THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEM RESPONSE ANALYSIS REPORT ON THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE), 2021

PHYSICS

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131 PHYSICS

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FOREWORD

This Item Response Analysis Report (CIRA) of the Advanced Certificate of Secondary Education Examination (ACSEE) 2021 for 131 Physics subject intends to provide feedback to educational stakeholders about the responses given by the candidates in the examination items. Principally, candidates' responses is an indicator of the achievement of teaching and learning objectives after two years of Advanced Secondary Education.

The performance of candidates in Physics was generally good as 93.60 per cent passed the examination. The analysed data revealed that, the candidates had good performance on the topics of Fluid Dynamics, Structure and Properties of Matter, Electronics and Mechanics. Three topics namely Heat, Vibrations and Waves and Current Electricity were averagely performed. However, the candidates' performance was weak in the topics of Atomic Physics, Environmental Physics, Electromagnetism, Measurement and Electrostatics.

The report highlights the factors that contributed to candidates' performance. These include candidates' adequate or inadequate knowledge about the concepts tested, lack of skills for solving numerical problems, failure to describe the terms and apply proper formula in analysing the concepts, failure to follow the given instructions to assemble the apparatus when performing experiments and lack of drawing skills.

It is expected that, suggestions and recommendations provided in this report will enable policy makers, teachers, students and other education stakeholders to identify appropriate ways to improve the candidates' performance in future examinations administered by the Council.

The Council would like to express its sincere appreciation to examiners, examination officers and all other staff members who participated in the preparation of this report.

Dr. Charles E. Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

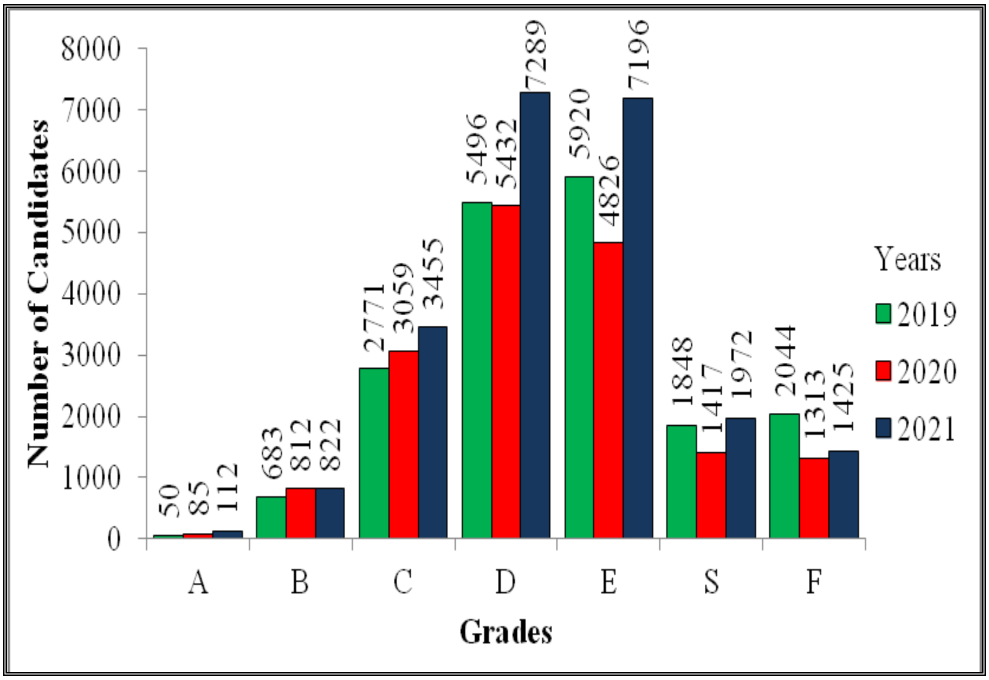
This report presents a detailed analysis of the Candidates' Item Responses in 131 Physics Examination for ACSEE 2021. The examination was comprised of three papers, namely 131/1 Physics 1, 132/2 Physics 2, and 131/3 Physics 3. Physics 1 and Physics 2 were theory papers while Physics 3 was actual practical paper. The examination was set according to the 2010 Physics Syllabus and it intended to measure the competences and skills achieved by the candidates.

The 131 Physics 1 examination paper comprised ten (10) questions grouped into sections A and B. Section A had seven (7) short-answer questions each carrying 10 marks. Section B consisted of three (3) structured essay questions, each carrying 15 marks. The candidates were required to attempt all questions in Section A and any two (2) questions from section B.

The 131 Physics paper 2 had six (6) structured essay questions. The candidates were required to answer any five (5) questions. Each question carried 20 marks.

The practical part had three alternative papers namely 131/3A Physics 3A, 131/3B Physics 3B, and 131/3C Physics 3C. Each alternative paper consisted of three questions. Question 1 carried 20 marks while questions 2 and 3 carried 15 marks each. The candidates were required to answer any one of the three alternative papers.

A total of 22,390 school candidates sat for the examination. Among them, 20,846 (93.60%) passed the examination, and 1,544 (6.40%) failed. In 2020, the number of school candidates who sat for the Physics examination was 17,045. Among them, 15,631 (92.25%) passed and 1,414 (7.75%) failed. This implies that the candidates' performance in this year has increased by 1.35 per cent. The following bar chart illustrates the candidates' performance in grades for three consecutive years: 2019, 2020 and 2021.



Candidates' Performance in terms of Grades in 2019, 2020 and 2021

Figure 1, shows that many candidates attained Grades C, D and E but only a few candidates attained grades A and B.

The analysis contains brief description of what the candidates were supposed to do and how they responded to each question. Sample Extracts of candidates' responses are inserted to illustrate the cases presented. Also, graphs and charts are used to analyse the candidates' performance on every question. Comments on individual questions have been thoroughly explained to illustrate the respective cases.

The percentage of performance in each question is divided into three categories, which are weak performance, ranging from 0 – 34 per cent; average performance, ranging from 35 – 59 per cent and good performance, ranging from 60 – 100 per cent. Red, Yellow and Green colours are used to represent these categories respectively.

Finally, the report draws a conclusion and gives recommendations that may help to improve candidates' performance in future examinations. It also provides a summary of the performance in each topic in appendices I and II.

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

This section describes the performance of the candidates in each question in 131/1 Physics 1. It covers the type of questions, topics from which the questions were constructed, requirements of the questions as well as the performance of candidates in each question. The candidates' scores have been termed as weak, average or good depending on the performance.

The Physics 1 examination paper contained ten (10) questions grouped into sections A and B. Section A had seven (7) short-answer questions, each carrying 10 marks. Section B had three (3) structured conceptual questions, each carrying 15 marks. The candidates were required to answer all questions in section A and any two (2) from section B.

This paper assessed six (6) topics. Four (4) topics of *Measurement*, *Mechanics*, *Heat* and *Environmental Physics* were assessed in section A while two topics of *Current Electricity* and *Electronics* were assessed in section B. The analysis of each question is as follows:

2.1 Question 1: Measurement

This question had two parts: (a) and (b). It was given that, in a simple pendulum experiment a period of 40 seconds was measured for 20 oscillations when the length of the pendulum was taken to be 100 cm. The candidates were required to calculate (a) the maximum error in measuring the acceleration due to gravity g given that the smallest readable units of stop watch and metre rule were 0.1 seconds and 0.1 cm respectively; and (b) the percentage error of acceleration due to gravity, g if its actual value at a particular place is $9.79\ \text{m/s}^2$.

A total of 22,366 (99.9%) candidates responded to the question. The analysis of data indicates that 2,160 (88.8%) scored from 0 to 3 marks, 1,655 (7.4%) scored from 3.5 to 5.5 marks, and 846 (3.8%) scored from 6 to 10 marks. The performance of candidates in this question was generally weak since only 2,501 (11.2%) candidates scored from 3.5 to 10 marks. Figure 1 is the graphical representation of the data analysed.

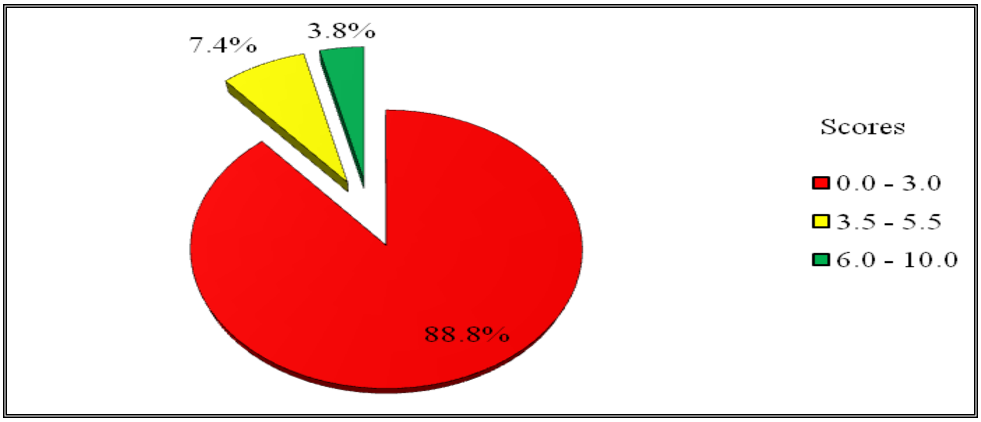


Figure 1: *The candidates' performance in Question 1 in Paper 1*

Candidates who scored low (0 - 3) marks in this question used wrong approach to estimate errors of derived physical quantities. This happened because they confused between least count and error. Most of the candidates failed to interpret the meaning of the term period in order to determine the actual data to be used in doing analysis. They used 40 s for 20 oscillations instead of 2 s for 1 oscillation when computing the fractional error and the maximum error in measuring the acceleration due to gravity. They also used a wrong formula and failed to deduce the experimental value of acceleration due to gravity. This affected many candidates as they failed to determine its percentage error provided that the actual value of acceleration due to gravity at a particular place was given as 9.79 m/s^2. Extract 1.1 is a sample of a candidates' weak response to this question.

01. Solution

Data Given

Period (T) = 40seconds

Oscillations = 20oscillation

Length (L) = 100cm

Required to calculate;

(a) The maximum error in measuring the acceleration due to gravity, g.

Readable unit of stop watch.

Time (t) = 0.1seconds

Length (L) = 0.1 cm.

Now; $T = 4\pi\sqrt{L/g}$

square both sides

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

Make 'g' the subject

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

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

$$\frac{\Delta g}{g} = \frac{\Delta L}{L} + \frac{\Delta T}{T}^2$$

$$\frac{\Delta g}{9.8} = \frac{0.1}{100} + \frac{0.1}{40}^2$$

$$\Delta g = 9.8 \times 1.25 \times 10^{-3}$$

01.	(a) $\Delta g = 9.8 \times 1.25 \times 10^{-3}$

$$\Delta g = 0.01225 \, M/s^2$$

∴ The maximum error in measuring the acceleration due to gravity, g is 0.01225 M/s²

(b) The percentage error of acceleration due to gravity, g if its actual value at a particular place is 9.79 m/s²

Now; from

$$T = 4\pi\sqrt{L/g}$$

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

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

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

$$\frac{\Delta g}{9.79} = \frac{0.1}{100} + \frac{0.1}{40}^2$$

$$\frac{\Delta g}{9.79} = 1.25 \times 10^{-3}$$

$$\Delta g = 1.25 \times 10^{-3} \times 9.79$$

$$\Delta g = 0.0122375$$

01. (b) $\Delta g\% = 0.0122375 \times 100\%$

$\Delta g\% = 1.22375\%$

$\therefore$ Percentage error of acceleration due to gravity, g is 1.22375%

Extract 1.1: *A sample of incorrect responses to Question 1 in Paper 1*

In Extract 1.1, the candidate applied the formula $T=4\pi\sqrt{\frac{l}{g}}$ instead of $T=2\pi\sqrt{\frac{l}{g}}$ and he/she wrongly analysed the data to obtain the incorrect values of maximum and percentage error.

In contrast, few (11.2%) candidates who scored high marks in this question seemed to have sufficient knowledge of the concept of error analysis. Most of them knew the meaning of the term period as they applied appropriate formula and techniques for error computation. They were also conversant with techniques of estimating errors of derived physical quantities. Extract 1.2 is a sample of candidates' good responses to this question.

1(a) hence

$$\frac{\Delta g}{g} = \frac{0.05\,cm}{100\,cm} + \frac{2 \times 0.05\,s}{2\,s}$$

$$\frac{\Delta g}{g} = 0.0505$$

again

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

$$g = \frac{4 \times (3.14)^2 \times 1m}{2^2}$$

$$g = 9.8596\ ms^{-2}$$

Hence

$\Delta g = 0.0505g$

$= 0.0505 \times 9.8596\ ms^{-2}$

$\Delta g = 0.4979098 \approx 0.498\ ms^{-2}$

$\therefore$ The maximum error in measurement of g is $0.498\ ms^{-2}$.

1(b) Soln,

given true value of $g = 9.79\ ms^{-2}$,

but

experimental value of g'.

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

$$g' = \frac{4 \times (3.14)^2 \times 1m}{(2s)^2}$$

$$g' = 9.8596\ ms^{-2}$$

1(a) hence

$$\frac{\Delta g}{g} = \frac{0.05cm}{100cm} + \frac{2 \times 0.05s}{2s}$$

$$\frac{\Delta g}{g} = 0.0505$$

again

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

$$g = \frac{4 \times (3.14)^2 \times 1m}{2^2}$$

$g = 9.8596\ ms^{-2}$.

Hence

$\Delta g = 0.0505g$

$= 0.0505 \times 9.8596\ ms^{-2}$

$\Delta g = 0.4979098 \approx 0.498\ ms^{-2}$

$\therefore$ The maximum error in measurement of g is $0.498\ ms^{-2}$.

1(b)

error in g $\Delta g = (9.8596 - 9.79)\ ms^{-2}$

$= 0.0696\ ms^{-2}$

Now,

percentage error $= \frac{\Delta g}{g} \times 100\%$

$= \frac{0.0696\ ms^{-2}}{9.79\ ms^{-2}} \times 100\%$

$= 0.71\%$

$\therefore$ The percentage error in acceleration due to gravity is 0.71%

Extract 1.2: *A sample of good responses to Question 1 in Paper 1.*

In Extract 1.2, the candidate correctly analysed the given data and applied the appropriate formula to estimate the error and determine the maximum and percentage error.

2.2 Question 2: Simple Harmonic Motion (S.H.M)

This question comprised two parts, namely (a) and (b). In part (a), the candidates were required to (i) distinguish between damped oscillations and un-damped oscillations, and (ii) elaborate three characteristics of simple harmonic motion (S.H.M). In part (b), the candidates were required to calculate the periodic time of a body of mass m attached to the lower end of a spiral spring which caused an extension of 1.5 cm when slightly displaced and released into vertical oscillations of small amplitude.

The question was attempted by 22,362 candidates corresponding to 99.9 per cent. Among them, 30.7 per cent scored from 0 to 3 of which 7.3 per cent scored 0 marks; 21.1 per cent scored from 3.5 to 5.5 while 48.2 per cent scored from 6 to 10 marks. These scores suggest that the performance in this question was generally good since 69.3 per cent scored from 3.5 to 10 marks. The following bar chart illustrates the data.

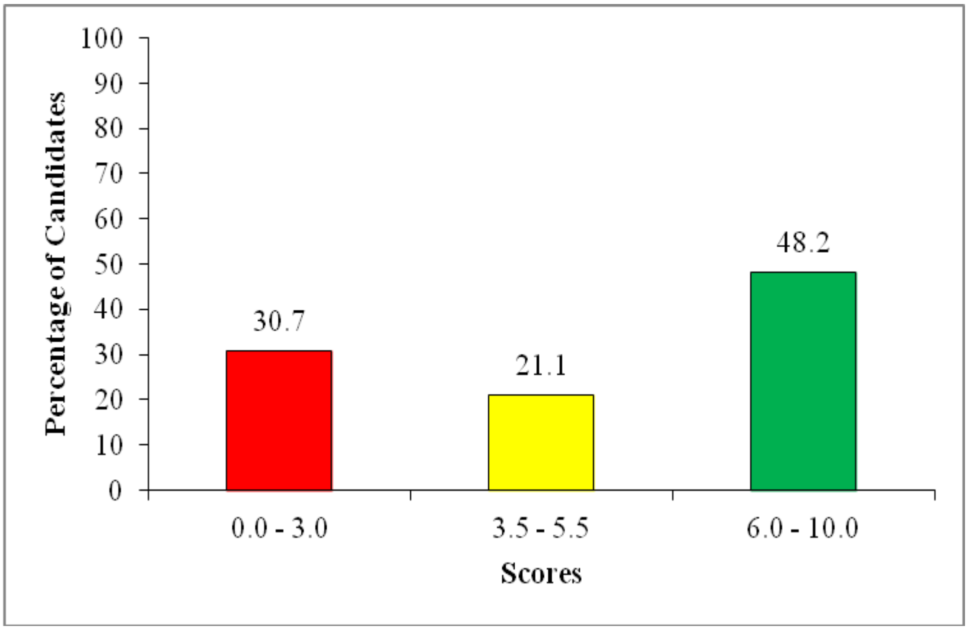
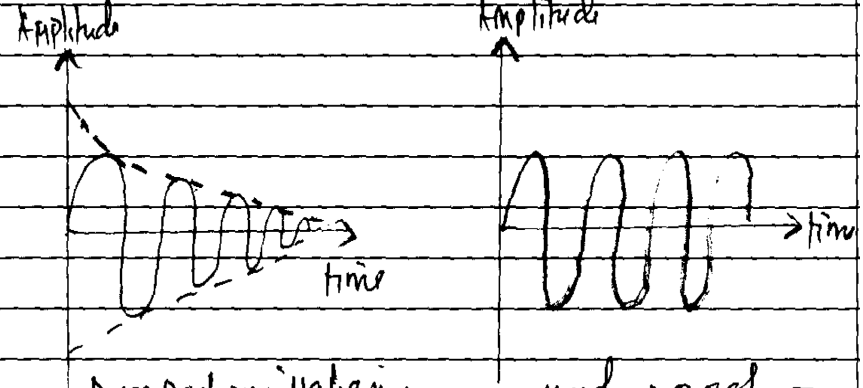


Figure 2: *Distribution of candidates' scores in Question 2 in Paper 1*

The analysis of the candidates' responses reveals that those who scored average marks (21.1%) had adequate knowledge about the concepts tested in part (a). These candidates demonstrated their skills by describing the concept of damping as used in mechanical oscillations. However, some of them failed to deduce the damping effect as it help to identify the characteristics of a body performing S.H.M. Furthermore, 48.2 per cent of the candidates who scored good marks adhered to the instructions given in part (b) which provided access to correctly give appropriate numerical treatment. These candidates were able to recall the relationship between periodic time, T, extension e, and acceleration due to gravity, g. Moreover, they managed to describe the concept and applied Hooke's law to determine the periodic time. Extract 2.1 is a sample of the correct response to this question.

2 (a) (i) · Damped Oscillations are those Oscillation whose amplitude goes on decreasing with time WHILE undamped oscillation are those oscillations whose amplitude remains constant.

· In Damped oscillation there is Continuous loose of energy WHILE in undamped oscillation there is no loss of energy.



Damped oscillation, undamped - Oscillations.

(ii) - The Simple Harmonic Motion is a Periodic motion ie Particle move to and fro about equilibrium position.

- The restoring force is directly proportional to the displacement but its directed toward the equilibrium position.

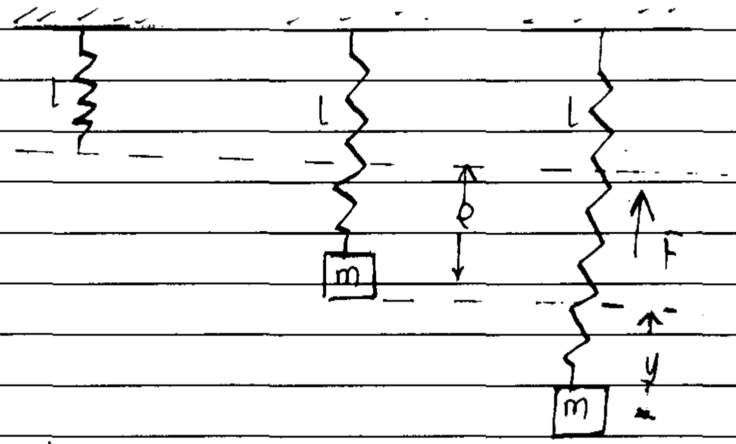
ie

$F \propto -y$.

2a) (ii) - The acceleration of the particle is directly proportional to displacement but in opposite direction towards equilibrium position.

$$a \propto -y$$

b) Consider the following illustrations.



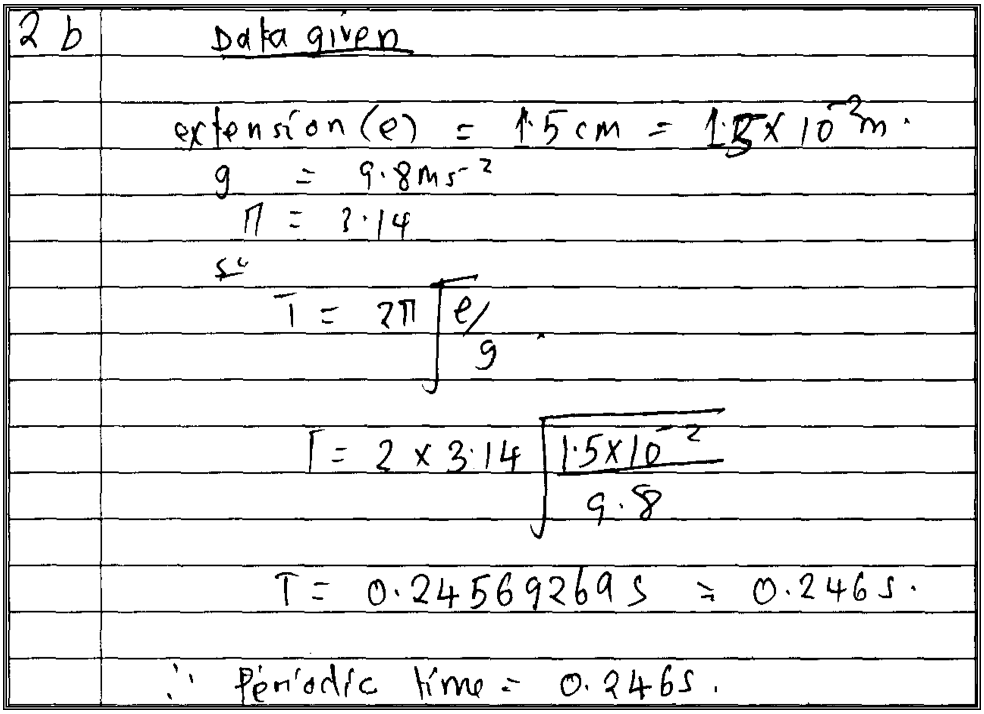
where e - extension
F - restoring force.
l - original length.

From Hooke's law
$F = -Ke$.
But from above $F = Mg$
$Mg = -Ke$.

Also when displaced:

$F_{net} = -(e+y)K - (-Ke)$
$F_{net} = -Ke - Ky + Ke$
$F_{net} = -Ky$
But $F_{net} = Ma$
$Ma = -Ky$.

2b	$Ma = -Ky$
	$a = -\frac{K}{m} y$
	$a = -(K/m) y$
	So $a \propto -y$ (S.H.M).
	Also:
	from $a = -w^2 y$.
	$w^2 = \frac{K}{m}$
	$w = \sqrt{\frac{K}{m}}$
	$\frac{2\pi}{T} = \sqrt{\frac{K}{m}}$
	$T = 2\pi\sqrt{\frac{M}{K}}$
	But
	$Mg = Ke$.
	$K = \frac{Mg}{e}$.
	$T = 2\pi\sqrt{\frac{M}{Mg/e}}$
	$T = 2\pi\sqrt{e/g}$



2 b Data given

extension (e) = 1.5 cm = 1.5×10^{-2} m.

g = $9.8\ ms^{-2}$

$\pi = 3.14$

so

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

$T = 2 \times 3.14\sqrt{\frac{1.5\times10^{-2}}{9.8}}$

T = 0.245692695 ≈ 0.246 s.

∴ Periodic time = 0.246 s.

Extract 2.1: *A sample of good responses in Question 2 in Paper 1*

In Extract 2.1, the candidate applied the concepts of S.H.M to give the correct answers in question 2.

Some of the candidates who scored low marks (30.7%) tried to give a pictorial transcription of the problem but they got wrong answers. These candidates failed to recall the appropriate formula that could match the available parameters since some of the quantities and constants were ignored. For example, some candidates wrote $t = \frac{T}{g}$ instead of $t = 2\pi\sqrt{\frac{T}{g}}$ where t, T, and g meant period, extension and acceleration due to gravity respectively. They also faced difficulties in providing the distinction between damped and un-damped oscillations. They had some basic knowledge of the given terms, but they could not link them thoroughly, and consequently provided illogical responses. Moreover, having the prior knowledge of the periodic time as related to length and acceleration due to gravity, they assumed those terms were the sole conditions for a body to execute S.H.M. Extract 2.2 shows one of the incorrect responses to this question.

(a) (i) *Damped oscillations is the kind of oscillation in which swilling up and down without expectation of getting clear oscillation. WHILE

*Un-damped oscillation is the one in which determined through acceleration due to gravity.

(a)(ii) characteristics of simple harmonic motion (S.H.M)

(a) It characterized with influence of acceleration due to gravity.

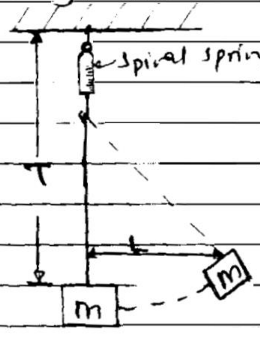
(b) It characterized with specified length when oscillated.

(c) It characterized with moving material due to acceleration of gravity.

02. (b) solution.

Data Given

consider below illustrated diagram.



Where; T = extension

m = Mass of a body

L = Amplitude

Required to calculate its period of time. (t)

Now;

$$t = \frac{T}{g}$$

$$t = \frac{1.5cm}{9.8}$$

02.	(b) $T = 1.5\text{cm} = 0.015\text{m}$
	$t = \dfrac{0.015\text{m}}{9.8\text{ m/s}^2}$
	$t = 1.53 \times 10^{-3}$ seconds.
	∴ The period of time is 1.53×10^{-3} seconds.

Extract 2.2: *A sample of the incorrect responses to Question 2 in Paper 1*

Extract 2.2, shows that the candidate failed to describe energy changes in a spiral spring, to correctly interpret the characteristics of S.H.M, and distinguish between damped and un-damped oscillations. He/she also used a wrong formula instead of Hooke's law to determine the periodic time.

2.3 Question 3: Gravitation

Part (a) of this question required the candidates to (i) write the mathematical expressions of Newton's laws of universal gravitational field and gravitational field strength and (ii) use the answers in 3 (a) (i) to show that the magnitude of the gravitational field at the earth's surface is given by $\frac{GM_e}{R_e^2}$, where M_e is the mass of the earth, R_e is the radius of the earth and G is the gravitational constant. In part (b), they were required to prove that the radius R_0 of the orbit of the satellite is given by $R_0 = \sqrt[3]{\frac{GM_eT^2}{4\pi^2}}$, where R_0 is the radius of the orbit of the satellite, T is the period of revolution, G and M_e have the same meaning as in 3 (a) (ii).

The data indicate that 22,346 candidates, equivalent to 99.8 per cent, attempted the question. Among them, 14.9 per cent scored from 0 to 3 marks; 13.1 per cent scored from 3.5 to 5.5 marks; and 72 per cent scored from 6 to 10 marks. The data are summarized in Figure 3.

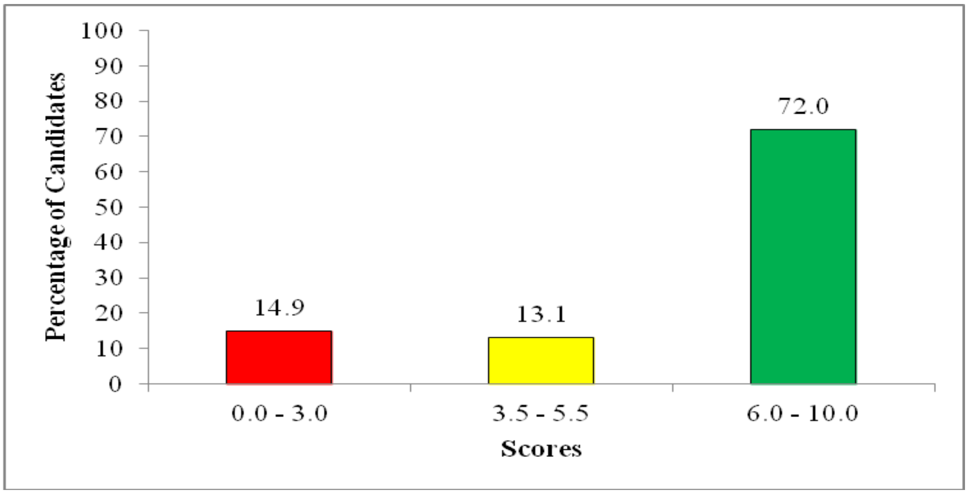


Figure 3: *The candidates' performance in Question 3 in Paper 1*

The statistical data in Figure 3 show that most of the candidates (72 %) scored above 5.5 marks. This implies that the performance in this question was generally good.

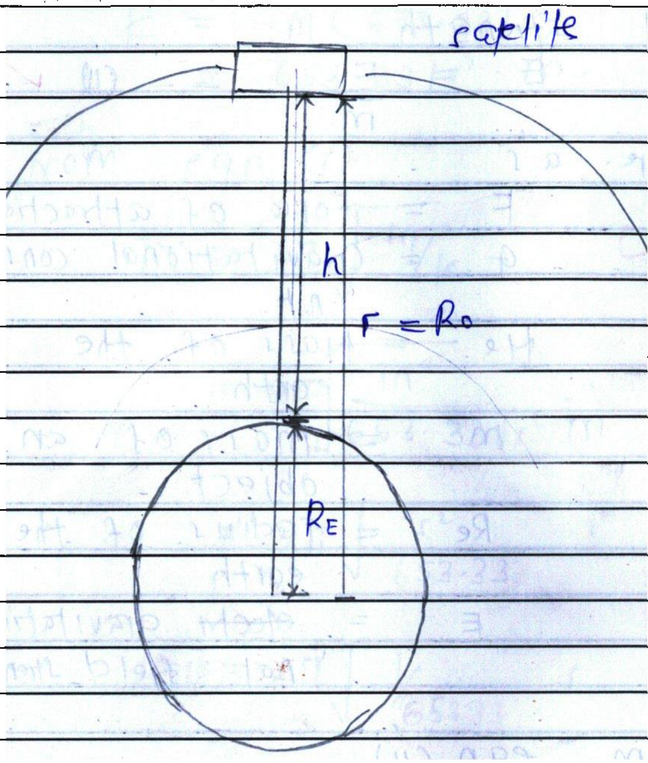
The candidates who scored good marks (72%) had sufficient knowledge of the concept of *Gravitation*. In part (a), some of them managed to formulate and correctly write an expressions of Newton's law of universal gravitation and gravitational field strength. In part (b), they demonstrated clear mathematical skills by showing that the radius of the orbit of the satellite is given by $R_0 = \sqrt[3]{\frac{GM_eT^2}{4\pi^2}}$.

In contrast, 13.1 per cent of the candidates who scored average marks (3.5 - 5.5) managed to attempt part (a) but faced challenge in examining the forces associated with the satellite when in motion. Extract 3.1 is a sample of responses from a candidate who scored good marks in this question.

3	(a) (i) Mathematical expressions of
	Newton's laws of universal
	gravitation
	$F = \frac{GM_e m}{R_e^2}$

3	(a) (i) Expression of gravitational field strength
	$E = \frac{F}{m}$ ---- (ii)
	Where as
	F = Force of attraction
	G = Gravitational constant
	Me = Mass of the earth.
	m = mass of an object
	Re = radius of the earth
	E = ~~electri~~ gravitational field strength
	(ii) From eqn (ii)
	$E = \frac{F}{m}$.
	But, $F = \frac{GMe\,m}{Re^2}$
	$E = \frac{\frac{GMe\,m}{Re^2}}{m}$.
	$E = \frac{GMe}{Re^2}$
	Hence, shown.
	(b) Required to show $Re = \sqrt[3]{\frac{GMeT^2}{4\pi^2}}$

3 (b) illustration.



$$F_c = F$$

$$\frac{mv^2}{R_o} = \frac{GM_eM}{R_o^2}$$

$$v^2 = \frac{GM_e}{R_o}$$

But

$$v = \frac{2\pi R_o}{T}$$

$$\frac{4\pi^2 R_o^2}{T^2} = \frac{GM_e}{R_o}$$

~~Make~~ cross multiplication

$$4\pi^2 R_o^2 \cdot R_o = GM_e \cdot T^2$$

$$4\pi^2 R_o^3 = GM_e T^2$$

3	(b) Make Ro the subject
	$Ro^3 = \frac{GMeT^2}{4\pi^2}$
	$Ro^3 = \frac{GMeT^2}{4\pi^2}$
	$\sqrt[3]{Ro^3} = \sqrt[3]{\frac{GMeT^2}{4\pi^2}}$
	$Ro = \sqrt[3]{\frac{GMeT^2}{4\pi^2}}$
	where as
	Ro = radius of orbit. of the satelite
	G = Gravitational constant
	T = Time period
	Me = Mass of the earth.

Extract 3.1: *A sample of good responses to Question 3 in Paper 1*

Extract 3.1, indicates how the candidate was precise and systematic in answering all parts of the question, and thus got it right.

Despite the good performance in the question, some of the candidates (14.9%) scored from 0 to 3 marks because they provided incorrect responses to most parts of the question. Most of them applied indistinct mathematical treatment to obtain an expression $R_0 = \sqrt[3]{\frac{GM_eT^2}{4\pi^2}}$ because this conclusion had been provided in the question item. It was also observed that, some of them expressed linear and angular velocities interchangeably and thus failed to exactly recall the formula linking Newton's law of universal gravitation. They attained the final expression but mathematical treatments were ambiguous. Extract 3.2 shows an incorrect response to the question.

3.	(a) i) Newton's law of universal gravitation and gravitational field strength include:
	$F = G\frac{Mm}{R}$
	where
	F = gravitational force
	M = Mass of the earth
	m = mass of the planet (moon)
	R = distance
	G - universal gravitational constant.
	ii) soln:
	From
	$\frac{mv^2}{r} = \frac{GMm}{r}$
	$\frac{v^2}{r} = \frac{GM}{r}$
	Since v^2/r = gravitational field
	$\left(Fg = \frac{GMe}{Re}\right)$. Hence shown.

3(b)	soln:
	From
	$C_F = \frac{mv^2}{r}$
	$F_G = \frac{GMem}{R^2}$.
	$C_F = F_G$
	$\frac{\cancel{m}v^2}{r} = \frac{GMe\cancel{m}}{R^2}$
	$\frac{V^2}{r} = \frac{GMe}{R^2}$
	$\frac{(2\pi r)^2}{T^2} = \frac{GMe}{R^2}$.
	$4\pi^2R^2 = GMe \times T^2$.
	$R^2 = \frac{GMeT^2}{4\pi^2}$.
	$R = \sqrt{\frac{GMeT^2}{4\pi^2}}$
	Hence proved.

Extract 3.2: *A sample of incorrect responses to Question 3 in Paper 1*

In Extract 3.2, the candidate failed to equate the centripetal force on satellite and the gravitational force if its orbit described a perfect circle in order to get the required expression of radius, R_o.

2.4 Question 4: Rotation of Rigid Bodies

This question had two parts: (a) and (b). Part (a) required the candidates to explain (i) how a man jumping from a certain height manage to increase the number of loops made in air, and (ii) why it is advisable to use a wrench with a long arm to tighten the bolt of a truck wheel. In part (b), the candidates were required to calculate the moment of inertia if the energy of 484 J was spent in increasing the speed of a fly wheel from 60 rev./min to 360 rev/min.

A total of 22,340 candidates equivalent to 100 per cent attempted this question. Their scores were as follows: 73.6 per cent scored below 3.5 marks, including 35.8 per cent who scored 0 marks; 12.8 per cent scored from 3.5 to 5.5; while only 13.6 per cent scored from 6 to 10 marks. These scores suggest that the candidates' performance was weak since only 26.4 per cent of them scored from 3.5 to 10 marks. Figure 4 summarizes these results.

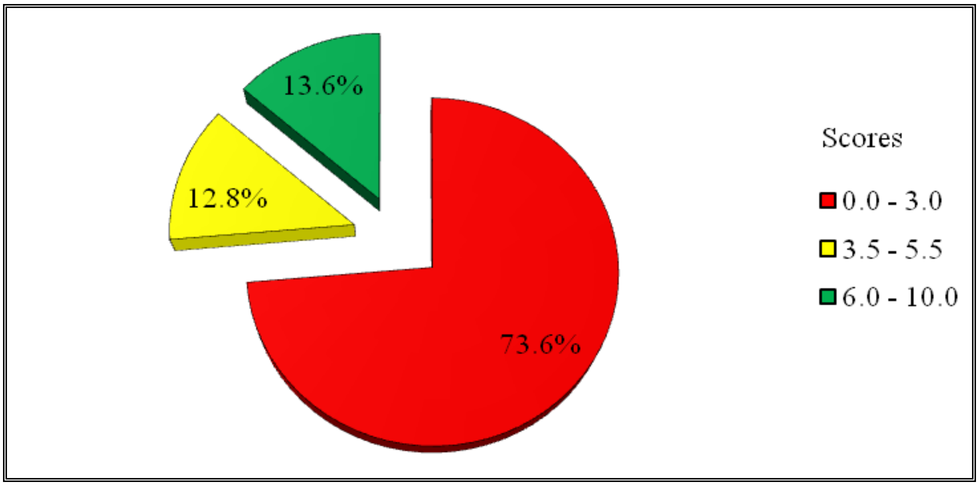


Figure 4: *The candidates' performance in Question 4 in Paper 1*

Most (73.6%) of the candidates who had weak performance faced difficulties in determining the applications of the principle of conservation of angular momentum in daily life. For resistance, in part (a), they failed to deduce how the decrease and increase of the moment of inertia and angular velocity affects the number of rotation. Similarly, they applied the concept of linear motion instead of rotation motion when responding to this part of the question. In part (b), most of them demonstrated poor knowledge of the application of lever when used as a simple machine. They failed to understand that, if the lever arm is long, the moment of force or torque (turning effect of force) increases thus, less force is used to produce a larger turning effect. Extract 4.1 is a sample of the incorrect responses to the question.

04. (a) (i) A man jumping from a certain weight manage to increase the number of loops made in the air, because he is free and not any force acting upon him, hence manage to increase the number of loops.

(ii) It advisable to use a wrench with a long arm to tighten the bolt of a truck wheel, because of that when a wrench with long arm used it can increase the circular of the bolt when tighten.

(b) Solution

Data Given

Energy (E) = 484 J

Initial velocity (V_0) = 60 rev./min

Final velocity (V_1) = 360 rev./min

Required to calculate the moment of initial.

Now;

$$\text{Energy (E)} = \frac{\text{Power}}{\text{time taken}}$$

$$E = \frac{\text{Power}}{(V_1 - V_0)}$$

$$484\,J = \frac{P}{(360-60)\,\text{rev./min}}$$

04	(b)	$4845 = \frac{P}{300\text{rev./min}}$
		$P = 484 \times 300$
		$P_1 = 145{,}200$ Watt
		∴ Moment of initial
		$P = 484 \times 60$
		$P_0 = 29{,}040$
		$P = P_1 - P_0$
		$P = 145200 - 29{,}040$
		$P = 116{,}160$ W
		∴ Moment of initial $= 116{,}160$ W.

Extract 4.1: *A sample of weak responses to Question 4 in Paper 1*

In Extract 4.1, the candidate provided an incorrect response in part (a). He/she also used irrelevant concepts to find the power and moment of inertia in part (b).

Further analysis indicates that 12.8 per cent of the candidates who scored average marks (3.5 - 5.5) managed to provide the correct responses to part (a) (i) and (b). Some of them failed to apply the concept of turning effect of force to explain what should be done to minimize the magnitude of force applied when using a wrench to tighten the bolt of a truck wheel. Nevertheless, 13.6 per cent of the candidates who scored good marks demonstrated clear understanding of the concepts tested in parts (a) and (b). Extract 4.2 is one of the correct responses to the question.

4 (a)(i) ~~A~~ man ~~a~~ manage to Increase th number of loopes ~~by~~ as follow:

By stretching his legs and arms Inward this decrease moment of inerhia since the angular momentum is conserved the angular ~~frequence~~ velocity Increases and hence th number of loops Increases

(ii) It is advisable to use a wrench with a lo ng arm to tighten th bolt of truck wheel because a wrench with long arm has large moment of force Therefore th force required to tighten th bolt will be small due to large lever arm.

(b) To calculate th moment of inerhia

Energy = 484 J

$$\text{Rotational KE} = \frac{1}{2} I\omega^2$$

$$= \frac{1}{2} I(\omega_f^2 - \omega_i^2)$$

$$\omega_i = \frac{60}{60} \times 2\times\pi = 6.28 \text{ rad s}^{-1}$$

$$\omega_f = \frac{360}{60} \times 2\times\pi = 37.699 \text{ rad s}^{-1}$$

$$484 = \frac{1}{2} I((37.699)^2 - (6.28)^2)$$

$$I = 0.7 \text{ kg m}^2$$

$\therefore$ The moment of inertia = 0.7 kg m^2.

Extract 4.2: *A sample of good responses to Question 4 in Paper 1*

Extract 4.2 shows how the candidate was precise and systematic in providing the correct responses to part (a) and (b).

2.5 Question 5: Heat (Thermal Convection and Thermal Conduction)

This question was comprised of two parts, namely (a) and (b). Part (a) required the candidates to (i) state the law applied when a body is cooling under forced convection and (ii) write the mathematical expression of the law stated in 5 (a) (i) and briefly give the physical meaning of each term. In part (b), the candidates were required to (i) sketch a graph of variation of temperature of the unlagged rod whose ends are maintained at temperatures of 100^0C and 20^0C versus its length in room temperature below 20^0C and (ii) comment on the nature of the graph drawn in 5 (b) (i).

The question was attempted by 22,338 candidates, corresponding to 99.8 per cent. Among them, 23 per cent scored from 0 to 3 marks; 32.6 per cent scored from 3.5 to 5.5 while 44.4 per cent scored from 6 to 10 marks. These scores suggest that the performance in this question was generally good since 77 per cent of them scored from 3.5 to 10 marks. The following bar chart is illustrative.

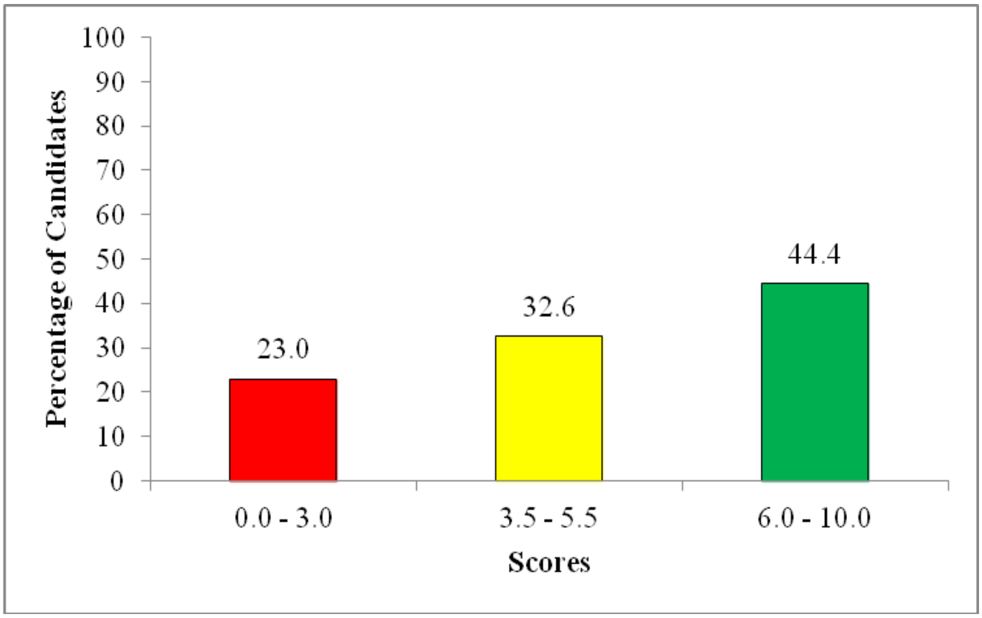


Figure 5: *The candidates' performance in Question 5 in Paper 1*

The analysis of the candidates' responses to this question indicates that most of them had a clear understanding of the concept of *Heat* specifically *Thermal conduction* and *Convection*. In part (a), they managed to identify and state Newton’s law of cooling by transcribing what is stated in the law and giving its physical meaning. In part (b), some of them labelled the given temperatures in a respective axis against length and managed to trace the nature of the graph recalling that unlagged material loses heat sideways. Extract 5.1 is a sample of good response from a candidate.

5 (a)(i) The law applied when a body is cooling under forced convection is Newton's law of cooling

Newton's law of cooling states that," Under the conditions of forced convection the rate of cooling of a body is directly proportional to the excess temperature over the surrounding"

ii) from Newton's law of cooling

$$\frac{d\theta}{dt} \propto -(\theta - \theta_s) \quad \ldots\ldots (1)$$

Introducing the constant of proportionality λ into equation (1)

5 (a) ii)

$$\frac{d\theta}{dt} = -\lambda(\theta - \theta_s)$$

Hence

$$\frac{d\theta}{dt} = -\lambda(\theta - \theta_s)$$

where $d\theta/dt$ - Rate of cooling of a body

λ - Constant of proportionality called Cooling Constant

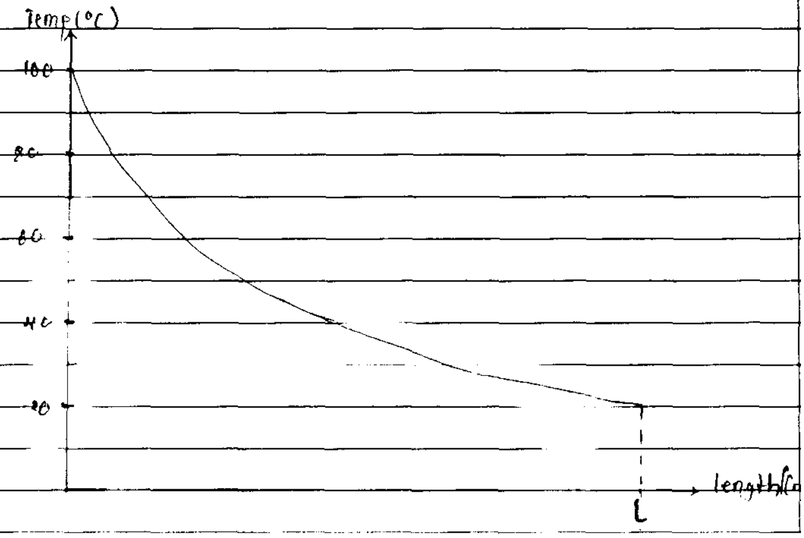
θ - Temperature of a body

θ_s - Temperature of the Surrounding.

(-)ve sign indicates the body is cooling.

(b) Because the rod is unlagged some amount of heat is lost to the surrounding as it moves from end at 100°C to the end at 20°C.

GRAPH OF TEMPERATURE AGAINST LENGTH OF A ROD (UNLAGGED)



5 (b) ii) The graph sketch is a curve

The graph is a curve because some heat is lost to the surrounding and hence the temperature gradient across the the metal rod is not constant hence the graph becoming a curve.

Extract 5.1: *A sample of good responses to Question 5 in Paper 1*

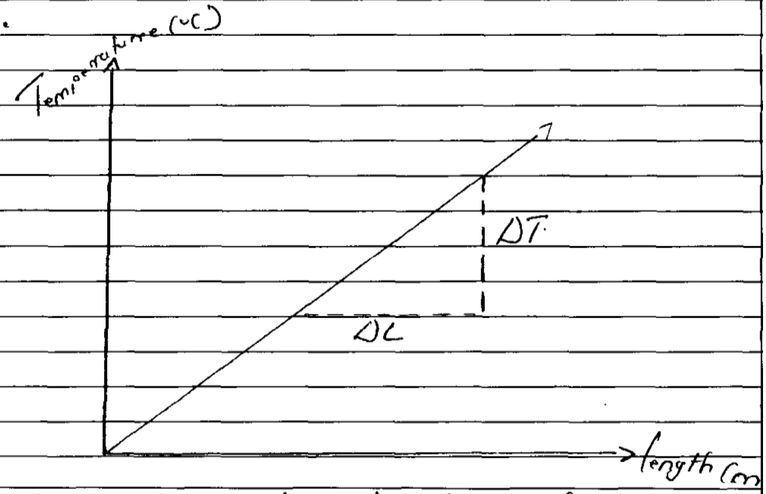
In Extract 5.1 the candidate identified and wrote the expression $\frac{dQ}{dt} = -\lambda\left(\theta - \theta_s\right)$ for Newton's law of cooling. He/she also correctly provided a relevant comment on the sketched graph.

Despite the good performance in the question, some candidates presented incorrect responses to most parts of the question. In part (a), they confused between Newton's law of cooling with Stefan's law. These candidates demonstrated poor knowledge of the processes of heat transfer and the laws associated with these methods. They failed to understand that Stefan's law applies in the process of heat transfer by radiation and not in forced convection. In part (b), some of them sketched a straight line graph instead of exponential curve. Thus they failed to investigate factors affecting the rate of cooling. Consequently, they failed to examine how the temperature gradient varies as the quantity of heat passing in a given time through successive cross-sections decreases because of heat loss through the sides of unlagged metal bar. Extract 5.2 shows a sample of the incorrect responses.

5(a)(i) The Stefan's law:
States that "The rate at which a body emit energy is directly proportional to the fourth power of absolute temperature of a body"

(ii) $P \propto T^4$.
$P = \varepsilon\sigma A T^4$.
$P = \varepsilon\sigma A(T_1^4 - T_0^4)$
whereby.
P – Rate of ~~emitted~~ heat emitted.
ε – Emissivity of a body.
A – The surface area.
T_1^4 – Absolute temperature of a body
T_0 – Absolute temperature of the surrounding.

b(i) The graph of variation of temperature of the rod versus its length.



b(ii) The nature of the graph is straight which shows that temperature varies with length.
Slope $= \frac{\Delta T}{\Delta L}$ = Temperature gradient.

Extract 5.2: *A sample of incorrect responses to Question 5 in Paper 1*

In extract 5.2, the candidate provided incorrect responses in all parts of the question.

2.6 Question 6: Heat (Thermometry and Thermodynamics)

Part (a) required the candidates to (i) explain two necessary requirements needed to establish a temperature scale and (ii) identify three limitations of the first law of thermodynamics. In part (b), the candidates were required to calculate the quantity of heat transferred to nitrogen in an isobaric heating such that the gas may perform 2 joules of work.

The question was attempted by 22,361 (99.9%) candidates whose scores were as follows: 16,296 (72.9%) scored from 0 to 3 marks, 3,501 (15.6%) scored from 3.5 to 5.5 marks and 2,564 (11.5%) scored from 6 to10 marks. These scores indicate that the candidates' performance was weak as only 6,065 (27.1%) candidates scored from 3.5 to 10 marks. Figure 6 presents these scores.

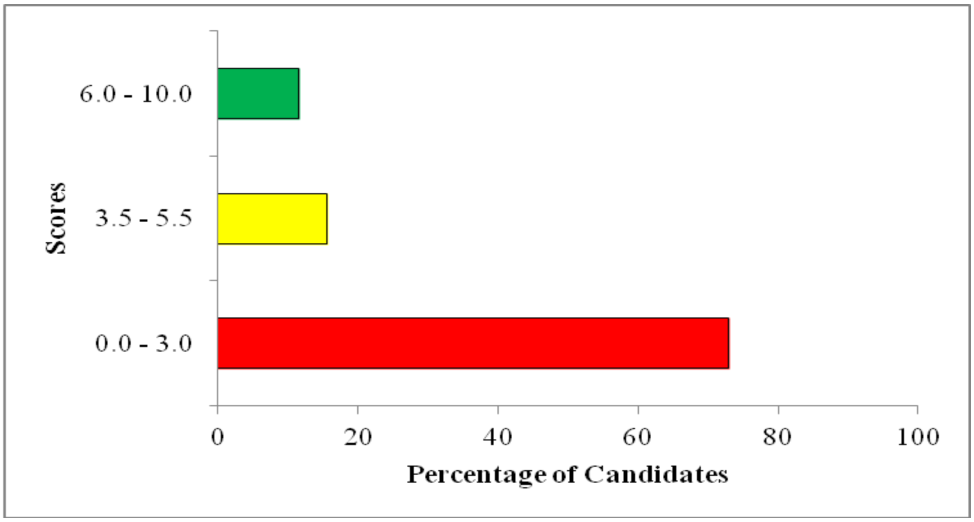


Figure 6: *Distribution of the candidates' scores in Question 6 in Paper 1*

Figure 6 shows that a large number of candidates (72.9%) scored from 0 to 3 marks. One of the factors noted to have affected performance in part (a), was lack of knowledge about the thermometric properties of substance. As a result, the candidates faced difficulties in identifying the necessary conditions for establishing a temperature scale. For example in part (a) (i), one candidate wrote: *'Constant volume gas thermometer, alcohol thermometer and platinum thermometer'*. These responses are types of thermometers and not the necessary conditions needed when establishing a temperature scale. This suggest that he/she had insufficient knowledge about thermometric properties of substance. Moreover, most of them failed to correctly specify limitations of the first law of thermodynamics and how the law correlates with the internal energy of the gas to determine the quantity of heat. Extract 6.1 is a sample of the incorrect responses.

6 (a) (i) For a temperature scale to be established, must consider:

- Surrounding temperature.
- Material made a conductor.

(ii) Limitation of Thermodynamics.

- Material made a conductor.
- Length of a conductor.
- Distance of separation between a conductor or plates.

(b) w.D = 2 J.

quantity of heat Q = ?

Isobaric means at constant volume of a gas.

Q = mcΔT

But w.D = F x d.

w.D = PV.

w.D = PA.d. where F = PA

$Q = mgc\frac{\Delta T}{g}$

$Q = Fc\frac{\Delta T}{g}$.

Extract 6.1: *A sample of incorrect responses to Question 6 in Paper 1*

Extract 6.1, shows that the candidate provided incorrect responses to part (a). In part (b), he/she used the formula for mechanical work (W = F x d) instead of $\Delta Q = \Delta W + \frac{\Delta W}{\gamma - 1}$ for internal energy to find the quantity of heat.

The candidates with good (27.1%) performance had sufficient knowledge on the concepts of thermometry and thermodynamic process. Most of them responded correctly to part (a), and correctly analysed the concept based on the first law of thermodynamics, and deduced the formula to determine the quantity of heat. Extract 6.2 presents a correct response from a candidate.

6 (a) (i) – There must be fixed point such that the lower and upper fixed points
– There must be thermometric properties which varies linearly with temperature.

(ii) – The law does not indicate the direction of flow of heat
– The law does not provide the conditions in which the heat can be converted to work
– The law does not explain why a whole heat cannot be converted into mechanical work

6 (b) given
work done by Nitrogen = 2J
Required is heat transfered.

from first law of thermodynamics
$\Delta Q = \Delta U + W$
but
$\Delta U = nC_v\Delta T$ and $\Delta Q = nC_p\Delta T$
also
$C_p = C_v + R$ from mayor's equation,
and $\frac{C_p}{C_v} = \gamma$

$\gamma C_v = C_v + R$
$\gamma C_v - C_v = R$

$C_v = \frac{R}{\gamma - 1}$

$\Delta Q = \frac{nR\Delta T}{\gamma - 1} + W$
but $nR\Delta T$ = work done W

$\Delta Q = \frac{W}{\gamma - 1} + W$

$= \frac{2}{1.4 - 1} + 2 = 7J$

∴ The heat transfered is 7 J

Extract 6.2: *A sample of correct responses to Question 6 Paper 1*

In Extract 6.2, the candidate managed to use the concept of thermometry and thermodynamic process to provide the correct responses to parts (a) and (b).

2.7 Question 7: Environmental Physics

This question had two parts: (a) and (b). Part (a) required the candidates to briefly explain the influence of humidity on plant growth. In part (b), they were required to (i) explain how thermal energy is transmitted in different layers of the earth and (ii) give evidence to justify that primary and secondary waves were used to ascertain that the outer core of the earth is in liquid form.

A total of 22,256 (99.4%) candidates responded to the question and their performance is illustrated in Figure 7.

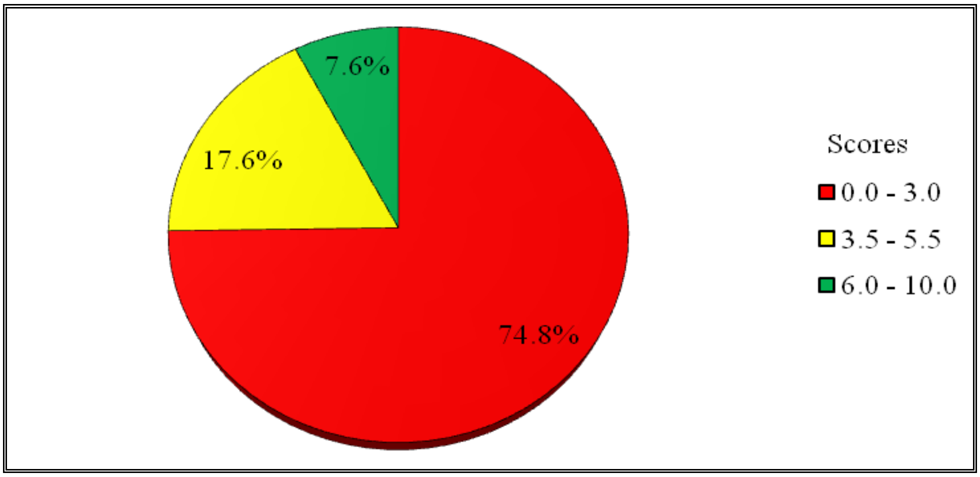


Figure 7: *Distribution of candidates' scores in Question 7 in Paper 1*

Figure 7 shows that only 25.2 per cent of the candidates scored from 6 to 10 marks while 74.8 per cent scored below 6 marks. Thus, the performance in this question was weak.

Most of the candidates with weak performance (74.8%) failed to retrieve and summarize correctly the main components of agricultural physics. Most of them identified sources and types of pollutants in the environment, contrary to the requirement of the question. As a result, they failed to ascertain the influence of aerial environment, specifically humidity, on plant growth.

In addition, some of them faced challenges in describing how the transfer of thermal energy and the propagation of seismic waves are influenced by the characteristics of different layers of the earth. These candidates failed to understand that thermal energy can be transferred through outer core, mantle and crust by either conduction, convection or radiation, depending on the physical properties of these three layers of the earth. The outer core being in liquid state allows energy to pass through it by convection and radiation while in the crust layer, energy is transmitted by conduction and radiation. However, energy is transmitted by convection, radiation and conduction in mantle due to its plastic properties.

Further analysis through candidates' responses revealed that most of the candidates in this category lacked knowledge about the properties of seismic waves, that they can be deflected as they move from one region to another. However, the unique behaviour of P-waves to travel in solid and liquid, unlike S-waves, which travel only in solid, provide proof that the outer core is in liquid form. Extract 7.1 is a sample of the incorrect responses.

7. (a) Influence of humidity on plant growth.
i/ windstorm
The movement of wind from one place to
another has effect on the plant growth.
Since it may move the ~~an~~ water vapour from one area to another
ii/ ~~Ocean~~ ocean
during the day ocean get heated
and then water start evaporating toward
the upper layer and some of them
absorbed by water.

iii/ human activities
Example ~~the~~ people ~~en~~ who engaging in
Irrigation scheme.

iv/ Industries
Industries use water during their operation
and these water become moving from
one place to another this results to the
contribution of humidity in plants.

5(ii)	~~B~~ Primary wave ; This is the longitudinal
	wave , as But $\eta = 0$
	for primary wave $P = \sqrt{\frac{\beta}{\rho}}$
	~~But~~ for secondary wave : this is
	the transverse wave ,
	for secondary wave $\beta = 0$ and $\eta = 0$
	hen $S = 0$

Extract 7.1: *A sample of the incorrect responses to Question 7 Paper 1*

In Extract 7.2, the candidate provided the incorrect responses to all parts of the question. He/she attempted to explain factors that affect environment instead of how high, moderate and low humidity affects plant growth.

On the other hand, few (25.2%) candidates who scored good (6 - 10) marks had a good understanding of the concepts tested. In part (a), they clearly explained how plant growth is affected by humidity. In part (b) (i), most of them were able to identify the layers of the earth, their states and the methods in which thermal energy could be transferred. However, only few candidates had good understanding of the characteristics of primary and secondary waves as they were able to justify that the outer core of the earth is in liquid form. Extract 7.2 shows correct responses to the question.

07	(a) Effect of humidity on plant growth:-
	→ Humidity is the amount of water vapour
	in the atmosphere at a particular temperature
	in a certain area.
	→ Humidity can cause high growth rate or
	low growth rate depending on its relative
	amount in the atmosphae and the needs of
	the plant.
	→ High humidity in the atmosphere prevents
	transpiration of the plants hence affecting the
	regular distribution of minerals and salts
	from the soil to the aerial parts of the
	plant body.

→ High humidity can cause photosynthesis to slow down as a result of closure of the stomata, hence, no carbon dioxide entering the spong mesophyll cells for photosynthesis.

→ Low humidity can cause excessive transpiration hence much water is lost into the atmosphere which may in turn lead to wilting of the plant, decreased growth.

→ Moderate humidity influences the growth of the plant body since the rate of photosynthesis and transpiration are at their maximum or optimal point. This leads to increased growth of the plant body.

07 (b) 1.) The earth is composed mainly by three layers
- Core
- Mantle
- Crust.

- These layers are made of various materials such as liquid magma and solid iron and nickel materials.

- Internal heat from the interior of the earth is transmitted through ~~three~~ two processes.

1. Conduction.

Heat is transmitted by conduction in the solid layers of the earth such as inner core and crust which are solid state

2. Convection

Heat is transmitted by convection through various layers such as outer core and mantle which are made of fluid materials

ii) Evidence to aceertain that the outer core is in liquid while the inner core is in Solid state.

→ Primary and secondary waves were used because of their differences in Characteristis Such as speed and medium through which they can be propagated.

→ Primary waves are longitudinal waves which can be propagated through any medium and

07 hence, they can pass through the outer core, inner core, mattle and finally through crust without hindrance on the way.

Evidences

→ Presence of shadow zones where there is no ~~deff def~~ detection of secondary waves.

• These places lie at areas directly to the outer core of the earth hence, primary waves are the only waves observed while secondary waves are not detected as they can not be propagated through these layers.

→ When primary and secondary waves are applied at a place, primary waves are detected first meaning that they travel in both liquid layers and solid layers but the Secondary waves arrive later after primary

Extract 7.2: *A sample of correct responses to Question 7 in Paper 1*

Extract 7.2, shows that the candidate provided the correct responses in most parts of the question.

2.8 Question 8: Current Electricity

This question was divided into three parts: (a), (b) and (c). Part (a) required the candidates to (i) distinguish between an e.m.f of a cell and potential difference and (ii) draw a circuit diagram to show how the e.m.f E and potential difference V are related if a cell of e.m.f E and internal resistance r is supplying a current I across the external resistor R. Part (b) required the candidates to (i) explain how an increase in length affects the resistivity and conductivity of a conductor and (ii) sketch the characteristic graph to show how the current varies with voltage in ohmic conductors. Part (c) required the candidates to study the circuit diagram in Figure 1 (presented here as Figure 8) and use it to (i) find the reading of the ammeter A, B and C, assuming that they have no internal resistance, and (ii) determine the potential difference between X and Y.

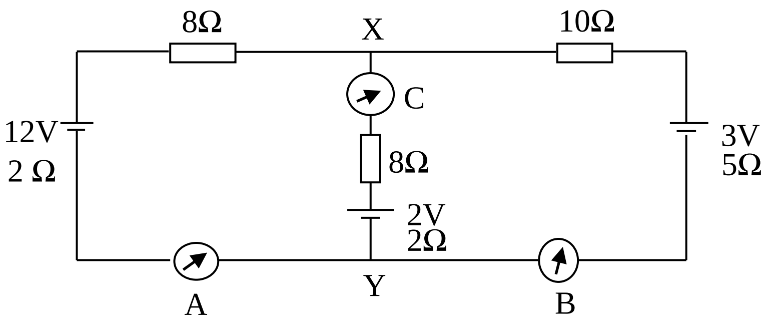


Figure 8

The data indicate that 10,641 candidates, equivalent to 47.5 per cent, attempted the question. Among them, 64.6 per cent scored from 0 to 5 marks; 25.3 per cent scored from 5.5 to 8.5 marks and 10.1 per cent scored from 9 to 15 marks. Although most of the candidates (64.6%) scored low marks (0 - 5), the performance in this question was generally average as 35.4 per cent of them scored 5.5 - 15 marks. Figure 9 graphically presents these scores.

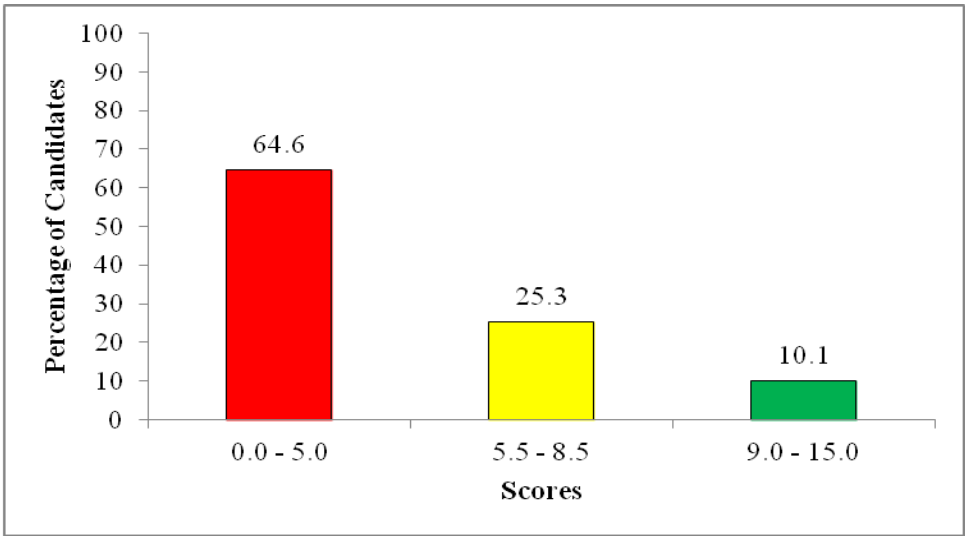


Figure 9: *The candidates' scores in Question 8 in Paper 1*

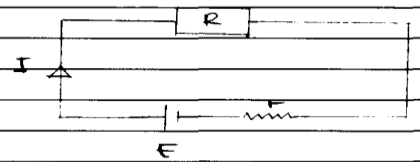
The candidates with good performance (35.4%) in this question demonstrated good understanding of the topic of *Current electricity*. This is evident in their responses about the concept of electric conduction in metals in parts (a) and (b). Although, some of them failed to sketch the characteristic graph showing the variation of current with voltage in ohmic conductor other candidates clearly explained how an increase in length affects both resistivity and conductivity of a conductor. In part (c), most of them managed to study the given circuit diagram and apply Kirchhoff's current and voltage laws to determine ammeter readings and the potential difference between junctions X and Y. Extract 8.1 is a sample of the candidates' good responses.

8. (i) Emf | Potential difference

(i) is the value of voltage when the cell is not delivering a current in the external circuit | - is the value of voltage when the cell is delivering current in the circuit.

(ii) it has large value than potential difference | - it has small value than emf of the cell

(ii) consider a circuit below



from

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

but

$$IR = V$$
$$E = V + Ir.$$

(b) (i) For resistivity

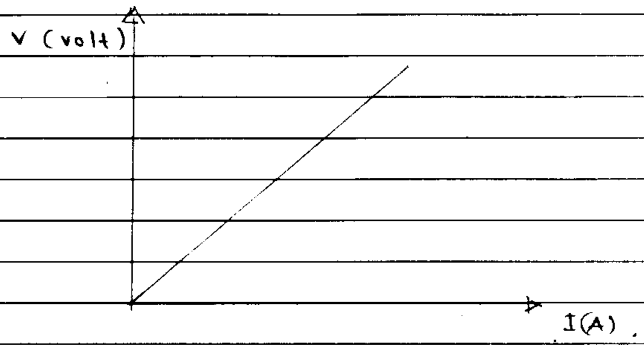
- The resistivity of material does not affected by its length, since resistivity is characteristics of a given material

(i) For conductivity

- also the conductivity of material does not affected by increase the length of a conductor but it depend on the number of charge carriers

(ii) For ohmic conductor

the V - I graph is linear.



Therefore,

$$V \propto I$$
$$V = kI$$

but constant k = Resistance R.

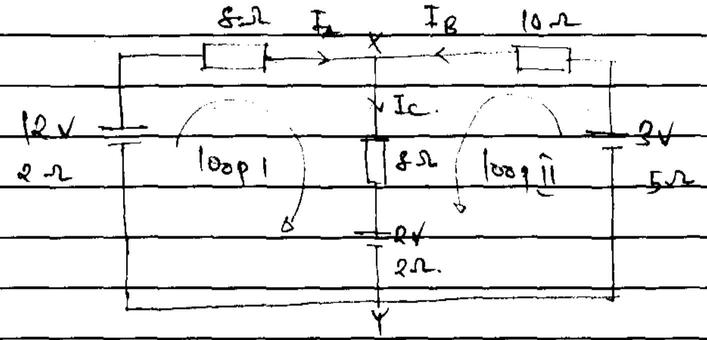
$$V = IR.$$

(i) Let

current through ammeter A = I_A
current through ammeter B = I_B
current through ammeter C = I_C.

then,

8 | ©



from, Kirchhoff's current law

$I_C = I_A + I_B$

then

Take loop I

$12V - (8\Omega \times I_A) - (8\Omega \times I_C) - 2V - (2\Omega \times I_C) - (2\Omega \times I_A) = 0$

then

$12 - 8I_A - 8I_C - 2 - 2I_C - 2I_A = 0$

$10 - 10I_A - 10I_C = 0$

$10I_A + 10I_C = 10$ —— (I)

then

take loop II.

$3V - (10\Omega \times I_B) - (8\Omega \times I_C) - 2V - (2\Omega \times I_C) - (5\Omega \times I_B) = 0$

then

$3 - 10I_B - 8I_C - 2 - 2I_C - 5I_B = 0$

$1 - 15I_B - 10I_C = 0$

$15I_B + 10I_C = 1$ — (II)

then

substitute the value of $I_C = I_B + I_A$.

$15I_B + 10(I_A + I_B) = 1$

$15I_B + 10I_A + 10I_B = 1$

$25I_B + 10I_A = 1$ —— (III)

then

$10I_A + 10(I_A + I_B) = 10$

& (ii) Then

$$10 I_A + 10 I_B + 10 I_X = 10$$

$$20 I_A + 10 I_B = 10 \quad \text{——— (iv)}$$

solve eq (iii) and (iv) simultaneous equation

$$\begin{cases} 10 I_A + 25 I_B = 1 \\ 20 I_A + 10 I_B = 10 \end{cases}$$

Then

$I_A = 0.6\,A$ and $I_B = -0.2\,A$.

Thus

$$I_C = I_A + I_B$$
$$= (0.6 - 0.2)\,A$$
$$= 0.4\,A.$$

The readings are.

(i) Ammeter A = 0.6 A
(ii) Ammeter B = 0.2 A
(iii) Ammeter C = 0.4 A.

(ii) Then

take loop 1

$$12V - (8 \times I_A) - V_{xy} - (2 \times I_A) = 0$$

but

$$I_A = 0.6\,A$$

$$12V - (8 \times 0.6) - V_{xy} - (2 \times 0.6) = 0$$
$$12 - 4.8 - V_{xy} - 1.2 = 0$$
$$V_{xy} = 12 - 4.8 - 1.2$$
$$= 6V$$

∴ The potential difference between X and y is 6 Volts

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

In Extract 8.1, the candidate correctly and systematically described the mechanism of electric conduction in metals and ended with correct responses in all parts of the question.

In contrast, the candidates who scored low (0 - 5) marks in this question provided incorrect responses to most parts of the question. Most of them lacked knowledge about the basic concepts of *Current electricity* particularly the mechanism of electric conduction in metals. They failed to determine how the variation of length influence the magnitude of resistivity and conductivity of a conductor. In addition, they sketched an incorrect characteristic graph showing how current varies with voltage in ohmic conductors. Furthermore, in part (c), they faced difficulties in analysing electrical networks as they used Ohm's law for the given complex circuit instead of Kirchhoff's laws. Extract 8.2 is one of the incorrect responses to the question.

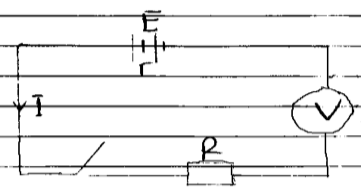
8bi when the length of aconductor increse it increase the resistivity of aconductor as well as decrese the conductivity of aconductor.

Resistivity $\propto$ Length.

Conductivity $\propto$ 1/Length.

8ai emf stand for internal resistance While Potential difference stand the voltage pass through aconductor.

8aii



8ci from Ameter A

$V = 12V$

$R = 8\Omega$

from $I = V/R$

$I = 12/8 = 1.5$ Ampere.

from Ameter B

$V = 3V$

$R = 10\Omega$

from $I = V/R$

$I = 3/10$

$= 0.3$ Amperes.

From Ammeter C

$V = 2V$

$R = 8\Omega$

From $I = V/R$

$= 2/8$

$= 0.25$ Amperes

∴ The reading of Ammeter

A = 1.5 Amperes

B = 0.3 Amperes

C = 0.25 Amperes.

8cii	Potential difference between X and Y
	$R = 8\Omega$
	$r = 2\Omega$
	$I = 0.25$ Ampere
	Then from $I = V/R$
	$V = IR$
8cii	$V = I(R+r)$
	$V = 0.25(8+2)$
	$V = 0.25 \times 10$
	$= 2.5V$
	∴ Potential difference between X and Y is
	$2.5V$.

Extract 8.2: *A sample of incorrect responses to Question 8 in Paper 1*

In Extract 8.2, the candidate provided the incorrect distinction between e.m.f of a cell and potential difference. He/she drew an incorrect circuit diagram showing how these two terms are related and applied a wrong formula and procedure to find the values of the tested concepts.

2.9 Question 9: Electronics (Semiconductor, Diodes and Transistors)

This question was divided into three parts: (a), (b) and (c). Part (a) required the candidates to (i) give any two differences between intrinsic semiconductor and extrinsic semiconductor and (ii) describe pn junction diode characteristics and sketch a graph to show how the current through it varies with potential difference (p.d) across it. In part (b) the candidates were required to use a junction-transistor voltage amplifier circuit diagram in Figure 2 (presented here as Figure 10) to calculate (i) the voltage across R_1 and (ii) the magnitude of I_B and I_C given that $R_1 = 100\,\Omega$, $V_{CC} = 6.0\text{ V}$, $h_{FE} = 60$ and $V_{BE} = 0.6\text{ V}$

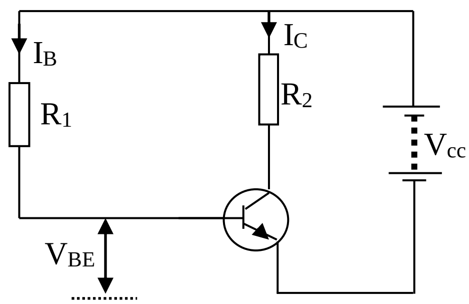


Figure 10

In part (c), candidates were required to (i) identify two distinguishing characteristics of semiconductors and (ii) analyse the effect of temperature in conduction of solids.

A total of 17,287 candidates, corresponding to 77.2 per cent attempted this question. Their scores were as follows: 43.4 per cent scored below 5.5 marks, including 4.6 per cent who scored 0 marks; 33.1 per cent scored from 5.5 to 8.5 marks; while 23.5 per cent scored from 9 to 15 marks. These scores suggest that the candidates' performance in this question was average because 56.6 per cent of them scored from 5.5 to 15 marks. Figure 11 is illustrative.

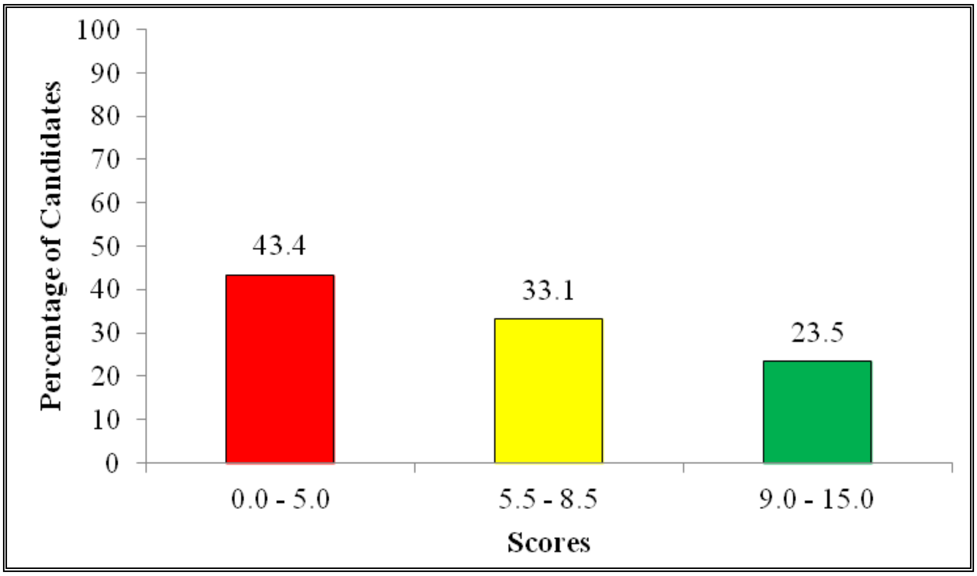


Figure 11: *Distribution of the candidates' scores in Question 9 in Paper 1*

The analysis of the candidates' responses in this question shows that 33.1 per cent of the candidates who scored average marks (5.5 - 8.5) had good understanding of the concepts of *Semiconductors*, *Diodes* and *Transistors*. In part (a), they managed to recall the working principle of diodes by describing the concept of biasing in both forward and reverse directions. They managed explain that, for a diode to be characterized, it should be observed in terms of how it works. Therefore these candidates recognised the conditions for its conduction. In part (b), some of them had knowledge about applications of Kirchhoff's laws but they failed to identify the input and output circuits, and to deduce the required equations to get the correct answer.

Further analysis shows that 23.5 per cent of the candidates scored good marks. These candidates had adequate knowledge of semiconductors and transistors. Most of them were able to interpret transistor characteristics and apply appropriate methods to find the magnitude of the tested concepts. Moreover, they managed to examine the characteristics of semiconductors and analyse the effect of temperature on the electrical conduction in solids. Extract 9.1 presents a sample of a good responses given by a candidate.

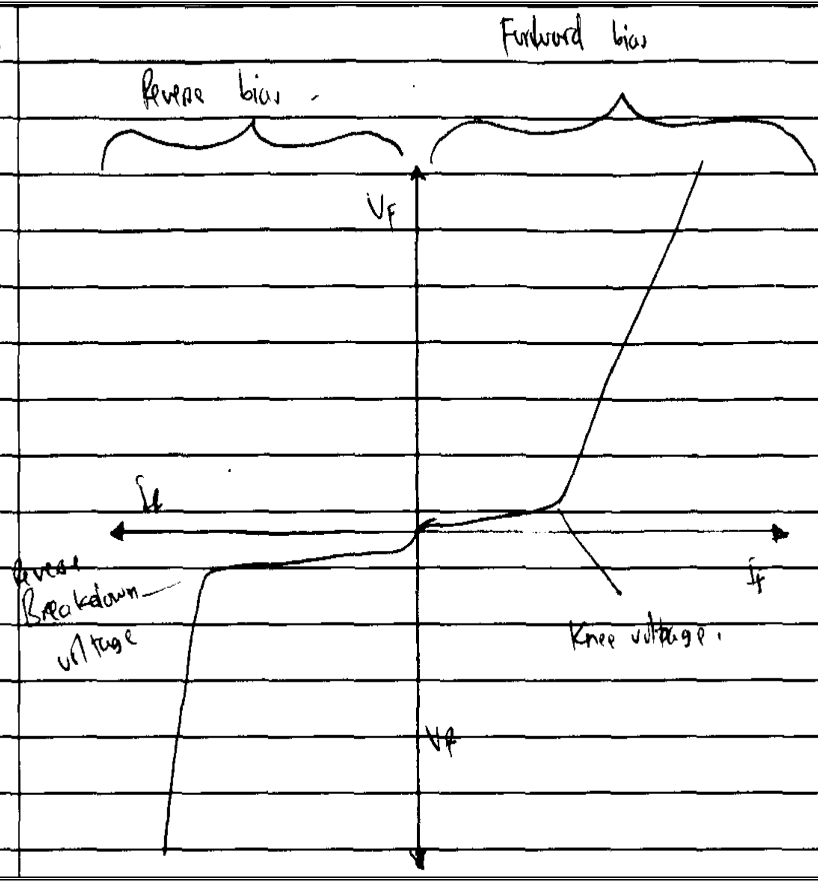
9 a/.

Intrinsic semiconductor	Extrinsic semiconductor.
It have equal number of free electron and hole.	It have unequal number of free electrons and holes.
It is conduction depend only on temperature.	It is conduction depend on temperature and doping.
It is pure group IV element without doped	It is impure formed when grouped IV element is doped with trivalent or pentavalent atom.

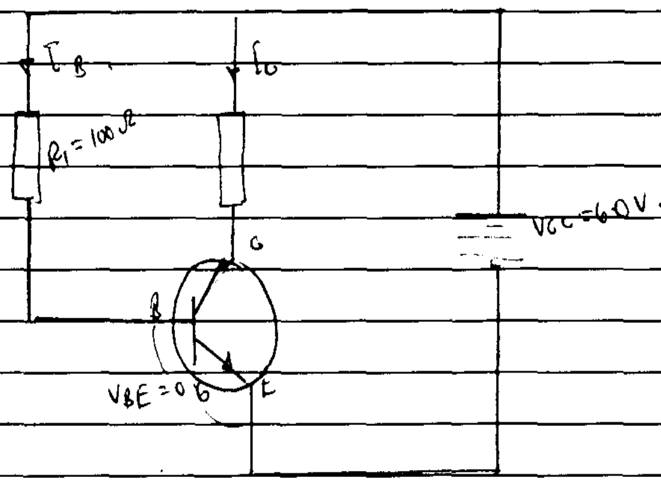
9 b) a/ ii/ P-N junction when is is forward biased the increase in current led to small increase in voltage. When the voltage reach to certain value in forward biased the current start to increase with respect to ~~the~~ voltage. This voltage is called Knee voltage.

When P-N junction is in reversed biased it doesnot conducts electricity however the small amount of the leakage current flowing in diode it ~~too~~ reach the point when the current ~~has~~ start to flow with the increase in temperature.

9a).



9 (b)



Apply KVL.

$I_B R_1 + V_{BE} = V_{CC}$.

But $I_B R_1 = V_{R_1}$.

$V_{R1} + V_B = V_{CC}$.

But $V_B = V_{BE}$.

$V_{R1} = V_{CC} - V_{BE}$.

$V_{R1} = 6.0V - 0.6V$.

$V_{R1} = 5.4V$.

The voltage across R_1 is $5.4V$.

The magnitude of I_B and I_C.

Since

$V_{R1} = I_B R_1$.

$I_B = \frac{V_{R1}}{R_1}$.

$I_B = \frac{5.4V}{100\Omega}$.

$I_B = 0.054A$.

$I_B = 0.054 A$.

for I_C.

Since $h_{FE} = \frac{I_C}{I_B}$.

then $I_C = h_{FE} \times I_B$.

$I_C = 60 \times 0.064A$.

$I_C = 3.24A$.

then $I_C = 3.24 A$

9 c) Characteristics of semiconductor:

- It have the negative temperature coefficient of resistance
- It have the narrow forbidden gap. that when electron gain enough energy can across through it.
-

ii) Effects of temperature depend whether the solid are conductor, semiconductor or ~~insulator~~. insulator.

- For conductor the increase in temperature decrease in the conduction of conductor.
- For semiconductor the increase in temperature increase the conduction of semiconductor
- For insulator increase in ~~conductor~~ temperature have no effect on the conduction of insulator. However to for high temperature electron can across the wide forbidden gap and hence conduct the electricity.

Extract 9.1: *A sample of correct responses to Question 9 in Paper 1*

Extract 9.1 indicates that the candidate clearly explained the tested concepts and applied the correct formula and procedures to determine the required values in all items.

In contrast, 43.4 per cent of the candidates with weak performance had insufficient knowledge of the subtopic of *Semiconductors, Diodes* and *Transistors*. The observed difficulties stem from their failure to identify the distinctions characteristics between intrinsic and extrinsic semiconductors, and their applications. They also failed to describe *p.n* junction diode characteristics. Consequently, they failed to analyse the effect of temperature in the conduction of solids. In addition, some of them lacked mathematical skills to answer part (b) on how to interpret the given junction-transistor voltage amplifier circuit diagram and apply the

Kirchhoff's voltage law to evaluate the tasks. Extract 9.2 presents a sample of the incorrect responses.

9a) i)

Intrinsic semiconductor	Extrinsic semiconductor
It is not the pure semi conductor as it is formed by doping	It is the pure semi conductor
It has high conductivity of electricity.	It has low conductivity of electricity.

C ii) If there is an increase in temperature in solids, it causes the increase in kinetic energy of the molecules within a solid and thus increase the collision between molecules of the solid hence high conductivity to electric charges or currents but if there is low temperature there will be no conduction of electricity.

c i) Distinguishable characteristics of semiconductors are;

i) At absolute temperature they behave as an insulators.

ii) At a given temperature which is not absolute they behave as conductors.

b) i) SOLUTION.

Data given;

$R = 100\Omega$ $V_{CC} = 6.0V$

$h_{FE} = 60$ $V_{BE} = 0.6V$

From;

$$V = I_B V_{BE} + I_C V_{CC}.$$

$$V = I_B 0.6 + I_C 6.$$

But $I_B = I_C$.

$$V = I_C 0.6 + I_C 6.$$

$$V = 0.6 + 6.$$

$$V = 6.6V$$

9 b) i) Voltage across R_1

$V_{ce} = I_c R_1$.

$V_{cc} = 6V$.

$R_1 = 100\Omega$.

$I_c = 6/100$.

$I_c = 0.06A$

But $I_c = I_B$.

Voltage;

$V = R_1 I_B$.

$V = 0.06 \times 100$.

$V = 6V$.

$\therefore$ Voltage across R_1 is $6V$.

ii) Magnitude of I_B and I_c.

$I_B = \Delta I_c \beta$

$\Delta I_B = 0.06 \times 60$.

$I_B = 3.6A$

$\therefore$ Magnitude of I_B, $= 3.6A$

Extract 9.2: *A sample of incorrect responses to Question 9 in Paper 1*

In Extract 9.2, the candidate provided incorrect responses in all parts of the question.

2.10 Question 10: Electronics (Op-amp, Logic Gates and Telecommunication)

This question comprised three parts: (a), (b) and (c). Part (a) required the candidates to (i) mention three characteristic features of op-amp and (ii) identify two types of op-amps with the aid of relevant diagrams. Part (b) required the candidates to (i) determine the output voltage in the circuit diagram in Figure 3. (presented here as Figure 12)

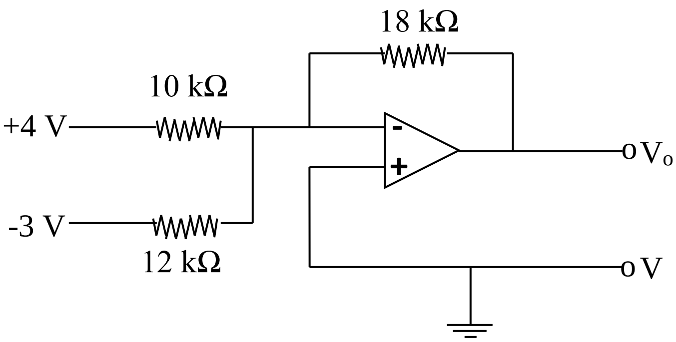


Figure 12

and (ii) study the logic circuit in Figure 4 (presented here as Figure 13) and then draw its truth table.

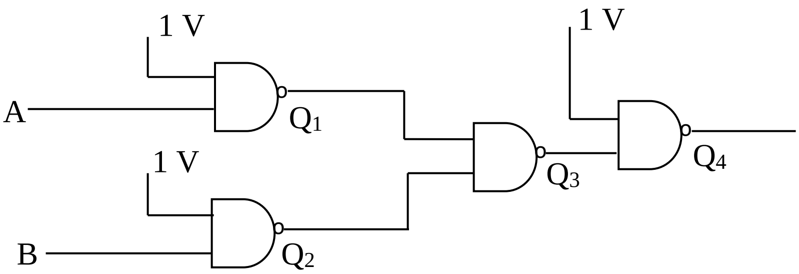


Figure 13

Part (c), required the candidates to (i) give the meaning of bandwidth of a signal and (ii) determine the bandwidth when an audio signal of 1 kHz is used to demodulate a carrier frequency of 500 kHz.

The question was attempted by 16,406 candidates, equivalent to 73.3 per cent. Among them, 23.8 per cent scored from 0 to 5 marks, 25.6 per cent scored from 5.5 to 8.5 marks; and 50.6 per cent scored from 9 to 15 marks. Figure 14 summarizes the results.

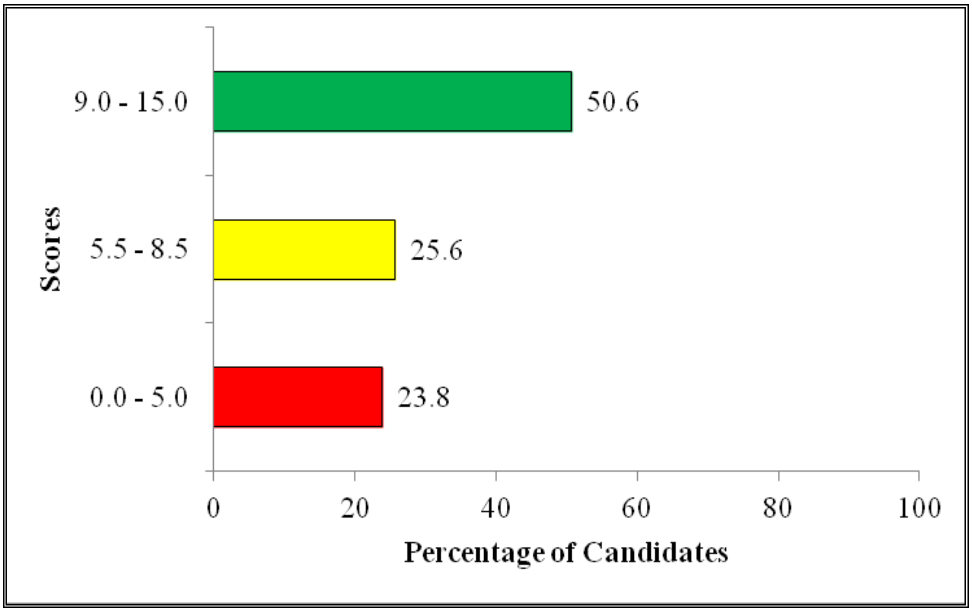


Figure 14: *Distribution of the candidates' scores in Question 10 in Paper 1*

Figure 14 shows that the performance in this question was generally good since 76.2 per cent of them passed the question.

Most of the candidates who scored good marks (9 - 15) had sufficient knowledge of the concepts tested. In part (a), they correctly sketched diagrams of Op-amp and described its properties. They further managed to study the given circuit diagrams and identify the basic types of logic gates and their modes of action, which helped them to draw the correct truth table.

However, 25.6 per cent of the candidates who scored average marks faced difficulties in part (c). They lacked knowledge of *Amplitude Modulation (AM)* and *Frequency Modulation (FM)*. Consequently, they failed to determine the sideband frequencies from the given demodulating frequency, which could help them to obtain the required bandwidth. Extract 10.1 is a sample of the correct responses.

10(a) (i) Features of op-amp.

- High Input Impedance / Resistance
- Low output Impedance / Resistance
- High open loop Gain in the order of 10^5.

(ii) Types of op-amps.

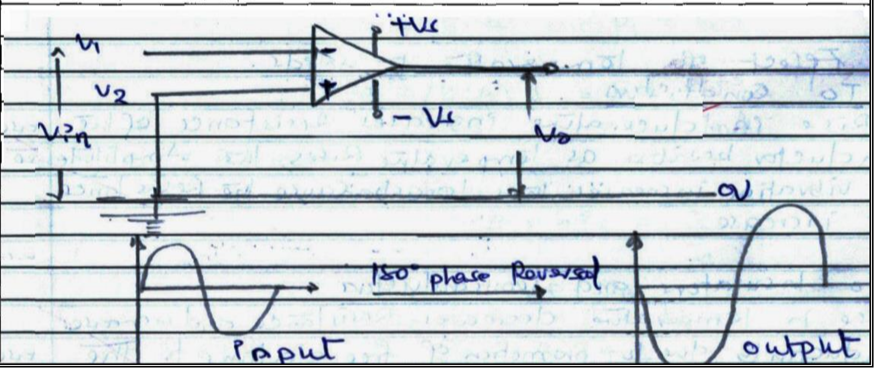
There are two types of op-amps depending on the part where the input terminals are connected.

- The ~~par~~ types are Inverting opamp and non-inverting op amps.

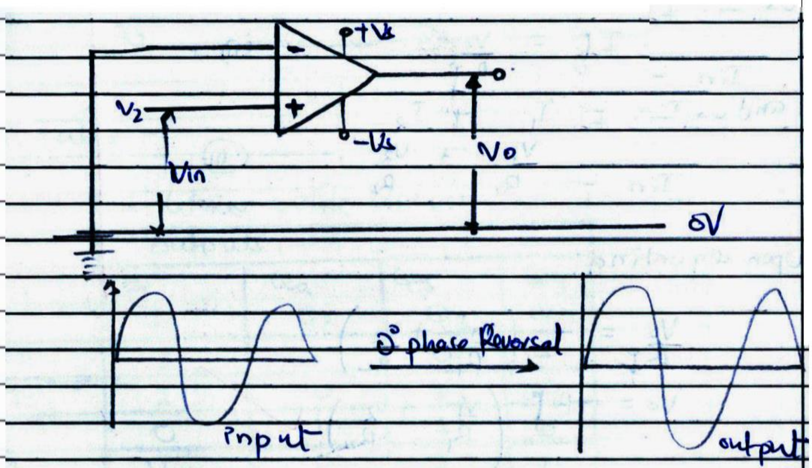
• Inverting opamps

These are the op-amps whose input is feed to the inverting terminal of the op-amp under this the non-inverting terminal is earthed, and the output has 180° phase Reversal w.r.t input.

Consider sketch Below.



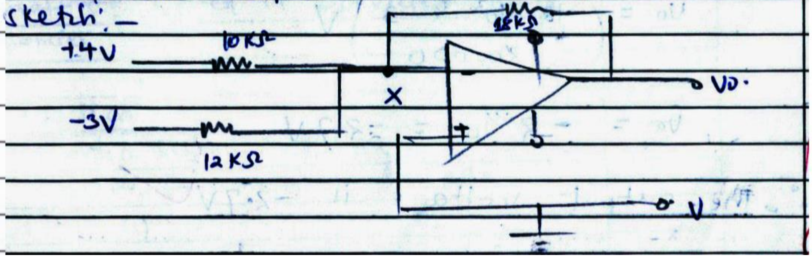
10(a)	• Non Inverting op-amps
	These are the op-amps whose input is fed to the non-inverting terminal of the op-amp. Under this the inverting terminal is earthed, and the output has 0° phase Reversal w.r.t input.
	Consider sketch Below: -



10(b) (i) Solution

Required output voltage (Vo)

sketch: -



10(b)	At point X: -
(i)	According to Kirchhoff current law: -
	$I_{in} + I_f = 0$
	$I_f = -I_n$ —— (i)
	but $V = IR$
	$I = \frac{V}{R}$ —— *
	thus: - $I_f = \frac{V_o}{R_f}$ —— (ii)
	and $I_{in} = I_1 + I_2$
	$I_{in} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$ —— (iii)

Upon equating:

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

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

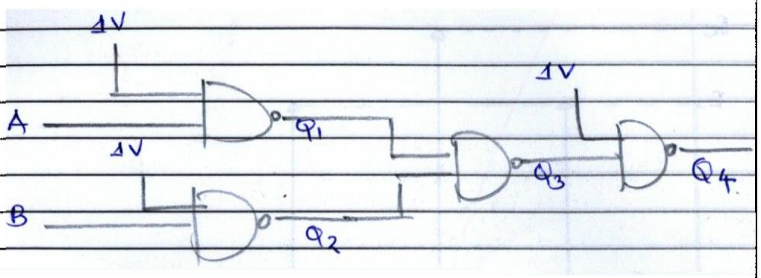
$$V_o = -18\times10^3\left(\frac{4}{10\times10^3} + \left(\frac{-3}{12\times10^3}\right)\right)$$

$$V_o = \left(\frac{-18\times10^3 \times 3}{20{,}000}\right)V$$

$$V_o = -27/10 = -2.7\,V$$

$\therefore$ The output voltage is $-2.7V$

1(b) (ii) Given ~~truth~~ ~~lot~~ logic circuit Below:-



Required Truth table:-

TRUTH TABLE FOR GIVEN LOGIC CIRCUIT

Inputs Given		Outputs			
A	B	Q_1	Q_2	Q_3	Q_4
0	0	1	1	0	1
0	1	1	0	1	0
1	0	0	1	1	0
1	1	0	0	1	0

1(c) (i) Bandwidth of a signal Refer to the Range of frequencies of which it operates nicely.

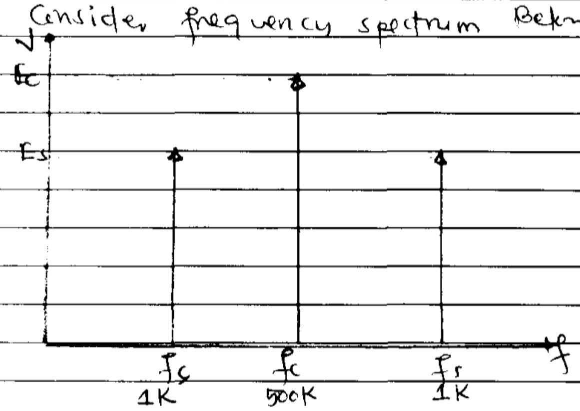
(ii) Solution

Given : Audio signal = 1 KHz

Carrier frequency = 500 KHz.

Required: Bandwidth

1(a)(ii) Consider frequency spectrum Below: −



where fs is the highest modulating frequency of the audio signal

fc is the carrier frequency.

from The spectrum drawn: −

Upper Side Band = fc + fs

= 500K + 1K

= 501KHz

Lower Side Band = fc − fs

= 500K − 1K

= 499 KHz

∴ Bandwidth = upper side Band − Lower side Band

= 501 KHz − 499 KHz

= 2KHz

∴ The Bandwidth Required is 2KHz

Alternative: −

Bandwidth = Twice highest modulating signal

Bandwidth = 2 × fs

= 2 × 1 KHz = 2KHz

Extract 10.1: *A sample of correct responses to Question 10 in Paper 1*

Extract 10.1, shows that the candidate correctly applied the concepts of electronics to answer all parts of the question.

On the other hand, 23.8 per cent of the candidates scored low marks (0 - 5). These candidates had insufficient knowledge of *Op-amp, Logic Gates* and *Telecommunication,* especially about describing the properties of basic logic gates and mode of action of operational amplifier. Most of them failed to analyse the given circuit diagrams. They used incorrect formulas and procedures to determine the output voltage. They also drew incorrect truth tables. In part (c), some of them had problems in deducing sideband frequencies to find the required bandwidth. Extract 10.2 is a sample of the incorrect responses to the question.

10 (a)(i)(a) Op-amp has higher input voltage.
(b) Op-amp has lower output voltage.
(c) op-amp has higher impedence.

(ii)

(b) Given.
• Input Voltage V_1 = ~~6~~ +4V.
V_2 = −3V.
• Input resistance = R_1 = 10kΩ
R_2 = 12 kΩ.
• Output resistance = R = 18kΩ.

From. Total Voltage $V_T = \frac{V_1 \times V_2}{V_1 + V_2}$

$V_T = \frac{4 \times 3}{4 + 3} = 1.71\,V$

∴ Therefore V_T = 1.71V
And.
Total resistance $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$.

10 (b) $R_T = \frac{10 \times 12}{10 + 12} = 5.455\,k\Omega$.

Therefore, R_T = 5.455 kΩ

Then.
From, $V_T = R_T \times I$.

$I = \frac{V_T}{R_T} = \frac{1.71V}{5.455k\Omega}$

I = 0.314 A.

∴ Current (I) is 0.314A.

The output voltage (V_0)/

~~$V_0 = IR = 0.316 \times 5.65$~~

~~$V_0 =$~~

$V_0 = IR_{out} = 0.316 \times 18$

$V_0 = 5.652V$.

$\therefore$ Output Voltage (V_0) is $5.652V$.

(ii) A truth table:

A	B	$\bar{A}$	$\bar{B}$	$\overline{AB}$
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

Extract 10.2: *A sample of incorrect responses to Question 10 in Paper 1*

In Extract 10.2, the candidate used incorrect concepts, formula and procedures to answer the question.

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

The 131/2 Physics 2 paper contained six (6) questions 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 pass mark for each question was 7 marks and above. 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 give the meanings of (i) critical velocity, (ii) incompressible fluid, (iii) streamline flow, and (iv) turbulent flow. In part (b), it was given that, (i) water flows through a pipe of internal diameter 20 cm at the speed of 1 m/s, what would be the radius of the nozzle if water is expected to emerge at the speed of 4 m/s, and (ii) determine the coefficient of viscosity of the fluid of density $1.47 \times 10^3 kg/m^3$ if an air bubble of radius 1 cm is moving through it at the steady rate of 0.2 cm/s. Part (c) required the candidates to (i) write Stoke's equation as applied to motion of a body in a viscous medium and define all symbols used, and (ii) state two conditions under which Stoke's equation is valid.

The question was attempted by 22,323 candidates, which correspond to 99.7 per cent. The analysis of data reveals that 11.5 per cent of the candidates scored from 0 to 6.5 marks, including 1.5 per cent who scored 0 marks; 30.8 per cent scored from 7 to 11.5; while 57.7 per cent scored from 12 to 20 marks. Figure 15 provides a summary of the data analysed.

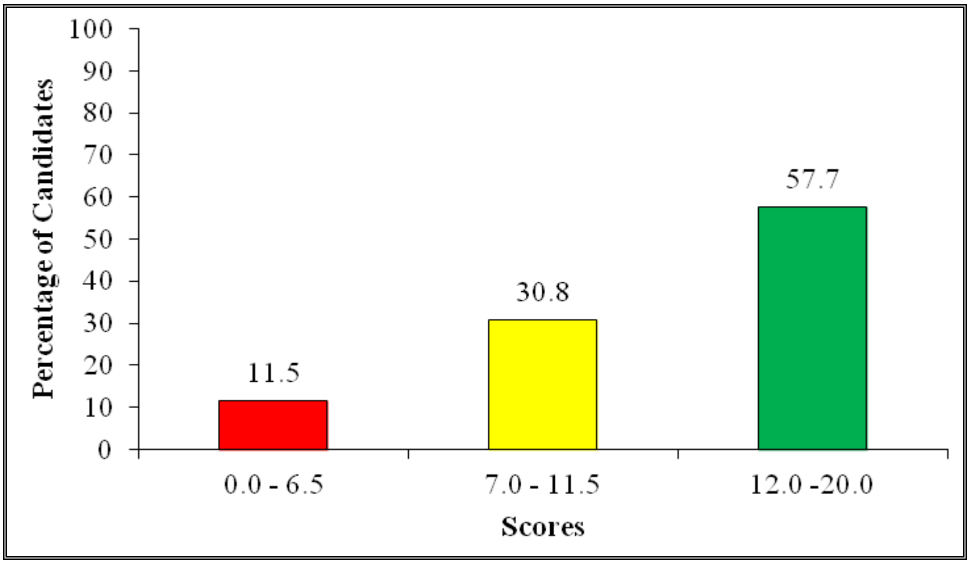


Figure 15: *Percentage of candidates' performance in Question 1 in Paper 2*

Figure 15 shows that the performance in this question was good since 88.5 per cent scored from 7 to 20 marks while only 11.5 per cent scored below 7 marks.

The candidates who scored good marks (88.5%) correctly analysed the mechanisms for streamline flow, continuity, viscosity and turbulent flow. In addition, they successfully applied continuity equation to determine the radius of the nozzle. However, some candidates faced challenges in providing the physical meaning of the parameters involved in Stoke's equation, and therefore scored average marks. Extract 11.1 is a sample of a good response given by a candidate.

1 (a)

(i) Critical velocity, is the velocity of a liquid upto which its flow is laminar and above which the flow is turbulent.

(ii) Incompressible fluid, this is a type of fluid whose density remains constant during its flow.

(iii) Streamline flow, is the smooth flow of a liquid at which tangents of velocity at any point do not intersect with each other.

(iv) Turbulent flow, is the rapid and vigorous flow of a liquid at which tangents of velocity at points intersect each other.

(b)

(i)

Data:

Diameter of pipe = 20cm = 0.2m

Speed of flow = 1 m/s.

Speed at nozzle = 4 m/s.

from, Equation of continuity

Rate at pipe = Rate at nozzle.

But Rate = Area × Velocity

$A_1 \cdot \text{Velocity}_1 = A_2 \cdot V_2$.

$\frac{\pi d_1^2}{4} \cdot 1\,m/s = A_2 \cdot 4\,m/s$.

1 (b)

(i)

$$\frac{\pi d_1^2}{4} \cdot 1 = \frac{\pi d_2^2}{4} \cdot 4$$

$$d_1^2 = 4d_2^2$$

$$d_2^2 = \frac{d_1^2}{4} = \frac{(0.2)^2}{4} = \frac{0.04}{4} = 0.01$$

$$d = 0.1 m.$$

$$\Rightarrow r = \frac{d}{2} = \frac{0.1}{2} = 0.05 m.$$

∴ Radius of the nozzle is 0.05m.

(ii)

Data:

$\rho_{liquid} = 1.47 \times 10^3 \, Kg/m^3$

Radius of buble = 1cm = 0.01 m

Velocity = ~~0.0..~~ 0.2 cm/s = 2×10^{-3} m/s.

from, Terminal velocity $= \frac{2}{9} \times \frac{r^2 g(\rho - \delta)}{\eta}$.

→ Assume the density of air to be negligible

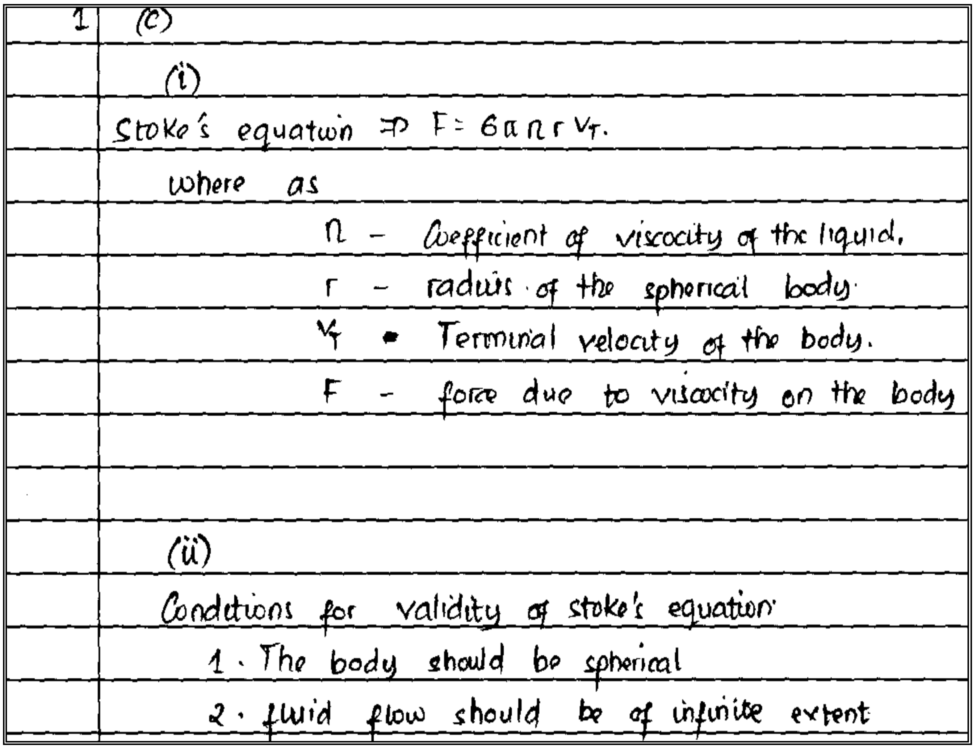
$$V_T = \frac{2}{9} \times \frac{r^2 g \rho}{\eta}.$$

$$\eta = \frac{2 r^2 g \rho}{9 \cdot V_T}$$

$$= \frac{2 \times (0.01)^2 \times 9.8 \times 1.47 \times 10^3}{9 \times 2 \times 10^{-3} \, m/s}.$$

$$= 160.07$$

∴ Viscosity of liquid is $160.07 \, Kg \, m^{-1} s^{-1}$



1 (c)

(i)

Stoke's equation ⇒ $F = 6\pi\eta r v_T$.

where as

η - Coefficient of viscocity of the liquid.

r - radius of the spherical body.

v_T - Terminal velocity of the body.

F - force due to viscocity on the body

(ii)

Conditions for validity of stoke's equation

1. The body should be spherical
2. fluid flow should be of infinite extent

Extract 11.1: *A sample of correct responses to Question 1 in Paper 2*

Extract 11.1 indicates the candidates' ability to describe and evaluate the tested concepts.

Among the 11.5 per cent of the candidates who scored 0 - 6.5 marks, 1.5 per cent scored 0 marks. These candidates lacked knowledge of the topic *Fluid dynamics*. Most of them failed to clarify correctly the meaning of the basic concepts used in this topic, and to analyse the tasks in all parts of the question. Those who scored low marks ($\angle 7$) failed to apply the law of mass continuity in part (b), to determine the volume rate of in-flow and out-flow of water in a pipe and hence the radius of the nozzle. They used product of radius and velocity instead of area and velocity to express volume flow rate. Moreover, some of them used the concepts of coefficient of viscosity and Newton's law of viscosity interchangeably. However, in part (c), since spherical bodies are thought to be moving in fluids as portrayed by fluid dynamics, some candidates recommended that a body should always move in liquid as a sole condition for validity of Stokes' equation. Extract 11.2 shows a sample of incorrect responses.

1(a) (i) Critical velocity ⇒ Is a velocity of the fluid flowing in tubular form.

(ii) Incompressible fluid ⇒ Is the fluid which can not be compressed example water.

(iii) Stream line flow - Is the flow of a flow in a ~~streat~~ straight line.

(iv) Turbulent flow - Is a flow of the liquid in a pipe in which upper particles does not mix with lower particle.

1(b)(i) Recall:

$$r_1 V_1 = r_2 V_2$$

$$r_2 = \frac{r_1 V_1}{r_2}$$

$$r_2 = \frac{0.1 \times 1}{4}$$

$$r_2 = \frac{0.1}{4}$$

$$r_2 = 0.025m \text{ or } 2.5cm$$

∴ The radius of the nozzle if water is expected at speed 4 m/s is 0.025m or 2.5cm.

1(b) (ii) Recall:

$1m = 100cm$

$x \cdot \quad 1cm$

$x = \frac{1m \times 1cm}{100cm}$

$x = 0.01m$.

change rate into

Rate in m/s $= \frac{0.2cm/s}{100m}$

Rate $= 2\times10^{-3}$ m/s.

Then viscosity (η) = Coefficient of viscosity x velocity gradie

$\eta = \frac{1.47\times10^{3} \times 2\times10^{-3}}{0.01}$

$\eta = \frac{2.94 \ kgm^{2}s^{-1}}{0.01 \ m}$

$\eta = 294 \ kgms^{-1}$

$\therefore$ The coefficient of viscosity will be $294kgms^{-1}$

(c)(i) The stokes Equation $V_T = 6\pi \eta r^3$

(ii) The Stokes law is valid in the following Conditions:-

(i) IN the Liquid where the Body moves

(ii) In Viscous medium where the Circular Body moves.

Extract 11.2: *A sample of incorrect responses to Question 1 in Paper 2*

In Extract 11.2, the candidate provided an incorrect meaning of the terms in part (a) and applied inappropriate formula in solving the question.

3.2 Question 2: Vibrations and Waves

Question 2 had three parts namely; (a) ,(b) and (c). Part (a), required the candidates to (i) clarify four distinctive properties between progressive and stationary waves based on the nature and its conditions, and (ii) calculate the fundamental frequency and the speed of the wave of a string 320 cm long having two adjacent resonances at frequencies of 170 Hz and 204 Hz respectively. Part (b) required the candidates to (i) identify four methods used to form interference patterns apart from Young's double slit experiment and (ii) determine the end correction of the open and closed pipes of 40 cm and 33 cm long respectively both being of the same diameters when sounding their first overtone which are in unison. In part (c), it was given that, in Young's double slit experiment, the distance of the screen from the two slits is 0.9 m. When light of wavelength $\lambda = 7.5 \times 10^{-7}$m is allowed to fall on the slits the width of the fringes obtained on a screen is 2.5 mm. If the wavelength of the incident light is 5.5×10^{-7}m; determine the (i) distance between the slits and (ii) width of the fringes.

A total of 19,671 candidates, equivalent to 87.9 per cent attempted this question and their scores were as follows: 53.7 per cent scored below 7 marks, including 10.6 per cent who scored 0 marks; 30.6 per cent scored from 7 to 11.5 and 15.7 per cent scored from 12 to 20 marks. These scores suggests that the candidates' performance in this question was average as 46.3 per cent of them scored from 7 to 20 marks. Figure 16 is illustrative.

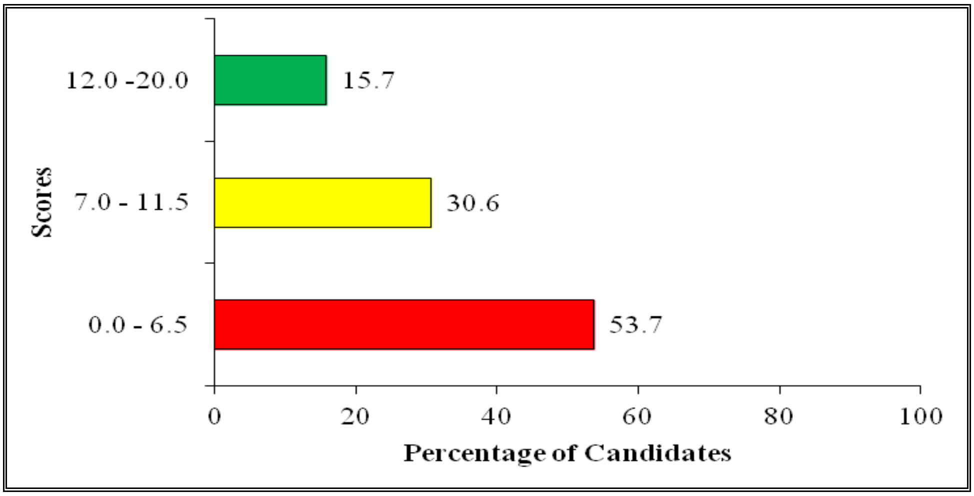


Figure 16: *The candidates' performance in Question 2 in Paper 2*

The analysis of the candidates' responses indicate that 30.6 per cent of them scored average marks. These candidates were able to specify the distinctive properties of progressive and stationary waves. They also knew that frequencies of the various harmonics are a whole number multiple of the fundamental frequency, f_o. With this knowledge, they managed to establish the correct formula for the n^{th} harmonic i.e $f_n = n\,f_o$ to determine the fundamental frequency and speed of the wave.

Moreover, 15.7 per cent of the candidates who scored good marks managed to assess the necessary conditions for interference of light to occur. They demonstrated their competence by deducing fringe separation between two consecutive bright fringes and calculate the distance between the slits and width of the fringes. Extract 12.1 provides an example of the correct responses.

02.	(a).	
	(i).	
	PROGRESSIVE WAVE	STATIONARY WAVES.
	- The wave profile is moving	- The wave profile is not moving that is it is stationary.
	- It is formed of a single independent wave. There is no superposition of two waves.	- It is formed when two waves with equal amplitude. frequency and wavelength. travelling in opposite direction superpose each other
	- The amplitude of the wave is constant throughout the wave motion	- The amplitude of the stationary waves is not constant that is ($A = 2a\cos kx$) It is maximum at the antinodes and minimum at the nodes.
	- It transfers energy from one point to the other. due to its moving nature.	- It does not transfer energy between two points since it is stationary

(ii). given $l = 320$.

$nf_0 = 170\ Hz$ ... (i)

$(n+1)f_0 = 204\ Hz$ ... (ii)

From equation (ii)

$(n+1)f_0 = 204$.

$nf_0 + f_0 = 204\ Hz$

but $nf_0 = 170\ Hz$.

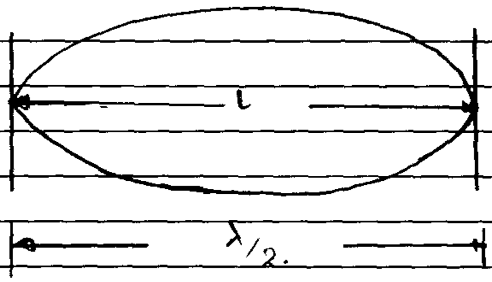
(a) (ii). $170\ Hz + f_0 = 204\ Hz$

$f_0 = 204 - 170\ Hz$

$= 34\ Hz$.

Hence the fundamental frequency of the wave is 34 Hz.

For the fundamental Frequence f_0.



$l = \lambda/2$

$\lambda = 2l$.

From

$v = f.\lambda$

$v = 2f_0 l$ but $l = 320\ cm = 3.2\ m$.

$v = 2 \times 34\ s^{-1} \times 3.2\ m$

$v = 217.6\ m s^{-1}$

Hence the velocity / speed of the wave is $217.6\ m s^{-1}$

02	Method Used to form interference pattern
(b)	
(i)	(i) Newton's Ring experiment
	(ii) Air wedge
	(iii) Lloyd mirror method
	(iv) Fresnel Biprism experiment
(ii)	soln
	Given
	(L_2) length of open pipe = 40cm.
	(L_1) length of closed pipe = 33cm.
	let e be the end correction
	1st for A closed pipe
	$\lambda = \frac{4(L+e)}{(2n-1)}$
	first overtone $n = 2$
	$\lambda = \frac{4(L_1+e)}{2\times2-1}$
	$\lambda = \frac{4(L_1+e)}{3}$
	$f_1 = \frac{V}{\lambda} = \frac{3V}{4(L_1+e)}$ — (i).

2	2nd for open pipe
(b)	
(ii)	$\lambda = \frac{2(L+2e)}{n}$
	$n = 2$
	$\lambda = \frac{2(L_2+2e)}{2}$
	$\lambda = (L_2+2e)$
	$f_2 = \frac{V}{\lambda_2} = \frac{V}{(L_2+2e)}$ — (ii)

Since $f_1 = f_2$

$$\frac{v}{(l_2 + 2e)} = \frac{3v}{4(l_1 + e)}$$

$$\frac{1}{40 + 2e} = \frac{3}{4(33 + e)}$$

$$120 + 6e = 132 + 4e.$$

$$6e - 4e = 132 - 120$$

$$\frac{2e}{2} = \frac{12}{2} \text{ cm}$$

$$e = 6\text{cm}.$$

$\therefore$ End correction of the pipes is 6cm.

2 (c) (i) Soln

Given.

Distance from the screen = 0.9m.

Wavelength $\lambda_1 = 7.5 \times 10^{-7}$ m.

$B_1 = 2.5$mm.

Let (d) be distance between the slits

$$B_1 = \frac{\lambda_1 D}{d}$$

$$d = \frac{\lambda_1 D}{B_1}$$

$$d = \frac{7.5 \times 10^{-7} \times 0.9\text{m}}{2.5 \times 10^{-3}\text{m}}$$

$$d = 2.7 \times 10^{-4}\text{m}.$$

$\therefore$ distance between the slits, is 2.7×10^{-4}m

Extract 12.1: *A sample of correct responses to Question 2 in Paper 2*

Extract 12.1, shows that the candidate correctly applied the concepts of vibrations and waves to answer the question.

However, more than a half (53.7%) of the candidates scored below 7 marks in this question including 10.6 per cent who scored 0 marks. These candidates had inadequate knowledge of *Vibrations and Waves* particularly on the concepts of *wave motion* and *interference*. For example, in part (b), (i) some of them mentioned Young's double slit experiment though it was excluded while others mentioned scattering which is used in polarization and not in interference. Moreover, most of them lacked mathematical skills as they failed to explore the requirement of the given tasks by using wrong formula and procedure on computing the data. Extract 12.2 is a sample of incorrect responses from a candidate.

2 a) i)

Progressive wave	Stationary wave
i) It requires material medium	It does not require the material medium
ii) It particle vibrate back and forth about the mean position	Its particle vibrates along the mean position.
iii) It occur in both all states of the particles	It occur in the solid
iv) It affected by temperature vibration	It does not affected by temperature.

2 b) (ii) Soln

Data given

Length of open pipes, $L_1 = 40cm$

Length of closed pipe, $L_2 = 33cm$

$d_1 = d_2$

Asked

end correction of the pipe

$P_1 = L_1 + L_2$

$P_1 = 40cm + 33cm$

$P = 73cm$

∴ The end correction of the pipe is 73cm

2 (b) i) methods used to for interference

i) Young's double slit experiment

ii) Resonance experiment

iii) scattering experiment

c) soln

Data given

distance, $d_1 = 0.9\,m$

wavelength, $\lambda_1 = 7.5 \times 10^{-7} m$

width, $W_1 = 25\,mm$

wavelength of incident light $\lambda_2 = 5.7 \times 10^{-7} m$

i) The distance between the slits

From

$\frac{\lambda_1}{\lambda_2} = \frac{d_1}{d_2}$

$d_2 = \frac{\lambda_2 d_1}{\lambda_1}$

$d_2 = \frac{5.7 \times 10^{-7} m \times 0.9\,m}{7.5 \times 10^{-7} m}$

$d_2 = \frac{5.7 \times 10^{-7} m \times 0.9\,m}{7.5 \times 10^{-7} m}$

$d_2 = 0.684\,m$

$\therefore$ The distance between slits is $0.684\,m$

ii) The width of the fringes is $2.5\,mm$

Extract 12.2: *A sample of incorrect responses to Question 2 in Paper 2*

Extract 12.2 shows incorrect responses from a candidate who failed to describe the concepts. In part (c) he/she applied wrong formula $d_2 = \frac{\lambda_2 d_1}{\lambda_1}$ instead of $y = \frac{\lambda_1 D}{d}$ to find the distance between the slits.

3.3 Question 3: Properties of Matter

The question had three parts (a), (b) and (c). Part (a) required the candidates to (i) use mathematical expressions to distinguish between Young's modulus of a material and Young's modulus of rigidity, and (ii) use a sketch graph to explain what happens when steel is stretched gradually by an increasing load until it breaks. In part (b), they were required to (i) determine the height at which water will rise in a capillary tube of radius 5×10^{-5}m if the angle of contact between water and the material of the tube is approximately zero and (ii) examine the extent at which a vertical steel beam of length 4.0 m and cross-section area of $8.0\times10^{-3}\text{m}^2$ supporting a load of 6.0×10^{4}N would be compressed along its length. Part (c), required the candidates to determine the excess pressure inside a drop of mercury of radius 0.2 cm if the surface tension of mercury at room temperature is 4.72×10^{-1}N/m.

A total of 21,864 (97.7%) candidates attempted this question. Among them, 15.6 per cent scored from 0 to 6.5 marks; 25.1 per cent scored from 7 to 11.5; and 59.3 per cent scored from 12 to 20 marks, out of whom 143 (0.7%) candidates scored all 20 marks These scores suggest that the general performance in this question was good. Figure 17 summarizes these results.

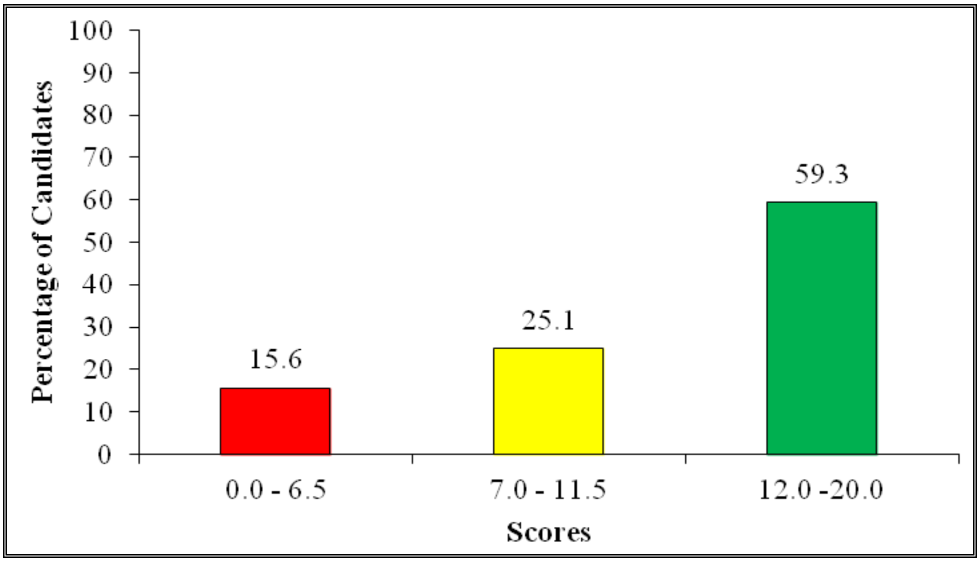


Figure 17: *The candidates' performance in Question 3 in Paper 2*

Those who scored good marks (84.4%) correctly analysed the mechanism of surface tension and elasticity in terms of molecular theory. Moreover, they had good understanding of the concepts of capillary rise and fall which enabled them to determine the height at which water will rise in the tube. For example, those who answered correctly in part (a) managed to quantitatively describe the terms as instructed. In addition, they successively associated force with extension by sketching the graph that describes different changes through which a loaded material undergoes till deformation. Extract 13.1 portray these findings.

03 (a) (i) Young's modulus of the material (E)

$$= \frac{\text{Normal stress}}{\text{longitudinal strain}}$$

$$E = \frac{F\,L}{A \cdot \Delta L}$$

While

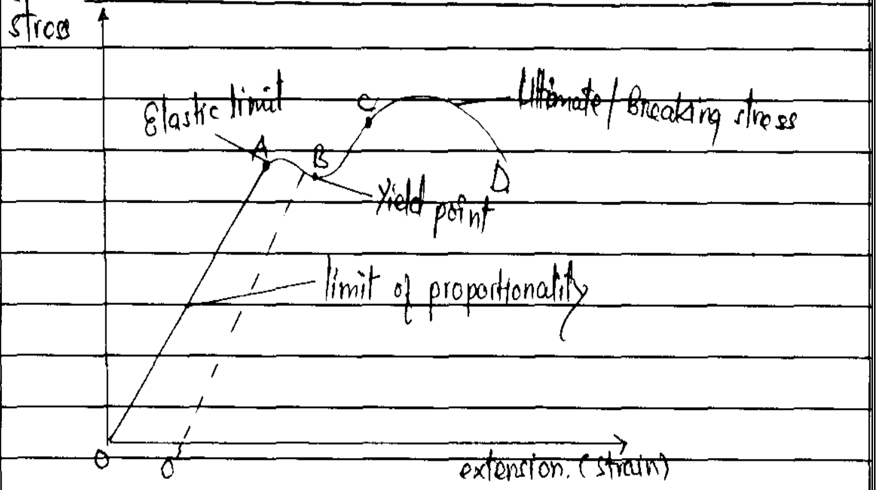
Young's modulus of rigidity (η)

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

$$\eta = \frac{F\,L}{A \cdot \Delta L}$$

3(a) (ii) The graph showing the stretching of steel.

THE GRAPH SHOWING THE STRETCHING OF STEEL TO BREAKING



from the graph.

from point OA

- This point show that hooke's law is applied as the forss applied is directly proportional to the extension and provided that elastic limit is not exceeded.

03 a(i) point A

This is the point of maximum stretching of the wire in which it will recover after the removal of deforming force.

Point AB.

This point also the ~~stell~~ steel will recover its original shape and size after removal of deforming force

point ~~a~~BC

This point is called yield point, At which further stretching will results into plastic range or breaking of the steel.

Point CD

This is called breaking stress point in which any application of force will result into breaking of the steel.

∴ At point CD further increase of the load will result into breaking stress which will cause the steel to break apart.

Extract 13.1: *A sample of a candidate's correct response to Question 3 (a) in Paper 2*

The candidate quantitatively distinguished Young's modulus of a material from Young's modulus of rigidity. He/she also used Hooke's law to describe the behaviour of steel when loaded.

The candidates who scored the highest marks in part (b) were able to qualitatively describe and find out the relation that exist between the radius of the capillary tube, the height through which a liquid would rise and the angle of contact. They correctly used the concept of surface tension to transform all qualitative descriptions into numerical attempts and finally compute the height. Some of the candidates correctly applied the formula of Young's modulus by recalling that when material is compressed by a certain load along its length, there exists an increase in length and thus extension. In part (c), most of the candidates managed to relate the surface tension of a mercury drop at room temperature with its radius to find the excess pressure. Extract 13.2 is a sample of the correct response from a candidate.

03 (b) (i) From

Data.

Radius = 5×10^{-5} m. Surface tension of water (T) = 0.073 N/m

Angle of contact = 0°.

from,

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$h = \frac{2\times0.073\times\cos\theta}{5\times10^{-5}\times1000\times9.8} = 0.3m$$

∴ The height is 0.3m

03 (b) (ii) From

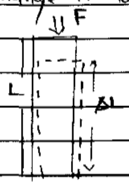
Data given

length (l) = 4m

Crossection area (A) = 8×10^{-3} m^2

Force (F) = 6×10^4 N

Required change in length (ΔL) after compression



from Young Modulus of steel beam. (E)

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

$$E = \frac{F}{A}\times\frac{L}{\Delta L}$$

$$\Delta L = \frac{F\cdot L}{A\cdot E}$$

$$= \cancel{20}\ \frac{6\times10^4\times4m}{8\times10^{-3}\times20\times10^{10}}$$

$\Delta L = 1.5\times10^{-4}$m.

∴ The steel will be compressed to 1.5×10^{-4}m.

03 (c) Data given

Surface tension of mercury (T) = 4.7×10^{-1} N/m

Excess pressure $(P_2 - P_1)$ = ?

Radius = 0.2 cm = 2×10^{-3}m.

from.

$$P_2 - P_1 = 2T/R.$$

03	© $P_2 - P_1 = \frac{2 \times 4.72 \times 10^{-1}}{2 \times 10^{-3}}$
	Excess pressure = 472 Pa.
	∴ The excess pressure is 472 Pa

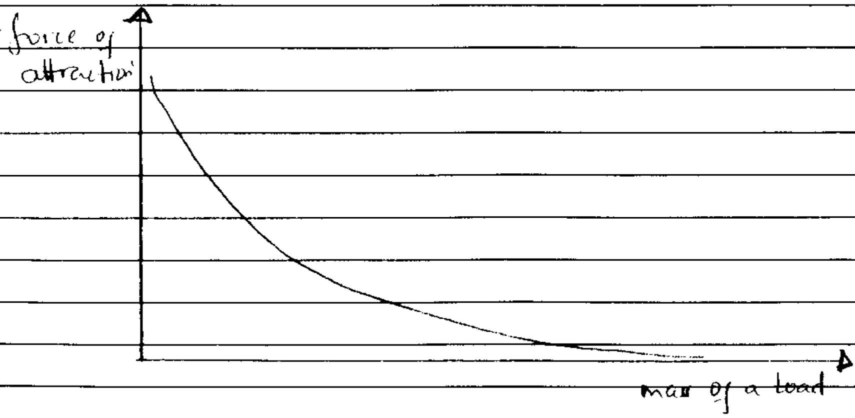
Extract 13.2: *A sample of a candidate's correct response to Question 3 (b)*

In Extract 13.2, the candidate correctly applied the appropriate formula and procedures to determine the height, compression of the steel and the excess pressure inside a mercury drop.

The candidates who scored low marks (15.6%) had insufficient knowledge about *Properties of matter,* specifically *surface tension, capillarity* and *elasticity*. In part (a), some of them used the parameters of fluid dynamics rather than those in elasticity to distinguish Young's modulus. Other candidates misinterpreted the question by plotting a graph of force against mass instead of force against extension. They also failed to show different regions on the plotted graphs as prescribed in Hooke's law. Moreover, in part (b), some candidates failed to analyse the concept of surface tension to determine the height at which water will rise in a capillary tube. They also, thought that the question in part (b) (ii) was about compression force rather that a decrease in length of a steel beam when loaded. Extract 13.3 depict a sample of incorrect response from a candidate.

3.	(a) (i) To distinguish between youngs modulus of the material and youngs modulus of the rigidity mathematically.
	$Y = \frac{\rho \eta r}{g}$
	Where ρ = density
	η = coefficient of viscosity
	r = Radius
	g = gravitational force.

(ii) When steel is stretched gradually by an increasing ~~a~~ load until it breaks what happen is that the ~~att~~ force of attraction holding its molecules tries to resist and when its exceeded, the force of attraction will have no effect again and then molecules of the steel will separate from each other.



3 (b) (i) Data given.

radius $= 5.0 \times 10^{-5}$ m

Angle $= 0^\circ$

From the equation

Height $= \cos\theta$ ~~x+θθ~~ $+ \tan\theta$

Height $=$ ~~Cosθ~~ $\cos\theta * \tan\theta$

Height $= \cos 0 + \tan 0$

Height $= 1 + 0$

Height $= \frac{1}{\text{radius}}$

Height $= \frac{1}{5 \times 10^{-5}}$

Height $= 20,000$ cm

Height $= 200$ m.

3 Soln .

Compression = Force ÷ length/area

= Force ÷ 4m/8.0 X 10^{-3}

Compression = Force ÷ 500M

= $\frac{\text{Force}}{500\text{m}}$

= $\frac{6.0 \times 10^4 \text{ N}}{500\text{m}}$

= 120 N/m .

∴ The compression will be 120 N/m .

Extract 13.3: *A sample of a candidate's incorrect response to Question 3*

In Extract 13.3, the candidate sketched a wrong graph of force against mass and applied incorrect formula and procedure in performing calculations.

3.4 Question 4: Electrostatics

This question was comprised of three parts: (a), (b) and (c). In part (a), the candidates were required to (i) state two relations which exist between field lines and electric fields, and (ii) determine the electric field at the foot of the perpendicular drawn from B on the side AC of Figure 1 (presented here as Figure 18) where ABC is a right angled triangle, the right angle being at B and charges of $-246\mu C$, $+278\mu C$ and $+71\mu C$ are placed at A, B and C respectively given that $AB=4$ cm and $BC=3$ cm.

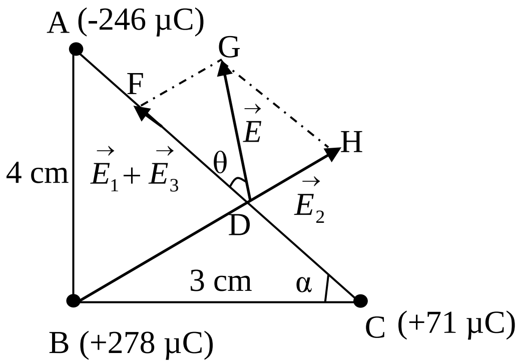


Figure 18

Part (b) required the candidates to (i) give the meaning of an electric line of force and (ii) carefully study Figure 2 (presented here as Figure 19) and then calculate the work done in moving a third charge (Q_3) from B to A along the diagonal of the rectangle.

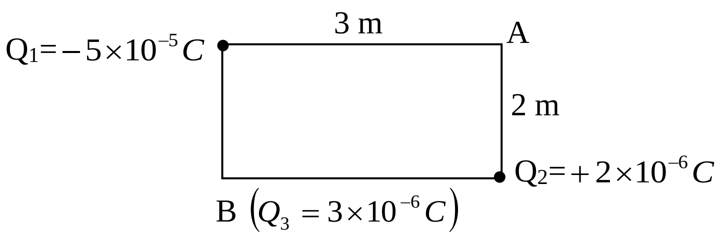


Figure 19

In part (c), the candidates were required to (i) explain what would happen when two spheres of different capacitances are charged to different potentials and then joined by a wire and (ii) calculate the capacitance of the parallel plate capacitor whose plate area of 4 m^2 is spaced by three layers of different dielectric materials given its relative permittivity and thicknesses are 3, 6, 9 and 1.0, 3.0 and 0.6 mm respectively.

A total of 16,658 candidates corresponding to 74.4 per cent attempted this question and their scores were as follows: 93.7 per cent scored from 0 to 6.5 marks; out of whom 31.6 per cent scored 0 marks; 4.9 per cent scored from 7 to 11.5 marks; and very few (1.4 %) scored from 12 to 20 marks. Figure 20 portrays these scores.

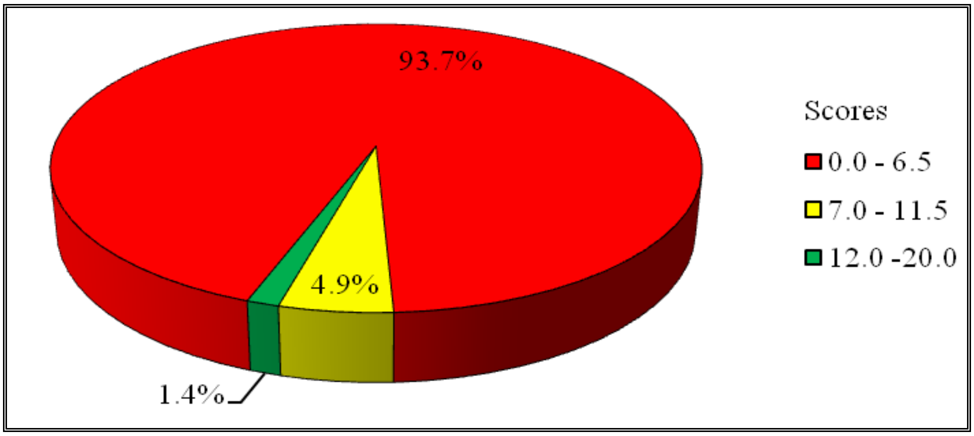


Figure 20: *Distribution of candidates' scores in Question 4, Paper 2*

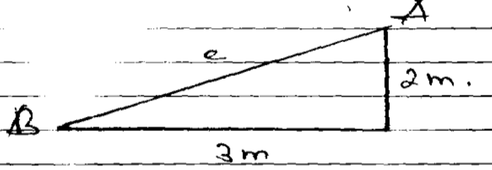
Figure 20 shows that the general performance of the candidates in this question was poor since most of them (93.7%) scored 0 to 6.5 marks.

Those who scored 0 to 6.5 marks had inadequate knowledge about *Electric Field* and *Electric Potential*. Most of them failed to assess the distinctive features of field lines and electric field as they used these two terms interchangeably. For example, one candidate provided an incorrect definition of these terms instead of stating how they relate to each other. The candidate wrote: *Field lines are regions where an electric charge experience a force while electric fields are electrostatic force per unit charge at that point*. This candidate confused the concepts field lines, electric field, and electric field strength, E at any point. In addition, some of the candidates failed to find the net force on a point charge due to other charges. In part (b), they confused the direction of the electric field by linking a line of force in both parallel and perpendicular alignment at once and ended with incorrect results. Consequently, in part (c), they failed to give the correct responses accordingly. Most of them failed to account for the sign of charges. They thought that charges could be pulling each other because they are sharing a common interface. Extract 14.1 illustrates an incorrect response.

4a	i/ Field lines	Electric fields.
	- Are the lines where the magnetic field surround bits course	Are the electrical materials of field where it surrounded by electric lines.

4b i) Electric line of force.
Refers to the line where the force is parallel and perpendicular to the electric field.

ii/ It will be



Distance of diagonal will be

$c^2 = 3^2 + 2^2$

$c = \sqrt{3^2+2^2}$

$c = \sqrt{9+4}$

$c = 3.6$ m or $\sqrt{13}$ m.

Then; Work done moving in third charge

~~$W = F \cdot d$~~

~~$= 0.$~~

$$F = \frac{9\times10^{9} \times 3\times10^{-6} \times 2\times10^{-6}}{3.6^{2}}$$

$F = 4.17\times10^{-3}\,m.$

$F_{AB} = 4.17\times10^{-3}\,m.$

$W = F \cdot d$

$= 4.17\times10^{-3} \times \sqrt{13}.$

$W = 0.015\,NM$

Hence, The Work done is 0.015Nm.

4 c i/ ~~When two~~ different ~~capacities~~ differen t ~~spheres~~

i/ When Two spheres of different capacit-ances are charged to different potentials the charge will be away from each other and after joining will attract each other

ii/ Given;

$A = 4m^2.$

Thickness are

(3, 6, 9, 1, 3, 0.6)mm

Capacitance in parallel.

$C_T = C_1 + C_2 + C_3 + C_4 + C_5 + \dots C_n$

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

In Extract 14.1, the candidate provided a wrong definition of line of force and used an incorrect formula and procedures to find the work done and capacitance.

Although majority (93.7%) of the candidates had weak performance in this question, 1.4 per cent scored good marks (12 - 20). These candidates had adequate knowledge about the topic of *Electrostatics*. Most of them were able to assess the concepts of electric field, electric potential and line of force. In addition, they correctly analysed the concepts by deducing expressions to determine the work done in moving the third charge, and finding the capacitance of a parallel plate capacitor.

Most of the candidates who scored average marks (7 - 11.5) skipped parts (a) (ii) and (b) (ii) due to poor mathematical skills. They failed to utilize the formula of electric field at a point charge and electric potential due to a point charge to organize and analyse the concepts so as to determine the electric field and the work done as required by these parts of the question. Extract 14.2 is a sample of the good responses.

4 (a) (i) Relationship between field lines and Electric fields

→ A tangent at any point to the electric field lines give the direction of electric field at that point

→ Spacing of the electric field lines indicate the strength of the electric field, where field lines are crowded electric field is strong and where they are far apart electric field is weaker

4 (b) (i) An electric line of force is a curve, or path a tangent to which give the direction of electric field vector at a given time at that point, it give the direction which a positive charge would take in moving

(C) (i) – When two spheres charged at different potential are joined, there will occur charge distribution between the spheres until both sphere attain the same potential.

– Hence charge will distribute until an equilibrium will be reached where both spheres have the same potential while their capacitance remains the same

4 (c)(ii) Soln

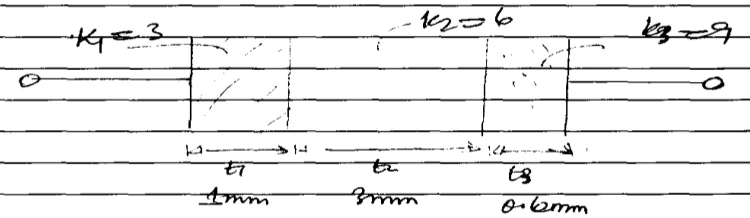
Area of plates, $A = 4m^2$

Relative permeabilities,

$\varepsilon_1 = 3, \quad \varepsilon_2 = 6, \quad \varepsilon_3 = 9$

Thickness

$t_1 = 1mm \quad t_2 = 3\,mm, \quad t_3 = 0.6mm$



This will make a series arrangement of capacitor

From capacitor, $C = \frac{\varepsilon A}{d}$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_T} = \frac{t_1}{K_1 \varepsilon A} + \frac{t_2}{K_2 \varepsilon A} + \frac{t_3}{K_3 \varepsilon A}$$

$$= \frac{1}{\varepsilon A}\left(\frac{t_1}{K_1} + \frac{t_2}{K_2} + \frac{t_3}{K_3}\right).$$

$$C_T = \frac{\varepsilon A}{t_1/K_1 + t_2/K_2 + t_3/K_3}$$

Extract 14.2: *A sample of the correct responses to Question 4, Paper 2*

In Extract 14.2, the candidate correctly explained the tested concepts in part (a) (i), (b) (i) and analysed the equation used to find the capacitance of parallel plate capacitor in part (c) (ii).

3.5 Question 5: Electromagnetism

Part (a) of this question required the candidates to (i) identify four useful applications of eddy currents and (ii) derive an expression for the mechanical power P needed to move the loop in terms of the magnetic field B, the length of the plane L, the constant velocity v and the total resistance of the loop R if a rectangular loop is partially held in a uniform magnetic field B which is perpendicular to the plane of the paper as shown in Figure 3 (presented here as Figure 21), given that the loop is moved towards the right in the plane of the paper and perpendicular to the field with constant velocity v.

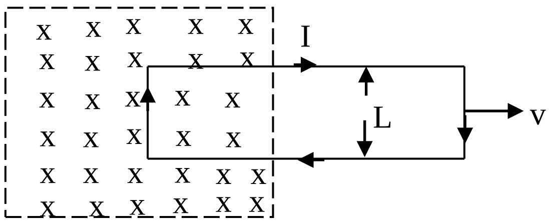


Figure 21

In part (b), the candidates were required to (i) give the meaning of electromagnetic induction and (ii) mention two methods of producing induced e.m.f. Part (c) required the candidates to give reason why spark is produced in the switch of a fan when it is switched off. In part (d), it was given that a toroid solenoid with air core has an average radius, cross-section area and number of turns of 15 cm, 18 cm^2 and 1500 respectively. If another coil of 600 turns is wound closely to the toroid, the current in the primary coil is changed from zero to 3A in 0.06 seconds. The candidates were required to calculate (i) self inductance of the coil and (ii) induced emf in the second coil.

The question was attempted by 10,196 candidates corresponding to 45.6 per cent. Among them, 78.7 per cent scored from 0 to 6.5, of which 23.3 per cent scored 0 marks; 15.4 per cent scored from 7 to 11.5 marks; while 5.9 per cent scored from 12 to 20 marks. These scores suggest that the general performance in this question was weak since only 21.3 per cent scored from 7 to 20 marks. These data are summarized in Figure 22.

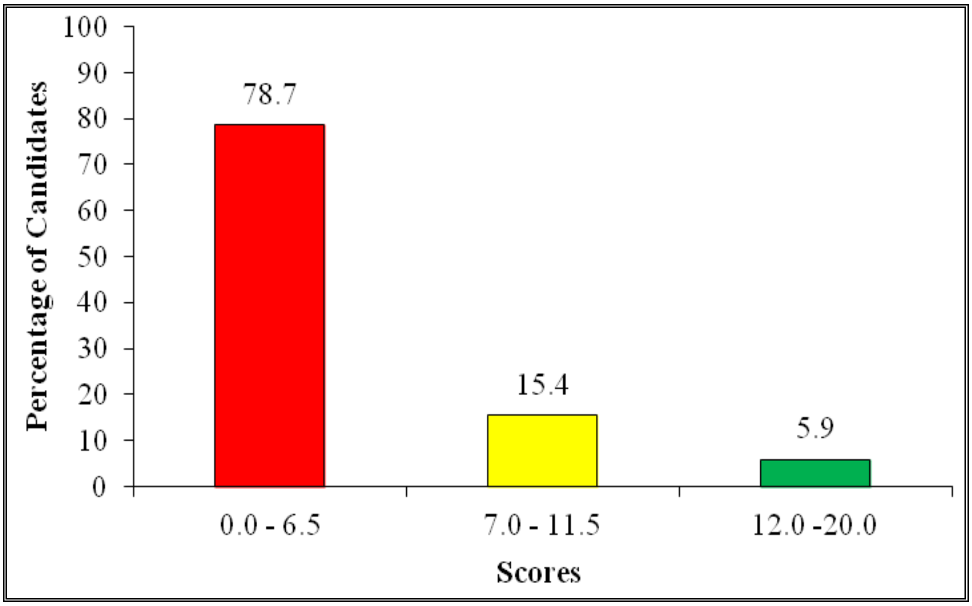


Figure 22: *Distribution of candidates' scores in Question 5, Paper 2*

Figure 22 reveals that this question was skipped by most candidates since only 45.6 per cent attempted the question. Among them, 78.7 per cent scored low marks (0 - 6.5).

The analysis of the candidates' responses shows that those who scored low marks had inadequate knowledge of magnetic forces and electromagnetic induction. Most of the candidates in this category failed to derive an expression for the mechanical power needed to move the loop. Some of them identified the area where eddy current can be used but failed to specify its applications as instructed by the question. Moreover, in part (d), they faced challenges in applying magnetic forces to calculate self-inductance and investigate factors which determine the induced e.m.f. Extract 15.1 is a sample of incorrect responses.

5.	(a)(i) Application of eddy Currents.
	> It Used in Hospitals
	> It Used in Industry.
	> It Used in Domestic purposes
	> It Used in ~~transformers~~. military activities.

ii/ From

$F = Bqv$

~~$f = mg$~~ $f = ma$.

$ma = Bqv$

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

also ~~$B =$~~ ~~$\frac{F}{A}$~~ Itv

Power = $\frac{\text{Input}}{\text{I output}}$ $\frac{Bav}{ma\cos}$

Power = $Bav\cos\theta$.

5 d.) ii.) Induced Emf = ?

from

~~$E = \frac{F_o}{}\ fr$~~

~~$F = nevA$~~.

~~$B = qv\sin\theta$.~~ ~~$\theta = 0$~~.

$B = nqv\cos\theta$ $\quad \theta = 0$.

$V = \frac{B}{q}$.

$= \frac{B}{nIt} = \frac{5.086 \times 10^{-7}}{600 \times 3 \times 0.06}$.

$E =$ ~~2.83×10^{-6} v~~. 4.709×10^{-9} V

$\therefore$ The Induce emf in second coil $= 4.71 \times 10^{-9}$ V.

Extract 15.1: *A sample of incorrect responses to Question 5, Paper 2*

In Extract 15.1, the candidate mentioned the areas where eddy current can be applied and used an incorrect formula to find the mechanical power and induced e.m.f.

Despite the general weak performance in the question, 15.4 per cent of the candidates scored average marks. These candidates demonstrated a good understanding of the factors which determine the magnetic force on a current carrying conductor in a magnetic field. They also managed to identify the useful applications of eddy current. However, some of them used inappropriate procedures to establish an expression for the mechanical power.

In contrast, the candidates who scored good marks (5.9%) were able to identify methods of producing e.m.f. Most of them provided an appropriate reason on part (c), that when the switch is put off, there is a sudden break as a result a large induced e.m.f appears and sparking takes place. In addition, they retrieved and applied the correct formulas and procedures to determine the self-inductance and induced e.m.f. Extract 15.2 is a sample of a candidates' good responses.

5a) (i) Eddy Currents application.

> Eddy Current damping is applied on galvanometer due to farciond.

> In Electromagnetic brakes of Electromagnetic transport trains.

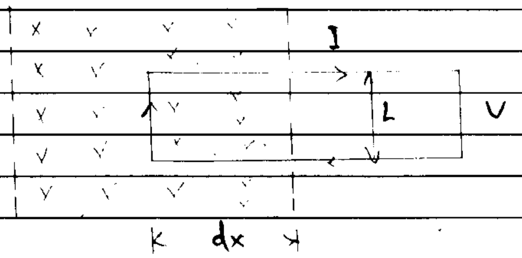
> Eddy Current heating, applied to melt large metallic masses.

> Eddy Current is used to Study the atomic Structures of the elements and Crystal lattice.

> Eddy Currents are used in "Energy meters"

(ii) Soln.

Illustration.



Let the small distance moved to the right be (dx)

Area of loop $A = L \cdot dx$

$$e = N \frac{d\phi}{dt}$$

but $\phi = BA \cos\theta$,

$\theta = 0°$

$\phi = BA \cos 0°$

$= BA$

$e = \frac{d(BA)}{dt}$

$e = \frac{d}{dt}(B \cdot L \cdot dx)$

$e = BL\frac{dx}{dt}$

but $\frac{dx}{dt} = V$

$e = BLV$ — (i).

Power $P = \frac{e^2}{R}$

$= \frac{(BLV)^2}{R}$

Mechanical power to move the loop would result

$P = \frac{B^2 L^2 V^2}{R}$

5b)	(i) Electromagnetic Induction is the process of producing induced emf as a result of change of magnetic flux linking the conductor

	(ii) Methods of producing Induced emf
	> By Varying the magnetic flux density $\vec{B}$ which links the conductor
	> By changing the area (A) of a coil which links with the magnetic flux.
	> by changing the orientation angle θ between the magnetic field and the area of the Conductor.

(c) On Switching off the fan, the large amount of induced emf flows in the opposite direction of the circuit, the circuit being open offers the infinite resistance at the switching point which on return amount of heat energy is generated which results to spark generation at the switching point

5d) soln.

Average radius (r) = 15 cm

Area = 18 cm^2

Number of turns = 1500 turns

Coil No of turns = 600 turns

Initial current = 0 A

Final current = 3 A

time taken = 0.06 s

(i) Self Inductance (Ls)

From $I L_s = N\Phi$

$I L_s = N BA$

$$N \frac{(N \mu_0 I) A}{L} = L_s I$$

$$L_s = \frac{\mu_0 N^2 A}{L}$$

length $L = 2\pi r$

$= 2\pi \times 15 \times 10^{-2}$ m

$= 0.942$ m

$$L_s = \frac{4\pi \times 10^{-7} \times (1500)^2 \times 18 \times 10^{-4}}{0.942}$$

$L_s = 5.402 \times 10^{-3}$ H

$= 5.4 \times 10^{-3}$ H

Hence the self Inductance of the coil would be $= 5.402 \times 10^{-3}$ H

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

In Extract 15.2, the candidate provided good responses and correctly applied the formulas and procedure in performing calculations.

3.6 Question 6: Atomic Physics

This question had three parts: (a), (b) and (c). Part (a) required the candidates to briefly explain the meaning of (i) activity (ii) chain reaction (iii) half-life and (iv) critical mass. Part (b) required the candidates to determine how many disintegrations per second occur in 1 g of Uranium $\left({}_{92}U^{238}\right)$ of half-life 4.5×10^{9} years when undergoes (α) decay. In part (c), they were required to (i) calculate the energy released by the fusion of 1 kg of deuterium and (ii) find out how many days would the station be able to function if 50% of the energy obtained in (c) (i) was continuously used to produce 1 MW of electricity given that the mass of deuterium nucleus ,neutron and one isotope of helium are 2.015 u, 3.017 u and 1.009 u respectively.

A total of 18,701 candidates, equivalent to 83.6 per cent attempted this question. Among them, 71.3 per cent scored from 0 to 6.5 marks; 24.5 per cent scored from 7 to 11.5 marks; and 4.2 per cent scored from 12 to 20 marks. These scores imply that the candidates' performance in this question was weak. Figure 23 summarizes the statistical analysis of this question.

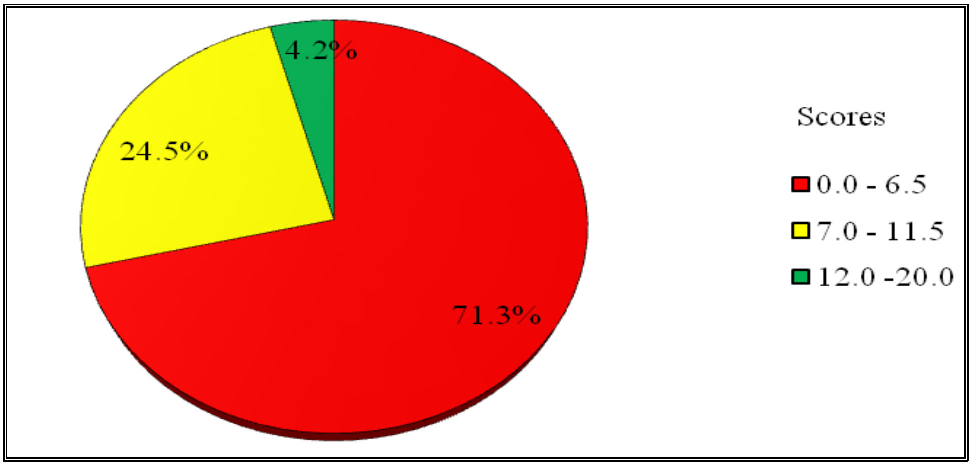


Figure 23: *Distribution of the candidates' scores on Question 6 in Paper 2*

Figure 23 indicates that a large number of candidates (71.3%) scored from 0 to 6.5 marks. One of the factors noted to have affected performance was inadequate knowledge about Nuclear Physics. Most of these candidates faced difficulties in explaining the basic terms used in nuclear physics and describing the structure of the nucleus. Some of them failed to identify the criteria for stable and unstable nucleus, determine the energy released and estimate the number of days at which the station would be able to function. Extract 16.1 is a sample of the incorrect responses.

6 a) i) Activity
Is the one which ~~is~~ used for the converting electrons

ii) Chain reaction
Is the reaction which occured in a chains.

iii) Half life
the is the life of an activity

iv) Critical mass
Is the mass which change Activity in a Half life.

(b) Given that.
Mass = 1g of uranium
Half life = 4.5x10^9 years
α (alpha decay) =
From:
$^{238}_{92}U + ^{4}_{2}He \longrightarrow ^{242}_{94}P$.

6 (b)
= $\frac{\text{Molar mass}}{}$.
$\frac{232}{4.5\times10^{9}}$.
$= 5.28\times10^{-8}$ mol year^{-1}
$= \frac{\text{mass}}{5.28\times10^{-8}}$
$= \frac{1g}{5.28\times10^{-8}}$
$= 1.89\times10^{-7}$ 7.5×10^{7} se
∴ it will take 7.5×10^{7} to disintegrate per second is 1g of uranium of half life.

(c) (i) Energy released = 3.017 + 2.015 − 1.009

= 24.023.

= 24.0234

∴ The Energy released by the fusion of 1kg of deuterium is 4.0234

(ii) From

~~$\frac{50}{100}$ = 1MW~~

1MW = 4.0234

50% = ? x.

$\frac{24.0234 \times 50\%}{1MW \times 100} = \frac{1MW \times x}{1MW}$.

x = 0.0115

∴ There are 2 days would the station be able to function if 50% of the energy obtained in (c) (i) was continuously used to produced 1MW of electricity.

Extract 16.1: *A sample of the incorrect responses to Question 6, Paper 2*

In Extract 16.1, the candidate provided wrong meaning of the terms and used an incorrect formulas and procedures to determine the energy released, number of days, as well as disintegrations per second.

The performance of the candidates who scored average (24.5%) marks was attributed to their ability to understand the requirement of the question in parts (a) and (b). These candidates provided the correct meaning of the terms and identified the relation between activity and the decay constant (λ) of a radioactive substance which enabled them to estimate the number of disintegrations per second. However, in part (c), they failed to interpret the mechanism of nuclear reaction to determine the energy released by fusion. Consequently, they lost some marks. Only 4.2 per cent of the candidates scored good marks (12 - 20). These candidates were conversant with the topic as they correctly analysed the concepts and applied the appropriate formula to manipulate the tasks in most parts of the question. Extract 16.2 is a sample of the correct responses to the question.

16: a) i) Activity ÷

Is the rate of disintergration of the radioactive substance when do subjected to higher energy radition like α and β-rays.

ii) chain reaction

÷ Is the spontaneous emmission of the radiation where once radio active substance start to disintergrate until it's finished example Nuclear fission in the device called chain reactor.

iii) Half - life:

÷ Is the time taken for the radioactive substance to decay half to it's original amount during radioactivity processes.

iv) critical mass:

÷ Is the small or minimum mass defects between nucleons and proton and electron which provide sufficient energy for the radioactive emmission to take place.

(b) Soln.

Rate of disintegration, dN/dt

$$\frac{dN}{dt} = \lambda N$$

Where

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$\lambda = \frac{\ln 2}{4.5 \times 10^{9} \times 365 \times 24 \times 60 \times 60}$$

$$\lambda = 4.889 \times 10^{-18}\ s^{-1}$$

$$N = \frac{m}{M_r} N_A$$

$$= \frac{1g}{238\ g/mol} \times 6.023 \times 10^{23}\ mol$$

$$N = 2.5306 \times 10^{21}\ at.$$

$$\frac{dN}{dt} = (4.884 \times 10^{-18}) \times (2.5306 \times 10^{21})$$

$$\frac{dN}{dt} = 12374.8 \text{ disintegrations per second.}$$

∴ The is 12374.8 disintegrations per second.

(b)	Soln.
	Rate of disintegration, dN/dt
	$\frac{dN}{dt} = \lambda N$
	Where
	$\lambda = \frac{\ln 2}{t_{1/2}}$
	$\lambda = \frac{\ln 2}{4.5 \times 10^9 \times 365 \times 24 \times 60 \times 60}$
	$\lambda = 4.889 \times 10^{-18}\ s^{-1}$
	$N = \frac{m}{M_r} N_A$
	$= \frac{1g}{238\ g/mol} \times 6.023 \times 10^{23}\ mol$
	$N = 2.5306 \times 10^{21}$ at.
	$\frac{dN}{dt} = (4.884 \times 10^{-18}) \times (2.5306 \times 10^{21})$
	$\frac{dN}{dt} = 12374.8$ disintegrations per second.
	∴ The is 12374.8 disintegrations per second.

06 c).	i) By using equation below:
	$^2_1H + ^2_1H \longrightarrow ^3_2He + ^1_0n$
	calculating the mass defect
	$\Delta m = 2M_{H} - (M_{^3He} + M_{^1_0n})$
	$= (2 \times 2.015) - (3.017 + 1.009)$
	$= 4.03 - 4.026$
	$\Delta m = 4 \times 10^{-3} u.$
	The value of mass defect (Δm) $= 4 \times 10^{-3} u.$
	But
	$E = \Delta m c^2$
	Binding Energy $= 4 \times 10^{-3} \times 931.5$ Mev
	$= 3.726$ Mev
	The energy released $= 3.726$ Mev.
	Then:
	1 Mev $= 1.6 \times 10^{-13}$ J
	∴ 3.726 $= x$
	$x = 5.9616 \times 10^{-13}$ J.
	∴ The magnitude of energy released $= 5.9616 \times 10^{-13}$ J.
	But:
	number of moles $= \frac{mass}{molar\ mass} = \frac{10 \times 10^2}{2}$
	The number of moles $=$ 500 moles.

06 c). i) But

$n = \frac{N \text{ (Number of molecules)}}{N_A \text{ (Avogadro's constant)}}$

$500 = \frac{N}{6.02 \times 10^{23}}$

$N = 3.01 \times 10^{26}$ molecules

Then:

2 molecules produced $\equiv 5.9616 \times 10^{-12}$ J

3.01×10^{26} molecules $\equiv X$

$X = 1.794 \times 10^{14}$ J $\cdot \approx \frac{1.8 \times 10^{14}\text{J}}{2} = 8.97 \times 10^{13}$ J

$\therefore$ The energy produced by 1kg of deuterium $=$ ~~1.8×10^{14}~~ J.

$= 8.97 \times 10^{13}$ J.

06 c) ii). efficiency $= \frac{P_{out}}{P_{in}}$

$P_{out} = \frac{50}{100} \times 1.794 \times 10^{14}$ J

$= 8.97 \times 10^{13}$ J.

The energy used in electricity $= \frac{8.97 \times 10^{13}\text{J}}{2} = 4.48 \times 10^{13}$ J.

Then:

Power $= \frac{\text{Energy}}{\text{Time}}$

Time $= \frac{8.97 \times 10^{13}}{2 \times 10^{6}} = \frac{8.97 \times 10^{7}\text{sec}}{2} = 44.85 \times 10^{6}$ sec

~~1 hour~~ $\equiv$ 1 day $= 3600 \times 24$ sec

$2x = 8.97 \times 10^{7}$ sec

$x = 1038.45$ days$/2 = 519$ days

Station will able to function for ~~1038.45~~ days.

Extract 16.2: *A sample of good responses to Question 6, Paper 2*

Extract 16.2 shows that the candidate was competent in the concept of nuclear physics since he/she precisely provided the correct responses to almost all parts of the question.

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

The Physics Paper 3 was comprised of three alternatives of Actual Practical Papers, namely 131/3A Physics 3A, 131/3B Physics 3B, and 131/3C Physics 3C. Each alternative paper consisted of three questions. Question 1 carried 20 marks while question 2 and 3 carried 15 marks each. The candidates were required to answer all questions. Question 1 was set from the topic of *Mechanics* while question 2 and 3 were set from the topics of *Heat* and *Current Electricity* respectively. The analysis of each question is as follows:

4.1 Question 1: Mechanics

4.1.1 131 Physics 3A, 3B & 3C

This question was attempted by 22,374 candidates, equivalent to 100 per cent. Their scores were as follows: 21.8 per cent scored from 0 to 6.5 marks, 31.2 per cent scored from 7 to 11.5 marks and 47 per cent scored from 12 to 20 marks. Figure 24 portrays the performance of the candidates in this question.

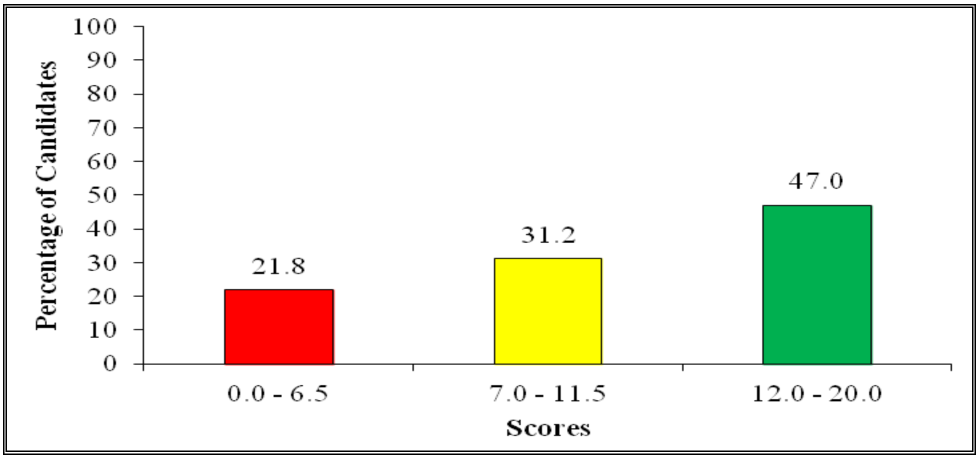


Figure 24: *Distribution of candidates' scores in Question 1*

Figure 24 shows that the general performance of the candidates in this question was good since 78.2 per cent of the candidates scored 7 to 20 marks.

4.1.1.1 131/3A Physics 3A

The aim of this experiment was to investigate the variation of length, L of the thread with the periodic time, T of simple pendulum. The candidates were required to:

(a) Set up the apparatus as shown in Figure 1 (presented here as Figure 25).

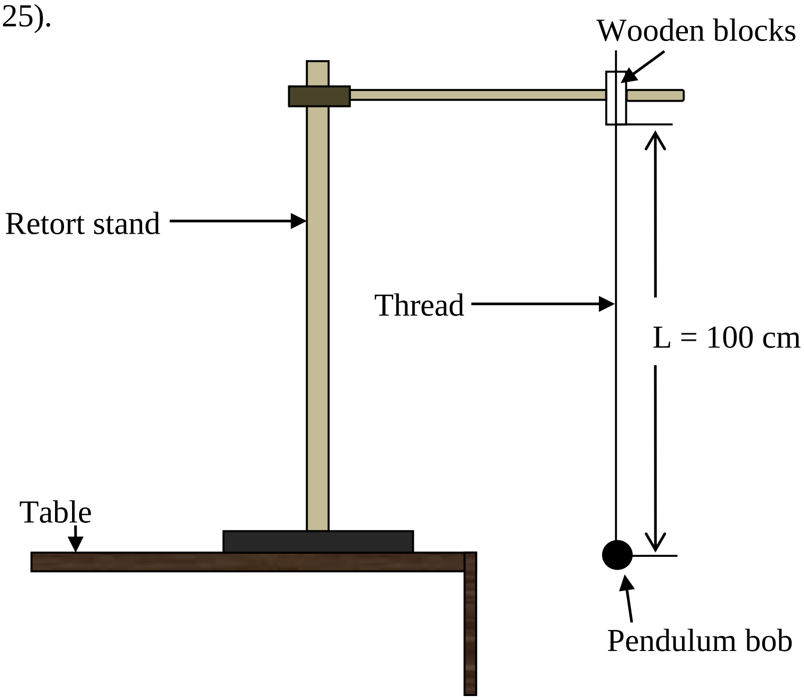


Figure 25

(b) Displace the pendulum through a small angle then release it so that it moves to and fro motion with small amplitudes. Measure and record the time, t for 10 complete oscillations and hence determine its periodic time T.

(c) Repeat the procedure in 1 (b) for the values of L = 80 cm, 50 cm, 40 cm and 15 cm.

Questions

(i) Use the dimensional analysis to find the value of n from the equation, $L=kT^n$; where k is in cms^{-1}.

(ii) Tabulate the results obtained in 1 (b) and (c) including the value of T^n.

(iii) Use the equation in 1 (i) and the results obtained in (ii) to determine the value of k graphically.

(iv) Compute the value of C, given that $C=\frac{g}{k}$ where g is the acceleration due to gravity.

(v) Determine the deviation of value of $C(\Delta C)$ from the true value.

(vi) Calculate the percentage error in performing this experiment.

Data analysis reveals that, 78.2 per cent of the candidates scored the pass mark (7 - 20), and among them 31.2 per cent scored average marks. These candidates had enough skills on how to set the given apparatus and estimate the angle of displacement to collect the experimental data. They also managed to tabulate the table of results and plot a graph of L (cm) against T (sec.). However, they faced difficulties in identifying the nature of the graph and in making analysis of the entire question.

The candidates who scored good marks (47%) demonstrated good mathematical skills. These candidates applied the basic concepts of dimensional analysis and mechanics in attempting the question. Most of them managed to analyse the data, interpret the plotted graph and evaluate the concepts tested. Extract 17.1 is a sample of the good responses.

1. (i) $L = KT^n$

$[L] = [L]$

$[K] = [L][T^{-1}] = cm\,s^{-1}$

$[K] = [LT^{-1}]$

$[T] = [T]$.

from

$L = KT^n$

$[L] = [LT^{-1}][T]^n$

$[L] = [LT^{-1+n}]$

$[M^0LT^0] = [M^0LT^{-1+n}]$

$-1+n = 0$

$n = 1$

$\therefore n = 1$ for $K = cm\,s^{-1}$

(ii) $n = 1$, $N = 10$

L (cm)	t(s)	T(s) t/10	T^n (s)
100	20.00	2.00	2.00
80	18.00	1.80	1.80
50	14.00	1.40	1.40
40	12.70	1.27	1.27
15	7.80	0.78	0.78

$T^n = T$

1. (iii) Graph of L(cm) against T^n (s)

Illustration on the graph.

from the graph:

$$\text{slope, } S = \frac{\Delta L\,(cm)}{\Delta T^n\,(s)}$$

$$S = \frac{100\,cm - 30\,cm}{2.8s - 0.84s}$$

$$S = \frac{70\,cm}{1.96\,s}$$

$$S = 35.71\ cm\,s^{-1}$$

from, $L = KT^n$

$$L = KT^n$$

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

$$y \quad m\ \ x.$$

$L = KT$, $n = 1$

K = slope

$\therefore K = 35.71\ cm/s$

(iv) $C = g/K$.

$g = 981\ cm/s^2$

1. (iv) $C = \dfrac{981\ \cancel{cm}/s^2}{35.71\ \cancel{cm}/s}$

$C = \dfrac{981}{35.71}\ \dfrac{\cancel{s}}{s^2}$

$C = 27.47\ s^{-1}$

(v) $g = 981\ cm/s^2$

$K = \dfrac{g}{4\pi^2}$

$K = \dfrac{981}{4 \times 3.14^2}$

$K = 24.87\ cm/s^2.$

Actual $C = \dfrac{981}{24.87}$

$C = 39.4384.$

$\Delta C = 39.4384 - 27.47$

$\Delta C = 11.9684\ s^{-1}$

1. (vi) $\%\ error = \dfrac{11.9684}{39.4384} \times 100\%$

$\%\ error = 0.3034\cancel{7} \times 100\%$

$= 30.347\%$

$\therefore \%\ error = 30.347\%$

Comment:
The units of K are cm/s^2 and not cm/s as from:

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

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

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

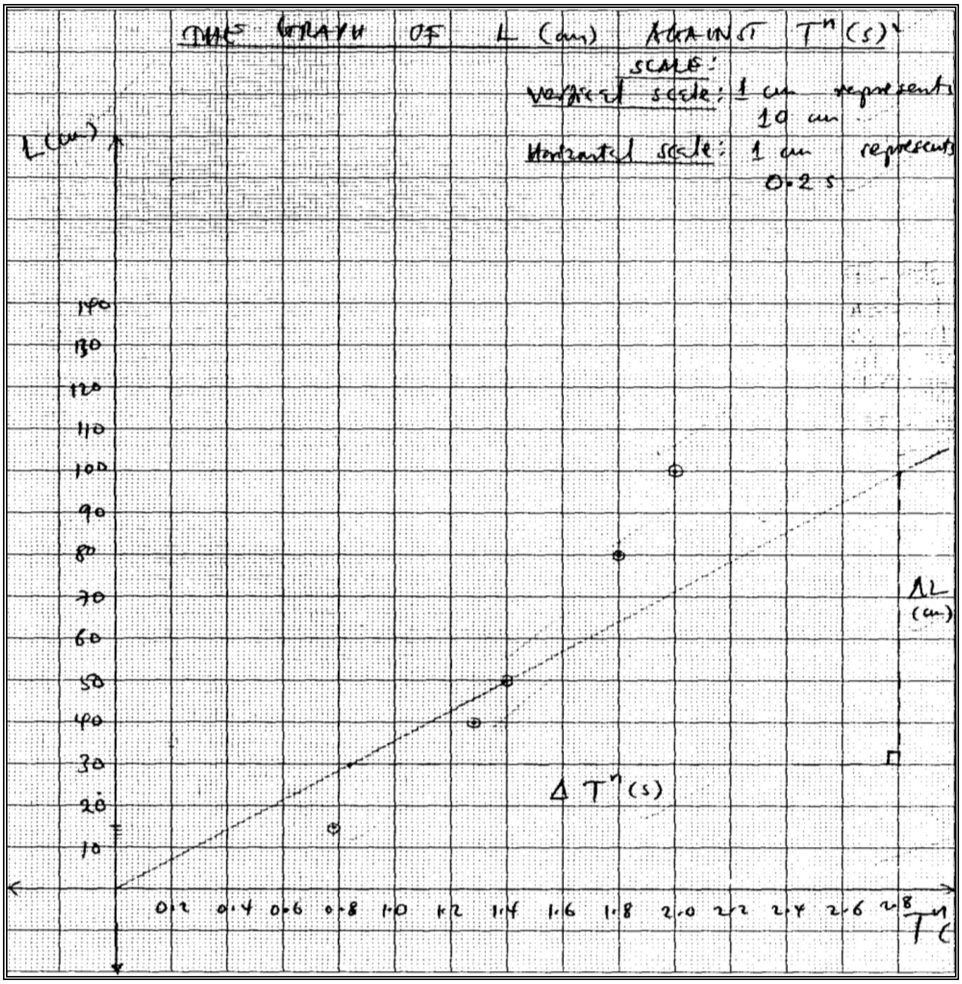
$$L = K \quad T^n$$

$$K = \frac{g}{4\pi^2}$$

$$[K] = [L\,T^{-2}]$$

Units of K = $cm\,s^{-2}$ in the experiment

The units of K $cm\,s^{-1}$ lead to discrepancies.



Extract 17.1: *A sample of candidate's good responses to Question 1 in Paper 3A*

In Extract 17.1, the candidate correctly employed the concept of dimensional analysis and formulas to analyse the tasks. He/she also plotted the graph based on the obtained data values.

However, the candidates who scored low marks (21.8%) in this question did not have enough knowledge on simple pendulum. Most of them collected wrong data. This was contributed by the failure to make proper setting of the apparatus, to count the number of oscillations and record time for the given values of length. They also faced difficulties in applying the concept of dimensional analysis to find the value of 'n' from the given relation, $L=kT^n$. In actual fact, this value of 'n' played an important role in the table of values used to plot a graph of L (cm) against (T^n). Failure to get the correct value of 'n' leads to a wrong table of results and the data analysis including the nature of the graph. Another observed weakness was failure to follow important steps when plotting a graph. Extract 1.2 is a sample of incorrect responses.

1. ii) Solution

TABLE OF RESULTS

L(cm)	t (sec)	T (sec)	T^{n} (sec^2)
100	10	2.00	4.01
80	10	1.79	3.2
50	10	1.42	2.02
40	10	1.26	1.6
15	10	0.77	0.6

i) Given

$$L = KT^n$$

but

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

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

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

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

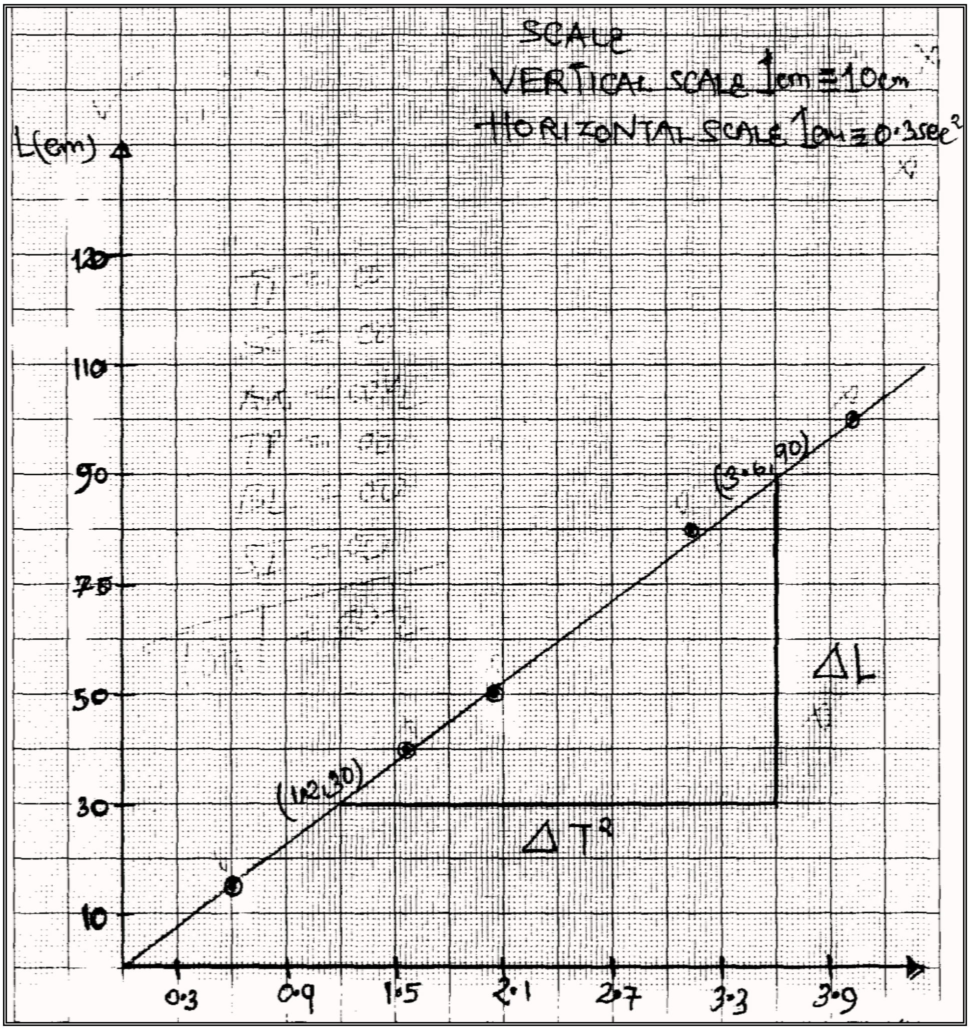
$$\frac{4\pi^2 L}{\pi^2} = \frac{T^2 g}{\pi^2}$$

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

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

ii	$L = \frac{T^2}{4}$
	Dimensionally by Comparing
	$L = \frac{T^2}{4}$
	$L = KT^n$
	Then $K = \frac{1}{4}$ and $n = 2$
	iii) from the graph
	Slope $= \frac{\Delta L}{\Delta T^2}$
	The Obtained points (3.6, 90)(1.2, 30)
	Now
	Slope $= \frac{(90 - 30)}{(3.6 - 1.2)}$
	Slope $= \frac{60}{2.4}$
	Slope $= 25$ cm
	from equation
	$L = KT^n$
	$y = mx$
	$K =$ slope $= 25$ cm or 0.25 m
	∴ The Value of K graphically is 25cm

1.	iv) solution
	from
	$C = \frac{g}{K}$
	$C = \frac{981 \text{ cm} s^{-2}}{25 \text{ cm}}$
	$C = 39.24 s^{-2}$
	∴ The Value of C is $39.24 s^{-2}$



Extract 17.2: *A sample of candidates' incorrect responses to Question 1 in Paper 3A*

In Extract 17.2, the candidate presented incorrect data values. He/she failed to apply the concept of dimensional analysis, and consequently obtained the incorrect value of 'n'. The candidate also failed to write the title of the graph, label both axes and write a scale used correctly.

4.3.1.1 131/3B Physics 3B

The aim of this experiment was to determine the acceleration due to gravity, g by simple pendulum. The candidates were required to:

(a) Set up the apparatus as shown in Figure 1 (presented here as Figure 26).

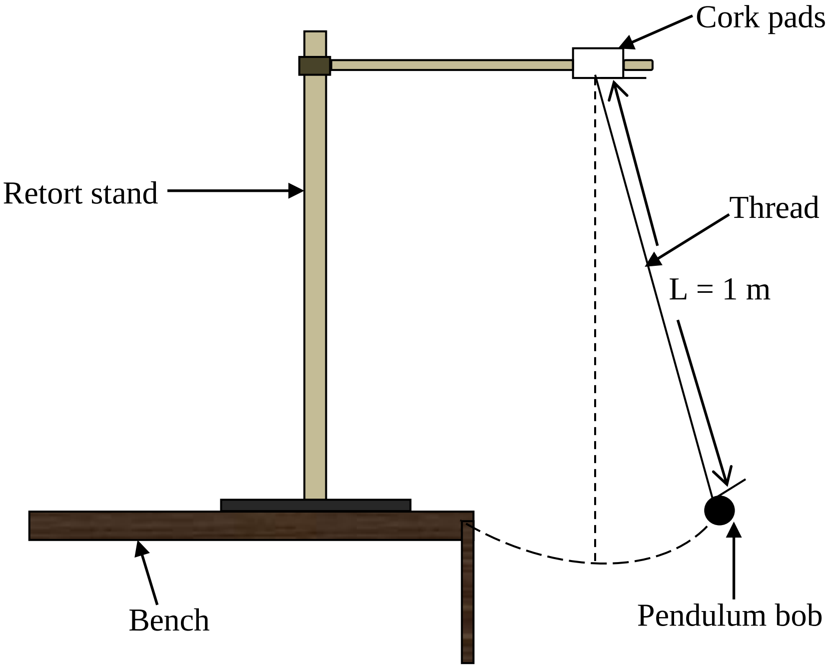


Figure 26

(b) Set the pendulum to oscillate through a small angle and record the time for 30 complete oscillations, hence determine its periodic time T.

(c) Repeat the procedure in 1 (b) for the values of L = 0.9 m, 0.8 m, 0.7 m, 0.6 m and 0.5 m.

Questions

(i) Tabulate your results including the value of T^2.

(ii) Plot the graph of L against T^2.

(iii) Deduce the slope of the graph.

(iv) Determine the acceleration due to gravity, g.

The candidates who scored good marks in this question demonstrated good skills in performing this experiment. Most of them tabulated the correct results and followed the required procedure for plotting the graph. They finally interpreted the graph and applied the correct formula to deduce the slope and acceleration due to gravity. Extract 18.1 is a sample of good responses.

1. c) i) Table of result.

L (cm)	t (sec)	T	T^2
0.9	57.71	1.924	3.70
0.8	54.5	1.817	3.30
0.7	51.09.	1.703	2.90
0.6	47.43	1.581	2.50
0.5	43.47	1.449	2.10

ii) See graph.

iii) From graph,

$$\text{Slope} = \frac{\text{change in } L}{\text{change in } T^2}$$

$$\text{Slope} = \frac{\Delta L}{\Delta T^2}$$

$$= \frac{0.65m - 0.25m}{2.75s^2 - 1.08s^2}$$

$$\text{Slope} = 0.2469 \, m/s^2$$

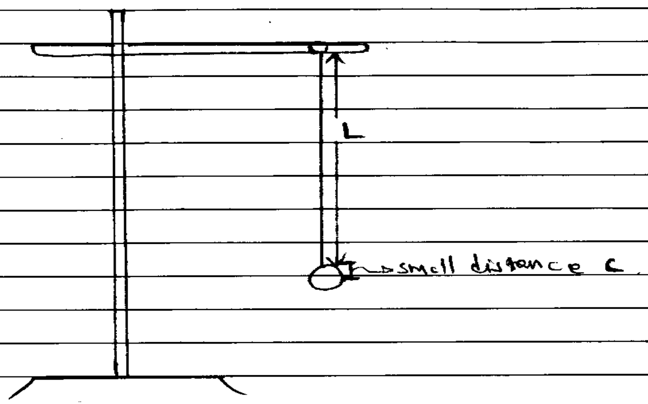
$\therefore$ Slope of a graph is $0.2469 \, m/s^2$.

iv) Acceleration due to gravity,

From, simple pendulum experiment equation,

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

1. c) iv) See below,



So

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

$$gT^2 = 4\pi^2 L + 4\pi^2 c.$$

Making L the subject

$$\frac{4\pi^2 L}{4\pi^2} = \frac{gT^2}{4\pi^2} - \frac{4\pi^2 c}{4\pi^2}.$$

$$L = \left(\frac{g}{4\pi^2}\right)T^2 - c.$$

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

1. c) iv) From equation above

$$\text{Slope } (M) = \frac{g}{4\pi^2}.$$

$$\frac{0.2469\,m/s^2}{1} = \frac{g}{4\times 3.14^2}.$$

$$g = 0.2469\,m/s^2 \times 4 \times 3.14^2$$

$$g = 9.78\,m/s^2.$$

$\therefore$ Acceleration due to gravity $= 9.78\,m/s^2$.

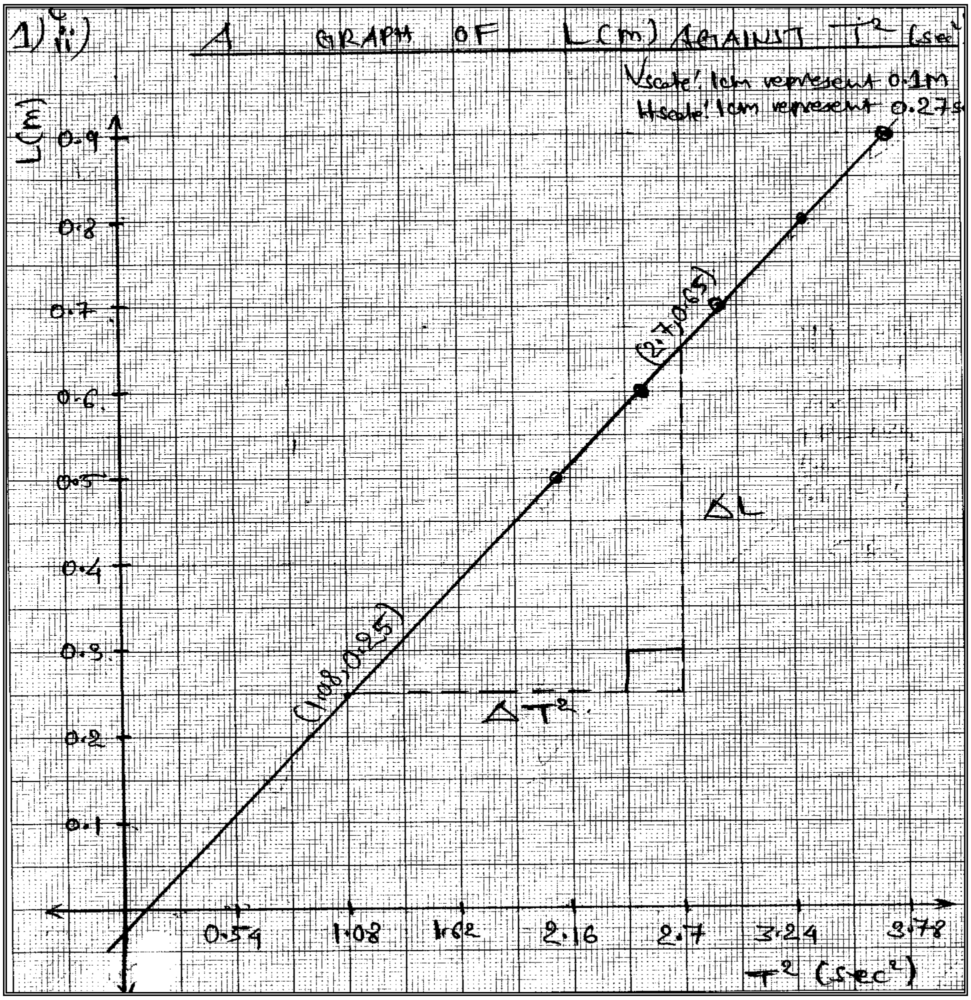
Conclusion:

⇒ The graph was not cut through origin due to the effect of not ~~being a bob to the~~ measuring the length L from the centre of bob.

⇒ L-intercept represents the value of small distance from point of attachment to the centre of bob.

i.e

L-intercept $= c = 0.025\,m$.



Extract 18.1: *A sample of candidates' correct responses to Question 1 in Paper 3B*

In Extract 18.1, the candidate correctly prepared a table of results, computed the data and got the correct answer. He/she then plotted the best line on the graph showing the slope indication and used such points to determine the slope and acceleration due to gravity.

In contrast, the candidates who scored low marks (0 - 6.5) had little knowledge on practical work specifically on setting and performing simple pendulum experiment. They faced challenge in recording time for 30 complete oscillations at different values of length, L hence the obtained values of periodic time, T and T^2 were not correct. Consequently, they had difficulties in transferring the data which had been collected. Some of them drew the graphs without indicating the axes, title of the graph, slope indication and the scale used, which are very important aspects to consider when drawing graphs. Extract 18.2 is one of the incorrect responses.

1 provided apparatus.
- Retort stand
- cork pads
- Thread
- Bench
- pendulum bob

i) TABLE of RESULTS

L (m)	Time oscillation	Time (sec)	T^2 (sec)
0.5	30	40	1600
0.6	30	44.3	1962.5
0.7	30	48.7	2.371.7
0.8	30	52	2704
0.9	30	55.6	3096.4
1	30	58.8	3457.4

iii)

$$\text{Slope} = \frac{\Delta L}{\Delta T^2}$$

$$\text{Slope} = \frac{3500 - 2500}{3.5 - 0.6}$$

Slope = 0.25 m/sec.

∴ The slope is 0.25 m/sec.

1 iv) from:

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

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

$$y = mx + c$$

Then.

$$T = 2 \times 3.14 \sqrt{\frac{0.1}{g}}$$

$$T = 6.28\sqrt{\frac{0.1}{g}}$$

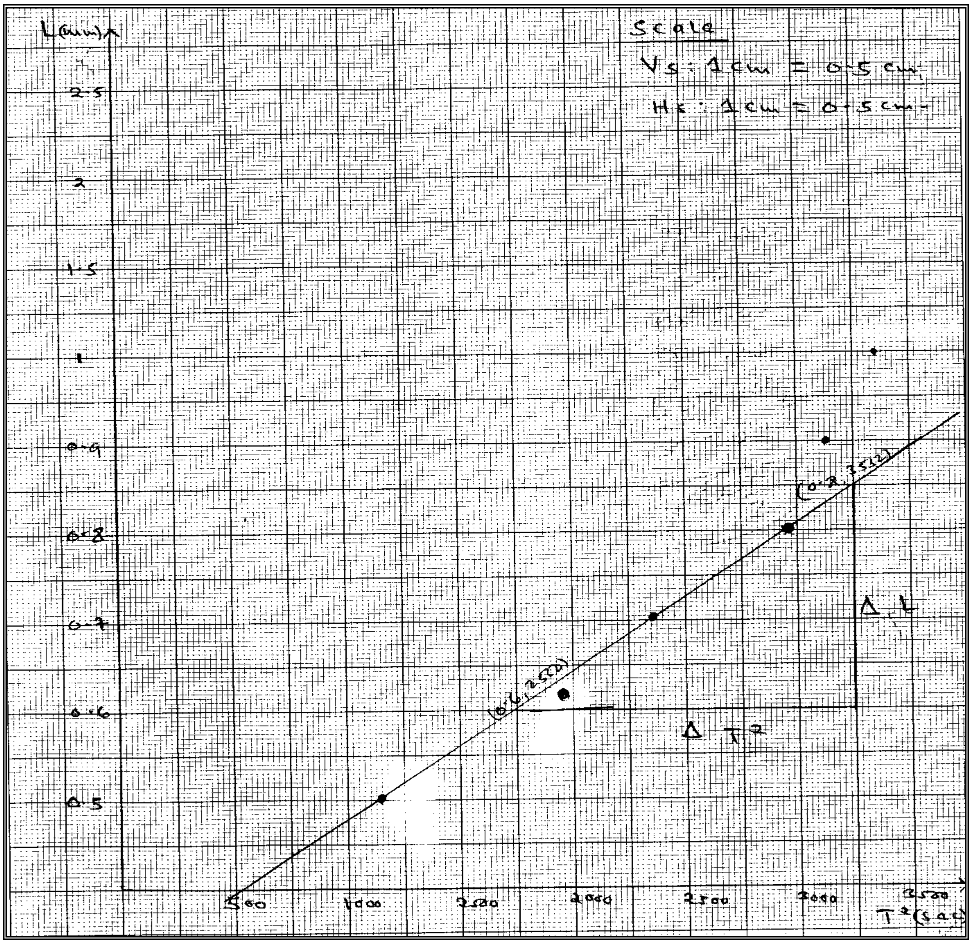
$$30 = 6.28 \times 0.1^2 - g^2$$

$$30 = 0.0628 - g^2$$

Then

$$g = 9.8 \times 10\ m/s^2$$

$$\therefore\ g = 9.8 \times 10\ m/s^2$$



Extract 18.2: *A sample of candidates' incorrect responses to Question 1 in Paper 3B*

In Extract 18.2, the candidate recorded the incorrect values of time, t hence the tabulated data of T^2 were not correct. For this reason, he/she failed to obtain the correct values of slope and acceleration due to gravity.

4.3.1.2 131/3C Physics 3C

In this question the candidates were provided with a pendulum bob, a thread, a stop watch, a metre rule, a retort stand and a pair of corks. Then, they were required to:

(a) Attach a piece of thread of 110 cm long to the pendulum bob. Make a knot at a distance of about 8 cm from the point of attachment of the bob. Set up the apparatus as shown in Figure 1 (presented here as Figure 27).

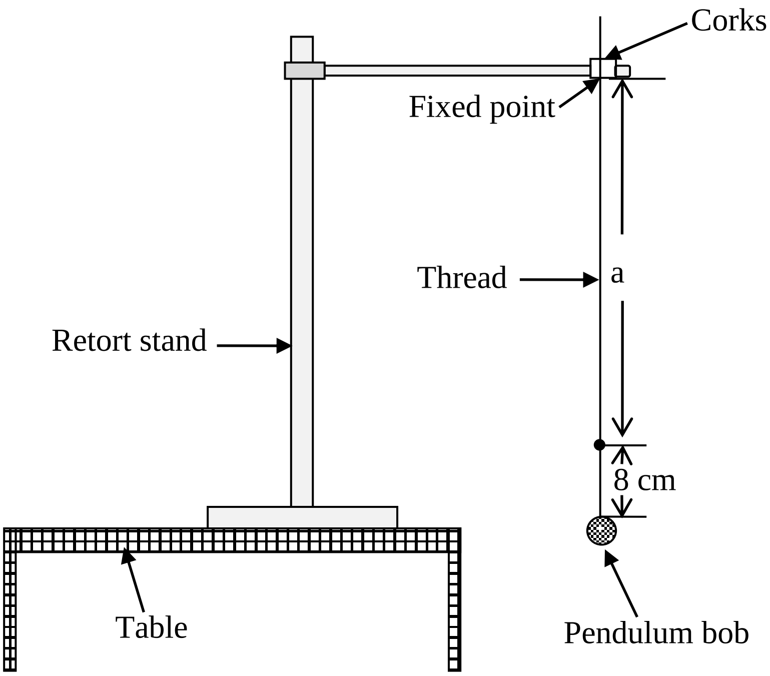


Figure 27

(b) Adjust the length, a = 92 cm from the knot to the fixed point. Set the bob to oscillate through a small angle and determine time, t for 10 complete oscillations and its periodic time, T.

(c) Repeat the procedure in 1 (b) for values of length, a = 82 cm, 72 cm, 62 cm, 52 cm, 42 cm and 32 cm.

Questions

(i) Tabulate the results including the values of T^2.

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

(iii) Use your graph in 1 (ii) to compute the value of the acceleration due to gravity.

(iv) Suggest the aim of the experiment.

The candidates who scored good marks in this question had adequate knowledge of simple pendulum experiment. They managed to study the diagram and assemble the apparatuses correctly. These candidates also prepared a table of values used to plot graphs correctly. Moreover, they were able to interpret the graphs, analyse the data to compute the value of the acceleration due to gravity and identify the aim of the experiment. Extract 19.1 presents a sample of the candidates' good responses.

1. (i) Table of result.

a (cm)	t (sec)	$T = t/10$ (sec)	T^2 (sec^2)
92	20.30	2.030	4.12
82	19.10	1.910	3.65
72	17.96	1.796	3.23
62	16.80	1.680	2.82
52	15.55	1.555	2.42
42	14.20	1.420	2.02
32	12.70	1.270	1.61

1. (ii) First find the slope of the graph.

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

$$\text{Slope(S)} = \frac{T_1^2 - T_2^2}{a_1 - a_2}$$

$$\text{Slope (S)} = \frac{(1.8 - 4.0) \text{ sec}^2}{(37 - 91) \text{ cm}}$$

$$\text{Slope(S)} = 0.041 \text{ sec}^2 \text{cm}^{-1}$$

from the equation.

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

But $L = a + 8\text{cm}$

$$T^2 = \frac{4\pi^2(a + 8\text{cm})}{g}$$

$$T^2 = \frac{4\pi^2 a}{g} + \frac{4\pi^2 \times 8\text{cm}}{g}.$$

1 (ii) The slope of the graph was

$$\frac{4\pi^2}{g} = S.$$

$$S = \frac{4\pi^2}{g}$$

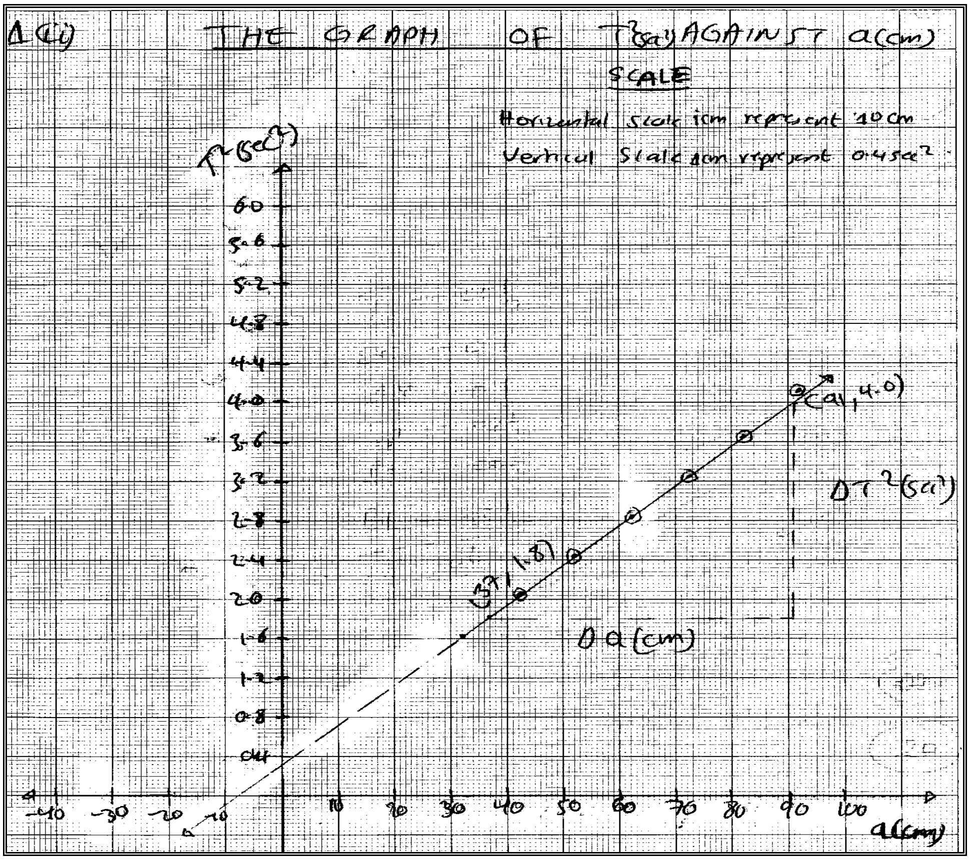
$$g = \frac{4\pi^2}{S}$$

$$g = \frac{4 \times 3.14^2}{0.0415\,sec^2\,cm^{-1}}$$

$$g = 961.91\ cm/sec^2.$$

$\therefore$ The acceleration due to gravity was 961.91 cm/sec²

(iv) The aim of the experiment was to determine the value of acceleration due to gravity



Extract 19.1: *A sample of candidates' good responses to Question 1 in Paper 3C*

In Extract 19.1, the candidate answered almost all parts of the question correctly.

Those who scored low marks (0 - 6.5) lacked knowledge of the concept of mechanics, particularly the knowledge about simple pendulum. The candidates who failed to set up the experiment correctly obviously failed to collect and record the data in tabular form. For example, the values of time recorded by some of the candidates were approximately the same for different values of length, 'a', which is practically not correct. In addition, most of them made common mistakes in indicating the axes, title of the graph, the scale used and in transferring the data when plotting the graphs. Extract 19.2 represents a sample of the incorrect responses.

Table of results'

T^2 (sec)	T (sec)	a (cm)	t (sec)
35.9	5.99	92	59.9
35.5	5.96	82	59.6
35.1	5.92	72	59.2
34.7	5.89	62	58.9
34.3	5.86	52	58.6
33.9	5.82	42	58.2
33.5	5.66	32	56.66

(iii)

For

slope was $24.8 cm s^{-1}$

Then.

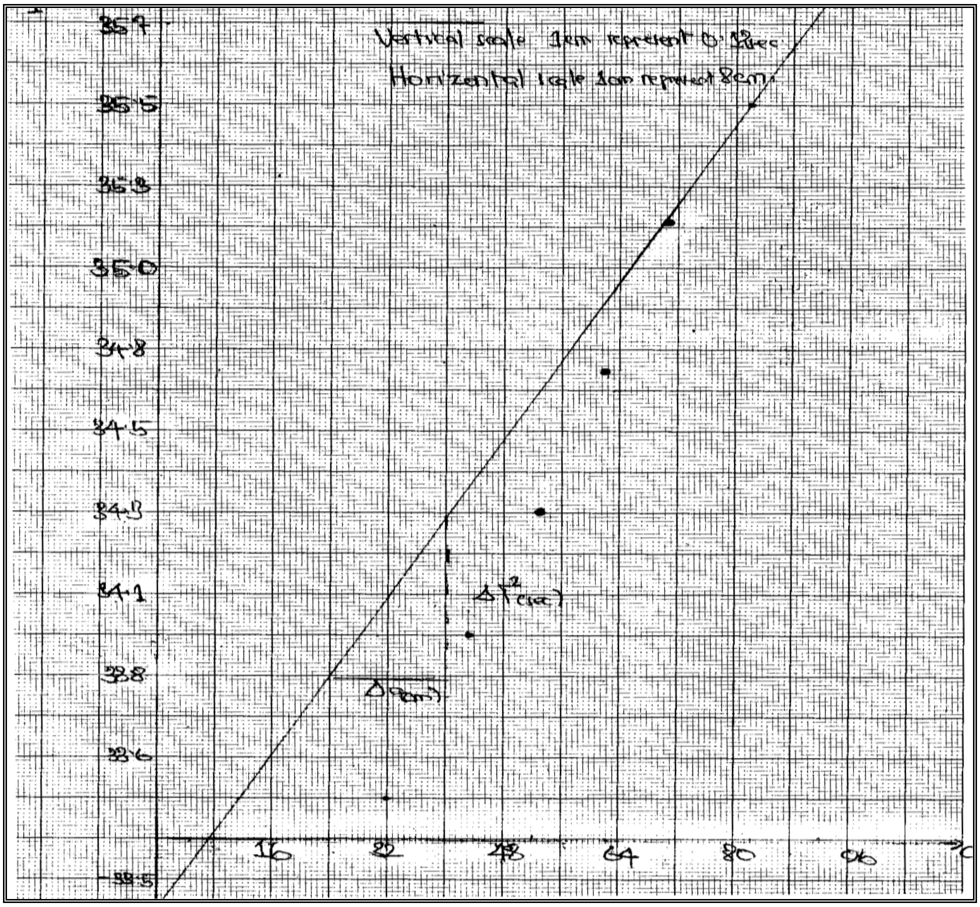
$$\text{slope} = \frac{g}{4\pi^2}$$

$$24.8 = \frac{g}{4\pi^2}$$

$$g = 24.8 \times 4\pi^2$$

$$g = 980 cm s^{-2}$$

Acceleration due to gravity was $980 cm s^{-2}$



Extract 19.2: *A sample of candidates' weak responses to Question 1 in Paper 3C*

Extract 19.2 shows the responses of a candidate who got low marks in this question. The candidate collected the incorrect data and transferred it on the graph paper. Moreover, he/she failed to draw the best line through those points, to write the title of the graph and label the axes.

4.2 Question 2: Heat

4.2.1 131 Physics 3A, 3B & 3C

The question was attempted by 22,373 (100%) candidates, of which 42.9 per cent scored from 0 to 5 marks, 36 per cent scored from 5.5 to 8.5 marks and 21.1 per cent scored from 9 to 15 marks. This suggests that the candidates' performance in this question was average since only 25.8 percent scored from 7.5 to 25.0 marks. Figure 28 presents these data.

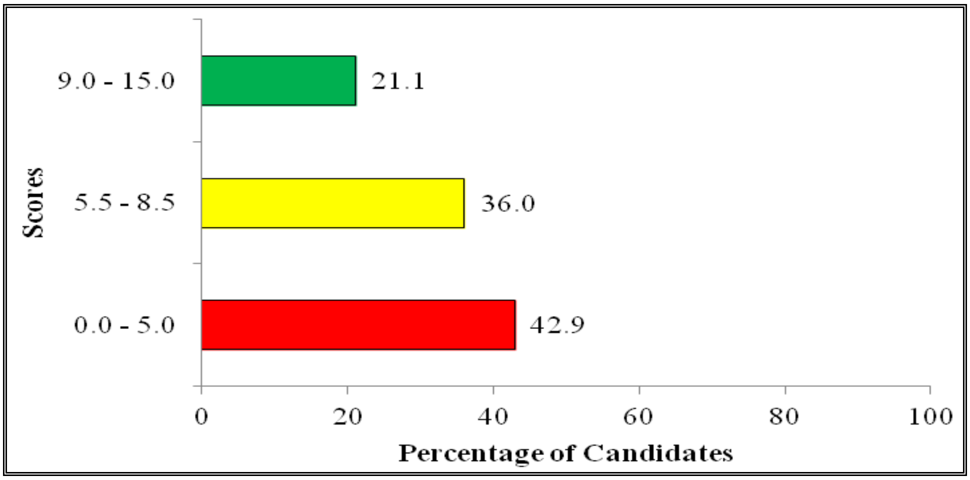


Figure 28: *Percentage of candidates' performance in Question 2*

Figure 28 indicates that the general performance of the candidates in this question was generally average since 57.1 per cent of the candidates scored from 5.5 to 15 marks.

4.3.1.3 131/3A Physics 3A

In this question the candidates were required to determine the specific heat capacity of a mass, M of a solid provided. The candidates were required to proceed as follows:

(a) Measure and record the mass of a given solid M, an empty calorimeter, M_c and the room temperature θ_R.

(b) Half-fill hot water in a calorimeter then observe and record the temperature of θ^0C of the water.

(c) Start with the temperature of 80^0C of hot water in the calorimeter while stirring and fanning after every one minute for about 10 minutes. Record the results.

(d) Record the mass of calorimeter with hot water; hence determine the mass, M_W of water used.

(e) Repeat the procedures in 2 (c) and (d), but in this case transfer quickly the mass, M provided to the calorimeter with water when the temperature is exactly 80^0C. Record the results.

Questions

(i) On the same graph, plot the cooling curves for both experiments, then determine the highest difference in temperature ΔT between the two curves by indicating the vertical line showing the upper temperature T_1 and lower temperature T_2.

(ii) Use the equation; $M_cC_c\Delta T+M_WC_W\Delta T=MC\left(T_2-\theta_R\right)$ to determine the specific heat capacity, C of the mass provided.

The candidates who scored average marks (36%) had good understanding of the concept of heat transfer. These candidates were able to apply the basic skills in setting and carrying out an experiment to determine the specific heat capacity of the given solid mass, M. Consequently, they managed to collect the data and plot the cooling curves for both experiments. However, some of them faced challenges in transferring the data when plotting the curves on the same graph paper.

Those who scored good marks (21.1%) had adequate knowledge on performing experiments regarding the rate of heat flow. Most of them managed to prepare scales, transfer the points, label the axes, and indicate the vertical line showing the upper temperature T_1 and lower temperature T_2 on the graphs drawn. Moreover, they were able to find the difference in temperature ΔT between the two curves and apply the principle of heat exchange; $M_c\,C_c\,\Delta T + M_w\,C_w\Delta T = M\,C\,(T_2 - \theta_R)$ to determine the specific heat capacity, C of the solid mass, M. Extract 20.1 is a sample of the good responses.

Qn 2.	(a) Mass of solid M = 100·5g
	Mass of empty calorimeter (Mc) = 34·5g
	Room temperature (θR) = 26°C
	(c) Table of results:

Temperature (θ)	Time (minutes)
80	00
72	01
68	02
64	03
60	04
57	05
54	06
51	07
49	08
47	09
46	10

	(d) Mass of calorimeter with hot water = 75.5g
	then
	Mass of water (M_w) = 75.5g − 34.5g
	M_w = 41g

Qn 2	(e) Table of results

Temperature, θ (°C)	Time (minutes)
80	00
69	01
66	02
63	03
60	04
58	05
56	06
54	07
53	08
52	09
51	10

from the graph

$T_2 = 55\ °C$

$T_1 = 49\ °C$

$\Delta T = T_2 - T_1 = 6°C$

Then

$$M_c C_c \Delta T + M_w C_w \Delta T = Mc (T_2 - \theta_R)$$

$$c = \frac{(M_c C_c + M_w C_w)\Delta T}{M (T_2 - \theta_R)}$$

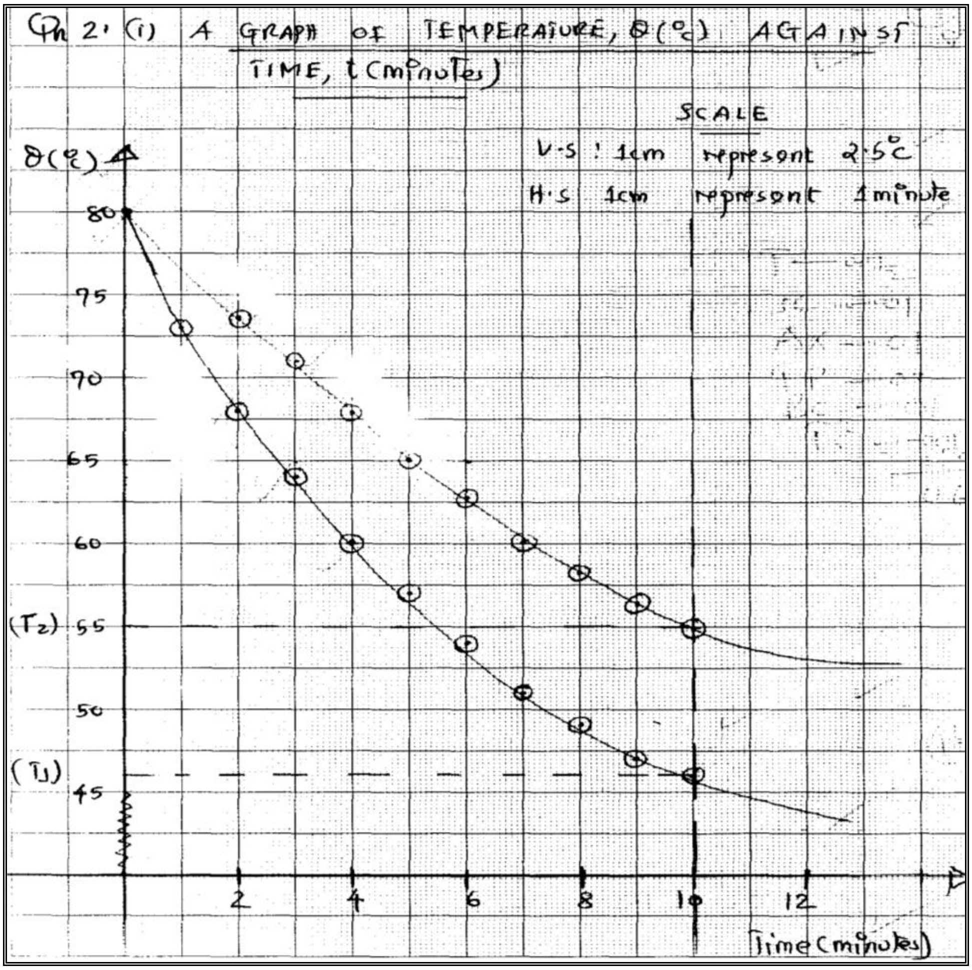
$$c = \frac{(34.5 \times 0.4) + (41 \times 4.2)\ (6)}{\cancel{100.5(55-26)}}$$

$c = 0.3848\ J/gK$

Qn 2 (e) $C = 0.384\ J/gK$

$C = 384\ J/KgK$

$\therefore$ Specific Heat capacity $= 384\ J/KgK$.



Extract 20.1: *A sample of candidates' good responses to Question 2 in Paper 3A*

Extract 20.1, shows that the candidate was systematic in collecting the data, plotting the graph and doing analysis to determine the difference in temperature and specific heat capacity of the solid mass, M.

In contrast, 42.9 per cent of the candidates who scored low (0 - 5) marks did not have enough knowledge and skills for carrying out heat experiments. These candidates recorded wrong data, suggesting that they faced difficulties in using beam balance and thermometer to measure and record the mass of calorimeter and temperature respectively. For example, in answering part (d) of the question one candidate wrote *Heat lose by solid = Heat gained by water i.e* $M_sC_s\Delta\theta = M_wC_w\Delta\theta \Rightarrow M_w = \frac{M_sC_s}{C_w}$, expecting to get the mass of water used. This candidate lacked the knowledge of eliminating the mass of empty calorimeter from the mass of calorimeter with its contents (hot water) to get the mass of water used. Most of the candidates misinterpreted the instruction given in part (c) of this question. They recorded the time after 10^0C drop of temperature instead of reading the temperature drop after every one minute for about 10 minutes starting from 80^0C. Extract 20.2 is a sample of the incorrect responses.

2 (a) Mass of solid M_s = 100g
Room temperature = 28°c

(b) The temperature of hot water = 97°c

(c)

Temperature (T_1)	Temperature (T_2)
80°c	72
70°c	68.1
60°c	66.3
50°c	65.2
40°c	62.3
30°c	60.4
20°c	68.7
10°c	57.1

2 (d) Soln.

$M_w = ?$ $\theta_o = 28°c$

$M_s = 100g$ $\theta_f = 97°c$

$C_w = 4.2\ J/gk$ $\theta_i = 80°c$

$C_s = 0.4\ J/gk$

Heat lose by solid = Heat gained by water

$M_sC_s\Delta\theta = M_wC_w(\Delta\theta)$

$M_sC_s(\theta_i - \theta_o) = M_wC_w(\theta_o - \theta_f)$

$M_w = \frac{M_sC_s(\theta_i - \theta_o)}{C_w(\theta_o - \theta_f)}$

2. (d) $M_w = \dfrac{100 \times 0.4\ (80-28)}{4.2 \times (97+28)}$

$M_w = \dfrac{\cancel{2860}}{\cancel{218.4}} \quad \dfrac{2080}{289.8}$

$M_w = \cancel{12.63g} \quad 7.177g.$

$\therefore$ Mass of water $= 7.177g$.

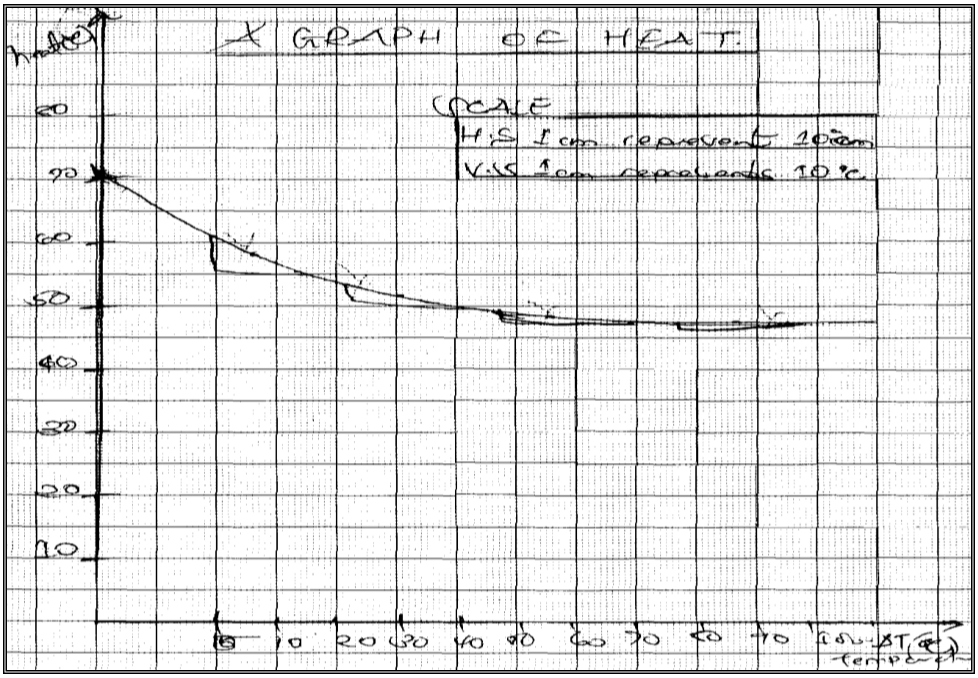
2. (b) (ii)

$M_cC_c\Delta T + M_wC_w\Delta T = MC(T_2 - \theta_R)$.

$(M_cC_c + M_wC_w)(\Delta T) = M_c(T_2 - \theta_R)$.

$\dfrac{(100 \times 0.4 + 7.177 \times 4.2)(80-28)}{(28-0)} = M_c$

$M_c = 380.25 /kg\,k$.



Extract 20.2: *A sample of candidates' incorrect responses to Question 2 in Paper 3A*

In extract 20.2, the candidate tabulated wrong values of temperature starting from 80^0C to 10^0C without indicating the time interval. He/she did a wrong analysis of data and consequently failed to plot the correct cooling curves on the same graph paper.

4.3.1.4 131/3B Physics 3B

In this question the candidates were required to compare the rate of cooling for hot water in a calorimeter when it is about a half-full of water and when it is about two-thirds through a fixed range of temperature. They were required to proceed as follows:

(a) Half-fill the calorimeter with water of about 80^0C.

(b) Stir the hot water in a calorimeter and fanning constantly, start the stop watch when the water is exactly 70^0C and record the time t_1 in seconds after every 5^0C drop until it has fallen to 50^0C. Weigh the calorimeter with water, and then determine the mass, m_1 (in grams) of water used.

(c) Repeat the procedures in 2 (a) and in (b) with the calorimeter about two-thirds full of water. Record the time t_2 in seconds then determine the mass m_2 (in grams) of water used.

Questions

(i) Tabulate your results obtained in 2 (b) and (c).

(ii) Record the mass of water obtained in 2 (b) and (c).

(iii) Plot the graph of t_2 against t_1 and determine its slope.

(iv) Compare the value of the slope obtained in 2 (ii) and the ratio of $\frac{m_2}{m_1}$.

The average performance of the candidates in this question was contributed by their ability to arrange the given apparatus and analyse heat experiments under forced convection. These candidates managed to measure accurately the mass of calorimeter when it is half-full and when it is two third -full of water. However, some of them had problems with reading stop watch when recording time after every 5^0C drop of temperature as instructed. They also failed to choose a proper scale when transferring the data on the graph to draw the best line and determine its slope.

Those who scored higher marks (9 - 15) were knowledgeable about the topic as they were able to perform the experiment and analyse the data. Moreover, they made a correct conclusion by making comparison between the slope of the graph and the ratio of two masses. Extract 21.1 is a sample of the responses from a candidate who scored good marks.

2. (i) Solution

Table of results.

Temperature (°C)	t_1 (sec) when ½ full	t_2 (sec) when ⅔ full
70	~~60~~ 0	0
65	58	60
60	130	135
55	198	205
50	275	315

(ii) (b) Mass of Calorimeter with water (M_c) = 92.60 g.

Mass of empty calorimeter (M_o) = 34.70 g.

Mass of water $M_1 = M_c - M_o$.

$= 92.60g - 34.70g$.

$= 57.90g$

$M_1 = 57.90g$.

(c) ~~M~~ Solution

Mass of Calorimeter with water (M_c) = 107.50 g.

Mass of empty calorimeter (M_o)

= 34.70 g

then

$M_2 = M_c - M_o$.

$= 107.5g - 34.70g$.

$M_2 = 72.80g$.

(iii) Solution

from the graph.

$$\text{Slope} = \frac{\Delta t_1}{\Delta t_2}.$$

$$\text{Slope} = \frac{(246 - 120)\ \text{sec}}{(225 - 125)\ \text{sec}}$$

$$\text{Slope} = 1.26$$

$$\therefore \text{Slope} = 1.26.$$

(iv) Solution

from:

$M_1 = 57.90g$

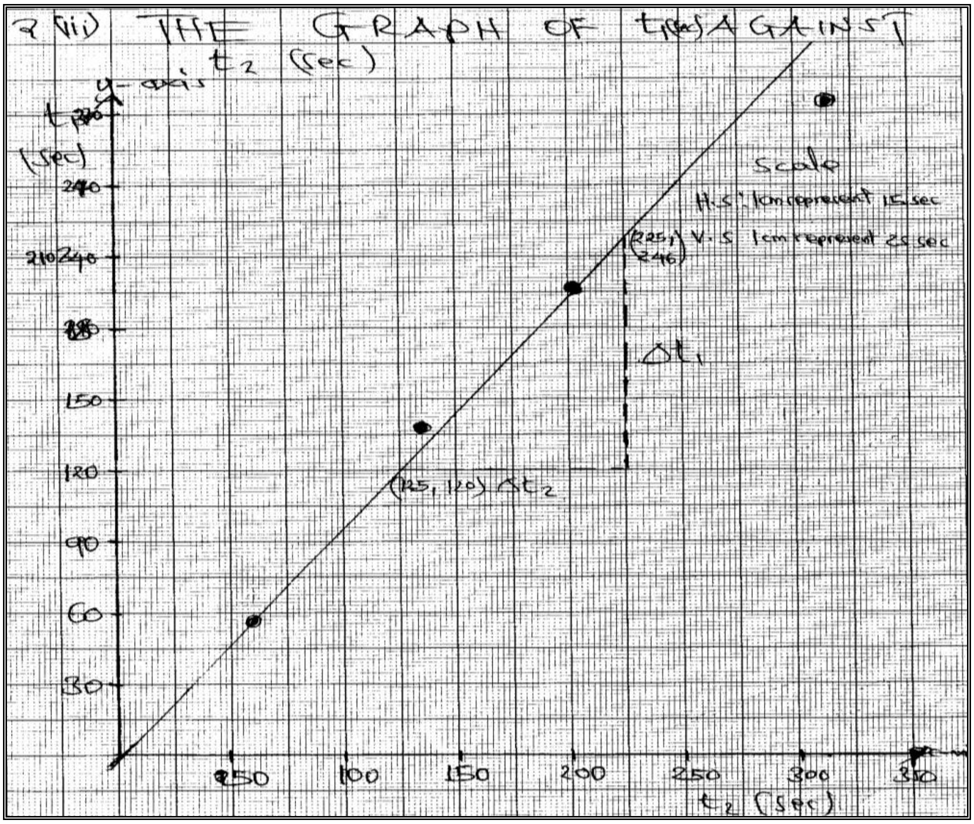
$M_2 = 72.80g$

then

$$\frac{M_2}{M_1} = \frac{72.80g}{57.90g}$$

$$\frac{M_2}{M_1} = 1.257$$

$\therefore$ The value of M_2/M_1 and the slope are nearly equal.



Extract 21.1: *A sample of candidates' good responses to Question 2 in Paper 3B*

Extract 21.1 shows that the candidate prepared a table of values but failed to get reasonable values of time. However, he/she plotted a graph and did an analysis to determine the masses of calorimeter and slope of the graph, and finally made a correct conclusion.

On the other hand, the candidates who scored low marks (42.9%) in this question faced the challenge of reading a stop watch. These candidates tabulated the results of time which were out of range. It seems they failed to estimate the starting and the ending time of reading a stop watch after every 5^0C drop of temperature as instructed. Some of them misunderstood the question as they drew two graphs of temperature against time on the same graph paper instead of a straight line graph of temperature t_2 against t_1 as instructed in part (iii). Generally, it was noted that, most of the candidates in this group had inadequate knowledge on conducting and analysing heat experiments. Extract 21.2 is a sample of incorrect responses.

2. i/.

Temperature (T) (°C)	Time (t_1) (Min)	Time (t_2) (min)
65	2.20	0.50
60	3.30	2.40
55	4.40	3.50
50	5.50	4.60

ii/. a. Mass of water (M_1) half of Calorimeter

M_1 = Mass of water with calorimeter − Mass of calorimeter

= 79.45g − 30.35g

M_1 = 49.1g.

b. Mass of water (M_2) two third of Calorimeter

M_2 = Mass of water with calorimeter − mass of calorimeter

= 108.84g − 30.35g

M_2 = 78.49g.

iii/. Refer to the Graph paper.

2. iv/.

From the graph.

Point. (4, 3) and ($\cancel{4}$5.5, 4.5)

Then slope $\cancel{(m)}$ = $\frac{4.5-3}{5.5-4}$

$= \frac{1.5}{1.5}$

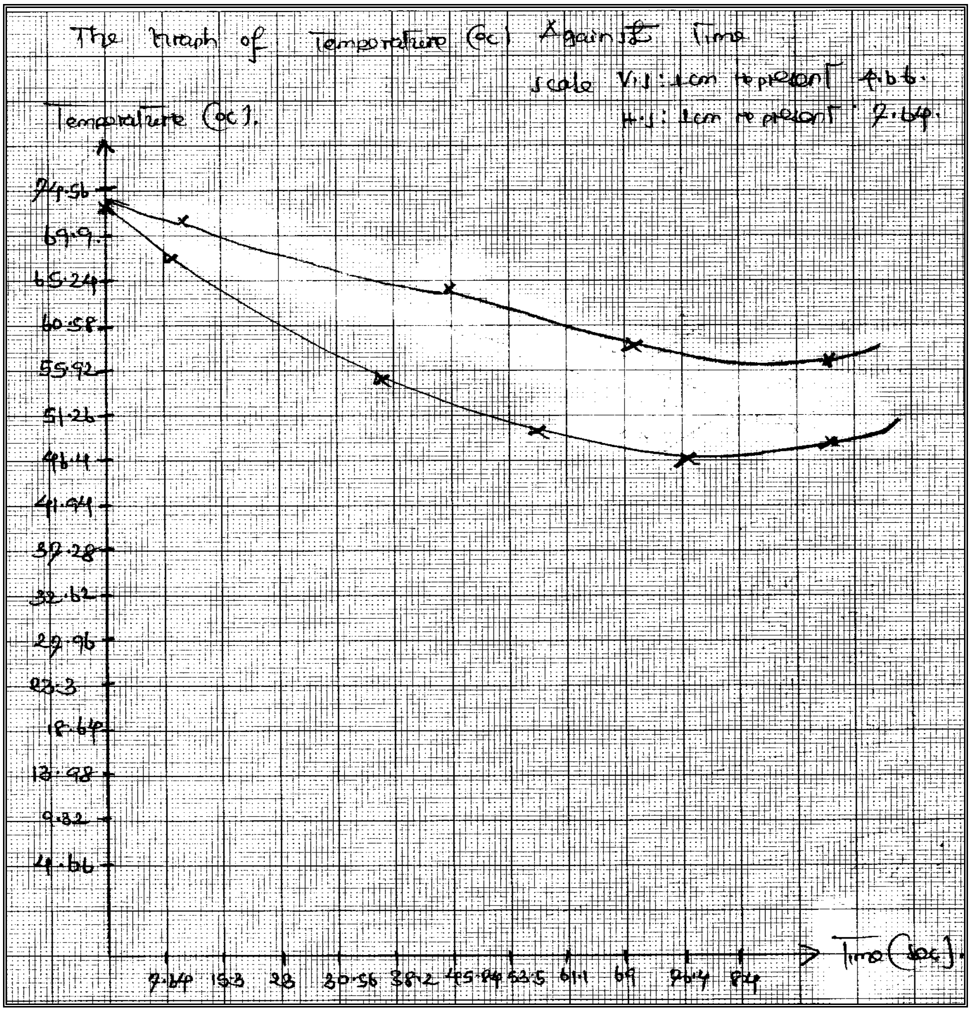
$= 1.$

∴ Slope = 1.

but

ratio of $\frac{M_2}{M_1}$ is $= \frac{78.439}{49.1} = 1.59 \simeq 2$

∴, By comparison the slope and ratio $\frac{M_2}{M_1}$ is that slope is two times the $\frac{M_2}{M_1}$



Extract 21.2: *A sample of candidates' incorrect responses to Question 2 in Paper 3B*

In extract 21.2 the candidate recorded the values of time in minutes instead of seconds as instructed. He/she further analysed the tested concepts and ended with wrong results due to incorrect data values.

4.3.1.5 131/3C Physics 3C

The aim of this experiment was to investigate the rate of heat loss of water at 70^0C. The candidates were required to proceed as follows:

(a) Weigh an empty beaker and record its value.

(b) Pour 150 ml of hot water heated to 85^0C in a beaker provided and weigh the beaker with its contents.

(c) Set up the apparatus as shown in Figure 2 (presented here as Figure 29).

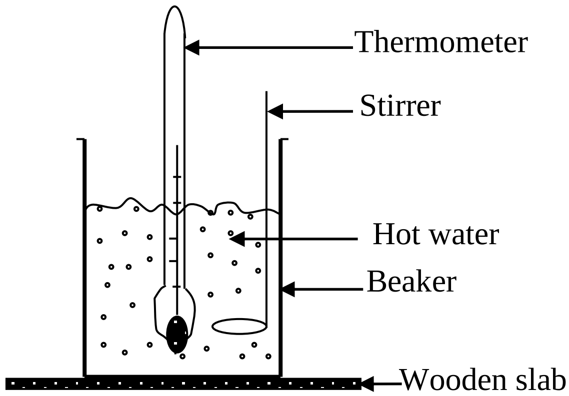


Figure 29

(d) While stirring gently, record the temperature $\left(\theta^0\text{C}\right)$ of water for every two minutes until it falls to 60^0C.

Questions

(i) Tabulate your results.

(ii) Plot a graph of temperature $\left(\theta^0\text{C}\right)$ against time t (minutes).

(iii) Determine the slope of the graph at the temperature of 70^0C.

(iv) Compute the rate of heat loss of water at 70^0C from the equation: $\frac{\text{Qdt}}{\text{m}} = \text{C}_\text{w}\text{td}\theta$, where m is the mass of 150 ml of boiled water and C_w is the specific heat capacity of water.

The candidates who scored average marks (5.5 - 8.5) in this question demonstrated good skills in setting up the apparatus, weighing the mass and recording the temperature accurately. Furthermore, they managed to prepare a table of results at a reasonable range and plot a graph of temperature (θ^0C) against time, t (minutes). Some of them transferred the data on the graph correctly but failed to choose the points to draw the best curve, and determine the slope and rate of heat loss of water at 70^0C.

However, 21.1 per cent of the candidates who scored good marks in this question were competent in applying mathematical skills to analyse and evaluate the tested concepts. These candidates considered important aspects to observe when plotting graphs, which are; the title of the graph with their units, the vertical and horizontal scales, the vertical and horizontal axes with their respective S.I units, transfer of points; best line or curve, and slope indication. Consequently, they applied the correct points from the graph and correctly used the formula to compute the slope and rate of heat loss. Extract 22.1 provides an example of the correct responses.

2 (a) Weight of the empty beaker let say
(W_1) = 108.95 g

(b) Weight of beaker with its content let say
(W_2) = ~~271~~ 9 265.75g

hence ~~water~~ of content, boiled (water) (W)
= Weight of beaker with its content (W_2) —
weight of empty beaker (W_1).

Then
$W = W_2 - W_1$
$W = 265.75g - 108.95g$
hence
weight of boiled water (content) = 156.8g

(c)(i) Table of results.

Time (t) minutes	Temperature θc
0	85
2	74
4	68
6	64
8	62
10	60

(iii) required to determine the slope
~~given~~ from the graph given point
A_1 = 2.4, 71.4
B = 3.3, 69

2d(iii) Hence from the graph point indication

$(2.4, 71.4), (3.3, 69)$
$x_1 \quad y_1 \quad x_2 \quad y_2$

$$\text{Slope } (m) = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta\theta °C}{\Delta t (\text{minute})}$$

$$\text{Slope } (m) = \frac{(69 - 71.4)°C}{(3.3 - 2.4)\text{ minutes}}$$

$$\text{Slope } (m) = \frac{-2.4 °C}{0.9 \text{ minutes}}$$

$$\text{Slope } (m) = -2.67 °C/\text{min}$$

∴ The slope of the graph at the temperature of 70°C is $-2.67 °C/\text{min}$

(iv) Given the equation

$$\frac{\theta dt}{M} = Cwt d\theta$$

To make $\frac{d\theta}{dt}$ as the subject

$$\frac{\theta dt}{m} = Cwt d\theta.$$

Then

$$\frac{d\theta}{dt} = \frac{\theta}{m Cw t}$$

2d(iv) Then

$$\frac{d\theta}{dt} = \frac{\theta}{m Cw t}$$

$$\frac{\theta}{t} = \frac{d\theta}{dt} \cdot M cw$$

But $\frac{d\theta}{dt}$ = slope at 70°C $= -2.67 °C/\text{min}$

But
Mass of beaker and its content (w_2)
$= 265.75g$.

Mass of water = mass of beaker with content − mass of empty beaker

$Mw = 265.75g - 108.95g$

$Mw = 156.8g$.

Then $Cw = 4.2J/gk$.

Then

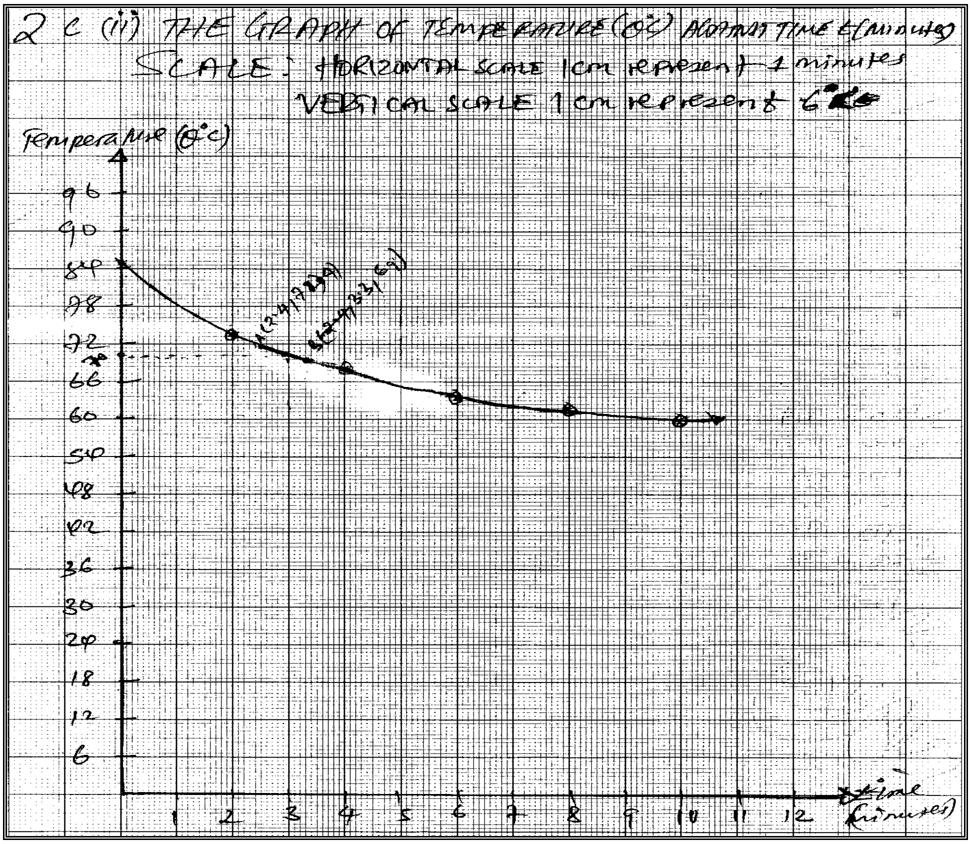
$$\frac{Q}{t} = \frac{d\theta}{dt} \cdot M C_w$$

$$\frac{Q}{t} = -2.67 K/min \times 156.88 \times 4.2 J/gK$$

$$\frac{Q}{t} = (-2.67 \times 156.8 \times 4.2) J/min$$

$$\therefore \frac{Q}{t} = -1.758 kJ/min$$

~~Rate of heat loss of water is = 1.~~



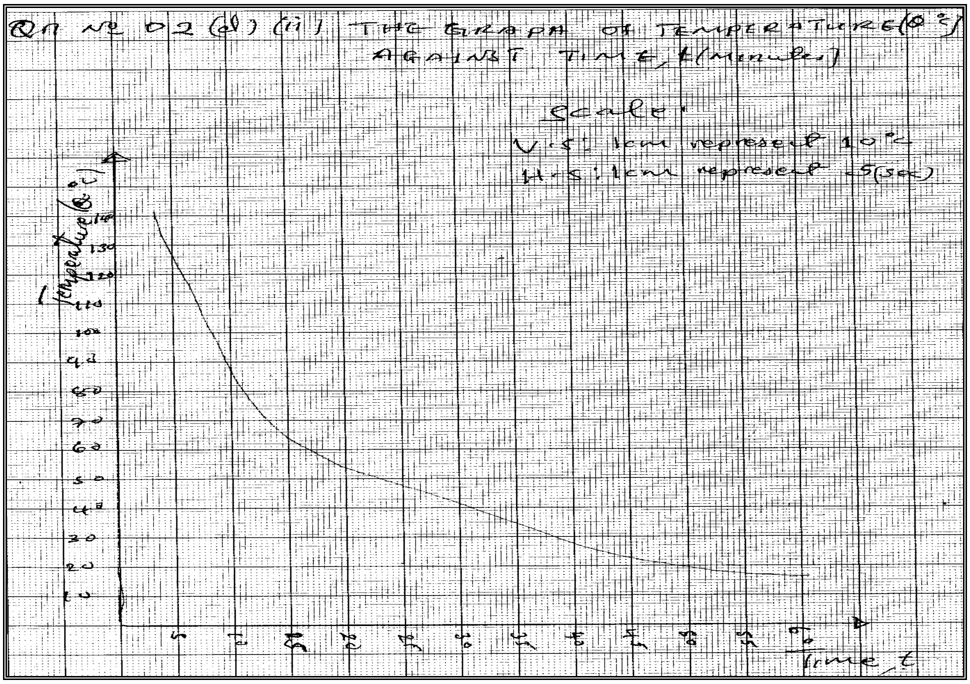
Extract 22.1: *A sample of candidates' good responses to Question 2 in Paper 3C*

Extract 22.1 shows how a candidate managed to measure and record the masses of empty beaker and water used. He/she also applied the data values to plot a graph and determine the slope and rate of heat loss.

Although the performance of some candidates in this question was average, 42.9 per cent of them scored low marks (0 - 5) including 0.9 per cent who scored 0 marks. These candidates lacked knowledge about retrieving and conveying the basic concepts of heat transfer into practical work. Most of them failed to collect the appropriate data and choose a good scale to incorporate it on the graph. They also lacked mathematical skills which could help them analyse the given tasks. For example, one candidate collected wrong data values and attempted to plot a graph without showing the actual positions of those points on the graph paper. Extract 22.2 presents a sample of the incorrect responses.

Q2. TABLE OF RESULT.

Temperature (θ °c)	time, t
70	10
75	20
80	30
85	40
90	50
95	60



Extract 22.2: *A sample of candidates' weak responses to Question 2*

Extract 22.2, portrays the responses of a candidate who provided a wrong table of values, and consequently failed to transfer those values on the graph and analyse the tasks.

4.3 Question 3: Current Electricity

4.3.1 131 Physics 3A, 3B & 3C

The question was attempted by 22,373 candidates, equivalent to 100 per cent. The distribution of their scores is shown in Figure 30.

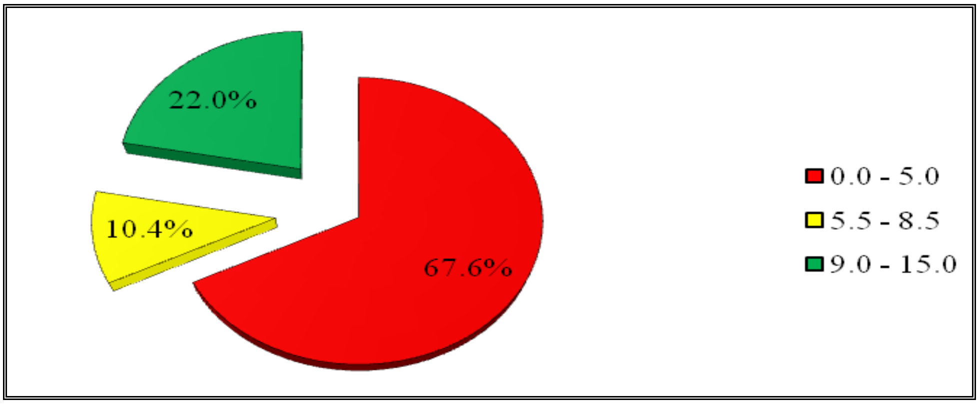


Figure 30: *Distribution of candidates' scores in Question 3*

Figure 30 shows that 67.6 per cent of the candidates scored from 0 to 5 marks, 10.4 per cent scored from 5.5 to 8.5 marks while 22.0 per cent scored from 9 to 15 marks.

4.3.1.6 131/3A Physics 3A

The candidates were provided with resistance box, R, wire Q joined with a coiled wire in an insulator, battery, E, galvanometer, G, a jockey, J, a switch, S and connecting wires. Then, they were required to proceed as follows:

(a) Connect the circuit as shown in Figure 2 (presented here as Figure 31). Make sure that the length of the wire Q which make a loop is 60 cm.

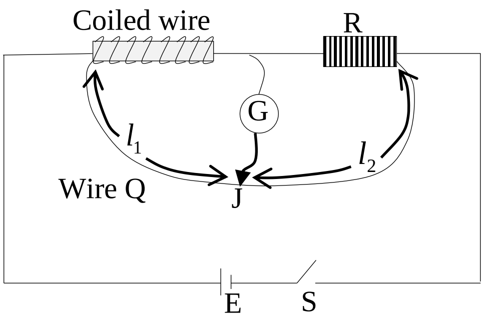


Figure 31

(b) Set R = 2 Ω in the resistance box and close the switch to obtain the value of length l_1 and l_2.

(c) Repeat the procedure in 3 (b) by increasing R by 2 Ω each time to obtain four more readings.

Questions

(i) Tabulate the results obtained in 3 (b) and (c) including the value of $\frac{l_2}{l_1}$.

(ii) Plot a graph of R against $\frac{l_2}{l_1}$.

(iii) What is the physical meaning of the slope of the graph in 3 (ii)?

(iv) Measure the diameter of the wire Q then calculate its cross-sectional area.

(v) If the length of the coiled wire is 50 cm, find the resistivity of wire Q.

The performance in this question was generally weak because more than a half (67.6%) of the candidates scored below average (< 5.5 mark). Among them, 2.9 per cent, equivalent to 647 candidates, scored 0 marks. These candidates lacked knowledge of the concept of current electricity specifically the metre bridge theory. Because of that they faced challenges in doing proper setting of the given apparatus and thus ended with incorrect table of values. Moreover, most of these candidates lacked drawing skills, hence failed to obtain the correct slope. They also failed to use the micrometer screw gauge in measuring the diameter of the wire. For this reason, they obtained an incorrect value of the cross-sectional area and resistivity of the wire. Extract 23.1 presents a sample of the incorrect responses.

03 : (a)

TABLE OF RESULTS:

(i)

Resistance Ω	l_1 cm	l_2 cm	l_2/l_1 cm
2 Ω	5.7	54.3	9.5
4 Ω	10.2	49.8	4.8
6 Ω	13.9	46.1	3.3
8 Ω	17.0	43.0	2.5
10 Ω	19.59	40.4	2.0

3: (iii)

The physical meaning of the slope of the graph is resistivity of the wire.

3: (iv)

(a) The diameter of the wire

$= 0.38 mm$ or

$0.38 \times 10^{-3} m$

(b) The cross section area.

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

$$A = \frac{3.14 \times (0.38 \times 10^{-3})^2}{4}$$

$$A = 1.133354 \times 10^{-7}$$

$\therefore$ its cross section area $= 1.134 \times 10^{-7} m^2$

3: (v) from

$$R = \frac{\rho l}{A}$$

$l = 0.5$

$A = 1.134 \times 10^{-7}$

$R = 2\Omega$

$\rho = ?$

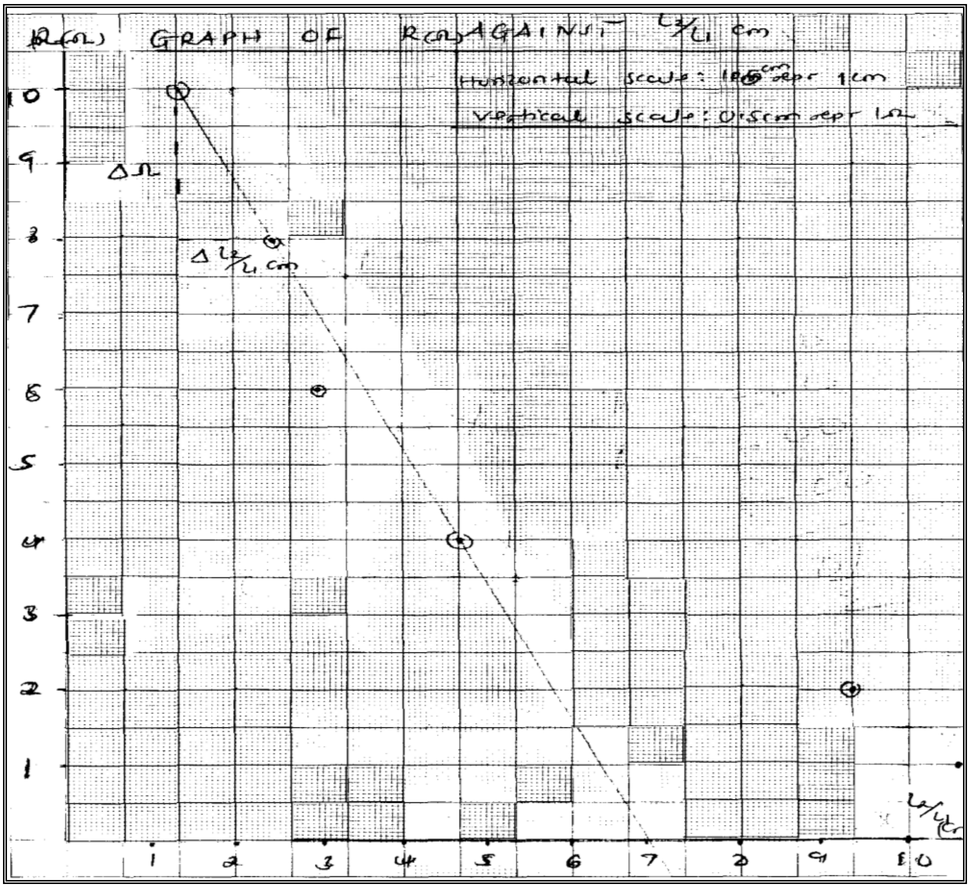
from

$$\rho = \frac{RA}{l}$$

$$\rho = \frac{2 \times 1.134 \times 10^{-7}}{0.5}$$

$$\rho = 1.6 \times 10^{-6}$$

$\therefore$ resistivity $= 1.6 \times 10^{-6}$



Extract 23.1: *A sample of candidates' weak responses to Question 3 in Paper 3A*

Extract 23.1 depicts the responses of a candidate who collected wrong data and performed calculations and resulted into incorrect answers. He/she also drew an incorrect graph with negative slope, contrary to the requirement of the question.

A total of 2323 candidates equivalent to 10.4 per cent scored average marks. These candidates demonstrated good understanding of setting and conducting meter bridge experiments. Most of them collected appropriate data values which were correctly used to plot a graph. In addition, they derived an expression and equated it with the equation of a straight line to investigate the physical meaning of the slope. However, some of them skipped parts (iv) and (v) due to poor mathematical skills.

Those who scored good marks (9 - 15) were competent in applying the theory of meter bridge into practical work. These candidates followed the proper procedures of measuring, reading and recording the tabulated table of results. They also interpreted the graph and correctly analysed the concepts tested. Extract 23.2 is a sample of the good responses.

3 i) Table of results.

$R (\Omega)$	L_1 (cm)	L_2 (cm)	L_2/L_1
2	42.7	17.3	0.41
4	33.1	26.9	0.81
6	27.0	33.0	1.22
8	22.8	37.2	1.63
10	19.8	40.2	2.03

ii) A graph (On the graph paper.)

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

$S = \frac{(11.25 - 6)\Omega}{(2.275 - 1.225)}$

$S = 5\Omega$

From Metre bridge

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

$R = \cancel{\frac{1}{P}}(P)\frac{L_2}{L_1} + 0$

∴ ~~The~~ $y = m \quad x \quad + c$

Slope = P (Resistance of coiled wire)

∴ The physical meaning of the slope is the resistance of a coiled wire

3(iv) diameter = 0·36 mm = 0·036 cm

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

$$A = \frac{3·14 \times (0·036\ cm)^2}{4}$$

$A = 1·01736 \times 10^{-3}\ cm^2$.

∴ Cross sectional area of the wire is $1·01736 \times 10^{-3}\ cm^2$.

v) $L = 50\ cm$.

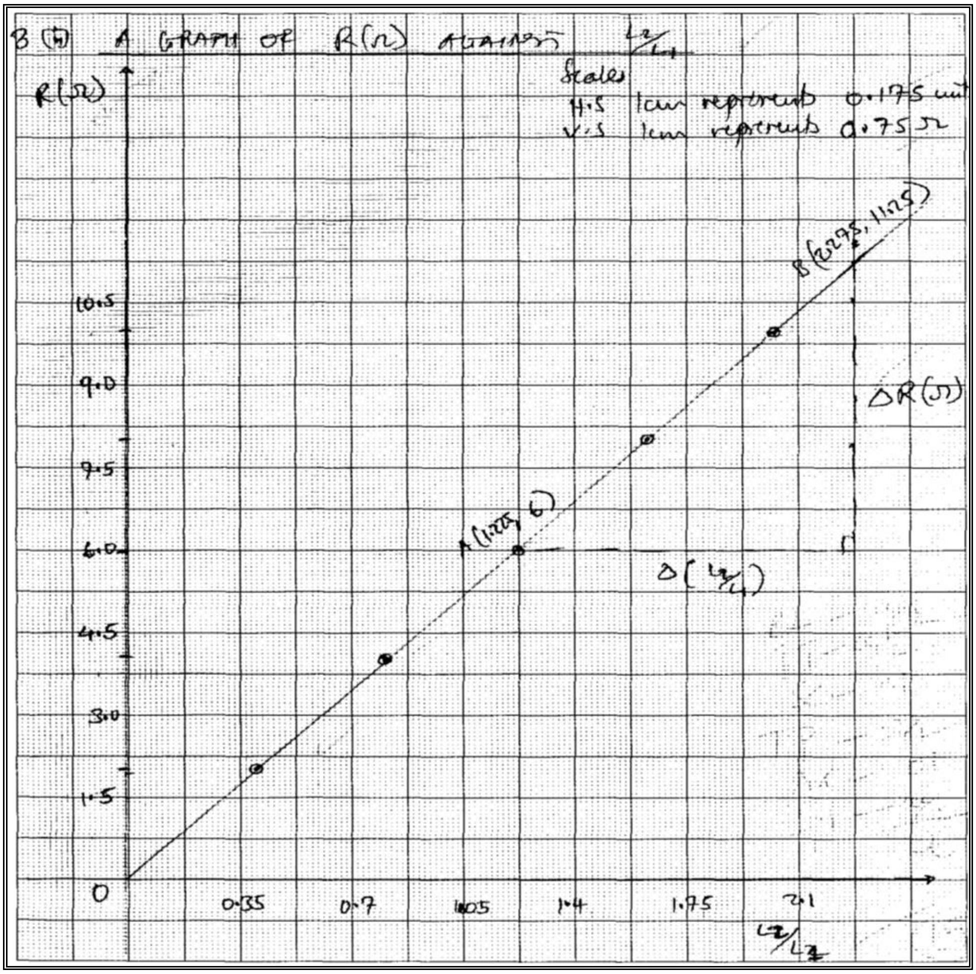
from $$\rho = \frac{AR}{L}$$

$$\rho = \frac{1·01736 \times 10^{-3}\ cm^2 \times 5\Omega}{50\ cm}$$

$\rho = 1·01736 \times 10^{-4}\ \Omega cm$

$\rho = 1·01736 \times 10^{-6}\ \Omega m$

∴ The resistivity of wire Q is $1·01736 \times 10^{-6}\ \Omega m$



Extract 23.2: *A sample of candidates' good responses to Question 3 in Paper 3A*

In extract 23.2, the candidate applied the concept of meter bridge in deducing an equation to identify the physical meaning of the slope. He/she finally, obtained the correct values of a cross-sectional area and resistivity of the wire.

4.3.1.7 131/3B Physics 3B

In this question the candidates were provided with a 2 Ω standard resistor, metre bridge, jokey, wire Y joined with a wire coiled in an insulator, a switch, crocodile clip, a dry cell, galvanometer and connecting wires. Then, they were required to proceed as follows:

(a) Connect the coiled wire together with free hanging wire Y. Connect free hand of coiled wire to the left terminal of the right hand gap of the metre bridge. Then connect the wire Y with crocodile clip to the other terminal of the right hand gap as shown in Figure 2 (presented here as Figure 32).

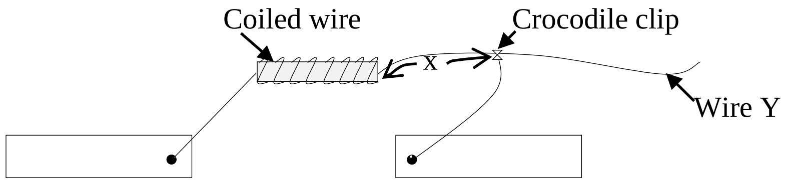


Figure 32

(b) Measure the length x of the wire Y equal to 10 cm and clip the crocodile clip at the end of this length. Using 2 Ω standard resistor, find the balancing length, l as measured from the left end and the equivalent resistance R in the right hand gap.

(c) Increase x by 10 cm each time and obtain four (4) more corresponding values of l and R.

Questions

(i) Tabulate your results.

(ii) Plot a graph of R against x.

(iii) Use the information in 3 (ii) to find the values of 'a' and 'b' from the equation $x = \frac{R}{a} - \frac{b}{a}$.

(iv) What is the physical meaning of the value of b obtained in 3 (iii)?

(v) Calculate the ratio $\frac{b}{a}$ and give its physical meaning.

(vi) Give a possible aim of performing this experiment.

The candidates who scored low marks (0 - 5) in this question failed to apply the necessary skills in setting the circuit components as instructed in the question. Most of them recorded incorrect data resulting into wrong table of values. They also failed to establish an equation based on the title of the graph and compare it with an equation $x = \frac{R}{a} - \frac{b}{a}$ in order to identify the physical meaning of 'b', $\frac{b}{a}$ and calculate its values. For this reason, they had difficulties in analysing and evaluating the concepts. Extract 24.1 is a sample of the incorrect responses.

3.

(i)

Length of X(cm)	L_1	R	L_2
10	17 ~~26.5~~	0.41	83
20	26.5	0.72	72.5
30	30	0.86	70
40	32	0.94	68
50	38	1.22	62
~~60~~	~~41~~	~~1.49~~	~~59~~

from

$R_1 \propto L$

$R_2 \propto 100 - L$

$$\frac{R_1}{R_2} = \frac{L}{100-L}$$

(iii)

$$X = \frac{R}{a} - \frac{b}{a}$$

$$X + \frac{b}{a} = \frac{R}{a}$$

$$aX + b = R$$

$$R = ax + b$$

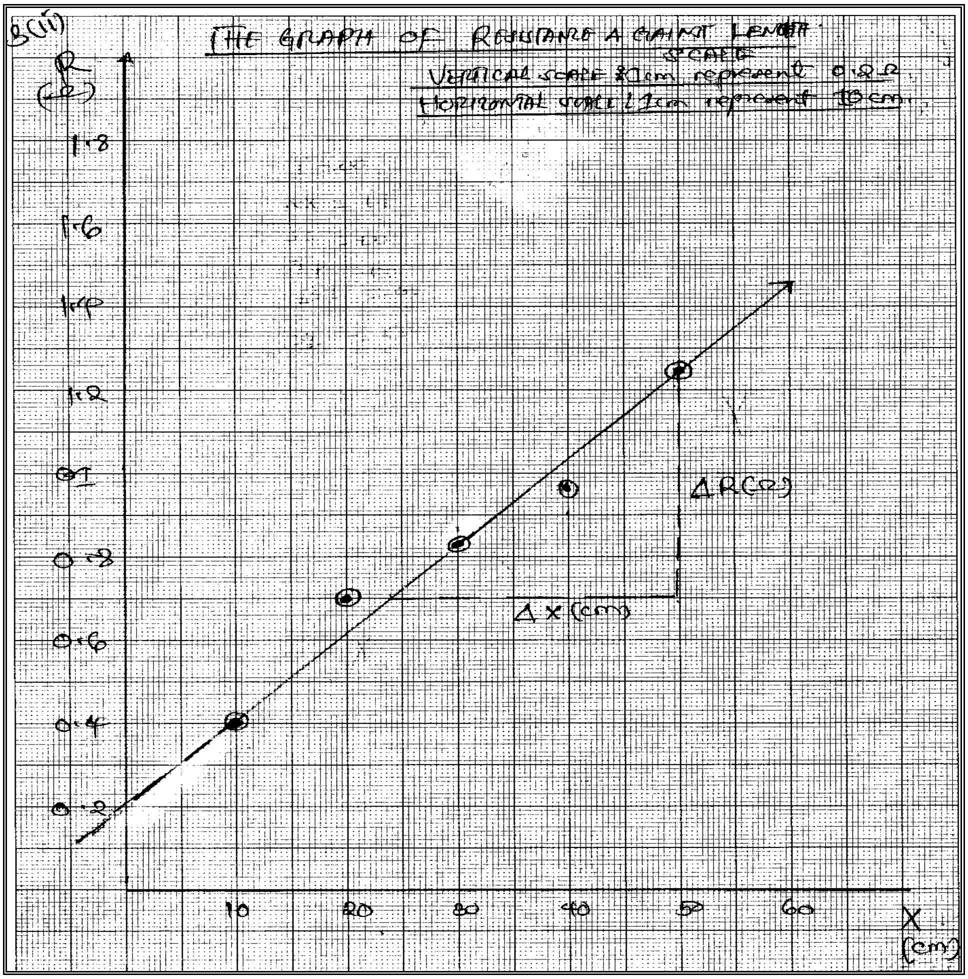
$$y = mx + c$$

$$a = \frac{\Delta R}{\Delta X}$$

$$a = \frac{0.72 - 0.41\ (\Omega)}{20 - 10\ (cm)}$$

$$a = 0.025\ \Omega cm^{-1}$$

3(iii)	The value of b
	b = y-intercept
	b = 0.27 Ω.
(iv)	b - is y-intercept'
(v)	$\frac{b}{a}$ = 0.27 Ω / 0.025 Ωcm^{-1}
	10.8 cm
(vi)	The aim of experment is to determine the ~~Res~~ resistance of the wire



Extract 24.1: *A sample of candidates' incorrect responses to Question 3 in Paper 3B*

Extract 24.1 indicates how the candidate analysed the tested concepts and ended with incorrect answers due to wrong data values.

Despite the weak performance in this question, there were some candidates (32.4%) who demonstrated good understanding including 10.4 per cent who scored average marks. These candidates managed to set and perform the experiment as per the given instruction. Most of them prepared a table of results and then used it to plot a graph of resistance R (Ω) against the length x (cm) correctly. However, some of them faced challenges in selecting the suitable points on the best line to find slope. The candidates who scored good marks (22%) demonstrated competence in mathematical skills. These candidates applied computational skills to elaborate and solve equations to identify the physical meaning of the terms. Extract 24.2 illustrates the correct responses.

3. i) TABLE OF RESULTS

Length X cm	Balancing length (L) (cm)	fixed resistance	Unknow resistance
10	40	2	3
20	33.5	2	4.16
30	27.6	2	5.3
40	24	2	6.3
50	20.5	2	7.4

from

$$\frac{2}{L_1} = \frac{R_{eq}}{100 - L_1}$$

$$200 - 2L_1 = L_1 \cdot R_{eq}$$

$$R_{eq} = \frac{200 - 2l_1}{L_1}$$

$$R_{eq} = \frac{200 - 2 \times 40}{40}$$

$$= 3.09\Omega$$

$$R_{eq} = \frac{200 - 2 \times 33.5}{33.5}$$

$$= 4.16\Omega$$

3.	$R_{eq} = \dfrac{200 - 2 \times 27.6}{27.6}$
	$= 5.3\,\Omega$ —— iii
	$R_{eq} = \dfrac{200 - 2 \times 24}{24}$
	$= 6.3\,\Omega$ —— iv
	$R_{eq} = \dfrac{200 - 2 \times 20.5}{20.5}$
	$= 7.4\,\Omega$ —— v
	iii) Given that:
	$X = \dfrac{R}{a} - \dfrac{b}{a}$
	but from the graph
	$\text{Slope} = \dfrac{\Delta R}{\Delta x}$
	then
	$y = mx + c$
	$X = \dfrac{R}{a} - \dfrac{b}{a}$
	$X + \dfrac{b}{a} = \dfrac{R}{a}$
	$R = aX + b$
	by dimensional analysis
	$R = aX$
	$\Omega = \Omega m^{-1} \times m$

3.	iii) Therefore a have dimension of length (m)
	then again
	$R = aX + b$
	$y = mx + c$
	$a = \text{slope}$
	then
	$\text{slope} = \dfrac{\text{change in } R}{\text{change in } X}$
	$= \dfrac{7.4 - 3}{50 - 10}$
	$= \dfrac{4.4\,\Omega}{40\text{ cm}}$
	$= 0.11\,\Omega\text{cm}^{-1}$
	$\therefore$ Value of "a" $= 0.11\,\Omega\text{cm}^{-1}$
	again from graph $b = y$ - intercept
	$b = 2\,\Omega$

3\. iv/ Since the value of b is constant (2Ω) then this is the resistance of the coiled wire on a wooden because its value is fixed

v/ Required to calculate ratio b/a

from $b = 2\Omega$

$a = 0.11\ \Omega\,cm^{-1}$

then

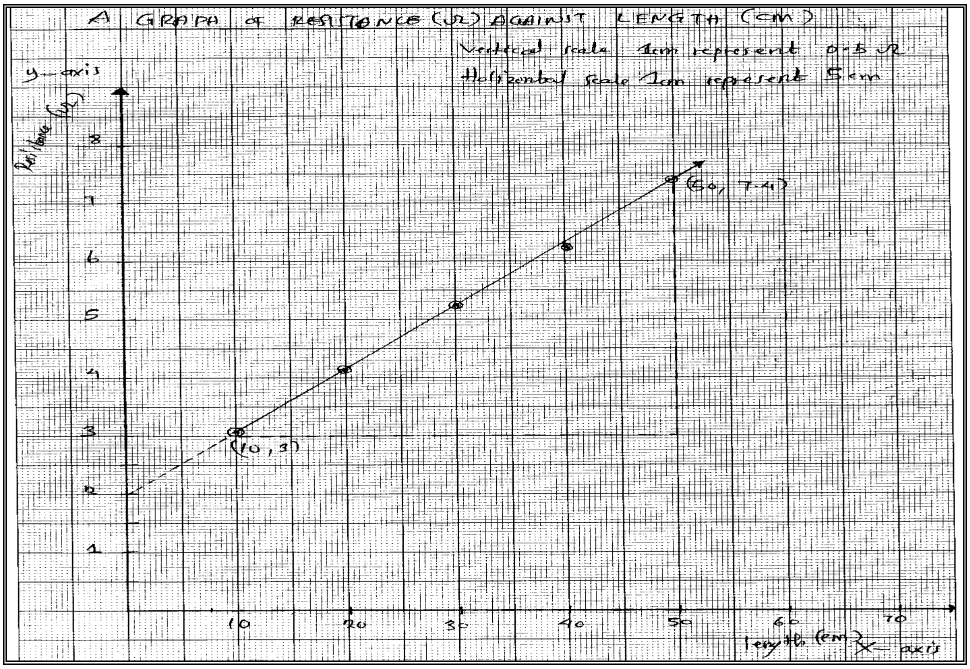
$$\frac{b}{a} = \frac{2\Omega}{0.11\ \Omega cm^{-1}}$$

$$\frac{b}{a} = 18.8cm$$

$$\therefore \frac{b}{a} = 18.8cm$$

∴ This is the length of the wire coiled on the wooden.

vi/ → The aim of this experiment is to determine the Resistance per length of the wire and to determine the length of the coiled wire.



Extract 24.2: *A sample of candidates' correct responses to Question 3 in Paper 3B*

Extract 24.2 shows that the candidate was precise in presenting, analysing and evaluating the data values to obtain the correct answers of the tested concepts.

4.3.1.8 131/3C Physics 3C

In this question the candidates were provided with dry cells, wire Y, voltmeter, masking tape, jockey, metre rule, a switch and connecting wires. Then, they were required to proceed as follows:

(a) Connect the circuit as shown in Figure 3 (presented here as Figure 33). Tape a given wire Y on a given metre rule and make sure that l_0 = 50 cm.

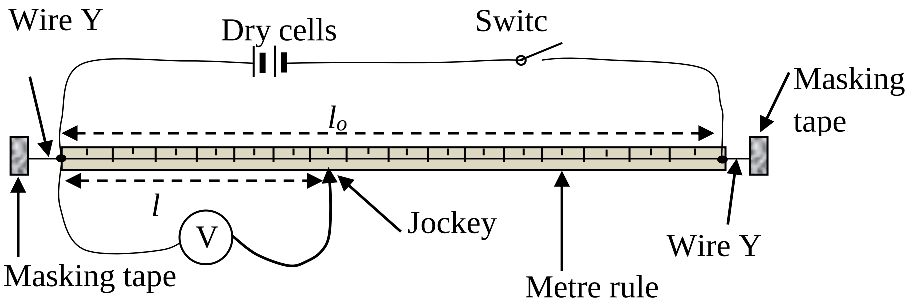


Figure 33

(b) Measure a length l = 10 cm, close the switch and record the voltage, V of the voltmeter.

(c) Repeat the procedure in 3 (b) for the values of l = 20 cm, 30 cm, 40 cm and 50 cm.

Questions

(i) Record your readings in a tabular form.

(ii) Plot a graph of V against l.

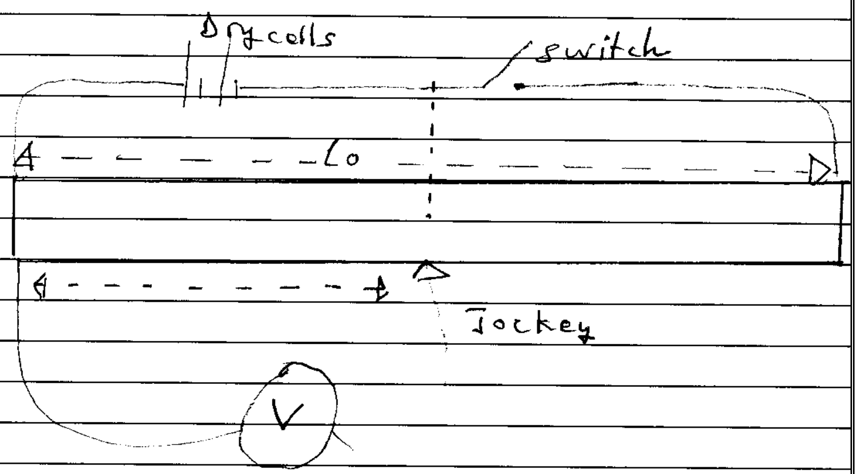
(iii) Determine the slope from your graph.

(iv) What does the slope obtained in 3 (iii) represent?

(v) Use the graph to find the length of a given wire when the voltmeter reading is 2 V.

Most of the candidates who scored low marks (67.6%) in this question lacked both practical knowledge and computational skills. Apart from being given the circuit diagram in Figure 33, they failed to connect the circuit , close the switch, read the voltmeter and record the correct values of voltage. In this particular case, most of them recorded incorrect values of voltage. Another challenge observed in their scripts was failure to interpret the drawn graphs, make analysis and evaluate the concepts tested. For example; in part (iii) one candidate wrote: *The slope obtained represent the total current flowing in the wire.* Such a candidate failed to recall the circuit formula, that, at balancing condition; $\frac{E}{l_0} = \frac{V}{l}$ or $V = \frac{E}{l_0} l$ and compare it with a straight line equation y = mx + c. The slope obtained represent the ratio $\frac{E}{l_0}$ which shows that, the resistance of a given wire increases uniformly with a length of the wire. Extract 25.1 is a sample of the incorrect responses.

03 · (a) THE DIAGRAM OF CONNECTED CIRCUIT.



(b) (i) TABLE OF RESULTS

Length of the wire, l (cm)	Voltage, V
20	0.5
30	0.3
40	0.2
50	0.1

03 (b) (iii) $Slope = \frac{\Delta V}{\Delta L}$

$Slope = \frac{0.2 - 20}{40 - 0.5}$

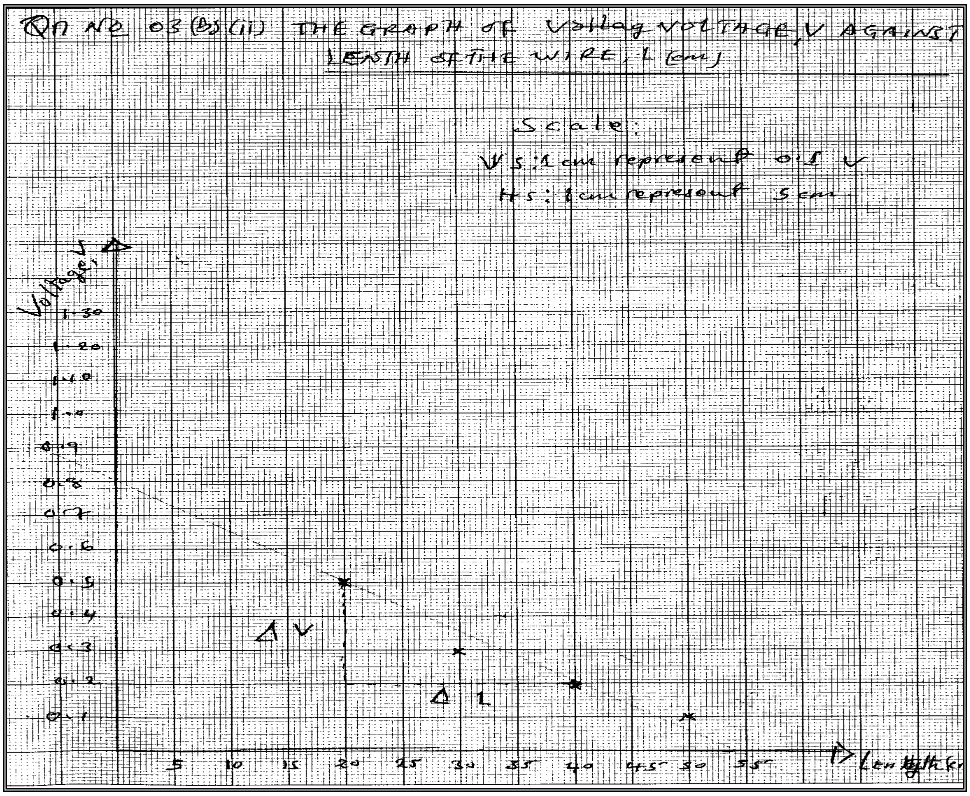
$Slope = -79.8$

$Slope = \frac{-19.8}{39.5} = -0.5$

∴ the slope of the graph is −0.5.

(iv) The slope obtained represent the ~~the re~~ Resistivity of the wire.

(v) the of the wire is 70 cm.



Extract 25.1: *A sample of candidates' incorrect responses to Question 3 in Paper 3C*

In extract 25.1, the candidate failed to adhere the given instruction on part (b). He/she started recording the voltage at the length, l = 20 cm instead of l=10 cm and received wrong data values. For this reason the drawn graph with negative slope was not correct.

In contrast, few (10.4%) candidates who scored average marks demonstrated average skills of recording and tabulating the correct data values. Most of them were able to plot a graph and used the points at the slope indication to determine the slope. In addition, 22 per cent of the candidates who scored good marks (9 - 15) demonstrated good skills in performing experiments regarding the concept of meter bridge. These candidates demonstrated their competence and skills by recalling and employing the theory of meter bridge to formulate a circuit formula. They further compared such formula with a straight line equation to identify what the slope of the graph represents. Finally, they managed to analyse the plotted graph at the value of 2 V to determine the length of the wire. Extract 25.2 is a sample of the correct responses.

3. Solution:

c) I. TABLE OF RESULTS:

L (cm)	V (v)
10	0·5
20	1·1
30	1·9
40	2·3
50	2·8

III) Slope:

From:

$$\text{Slope} = \frac{\Delta V (v)}{\Delta L (cm)}$$

$$\text{slope} = \frac{V_1 - V_2}{L_1 - L_2}.$$

But: From the graph:

A (35, 2·0)

B (10, 0·6)

$$\text{Slope} = \frac{(2{\cdot}0 - 0{\cdot}6)\,v}{(35 - 10)\,cm}$$

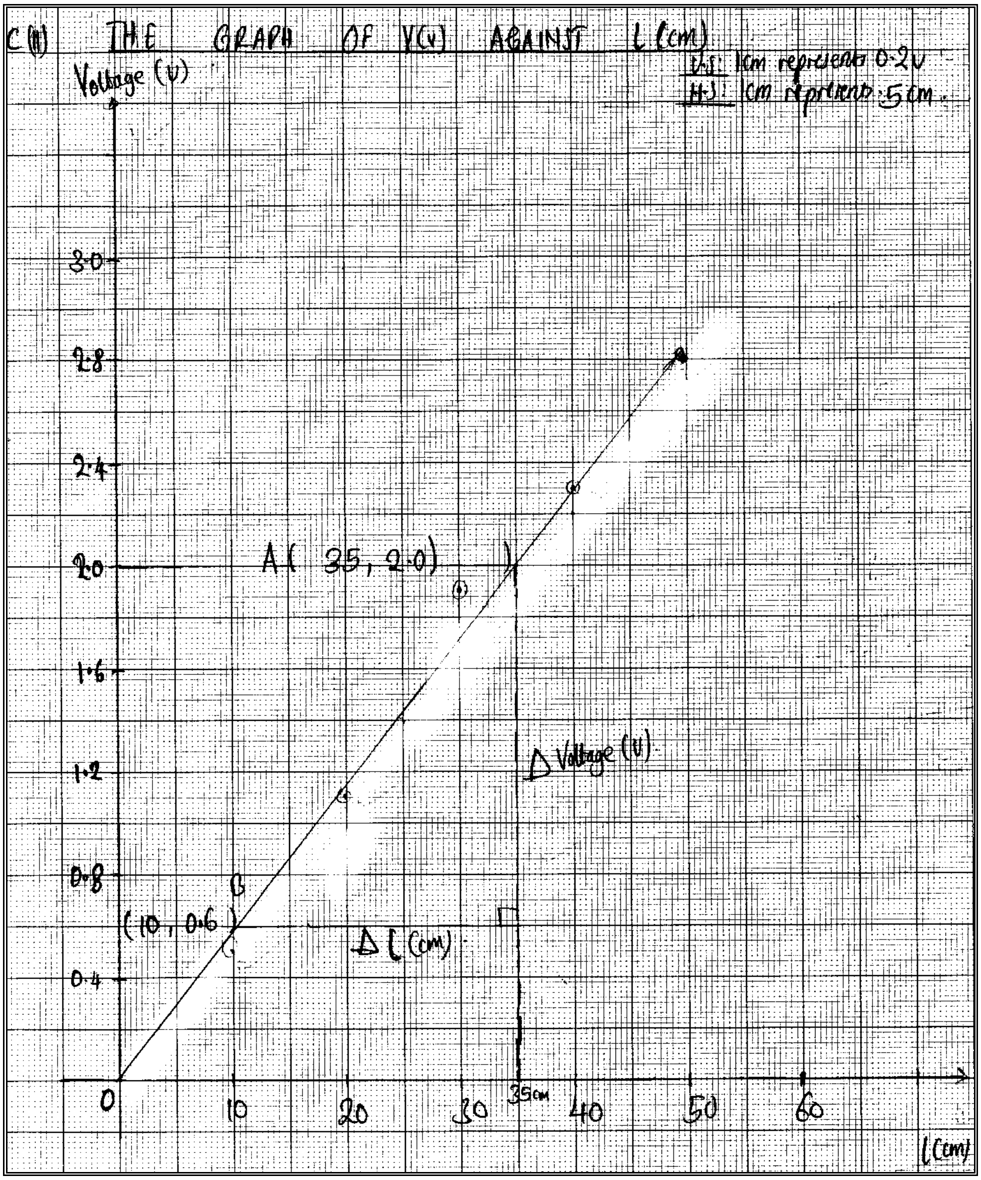
$$\text{Slope} = 0{\cdot}056\,Vcm^{-1}.$$

$\therefore$ Slope is $0{\cdot}056\,Vcm^{-1}$.

IV. The slope obtained indicates the potential gradient of the ~~curr~~ wire in circuit.

3 C. V) From the graph:

For Value of V is 2v, the length of the wire will be 35 cm.



Extract 25.2: *A sample of candidates' correct responses to Question 3 in Paper 3C*

Extract 25.2 indicates how the candidate was systematic and precise in presenting the correct experimental data values. He/she correctly selected the points from slope indication on the graph to determine the slope and identify what it represents.

5.0 ANALYSIS OF CANDIDATES' PERFORMANCE PER TOPIC

In Physics Paper 1, six (6) topics were tested. These topics included *Measurement, Mechanics, Heat, Environmental Physics, Current Electricity* and *Electronics*. Similarly, in Physics Paper 2, also six (6) topics were examined including *Fluid Dynamics, Vibrations and Waves, Properties of Matter, Electrostatics, Electromagnetism* and *Atomic Physics*. In Physics Paper 3, three (3) topics were tested namely *Mechanics, Heat* and *Current Electricity*.

The statistical analysis reveals that candidates had good performance in four (4) out of twelve (12) topics that were tested in both Physics Paper 1 and 2. These topics are *Fluid Dynamics* (88.5%), *Structure and Properties of Matter* (84.4%), *Electronics* (66.4%) and *Mechanics* (60.3%). The candidates had average performance in three (3) topics of *Heat* (52.1%), *Vibrations and Waves* (46.3%) and *Current Electricity* (35.4%). These candidates demonstrated adequate knowledge on the subject matter as they were able to describe and analyse the concepts tested. However, some of them lacked skills of applying the correct formulas and procedures in performing calculations.

Further analysis shows that, the candidates had weak performance in five (5) topics of *Atomic Physics* (28.7%), *Environmental Physics* (25.2%), *Electromagnetism* (21.3%), *Measurement* (11.2%) and *Electrostatics* (6.3%). In Physics Paper 3 the topics of *Mechanics, Heat* and *Current Electricity* had good, average and weak performance respectively. The reasons behind weak performance include poor mastery of the subject matter, especially the tested concepts, misconceptions when presenting the ideas, lack of analytical skills, failure to describe and analyse the concepts to draw conclusion, lack of drawing skills and failure to follow the given instructions for assembling apparatuses and performing experiments. The summary of the candidates' performance in each topic is shown in Appendices I and II.

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The analysis of the candidates' performance shows that the general performance of the candidates in this year has increased by 1.35 per cent compared to the year 2020. In Physics Papers 1 and 2 the topics of *Fluid Dynamics*, *Structure and Properties of Matter*, *Electronics* and *Mechanics* had good performance. The topics which were averagely performed are *Heat*, *Vibrations and Waves* and *Current Electricity*. Further analysis indicated that the candidates' performance was weak in the questions constructed from the topics of *Atomic Physics*, *Environmental Physics*, *Electromagnetism*, *Measurement* and *Electrostatics.*

The analysis of the candidates' performance in Physics Paper 3 revealed that, question 1 which was set from the topic of *Mechanics* had good performance, question 2 from the topic of *Heat* had an average performance while question 3 from the topic of *Current Electricity* had weak performance.

One of the reasons behind candidates' weak performance in the mentioned topics is lack of knowledge of the tested concepts. Some of the candidates provided inappropriate responses to the questions due to misconceptions in analysing the concepts. They further, failed to respond correctly to the questions due to poor mastery of the subject matter.

Another factor which affected most of the candidates is lack of mathematical skills. These candidates failed to think critically, establish and apply proper formula when performing calculations. It was also observed that, some candidates attempted few parts of the questions wrongly specifically the structured type questions and skipped others. Failure in describing the concepts as well as the use of incorrect procedures in attempting the tasks greatly affected many candidates.

Moreover, poor mastery of drawing skills contributed to candidates' weak performance, especially in Physics Paper 3 of which, question 1, 2 and 3 required the candidates to plot graphs. Most of them ignored the important aspects to consider when drawing graphs. They also faced difficulties in specifying the title of the graphs, including their units, the axes with their respective S.I units, the scales used, the transfer of points, the best line or curve and the slope indication which could help them score good marks. Furthermore, they failed to tabulate the table of results, interpret the plotted graph and analyse the data to make conclusion.

6.2 Recommendations

In order to improve the candidates' performance in Physics Examinations in the future, teachers are strongly advised to:

(a) guide students in their groups to discuss how wind, rainfall, humidity and air temperature influence plant growth;

(b) assist students in groups to brainstorm the methods of extracting geothermal energy and identify types of seismic waves and their characteristics;

(c) provide students with enough tests and examinations so as to improve their confidence and ability to describe, analyse and evaluate the tested concepts;

(d) encourage students to put more effort on reading text and reference books in order to improve their knowledge about concepts, theories, laws and formula in performing calculations;

(e) assist students to be critical when reading the questions. This could help them organise the concepts before attempting it;

(f) use participatory methods to guide students to conduct experiments to test different concepts of *Mechanics*, *Heat* and *Current Electricity* on time as stipulated in Physics Syllabus;

(g) demonstrate to students how to assemble the apparatuses, perform an experiment, tabulate the table of results, analyse the data and the technique used in plotting the proper graphs;

(h) guide students to discuss the structure of the magnetic field for a long straight conductor, a circular coil and a solenoid;

(i) help students to perform an experiment to identify the relationship between magnetic force and magnetic flux, current and length of a conductor;

(j) lead students in groups to discuss and identify criteria for stable and unstable nucleus; and

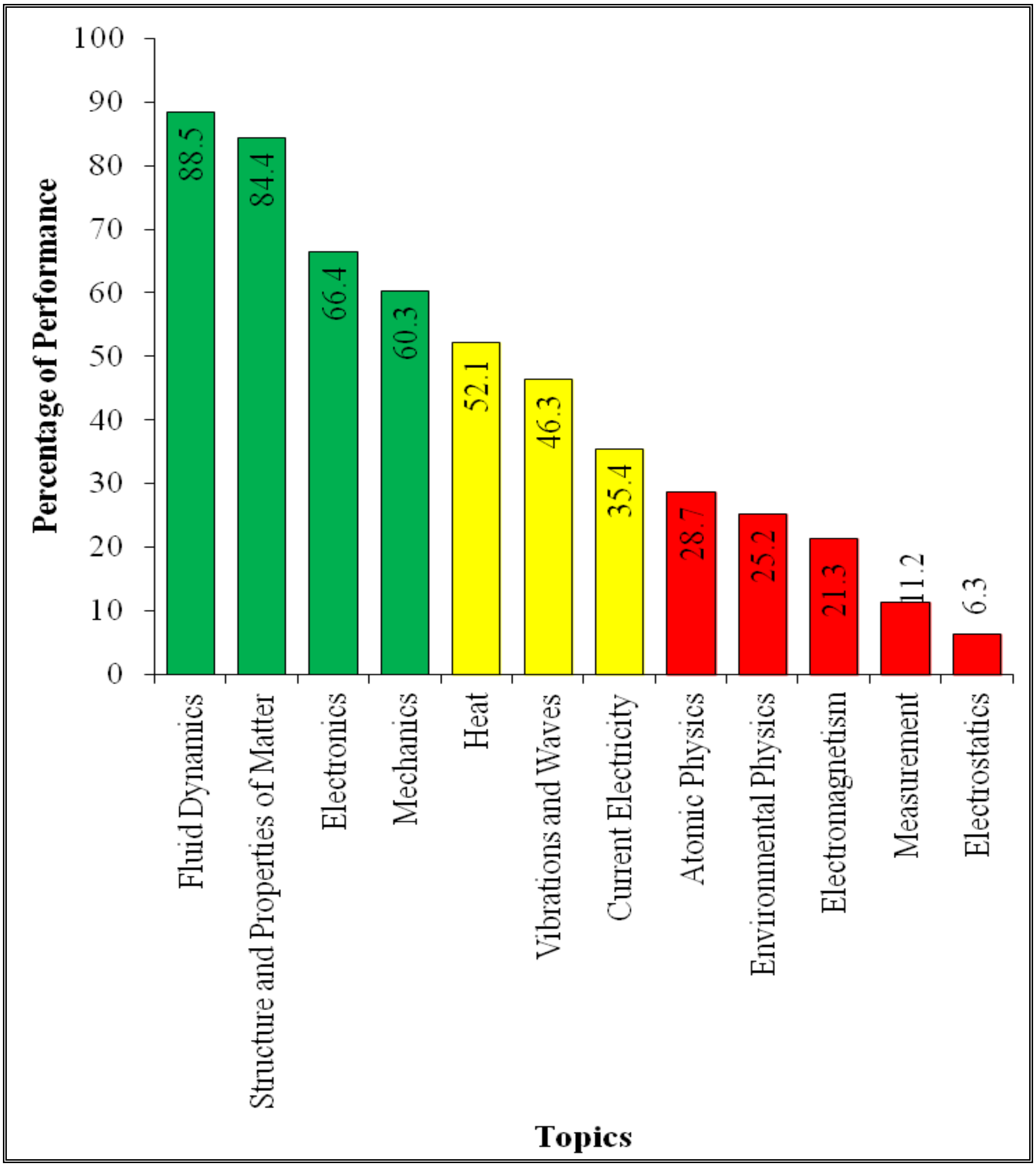
(k) assist students acquire drawing skills by providing them with more assignments during practical sessions.

Appendix I

THE CANDIDATES’ PERFORMANCE IN EACH TOPIC IN PHYSICS 1 & 2 IN THE YEAR 2021

S/n.	Topic	2021 EXAMINATION PAPER		
		Number of questions	Percentage of Candidates Who Scored an Average of 35 Percentage or Above	Remarks
1	Fluid Dynamics	1	88.5	Good
2	Structure and Properties of Matter	1	84.4	Good
3	Electronics	2	66.4	Good
4	Mechanics	3	60.3	Good
5	Heat	2	52.1	Average
6	Vibrations and Waves	1	46.3	Average
7	Current Electricity	1	35.4	Average
8	Atomic Physics	1	28.7	Weak
9	Environmental Physics	1	25.2	Weak
10	Electromagnetism	1	21.3	Weak
11	Measurement	1	11.2	Weak
12	Electrostatics	1	6.3	Weak

(i)


Percentage of Performance
100
90
80
70
60
50
40
30
20
10
0
88.5
84.4
66.4
60.3
52.1
46.3
35.4
28.7
25.2
21.3
11.2
6.3
Fluid Dynamics
Structure and Properties of Matter
Electronics
Mechanics
Heat
Vibrations and Waves
Current Electricity
Atomic Physics
Environmental Physics
Electromagnetism
Measurement
Electrostatics
Topics

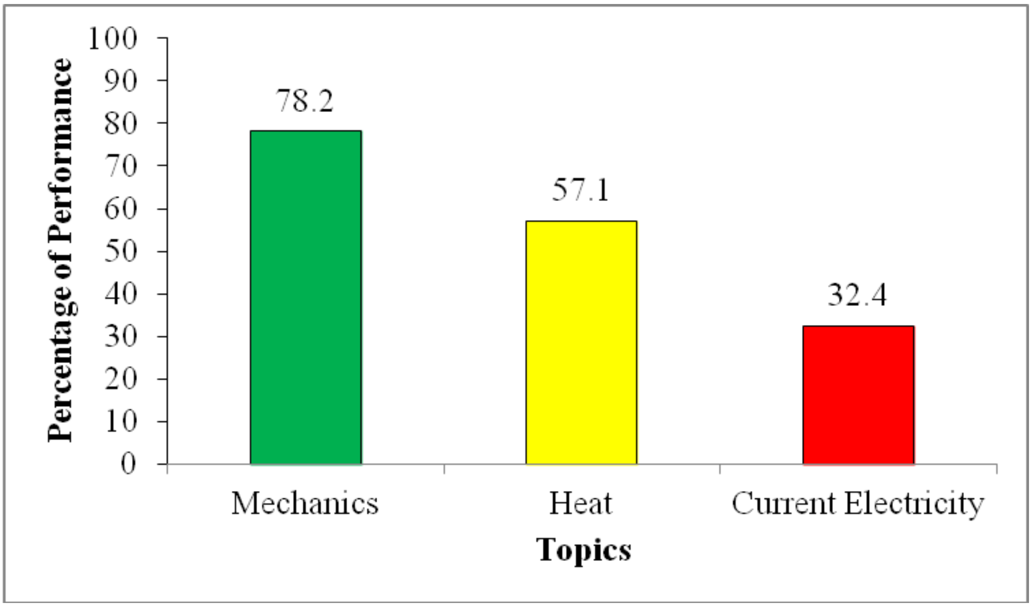
(ii)

Appendix 1I

THE CANDIDATES' PERFORMANCE IN EACH TOPIC IN PHYSICS PAPER 3 (Actual Practical Paper 3A, 3B & 3C) IN THE YEAR 2021

S/N	Topic	Question Number	Percentage of Candidates Who Scored an Average of 35 Percentage or Above	Remarks
1.	Mechanics	1	78.2	Good
2.	Heat	2	57.1	Average
3.	Current Electricity	3	32.4	Weak

(i)



(ii)