THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2016

131 PHYSICS

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FOREWORD

The Advanced Certificate of Secondary Education Examination (ACSEE) marks the end of two years of secondary education. It gives a picture of the effectiveness of the education system in general and education delivery system in particular as it is a summative evaluation. The candidates' answers to the examination questions are a strong indicator of what the education system was able or unable to offer to the students in their two years of secondary education.

The candidates' items response analysis report on Physics subject ACSEE 2016 was prepared in order to give feedback to students, teachers, parents, policy makers and the public in general on how the candidates responded to the examination questions.

The report highlights some of the factors which made the candidates fail to score high marks in the questions. The factors include failure to identify the task of the question, inability to follow instructions, lack of mathematical skills, and inadequate knowledge of the topics. The views provided will help the educational administrators, school managers, teachers and students to identify proper measures to be taken in order to improve the candidates' performance in future examinations administered by the Council.

The National Examinations Council of Tanzania will highly appreciate observations and suggestions from teachers, students and the public in general that can be used in improving future examiners' reports.

Finally, the Council would like to thank the Examiners and different stakeholders who participated in the preparation of this report.

Dr. Charles E.Msonde
EXECUTIVE SECRETARY

1.0 INTRODUCTION

This report is based on the analysis of candidates' responses to the 2016 ACSEE questions in Physics paper 1 & 2. The papers projected to measure and evaluate the skills acquired by the candidates which are stipulated in the 2010 syllabus, and it adhered to the 2011 Examination format.

Physics paper 1 comprised fourteen (14) questions which were categorized into three sections A, B and C. Section A was composed of six (6) questions and section B and C had four (4) questions each. The candidates were required to answer ten (10) questions by choosing four (4) questions from section A, three (3) questions from section B and three (3) questions from section C.

Physics paper 2 had three sections, namely A, B and C. Each section was comprised of three (3) questions to make a total of nine (9) questions. Candidates were instructed to answer five (5) questions by choosing at least one (1) question from each section.

A total of 17,466 candidates sat for Physics examination of which 80.34 percent passed the examination and 19.66 percent failed. In 2015, the number of candidates who sat for Physics examination was 13,106 of which 85.7 percent passed the examination. This implies that the candidates' performance in this year has dropped by 5.36 percent.

The following section analyses the candidates' responses in relation to the demands of the questions in the course of analysis brief notes on what the candidates were required to do and the reasons for their performance are provided. The samples of candidates' responses are also inserted as extracts to illustrate the cases presented. Also graphs and charts are used to summarize the candidates' performance in particular question. The analysis categorizes the performance as good, average and poor, if the percentage of the candidates who scored from 35 percent or more of the marks allocated in the question lies in the interval of 60–100, 35–59 and 0–34 respectively. Green, yellow and red colours are used to denote good, average and weak performance respectively. The report also contains an appendix which indicates the general performance in each topic. Finally, it provides some recommendations that may help to improve the candidates' performance in the future examinations.

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

2.1 Question 1: Measurements

This question was divided into three parts: (a), (b) and (c). In part (a) the candidates were required to (i) define the term dimension of a physical quantity, and (ii) find the dimensions of diffusion constant D, given that the number of particles *n* crossing a unit area perpendicular to the x–axis in a unit time is given by $n = -D\frac{(n_2 - n_1)}{(x_2 - x_1)}$ where n_1 and n_2 are the number of particles per unit volume for the values of x_1 and x_2 respectively. In part (b) the candidates were required to (i) mention two basic rules of dimensional analysis, and (ii) use dimensions to show how the frequency, f of a vibrating string is related to the applied force, F, the length, l of the string and the mass per unit length, µ. Part (c) required the candidates to (i) give the meaning of least count of a measurement and (ii) calculate the maximum percentage error in the measurement of g when the period of oscillation of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$ where by 100 vibrations were taken to measure 200 seconds and that the least count for the time and length of a pendulum of 1m are 0.1sec and 1mm respectively.

A total of 14,081(80.6%) candidates attempted this question, of which 46.4 percent scored from 0 to 3.0 marks. Out of these 4.8 percent scored 0. The data show that 40.7 percent scored 3.5 to 5.5 marks and 12.9 percent scored from 6.0 to 10.0 out of 10 marks allocated to this question. These data are presented in Figure 1.

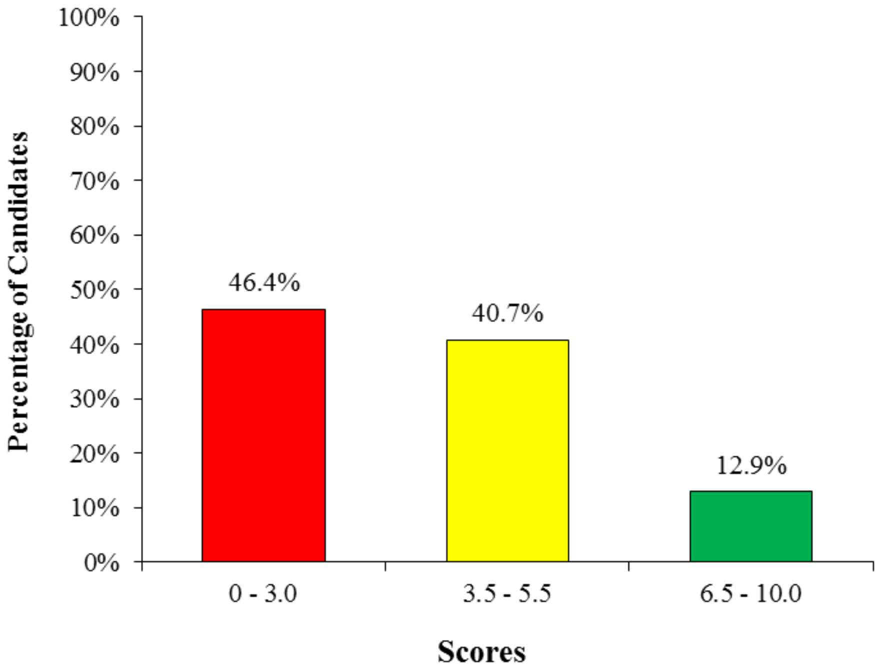


Figure 1: Illustration of candidates' performance in question 1.

Figure 1 shows that the candidates who scored 3.5 marks or above were 53.6 %, this is an indication that the general performance in the question was average.

Those candidates who performed well in this question had adequate knowledge on the concept of measurements. They provided the correct definition of the term dimension of a physical quantity, used correctly dimensional analysis to find the dimension of the diffusion constant D, mentioned correctly the basic rules of dimensional analysis and used the rules to show the relationship between f and quantities F, l and µ. They were also able to define correctly the term least count of a measurement and they calculated correctly the percentage error in the measurement of g. Extract 1.1 shows the responses from the candidate who answered the question correctly.

Extract 1.1

1. (a) (i) Dimension of a physical quantity is a power to which the fundamental quantities (Mass, length and time) have to be raised so as to represent that physical quantity.

Example; dimension of area = $[L^2]$.

(ii) Given;

$$n = -D\frac{(n_2 - n_1)}{(x_2 - x_1)}.$$

~~Hati~~ Required dimensions of $D = ?$

Making D the subject;

$$D = -n\frac{(x_2 - x_1)}{(n_2 - n_1)} \quad \text{———(i)}$$

now;

$$n = \frac{\text{Number of particles}}{\text{Area} \times \text{time}} = \frac{1}{[L^2T]}.$$

$$[n] = [L^{-2}T^{-1}].$$

$$[x_2 - x_1] = \text{distance crossed} = [L].$$

$$n_2 - n_1 = \frac{\text{Number of particles}}{\text{Volume}} = \frac{1}{[L^3]}$$

$$[n_2 - n_1] = [L^{-3}]$$

On plugging the values on eqn (i) above.

$$[D] = \frac{[L^{-2}T^{-1}][L]}{[L^{-3}]} = \left[\frac{L^{-1}T^{-1}}{L^{-3}}\right]$$

$$[D] = [L^2T^{-1}]$$

1\. (a) (ii) $\therefore$ Dimension of diffusion constant, $D = [L^2T^{-1}]$

(b) (i) Basic rules of dimensional analysis are;

- Addition or subtraction of quantities takes place to those only having same dimensions.
- An equation is dimensionally correct if each and every term on either side of an equal sign are the same. (i.e have same dimensions).

(ii) Given;

$$f \propto F\, l\, \mu .$$

$$f = kF^x l^y \mu^z \quad \text{——— (i)}$$

where;

k is dimensionless constant

x, y and z are unknown variables

Dimensions of each term are

$[f] = [T^{-1}]$, $[F] = [MLT^{-2}]$, $[L] = [L]$

$[\mu] = [ML^{-1}]$

On inserting the dimensions on eqn (i)

$$[M^0L^0T^{-1}] = [MLT^{-2}]^x [L]^y [ML^{-1}]^z .$$

$$[M^0L^0T^{-1}] = (M^{x+z}\, L^{x+y-z}\, T^{-2x})$$

On equating the indices ;

1. (b) (ii) for M;

$0 = x + z$ ——(i)

for L

$0 = x + y - z$ ——(ii)

for T

$-1 = -2x$

$x = \frac{1}{2}$.

from (i)

$z = -x$.

$z = -\frac{1}{2}$

from (ii)

$y = z - x = -\frac{1}{2} - \frac{1}{2}$

$= -1$.

$y = -1$

Then;

$f = k F^{\frac{1}{2}} L^{-1} \mu^{-\frac{1}{2}}$.

$f = k \frac{1}{L}\sqrt{\frac{F}{\mu}}$

$f = \frac{k}{L}\sqrt{\frac{F}{\mu}}$

$\therefore$ f is related to F, L and μ in → $f \propto \frac{1}{L}\sqrt{\frac{F}{\mu}}$.

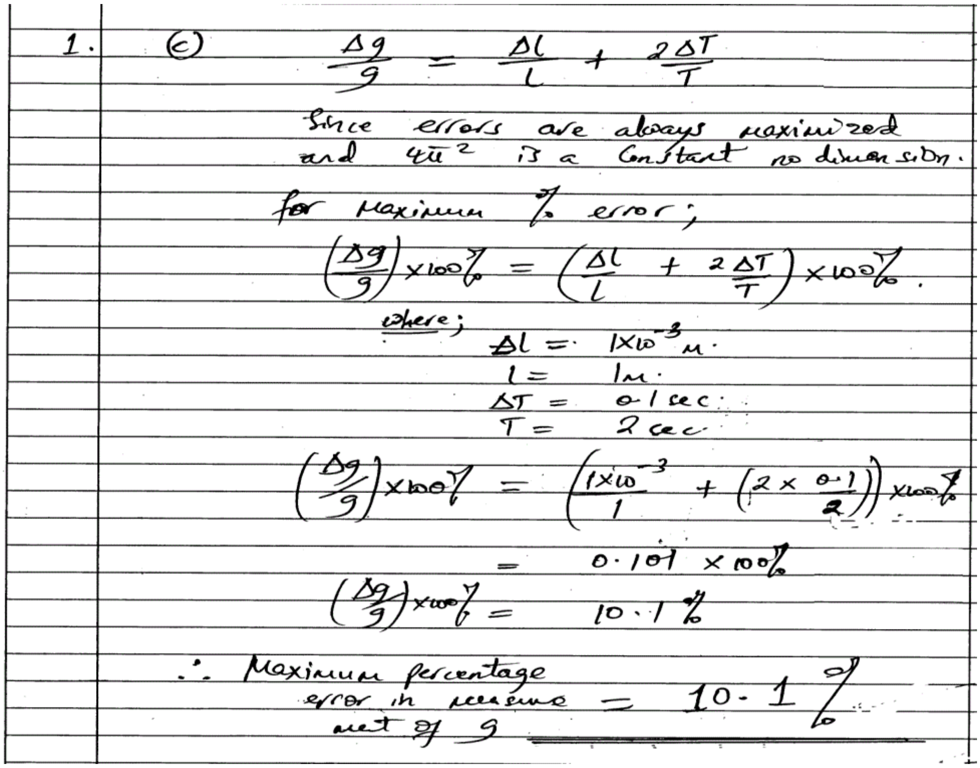
1. (c) (i) least count of a measurement is that smallest measurement that can be made accurately by an instrument;
E.g; least count of Vernier Calliper is 0.01 cm.

(ii) Given;
$$T = 2\pi\sqrt{l/g}$$

length of pendulum, l = 1m.
least count in length, Δl = 1mm $(= 1\times10^{-3}\,m)$.
least count in time, Δt = 0.1 sec.
Time for one vibration, $T = \frac{200\ sec}{100}$
$= 2\ sec.$

Required Maximum percentage error in g = ?%.

Making g the subject in given eqn;
$$T^2 = 4\pi^2 \cdot \frac{l}{g}$$
$$g = \frac{4\pi^2 l}{T^2}$$
Introducing ln both sides;
$$\ln g = \ln\left(\frac{4\pi^2 l}{T^2}\right)$$
Differentiating both sides;


1. (c) $\frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$

Since errors are always maximized and $4\pi^2$ is a constant no dimension.

for maximum % error;

$$\left(\frac{\Delta g}{g}\right)\times 100\% = \left(\frac{\Delta l}{l} + \frac{2\Delta T}{T}\right)\times 100\%.$$

where;
$\Delta l = 1\times 10^{-3}\ m.$
$l = 1m.$
$\Delta T = 0.1\ sec.$
$T = 2\ sec$

$$\left(\frac{\Delta g}{g}\right)\times 100\% = \left(\frac{1\times 10^{-3}}{1} + \left(2\times\frac{0.1}{2}\right)\right)\times 100\%$$

$$= 0.101 \times 100\%$$

$$\left(\frac{\Delta g}{g}\right)\times 100\% = 10.1\%$$

∴ Maximum percentage error in measurement of g = 10.1%

Extract 1.1 shows how the candidate attempted the question and provided correct responses to all the parts of the question. He/she defined the terms correctly, found the dimension of diffusion constant D and followed correctly the procedures in calculating the percentage error in measurement of g.

On the other hand, some of the candidates who performed poorly in this question could not define the term dimension of a physical quantity and some of them stated the dimensions of *velocity* LT^{-1} instead of *length L*. Yet others stated the dimensions of *mass per unit length* as *ML* instead of ML^{-1}. They were also unable to use dimensional analysis to find the dimensions of diffusion constant D. A few candidates were able to mention the basic rules of dimensional analysis but failed to use them in showing the relationship between *f* and quantities *F*, *l* and µ. They also failed to calculate the maximum percentage error in the measurement of g, implying showing that they had inadequate knowledge on the concepts of dimension of physical quantities and had poor numerical skills in parts involving mathematics. Extract 1.2 is from a candidate who performed this question poorly.

Extract 1.2

1\. (a) Dimension of physical quantity
— Is the quantity which is depend on the quantity physical properties such as mass, Length and Volume.

(b) Rules of dimensional analysis.
(i) The equation must be Correct.
(ii) There is no Unit in the dimensional analysis is Unitless.

(ii) Given.
F - frequency
l - Length
M - Using dimension show how
f is related to F, l, and M.

Soln

$F = [MLT^{-1}]$

$L = [ML^{-1}T]$

$M = [MLT]$

$F, L, M = [MLT^{-1}][ML^{-1}T][MLT]$

$[MLT^{-1}][ML^{-1}T][MLT^{-}]$

$f = [MLT^{-1}][ML^{-1}T][MLT^{-1}]$

$f = [MLT^{-}][ML^{-1}T][MLT^{-1}]$

(c) i) Least Count of a measurement - Is the Last Count which recorded during the Experiment.

(ii) Data Given

from

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

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

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

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

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

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

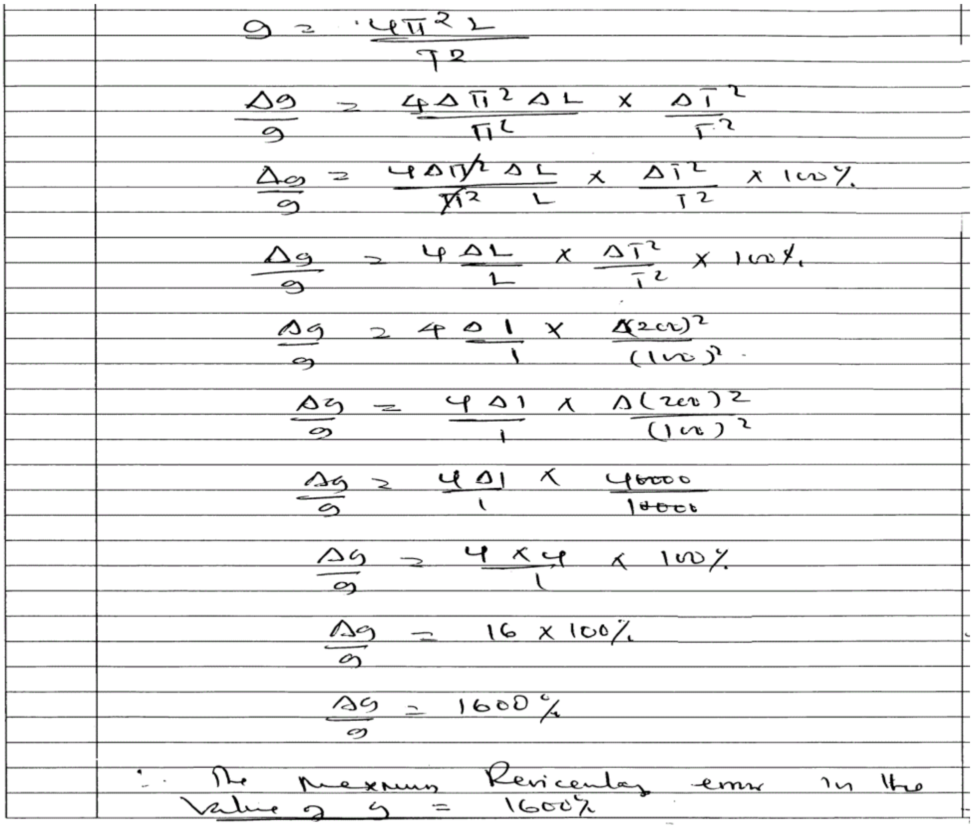
$$g \times T^2 = 4\pi^2 \frac{L}{g} \times g$$

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

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

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

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



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

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

$\frac{\Delta g}{g} = \frac{4\Delta\pi^2 \Delta L}{\pi^2 \; L} \times \frac{\Delta T^2}{T^2} \times 100\%$

$\frac{\Delta g}{g} = \frac{4\Delta L}{L} \times \frac{\Delta T^2}{T^2} \times 100\%$

$\frac{\Delta g}{g} = \frac{4\Delta 1}{1} \times \frac{\Delta(200)^2}{(100)^2}$

$\frac{\Delta g}{g} = \frac{4\Delta 1}{1} \times \frac{\Delta(200)^2}{(100)^2}$

$\frac{\Delta g}{g} = \frac{4\Delta 1}{1} \times \frac{40000}{10000}$

$\frac{\Delta g}{g} = \frac{4 \times 4}{1} \times 100\%$

$\frac{\Delta g}{g} = 16 \times 100\%$

$\frac{\Delta g}{g} = 1600\%$

∴ The maximum Rericentag error in the value g is = 1600%

Extract 1.2 shows the work of a candidate who failed to define the term dimension of the physical quantity and to find the dimensions of diffusion constant D. The candidate stated the dimensions of length as $ML^{-1}T$ instead of L and the dimensions of mass per unit length as MLT instead of ML^{-1}. Although the candidate successfully managed to make g the subject, he/she failed to calculate the maximum percentage error in the measurement of g.

2.2 Question 2: Projectile Motion and Newton's Laws of Motion

This question was divided into three parts: (a), (b) and (c). In part (a) the candidates were required to (i) mention two characteristics of projectile motion, and (ii) calculate the angle of projection and initial velocity given the range of the projectile is 120m, its time of flight is 4sec and acceleration due to gravity is 10m/s^2. In part (b) (i) the candidates were required to state the principles on which the rocket propulsion is based and in (b) (ii) they were given that "A jet engine on a test bed takes in 40kg of air per second at a velocity of 100m/s and burns 0.80kg of fuel per second and after compression and heating the exhaust gases are ejected at 600m/s relative to the air craft". Then they were required to calculate the thrust of engine. Part (c) required the candidates to calculate the reading on the spring balance with an object of 2kg when the lift is (i) going up with the rate of 0.2m/s^2,

(ii) going downwards with an acceleration of $0.1 m/s^2$, and (iii) ascending with uniform velocity of 0.15m/s.

The question was attempted by 80.0 percent of the candidates, out of which 63.4 percent scored below 3.5 marks out of 10 marks. A total of 10.7 percent scored 0. The candidates who scored from 3.5 to 5.5 marks were 25.1 percent and those who scored from 6.0 to 10 marks were 11.5 percent. These data are pictorially presented in Figure 2.

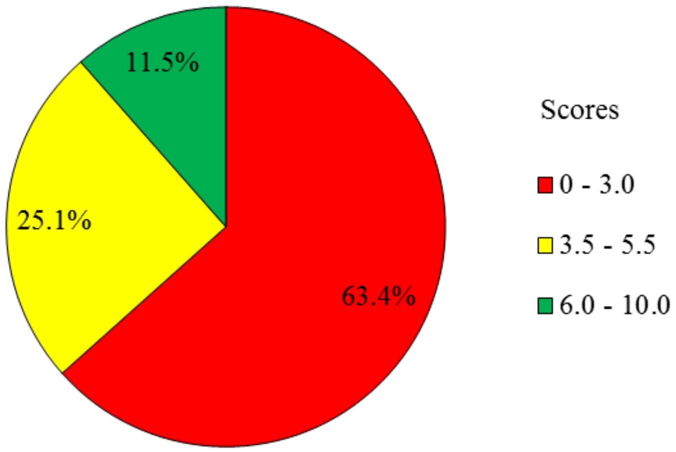


Figure 2: A summary of candidates' performance in percentage.

The data presented in Figure 2 indicate that a total of 36.6 percent of the candidates scored 3.5 marks or above, which is an average performance.

The candidates who performed well in this question were able to mention correctly the characteristics of projectile motion. They used appropriate formula and correctly manipulated the data to determine the angle of projection and the initial velocity of projection. Moreover, they were able to state the principles on which the rocket propulsion is based and used proper formula to calculate the thrust of the engine. Finally, they were also able to properly calculate the reading on the spring when the lift is going upwards, downwards and when ascending with uniform velocity. Extract 2.1 shows the responses from the script of one of the candidates who answered the question correctly.

Extract 2.1

maximum percentage error of g
= 0.2%

2.(a) i. CHARACTERISTICS OF PROJECTILE MOTION

- It is a 2 dimensional motion, this means that its movement can be regarded into the vertical and Horizontal motion

-

ii soln data.

Given

Range = 120m.

T (Time of flight) = 4 secs

$\theta = ?$

$g = 10m/s.$

$u_o = ?$

From

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

$$T = \frac{2u_o \sin\theta}{g}$$

$$T^2 = \frac{4u_o^2 \sin^2\theta}{g^2} \quad \text{--- (i)}$$

$$R = \frac{2u_o^2 \sin\theta\cos\theta}{g} \quad \text{--- ii}$$

Dividing the equations i ÷ ii

$$\frac{T^2}{R} = \frac{4u_0^2\sin^2\theta}{g^2} \times \frac{g}{2u_0^2\sin\theta\cos\theta}$$

$$\frac{T^2}{R} = \frac{2\tan\theta}{g}$$

but $T = 4$

$R = 120$.

$$\frac{4^2}{120} = \frac{2\tan\theta}{10}.$$

$$\frac{4^2 \times 10}{120 \times 2} = \tan\theta.$$

$$\theta = \tan^{-1}\left(\frac{4^2 \times 10}{120 \times 2}\right.$$

$$\theta = 33.69^\circ$$

Initial velocity = ?

from.

$$T = \frac{2u_0\sin\theta}{g}.$$

$$u_0 = \frac{Tg}{2\sin\theta}$$

$$u_0 = \frac{4 \times 10}{2 \times \sin(33.69^\circ)}$$

$u_0 = 36.1\ m/s.$

Initial velocity = $\underline{36.1\ m/s}$.

2 (b) i. The principle states that, "In an isolated system the total momentum of the system remains constant".

2 (b) ii soln data.

Given.

$\frac{dm_i}{dt} = 40kg/s$

$u_i = 100m/s.$

$\frac{dm_f}{dt} = 0.8\ kg/s.$

$u_f = 600m/s.$

$$\text{Thrust} = u_f\left(\frac{dm_i}{dt} + \frac{dm_f}{dt}\right) - \frac{dm_i}{dt}u_0$$

$$= 600(40 + 0.8) - 100 \times 40$$

$$= \underline{20480N}.$$

Extract 2.1 shows a sample of responses from a candidate who answered correctly a large part of the question but only failed to state the principles on which the rocket propulsion is based.

On the contrary, some of the candidates who performed poorly failed to mention the characteristics of projectile motion. For example, one of the candidates mentioned "neglection of air resistance and acceleration is directed towards fixed point" as the characteristics of projectile motion. The candidate should have mentioned *constant horizontal motion* and *vertical motion assumes a constant acceleration due to gravity*. The majority gave the characteristics of the projectile motion as *the motion is horizontal as well as vertical*. Likewise, they failed to calculate the angle of projection and initial velocity of projection as they used the incorrect formula. They also failed to state the principles on which the rocket propulsion is based and consequently they failed to calculate the thrust of the engine. The candidates who scored average marks were able to mention the characteristics of projectile motion and they determined correctly both the angle of projection and its initial velocity of projection. They also performed well part (c) of the question but failed to do part (b) which involved the concepts of rocket propulsion. Extract 2.2 shows a sample of responses from a candidate who performed poorly.

Extract 2.2

2. (a) i/ Characteristics of Projectile motion

— A body Must be moved due to the Under the gravity force.

— A body must occur at a certain angle

ii/ Data given

Range = 120 m

Time of flight = 4 sec

Acc due to gravity = 10 ms⁻²

Angle of Projection = ? required

Initial velocity of Projection = Required ?

$V = U + at$

$V_y = U\sin\theta + at^2$

But $a = -g$

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

But

remember

$Max_{range} = \frac{U^2}{g}$

$120 = \frac{U^2}{10}$

$U^2 = 1200$

$U = \sqrt{1200}$

$U = 34.64$ m/s

(b) ii) Data given

$M_1 = 40kg$

$V_1 = 100ms^{-1}$

$M_2 = 0.80kg$

$V_2 = 600ms^{-1}$

Thrust = ? Required

$= \frac{M_1V_1 - M_2V_2}{V_2 - V_1}$

$= \frac{40 \times 100 - 0.80 \times 600}{600 - 100}$

$= \frac{4000 - 480}{500}$

$= 7.04$

∴ Thrust of the engine is 7.04.

(C) Data given

Mass of object = 2kg

ii) $V = ma$

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

$a = \frac{0.2}{2 \times 10^{-3}}$

$a = 100 m$

2. (a) ii/ Then from

$V_y = U\sin\theta - \frac{gt^2}{2}$

Velocity = 34.64m/s

~~$34.64 = U\sin\theta - \frac{10 \times 4^2}{2}$~~

~~34.64~~ =

Initial velocity = 34.64m/s

$V_y = U\sin\theta - \frac{gt^2}{2}$

$U_0 = 0$

$V_y = \frac{-gt^2}{2}$

$V = \frac{-10 \times 4^2}{2}$

$V = -80m/s$

$V_y = U\sin\theta - \frac{gt^2}{2}$

$+80 = 34.64\sin\theta - \frac{10 \times 4^2}{2}$

$+80 = 34.64\sin\theta - 80$

$80 + 80 = 34.64\sin\theta$

$160 = 34.64\sin\phi$

$\sin\theta = \frac{160}{34.64}$

$\sin\theta = 4.618937644$

$\theta = \sin^{-1}(4.618937644)$

$\theta = \alpha$

∴ The angle of projection is α and the initial velocity is 34.64m/s.

In Extract 2.2 the candidate provided incorrect responses to all parts of the question. He/she failed to mention the characteristics of projectile motion. The candidate failed to relate the formula for time of flight and range in projectile motion to obtain the angle of projection and its initial velocity of projection. He/she applied the ratio of the change in momentum to the change in velocity to calculate the thrust instead of using the rate of change of momentum (Newton's 2nd Law of Motion) to get it.

2.3 Question 3: Newton's Laws of Motion and Circular Motion

This question had three parts, namely (a), (b) and (c). In part (a) the candidates were required to (i) define the term inertia and (ii) explain why Newton's first law of motion is called the law of inertia. In part (b), the candidates were required to calculate (i) the minimum speed of water from the hose, (ii) mass of water leaving the hose each second and (iii) the force on the hose due to the water jet when a jet of water from a fire hose is capable of reaching a height of 20m given that the cross sectional area of the hose outlet is 4.0×10^{-4} m^2. In part (c) the candidates were required to (i) calculate the tension in the string and (ii) state one assumption taken to reach the answer in (c) (i) given that “A boy ties a string around a stone of mass 0.15kg and then whirls it in horizontal circle at constant speed. If the period of rotation of the stone is 0.4sec and the length between the stone and boy’s hand is 0.50m”.

A total of 12,924 (74.0%) candidates attempted the question, out of which 56.3 percent scored below 3.5 marks out of 10 marks, and 9.6 percent scored 0. The candidates who scored from 3.5 to 5.5 marks were 24.7 percent and those who scored from 6 to 10 marks were 19.0 percent. The candidates’ performance was average because 43.7 percent scored 3.5 or more out of 10 marks. A graphical representation of these data is shown in Figure 3.

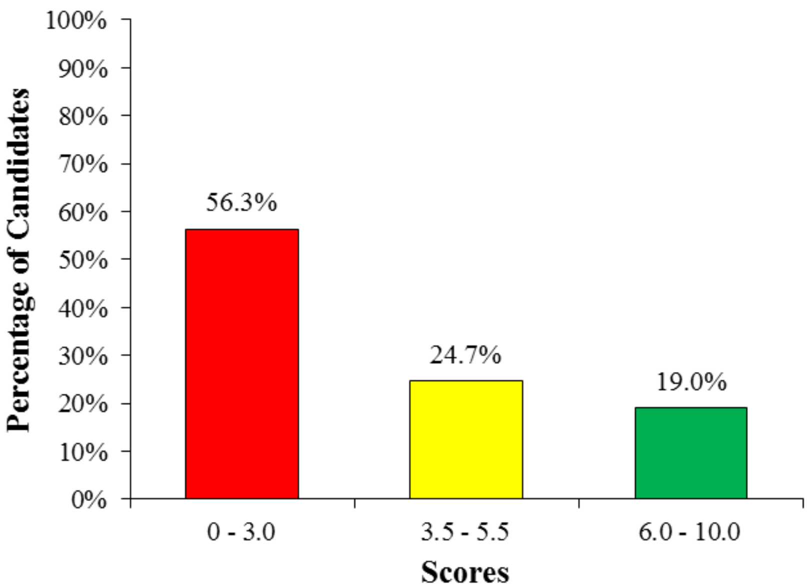
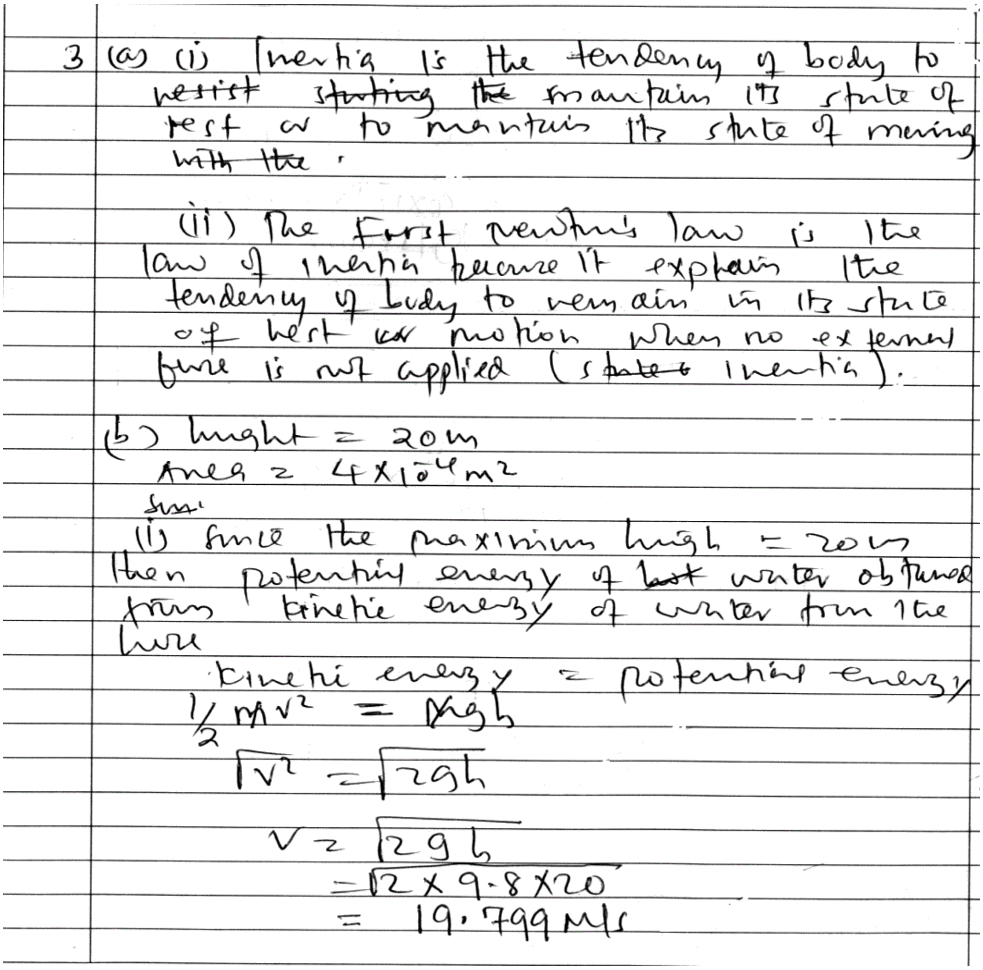


Figure 3: The performance of the candidates in question 2.

Figure 3 shows that 19.0 percent of the candidates scored 6.0-10 marks.

The candidates who performed well in this question were able to give the definition of the term inertia, explain why Newton’s first law of motion is called the law of inertia and calculate correctly the minimum speed of water from the hose, the mass of water leaving the hose each second and the force on the hose due to the water jet. Some of the candidates confused the concept of conical pendulum with a planar circular motion of an object and therefore they were unable to calculate the tension in the string. Extract 3.1 shows a sample of good responses from one of the candidates.

Extract 3.1



3 (a) (i) Inertia is the tendency of body to ~~resist~~ ~~starting the~~ maintain its state of rest or to maintain its state of moving ~~with the~~.

(ii) The First newton's law is the law of inertia because it explain the tendency of body to remain in its state of rest or motion when no external force is not applied (~~state~~ inertia).

(b) height = 20m

Area = $4 \times 10^{-4} m^2$

(i) since the maximum height = 20m then potential energy of ~~last~~ water obtained from kinetic energy of water from the base

kinetic energy = potential energy

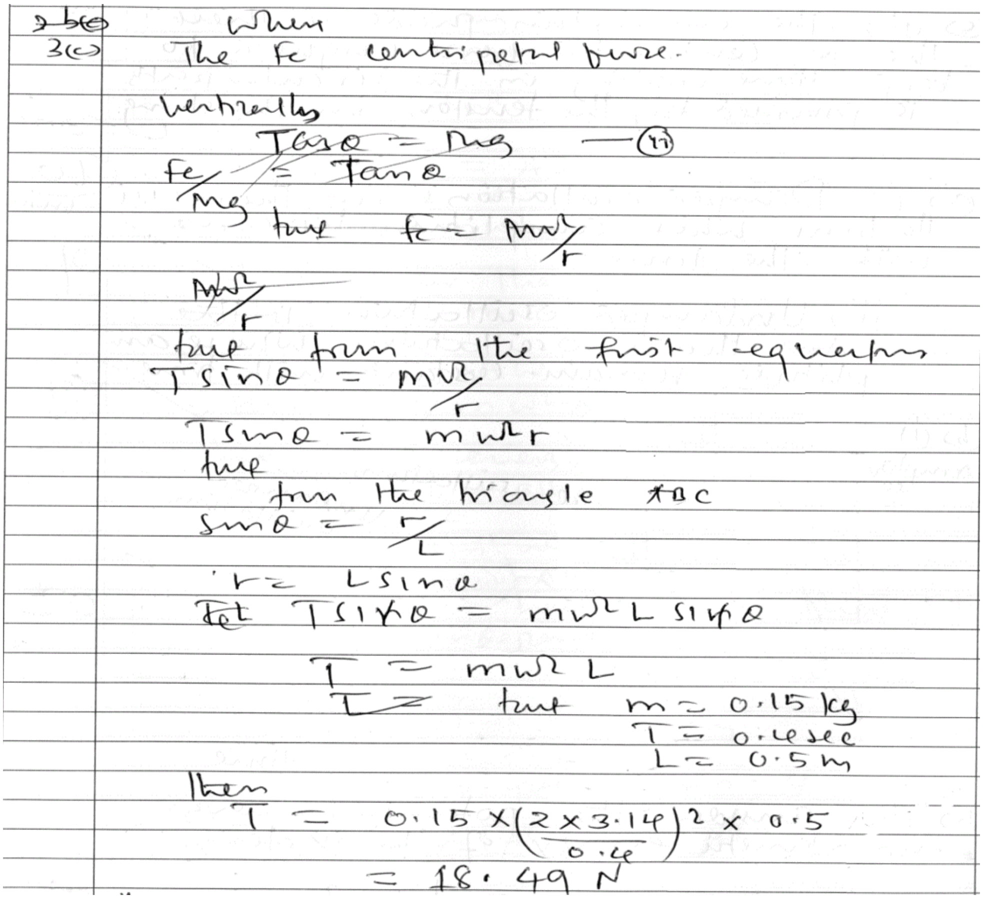
$\frac{1}{2} m v^2 = mgh$

$\sqrt{v^2} = \sqrt{2gh}$

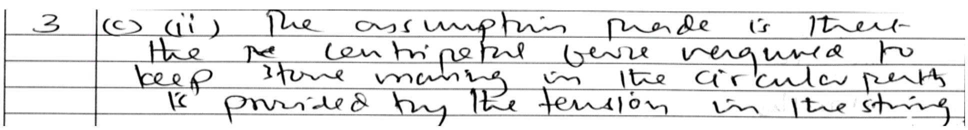
$v = \sqrt{2gh}$

$= \sqrt{2 \times 9.8 \times 20}$

$= 19.799 M/s$



2 b(c) when
3(c) The Fc centripetal force.
vertically
$T\cos\theta = Mg$ — (ii)
$Fc/Mg = \tan\theta$
true $Fc = Mv^2/r$
Mv^2/r
true from the first equation
$T\sin\theta = mv^2/r$
$T\sin\theta = m\omega^2 r$
true
from the triangle ABC
$\sin\theta = r/L$
$r = L\sin\theta$
Let $T\sin\theta = m\omega^2 L\sin\theta$
$T = m\omega^2 L$
$T =$ true $m = 0.15$ kg
$T = 0.6$ sec
$L = 0.5$ m
then
$T = 0.15 \times \left(\frac{2 \times 3.14}{0.6}\right)^2 \times 0.5$
$= 18.49$ N



3 (c) (ii) The assumption made is that the centripetal force required to keep stone moving in the circular path is provided by the tension in the string.

Extract 3.1 is the work of the candidate who provided the correct answers as required. He/she defined the term inertia, explained correctly why Newton’s first law is called the law of inertia and used correct formula in all calculations.

The candidates who performed poorly had inadequate knowledge on the concepts of Newton’s laws of motion and circular motion as they failed to define the term inertia. In explaining why Newton’s first law of motion is called the law of inertia most of the candidates were unable to recognize that every body has a tendency to maintain its state of rest or uniform motion hence it is inertia. Some of the candidates used incorrect formula and others substituted wrong data in formula or equations and hence failed to calculate the minimum speed of water from the hose, the mass of water leaving the hose each second, force on the hose due to the water jet and the tension in the string. Other candidates were able to write the required formula but failed to make substitution hence scored low marks. Extract 3.2 shows a sample answer from one of the candidates who answered the question incorrectly.

Extract 3.2

3. (i) Inertia ⇒ Is state where a body tend to move in a line of motion after abrupt stop.

(ii) Newton's first law of motion is called the law of inertia simply because it explain how inertia and its moment can occur.

(b) Given
$h = 20m$
$A = 4.0 \times 10^{-4} m^2$

(i) minimum speed

Speed = Ah
Speed = $20m \times 4.0 \times 10^{-4} m^2$
Minimum Speed = $8 \times 10^{-3} m^2$
∴ Minimum Speed = $8 \times 10^{-3} m^2$

(ii) mass of water leaving

mass (m) = $\frac{Force(F)}{Area(A)}$
$m = \frac{8 \times 10^{-3} m^2}{4.0 \times 10^{-3} m^2}$
$m = 20 kg$

∴ Mass = 20kg Ans

(iii) Force due to water jet

F = MA
$F = 20 \times 4.0 \times 10^{-4} m^2$
$F = 8 \times 10^{-3} m/s$ Ans

(c) Given
$m = 0.15kg$
$T = 0.4 Sec$
$L = 0.50m$
Tension T = ?

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

but
According to the data given
$T = F/t$

but F = mL
$F = 0.15kg \times 0.50m$
$F = 0.075$
T =
$F = 0.075$
$T = \frac{0.075}{0.4 Sec}$
$T = 0.1875 m.$

In extract 3.2 the candidate provided wrong answers to all parts of the question. The candidate wrongly calculated the speed using the formula for finding volume (Ah). He/she also calculated the mass flux as pressure, and force as a product of mass and area. Furthermore, the candidate confused tension with period of simple pendulum then expressed it in a metre which is the SI unit of displacement and not tension.

2.4 Question 4: Simple Harmonic Motion

This question required the candidates to (a) explain the terms (i) damped oscillations and (ii) undamped oscillations. In part (b) the candidates were required to (i) sketch the waveform diagrams that represent the terms in (a) (i), and (ii) show that the total energy of a body executing S.H.M is independent of time. In part (c) the candidates were required to calculate (i) maximum speed of the mass and (ii) the kinetic energy of the system when the displacement is 2.0cm given that “A mass of 0.5 kg connected to a light spring of force constant $20Nm^{-1}$ oscillates on a horizontal frictionless surface if the amplitude of the motion is 3.0cm”.

More than two thirds (68.2%) of the candidates attempted this question, of which 38.2 percent scored below 3.5 marks including 16.3 percent scored 0 marks out of 10 marks. The candidates who scored from 3.5 to 5.5 marks were 25.4 percent and those who scored from 6.0 to 10 marks were 36.4 percent. The candidates’ performance was good because 61.8% of them scored above 3.5 marks. These data are shown in figure 4.

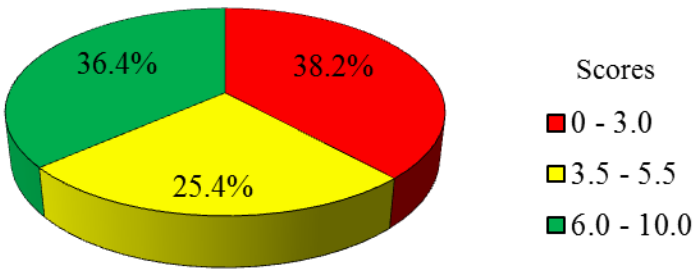


Figure 4: Illustration of candidates’ good performance in question 4.

Good performance in this question was contributed by the candidates’ good understanding of the concepts of simple Harmonic Motion. Therefore they were able to explain the meaning of the terms damped oscillations and undamped oscillations, to sketch the waveform diagrams to represent the terms damped and undamped oscillations, and to calculate the maximum speed of the mass and the kinetic energy of the system.

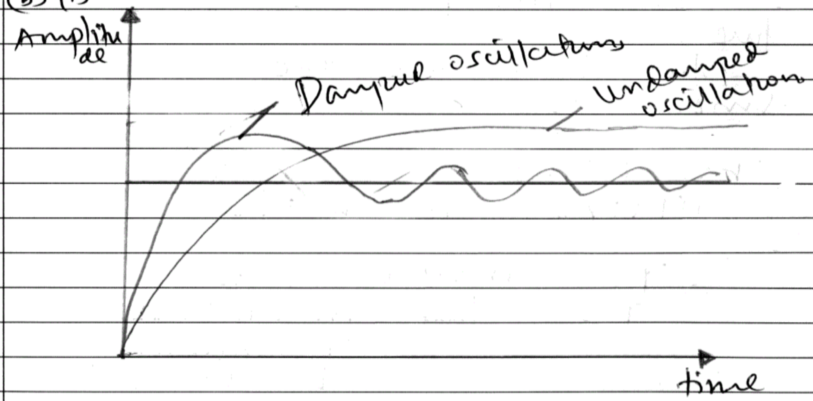
Few candidates failed to score full marks because they confused the terms overdamped with critical damped. Due to this confusion they failed to sketch correctly the required waveform diagrams. Extract 4.1 shows responses of a candidate who scored high marks.

Extract 4.1

4 (a) (i) Damped oscillations are those oscillations whose amplitudes decreases with the time.

(ii) Undamped oscillation ~~is the~~ Are those oscillations whose amplitude remain constant with time.

(b) (i)



(b) (ii) Consider the potential energy and kinetic energy of the system.

Potential energy $= \frac{1}{2}kx^2$

4 b(ii) where k - ~~spring~~ constant
but $k = m\omega^2$

$p.e = \frac{1}{2} m\omega^2 x^2$

but $x = A \sin \omega t$
where A - amplitude

$p.e = \frac{1}{2} m\omega^2 A^2 \sin^2 \omega t$

Also consider the kinetic energy

$k.e = \frac{1}{2} m v^2$

but $v = A\omega \cos \omega t$

$K.e = \frac{1}{2} m\omega^2 A^2 \cos^2 \omega t$

Then total energy = p.e + k.e

$E_T = \frac{1}{2} m\omega^2 A^2 (\sin^2 \omega t + \cos^2 \omega t)$

but $\sin^2 \omega t + \cos^2 \omega t = 1$

$E_T = \frac{1}{2} m\omega^2 A^2$

hence shown that total energy is independence of the time.

(c) Mass of body = 0.5kg
spring constant = 20N/m
Amplitude $= 3 \times 10^{-2}$m

(i) Maximum speed when $y = 0$
from

$V_r = \omega \sqrt{A^2 - y^2}$ At Vmax $y = 0$

Then

$V_{max} = \omega A$

4(c) (i) but
from $\frac{m\omega^2}{m} = \frac{k}{m}$

$\sqrt{\omega^2} = \sqrt{k/m}$

$\omega = \sqrt{k/m}$

Then

$V_{max} = A \cdot \sqrt{k/m}$

$= 3 \times 10^{-2} \sqrt{\frac{20}{0.5}}$

$V_{max} = 0.1897$ M/s.

(ii) Kinetic energy at $x = 2 \times 10^{-2}$m
from the formula of kinetic energy

$k.e = \frac{1}{2} m v^2$

$v^2 = \omega^2 (A^2 - y^2)$

$= \frac{1}{2} m\omega^2 (A^2 - y^2)$

but $\omega^2 = k/m$

$= \frac{1}{2} \frac{k}{m} \cdot m (A^2 - y^2)$

$= \frac{1}{2} k (A^2 - y^2)$

$= \frac{1}{2} \times 20 ((3 \times 10^{-2})^2 - (2 \times 10^{-2})^2)$

4c(ii)	K.E = 5×10^{-3} J

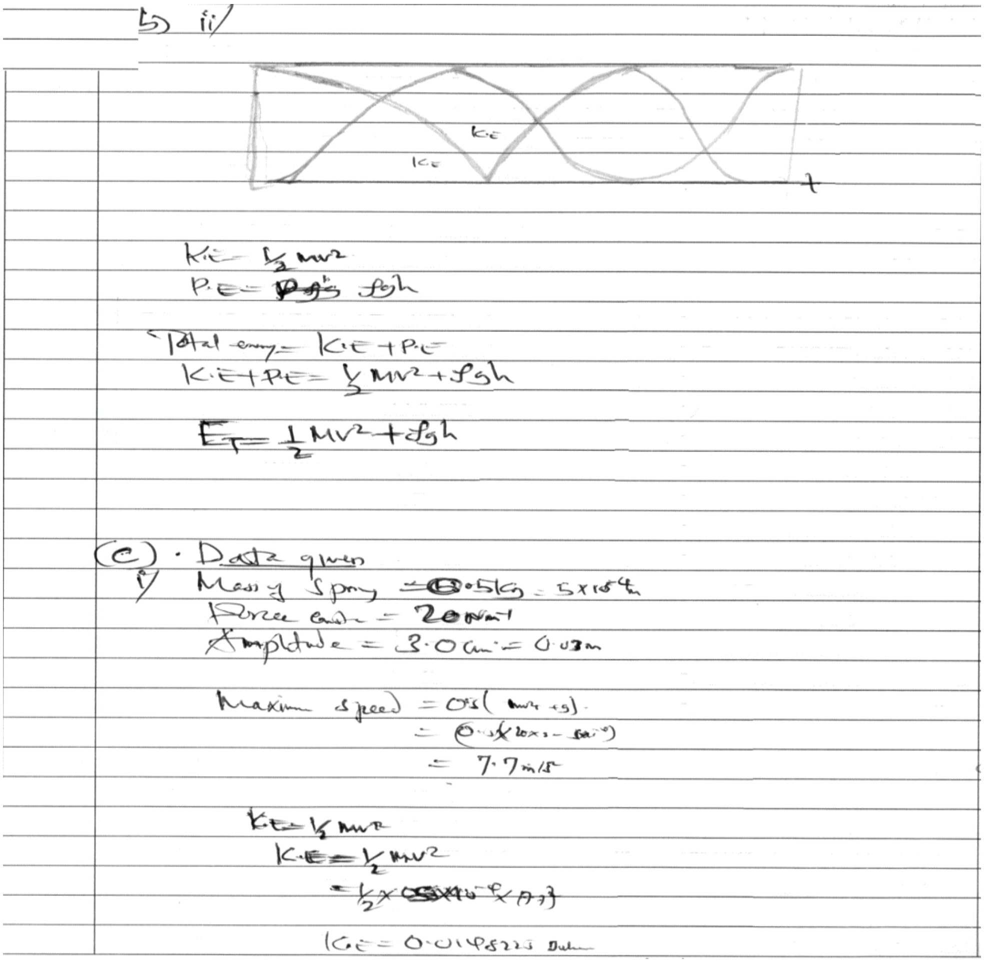
Extract 4.1 shows the responses of a candidate who provided the correct answers to almost all parts of the question. However the candidate confused the waveforms for damped and undamped oscillations and therefore sketched an incorrect waveform diagram.

On the other hand, the candidates who performed poorly in the question lacked knowledge on Simple Harmonic Motion. The analysis shows that the candidates failed to provide correct answers to most parts of the question. They were unable to explain the terms damped oscillations and undamped oscillations. For instance, some of the candidates defined damped oscillations as “torsional oscillations”, and damped oscillations as “the type of oscillations where vibrations overlap each other”. Similarly, most of the candidates could not sketch the correct waveform diagrams that represent damped and undamped oscillations. These insufficient responses indicate lack of knowledge.

Only few candidates were able to write the formula for total energy of the system but failed to obtain the required total energy in the system because they did not recognize that the total energy of the oscillating system is found by taking the sum of the kinetic energy and the potential energy. These candidates also failed to link the concepts between trigonometric functions and the derivatives of quantities like velocity which could help to show that the total energy of a body executing S.H.M is independent of time. Extract 4.2 shows the sample of incorrect response from one of the candidates.

Extract 4.2

4	(a). i/ Damped oscillation
	— Is the oscillation in which their motion are
	like a ~~torti~~ torsional
	ii/ Undamped oscillation
	— Is the type of oscillation in which a body
	move forward and backward.



b) ii/

K.E

K.E

K.E = ½ mv²
P.E = ρgh

Total energy = K.E + P.E
K.E + P.E = ½ mv² + ρgh

E_T = ½ mv² + ρgh

(c) · Data given
i/ Mass of spring = 0.5kg = 5×10⁻⁴
Force const = 20Nm⁻¹
Amplitude = 3.0cm = 0.03m

Maximum speed = ωs(...)
= (0.5(20×3 − ...))
= 7.7m/s

K.E = ½ mv²
K.E = ½ mv²
= ½ × ... × (7.7)²
K.E = 0.0148225 Joule

Extract 4.2 shows that the candidate failed to define the required terms. He/she was unable to show that the total energy for a body executing SHM is independent of time. Instead, he/she answered that the total energy is the sum of kinetic energy and pressure due to height. He/she also used incorrect formula to calculate the values of maximum speed and kinetic energy.

2.5 Question 5: Rotation of Rigid Bodies

The question had three parts: (a), (b) and (c). In part (a) the candidates were required to (a) (i) define moment of inertia, and (ii) mention two factors on which the moment of inertia of a body depends. In part (b) the candidates were required to find the moment of inertia on the plane of a thin sheet of aluminium of mass 0.032kg with the length 0.25m and width of 0.1m, about an axis parallel to the (i) length and passing through its centre of mass m, (ii) width and passing through the centre of mass m in its own plane. In part (c) they were required to (i) define the term angular momentum, and (ii) show how the final angular velocity of the rotating wheel relates with the mass m of a thin circular ring of radius r rotating about its axis with constant angular velocity ω_1 if the two objects each of mass m are attached gently to the ring.

A total of 7673 (43.9%) candidates attempted this question, out of them 25.3 percent scored 0, 57.9 percent scored from 0.5 to 3.0 marks, 13.0 percent scored from 3.5.0 to 5.5 marks, and 3.8 percent scored from 6.0 to 10 marks.

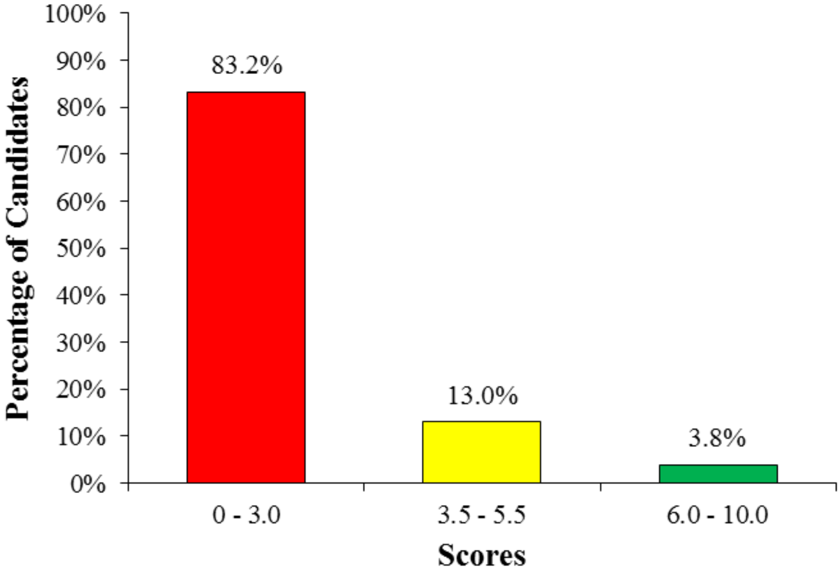


Figure 5: Percentage of candidates' performance per score in question 5.

Figure 5 shows that the performance was poor as 83.2% scored below 3.5 marks. The candidates who did not perform well had inadequate knowledge on the subject matter. Most of them were not able to calculate the moment of inertia on the plane of a thin sheet of aluminium. They used incorrect formula and did poor substitution and manipulation of data. The analysis also noted that most of the candidates were unable to calculate the angular velocity of the rotating wheel. It was revealed that some of them calculated the angular velocity as a quotient of mass and the radius instead of rate of angular displacement. They were supposed to use the law of conservation of angular momentum to find the angular velocity of the rotating wheel. Extract 5.1 shows a sample of an incorrect answer from one of the candidates.

Extract 5.1

5 (a) (i)

(ii) a/ Depend on mass of the body
b/ Surface.

b/

c/ (i) Angular momentum is the rate of change of displacement example.
Angular momentum = θ
$\theta = s/r$.

(ii) A circular ring rotating on an axis was exprienced force called centripetal force that shown below.
$F = ma$.
But a = rate of change of

5 c/ ii/ velocity

hence.

$$a = \frac{V\sin\theta - (-V\sin\theta)}{2/dt}$$

$$a \; \frac{\frac{2V\sin\theta}{2}}{dt}$$

$$a = \frac{V\sin d\theta}{dt}$$

$\sin = 1$.

$$a = \frac{V d\theta}{dt}$$

$$\frac{d\theta}{dt} = \omega$$

$$a = V\omega$$

But

$$\omega = \theta/t = V/r.$$

$$a = \frac{V.V}{r}$$

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

$F = ma$.

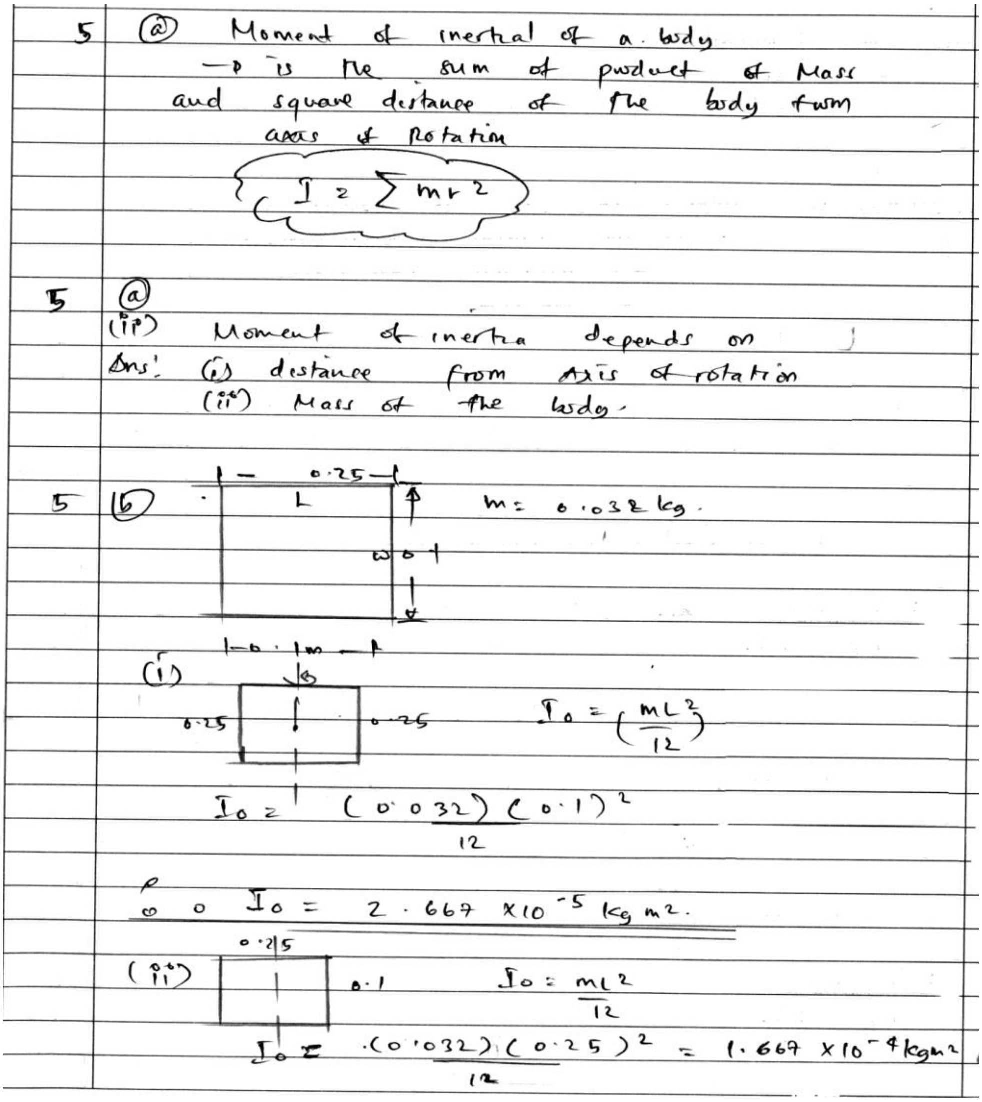
$$F = m\left(\frac{v^2}{r}\right)$$

$$\therefore F = \frac{mv^2}{r}$$ this force was exprienced by the wheel during it motion.

In extract 5.1 the candidate failed to give correct responses to all parts of the question. He/she described the surface of a body as a factor that affects moment of inertia of the body rather than the position of an axis of rotation and the mass distribution about such an axis. He/she also defined velocity instead of angular velocity.

The candidates who performed well were able to define moment of inertia, and mentioned correctly the factors on which the moment of inertia of a body depends. They also used the required procedures and formula to calculate the moment of inertia on the plane of a thin sheet of aluminium. Most of the candidates were able to define the term angular momentum and they used correctly the law of conservation of angular momentum to calculate the angular velocity of the rotating wheel. Extract 5.2 displays the work of a candidate who performed the question well.

Extract 5.2



5 (a) Moment of inertial of a body
→ is the sum of product of Mass and square distance of the body from axis of Rotation

$I = \sum mr^2$

5 (a) (ii) Moment of inertia depends on
Ans: (i) distance from Axis of rotation
(ii) Mass of the body.

5 (b) m = 0.032 kg.

(i) $I_o = \left(\frac{mL^2}{12}\right)$

$I_o = \frac{(0.032)(0.1)^2}{12}$

$\therefore I_o = 2.667 \times 10^{-5}$ kg m².

(ii) $I_o = \frac{mL^2}{12}$

$I_o = \frac{(0.032)(0.25)^2}{12} = 1.667 \times 10^{-4}$ kgm²

5 (ii) The Moment of inertia is $1.667 \times 10^{-4}\ kgm^2$

5 (c)(i) Angular Momentum: is the product of the Linear Momentum and its distance from axis of rotation

$L = P \cdot r$

$= mv \cdot r$

$= m\omega r \cdot r$

$L = mr^2\omega = I\omega$ (Angular Momentum).

5 (c) (ii) I_0 of ring (thin circular ring)

$I_0 = MR^2$ ω_1

$I_0 = Mr^2$ $I_2 = Mr^2 + 2mr^2$

From $I_0\omega_1 = I_2\omega_2$.

required ω_2.

$Mr^2\omega_1 = (Mr^2 + 2mr^2)\omega_2$

$\omega_2 = \frac{Mr^2\omega_1}{(Mr^2 + 2mr^2)}$

The angular velocity will be

$\omega_2 = \frac{Mr^2\omega_1}{(Mr^2 + 2mr^2)}$

Extract 5.2 presents a response from a candidate who managed to provide correct answers to all parts of the question.

2.6 Question 6: Gravitation

This question was divided into three parts: (a), (b) and (c). Part (a) required the candidates to (i) mention one application of parking orbit, and (ii) explain how parking orbit of a satellite is achieved. Part (b) required the candidates to calculate (i) the velocity of the satellite and (ii) the period of the satellite if the earth satellite revolves in a circular orbit at a height of 300km above the earth's surface. In part (c) the candidates were required to (i) explain why the space rockets are usually launched from west to east, and (ii) calculate the additional velocity that has to be imparted to the spaceship in order to overcome the gravitational pull given that, the spaceship is launched into a circular orbit close to the earth's surface.

The question was attempted by a total of 9,289 (53.2%) candidates of which 26.3 percent scored 0, 39.3 percent scored from 0.5 to 3.0 marks, 28.0 percent scored 3.5 to 5.5 marks and 6.4 percent scored 6.0 to 10 marks. Generally candidates' performance in this question was average because 37.4 percent of them scored from 3.5 to 10 marks. Figure 6 provides the graphical presentation of these data.

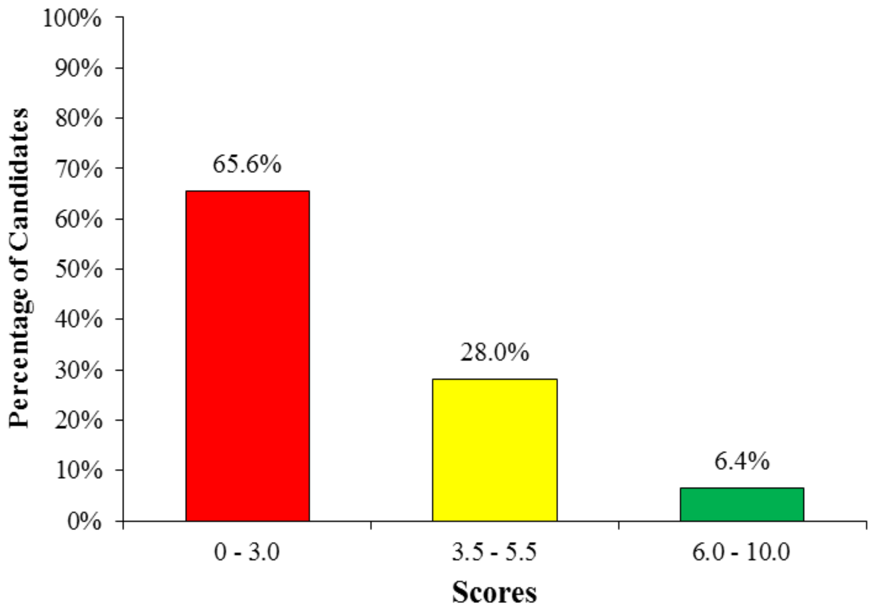


Figure 6: Percentage of candidates' performance per score in question 6.

The candidates who performed well in this question had good understanding of the concept of gravitation and therefore were able to give the application of a parking orbit, to explain how parking orbit of a satellite is achieved and to calculate the velocity of the satellite and its period. Moreover, most of these candidates were able to explain why the space rockets are usually launched from west to east and to calculate the additional velocity that has to be imparted to the spaceship in order to overcome the gravitational pull. Extract 6.1 presents a sample of good response from one of the candidates

Extract 6.1

6 (a) (i) application of Parking Orbit.

- Placing satellites which are used in communication systems.

(ii) → Orbit coplanar with the equator thus should be vertical above the equator

→ when a satellite is lounched in parking orbit with the same period as that of earth rotation 24 hrs

→ when a satellite is lounched in same direction as the rotation of the earth.

6 (b) $h = 300 \times 10^3$ m.

(i) orbital velocity.

from -

$$\frac{mv^2}{(r_e+h)} = \frac{GM_e m}{(r_e+h)^2}$$

$$v^2 = \frac{GM_e}{(r_e+h)}$$

but $GM_e = gr_e^2$.

$$v^2 = \frac{gr_e^2}{r_e+h}$$

r_e → radius of the earth.

6(b) (i)

$$v = \sqrt{\frac{g r_e^2}{(r_e + h)}}$$

$$v = \sqrt{\frac{9.8 \times (6.37 \times 10^6)^2}{(6.37 \times 10^6 + 300 \times 10^3)}}$$

$$v = 7721.28 \text{ m/s}$$

(ii) from $v = wr$

$$7721.28 = w \times (6.37 \times 10^6 + 300 \times 10^3)$$

$$w = 1.1576 \times 10^{-3}$$

$$w = \frac{2\pi}{T}$$

$$T = \frac{2\pi}{w}$$

$$T = 5424.95 \text{ seconds}$$

6 (c) (i) They are launched from west to east in order to increase velocity which is due to earth rotation thus added as a vector to velocity of a rocket.

$$V_{net} = V_e + V_r$$

V_e → velocity of the earth rotation.
V_r – velocity of rocket.
V_{net} → net velocity propelling a rocket.

6 (c) (ii) from

$v_o = \sqrt{g r_e}$

but

$v_e = \sqrt{2 g r_e}$

$v_e = \sqrt{2} \cdot v_o$

$v_o = 7901.012$

but $v_e = \sqrt{2} \cdot v_o$

$v_e = 11173.72$

Thus velocity to be increased is

$11173.72 - 7901.012$

$\Delta v = 3272.7$ m/s

The velocity should increase by 3272.7 m/s.

In extract 6.1 the candidate provided the correct responses required by the question. He/she mentioned an application of parking orbit and explained correctly all parts which required explanations. He/she also used correct formula in calculating velocity, period and additional velocity.

On the other hand, the candidates who performed poorly in this question had very little understanding of the sub-topic of gravitation as they failed to explain how parking orbit of a satellite is achieved. These candidates used wrong procedures and formula in calculating the velocity, period and additional velocity that has to be imparted to the spaceship in order to overcome the gravitational pull. They also failed to explain why the space rockets are usually launched from west to east. Extract 6.2 shows a response from a candidate who scored poorly in this question.

Extract 6.2

6 a, i, Application of parking orbit.

- It is applied in launching of the satellite in the sky.

ii,

6 b, soln

Data

$h = 300km = 300 \times 10^3 m$.

$r_e = 6.37 \times 10^6 m$

$M_e = 6 \times 10^{24} kg$

$G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$

From

$$F = \frac{GmM_e}{(r+h)^2} \quad \text{--- (i)}$$

$$F_c = \frac{mv^2}{r} \quad \text{--- ii,}$$

$$F = F_c.$$

$$\frac{GmM_e}{(r+h)^2} = \frac{mv^2}{r}.$$

$$V^2 = \frac{GM_e r_e}{(r_e+h)^2}.$$

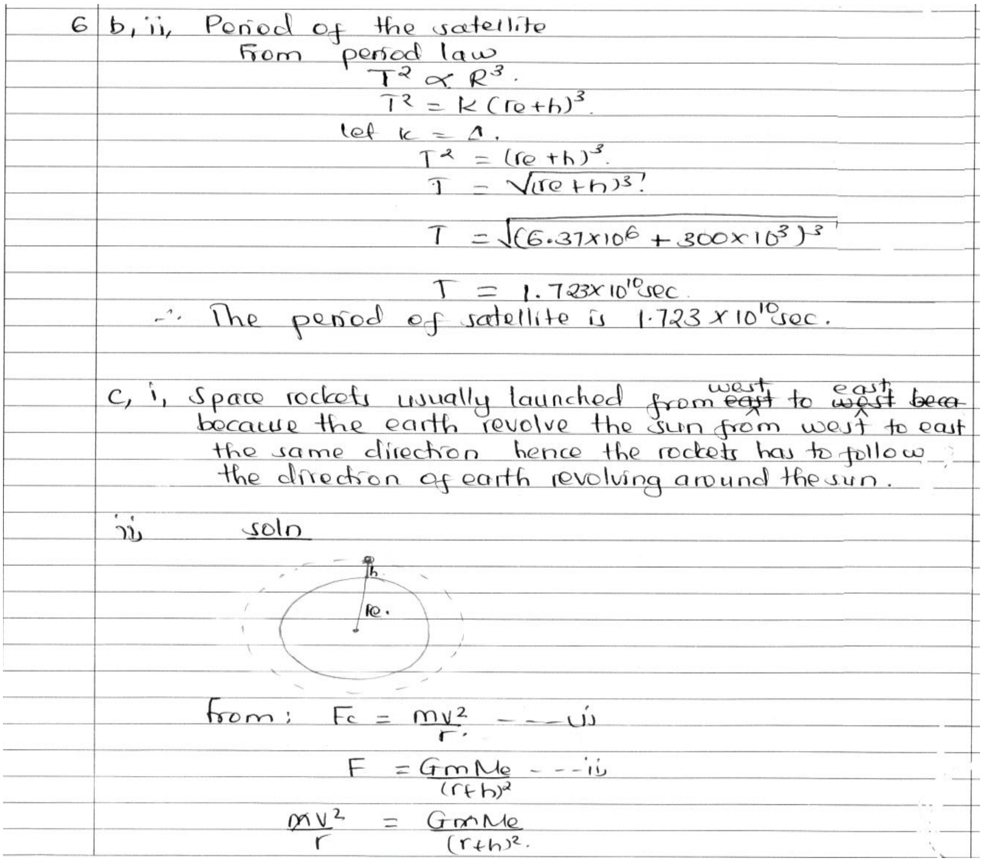
$$V = \sqrt{\frac{GM_e r_e}{r_e+h}}.$$

$$V = \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 6.37 \times 10^6}{6.37 \times 10^6 + 300 \times 10^3 m}}$$

$$V = \frac{5.049 \times 10^{10}}{6.67 \times 10^6}$$

$$V = 7569.8 m/s.$$

∴ Velocity of the satellite is 7569.8 m/s.

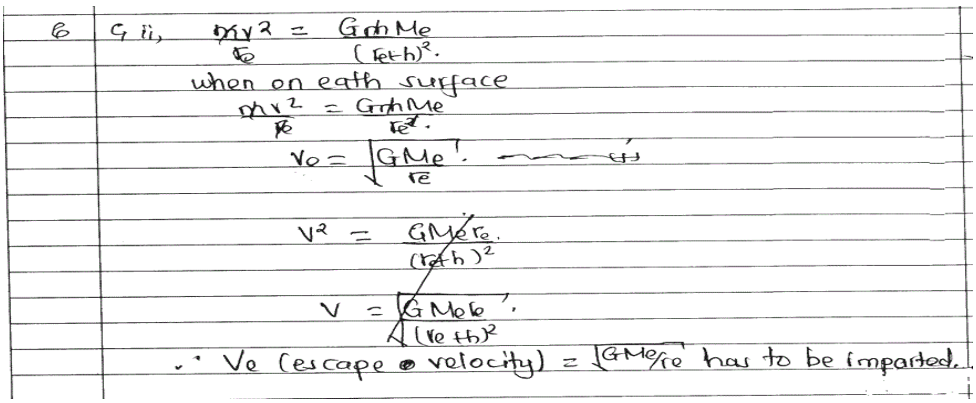


6 b, ii, Period of the satellite
From period law
$T^2 \propto R^3$.
$T^2 = K(re+h)^3$.
let $k = 1$.
$T^2 = (re+h)^3$.
$T = \sqrt{(re+h)^3}$.
$T = \sqrt{(6.37\times10^6 + 300\times10^3)^3}$
$T = 1.723\times10^{10}$ sec.
∴ The period of satellite is 1.723×10^{10} sec.

c, i, Space rockets usually launched from ~~east~~ west to ~~west~~ east ~~beca~~ because the earth revolve the sun from west to east the same direction hence the rockets has to follow the direction of earth revolving around the sun.

ii, soln

from: $F_c = \frac{mv^2}{r}$ ---(i)
$F = \frac{GmMe}{(r+h)^2}$ ---(ii)
$\frac{mv^2}{r} = \frac{GmMe}{(r+h)^2}$.



6 c ii, $\frac{mv^2}{re} = \frac{GmMe}{(re+h)^2}$.
when on eath surface
$\frac{mv^2}{re} = \frac{GmMe}{re^2}$.
$Vo = \sqrt{\frac{GMe}{re}}$. ---(i)
$V^2 = \frac{GMe\,re}{(re+h)^2}$
$V = \sqrt{\frac{GMe\,re}{(re+h)^2}}$.
∴ Ve (escape velocity) = $\sqrt{GMe/re}$ has to be imparted.

Extract 6.2 shows the work of a candidate who performed poorly in this question. The candidate was able to write the formula for calculating the orbital velocity of a satellite but failed to substitute data correctly.

2.7 Question 7: Thermometry and Thermal Conduction

This question required the candidates to (a) explain why (i) a body with large reflectivity is a poor emitter, and (ii) the earth without its atmosphere would be too cold to live. In part (b) the candidates were required to (i) identify two factors on which the coefficient of thermal conductivity of the material depends, and (ii) estimate the temperature of the part of the flame in contact with the brass boiler given that the brass boiler has the base area of $50x10^{-1}m^2$ and thickness of 1.0cm that boils water at the rate of 6.0kg/min when placed on a gas stove. In part (c) the candidates were required to (i) briefly describe the working principle of a thermocouple, and (ii) calculate neutral temperature of thermocouple thermometer of e.m.f $E = a\theta + \frac{1}{2}b\theta^2$ where θ is the temperature of hot junction, a = $10mV^0C^{-2}$, $b = -\frac{1}{20}mV^0C^{-1}$ and the cold junction is at 0^oC.

A total of 12,131 (69.5%) candidates attempted this question, of which 6.9 percent scored 0, 51.1 percent scored 0.5 to 3.0 marks, 32.5 percent scored 3.5 to 5.5 marks, and 9.5 percent scored 6.0 to 10 marks. These scores imply that the candidates' performance was average because 42.0% of them scored 3.5 or more out of 10 marks. The pie chart in Figure 7 depicts the data analysed.

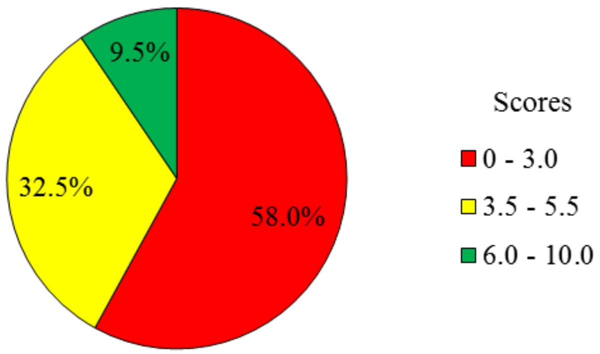


Figure 7: Percentage of candidates' performance per score in question 7.

The analysis indicates that the question was averagely performed by most of the candidates. The candidates who scored good marks (6-10) had adequate knowledge on thermometry and thermal conduction. These candidates were able to briefly explain why a body with large reflectivity is a poor emitter and why the earth without its atmosphere would be too cold to live. Most of them were able to identify factors on which the coefficient of thermal conductivity of the material depends. They were also able to use correct formula to calculate the temperature of the flame in contact with the boiler and to describe the working principle of a thermocouple. Extract 7.1 shows the work of one of the candidates who gave correct responses required by the question.

Extract 7.1

7. (a) i/ A body with large reflectivity is a poor emitter due to the fact that a body radiates or emits what it has absorbed, since it is a good reflector then it absorbs less heat therefore poor emitter.

ii/ the Earth without its atmosphere would be too cold to live due to the reason that all the radiant energy from the sun incident to the earth after reflection by the ground would be lost to the Outer space hence making the earth very cold.

(b) i/ Factors on which thermal conductivity Coefficient depends are

I. Temperature gradient of material

II. Cross sectional area of the material

$$\theta = \frac{L_v \cdot x}{KA}\left(\frac{dm}{dt}\right) + 100$$

$$\theta = \frac{2256 \times 10^3 \times 10^{-2}}{1.5 \times 10^{-1} \times K}\left(\frac{6}{60}\right) + 100$$

$$\theta = \frac{15040}{K} + 100$$

But the value of K is not provided

∴ Temperature of the flame is

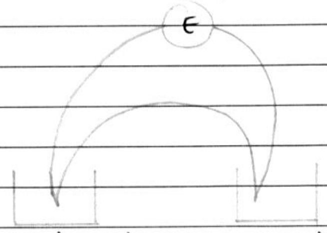
$$\theta = \left(\frac{15040}{K} + 100\right)^\circ C$$

where K is the thermal conductivity of brass

(c) Working of Thermocouple

Thermocouple is the instrument used in measuring of temperature by using the variation of emf with temperature as its thermometric property.

Consider the figure below



7 (b) ii) Required the temperature of the flame,

Data given

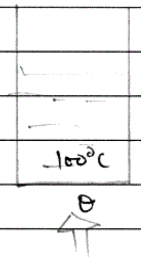
Area of brass $(A) = 1.5 \times 10^{-1}\ m^2$

thickness of brass $(X) = 1 \times 10^{-2}\ m$

Rate of water boiling $\frac{dm}{dt} = 6\ kg/min$

$$\frac{dm}{dt} = \frac{6}{60}\ kg/s$$

Consider the figure below



Recall from $Q_1 = KA \frac{d\theta}{dx}$

Also $Q_2 = L_v \frac{dm}{dt}$

Since heat conducted by the brass (Q_2) is whole used to boil the water then

$$Q_1 = Q_2$$

$$\frac{KA(\theta - 100)}{x} = L_v \frac{dm}{dt}$$

$$\theta - 100 = \frac{L_v \cdot x}{KA}\left(\frac{dm}{dt}\right)$$

$$\theta = \frac{L_v \cdot x}{KA}\left(\frac{dm}{dt}\right) + 100$$

One terminal of the thermocouple is maintained at cold junction (melting ice) and the other is maintained at hot junction (boiling water) the temperature difference results to the flow of emf whose variation is given by

$$E = a\theta + b\theta^2$$

where a and b are constants

7C ii/ Required the neutral temperature given that

$$E = a\theta + \frac{1}{2}b\theta^2$$

and $a = 10 \times 10^{-3}\ V^{\circ}C^{-2}$

$b = -\frac{1}{20} \times 10^{-3}\ mV^{\circ}C^{-1}$

at neutral temperature, where emf is maximum

$$dE/d\theta = 0$$

from $E = a\theta + \frac{1}{2}b\theta^2$

$$\frac{dE}{d\theta} = a + b\theta$$

$$0 = a + b\theta_n$$

$$\theta_n = -a/b$$

$$\theta_n = \frac{-10\ mV^{\circ}C^{-2}}{-1/20\ mV^{\circ}C^{-1}}$$

$\therefore$ Neutral temperature is $200\ ^{\circ}C$

In extract 7.1 the candidate was able to explain correctly the parts which required explanations and identified factors on which the coefficient of thermal conductivity of a material depends. He/she also used correct procedures in calculating the value of neutral point.

The candidates who performed poorly had inadequate knowledge of the concept of thermometry and thermal conduction. These candidates failed to discover that bodies which are poor absorbers of heat are good reflectors. Consequently they failed to explain why a body with large reflectivity is a poor emitter and that the earth without its atmosphere would be too cold to live. Moreover, they could not identify factors on which the coefficient of thermal conductivity of the material depends. It was noted that some of them stated "thermometric property and fixed point" as factors that affect the thermal conductivity.

Most of them used incorrect procedures and wrong formula to calculate the temperature of the part of the flame in contact with the boiler and the neutral point. Extract 7.2 shows responses of a candidate who performed poorly in this question.

Extract 7.2

7. a/ ii/ The Earth without its Atmosphere would be too cold due to fact that the Atmosphere reflects the Sun light Energy to the Earth thus if it Absent no reflecting of the Energy to the earth.

iii/ ~~For~~: large reflectivity is poor emitter because do not possess the free ions that can be stored on it.

b/ i/ from the formular of rate of Heat ~~Rch~~

$$\cancel{R}\ dQ/dt = KA\left(\frac{Q_2 - Q_1}{L}\right)$$

$$K = \frac{dQ/dt \cdot L}{A\left(\frac{Q_2-Q_1}{L}\right)}$$

The coefficient of thermal conductivity depend are

i/ the rate of heat change.

ii/ the length of the conductor

ii/ ~~Dat~~

iii/ Data collection

Area (A) = $1.50 \times 10^{-1} m^2$

Thickness (L) = ~~10~~ 1.0cm = 1×10^{-2}m.

7 5/(ii)

~~Rate of heat change dan~~

Rate of Mass change $(dm/dt) = 6t5/min$

Heat of vaporization of water $= 2256 \times 10^3$ JKg^{-1} (Lv)

Stefan's constant $5.67 \times 10^{-8} Wm^{-2}K^{-4}$.

from

$$d\theta/dt = k\left(dm/dt \cdot L \cdot v\right)$$

But

$$E = A\delta T^4.$$

Recall $E = \left(dm/dt \cdot Lv\right)$

$$\frac{dm}{dt} \cdot Lv = A\delta T^4.$$

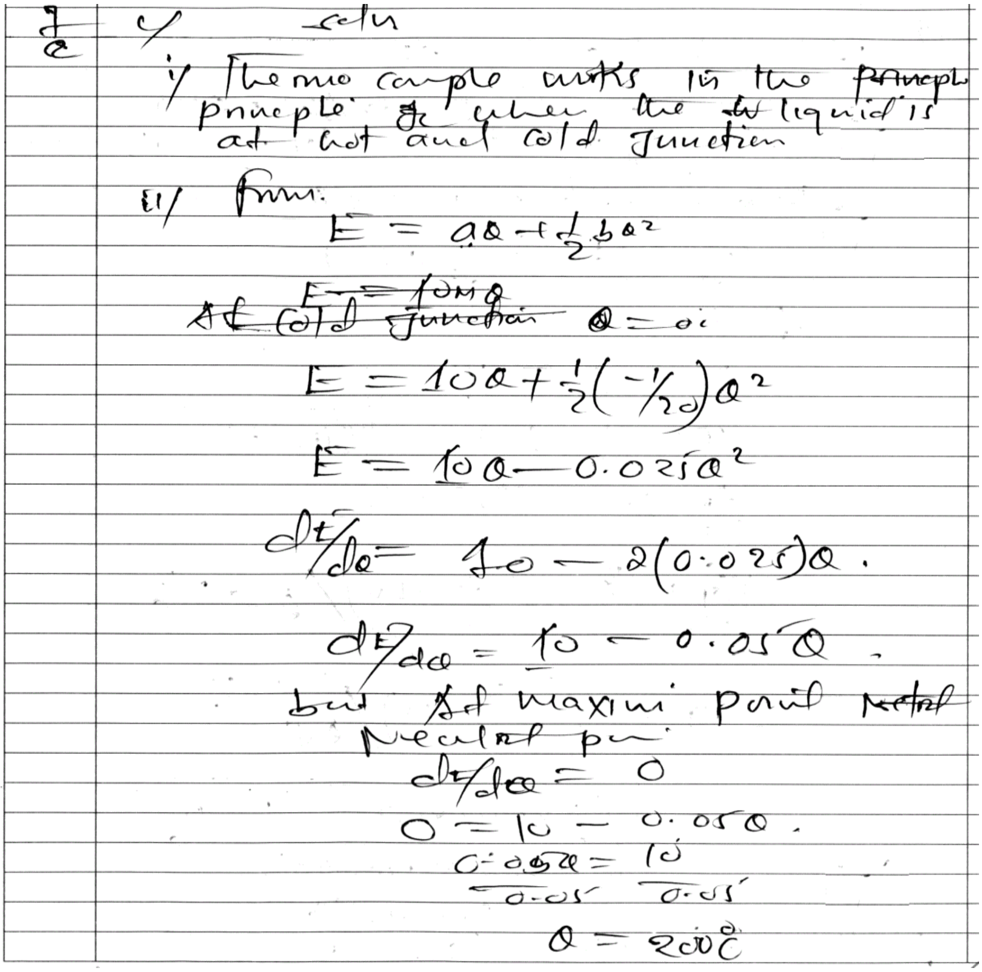
$$\left(T^4\right)^{1/4} = \left(\left(\frac{dm}{dt} \cdot Lv\right) / A\delta\right)^{1/4}$$

$$T = \left(\left(\frac{dm}{dt} \cdot Lv\right) / A\delta\right)^{1/4}$$

$$T = \left(\frac{6 \times 2256 \times 10^3}{1.5 \times 10^{-1} \times 5.67 \times 10^{-8}}\right)^{1/4}$$

$$T = 3.9788 \times 10^{4} K$$

∴ The temperature is $3.979 \times 10^4 K$.


7 c) soln

i) Thermo couple works in the principle principle of when the liquid is at hot and cold junction

ii) From.

$E = a\theta + \frac{1}{2}b\theta^2$

~~E = 10m θ~~

~~At cold junction~~ θ = 0°c

$E = 10\theta + \frac{1}{2}(-\frac{1}{20})\theta^2$

$E = 10\theta - 0.025\theta^2$

$dE/d\theta = 10 - 2(0.025)\theta$.

$dE/d\theta = 10 - 0.05\theta$.

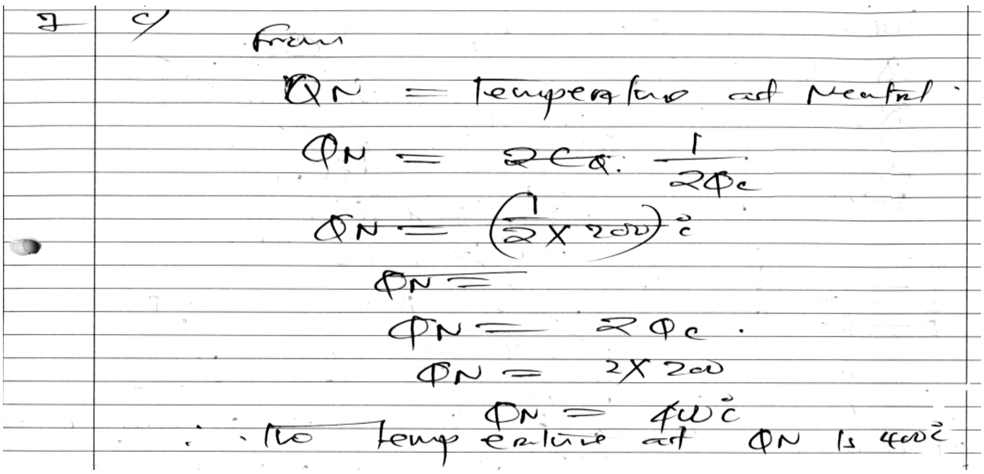
but At maximi point ~~metal~~ Neutral pn

$dE/d\theta = 0$

$0 = 10 - 0.05\theta$.

$\frac{0.05\theta}{0.05} = \frac{10}{0.05}$

$\theta = 200°C$


7 c) From

θN = temperature at Neutral.

$\theta N = 2\theta c \cdot \frac{1}{2\theta c}$

$\theta N = (\frac{1}{2 \times 200})°c$

θN =

θN = 2θc.

θN = 2 X 200

θN = 400°c

∴ The temperature at θN is 400°c

Extract 7.2 shows that the candidate failed to provide correct answers to all parts of the question. The candidate mentioned the length of a conductor and rate of heat change as factors that affect thermal conductivity instead of cross-sectional area of the material and the temperature gradient across the conductor. He/she also used an incorrect formula to calculate the values of temperature of the flame and neutral temperature.

2.8 Question 8: Thermal Radiation and Thermal Convection

In part (a) of this question the candidates were required to (i) define the term thermal radiation, and (ii) briefly explain why forced convection is necessary for excess temperature less than 20K. Part (b) required the candidates to (i) give reason why the energy of thermal radiation is less than that of visible light, and (ii) calculate emissivity of the body with a surface area of 5.0cm^2 and a temperature of 727^{o}C that radiates 300J of energy in one minute. In part (c) the candidates were required to (i) state Newton's law of cooling and (ii) calculate the time it takes a body to cool from 50^{0}C to 20^{0}C at the surrounding temperature of 10^{0}C if it cools from 70^{0}C to 40^{0}C in 5 minutes.

The question was attempted by 92.4 percent of the candidates, out of which 55.3 percent scored 0 to 3.0 marks, including 16.9 percent who scored 0. The candidates who scored 3.5 to 5.5 marks were 37.3 percent while those who scored 6.0 to 10 marks were 7.4 percent. Generally, the performance of the question was average as 44.7% of the candidates scored 3.5 to 10 marks. The graphical presentation of the data analysed is shown in Figure 8.

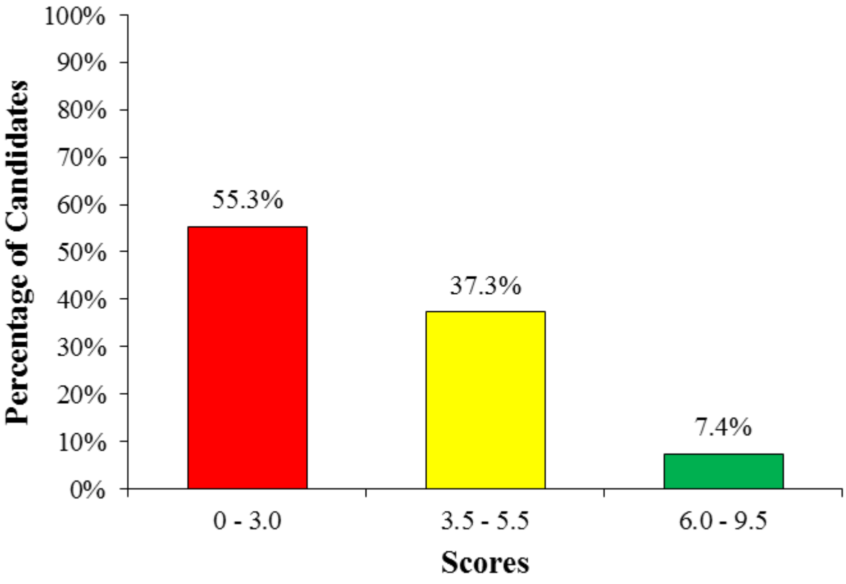


Figure 8: Percentage of candidates' performance per score in question 8.

The candidates who performed well in this question had enough knowledge to define the term thermal radiation, and briefly explain why forced convection is necessary for excess temperature less than 20K. They also used correct formula to calculate emissivity of the body. They were also able to state Newton's law of cooling and to use it to calculate the time taken by the body to cool from 50^0C to 20^0C. Extract 8.1 is a response from a candidate who performed well in this question.

Extract 8.1

8a/ i/ Thermal radiation; Is the transfer of heat through electromagnetic radiation.

ii/ Forced convection it works under Law of Newtons of cooling where its necessarily for the excess temperature less than 20k. so Newtons Law of cooling It work under Low excess temperature.

b/ i/ Energy of thermal radiation is less than that of visible light due to that the energy which gives out by thermal is infrared radiation which it has high waveLength so the energy received will be Less than that of visible light with low waveLength ~~by~~ but higher energy.

$$E \propto \frac{1}{\lambda}.$$

ii/ $A = 5 \times 10^{-4} m^2$

$T = (727 + 273) = 1000 k$

$P = 300 J/min$

$P = 5 J/sec.$

From $P = Ae\delta T^4$

$\delta = 5.67 \times 10^{-8} Wm^{-2}k^{-4}$

$$e = \frac{P}{A\delta T^4}$$

$$e = \frac{5}{5 \times 10^{-4} \times 5.67 \times 10^{-8} \times (1000)^4} = 0.176$$

c) Newtons Law of cooling states that the rate of change of heat is directly proportional to the excess temperature.

$$\frac{d\theta}{dt} \alpha (\theta - \theta_s).$$

Data
$\theta_1 = 70°c$
$\theta_2 = 40°c$
time (t) = 5 minutes
$\theta_s = 10°c$
also
$\theta_1 = 50°c$
$\theta_2 = 20°c.$

from $\frac{d\theta}{dt} = -k(\theta - \theta_0)$

$$\int_{\theta_2}^{\theta_1} \frac{d\theta}{\theta - \theta_0} = -k\int dt$$

$$\ln(\theta - \theta_0)_{\theta_2}^{\theta_1} = -kt.$$

$$\ln\left(\frac{\theta_1 - \theta_0}{\theta_2 - \theta_0}\right) = -kt.$$

$$\ln\left(\frac{70-40}{40-10}\right) = -k5$$

$$0.69314 = -k5 \quad ---- (I)$$

also from

$$\ln\left[\frac{50-10}{20-10}\right] = -kt.$$

$$1.38629 = -kt \quad --- (II)$$

dividee eqn (I) with eqn (II)

$$\frac{0.69314}{1.38629} = \frac{-k5}{-kt}$$

$$\frac{6.93147}{0.69314} = \frac{0.69314t}{0.69314}$$

$t = 10$ minute.

∴ The time taken is 10 minutes.

In extract 8.1 the candidate provided the correct meaning of thermal radiation and correctly explained all parts which required explanations. He/she followed the right procedures to derive appropriate formula and used it to calculate the time taken by a body to cool.

However, majority of the candidates scored low marks because of inadequate knowledge and poor mathematical skills in solving heat questions specifically on the applications of Newton's law of cooling and thermal radiation. These candidates failed to provide correct answers to most parts of the question. Most of them failed to define the term thermal radiation. Some of them defined thermal radiation "as the form of heat transformation of energy". They failed to recall that thermal radiation is "the amount of radiant energy emitted by the body solely on account of its temperature". They also failed to explain why forced convection is necessary for excess temperature less than 20K. Some of the candidates were able to recall and write the formula for calculating the emissivity of the body but failed to calculate its value because of wrong substitution of data values. Extract 8.1 is the response of a candidate who performed poorly in this question.

Extract 8.2

8(a) (i) Thermal radiation is defined as the heat transfer through empty space called ozone. This is exemplified as the radiation from the sun on earth.

(ii) Convection is the heat transfer which does not require medium of heat transfer for example, heating a metal on fire or flame.
- Forced convection is necessary because the heat must transferred from high range to the lower range and after reaching to the maximum point both conditions become at equilibrium position i.e the heat and heated object or rod-like metal.

8(c) (i) Newton's law of cooling states that, "At ~~physi~~ constant physical conditions like temperature and pressure, heat loss in the cooling system is equal to the heat gain to that system".

(ii) Data given
Body temperature from 70°C to 40°C in 5minutes
Temperature of the surrounding = 10°C
Required to calculate time taken to cool from 50°C to 20°C.
SOLUTION

8(c) (ii) From the equation.

$$\theta = (\theta_0 - \theta_s) e^{-kt} - \theta_s$$

Where $\theta = ~~70^\circ C~~ \; 40^\circ C$

$\theta_0 = 70^\circ C$

$\theta_s = 10^\circ C$

$t = 5$ minutes

Then

$$40 = (70 - 10) e^{-kt} - 10$$

$$40 = 60e^{-kt} - 10$$

But $t = 5$ minutes

$$40 = 60e^{-5k} - 10$$

$$40 + 10 = 60e^{-5k}$$

$$50 = 60e^{-5k}$$

Introduce log both sides

$\log 50 = -5k \log 60e$

$\log 50 = -5k \log 163.1$

Hence $k = -0.0613$

Again

From $\theta = (\theta_0 - \theta_s) e^{-kt} - \theta_s$

Where

$\theta = 20^\circ C$

$\theta_0 = 50^\circ C$

$\theta_s = 10^\circ C$

$t = ?$

8(c) (ii) $20 = (50 - 10) e^{+0.0613t} - 10$

~~20 =~~

$$20 = 40e^{0.0613t} - 10$$

$$20 + 10 = 40e^{0.0613t}$$

$$30 = 40e^{0.0612t}$$

Introduce log both sides

$\log 30 = 0.0613t \log 40e$

$\log 30 = 0.0613t \log 108.73$

$t = 0.7$ minutes or 42 seconds

Hence, the time will be 0.7 minutes or 42 seconds.

In extract 8.2 the candidate defined incorrectly thermal radiation as the method of heat transfer in empty space called ozone and thermal convection as method of heat transfer which does not require medium of heat transfer. He/she also failed to state Newton's law of cooling and hence failed to apply it to calculate the time taken by the body to cool from 50^0C to 20^0C.

2.9 Question 9: Current Electricity

Part (a) of the question required the candidates to (i) define the term junction as applied in electrical network, and (ii) state the physical significance of Kirchhoff's first law. Part (b) required them to (i) explain why Kirchhoff's second law is sometimes referred to as the voltage law, and (ii) list five points to be considered when applying Kirchhoff's second law in formulating analytical problems or equations. In part (c) the candidates were required to study the circuit diagram provided and then to (i) mention the number of loops in the circuit and (ii) find the current flowing through the 2Ω, 4 Ω and 8 Ω resistors.

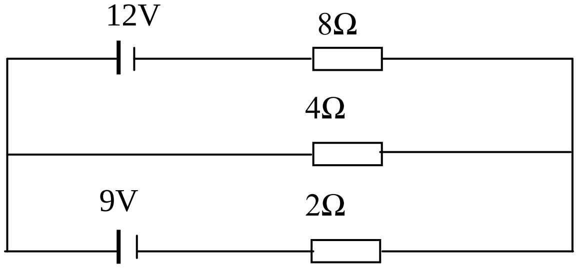


Figure 1

About ninety percent (89.7%) of the candidates attempted this question, and their scores were as follows: 42.5 percent obtained below 3.5 marks, including 12.5 percent who scored 0; 31.3 percent of the candidates scored 3.5 to 5.5 marks; and 26.2 percent scored 6.0 to 10 marks. This analysis shows that 57.5 percent of the candidates scored from 3.5 to 10 marks, which implies that the question was averagely performed. Figure 9 is a graphical presentation of this analysis.

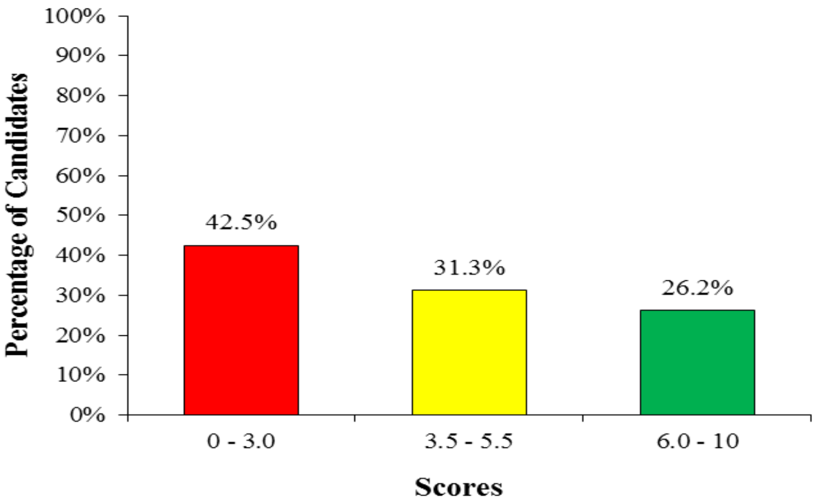


Figure 9: Percentage of candidates' performance per score in question 9.

The candidates who scored high (6-10 marks) in this question demonstrated a good mastery of current electricity as they were able to define the term junction as applied in electrical network, state the physical significance of Kirchhoff's first law, and explain why Kirchhoff's second law is sometimes referred to as the voltage law. Most of them were able to study the circuit diagram provided and they correctly calculated the required values of currents through the resistors. Extract 9.1 shows a sample of a good answer.

Extract 9.1

9(a) (i) Junction
- Is the point where by various electric connections meet, it sometimes called node

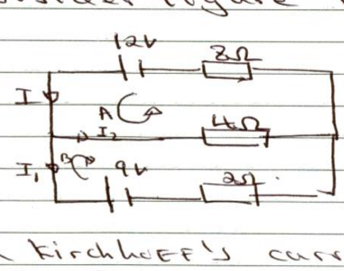
(ii) It show Law of conservation of charge

(b) (i) It's because it ~~consist of~~ deals with potential drop across the whole circuit and electromotive force of a circuit

9(b) (1) Indicate direction of current
(2) Indicate number and direction of Loop
(3) consider direction of current in which:
(i) When direction of current and loop are the same potential drop is positive
(ii) When direction of current and loop are opposite potential drop is negative
(4) Consider terminal of power supply
(i) When terminal are in same direction resultant electromotive force is obtained by summing volts of individual.
(ii) When terminal are in opposite direction the resultant electromotive force is Obtained ~~obtained by~~ different between electromotive force of the supply

(c). (i) There are three (3) loops

(ii) Consider figure below



From Kirchhoff's current law
$I = I_1 + I_2$
consider loop A and Kirchhoff's voltage law

9(c) (ii) $12V = 4I_2 + 8(I_1 + I_2)$

$12V = 4I_2 + 8I_1 + 8I_2$

$12V = 12I_2 + 8I_1$ --- (i)

Now consider loop and Kirchhoff's voltage law

$9V = 4I_2 - 2I_1$ --- (ii)

solving equa (i) and (ii)

$I_1 = -1.071428A$ $I_2 = 1.714A$

$I = I_1 + I_2$

$I = -1.071428A + 1.71428\ A$

$I = 0.6428\ A$

∴ current through 2Ω, 4Ω and 8Ω resistor are 1.071428 A, 1.71428 A, and 0.6428 A respectively.

In extract 9.1, the candidate gave correct responses to all parts of the question.

The candidates who scored low marks in this question lacked knowledge on current electricity as they failed to provide correct answers to almost all parts of the question. They failed to define the term junction as applied in electrical networks. Some of them defined the term junction as "a point where all currents originate". Others defined junction as "the gap which inhibits the flow of both electric current and charge". The correct response should have been "junction is a point in an electric circuit that joins three or more branches". They also failed to state the physical significance of Kirchhoff's first law and to explain why Kirchhoff's second law is sometimes referred to as the voltage law. Some candidates explained the significance of Kirchhoff's first law as "it implies the conservation of mass" instead of "conservation of charge as no charges accumulate at any given point in the electric circuit". Furthermore, they failed to use Kirchhoff's laws of electric network to calculate the value of the currents through resistors in the circuit. Extract 9.2 shows the sample of the candidate who performed poorly.

Extract 9.2

9.(a) (i) Junction in electrical network is defined as the gap which can resist the flow of electric charge. This happens when it becomes wider. For example from the comparison of conductors, semiconductors and insulators.

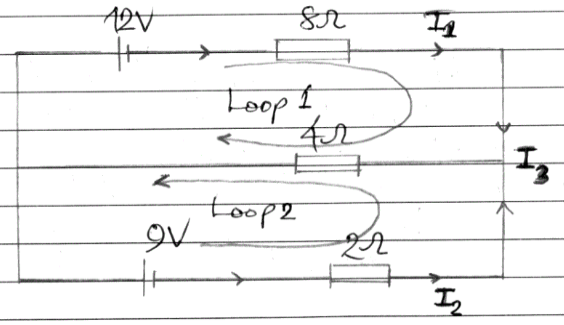
(ii) Physical significance of Kirchhoff's first law is to determine the conservation of energy and electric current in a circuit or system.

9.(b) (i) Reasons for Kirchhoff's second law to be referred as voltage law is that the majority charges supplied are potential differences or volts.

(ii) Points to consider when applying Kirchho-

9.(b) (ii) K's second law in formulating analytical problems or equations.
From $V = IR$ or $V = I(R+r)$
(a) Voltage across the conductor or system
(b) Current supplied in the system or circuit
(c) Resistance or resistors available.
(d) Internal resistance of the cell.
(e) Effect of temperature as the physical factor produced on most electric devices.

9.(c)



(i) There are two (2) loops in the circuit.
(ii) Required to find the current through 2Ω, 4Ω and 8Ω
SOLUTION.
Total resistance
Conditions: All resistances are in parallel system

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

Where $R_1 = 8Ω$, $R_2 = 4Ω$

In extract 9.2 the candidate failed to define junction and to state the significance of Kirchhoff's first law. Also he/she wrongly calculated current in the loops using Ohm's law instead of Kirchhoff's laws of electrical networks.

2.10 Question 10: Current Electricity

This question required the candidates to (a) give the definitions of the terms (i) phase of alternating e.m.f and (ii) the root mean square (r.m.s) value of alternating e.m.f. Part (b) required the candidates to calculate the (i) current flowing in the circuit and (ii) the power dissipated in an a.c circuit that consists of a pure resistance of 10 Ω which is connected across an a.c supply of 230V, 50Hz. In part (c) the candidates were required to determine the (i) frequency of the e.m.f and (ii) the net reactance of the circuit consisting of a 25μF capacitor, a 0.10H inductor and a 25Ω resistor that are connected in series with an a.c source whose e.m.f is given by $E = 310 \sin 314t$ volt.

The question was answered by 48.3 percent of the candidates, out of which 51.0 percent scored below 3.5 marks out of 10 marks, of which 33.4 percent scored 0. The candidates who scored 3.5 to 5.5 marks were 24.4 percent while those who scored 6.0 to 10 marks were 24.6 percent. The candidates who scored from 3.5 to 10 marks were 49.0% indicating that the performance of the question was average. The graphical presentation of these data is shown in Figure 10.

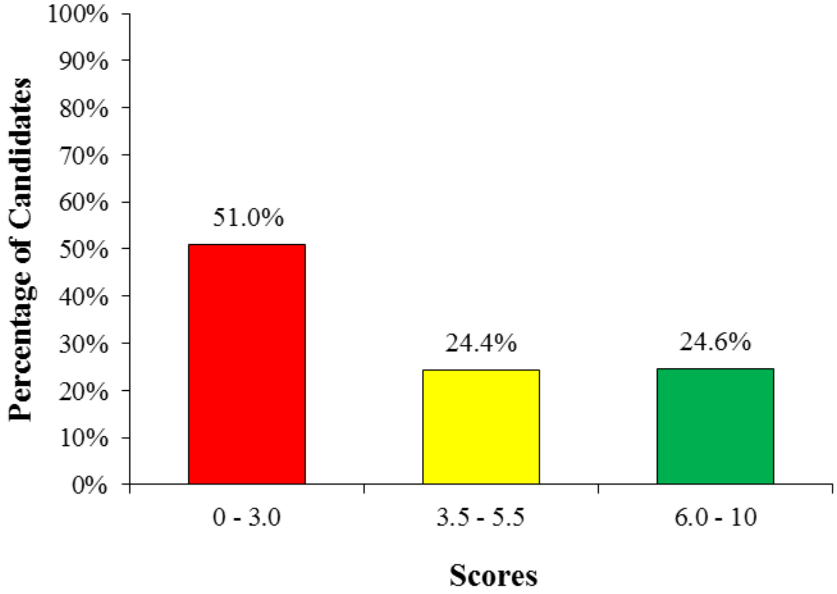
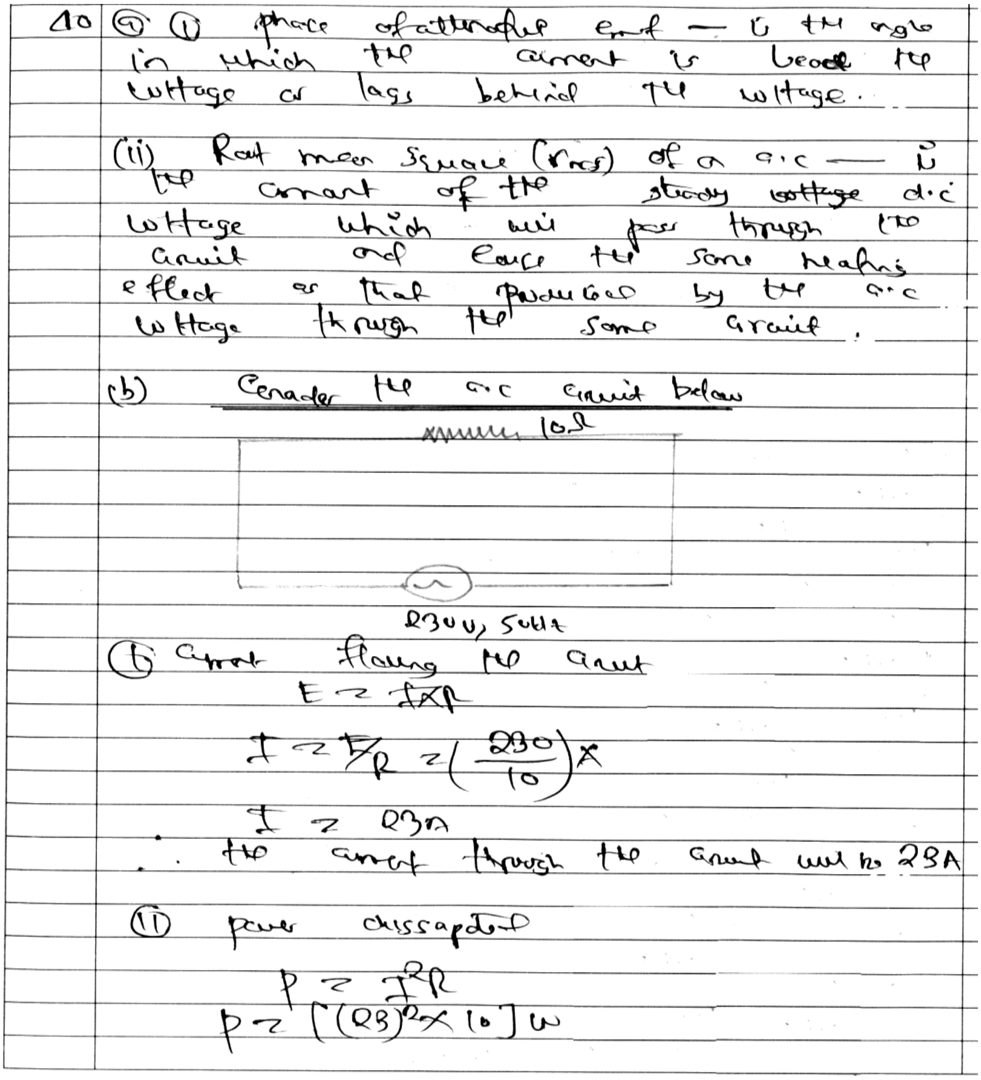


Figure 10: Percentage of candidates' performance per score.

The majority of the candidates who scored good marks (6.0-10) were able to give the definitions of the terms phase of alternating e.m.f and the root mean square (r.m.s) value of alternating e.m.f. They were also able to use the required procedures and formulae to calculate the current flowing in the circuit and the power dissipated. Extract 10.1 shows a typical answer.

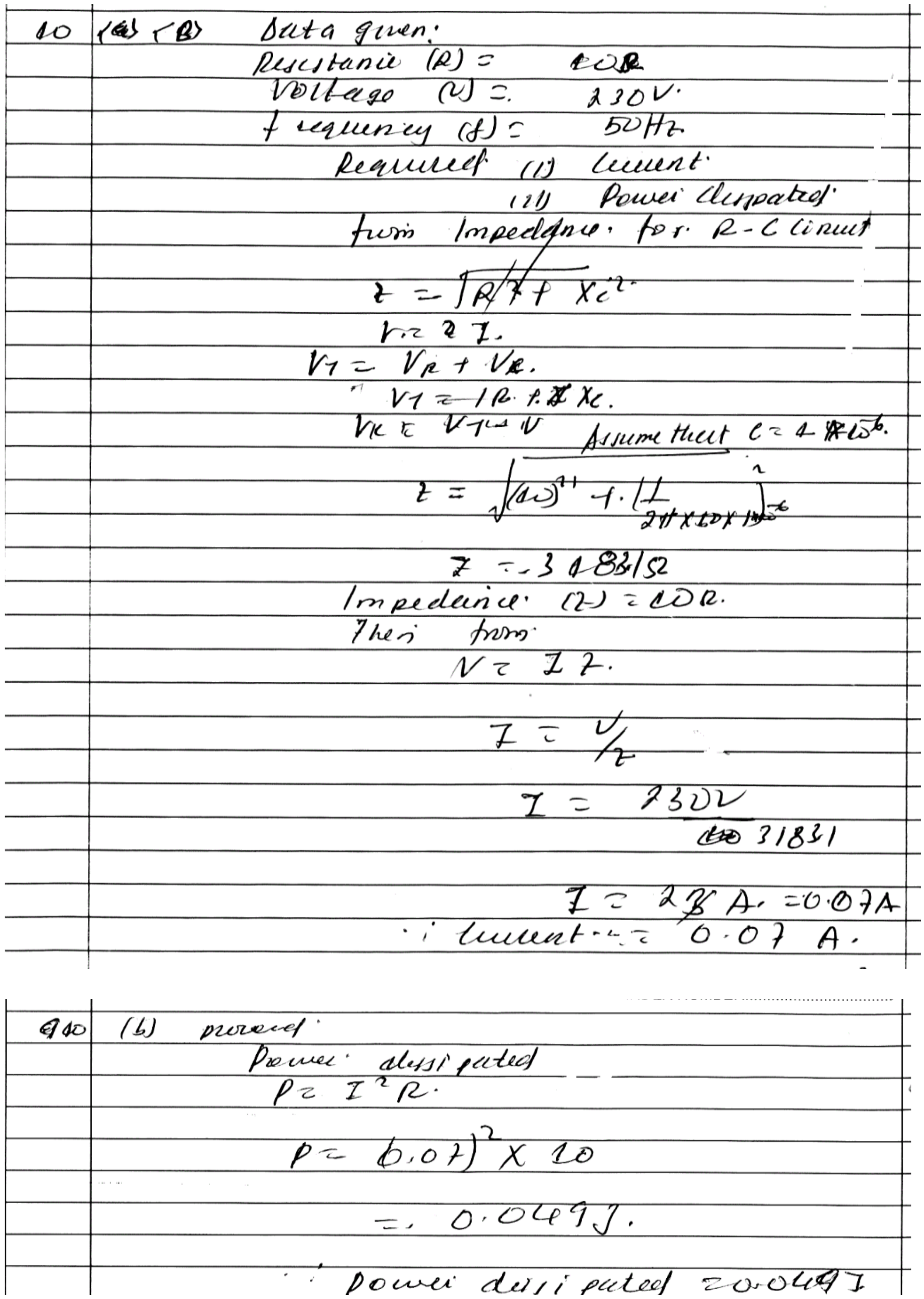
Extract 10.1



In extract 10.1 the candidate provided correct answers to most parts of the question but failed to correctly define the phase of alternating e.m.f.

On the other hand, most of the candidates with low scores (0-3.0) failed to give the definitions of the term phase of alternating e.m.f. One candidate defined it as “the phase that occurs due to variation of time”. Others wrote the phase of alternating e.m.f as “the angle that the alternating e.m.f. subtends to the horizontal”. The correct response of the term phase of alternating e.m.f is “the fraction of the time period that has elapsed since the e.m.f last passed its zero value in the positive direction”. They also failed to define the root mean square (r.m.s) value of alternating e.m.f and to calculate the current flowing in the circuit. Most of them confused the r.m.s values with instantaneous values of voltages and currents. Extract 10.2 shows a sample of a poor answer.

Extract 10.2


10 (a) (B) Data given:
Resistance (R) = 10Ω
Voltage (V) = 230V.
frequency (f) = 50Hz
Required (i) current
(ii) Power dissipated
from Impedance for R-C circuit
$Z = \sqrt{R^2 + X_C^2}$
V = IZ.
$V_T = V_R + V_C$.
$V_T = IR + IX_C$.
$V_C = V_T - V$ Assume that C = 1×10⁻⁶.
$Z = \sqrt{(10)^2 + \left(\frac{1}{2\pi \times 50 \times 10^{-6}}\right)^2}$
Z = 3183Ω
Impedance (Z) = 10Ω.
Then from
V = IZ.
$I = V/Z$
$I = \frac{230V}{3183}$
I = 2.8A = 0.07A
∴ current = 0.07 A.

Q10 (b) proceed
Power dissipated
$P = I^2R$.
$P = (0.07)^2 \times 10$
= 0.049J.
∴ power dissipated = 0.049J

In extract 10.2 a candidate was only able to write correctly the expression for finding power dissipated in the wire.

2.11 Question 11: Electronics

Part (a) of the question required the candidates to (i) mention the importance of doping as applied to semiconductors, and (ii) mention three differences between n-type and p-type semiconductors. Part (b) required the candidates to explain (i) why transistors are used mostly in common emitter arrangement and (ii) the condition necessary for a transistor amplifier to work as an oscillator. In part (c) the candidates were required to (i) explain the use of an op–amp as a summing amplifier and (ii) calculate the output potential V_0 given that the input voltage $V_1 = 4.0V$, $V_2 = -2.5V$ and $V_3 = 1.5V$ and the resistances are $R_1 = 39\Omega$, $R_2 = 4.7k\ \Omega$, $R_3 = 10k\Omega$ and $R_4 = 2.7k\Omega$.

The majority (92.1%) of the candidates attempted the question, out of which 29.0 percent scored below 3.5 marks, including 3.8 percent who scored 0. The candidates who scored 3.5 to 5.5 marks were 37.0 percent and those who scored 6.0 to 10 marks were 34.0 percent. The statistics show that the majority (71%) of the candidates scored 3.5 to 10 marks, indicating that the topic was well understood by most of the candidates. The data are pictorially presented in Figure 10.

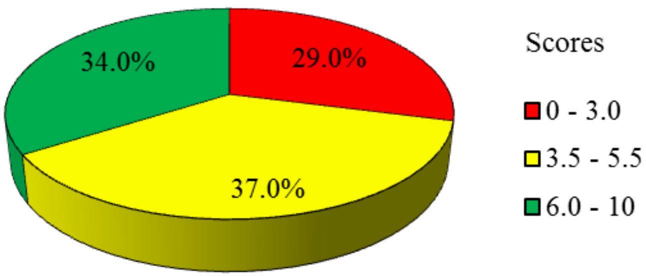


Figure 10: A summary of candidates' performance in percentage.

The candidates who did well in this question, (34%) were able to mention the importance of doping as applied to semiconductors and to differentiate between n-type and p-type semiconductors. Most of them were able to explain the use of an op–amp as a summing amplifier and to calculate correctly the output potential V_0 of a circuit. Extract 11.1 shows a sample response from one of the candidates who performed well in this question.

Extract 11.1

11. (a) (i) The doping used to increase the number of carrier charge carriers in semiconductors (ie silicon and Germanium). So this leads to increase the eletrical conductivity of the semiconductor

(ii). differences between n-type and p-type semicon

n-type semiconductors	p-type semiconductors
(a) They are formed by doping with pentavalent atom's	(a) They are formed by doping with trivalent atoms
(b) The electrons are majority charge carriers while holes are minority	(b) They have holes which are majority charge carriers while electrons are minority

11 (a) (ii)

n-type semiconductors	p-type semiconductors
(c) They have donor energy level just below conduction band in energy level diagram	(c) They have acceptor energy level just above covalence energy (band) in the energy level diagram.

(b) (i) The following are Reasons

(a) The common emitter arrangement has greater current gain, β

(b) It has high voltage and power gain than other arrangements.

(c) It has greater temperature range of operation.

(ii) The transistor work as oscillator, when the inductor is connected as the Load, means, the Load resistor should be replaced by inductor

11. (c) (i) Opamp used as summing amplifier when the small input voltages are applied at once as single input voltage during amplification process.

11 (c) (ii) Soln:

Given, $R_1 = 39\,k\Omega$, $V_1 = 4\,V$

$R_2 = 4.7\,k\Omega$, $V_2 = -2.5\,V$

$R_3 = 10\,\Omega$, $V_3 = 1.5$

$R_f = 2.7\,k\Omega$

From

$$I_T + I_f = 0$$

$$I_f = -I_T$$

But $I_f = \frac{V_0}{R_4}$

$$I_T = I_1 + I_2 + I_3$$

$$I_T = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

$$\frac{V_0}{R_f} = I_f = -\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$$

$$V_0 = -R_4\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$$

$$= -2.7\left(\frac{4}{39} - \frac{2.5}{4.7} + \frac{1.5}{10}\right)$$

$$V_0 = 0.754\,V.$$

11 (c) (ii) The output potential, $V_0 = 0.754\,V$

Extract 11.1 shows that the candidate managed to meet the demands of the question by giving the correct answers as required. However, he/she failed to explain how a transistor can work as an oscillator.

Conversely, the candidates who scored low marks in this question lacked both mathematical skills and basic concepts on electronics. They failed to mention the importance of doping as applied to semiconductors. For instance one of the responses from the candidates was: "the importance of adding impurities in the pure intrinsic semiconductor are due to allow the semiconductor to function from positive to negative". The correct response should have been "the importance of doping is to increase conductivity of semiconductor by increasing the number of charge carriers". Some mentioned the differences between n–type and p–type semiconductors but in reverse order and others used the formula for potential division to calculate the output potential V_0 of a summing amplifier. Extract 11.2 is a sample of a candidate's poor answer.

Extract 11.2

11a(i) i/ To Increase the Conductivity of the Substance.

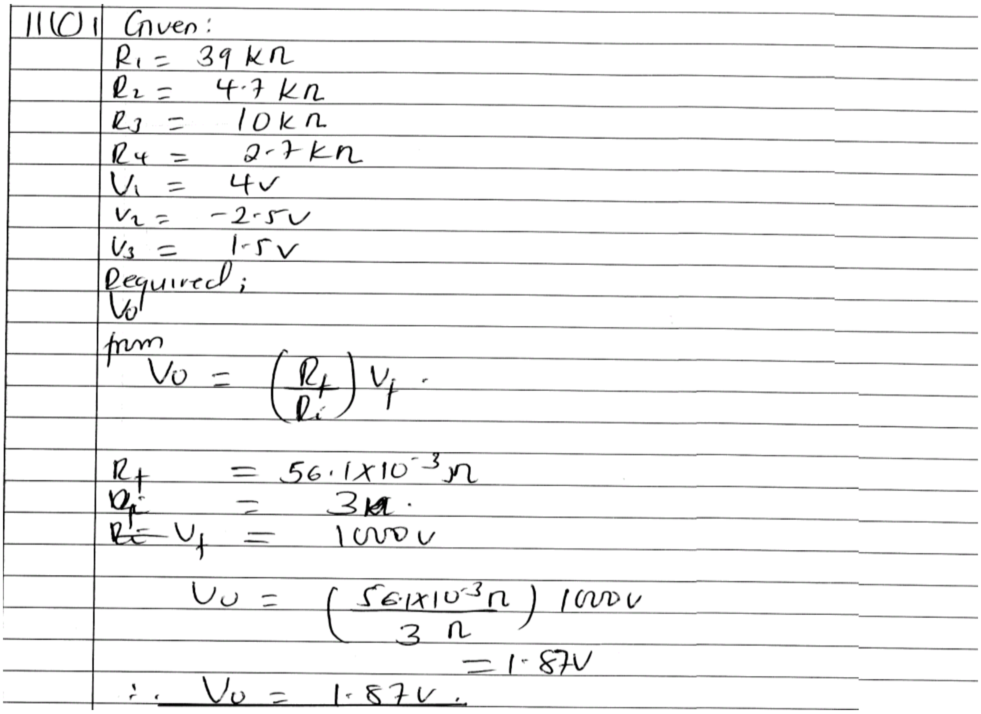
(ii)

n- type	P- type.
i/ Contain the trivalent element	i/ Contain the pentavalent element
ii/ Involve doping	ii/ Involve the temperature

11b(i) Because the transistors have high voltage therefore when it arranged to the base can burst due to that are arranged to the emmiter Inorder to do not destroy.

b (ii) Because transistor also can oscillate the substance due to the amplification which take place In the oscillator.

c(i) i/ The Op-amp used as summing amplifier by Increase the voltage and minimize the current the voltage used is very high compare to the voltage operate In the circuit.


11(c)(i) Given:
$R_1 = 39\,k\Omega$
$R_2 = 4.7\,k\Omega$
$R_3 = 10\,k\Omega$
$R_4 = 2.7\,k\Omega$
$V_1 = 4V$
$V_2 = -2.5V$
$V_3 = 1.5V$
Required;
V_o
from
$$V_o = \left(\frac{R_f}{R_i}\right) V_f$$
$R_f = 56.1\times10^{-3}\,\Omega$
$R_i = 3\,\Omega$
$V_f = 1000V$
$$V_o = \left(\frac{56.1\times10^{-3}\,\Omega}{3\,\Omega}\right) 1000V$$
$= 1.87V$
$\therefore V_o = 1.87V.$

In extract 11.2 the candidate provided incorrect responses to all parts of the question. For example in differentiating types of extrinsic semiconductors, the candidate wrote that *the n-type contains trivalent element and p-type contains pentavalent element* instead *of n-type is formed by adding pentavalent while p-type is formed by adding trivalent*.

2.12 Question 12: Electronics

Part (a) of the question required the candidates to name three electronic circuits in which multi vibrators can be constructed. Part (b) required the candidates to (i) list down three types of multi vibrators and (ii) briefly explain the applications of multi vibrators listed in 12 (b) (i). In part (c) candidates were required to (i) mention two characteristics of op-amps and (ii) briefly explain why op-amps are sometimes called differential amplifiers.

The question was attempted by 4,923 (28.2%) candidates, out of whom 46.8 percent scored 0 marks, 41.3 percent scored 0.5 to 3.0 marks, 9.7 percent scored from 3.5 to 5.5 marks, and only 2.2 percent scored 6.0 to 10 marks. These scores imply that the performance of the question was generally poor.

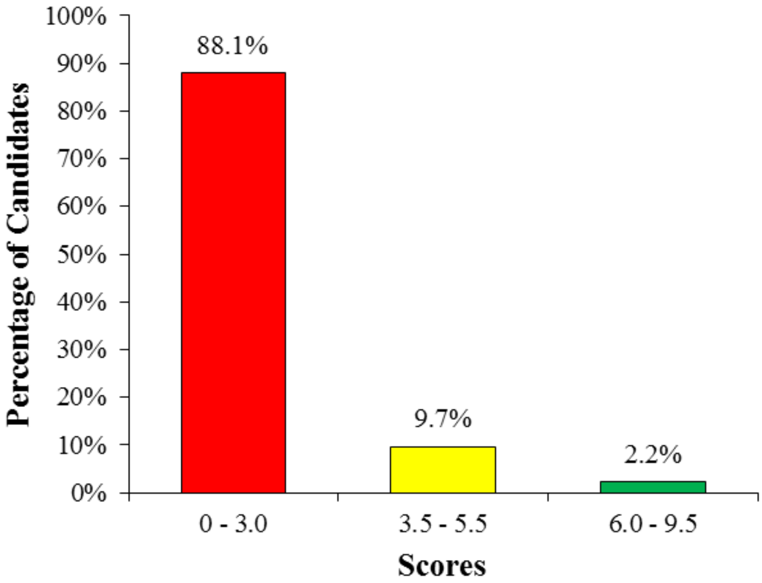
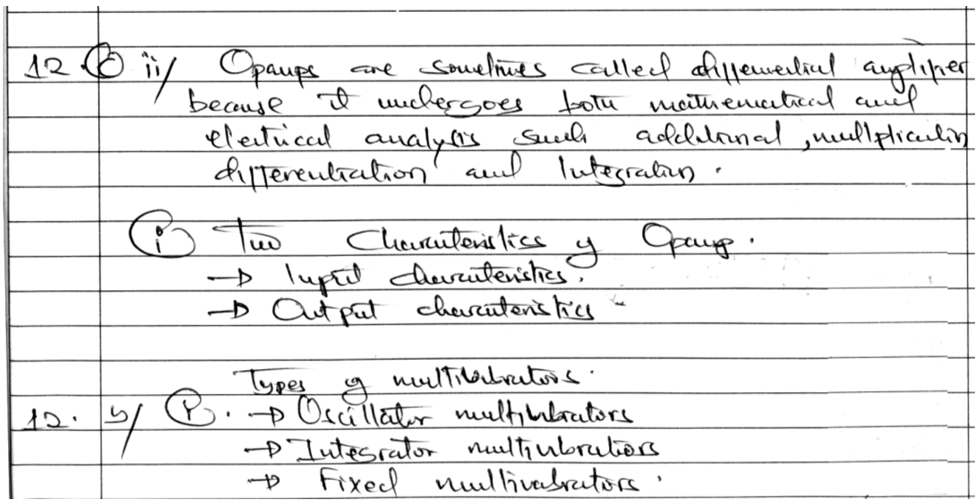


Figure 12: Illustration of candidates' performance in question 12.

Figure 12 shows that, the candidates who scored 3.5 marks or above were 11.9 %, implying that the general performance in the question was poor.

The candidates who performed poorly in this question (88.1%) lacked basic knowledge on multivibrators and op-amps hence they provided incorrect responses to most parts of the question. For example, one of the candidates mentioned types of multivibrators as "weight multivibrators" and "unweight multivibrators" instead of "astable, bistable and monostable" other listed "fixed circuits and integrated circuits" as part of the circuits where multivibrators can be constructed. Extract 12.1 presents a sample of a poor response.

Extract 12.1


12 (a) ii/ Opamps are sometimes called differential amplifier because it undergoes both mathematical and electrical analysis such additional, multiplication differentiation and integration.

(b) (i) Two characteristics of Opamp.
→ Input characteristics.
→ Output characteristics.

Types of multivibrators.
12. b/ (i). → Oscillator multivibrators
→ Integrator multivibrators
→ Fixed multivibrators.

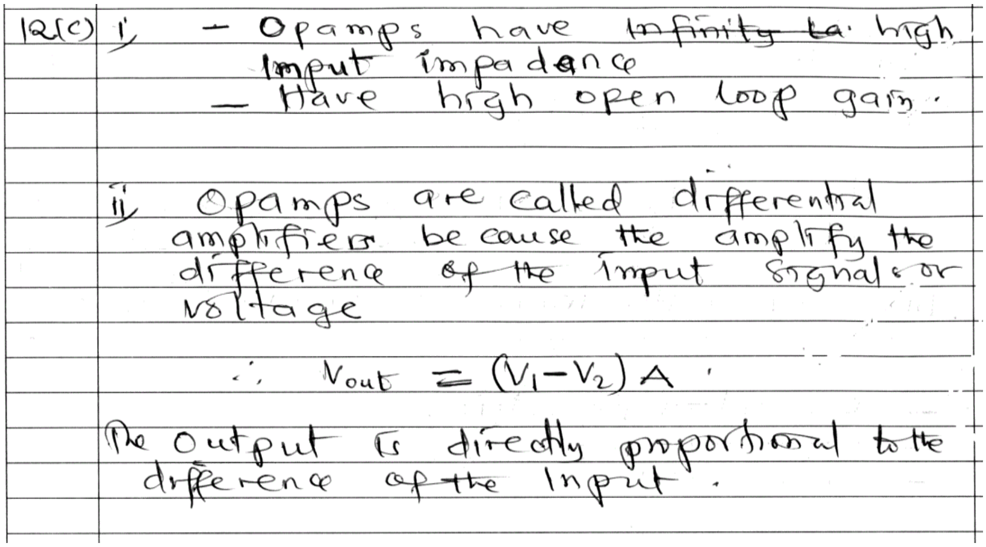
12	a/ Three electronic circuit in which multivibrator can be constructed
	i. Fixed circuit
	ii. Oscillator circuit
	iii. Integrator circuit

In Extract 12.1 a candidate mentioned “fixed circuit, oscillator circuit and integrator circuits” as three types of multivibrators instead of “astable, bistable and monostable multivibrators”. The candidate also mentioned “input and output” as characteristics of op-amps instead of “very low output impedance and very high input impedance”.

The candidates (2.2%) who performed well in this question were able to list three types of multi vibrators and to explain the applications of multi vibrators. Most of them were also able to mention the characteristics of op–amps and to explain why op-amps are sometimes called differential amplifiers. But some of these candidates failed to name three electronic circuits in which multi vibrators can be constructed. Consequently they failed to score all marks in the question. Extract 12.2 is a sample answer from a candidate who answered this question well.

Extract 12.2

12(a)	— ~~Capacitors~~ Resistors
	— Capacitors
	— Transistors.
(b)	i/ TYPES OF MULTIVIBRATORS.
	— Astable multivibrator.
	— Bistable multivibrator
	— Monostable multivibrator.
	ii/ Application
	— Bistable multivibrator is used as frequency divider. and also as binary converter
	— Monostabable can be used to generate signals of various wave forms.
	— Astable is used to produce output voltage/signals of different wave forms.


12(c) i, – Opamps have ~~infinity to~~ high input impedance
– Have high open loop gain.

ii, Opamps are called differential amplifier because the amplify the difference of the input signal or voltage

∴ $V_{out} = (V_1 - V_2) A$

The output is directly proportional to the difference of the input.

Extract 12.2 shows the work of one of the candidates who scored high marks. Though the candidate provided correct responses to most parts of the question, he/she failed to name the types of electronic circuits in which multivibrators can be constructed. He/she mentioned *transistors*, *capacitors* and *resistors* instead of *junction/field effect transistor*, *logic gates* and *operational amplifier*.

2.13 Question 13: Telecommunication

Part (a) required the candidates to discuss the mode of action of each of the following sensors (i) Thermistors (TH) and (ii) Light Dependent Resistor (LDR). Part (b) required the candidates to give symbols, expressions and truth tables for (i) NAND gate and (ii) exclusive NOR gate. In part (c) the candidates were required to (i) explain why NAND gate is considered to be basic building block for a variety of logic circuits, and (ii) produce the truth table for the gate provided in Figure 3 and show that it behaves as an AND gate.

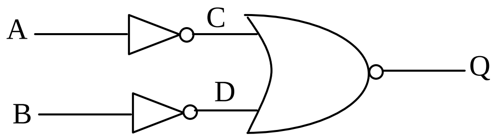


Figure 3

The question was attempted by 96.3 percent of the candidates, of which 60.7 percent scored 0 to 3.0 marks, including 18.1 percent who scored 0. The data further indicate that 31.9 percent scored 3.5 to 5.5 marks, 7.4 percent scored 6.0 to 10 marks. This analysis shows that 39.3 percent of the candidates scored from 3.5 to 10. These scores imply that the question was averagely performed. These data are pictorially presented in Figure 13.

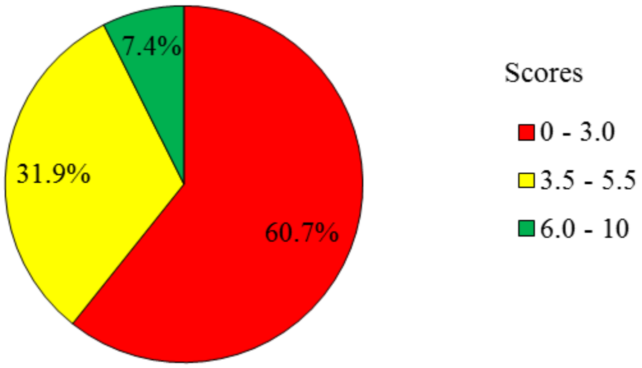
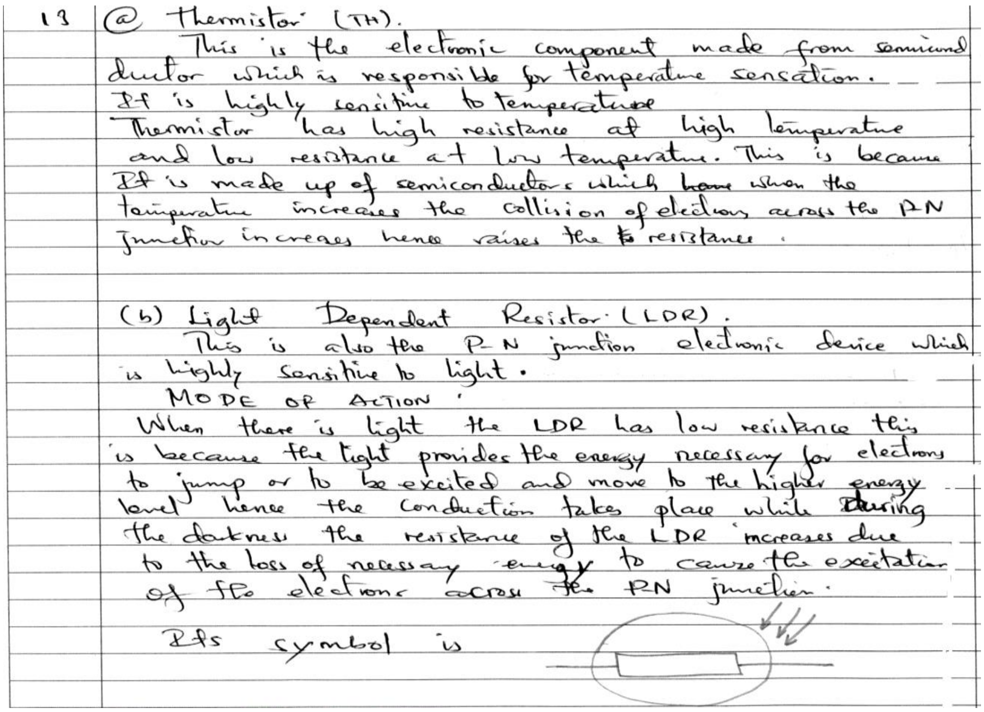


Figure 13: A summary of candidates' performance in percentage.

The data presented in the Figure 13 indicate that a total of 39.3 percent of the candidates scored 3.5 marks or above, which is an average performance.

The candidates who performed well were able to discuss the mode of action of a thermistor (TH) and a Light Dependent Resistor (LDR). Most of the candidates responded correctly by constructing truth tables for NAND gate and Exclusive NOR gate. They were also able to explain why a NAND gate is considered to be a basic building block for a variety of logic circuits. Extract 13.1 shows a sample answer given by a candidate who performed well in this question.

Extract 13.1

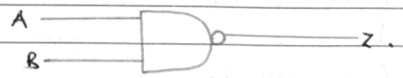

13 (a) Thermistor (TH).
This is the electronic component made from semiconductor which is responsible for temperature sensation. It is highly sensitive to temperature
Thermistor has high resistance at high temperature and low resistance at low temperature. This is because It is made up of semiconductors which ~~have~~ when the temperature increases the collision of electrons across the PN junction increases hence raises the ~~to~~ resistance.

(b) Light Dependent Resistor (LDR).
This is also the P-N junction electronic device which is highly sensitive to light.
MODE OF ACTION:
When there is light the LDR has low resistance this is because the light provides the energy necessary for electrons to jump or to be excited and move to the higher energy level hence the conduction takes place while during the darkness the resistance of the LDR increases due to the loss of necessary energy to cause the excitation of the electrons across the PN junction.

Its symbol is

13 (b) (i) NAND gate:

(i) Symbol.



(ii) Expressions of the NAND gate:

(i) $\overline{A \cdot B} = Z$.

OR.

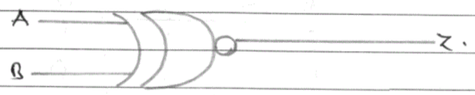
(ii) $\bar{A} + \bar{B} = Z$.

(iii) The truth table.

Inputs.			out Put.
A	B	AB	$\overline{AB} = Z$.
0	0	0	1
0	1	0	1
1	0	0	1
1	1.	1	0.

(ii). Exclusive NOR gate:

(i) Symbol.



(ii) Expression:

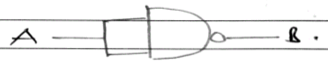
$\overline{A \oplus B} = Z$.

13 the truth table.

Inputs		output.
A	B	Z.
0	0	1
0	1	0
1	0	0
1	1	1

(c)(i) NAND gate is considered as a basic building block of all other gates because it has the ability of forming all other basic logic gates for example OR gate, NOT gate, AND gate and other gates.

example. NOT gate

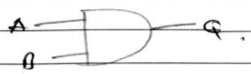


(ii). The truth table.

A	B	C	D	Q.
0	0	1	1	0
0	1	1	0	0
1	0	0	1	0
1	1.	0	0	1.

Also the truth table for AND.

A	B.	Q
0	0	0
0	1	0
1	0	0
1	1	1



Since the truth table of AND gate is similar to that of the logic circuit then it is similar to AND gate.

In Extract 13.1 the candidate answered correctly all parts of the question.

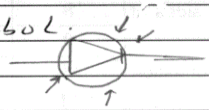
However, some of the candidates performed poorly in this question because they had inadequate knowledge on concepts of logic gates. They could not discuss the mode of action of thermistors (TH) and that of Light Dependent Resistor (LDR). Most of them gave incorrect symbols, expressions and truth tables for NAND gate and exclusive NOR gate. Extract 13.2 shows a sample answered by a candidate who performed poorly in this question.

Extract 13.2

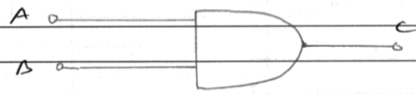
13. (a) The mode of Action of the following
(i) Thermistor (TH)
This is the type of diode which work under the reverse bias where by it depend on the amount of heat applied. The amount of heat determine its conductivity to be high or low. Inorder to minimize the forbizden gap to allow the flow of current at the Junction.

(ii) Light Dependent Resistor (LDR)
Is the diode which work in a reverse bias where it conductivity depend on light which strike on that Junction. Higher the light intensity high conductivity.

symbol.



(b) (i) NAND GATE



Truth table.

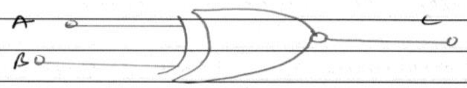
Input		output
A	B	C.
0	0	0
0	1	0
1	0	0
1	1	1

NAND GATE is the gate which output is high only when the both input are high the otherwise low.

13. (b) EXCLUSIVE NORGATE

Is the gate having only one output where by output is high only when the input are in different state.

Symbol.



Truth table

Input		output
A	B	C.
0	0	0
0	1	1
1	0	1
1	1	0

(c)(i) A NAND GATE is considered as the building block for variety of logic gate circuit because a NAND GATE show high output only when the both input are high. Where there is no any confusion.

Extract 13.2 shows a sample given by a candidate who performed poorly in this question. Although, the candidate drew correctly the symbol for Exclusive NOR gate, but he/she produced the truth table for Exclusive OR gate instead of Exclusive NOR.

2.14 Question 14: Environmental Physics

In part (a) the candidates were required to (i) define the term aerial environment and give two examples and (ii) describe three ways at which the aerial environment is threatened. In part (b) they were required to (i) briefly explain three major concepts on solar wind and (ii) mention four points on how soil environmental components influence plant growth.

A total of 14,570 (83.4%) candidates attempted this question. The data shows that 29.2 percent scored 0, 37.4 percent scored 0.5 to 3.0 marks, 24.8 percent scored 3.5 to 5.5 marks, and 8.6 percent scored 6.0 to 10 marks. These scores imply that the performance of the question was poor as 66.6% of the candidates scored below 3.5 marks.

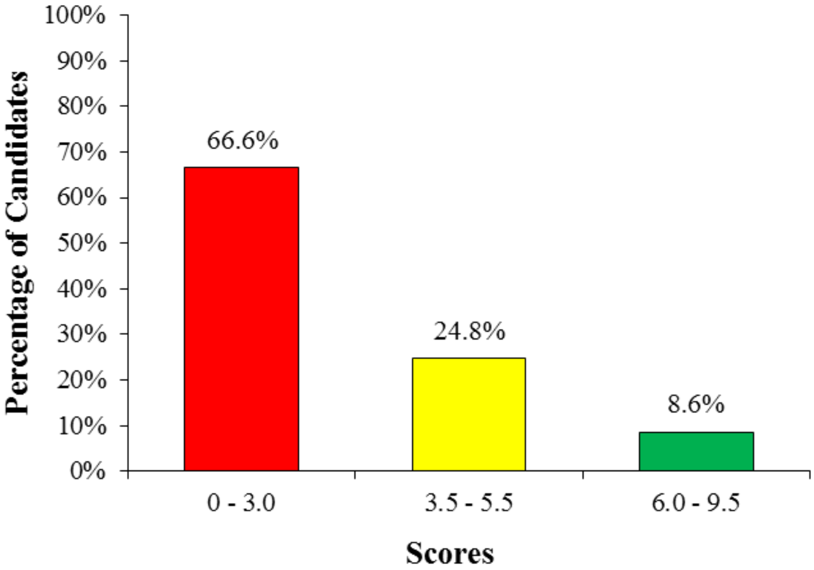


Figure 14: Percentage of candidates' performance in question 14.

Figure 14 shows that the candidates who scored 3.5 marks or above were 33.4 %, implying that the general performance in the question was poor.

The candidates who scored low marks (66.6%) provided incorrect answers to most parts of the question as they lacked knowledge on basic concepts on Environmental Physics. They failed to define the term aerial environment and give its examples. For example one of the candidates defined aerial environment as "the environment which consists all things that are found on the earth's surface example schools and JKT". The correct response should have been "the atmospheric zone in which every living organism depends; examples are air, water vapour, dust, ozone layer and bacteria". Furthermore, the majority could not explain the major concepts on solar wind. Extract 14.1 is a sample of a candidate's poor response.

Extract 14.1

14. (a) (i) Aerial environment is the upper surface of the earth's crust.
example; Land scape and Land or sand within the ocean (of water bodies)

(ii) 1. Mining processes
2. Dumping of ~~du~~ garbages
3. Earth quakes.

(b) (i) 1. Uses wind to produce electricity.
2. ~~Electr~~ It is a renewable source of energy
3. Mechanical energy changes to electrical energy within the solar wind.

(ii) 1. Provide necessary nutrients example, micronutrients and macronutrients.
2. Provide fertility to the soil
3. Surport a plant on searching of water.
4. Provide the necessary pH for the plant.

In Extract 14.1 the candidate failed to provide the correct answers to all parts of the question. For example he/she defined the aerial environment as the upper surface of the Earth's crust, that is, landscape and land within the ocean.

Conversely, the candidates who did well (8.6%) demonstrated mastery of the concepts of Environmental Physics as they were able to define the term aerial environment and give examples. They were also able to describe three ways in which the aerial environment is threatened, explain major concepts on solar wind, and mention points on how soil environmental components influence plant growth. Extract 14.2 shows a good response from one of the candidates who scored high marks in this question.

Extract 14.2

14(a) i, Aerial environment.
This is the environment of the atmosphere, i.e the environment above the earth's surface.

Examples of aerial environments are;
- The ozone layer.
- Mixture of gases in the atmosphere.

ii/ The aerial environment is threatened by the following;
- Building of large industries and exposing the waste products from them to the atmosphere. This result to excessive soot in the sky which may cause acid rain.
- Cutting down of trees. By cutting down trees much heat will fall directly to earth's surface, and may fail to absorb all this. The reflected sunlight energy will result to a global warming.
- Distruction of the ozone layer. The ozone layer is distructed by several ways but the major ones may be due to increase in green house gases in the atmosphere.

4.(a) ii/ When the ozone layer is destroyed, UV light and cosmic rays will fall directly to living organisms on the earth's surface causing health problems like skin cancer.

(b) i/ Solar winds are moving electrons and protons resulted from the flare of the sun.
The major concepts of solar winds are;
⇒ The observed moving electrons and protons which arrange themselves under the influence of earth's magnetic/electric field to form the so called Van-Allen Belts. These are the results of flare or eruption of the sun.

⇒ Solar winds may be due to unequal heating of the sun.

ii/ Soil environmental components influence plant growth, these components are;
(a) Soil water.
soil water is very important in plant growth as it hydrolyse the seed testa inorder for seed to germinate easily.
Also provide basic medium for enzymes.

14.(b) ii (b) Soil Air

Air as the components of the soil is very important in influencing plant growth as gives or provide ventilation of the roots, easy penetration hence growing.

(c) Living organisms

Living organisms play a major role in plant growth, these may be enzymes which catalyse the physiology of growth.

Extract 14.2 shows a candidate's good responses to the question. The candidate was able to give the correct answers to most parts of the question but he/she failed to mention one of the ways which threaten aerial environment.

3.0 ANALYSIS OF THE CANDIDATES' PERFORMANCE PER QUESTION IN PHYSICS 2

3.1 Question 1: Fluid Dynamics

This question had four parts, namely (a), (b), (c) and (d). In part (a) the candidates were required to (i) distinguish between static, dynamic and total pressure as applied to streamline flow and write their respective expression in terms of fluid velocity v, fluid density ρ, pressure P and height h of the point with respect to a datum and (ii) calculate the flow velocity and volume flow rate in the pipeline in which the static pressure is 4.3×10^4 Pa, total pressure is 4.7×10^4 Pa, the area of cross–section is 20 cm^2 and the density of a non–viscous fluid is 1000 kg/m^3. In part (b) the candidates were required to (i) state the Newton's law of viscosity and hence deduce the dimensions of the coefficient of viscosity and (ii) calculate the coefficient of viscosity of motor oil from the given experimental measurements; when the mass of glass sphere is 1.2×10^{-4}kg, diameter of sphere is 4.0×10^{-3}m, the terminal velocity of sphere is $5.4 \times 10^{-2} ms^{-1}$ and the density of oil is 860 kgm^{-3}. Part (c) required them to (i) explain briefly the working of a car carburetor by applying the Bernoulli's theorem, (ii) find the pressure across the first capillary in a system of three capillaries whose internal radii are 3R, 4R and 5R connected in series when the pressure across the third capillary is 8.1mm of liquid. In part (d) the candidates were required to give reasons on the following observations: (i) A flag flutter when strong winds are blowing on a certain day, (ii) a parachute is used while jumping from an airplane, and (iii) hotter liquids flow faster than cold ones.

The question was attempted by 83.6 percent of the candidates, out of those 5.0 percent scored a 0, 64.8 percent scored from 0 to 6.5 marks, 29.1 percent scored from 7.0 to 11.5 marks and 6.1 percent scored from 12 to 20 marks. These score indicate that the question was averagely performed. The performance of the candidates in this question is also depicted by the histogram in Figure 15.

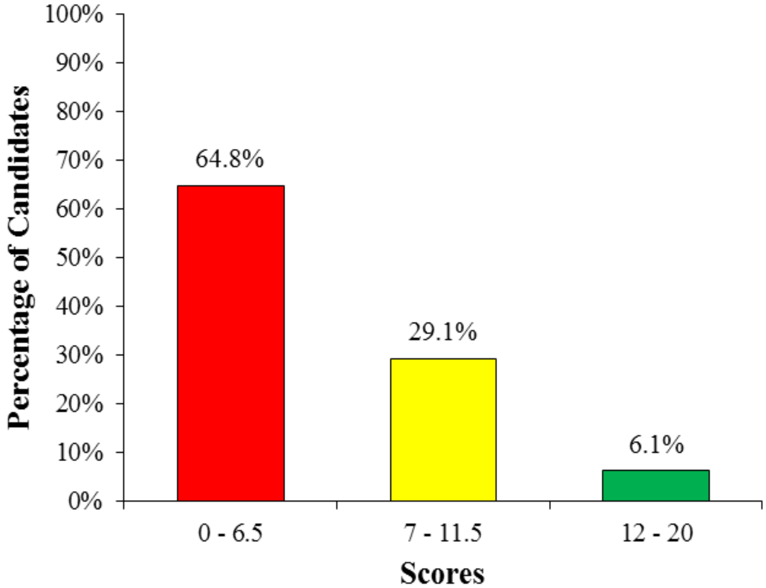


Figure 15: The candidates' performance in question 1.

The candidates who scored 12 – 20 marks had a good conceptual understanding on the fluids dynamics. They were able to distinguish between static pressure, dynamic pressure, and total pressure and use the knowledge to calculate the numerical value of flow velocity in a pipe. Furthermore, they calculated the coefficient of viscosity of oil, pressure across a capillary tube and managed to explain the given observations in fluid dynamics. Extract 1.1 shows the answers given by a candidate who performed well in all parts of the question.

Extract 1.1

Qn 1 (a) (i) static pressure is the pressure which does not change when fluid is flow in a cross-section al area of pipe while dynamic pressure is the pressure in which varies with velocity when fluid flow in a pipe while total pressure is the sum of dynamic pressure and static pressure of the fluid flow in a pipe of cross-section area

expressions

velocity (v)

pressure (P)

density (ρ)

from bernoulli's principle

$P + \rho gh + \frac{1}{2}\rho v^2 = $ constanst

expression will be

$P + \rho gh + \frac{1}{2}\rho v^2 = $ constant

Qn 1 (a) (ii) Data

static pressure (P) $= 4.3 \times 10^4$ pa

totall pressure (PT) $= 4.7 \times 10^4$ pa

Area (A) = 20cm²

Qn 1 (b) (ii)

density (ρ) = 1000 kg/m³

velocity = ?

volume rate = ?

From bernoulli's theorem

$$P + \rho gh + \frac{1}{2}\rho v^2 = c$$

$$P_1 + \rho gh_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho gh_2 + \frac{1}{2}\rho v_2^2$$

but fluid is incompressible

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho gh_2 + \frac{1}{2}\rho v_2^2$$

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$\frac{1}{2}\rho v_1^2 - \frac{1}{2}\rho v_2^2 = (P_2 - P_1)$$

$$\frac{1}{2}\rho (v_1^2 - v_2^2) = (P_2 - P_1)$$

$$\frac{1}{2}\rho (v^2) = (4.7\times10^4 - 4.3\times10^4)$$

$$\frac{1}{2}\times 1000 (v^2) = 4000$$

$$500v^2 = 4000$$

Qn 1 (a) (i)

$$V^2 = \left(\frac{4000}{500}\right)$$

$$V^2 = 8 m/s$$

$$V = \sqrt{8} m/s$$

Velocity (V) is 2.828 m/s

(ii) Volume rate

soln

from

$$Q = VA$$

V - velocity and A - area

$$Q = (2.828 \times 20 \times 10^{-4})$$

$$Q = 5.656 \times 10^{-3} m^3/s$$

∴ Volume flow rate (Q) is $5.656 \times 10^{-3} m^3/s$

Qn 1 (b) Newton law of law of viscosity state that force exist between the layer of the fluid per unit area per unit velocity gradient

Qn 1 (b) (i) always is constant

Dimensions

from

$F = \eta A \frac{dv}{dx}$

$\eta = \frac{F}{A\, dv/dx}$ $[F] = [MLT^{-2}]$

$[A] = L^2$

$[\frac{dv}{dx}] = \frac{[LT^{-1}]}{[L]}$

$[\eta] = \frac{[MLT^{-2}]}{[L^2][T^{-1}]}$

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

Dimension of η is $[ML^{-1}T^{-1}]$

Qn 1 (b) (ii) Data

Mass $= 1.2 \times 10^{-4}$ kg

Diameter (D) $= 4 \times 10^{-3}$

Terminal velocity $= 5.4 \times 10^{-2}$ m/s

Qn 1 (b) (ii)

Data

$\rho_{oil} = 860 kg/m^3$

$\eta = 1.0$

from

Volume = Ah — (i)

$\rho = m/v$

from volume of sphere

$V = \frac{4}{3}\pi R^3$

$R = (D/2) = (\frac{4.0 \times 10^{-3}}{2})$

$R = 2.0 \times 10^{-3}$

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

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

from

density $= (\frac{mass}{volume})$

Qn 1 (b) (ii)

$$\rho = \left(\frac{1.2\times10^{-4}\,kg}{3.35\times10^{-8}\,m^3}\right)$$

$$\rho = 3580.99\ kg/m^3$$

from

$$V_T = \frac{2}{9}\,\frac{r^2\rho(\sigma-\rho)g}{\eta}$$

$$V_T = \frac{2}{9}\,\frac{r^2 g(\sigma-\rho)}{\eta}$$

$$(5.4\times10^{-2}) = \frac{2}{9}\,\frac{(2\times10^{-3})^2\times9.8\,(3580.99-860)}{\eta}$$

$$(5.6\times10^{-2}) = \left(\frac{0.0023703}{\eta}\right)$$

$$\eta = \left(\frac{0.0023703}{5.4\times10^{-2}}\right)$$

$\eta = 0.4389\ Nsm^{-2}$

coeffient of viscosity of oil is $0.4389\ Nsm^{-2}$

Qn 1

(c) (i) from bernoulli's theorem it can anable carburetor of car to operate well in their function due to pressure of the fluid varies with velocity

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

(ii) Data

$R_1 = 3R$

$R_2 = 4R$

$R_3 = 5R$

Pressure = 8.1 mm Hg

from

$$Q_1 = \frac{\pi P R_1^4}{8\eta l_1} = \frac{\pi P R_2^4}{8\eta l_2} = \frac{\pi P R_3^4}{8\eta l_3}$$

Qn

1 (c)

$$Q = \frac{\pi P(3R)^4}{8\eta l} = \frac{\pi P(4R)^4}{8\eta l} = \frac{\pi P(5R)^4}{8\eta l}$$

$$Q = (3R)^4 = (4R)^4 = (5R)^4$$

$$P_1 81 R_1^4 = 256 R_2^4 P_2 = P_3 (625 R^4)$$

$$81 P_1 = 256 P_2 = 625 P_3$$

$$81 P_1 = 625 P_3$$

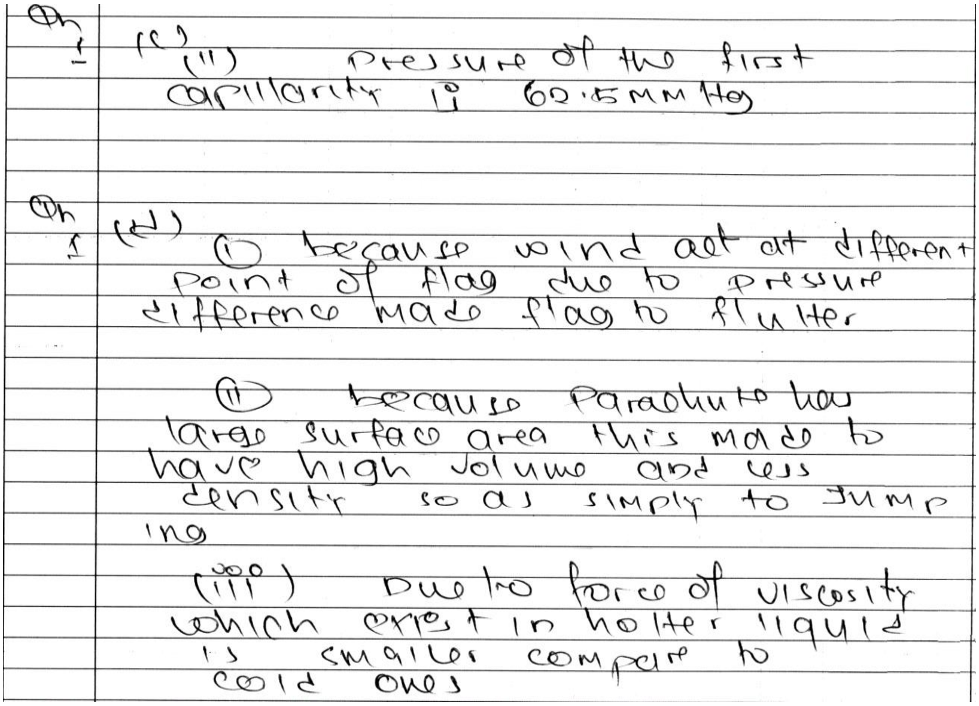
$$P_3 = 8.1 \text{ mm Hg}$$

$$81 P_1 = (625 \times 8.1)$$

$$81 P_1 = 5062.5$$

$$P_1 = \left(\frac{5062.5}{81}\right) \text{ mm Hg}$$

$$P_1 = 62.5 \text{ mm Hg}$$



Qn 1 (c) (ii) pressure of the first capillarity is 62.5 mm Hg

Qn 1 (d) (i) because wind act at different point of flag due to pressure difference made flag to flutter

(ii) because parachute has large surface area this made to have high volume and less density so as simply to jumping

(iii) Due to force of viscosity which exist in hotter liquid is smaller compare to cold ones

In Extract 1.1 the candidate managed to answer correctly all parts of the question.

On the other hand, the candidates who performed poorly, particularly those who scored zero in this question lacked conceptual understanding in fluids dynamics and had poor numerical skills in questions involving mathematics. Most of them could not distinguish the pressure terms in fluid flow: the static pressure when fluid is at rest, the dynamic pressure when the fluid is flowing and the total pressure which is the sum of static and dynamic pressures. Furthermore, they failed to calculate the pressure in capillary tube and to give explanations of the given observations in fluid dynamics. Extract 1.2 indicates the answers of one of the candidates who performed poorly.

Extract 1.2

1. (a) i/ Static pressure

$$C = \rho g h$$

Where, C = constant
ρ = density fluid
g = acceleration due to gravity
h = height of a fluid

Dynamic pressure

$$C = \frac{1}{2}\rho v^2$$

Where, C = constant
ρ = density of a fluid
v^2 = velocity of a flowing fluid.

Total pressure

~~$C = P_1 + P_2$~~

$C = P.$

where, C = constant
P = Pressure

(b) ii/ from the formular

$$V = \sqrt{\frac{2A_1^2 g}{\rho (A_1^2 - A_2^2)}}$$

1	(a) ii/ $v^2 = \frac{2A_1^2 g}{\rho A_1^2 - A_2^2}$
	$\rho A_1^2 - A_2^2 v^2 = 2A_1^2 g$
	$\rho A_1^2 - 2A_1^2 g = A_2^2 v^2$
	$\rho A_1^2 - A_1^2 2g = A_2^2 v^2$
	$\rho - 2g = A_2^2 v^2$
	$\frac{\rho - 2g}{A_2^2} = v^2$
	$v^2 = \frac{\rho - 2g}{A_2^2}$
	$V = \sqrt{\frac{\rho - 2g}{A_2^2}}$
	$V = \sqrt{\frac{1000 - 2 \times 9.8}{(0.04 m)^2}}$
	$V = 782.78$ m/s
	∴ The flow of velocity is 782.78 m/s.
	To find volume rate
	$V/t = \frac{\pi r^4 \Delta P}{8\eta L}$

1	(a) ii/	Area $= \pi r^2$
		$\frac{0.04}{\pi} = \frac{\pi r^2}{\pi}$
		$r^2 = \sqrt{0.0127}$
		$r = 0.113.$
		but
		length, $L = r + r$
		$= 0.113 + 0.113$
		$= 0.226.M.$
		$V/t = \frac{\pi r^4 \; P_1 - P_2}{8 \cdot \eta \cdot L}$
		but
		$f = \eta / V.g$
		but $F = P.A$
		$F = 4.7 \times 10^4 \cdot 0.04$
		$F = 1880$ N.
		$F = \eta / V.g$
		$1880 = \eta / 782.78$
		$\eta = 1.47 \times 10^6$ Nms^{-1}
		$\therefore V/t = \frac{\pi r^4 \rho g h}{8 \cdot \eta \cdot L} = \frac{\pi \cdot 0.113^4 \cdot 4.7 \times 10^4}{8 \cdot 1.47 \times 10^6 \cdot 0.226}$
		$= 8.28 \times 10^{-6}$
		$\therefore$ Volume flow rate is 8.28×10^{-6} $dm^3 s^{-1}$.

1	(b) i/	Newtons law of viscosity state that "the flow of a liquid to the substance is ~~inversely proportion~~ direct proportional to the applied force and inversely to the velocity terminal and their radius.
		$\eta \alpha \frac{F}{V_T r}$, $\eta = \frac{F}{6\pi V_T r}$
		Dimension
		$F = 6\pi \eta r V_T$.
	ii/	$\eta = F / 6\pi r . V_T$
		$F = mg$
		$F = 1.2 \times 10^{-4} \times 9.8$
		$F = 1.176 \times 10^{-3}$
		$\eta = \frac{1.176 \times 10^{-3}}{6\pi . 2 \times 10^{-3} \times 5.4 \times 10^{-2}}$
		$\eta = 15.59\ N m^{-2} s^{-1}$.
		∴ Coefficients of viscocity of a oil is $15.59\ N m^{-2} s^{-1}$
	(d) i/	because of the aerofoil, the upper layer having high velocity than the lower part.
	ii/	because the gravitational force approach to zer
	iii/	Because the density was decreased by temperature, due to that fact the move fast.

Extract 1.2 shows the response of a candidate who failed the whole question by using incorrect responses to the tasks given. For example, in part (a) (ii), the candidate applied the Poiseuille's formulae, $\frac{V}{t} = \frac{\pi h \rho g r^4}{8 \eta l}$ to find the volume flow rate in the pipeline instead of using the simple relation, *volume flow rate = area ×velocity of flow in the pipeline*.

3.2 Question 2: Vibrations and Waves

This question had four parts, namely (a), (b), (c) and (d). Part (a) required the candidates to define the terms (i) intensity of sound, (ii) beats (iii) ultrasound and (iv) overtones. In part (b), the candidates were required to calculate the fundamental frequency emitted by a vertically hanging steel wire of length 1.5 m and diameter 0.5 mm if it is plucked while supporting a weight of 80N. In part (c) they were required to (i) give any two applications of ultrasonic as applied to sound waves (ii) calculate the blood flow velocity and volume flow rate of blood if the ultrasound of frequency 4.0Hz is incident at an angle of 30^0 to a blood vessel of diameter 1.6 mm, and that the speed of ultrasound 1.5 kms^{-1} and a Doppler shift of 3.2 kHz is observed. In part (d), the candidates were required to (i) determine whether the galaxy is moving towards or away from the observer on the earth, and (ii) determine the speed of a faint galaxy relative to an observer on the earth if in its absorption spectrum one of the lines identified as calcium H line is 478 nm and that the same line has a wavelength of 397nm when measured in a laboratory.

The question was attempted by 30.7 percent of the candidates whose scores are as follows: 82.4 percent scored from 0 to 6.5, including 19 percent who scored 0, 13.9 percent scored from 7.0 to 11.5 marks, and 3.7 percent scored from 12 to 20 marks. Only one candidate managed to score full marks. These scores indicate that the question was poorly performed. The following chart presents the above data in percentages.

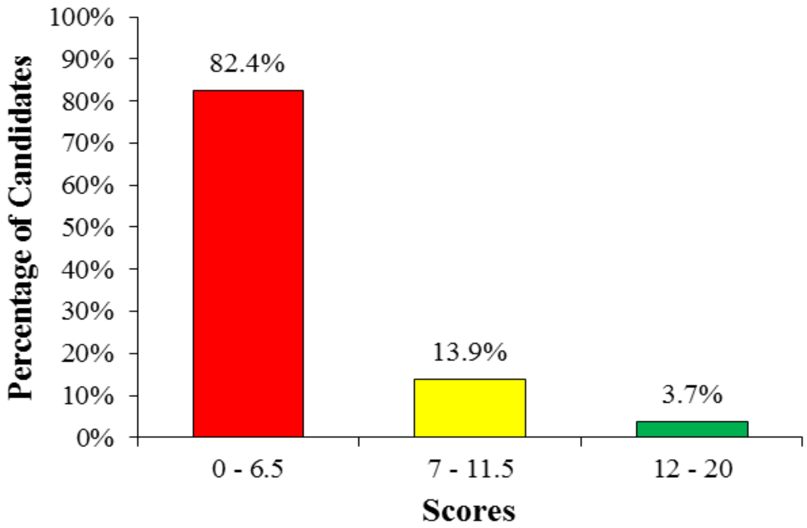


Figure 16: Performance of the candidates in question 2.

The candidates who performed poorly (82.4%) had inadequate knowledge on mechanical waves as they failed to provide the correct responses to most parts of the question. Most of them appeared to lack knowledge on normal modes of vibrations and consequently failed to calculate the fundamental frequency on a plucked steel wire. Also, the concept of Doppler effect as applied in light seemed to be unfamiliar to most of them as they failed to find the apparent change in wavelength that would have helped them to identify the direction of motion of a moving galaxy. Extract 2.1 is a sample of a poor answer taken from the script of one candidate.

Extract 2.1

Qn 2

i Intensity of sound: Is the fixed path of the sound in a medeium.

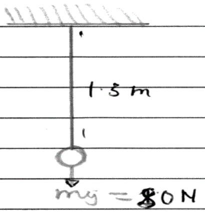
ii Beats: Is the regular sound which are produced by the defferent instrument of the same frequency and head.

iii Ultrasonic: Is the wave form which are produced by the rada effect.

iv Overtone Is the multiple of the fundamental frequency.

(b) Data given
weight = 80N
length (L) = 1.5 m
Diameter = 0.5 mm = 5×10^{-4} m.
1m = 1000 mm
X. = 0.5 mm

Wavelength(λ) = length of the wire. (L)
Wavelength = 1.5 m
fundamental frequency (f_o) = $\frac{Velocity}{wavelength}$



Qn 2

b

$$V = \sqrt{\rho g / L}$$

$mg = 80N$

$9.8m = 80N$

Mass (m) = 80/9.8

mass (m) = 8.16327 kg

Recall

Density (ρ) = $\frac{mass}{volume}$

Volume of the sphere (v) = $4\pi r^3$

$= 4 \times 3.14 \times \left(\frac{5\times10^{-4}}{2}\right)^3$

Volume of the sphere (v) = $1.9625 \times 10^{-10} m^3$

Density = $\frac{8.16327}{1.9625\times10^{-10}}$

Density = 4.1596×10^{10} kg/m3

$$V = \sqrt{\frac{4.1596\times10^{10}\times9.8}{5\times10^{-4}m}}$$

$V = 28.55 \times 10^{6}$ m/s.

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

fundamental frequency = $\frac{28.55\times10^{6}}{5\times10^{-4}}$

∴ fundamental frequency = 5.7×10^{10} Hz.

Qn 2

C i Application of ultrasonic

1 ~~Used in hospital to check the internal Beats in the body~~

1. Used in traphic to measure the velocity of the moving Car.

2 Used to measure the ~~sea~~ depth of the ocean.

(ii) Data given

frequency 4.0MHz

Velocity of ultrasonic (v) = 1.5Km/s

Beat frequency = 3.2kHz.

Diameter of the 1.6 mm

$1m = 1000mm$

$x = 1.6mm$

$1.6 \times 10^{-3}m$.

From

$$\text{Velocity (V)} = \frac{\Delta fC}{2f}$$

$$\text{Velocity (V)} = \frac{3.2 \times 3 \times 10^{8}}{2 \times 4.0 MHz}$$

$$\text{frequency (f)} = \frac{40 MHz}{1000 m} = 4 \times 10^{-3} Hz.$$

$$\text{Beat frequency } (\Delta f) = 3.2kHz = 3.2 \times 10^{-6} Hz$$

$1.5 \times 10^{-6} m/s$ = Velocity of ultrasonic

$$C \text{ (Velocity of sound)} = \frac{2VF}{\Delta F}$$

$$\text{Velocity of sound (C)} = \frac{2 \times 1.5 \times 10^{-6} \times 4 \times 10^{-3}}{3.2 \times 10^{-6}}$$

Qn 2.

Velocity (c) = 3.75×10^{-3} m/s.

$V = C - V_0$

$V = 3.75 \times 10^{-3} - 1.3 \times 10^{-6}$

Velocity of blood is 3.7485×10^{-3} m/s.

d.

i The galax is moving toward the observer on the earth

ii

~~Wavelength~~ (λ_1) = 478 nm. = 8.853×10^5 m

Wavelength (λ_2) = 347 nm. = 7.352×10^5 m.

~~Relative~~

frequency = $\frac{V}{\lambda}$

frequency(f_1) = $\frac{\text{Velocity of light}}{\text{wavelength } (\lambda_1)}$

frequency = $\frac{3 \times 10^8 \text{ m/s}}{8.853 \times 10^5}$

frequency (f_1) = 338.87 Hz.

Also frequency(f_2) = $\frac{3 \times 10^8}{7.352 \times 10^5}$

frequency(f) = 408 Hz.

Relative frequency(f) = ($f_2 - f_1$)

= (408 − 338.87) Hz.

Q. d Relative frequency(F) = 69.13 Hz

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

Speed = 69.13 × ~~347~~ 7.352 × 10^5

∴ speed of the galaxy is 50.82×10^6 m/s.

In Extract 2.1 the candidate failed all parts of the question. The candidate confused Doppler shift with beat frequency and used the two phenomena interchangeably. Also he/she used an incorrect formula to calculate the velocity of wave on a plucked string.

On the other hand, a few (3.7%) candidates who scored high marks had sufficient knowledge on vibrations and waves. They managed to define the terms intensity of sound, beats, ultrasonic and overtones. They also managed to calculate fundamental frequency emitted by a plucked wire, give applications of ultrasonic as applied to sound waves, calculate the blood flow velocity and volume flow rate of blood, determine that the galaxy is moving towards the observer on the earth and correctly determine the speed of a faint galaxy relative to an observer on the earth. Extract 2.2 is the work of a candidate who managed to provide the correct responses to most parts of the question.

Extract 2.2

2 (a) (i) Intensity of sound is the measure of amount of energy per unit area per unit time in propagating the sound waves.

(ii) Beat is the periodic rise and fall of sound intensity (variation in sound intensity) observed when two sound sources of nearly equal frequency are sounded simultaneously.

(iii) Ultrasonic, These are waves whose frequency is greate than 20kHz hence They are inaudible.

(iv) Overtones These are notes whose frequency is higher than that of fundamental frequency of the vibrating instrument

2 (b) Data

$T = 80N$

$L = 1.5m$

diameter (d) = 0.5mm.

2 (b) from

fundamental frequency

$$f_0 = \frac{1}{2L}\sqrt{T/y}$$

But $y = \frac{mass}{Length} = \frac{\rho \times Volume}{L}$

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

$$Area = \pi r^2$$

4 r = radius

$$f_0 = \frac{1}{2L}\sqrt{\frac{T}{\rho \pi r^2}}$$

$$f_0 = \frac{1}{2 \times 1.5}\sqrt{\frac{80}{7800 \times 3.14 \times (2.5 \times 10^{-4})^2}}$$

$$f_0 = 76.20 Hz$$

fundamental frequency = 76.20 Hz.

2 (c) (i)

- Used in detemmation of the depth of the sea or any wate bodies
- Used in cleaning surgical instruments or apparatis, also for treatment of various diseases in medicine field such as cancer.

(ii) Data

frequency (f) = 4.0×10^6 Hz

θ = 30°C

diamete = 1.6mm

Δf = 3.2kHz

Speed of ultrasound = 1.5km/s.

Now from

$$u = \frac{\Delta f}{2f\cos\theta} V$$

where Δf = dopple shift

V = speed of ultrasound

u = speed of blood

$$u = \frac{3.2 \times 10^3 \times 1.5 \times 10^3}{2 \times 4 \times 10^6 \times \cos 30^\circ} \text{ m/s}$$

$$u = 0.69 \text{ m/s}$$

Speed of blood flow = 0.69m/s

Volume flow rate = Area × speed

= $\pi r^2 \times 0.69$ m/s

2 (c) (ii)

$= 3.14 \times (0.8 \times 10^{-3})^2 \times 0.69\ m^3/s$

$= 1.39$ ~~m^3/s~~ $\times 10^{-6}\ m^3/s$

~~Speed of blood flow = 0.69 m/s~~

Volume flow rate $= 1.39 \times 10^{-6}\ m^3/s$

2 (d) (i) The galaxy is moving away from the observe on the earth since its true wavelength 397nm measured in the laboratory is less than the observed wavelength, 478nm.

(ii) **Data**

Observed wavelength $\lambda' = 478\ nm$

Its true wavelength $\lambda = 397\ nm$

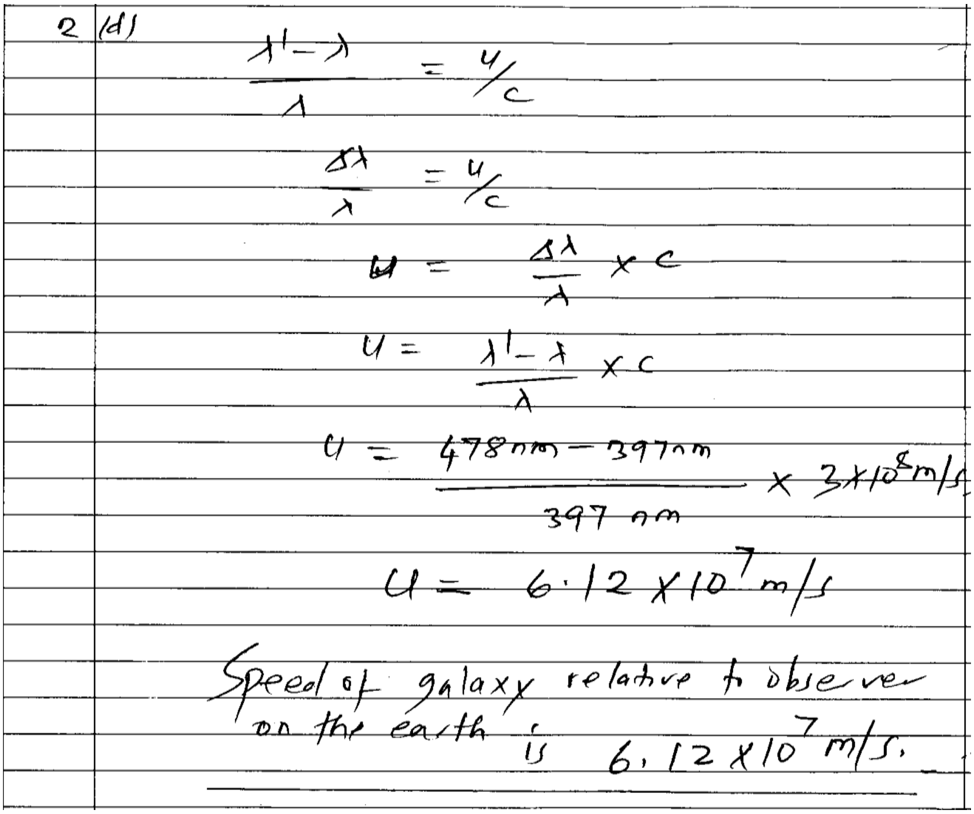
Required speed of the galaxy,

~~But~~ $\lambda' = \dfrac{\text{velocity of light relative to the source}}{\text{frequency of the source}}$

$$\lambda' = \left(\frac{u+c}{f}\right) = \left(\frac{u+c}{c}\right)\lambda$$

$$\lambda' = \left(\frac{u}{c} + 1\right)\lambda$$

$$\frac{\lambda' - \lambda}{\lambda} = \frac{u}{c}$$


2 (d)

$$\frac{\lambda' - \lambda}{\lambda} = \frac{u}{c}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{u}{c}$$

$$u = \frac{\Delta\lambda}{\lambda} \times c$$

$$u = \frac{\lambda' - \lambda}{\lambda} \times c$$

$$u = \frac{478\,nm - 397\,nm}{397\,nm} \times 3\times10^8\,m/s$$

$$u = 6.12 \times 10^7\,m/s$$

Speed of galaxy relative to observer on the earth is $6.12 \times 10^7\,m/s$.

Extract 2.2 shows the correct responses from the candidate who managed to perform the question as per its demand.

3.3 Question 3: Vibrations and Waves

This question had four parts, namely (a), (b), (c) and (d). In part (a) the candidates were required to state the principle of (i) superposition of waves, and (ii) Huygens construction of wave fronts. Part (b) required the candidates to (i) calculate the spacing between fringes observed on the screen if a monochromatic beam of light of wavelength 450 nm is incident parallel on two slits A and B whose centers are 0.3 mm apart and that the screen is placed 2.0 m from the slits, and (ii) suggest the change on the pattern of fringes when the slits A and B are each made wider. Part (c) required the candidates to describe the formation of interference patterns by using Newton's rings experiment. Part (d) required the candidates to calculate the radius of curvature of a Plano – convex lens used to produce Newton's rings with a flat glass plate and the diameter of the twentieth bright ring if the diameter of the tenth dark ring is 4.48 mm and viewed by a normally reflected light of wavelength 5.00 x 10^{-7}m.

A total of 6,976 (40%) candidates attempted this question. Out of them 69.8 percent scored from 0 to 6.5 marks, 7.8 percent scored 0, 25.1 percent scored from 7.0 to 11.5 marks and 5.1 percent scored from 12 to 20 marks. These scores indicate that the question was poorly performed. The following pie chart divulges the information given above.

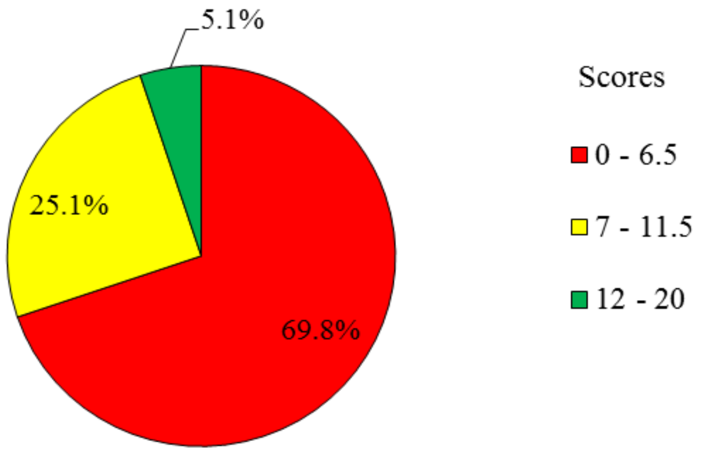


Figure 17: The candidates' performance in question 3.

The data presented in Figure 17 indicate that 69.8 percent of the candidates scored below 3.5 marks, which is poor performance.

The candidates who performed poorly (69.8%) in this question were not able to state the principle of superposition of waves and Huygens construction of wave fronts. Also they could not calculate the spacing between fringes observed on the screen due to monochromatic beam of light incident parallel on two slits. For example, one of the candidates interchanged the distance between the slits and the screen D and the separation of the slits d in calculating the fringes width. He/she used the formula $\beta = \frac{\lambda d}{D}$ instead of $\beta = \frac{\lambda D}{d}$. Similarly, these candidates could not describe the formation of interference patterns by using Newton's rings experiment. They also failed to calculate the radius of curvature of a Plano–convex lens used to produce Newton's rings with a flat glass plate. Extract 3.1 is a sample of a poor answer given by one candidate.

Extract 3.1

Qn 3

@

i The principle of superposition state that wave light of the same frequency are supoporpoint when the light are monarcromatic light and also are Coherent light.

ii When the light of monocromatic are pasing throug ~~h~~ a small hole ~~of the~~ soparated in small distance the fringe are arpera on the screan.

b. Data given

wave length 450nm $= 8.334 \times 10^{6}$ m

Diameter 3 mm

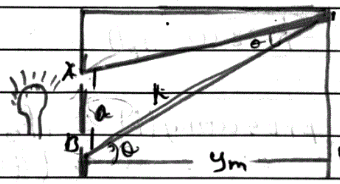
1m = 1000mm

x = 0.3mm

Diameter $= 3 \times 10^{-4}$ m

Distance of the screen (ym) = 2.0 m

(i) From diagram



frequency $= 1/x = 119.99 \times 10^{-9}$

Space between observer of the screen (W)

From $y_m = \frac{PD}{a} = \frac{119 \times 10^{-9} \times 3 \times 10^{-4}}{2}$.

~~$a = \frac{PD}{y_m}$.~~

$y_m = 2 \cdot m$ $y_m = 1.79985 \times 10^{-11}$ m.

~~path difference (P) = mx.~~ for

~~$a = \frac{8.334 \times 10^{6} \times 3 \times 10^{-4}}{2}$~~

~~a = 1250.1 meter.~~

∴ The space between fringes is 1.79985×10^{-11} m.

ii When parton A and B are each change wider to cause the fringes in the screen to be unseen.

C. 1. The ~~colour~~ light should be monocromatic light.

2. The two wave light should be of the same frequency

3 The two wave should be of different velocity

4. The wavelegh should be ~~of~~ moving in opposite directions to each other.

5 The light wave should do two total internal reflection.

8 Data given

Diameter (D) = 4.48mm

1m = 1000 mm

X = 4.48mm

Diameter (D) = 4.48×10^{-3} m

Wavelength 5.00×10^{-7} m

Number of bright ring (m) = 20

Qn 3	$y_m =$ ~~$\frac{m\lambda D}{a}$~~
C	From
	$y_m = \frac{PD}{a}$
	$P = m\lambda$
	$y_m = \frac{m\lambda D}{a}$ — — (i)
	For bright rings
	For dark
	$y_m = m\lambda + \lambda/2.$
	$y_m = \frac{PD}{a}$
	$y_m = \frac{(m\lambda + \lambda/2)D}{a}$ — — (ii)
	Compare equation (i) and (ii)
	$\frac{m\lambda D}{a} = \frac{(m\lambda + \lambda/2)D}{a}.$
	$m\lambda a D = (m\lambda + \lambda/2)Da.$
	$m\lambda = m\lambda + \lambda/2.$
	$y_m = (10 \times 5\times10^{-7} + \frac{5\times10^{-7}}{2})4.48 \times 10^{-3}$
	$y_m = 2.352 \times 10^{-8}m.$
	$y_m = m\lambda D$ For bright rings
	$2.352\times10^{-8} = 20 \times 5\times10^{-7} \times D$
	Diameter $D = 2.352\times10^{-3}m.$
	∴ The diameter of bright ring is $2.352\times10^{-3}m.$

In Extract 3.1 the candidate failed to answer correctly all parts of the question. He/she gave incorrect and incomplete description about producing Newton's rings and poorly performed calculations by employing incorrect formula.

A small number of candidates (5.1%) who performed well this question managed to state the principle of superposition of waves and Huygens construction of wave fronts. Also they were able to calculate the spacing between fringes observed on the screen when a monochromatic beam of light was incident parallel on two slits A and B and they suggested correctly the change on the pattern of fringes when the slits A and B are each made wider. However some of them were not able to describe the formation of interference patterns by using Newton's rings experiment. Nevertheless the candidates managed to calculate the radius of curvature of a Plano–convex lens used to produce Newton's rings with a flat glass plate.

Extract 3.1 is the work of a candidate who managed to provide correct responses to most parts of the question.

Extract 3.2

3. a) i) ~~is~~ Principle of Superposition of waves states that;

" When two or more waves travell simultane at a point the resultant displacement ~~of~~ at that point is equal to vector sum due to individual displacement."

Principle of;

ii). Huygens Construction of wave fronts. States that

⇒ " Each point on a wavefront acts as a fresh source of secondary wavelets which spread out with the speed of light in that medium"

⇒ " The new wave front at any letter time is given by the forward envelope of the secondar wavelets at that time."

b).

Data:

wavelength, $\lambda = 450nm$

slits separation distance, $a = 0.3 \times 10^{-3} m$

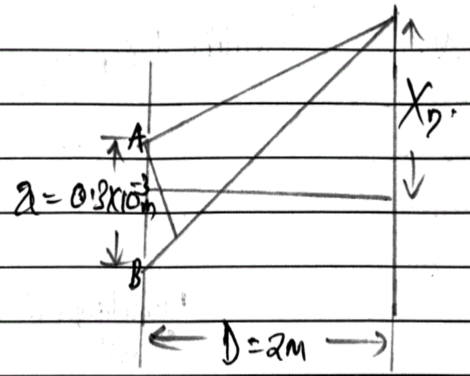
Distance of the screen, ~~d =~~ $D = 2M$

then:

⇒ Let the spacing between fringes be X_n

3. b) i).

Solution:



from

$$X_n = \frac{\lambda D}{a}$$

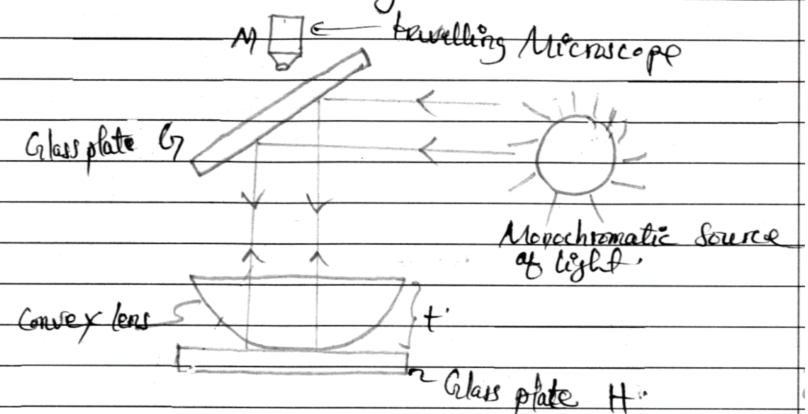
$$X_n = \frac{45nm \times 2M}{0.3\times10^{-3}}$$

$$X_n = 3\times10^{-3}m.$$

∴ The spacing between fringes at is $3\times10^{-3}m$

ii). when the slits A and B are made wider then there will be no interference pattern and hence fringe separation disappears.

3. Q. Consider the diagram below



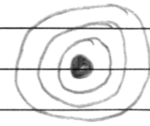
formation

when the ~~ch~~ Monochromatic light is illuminated from the Source to the glass plate "G", the ligh is reflected Vertically downwards towards Convex lens.

→ Part of these rays are ~~f~~ reflected by the lens while others pass through the lens and get reflected by the glass plate "H".

→ Both reflected rays are going to be analysed by the travelling Microscope (M).

→ And It seems that at the point of contact of the lens and glass plate "H" dark spot is seen surrounded by ~~by~~ Series of alternating dark and bright fringes. These are called Newton's rings.



3. d).

Data.

→ Radius of the tenth, 10^{th} dark ring, $\frac{4.48\times10^{-3}m}{2}$

$r_{10} = 2.24\times10^{-3}m$.

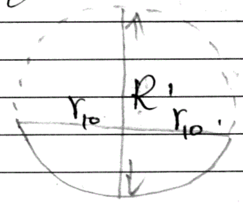
→ wavelength, $\lambda = 5\times10^{-7}m$

Solution.

– let the radius of curvature of a lens be R.

then

⇒ from



⇒ from

$$n\lambda = \frac{r_n^2}{R}.$$

$$R = \frac{r_n^2}{n\lambda}$$

$$R = \frac{(2.24\times10^{-3}m)^2}{10\times5\times10^{-7}m}$$

3\. d) $R = 1.003 m$

∴ Radius of Curvature is 1.003m.

Again

— let $2r_n$ be diameter of 20th bright ring

then

Given.

→ wavelength, $\lambda = 5 \times 10^{-7} m$

→ Radius of Curvature, $R = 1.003 m$.

Solution.

⇒ for bright fringes:

$(n + \frac{1}{2})\lambda = \frac{r_n^2}{R}$

But $n = 20 - 1 = 19$.

$n = 19$.

Hence:

$1.003 m \times (19 + 0.5) \times 5 \times 10^{-7} = r_{20th}^2$

$r_{20th}^2 = 9.779 \times 10^{-6} m^2$

$r = 3.13 \times 10^{-3}$

$2r = 3.13 \times 10^{-3} \times 2$

$2r = 6.25 \times 10^{-3} m$

∴ The diameter of the twentieth bright ring is 6.25 x

Extract 3.2 shows the correct responses from a candidate who had good knowledge on physical optics and Doppler effect and thus correctly responded to the question requirements.

3.4 Question 4: Properties of matter

This question had four parts, namely (a), (b), (c) and (d). Part (a) required the candidates to define the terms (i) free surface energy, (ii) capillary action, and (iii) angle of contact. In part (b) the candidates were required to explain the following observations: (i) soap solution is a better cleansing agent than ordinary water, (ii) when a piece of chalk is put into water, it emits bubbles in all directions. Part (c) required the candidates to (i) show that $3P_aV + 4AT = 0$ if two spherical soap bubbles are combined where T is the surface tension, Pa is the atmospheric pressure, V is the change in volume of the contained air and A is the change in total surface area; and (ii) calculate the final pressure of air in the cylinder which contains a soap bubble of radius $3.6x10^{-4}$m if the air in the cylinder is compressed isothermally until the radius of the bubble is halved. The initial pressure of air in the cylinder is $10^5N/m^2$. Part (d) required the candidates to give the meaning of strain energy and to determine the point of suspension of weight on the weightless bar of length 1.05m whose ends are supported by wires Q and P such that the cross section area of P is $1mm^2$ and that of Q is $2mm^2$ if (i) equal stresses are produced on P and Q (ii) equal strains are produced on P and Q given the Young's modulus of wires P and Q as $2.4x10^{11}Nm^{-2}$ and $1.6x10^{11}$ Nm^{-2} respectively.

The question was attempted by 55.9 percent of the candidates whose scores were as follows: 88.5 percent scored from 0 to 6.5 marks, out of which 11.7 percent scored 0. Only 9.1 percent scored from 7 to 11.5 marks and very few 2.4% scored from 12 to 19. These scores suggest that the question was poorly done. These data are pictorially presented in Figure 18.

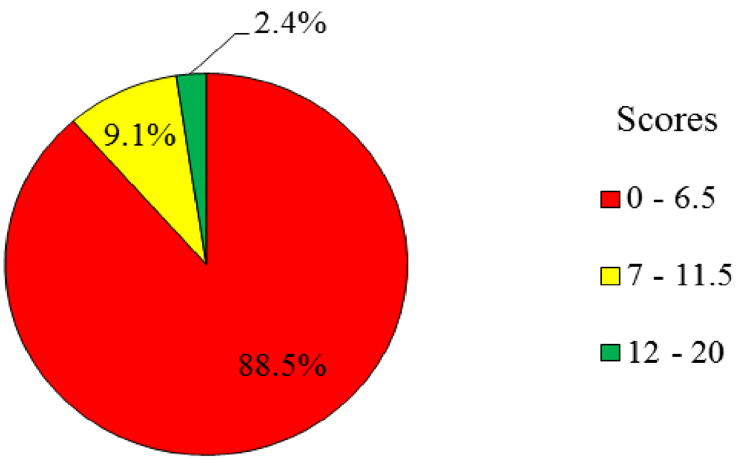


Figure 18: The candidates' performance in question 4.

The data presented in Figure 18 indicate that a total of 88.5percent of the candidates scored below 3.5 marks which is an indication of poor performance.

The candidates who performed poorly had inadequate knowledge on the concepts of surface tension and elasticity. They failed to define the phenomenon of surface tension and to explain their respective observations. Some candidates used the concept of diffusion to explain why a piece of chalk emits bubbles in all directions when put in water. These candidates were supposed to use the concept of capillarity to explain the action. Other candidates used pressure law instead of Boyle's law to show that

$3P_aV + 4AT = 0$. Moreover, these candidates could not determine the point of suspension of weight on the weightless bar whose ends are supported by two wires Q and P such that equal stress and strain are produced on P and Q. Extract 4.1 shows a sample of a poor response from one of the candidates.

Extract 4.1

SECTION B

4. (a) (i) Free surface energy is the work done per unit length.

(ii) Capillary action is the action btn the surface energy and angle of contact.

(iii) Angle of contact is the angle ~~btn~~ between the normal area to the height.

(b) Because the soap solution is greter than ordenary water.

(ii) Chalk is small area it take place and then the water is large surface area.

(c) (ii) data given

radius = 3×6 x10⁻⁴m

Pressure = 10⁵ N/m

Pressure of the air = ?

γ = 0.08 N/m

~~Ans~~

From

$P = \frac{4\gamma}{r}$

$P = \frac{4 \times 0.08}{1.8 \times 10^{-4}}$

Pressure of the air is $1.8 \times 10^{3} N/m^2$

4(a) Strain energy

is the energy of ~~on~~ change length to the original length energy.

(i) data given

Area of P = $1 \times 10^{-6} m^2$

Area of Q = $2 \times 10^{-6} m^2$

Equal stress of P and Q

$E_P = 2.4 \times 10^{11}$

$E_Q = 1.6 \times 10^{11} N/m^2$

From

$E_P = \frac{FL}{Ae}$

$E_Q = \frac{FL}{Ae}$

$\frac{FL_P}{Ae} = \frac{FL_Q}{Ae}$

$E_P = \frac{FL}{Ae}$

$2.4 \times 10^{11} = \frac{F \times L}{1 \times 10^{-6} \times e}$

$\frac{2.4 \times 10^{11} \times 1 \times 10^{-6} e}{L} = F$

$F_P = \frac{240 \times 10^{3} e}{L}$ --(1)

$F_Q = \frac{1.6 \times 10^{11} \times 2 \times 10^{-6} e}{L}$

$F_Q = \frac{320 \times 10^{3} e}{L}$

divided eqn

$\frac{320 \times 10^{3} e}{L} = \frac{240 \times 10^{3} e}{L}$

In Extract 4.1 the candidate failed to define various surface tension phenomena. He/she also failed to determine the point of suspension of weight on the weightless bar.

The candidates who performed well (2.4%) in this question managed to define the terms free surface energy, capillary action and angle of contact. Also they were able to explain physical observations based on surface tension and show that $3P_aV + 4AT = 0$ when two spherical soap bubbles are combined. They gave the meaning of strain energy and determined the point of suspension of weight on the weightless bar whose ends are supported by two wires Q and P when equal stress are produced on P and Q and when equal strain are produced on P and Q. Extract 4.2 is a sample of a good answer taken from the script of one candidate.

Extract 4.2

SECTION B

4. (a) (i) Free surface energy
is the work done per unit length.

(ii) Capillary action
is the action btn the surface energy and angle of contact.

(iii) Angle of contact
is the angle ~~btn~~ between the normal area to the height.

(b) Because the soap solution is greter than ordinary water.

(ii) Chalk is small area it take place and then the water is large surface area.

(c) (ii) data given
radius = $3 \times 6 \times 10^{-4}$ m
Pressure = 10^5 N/m
Pressure of the air = ?
γ = 0.08 N/m

~~Arer~~
from

$$P = \frac{4\gamma}{r}$$

$$P = \frac{4 \times 0.08}{1.8 \times 10^{-4}}$$

Pressure of the air is 1.8×10^3 N/m^2

4 (b) (ii) Bubbles in all direction are observed because of surface tension force which tend to make the liquid contract for the area to be minimized therefore its contr action results into distribution of chalk pieces and bubbles are formed.

(c) let the radius of the two spherical bubbles be R_1 and R_1 and that of the resultant buble formed be R

Pressure inside the bubble of radius R_1

$$P_1 = P_a + \frac{4T}{R_1}$$

Volume of this bubbe $V_1 = \frac{4}{3}\pi R_1^3$

where T = Surface tension

Pressure inside the bubble of radius R_2

$$P_2 = P_a + \frac{4T}{R_2}$$

Volume $V_2 = \frac{4}{3}\pi R_2^3$

for the bubble formed

Volume $V = \frac{4}{3}\pi R^3$

Pressure inside this bubble $P = P_a + \frac{4}{3}\pi R$

4 (c) (ii)

Radius of soap bubble $R_1 = 3.6 \times 10^{-4}$ m

Original pressure $P_1 = 10^5 N/m^2$

let

final radius $= R_2$ after compression

final pressure $= P_2$

Now

$$\left(P_1 + \frac{4T}{R_1}\right)\frac{4}{3}\pi R_1^3 = \left(P_2 + \frac{4T}{R_2}\right)\frac{4}{3}\pi R_2^3$$

$$\left(P_1 + \frac{4T}{R_1}\right)R_1^3 = \left(P_2 + \frac{4T}{R_2}\right)R_2^3$$

$$P_2 + \frac{4T}{R_2} = \left(\frac{R_1}{R_2}\right)^3\left(P_1 + \frac{4T}{R_1}\right)$$

But $R_2 = \frac{R_1}{2}$

$$= \left(\frac{2R_1}{R_1}\right)^3\left(P_1 + \frac{4T}{R_1}\right)$$

$$= 8\left(P_1 + \frac{4T}{R_1}\right)$$

$$P_2 = 8\left(P_1 + \frac{4T}{R_1}\right) - \frac{4T}{R_2}$$

$$P_2 = 8\left(10^5 + \frac{4 \times 0.08}{3.6 \times 10^{-4}}\right) - \frac{4 \times 0.08}{1.8 \times 10^{-4}}$$

4 (c) (ii)

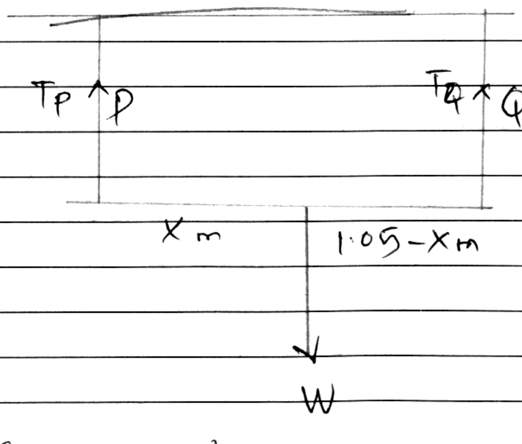
$$P_2 = 8\left(10^5 + \frac{0.32}{7.6\times10^{-4}}\right) - \frac{0.32}{1.8\times10^{-4}}\ N/m^2$$

$$P_2 = 8.05\times10^5\ N/m^2$$

Pressure of air $= 8.05\times10^5\ N/m^2$

4 (d) strain energy is the amount of energy which required to produce change in dimension of the body (length, volume or shape) due to the application of stress

4 (f)



(i) for equal stress

$$\frac{T_1}{A_P} = \frac{T_Q}{A_Q}$$

4 (d)(i)

$$\frac{T_P}{A_P} = \frac{T_Q}{A_Q}$$

$$\frac{T_P}{T_Q} = \frac{A_P}{A_Q} = \frac{1mm^2}{2mm^2}$$

$$2T_P = T_Q$$

But

$$T_P x = T_Q(1.05 - x)$$

$$T_P x = 2T_P(1.05 - x)$$

$$x = 2(1.05 - x)$$

$$3x = 2.1$$

$$x = 0.7m = 70cm$$

Now

For equal stress, the mass should be applied 70cm from P

4 (d) (ii) for equal strain

from $Y = \frac{FL}{A\Delta L}$

$\frac{\Delta L}{L} = \frac{T}{AY}$

$\frac{T_P}{A_P Y_P} = \frac{T_Q}{A_Q Y_Q}$.

$\frac{T_P}{T_Q} = \frac{A_P Y_P}{A_Q Y_Q}$

$\frac{T_P}{T_Q} = \frac{1mm^2 \times 2.4\times10^{11} N/m^2}{2mm^2 \times 1.6\times10^{11} N/m^2}$

$T_P = 0.75 T_Q$

But $T_P X = T_Q(1.05 - X)$

$0.75 T_Q X = T_Q(1.05 - X)$

4 (d)(ii) $0.75X = 1.05 - X$

$1.75X = 1.05$

$X = 0.6 = \frac{1.05}{1.75} = 0.6m$

$X = 60cm$

For equal strain, the mass should be applied at 60cm from P

Extract 4.2 is a sample answer from one of the candidates who managed to give the correct answers but failed to explain the observations 'soap solution is a better cleansing agent than ordinary water'. He/she used the concept of capillarity instead of surface tension. He/she also used the idea of surface energy instead of capillarity action.

3.5 Question 5: Electrostatics

This question had four parts, namely (a), (b), (c) and (d). In part (a) the candidates were required to (i) state Coulomb's law of electrostatics, (ii) define electric field strength E at any point and (iii) mention two common properties of electric field lines. Part (b) required the candidates to calculate the charge on either of the two balls each of mass 0.8kg carrying identical charges supported by two threads of equal length and that at equilibrium the balls are separated by a distance of 1.2 cm. In Part (c) the candidates were given the following problems, "Two capacitors C_1 and C_2 each of area 36 cm^2 separated by 4cm have capacitances of 6μC and 8μ. The capacitors C_1 is charged to a potential of difference of 110V whereas the capacitor C_2 is charged to a potential difference of 140V. The capacitors are now joined with plates of like charges connected together". Then they were required to (i) calculate the loss of energy that is transferred to heat in the connecting wires, and (ii) the loss of energy per unit volume transferred to the connecting wires.

A total of 10,981 (62.9%) candidates attempted this question, and out of them 69.4 percent scored from 0 to 6.5 marks, including, 5.8 percent who scored zero; 22.5 percent scored from 7.0 to 11.5 marks; and 8.1 percent scored from 12 to 20 marks. Only twenty five (0.1%) candidates scored full marks which is 20 out of 20 marks. The above data are summarized in the chart below.

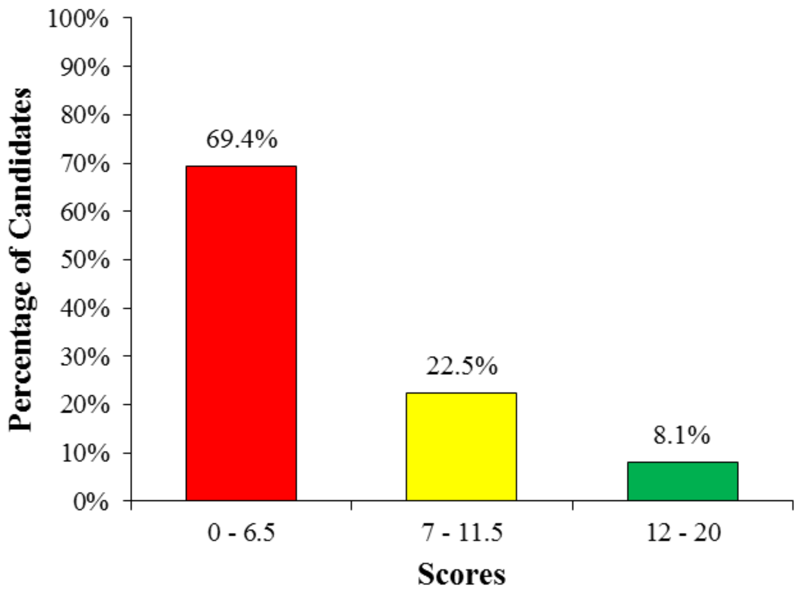


Figure 19: The candidates' performance in question 5.

The candidates who performed poorly failed to give correct responses to meet the requirements of the question. They failed to state Coulomb's law of electrostatics, and to define electric field strength E at any point. Some of them could not mention common properties of electric field lines. For example, one of the candidates stated Newton's law of gravitation instead of Coulomb's law of electrostatics, and another candidate defined magnetic field strength instead of electric field strength. Furthermore, these candidates failed to calculate the charge at equilibrium on either of the two balls each carrying identical charge.

They were also not able to calculate the loss of energy that is transferred to heat in the connecting wires and the loss of energy per unit volume transferred to the connecting wires when two capacitors initially charged to their respective potential differences are connected in parallel. These candidates were supposed to use the principle of conservation of charge to get the common potential difference across the two capacitors and the difference between the energy before connection and that after connection to obtain the loss of energy transferred to heat in the connecting wires. To state the coulomb's law of electrostatics, the candidates had to recall that in electrostatics, the force of attraction or repulsion involves the product of two point charges and that it obeys an inverse square law. Some candidates employed the use of an inverse square law only when stating the coulomb's law of electrostatics. Extract 5.1 shows a sample of a poor response given by one of the candidates.

Extract 5.1

5 a) i) Colums law State that the force of attraction or repulsion between two Charges is inversely proporhonal to the square of its radius

ii) electric field Strength is the region where by electron experience to be found.

iii) i/ must have Charges
ii/ must have elistence

5 b) Data
hf = 0.8
r = 1.2 Cm
from
$F_A = k\frac{Q_1 Q_2}{r^2}$

5 b) $F = mg$

$F = 0.8 \times 9.8$

$F = 7.84N$

so

$F = \frac{KQ_1 Q_2}{r^2}$

$7.84 = \frac{9\times10^9 \times Q_1 Q_2}{2\times10^{-2}}$

$\frac{0.1568}{9\times10^9} = \frac{9\times10^9 \times Q_1 Q_2}{9\times10^9}$

$1.742\times10^{-11} = Q_1 Q_2$

$Q = \sqrt{1.74\times10^{-11}}$

$Q = 4.17\times10^{-6}C$

So because they have equal mass the charge betwen A and B = 4.17×10^{-6} C.

5 c) Data given

$C_1 = 6\mu C$

$C_2 = 8\mu C$

$A_1 = 36\times10^{-4}m^2$

$r_2 = 4\times10^{-2}m$

$V_1 = 110V$

$V_2 = 140$

Requred to find

% loss of ~~heat~~ Ene.

5 (i)

from

$Q = C_1 V_1$

$Q_1 = 6 \times 110$

$Q_1 = 660C.$

and

$Q_2 = C_2 V_2$

$Q_2 = 140 \times 8$

$Q_2 = 1120C$

but

from

$E = \frac{1}{2} C_1 V_1^2$

$E = \frac{1}{2} \times 6 \times (140)^2$

$E =$ ~~$5.88 \times 10^4 J$~~ $36.3 \times 10^3 J$

$E_2 = \frac{1}{2} \times 8 \times (140)^2$

$E_2 = 7.84 \times 10^4 J$

Energy loss $= 7.84 \times 10^4 - 36.3 \times 10^3$

$=$ ~~4120~~

$42100 J$

$\therefore$ Energy loss $= 42100 J.$

5 c) $E = \frac{V}{d}$

$E = \frac{110}{4\times10^{-2}}$

$E_1 = 0.275$ V/m.

$E_2 = \frac{V_2}{d}$

$E_2 = \frac{140}{4\times10^{-2}}$

$= 0.35$ V/m

loss of electric $= 0.35 - 0.275 = 0.075$

$\therefore$ Energy loss $= 0.075$.

5 c) ii) $\frac{E}{V} = \frac{\frac{1}{2}CV^2}{V}$

$\frac{E}{V} = \frac{\frac{1}{2}\times 6\times(110)^2}{}$

$V = AL$

$\frac{E}{V} = \frac{1\times 6\times(110)^2}{2\times 36\times10^{-4}\times 4\times10^{-2}}$

72600

$\frac{E}{V} = 2.52\times10^{8}$ J/m3

$\therefore$ ~~Volume~~ Energy per volume $= 2.52\times10^{8}$ J

5 c) ii)

$$\frac{E}{V} = \frac{\frac{1}{2}CV_2^2}{V}$$

$$\frac{E}{V} = \frac{\frac{1}{2} \times 8 \times (140)^2}{36 \times 10^{-4} \times 4 \times 10^{-2}}$$

17640

$$\frac{E}{V} = 6.125 \times 10^{8} J/m^3$$

$$loss = \frac{E}{V_2} - \frac{E}{V_1}.$$

Energy loss $= 6.125 \times 10^8 - 2.52 \times 10^8$

$\therefore$ Energy loss per volume $= 3.605 \times 10^7 J/m^3$.

In Extract 5.1 the candidate failed to provide the correct answers to all parts of the question. For example, he/she failed even to state Coulomb's law of electrostatics.

On the contrary, the candidates who performed well (8.1%) in this question were able to state Coulomb's law of electrostatics, define electric field strength E at any point, and mention two common properties of electric field lines. Moreover, the candidates managed to calculate the charge on either of the two balls, each carrying identical charges supported by two threads of equal length at equilibrium. Also they managed to calculate the loss of energy that is transferred to heat in the connecting wires and the loss of energy per unit volume transferred to the connecting wires when two capacitors initially charged to their respective potential differences are connected in parallel. Extract 5.2 shows a sample of a good response from one of the candidates.

Extract 5.2

5 a) i. Coulomb's law, state that
" The electrostatic force of attraction between two charges is directly proportional to the products of its charges and inversely proportional to the square distance apart".

$$F_e \propto \frac{q_1 q_2}{r^2}$$

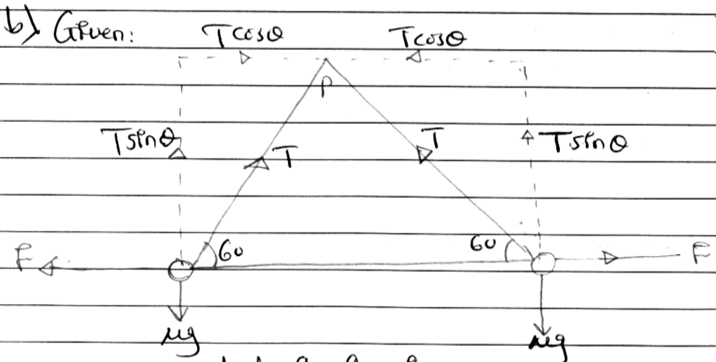
~~ii. Electric field strength: Is the force required to bring a unit charge from infinity to an electric field~~

ii. Electric field strength. Is the force experienced by a unit charge to ~~that~~ point.

$$E = F/Q$$

iii. - It does not cross each other
- Come from positive charge toward negative charge

b) Given:



but $q_1 = q_2 = q$

$T\sin\theta = mg$ - - - (i)

$F_e = T\cos\theta$ - - - (ii)

divide eqn (i) and (ii)

5 b) $\frac{T\sin\theta}{T\cos\theta} = \frac{mg}{F}$

$\tan\theta = \frac{mg}{F_e}$

But, $F_e = \frac{q^2}{4\pi\varepsilon_0 r^2}$

$F_e = \frac{9\times10^9 q^2}{r^2}$

$\tan\theta = \frac{mg}{\frac{9\times10^9 q^2}{r^2}}$

$\tan\theta = \frac{mgr^2}{9\times10^9 q^2}$

$q = \sqrt{\frac{mgr^2}{9\times10^9 \tan\theta}}$

$q = \sqrt{\frac{0.8\times9.8\times(1.2\times10^{-2})^2}{9\times10^9\times\tan 60^\circ}}$

$q = 2.69\times10^{-7}C$

∴ Charges is $2.69\times10^{-7}C$

5 c) Given:

Area $(A) = 36\ cm^2 = 36 \times 10^{-4} m^2$

distance $(d) = 4\ cm = 4 \times 10^{-2} m$

Capacitance $(C_1) = 6 \mu C$

$(C_2) = 8 \mu C$

Voltage $(V_1) = 110V$

$(V_2) = 140V$

i. loss of energy

loss of energy = Energy before joined − Energy after joined

$$E_{loss} = E_b - E_a$$

$$E_b = \frac{1}{2} C_1 V_1^2 + \frac{1}{2} C_2 V_2^2$$

$$= \frac{1}{2} \times 6 \times 10^{-6} \times 110^2 + \frac{1}{2} \times 8 \times 10^{-6} \times 140^2$$

$$= 0.0363 + 0.0784$$

$$E_b = 0.1147\ J$$

$$E_a = \frac{1}{2} C_1 V^2 + \frac{1}{2} C_2 V^2$$

$$E_a = \frac{1}{2} V^2 (C_1 + C_2)$$

But

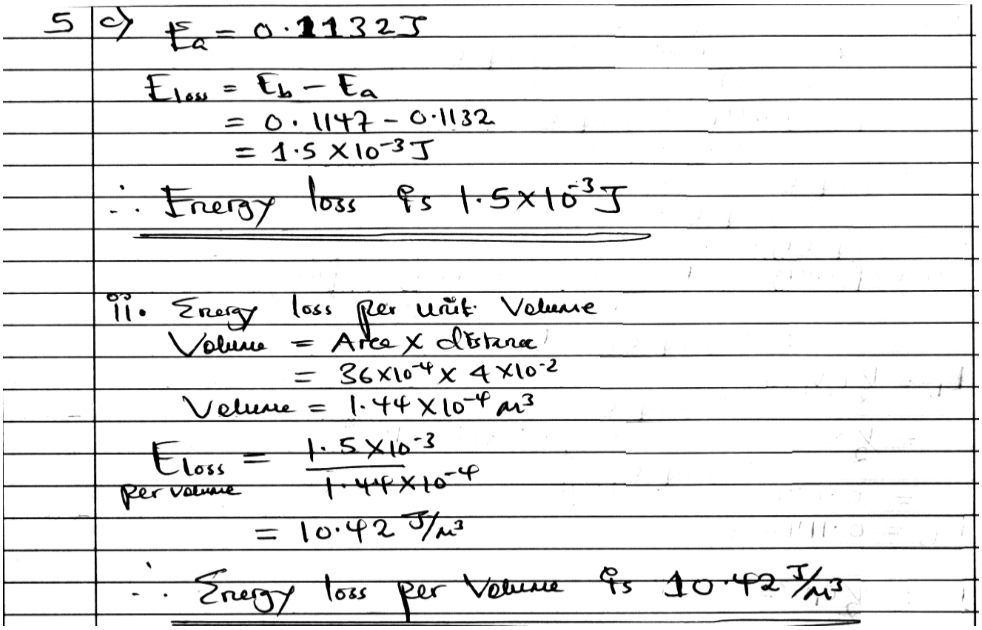
$$C_1 V_1 + C_2 V_2 = (C_1 + C_2) V$$

$$V = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$$

$$V = \frac{6 \times 10^{-6} \times 110 + 8 \times 10^{-6} \times 140}{6 \times 10^{-6} + 8 \times 10^{-6}}$$

$$V = 127.14V$$

$$E_a = \frac{1}{2} \times 127.14^2 (6 \times 10^{-6} + 8 \times 10^{-6})$$



5 c) $E_a = 0.1132J$

$E_{loss} = E_b - E_a$

$= 0.1147 - 0.1132$

$= 1.5 \times 10^{-3} J$

$\therefore$ Energy loss is $1.5 \times 10^{-3} J$

ii. Energy loss per unit Volume

Volume = Area x distance

$= 36 \times 10^{-4} \times 4 \times 10^{-2}$

Volume $= 1.44 \times 10^{-4} m^3$

$E_{loss\ per\ volume} = \frac{1.5 \times 10^{-3}}{1.44 \times 10^{-4}}$

$= 10.42 J/m^3$

$\therefore$ Energy loss per Volume is $10.42 J/m^3$

Extract 5.2 shows how the candidate managed to respond to the question. The candidate managed to attempt many parts of the question. Nonetheless, he/she provided an incomplete definition of the electric field strength E at any point.

3.6 Question 6: Electrostatics

Part (a) of this question required the candidates to define the terms (i) capacitance, (ii) charge density, and (iii) equipotential surface. In part (b) they were required to use coulomb's law of electrostatics to derive an expression for the electric field strength E, due to a point charge if the material is surrounded by a material of permittivity ε, and to show how E relates with charge density δ. Part (c) required them to describe the structure and the mode of action of a simplified version of the Van de Graff generator. Part (d) required the candidates to (i) identify any three factors on which the capacitance of parallel plate capacitor depends, (ii) determine the time of fall of a proton of mass 16.7×10^{-28}kg through a distance of 2.5cm in a uniform electric field of magnitude 2.65×10^{4}V/m if the effects of air resistance and gravity were neglected, and (iii) determine the length of a paper sheet required to construct capacitance of 15μF for a parallel plate capacitor made of paper of width 40 mm, thickness 3.0×10^{-2} mm and relative permittivity of 2.5.

The question was attempted by 47.4 percent of the candidates, with the following scores: 58.2 percent scored from 0 to 6.5 marks, with 4.1 percent scoring zero; 37.0 percent scored from 7.0 to 11.5 marks; and 4.8 percent scored from 12 to 19 marks. These data signify that the performance in this question was generally average. Below is the pie chart that expresses the candidates' performance in this question.

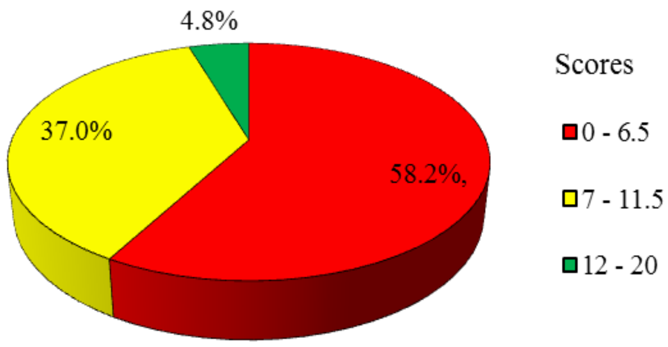


Figure 20: The candidates performance in question 6.

The data presented in Figure 20 indicate that 41.8 percent of the candidates scored 3.5 marks or above, which is average performance.

Despite the fact that the question was generally not well performed, some candidates managed to score high marks. The candidates who scored high marks (4.8%) successfully defined the terms capacitance, charge density and equipotential surface. Additionally, they derived an expression for the electric field strength E, due to a point charge and correctly showed how E relates with charge density δ. The candidates described the structure and the mode of action of a simplified version of the Van de Graff generator and identified three factors on which the capacitance of parallel plate capacitor depends on. Also, they determined the time of fall of a proton in a uniform electric field neglecting the effect of air resistance and gravity and determined the length of a paper sheet required to construct the capacitance of a parallel plate capacitor. Extract 6.1 depicts a work of a candidate who performed the question well.

Extract 6.1

6(a) i) CAPACITANCE — Is the ability of material such as capacitor to store charge which is given as the ratio of charge stored to the potential difference applied

ii) CHARGE DENSITY — Is the concentration of charge on a material which is given as the total amount of charge per unit volume / Area or length.

iii) EQUIPOTENTIAL SURFACE — Is the surface in which electric potential is the same at each point

6(b) Consider q_1 .... P $\cdot q_0$

6(b) From coulomb's law of electrostatic

$$\text{Force } (F) = K\frac{q_1 q_0}{r^2}, \quad K = \frac{1}{4\pi\varepsilon}$$

ε – permittivity of a medium;

$$F = \frac{q_1 q_0}{4\pi\varepsilon r^2} \quad \text{---(i)}$$

Now Electric field (E) at P, is

$$E = F/q_0 \quad \text{---(ii)} \quad \{\text{From definition of E}\}$$

eqn (i) and (ii)

Then
$$E = \left(\frac{q_1 q_0}{4\pi\varepsilon r^2}\right) \div q_0 = \frac{q_1}{4\pi\varepsilon r^2}$$

$$E = \frac{q}{4\pi r^2} \times \frac{1}{\varepsilon} = \frac{q}{4\pi r^2 \varepsilon} \quad \text{Hence derived}$$

But $\frac{q}{4\pi r^2} = \sigma$ = charge density

$$E = \frac{\sigma}{\varepsilon}.$$

If ε is constant

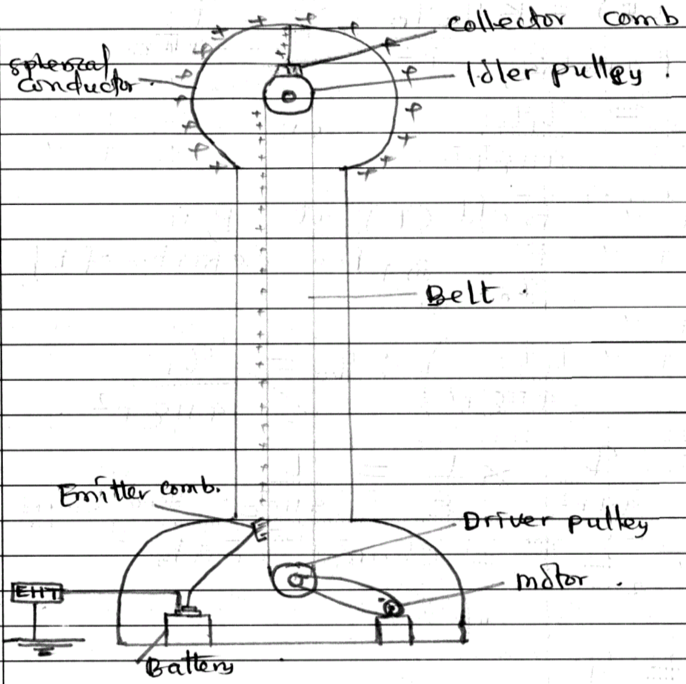
$$E \propto \sigma$$

∴ Electric field strength increases with increase in charge density.

Shown.

6(c) VAN DE GRAAF GENERATOR — Is an electrostatic generator which produces large voltages of order of 10^7 Volts.

6(c) STRUCTURE FOR VAN DE GRAAF GENERATOR



mode of action.

- The motor rotates the driver pulley leading to movement of the belt.
- The positive charge from the battery migrate to the belt through the emitter comb.
- The positive charges are carried to the collector comb where they are allowed to flow to the spherical conductor.
- As the motor continues rotating a large amount of charge accumulate on the spherical conductor hence high –

c) production of voltage of order 10^7 V.

6(d) i/ FACTORS WHICH CAPACITANCE DEPEND.

(a) Area of the plates
The capacitance of capacitor increases with increase in Area of plates.

(b) Distance of separation of plates

$$\text{Capacitance} \propto \frac{1}{\text{distance of separation}}$$

(c) Nature of dielectric materials.

$$C \propto \varepsilon_r$$

ii/ Given

mass of proton (m_p) = 16.7×10^{-28} kg.
distance (d) = 2.5 cm.
Electric field (E) = 2.65×10^4 V/m.
Time (t) = ?

From Force (F) = ma = Eq

$$a = \frac{Eq}{m} \quad \text{---(i)}$$

Also $d = \frac{1}{2}at^2$ ---- (ii)

$$d = \frac{1}{2}\frac{Eq}{m}t^2.$$

$$t^2 = \left[\frac{2dm}{Eq}\right]^{1/2}.$$

6(d). ii) But $q = +e = 1.6\times10^{-19}C$.

$$t = \frac{2\times2.5\times10^{-2}\times16.7\times10^{-28}}{[2.65\times10^{4}\times1.6\times10^{-19}]}$$

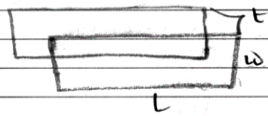
$t = 1.4\times10^{-7}s$

∴ The time of fall is $1.4\times10^{-7}s$.

iii) Given.

(w) width = 40mm, thickness (t) = 3×10^{-2} mm.

length (L) = ?



$C = 15\times10^{-6}$.

$\varepsilon_r = 2.5$.

From $C = \frac{\varepsilon_r \varepsilon_0 A}{d}$.

Area (A) = $L\times w = 40\times10^{-3}\times L$.

$d = t = 3\times10^{-5}m$.

$$A = \frac{dC}{\varepsilon_r\varepsilon_0} = 40\times10^{-3}\times L$$

$$L = \frac{3\times10^{-5}\times15\times10^{-6}}{2.5\times40\times10^{-3}\times\varepsilon_0} = 508.23$$

The length should be 508.2 mm.

Extract 6.1 shows how the candidate fulfilled the demands of all parts of the question. Consequently he/she achieved a high score.

On the contrary, the candidates who performed poorly in the question lacked both content knowledge and numerical skills. These candidates failed to define the terms capacitance, charge density and equipotential surface. For example, some of the candidates showed that the relation between electric field strength and charge density is direct relation instead of inverse relation. The majority failed to describe the structure and the mode of action of a simplified version of the Van de Graff generator and to identify three factors on which the capacitance of parallel plate capacitor depends on, which are area of plates, plate separation and permittivity of dielectric medium. Also they failed to determine the time of fall of a proton in a uniform electric field and the length of a paper sheet required for constructing the capacitance of a parallel plate capacitor. The candidates lacked general knowledge on the concepts of static electricity.

Extract 6.2

6(a) (i) Capacitance this is the reciprocal of resistance or is the ratio of electric current and the charge produced by the conductor

(ii) Charge density is the ratio of charged mass produced in a conductor and the volume of current entering and leaving the conductor

(iii) Equipotential surface this refers to the place where the energy produced in the conductor and that one leaving the conductor are the same.

b. Solution, Expression

Data given

Electric field strength = E

Permittivity = ε

Charge density = б

Solution.

$$\frac{1}{\varepsilon_0} = 4\pi \cdot \frac{1}{E + б}$$

$$E = \frac{1}{4\pi\varepsilon}\sqrt{\frac{1}{Q + б}}$$

9(ii) Factors which the capacitance of parallel plate capacitor depend

(1) Length of wire

(2) Cross section area.

(3)

(iii) Solution Data given

Mass of proton = 16.7×10^{-28} Kg

Distance / length = 2.5 cm

magnitude = 2.65×10^{4} V/m

T = Required

$$V = \frac{\text{distance}}{\text{Time}}$$

$$V = \frac{\text{magnitude}}{\text{mass of proton}} = \frac{2.65 \times 10^{4}}{16.7 \times 10^{28}}$$

$V = 1.6 \times 10^{31}$ m/s.

d $T = \frac{distance}{velocity} \Rightarrow \frac{0.025m}{1.6 \times 10^{31} m/s}$

Time $= 1.6 \times 10^{-33}$ Second.

d(ii) Data given

wide = 40mm

Thick = 3×10^{-2} mm

length = ?

Capacitance = 15μF

Relative ~~permeability~~ permitivity = 2 = 2.5

$L = \frac{1}{4\pi \varepsilon} \sqrt{E + 6}$

$L = \frac{1}{4\pi \cdot 2.5} \sqrt{15 \times \frac{1}{12 \times 10^{6}}}$

$= \frac{1}{4\pi \cdot 2.5} \sqrt{12,500,000}$

$= \frac{1}{10\pi} \cdot 3535$

$= 112.53mm.$

$\therefore$ length = 112.53mm.

In extract 6.2, the candidate was incompetent in providing correct responses. He/she defined incorrectly the terms capacitance, charge density and equipotential surface. Also the candidate used an incorrect formula to determine the time of fall of a proton in a uniform electric field and to determine the length of a paper sheet required to construct capacitance of a parallel plate capacitor.

3.7 Question 7: Electromagnetism

In part (a) of this question, the candidates were required to (i) state any three magnetic components of the earth's magnetic field and (ii) determine the earth's magnetic field and its angle of inclination I at a location where the horizontal and vertical components of earth's magnetic field are 2.7×10^{-5}T and 2.0×10^{-5}T respectively. In part (b), they were required to state: (i) Biot–Savart law, and (ii) Ampere's theorem as applied in magnetism. Part (c) required the candidates to (i) draw hysteresis loops diagram for soft iron and hard steel and use them to discuss permanent magnets, (ii) define permeability constants and (iii) derive an expression for the magnetic flux density B at the center of a circular coil of radius r and N turns placed in air carrying a current I. In part (d), they were required to calculate the (i) magnetic induction at the centre of the coil, (ii) magnetic moment of the coil, and (iii) torque acting on the coil if it is suspended in a uniform magnetic field of induction 0.6T such that its plane is parallel to the field.

The question was attempted by 33.7 percent of the candidates and out of them, 45.8 percent scored from 0 to 6.5 marks including 8.1 percent who scored zero; 31.9 percent scored from 7.0 to 11.5 marks; and 22.3 percent scored from 12 to 20 marks. Only one candidate scored full marks in this question. The analysis shows that the question was averagely done. The histogram below summarizes the performance of the candidates in this question.

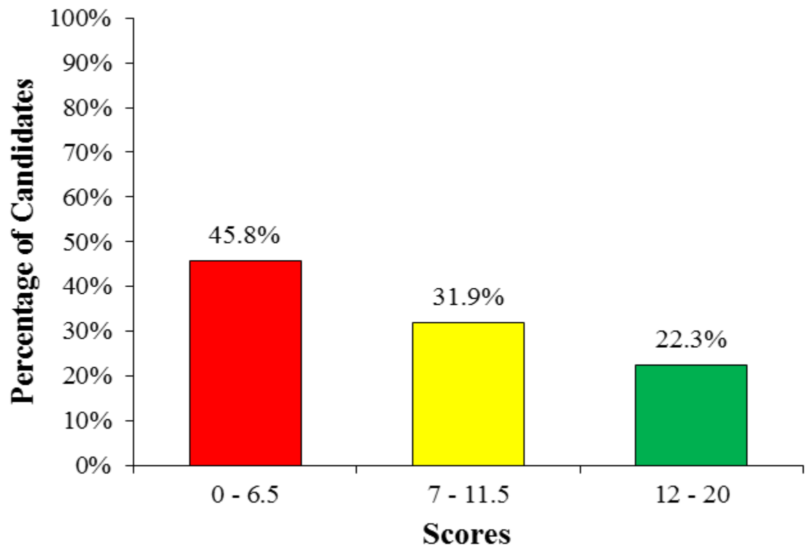
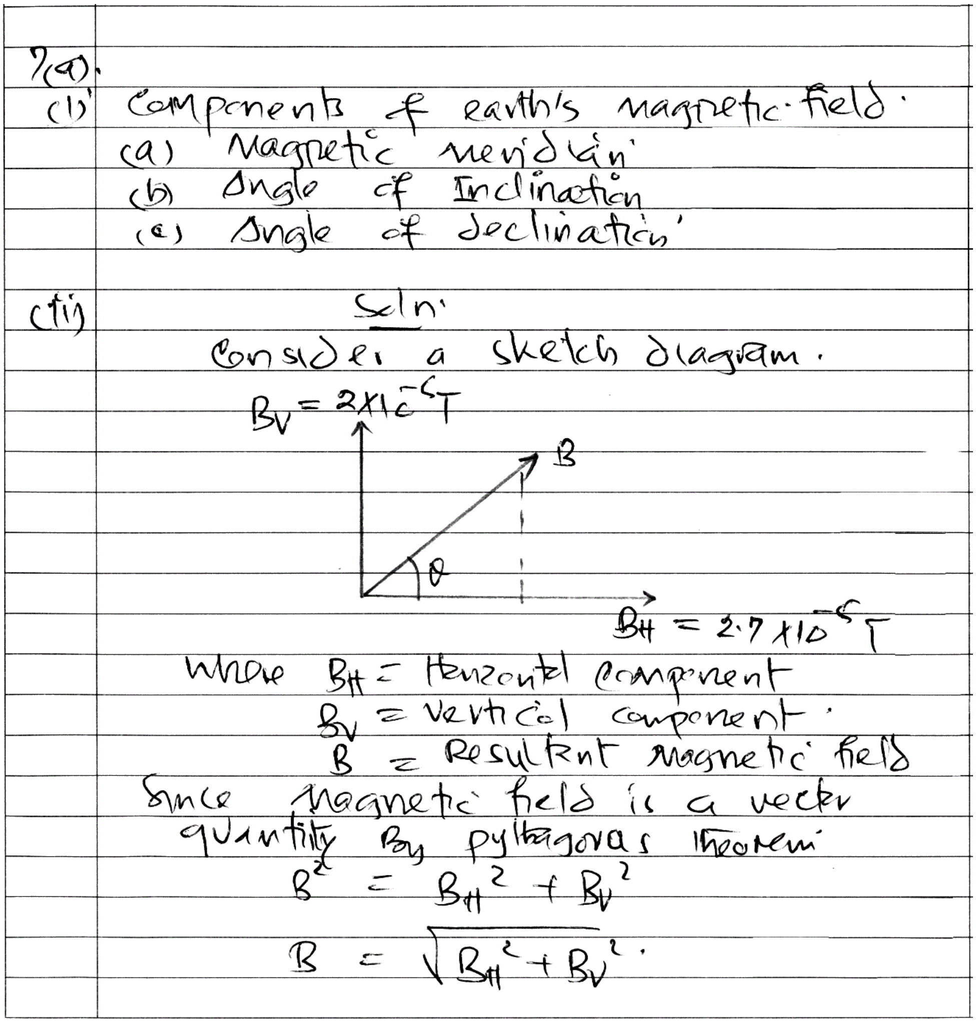


Figure 21: The candidates' performance in question 7.

Figure 21 shows that 22.3 percent of the candidates scored 12-20 marks.

Some of the candidates who attempted the question and performed well (22.3%) had good knowledge on electromagnetism as they managed to state the components of the earth's magnetic field, determine the earth's magnetic field and its angle of inclination I at a location, and state Biot–Savart law and Ampere's theorem. These candidates were also able to draw hysteresis loops diagram for soft iron and hard steel and use them to discuss permanent magnets. They also managed to define permeability constants and to derive an expression for the magnetic flux density B at the centre of a circular coil of radius r and N turns placed in air carrying a current I. Furthermore, they managed to calculate the magnetic induction at the centre of the coil, the magnetic moment of the coil and the torque acting on the coil when suspended in a uniform magnetic field with its plane parallel to the field. Extract 7.1 shows a sample of a good response from one of the candidates.

Extract 7.1



7(a).
(i) Components of earth's magnetic field.
(a) Magnetic meridian
(b) Angle of Inclination
(c) Angle of declination

(ii) Soln:
Consider a sketch diagram.

$B_V = 2 \times 10^{-5}$ T

B

θ

$B_H = 2.7 \times 10^{-5}$ T

where B_H = Horizontal component
B_V = vertical component.
B = Resultant magnetic field
Since magnetic field is a vector quantity By pythagoras theorem
$B^2 = B_H^2 + B_V^2$
$B = \sqrt{B_H^2 + B_V^2}$.

7a(ii) $B = \sqrt{B_H^2 + B_V^2}$.

$B = \sqrt{(2.7\times10^{-5})^2 + (2\times10^{-5})^2}$

$B = \sqrt{7.29\times10^{-10} + 4\times10^{-10}}$

$B = 3.36\times10^{-5}\,T$.

∴ Also

$\tan\theta = \frac{B_V}{B_H}$.

$\theta = \tan^{-1}\left(\frac{B_V}{B_H}\right)$

$\theta = \tan^{-1}\left(\frac{2\times10^{-5}}{2.7\times10^{-5}}\right)$

$\theta = 36.53^\circ$.

∴ Earth's magnetic field is $3.36\times10^{-5}\,T$ and its angle of inclination is 36.53°.

7(b).

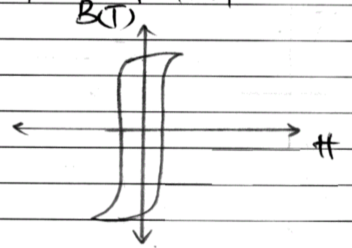
(i) Biot-Savart law states that "The magnetic flux density at a point which is at a distance r from a small length δl of a conductor carrying a current I in a region of magnetic field is given by $\delta B \propto \frac{I \delta l \sin\theta}{r^2}$."

(ii) "Ampere's theorem states that "The line integral of magnetic flux density in a closed circuit in magnetic field is equal to the product of permeability of free space and total current enclosed by the circuit ($\oint B\,dl = \mu_0 I$)."

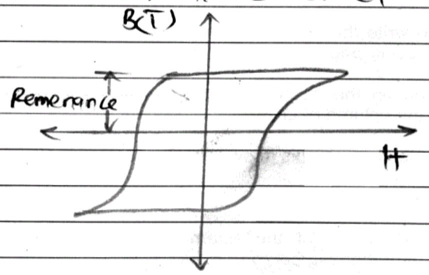
7(c)

(i) Hysteresis loop diagram ~~showing~~ for soft and hard steel.

For soft iron



For hard steel



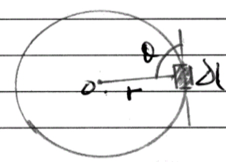
Permanent magnet ~~bare~~ are made of hard steel because hard steel has high remenance, high coercive force to prevent easier demagnetization.

7(ii) Permeability constant is defined as the ratio of magnetic flux density of a material in a medium to the magnetic field strength (magnetising force).

(iii). Soln.

Derivation of magnetic flux density B at the centre of the circular coil of radius r. and N turns placed in air carrying current I.

Consider the diagram below.



From Biot-Savart Law.

$B = \int dB$. but $dB = k \frac{I\delta l \sin\theta}{r^2}$.

Since a coil is in air

$k = \frac{\mu_0}{4\pi}$.

then

$B = \int_0^l \frac{\mu_0 I \delta l \sin\theta}{4\pi r^2}$ but $\theta = 90^\circ$.

$l = 2\pi r N$.

then

$B = \int_0^{2\pi r N} \frac{\mu_0 I \delta l}{4\pi r^2}$.

7c. (iii)

$$B = \int_0^{2\pi rN} \frac{\mu_0 I\, dl}{4\pi r^2}$$

$$B = \frac{\mu_0 I}{4\pi r^2}\int_0^{2\pi rN} dl.$$

$$B = \frac{\mu_0 I}{4\pi r^2}\left[l \right]_0^{2\pi rN}$$

$$B = \frac{\mu_0 I}{4\pi r^2}(2\pi rN)$$

$$B = \frac{\mu_0 I N}{2r}.$$

∴ Magnetic flux density of circular coil at the centre is

$B = \frac{\mu_0 I N}{2r}$ shown.

7d) (i)

soln.

Given diameter $d = 16cm$

radius $r = 16/2 = 8cm.$

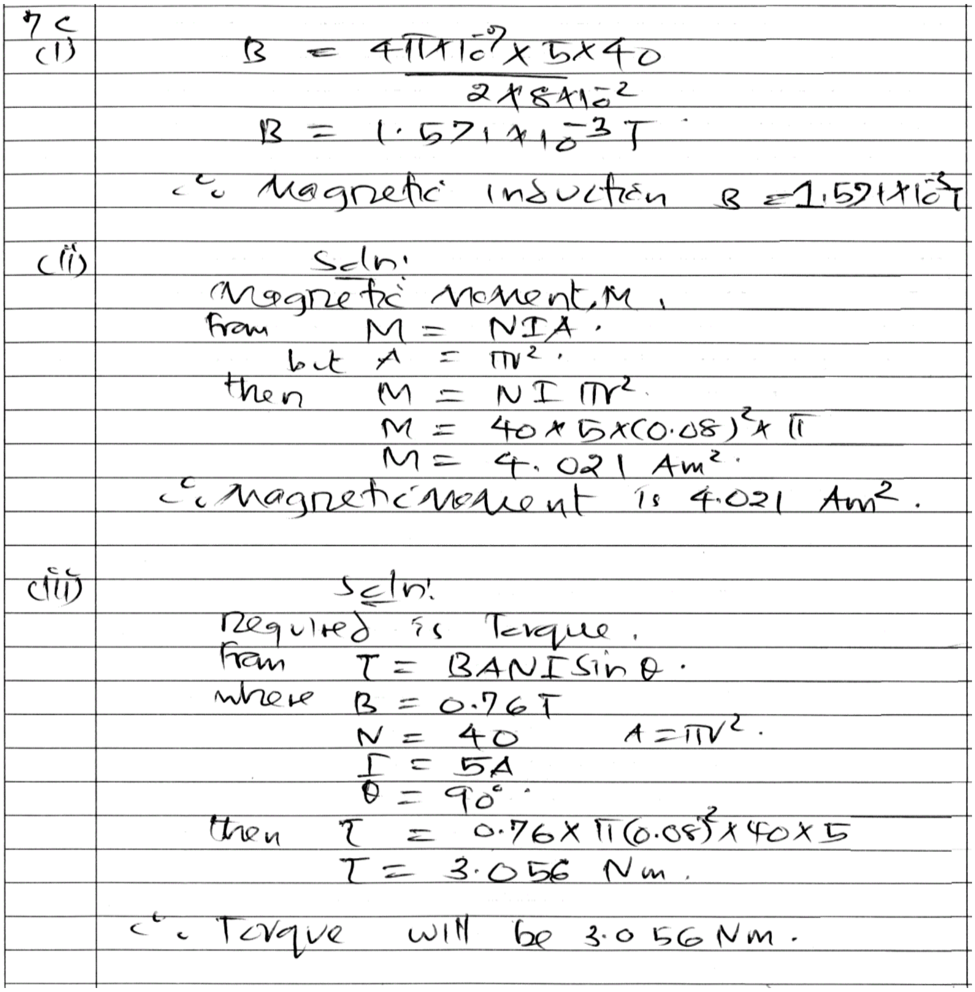
turns $N = 40$

current, $I = 5A$

Required is $B = ?$

From. $B = \frac{\mu_0 I N}{2r}$

but $\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$



7 c (i)

$B = \frac{4\pi \times 10^{-7} \times 5 \times 40}{2 \times 8 \times 10^{-2}}$

$B = 1.571 \times 10^{-3}\,T$

∴ Magnetic induction $B = 1.571 \times 10^{-3}\,T$

(ii) Soln:

Magnetic moment, M.

from $M = NIA$.

but $A = \pi r^2$.

then $M = NI\pi r^2$.

$M = 40 \times 5 \times (0.08)^2 \times \pi$

$M = 4.021\,Am^2$.

∴ Magnetic moment is $4.021\,Am^2$.

(iii) Soln:

Required is Torque.

from $\tau = BANI\sin\theta$.

where $B = 0.76\,T$

$N = 40$ $A = \pi r^2$.

$I = 5A$

$\theta = 90°$.

then $\tau = 0.76 \times \pi (0.08)^2 \times 40 \times 5$

$\tau = 3.056\,Nm$.

∴ Torque will be $3.056\,Nm$.

Extract 7.1 shows how the candidate attempted the question and provided the correct responses to all parts of the question.

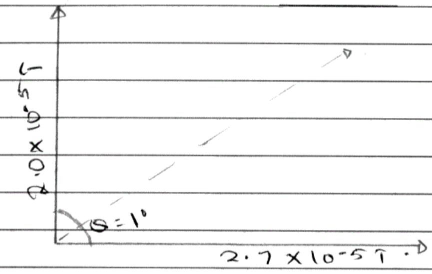
Some of the candidates who attempted the question performed poorly as they provided wrong responses to most parts of the question. These candidates had an insufficient knowledge on electromagnetism especially on the concepts of the earth's magnetism, magnetic properties of materials and the application of Biot–Savart law. Extract 7.2 shows how the candidate attempted the question but failed to provide the correct answers.

Extract 7.2

7(a) (i) Magnetic components of the earth's magnetic fiels (3)

1. Magnetic induction
2. Shreshold.
3. Magnetic flux.

7(a)(ii)



Earth's magnetic field = Required.

From.

Magnetic field = HC XUC.

Magnetic field = 5.4 x10⁻¹⁰.

Therefore magnetic field = 5.4×10^{-10} T.

7(b) Data given.

Diameter, (D₁) = 40 turns.

Diameter₂ (D₂) = 16cm.

Current (I) = 5A.

Magnetic induction = Required.

Magnetic moment = Required.

Torque = Required.

Solution.

7 (i) Magnetic Induction = $\frac{D_1 \times D_2}{I}$

$= \frac{40 \times 16}{5}$

$= \frac{40 \times 16 cm}{5A}$

$= 128$

Magnetic induction = 128T.

(ii) Magnetic moment

= Magnetic moment × Current

128T × 5A

= 640T/A

Magnetic moment = 640T/A

(iii) Torque.

= $\frac{\text{Magnetic induction} \times \text{Magnetic Fi}}{\text{Magnetic field}}$

$= \frac{128T}{0.76}$

$= 168.42$

Therefore torque = 168.42

Extract 7.2 shows how the candidate attempted the question by using incorrect formula and procedures and consequently obtained incorrect answers. The candidate provided responses which did not relate to the demand of the question. For example, instead of giving components of the earth's magnetic field which includes north component, vertical component and inclination or dip, he/she listed them as *magnetic induction, shreshold* and *magnetic flux*.

3.8 Question 8: Atomic Physics

Part (a) of this question required the candidates to (i) explain briefly the production of X–rays, (ii) list down any three uses of X–rays, and (iii) show how intensity and penetrating power of an X–ray beam is controlled. In part (b), the candidates were required to calculate (i) the number of electrons per second striking the target, (ii) the velocity of the of the incident electrons, and (iv) the energy of incident electrons given that “an X-ray tube, operated at d.c. potential difference of 60kV, produces heat at the target at the rate of 840W. Assuming 0.65% of the energy of the incident electrons is converted into X-radiation”.

In part (c) they were required to (i) show that the possible energy levels (in joules) for the hydrogen atom are given by the formula: $E_n = -k^2 \frac{2\pi^2 me^4}{h^2} \frac{1}{n^2}$ where m is the mass of electron, e is the electronic charge, h is the Planck’s constant, $k = \frac{1}{4\pi\varepsilon_0}$ and ε_0 is the permittivity constant of vacuum, (ii) give the significance of the negative sign in the formula for E_n in (c) (i) above and (iii) calculate the wavelength of second member of Balmer series of hydrogen spectrum if the first member has wavelength of 6563×10^{-10}m.

The question was attempted by 13,299 (76.2%) candidates. Out of them 58.8 percent scored from 0 to 6.5 marks, including 4.1 percent who scored zero; 29.5 percent scored from 7.0 to 11.5 marks; 11.7 scored from 12 to 20 marks; and 41.2 percent scored from 7.0 to 20 marks. These scores indicate that the question was averagely performed, as captured in the chart below.

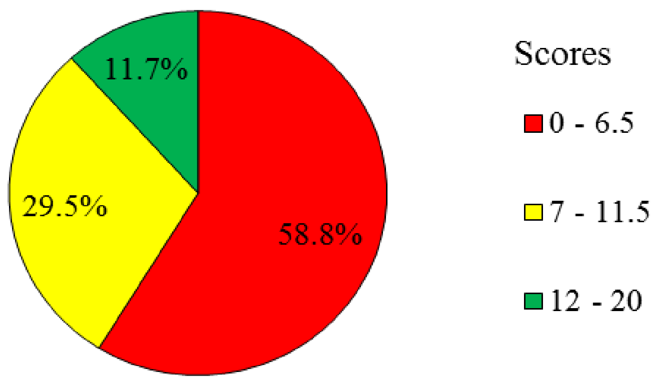


Figure 22: The performance of the candidates in question 8.

The candidates who performed well (11.7%) in this question had mastered the content on the topic of Atomic Physics. The majority of them were able to explain the production of X–rays, list down uses of X–rays, and show how intensity and penetrating power of an X–ray beam is controlled. Also they were able to calculate the number of electrons per second striking the target, the velocity of the incident electrons and the energy of incident electrons. They showed correctly that the possible energy levels (in joules) for the hydrogen atom are given by the formula: $E_n = -k^2 \frac{2\pi^2 me^4}{h^2}\frac{1}{n^2}$ where m is the mass of electron, e is the electronic charge, h is the Planck's constant, $k = \frac{1}{4\pi\varepsilon_0}$ and ε_0 is the permittivity constant of vacuum. Finally they were able to give the significance of the negative sign in the formula for E_n and to calculate the wavelength of second member of Balmer series of hydrogen spectrum. Extract 8.1 shows a sample of a good response from one of the candidates.

Extract 8.1

8. a/ i/ The production of X-rays happens when a stream of fast moving electrons are suddenly stopped by a metal target. The X-rays are produced by exicitation of electrons close to the nucleus while the optical rays which are due to excitation of electrons of valence shells. The set up is such that the filament is heated to produce the electrons which are then accelerated by the presence of an electric field to high velocities and they hit the metal target and cause the development of X-rays. The transformer provides the potential needed for heating the filament and acceleration of electrons. The metal target should be hard and have a high melting point to prevent it from suddenly melting. Only a small fraction ~~to~~ ~~be~~ of the energy of electrons is transformed to x-rays, the rest being ~~used~~ ~~for~~ wasted as heat which has to be conducted away by the coolant oil behind the target. The target is embedded in the anode which attracts the electrons from the filament.

ii/ Uses of X-rays.

→ Can be diffracted and their patterns of diffraction can be used for study of the molecular structures of compact solid materials.

→ They are used in medical institutions for determining various flaws within the body such as bone fracture and others.

→ Since are electromagnetic waves of short wavelengths they can be used for energy requiring process as they possess a large amount of energy

iii/ The intensity of X-ray beam is controlled by the flowing current while its penetrating power is controlled by the accelerating pd given to the electrons in the first place by the transformer.

b/. Power = 840 W,
X-ray percent = 0.65%. The rest of the energy is converted into heat 99.35%.

8 b/ i/ Supply voltage 60kV.

$H/t = IV$.

$I = Q/t = ne/t$

$P = 99.35 \times 1.6 \times 10^{-19} \times 60 \times 10^{3} \times n/t$.

$\frac{840}{9.5376 \times 10^{-13}} = \frac{9.5376 \times 10^{-13}}{9.5376 \times 10^{-13}} n/t$.

$n/t = 8.807 \times 10^{14}$ electrons per second.

ii/ $eV = \frac{1}{2} m v^2$.

$v^2 = \frac{2eV}{m}$

$v = \sqrt{2eV/m}$.

$v = \sqrt{2 \times 1.8 \times 10^{11} \times 60 \times 10^{+3}}$

Velocity of electrons $= 146.97 \times 10^{6}$ m/s.

iii/ Incident electrons had Kinetic energy $= \frac{1}{2} m v^2$.

$= 0.5 \times 9.1 \times 10^{-31} \times (146.97 \times 10^{6})^2$.

Energy of incident electrons $= 9.84 \times 10^{-15}$ J.

8 c/ i.

Potential energy $E_p = \frac{-e^2}{4\pi\varepsilon_0 r}$

$\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$

$\frac{1}{2}mv^2 = \frac{e^2}{8\pi\varepsilon_0 r}$.

Kinetic energy $E_k = \frac{e^2}{8\pi\varepsilon_0 r}$.

Total energy, $E_T = E_k + E_p$

$= \frac{e^2}{8\pi\varepsilon_0 r} - \frac{e^2}{4\pi\varepsilon_0 r}$

$E_T = \frac{-e^2}{8\pi\varepsilon_0 r}$

from

$mvr = \frac{nh}{2\pi}$ quantisation of angular momentum.

$mv = \frac{nh}{2\pi r}$.

$v = \frac{nh}{2\pi mr}$.

$m\left(\frac{nh}{2\pi mr}\right)^2 = \frac{e^2}{4\pi\varepsilon_0 r}$.

$\frac{m n^2h^2}{4\pi^2 m^2 r^2} = \frac{e^2}{4\pi\varepsilon_0 r}$.

$\frac{n^2h^2}{4\pi^2 mr} = \frac{e^2}{4\pi\varepsilon_0}$.

$r = \frac{4\pi\varepsilon_0 n^2h^2}{4\pi^2 e^2 m}$

8 c)

$$r = \frac{\varepsilon_0 n^2 h^2}{\pi e^2 m}.$$

$$E_1 = -e^2 / 8\pi\varepsilon_0 r$$

$$E_n = -e^2 / 8\pi\varepsilon_0 \left(\frac{\varepsilon_0 n^2 h^2}{\pi e^2 m}\right).$$

$$E_n = \frac{-e^2 \pi e^2 m}{8\pi\varepsilon_0^2 n^2 h^2}.$$

$$E_n = \frac{-\pi e^4 m}{8\pi\varepsilon_0^2 n^2 h^2}$$

$$E_n = \frac{-e^4 m}{8\varepsilon_0^2 n^2 h^2}.$$

compare.

$$E_n = \frac{-k^2 2\pi^2 m e^4}{h^2} \frac{1}{n^2}$$

$$E_n = -1 / 2\,16\pi^2\varepsilon_0^2 \cdot \frac{2\pi^2 m e^4}{h^2 n^2}.$$

$$E_n = \frac{-m e^4}{8\varepsilon_0^2 n^2 h^2}.$$

So. $E_n = \frac{-m e^4}{8\varepsilon_0^2 n^2 h^2} = \frac{-k^2 2\pi^2 m e^4}{h^2} \cdot 1/n^2$ where $k = 1/4\pi\varepsilon_0 r$

hence shown.

8 c/ ii/ The negative sign implies that the energy tends to increase from the ground state to the ionisation state where it is maximum and that is zero.

iii/ $\lambda = 6563 \times 10^{-10} m$

for first member.

$n_1 = 2$

$n_2 = 3.$

$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right).$

$\frac{1}{6563 \times 10^{-10}} = R_H \left(\frac{1}{4} - \frac{1}{9}\right)$

$\frac{36}{5 \times 6563 \times 10^{-10}} = R_H.$

$R_H = 10,970,592.72.$

for second member

$n_1 = 2$

$n_2 = 4.$

$R_H = 10,970,592.72.$

$\frac{1}{\lambda} = 10,970,592.72 \left(\frac{1}{4} - \frac{1}{16}\right)$

$\frac{1}{\lambda} = 2056986.135.$

$\lambda = 4.861 \times 10^{-7} m.$

Extract 8.1 shows how the candidate managed to provide proper responses and applied the correct formula in calculations and consequently ended up with the required answers. However, this candidate included an incorrect application of X–rays in his/ her list by saying “X–rays are used for energy requiring process”.

On the contrary, the candidates who performed poorly in this question lacked the understanding of the concepts of X–rays; and their production and uses. As a result, they could not calculate velocity of incident electrons and their respective energy. In general, these candidates had limited knowledge on the concepts of X-rays and Bohr's model of the atom as applied to atomic Physics. Extract 8.2 shows the sample answer from a candidate who performed poorly in this question.

Extract 8.2

8 a) i) Production of X- rays

This x - rays is produced when the radiation energy or when rays are strike to the target and release energy which known as x - rays.

ii) Uses of X- rays

→ used to check destroyed part organ in human eg in brain

→ Used to show how ultraviolet travel in the body.

→ Used to show the affected part in vital organ of the human example it show how Ribs affected by smoker person.

8a) iii) The intensity and penetrating power of an X-rays beam controlled by skin of the human or of any object

b) Data given

$V = 60kV$

$P = 840W$

$E = 0.65\,J$

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

$$K.E = W_o - E_o$$

$$eV_s = E_o$$

$$e \times 60 \times 10^{-3} = \frac{0.65}{100}$$

$$e = ~~0.108~~ = 1.0656 \times 10^{-8}$$

The number of electron $= 1.065 \times 10^{-8}$

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

$$eV = \frac{1}{2}mv^2$$

$$P = \frac{V^2}{I}$$

$$\frac{e}{m_e}V_i = \frac{1}{2}v^2$$

$$1.8 \times 10^{11} \times 60 \times 10^{-3} = \frac{1}{2}v^2$$

Velocity $= 146.97 \times 10^{3}\,m/s$

8 c i) $E_n = -k^2 \frac{2\pi^2 me^4}{h^2} \cdot \frac{1}{n^2}$

Form:

Angular ~~Momentum~~ Momentum,

$Mv_n r_n = \frac{2\pi}{nh}$ $\quad m = \frac{2\pi}{nh v_n r_n}$

$F = \frac{Ze^2}{4\pi\varepsilon_0 r^2}$

$v_n = \frac{2\pi}{nhmr_n}$ $\quad Mv_n r_n nh = 2\pi$

$r = \frac{2\pi}{Mv_n nh}$

$\frac{Ze^2}{4\pi\varepsilon_0 r^2} = \frac{2\pi}{nhmr_n}$

$\frac{Ze^2}{2\pi\varepsilon_0 r^2} = \frac{1}{nhmr_n}$

$\frac{Ze^2}{2\pi^2\varepsilon_0 \left(\frac{2\pi}{mvnh}\right)^2}$

$\frac{Ze^2 me\, 2\pi}{n^2h^2}$

$\frac{ZMe^4\, 2\pi^2}{n^2h^2} = E_n$

$Z = 1$

$E = -k^2 \frac{2\pi^2 Me^4}{h^2} \cdot \frac{1}{n^2}$

$E_n = -\frac{k^2\, 2\pi^2 Me^4}{h^2\, n^2}$

Hence shown.

c) ii) The negative sign this Means that the energy was released

iii) Data given

$n_1 = 2$

$n_2 = 3$

$\lambda = 6563 \times 10^{-10} m$

Second in balmer = 4

$\Delta E = \frac{-13.6 ev}{n^2}$

$\Delta E = \frac{-13.6 ev}{4^2}$

$\Delta E = \frac{-13.6 \times 1.6 \times 10^{-19}}{4^2}$

$\Delta E = 1.36 \times 10^{-19}$

$\Delta E = E_1 - E_2$

$\Delta E = \frac{hc}{\lambda} - \frac{hc}{\lambda}$

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

$1.36 \times 10^{-19} = \frac{3 \times 10^8 \times 6.63 \times 10^{-34}}{\lambda}$

$\lambda = 1.462 \times 10^{-6}$

$1.36 \times 10^{-19} = hc\left(\frac{1}{6563 \times 10^{-10}} - \frac{1}{\lambda}\right)$

$= 1.4625 \times 10^{-6}$

The Wave length of Second Member = $1.4625 \times 10^{-6} m$

Extract 8.2 indicates how the candidate answered the question wrongly. The candidate explained that X–rays are produced when rays hit a target instead of fast moving electrons hitting a metal target. He/she used Einstein's photoelectric equation to calculate the velocity and energy of incident electrons instead of using the mass-energy relations.

3.9 Question 9: Atomic Physics

Part (a) of this question required the candidates to (i) differentiate between natural radioactivity from artificial radioactivity, (ii) name three applications of radioisotopes in medicine, and (iii) state two conditions for stability of nuclides referring to light nuclides and heavy nuclides. In part (b), the candidates were required to (i) derive an expression for the half–life using the radioactive decay law, (ii) give meaning of carbon–14, and explain its production and how it is used in dating process. In part (c) the candidates were required to calculate the age of the sample of dead wood if the half–life of carbon–14 is 5568 years given that Living wood has an activity of 16.0 counts per minute per gram of carbon, and that a certain sample of dead wood is found to have an activity of 18.4 counts per minute for 4.0 grams".

The question was attempted by 69.7 percent of the candidates. Out of them, 70.1 percent scored from 0 to 6.5 marks including 8.0 percent who scored zero; 25.9 percent scored from 7.0 to 11.5 marks and 4.0 percent scored from 12 to 20 marks. The chart below summarizes the candidates' performance in percentage against the scores in this question.

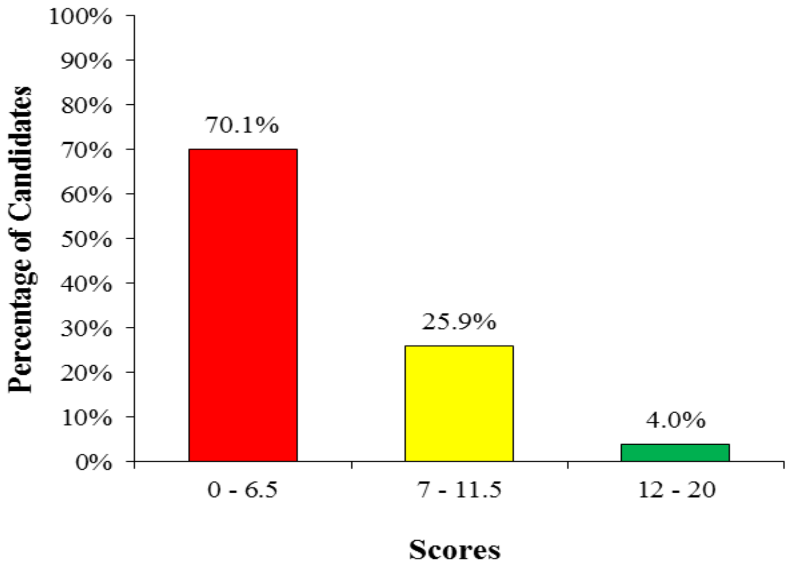


Figure 23: The candidates scores in question 9.

The data in Figure 23 indicate that 70.1 percent of the candidates scored below 3.5 which is an indication of poor performance.

Poor performance in this question was contributed by candidates' inability to differentiate between natural radioactivity and artificial radioactivity. They failed to outline the applications of radioisotopes in medicine. Moreover, they were unable to state the conditions for stability of nuclides referring to light nuclides and heavy nuclides. Furthermore, these candidates failed to derive an expression for the half–life using the radioactive decay law. The majority failed to give the meaning of carbon – 14, its production and how it is used in dating process. Also, they failed to calculate the age of a sample of dead wood because they used incorrect formula; For example, one of the candidates used the formula $A_0 = Ae^{-\lambda t}$ instead of $A = A_0 e^{-\lambda t}$ in calculating the age of the sample of dead wood. Extract 9.1 shows the work of a candidate who did the question poorly.

Extract 9.1

9 (a) (i) Natural radioactivity
This is the disintegration of particles of an elements while
Artificial radioactivity; Is the property of of the body to disintegrate on their own Spontaneously.

(ii) (a) To clean medicine from Natural medicine to artificial medicine
(b). To Used to mix and magnify the reagent of medicine and mix with the medicine from traditional to modern medicine
eg from Roots/Leaf → Tablets.
(c). Use to trap radioactive elements entering in the process of making medicine

9 (b)(i) Radioactive decay law
states that The rate of disintegration of the ~~decay~~ radioactive element is equal to the number of disintegrated in a constant number

i.e

$$\frac{d\theta}{dt} \propto -N \qquad N = (\theta - \theta_1)$$

$$\frac{d\theta}{dt} = -kN$$

separating variables

$$\frac{d\theta}{\theta - \theta_1} = -dt$$

Integrate through out

$$\int \frac{d\theta}{\theta - \theta_1} = k\int dt$$

$$\ln(\theta - \theta_1) = -kt$$

$$\ln\theta - \ln\theta_1 = -kt$$

$$\ln\left(\frac{\theta}{\theta_1}\right) = -kt$$

Introduce logarithm under base e

$$\frac{\theta}{\theta_1} = e^{-kt}$$

9 (b)(i) $\theta = \theta_i e^{-kt}$

but $t = t_{1/2}$

$\theta = \theta_i e^{-kt_{1/2}}$

$$\frac{-kt_{1/2}}{-k} = \frac{\ln(\theta/\theta_i)}{-k}$$

but $k = -k$

$$t_{1/2} = \frac{\ln(\theta/\theta_i)}{-k}$$

but $\ln(\theta/\theta_i) = \ln(\theta/\theta_i) = 0.936$

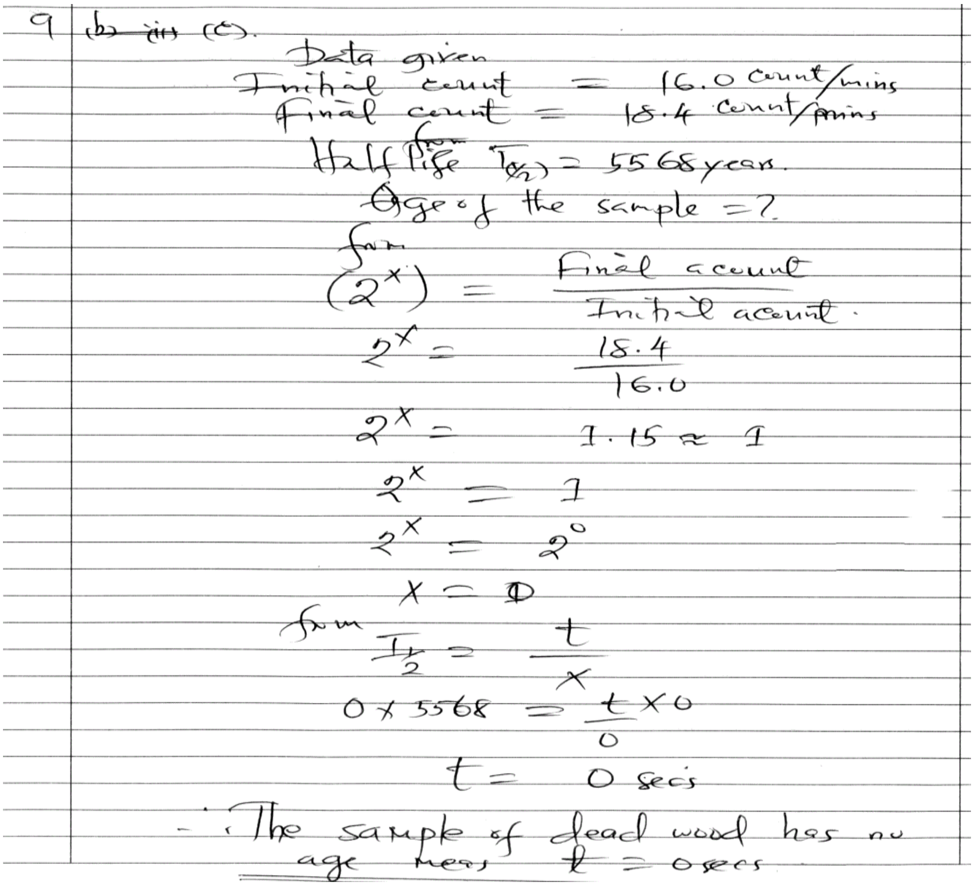
Then

$$T_{1/2} = \frac{\ln(\theta/\theta_i)}{+k}$$

$$T_{1/2} = \frac{0.936}{k}$$

∴ The half life $T_{1/2} = \frac{0.936}{k}$

Hence proved


9 (b) (iii) (c).

Data given

Initial count = 16.0 count/mins

Final count = 18.4 count/mins

from

Half life $T_{1/2}$ = 5568 years.

Age of the sample = ?

from

$(2^x) = \frac{\text{Final count}}{\text{Initial count}}$

$2^x = \frac{18.4}{16.0}$

$2^x = 1.15 \approx 1$

$2^x = 1$

$2^x = 2^0$

$x = 0$

from

$T_{\frac{1}{2}} = \frac{t}{x}$

$0 \times 5568 = \frac{t \times 0}{0}$

$t = 0$ secs

∴ The sample of dead wood has no age hence $t = 0$ secs

Extract 9.1 displays the incorrect responses given by a candidate who performed poorly on this question. The candidate interchanged the contrast between natural and artificial radioactivity. He/she presented incorrect applications of radioisotopes in medicine and used the concept of the rate of cooling in deriving the decay law instead of number of particles decaying per time (rate of decay) and ended up with incorrect expression.

There were very few candidates (4.0%) who performed well in the question. Good performance was attributed by the ability of the candidates to retrieve and comprehend the need of the question. The majority were knowledgeable enough to differentiate between natural radioactivity and artificial radioactivity. They also named the applications of radioisotopes in medicine precisely. Furthermore, they stated the conditions for stability of nuclides referring to light nuclides and heavy nuclides correctly. These candidates derived an expression for the half–life using the radioactive decay law correctly. They managed to give the meaning of carbon–14 and to explain its production and use in dating process. Finally, the candidates calculated the age of the sample of dead wood by employing the appropriate formula. Extract 9.2 shows a sample of a good response from one of the candidates.

Extract 9.2

09. (i) Natural radioactivity is a type of radioactive decay which occurs spontaneously, and does not involve to be stimulated by agents like neutrons.
Example is the natural decay of Uranium
While
Artificial radioactivity is one in which the radioactive atom is forced to undergo radioactivity by bombarding it with other particles like neutrons

(i) Natural radioactivity does not require external agent while artificial radioactivity requires external agent like bombarding with other particles

(ii) Applications of radioisotopes

1) Radioisotopes are used to treat cancer problems in medical field
2) Radioisotopes are used to identify and treat tumours in the body of patient

3) Radioisotopes are used to recognize fracture of internal parts of a body

(iii) Two conditions for stability are

i) Neutron to proton ratio. When the ratio is around 1, the nuclide is very stable.

ii) Binding energy per nucleon: The larger the value of Binding energy per nucleon, the more stability is the nuclide.

09. b) (i) From radioactive decay law

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

$$\frac{dN}{N} = -\lambda \, dt. \quad \text{Intergrating}$$

$$\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t dt$$

$$\ln[N]_{N_0}^{N} = -\lambda t$$

$$\ln N - \ln N_0 = -\lambda t.$$

$$\ln\left(\frac{N}{N_0}\right) = -\lambda t$$

$$\frac{N}{N_0} = e^{-\lambda t}$$

$$N = N_0 e^{-\lambda t}$$

For half life $N = \frac{1}{2}N_0$, $t = T_{1/2}$

$$\frac{1}{2}N_0 = N_0 e^{-\lambda T_{1/2}}$$

$$\frac{1}{2} = e^{-\lambda T_{1/2}}$$

$$2^{-1} = e^{-\lambda T_{1/2}}$$

$$2 = e^{\lambda T_{1/2}}$$

$$\ln 2 = \lambda T_{1/2}$$

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.69314718}{\lambda}$$

(c) $T_{1/2} = \frac{0.693}{\lambda}$

9 (b) (ii) • Carbon 14 is a Carbon forteen Isotope of Carbon which is formed in atmosphere when nitrogen combines with neutron in Cosmic ray region in the atmosphere.

that is $^{14}_{7}N + ^{1}_{0}n \rightarrow ^{14}_{6}C + ^{1}_{1}H$

• Plants absorbs most of $^{14}_{6}C$ isotope during their time, and their Concentration keeps on Increasing when plant dies, no more $^{14}_{6}C$ isotope is absorbed.

• Studies have shown that the age of died plant wood can be estimated by comparing the activity of the sample of $^{14}_{6}C$ in the wood and the

activity of $^{14}_{6}C$ in the ancient living wood. This is called Carborn-14 dating

c) • 18.4 Counts per minute → 4 grams

x → 1 grams

x = 4.6 counts per minute per gram

• From half life $T_{1/2} = \frac{\ln 2}{\lambda}$

• $\ln\left(\frac{A}{A_0}\right) = -\lambda T_{1/2}$ or $\ln\left(\frac{A}{A_0}\right) = -\lambda t$

$t = \frac{-\ln\left(\frac{A}{A_0}\right)}{\lambda}$ but

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

9. c) $t = \frac{-\ln\left(\frac{A}{A_0}\right)}{\lambda}$ but $\lambda = \frac{\ln 2}{T_{1/2}}$

$t = \frac{-T_{1/2} \ln\left(\frac{A}{A_0}\right)}{\ln 2}$ where $A = 4.6$, $A_0 = 16$, $T_{1/2} = 5568$ years

$= \frac{-5568 \times \ln\left(\frac{4.6}{16}\right)}{\ln 2} = 10013$ years

∴ The age of sample is 10013 years

Extract 9.2 is a sample response from the script of one of the candidates who managed to give the correct answers to almost all parts of the question.

4.0 ANALYSIS OF CANDIDATES' PERFORMANCE PER TOPIC

The analysis of the candidates' performance in each topic shows that the topic of *Simple Harmonic Motion* from Physics paper 1 was performed well by 61.8 percent of the candidates. The topics of *Measurements, Current electricity, Newton's laws of motion, Circular motion, Heat, Electronics, Gravitation, Projectile motion* from the same paper had average performance. The reasons behind the average performance in these topics were that the candidates had inadequate knowledge and skills on questions which involved the detailed explanations and numerical computations.

The topics of *Environmental Physics* and *Rotation of rigid bodies* had weak performance. The reasons behind weak performance in these topics include lack of content drawing skills, inability to derive different physical quantities, and lack of knowledge in giving detailed explanations on different Physics facts and phenomena.

The analysis also shows that in Physics paper 2, the candidates had average performance in *Electromagnetism, Electrostatics, Atomic Physics* and *Fluid dynamics* topics. The reasons behind the average performance in these topics include insufficient knowledge on mathematical questions, and improper substitutions of data values in the formulated equations, and application of inappropriate formulae in solving problems.

The analysis further indicates that, 2 out of 6 topics that were examined in Physics paper 2 had weak performance. These topics were *Vibrations and Waves,* and *Properties of matter*. The reasons behind weak performance in these topics include lack of knowledge on the application of Doppler effects and the concepts of Young's double slits and Newton's rings experiments in interference of waves; and inability to explain different terms in waves, surface tension and elasticity. The summary of candidates' performance in different topics is shown in the appendix.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The analysis of the candidates' performance per question has highlighted the challenges faced by the candidates in attempting the questions. It has also given the summary of performance in each topic and recommendations that can help to overcome the identified challenges.

The analysis has shown that the major problem faced by the candidates who scored low marks was inadequate knowledge on the concepts of different topics. Due to this problem, most of the candidates failed to show their competences by giving unsuitable and incorrect responses to some of the questions. For example, in Physics paper 1, they had insufficient knowledge on Rotation of rigid bodies and Environmental Physics for questions 5 and 14 respectively. In Physics paper 2, candidates had limited knowledge on Vibrations and waves for questions 2 and 3 and Properties of matter for question 4 where the performance appeared to be weak.

In addition to that, some candidates had misconception on the subject matter as they failed to identify the requirements of the questions by providing irrelevant responses. Another problem encountered by the candidates was lack of numerical skills. This caused some candidates to provide incorrect answers because they applied inappropriate formulae. Of all the topics which were tested, only one topic *Simple Harmonic Motion* was well performed. Other topics which include *Environmental Physics*, *Vibrations and Waves*, *Rotation of Rigid Bodies* and *Properties of Matter* were performed poorly. The rest of the topics were averagely performed as shown in the appendix. On the basis of these performances, the performance of Physics subject in this year has decreased by 5.36 percent compared to last year examinations because in this year some of the candidates failed to provide the correct responses in many parts of the question.

It is expected that, the feedback given in this report will enable the stakeholders, students and teachers to take the necessary measures to improve the candidates' performance on ACSEE Physics examinations in the future.

5.2 Recommendations

In order to improve performance in future, it is recommended that:

(a) candidates have to make good preparations for the examinations and they have to carefully read and understand the demands of the questions when doing examinations;

(b) candidates have to concentrate on conceptual understanding of theories and the subject matter of each topic covered under the syllabus and they should not to rush to solve questions without adequate theoretical knowledge;

(c) candidates should work hard on attaining mathematical skills to improve their learning so that they can be able to solve problems which include calculations; and

(d) teachers should conduct and encourage students to attempt more practical work during normal learning hours. This will improve the level of understanding of the contents and improve students' level of competence on the subject matter.

THE CANDIDATES' PERFORMANCE PER TOPIC IN PHYSICS

Na.	Topic	Number of questions	Percentage of Candidates Who Scored an Average of 35 Percentage or Above	Remarks
1	Simple Harmonic Motion	1	61.8	Good
2	Electromagnetism	1	54.2	Average
3	Measurements	1	53.6	Average
4	Current Electricity	2	53.3	Average
5	Newton's Laws of Motion; Circular Motion	1	43.7	Average
6	Heat	2	43.4	Average
7	Electronics	3	43.1	Average
8	Gravitation	1	37.4	Average
9	Projectile Motion	1	36.6	Average
10	Electrostatics	2	36.2	Average
11	Atomic Physics	2	35.6	Average
12	Fluids Dynamics	1	35.2	Average
13	Environmental Physics	1	33.4	Weak
14	Vibrations and Waves	2	23.9	Weak
15	Rotation of Rigid Bodies	1	16.8	Weak
16	Properties of Matter	1	11.5	Weak