THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORTON THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2023

PHYSICS

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131 PHYSICS

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FOREWORD

The report on Candidates' Item Response Analysis (CIRA) on the 2023 Advanced Certificate of Secondary Examination (ACSEE) has been prepared to provide feedback to different education stakeholders and the general public on the performance of candidates in Physics subject. It also aims to show the extent to which the instructional goals and objectives of teaching and learning Physics were met.

The analysis shows that the general performance of the candidates in Physics subject was good since the majority (97.74%) of the candidates passed while a few (2.26%) failed. This good performance was obtained in 9 out of 12 topics examined. These topics are Environmental Physics, Measurement, Heat, Electronics, Current Electricity, Mechanics, Properties of Matter, Fluid Dynamics and Electrostatics. However, three topics; Vibrations and Waves, Atomic Physics and Electromagnetism had average performance. Moreover, there was no topic with weak performance.

Factors that contributed to the candidates' good performance include adequate knowledge of the subject matter, ability to explain theories, laws and principles of Physics and understanding the scientific methods to solve problems. The analysis also reveals that there were some candidates with weak performance. These candidates faced various challenges including: lack of skills for solving numerical problems, failure to describe different terminologies and applying inappropriate formulae and procedures in analysing various concepts, failure to abide by the given instructions in assembling the apparati when performing experiments and lack of practical skills.

The National Examinations Council of Tanzania believes that this report will help education stakeholders such as students, teachers and parents to take appropriate teaching and learning interventions to enable students obtain the required skills and knowledge so as to improve candidates' performance in the future examinations administered by the Council.

Finally, the Council would like to express its sincere appreciation to all who participated in the preparation of this report.

Dr Said A. 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 comprised of three papers namely; 131/1 Physics 1 and 131/2 Physics 2 which were theory papers and 131/3 Physics 3, the practical paper.

The theory paper 1 comprised of Sections A and B with a total of ten (10) questions. Section A had seven (7) short answer questions which carried 10 marks each. Section B consisted of three (3) structured questions, each carrying 15 marks. The candidates were required to answer all questions in Section A and two (2) questions from Section B. The theory paper 2 had six (6) structured questions. The candidates were required to answer five (5) questions. Each question carried 20 marks. The practical paper 3 had three alternative papers, namely 131/3A Physics 3A, 131/3B Physics 3B and 131/3C Physics 3C. Each of these papers consisted of three questions. Question 1 carried 20 marks while questions 2 and 3 carried 15 marks each. The candidates were required to sit for either alternative papers and answer all questions.

A total of 23,153 candidates sat for the ACSEE 2023 in Physics subject out of which 22,589 (97.74%) passed while 522 (2.26%) failed. The candidates' performance in the Physics Examination 2023 has increased by 0.26 per cent compared to that of 2022 in which 97.48 per cent of candidates passed. This substantial increase in percentage was contributed by the candidates' good performance in the tested concepts including the improvement observed in four topics which appeared to have weak or average performance in previous years. Table 1 shows the topics with improved performance in 2023 compared to 2022.

Table 1: Candidates' Improved Performance in 4 Topics in ACSEE 2023 Compared to 2022

S/n	Topic	ACSEE 2022			ACSEE 2023		
		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.	Heat	3	56.02	Average	3	80.91	Good
2.	Current Electricity	2	46.05	Average	2	72.63	Good
3.	Fluid Dynamics	1	47.50	Average	1	66.37	Good
4.	Electrostatics	1	58.50	Average	1	63.44	Good

In addition, Figure 1 illustrates the candidates' performance according to grades for two consecutive years 2022 and 2023.

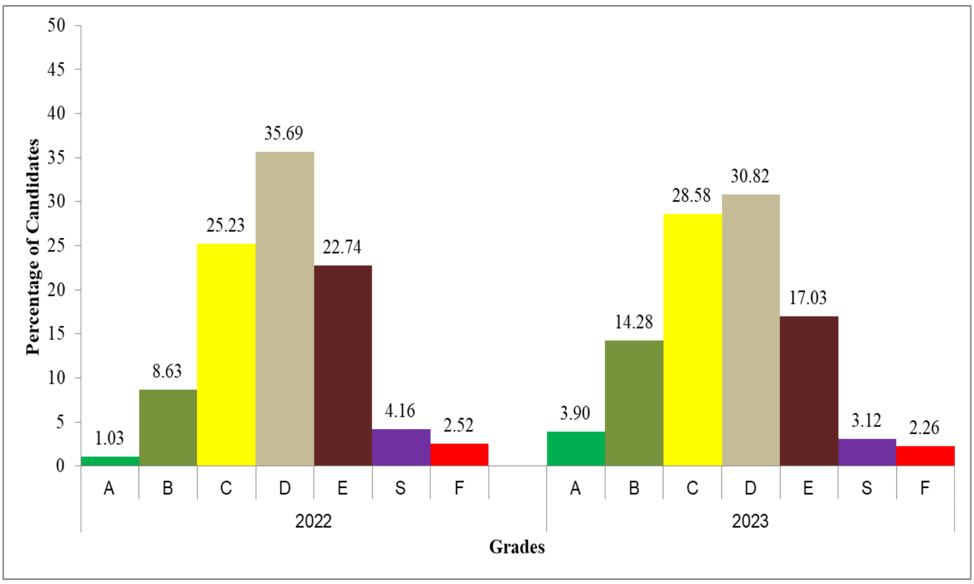


Figure 1: *Candidates' performance according to grades*

Figure 1 shows that in 2023 there is an increase in the percentage of candidates who scored grades A, B and C and a decrease in those who scored grades D, E, S and F as compared to 2022. This reveals a normal distribution curve across the grades.

The next part 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. Subsequently, 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 comprised a total of 10 questions each carrying 10 marks. The pass mark was 3.5 marks. Six (6) topics were examined which are: *Measurement (Physical Quantities and Errors)*, *Mechanics (Projectile motion, Uniform Circular motion and Newton's laws of motion), Heat (Thermometers and First law of Thermodynamics), Environmental Physics, Current Electricity* and *Electronics (The band Theory of Solids, Semiconductors, Transistor, Logic gates & Operational Amplifiers).* The candidates' response analysis for each question is as follows:

2.1 Question 1: Measurement

The question comprised of two parts (a) and (b). In part (a), the candidates were required to (i) differentiate between dimension and

$F = kA\rho A^x$, where F, V, A, ρ and k are the force acting on the body, speed, surface area, density and dimensionless constant respectively. In part (b), they were required to determine the possible percentage error of P from the relation $P = \frac{F}{\pi R^2}$, where F is a force and R the radius given that the percentage error of F and R are ± 2 and ± 1 respectively.

The question was attempted by 23,153 (100%) candidates and its performance was good since a few candidates (4.26%) failed by scoring from 0 to 3.0 marks and the majority (86.08%) scored high marks (from 6.0 to 10), while 9.66 per cent scored average marks (from 3.5 to 5.5). Figure 2 provides the graphical presentation of the candidates' performance in question 1.

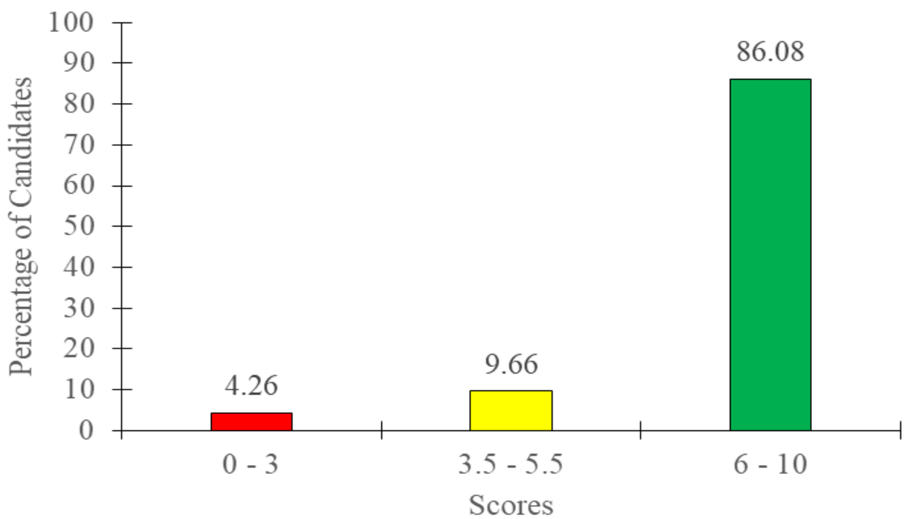


Figure 2: *Candidates' performance in question 1 of paper 1*

Analysis of data reveals that, 86.08 per cent of the candidates who scored higher marks (6.0 to 10) correctly differentiated dimension from dimensional formula with the provision of relevant examples. Most of them had good analytical skills in applying the method of dimension to deduce the value of x in the given expression. However, some of these candidates had wrong perception in formulating the required expression to find the percentage error of pressure and therefore, their marks ranged from 6.0 to 10 depending on the ability of each candidate in describing the concept. Extract 1.1 is a sample of candidates' correct responses to this question.

1 (a) (i) Dimension refers to the power to which ~~a phys:~~ fundamental physical quantities must be raised to represent other physical quantity while dimensional formula is an physical expression written in terms of its dimensions.

For example the dimension of velocity is M^0LT^{-1} but for the formula $V = u + at$ in terms of dimensional formula is written as

$$M^0LT^{-1} = M^0LT^{-1} + M^0LT^{-2}.T$$

(ii). soln:

Given that:

$$F = KA\rho V^x$$

Assume the physical relation is dimensionally correct.

ie $[LHS] = [RHS]$

$$[F] = [KA\rho V^x]$$

$$[F] = [K][A][\rho][V]^x$$

$$M^1LT^{-2} = (L^2)(ML^{-3})(LT^{-1})^x$$

$$MLT^{-2} = (L)^{2-3+x}(M)(T)^{-x}$$

By comparing

$$T: -x = -2$$

$$x = 2$$

∴ The value of x in the expression $F = KA\rho V^x$ is 2.

(b). Soln:

Given: Expression

$$P = \frac{F}{\pi R^2}$$

% age error in $F = \pm 2$

% age error in $R = \pm 1$

Required; to determine percentage error in P.

1 (b) From the expression.

$$P = \frac{F}{\pi R^2}$$

Apply ln to both sides

$$\ln P = \ln\left(\frac{F}{\pi R^2}\right)$$

$$\ln P = \ln F - \ln \pi - \ln R^2$$

$$\ln P = \ln F - 2\ln R - \ln \pi$$

Differentiate with respect to each variable

$$\frac{\Delta P}{P} = \frac{\Delta F}{F} - \frac{2\Delta R}{R}$$

Take the absolute values

$$\left|\frac{\Delta P}{P}\right| = \left|\frac{\Delta F}{F}\right| + \left|-\frac{2\Delta R}{R}\right|$$

$$\frac{\Delta P}{P} = \frac{\Delta F}{F} + \frac{2\Delta R}{R}$$

For percentage error in P

$$\frac{\Delta P}{P} \times 100\% = \left(\frac{\Delta F}{F} + \frac{2\Delta R}{R}\right) \times 100\%$$

$$\frac{\Delta P}{P} \times 100\% = \frac{\Delta F}{F} \times 100\% + 2\frac{\Delta R}{R} \times 100\%$$

But $\frac{\Delta F}{F} \times 100\% = \pm 2\%$ and $\frac{\Delta R}{R} \times 100\% = \pm 1\%$

so

$$\frac{\Delta P}{P} \times 100\% = 2\% + 2(1)\%$$

$$= 2\% + 2\%$$

$$= 4\%$$

∴ The percentage error in P is 4%

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

In Extract 1.1, the candidate provided correct responses about errors in measurement as required.

Some candidates (9.66%) who scored from 3.5 to 5.5 marks provided proper responses but lacked adequate explanations and appropriate computational skills. Consequently, a few candidates did not exhaust all steps in deducing the required expression to find the percentage error of pressure, P. One candidate for example wrote: $P = \frac{F}{\pi R^2}$

$\ln P = \ln F - \ln \pi - 2\ln R$ then

$\frac{\Delta P}{P}=\frac{\Delta F}{F}-\frac{2\Delta R}{R}=\frac{2}{2}-\frac{2(1)}{1}=-1$. Such a response indicated that the candidate lacked the knowledge about maximizing errors. The candidate was supposed to take $\frac{\Delta P}{P}=\frac{\Delta F}{F}+\frac{2\Delta R}{R}$ then multiplying it by 100 % on both sides to get $\frac{\Delta P}{P}\times 100\%=\left(\frac{\Delta F}{F}\times 100\%\right)+2\left(\frac{\Delta R}{R}\times 100\%\right)$ which ends up with $\frac{\Delta P}{P}\times 100\%=\pm(2\%+2(1)\%)=\pm 4\%$.

The responses of 308 (4.26%) candidates who scored from 0 to 3 marks had several weaknesses. Most responses had a mixture of correct and incorrect explanations and procedures of analysing the possible percentage error of pressure and ended up scoring low marks. One candidate for example wrote: *Dimension is the physical quantity that represents the relationship of physical quantities while dimensional formula is the formula that represents the physical quantities*. All these statements were incorrect. Moreover, some of them wrongly used the square bracket for example $[Area]=[L^2]$ or $Area=[L^2]$ instead of $[Area]=L^2$ to represent dimensions. On the other hand, 244 (1.05%) candidates who scored zero diverged from the subject matter. Such candidates failed to apply the methods of dimension and error in the expressions $\mathrm{F}=\mathrm{kA\rho A^x}$ and $\mathrm{P}=\frac{\mathrm{F}}{\pi\mathrm{R}^2}$ to deduce the values of x and possible percentage error of P respectively. Extract 1.2 is an example of a weak response to this question.

1\. i) Dimension differ; is the force acting on the body on the surface area

WHILE

Dimension formular; is the formular that value in expression of density'

ii)

from

$F = K_A \rho V^x$

where F, V, A, ρ and K

from

$F = K_A \rho V^x$

$F = K_A \rho V^x$

$V = V^x \rho$

$A = \rho_A K$

$K = A \rho V^x$

Also

$F = \frac{K_A \rho V^x}{V^x}$

$\therefore F = \frac{K\rho}{V}$

6) Golution

Data given.

$P = \frac{F}{\pi R^2}$

Where F is force

F and R are ± 2 and ± 1.

Required to determine the possible percentage error of P

From

$$P = \frac{F}{\pi R^2}$$

$$F = \pm 2$$
$$R = \pm 1$$

$$P = \frac{F}{\pi R^2}$$

$$P = \frac{\pm 2}{\pm 1}$$

$$P = \pm 1 \times 100\%$$

$$P = \frac{100\%}{2}$$

$$P = 50\%$$

$\therefore$ The percentage error of $P = 50\%$

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

In Extract 1.2, the candidate wrongly related the term dimension with the type of force and applied incorrect procedures to determine the percentage error of pressure.

2.2 Question 2: Mechanics (Projectile Motion)

The question had two parts, (a) and (b). In part (a), the candidates were required to show how the horizontal range will be affected when its initial velocity is doubled by a given angle of projection, θ. In part (b), the candidates were given the velocity of an aircraft of 150 km/hr travelling at the altitude of 250 m which dropped a luggage of food to flood victims isolated on a patch of land below the aircraft. Candidates were required to determine (i) the time which the luggage should be dropped before the aircraft is directed overhead and (ii) the speed of the luggage as it reaches the ground.

A total of 23,153 (100%) candidates attempted this question and the general performance was good since 76.69 per cent of the candidates got the pass mark or above. Data analysis reveals that, 54.97 per cent of the candidates scored from 6 to 10 marks and 21.72 per cent scored from 3.5 to 5.5 marks while 23.31 per cent failed by scoring from 0 to 3 marks. Figure 3 shows the performance of the candidates in this question.

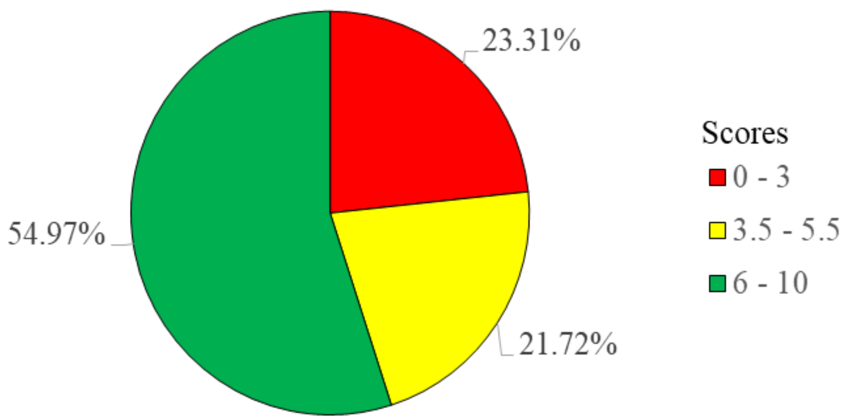


Figure 3: *Candidates' performance in question 2 of paper 1*

The candidates (54.97%) who scored from 6 to 10 marks described correctly projectile motion parameters and its applications in real life. In part (a), most of these candidates used correct formula and procedures to analyse how the horizontal range of a projectile is affected when the initial velocity is doubled while the angle of projection remains constant. Answers like: *if the initial velocity of a projectile is doubled* *the range will be four times the initial horizontal range* prevailed in their responses. In part (b), they described the motion of an aircraft by drawing a clear and well labelled diagram to evaluate the time which supplies were dropped and the velocity of the luggage as it reaches the ground. However, some of these candidates (21.72%) who scored 3.5 to 5.5 marks lacked mathematical skills to analyse correctly the speed and time which the luggage should be dropped before an aircraft is directed overhead. Extract 2.1 represents a sample of candidates' correct response to this question.

2. (a) Soln.

from, Horizontal range (R)

$$R = \frac{U^2 \sin 2\theta}{g}$$

Where θ - is angle of projection

U is initial velocity

Then

$$R' = \frac{U'^2 \sin 2\theta}{g}$$

Where $U' = 2U$

Since the initial velocity is doubled then,

$$R' = \frac{(2U)^2 \sin 2\theta}{g}$$

$$R' = \frac{4U^2 \sin 2\theta}{g}$$

Then,

2 (a) $R = \frac{U^2 \sin 2\theta}{g}$

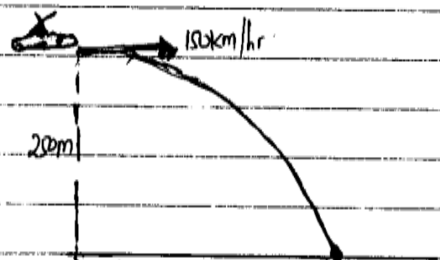
$R' = 4R$

Then The horizontal range will be four times the first horizontal range.

i.e $R' = 4R$.

(b) Soln

Illustrative figure below.



(i) Required is time on which the luggage is droped

from $s = ut + \frac{1}{2}at^2$

$S_y = U_y t + \frac{1}{2}a_y t^2$

$-h = U\sin\theta t - \frac{1}{2}gt^2$

$-h = -\frac{1}{2}gt^2$

$\frac{2h}{g} = t^2$

$t = \sqrt{\frac{2h}{g}}$

$t = \sqrt{\frac{2 \times 250}{g}}$ since $h = 250m$, $g = 9.8 m/s^2$

$t = \sqrt{\frac{500}{9.8}}$

$t = 7.143 sec$

The required time (t) is 7.143 sec.

2 (b) (ii) Required, speed of luggage as it reaches the victim from

$V = u + at$

$V_x = U_x + a_x t$

$V_x = U\cos 0$

$V_x = U$

$V_y = u_y + a_y t$

$V_y = U\sin 0 - gt$

$V_y = -gt$

Then,

$V = \sqrt{V_x^2 + V_y^2}$

$V = \sqrt{U^2 + (-gt)^2}$

$V = \sqrt{(41.67)^2 + (9.8 \times 7.143)^2}$

$V = \sqrt{6636.58}$

$V = 81.465\,m/s$

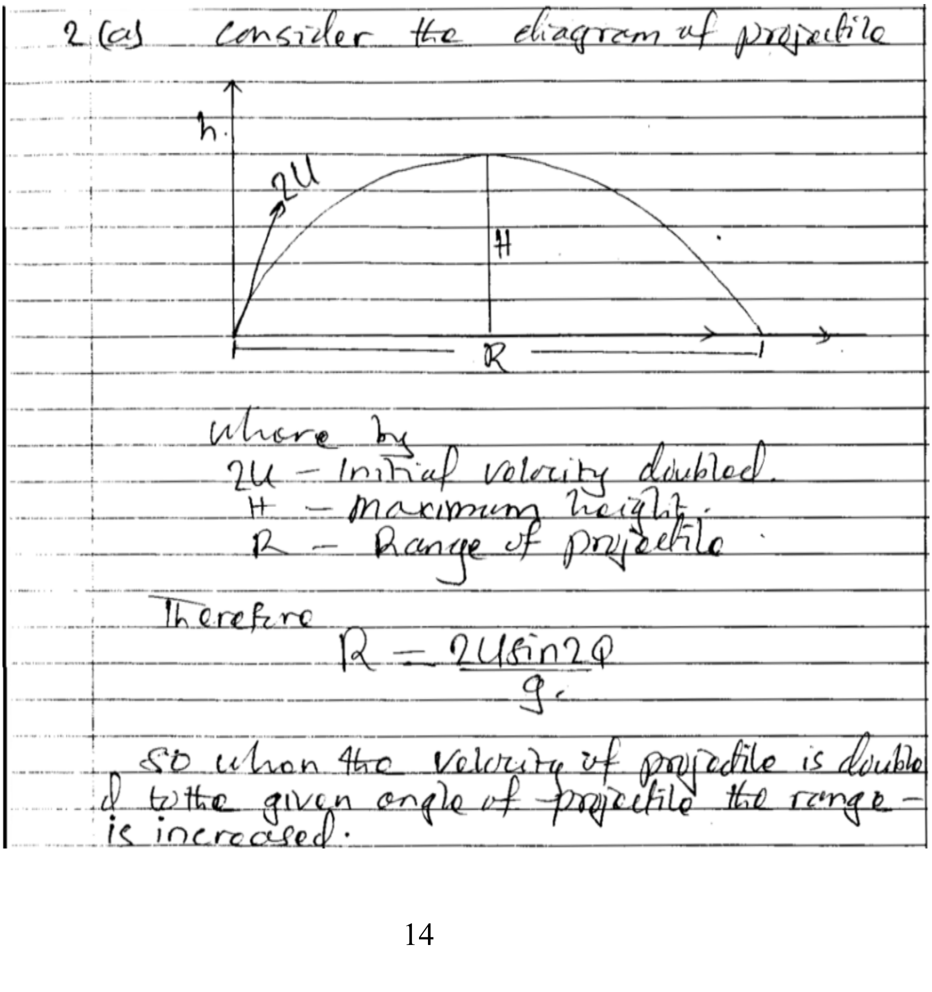
The speed of luggage as it reaches victim is $81.465\,m/s$

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

In Extract 2.1, the candidate applied the correct formula and procedures to obtain the time of flight and speed of luggage as it reaches the ground.

The candidates (23.31%) who scored from 0 to 3 marks had weaknesses in their responses. Some responses presented were either wrong or partially analysed. Other candidates only responded to part (a) of this question. Whereas, candidates who scored 0 marks went astray from the subject matter. Some of these candidates for example derived the formula for the horizontal range such as $R = \frac{V_o^2 \sin 2\theta}{g}$

$t = \dfrac{v_0 \sin\theta}{g}$ and $v = \sqrt{vgt}$ to determine the time and velocity respectively. These candidates failed to understand that a horizontal projection had an angle $\theta = 0$, so in substituting this value in the Newton's second equation of motion we obtain $y = v_0 \sin\theta t + \frac{1}{2}gt^2 = \frac{1}{2}gt^2$ and finally the expression to find time becomes $t = \sqrt{\dfrac{2y}{g}}$. Moreover, they could manipulate and insert the values of $V_x = V_0\cos\theta$ and $V_y = V_0\sin\theta - gt$ in the formula $V = \sqrt{V_x^2 + V_y^2}$ that finds the speed of the luggage as it reaches the ground. Extract 2.2 shows one of the incorrect responses to this question.


2 (a) Consider the diagram of projectile

where by
2U - Initial velocity doubled.
H - Maximum height.
R - Range of projectile.

Therefore
$R = \dfrac{2U\sin 2\theta}{g}$

So when the velocity of projectile is doubled to the given angle of projectile the range is increased.

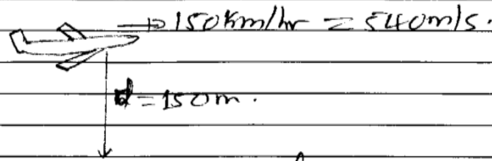
2 b) Soln.

Velocity of aircraft (V) = 150km/hr.

height from ~~abov~~ the aircraft to the land 250m

(i) required time

consider.



from Newton's second ~~law~~ eqn.

$S = ut - \frac{1}{2}gt^2$.

$150 = 540t - \frac{1}{2} \times 9.8 \times t^2$.

$150 = 540t - 4.9t^2$

$4.9t^2 - 540t + 150 = 0$

$t = 109.93$ sec $\approx$ ~~10~~ 110sec

∴ The time required = 110 sec.

Ti) Speed = ?

from Newton's ~~3~~rd eqn

Now

$V = u + at$.

$V = u - gt$.

$V^2 = u^2 - 2gs$.

$V^2 = -2gs$

2 b(ii) $V^2 = -gs$

$V = \sqrt{-gs}$

$V = \sqrt{9.8 \times 250}$

$V = 49.5$ m/s.

∴ Speed of luggage = 49.5m/s.

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

In Extract 2.2, the candidate drew an incorrect diagram and applied incorrect formulae and procedures to obtain incorrect responses of time and speed of the luggage.

2.3 Question 3: Mechanics (Uniform Circular Motion)

The question consisted of two parts (a) and (b). In part (a), the candidates were required to determine the least coefficient of friction at which the car with a speed of 40 m/s will be able to negotiate the unbanked curve of radius 500 m without sliding. In part (b), the candidates were given a stone of mass 1 kg attached to a string of length 1 m which was whirled in a horizontal circle of radius 0.6 m at a constant speed. The candidates were required to calculate (i) the tension in the string and (ii) the maximum number of revolution per second it can make.

A total of 23,151 (99.99%) candidates attempted this question and their scores were as follows: 29.0 per cent scored from 0 to 3 marks, 17.25 per cent scored from 3.5 to 5.5 marks and 53.75 per cent scored from 6 to 10 marks. Generally, the candidates' performance in this question was good as 71 per cent scored above 3.0 marks. Figure 4 summarizes the performance of the candidates in this question.

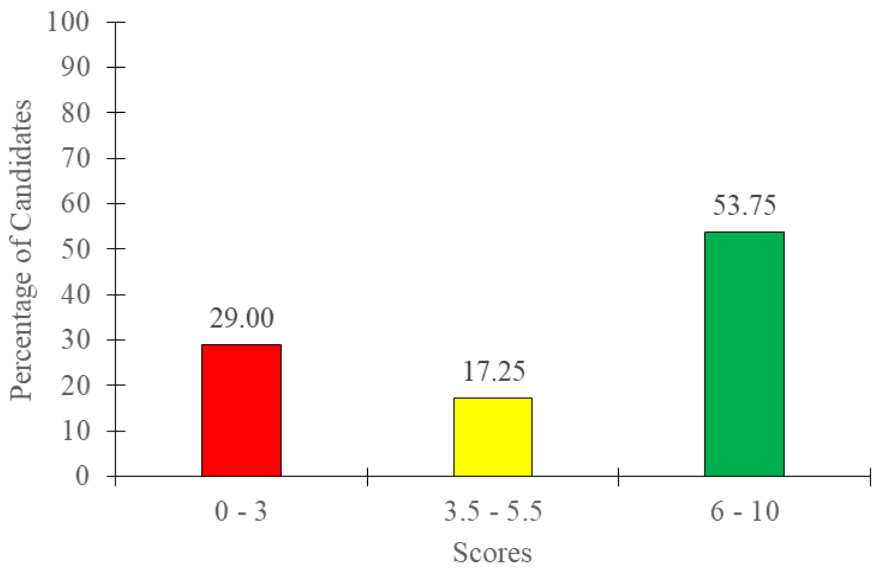


Figure 4: *Candidates' performance in question 3 of paper 1*

Candidates (53.75%) who performed well in this question had adequate knowledge to give the correct responses. In part (a), most of these candidates correctly applied the formula and procedure to determine the least coefficient of friction which allows the car to negotiate the curve without sliding. In part (b), they applied computational skills to draw and resolve the diagram in formulating expressions to compute the tension and maximum number of revolutions per second. Extract 3.1 is a sample of such a correct response.

03 (a) Solution

Data given.

speed (v) = 40 m/s

radius (r) = 500 m.

Required the coefficient of friction (μ_s) = ?

from the formular.

$$V = \sqrt{\mu r g}$$

$$V^2 = \mu r g$$

$$\mu = \frac{V^2}{rg}$$

$$= \frac{(40)^2}{500 \times 9.8}$$

$$= 0.327$$

∴ least coefficient of friction is 0.327

3 (b) solution

Data given

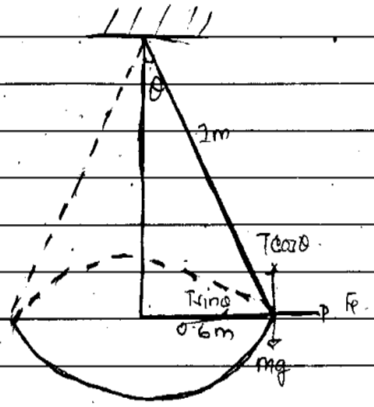
mass(m) = 1Kg

Length of the string(L) = 1 m

radius (r) = 0.6m

Required tension (T) = ?

Consider the figure below.



from the above the angle can be found as follow

$$\sin\theta = \frac{0.6}{1}$$

$$\theta = \sin^{-1}(0.6)$$

$$\theta = 36.87°$$

Balancing the forces vertically

$$T\cos\theta = mg$$

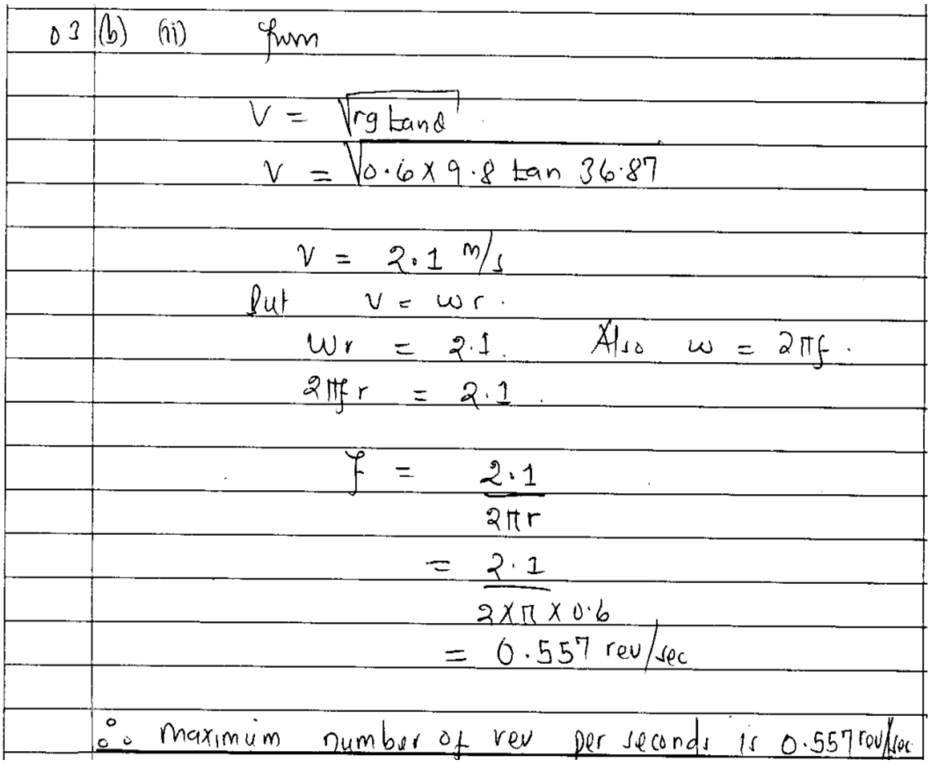
$$T = \frac{mg}{\cos\theta}$$

$$T = \frac{1\,Kg \times 9.8\,m/s^2}{\cos 36.87}$$

$$T = 12.25\,N$$

∴ tension of the string is 12.25 N

(ii) maximum number of revolution



03 (b) (ii) from

$V = \sqrt{rg\tan\theta}$

$V = \sqrt{0.6 \times 9.8 \tan 36.87}$

$V = 2.1\ m/s$

Put $v = \omega r$.

$\omega r = 2.1$. Also $\omega = 2\pi f$.

$2\pi f r = 2.1$.

$f = \frac{2.1}{2\pi r}$

$= \frac{2.1}{2 \times \pi \times 0.6}$

$= 0.557$ rev/sec

∴ maximum number of rev per seconds is 0.557 rev/sec

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

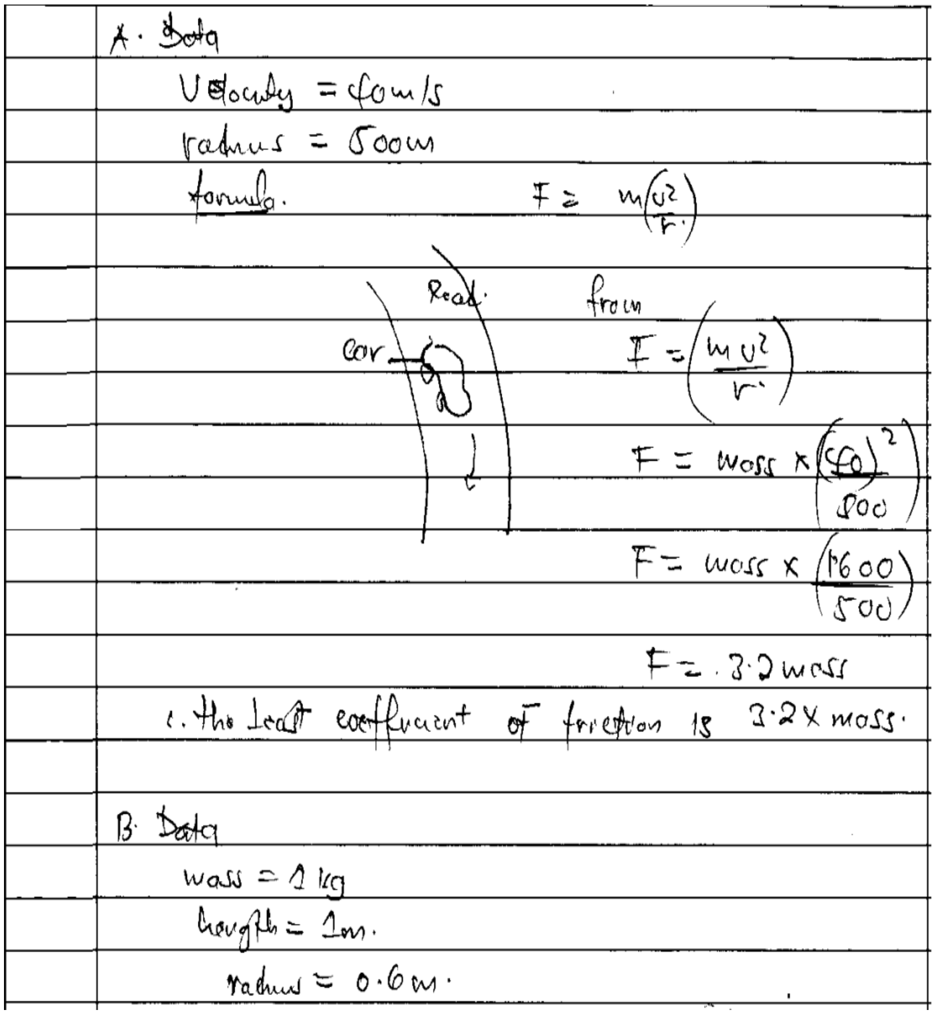
In Extract 3.1, the candidate applied the correct formula, procedures and free-force diagram to evaluate the least coefficient of friction, tension and maximum number of revolutions per second.

On the other hand, 29 per cent of the candidates who scored 0 to 3 marks had inadequate knowledge of uniform circular motion specifically, the motion of a curved road and the concept of motion in a horizontal circle. They failed to apply mathematical skills to solve most parts of the question. In part (a) for example some of these candidates used wrong formulae such as $\mu = \frac{v^2}{r}$ $\mu = \sqrt{\frac{g \times r}{v^2}}$

$\mu = \frac{v^2}{rg}$ $v^2 >$

μrg

$\mu = \frac{v^2}{r \times g}$ is used to determine the least coefficient of friction. In part (b), most of them lacked knowledge and skills to deduce the vertical and horizontal components of tension such as $T\cos\theta = mg$ and $T\sin\theta = \frac{mv^2}{r}$ respectively. Another weakness was observed by some candidates who applied incorrect formulae for instance $r^2 = vg\tan\theta$ and $\omega = \sqrt{\frac{r\tan\theta}{g}}$ instead of $v^2 = rg\tan\theta$ and $\omega = \sqrt{\frac{g\tan\theta}{r}}$ respectively. As a result, they obtained incorrect values of tension and a maximum number of revolutions per second. Extract 3.2 is a sample of a candidates' incorrect response to this question.



A. Data

Velocity = 40 m/s

radius = 500 m

formula. F = m(v²/r)

Road. car

from F = (mv²/r)

F = mass × (40)²/500

F = mass × (1600/500)

F = 3.2 mass

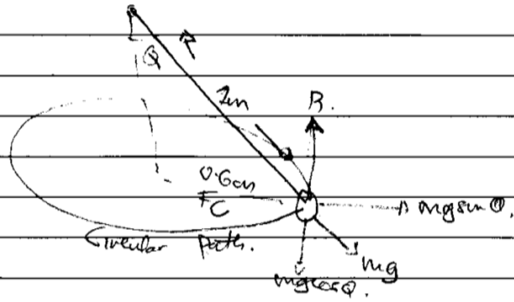
∴ the least coefficient of friction is 3.2 × mass.

B. Data

mass = 1 kg

length = 1 m.

radius = 0.6 m.



from

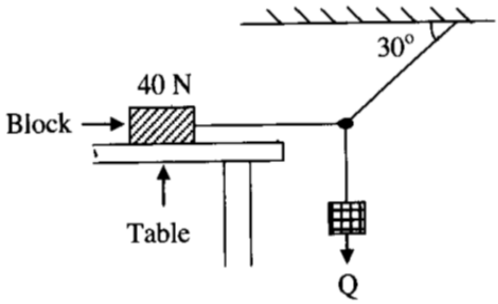
	1) $T = mg$.
	$T = 1\text{kg} \times 9.8\ \text{m/s}^2$.
	Tension = 9.8N.
3	B. 1) Maximum Number of revolution
	from
	$F_c = mg \sin\theta$
	from
	$F_c = \left(\frac{mv^2}{r}\right)$
	$F_c = mw^2r$.
	F_c = Centripetal force.
	Tension = F_c.
	$F_c = T = 9.8N$.
	$9.8N = mg$.
	$mg = mw^2r$.
	$\frac{g}{r} = \frac{w^2r}{r}$.
	$w^2 = \left(\frac{g}{r}\right)$
	$w^2 = \left(\frac{g}{r}\right)$
	$w = \sqrt{\left(\frac{g}{r}\right)}$
	$2\pi f = \sqrt{\left(\frac{g}{r}\right)}$
	$f = \left(\frac{1}{2\pi}\right)\sqrt{\frac{g}{r}}$
	$f = \left(\frac{1}{2\pi}\right)\sqrt{\frac{9.8}{0.6}}$
	$f = 0.6432$ /sec
	$f = 0.6432\ \text{sec}^{-1}$

Extract 3.2: A sample of an incorrect response to question 3 in paper 1

Extract 3.2 shows that the candidate lacked knowledge of the key concepts of uniform circular motion, specifically the resolution of formulae for tension and maximum number of revolutions.

2.4 Question 4: Mechanics (Newton's Laws of Motion)

This question had two parts (a) and (b). Part (a) required the candidates to (i) give two daily life examples where Newton's first law of motion is applicable and (ii) find the force required to keep the conveyor belt moving at a speed of 5 cm/s, if a sand drops vertically at the rate of 100 g/s on it. In part (b), the candidates were given the following figure showing the system of forces being at equilibrium and required to determine the maximum force Q if the friction on the block cannot exceed 12 N.



The question was attempted by 23,153 (100%) candidates whose scores were as follows: 35.13 per cent scored from 0 to 3 marks, 46.13 per cent scored from 3.5 to 5.5 marks and 18.74 per cent scored from 6 to 10 marks. These scores imply that the general performance in this question was good as 64.87 per cent scored from 3.5 to 10 marks. Figure 5 is a graphic representation of these scores.

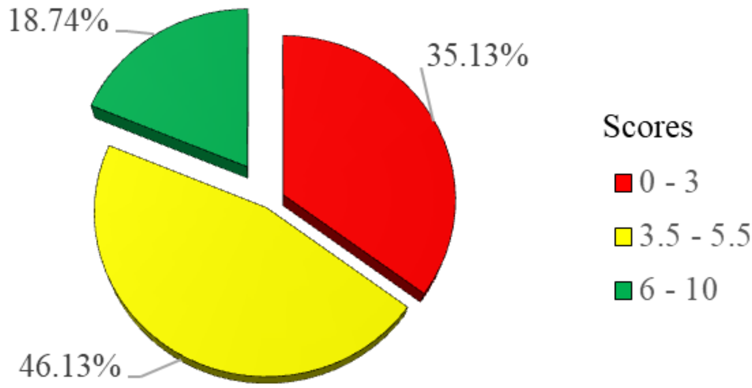
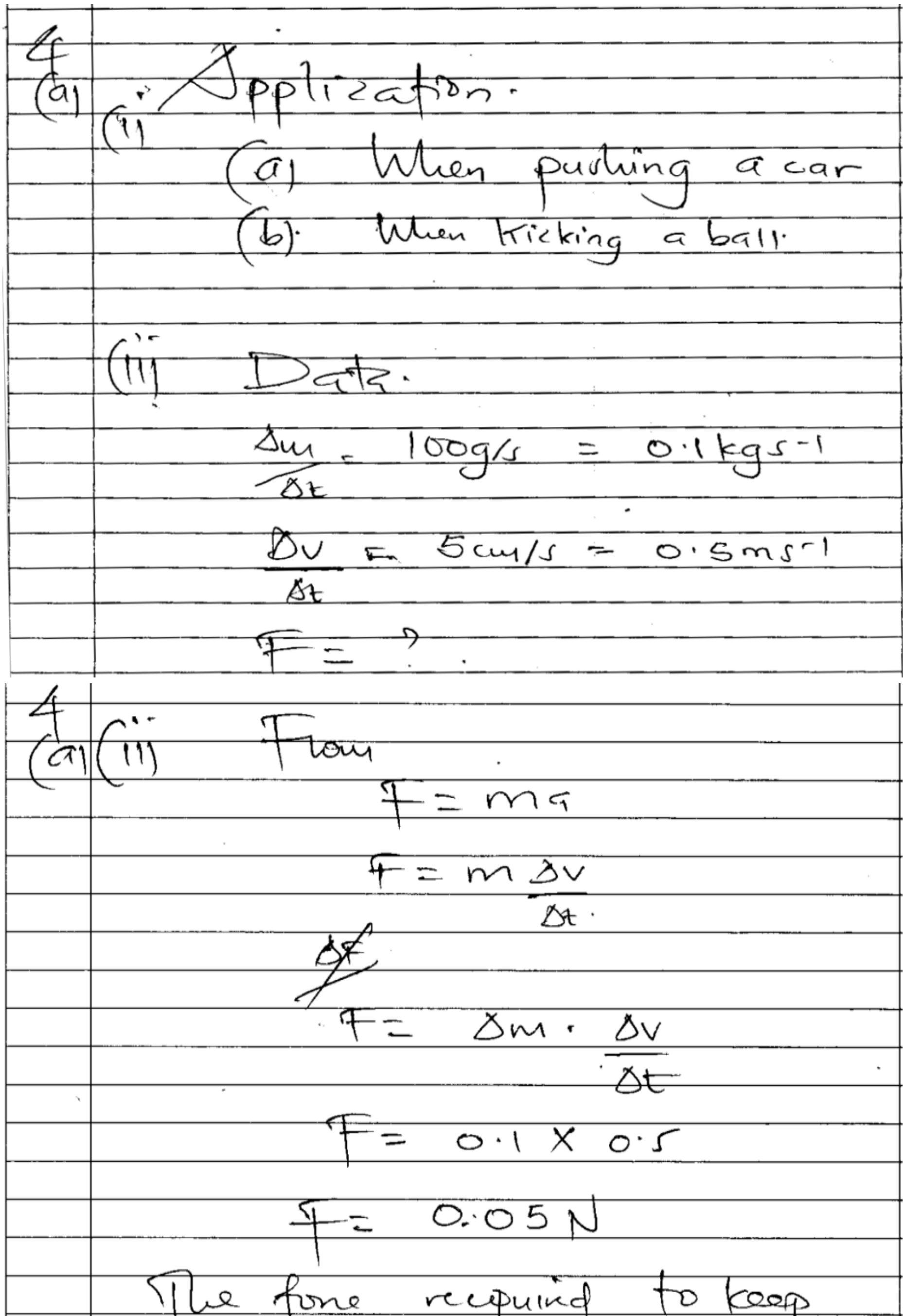


Figure 5: *Candidates' performance in question 4 of paper 1*

Although the question was well performed by a majority (64.87%) of the candidates, more than one third (35.13%) scored low (0 to 3) marks in this question. In part (a), some candidates gave irrelevant examples where Newton's first law of motion applies. Such responses includes: *Kicking of a soccer ball at rest, pushing of a swing from rest to start oscillating, pull or push of some doors.* The candidates were required to respond as follows: When a car suddenly starts passengers in it tend to fall backward, when a man jumps into a moving car he falls backward, an athlete runs some distance before executing a jump, when a moving bus suddenly stopped the passengers in it tend to fall forward, the mud from the wheels of a moving vehicle flies of tangentially and tightening of seat belts in a car when it stops quickly. In addition, some candidates failed to recall and apply Newton's second equation of motion by writing $\frac{R}{v} = \frac{v \times f}{v}$ and $F = \frac{100\ g/s}{5\ cm/s} = 20\ N$ instead of $F = \frac{mv - mu}{t}$ or $F = v\frac{dm}{dt}$ to find the force required to keep the belt moving. In part (b) they encountered difficulties in describing the diagram and applying the correct formula and procedures in answering the question. Some of these candidates scored 2 to 3 marks depending on the relevance of their responses. Moreover, candidates who scored a zero mark diverged from the demand of the question. Most of them skipped part (b) while other candidates provided inappropriate responses to part (a). Such incorrect responses indicate that most candidates had inadequate knowledge of the subject matter. Extract 4.1 is an example of a candidate who provided irrelevant responses.



4 (a) (i) Application.

(a) When pushing a car

(b) When kicking a ball.

(ii) Data.

$\frac{\Delta m}{\Delta t} = 100g/s = 0.1kgs^{-1}$

$\frac{\Delta v}{\Delta t} = 5cm/s = 0.5ms^{-1}$

$F = ?$

4 (a) (ii) From

$F = ma$

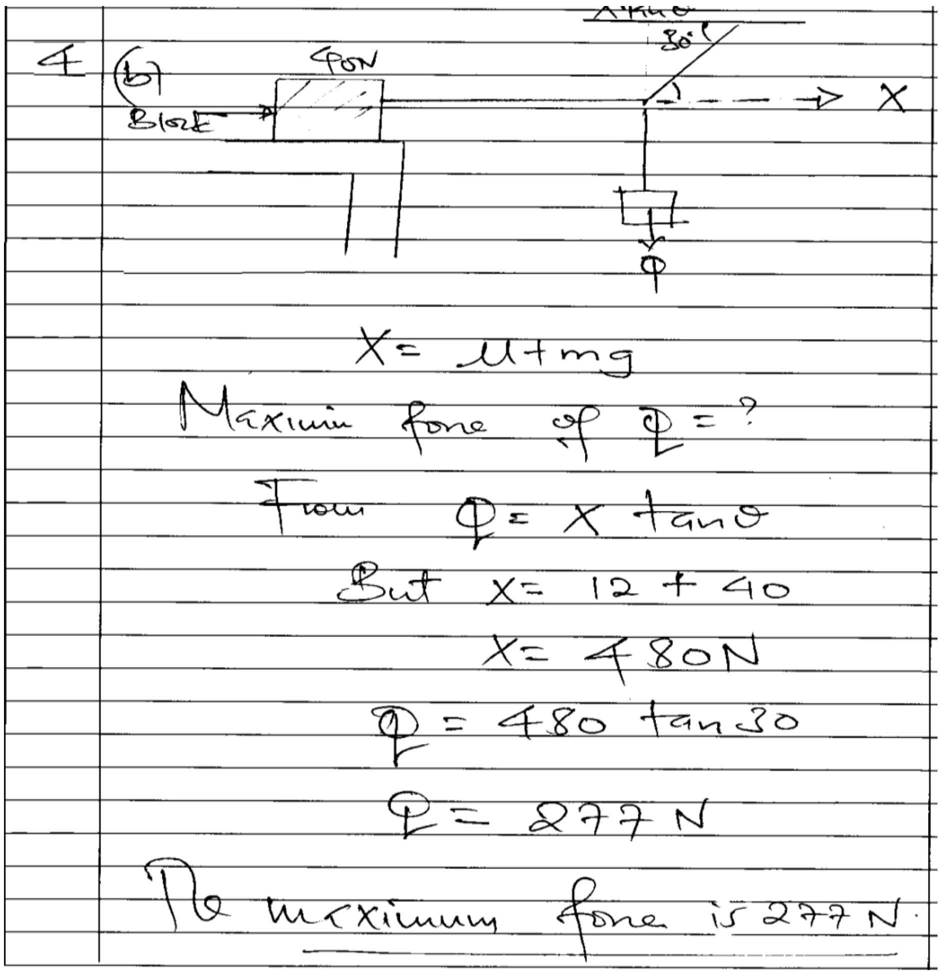
$F = m\frac{\Delta v}{\Delta t}$

$F = \Delta m \cdot \frac{\Delta v}{\Delta t}$

$F = 0.1 \times 0.5$

$F = 0.05N$

The force required to keep the belt in motion is 0.05N.



Extract 4.1: A sample of an incorrect response to question 4 of paper 1

In Extract 4.1, the candidate provided irrelevant responses in part (a) and applied incorrect formula and procedures in part (b) to resolve equilibrant forces on a body.

The candidates (18.74%) who scored from 6 to 10 marks understood and interpreted the question correctly. In part (a), most of these candidates identified daily life examples where Newton's first law of motion applies. Moreover, they applied the expression of Newton's second equation of motion to determine the force required to keep the belt moving. In part (b), they used mathematical skills to resolve the tension of determining the maximum value of force Q. However, candidates' scores varied due to their diverse strengths in identifying examples where Newton's first law of motion is based and interpreting the system of forces in the given figure. Extract 4.2 is a sample of a correct response to question 4.

4(a) i) Two daily life examples are

→ When a car suddenly applying brakes passengers tend to move forward since their upper part of body are in motion while lower part of the body become at rest with a car.

→ falling of mango fruits when mango branches are suddenly shaken. since the mango resist the state of motion of mango branches made them to fall down.

ii) solution.

Required the force to keep the belt moving

From Newton's second law of motion.

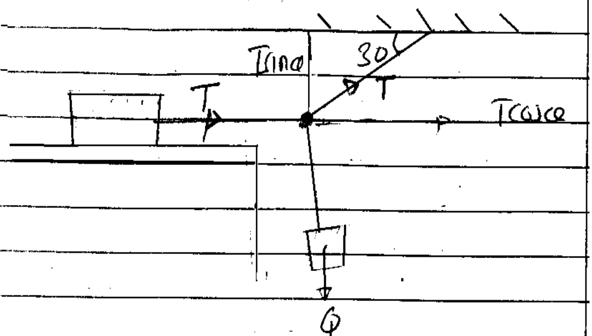
$$F = \frac{Vdm}{dt}$$

$$F = 0.05 m/s \times 0.1 kg/s$$

$$F = 5 \times 10^{-3} N.$$

∴ The force required is $5 \times 10^{-3} N$.

4(b) solution.
consider the resolved diagram.



Required the maximum value of Q
from diagram above

Sum of upward force = sum of downward force.

$T\sin\alpha = Q$

$T\sin 30 = Q$

$Q = \frac{1}{2}T$ —— (1)

since the system is at equilibrium.

$T\cos\alpha = 12$

$T = \frac{12}{\cos\alpha}$

$T = \frac{12}{\cos 30}$

$T = 13.86N$

from eqn (1)

$Q = \frac{1}{2}T$

$Q = \frac{1}{2} \times 13.86$

$Q = 6.928N$

∴ Maximum value of force Q is 6.928N

Extract 4.2: A sample of correct responses to question 4 of paper 1

In extract 4.2, the candidate correctly specified daily life examples of Newton's first law of motion and evaluated the required values of forces.

2.5 Question 5:Heat (Thermometers and First law of Thermodynamics)

This question consisted of two parts (a) and (b). In part (a), the candidates were required to (i) calculate the temperature of the escaping air from the suddenly bursting tyre, if before bursting the car tyre has a pressure of 4 atmospheres at a room temperature of 27ºC. In part (b), they were required to (i) distinguish between triple point of water and thermometric property as used in heat and (ii) calculate the temperature as measured on the scale of the resistance thermometer which corresponds to a temperature of 70ºC on the gas thermometer when the resistance R_θ of a particular resistance thermometer at a Celsius temperature θ as measured by a constant volume gas thermometer is given by $R_\theta = 2.50\times10^{-4}\theta^2 + 0.18500\theta + 40.0$.

The question was attempted by 23,152 (99.99%) candidates and their performance was good since less than one third (23.44%) candidates failed by scoring from 0 to 3 marks and more than a half (50.86%) of the candidates scored higher marks (from 6 to 10), while 25.70 per cent scored average marks (from 3.5 to 5.5). Figure 6 shows the performance of the candidates in question 5.

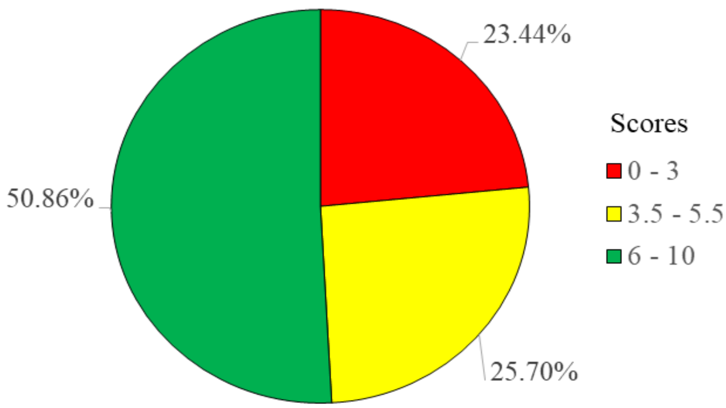


Figure 6: *Candidates' performance in question 5 of paper 1*

The candidates (50.86%) who scored high marks (6 to 10) were competent in describing thermodynamics processes especially in adiabatic process. In part (a), most of these candidates applied the correct formula $P^{\gamma-1}T^{-\gamma} = K$ to determine the temperature of the escaping air. In part (b), they correctly distinguished the triple point of water from thermometric property and applied the correct formula $\theta = \left(\frac{R_\theta - R_0}{R_{100} - R_0}\right) \times 100^0 C$ to determine the temperature as measured on the scale of resistance thermometer at 70^0C. However, their scores varied due to inadequate knowledge of temperature scales as they failed to analyse the concept correctly. Extract 5.1 is a sample of a candidate's correct response.

5. (a) Soln

Data given

Initial pressure (P_1) = 4atm.

temperature (T) = 27°C

Then, after burst the final pressure is atmospheric pressure

P_2 = 1atm

Then the bursting of tyre is adiabatic process then,

$$P_1V_1^\gamma = P_2V_2^\gamma$$

from

$$PV = nRT.$$

$$P_1\left(\frac{nRT_1}{P_1}\right)^\gamma = P_2\left(\frac{nRT_2}{P_2}\right)^\gamma$$

$$\frac{P_1T_1^\gamma}{P_1^\gamma} = \frac{P_2T_2^\gamma}{P_2^\gamma}$$

$$P_1^{1-\gamma}T^\gamma = P_2^{1-\gamma}T_2^\gamma$$

Then but $\gamma = 1.4$

$$4^{1-1.4}(273+27)^{1.4} = 1^{1-1.4}T_2^{1.4}$$

$$0.574 \times 2937.44 = T_2^{1.4}$$

$$1{,}686.09 = T_2^{1.4}$$

$$T_2 = 201.797K$$

5 (a) $T_2 = 201.797 K$.

$T_2 = (201.797 - 273)°C$

$T_2 = -71.2°C$.

Hence, The final Temperature is $-71.2°C$.

(b) (i) Triple point of water is the temperature in which all three states of water (solid, liquid, vapour) exist in equilibrium and it is at 273.16K ~~white~~

WHILE

Thermometric property is the property of any material which varies linearly and continuous with variation of temperature example resistance of platinum wire.

(ii) Soln

from

$R_\theta = 2.5 \times 10^{-4}\theta^2 + 0.1850\theta + 40$

At melting point $\theta = 0°C$

$R_0 = 40.0$

at boiling point of water, $\theta = 100°C$

$R_{100} = 2.5 \times 10^{-4} \times 100^2 + 0.1850 \times 100 + 40$

$R_{100} = 2.5 + 18.50 + 40$

$R_{100} = 61$.

Then at Temperature $(t = 70°C)$.

$R_{70} = 2.5 \times 10^{-4} \times 70^2 + 0.1850 \times 70 + 40$

$R_{70} = 1.225 + 12.95 + 40$

$R_{70} = 54.175$

Then from $°C = \left(\frac{R_\theta - R_0}{R_{100} - R_0}\right) \times 100°C$.

$°C = \left(\frac{54.175 - 40}{61 - 40}\right) \times 100°C$

5 (b)(ii) $°C = \frac{14.175}{21} \times 100°C$

$°C = 67.5°C$

The corresponding temperature is $67.5°C$.

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 adequate knowledge of adiabatic equations and mathematical skills as he/she applied the correct formula to obtain the required answer.

The responses of the candidates who scored from 0 to 3 marks had several weaknesses. Most of these candidates presented inappropriate responses in analysing the asked concepts. Furthermore, candidates who scored zero lacked mathematical skills in applying formulae based on thermodynamic processes. Consequently, they lacked knowledge of thermometric properties of a substance and therefore, failed to describe thermodynamic scale of temperature. Other candidates in this category provided irrelevant responses. One candidate for example wrote: *Triple point of water is a point where* 0^0C *of water is raised to* 100^0C *while thermometric property is the ability of a substance to apply thermometer at different condition*. This candidate had inadequate knowledge about triple point of water which is a point at which vapour, liquid and solid states of a substance co-exist in equilibrium while thermometric property is a physical property which varies linearly and continuously with change in temperature. In addition, some of these candidates applied wrong formulae like Boyle's law equation, PV=K and Pressure law equation $\text{PT}^{-1} = \text{K}$ instead of adiabatic equation $\text{P}^{\gamma-1}\text{T}^{-\gamma} = \text{K}$ or $\text{T}_1^{\gamma}\text{P}_1^{1-\gamma} = \text{T}_2^{\gamma}\text{P}_2^{1-\gamma}$ to determine the temperature of the escaping air. Extract 5.2 is a sample of an incorrect response to this question.

5. ⓐ. Given:

Pressure(P) = 4 atm.

Temperature (T) = 27°C. = 300K.

From:

$PV = nRT$.

$P = \left(\frac{nR}{V}\right)T$

$\frac{nR}{V}$ = constant.

$P = KT$

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$.

$P_1 = 4atm$

$P_2 = 1atm$

$\frac{4atm}{300K} = \frac{4atm}{T_2}$.

$\frac{4}{300K} = \frac{4}{T_2}$.

$T_2 = 75K$.

∴ The temperature of the escaping air is 75K.

5. b (i) Triple point of water is the point where by the boiling point of water is about 100°C. Where as Thermometric property are the properties of the material which have varying ability to conduct heat.

(ii) Given:

$R_\theta = 2.50 \times 10^{-4}\theta^2 + 0.1850\theta + 40$

$\frac{dR}{d\theta} = 5 \times 10^{-4}\theta + 0.185$

$R_\theta = 2.5 \times 10^{-4}(70)^2 + 0.1850 \times 70 + 40$

$R_\theta = 54.175°C$

$R_\theta = 54.2°C$

∴ ~~The Them~~ The temperature is 54.2°C

Extract 5.2: A sample of an incorrect response to question 5 of paper1

In Extract 5.2, the candidate applied the gas equation $Pv = nRT$ instead of adiabatic equation $T_1^{\gamma}P_1^{1-\gamma} = T_2^{\gamma}P_2^{1-\gamma}$ for calculating the temperature of the escaping air. In part (b), the candidate failed to apply knowledge of thermometric property of a substance in the given expression to determine the required temperature.

2.6 Question 6: Heat (First law of Thermodynamics)

The question consisted of two parts (a) and (b). In part (a), the candidates were required to (i) give the meaning of reversible process as applied in the thermodynamics and (ii) distinguish isobaric process from isochoric process. In part (b) it was given that, 1 g of water becomes 1671 cm^3 of steam when subjected to pressure of 1.013×10^5 Pa. The candidates were required to calculate (i) the external work done and (ii) the increase in internal energy of the system.

The question was attempted by 23,153 (100%) candidates and their scores were as follows: 56.23 per cent scored from 6 to 10 marks, 24.65 per cent scored from 3.5 to 5.5 marks and 19.12 per cent scored from 0 to 3 marks as presented in Figure 7.

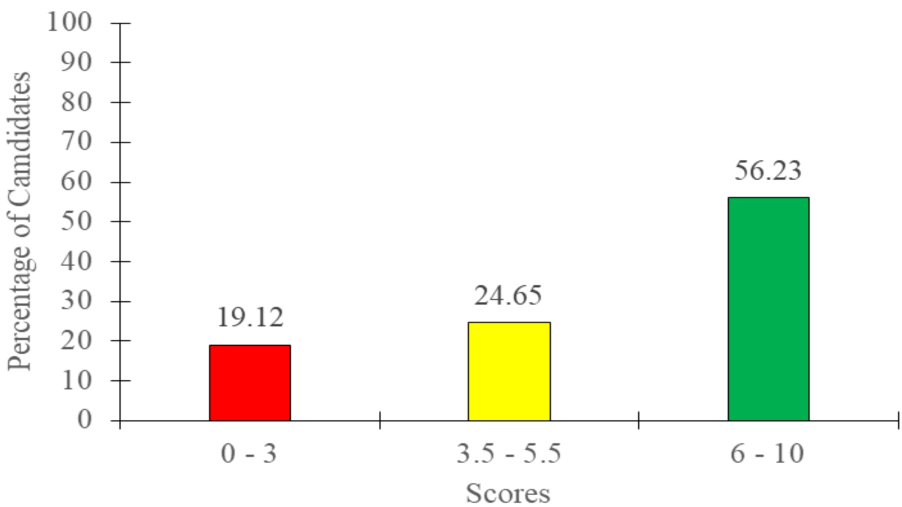


Figure 7: *Candidates' performance in question 6 of paper 1*

Figure 7 reveals that the candidates' general performance in this question was good because 80.88 per cent of the candidates scored above 3 marks.

The candidates (56.23%) who scored high marks (6 - 10) had adequate knowledge about the application of First law of Thermodynamics in real life. In part (a), most of these candidates correctly described thermodynamic processes by explaining the meaning of reversible, isochoric and isobaric processes. Subsequently, some candidates used diagrams to distinguish the two concepts. In part (b), they applied mathematical skills to organise the data in calculating the external work done required to convert 1 g of water into vapour and the increase in internal energy of the system. However, some of the candidates who scored average mark skipped part (b) (ii) while others described reversible, isobaric and isochoric processes interchangeably. Extract 6.1 is a sample of a candidates' correct response.

6(a) (i) Reversible process is any process which can be made to proceed in the reverse direction so that it passes through exactly the same state in all respects as in the direct process.

(ii) ~~Isobarick~~ Isobaric process is the process which proceeds in such a way that pressure is kept constant throughout the thermodynamic process.

While

Isochoric process is the thermodynamic process which proceeds in such a way that volume remains constant throughout the thermodynamic process

(b) given: $P = 1.013 \times 10^5$ Pa

$V_2 = 1671$ cm^3

$V_1 = 1$ cm^3

$W = P(V_2 - V_1)$

$W = 1.013 \times 10^5 \text{ Pa} (1671 - 1) \text{ cm}^3$

$W = 1.013 \times 10^5 \text{ Pa} \times 1670 \text{ cm}^3$

But $1 \text{ m}^3 = 1000000 \text{ cm}^3$

$x = 1670 \text{ cm}^3$

$x = \frac{1670}{10^6} \text{ m}^3$

$x = 1.67 \times 10^{-3}$

$W = 1.013 \times 10^5 \text{ Pa} \times 1.67 \times 10^{-3}$

$W = 169.171$ Joules.

∴ External Work done is 169.171 J

6(b) ~~mass~~.

From

$Q = \Delta U + W$

$Q = mL_v$

$Q = 1g \times 2256$ J/g

$Q = 2256$ J

Now: $\Delta U = Q - W$

$= 2256 \text{ J} - 169.171$

$\Delta U = 2,086.829$ J

∴ Increase in internal energy is 2,086.829 J

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

In Extract 6.1, the candidate correctly explained the meaning of thermodynamic processes and applied the correct formula and procedures to determine the external work done and increase in internal energy of the system.

In contrast, 19.12 per cent of the candidates who scored low marks (0 - 3) demonstrated lack or inadequate knowledge of the tested concepts. These candidates either failed to give the meaning of the terms or provided responses which had unclear explanations. One of these candidates for example wrote: *reversible process is any process in which heat supplied to the system change automatically and equal to external work done.* Another candidate wrote: '*Isobaric process is the process of pressure while isochoric process is the process of volume.* This candidate failed to understand that in isobaric process pressure remain constant because when heat energy is added to the system, both the internal energy of the gas and external work increases while isochoric process occur at constant volume because all heat added increases only the internal energy of the system. Further, analysis reveals that, most of the candidates in this category applied irrelevant formula such as $density = \frac{m}{v}$, $P_1V_1^\gamma = P_2V_2^\gamma$ and $W = \frac{nR}{1-\gamma}\left(P_1V_1 - P_2V_2^\gamma\right)$ instead of $W = P\ (V_2 - V_1)$ and $Q = \Delta U + W$ to compute the external work done and internal energy of the system. Extract 6.2 shows incorrect responses given by one of these candidates.

6(a) (i) Reversible process is the state in which the temperature of the system is at equilibrium.

ii) Isobaric process is the condition in which pressure and volume are inter-changing such as pressure may be constant while volume change.

But

Isochoric process is the state in which both pressure and volume are balanced / constant.

(b) i) External work done.

W·done = Fd.

W·done = P·A·d.

~~W·done = Pressure x Volume.~~

W·done = P x V

6 (b) i) External work done, w = V·P.

W = V·P.

~~W = (1671 x 10⁻⁶ x 1.013 x 10⁵) J.~~

W = 169.3 J.

∴ The external work done will be 169.3 J

ii) The increase in internal energy of the system.

Internal energy = U + ΔW

Q = MLv + 169.3

Q = 1 x 2256 + 169.3 = 2,425.3 J

The increase in internal energy of the system is 2,425.3 J.

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

In Extract 6.2, the candidate provided responses which do not fulfil the demands of the question by applying incorrect formula and procedures in performing calculations.

2.7 Question 7: Environmental Physics

The question consisted of two parts (a) and (b). In part (a), the candidates were required to analyse three possible solutions to the side effects of global warming. Part (b) required the candidates to (i) explain briefly four major causes of water pollution and (ii) state three disadvantages of using solar energy.

A total of 23,153 (100%) candidates attempted this question and the general performance was good since 92.20 per cent of the candidates scored from 6 to 10 marks and 5.98 per cent scored from 3.5 to 5.5 marks while a few candidates (1.81%) failed by scoring from 0 to 3 marks. Figure 8 shows the performance of the candidates in this question.

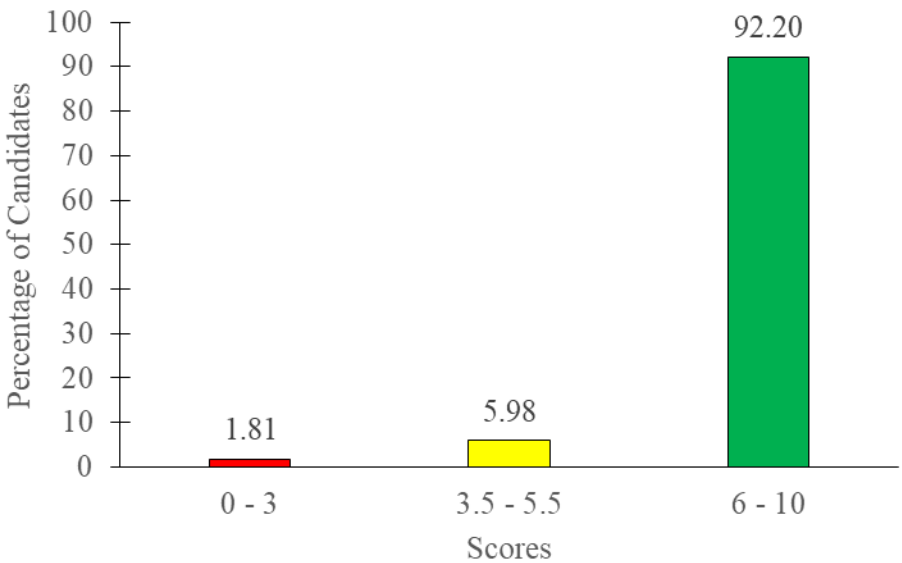


Figure 8: *Candidates performance in question 7 of paper 1*

The analysis of candidates' responses reveals that most of the candidate scored high marks in this question. This shows that the candidates had adequate knowledge of environmental Physics specifically in environmental pollution and energy from the environment (solar energy), as illustrated in Extract 7.1.

The candidates (92.2%) who scored high marks (from 6 to 10) provided clear and detailed answers which were featured with appropriate examples. These candidates had adequate knowledge on the environmental physics specifically in the part of environmental pollution and energy from the environment (solar energy). In part (b) (i) for example, they identified the sources of water pollution in agriculture, settlement and industries, thermal pollution and deforestation which leads to excessive soil erosion. Generally, it was observed that most of these candidates were consistent, neat and precise in providing their responses with a few grammatical errors due to good mastery of the English Language. However, varied accuracies of explanations and examples caused some candidates to score higher marks than others. Extract 7.1 is a sample of good response from one of these candidates in this question.

7. (a) - People should use the renewable sources of energy which are environmental friends as they do not produce soot and harmful gases such as CO_2 and SO_2 so people should use gas and solar or wind energy.

- Frequently repairing of the mechanically vehicles so as they do not produce soot which can destruct the ozone layer hence global warming.

- The industrial waste gases should be converted into usable gas products so as to avoid the destruction of the ozone layer.

(b) (i)

- Poor waste disposal.

In our society you may find someone exposing the waste products very poor either by throwing them away or some homes do not have toilets as the result they deficate in rivers or at any place they think is right hence water pollution.

- Industrial waste products.

The industries do dispose their wastes in rivers and the industrial wastes contain chemicals and other harmful substances hence water pollution

- The use of bombs and chemicals to kill the fish in fishing activities.

This also is the major ~~cause~~ cause of water pollution as the water are contaminated by the chemicals.

7 (b) i. - The chemicals sprayed during agricultural activities in killing pests. ~~and~~

When the chemicals are sprayed they fall on the land and others remain on the crop leaves on raining the poisons or chemicals are taken by the running water to the ~~river~~ river hence water pollution.

ii. - The solar energy gives low fidelity, that during humid periods gives a minimum energy hence do not fulfil the needs.

- The solar energy components are very expensive so many poor people can not afford the cost.

- The solar energy components such as a battery have a short life span hence frequently ~~repair~~ replacement which increases the cost also.

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

In Extract 7.1, the candidate provided responses on the concepts of global warming, water pollution and solar energy which suited the requirements of the question.

The responses of a few (1.81%) candidates who scored low marks (0 to 3) had some errors. Some responses contained correct points which had unclear explanations. On the other hand, repetition of some points was a common attribute in some candidates' responses. In part (a) for example they interchanged the concepts of analysing the possible solutions about the side effects of global warming with major causes of water pollution in part (b) (i). These candidates failed to understand that the use of clean alternative energy sources such as solar and wind, reduces deforestation which minimizes carbon dioxide in the atmosphere and implementations of the international agreements of the state such as Kyoto Protocol Agreement (KPA) that aims to minimize the emission of greenhouse gases into the atmosphere are among the solutions to the side effects of global warming. In part (b), they lacked knowledge that, the discharge of sewage from coastal settlements (sometimes untreated) into coastal water generates a direct health hazard from recreational bathers as well as marine organisms. In addition, land drainage from urban areas, industries and waste disposal sites into rivers and lakes often contaminated with heavy metals or hydrocarbons are the sources of water pollution. Furthermore, deforestation leads to excessive soil erosion that increases silt load in rivers and coastal water leading to coral leaf destruction are pollutants in the environment. However, 100 (0.43%) candidates who scored zero misinterpreted the question and provided irrelevant responses. Some of these candidates for example defined global warming instead of analysing possible measures to encounter the problem. Extract 7.2 is an example of one of the incorrect responses to this question.

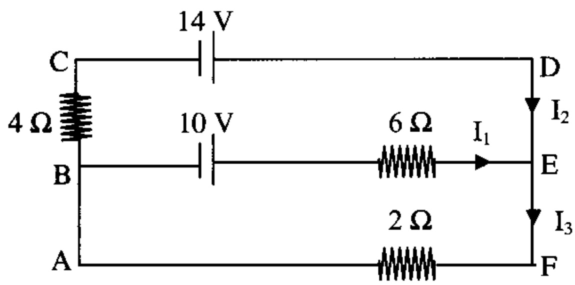
7	(a) – To reduce deffforestation
	– Provision of education about the effect of global warming
	– Enaction of strictly laws
	(b)(i) – Eruption of disease
	– global warming
	– produce rain

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

In Extract 7.2 the candidate listed irrelevant responses on the side effects of global warming and causes of water pollution without explaining it as demanded by the question.

2.8 Question 8: Current Electricity

This question had three parts: (a), (b) and (c). Part (a) required the candidates to (i) identify two conservation laws embodied in Kirchhoff's laws by stating its physical significance and (ii) explain why is it safe for a bird to stand on a high voltage wire without being harmed. Part (b) required the candidates to study the circuit diagram given in Figure 2 and apply Kirchhoff's rules to find the values of current I_1, I_2 and I_3.



In part (c), the candidates were required to (i) compute the voltage across the capacitor of $1\,\mu F$ used in a television circuit where the frequency and the current flowing through it are 1000 Hz and 2 mA (r.m.s) respectively and (ii) determine the current flowing when an a.c voltage of 20 V (r.m.s) and frequency of 50 Hz is connected to a capacitor in 8 (c) (i).

This was an optional question attempted by 9,519 (41.11%) candidates whose scores were as follows: 50.50 per cent scored from 9 to 15 marks, 21.86 per cent scored 5.5 to 8.5 marks and 27.64 per cent scored from 0 to 3 marks. These data are summarised in Figure 9.

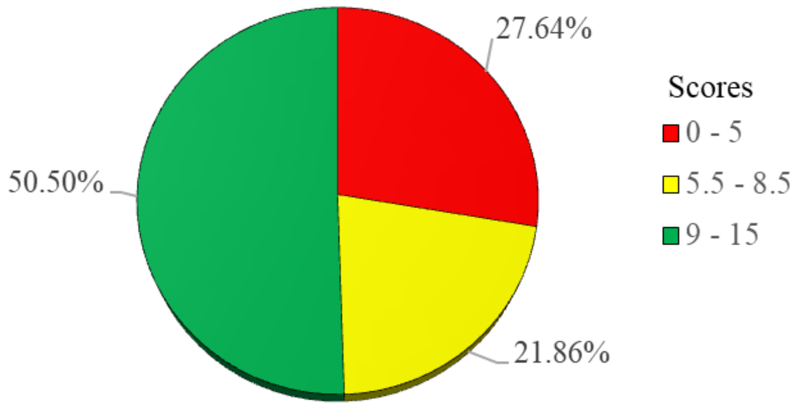
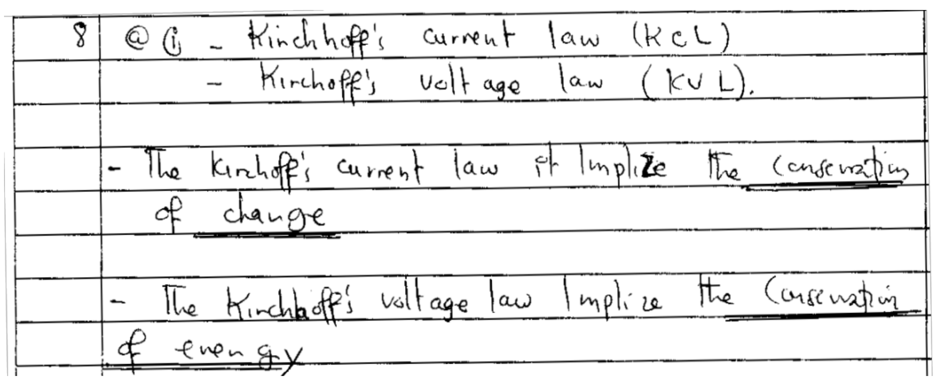


Figure 9: *Candidates' performance in question 8 of paper 1*

Figure 9 shows that the general performance in this question was good since 72.36 per cent of the candidates passed by scoring from 5.5 to 15 marks.

Candidates (50.50%) whose marks ranged from 9 to 15 had enough knowledge of Kirchhoff's rules and alternating current. Most of the candidates in this category identified correctly the conservation laws embodied in Kirchhoff's rules by stating its physical significance. This shows that they had adequate knowledge of the concept of electrical conduction in metals. Moreover, they analysed electrical network by applying the Kirchhoff's rules to find the values of the current. However, 21.86 per cent of the candidates scored average marks (from 5.5 to 8.5) since they provided relatively appropriate responses with diverse strengths in explaining, computing and analysing features of electrical network. Extract 8.1 represents a sample of a correct response to this question.

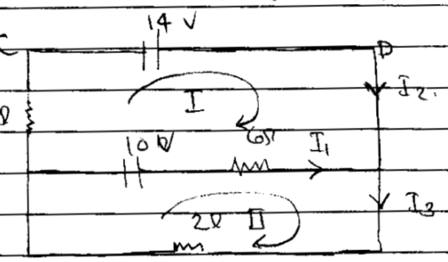

8 (a) (i) - Kirchhoff's current law (KCL)
- Kirchoff's voltage law (KVL).

- The Kirchoff's current law it implize the conservation of change

- The Kirchhoff's voltage law implize the conservation of energy

8 (a) (ii) - The bird is safe to stand on high voltage wire without being harmed this is because ~~there~~ on standing on that wire there is no full complete circuit of current that pass there so, not harmed

8 (b) Consider the sketch.



Consider loop I. (C D B F)

From, Kirchoff's voltage law (KVL)

Σ pds = Σ e.m.fs

$14V - ~~10V~~ = 4I_2 - 6\Omega I_1$

$4V = 4I_2 - 6\Omega I_1$

but.

$I_1 + I_2 = I_3$

8(b) $I_2 = I_3 - I_1$

$4v = 4(I_3 - I_1) - 6\Omega I_1$

$4v = 4I_3 - 4I_1 - 6I_1$

$4v = 4I_3 - 10I_1$ ------ (i).

also, Consider loop (II) B E A F.

Σ pds = Σ e.m.fs.

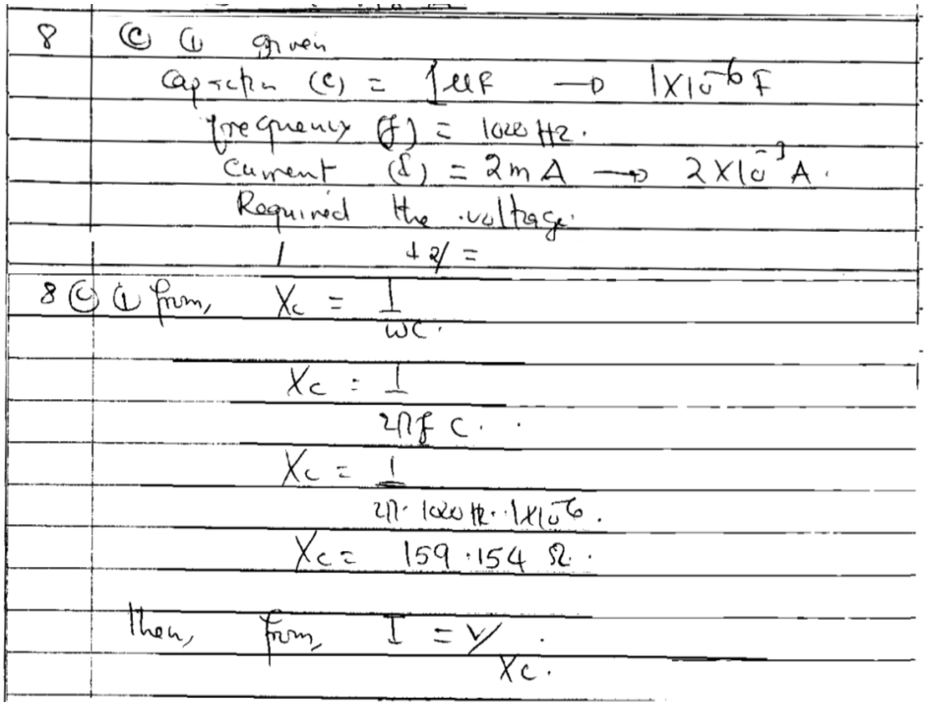
$10v = 6I_1 + 2I_3$. ------ (ii)

Solve equation (i) and (ii) by simultaneous equation

$I_1 = 0.727$ A

$I_2 = 2.091$ A

$I_3 = 2.818$ A



8 (c) (i) given

Capacitance (C) = 1µF → 1×10^{-6} F

frequency (f) = 1000 Hz.

Current (I) = 2mA → 2×10^{-3} A.

Required the voltage.

8 (c) (i) from, $X_c = \frac{1}{\omega C}$

$X_c = \frac{1}{2\pi f C}$

$X_c = \frac{1}{2\pi \cdot 1000 Hz \cdot 1 \times 10^{-6}}$

$X_c = 159.154\ \Omega$.

Then, from $I = \frac{V}{X_c}$.

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

In Extract 8.1, the candidate correctly applied Kirchhoff's rules and appropriate formulae from a.c theory to compute the voltage and current across the capacitor.

The responses of the candidates (27.64%) who scored from 0 to 5 marks comprised of several weaknesses. Most of the candidates in this group lacked mathematical skills in evaluating the concepts. The notable weaknesses include: failure of identifying conservation laws embodied in Kirchhoff's rules, providing partial explanations of a bird standing on a high voltage wire without being harmed and providing a mixture of correct and incorrect responses in part (c). Moreover, they failed to interpret the given circuit diagram to evaluate the values of the current thus they gave diverse responses. Some candidates for example used Ohm's law $I = \frac{V}{R}$ instead of Kirchhoff's rules and the formulae $X_c = \frac{1}{2\pi\pi f}$ and $I_V = \frac{E_V}{X_C}$ to determine currents and voltage across the capacitor. Other candidates in this category drew incorrect circuit diagrams with inappropriate directions of current flow and incorrectly applied Kirchhoff's rules to compute the values of currents I_1, I_2 and I_3.

Extract 8.2 is a sample of an incorrect response from one of these candidates.

8. a. (i) a. law of conservation of energy

b. law of conservation of charge

(ii) A bird body does not conduct electricity at its legs since it has no blood in legs.

8b Consider loop CAFDC

$14 - 4I_3 - 2I_3 = 0$ . . . (i)

Consider loop BAFEB.

$10 + 10I_1 + 2(I_1 + I_2) = 0$ . . (ii)

$10 - 10I_1 - 2I_1 - 2I_2 = 0$

$10 - 12I_1 - 2I_2 = 0$

$12I_1 + 2I_2 = 10$ . . . (ii)

from.

$14 - 4(I_1 + I_2) - 2(I_1 + I_2) = 0$

$-4I_1 - 4I_2 - 2I_1 - 2I_2 = -14$

$6I_1 + 6I_2 = 14$

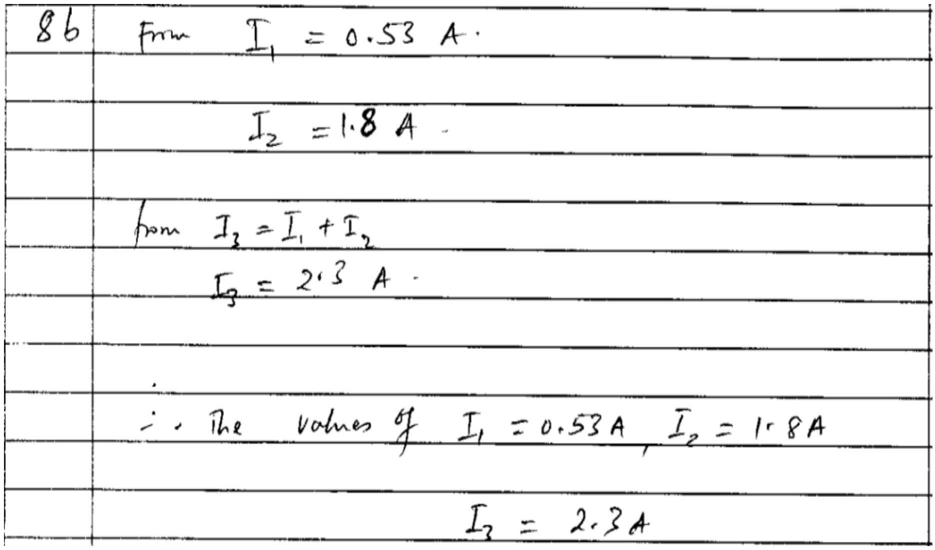
$3I_1 + 3I_2 = 7$ . . . (iii)

Solving simultaneously.

$12I_1 + 2I_2 = 10$

$3I_1 + 3I_2 = 7$

$I_1 = 0.5$ $I_2 = 1.8$


8b From $I_1 = 0.53$ A.

$I_2 = 1.8$ A.

from $I_3 = I_1 + I_2$

$I_3 = 2.3$ A.

∴ The values of $I_1 = 0.53$A, $I_2 = 1.8$A

$I_3 = 2.3$A

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

In part (a) of extract 8.2, the candidate partially identified two conservation laws. In part (b), he/she applied incorrect formulae and procedures in computing the values of currents.

2.9 Question 9: Electronics (Semiconductors,Logic Gates & Op-Amps)

This question was divided into three parts (a), (b) and (c). Part (a) required the candidates to (i) comment on the argument that the electrical conductivity of a semiconductor depends on temperature variation, (ii) draw a circuit diagram showing a reverse biased diode and (iii) give reason why there is a very little current flow in the circuit drawn in 9 (a) (ii). Part (b) required the candidates to (i) study the circuit in Figure 3 and find the gain of the amplifier and (ii) generate the truth table for the logic gates in Figure 4.

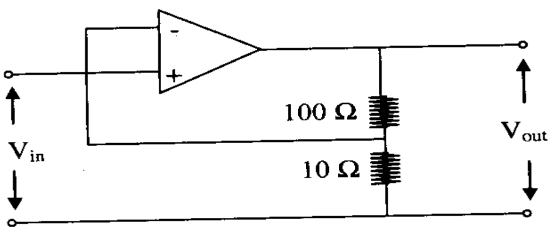


Figure 3

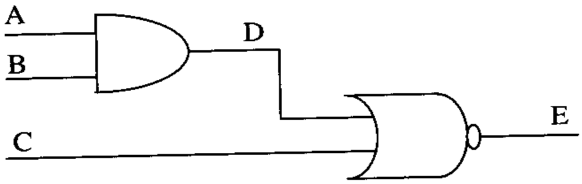


Figure 4

Part (c) required the candidates to (i) give the meaning of a voltage follower and state one importance of it and (ii) draw a diagram to show an operational amplifier (Op-Amp) as a voltage follower.

This was an optional question. The question was attempted by 19,794 candidates equivalent to 85.49 per cent and the distribution of their scores is shown in Figure 10.

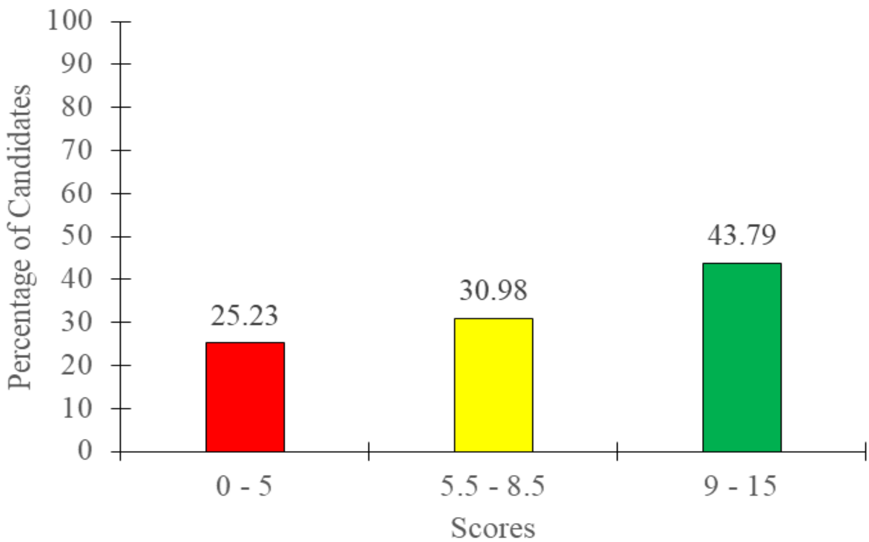


Figure 10: *Candidates' performance in question 9 of paper 1*

Figure 10 shows that 25.23 per cent of the candidates scored from 0 to 5 marks; 30.98 per cent scored from 5.5 to 8.5 marks while 43.79 per cent scored marks ranging from 9 to 15 marks. The data analysis reveals that the general performance in this question was good because 74.77 per cent of the candidates scored above 5 marks.

The candidates who scored high marks correctly stipulated the argument about the effects of varying temperature on electrical conductivity of a semiconductor. Most of them demonstrated their drawing skills of a reverse biased diode with detailed explanations about the presence of very little current flow in the circuits drawn. Consequently, they successfully applied an expression of non-inverting operational amplifier $\left(A = 1 + \frac{R_f}{R_1}\right)$ to determine the voltage gain and create the truth table of the given logic circuit. However, some candidates (30.98%) faced difficulties in drawing the diagram of an OP-Amp circuit and in describing the logic gates to generate a truth table and therefore they scored average marks. Extract 9.1 is a sample of candidates' correct response.

9. (a) (i) Electrical conductivity of a semiconductor depends on the temperature in the sense of that
- At low temperature, semiconductor do not conduct electricity because no kinetic energy for exciting electrons from valence band to conduction band.

- At room temperature, semiconductor conducts electricity because there is kinetic energy necessary for moving electrons from covalent bonds of valence band to conduction band.

- At high temperature, its conductivity decreased which resulted to accumulation of number of charge carriers at the conduction band hence low conductivity.

(ii)

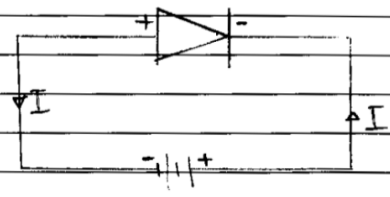


Diagram showing circuit of reverse biased diode

(iii) - Because these form of bias results into widening a depletion layers hence charge carriers necessary to conduct the electricity fails to pass through.

9. (b) (i) From the circuit above.

$$V_{in} = \left(\frac{R_1}{R_1+R_2}\right)V_0$$

Then;

$$\frac{V_{in}}{V_0} = \frac{R_1}{R_1+R_2}$$

$$\frac{V_0}{V_{in}} = \frac{R_1+R_2}{R_1}$$

$$A = 1 + \frac{R_2}{R_1}$$

$$A = 1 + \frac{100\Omega}{10\Omega}$$

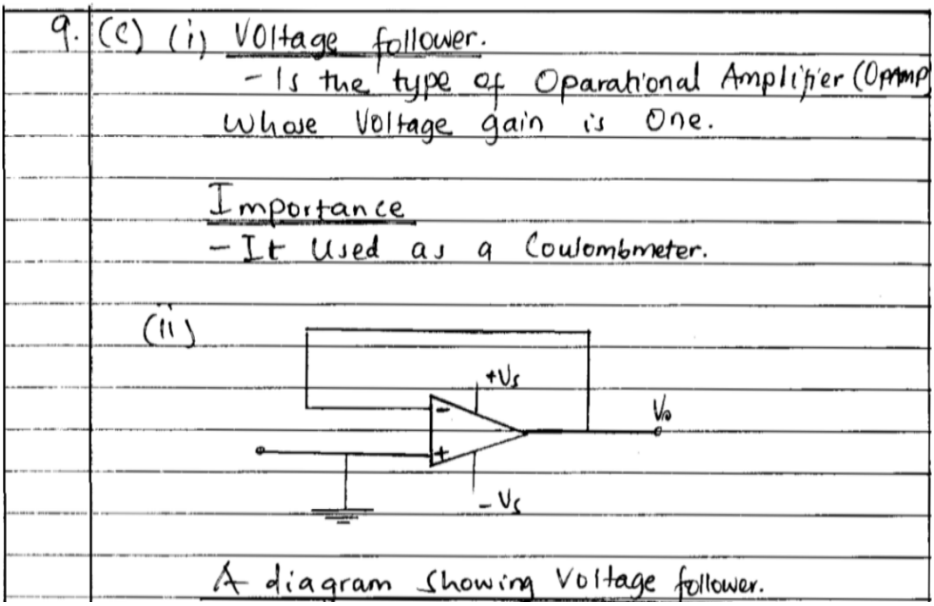
$$A = 1+10$$

$$A = 11.$$

$\therefore$ Voltage gain of Amplifier is 11.

(ii) Truth table

Inputs			Outputs	
A	B	C	D	E
0	0	0	0	1
0	0	1	0	0
0	1	0	0	1
0	1	1	0	0
1	0	0	0	1
1	0	1	0	0
1	1	0	1	0
1	1	1	1	0



9. (c) (i) Voltage follower.
- Is the type of Oparational Amplifier (OpAmp) whose Voltage gain is One.

Importance
- It Used as a Coulombmeter.

(ii)

A diagram Showing Voltage follower.

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

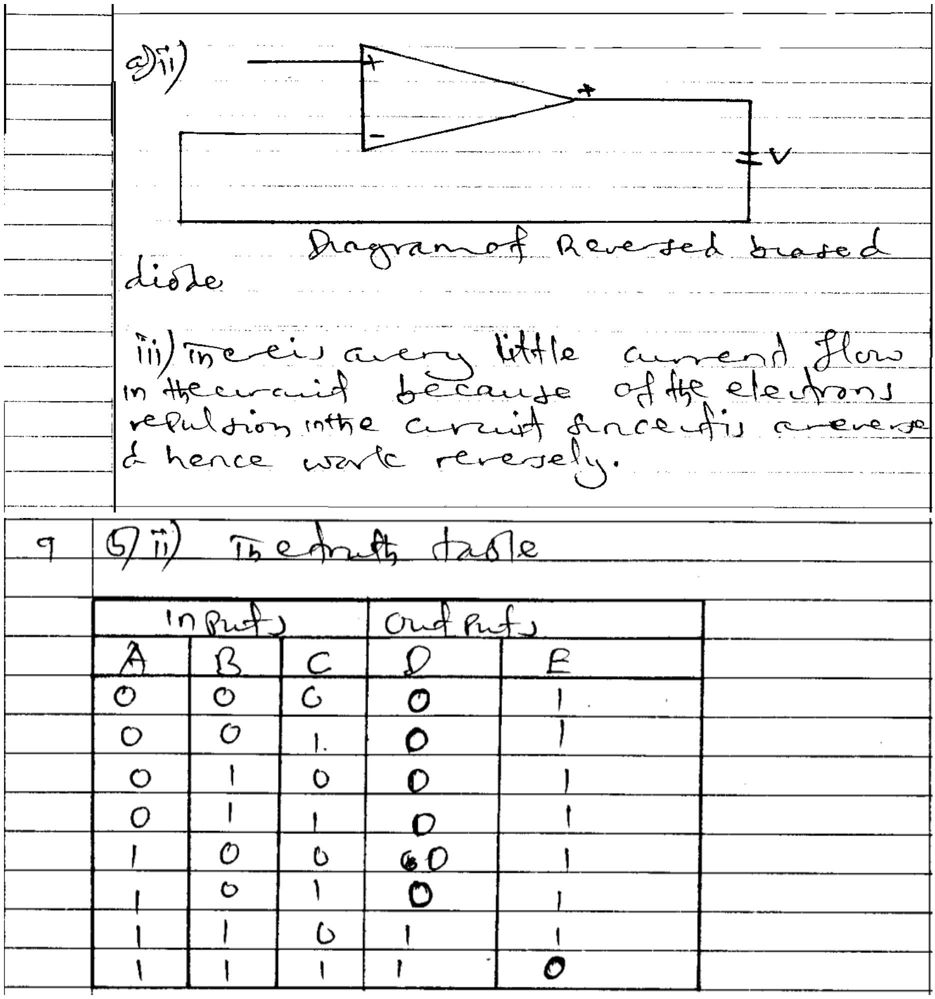
In Extract 9.1, the candidate drew the correct truth table, circuit diagrams and applied the correct formula and procedure to determine the tested concepts.

Although the candidates' performance in this question was good, 25.23 per cent of the candidates scored low marks (0 - 5). Some of these candidates had inadequate knowledge of semiconductors, OP-Amp and digital electronics. A further loss of marks was observed among those who lacked skills to study, draw and analyse the circuit diagrams. Some candidates for example wrote that: *the electrical conductivity of a semiconductor increases with an increase in temperature*. They also drew a transistor circuit instead of a reverse biased diode by interchanging the polarity of P-side connected to the cathode and N-side to the anode. Another observed weakness in their responses was lack of computational skills to recall and express correctly the formula that determines the gain of the amplifier by substituting the values of R_f and R_1 interchangeably in the formula $\left(A = 1 + \frac{R_f}{R_1}\right)$

$$Gain = \left(A = 1 + \frac{R_1}{R_f} \right) = \left(1 + \frac{10}{100} \right) = 1.1$$ instead of $\text{Gain} = \text{A} = 1 + \frac{100}{10} = 11$. However, a widely notable error observed in most scripts of 442 (2.23%) candidates who scored zero marks was failure to construct the truth table. Some of these candidates also drew a non-inverting amplifier as a voltage follower instead of Op-Amps without stating its importance. One candidate for example defined: *voltage follower as the flowing of charge from one plate to another whose importance is to transport current, charge and create potential difference*. Others stated that voltage follower is the voltage of an Op-Amp when an Op-amp is used without the effect of feedback. In addition, application of incorrect formulae such as $A_r = \frac{R_i}{R_f}$ and $A_r = A - \frac{R_f}{R_i}$ prevailed in their responses. Extract 9.2 is a sample of incorrect responses.

9 a) i) The electrical conductivity of se
mi conductor depends on temperature
variation because of increase with the
increase in Temperature. When the tem
perature increases it leads to the increa

a) i) in the valence electrons and decrease
in the valence band which leads to the increa
se in conductivity of a semi condu
ctor.
Therefore The electricity conductivi
ty is increase with the increase in tem
perature in a semi conductor.



Inputs			Outputs	
A	B	C	D	E
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	0	1
1	0	0	0	1
1	0	1	0	1
1	1	0	1	1
1	1	1	1	0

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

In Extract 9.2, the candidate drew an incorrect truth table, a reverse biased diode and provided irrelevant responses to other parts of the question.

2.10 Question 10: Electronics (The Band Theory of Solids, Semiconductors & Transistors)

This question had three parts (a), (b) and (c). Part (a) required the candidates to (i) sketch the circuit symbol for NPN transistor showing the direction of convectional current (ii) identify the condition which makes a semiconductor diode behaves as an open switch. Part (b)

$0.5\,\Omega$ and output resistance of $45\,\Omega$.

In part (c), the candidates were required to (i) explain the purpose of barrier potential difference in P-N junction and (ii) identify two advantages of junction diode and sketching its characteristic curve which shows the way it can act as a rectifier.

A total of 16,995 (73.4%) candidates attempted this question and their scores were as follows: 42.85 per cent scored from 9 to 15 marks, 29.25 per cent scored from 5.5 to 8.5 marks while 27.90 per cent scored from 0 to 5 marks. Figure 11 summarizes the performance of the candidates in this question.

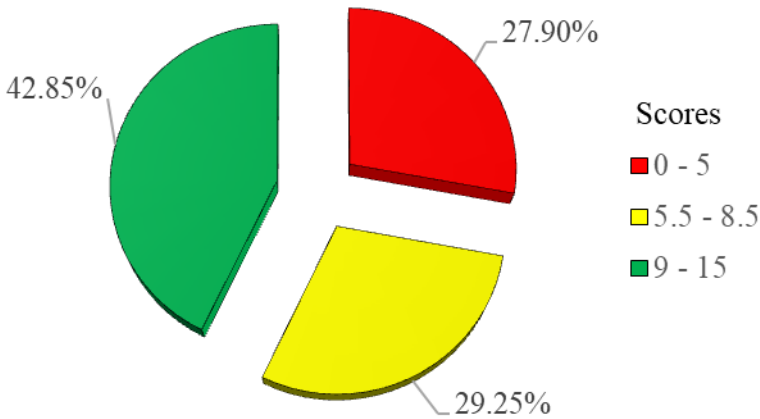
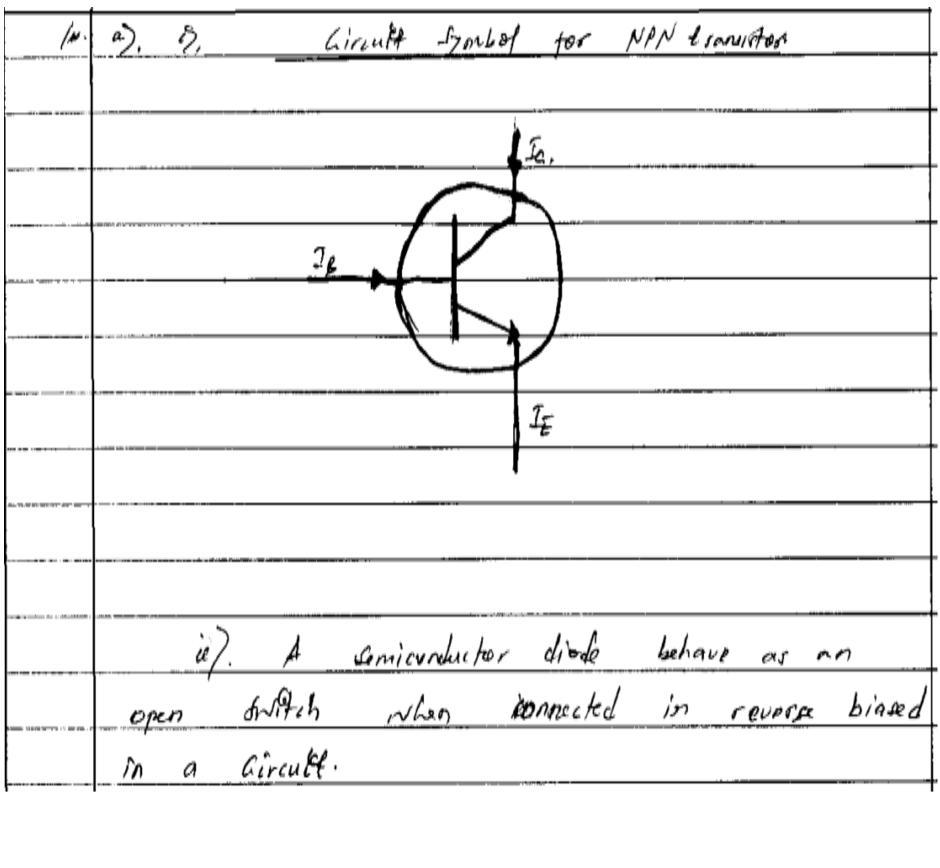


Figure 11: *Candidates' performance in question 10 of paper 1*

The analysis of data reveals that the overall performance in this question was good as 72.10 per cent of the candidates scored above 5 marks. The candidates (42.85%) who scored from 9 to 15 marks comprehended and interpreted the question correctly. Most of them sketched a correct circuit symbol for a NPN transistor showing that they had sufficient knowledge of transistors, semiconductors and its mode of operation. Some candidates for example wrote: *Semiconductor diode behaves as an open switch when the diode is reverse biased because a reverse biased diode has infinite resistance and conducts no current. Insulators do not conduct electricity under ordinary condition, because*

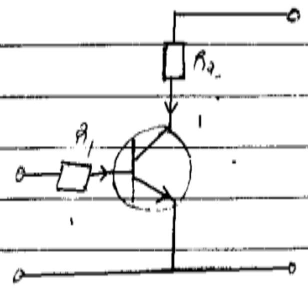
$$A_v = \frac{\text{output voltage}}{\text{input voltage}} \Rightarrow A_v = \frac{I_C R_O}{I_B R_i}$$ to determine the voltage gain of a common emitter amplifier. Extract 10.1 shows a sample of the correct response to this question.


1(a). a). i). Circuit Symbol for NPN transistor

ii). A semiconductor diode behave as an open switch when connected in reverse biased in a circuit.

b). i) Insulator does not conduct electricity under ordinary condition because it has wider forbidden gap so, it become difficult at ordinary condition for electron in valence band to jump to conduction band for conduction of electricity as free electron.

c). A consider a circuit below,



Here $R_1 = 0.5\Omega$ and $R_2 = 45\Omega$

$\beta = 65$

10. b) ii). voltage gain, $A_v = \frac{V_o}{V_{in}}$

But $V = IR$. from ohm's law

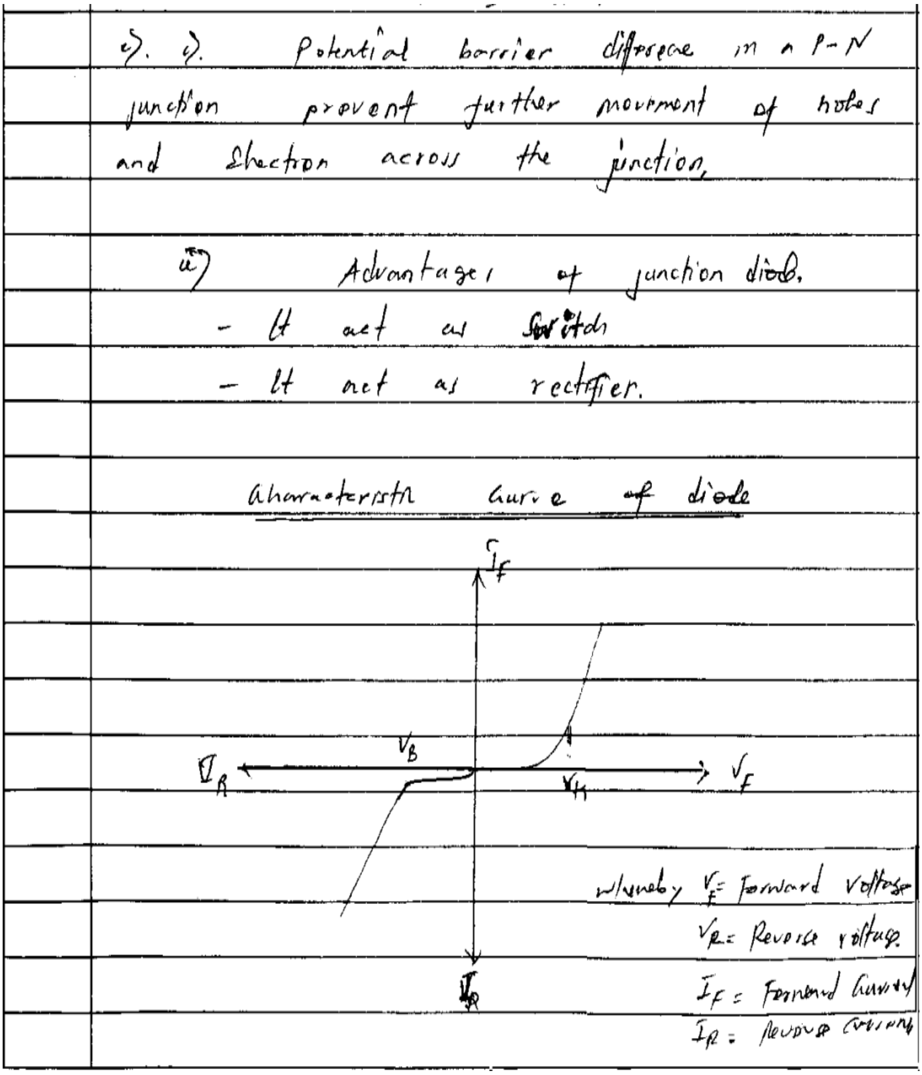
$A_v = \frac{I_c R_c}{I_B R_B}$.

But $\frac{I_c}{I_B} = \beta$.

$A_v = \frac{\beta . R_c}{R_B}$.

$A_v = \frac{65 \times 45}{0.5}$

$\therefore A_v = 5850$.


c). i). Potential barrier diffrence in a P-N junction prevent further movement of holes and Electron across the junction.

ii) Advantages of junction diode.
- It act as Switch
- It act as rectifier.

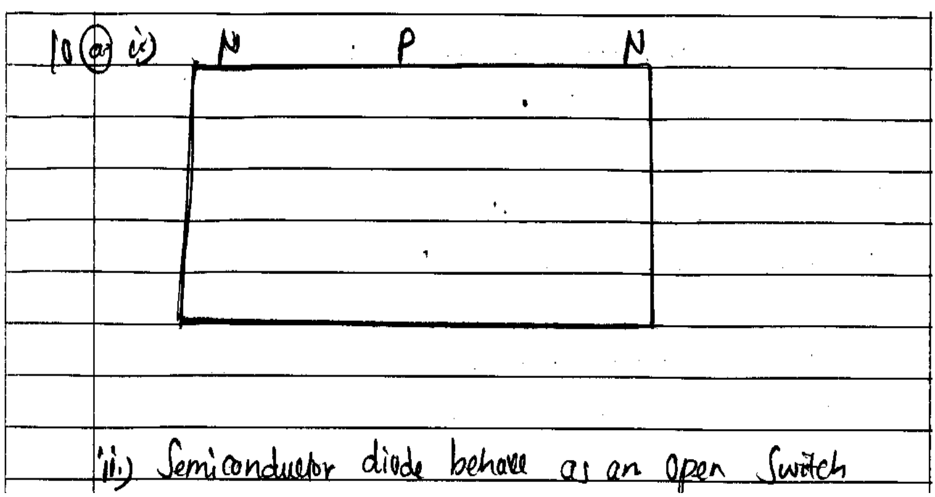
Characteristic Curve of diode

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

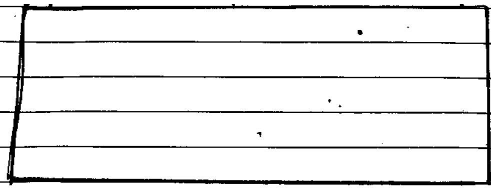
In Extract 10.1, the candidate correctly applied the concepts of transistors, semiconductors and junction diode to analyse all parts of the question.

However, candidates (29.25%) who scored marks ranging from 5.5 to 8.5, provided relevant responses which had some errors. Some of these errors included: failure to show the direction of a convectional current in the circuit symbol of a NPN transistor, providing inappropriate conditions that make a semiconductor diode to behave as an open switch, failure to explain the significance of barrier potential difference in the P-N junction and sketching its characteristic curve.

Among 1,413 (27.9%) candidates who scored 0 to 5 marks, 562 candidates corresponding to 3.31 per cent scored 0 marks. Major weaknesses observed in the responses of those who scored zero marks included: failure to describe the concepts of band theory of solids, semiconductors and transistor circuits. Most of the candidates drew a block diagram of the transistor instead of the circuit symbol for NPN transistor. Furthermore, they applied incorrect formulae such as: $\beta = \frac{I_B}{I_c}$ instead of $A_v = \beta \frac{R_o}{R_i}$ or $A_v = \frac{I_C R_O}{I_B R_i}$ to evaluate the voltage gain of amplifier. Moreover, other candidates in this category provided inappropriate explanations about the application of semiconductor diodes and its advantages. Some candidates for example wrote: *The advantage of a junction diode is that it acts as a switch and as an amplifier* while others wrote; *the purpose of the barrier potential difference in a P-N junction is to allow further movement of electrons between two bands*. These candidates lacked knowledge that a barrier potential opposes more diffusion of charges across the junction and its magnitude becomes very small when the flow ceases. However, some of these candidates scored 5 marks because they correctly sketched the circuit symbol of a NPN transistor and provided sufficient explanations in part (a) (ii) or (b) (i). Extract 10.2 is a sample of incorrect responses to this question.



(b) i) Because insulators has a Large energy band Compare to Semiconductor and Conductor also the Large band of insulator hinders the electrons to pass through that band inorder to reach in the area where it can Conduct electricity so due to the large band of insulator may lead to the electric don't conducted there.



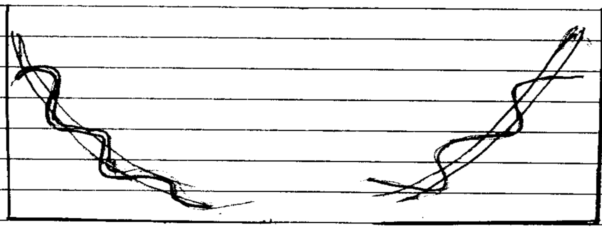
ii.) Semiconductor diode behave as an open Switch

(b) i) Because insulators has a Large energy band Compare to Semiconductor and Conductor also the Large band of insulator hinders the electrons to pass through that band inorder to reach in the area where it can Conduct electricity so due to the large band of insulator may lead to the electric don't conducted there.

10 (c) i) Junction diode it is used to connect one type materi-al to another type material.

ii) Junction diode is used to act as amplifier and ~~rectifier~~ rectifier between the two material.

THE CHARACTERISTICS CURVE WHICH SHOWS HOW IT CAN ACT AS A RECTIFIER.



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

In Extract 10.2, the candidate provided irrelevant responses on the tested concepts.

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

The 131/2 Physics 2 contained six (6) structured questions, which were set from six topics. The topics included *Fluid Dynamics, Vibrations and Waves, Properties of Matter, Electrostatics, Electromagnetism* and *Atomic Physics*. Each question carried 20 marks. The analysis of each question is as follows:

3.1 Question 1: Fluid Dynamics

This question had three parts (a), (b) and (c). Part (a) required the candidates to (i) give the meaning of laminar flow as used in fluid dynamics (ii) state continuity equation for the incompressible fluid flowing through the pipe and (iii) identify two assumptions made to develop an equation in 1 (a) (ii). In part (b), they were given 0.56 seconds taken by a steel ball bearing of diameter 8.0 mm to fall through oil at steady speed over a vertical distance of 0.2 m and they were required to determine the (i) weight of the ball (ii) upthrust on the ball and (iii) the viscosity of the oil. In part (c) they were given a large tank which contains water to a depth of 1m and water emerges from the small hole in the side of the tank 20 cm below the level of the surface. The candidates were tasked to calculate (i) the speed at which water emerges from the hole (ii) the distance from the base of the tank at which water strikes the floor on which the tank is standing.

The question was attempted by 23,001 candidates, equivalent to 99.34 per cent and their scores were as follows: 33.63 per cent scored from 0 to 6.5 marks, 36.37 per cent scored from 7 to 11.5 marks while 30.00 per cent scored from 12 to 20 marks. Figure 12 illustrates overall performance of this question.

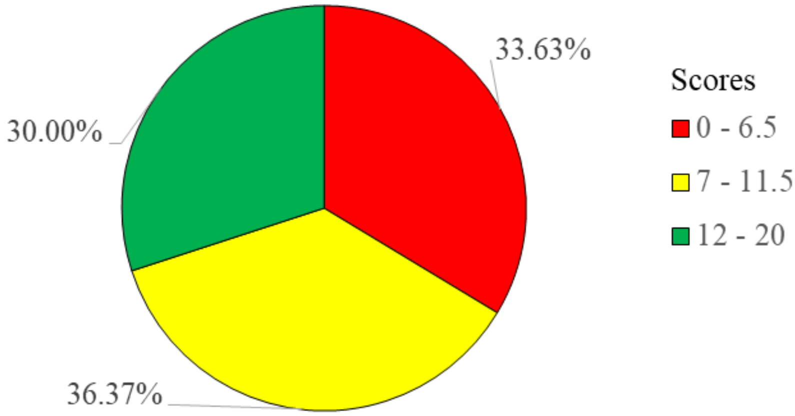


Figure 12: *Candidates' performance in question 1 of paper 2*

The data shows good candidates' performance in this question, since 76.37 per cent scored above 6.5 marks.

The analysis reveals that 677 (33.63%) candidates who scored low marks (0 – 6.5) faced difficulties in answering the question. In part (a), most of the candidates failed to give the meaning of a laminar flow, to state the continuity equation and assumptions made to develop the continuity equation. Some of their responses for example were: *Laminar flow is the type of flow in which the speed is constant throughout the flow* instead of *Laminar flow is the type of flow in which the velocities of all particles in any given streamline are always the same*. Likewise, in part (b) some of them applied incorrect formulas in determining the weight of the ball as $F = 6\pi\eta r$ instead of $W = \frac{4}{3}\pi r^3 \rho g$. However, for those who applied the correct formula, they failed to identify the required height between the depth of water in the tank (1 m) and height from the surface of water to the hole (20 cm) in determining the speed at which water emerged from the hole. Moreover, some of these candidates provided the correct formula but they used the height in centimetres instead of metres as required in the expression $v = \sqrt{2gh}$ which led them provide incorrect values in part (c). Extract 11.1 illustrates a sample of incorrect responses.

10 (i) laminar flow is the type of fluid flow in which density, velocity are constant and ~~travel~~ do not affected by pressure.

ii/ ~~continuity equation state that the flow in horizontal pipe is constant when density is constant~~

~~or~~ The principle of ~~equ~~ continuity

"continuity equation state that the fluid flow in ~~hori~~ the crossection area of horizontal pipe is constant when the density is constant"

iii/ 1. The density always kept constant.

ii/ Always area and velocity is constant.

b/ Data given

time (t) = 0.56 sec

Diameter of the ball (D) = ~~7~~.0mm ~~&~~ $\times 10^{-3}$ m

Distance (d) = 0.2m.

Required

(i) The weight of the ball

ii/ the up thrust of the ball.

iii/ The viscosity of the oil

solution.

consider the diagram.

1\. b/ solution

$W = f + U.$

from

$f = 6\pi \eta V_T r$

now

$f = W - U$

$f = mg - m'g$

$f = V \times \rho g - V \times \sigma g$

$f = Vg(\rho - \sigma)$

but $V = \frac{4\pi r^3}{3}$

$f = \frac{4\pi r^3}{3} g(\rho - \sigma)$

1\. b/ ii/ solution

from

$\eta = \frac{A\, dx}{dt}$

but

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

$A = \frac{4 \times \pi \times (8 \times 10^{-3})^2}{4}$

$A = 5.024 \times 10^{-5} m^2$

$\eta = \frac{5.024 \times 10^{-5} \times 0.2}{0.68} = 1.998 \times 10^{-5}$

$\therefore$ The viscosity of the oil is

~~1.794 m/s × m²~~ $1.794 \times 10^{-5} m^3/s$

1. c/	Height of water from the tank (h) = 1m.
	Distance on which water emerge from
	the surface = 20cm. = 20×10^{-2} m.
	Required
	(i) The speed at which the water
	emerges from the hole.
	(ii) The distance from the base of tank at which

1.	c (i)
	$\frac{1}{2}\rho V^2 = \rho g(h_1-h_2)$
	$\frac{1}{2}V^2 = g(h_1-h_2)$
	$2\times\frac{1}{2}V^2 = 2g(h_1-h_2)$
	$\sqrt{V^2} = \sqrt{2g(h_1-h_2)}$
	$V = \sqrt{2g(h_1-h_2)}$
	$V = \sqrt{2\times 9.8(1-20\times10^{-2})}$
	$V = 3.9597 \approx 3.96$ m/s.
	$V = 3.96$ m/s.
	~~but~~
	~~$V \approx 4$~~
	∴ The speed at which water
	emerges from the hole is
	3.96 m/s

ii/ solution

range (R) = $V \times t$.

but

from

$S = \frac{1}{2}gt^2$

$S = H$

$2 \times H = \frac{1}{2}gt^2 \times 2$

$\frac{2H}{g} = \frac{gt^2}{g}$

1. c (ii) then

$t = \sqrt{\frac{2H}{g}}$

$t = \sqrt{\frac{2 \times 1}{9.8}}$

Then

range $= 0.452 \times 3.96$.

$= 1.78992 \approx 1.8m$

∴ The distance from the base of tank at which water strike the flow is 1.8m.

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

In extract 11.1, the candidate wrote the incorrect meaning of Laminar flow and the description of continuity equation. The assumptions made to develop the continuity equation were also incorrect. In addition, he/she used inappropriate concepts and applied incorrect formula to obtain the weight, upthrust and viscosity of the oil in part (b). Furthermore, he/she used incorrect height to determine the speed at which water emerges from the hole and the distance from the base of the tank to which water strikes the floor in part (c).

However, 30 per cent of the candidates who attempted this question scored high marks (12 – 20). Most of these candidates correctly provided the meaning of the laminar flow, the continuity equation for the incompressible fluid flow and assumptions that they made to develop the continuity equation. They also applied the correct formula to determine the weight of the ball, the upthrust on the ball and the viscosity of the oil. Consequently, their computational skills enabled them to obtain the correct values of the weight of the ball, the upthrust and the viscosity of oil. Moreover, some of them used the concept of Torricelli's theorem to determine the speed at which water emerges from the hole and the distance from the base of the tank to the point where water strikes the floor. Extract 11.2 shows correct responses to this question.

1. a) i) Laminar flow is a type of streamline flow whereby a fluid flows in a series of parallel layers called Laminae

ii) From; $\left(\frac{dm}{dt}\right)_1 = \left(\frac{dm}{dt}\right)_2$ (mass continuity).

$$\rho_1 A_1 \frac{dl_1}{dt} = \rho_2 A_2 \frac{dl_2}{dt}$$

$$\rho_1 A_1 V_1 = \rho A_2 V_2 .$$

But, fluid is incompressible

$$\rho_1 = \rho_2$$

$$A_1 V_1 = A_2 V_2$$

∴ The continuity equation for incompressible fluid is given by;

$$A_1 V_1 = A_2 V_2$$

iii) Assumptions;

- The fluid is assumed to be non-viscous.
- The fluid is assumed to be irrotational and steady flowing.

1.b) i) Solution:

weight of the ball.

$w = mg$.

But; $m = \rho_s \times V \times g$

Then;

weight of the ball $= \rho_s \times \frac{4}{3}\pi R^3 \times g$.

where; $\rho_s = 7800\ Kg/m^3$

$R = 4\times10^{-3}\ m$.

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

Thus; $w = 7800\ Kg/m^3 \times \frac{4}{3}\pi \times (4\times10^{-3}m)^3 \times 9.8\ m/s^2$

$w = 0.0205\ N$.

$\therefore$ weight of ball $= 0.0205N$.

ii) Solution;

upthrust on the ball

$U = \sigma_0 V_b g$.

where; $\sigma_0 =$ density of oil $= 900\ Kg/m^3$

$V_b = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi \times (4\times10^{-3}m)^3$

$g = 9.8\ m/s^2$

On substituting values.

$U = 900\ Kg/m^3 \times \frac{4}{3}\pi \times (4\times10^{-3}m)^3 \times 9.8\ m/s^2$

$U = 2.36\times10^{-3}\ N$.

$\therefore$ Upthrust on the ball $= 2.36\times10^{-3}\ N$.

1.b)ii) solution:

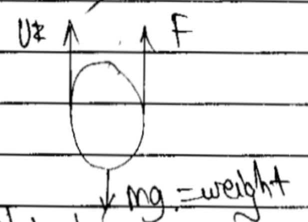
From;

Viscous force $F = 6\pi \eta r V_T$.

But where; $V_T = d/t = \frac{0.2m}{0.56s}$

$V_T = 0.357\,m/s$.

Also consider;



At equilibrium;

$F + U = W$

$F = W - U$

$F = 0.0205N - (2.36\times10^{-3})N$

$F = 0.01814N$.

Then;

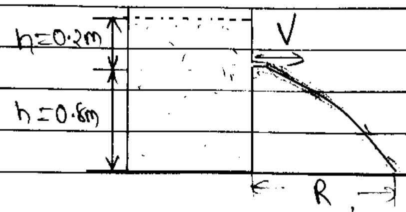
$0.01814N = 6\times3.14\times\eta\times(4\times10^{-3}m)\times0.357\,m/s$

$\eta = \frac{0.01814\,N}{0.0269\,m^2/s}$

$\eta = 0.674\,Kg\,m^{-1}s^{-1}$

∴ Viscosity of oil (η) = 0.674 Poise or $0.674\,Kg\,m^{-1}s^{-1}$

1. c) i) Solution;



From Toricelli's theorem.
velocity of efflux is given by;

$V = \sqrt{2gh}$ where; $h = 0.2m$

$V = \sqrt{2 \times 9.8 m/s^2 \times 0.2m}$

$V = 1.979 m/s$.

$V \approx 1.98 m/s$.

∴ speed at which water emmerges = 1.98 m/s.

ii) solution;

From; Range(R) = V × T.

where; $V = \sqrt{2gh}$ (Toricelli's theorem)

$T = \sqrt{\frac{2h'}{g}}$

Thus; $R = \sqrt{2gh'} \times \sqrt{2h'/g}$

$R = 2\sqrt{hh'}$

where; $h = 0.2m$

$h' = 0.8m$

Thus;

$R = 2 \times \sqrt{0.2m \times 0.8m}$

$R = 0.8m$

∴ Distance from base = 0.8m.

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

In Extract 11.2, the candidate provided the correct meaning of laminar flow and the continuity equation for the incompressible fluid flowing through the pipe. In addition, the candidate identified assumptions made to develop the continuity equation. In part (b), the candidate applied the correct equation to determine the weight, the upthrust and viscosity of the oil. The candidate also sketched a clear diagram in part (c) and applied the correct formula to calculate the required speed and the distance.

3.2 Question 2: Vibrations and Waves

This question comprised of three parts (a), (b) and (c). Part (a) required the candidates to (i) give two points which differentiate stationary wave from a progressive wave (ii) state the principle of superposition as applied in wave motion and (iii) determine the phase difference in radians from a given progressive wave equation $y = 0.4\sin\left(200\pi t - \frac{20}{17}\pi x\right)$ between a point 0.25 m from the fixed point and a point 1.1 m from the same fixed point when y is in metre and t in seconds. In part (b), they were required to (i) explain the reason that changes in pressure will not affect the velocity of sound and (ii) calculate the temperature at which the velocity of sound in air becomes twice than the velocity in air at 0 °C. Part (c) required the candidates to (i) give reasons for an empty vessel to produce more sound than a filled one and (ii) compute the wavelengths and frequencies of the three lowest frequency modes of vibrations from a closed organ pipe of length 0.68 m.

A total of 20,306 candidates, equivalent to 87.73 per cent attempted this question and their scores were as follows; 46.86 per cent scored from 0 to 6.5 marks, 32.32 per cent scored from 7 to 11.5 marks and 20.82 per cent scored from 12 to 20 marks. The score was average since 53.14 per cent of the candidates attempted the question scored from 7 to 20 marks. Figure 13 illustrates the candidates' performances in this question.

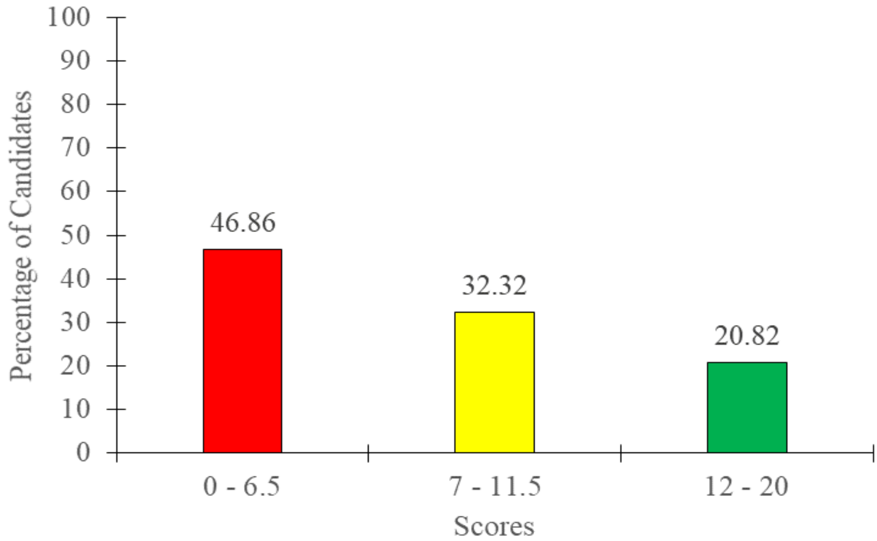
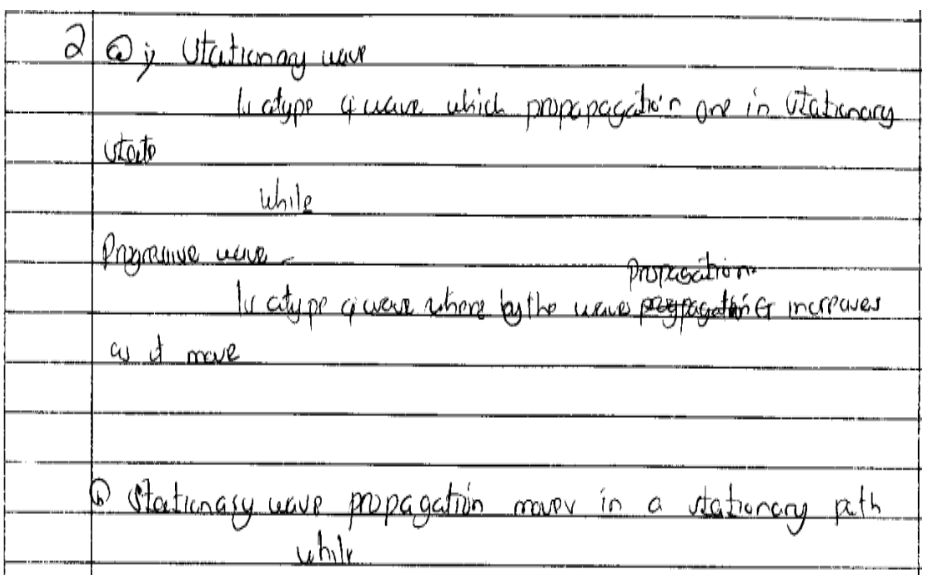


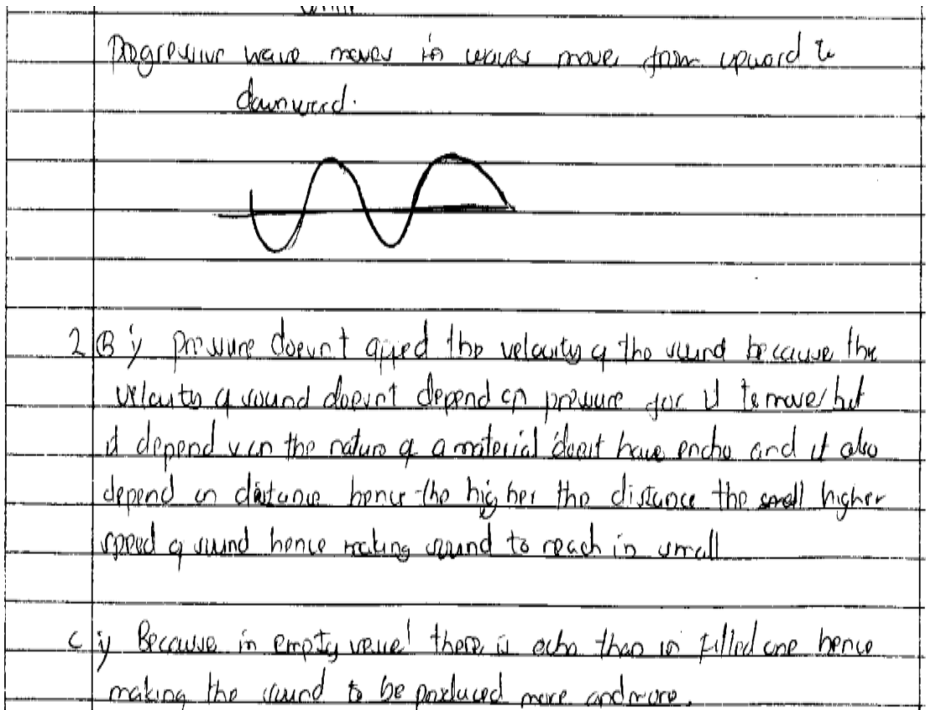
Figure 13: *Candidates' performance in question 2 of paper 2*

The analysis of the scores shows that 46.86 per cent of the candidates scored low marks (0 – 6.5). These candidates provided inappropriate responses which contained various weaknesses. Such weaknesses included: failure to differentiate a stationary wave from a progressive wave and recall the correct formula to determine the phase difference between two fixed points. In addition, they failed to compare the progressive wave equation $y = a\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$ with the given expression $y = 0.4\sin\left(200\pi t - \frac{20}{17}\pi x\right)$ to determine the phase difference. Some of the candidates for example applied the correct formula $\Delta\theta = \frac{2\pi\pi\Delta}{\lambda}$ $\Delta x = 1.1\,\text{cm}$

instead of $\Delta x = 1.1\,\text{cm} - 0.25\,\text{cm}$

π radian or 180°. Likewise, others wrote: *phase difference*, $k = \frac{2\pi t}{\lambda}$ or 200π *radians while others wrote: phase difference* $\phi = \frac{2\pi x}{\lambda}$ *instead of* $\frac{2\pi x}{\lambda} = \frac{20\pi x}{17}$. Another observed weakness was failure to associate the relationship of pressure and density to give a reason why change in pressure does not affect the velocity of sound in air. These candidates failed to understand that, change in pressure causes change in density as prescribed in the equation $v = \sqrt{\frac{\gamma P}{\rho}}$. Since the term $\frac{\Delta P}{\Delta \rho}$ always remains constant then changes of pressure do not affect the velocity of sound. Consequently, few candidates failed to apply the correct relationship of velocity and absolute temperature. They wrote for instance: $\frac{v_1}{T_1} = \frac{v_2}{T_2}$, $\frac{p_1 v_1}{T_1} = \frac{p_2 v_2}{T_2}$ and $V \propto T$ instead of $V \propto \sqrt{T}$ or $\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}}$ ended with incorrect responses. Moreover, some of these candidates failed to identify how the magnitude of amplitude varies with the intensity of a sound wave. These candidates provided incorrect reasons that make an empty vessel to produce more sound than a filled one. One of the candidates for example wrote: *An empty vessel produces more sound than the filled one because the empty vessel produce a high pitch compared to filled one.* In addition, they applied incorrect formulae such as $f = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$ instead of $\lambda_3 = \frac{4}{5}L$ and $f_3 = \frac{c}{\lambda_3}$ to determine the wavelength and frequency respectively. Extract 12.1 is a sample of incorrect responses to this question.


2 (a) i) Stationary wave
Is a type of wave which propagation are in stationary state
while
Progressive wave
Is a type of wave where by the wave propagation increases as it move
(b) Stationary wave propagation moves in a stationary path
while


Progressive wave moves in waves move from upward to downward.

2 B i) Pressure doesn't affect the velocity of the sound because the velocity of sound doesn't depend on pressure for it to move/but it depend v on the nature of a material doesn't have echo and it also depend on distance hence the higher the distance the small higher speed of sound hence making sound to reach in small

c i) Because in empty vessel there is echo than in filled one hence making the sound to be produced more and more.

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

In Extract 12.1, the candidate failed to give the correct features which distinguish the stationary wave from a progressive wave. The candidate failed to show the relationship of pressure and density to explain why change of pressure in air does not give any effect on the velocity of sound. Furthermore, the candidate explained the concept of echo as the reason for the empty vessel to produce more sound than the filled one which was incorrect.

A few candidates (20.82%) scored high marks (12 – 20) as they demonstrated their competence on the subject matter. Most of these candidates differentiated a progressive wave from a stationary wave and deduced correctly the principle of superposition of waves. Furthermore, they applied the correct formula to determine the phase difference between two points from the given expression. In part (b) and (c), they applied their numerical skills to compute temperature, wavelengths and frequencies. Whereas, most of the candidates who scored average marks (7 – 11.5) attempted some parts of the question and skipped other parts. Extract 12.2 is a sample of a candidate's correct responses.

2. (a) (i) difference between stationary wave and progressive waves.

	Progressive waves	Stationary waves.
1.	They carry energy from one point to another	They does not carry energy at all.
2.	formed due to vibration of particles of medium	they formed due to superposition of two travelling opposite wave
3.	example is water waves	example is waves in string.

(ii) Principle of superposition states that "The two travelling progressive wave will superpose each other if they will have same amplitude and moves in the opposite direction".

(iii) Solution

Given

$$Y = 0.4\sin\left(200\pi t - \frac{20}{17}\pi X\right)$$

$$\phi = \frac{20\pi X}{17}$$

$$\phi = \frac{20 \times \pi \times 0.25m}{17}$$

$$\phi_1 = \frac{5\pi}{17}$$

and

$$\Phi_2 = \frac{2\pi x}{\lambda}$$

$$\Phi_2 = \frac{2 \times \pi \times 1.1\,m}{17}$$

$$\Phi_2 = \frac{22\pi}{17}$$

So

phase difference = $\Phi_2 - \Phi_1$

$$\Delta\Phi = \frac{22\pi}{17} - \frac{5\pi}{17}$$

$$\Delta\Phi = \frac{17}{17}\pi$$

$$\Delta\Phi = \pi.$$

∴ So the phase angle difference is π.

2 (B, i) From the formula of velocity of sound in Air $V = \sqrt{P/\rho}$ this means that

when pressure changes also density changes which cause no change in value for velocity of sound in air.

(ii) solution

Given

$V_1 = V$

$V_2 = 2V$

$T_1 = 273\,k$

$T_2 = ?$

from

$V \propto \sqrt{T}$

$V_1 = k\sqrt{T}$

$V_1 = k\sqrt{273}$ ——— (i)

$V_2 = k\sqrt{T_2}$ ——— (ii)

take ratio of two eqn

$$\frac{1}{2} = \sqrt{\frac{273}{T_2}}$$

comments: question continue on next booklet.

2 (b)(ii) so it will be

$$\left(\frac{1}{2}\right)^2 = \left(\sqrt{\frac{273}{T}}\right)^2$$

$$\frac{1}{4} = \frac{273}{T}$$

$T_2 = 4 \times 273$

$T_2 = 1092\ k$

∴ the temperature at which the velocity will double is 1092 K or 819°C.

© (i) because the Vibration in the empty vessel Vibrate with high amplitude hence Produce more Intensity since $A \alpha I^2$ but in the filled one the sound will vibrate of low amplitude so the Intensity of sound will be low.

$a \alpha I^2$

2 © (ii) Solution

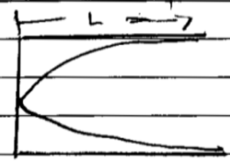
Given

wavelength (λ) = 0.68m

So from

For a closed pipe

In first mode of Vibration



So

$L = \lambda/4$

$\lambda = 4L$

$\lambda = 4 \times 0.68m$

$\lambda = 2.72m$.

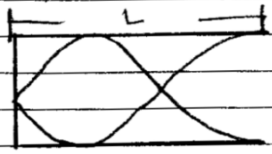
but

$\text{frequency} = \frac{\text{Velocity}}{\text{wavelength}}$

$f = 340/2.72 = 125 Hz$

$\therefore$ the First mode has $\lambda = 2.72m$ and $f = 125 Hz$.

2 ⓒ (ii) for second mode



$L = \frac{3}{4}\lambda$

so

$\lambda = \frac{4L}{3}$

$\lambda = \frac{4 \times 0.68m}{3}$

$\lambda = 0.91m$.

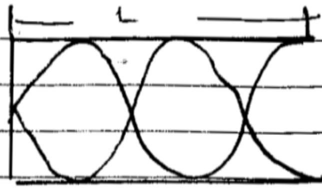
so frequency = $\frac{\text{Velocity}}{\text{wavelength}}$

frequency = $\frac{340 m/s}{0.91}$

$f = 373$ Hz

∴ the frequency is 373 Hz and wavelength is 0.91m

2 ⓒ (ii) For third mode of vibration



so

from

$L = \frac{5}{4}\lambda$

$$\lambda = \frac{4L}{5}$$

$$\lambda = \frac{4 \times 0.68m}{5}$$

$$\lambda = 0.544m$$

but $\text{Frequency} = \frac{\text{Velocity}}{\text{wavelength}}$

$$f_3 = \frac{340m/s}{0.544}$$

$$f_3 = 625\ Hz$$

∴ the wavelength of third mode is 0.544 m and frequency is 625 Hz.

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

In Extract 12.2, the candidate correctly distinguished a stationary wave from a progressive wave, stated the principle of superposition of waves and calculated the phase difference. The candidate also applied the correct formulae and procedures to provide the correct responses in part (b) and (c).

3.3 Question 3: Properties of Matter

This question had three parts (a), (b) and (c). Part (a) required the candidates to (i) give the meaning of modulus of elasticity and modulus of rigidity as used in properties of matter and (ii) calculate the shearing strain and shearing stress of an aluminium cube having dimensions of 4cm x 4cm x 4cm and modulus of rigidity of 2.08×10^{10} N/m^2 when subjected to a tangential force and its top face sheared by a length of 0.012 cm with respect to the bottom. In part (b), they were given a rubber cord of a catapult having a cross- sectional area of 2 mm^2 and initial length of 0.2 m, stretched to 0.24 m in order to fire a small object of mass 10 g and they were required to compute, (i) the energy stored in the rubber and (ii) the initial velocity of the object as it just leaves the catapult. In part (c), they were required to (i) give brief explanations on the classification of the materials based on their elastic properties and (ii) give a reason that makes spring balances to show wrong readings after they have been used for a long time.

A total of 22,745 (98.27%) candidates attempted this question and their scores were as follows: 29.20 per cent scored from 0 to 6.5 marks, 34.08 per cent scored from 7 to 11.5 marks and 36.72 per cent scored from 12 to 20 marks. These scores indicate that the candidates' performance in this question was good as 70.80 per cent of them scored from 7 to 20 marks. Figure 14 presents a summary of the candidate's performance.

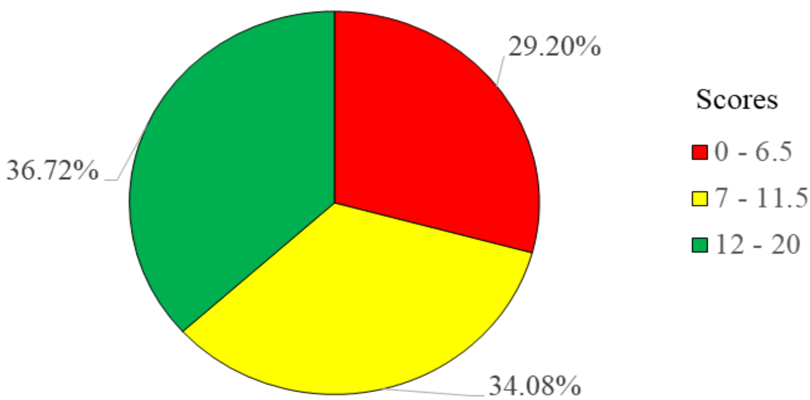


Figure 14: *Candidates' performance in question 3 of paper 2*

In attempting this question, 36.72 per cent of the candidates scored high marks (12 – 20). These candidates interpreted correctly the demands of the question. Most of them gave the correct meaning of the terms modulus of elasticity and modulus of rigidity as used in properties of matter. They showed their competence by applying the correct formula and procedure to calculate shear strain and shear stress. Another noted strength in their responses was the acquisition of knowledge about the concepts of strain energy. This enabled them to apply the correct formula to calculate the energy stored in the rubber and the initial velocity of the object as it just leaves the catapult but also to classify materials into Ductile, Brittle and Elastomers. Extract 13.1 presents an example of correct responses from one of these candidates.

3. (a) (i) modulus of elasticity is ratio of stress to the strain produced by application of deforming force. It shows the degree of elasticity of a material.

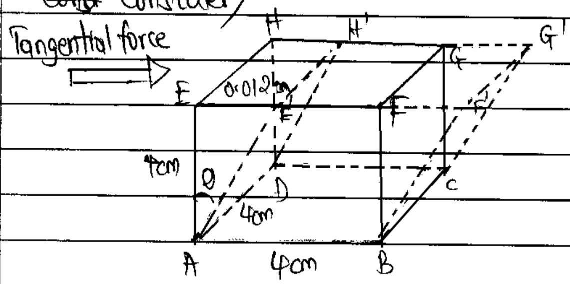
$$Y = \frac{\text{stress}}{\text{strain}}$$

modulus of rigidity is ratio of shearing stress to the shearing strain produced in a materia on applying deforming force. It express a body's ability to undergo shear deformation

$$\eta = \frac{\text{shearing stress}}{\text{shearing strain}}$$

(ii) Solution;

Consider;



Then; shearing strain $= \frac{\Delta L}{L} = \tan(\theta)$

Shearing strain $= \frac{0.012\text{ cm}}{4\text{ cm}}$

$= 3 \times 10^{-3}$.

∴ Shearing strain $= 3 \times 10^{-3}$

To find shearing stress;

From; Shear modulus $(\eta) = \frac{\text{Shearing stress}}{\text{shearing strain}}$;

Given $\eta = 2.08 \times 10^{10}\ N/m^2$

Thus; shearing stress $= 2.08 \times 10^{10}\ N/m^2 \times 3 \times 10^{-3}$

$= 62400000\ N/m^2$.

∴ Shearing stress $= 62400000\ N/m^2$ or $6.24 \times 10^7\ N/m^2$

3.b) i) Solution;

Required; The energy stored in the rubber

Given; $A = 2 \times 10^{-6} m^2$ $m = 10g$.

From; Elastic strain energy $= \frac{1}{2} \times Fe$.

where; $e = l_f - l_i$

$= 0.24m - 0.2m$

$= 0.04m$.

Also; $Y = \frac{FL}{A\Delta L}$ $(Y = 6 \times 10^8 N/m^2)$

$F = \frac{6 \times 10^8 N/m^2 \times 2 \times 10^{-6} m^2 \times 0.04m}{0.2m}$

$F = 240N$.

Then;

Energy $= \frac{1}{2} \times 240N \times 0.04m$

$= 4.8J$.

∴ Energy stored in the rubber $= 4.8J$.

ii) Solution;

Required; Initial velocity of stone as it leaves catapult.

By conserving energy.

Elastic strain energy = Kinetic energy of object.

$\frac{1}{2} mV^2 = 4.8J$.

where; $m = 10 \times 10^{-3} Kg$.

$\frac{1}{2} \times 10 \times 10^{-3} Kg \times V^2 = 4.8J$.

$V = \sqrt{960 m^2/s^2}$

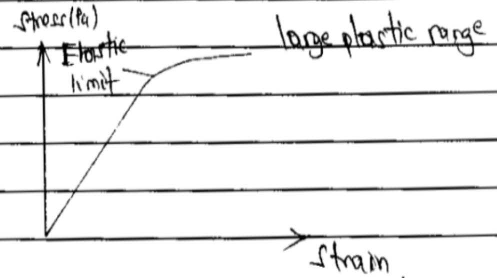
$V = 30.98 m/s$.

∴ Initial velocity of object $= 30.98 m/s$.

3.c)i) The classifications are;

- Ductile materials;

These are materials which show large plastic range beyond elastic limit. They can be made into wires. They include; metals such as aluminium, copper and tin. Below is the stress-strain curve.

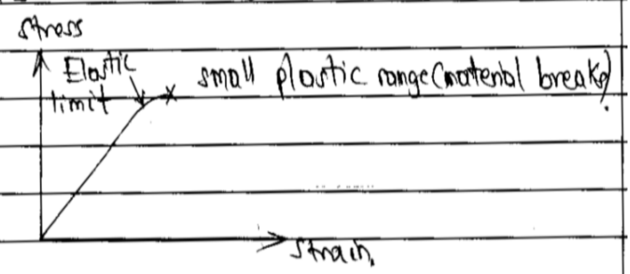


- Brittle materials

These are materials which show small plastic range beyond elastic limit. By applying a greater stress beyond elastic limit it breaks.

They include; plastics and wood.

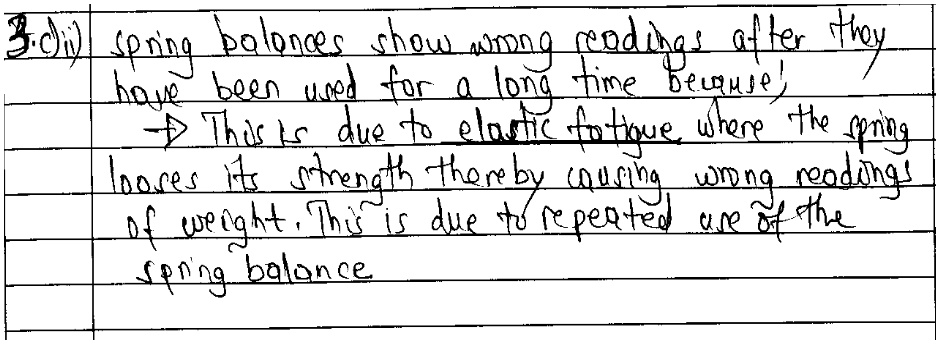
Below is a stress-strain curve



- Elastomers.

These are materials which do not obey Hooke's law at any condition.

They include) Rubbers.


3.c)ii) spring balances show wrong readings after they have been used for a long time because;
→ This is due to elastic fatigue where the spring looses its strength thereby causing wrong readings of weight. This is due to repeated use of the spring balance

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

In Extract 13.1 the candidate correctly provided the meaning of modulus of elasticity and modulus of rigidity and calculated the shearing strain, shearing stress, extension and energy stored. The candidate applied the principle of mechanical energy to relate the kinetic energy and the elastic energy stored in the rubber. Likewise, the candidate sketched the correct diagrams to classify the materials based on their elastic properties.

The candidates (29.20%) who scored low marks (0 - 6.5) marks provided inappropriate responses to this question. Most of them confused the definition of the terms modulus of elasticity and modulus of rigidity. They also applied incorrect formulae to determine shearing strain, shearing stress, energy stored and initial velocity of the object as it just leaves the catapult. Most of these candidates failed to interpret the information of the given data in their responses. In part (b) for example some candidates used 0.24 m as the extension instead of 0.04 m while others applied the formula: $force\ mg = \frac{mv^2}{r}$ instead of $\frac{1}{2}Fe = \frac{1}{2}mv^2$ to determine the initial velocity of the object. In part (c), most of these candidates faced difficulties in classifying materials based on the elastic properties. One of these candidates for example wrote: *elastic materials are divided into three parts which are plastic material, cooper wire and silver wire* while another candidate wrote: *spring balance show wrong readings because of being not calibrated to zero reading for a long time.* These candidates failed to understand that plastic, copper and silver are examples of materials which belong to one of the three classes which are ductile materials, brittle materials and elastomers materials. Similarly, if a material is repeatedly stressed and unstressed, it becomes weaker such that the strain produced by a given amount of stress increases. Due to this reason, the spring balances which have been used for a long time give wrong readings. Extract 13.2 portrays a sample of an incorrect response to this question.

3a) Solns

i) Modulus of elasticity is the process in which the modulus have reach its minimum extension while modulus of rigidity is the process in which modulus have reach in rigid position

ii) Solns

L = 0.012 cm.

Y = 2.08 $\times 10^{10}$ N/m².

Shearing strain = ~~F/A~~ $\Delta L/L$

Shearing stress = ~~$\Delta L/L$~~ F/A

3b) i) Solns

A = 2mm² → 2$\times 10^{-6}$m²

L = 0.2m

ΔL = 0.24m.

M = 10g → 0.01 kg

Energy = ½ × stress × strain.

Stress = F/A

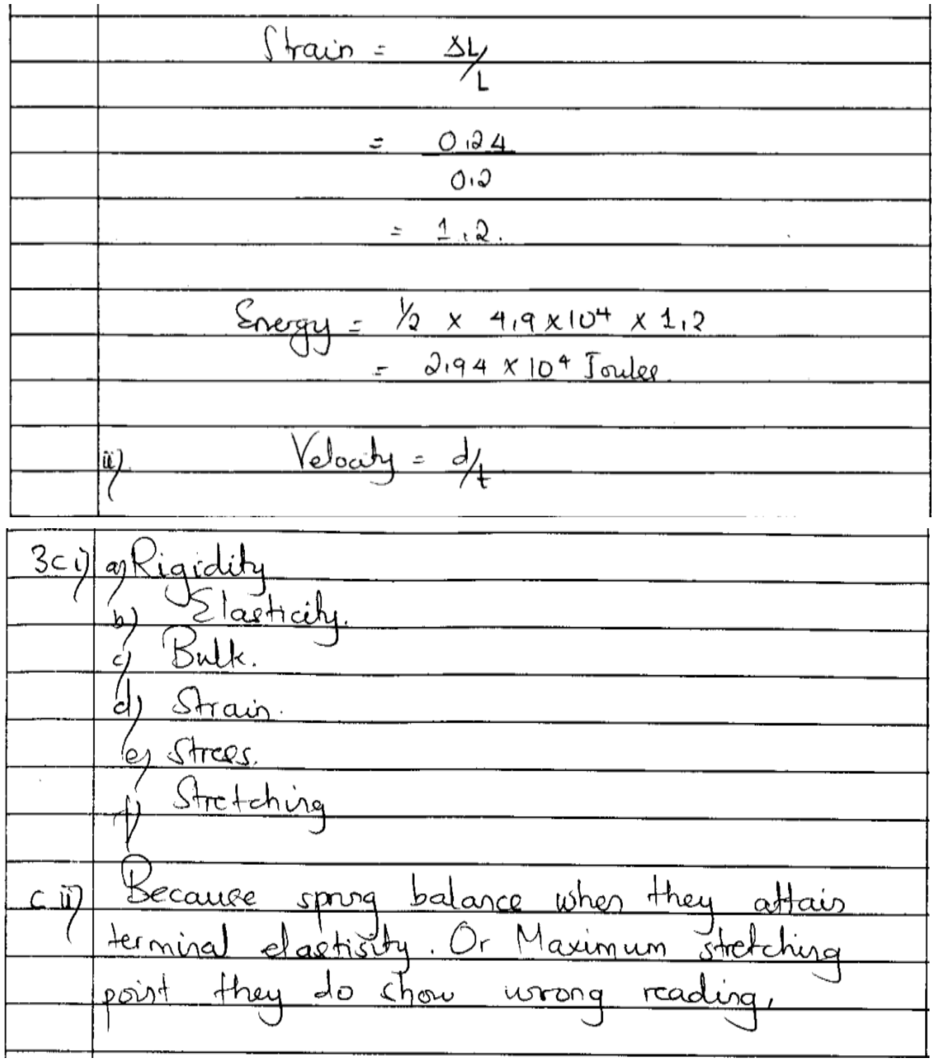
F = ma

= 0.01 × 9.8

= 0.098N.

= $\frac{0.098}{2\times 10^{-6}}$

= 4.9 $\times 10^{4}$


Strain = ΔL/L
= 0.24/0.2
= 1.2.
Energy = ½ × 4.9×10⁴ × 1.2
= 2.94 × 10⁴ Joules.
ii) Velocity = d/t
3c i) a) Rigidity
b) Elasticity.
c) Bulk.
d) Strain.
e) Stress.
f) Stretching
c ii) Because spring balance when they attain terminal elastisity. Or Maximum stretching point they do show wrong reading,

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

In Extract 13.2 the candidate provided incorrect meaning of modulus of elasticity and modulus of rigidity. In part (b), the candidate applied incorrect formula of energy: $E = \frac{1}{2} \times stress \times strain$ instead of: $E = \frac{1}{2} Fe$ to find the energy stored in the rubber. In part (c), the candidate provided the terminologies of elasticity instead of classifying the materials based on their elastic properties.

3.4 Question 4: Electrostatics

This question consisted of three parts (a), (b) and (c). In part (a), the candidates were required to (i) distinguish between electric dipole and dipole field and in (ii) they were given an electric dipole which consists of two charges of +20 μC and -20 μC separated by a small distance of '2*a*' in a free space and were required to calculate the electric field intensity at a point on the axial line of the dipole at a distance of 10 cm from the centre of the dipole. In part (b) the candidates were given Figure 1 which has two points; A and B in it and they were required to (i) identify by giving reasons the point at which the electric field intensity is expected to be high

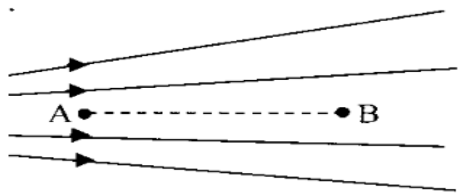


Figure 1

and (ii) find the charge on the ball having a mass of $8.4\times10^{-16}kg$ suspended in a uniform electric field of 2.6×10^{4} V/m. In part (c), the candidates were required to (i) give the meaning of the term electric potential and (ii) calculate the electric potential at the surface of a silver nucleus of radius 3.4×10^{-14} m given that the atomic number of silver and charge 'e' on proton are 47 and 1.6×10^{-16} respectively.

This question was attempted by 16,137 candidates, which corresponds to 69.72 per cent. The analysis of data reveals that 36.56 per cent of the candidates scored from 0 to 6.5 marks, 35.94 per cent scored from 7 to 11.5 marks while 27.50 per cent scored from 12 to 20 marks. These scores shows that 63.44 per cent of the candidates scored from 7 marks and above which portrays good performance. Figure 15 summarizes the candidates' performance in this question.

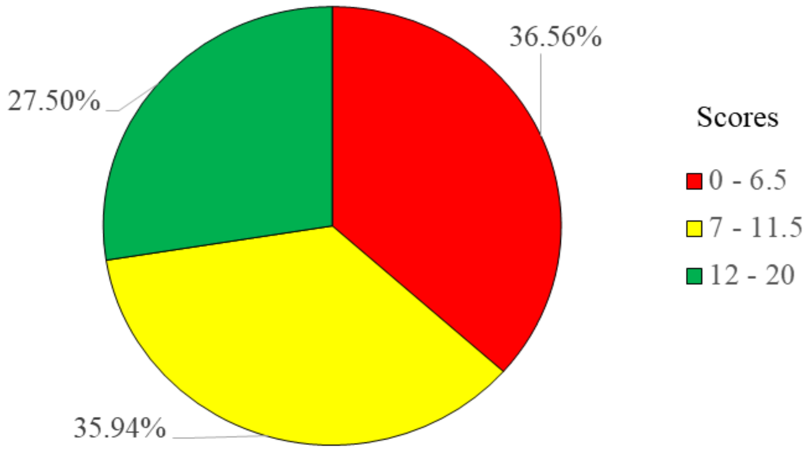


Figure 15: *Candidates' performance in question 4 of paper 2*

The analysis of data reveals that among 16,137 (69.70%) candidates who attempted this question, 36.56 per cent scored low marks (0 – 6.5). This was mainly caused by partial understanding of the subject matter. Most of these candidates lacked knowledge to describe the concepts of electric field of a point charge and electric field intensity for simple symmetrical charge distribution. In part (a) they failed to distinguish electric dipole from dipole field but also to use the correct formulae to calculate the electric field intensity. Some of these candidates for example applied the incorrect formula such as $E = k\frac{e}{r^2}$ instead of $E_P = k\frac{2P}{x^3}$. Another noted weakness in their responses was observed in part (b) where they were required to identify the point at which the electric field intensity was expected to be high. Most candidates chose point B as they failed to understand that, electric field intensity is more at a point/place where the electric lines of force are closely spaced. Moreover, in part (c) some of these candidates lacked knowledge about the concept of electric potential due to a charge distribution. These candidates applied incorrect formulae such as $\frac{1}{4\pi\varepsilon_o}\frac{r}{q}$ and $\frac{4\pi}{\varepsilon_o}\frac{r}{q}$ instead of $\frac{1}{4\pi\varepsilon_o}\frac{q}{r}$ to calculate the electric potential. Extract 14.1 is a sample of incorrect responses to this question.

4(a)(i) Electric dipole is the electrical charge which passes through a given point charge at a given period of time While dipole field is the type of dipole which is obtained due to the effect of electric field in the materials.

(ii) Given that
charges: +20μc and −20μc
Distance between charges = 2a
Distance from the centre = 10cm
Required
Electric field intensity = ?
Solution

Field intensity (I) = $\frac{q_1 q_2}{r^2} = \frac{20 \times -20}{10^2}$

∴ Field intensity = $-4\,\mu c/m$

4. (b) (ii) From
Data given
Mass of plastic ball = 8.4×10^{-16} kg
Uniform electric field = 2.6×10^{4} V/m
Required:-
Charge on the ball = ?

4. (c)(i) Electric potential is the potential difference of the amount of voltage passed through the conductor to the electrical circuit.

(ii) Data given
Radius of nucleus = 3.4×10^{-14} m
Atomic number of silver = 47.
Charge (e) of silver = 1.6×10^{-16} C.
Required
Electric potential = ?

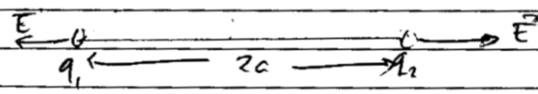
Extract 14.1: A sample of incorrect responses to Question 4 of Paper 2

In Extract 14.1, the candidate provided incorrect responses on electric dipole, dipole field and electric field intensity. The candidate failed to apply the concepts of Coulomb's law, gravitational force and electric potential to determine the charge on the ball and electric potential at the surface of a silver nucleus respectively.

Moreover, 27.50 per cent of the candidates who scored high marks (12 – 20) had enough knowledge about the subject matter. They gave clear descriptions which distinguished electric dipole from a dipole field. In addition, most of such candidates applied appropriate formula to calculate the electric field intensity. They also used their knowledge about electric field and electric potential to identify correctly the point where the electric field is stronger. Most of these candidates applied appropriate formulae and procedures to calculate the electric field intensity and electric potential. Generally, the variation of scores in this question was caused by the candidates' differences in providing irrelevant responses in some parts of the question. Extract 14.2, presents a sample of correct responses provided by one of these candidates.

4(a) (i) Electric dipole is the product of magnitude of either charge and the distance of their separation WHILE Dipole field is an electric field produced by an electric dipole.

(ii) Consider the figure below.



Given: $r = 10\,cm = 0.1\,m$,
$q = 20\mu C = 20\times10^{-6}C$

Now! Electric field along the axial line is given by.

$E_{axial} = \frac{2P}{4\pi\varepsilon_0 r^3}$

Where P is electric dipole moment.

$$E_{axial} = \frac{2(2a)q}{4\pi\varepsilon_0 r^3}$$

$$E_{axial} = \frac{4aq}{4\pi\varepsilon_0 r^3}$$

$$= \frac{aq}{\pi\varepsilon_0 r^3}$$

$$E_{axial} = \frac{20\times10^{-6} \times a}{3.14 \times 8.854\times10^{-12} \times (0.1)^3}$$

$$= 7.194\times10^{8} a \ N/C$$

∴ Electric field on the axial line is $7.194\times10^{8} a$ N/C where a is the distance from either charge to the centre of the dipole.

4(b) (i) Electric field intensity is expected to be high at point A.
This is because, electric field intensity is stronger where electric lines of force are closer to each other and weak were they are spaced.

ii) Given: Mass = 8.4×10^{-16} kg

$E = 2.6\times10^{4}$ V/m.

Required, Charge (q) = ?

Solution.

Electric field intencity is given as a force per unit charge

ie $E = F/q$.

b (ii) $\Rightarrow F = qE$.

But Force = mg.

$mg = qE$.

$q = \frac{mg}{E}$.

$q = \frac{8.4 \times 10^{-16} kg \times 9.8 m/s^2}{2.6 \times 10^{4} V/m}$

$q = 3.166 \times 10^{-19} C$.

∴ Charge on the ball is $3.166 \times 10^{-19} C$.

c (i) Electric potential: Is the workdone in bringing a unit positive charge from infinity to that point.

ii) From $E = \frac{V}{r}$

Where r is radius
V is electric potential and
E is electric field intensity

$E = \frac{dv}{dr}$.

$\Rightarrow dv = E dr$.

Integrating both side to obtain

$V = \int^{r} E dr$

4(c) (ii) but $E = \frac{q}{4\pi\varepsilon_0 r^2}$,

$V = \int_0^r \frac{q}{4\pi\varepsilon_0 r^2} dr$,

$V = \frac{q}{4\pi\varepsilon_0} \int_0^r r^{-2} dr$.

$V = \frac{q}{4\pi\varepsilon_0 r}$.

but total charge of protons say e is equal to $q = ne$.

$V = \frac{ne}{4\pi\varepsilon_0 r}$

Given: $n = 47$

$e = 1.6 \times 10^{-16} C$

$r = 3.4 \times 10^{-14}$.

$V = \frac{47 \times 1.6 \times 10^{-16} C}{4 \times 3.14 \times 8.854 \times 10^{-12} \times 3.4 \times 10^{-14}}$

$V = 1.988885 \times 10^6$ Nm/C $\approx 1.99 \times 10^6$ Nm/C.

∴ The electric potential is 1.99×10^6 Nm/C.

Extract 14.2: A sample of correct responses to question 4 of paper 2

In Extract 14.2, the candidate correctly distinguished the electric dipole from dipole field. The candidate also applied the correct formula to calculate the electric field intensity and electric potential at the surface of the silver nucleus radius. Moreover, the candidate provided the correct meaning of electric potential and identified the point where the electric field intensity is high.

3.5 Question 5: Electromagnetism

This question had three parts: (a), (b) and (c). Part (a) required the candidates to (i) explain the production of magnetic field in a moving coil galvanometer and (ii) differentiate a wire carrying current from another wire carrying no current. In part (b), the candidates were required to (i) identify four factors which affect the magnitude of force exerted by the magnetic field on the charge and (ii) describe with the aid of a well labelled diagram the principle, construction and mode of action of a moving coil galvanometer. Part (c) required the candidates to (i) explain the reason of the force that a current carrying conductor experiences in magnetic field and (ii) calculate the strength of the magnetic field produced if a force of 1.09×10^{-11} N is acting on a proton which enters a magnetic field with a speed of 3.4×10^{7} m/s in a direction perpendicular to the field.

The analysis reveals that 13,801 (59.62%) candidates attempted this question. Among them, 45.29 per cent scored from 0 to 6.5 marks, 44.38 per cent scored from 7 to 11.5 marks and 10.33 per cent scored from 12 to 20 marks. Despite having a reasonable number of candidates (45.29%), who failed the general candidates' performance in this question was average as more than a half passed by scoring 7 marks or above. Figure 16 presents these scores.

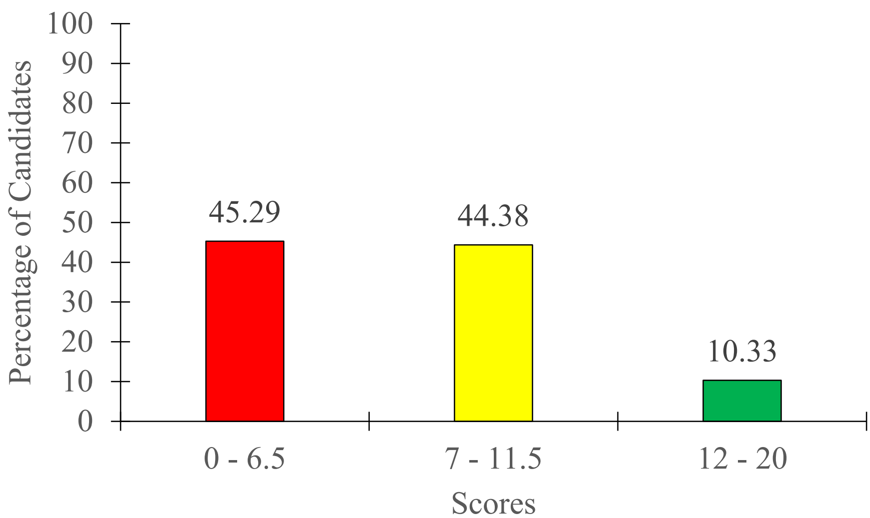
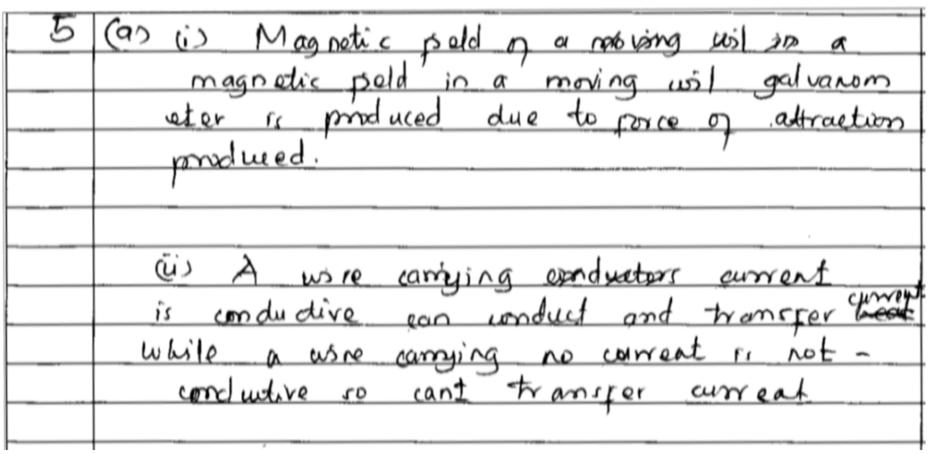


Figure 16: *Candidates' performance in question 5 of paper 2*

The candidates (45.29%) who scored from 0 to 6.5 marks had several mistakes including provision of unclear explanations about the: production of magnetic field in a moving coil galvanometer, factors that affect the magnitude of force exerted by magnetic field on the charge and reasons that makes a current carrying conductor to experience a force in a magnetic field. In part (a) (ii) for example one candidate wrote: *the wire carrying current contain more electrons while the wire carrying no current contain more neutrons than electrons which are at rest.* This candidate failed to understand that a wire carrying a current contains free electrons which move in a definite direction such that it produces magnetic fields while a wire not carrying current does not produce any magnetic field because it contain electrons which are in random motion such that their average velocity in a particular direction is zero. Another shortcoming observed in part (b) (ii) was that most of the candidates provided incorrect diagrams of the moving coil galvanometer without providing basic features such as two half ring magnets with opposite poles, coil in soft iron cylinder core, pivoted spring, scale and a pointer. In part (c), some of these candidates applied incorrect formulae such as: $\frac{mv^2}{r} = Bqv$ instead of $F = Bev\sin\theta$ or $B = \frac{F}{ev\sin\theta}$ to calculate the magnetic field strength which leds them to provide incorrect responses. Extract 15.1 represents a sample of incorrect responses to this question.


5 (a) (i) Magnetic field of a moving coil in a magnetic field in a moving coil galvanometer is produced due to force of attraction produced.

(ii) A wire carrying conductors current is conductive can conduct and transfer current while a wire carrying no current is not conductive so cant transfer current

(b) (i) i - Temperature

ii - Pressure.

- Repulsion force.

- ~~Distance~~ Distance from the charge to magnetic field

(b) (b) (ii)

5 c (i) Current carrying conductor experience a - force of magnetic field due to ~~forces of~~ attraction and repulsion of charges.

(ii) from

$B = \frac{v}{\beta f}$

$B = \frac{1.09 \times 10^{-11}}{3.4 \times 10^{7}}$

$B = 3.205882 \times 10^{-19}$

$B = 3.21 \times 10^{-19}\ T$

$\therefore$ strength $= 3.21 \times 10^{-19}\ T$

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

In Extract 15.1, the candidate incorrectly explained the force of attraction as the source of a magnetic field, but also the responses given in part (a) (ii), (b) (i) and (c) (i) were incorrect. The candidate failed to provide a diagram which could be used to describe the principle, construction and mode of action of a moving coil galvanometer.

$B = \frac{v}{F}$ to calculate the strength of the magnetic field.

The candidates (10.33%) who scored marks ranging from 12 to 20, portrayed a good knowledge of the concept of electromagnetism. They were competent because they analysed correctly the tested concepts. Most of them provided a clear description of the production of magnetic field in a moving coil galvanometer. One candidate for instance wrote: *the curved poles and the soft iron cylinder produces the magnetic field in the air gap such that the coil is always parallel to the field experiencing a constant torque whose magnitude is given by* $\tau = BANI$. Other candidates in this category presented a well labelled diagram of a moving coil galvanometer and a description of its working principle and mode of action. Moreover, these candidates gave reasons which make a current carrying conductor experience force in a magnetic field. The reasons they provided included: *when current flows in a conductor free electrons drift in a definite direction such that it tend to experience a force in the magnetic field which is transmitted to the conductor as a whole*.

However, a number of candidates (44.38%) scored average marks (7 – 11.5) as they provided irrelevant responses especially in the parts which required sketching of a diagram and use of mathematical skills to analyse the tested concepts. In part (c) (i) for example some candidates wrote: *Because the current is attracted by a magnetic force, because of the attraction between the magnetic lines of force and electrons of the current carrying conductor*. Moreover, some of these candidates applied the correct formula such as: $F = qVB\sin\theta$ but failed to analyse and substitute the data correctly in calculating the strength of a magnetic field. Extract 15.2 represents a sample of correct responses from one of the candidates.

5(a) (i) When a moving coil galvanometer is subjected to the magnet, and current is allowed to flow through the coil, coil start to rotate and by doing so, magnetic fields are produced on it.

(ii) A wire carrying current ~~produce~~ have magnetic field and electrons on it move in a specific direction

~~whi~~ while

→ A wire with no current, have no induced magnetic velocity and electrons on it move randomly, hence the moments cancells out.

(b) (i) Factors that affect magnitude of force.

from;

$$F = BqV\sin\theta$$

→ the factors are.

(i) Magnetic flux density

(ii) Velocity of the charge.

(iii) Magnitude of charge.

(iv) Orientation (Angle).

(ii)

Principle.

→ When a moving coil is placed between magnets, and current is allowed to flow on the coil, the coil start to rotate and thus producing torque. The copper bronze coil also rotate and thus producing a restoring torque.

→ Torque produced $\tau \propto \theta$

$$\tau = K\theta.$$

where K = Torsional constant.

5(b) (ii) → Galvanometer is made up of ~~b~~ coil, one is a 'copper bronze coil,

→ Also the coil is placed ~~betwen~~ between two magnets that exerts magnetic field.

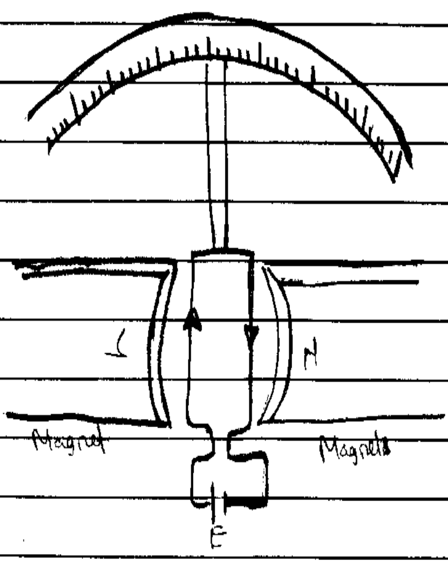
→ It is made up of wires and source of current that provide necessary current for the coil to rotate.

→ It has a scale where the current induced may be recorded.

Mode of action

→ It operates when the current from the source is allowed to flow through the coil, and itself start rotating across the two magnets. It's rotation cause torque and thus producing necessary magnetic field.

→ Consider the diagram below:



A moving coil galvanometer

5(c) (i) A current carrying conductor experience a force, since when it is placed in magnetic field, a conductor get subjected to magnetic force ~~hence it exp~~ produced by magnetic field, thus why a conductor experience a force.

(ii) soln'

Force, $F = 1.09 \times 10^{-11} N$.

Velocity, $V = 3.4 \times 10^7 m/s$

$\theta = 90$

$F = Bqv \sin\theta$.

$B = \frac{F}{qv \sin\theta}$.

$B = \frac{1.09 \times 10^{-11}}{1.6 \times 10^{-19} \times 3.4 \times 10^7 \times \sin 90}$

$B = 2T$.

$\therefore$ Magnetic field produced, $B = 2T$.

Extract 15.2: A sample of correct responses to Question 5 of Paper 2

In Extract 15.2, the candidate applied correct formula and appropriate procedures in performing calculations. However, the candidate sketched a diagram of a moving coil galvanometer without indicating the basic features such as pointer, cylindrical soft iron core and the pivoted spring.

3.6 Question 6: Atomic Physics

This question had three parts (a), (b) and (c). Part (a) required the candidates to (i) explain the stability of an atom is related to its binding energy and (ii) use the given nuclear reaction equation: $^{7}_{3}Li + ^{1}_{1}H \rightarrow 2^{4}_{2}He + 17.3MeV$ $^{4}_{2}He$ in *a.m.u*, when the

$^{7}_{2}Li$ and $^{1}_{1}H$ are 7.0186 *a.m.u* and 1.00813 *a.m.u* respectively. In part (b), they were required to (i) give reasons that make a neutron be a most effective bombarding particle in nuclear reactions and (ii) determine the time taken for $\frac{3}{4}$ of its original mass of radioactive substance with half-life of 30 days to disintegrate. Part (c) required the candidates to determine (i) the work function of the metal and (ii) the stopping potential for the photoelectrons ejected by a longer wave length in an experiment which accounts for the photoelectric effect phenomenon in which students noted some electrons in hydrogen-like atoms (Z= 3) making transition from fifth to fourth orbit and from fourth to third orbit such that the resulting radiations were incident normally on a metal plate ejecting photoelectrons given that the stopping potential for the photoelectrons ejected by a shorter wavelength is 3.96 V.

A total of 19,726 (85.23%) candidates attempted this question and their scores were distributed as follows: 43.82 per cent scored from 0 to 6.5 marks; 38.80 per cent scored from 7 to 11.5 marks and 17.38 per cent scored from 12 to 20 marks. This indicates that the general performance in this question was average since 56.18 per cent of the candidates scored from 7 to 20 marks. Figure 17 summarizes the candidates' performance in this question.

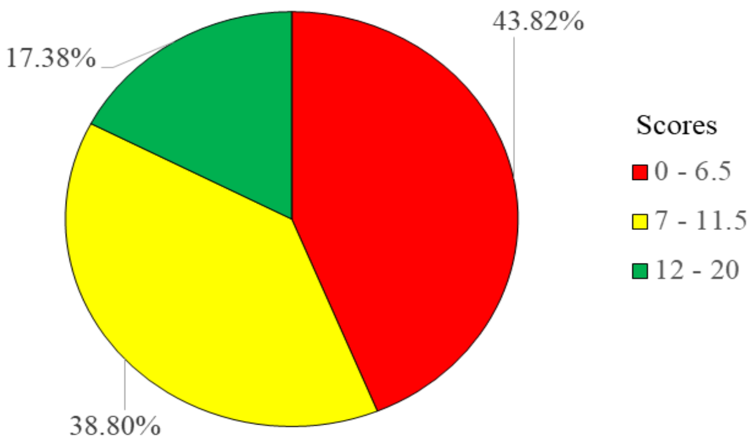


Figure 17: *Candidates' scores in question 6 of paper 2*

The candidates (43.82%) who scored from 0 to 6.5 marks provided insufficient descriptions. In part (a) (i), some candidates provided relevant explanation on how stability of an atom is related to its binding energy but scored zero in part (a) (ii). In part (b) (i) for instance they provided a reason that makes neutron to be a most effective bombarding particle in nuclear reactions but they scored zero in part (b) (ii). These candidates revealed poor understanding of the subject matter as they failed to identify criteria for stable and unstable nucleus such that they could determine the time taken for $\frac{3}{4}$ of its original mass of radioactive substance with the half-life of 30 days to disintegrate. Some candidates for example directly used the given fraction $\frac{3}{4}$ instead of using the formula $\frac{N_0 - N}{N_0} = \frac{3}{4}$ which leads to $\frac{N}{N_0} = \frac{1}{4}$ and $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{t}{T}}$ as a remaining fraction of mass in analysing the time taken, t given that T = 30 days. In part (c), most of these candidates failed to account for the photoelectric effect phenomenon for deducing the work function for stopping potential of a metal. They used Bohr's equation of the hydrogen atom for example $\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ instead of the Bohr's model for hydrogen-like atoms $\frac{1}{\lambda} = Z^2 R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ and the Einstein quantum theory equation $\frac{hc}{\lambda} = W_0 + eV$ to determine the tested concepts. Extract 16.1 represents a sample of incorrect responses to this question.

6

A

(i) Binding energy - is the energy required to liberate all nucleons from the nucleus of an atom

∴ When the stability of an atom is high than the minimum energy required to liberate the nucleons from the nucleus of an atom

(ii)

Given

$17.3ev = 0.0185742 a.m.u.$

$0.0185742 = (7.0186 - X) a.m.u$

$0.0185742 - 7.0186 = -X$

$+7 = +X$

$X = 7.00025811 a.m.u.$

Recall

$Mass defect = M - M'$

$X = 7.00025811 a.m.u$

∴ The mass of $^{4}_{2}He$ is $7.00025811 a.m.u.$

B

(i) It's because it contain zero mass number and 1 of the number of an electrons found on it

$^{0}_{1}n$

This help him to be more reactive and most effective in bombarding

(ii)

Given

$T_{1/2} = 30$

$\left(\frac{N_0}{N}\right) = 3/8$

6 B

from

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

where $n = \frac{T}{T_{1/2}}$

$$\left(\frac{N_0}{\frac{3}{4}N_0}\right) = \left(\frac{1}{2}\right)^n$$

$$\frac{4}{3} = \left(\frac{1}{2}\right)^n$$

$$\ln\left(\frac{4}{3}\right) = n \ln\left(\frac{1}{2}\right)$$

$$n = \frac{\ln\left(\frac{4}{3}\right)}{\ln\left(\frac{1}{2}\right)}$$

$$n = 0.415$$

Then.

$$n = \frac{T}{T_{1/2}}$$

$$0.4 = \frac{T}{30}$$

$$T = 0.4 \times 30$$

$$= 12.45$$

∴ Time for the materials to being disintegrate is 12.45

6 C

from.

$$hf = w_0 + eV_s$$

from

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{7}{144}\right)$$

$$\lambda = 1.875 \times 10^{-6} m.$$

But

$$E = hf = \frac{hc}{\lambda}$$

$$E = \frac{6.626\times10^{-34} \times 3\times10^{8}}{1.875\times10^{-6}}$$

$$E = 1.\times10^{-19}$$

$$hf = 1.\times10^{-19} \text{ Joules}$$

$$1ev = 1.6\times10^{-19} J$$

$$3.96 = x$$

$$= 6.336\times10^{-19}$$

Also

$$\frac{1}{\lambda} = 1.097\times10^{7}\left(\frac{1}{5^2} - \frac{1}{4^2}\right)$$

$$\lambda = 4\times10^{-6} M.$$

$$W_o = 1\times10^{-19}$$

$$hf = w_o + ev.$$

$$1\times10^{-19} = w_o + 6.336\times10^{-19}$$

$$w_o = -5.336\times10^{-19}$$

$\therefore$ Working function is -5.336×10^{-19} Joules

C

(ii)

$$E = hf.$$

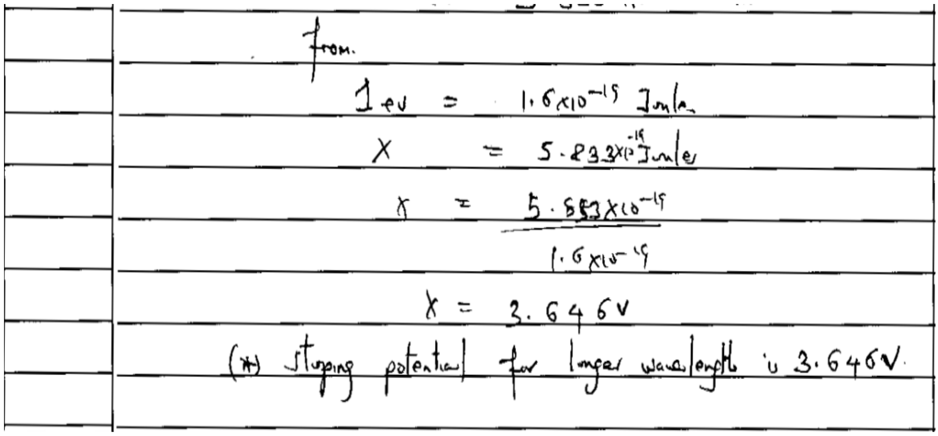
$$= \frac{hc}{\lambda} = \frac{6.626\times10^{-34} \times 3\times10^{8}}{4\times10^{-6}}$$

$$E = 4.97\times10^{-20} \text{ Joules}$$

$$E = W_o + ev.$$

$$4.97\times10^{-20} = -5.336\times10^{-19} + ev.$$

$$ev = 5.833\times10^{-19} \text{ Joule}$$


from.
$1 eV = 1.6\times10^{-19}$ Joule
$X = 5.833\times10^{-19}$ Joule
$X = \frac{5.833\times10^{-19}}{1.6\times10^{-19}}$
$X = 3.646V$
(iii) stopping potential for longer wavelength is 3.646V.

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

In Extract 16.1, the candidate provided inappropriate responses in most parts of the question and applied wrong formulae such as $\frac{N_o}{N} = \left(\frac{1}{2}\right)^n$ instead of $\frac{N}{N_o} = \left(\frac{1}{2}\right)^n$ to find the time taken but also, the wavelength equation of Bohr's model of hydrogen atom instead of the wavelength equation of Bohr's model for hydrogen-like atoms and ended up getting incorrect values of work function and stopping potential.

Despite having some knowledge of atomic Physics specifically in the Structure of the Atom, Nuclear physics and Quantum physics some candidates got average scores (from 7 to 11.5 marks) due to: failure to provide a detailed clarification in part (a) (i) and (b) (i) and lack of mathematical skills to recall theories and laws to establish expressions used in solving the tasks. However, 17.38 per cent of the candidates who scored high marks (12 – 20) had a good understanding about the relation of nuclear mass and binding energy as they applied the given data to determine the mass of ${}^{4}_{2}He$

$\frac{3}{4}$ of the original mass of a radioactive substance to disintegrate. Therefore, such candidates correctly applied the hydrogen like atoms equation $\frac{1}{\lambda} = Z^2 R_H\left(\frac{1}{n_1^{\;2}} - \frac{1}{n_2^{\;2}}\right)$ and the photoelectric effect phenomenon equation for a longer wavelength $\frac{hc}{\lambda_1} = W_0 + eV_1$ to evaluate the work function and stopping potential respectively. Extract 16.2 is a sample of correct responses to this question.

(a) i) Stability of an atom related to binding energy

- The higher the binding energy of an atom the highly stable the atom is
- This is the reason why large atomic mass atoms undergo fission to give atoms with intermediate atomic number and mass number so as to raise binding energy and stability. The process is associated with energy release.
- Also lower mass number atoms undergo fusion to form intermediate mass number atoms with higher binding energy

(a) i) hence attaining higher stability.

(a) ii Given.

$^{7}_{3}Li + ^{1}_{1}H \longrightarrow 2\,^{4}_{2}He + 17.3\ MeV$

1 a.m.u = 931 MeV

m $^{7}_{3}Li$ = 7.0186 am.u

m $^{1}_{1}H$ = 1.00813 a.m.u

Required

Mass of $^{4}_{2}He$ (me)

Soln

Let Q = 17.3 MeV

$m(^{7}_{3}Li) + m(^{1}_{1}H) - 2m(^{4}_{2}He) = \Delta m$

$7.0186\,a.m.u + 1.00813\,a.m.u - 2m(^{4}_{2}He) = \Delta m$

$8.02673\,a.m.u - 2m(^{4}_{2}He) = \Delta m$

Also;

$Q = 931 \text{ MeV} \times \Delta m$

Since;

$1 \text{ a.m.u} = 931 \text{ MeV}$

$\Delta m \text{ a.m.u} = ?$

$= 931 \Delta m \text{ MeV}$

Then;

$\Delta m = Q / 931 \text{ MeV a.m.u}^{-1}$

$= \frac{17.3 \text{ Mev a.m.u}}{931 \text{ MeV}}$

$= 0.018582169 \text{ amu}$

$\frac{8.02673 \text{ a.m.u} - 0.018582169 \text{ a.m.u}}{2} = \frac{2m(^4_2He)}{2}$

$m(^4_2He) = 4.004073915 \text{ a.m.u}$

$\therefore$ Mass of $^4_2He = 4.004073915 \text{ a.m.u}$

(6b) ii Neutron is a most effective bombarding particle in nuclear reactions;

• This is just because neutron is uncharged and therefore it does not get either attracted or repelled by both electrons and protons hence penetrates the nucleus without being deflected at all.

(6b) iii Given

Half life of a radioactive substance $t_{1/2} = 30$ days

Required

Time taken for $\frac{3}{4}$ of its original mass to disintegrate.

Soln

Let initial mass before disintegration (m_i) = m_o

Final mass $= m_o - \frac{3}{4} m_o$ (m_f) $= \frac{1}{4} m_o$

From;

$m_f = \frac{m_i}{2^n}$

$$\frac{1}{4}m_0 = \frac{m_0}{2^n}$$

$$\frac{1}{4} = \frac{1}{2^n}$$

$$\frac{1}{2^2} = \frac{1}{2^n}$$

Compare LHS with RHS

$n = 2$

Then;

$$n = \frac{T}{t_{1/2}}$$

$$T = n \times t_{1/2}$$

$= 2 \times 30$ days $= 60$ days

∴ Time taken for $3/4$ of original mass to disintegrate (T) $= 60$ days.

6(c) Given

Electron transitions;

$n = 5 \longrightarrow n = 4$

$n = 4 \longrightarrow n = 3$

$Z = 3$

Stopping potential $(V_0) = 3.96\,V$ (photoelectrons with shorter wavelength)

Required

6(c)(i). Work function of the metal.

Soln.

From;

$$hf = \phi_0 + KE_{max}$$

$$hf = \phi_0 + qV_0$$

Also,

From;

$$E = \frac{-13.6\,Z^2 eV}{1}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

For $n=5 \longrightarrow n=4$

$$E = -13.6 \times 3^2 \left(\frac{1}{5^2} - \frac{1}{4^2}\right)$$

$E = 2.754$ eV (gives longer wavelength $E \propto \frac{1}{\lambda}$)

For $n = 4 \longrightarrow n=3$

$$E = -13.6 \times 3^2 \left[\frac{1}{4^2} - \frac{1}{3^2}\right]$$

$E = 5.95$ eV (gives shorter wavelength $E \propto \frac{1}{\lambda}$)

6(c)(i) Also;

$1\text{ eV} = 1.6 \times 10^{-19}$ J

$? = 1.9008 \times 10^{-18}$ J

$$= \frac{1.9008 \times 10^{-18}\text{ J} \times 1\text{ eV}}{1.6 \times 10^{-19}\text{ J}}$$

$$= \frac{11.88\text{ eV}}{3}$$ (Using only a single electron)

$= 3.96$ eV

Then;

$E = \phi_0 + 3.96$ eV

$5.95\text{ eV} = \phi_0 + 3.96$ eV

$\phi_0 = (5.95 - 3.96)$ eV

$= 1.99$ eV

$\therefore$ Work function of the metal

$(\phi_0) = 1.99$ eV or

$= 3.184 \times 10^{-19}$ J

6c (ii) Stopping potential for photoelectrons ejected by longer wavelength.

Soln

Energy from longer wavelength $E = hf = 2.754 eV$

Then;

$E = \phi_o + E_{max}$

$2.754 eV = 1.99 eV + E_{max}$

$E_{max} = 0.764 eV$

But $E_{max} = qV$

$1.6 \times 10^{-19} C \; V_o = 0.764 \times 1.6 \times 10^{-19}$

$V_o = 0.764 V$

∴ Stopping potential for the photoelectrons ejected by longer wavelength $(V_o) = 0.764 V$

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

In Extract 16.2, the candidate correctly provided the relationship between binding energy and the stability of an atom and applied formulae correctly to find the mass of helium nucleus. In addition the candidate provided relevant descriptions about a neutron being the most effective bombarding particle as well as establishing the required expressions/formulae to compute time, work function and the stopping potential for the ejected photoelectrons.

4.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN 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 comprised 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 each alternative papers, Physics 3A, 3B and 3C. The analyses of these questions are as follows:

A total of 23,141 (100%) candidates attempted these questions. Among them, 20.44 per cent scored from 0 to 6.5 marks, 20.52 per cent scored from 7 to 11.5 marks and 59.04 per cent scored from 12 to 20 marks. The analysis reveals that the candidates' general performance in these questions was good as 79.56 per cent of the candidates scored 7 marks or above. Figure18 summarizes candidates' performance.

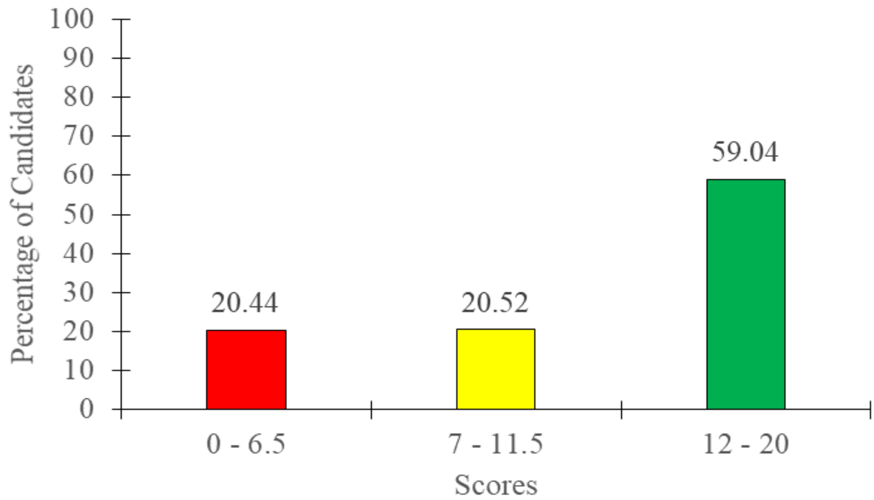


Figure18: *Candidates' performance in question 1 of paper 3*

4.1.1 Physics 3A

The candidates were required to perform an experiment according to the following instruction:

(a) Tie up the given metal ring suspended from the retort stand, then tie a pendulum bob at the lower position of the ring as shown in Figure 1.

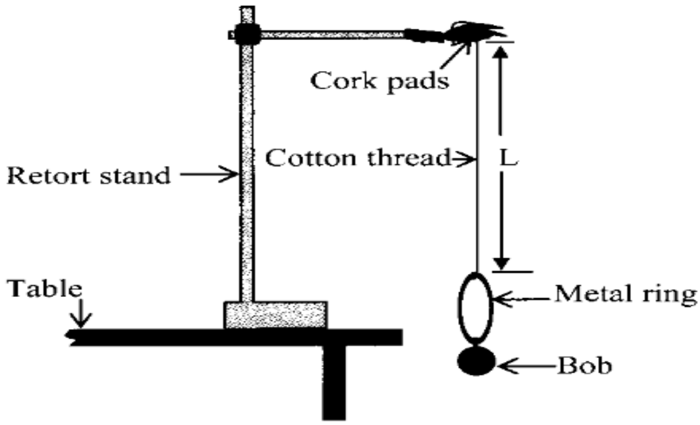


Figure 1

(b) Starting with the length L = 30 cm, displace the bob slightly side way and then release it in such a way that it oscillates in a horizontal plane. Determine the time, t for 20 complete oscillations and the value of T.

(c) Repeat the procedure in 1 (a) and (b) for L = 40 cm, 50 cm, 60 cm and 70 cm in each experiment and record the value of t and T.

Questions

(i) Tabulate the results of L, t, T, and T^2

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

(iii) From the graph, read and record the value of L at $T^2 = 0$.

(iv) What is the significance of the value obtained in 1(iii)?

(v) What is the aim of doing this experiment?

The candidates (59.04%) who scored high marks (12 – 20) had adequate knowledge of the tested concepts in Mechanics. Most of them were competent in setting the experiment, collecting the data, analysing and applying mathematical skills to obtain the required solution. They also used the collected data and followed the required procedures of plotting the graph of L against T^2. Moreover, some of them correctly interpreted the plotted graph by reading and recording the value of L at $T^2 = 0$ which helped them to state the significance of the value of L obtained and the aim of doing the given experiment. Extract 17.1 is a sample of the candidate's correct responses.

1. (c)

(i)

L (cm)	t (sec)	T (sec)	T^2 (sec^2)
30	28.31	1.4155	2.004
40	31.09	1.5545	2.416
50	32.96	1.648	2.716
60	35.75	1.7875	3.195
70	37.75	1.8875	3.563

(ii)

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

$$T^2 = 4\pi^2\left(\frac{l}{g}\right)$$

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

but; $l = L + d + c$

Let d be diameter of the metal ring

c be radius of the bob

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

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

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

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

1.(c)(ii)

$L = \frac{g}{4\pi^2} \cdot T^2 - (d+c)$.

$y = m \cdot x + c$.

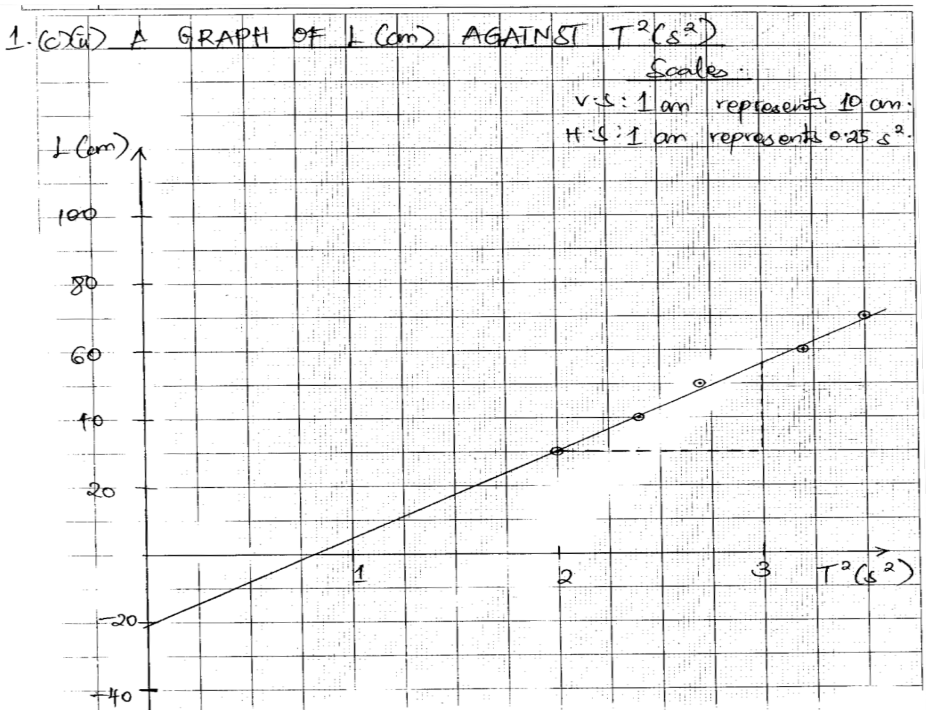
(iii) when $T^2 = 0$

$L = -21$ cm.

∴ When $T^2 = 0$, the value of L is -21 cm.

(iv) The value helps to determine the diameter of the metal ring and the radius of the bob.

(v) The aim of the experiment is to determine the diameter of the ring and the radius of the bob.



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 them to plot the graph of L (cm) against the T^2 (s^2). Then, he/she applied the equation of a period of oscillation of the simple pendulum to obtain the equation which related to the graph plotted. Similarly, this candidate obtained the value of L when the value $T^2 = 0$ and stated correctly its significance and aim of doing the experiment.

A few candidates (20.44%) scored low marks (0 – 6.5). Most of these candidates had insufficient practical skills in setting the length of the cotton thread from the metal ring to the point of attachment as instructed in Figure 1. Another noted weakness in their responses was candidates' lack of mathematical skills of using the theory of a simple pendulum in deducing the required equation of simple pendulum when attached with a metal ring and a bob. These candidates were required to recall the equation of a simple pendulum $T = 2\pi\sqrt{\frac{L}{g}}$ such that by adding with the diameter of the ring, d and the distance from the centre of the bob to the point at which the bob is attached to the ring, c they could get the expression $T = 2\pi\sqrt{\frac{L+d+c}{g}}$. Using numerical skills the candidates could obtain the required equation $L = \frac{g}{4\pi^2}T^2 - (d+c)$ in which the significance of the value of L at $T^2 = 0$ is the $L - \text{intercept} = -(d+c)$. In addition, the graphs presented by these candidates lacked some of the basic features such as the title of the graph, the axes, the proper scales and the best fit lines. Moreover, some of these candidates plotted the graph to determine the slope instead of the intercept which led them to provide incorrect responses in other parts of the question. Extract 17.2 is a sample of incorrect responses to this question.

1 (a) Table of results

n = 20 oscillation

L(cm)	t	T	T^2
30	5.4	0.27	0.0729
40	6	0.30	0.090
50	6.8	0.34	0.116
60	7.4	0.37	0.137
70	8	0.40	0.16

1 (b) at $T^2 = 0$ the value of $L = -$ ~~35cm~~ $35.5cm$

(iv) The significance value of L is the length of the ring and the acceleration due to gravity helps to get the radius of a ring.

From

$$T^2 = \frac{4\pi^2 (L_0)}{g}$$

but $L_0 = L + 2\pi r$

Then

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

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

$$y = m x + c$$

1. ~~y~~- intercept $= \frac{4\pi^2 2\pi r}{g}$

compare with from graph

$X_0 = 0.264$

$0.264 = \frac{4\pi^2 \times 2\pi r}{g}$

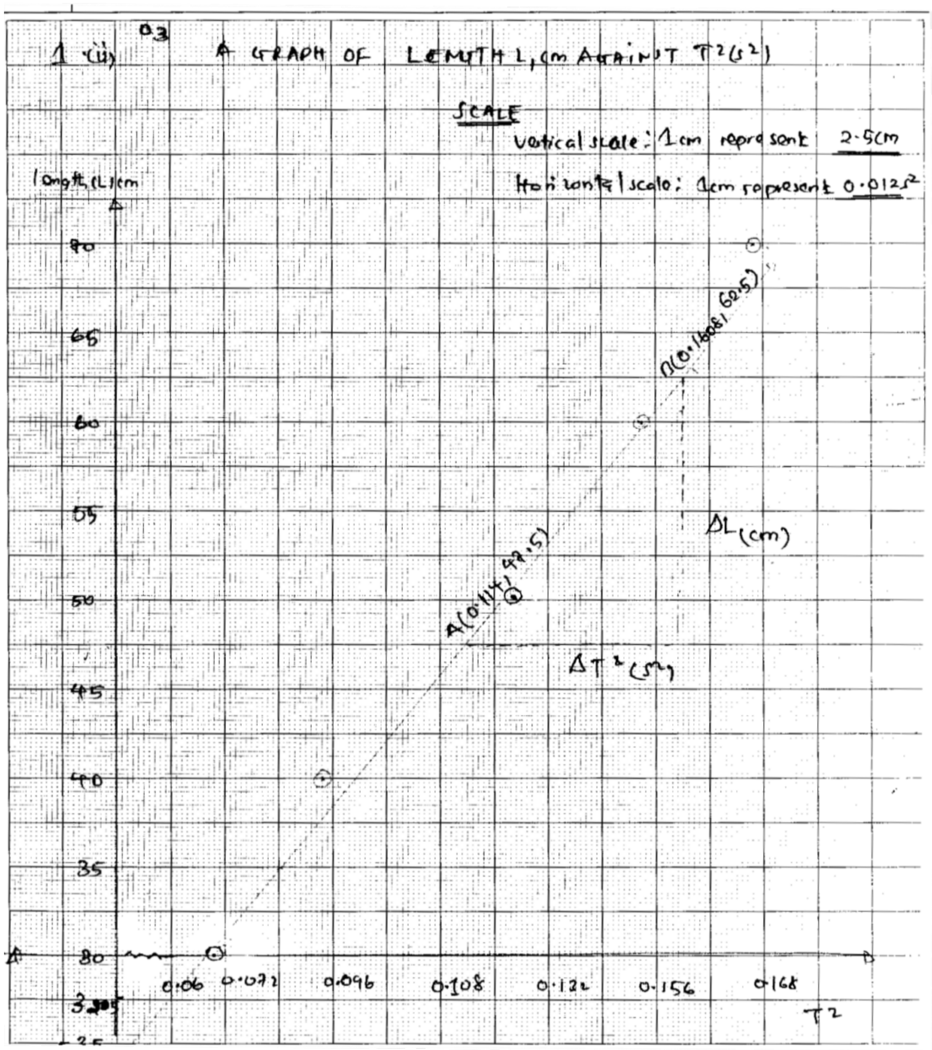
Then

$r = \frac{0.264 \times 980}{4\pi^2 \times 2\pi}$

$r = 10.4\,cm$

$\therefore$ The value of radius (r) = 10.4 cm.

(v) The aim of experiment is to determine the value of radius of a circular ring given at the point of an oscillating pendulum



Extract 17.2: A sample of incorrect responses to question 1 of paper 3A

In Extract 17.2, the candidate failed to indicate the units used in the table of results and plotted the graph without units in horizontal axis and recorded the value of L at $T^2 = 0$ without stating its significance. Moreover, the aim of performing this experiment provided by the candidate was not correct.

4.1.2 Physics 3B

In this question, the candidates were required to examine the oscillations of a simple pendulum using the given apparatus. The candidates were required to proceed as follows:

(a) Suspend a pendulum bob from the length L equals to 0.90 m and displace it through a small angle so that it swings parallel to the edge of the bench.
(b) Determine the time, t for 20 oscillations and the corresponding periodic time, T.
(c) Repeat the procedures in 1 (a) and (b) above for the values of L = 0.70 m, 0.50 m, 0.30 m, and 0.10 m.

Questions

(i) Record your readings in a table including the values of log L and logT.
(ii) Plot a graph of $\log_{10}\mathrm{T}$ against $\log_{10}$ L.
(iii) Use the graph in 1 (ii) to resolve the values of constants n and k from the equation $\mathrm{L}^{\mathrm{n}} = \mathrm{Tk}^{-1}$.

The analysis of data reveals that 59.04 per cent of the candidates scored high marks (12 – 20). These candidates had adequate knowledge to perform the experiment correctly. Most of them used numerical skills to relate the given equation and the results from the graph to obtain the value of n and k. In addition, they collected and tabulated correctly the table of results and used proper procedures in plotting and interpreting the graph. Furthermore, most of these candidates applied the given equation $\mathrm{L}^{\mathrm{n}} = \mathrm{Tk}^{-1}$ to establish the equation $T = kL^n$ after which they applied logarithmic function on both sides to obtain the equation $\log_{10} T = n\log_{10} L + \log k$. Furthermore, they interpreted this equation by relating it with the general equation of a straight line $y = mx + c$ to obtain the significance of the slope of the graph and the value of $\log_{10}\mathrm{T}$ $-\mathrm{intercept}$. The correct responses were as follows: $\mathrm{slope} = \mathrm{n} \approx$ (0.5 ± 0.05) and $\log_{10}\mathrm{T} - \mathrm{intercept} = \log_{10}\mathrm{k} \approx$ 0.2 to 0.38 which gives the value of k ≈ 1.58 to 2.4. Extract 18.1 is a sample of a candidates' correct responses.

01. i. Table of results.

L(m).	t(sec).	T(sec).	$\log_{10} T$	$\log_{10} L$.
0.90	38.04	1.902	0.279	-0.046
0.70	33.54	1.677	0.225	-0.155
0.50	28.34	1.417	0.151	-0.301
0.30	21.95	1.098	0.041	-0.523
0.10	12.66	0.633	-0.199	-1.000

iii. Solution.

From: $L^n = TK^{-1}$.

Graph of $\log T$ against $\log L$.

$TK^{-1} = L^n$

Apply log both sides.

$\log(TK^{-1}) = \log L^n$

$\log T + \log K^{-1} = \log L^n$

$\log T = \log L^n - \log K^{-1}$.

$\log T = n \log L - \log K^{-1}$.

$\text{Log} T = n \text{Log} L - \text{Log} K^{-1}$

$y = m x + c$.

a. The Value of n.

n = Slope of graph.

$\text{Slope} = n = \dfrac{\Delta \log T}{\Delta \log L}$.

$n = \dfrac{0.151 - 0.041}{-0.301 - -0.523}$.

$n = 0.495$.

∴ $n = 0.495 \pm 0.5$

01. iii

b. The Value of K.

$\log T = n \log L - \log K^{-1}$

$\log T = n \log L + \log K.$

$y = mx + c$

$\therefore c = y \text{ Intercept} = \log K.$

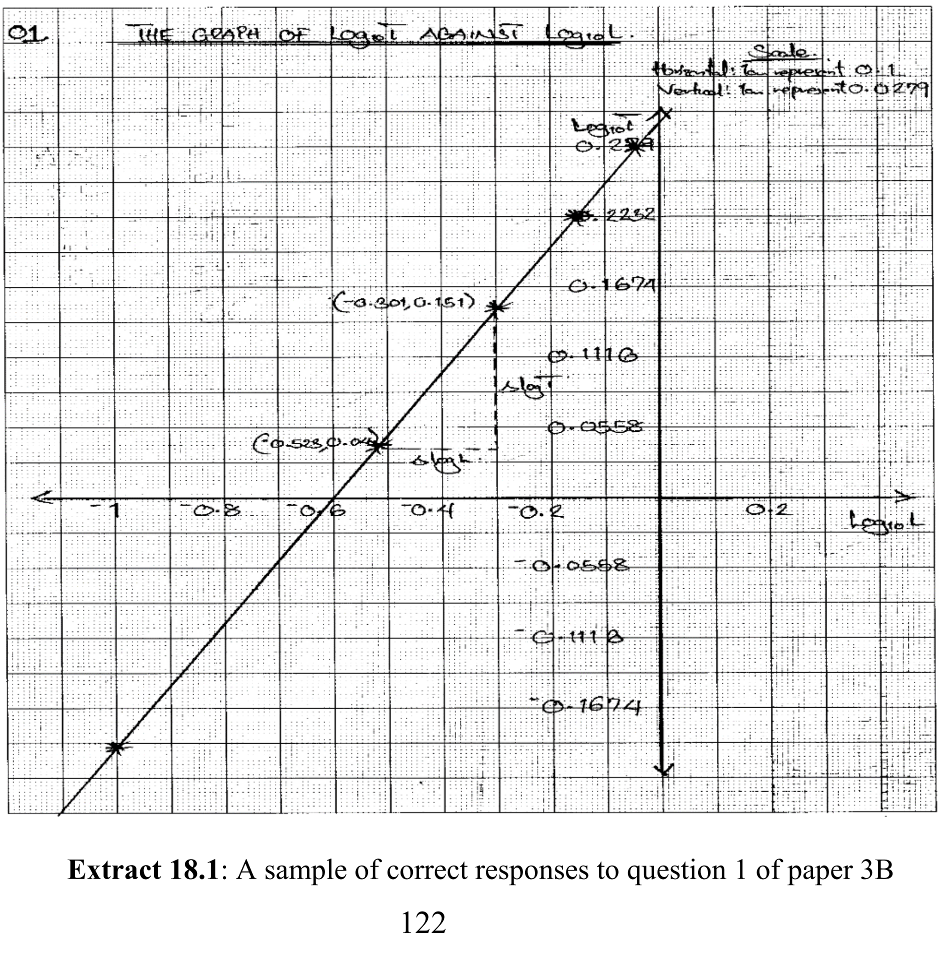
$\therefore 0.298 = \log K.$

$\therefore K = \log^{-1} 0.298$

$K = 1.988 \approx 2.$

$K = 2.$

$\therefore K = 2.$



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 drew the graph with the required aspects. He/she applied numerical skills to deduce the necessary equations for analysing the values of n and k from the graph.

However, 20.44 per cent of the candidates scored low marks (0 – 6.5) due to several weaknesses. Such weakness include: Lack of knowledge of using stop a watch for recording the time t (s) for 20 oscillations as a result they incorrectly determined the periodic time, T and failed to present the data graphically. Another mistake was the failure to abide to the important features when drawing a graph which include; the title, the axes, the scales used and the slope indication. Furthermore, some of the candidates failed to: analyse the information from the graph and to deduce the intended equation which could lead them to the correct value of n and k. Extract 18.2 is an example of one of the candidates' incorrect responses.

1\. (i) Table of results

L(cm)	t sec	T(sec)	log L	log T(sec)	
90	0.37	0.0185	1.95	-1.73	=1.773
		0.0165			
70	0.33	0.0165	1.85	-1.78	1.78
50	0.28	0.014	1.70	-1.85	1.85
30	0.21	0.0105	1.48	-1.98	1.98
10	0.12	0.006	1	-2.22	2.22

(ii) Graph.

(iii) $L^n = Tk^{-1}$

from

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

$T^2 = 4\pi^2 L/g$

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

$y = m \cdot x$

$L^n = Tk^{-1}$

$y = m x$

from the graph

n = 0.5

∴ L = length

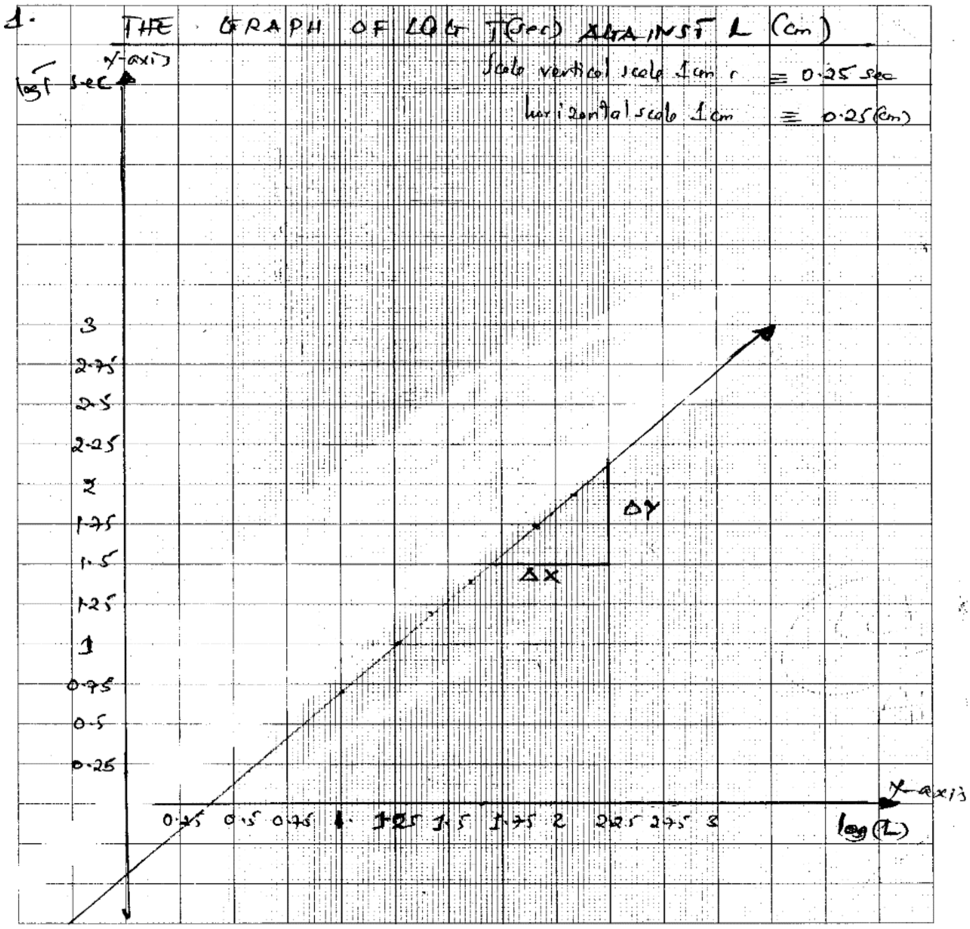
$L^2 = T k^{-1}$

where k^{-1} = ~~slope~~

∴ k^{-1} = value of x

whereby

K = 2



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 20 oscillations in seconds and drew an incorrect graph. The candidate also failed to derive the required equation in order to obtain the values of n and k from the graph.

4.1.3 Physics 3C

The candidates were provided with a half metre rule, metre rule, two retort stands and two pieces of threads. The candidates were required to proceed as follows:

(a) Set up the apparatus as shown in the following figure 1 with the length of threads L= 60cm.The flat side of the ruler with a scale must be horizontal.

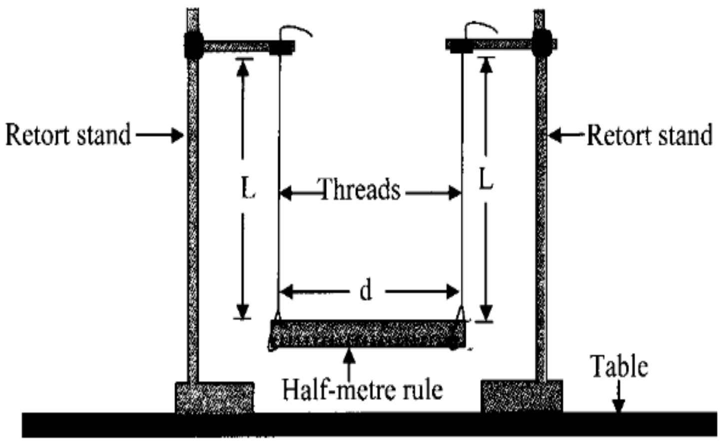


Figure 1

(b) Set the threads very near to the ends; such that, distance d is 50 cm. Displace the ends of the ruler through a small angle along the horizontal plane so that it swings. Determine the time, t for 20 complete oscillations and the corresponding periodic time, T. Also to record the distance d between the threads.

(c) Without removing the retort stands, adjust the threads 5cm from each end to make the distance d = 40cm, then repeat the procedure in 1 (b). Continue moving the threads from each end by 5cm to obtain a total of five readings.

Questions

(i) Tabulate the values of d (m), t(s), T(s) and $\frac{1}{d}$ (m^{-1}).

(ii) Plot a graph of T(s) against $\frac{1}{d}$ (m^{-1}).

(iii) Use the graph in 1 (ii) and the equation $d = \frac{0.31\pi}{T}\sqrt{\frac{L^3}{g}} + \text{Constant}$, determine the value of acceleration due to gravity, g.

Data analysis reveals that 59.04 per cent of the candidates who scored high marks (12 – 20) had adequate knowledge of the subject matter. Most of these candidates demonstrated their practical skills in performing the experiment. They managed for example to set up the given apparati as instructed, they collected the data which was in a good range and presented it in the tabular form. Another competence which verified their skills was the interpretation of data collected in plotting the graph of period T (s) against the reciprocal of distance d (m^{-1}) where by most of them got it right. Moreover, some of these candidates used the plotted graph and the given equation $d = \frac{0.31\pi}{T}\sqrt{\frac{L^3}{g}} + \text{constant}$ to analyse the slope and acceleration due to gravity g. Extract 19.1 is a sample of a correct response to this question.

1 The aim of the experiment is to determine the acceleration due to gravity g.

(i) Table of result.

d(cm)	d(m)	t(s)	T(s)	1/d (m⁻¹)
50	0.50	18.38	0.919	2.00
40	0.40	20.50	1.025	2.50
30	0.30	23.62	1.181	3.33
20	0.20	28.47	1.424	5.00
10	0.10	38.34	1.917	10.00

1(ii). from the equation

$$d = \frac{0.31\pi}{T}\sqrt{\frac{L^3}{g}} + \text{constant}$$

$$Td = 0.31\pi\sqrt{\frac{L^3}{g}} + \text{constant} \times T$$

divide by d both side.

$$T = 0.31\pi\sqrt{\frac{L^3}{g}} \cdot \frac{1}{d} + \text{constant} \times \frac{T}{d}.$$

By comparing from the equation of line

$$T = 0.31\pi\sqrt{\frac{L^3}{g}} \cdot \frac{1}{d} + \text{constant} \times \frac{T}{d}$$

$$y = m \quad x + c$$

$$\text{slope} = 0.31\pi\sqrt{\frac{L^3}{g}}.$$

From the graph

$$\text{slope} = \frac{\Delta T(s)}{\Delta 1/d\,(m^{-1})}.$$

$$\text{Slope} = \frac{(1.42 - 0.92)\,s}{5.00 - 2.00\,(m^{-1})}$$

Slope = 0.1453 ms.

∴ The slope is 0.1453 mks.

From

$$\text{slope} = 0.31\pi\sqrt{\frac{L^3}{g}}$$

$$(\text{slope})^2 = (0.31\pi)^2 \cdot \frac{L^3}{g}$$

$$g = \frac{(0.31\pi)^2 L^3}{(\text{Slope})^2}$$

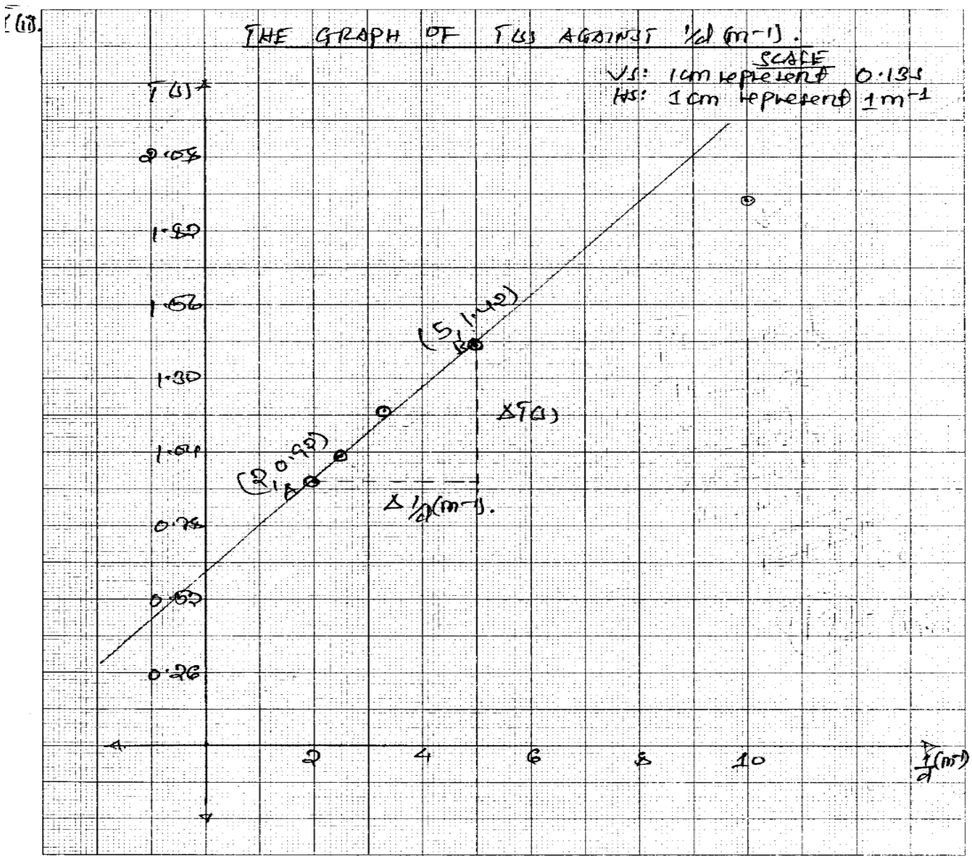
$$g = \frac{(0.31\pi)^2 L^3}{(0.1453)^2}$$

where L = 60cm = 0.6m.

$$g = \frac{(0.31\pi)^2 \times (0.6)^3}{(0.1453)^2}$$

$$g = 9.704\ m/s^2$$

∴ The value of acceleration due to gravity, g is $9.704\ m/s^2$.



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 acceleration due to gravity, g.

A few candidates, (20.44%) scored low marks (0 – 6.5) due to various reasons. Most of these candidates faced difficulties in setting the given apparatii to start oscillations of the entire system. It was noted that, some of them displaced the ruler along the vertical plane when recording the time, t for 20 oscillations as a result they obtained incorrect values of the periodic time, T. In addition, they drew graphs using incorrect data values without indicating some of the important aspects such as; the title, axes, scales, the best line and slope indication. Another candidates' weakness noted in their responses was failure to suggest the suitable scale based on the data collected. This affected most of the candidates when transferring the data to choose the points when drawing the best-fit line. However, variation of marks occurred because some of the candidates failed to deduce the relationship between T and d^{-1} from the given equation, $d = \frac{031\pi}{T}\sqrt{\frac{L^3}{g}} + \text{constant}$ to formulate the equation $T = 0.31\pi\sqrt{\frac{L^3}{g}}\frac{1}{d} + A$ used to determine the slope and acceleration due to gravity g. Extract 19.2 is a sample of a candidates' incorrect responses to the question.

d(m)	t(s)	T(s) = t/20	1/d(m^{-1})
50	31	1.55	0.02
40	32.25	1.6125	0.025
30	32.90	1.64	0.033
20	32.98	1.65	0.05
10	33.10	~~1.66~~ 1.7	0.1

The graph of T(s) against 1/d(m^{-1})

$d = \frac{0.31\pi}{T}\sqrt{\frac{L^3}{g}} + K$

$(d)^2 = \left(\frac{0.31\pi}{T}\right)^2\left(\sqrt{\frac{L^3}{g}}\right)^2 + K$

$d^2 = 0.31\pi^2$

$$d^2 = \frac{0.0961\,\pi^2}{T^2}\,\frac{L^3}{g} + K$$

$$d^2 = \frac{0.0961\pi^2}{g}\left(\frac{L^3}{T^2}\right) + K$$

from

$$y = mx + c$$

$$y = d^2$$

$$m = \frac{0.0961\,\pi^2}{g}$$

XI# From the graph
$m = 0.09767$

hence

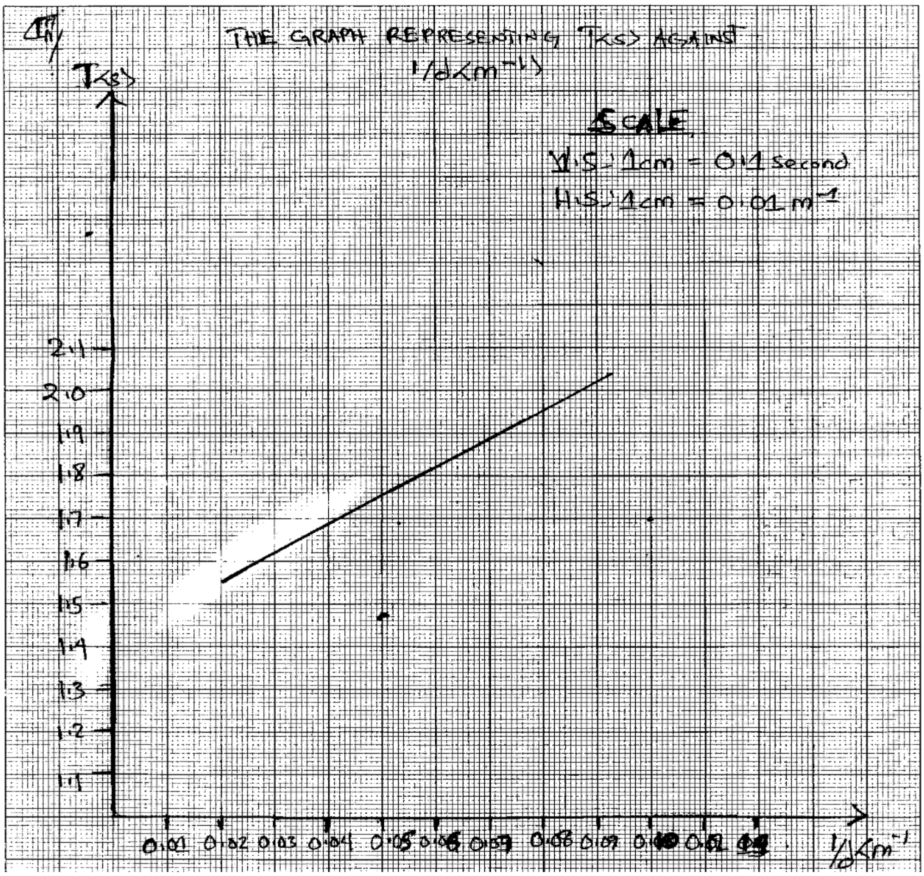
$$m = \frac{0.0961\pi^2}{g}$$

$$g = \frac{0.0961\pi^2}{m}$$

$$g = \frac{0.0961 \times (3.14)^2}{0.09767}$$

$g = 9.70\,m/s$

$\therefore$ the value for gravity g is $9.70\,m/s$



Extract 19.2: A sample of an incorrect response to question 1 of paper 3C

In Extract 19.2, the candidate tabulated the incorrect values of time t (s) for 20 complete oscillations and failed to change the values of distance d in a metre as instructed in 1 (i). The candidate also lacked skills of using proper scales to transfer the data into the graph and ended with incorrect values of slope and acceleration due to gravity, g.

4.2 Question 2: Heat

This part contained three questions from the topic of Heat. It is a collection of questions from three alternatives papers, physics 3A, 3B and 3C. The analysis of these questions is as follows:

The questions were attempted by 23,141 candidates equivalent to 100 per cent, out of which 16.95 per cent scored from 0 to 5 marks, 26.19 per cent scored from 5.5 to 8.5 marks and 56.86 per cent scored from 9 to 15 marks. This shows that the candidates' performance in these questions was good since 83.05 per cent scored from 5.5 to 15 marks. Figure 19 presents a summary of candidates' performance in this question.

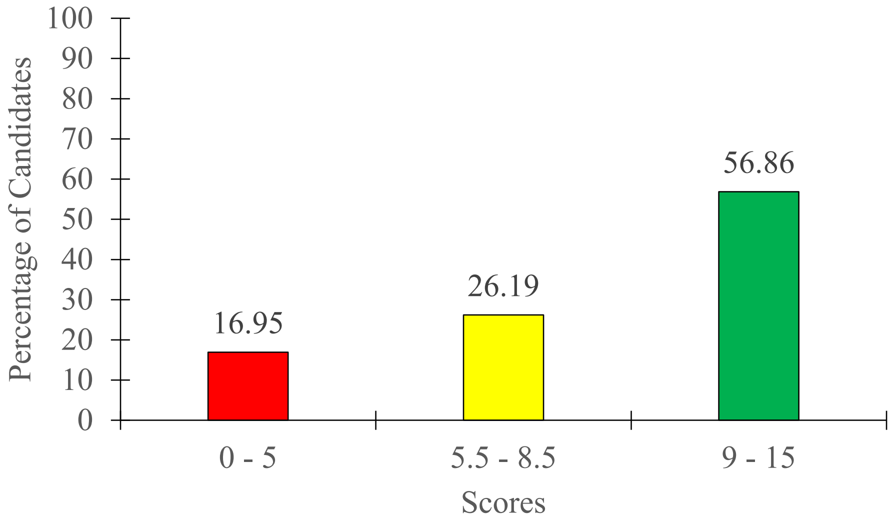


Figure 19: *Candidates' performance in question 2 of paper 3*

4.2.1 Physics 3A

The candidates were provided with a beam balance, thermometer, calorimeter with its lid and stirrer and a hot liquid labelled B. They were then required to:

(a) Weigh an empty calorimeter with its lid and stirrer and record its mass as M_1.

(b) Fill the calorimeter to about two-thirds full with a liquid B that has been heated to a temperature of about 85 °C.

(c) While stirring, insert the thermometer and start the stopwatch. Read and record the temperature after every 2 minutes intervals as the liquid cools under forced conditions to a temperature of about 55 °C.

(d) After cooling the liquid B to about 55 °C, remove the thermometer and weight the calorimeter with its contents and record its mass as M.

(e) Find the mass of liquid B and record it as M_2.

Questions

(i) Tabulate your results of time (seconds) and the temperature in (°C).

(ii) Plot a cooling curve for liquid B.

(iii) Draw the tangent at the temperature of 70 °C and obtain the rate of cooling of liquid B.

(iv) Use the equation $(M_2C_B + 400M_1)\frac{d\theta}{dt} = 10.096\,Js^{-1}$ and the value obtained in 2 (iii) to calculate the specific heat capacity of liquid B (C_B).

More than a half (56.86%) of the candidates who attempted this question scored high marks (9 - 15). Most of the candidates had enough knowledge of performing an experiment involving the rate of cooling under forced convection. Their responses illustrated their skills of collecting data and plotting the graph of the cooling curve. This suggests that these candidates had good masterly of the subject matter especially in the concept of Newton's law of cooling. Candidates also were able to show the necessary features in plotting the graph including the title of the graph, the scales, the axes with their respective units and the best curve. Moreover, some of them obtained the correct value of the rate of cooling by drawing the correct tangent in the curve at the temperature of 70 °C and used the value obtained and the given relation to calculate the specific heat capacity of liquid B.

The scores of the candidates (26.19%) who scored average (5.5 – 8.5) marks varied due to their diverse ability in organizing and analysing their responses. Some of them for example lacked computational and drawing skills which led to loss of marks. Furthermore, they lacked mathematical skills to associate the tangent obtained at a temperature of $70\ ^{\circ}C$ and the rate of cooling of liquid B with the equation $(M_2C_B + 400M_1)\frac{d\theta}{dt} = 10.096\,Js^{-1}$ to evaluate the required specific heat capacity of liquid B. Extract 20.1 provides a sample of a candidate's correct response.

2	(a) Mass of Calorimeter with its lid (M_1)
	⇒ $M_1 = 88.75$
	(b) Mass of Calorimeter with its Content (M)
	⇒ $M = 156.65$
	(c) Mass of liquid B (M_2)
	⇒ $M_2 = M - M_1$
	$M_2 = 156.65 - 88.75$
	$M_2 = 67.95$

2 (i) TABLE OF RESULTS

time (sec)	Temperature (°C)
0	85
120	80
240	75
360	71
480	68
600	63
720	60
840	57
960	55

2 (ii) A Cooling Curve for liquid B
⇒ Refer to the graph.

(iii) At temperature $\theta = 70°c$

$$\text{Gradient} = \frac{\delta \text{Temperature } (°C)}{\delta \text{time } (sec)}$$

$$= \frac{(T_2 - T_1)°C}{(t_2 - t_1)s}$$

$$= \frac{(74 - 65)°c}{(259 - 525)\ sec}$$

$$= \frac{9°c}{-266s}$$

$$\frac{d\theta}{dt} = -0.0338 °C\ sec^{-1}$$

∴ The gradient at 70°c is $\frac{d\theta}{dt} = -0.0338 °c\ sec^{-1}$

2 (iv) Soln.

Given the equation:

$$(M_2 C_Q + 400 M_1)\frac{d\theta}{dt} = 10.096\, J s^{-1}$$

For, C_Q

$$M_2 C_Q + 400 M_1 = \frac{10.096\, J s^{-1}}{d\theta/dt}$$

$$M_2 C_Q = \frac{10.096\, J s^{-1}}{d\theta/dt} - 400 M_1$$

$$C_Q = \frac{\frac{10.096\, J s^{-1}}{d\theta/dt} - 400 M_1}{M_2}$$

but

$$\frac{d\theta}{dt} = -0.03382\, s^{-1}$$

$$\Rightarrow C_Q = \left(\frac{10.096}{0.3382\, s^{-1}} - 400 \times 88.75\right) J/gK$$

67.95

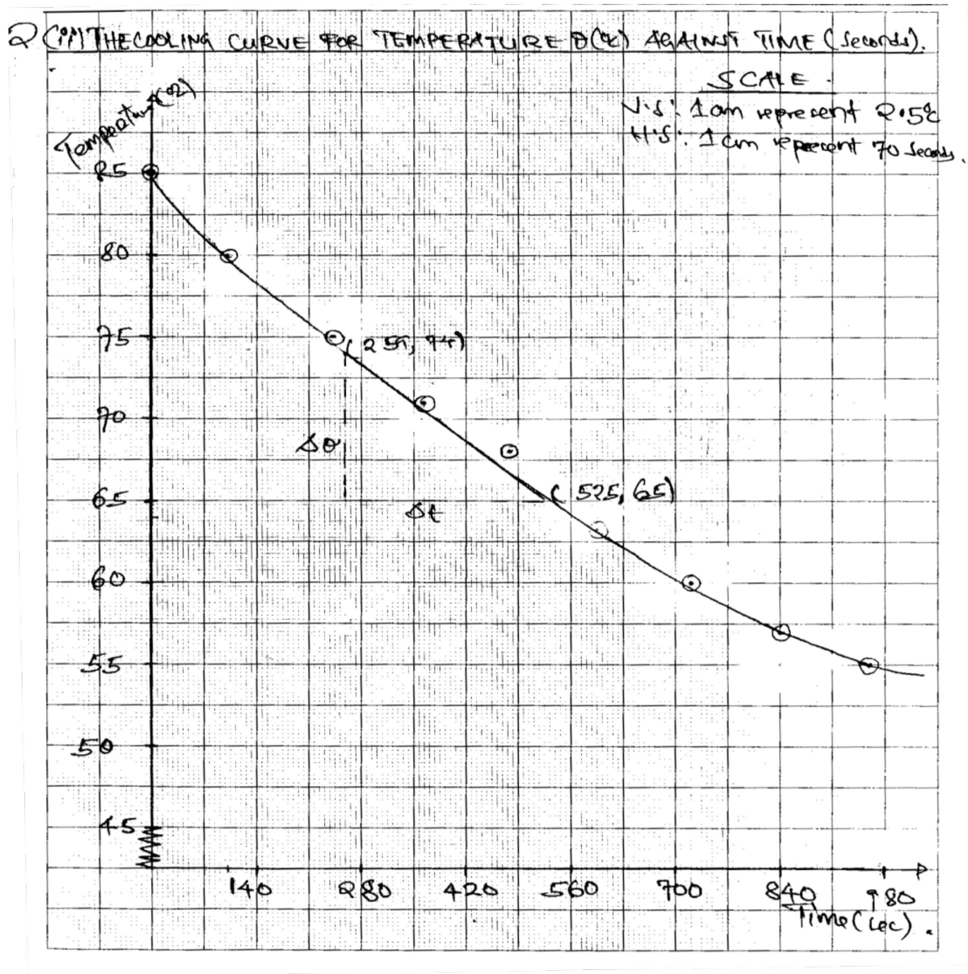
$C_Q = 4.168$ J/gK

$C_Q = 4.17$ J/gK

So specific heat capacity of liquid Q (C_Q)

$\Rightarrow$

$C_Q = 4.17$ J/gK.



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 rate of cooling at 70 ºC as well as the specific heat capacity of liquid B.

On contrary,16. 95 per cent of the candidates scored low marks (0 – 5) due to a number of reasons that included: Failure to follow instruction on how to measure and record the data by using either a thermometer, beam balance or stopwatch. In recording the values of time, t for instance one candidate wrote: *t = 2.18 s, t = 4.73 s, t = 6.81 s* e.t.c. showing that he/she was taking the readings in minutes instead of converting it to seconds. In addition, a notable weakness observed in most scripts was the candidates' inadequate skills of drawing cooling curves without showing the important features. Moreover, candidates' poor scales, wrong transferring of points from the table of results to the graph and incorrect tangents at 70 ºC to obtain the rate of cooling of liquid B affected most of the candidates. Extract 20.2 is a sample of candidates' incorrect responses to this question.

2. @ $M_1 = 7054g$
$M = 14757g$
$M_2 = ?$
soln.
$M_2 = M - M_1$
$M_2 = 14757g - 7054g$
$M_2 = 7703g.$
∴ Mass of Liquid B is 7703g.

ii) TABLE OF RESULTS

Time, t (sec)	Temp θ (°c)
0	82
2	76
4	72
6	70
8	66
10	63
12	60
14	58
16	55
18	53
20	51

iii) Cooling rate $= \frac{\Delta\theta (°c)}{\Delta t \text{ (sec)}}$

At 70°c

Rate $= \frac{(73-67)°C}{(6.75-4.8) sec} = 3.07°c/sec$

Cooling rate of liquid B at 70°c is 3.07°c/sec

iv) From

$$\left(M_2 C_B + 400 M_1\right)\frac{d\theta}{dt} = 10{,}096\ Js^{-1}$$

where $\frac{d\theta}{dt}$ = cooling rate of liquid B

$$\frac{d\theta}{dt} = 3{,}07\ °C/sec$$

$$M_2 = 7703g$$
$$M_1 = 7054g$$

Then.

$$\left(7703g \cdot C_B + 400(7054)\right) \cdot 3{,}07 = 10{,}096\ J/s$$

$$2364821\ C_B + 8662312 = 10{,}096$$

$$C_B = \frac{10{,}096 - 8662312}{2364821}$$

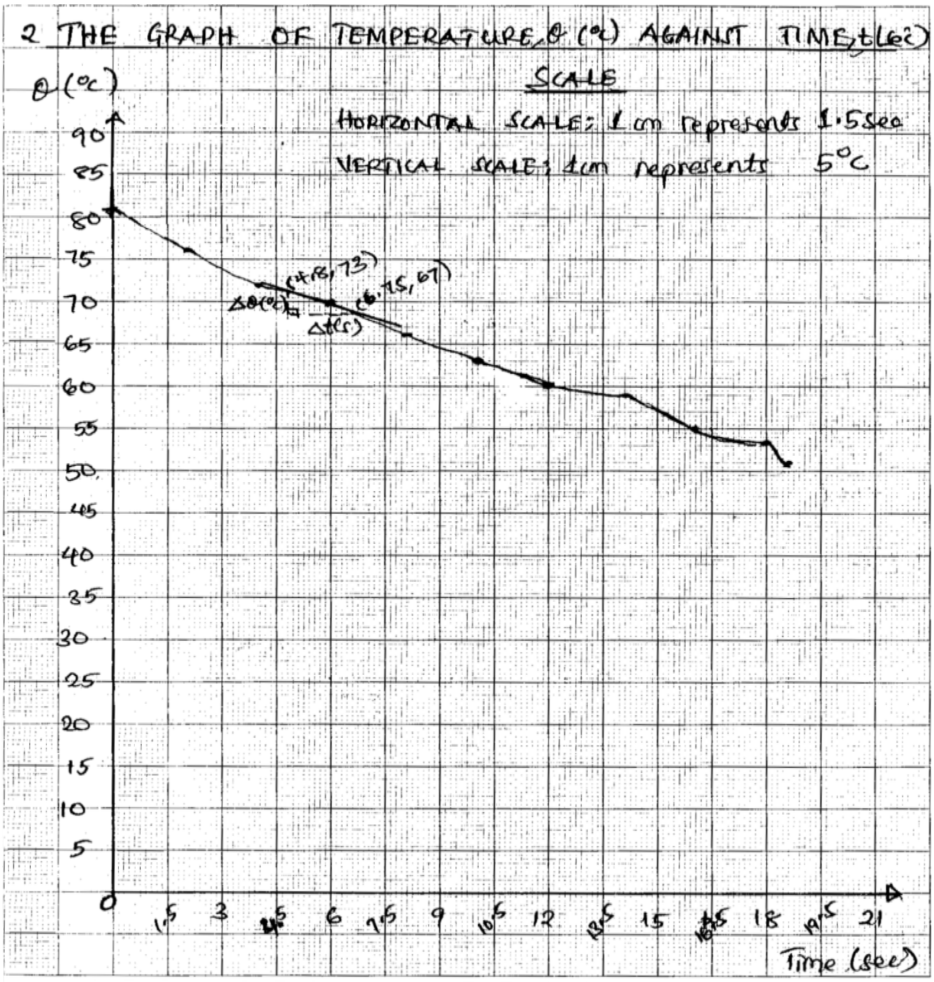
$$C_B = -3{,}66\ J/gK$$

But

-ve sign shows the decrease in temperature of liquid B. Hence it is neglected.

$$C_B = 3{,}66\ J/gK$$

∴ Specific heat capacity of liquid B is 3,66J/gK.



Extract 20.2: A sample of incorrect responses to question 2 of paper 3A

In Extract 20.2, the candidate tabulated incorrect data values of mass, time and temperature. The candidate also failed to draw a cooling curve and to determine the rate of cooling at 70 ºC and the specific heat capacity of liquid B.

4.2.2 Physics 3B

The candidates were provided with hot water, metal foil, wooden block, thermometer, stopwatch, marker pen, rubber bands, copper calorimeter with its lids, stirrer and kerosene lamp/Bunsen burner. The candidates were required to proceed as follows:

(a) Cover the outer surface of the calorimeter with the meter foil provided and use the rubber bands to hold the metal foil tightly on the calorimeter.

(b) Use a marker pen; indicate a mark of about two-thirds inside the calorimeter.

(c) Fill the calorimeter with hot water of about 90 ºC to the mark indicated in 2 (b).

(d) Cover the calorimeter with its lid when the stirrer and thermometer are inserted.

(e) While stirring, start the stopwatch when the temperature of the liquid in the calorimeter is about 80 ºC. Read and record the temperature of the liquid after every 2 minutes until it reaches 60 ºC.

(f) Empty the calorimeter, remove the metal foil and carefully blacken the outer surface of the calorimeter using the soot from a kerosene lamp/ Bunsen burner provided. Repeat the procedures in 2 (c) up to (e).

Questions

(i) Tabulate your results.

(ii) Using the same axis, plot the cooling curves for the blackened calorimeter with its content and for the calorimeter with metal foil together with its content.

(iii) From each of the curves, read and record the time taken for hot water to cool from 80 ºC to 60 ºC.

(iv) What is the implication of the results in 2 (iii).

(v) What is the aim of doing this experiment?

The candidates (56.86%) who scored high marks (9 - 15) correctly applied the thermometer and stopwatch in recording the respective data. Consequently, they were able to use the collected data to draw the graph of cooling curves taking into consideration all important aspects such as the tittle, the scale, the axes, the best curves connecting the most accurate points and the extrapolated time for both curves. Moreover, some of them stated correctly the implication of the difference in time taken for the hot water to cool from 80 ºC to 60 ºC for two curves. One candidate for example wrote: *The blackened body cools faster than the* *foiled one. This is because the blackened calorimeter is a good radiator and foiled calorimeter is a good reflector of radiant energy.* However, 26.19 per cent of the candidates who scored average marks provided inappropriate responses with multiple errors while others skipped some parts of the question. Extract 21.1 is a sample of candidates' correct responses to this question.

02. (i) Table of Results.

When the calorimeter is covered with metal foil

Time t (sec) (min)	Temperature θ (°C)
0	80
2	78
4	74
6	71
8	69
10	65
12	63
14	60.

When calorimeter is covered with soot

Time (min)	Temperature θ (°c)
0	80
2	75
4	71
6	~~60~~ 65
8	63
10	60

(iii) Time taken for temperature to decrease from 80°C to 60°C:

For calorimeter covered with metal foil it took **14 minutes**

For calorimeter covered with soot (blackened) it took only **10 minutes**.

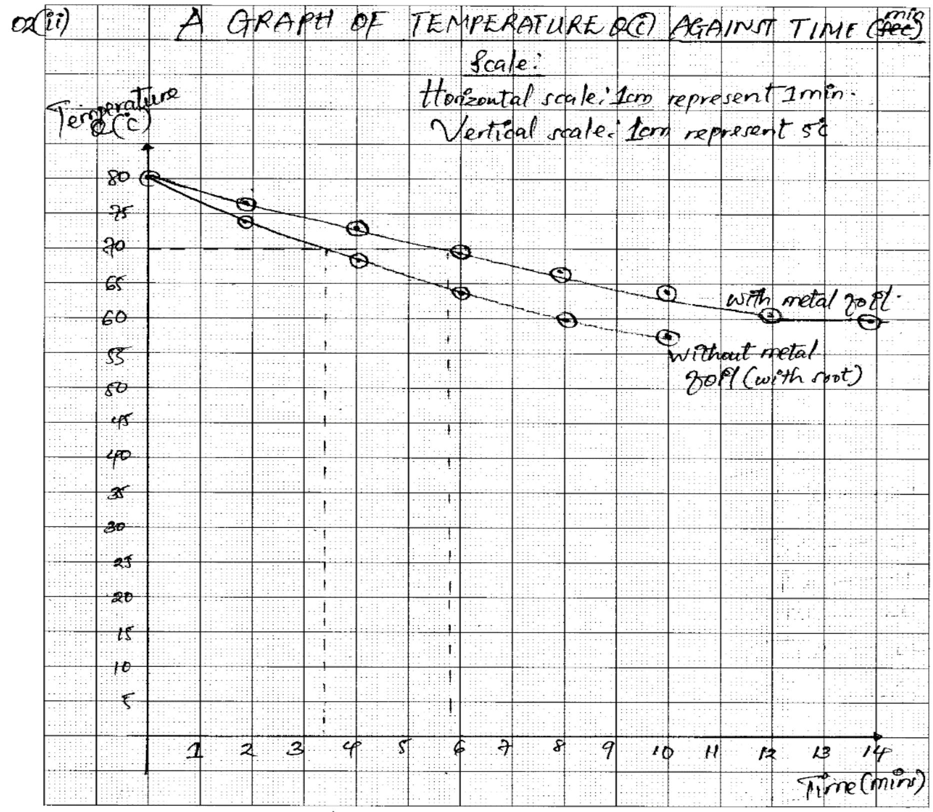
(iv) Implications.

For curve with metal foil, temperature is seen to decrease slowly with the increase in time, this is because metal foil decrease the rate of heat loss since it act as insulating material;

For curve without metal foil (covered with soot).

- Temperature is seen to decrease very fast with the increase in time, this is because of absence of metal foil on the calorimeter which act as insulator.

(v) The aim of experiment is to determine the rate of cooling of water in the calorimeter covered with metal foil and that covered with soot.



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, determined the time taken in all conditions and stated the aim of performing the experiment.

A few candidates (16.95%) scored low marks (0 – 5) as they had inadequate knowledge about Newton's law of cooling in finding the experimental results. Most of these candidates failed to apply the skills associated for measuring the intended physical quantities. This defect was observed by some of the candidates who lacked accuracy in recording the data values and in transferring data into the graph. Further analysis shows that the nature of graphs plotted by these candidates was straight lines instead of cooling curves while other graphs missed the key features. Consequently, they failed to analyse the data and interpret the graph to state the implication of the results to give a conclusion. Extract 21.2 is a sample of a candidate's incorrect responses.

2(i) Table of results

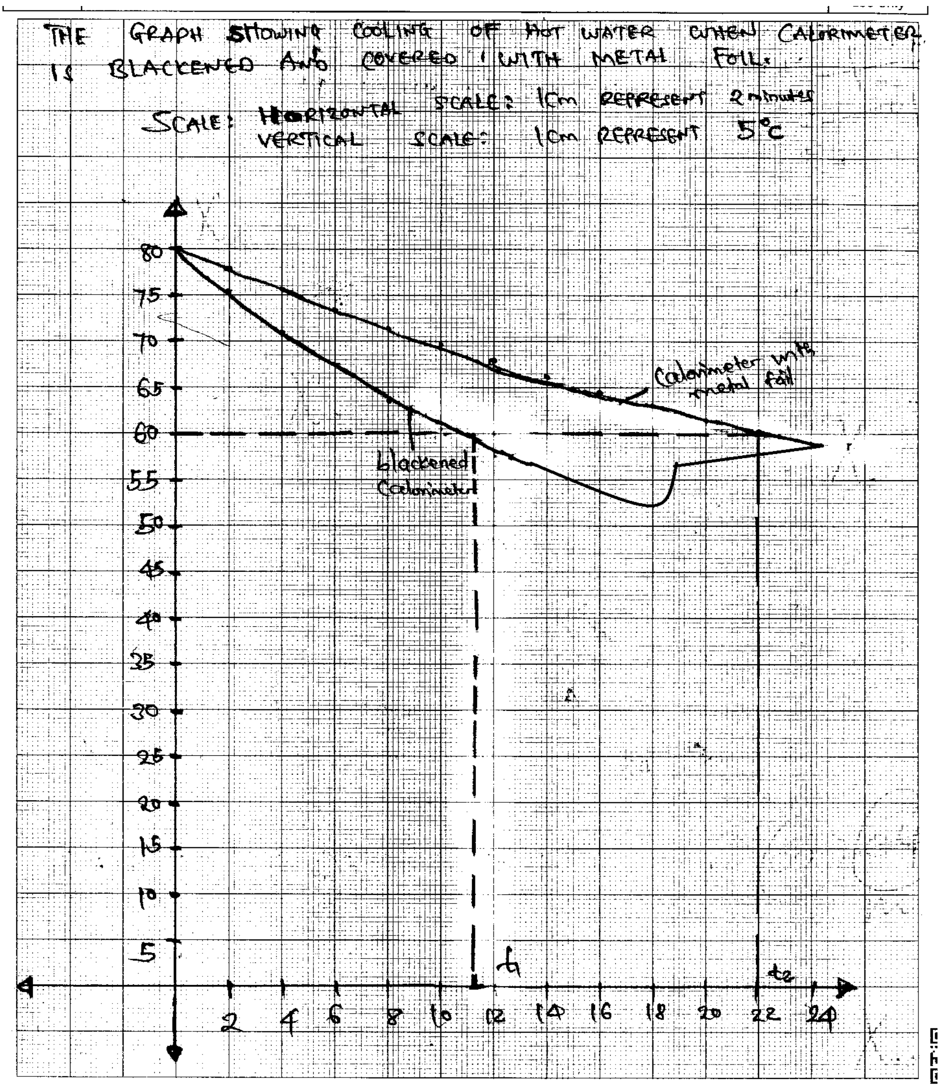
Time (min)	Temperature (metal foil)	Temperature (without metal foil)
0	80	80
2	77.8	~~75.4~~ 75.4
4	75.7	71.2
6	73.6	67.3
8	71.7	63.8
10	69.8	60.6
12	68.1	57.7
14	66.3	
16	64.7	
18	63.1	
20	61.6	
22	60.2	
24	58.8	

iii) Time taken by blackened calorimeter to cool from 80°C to 60°C is t_1 = ~~12 minutes~~. 11.7 minutes

Time taken by calorimeter with metal foil to cool from 80°C to 60°C is t_2 = 22 minutes

(iv) The results show that when the calorimeter is covered with metal foil the process of cooling occur slowly but when the calorimeter is blackened the process of cooling occur very fast.

Q(v) The aim of the experiment is to investigate the cooling of liquid (water) when the calorimeter is blackened and when the calorimeter is covered with metal foil



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 temperature in the table of results and wrote an incorrect title of the graph. The candidate also plotted incorrect graph without units on both axes.

4.2.3 Physics 3C

The candidates were provided with the following apparatus: Copper calorimeter, kerosene lamp/ bunsen burner, a metal foil, thermometer, hot water, stopwatch, stirrer, lid, a container with 250 ml of hot water of about 85 ºC and a wooden base. The candidates were required to proceed as follows:

(a) Carefully blacken the outer surface of the calorimeter using soot from a kerosene lamp/Bunsen Burner and set up the given apparatus as required.

(b) Fill to about $\frac{2}{3}$ of the blackened calorimeter with hot water whose initial temperature is 85 ºC.

(c) Stir constantly the hot water in the calorimeter then read and record the temperature t of water at one minute intervals until it has fallen to about 75 ºC.

(d) Empty the water in the calorimeter and cover the outer surface of the calorimeter with the metal foil provided and repeat the procedures in 2 (b) to (c).

Questions

(i) Draw the set-up of your experiment.

(ii) Tabulate the results obtained in 2 (c) and (d).

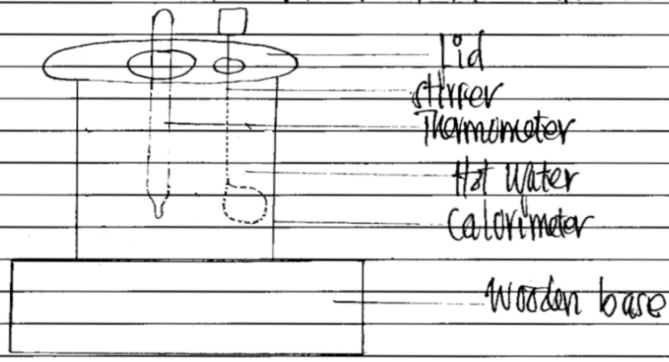
(iii) Plot the cooling curves for both the blackened calorimeter with its contents and the calorimeter covered with the metal foil together with its contents in the same axis.

(iv) From each of the curves plotted in 2 (iii), read the time taken by the hot water to cool from 80 ºC to 75 ºC.

(v) Compare the results obtained in 2 (iv). Give a reason for your answer.

The candidates (56.86%) who scored high marks (9 - 15) had a great understanding of the subject matter. Most of these candidates followed the necessary procedures in setting the given apparatus to obtain the correct data with proper units. In addition, they plotted graphs which contained important aspects such as tittle, scales and axes. However, their marks varied because some of them lacked skills of transferring of data values into graphs to join the points when drawing the best curves. Moreover, some of them analysed and interpreted the graphical data by providing correct reasons on the difference in the time taken. Extract 22.1 is a sample of a candidates' correct responses to this question.

2 (i) THE DIAGRAM OF SET UP OF THE EXPERIMENT



(ii) TABLE OF RESULTS
FOR CALORIMETER COVERED WITH SOOT (BLACKENED CALORIMETER). EXPERIMENT 1

t (min)	θ (°C)
0	85
1	82
2	80
3	78
4	76
5	75

2 (ii) FOR CALORIMETER COVERED WITH METAL FOIL (EXPERIMENT 2)

t (min)	θ(°C)
0	85
1	83
2	81
3	79
4	77
5	75

(iii) The graph of temperature (°C) against time (min) for experiment 1 and experiment 2 in the same axis was plot on the graph paper.

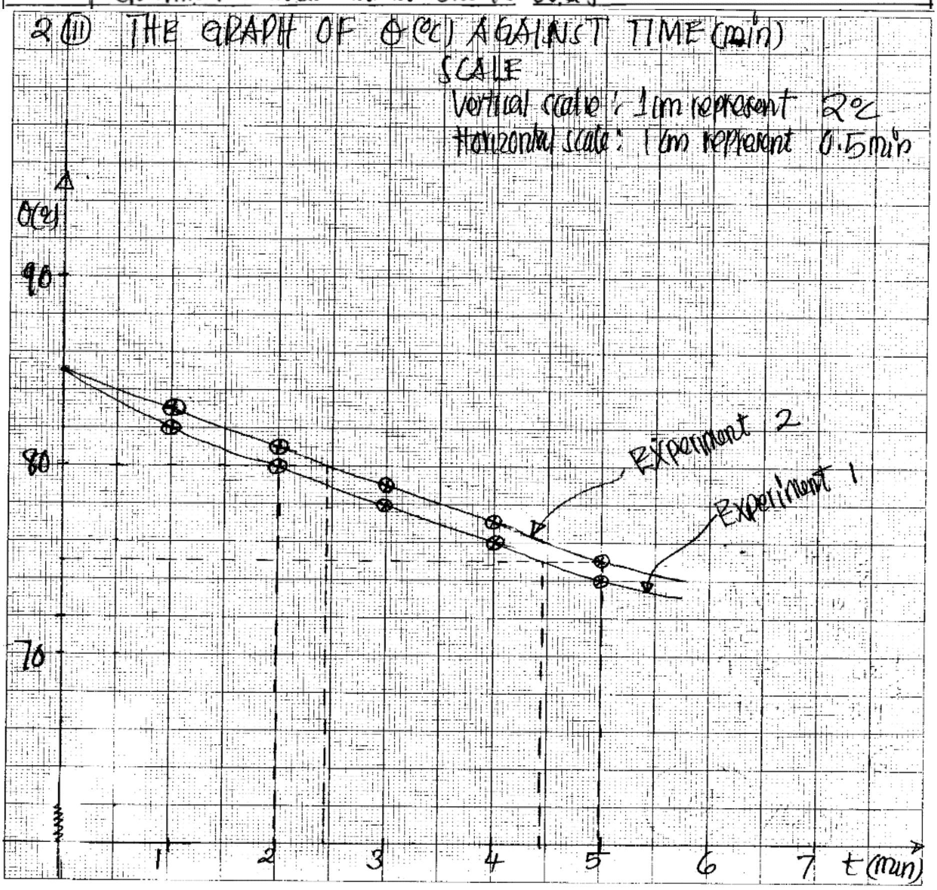
(iv) From the graph
The time taken by hot water to cool from 80°C to 75°C
For
experiment 1: $t_1 = t_{75°C} - t_{80°C} = 4.05 - 2 = 2.05$ min
experiment 2: $t_2 = t_{75°C} - t_{80°C} = 5 - 2.05 = 2.95$ min

(v) consider
ratio of time $= \frac{t_2}{t_1}$

$$\frac{t_2}{t_1} = \frac{2.95}{2.05}$$

$$t_2 = 1.439\, t_1$$

∴ The blackned calorimeter cools at fast rate compared to calorimeter covered with metal foil because blackned calorimeter act as a black body.



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.

The candidates (16.95%) who scored low marks (0 – 5) had several weaknesses. Their responses contained a mixture of correct and incorrect answers. Most of these candidates drew diagrams without providing some of the important features such as: tittle of the graph, labelling of the vertical and horizontal axes, the scales, and the correct transferred data to provide the best curves. Lack of mathematical skills affected most of these candidates as they failed to analyse the obtained data and give the comparison of the time taken to cool from 80 ºC to 70ºC in each case. Extract 22.2 is a sample of the candidates' incorrect responses.

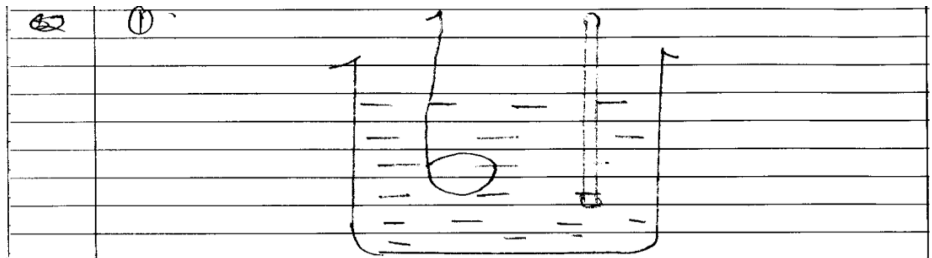


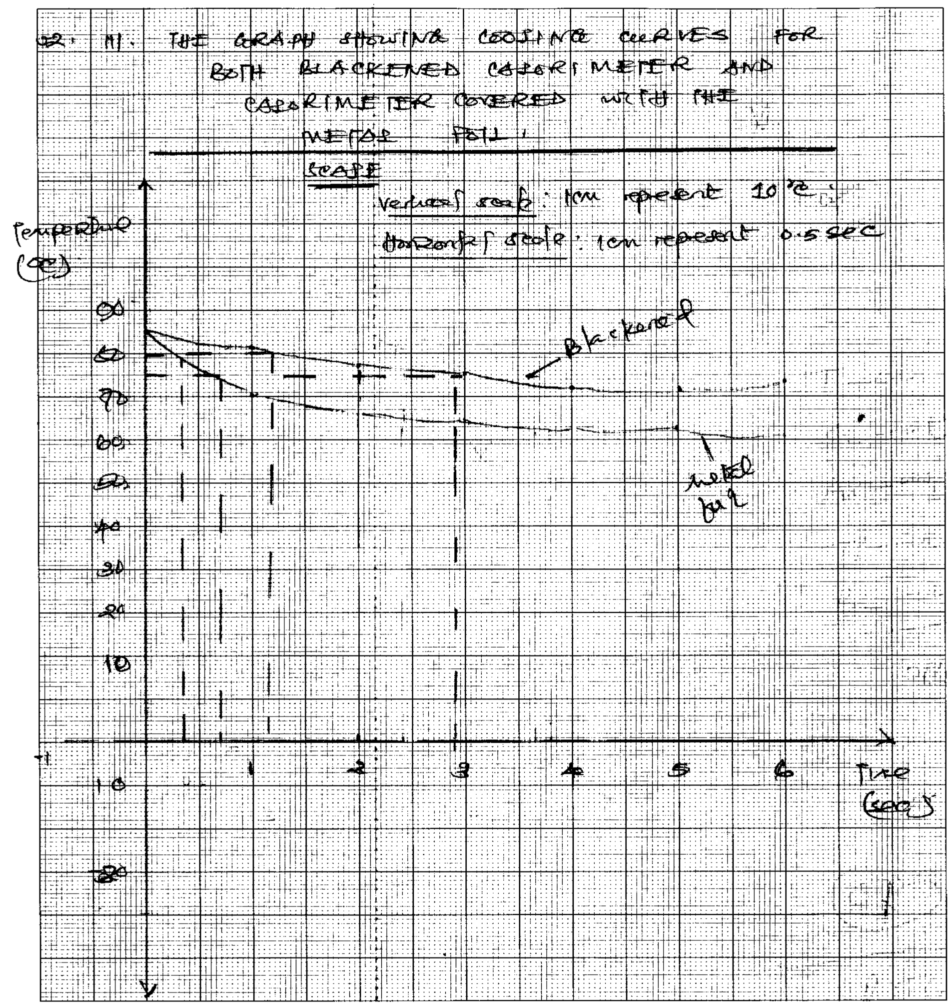
Table of results

For the beaker calorimeter

Temperature θ (°C)	Time (sec)
85	77
75	74
65	71
55	69
45	67
35	65
25	63
15	61
5	59
0	56

52 | 11 · For the calorimeter with the metal part :

Temperature θ (°C)	Time
85	78
75	76
65	74
55	72
45	70
35	69
25	66
15	63
5	60
0	58



Extract 22.2: A sample of incorrect responses to question 2 of paper 3C

In Extract 22.2, the candidate provided an unlabelled diagram of colorimeter with its contents. The candidate also provided the table of results with the values of time in descending order instead of ascending order. Lastly, he/she plotted incorrect curves showing the cooling rate of hot water in the calorimeter.

4.3 Question 3: Current Electricity

This question was from the topic of Current Electricity and contained three sub questions from three alternative papers. The analysis of the three questions is as follows:

The questions were attempted by 23,141 candidates equivalent to 100 per cent and their scores are as follows: 27.10 per cent scored below 5.5 marks, 34.22 per cent scored from 5.5 to 8.5 marks and 38.68 per cent scored 9 marks or above. The general performance of candidates in these questions was good as 72.90 per cent scored above 5.0 marks. Figure 20 summarizes the candidates' performance in the questions.

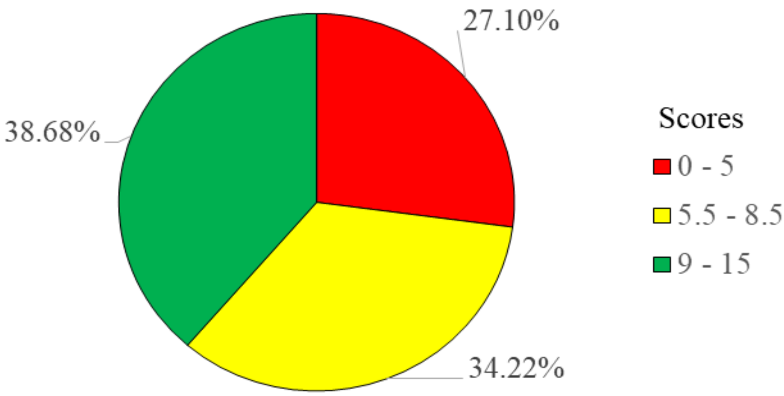


Figure 20: *Candidates' performance in question 3 of paper 3*

4.3.1 Physics 3A

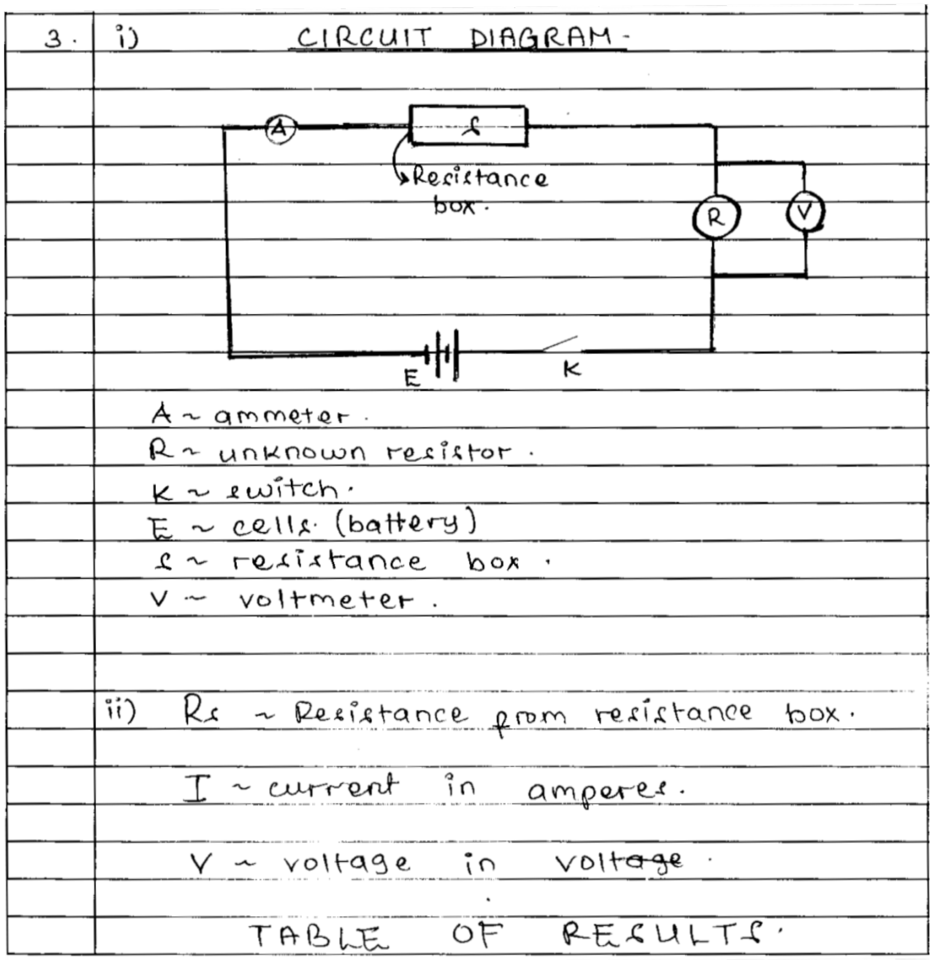
The candidates were provided with a battery E, a key K, ammeter A, Voltmeter V, resistance box S, unknown resistance R and pieces of connecting wires. They were asked to proceed as follows;

(a) Connect the given components in a series except the voltmeter which should be connected in parallel with the unknown resistor.
(b) Set the resistance of 10Ω in a resistance box. Close the key and record the readings of the ammeter and voltmeter.
(c) Repeat the procedures in 3 (b) each time by setting the resistance to 15 Ω, 20 Ω, 25 Ω, and 30 Ω.

Questions

(i) Draw a circuit diagram for the connection.
(ii) Tabulate the results obtained in 3(b) and (c).
(iii) Plot a graph of Voltage (V) against Current (I).
(iv) Compute the value of the unknown resistance.

The analysis reveals that 38.68 per cent of the candidates who attempted this question scored high marks (9 – 15). These candidates were conversant enough with the theory of electric conduction in metals. Most of them connected the circuit correctly as indicated in their circuits diagrams presented. They also recorded data correctly in the table of results and transferred them correctly into the graphical presentation which had all the necessary requirements on the graph such as; the tittle of the graph, the axes with their respective units, the scales, the slope indication and the coordinated best line which passed through the origin. Some of the candidates were able to analyze the information and provide the required unknown resistance. Extract 23.1 shows a sample of correct responses provided by a candidate.


3. i) CIRCUIT DIAGRAM.

A ~ ammeter.
R ~ unknown resistor.
K ~ switch.
E ~ cells. (battery)
S ~ resistance box.
V ~ voltmeter.

ii) Rs ~ Resistance from resistance box.
I ~ current in amperes.
V ~ voltage in voltage.
TABLE OF RESULTS.

3. ii)

$R_s(\Omega)$	I (A)	V(V)
10	0.22	0.45
15	0.16	0.33
20	0.13	0.26
25	0.11	0.21
30	0.09	0.18

iv) Value of unknown resistance = slope

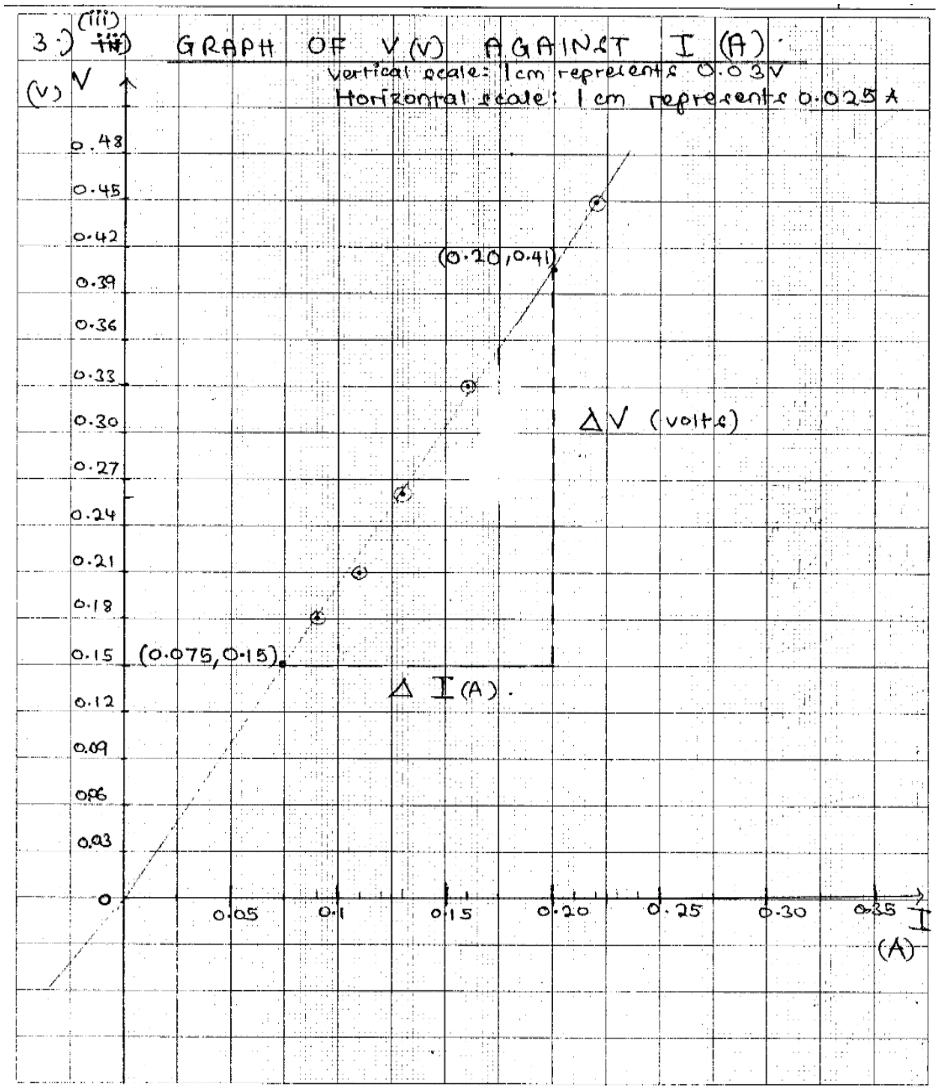
$$\text{slope} = \frac{\text{Change in V (V)}}{\text{chang in I (A)}}$$

$$\text{slope} = \frac{\Delta V\ (V)}{\Delta I\ (A)}$$

$$\text{slope} = \frac{0.41 - 0.15\ (V)}{0.20 - 0.075\ (A)}$$

$$\text{slope} = 2.08\ \Omega \approx 2.1\ \Omega$$

$\therefore$ Unknown resistance = $2.08\ \Omega$

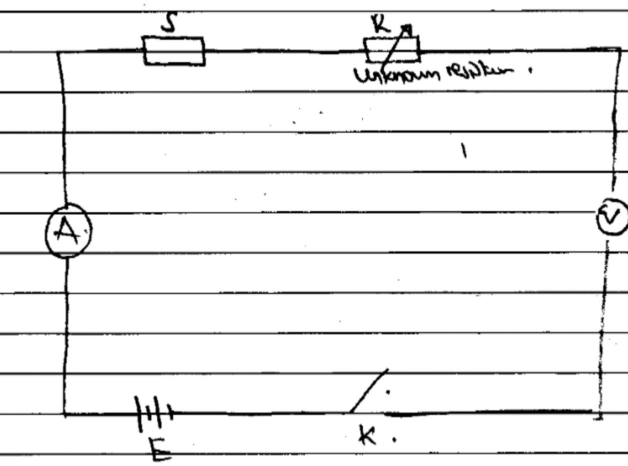


Extract 23.1 A sample of correct responses to question 3 of paper 3A

In Extract 23.1, the candidate provided the correct circuit diagram and obtained correct data in a tabular form. The candidate also plotted the correct graph and obtained the correct value of the slope. In addition, the candidate interpreted the value of the slope to obtain the correct value of unknown resistance.

Contrary, the candidates (27.10%) who scored low marks (0 – 5) had inadequate knowledge about the subject matter. Some of them presented an incorrect circuit diagram while others failed to read the ammeter and voltmeter according to the scale as indicated in their table of results. Another weakness observed in some candidates' responses was presenting larger values of either current or voltage than the maximum value provided by the cell. Furthermore, they failed to transfer the obtained data from the table of results when plotting the graphs. In addition, some of these candidates were negligent of some key aspects when drawing the graphs in their responses. They also failed to analyse the data and interpret the plotted graphs to determine slope and unknown resistance. Extract 23.2 is a sample of an incorrect response.

02. (i).



02. (ii). Table of the result.

5(a).

R	Ammeter (A)	voltmeter (V)	1/v	1/R
10	0.5	5	0.45	0.1
15	0.5	7.51	0.41	0.07
20	0.5	10.02.	0.39	0.05
25	0.5	12.52	0.38	0.04
30	0.5.	15.02.	0.37	0.03

(iv). From

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

but $I = \frac{V}{RS}$

$$E = \frac{V}{RS}(r + R + S).$$

$$\frac{E}{V} = \frac{1}{RS}(r + R + S)$$

$$\frac{1}{V} = \frac{1}{ERS}(r + R + S).$$

$$\frac{1}{V} = \frac{r + R}{ER} + \frac{S}{ER}.$$

$$\frac{1}{V} = \frac{r + S}{ERS} + \frac{S}{ERS}$$

$$\frac{1}{V} = \frac{1}{S}\left(\frac{r + R}{E}\right) + \frac{S}{ERS}$$

That V = voltage.

R = unknown resistance.

S = Resistance box.

That $\frac{1}{V} = \frac{1}{S}\left(\frac{r + R}{E}\right) + \frac{1}{E}$.

02 (iv). $\frac{1}{V} - \frac{1}{E} = \frac{1}{S}\left(\frac{r+R}{E}\right)$.

$$\left(\frac{1}{V} - \frac{1}{E}\right)S = \frac{r+R}{E}.$$

$$r+R = \left(\frac{1}{V} - \frac{1}{E}\right)SE$$

$$R = \left(\frac{1}{V} - \frac{1}{E}\right)SE - r$$

that r = Internal resistance.

When substitute that value $1/V = 0.45\,V^{-1}$ $1/E = 0.33\,V$

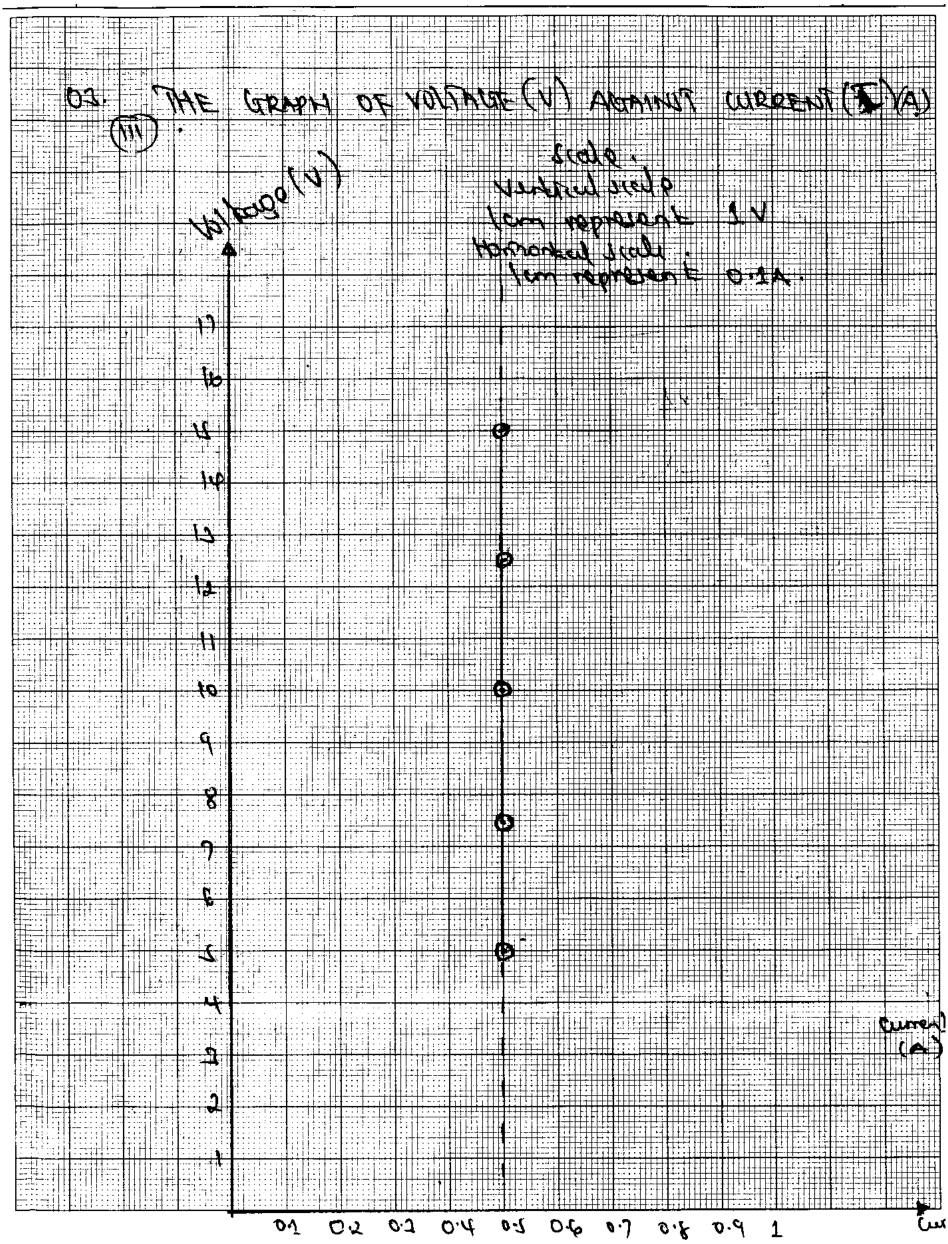
$S = 10\Omega$ $E = 3\,V$

$r = 1.6\Omega$.

$$R = (0.45 - 0.33)30 - 1.6$$

$R = 2\Omega$.

∴ The value of unknown resistance in the experiment is 2Ω.



Extract 23.2: A sample of incorrect responses to question 3 of paper 3A

In Extract 23.2, the candidate drew the circuit showing the voltmeter connected in series instead of being in parallel with the unknown resistor R. The readings of the voltmeter presented by the candidate were larger than the maximum value of the voltage supplied by the battery E as instructed. In addition, this candidate drew an incorrect graph with an infinite slope contrary to the Ohm's law.

4.3.2 Physics 3B

The candidates were required to determine the e.m.f. of the given dry cell E using ammeter A, resistance box R, switch K, masking tape and pieces of connecting wires. In order to achieve the task, the following instructions were given:

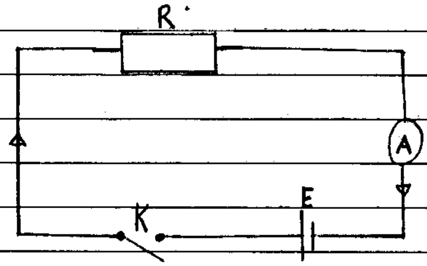
(a) Carefully set up the circuit as required using the given apparatuses.
(b) Start with R = 2Ω, close the switch and record the current I from the ammeter.
(c) Repeat the procedure in 3 (b) for the values of R = 4 Ω, 6 Ω, 8 Ω and 10 Ω.

Questions

(i) Draw a well labelled circuit diagram of your connections.
(ii) Tabulate the obtained data including the value of $\frac{1}{I}$.
(iii) Plot a graph of R against $\frac{1}{I}$.
(iv) Use the graph in 3 (iii), determine the e.m.f. of the dry cell E.

The candidates (38.68%) who scored high marks (9 – 15) were conversant with the concept of current electricity. They followed correctly the given instructions and paid great attention on setting and drawing the required circuit diagram. Most of these candidates had ability to collect and present the data with their respective units in a tabular form. In plotting the graph, they showed all the key aspects on plotting the graph including: the title, the axes with their units, the scales and the slope indication with the coordinates. In addition, some of these candidates used the graphical analysis to determine the e.m.f of the dry cell. Extract 24.1 provides a sample of a correct response from one of these candidates.

3 i)



ii) TABLE OF RESULTS

R(Ω)	I(A)	1/I (A^{-1})
2	0.6	1.67
4	0.3	3.33
6	0.23	4.35
8	0.18	5.56
10	0.14	7.14

iii) Solution

from the graph

$$\text{slope}(m) = \Delta R / \Delta \tfrac{1}{I}$$

but $R_1 = 2\Omega$ $R_2 = 10\Omega$

$I_1^{-1} = 1.67A^{-1}$ $I_2^{-1} = 7.14A^{-1}$

$$\text{slope}(m) = \frac{R_2 - R_1}{I_2^{-1} - I_1^{-1}}$$

$$\text{slope}(m) = \frac{10\Omega - 2\Omega}{7.14A^{-1} - 1.67A^{-1}}$$

$$\text{slope}(m) = 8\Omega / 5.47A^{-1}$$

$\therefore$ slope (m) of the graph $= 1.46V$

iv) from the equation

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

$$E/I = R+r$$

$$R = E/I - r$$

$$R = E\left(1/I\right) - r \quad \text{——} \ (1)$$

Compare eqn (1) with linear equation

$$R = E\left(1/I\right) - r$$

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

$$y = mX + c$$

then $E = m$

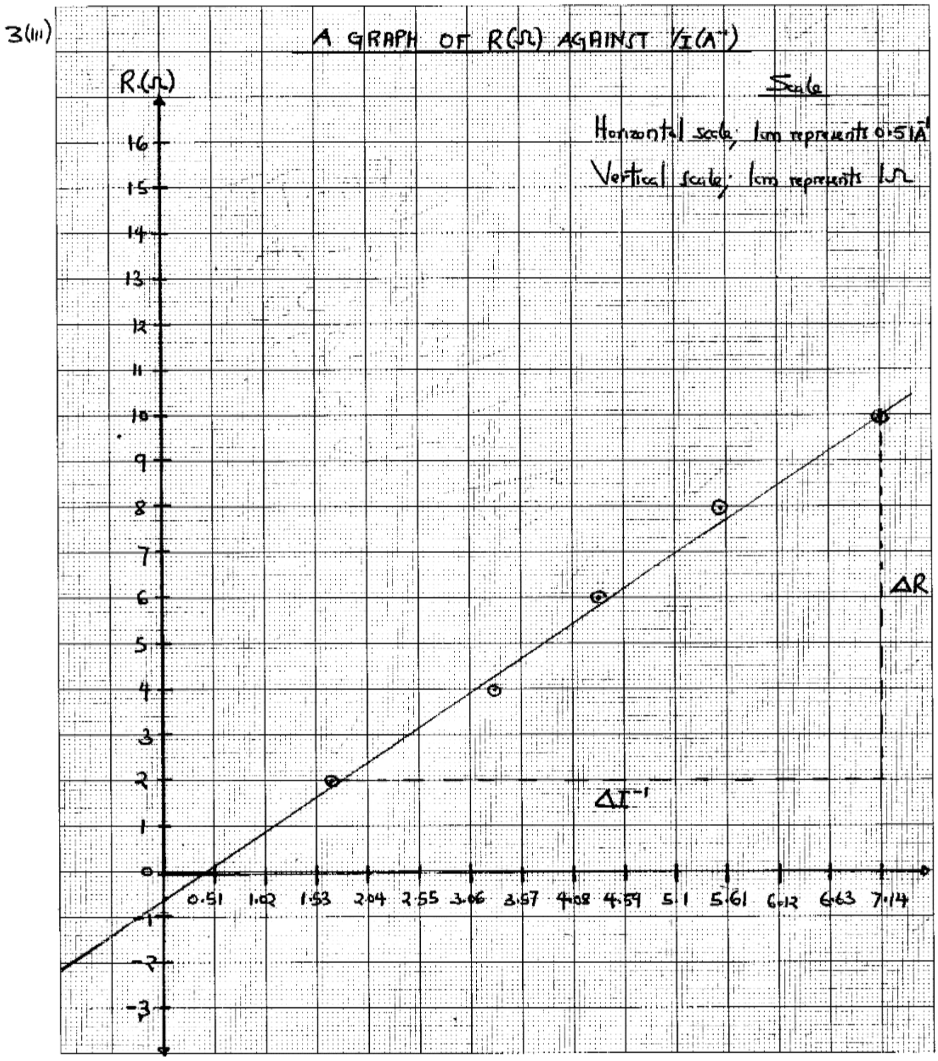
but $m = \text{slope}$

from the graph

$$\text{slope}(m) = 1.46V$$

$$E = 1.46V$$

$\therefore$ The value of e.m.f of the dry cell $(E) = 1.46V$

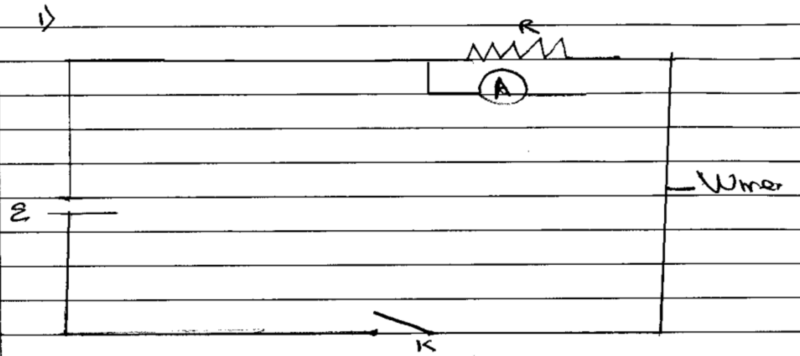


Extract 24.1: A sample of correct responses to question 3 of paper 3

In Extract 24.1, the candidate presented the correct data and drew the correct circuit showing the labelled symbols as provided in this question. The candidate also drew the correct graph although it had an unlabelled horizontal axis. In addition, the candidate related the graph with Kirchhoff's second law equation of the circuit and ended with an appropriate value of e.m.f from the slope of the graph.

A total of 27.10 per cent of the candidates scored low marks (0 – 5). Most of these candidates lacked knowledge of electric conduction in metals. Some of them failed to set-up the given electrical components based on the given instructions and ended with incorrect data values. Most of these candidates also failed to transfer the obtained data into graphs. They also did not include some of the key aspects when plotting the graphs such as: the title, the axes, the slope indication, the scales and the best line which contributed to loss of marks. Another weakness in their responses was lack of numerical skills whereby they failed to use the plotted graph in analysing and evaluating the e.m.f of the dry cell. Extract 24.2 is a sample of a candidates' incorrect responses to the question.

3. i)



ii)

R	I	1/I
2Ω	1.25	0.8
4Ω	1.67	0.6
6Ω	2.00	0.5
8Ω	2.50	0.4
10Ω	3.33	0.3

iii) Graph of R vs $\frac{1}{I}$.

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

$$\text{Slope} = \frac{8.004 - 2.001}{2.856 - 0.742}$$

3 Slope = $\frac{6.007}{1.88}$

Slope = ~~2.80278.~~ 3.54644 Ω A^{-1}

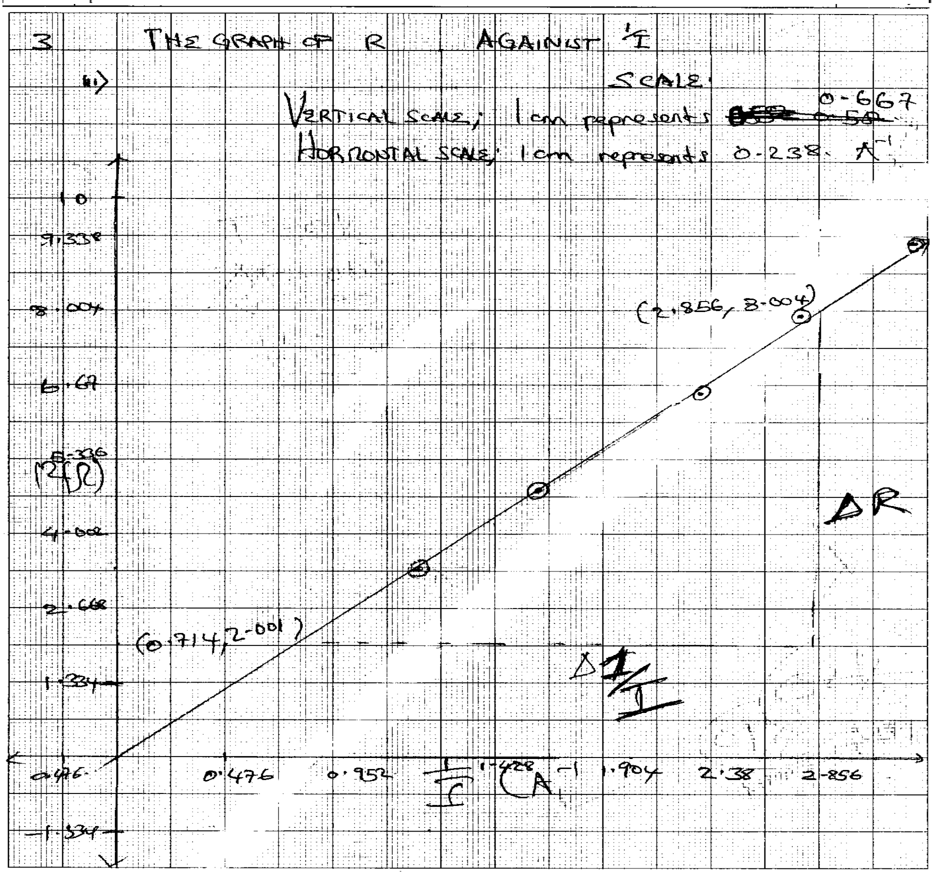
iv) Emf = 3.5V

because

V = IR.

ε = IR.

Emf = 3.5V.



Extract 24.2: A sample of incorrect responses to question 3 of paper 3B

In Extract 24.2, the candidate provided an incorrect circuit diagram indicating parallel connection of the ammeter with the resistance box R. In addition, the candidate obtained an incorrect value of the current corresponding to the value of resistance provided. The candidate also plotted an incorrect graph and obtained an incorrect value of the slope.

4.3.3 Physics 3C

In this question the candidates were required to determine the e.m.f. and internal resistance of a cell using an ammeter, voltmeter, switch, dry cell, rheostat, masking tape and connecting wires. The candidates were asked to proceed as follows:

(a) Connect the circuit using the given apparatuses. Close the switch and adjust the rheostat so that the cell supplies a current of 0.4A. Read the Voltmeter and record the value of voltage, V.

(b) Repeat the procedures in 3 (a) for the values of current, I equal to 0.6A, 0.8A, 1.2A, and 1.6A. Read and record the value of voltage, V in each case.

Questions

(i) Draw a well labelled diagram of the circuit you connected.
(ii) Record your results in a tabular form.
(iii) Plot a graph of V (volts) against I (amperes).
(iv) Formulate the equation governing this experiment.
(v) Determine the internal resistance, r and the e.m.f, E of the cell.

The analysis of data reveals that 38.68 per cent of the candidates scored high marks (9 – 15). These candidates had a good understanding about the theory of electric conduction in metals. Most of these candidates followed the correct procedures for connecting the given electrical devices to collect the data. Some of these candidates provided a well labelled circuit diagram and presented the collected data in a tabular form. Good mathematical skills were a key factor which contributed to candidates' high scores. Some of these candidates used a graphical method to analysis and determine the e.m.f and internal resistance of the dry cell. Extract 25.1 shows a candidates' correct responses to this question.

3.

(ii) TABLE OF RESULTS.

Volts (V)	I (A)
1.29	0.4
1.90	0.6
1.10	0.8
0.90	1.2
0.69	1.6

$$\text{Slope}(m) = \frac{\Delta V\,(\text{Volts})}{\Delta I\,(A)}$$

$$\text{Slope}(m) = \frac{1.35V - 0.9V}{0.32A - 1.2A}$$

$$\text{Slope}(m) = -0.5\,\Omega$$

(iv) Solution

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

$$E = IR + Ir$$

but $V = IR$

$$E = V + Ir$$

$$V = E - Ir$$

$$V = -Ir + E$$

$$V = -rI + E$$

$$y \quad mx + c$$

(v) Internal resistance

$$\text{Slope}(m) = -r$$

$$-0.5 = -r.$$

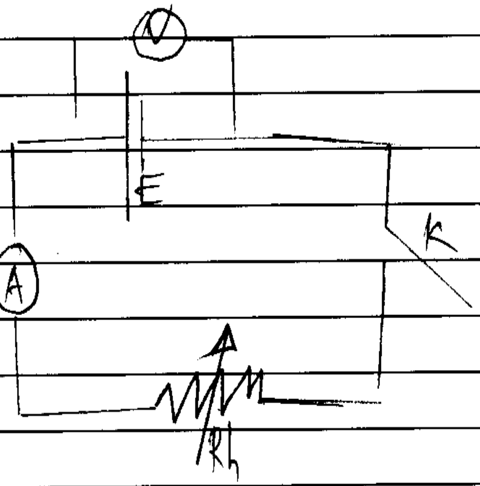
$$r = 0.5\,\Omega$$

3(v) E.m.f of the cell.

Emf is equal to the intercept

Emf of the cell is 1.5V

3(i) A WELL LABELLED DIAGRAM OF THE CIRCUIT



KEY

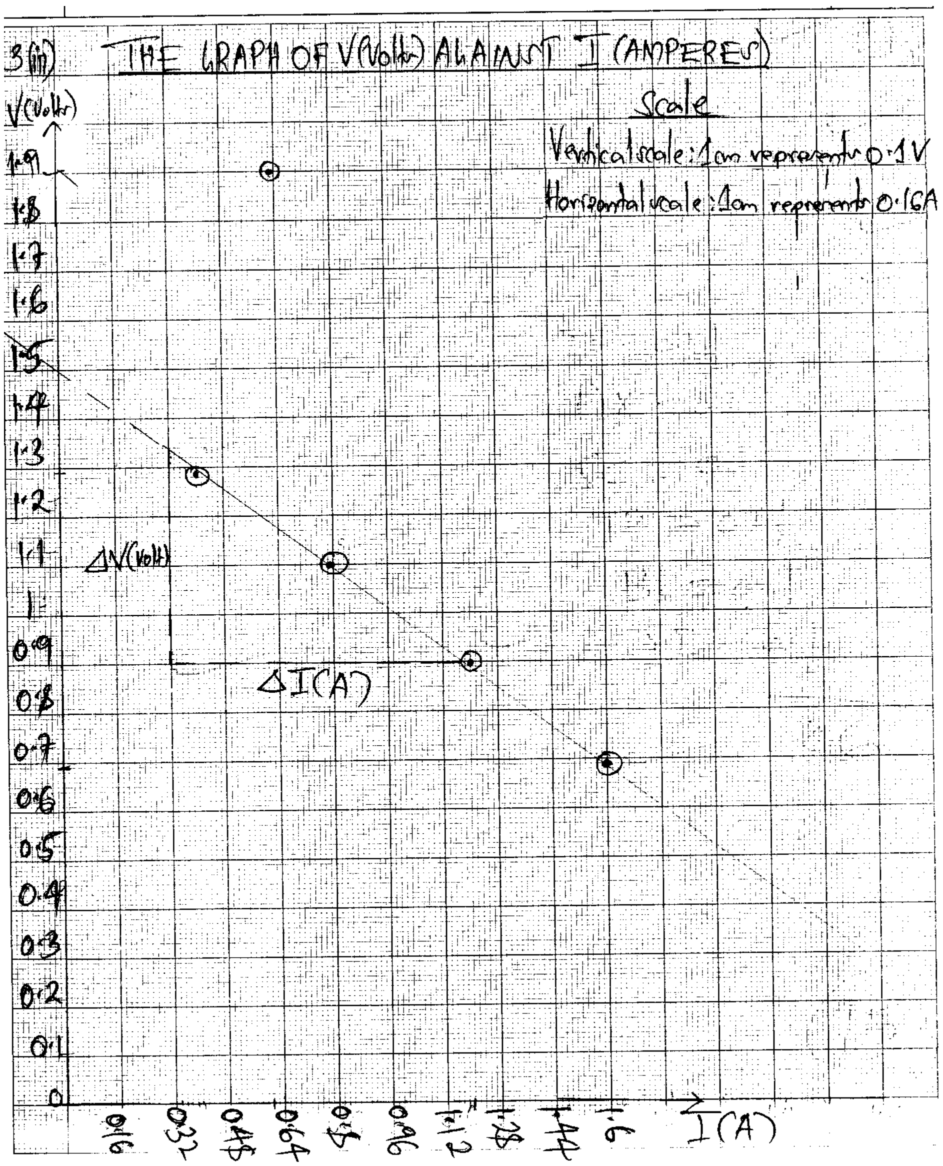
V: Voltmeter

E: Cell

K: Switch

A: Ammeter

Rh: Rheostat.

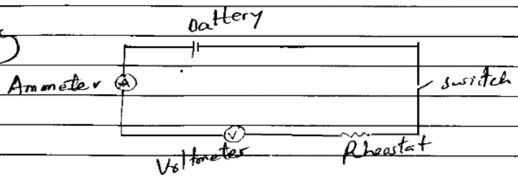


Extract 25.1: A sample of correct responses to question 3 of paper 3C.

In Extract 25.1, the candidate correctly presented the data and used it to plot the graph. The candidate also obtained the slope and V – intercept which he/she used to determine the internal resistance and e.m.f of the dry cell.

The responses of the candidates (27.10%) who scored low marks (0 – 5) had several weaknesses. The notable weaknesses included: failure of the candidates to connect the given ammeter and voltmeter and other electrical components appropriately. These candidates lacked knowledge that an ammeter should be connected in series with a resistor or a cell while a voltmeter should always be in a parallel connection. Moreover, some of these candidates lacked skills of reading an ammeter and a voltmeter while others failed to interpret the given instructions to draw the circuit diagram of an experimental set up. Failure to design a proper circuit led to obtaining incorrect data. Further analysis revealed that, most of these candidates faced difficulties in selecting a suitable scale when drawing graphs and points of the best line to determine the slope. Extract 25.2 presents a candidate's incorrect responses to this question.

3 (i)



(ii) The table of Result.

I (A)	V (V).
0.4	20
0.6	30
0.8	40
1.2	60
1.6	80

(iii) The equation governing this experiment is from Ohm's law.
$V = IR$.
Hence.
$V = IR$.

The slope of the graph V against I

$S = \frac{\Delta V \text{ (volts)}}{\Delta I \text{ (Amperes)}}$

$S = \left(\frac{70 - 40}{1.4 - 0.8}\right) = 50 V/A$.

Slope $= 50 V/A$.

3 (iv) The governing equation.

from ohm's law

$V = IR$.

if

$y = mx + c$

$y = V$

$m = R$

$I = x$,

thence the governing eqn is

$V = IR$.

(v) from

$V = IR$.

$E = I(R + r)$

at

$I_1 = 0.4 \quad R = 50$,

$I_2 = 0.6 \quad R = 50$.

$E_1 = 0.4(50 + r_1)$ — (i)

$E_1 = 0.6(50 + r)$ — (ii),

$E = 0.4(50) + 0.4r$.

$E = 20 + 0.4r$ — (i)

$20 = E - 0.4r$

$E = 0.6(50) + 0.6r$

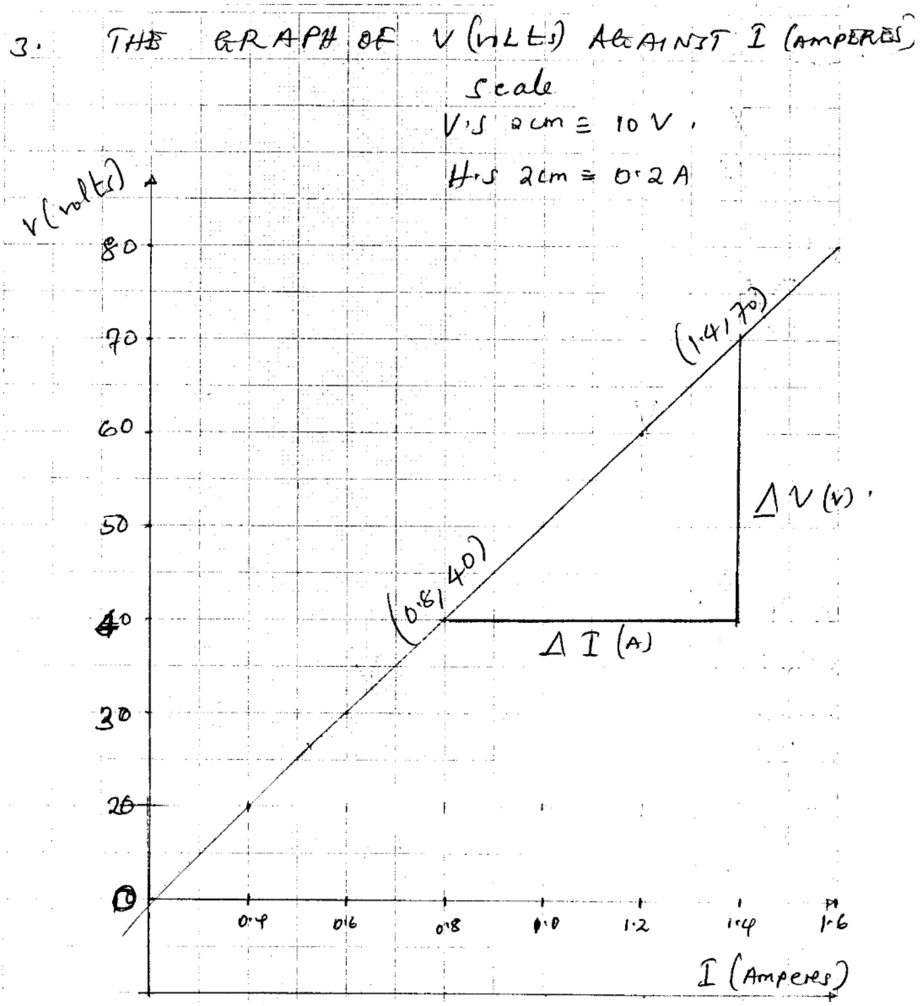
$E = 30 + 0.6r$ — (ii)

$30 = E - 0.6V$

solve simultenous eqn for equations (1) and

$E = 1.5V$.

$r = 0.5\Omega$.



Extract 25.2: A sample of incorrect responses to question 3 of paper 3C

In Extract 25.2, the candidate showed a series connection of the voltmeter instead of a parallel connection to the cell. He/she also presented large values of voltage compared to the expected ones and ended up with incorrect values of internal resistance and e.m.f of the cell.

5.0 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH TOPIC

The analysis of candidates' performance in each topic shows that the candidates had good performance in 9 out of 12 topics tested in the theory papers. These topics were *Environmental Physics (98.19%), Measurement (95.74%), Heat (78.72%), Electronics (73.44%), Current Electricity (72.36%), Mechanics (70.85%), Properties of Matter (70.80%), Fluid Dynamics (66.37%)* and *Electrostatic (63.44%)*. The candidates demonstrated competence in the subject matter as they correctly analysed the examined concepts. However, the candidates performed averagely in 3 topics namely *Atomic Physics (56.18%), Electromagnetism (54.71%)* and *Vibrations and Waves (53.14%)*. The average performance was a result of the candidates' inappropriate explanations, misinterpretation of the questions and insufficient knowledge and skills in the prescribed topics.

In Physics Paper 3, three topics namely *Heat (85.05%), Mechanics (79.56%)* and *Current Electricity (72.90%)* were well performed. 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 draw conclusion. Furthermore, candidates had good drawing skills and were able to follow instructions when assembling various apparatus associated in the respective experiments in their responses. The candidates' performance in each topic is summarized in Appendix I and II.

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The analysis done revealed that, majority (97.74%) of the candidates passed the examination. These candidates identified the requirement of each question and had adequate knowledge of the subject matter. They also mastered computational skills in questions that involved the use of formulae and procedures to obtain the correct answers. Another factor that contributed to good performance was the skills of interpreting diagrams. Most of these candidates had the ability of studying, interpreting and applying the relevant formulae in the given figures to analyse different concepts. Most of the candidates, for example, performed well on Question 4 of Physics Paper 2 and Question 4, 8 and 9 of Physics Paper 1. These questions involved diagrams.

Further, the analysis revealed that the few (2.26%) candidates who failed faced difficulties in answering some questions. Lack of mathematical skills, failure to explain and apply theories, laws and principles of physics to analyse various concepts affected most of the candidates. They also failed to establish and apply proper formulae and procedures when performing calculations. Some of them provided irrelevant responses in few parts of the questions especially the structured questions and skipped other parts. It was also observed that poor mastery of practical skills contributed to the weak performance. Most of the candidates, for instance, ignored the important aspects to consider when drawing graphs such as providing the title of the graphs, units, axes with their respective S.I units, scales used, transfer of points, best line or curve and slope indication which would help them score high marks. Furthermore, they failed to interpret the plotted graph and analyse the data to provide a conclusion.

6.2 Recommendations

In order to improve the performance in Physics subject, teachers are strongly advised to:

(a) Guide students to explain and apply theories, laws and principles of electromagnetism, atomic physics and vibrations and waves.

(b) Assist students to investigate the structure of the magnetic field for a long straight conductor and analyse the motion of a charged particle moving in a magnetic field.

(c) Help students to account for the photoelectric effect phenomenon and deduce stopping potential, threshold frequency and work-function of a metal.

(d) Guide students to derive expressions for progressive and stationary wave motion and deduce the principle of superposition of waves.

(e) Lead students in groups to compute and analyse the Neutron (N) and Proton (Z) ratio and plot the graph of N against Z for radioactive elements.

APPENDIX I: The Candidates' Performance in Each Topic in Physics 1 & 2 in ACSEE 2023

S/n.	Topic	2023 EXAMINATION PAPER		
		Number of Questions	Percentage of Candidates who Scored an Average of 35 Percentage or Above	Remarks
1.	Environmental Physics	1	98.19	Good
2.	Measurement	1	95.74	Good
3.	Heat	2	78.72	Good
4.	Electronics	2	73.44	Good
5.	Current Electricity	1	72.36	Good
6.	Mechanics	3	70.85	Good
7.	Properties of Matter	1	70.80	Good
8.	Fluid Dynamics	1	66.37	Good
9.	Electrostatics	1	63.44	Good
10.	Atomic Physics	1	56.18	Average
11.	Electromagnetism	1	54.71	Average
12.	Vibrations and Waves	1	53.14	Average

APPENDIX 1I: The Candidates' Performance in Each Topic in Actual Practical Papers 3A, 3B and 3C in ACSEE 2023

S/n.	Topic	Number of Questions	Percentage of Candidates who Scored an Average of 35 Percentage or Above	Remarks
1.	Heat	1	83.05	Good
2.	Mechanics	1	79.56	Good
3.	Current Electricity	1	72.90	Good