threads to 100 cm.

(e) Tie off the loose ends of the threads on the clamped metre rule. Make sure the threads are vertical and parallel as shown in Diagram 7.

(f) Give the bar a small angular displacement about a vertical axis.

(g) Record the time, t(s) by timing 10 oscillations and hence determine the periodic time T(s).

(h) Repeat procedures (d) to (g) using, d=70 cm, 50 cm, 30 cm and 10 cm.

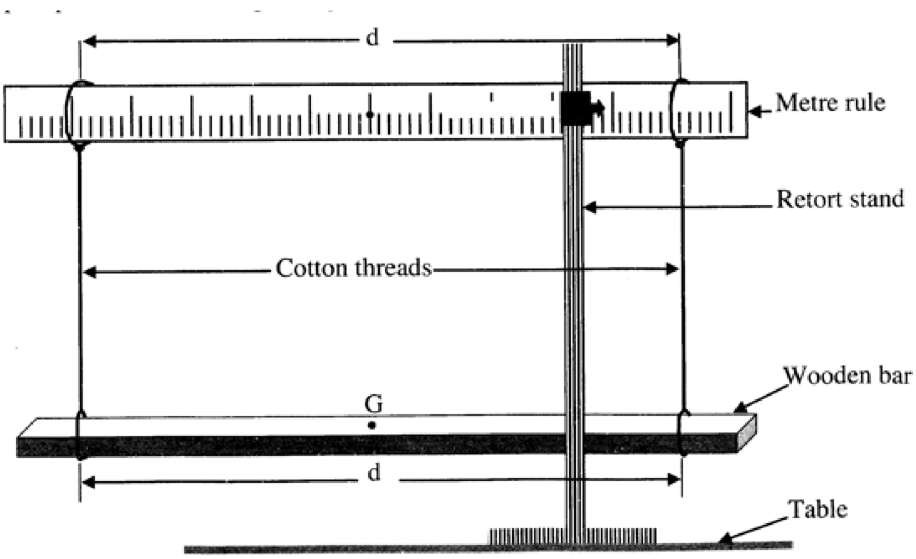


Diagram 10

Questions:

(i) *Prepare a table of results including* $\frac{1}{d}\left(m^{-1}\right)$, *time, t (s) of 10 oscillations and period of oscillation, T (s).*

(ii) *Plot a graph of T(s) against* $\frac{1}{d}\left(m^{-1}\right)$.

(iii) *Determine the slope of the graph.*

(iv) *Using the slope obtained in 1 (iii), evaluate the mass (kg) of the wooden bar given that d and T are related by the equation:* $T = \frac{2.81}{d}\sqrt{\frac{1}{mg}}$ *, where, m is the mass of the bar and g is the acceleration due to gravity.*

(v) *What will happen to the oscillation of the bar if, d = 0?*

(vi) *If the floor of the bridge is* $50\,\text{m}\times 2\,\text{m}$ *and the sample supporting pillar has a breaking stress of 12* Nm^{-2}*, estimate the least number of pillars needed to erect the bridge.*

The analysis of data reveals that 77.96% of the candidates scored higher marks (12 – 20). These candidates had adequate knowledge to perform the experiment to determine Young's modulus of a wooden bar. They collected and tabulated correctly the table of results and used proper procedures in plotting and interpreting the graph. Furthermore, most of these candidates used the slope of the graph, which led them to evaluate the mass of a wooden. This is to say that the used mathematical skills to relate to the equation $T = \frac{2.81}{d}\sqrt{\frac{1}{mg}}$ and the results from the graph of T(s) against $\frac{1}{d}\left(m^{-1}\right)$ to estimate the number of pillars needed to erect the bridge.

Therefore, the candidates were able to determine correctly the number of pillars needed to erect the bridge. They understood that when d = 0, the bar will rotate instead of oscillating. Extract 18.1 is a sample of a candidate's correct responses.

1. (i). TABLE OF RESULTS

d(cm)	$\frac{1}{d}$ (cm^{-1})	time, t(s) (10 oscillations)	T (s)	$\frac{1}{d}$ (m^{-1})
90	0.0111	12.60	1.26	1.11
70	0.0143	16.20	1.62	1.43
50	0.0200	22.70	2.27	2.00
30	0.0333	37.80	3.78	3.33
10	0.1000	113.40	11.34	10.0

(iii). Slope of the graph

$$\text{Slope} = \frac{\Delta T\ (s)}{\Delta \frac{1}{d} (m^{-1})}$$

From graph

A (4, 4.56)

B (8, 9.12)

$$\text{Slope, } m = \frac{(9.12 - 4.56)\,s}{(8 - 4)\,m^{-1}}$$

$$= 1.14\,sm$$

∴ The slope of the graph is 1.14ms

1 (iv). To evaluate the mass, M(kg) of the wooden bar from

$$T = \frac{2.81}{d}\sqrt{\frac{1}{Mg}}$$

$$T = \left(2.81\sqrt{\frac{1}{Mg}}\right)\frac{1}{d}$$

Compare with $y = mx + c$

$$\text{Slope, } M_0 = 2.81\sqrt{\frac{1}{Mg}}$$

$$M_0 = 2.81\sqrt{\frac{1}{Mg}}$$

$$M_0^2 = (2.81)^2 \frac{1}{Mg}$$

$$M = \frac{(2.81)^2}{M_0^2\, g}$$

But

$$g = 981\ cms^{-2}$$

$$g = 9.81\ ms^{-2}$$

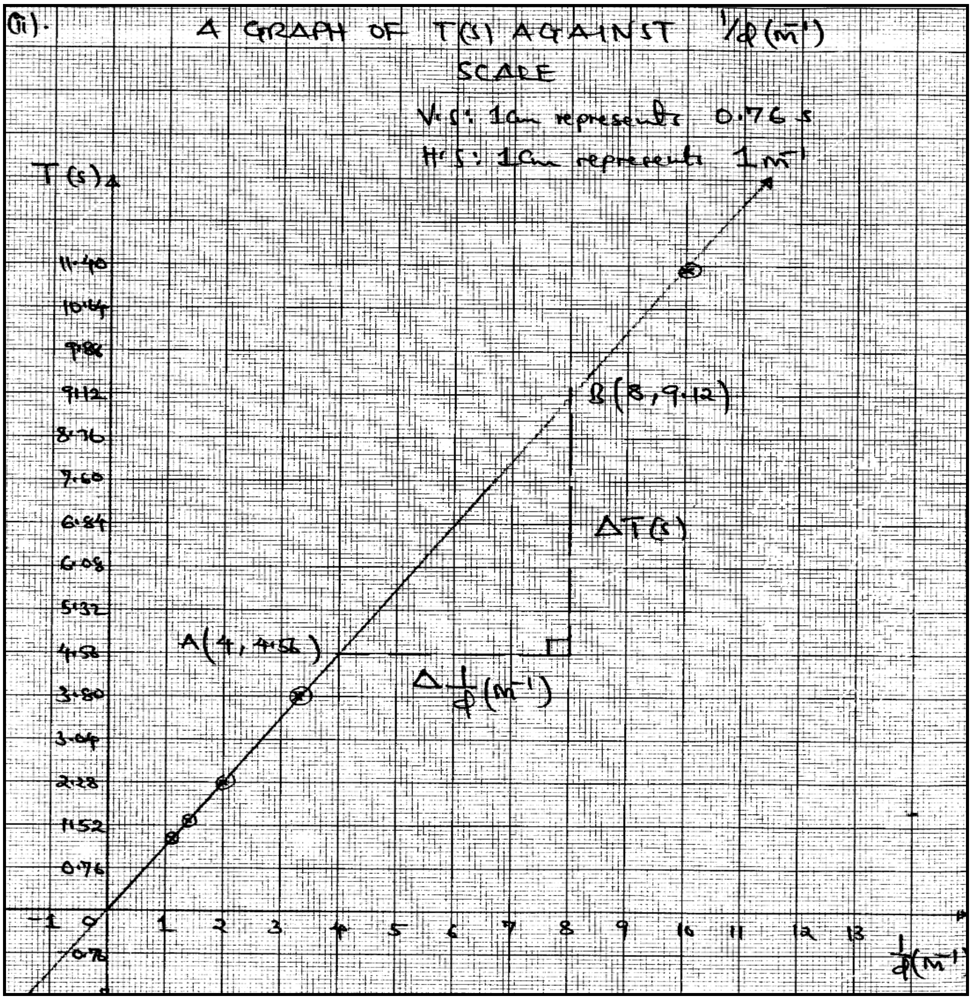
also

$$M_0 = \text{slope} = 1.14ms$$

$$M = \frac{(2.81)^2}{(1.14ms)^2 \times 9.81ms^{-2}}$$

$$M = \frac{7.8961}{12.749076}$$

1	(iv).
	$M = \frac{7.9}{12.7}$
	$M = 0.622kg$
	∴ The mass, M of the bar is 0.622kg.
1	(v). when $d = 0$
	$T = \frac{2.81}{d}\sqrt{\frac{1}{mg}}$
	$T = \frac{2.81}{0}\sqrt{\frac{1}{mg}}$
	$T = \infty\sqrt{\frac{1}{mg}}$
	$T = \infty$
	∴ When $d=0$, the period of oscillation (T(s)) will be infinity hence the time taken for a bar to oscillate will increase rapidly up to infinity, hence the bar will rotate.



Extract 18.1: A sample of correct responses to question 1 of paper 3B

In Extract 18.1, the candidate tabulated the correct data in the table of results and plotted the graph with the required aspects. The candidate applied numerical skills to deduce the necessary equations for analysing the values of mass *m* and the number of pillars needed for a bridge.

Statistical analysis shows that 22.04% of the candidates scored low marks (0.0–6.5). These candidates showed several weaknesses. Such weakness includes: Lack of knowledge of using a stopwatch for recording the time t (s) for 10 oscillations. They incorrectly determined the periodic time T and failed to present the data graphically. Moreover, most of these candidates failed to adhere to procedures for plotting scientific graphs. They failed to include the title, the axes, the scales used and the slope indication in the graph. Furthermore, some of the candidates failed to analyse the information from the graph and deduce the equations which could lead to the correct value of the mass of a wooden block and the number of pillars to erect the bridge. Most of them provided incorrect or irrelevant responses. For instance, one of them responded in part (v) by writing: *"if the separation distance become zero (d = 0) then the wooden bar oscillates at very high speed*. This was an incorrect response. They were supposed to understand that when the separation distance (d) is zero, the bar will not oscillate, but it will rotate. Extract 18.2 is an example of one of the candidates' incorrect responses.

1. Table of Result:

d (cm)	t (s)	T (s)	1/d
90	11·3	1·2	0·011
70	15·00	0·6	0·d4
50	20·37	0·4	0·02
30	32·53	0·3	0·03
10	93·85	0·1	0·1

from the Graph slope

$$\text{slope } \Delta m = \left(\frac{\Delta T s}{\Delta 1/d}\right)$$

$$\text{slope } \Delta m = \left(\frac{\Delta T s}{\Delta 1/d}\right)$$

slope $\Delta m = (0 \cdot 6$

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

$$\Delta m = \left(\frac{0\cdot 3 - 0\cdot 6}{0\cdot 03 - 0\cdot 2}\right) = 1\cdot 42 m/^2$$

$\Delta m = 1\cdot 42$ m/ᶜ

slope of the graph = 1·42

1

from the slope (i) 1.42 m/s²

Relation

$$T = \frac{2.81}{d}\sqrt{\frac{1}{mg}}$$

but Required to find the mass of wooden bar

$$T = \frac{2.81}{d} \cdot \sqrt{1/ms}$$

$$T = \frac{2.81}{d} = \sqrt{1/mg}$$

$$T = \frac{2.81}{d} = \sqrt{1/ms}$$

Make m the subject

$$Td = 2.81\left(\sqrt{1/mg}\right)^{1/2}$$

$$Td^2 = 2.81 \; 1/mg$$

$$M = \sqrt{Td/2.81} \times g$$

$$M = Td/2.81 \times g$$

$$T = \sqrt{2.8961 \; 1/mg} \; 1/d$$

$$w = m \; L \; \gamma$$

(v) M = √(Td/9.81) × 9

M = (Td/9.8) × 9.8

M = (1.2 × 100 / 9.81) × 9.81²

M = (1.2 × 100 / 9.81) × 9.81

M = (1.2² × 100 / 9.81) × 9.81

M = 453.6 gram

but 1 kg = 1000 gram

(v) 1 ox = 453.6

It will be 0.4536 kg

The mass of the bar will be 0.4536 kg

(vi) There will be no oscillation due to gravity ~~for~~ will be oscillation

Extract 18.2: A sample of incorrect responses to question 1 of paper 3B

In Extract 18.2, the candidate failed to collect the time t for 10 oscillations in seconds. The candidate also failed to manipulate the given equations with the linear equation to obtain the values of mass, m and number of pillars.

4.1.3 Physics 3C

The candidates were provided with wire **W** and they were tasked to perform an experiment to determine the shear modulus η of the wire given. They were required to proceed as follows:

(a) Arrange the apparatus as shown in Diagram 11

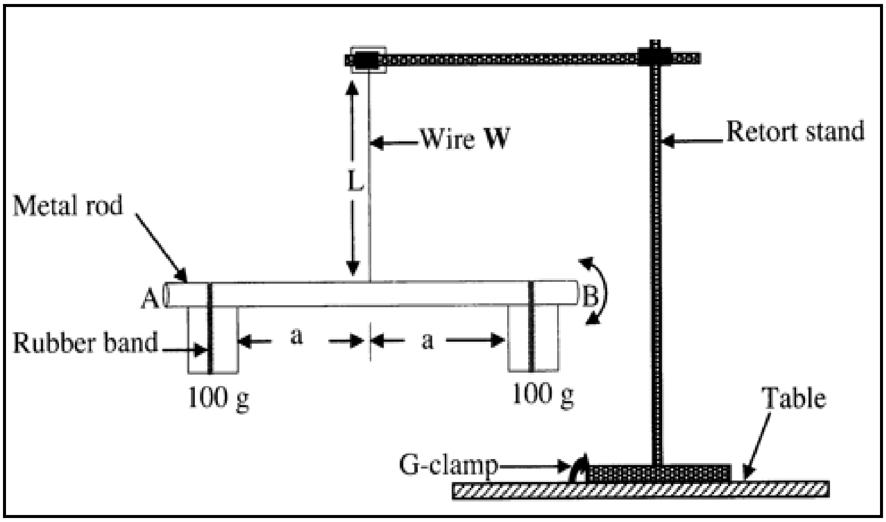


Diagram 11

(b) Mount a metal rod AB at its centre point, then adjust the length, L of wire, **W** about 50 cm so that when the metal rod AB is twisted through A at a small angle in the horizontal plane about its centre point, it executes oscillations.

(c) Fasten the two masses firmly on the rod by using a rubber band, at equal distance in centimetres measured from the suspended wire, **W** to the mid-point of each mass

(d) Twist the metal rod and record the time, t for 10 oscillations of the rod when the distance from the wire to the mass, a=3 cm. Hence obtain its periodic time T

(e) Repeat the procedure outlined in 1 (d) for the values of a = 5 cm, 7 cm, 9 cm and 11 cm.

Questions:

(i) Tabulate you results, including the values of t, T, T^2, a, a^2 and $10a^2$.

*(ii) Read and record the diameter of the wire **W** hence find its radius.*

(iii) Plot a graph of $10a^2$ against T^2.

(iv) Determine the slope of your graph.

(v) *Evaluate the shear modulus* η *of the wire* ***W****, from the equation,*

$$\eta = \frac{80a^2 \pi L}{r^4 T^2}$$

The candidates who scored high marks (12 – 20) in this question demonstrated the necessary skills for experimenting on Mechanics. Their responses indicate that these candidates had sufficient knowledge of the mechanical properties of matter (elasticity of a wire). They correctly collected data for distance and time for 10 oscillations of the rod, plotted a graph of $10a^2$ against T^2. Furthermore, the candidates applied mathematical skills to calculate the correct value of slope from the graph plotted. They managed to relate the linear equation to obtain the value of the shear modulus. Extract 19.1 is a sample of correct responses to this question from one of the candidates.

iv $\quad \text{slope} = \dfrac{(986.10 - 692)\ \text{cm}^2}{(607.38 - 418)\ \text{s}^2}$

$= 1.56\ \text{cm}^2/\text{s}^2$

$= 1.56 \times 10^{-2}\ \text{cm}^2/\text{s}^2$

v $\quad \text{slope} = \dfrac{\eta \times r^4}{8 \times \pi \times L}$

$\eta = \dfrac{\text{slope} \times 8\pi L}{r^4}$

$r = d/2$

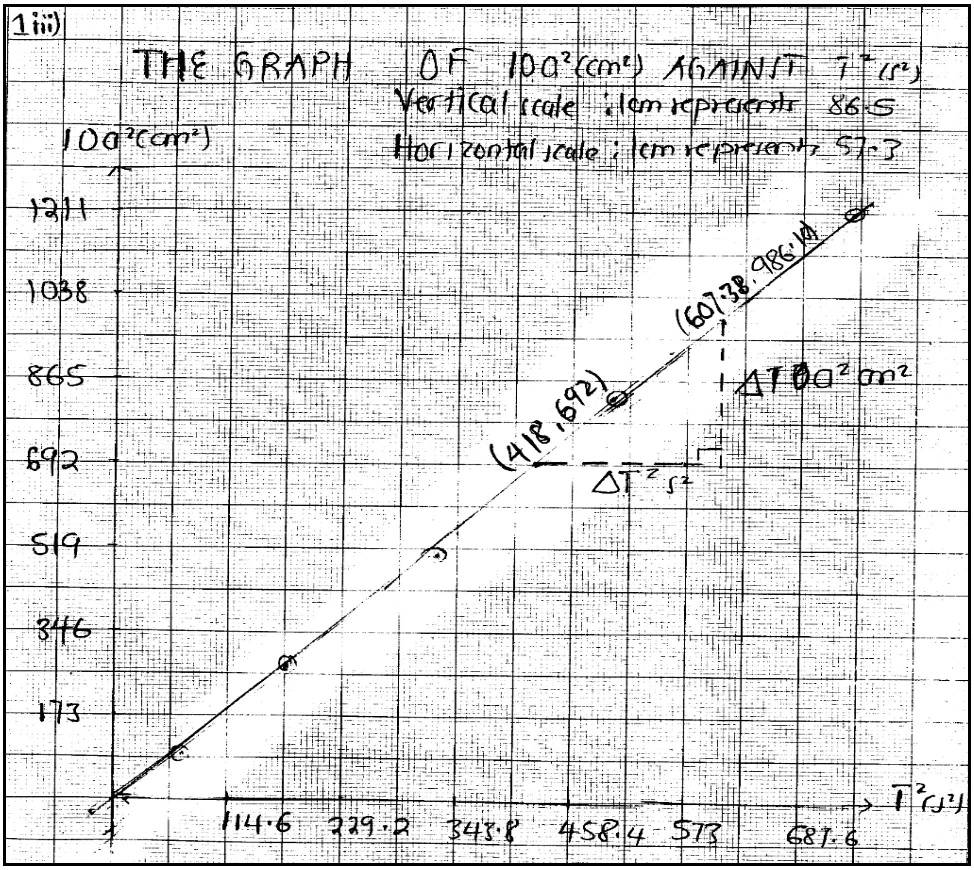
$= \dfrac{0.320\ \text{mm}}{2}$

$0.016\ \text{mm}$

$= 0.016 \times 10^{-3}$

$= \dfrac{1.56 \times 10^{-2}\ \text{m}^2\text{s}^{-2} \times 8 \times 3.14 \times 0.5}{(0.016 \times 10^{-3})^4}$

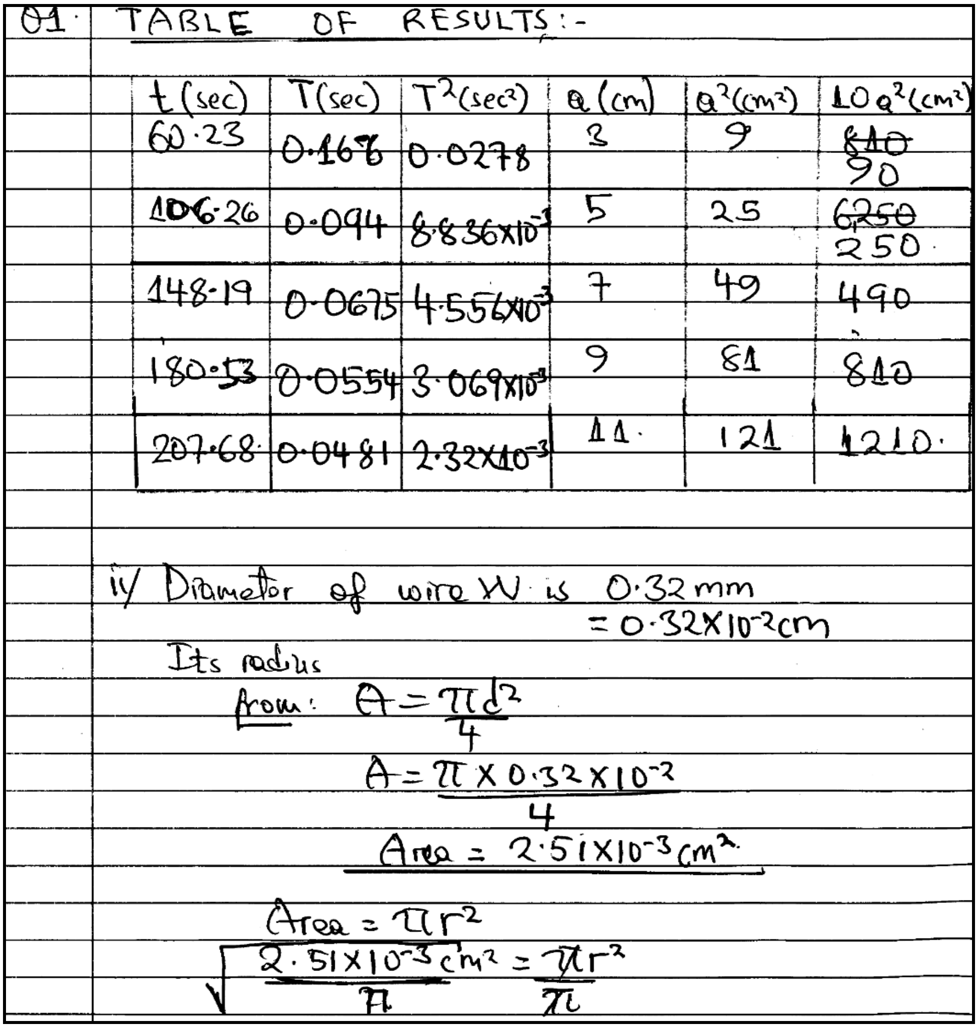
$= 2.98 \times 10^{18}\ \text{N/m}^2$.



Extract 19.1: A sample of correct responses to question 1 of paper 3C

In Extract 19.1, the candidate presented the correct data in tabular form and plotted the correct graph containing all aspects. The candidate also deduced the value of the slope and used it to determine the value of the shear modulus of the wire.

On the other hand, the candidates (22.04%) scored lower marks (0.0–6.5). Some candidates encountered difficulties in obtaining accurate data due to improper apparatus setup and incorrect measurement readings. Some of them inaccurately measured the diameter of the wire because they lacked skills in measurement. Moreover, these candidates demonstrated weakness in plotting the graph since they lacked some important aspects of the graph, such as well well-stated title of the graph, a reasonable scale, labelled axes, slope indication and the best fit line. They also lacked the mathematical skills necessary to calculate the shear modulus of the wire W. They provided the incorrect value of the slope and the radius of a wire, which could be used in other procedures for evaluating the shear modulus of the wire. For instance, one candidate derived an incorrect equation for the experiment as $10a^2 = \frac{\eta r^4}{70\pi L} T^2$ and the other wrote $80a^2 = \pi r^4 T^2$ instead of $\eta = \text{slope} \times \frac{8\pi L}{r^4}$. Extract 19.2 is a sample of a candidate's incorrect responses to the question.



01. TABLE OF RESULTS:-

t (sec)	T (sec)	T^2 (sec²)	a (cm)	a^2 (cm²)	$10a^2$ (cm²)
60.23	0.166	0.0278	3	9	~~810~~ 90
106.26	0.094	8.836×10^{-3}	5	25	~~6250~~ 250
148.19	0.0675	4.556×10^{-3}	7	49	490
180.53	0.0554	3.069×10^{-3}	9	81	810
207.68	0.0481	2.32×10^{-3}	11	121	1210

ii/ Diameter of wire W is 0.32 mm
$= 0.32\times10^{-2}$ cm

Its radius

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

$A = \frac{\pi \times 0.32\times10^{-2}}{4}$

Area $= 2.51\times10^{-3}$ cm²

Area $= \pi r^2$

$\sqrt{\frac{2.51\times10^{-3}\,\text{cm}^2}{\pi}} = \frac{\pi r^2}{\pi}$

Qu 01. (ii) $\sqrt{8 \times 10^{-4}} = r$

$r = 0.028$

∴ Radius of wire W is 0.028cm

or

Radius of wire W is 2.8×10^{-4}mm.

(iv) Slope of the graph:-

$\text{slope} = \frac{\Delta 10a^2 (cm^2)}{\Delta T^2 (cm^2)}$

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(810 - 90) cm^2}{(3.069 \times 10^{-3} - 0.0278) sec^2}$

Slope (m) = 720 cm/sec.

Slope of the graph = 720 cm/sec.

(v) from: $\eta = \frac{80a^2 \pi L}{r^4 T^2}$

~~a = 50~~ r = 0.028cm or 2.8×10^{-4}m

$\eta = \frac{80a^2 \pi L}{r^4 T^2}$

Qn 01. (i) $\eta = \frac{80a^2\pi L}{r^4 T^2}$

given:

r = 0.028 cm

L = 50cm

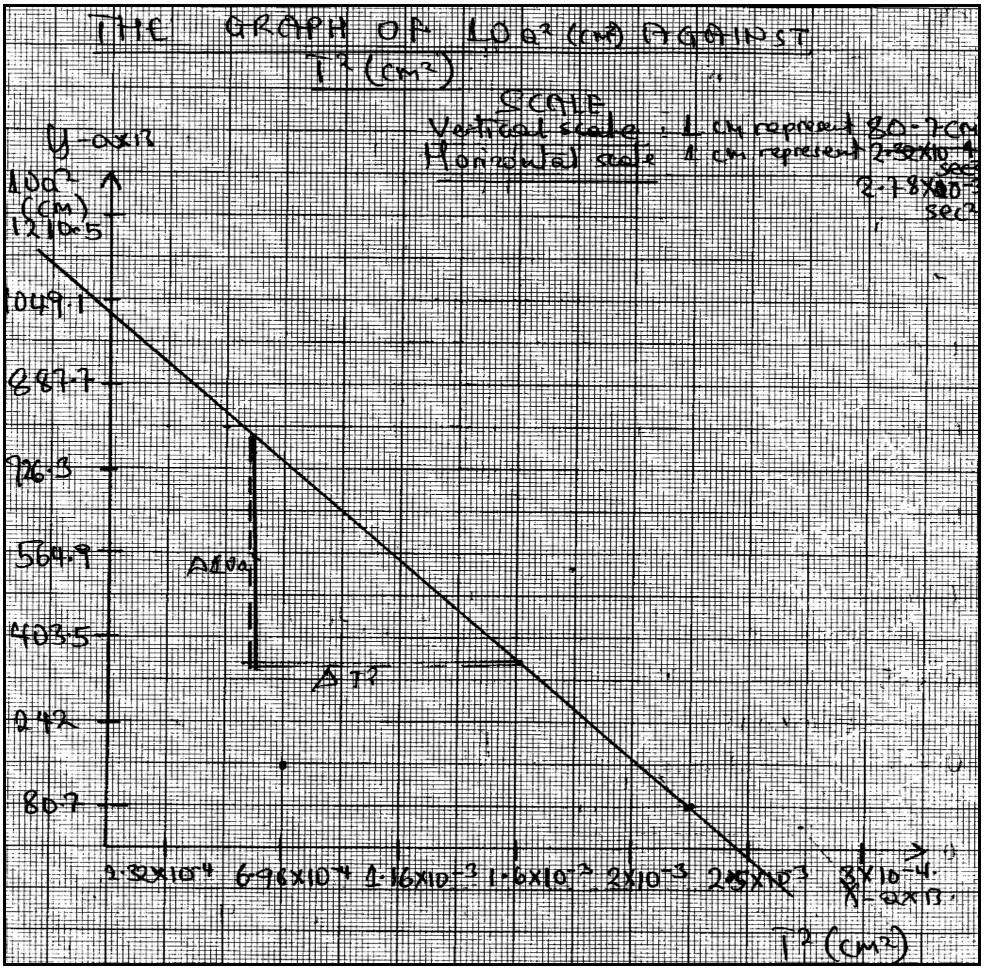
$$\eta = \frac{80a^2\pi L}{r^4T^2}$$

$$\eta = \frac{80a^2}{T^2}\left(\frac{\pi L}{r^4}\right)$$

$$\eta = \frac{80\times(5)^2}{(0.0278)^2} \times \frac{\pi\times 50}{(0.028)^4}$$

$$\eta = 6.61345\times10^{-14}$$

Shear modulus = 6.61345×10^{-14}.



Extract 19.2: A sample of an incorrect response to question 1 of paper 3C

In Extract 19.2, the candidates provided a wrong table of values, and consequently failed to draw the graphs of $10a^2$ against T^2.

4.2 Question 2: Heat

This part contained three questions on the topic of Heat. It is a collection of questions from three alternative papers, Physics 3A, 3B and 3C.

The question was attempted by 29,604 (100%) candidates, and their scores were distributed as follows: 15.32% scored between 0.0 and 5.0 marks; 33.59% scored between 5.5 and 8.5 marks; and 51.09% scored between 9.0 and 15.0 marks. This indicates generally good performance, as 84.68% of candidates scored between 5.5 and 15.0 marks. Figure 12 illustrates the overall performance on this question.

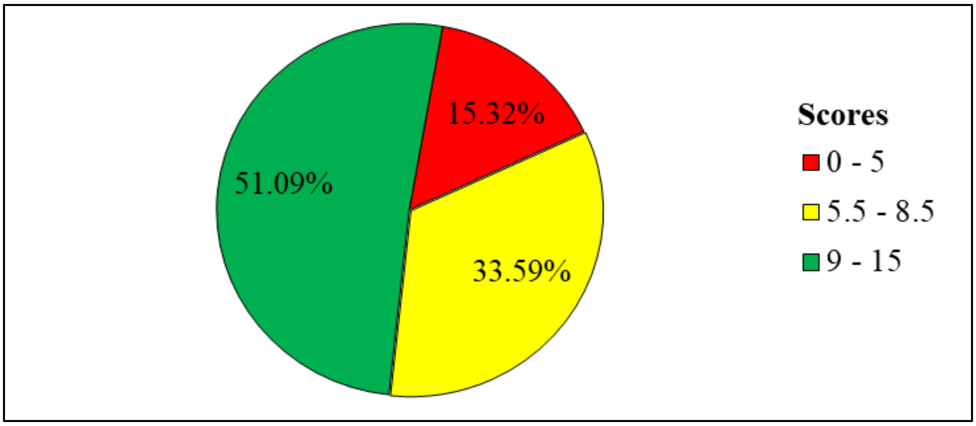


Figure 19: *Candidates' performance in question 2 of paper 3*

4.2.1 Physics 3A

The candidates were required to investigate the cooling behaviour of a copper calorimeter under different conditions. They were required to proceed as follows:

(a) Half-filled the calorimeter with hot water of about 90^0C. Cover the calorimeter with a lid and insert the calorimeter through the opening so as to read the temperature of water.

(b) Starting with temperature of 80^0C, read and record the temperature of water at the interval of one minute for 10 minutes while stirring and fanning using cardboard.

(c) Wet the given cloth normal tap water.

(d) Repeat the procedures in 2 (a) and (b), but in this case wrap the calorimeter with a wet cloth just before starting recording the temperature.

Questions

(i) Tabulate your results obtained in 2 (b) and (d).

(ii) Plot the cooling curves for the results in 2 (b) and (d) on the same plane of axes.

(iii) Determine the temperature of water at 7^{th} minute for both cooling curves.

(iv) In which of the two settings did water cools faster? Justify the answer by giving two points.

The analysis of candidates' performance indicates that 51.09% of the candidates who scored higher marks (9.0–15.0) in this question had enough knowledge of performing experiments related to heat. The analysis indicates that these candidates had sufficient knowledge of Newton's law of cooling. Their responses illustrated their skills in setting up, collecting and presenting data and plotting the graph of the cooling curves on the same plane axis. Candidates were able to show the necessary features of the graph that include the title of the graph, the scales, the axes with their respective units and the best curves.

The analysis further reveals that these candidates correctly determined the temperature of water after the seventh minute for both cooling curves. They were also able to provide a scientific explanation for why water in a colorimeter covered with a wet cloth cools faster than in an uncovered one. Extract 20.1 presents a sample of correct responses to Question 2 of Paper 3A.

2 i) . TABLE OF RESULTS.

Time interval t (min)	Temperature for Calorimetre without cloth	Calorimetre with wet cloth.
0	80°c	80°c
1	72°c	70°c
2	65°c	62°c
3	59°c	55°c
4	54°c	50°c
5	50°c	45°c
6	46°c	41°c
7	43°c	38°c
8	41°c	36°c
9	38°c	34°c
10	36°c	32°c.

2 ii) A graph for Cooling Curve was Plotted.

2 iii) The temperature of water at 7th minute Is 43°c for Calorimetre without wet Cloth and Is 38°c for Calorimeter Covered with wet cloth.

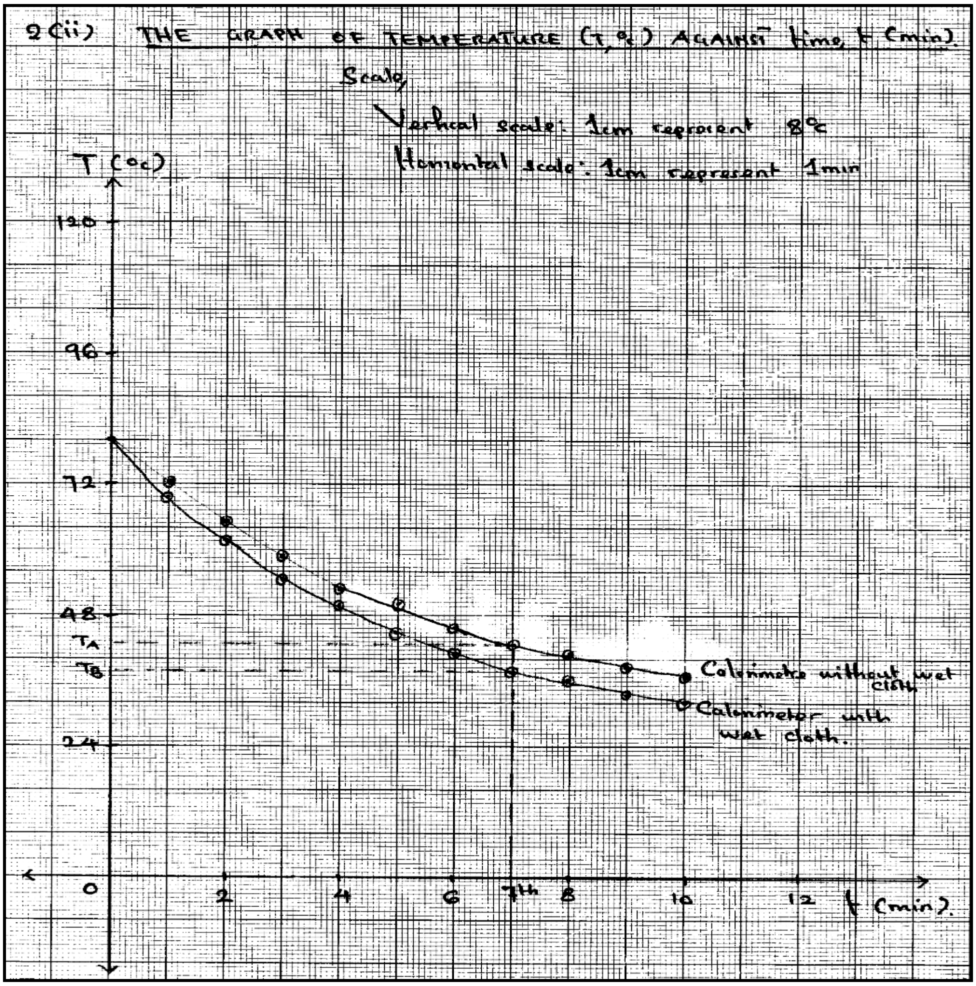
$T_A = 43°c$

$T_B = 38°c$.

2 iv) Water Cooled faster Ina Setting with wet Cloth because;

a) The wet cloth absorb heat from the Calorimeter hence facilitate cooling.

b) The wet cloth contained water which can has high specific heat capacity hence Facilitate heat loss from calorimetre.



Extract 20.1: A sample of correct responses to question 2 of paper 3A

In Extract 20.1, the candidate correctly collected the data, plotted the graph and determined the temperature of water at the seventh minute for both cooling curves.

On the contrary,15.32% of the candidates scored lower marks (0.0–5.0). These candidates demonstrated several weaknesses, including: Failure to follow experimental instructions; failure to measure and record experimental data; failure to present and analyse the experimental data. For instance, one candidate presented data as follows: t = 20.16 s, t = 40.63 s, t = 60.71 s, etc. This is an indication that candidates failed to follow experimental instructions. The candidates were supposed to present the time in minutes. In addition, a notable weakness observed in most of the candidates" scripts were the candidates' inadequate skills in drawing cooling curves on the same plane of axis without showing the important features.

Moreover, candidates failed to write proper scales, wrong transfer of points from the table of results to the graph and incorrect determination of the temperature of water at the seventh minute for both cooling curves. They failed to provide the correct response regarding the setting in which water cools faster. Most of them provided irrelevant responses. For instance, one candidate wrote: *water cools faster in unwrapped calorimeter for the reasons that, a piece of wetted cloth acts as an insulator, so it takes much time for water inside calorimeter to cool than that which is not covered by the piece of cloth (insulator).* This statement has several misconceptions: (i) assuming a wet cloth purely as an insulator. The candidate was supposed to know that a dry cloth can reduce heat transfer by acting as an insulator; a wet cloth does not necessarily have the same effect. The wet close is expected to enhance evaporation of water, thus increasing the cooling rate. This is because it absorbs latent heat from the calorimeter and its contents. Extract 20.2 is a sample of candidates' incorrect responses to this question.

2.

(a) Table of value without wet cloth

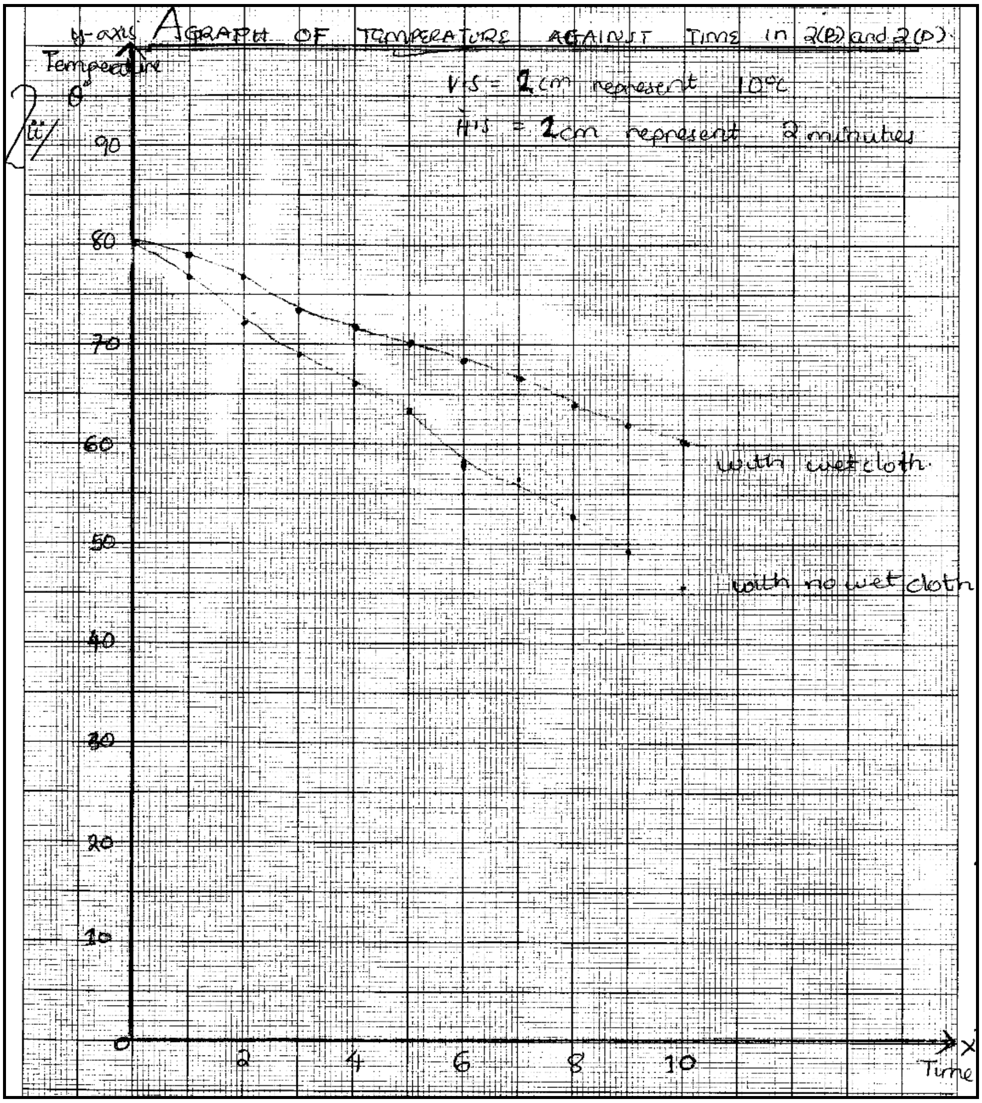
Time (min)	Temperature
0	80
1	78
2	76
3	74
4	72
5	70
6	68
7	6
8	64
9	62
10	60

(b) Table of value with wet ~~glass~~ cloth

Time (min)	Temperature
0	80
1	77
2	73
3	69
4	66
5	63
6	57
7	56
8	53
9	49
10	46

iii/ Temperature of 7th minutes for both cooling curve is. 55°C - 56°C

iv/ The setting. which having wet cloth. cools. faster than without having wet cloth. because exces temperature is greater than with out having wet cloth.



Extract 20.2: A sample of incorrect responses to question 2 of paper 3A

In Extract 20.2, the candidate collected incorrect data, wrote an incorrect scale to determine the temperature of water at the 7th minute for cooling curves and failed to identify which setting cools water faster.

4.2.2 Physics 3B

The candidates were required to determine the specific heat capacity of a solid mass using Newton's law of cooling. They were required to proceed as follows:

(a) Measure and record the mass of the empty calorimeter.

(b) Record the room temperature θ_R .

(c) Half-filled the calorimeter with hot water and cover it with lid. Insert the thermometer through the opening so as to be able to read the temperature of the water.

(d) Start with temperature of 80 ^{o}C while stirring and fanning using cardboard read and record the temperature, θ of the water after every 1 minute for ten minutes.

(e) Measure and record the mass of the calorimeter that is half filled with water then pour it out.

(f) Quickly transfer the solid, m of mass, X into the calorimeter and repeat the procedures 2 (c), (d) and (e) to obtain the cooling behaviour of the mixture.

Questions

(i) Determine the mass of the water that half-filled the calorimeter.

(ii) Tabulate the results obtained in 2 (d) and (f).

(iii) Briefly explain the importance of the procedure (d) in this experiment.

(iv) Plot on the same axis the cooling curves for the results tabulated in 2 (ii).

(v) Using the graph, determine the time at which the difference in temperature between the two curves is highest.

(vi) Evaluate the specific heat capacity of the solid, m of mass X from the equation, $XC(\theta_2 - \theta_R) = (m_c C_c - m_W C_W)\Delta\theta$.
where;
X Represents the mass of the solid, **m**
C Represents the specific heat capacity of the solid, **m**
m_c Represents the mass of empty calorimeter.
C_c Represents the specific heat capacity of copper
m_W Represents the mass of water

C_W Represents the specific heat capacity of water.

θ_R Represents room temperature.

$\Delta\theta$ Represents the difference in temperature for the time obtained in 2 (v).

θ_2 Represents the temperature of the mixture at the highest temperature difference.

The statistical data shows that 84.68% of the candidates who attempted this paper scored higher marks (9.0–15.0). Those who scored higher marks demonstrated a comprehensive mastery of experimental skills in Physics. They showed proficiency in data collection, presentation, and analysis. Furthermore, they displayed skill in plotting graphs. Using appropriate scales for both the vertical and horizontal axes, they plotted the cooling curves on the same axis. In addition, these candidates included all essential graph features, such as the title (with units), labelled axes, and plotted points. Besides, most of them correctly determined the time for the highest temperature for both curves. They demonstrated their mathematical skills by manipulating the given equation and obtaining the specific heat capacity of the solid. Extract 21.1 shows a candidate who followed the correct procedures, recorded the data, plotted the graph, used the graph for calculations, and ultimately determined the specific heat capacity of the solid.

2	(a) Mass of empty Calorimeter is 32.5g
	(b) Room temperature is 24°C
	(c) Mass of the Calorimeter that is half-filled with water is 85.1g
	(d) Mass of the Calorimeter with half-filled water and a solid of mass X is 184.4
	i) Mass of the water that half-filled the Calorimeter
	85.1 − 32.5 = 52.6g
	ii) TABLE OF RESULTS

Time (t) min	θ°C without solid mass	θ°C with solid mass
0	80	80
1	78	77
2	76	75
3	74	73
4	72	71
5	70	68
6	68	66
7	66	65
8	64	63
9	62	60
10	60	58

2	iii)
	- Is to determine the time taken for water to cool from 80°C after every one minute.
	iv) The graph was plotted on the graph paper
	v) From the graph the time at which the difference in temperature is at 6 minutes
	vi) From
	$X_C(\theta_2 - \theta_R) = (M_cC_c + M_wC_w)\Delta\theta$
	$\Delta\theta = 68 - 66$
	$\Delta\theta = 2°C$
	$\theta_2 = 68°C$

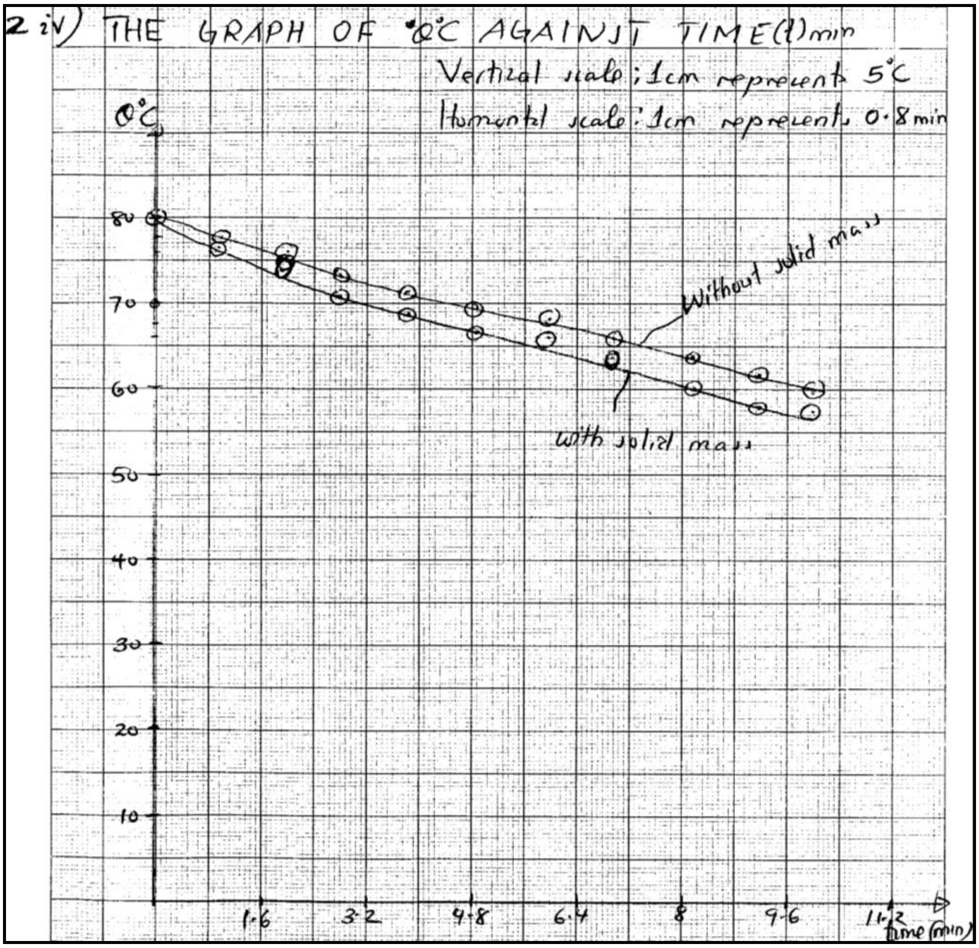
2 vi)

$$C = \frac{(M_c C_c + M_w C_w)\Delta\theta}{x(\theta_2 - \theta_R)}$$

$$C = \frac{((52.6\times10^{-3}\times 4200) + (32.5\times10^{-3}\times 400))\,20}{100\times10^{-3}(68-24)}$$

$$C = 395\ \mathrm{J\,kg^{-1}\,K^{-1}}$$

∴ The specific heat capacity of a solid mass is 395 J kg⁻¹ K⁻¹



Extract 21.1: A sample of correct responses to question 2 of paper 3B

In Extract 21.1, the candidate correctly collected the data, plotted the cooling curves, and determined the time at which the difference in temperature between the curves is highest. The candidate correctly determined the specific heat capacity of a solid mass

The analysis further shows that 15.32% of the candidates who attempted this alternative paper scored 0.0 to 5.0 marks. Candidates who scored lower (0.0-5.0) marks failed to demonstrate mastery of basic experimental skills related to the topic of heat. Other candidates collected incorrect data, which led to incorrect presentation and analysis of their experimental results. For example, some candidates neglected to include proper units for the measured experimental variables, while others failed to include important graph features such as the title (with units), labelled axes (both vertical and horizontal), and appropriate scales (vertical and horizontal). Additionally, some candidates did not transfer the data points correctly. Some of the candidates got lower marks because they failed to transfer data points and plot both cooling curves on the same axis. This suggests that the candidates failed to adhere to the experimental procedures.

Some of the candidates failed to manipulate the given mathematical equation and determine the specific heat capacity of a solid mass. Moreover, some candidates failed to determine the mass of water. For instance, one candidate wrote the mass of a half-filled water calorimeter as the mass of water, instead of taking the mass of the half-filled water calorimeter minus the mass of the empty calorimeter. Extract 21.2 A sample of incorrect responses to question 2 of paper 3B.

2 (b)(ii) Table of results.

Tepo

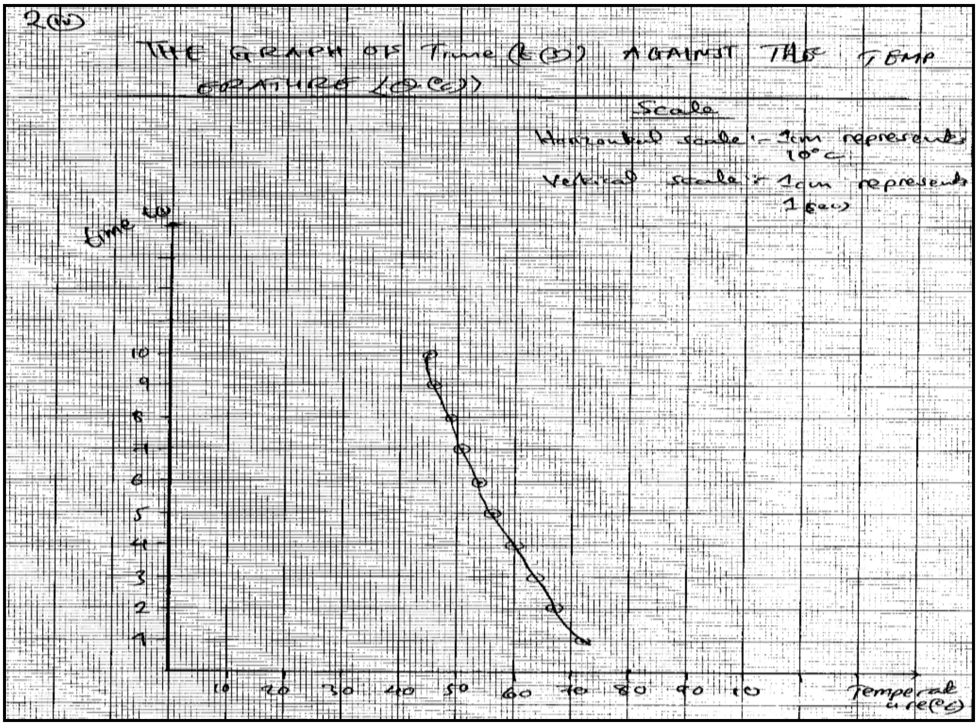
Temperature θ(°c)	time
0	80
1	72
2	68
3	64
4	60
5	57
6	54
7	51
8	49
9	47
10	46

(ii)
⇒ The importance of of procedure (d) in this experiment is to ensure the rate of cooling of water in a calorimeter this to among the strong importance

(iii) $T_1 = 49$
$T_2 = 55$

(i) The mass of water that was filled-half is equal to 70g.

2 (iv)



Extract 21.2: A sample of incorrect responses to question 2 of paper 3B

In Extract 21.2, the candidate provided irrelevant responses and failed to indicate the unit of time in the table of results and plotted one incorrect cooling curve instead of two curves on the same plane of the axis.

4.2.3 Physics 3C

The candidates were provided with hot water of about $70\ ^{o}C$, a copper calorimeter and a thermometer. They were required to determine the effect of the mass of an object on the cooling process. They were required to proceed as follows:

(a) Measure and record the mass of the empty calorimeter.

(b) Half filled the calorimeter with hot water of about $70\ ^{o}C$.

(c) Observe and record the temperature of water at an interval of 2 minutes as water cools from $60^{0}C$ to $45^{0}C$.

(d) Weigh the calorimeter that is half filled with hot water.

(e) Repeat the procedures in 2 (c) and (d) when the ncalorimeter is $\frac{2}{3}$ full of hot water.

Questions

(i) What are the masses of water obtained in 2 (d) and (e)?

(ii) Tabulate the results obtained in 2 (c) and (e).

(iii) Plot the cooling curves of two setting in the same plane of axis.

(iv) From the graph in 2 (iii), determine the ratio between the time taken to cool half full of water to that of two third full of water at the following intervals; $60^{0}C-50^{0}C$ *and* $60^{0}C-45^{0}C$.

(v) Using the data obtained in $2(c)$ *and* (e)*, determine the thermal capacities of water.*

(vi) Determine the ratios of thermal capacities obtained in 2 (v).

(vii) How do the ratios obtained in 2 (iv) and (vi) relate?

The statistical data shows that (84.68%) of the candidates who attempted this paper scored higher marks (9.0 – 15.0). Those who scored higher marks demonstrated a comprehensive mastery of experimental skills in Physics. These candidates in this category adhere to the experimental procedures. Thus, they collected and presented data. Furthermore, they displayed skill in plotting graphs. Using appropriate scales for both the vertical and horizontal axes, they plotted the cooling curves of the two settings on the same axis.

Moreover, some of them analysed and interpreted the graphical data by providing the correct ratio of the time taken to cool half-filled and two-thirds filled settings. The candidates also correctly determined the thermal capacities of water. Extract 22.1 is a sample of a candidate's correct responses to this question.

2 (i). Table of results

when 1/2 filled with water

time (min)	temperature (°C)
0	60
2	57
4	54
6	51
8	49
10	47
12	45

when 2/3 filled with water

time (min)	temperature (°C)
0	60
2	58
4	56
6	54
8	52
10	50
12	48
14	~~47~~ 46
16	45

(ii). The cooling curves was plotted on the graph paper.

2. iv. Ratio of time taken to cool from
(i) 60°C - 50°C
(ii) 60°C - 45°C

when half filled with water t_1 = t_1

t_1/t_2

(i) 60°C - 50°C

Half filled water (t_1) = 7 minutes

2/3 filled with water (t_2) = 10 minutes

Ratio = t_1 / t_2

= $7/10$ = 0.7

Ratio : R_1 = 0.7

(ii) 60°C - 45°C

Half filled water (t_1) = 12 minutes

2/3 filled water (t_2) = 16 minutes

Ratio (R_2) = $\frac{12}{16}$ = 0.75

∴ Ratio (R_2) = 0.75

2. vi. Thermal capacities of water from

(i) when half filled with water

Thermal capacity = $M_wC_w + M_cC_c$

M_w = 57.88g = 0.05788kg
C_w = 4200 J kg⁻¹ K⁻¹

M_c = 36.02g = 0.03602kg
C_c = 420 J kg⁻¹ K⁻¹

Then

Q = 0.05788 × 4200 + 0.03602 × 420

Q = 243.096 JK⁻¹ + 15.1284 JK⁻¹

Q = 258.2244 JK⁻¹

∴ Thermal capacity of water when calorimeter is half filled with water = 258.2244 JK⁻¹

ii. when 2/3 filled with water from

Thermal capacity = $M_cC_c + M_wC_w$

M_w = 86.23g

Then

2. vi. $Q = 0.03602 \times 420 + 0.08632 \times 4200$

$Q = 15.128 + 362.166$

$Q = 377.294\ JK^{-1}$

∴ thermal capacity when calorimeter is filled with $^2/_3$ water $= 377.294\ JK^{-1}$

vi. Ratios of thermal capacities obtained from

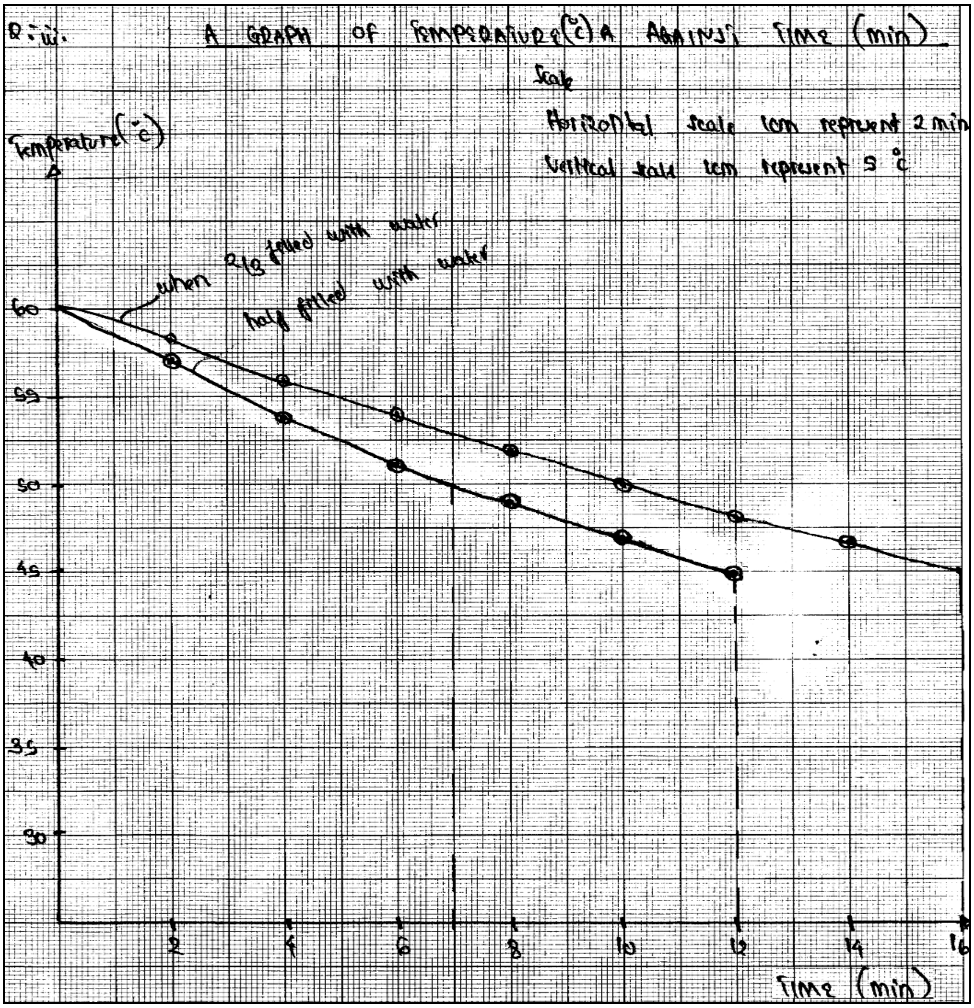
Ratio $= \frac{Q_1}{Q_2}$

Ratio $= \frac{298.2244\ JK^{-1}}{377.294\ JK^{-1}}$

Ratio $= 0.7$

∴ Ratio of thermal capacities $= 0.7$

vii. Ratios obtained in 2(iv) and (v) are nearly the same. Hence ~~fro~~ it implies that ~~wa~~ water in the calorimeter when filled $^2/_3$ takes long time to cool as compared to that filled with $^1/_3$.



Extract 22.1: A sample of correct responses to question 2 of paper 3C

In Extract 22.1, the candidate measured and recorded correctly the values of temperature and time. The candidate also used the collected data to plot the correct cooling curves. Candidate demonstrated mathematical skills to determine the ratio of thermal capacities correctly.

The candidates (15.32%) who attempted this examination paper scored lower (0.0 – 5.0) marks. This is an indication of a lack of adequate experimental knowledge and skills on the topic of heat. Some of them failed to adhere to experimental procedures. Thus, they struggled to obtain correct data due to improper setup of the experiment and incorrect measurement observations. Additionally, many were unable to present the collected data graphically, often making inaccurate transfers of points onto the graph. Some candidates also lacked the necessary skills to solve numerical parts of the question, such as the ratio between the time taken to cool half full and two-thirds full of water, thermal capacities of water and the ratio of thermal capacities. Extract 22.2 is a sample of the candidates' incorrect responses.

2. (i)

Mass of water in half filled Calorimeter is 57g.

Mass of water in 2/3 filled Calorimeter is 87g.

(ii) TABLE OF RESULTS.

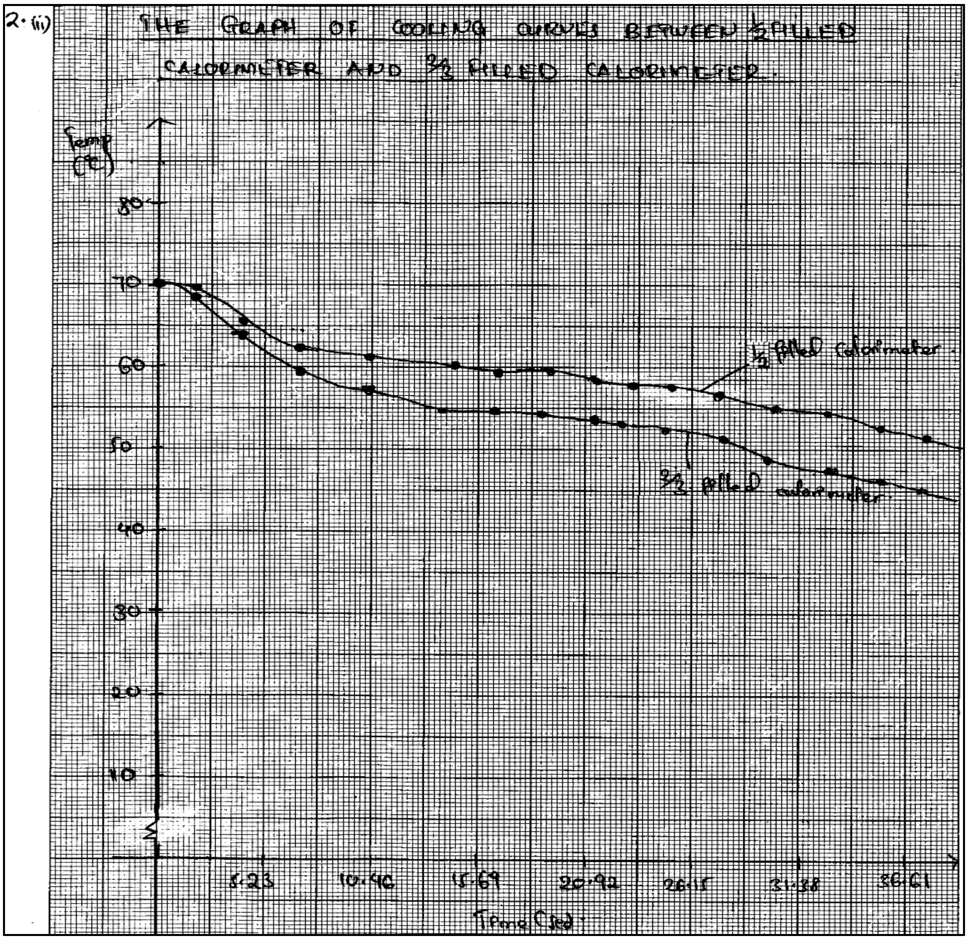
Time	0	2	4	6	8	10	12	14	16	18	20
θ in 1/2 filled calorimeter	70	67	64	62	59	58	57	56	55	54	53
θ in 2/3 filled Calorimeter	70										

TABLE OF RESULTS.

Time taken.	θ in 1/2 filled Calorimeter	θ in 2/3 filled Calorimeter
0	70	70
2	67	68
4	64	66
6	62	64
8	59	63
10	57	62
12	56	61
14	55	60
16	54	59
18	53	58
20	52	57
22	51	56
24	50	55
26	49	54
28	48	53
30	47	52
32	46	51
34	45	50

2.	i) Thermal capacity on 2/3 filled calorimeter.
	from.
	$C = \frac{Q}{\Delta\theta}$
	but.
	$Q = MC\Delta\theta$
	then.
	$C = \frac{MC\Delta\theta}{\Delta\theta}$
	$C = MC$
	where
	$M = 87g = 0.087kg$
	$c = 4200 Jkg^{-1}K^{-1}$
	then.
	$4200 J kg^{-1} K^{-1} \times 0.087 kg$.
	$= 365.4 JK^{-1}$
	∴ Thermal capacity in 2/3 filled calorimeter
	is $365 JK^{-1}$.
	vi). Ratio of thermal capacities.
	from.
	$\frac{C \text{ of } \frac{1}{2} \text{ filled calorimeter.}}{C \text{ of } \frac{2}{3} \text{ filled calorimeter.}}$
	$= \frac{239.4 JK^{-1}}{365.4 JK^{-1}} = 0.65$
	Ratio of thermal capacities is 0.65.

2.	vii) Ratios obtained in 2(iv) and v relate since they
	are almost the same.
	$iv = 0.685$
	$v = 0.65$
	$iv = v$
	$0.685 = 0.65$ are same.



Extract 22.2: A sample of incorrect responses to question 2 of paper 3C

In Extract 22.2, the candidate provided an incorrect table of results. Moreover, the candidate, plotted incorrect curves showing the cooling rate of hot water in the calorimeters.

4.3 Question 3: Current Electricity

Question 3 in each alternative paper was derived on the topic of current electricity. The questions aimed to assess the candidates' ability to assemble a simple electric circuit using the provided electrical components. Candidates were then required to use the assembled circuit to collect and analyse data to determine the value of the required parameters, following the given experimental instructions.

This question was attempted by 29,604 (100%) candidates. Of these, 18,332 (61.93%) candidates scored from 0.0 to 5.0 marks. 3,182 (10.75%) scored from 5.5 to 8.5 marks, and 8,086 (27.32%) scored from 9.0 to 15.0

marks. The data analysis shows that the candidates' performance was average, as 11,268 (38.07%) scored from 5.5 to 15.0 marks. Figure 20 summarizes the candidates' performance on the questions.

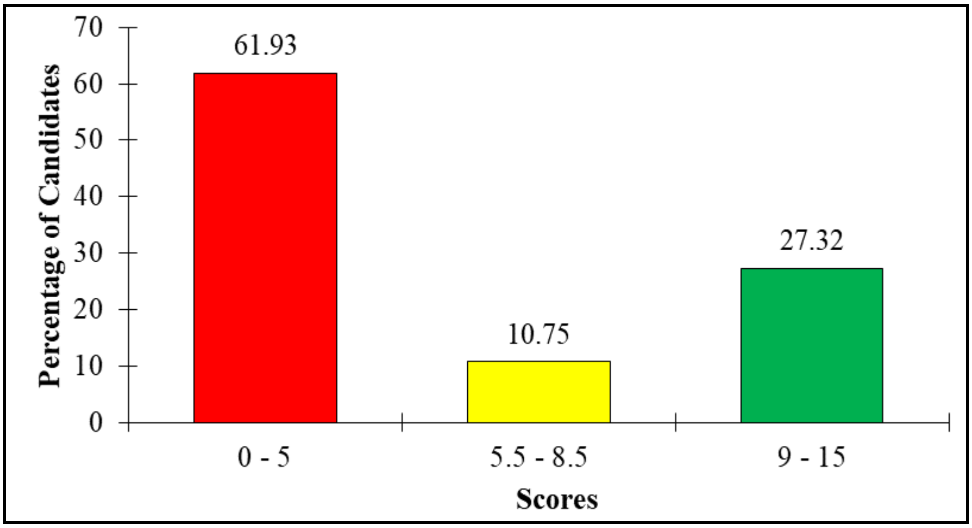


Figure 20: *Candidates' performance in question 3 of paper 3*

4.3.1 Physics 3A

The candidates were provided with a 2 Ω standard resistor, resistance wire **S**, galvanometer G, dry cell E (1.5 V, size D), switch K, jockey and connecting wires. They were required to determine the resistivity of wire, **S** through the following procedures.

(a) Connect 80 cm of wire S together with 2 Ω resistor in series to make a loop.

(b) Connect wires from the terminals of the dry cell E, at junction B and junction D, then connect resistance wire **S** from the junction A to junction B and complete the circuit as shown in a Diagram 9

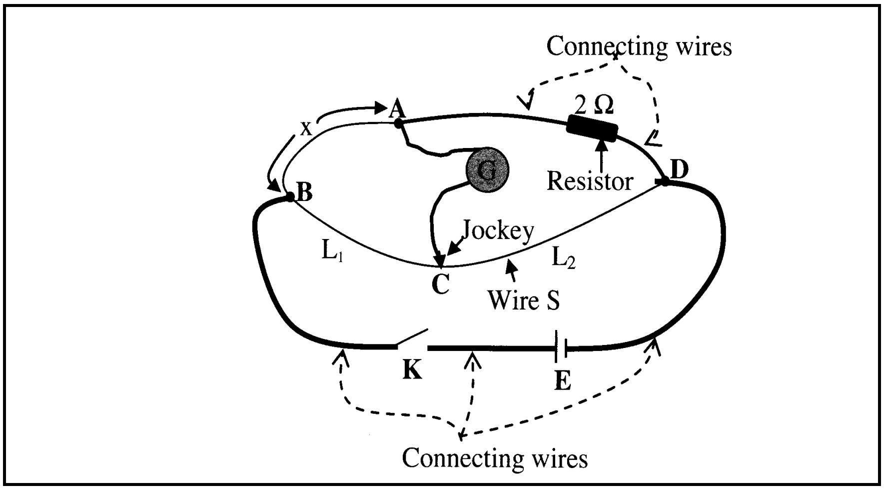


Diagram 12

(c) Close the switch, **K** and determine the balancing point **C**. Read and record the lengths, L_1 and L_2

(d) Repeat the procedures in 3(b) and (c) for the value of x equal to 20cm, 30cm, 40cm, and 50cm.
Questions:

(i) Tabulate your results including the value of x, L_1 L_2 and $\frac{L_1}{L_2}$

(ii) Plot a graph of x (cm) against $\frac{L_1}{L_2}$.

(iii) Determine the slope of the graph

(iv) Measure and record the diameter of the wire, **S** by using micro meter screw gauge.

(v) Determine the resistivity of a wire, **S** using the answer obtained in 3 (iii) and (iv).

The statistical data shows that only 27.32% of the candidates who attempted this alternative paper scored higher marks (9.0 to 15.0). These candidates demonstrated their mastery of experimental knowledge and skills related to the topic of current electricity. These candidates were able to connect an electric circuit and collect accurate data. Furthermore, they plotted the graph that included all the essential features such as: a clear title, properly labelled axes with appropriate units, correctly chosen scales, an indicated slope, and a best-fit line. They used a plotted graph and determined the unknown resistivity of a wire. Their solid mathematical skills enabled them to perform calculations effectively, contributing to their high scores. Extract 23.1 is a sample of a correct response from one of the candidates who scored high marks in this question.

3 i) THE TABLE OF RESULTS

X (cm)	L1 (cm)	L2 (cm)	L1/L2
10	16.3	53.7	0.304
20	22.5	37.5	0.600
30	23.7	26.3	0.901
40	21.8	18.2	1.198
50	18.2	11.8	1.542

3 ii) A graph of x (cm) against L_1/L_2 was plotted.

3 iii) The slope

from

$$\text{Slope}(s) = \frac{\Delta x}{\Delta L_1/L_2}$$

$$(s) = \frac{(42.5 - 15)\,\text{cm}}{(1.3 - 0.455)}$$

$$s = 32.54\ \text{cm}$$

∴ The slope of the graph was 32.54 cm.

3 iv) The diametre of wire S was 0.32 mm

3 v) The resistivity of wire S.

from

$$\frac{R_x}{L_1} = \frac{2\Omega}{L_2}.$$

but $R_x = \frac{\rho x}{A}$

3) Since

$$\frac{\rho x}{A L_1} = \frac{2\Omega}{L_2}$$

$$\rho x = \frac{2 A L_1}{L_2}$$

$$x = \frac{2A}{\rho} \cdot \frac{L_1}{L_2}$$

$y \quad m \quad x$

$$\text{Slope}(s) = \frac{2A}{\rho} \qquad \text{Where } \rho \rightarrow \text{resistivity of wire } S.$$

$$\rho = \frac{2A}{S}$$

but

$$A = \frac{\pi d^2}{4} = 8.04 \times 10^{-4}\ cm^2$$

$$\rho = \frac{2 \times \pi d^2}{4 S}$$

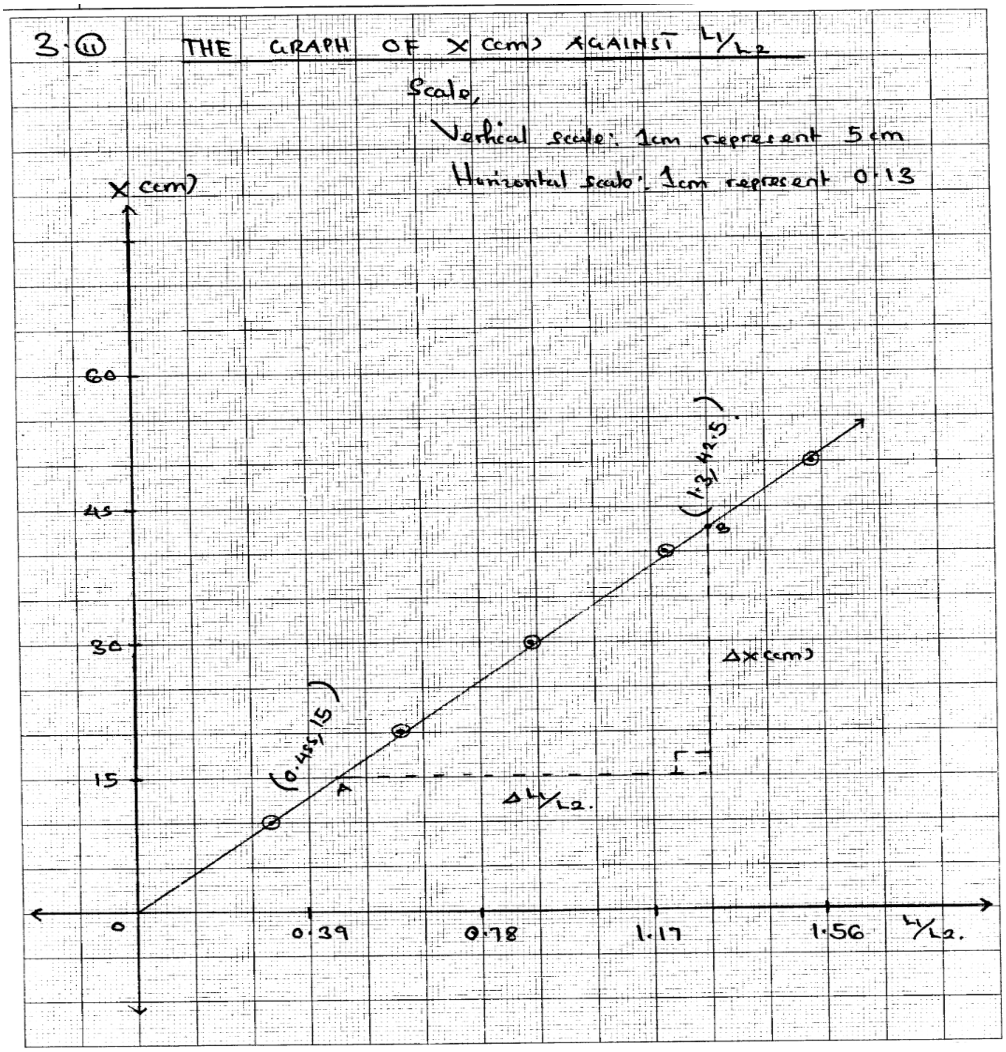
$d = 0.32mm$
$= 0.032cm$

$$\rho = \frac{2 \times \pi \times (0.032cm)^2}{4 \times 32.54cm}$$

$$\rho = \frac{6.43 \times 10^{-3}\ cm^2\ \Omega}{4 \times 32.54\ cm}$$

$$\rho = 4.9 \times 10^{-5}\ \Omega cm.$$

∴ The resistivity of wire S was $4.9 \times 10^{-5}\ \Omega cm$.



Extract 23.1 A sample of correct responses to question 3 of paper 3A

In Extract 23.1, the candidate successfully presented the data in tabular form and accurately plotted the graph, which was essential for computing the correct value of the slope. Furthermore, the candidate measured the diameter of a wire S using a micrometre screw gauge correctly. By utilising the slope and the diameter of the wire, the candidate was able to determine the resistivity of wire S.

On the contrary, further analysis reveals that some candidates scored lower (0.0-5.0) marks on this question, which reflects poor organisation in performing experimental tasks. Additionally, they failed to apply the concepts learned in electricity to connect the given circuit components and to connect a circuit. That is to say, they failed to adhere to experimental procedures. As a result, they connected the wrong electric circuit. Additionally, the majority of these candidates lacked the necessary measurement skills, as evidenced by their inability to use the micrometre screw gauge to measure the diameter of wire S accurately. Furthermore, most of these candidates failed to plot a graph. This was observed in their graphs, which often lacked essential elements such as a title, appropriate scale, clearly labelled axes with corresponding units, a best-fit line, and accurate transfer of data points. In addition, some candidates demonstrated weak mathematical skills, resulting in the calculation of incorrect slopes. For example, one candidate used an incorrect formula, which led to an inaccurate value for the slope. One candidate wrote: "The slope of the graph is $\frac{\Delta \frac{L_1}{L_2}}{\Delta x}$. This was an incorrect expression. As per experimental instruction, the slope of the graph is $\frac{\Delta x}{\Delta\left(\frac{L_1}{L_2}\right)}$, instead of writing the formula for slope as $\frac{\Delta X}{\Delta \frac{L_1}{L_2}}$. Extract 23.2 shows the incorrect responses obtained from one of the candidates who scored less than 5.0 marks.

3. Table of results

X (cm)	L_1 (cm)	L_2 (cm)	$\frac{L_1}{L_2}$	
10	95.8	4.2	22.7	
20	97.8	2.2	44.45	
30	99.0	0.2	4.2	
40	102	-3	-34	
50	103	-5	-20.6	

3 Slope

$M = \frac{\Delta X}{\Delta \frac{L_2}{L_1}}$

$M = 27cm - 5cm$

$= \frac{22cm}{60 - 14}$

$M = 0.47cm$

Slope of the graph is 0.47cm

(ii) Diameter of the wire is 0.37mm

(i) Resistivity of the wire

From $\rho = \frac{AR}{L}$

$A = 1.07 \times 10^{-4} m^2$

$L =$ Constant

$R =$ Const.

$\frac{X}{L_1/L_2} = \frac{XL_2}{L_1}$

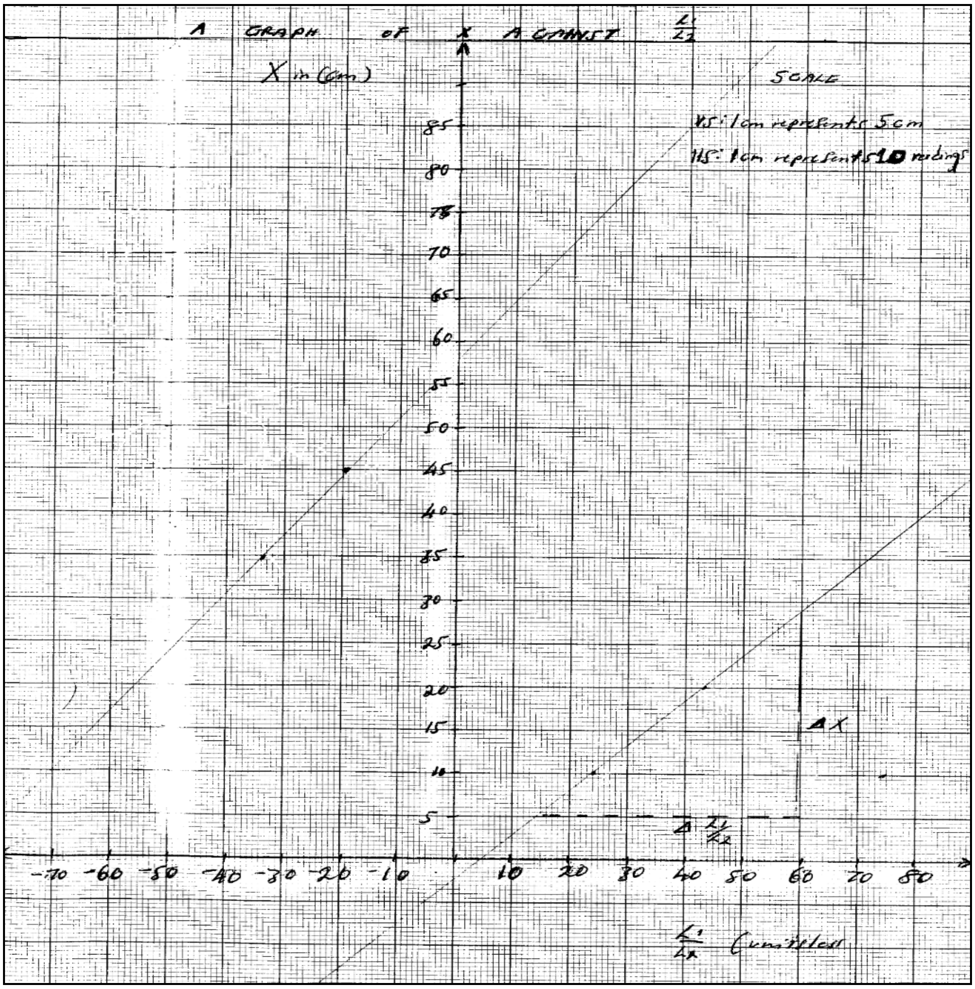
$M = \frac{XL_2}{L_1}$

$\rho = A \times M$

$\rho = 1.07 \times 10^{-4} \times 0.47 \times 10^{-2}$

$\rho = 5 \times 10^{-7} \Omega m$

∴ Resistivity of the wire is $5 \times 10^{-7} \Omega m$



Extract 23.2: A sample of incorrect responses to question 3 of paper 3A

In Extract 23.2, the candidate tabulated incorrect data values, which resulted in an inaccurate graph. Consequently, the calculated slope was also incorrect. Furthermore, the candidate used an incorrect value for the diameter of wire S when determining its resistivity, leading to an erroneous result.

4.3.2 Physics 3B

The candidates were provided with the coiled wire $\mathbf{R_c}$, a metre bridge standard resistor $\mathbf{R_s}$ of 1 **Ω**, resistance box **R,** dry cell **E**, key **K**, micro meter screw gauge, jockey **J,** galvanometer **G** and connecting wires. They were required to perform the experiment to determine the resistivity of the wire according to the following procedures.

(a) Connect your circuit as shown in Diagram 10.

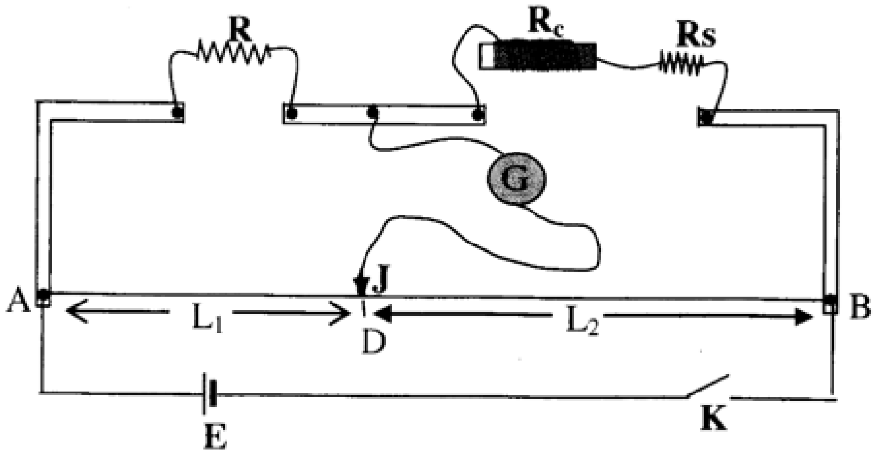


Diagram 13

(b) Set R=1Ω, close the key**, K** and determine the balancing point D. Record the lengths, L_1 and L_2

(c) Repeat the procedures in 3(b) by setting R=2Ω, 3Ω, 4Ω, 5Ω and 6Ω each time recording lengths, L_1, L_2 corresponding to the value of R used.

Questions

(i) Tabulate your results including the values of R, L_1, L_2 *and* $\frac{L_1}{L_2}$.

(ii) Measure the diameter of the coiled wire and calculate its cross-sectional area.

(iii) Establish a formula, which relates L_1, L_2, R, R_c *and* R_s.

(iv) Plot the graph of $\frac{L_1}{L_2}$ *versus* R

(v) Determine the slope, S of the graph in 3(iv).

(vi) If the length of a coiled wire, R_c *is 40cm, use the answer obtained in 3(ii) and (v) to determine the resistivity of the wire.*

Most of the candidates who scored high marks (9.0 – 15.0) had a good understanding of the concept of the Metre bridge. They were able to accurately connect the circuit as instructed and effectively use it to collect data and present them in tabular form. Furthermore, these candidates were able to plot graphs that included all essential features such as appropriate titles, correctly scaled axes with units, and best-fit lines passing through the origin. In addition, the majority of candidates exhibited good mathematical skills, as showed by their ability to derive the fundamental equation governing the experiment. Moreover, many of them accurately measured the diameter of the wire, which enabled them to calculate its resistivity. Extract 24.1 provides a sample of a correct response from one of these candidates to this question.

03. Question:

(i) Table of Results:

$R(\Omega)$	L_1 (cm)	L_2 (cm)	L_1/L_2
1	26.5	73.5	0.361
2	41.9	58.1	0.721
3	51.9	48.1	1.079
4	59.0	41.0	1.439
5	64.3	35.7	1.801
6	68.4	31.6	2.165

(ii) Diameter of the coiled wire = 0.375 mm = 0.375×10^{-3} m

from Cross-sectional area $= \pi r^2 = \frac{\pi d^2}{4}$

$$= 3.14 \times \frac{(0.375 \times 10^{-3} m)^2}{4}$$

$$= 1.104 \times 10^{-7} m^2$$

∴, the cross-sectional area of the coiled wire is $1.104 \times 10^{-7} m^2$

(iii) Solution:

According to wheatstone bridge principle,

$$\frac{R}{L_1} = \frac{R_c + R_s}{L_2}$$

$$\frac{L_1}{L_2} = \frac{R}{R_c + R_s}$$

$$\frac{L_1}{L_2} = \left(\frac{1}{R_c + R_s}\right) R$$

(v) from slope $= \Delta y / \Delta x$

03. (v) Slope, $S = \dfrac{\Delta\, L_1/L_2}{\Delta R\ (\Omega)}$

$= \dfrac{(1.65945 - 0.8658)}{(4.615 - 2.3998)\ \Omega}$

$= \dfrac{0.79365}{2.2152\ \Omega}$

Slope, $S = 0.35827\ \Omega^{-1}$

∴, the slope of the graph is $0.35827\ \Omega^{-1}$

(vi) Solution :

Length, $L = 40\text{ cm} = 40/100\ \text{m} = 0.4\text{m}$

Area of cross-section, $A = 1.104 \times 10^{-7}\ \text{m}^2$

slope, $S = 0.35827\ \Omega^{-1}$

from

$$\frac{L_1}{L_2} = \left(\frac{1}{R_c + R_s}\right) R + 0$$

$$y = m\, x + c$$

On comparing

$m = 1/(R_c + R_s)$

$0.35827\ \Omega^{-1} = \dfrac{1}{R_c + 1\Omega}$

$R_c + 1\Omega = 1/0.35827\Omega^{-1}$

$R_c + 1\Omega = 2.79\,\Omega$

$R_c = 1.79\,\Omega$

03 (vi) from

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

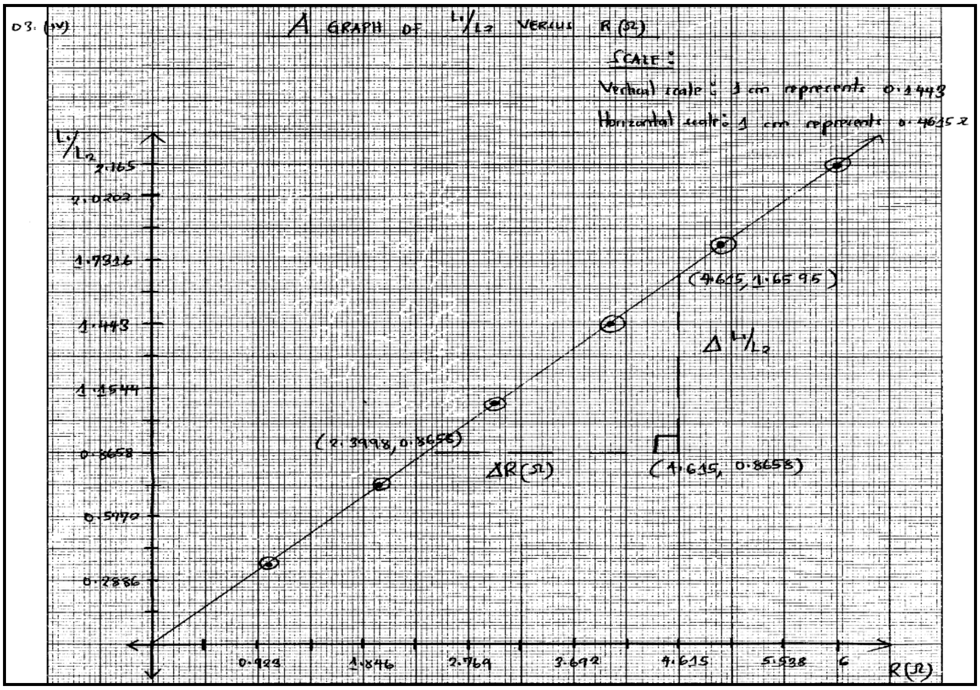
$$\rho_c = \frac{A_c R_c}{L_c}$$

$$= \frac{1.104 \times 10^{-7} m^2 \times 1.79 \Omega}{0.4 m}$$

$$= \frac{1.9774 \times 10^{-7} \Omega m}{0.4}$$

$$\rho_c = 4.94 \times 10^{-7} \Omega m$$

∴ the resistivity of the wire is $4.94 \times 10^{-7} \Omega m$



Extract 24.1: A sample of correct responses to question 3 of paper 3B

In extract 24.1, the candidate presented accurate data and plotted a correct graph. Moreover, the candidate correctly calculated the correct value of the slope from the plotted graph. In addition, the candidate had good measurement skills, which enabled him/her to precisely measure the diameter of the wire and subsequently calculate its resistivity.

On the other hand, further analysis reveals that most of the candidates (61.93%) scored lower (0.0-5.0) marks on this question. Most of them failed to perform experimental tasks accordingly. That is to say, they failed to adhere to experimental procedures. As a result, they connected the wrong electric circuit. Some of these candidates were able to obtain some correct experimental data. In addition, several candidates failed to distinguish between diameter and area. For example, one candidate incorrectly stated that *the value obtained using a micrometre screw gauge represented the cross-sectional area of the wire*. This was incorrect, as a micrometre screw gauge measures the diameter, not the area. Moreover, it was observed that most candidates failed to indicate the scale on their graphs. In addition, some candidates failed to perform unit conversion, particularly in converting square metres to square millimetres. For instance, one candidate incorrectly wrote that "1 m^2 is equivalent to 1,000 mm^2," whereas the correct conversion is 1 m^2 = 1,000,000 mm^2.

Furthermore, some candidates lacked adequate mathematical skills, which prevented them from deriving the equation governing the experiment. Some of the candidates applied an incorrect mathematical formula to determine the resistivity value of a wire. For instance, one candidate wrote: $\frac{R}{L_1} = \frac{R_C + R_S}{L_2}$. However, upon manipulating this equation, the candidate wrote: $\frac{L_1}{L_2} = \left(R_C + 1\right)\frac{1}{R}$, which is an incorrect expression. The correct equation was supposed to be $\frac{L_1}{L_2} = \left(\frac{1}{R_C + R_S}\right)R$. Extract 24.2 provides a sample of an incorrect response from one of the candidates.

3 Table of results.

(i)

$R(\Omega)$	L_1 (cm)	L_2 (cm)	$(L_1/L_2) \times 10^{-3}$
1	0.5	99.5	5.1
2	1.0	99.0	10.1
3	1.5	98.5	15.2
4	2.0	98.0	20.2
5	2.5	97.5	25.3
6	3.0	97.0	30.4

(ii) Diameter of a coiled wire = 0.036mm

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

$$Area = \frac{\pi (0.036\,mm)^2}{4}$$

$$Area = 1.02 \times 10^{-3}\ mm^2$$

$$Area = 1.02 \times 10^{-5}\ cm^2$$

(iii) $$\frac{R}{L_1} = \frac{R_c + R_s}{L_2}$$

(v) Slope (s) = $\frac{\Delta L_1/L_2}{\Delta R(\Omega)}$.

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

$$s = \frac{13 - 8}{2.5\Omega - 1.5\Omega}$$

$$s = 5\Omega^{-1}$$

$\therefore$ Slope (s) = $5\Omega^{-1}$

(vi) Length of wire R_c (L) = 40cm

$$\frac{R}{L_1} = \frac{R_c + R_s}{L_2}.$$

3 (vi)

$$\frac{l_1}{R} = \frac{l_2}{R_c + R_s}$$

$$\frac{l_1}{l_2} = \frac{R}{R_c + R_s}$$

But $R_s = 1\,\Omega$

$$\frac{l_1}{l_2} = \frac{R}{R_c + 1}.$$

$$\frac{l_1}{l_2} = \frac{R}{1 + R_c}$$

But $R_c = \frac{\rho l_c}{A}$.

Area $(A) = 1.02 \times 10^{-5}\,cm^2$.

$l_c = 40\,cm$.

$$\frac{l_1}{l_2} = \frac{R}{1 + \frac{\rho(40\,cm)}{1.02 \times 10^{-5}\,cm^2}}$$

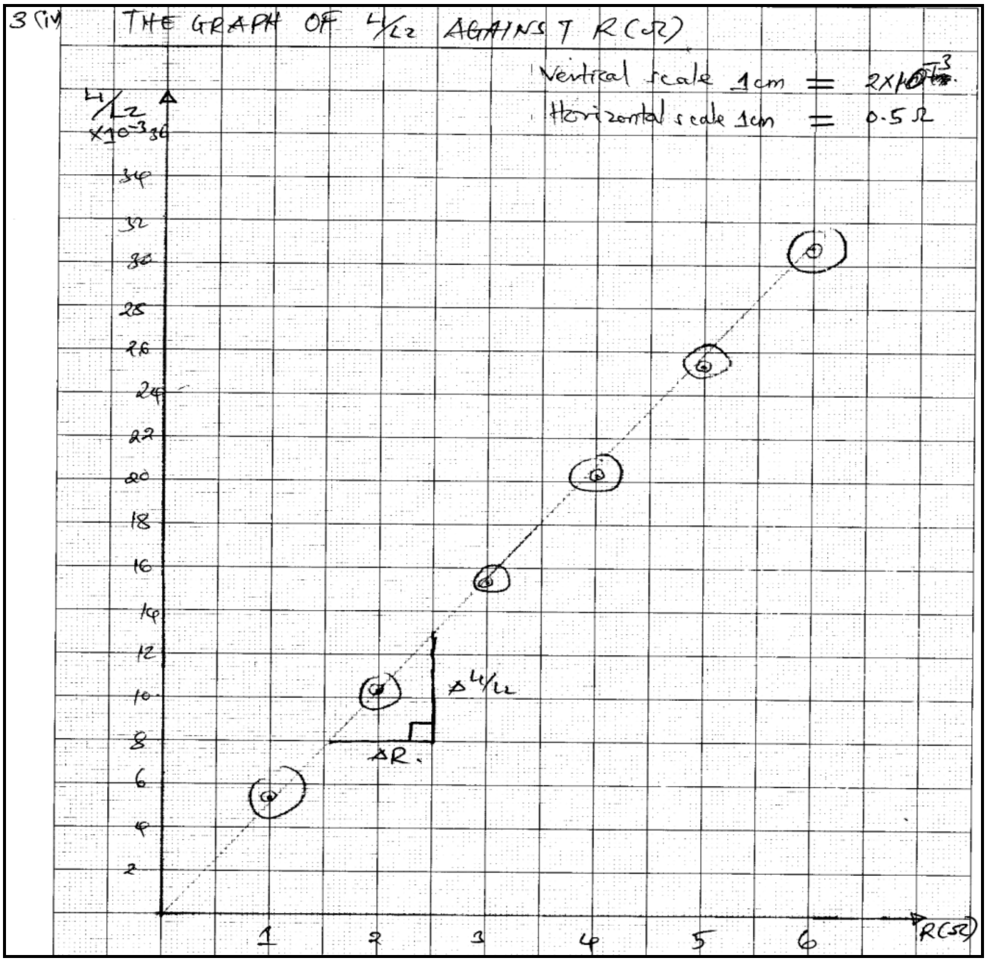
$$\frac{l_1}{l_2} = \frac{R}{1 + 3921568.627\,cm^{-1}\rho}$$

$$\frac{l_1}{l_2} = \left(\frac{1}{1 + 3.92 \times 10^6/cm\,\rho}\right) R.$$

$$slope\ (s) = \frac{1}{1 + 3.92 \times 10^6 \rho}$$

$$5\,\Omega^{-1} = \frac{1}{1 + 3.92 \times 10^6/cm\,(\rho)}$$

$$5\,\Omega^{-1} + 19.6 \times 10^6 \rho/cm = 1.$$



Extract 24.2: A sample of incorrect responses to question 3 of paper 3B

In Extract 24.2, the candidate presented incorrect data and computed an inaccurate slope. Furthermore, the candidate failed to calculate the resistivity of the wire due to a lack of measurement and computational skills.

4.3.3 Physics 3C

The candidates were provided with a meter bridge with its accessories, resistance box (1Ω-10Ω) labelled R, 2 Ω standard resistor, galvanometer labelled **G**, dry cell soldered both ends labelled E, key **K**, connecting wires and hard paper wrapped with wires of resistance 6 Ω labelled R_E. Referring to the information provided, they were required to perform the experiment in order to determine the number of wires that the resistor, $\mathbf{R_E}$ contains if each wire has a resistance of 6 Ω as follows in Diagram 11.

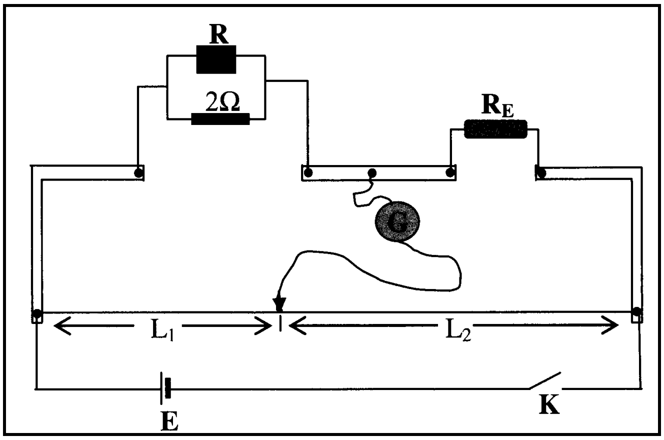


Diagram 14

(a) Starting with R =10 Ω, close the key, K and determine the length, L_1 where by, the galvanometer reads 0 and hence determine the corresponding value of length, L_2.

(b) Repeat the procedure ion 3(a) for values of R=5 Ω, 3 Ω, 2 Ω, and 1 **Ω.**

Questions

(i) Prepare a table of results including of values of R, $\frac{1}{R}$, L_1, L_2 and $\frac{L_2}{L_1}$

(ii) Plot a graph of $\frac{1}{R}$ against $\frac{L_2}{L_1}$ and determine its slope.

(iii) Develop the relation that governs this experiment.

(iv) Use your results in 3(ii) and (iii) to determine the number of wires that the resistor, R_E contains if each wire has a resistance of 6 Ω.

Statistical analysis revealed a wide range of scores. Some candidates scored between 16.5 and 25 marks, while others scored below 16.5. Those who achieved higher marks demonstrated a strong understanding of the concepts related to current electricity. These candidates correctly applied the given procedures to obtain accurate data, which allowed them to plot neat and precise graphs. Moreover, they were able to calculate the slope and deduce the expected value of the resistance of resistor R. Furthermore, they effectively interpreted their results and performed accurate mathematical manipulations to find the gradient of the graph and calculate the value of R as required. Extract 25.1 summarises a sample of a candidate's correct responses to this question.

3 i. Table of Results.

R (Ω)	1/R (Ω⁻¹)	L_1 (cm)	L_2 (cm)	L_2/L_1
10	0.1	45.8	54.2	1.18
5	0.2	42.2	57.8	1.37
3	0.33	37.3	62.7	1.68
2	0.5	33.9	66.1	1.95
1.	1	24.7	75.3	3.05

3 ii. Graph.

slope $= \frac{\Delta y}{\Delta x} = \frac{\Delta 1/R\ (\Omega^{-1})}{\Delta L_2/L_1}$

slope $= \frac{0.6 - 0.2\ (\Omega^{-1})}{2.16 - 1.37} = 0.506\ \Omega^{-1}$

slope $= 0.506\ \Omega^{-1}$

∴ The slope of the graph is $0.506\ \Omega^{-1}$

3 iii. R and 2Ω are in parallel so the equivalent resistance will be

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

3 iii.

$$\frac{R_T}{L_1} = \frac{R_E}{L_2}.$$

$$\frac{R_T}{R_E} = \frac{L_1}{L_2}.$$

$$\frac{2R}{2+R} \div R_E = \frac{2R}{(2+R)R_E}$$

$$\frac{2R}{(2+R)R_E} = \frac{L_1}{L_2}$$

$$\frac{(2+R)R_E}{2R} = \frac{L_2}{L_1}$$

$$\frac{2}{2R} + \frac{R}{2R} = \frac{L_2}{L_1} \cdot \frac{1}{R_E}$$

$$\frac{1}{R} + \frac{1}{2} = \frac{L_2}{L_1} \cdot \frac{1}{R_E}$$

$$\frac{1}{R} = \frac{L_2}{L_1} \cdot \frac{1}{R_E} - \frac{1}{2} = \frac{1}{R} = \frac{1}{R_E} \cdot \frac{L_2}{L_1} - \frac{1}{2}$$

$y \quad x \quad m \quad -c \qquad y \quad m \quad x \quad -c$

3 iv. from slope $= 1/R_E$

slope $= 0.51\ \Omega^{-1}$

$$0.51\ \Omega^{-1} = \frac{1}{R_E}$$

$R_E = 1/0.51\ \Omega^{-1} = 2\ \Omega.$

3 iv. $R_E = 2\Omega$

$$n = \frac{R}{R_E}$$

$R = 6\Omega$

$$n = \frac{6\Omega}{2\Omega} = 3$$

∴ the number of wires are 3 wires.

Extract 25.1: A sample of correct responses to question 3 of paper 3C

In Extract 25.1, the candidate successfully recorded accurate data in the table of results and plotted a graph that included all essential features, such as a title, appropriate scale, labelled axes with corresponding units, and a best-fit line. Furthermore, the candidate was able to derive the equation governing the experiment and determine the number of wires involved.

The candidates who scored low marks (0.0–5.0) demonstrated a lack of understanding of the experimental knowledge and skills of electricity. They were unable to meet the requirements of the question, especially in setting up the experiment and tabulating the results from the collected data. Most of these candidates failed to plot a correct graph. They omitted key features such as a title, appropriate scale, and labelled axes with correct units. Moreover, it was observed that some candidates were unable to derive the general equation governing the experiment. For example, one candidate incorrectly wrote the general equation as $\frac{1}{R_1} = \frac{L_2}{L_1}\left(\frac{1}{15}\right)$ which is incorrect.

They were supposed to do the following to get the correct equation which governs the experiment:

From the balanced bridge equation:

$$\frac{\frac{2R}{2+R}}{L_1} = \frac{R_E}{L_2}$$

Thus:

$$\frac{1}{R} = \left(\frac{1}{R_E}\right)\frac{L_2}{L_1} - \frac{1}{2}.$$

In addition, some of these candidates failed to compute the number of wires because they considered the wires to be arranged in series, while they were arranged in parallel connection. Extract 25.2 presents a candidate's incorrect responses to this question.

3: (I) TABLE OF RESULTS

$R(\Omega)$	$1/R\ (\Omega^{-1})$	L_1 (cm)	L_2 (cm)	L_2/L_1
5	0·2	25·9	74·1	2·84
3	0·33	29·4	70·6	2·4
2	0·5	33·3	66·7	2
1.	1	42·8	57·2.	1·34

(ii) Graph of $1/R$ against L_2/L_1.

$$\text{Slope} = \frac{\Delta 1/R}{\Delta L_2/L_1}$$

$$= -0·53$$

Slope = −0·53 cm

The slope from the graph is −0·53 cm

3: (III) Relation govern this experiment; :

From:

$$\frac{R_x}{L_1} = \frac{R_E}{L_2}$$

~~but $L_2 =$ 10~~

but

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

$$= \frac{1}{R_1} + \frac{1}{R_1} + \frac{1}{R_1}$$

$$R_E = \frac{3}{R_1} = \frac{3}{6}$$

$$R_E = 2\Omega$$

Also

$$R_x = \frac{1}{R} + \frac{1}{2}$$

$$\frac{2+R}{2R}$$

$$R_x = \frac{2+R}{2R}$$

3: (iii) Therefore:

$$\frac{2+R}{2R} \div L_1 = \frac{2}{L_2}$$

$$\frac{2+R}{2L_1R} = \frac{2}{L_2}$$

$$L_2(2+R) = 4L_1R$$

$$2L_2 + L_2R = 4L_1R$$

$$\frac{L_2(2+R)}{L_2} = \frac{4L_1R}{L_2}$$

$$2 + R = \frac{4L_1R}{L_2}$$

$$R - \frac{4L_1R}{L_2} = 2$$

$$\frac{R\left(1 - \frac{4L_1}{L_2}\right)}{\left(1 - \frac{4L_1}{L_2}\right)} = \frac{2}{\left(1 - \frac{4L_1}{L_2}\right)}$$

$$R = 2 \div \left(\frac{L_2 - 4L_1}{L_2}\right)$$

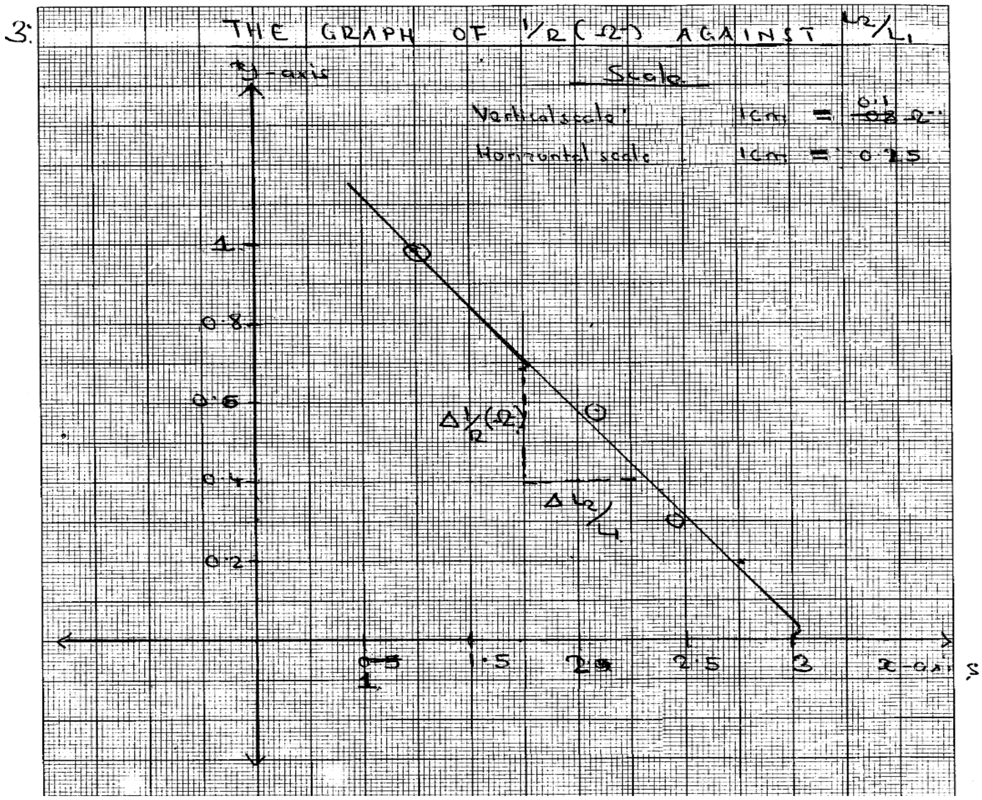
$$R = 2 \times \left(\frac{L_2}{L_2 - 4L_1}\right)$$

3: (iii). $R = \frac{2L_2}{L_2} \cdot \frac{L_2}{4L_1}$

$$R = \frac{2L_1}{L_2}$$

~~$R = 2$~~ $\frac{1}{R} = 2\left(\frac{L_2}{L_1}\right) + 0$

y m x y



Extract 25.2: A sample of incorrect responses to question 3 of paper 3C

In extract 25.2, the candidate recorded incorrect data and subsequently plotted an inaccurate graph, which resulted in an incorrect calculation of the slope. In addition, the candidate applied the parallel connection equation to derive the formula for R_E rather than using the balanced bridge equation and hence, failed to determine the number of wires in the resistor, where each wire has a resistance of 6 **Ω**.

5.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH TOPIC

The analysis of candidates' performance across individual topics indicates that they performed well in 8 out of the 12 topics assessed in the theory papers. These topics included *Environmental Physics* (97.03%), *Electromagnetism* (80.78%), *Heat* (75.14%), *Fluid Dynamics* (72.92%), *Atomic Physics* (72.06%), *Properties of Matter* (71.39%), *Electronics* (68.06%), and *Vibrations and Waves* (62.77%). In these areas, the candidates demonstrated competence in the subject matter by correctly analysing the examined concepts.

However, candidates exhibited average performance in the remaining four topics: *Mechanics* (51.90%), *Measurement* (50.62%), *Current Electricity* (43.27%), and *Electrostatics* (38.67%). This average performance was primarily attributed to inappropriate explanations, misinterpretation of the questions, and insufficient knowledge and skills related to the specified topics.

In Physics Paper 3, the analysis of candidates' performance in the tested topics indicates that they had good performance in 2 out of the 3 topics assessed in the practical papers. These topics included *Heat* (84.68%) and *Mechanics* (77.97%). Good performance in these topics was attributed to the candidates' adequate knowledge of the subject matter, good practical and analytical skills in collecting the data, describing and analysing the concepts to provide a scientific conclusion. Furthermore, candidates had good drawing skills and were able to follow instructions when assembling various apparatus associated with the respective experiments in their responses.

On the other hand, the topic of *Current Electricity*, with an average score of 38.07%, was among the average-performed areas. This average performance observed through the responses has been largely due to candidates' difficulties in drawing and interpreting practical diagrams and graphs. Common issues included the omission or improper presentation of key graph features such as titles, scales, labelled axes, best-fit lines, transfer of data points, and slope indication. Moreover, many candidates applied incorrect formulas when solving numerical problems and demonstrated inadequate computational skills. A summary of candidates' performance in each topic is provided in Appendices I and II.

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The analysis revealed that the majority of candidates (97.48%) passed the examination. These candidates demonstrated a good understanding of the questions' requirements and possessed adequate knowledge of the subject matter. They effectively applied a range of skills, including language proficiency, mathematical ability, practical competence, and drawing skills to provide accurate and relevant responses. Furthermore, they showed the ability to interpret diagrams and graphs appropriately, particularly in questions that required such understanding. In addition, they were able to identify and apply the correct formulas and equations in solving calculation-based questions.

On the contrary, the observation revealed that 2.52 per cent of the candidates who failed encountered difficulties in providing accurate responses to certain questions. These candidates demonstrated a limited understanding of the subject matter, which hindered their ability to explain key theories, laws, and principles of Physics necessary for analysing related concepts. Likewise, they exhibited a lack of competence in essential skills, particularly mathematical and practical skills, which are crucial for solving calculation-based questions and conducting experiments. Their weaknesses in these areas significantly contributed to their weak performance. For instance, candidates who lacked practical skills often drew graphs which had deficiency of some crucial elements such as titles, appropriate scales, slope indication, best-fit lines, and properly labelled axes with correct units. Furthermore, their inability to interpret graphs accurately led to inadequate responses to questions that required such interpretative skills.

6.2 Recommendations

The following must be considered by teachers to improve the performance of the Physics subject, on the topics which had an average performance:

(a) Guide students in discussing the concepts of displacement, velocity, acceleration, and centripetal force by analysing the motion of an object being whirled in a horizontal plane using a string. Incorporate the use of a stopwatch and a chart containing diagrams of bicycles or vehicles on curved roads to help students determine the magnitude and direction of motion in circular paths.

(b) Guide students, working in groups, to discuss the changes in potential energy (PE) and kinetic energy (KE) during simple harmonic motion (SHM), and to sketch graphs representing these energy variations with respect to displacement using charts illustrating energy changes in SHM. Similarly, facilitate their discussion and derivation of expressions for displacement, velocity, acceleration, and the period of SHM, using experimental setups such as a simple pendulum, a loaded spring, water in a U-tube, a floating loaded test tube, and a stopwatch.

(c) Organise students into groups to perform experiments aimed at determining the radius of gyration for various rigid bodies, such as a rod, disc, lamina, cylinder, and sphere, and to explore their physical significance. Subsequently, guide students to deduce the expression for torque through demonstration, using examples such as a hinged door, and rigid bodies like a disc and a lamina.

(d) Guide students to work in groups to discuss the limits of precision of various measuring instruments, such as the stopwatch, metre rule, micrometre screw gauge, and Vernier calliper. Additionally, assist students in using dimensional analysis to deduce the dimensions of given physical quantities, supported by charts displaying the dimensions of corresponding physical quantities. Furthermore, lead students in brainstorming how to estimate errors in derived physical quantities using instruments such as the metre rule, stopwatch, and beam balance.

(e) Guide students in demonstrating the behaviour of alternating current (AC) as it passes through a resistor, inductor, and capacitor. Assist them in deducing the expressions for capacitive and inductive reactance using an AC source, oscilloscope, inductor, capacitor, and resistor. Subsequently, guide students in applying Kirchhoff's laws and conducting experiments to determine the resistivity of a wire and other electrical properties using the Wheatstone bridge and metre bridge. This should involve instruments and materials such as connecting wires, manganin wire, nichrome wire, constantan wire, sliding wire, galvanometer, resistors, graph paper, and a battery.

(f) Lead students in group discussions to explore the concept of the electric field and lines of force, using charts that display diagrams of electric field patterns. Moreover, guide students in demonstrating and analysing the motion of a charged particle in a uniform electric field. Subsequently, assist students in calculating the electric field intensity for symmetrical charge distributions, including a point charge, a charged sphere, a plane conductor, and a line charge.

Appendix I: The Candidates' Performance in Each Topic in Physics 1 & 2 in ACSEE 2025

S/n.	Topic	2025 EXAMINATION PAPER		
		Number of Questions	Percentage of Candidates who Scored an Average of 35 Percentage or Above	Remarks
1	Environmental Physics	1	97.03	Good
2	Electromagnetism	1	80.78	Good
3	Heat	2	75.14	Good
4	Fluid Dynamics	1	72.92	Good
5	Atomic Physics	1	72.06	Good
6	Properties of Matter	1	71.39	Good
7	Electronics	2	68.06	Good
8	Vibrations and Waves	1	62.79	Good
9	Mechanics	3	51.90	Average
10	Measurement	1	50.62	Average
11	Current Electricity	1	43.27	Average
12	Electrostatics	1	38.67	Average

Appendix II: The Candidates' Performance in Each Topic in Actual Practical Papers 3A, 3B and 3C in ACSEE 2025

S/n.	Topic	2025 EXAMINATION PAPER		
		Number of Questions	Percentage of Candidates who Scored an Average of 35 Percentage or Above	Remarks
1	Heat	1	84.68	Good
2	Mechanics	1	77.96	Good
3	Current Electricity	1	38.07	Average