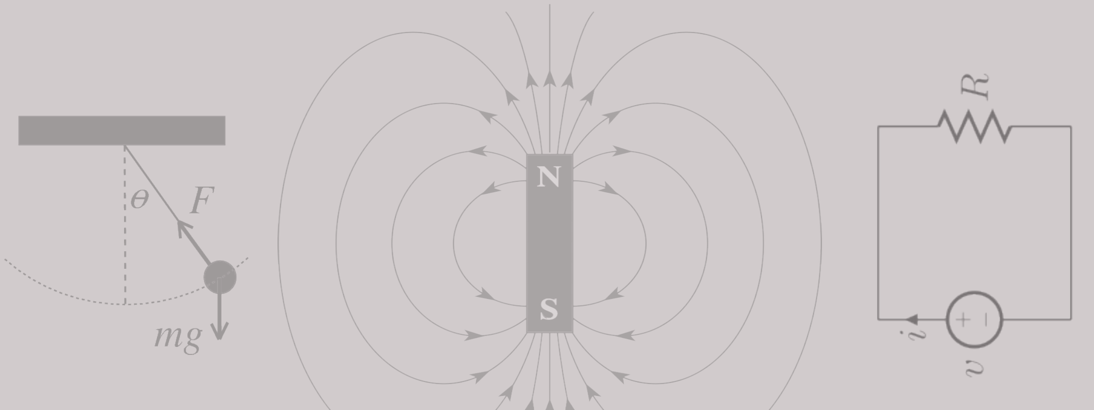
THE NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CANDIDATES' ITEMS RESPONSE ANALYSIS REPORT FOR THE ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION (ACSEE) 2017



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 candidates in their two years of advanced level secondary education.

The candidates' items response analysis report on Physics subject ACSEE 2017 was prepared in order to give feedback to students, teachers, parents, policy makers and the public in general on how the candidates answered the examination questions.

The report highlight some of the factors which made the candidates fail to score high marks in the questions. The factors include; inadequate knowledge of the various topics, failure to identify the task of the question; lack of mathematical and communication skills. The analysis made will help the educational administrators, school managers, teachers and students to identify appropriate 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 any fruitful comments and recommendations from teachers, students and other education stakeholders aiming at improving the quality of future analysis reports.

Finally, the council would like to express sincere gratitude to the examination officers and all others who contributed to 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 2017 ACSEE questions in Physics paper 1 & 2. The papers aimed at measuring and evaluating the skills acquired by the candidates as stipulated in the 2010 syllabus and adhered to in the 2011 examination format for advanced secondary education.

Physics paper 1 comprised of 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 and three (3) questions each from sections B and C.

Physics paper 2 had three sections, namely A, B and C. Each section comprised of three (3) questions making 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 18,433 candidates sat for Physics examination, of which 85.78 percent passed the examination and 14.22 percent failed. In 2016, the number of candidates who sat for Physics examination was 17,312 of which 80.34 percent passed the examination and 19.66 percent failed. This implies that the candidates' performance in this year has improved by 5.44 percent.

The following section analyses the candidates' responses with regard to the demands of the questions. In the course of analysis a brief note on what the candidates were required to do and the reasons for their performance are provided. The samples of candidates' good and poor responses are also inserted as extracts to illustrate the cases presented. Graphs and charts are also used to summarize the candidates' performance in a particular question. The analysis groups the performance as good, average and poor in the ranges of 60–100, 35–59 and 0–34 respectively. Green, yellow and red colours are respectively used to represent these groups of performance. The report also indicates the general performance in each topic as compared to year 2016. Finally, it provides some recommendations that may help to improve the candidates' performance in future examinations.

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

2.1 Question 1: Measurements (Errors)

This question was divided into three parts: (a), (b) and (c). In part (a) the candidates were required to give the meaning of the terms: (i) absolute error and (ii) relative error as used in error analysis. In part (b) the candidates were given a stem which state that; "the force "F" acting on an object of mass "m" travelling at velocity "V" in a circle of radius "r" is given by $F = \frac{mv^2}{r}$ and the measurements were recorded as: $m = (3.5 \pm 0.1)kg$, $v = (20 \pm 1)m/s$ and $r = (12.5 \pm 0.5)m$". Then they were required to find the maximum possible (i) fractional error and (ii) percentage error in the measurement of force. In part (c), the candidates were required to show how to record the reading of force as expressed in part (b).

A total of 17,760 (95.8%) candidates attempted this question; 11.7 percent of the candidates scored from 0 to 3.0 marks, 17.1 percent scored 3.5 to 5.5 marks and 71.2 percent scored from 6.0 to 10.0. These data reveal that the general candidates' performance in this question was good because 88.3 percent of them scored 3.5 marks and above as shown in Figure 1.

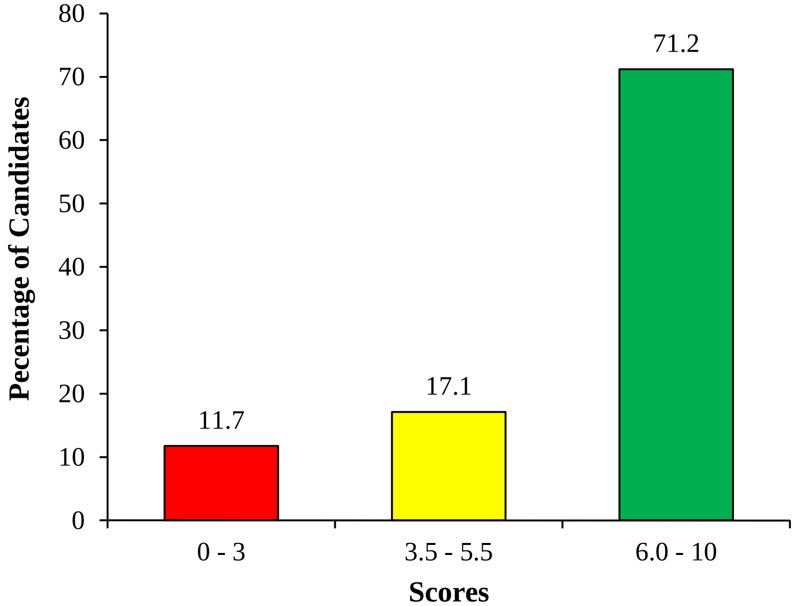


Figure 1: Candidates performance in Question 1.

The candidates who performed well were able to identify and determine errors in measurement. Most of them defined correctly the given terms, wrote correct formulae for the maximum possible fraction and percentage errors. Furthermore, they identified the values of errors for mass, velocity and radius. They also able to substitute and compute the required values for fractional and relative error. This shows that the candidates were conversant with the concept of errors. Extract 1.1 shows one of the responses from a candidate who performed well in this question.

Extract 1.1

1 (a) (i) Absolute error → is the magnitude difference between the true value and measured value of a physical quantity. i.e $|A|$

(ii) Relative error → is the fraction of Absolute error to the true value of a physical quantity.

i.e $\frac{|A|}{A}$

1 (b) (i) Soln.

Data given

$m = (3.5 \pm 0.1)\,kg$, $V = (20 \pm 1)\,ms^{-1}$

$r = (12.5 \pm 0.5)\,m$

fractional error = asked.

from.

$F = \frac{Mv^2}{r}$ apply ln both side

$\ln F = \ln \frac{Mv^2}{r}$

$\ln F = \ln M + \ln v^2 - \ln r$

$\ln F = \ln M + 2\ln v - \ln r$ differentiate throught.

$\frac{\Delta F}{F} = \frac{\Delta M}{M} + \frac{2\Delta V}{V} - \frac{\Delta r}{r}$

but alway error is maximized

$\frac{\Delta F}{F} = \frac{\Delta M}{M} + \frac{2\Delta V}{V} + \frac{\Delta r}{r}$

$\frac{\Delta F}{F} = \left(\frac{0.1}{3.5}\right) + 2\left(\frac{1}{20}\right) + \left(\frac{0.5}{12.5}\right)$

$\frac{\Delta F}{F} = \frac{59}{350} = 0.16857$

$\therefore$ fractional error $\frac{\Delta F}{F} = \frac{59}{350}$

1(b) (ii) Soln.

percentage error = asked.

From

$\frac{\Delta F}{F} = 0.16857$

$\%_{error} = \frac{\Delta F}{F} \times 100$

$\frac{\Delta F}{F} = 0.16857 \times 100 = 16.857$

∴ Percentage error in the measurement of force $= 16.857\%$

1(c) Soln.

from $F = \frac{mv^2}{r}$

mass = 3.5 kg

$F = \frac{mv^2}{r}$

V = 20 ms^{-1}

r = 12.5 m.

$F = \frac{3.5 \times (20)^2}{12.5}$

F = 112N.

but From. $\frac{\Delta F}{F} = 0.16857$.

$\Delta F = 0.16857 \times F$.

$\Delta F = 0.16857 \times 112$

$\Delta F = 18.88N$.

∴ Force $= (112 \pm 18.88)N$.

In extract 1.1 the candidate provided precise definitions for relative and percentage errors and systematically calculated the fractional and percentage error.

Conversely, few candidates (11.7%) who performed poorly in this question failed to use the required key words for defining absolute and relative errors. Moreover, they incorrectly derived the formulae for fractional and percentage errors. Most of these candidates failed to answer part (b) of the question as they failed to consider an important idea in error analysis which states that, *errors are always additive*, therefore they calculated fractional error using the incorrect formula, $\frac{\Delta F}{F} = \frac{\Delta m}{m} + \frac{2\Delta V}{V} - \frac{\Delta r}{r}$ instead of $\frac{\Delta F}{F} = \frac{\Delta m}{m} + \frac{2\Delta V}{V} + \frac{\Delta r}{r}$. Extract 1.2 shows the answer of one of the candidates who performed poorly in this question.

Extract 1.2

1(a) a) Absolute error:
Is the way of making an error positive
X_m – Measure value.
X_t – Exact value.

Absolute error $\Delta X = |X_m - X_t|$.
or
Absolute error $\Delta X = |X_t - X_m|$

(ii) Relative error:
Is the ratio between Absolute error to the measured value.

R.E – Relative error
$R.E = \frac{|X_m - X_t|}{X_m}$

$R.E = \frac{\Delta X}{X_m}$.

1(b) (i) Solution:
$F = \frac{Mv^2}{r}$.
$m = (3.5 \pm 0.1)$
$V = (20 \pm 1)$
$r = (12.5 \pm 0.5)m$.
from
$F = \frac{Mv^2}{r}$.
$\ln F = \ln(Mv^2) - \ln r$.
$\ln F = \ln M + \ln v^2 - \ln r$

1(b) (i) $\frac{\Delta F}{F} = \frac{\Delta m}{m} + \frac{2\Delta V}{V} - \frac{\Delta r}{r}$

$\frac{\Delta F}{F} = \frac{0.1}{3.5} + 2\left(\frac{1}{20}\right) - \frac{0.5}{12.5}$

$\frac{\Delta F}{F} = \frac{0.1}{3.5} + 0.1 - 0.04.$

$\frac{\Delta F}{F} = 0.028571428 + 0.1 - 0.04$

$\frac{\Delta F}{F} = 0.088571428$

$\frac{\Delta F}{F} = 0.089.$

The maximum fractional error = 0.089.

1(b) (ii) Percentage error in Measurement of force.

$M = (3.5 \pm 0.1)$

$V = (20 \pm 1)$

$r = (12.5 \pm 0.5)$

$F = \frac{MV^2}{r}$

$\ln F = \ln(MV^2) - \ln r$

$\ln F = \ln M + \ln V^2 - \ln r.$

$\frac{\Delta F}{F} = \frac{\Delta M}{M} + \frac{2\Delta V}{V} - \frac{\Delta r}{r}$

$\frac{\Delta F}{F} = \frac{0.1}{3.5} + 2\left(\frac{1}{20}\right) - \frac{0.5}{12.5}$

$\frac{\Delta F}{F} = 0.088571428$

$\frac{\Delta F}{F} = 0.089 \times 100\%.$

$\Delta F/F = 8.9\%.$

In extract 1.2 the candidate attempted part 1(a) by using both words and mathematical notation to define fractional and percentage error with incorrect responses. The formula written in part (b) to calculate the fractional and percentage errors was also not correct.

2.2 Question 2: Measurements (Dimension Analysis)

This question had 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) identify two uses of dimensional equations. In part (b), the candidates were required to: (i) state the basic requirement for a physical relation to be correct (ii) list two quantities whose dimension is $[ML^2T^{-1}]$. In part (c), they were required to: (i) use the method of dimensions to derive the formula relating the physical quantities given that; the frequency, 'f' of vibration of a stretched string depends on the tension 'F', the length 'l' and the mass per unit length, ' μ' of a stretched string, (ii) apply the principles of dimensional analysis to prove the correctness of the relation $\rho = \frac{3g}{4\pi RG}$ whereby, ρ is the density of the earth, g is the acceleration due to gravity, R is the radius of the earth and G is gravitational constant.

The question was attempted by 97.8 percent of the candidates, out of which 8.2 percent scored below 3.5 marks out of 10 marks. Few candidates (0.8%) scored 0. The candidates who scored from 3.5 to 5.5 marks were 22.6 percent while those who scored from 6.0 to 10 marks were 69.2 percent. This question was the best performed question by many candidates because 91.8 percent of them scored 3.5 marks or above. Figure 2 illustrates the performance of candidates in question 2.

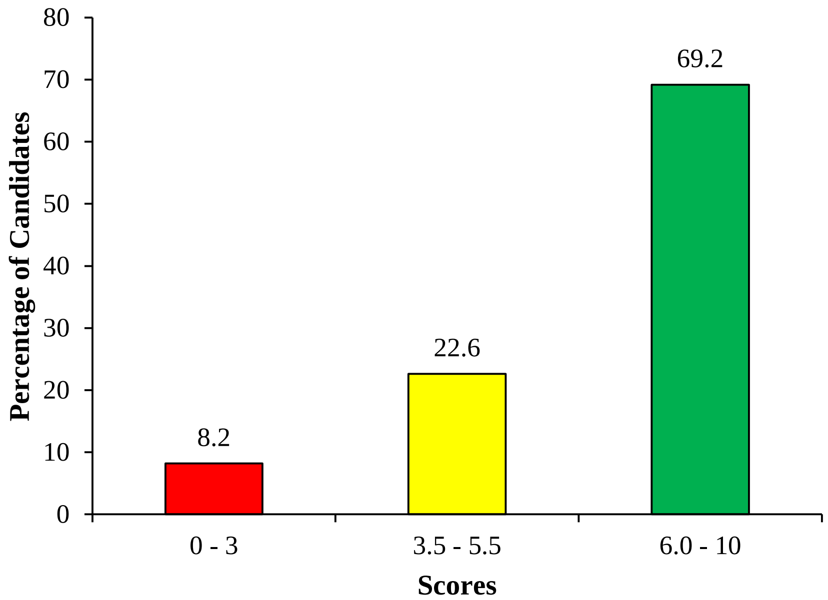
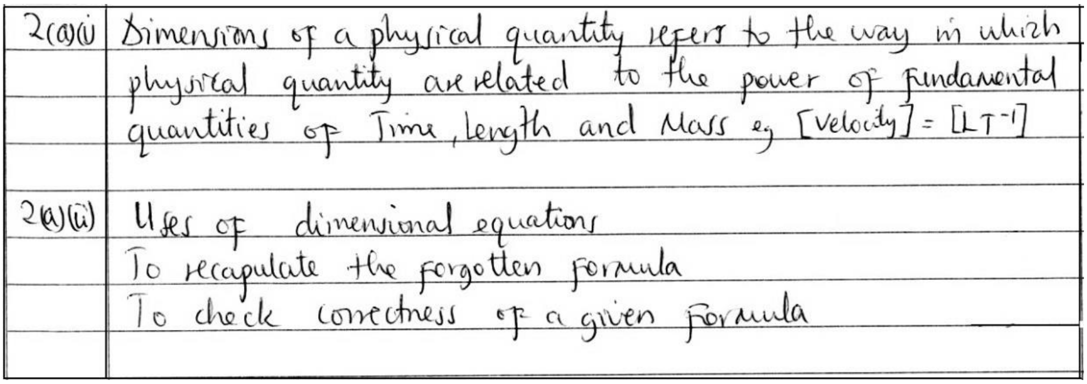


Figure 2: Candidates' performance in Question 2

The candidates whose performance was good were able to define and provide the correct examples of dimensions as used in measurement of physical quantity, stating the key principle used to check whether a given equation is dimensionally correct or not and correctly identified the two quantities represented by the dimensions ML^2T^{-1}. They were also able to use rules of dimensional analysis to derive the relationship between the frequency of a vibrating stretched string and its tension, length and mass per unit length. Extract 2.1 shows the work of one of these candidates who managed to answer this question correctly.

Extract 2.1



2(a)(i)	Dimensions of a physical quantity refers to the way in which
	physical quantity are related to the power of fundamental
	quantities of Time, length and Mass e.g [Velocity] = [LT^-1]
2(a)(ii)	Uses of dimensional equations
	To recapulate the forgotten formula
	To check correctness of a given formula

2(b)(i)	The basic requirement for a physical relation to be correct is dimension consistency such that the dimension of each and every term on either sides of the equation must be the same.
2(b)(ii)	Quantities whose dimension is $[ML^2T^{-1}]$ are
-	Planck's constant
-	Angular momentum.
2(c)(i)	Given $f \propto F^x \cdot l^y \cdot \mu^z$ ------ X_0
	$[f] = T^{-1}$
	$[F] = MLT^{-2}$
	$[L] = L$
	$[\mu] = ML^{-1}$
	from $f \propto F^x L^y \cdot \mu^z$
	$f = K F^x \cdot l^y \cdot \mu^z$
	$[f] = [K]\ [F]^x \cdot [L]^y [\mu]^z$
	Since k is constant hence it's dimensionless $[K] = 1$
	$[f] = [F]^x \cdot [l]^y [\mu]^z$
	$[T^{-1}] = [MLT^{-2}]^x \cdot [L]^y \cdot [ML^{-1}]^z$
	$[M]^0 [L]^0 [T]^{-1} = [M]^{x+z} \cdot [L]^{x+y-z} \cdot [T]^{-2x}$
	By comparison
	$M : x + z = 0$ --- (i)
	$L : x + y - z = 0$ --- (ii)
	$T : -2x = -1$ --- (iii)
	consider eqn (iii)
	$-2x = -1$
	$x = \frac{1}{2}$
	Consider eqn (i)
	$x + z = 0$ but $x = \frac{1}{2}$
	$\frac{1}{2} + z = 0$
	$z = -\frac{1}{2}$

2(c)(i) consider eqn (ii)

$x + y - z = 0$ but $x = \frac{1}{2}$, $z = -\frac{1}{2}$

$\frac{1}{2} + y - -\frac{1}{2} = 0$

$y = -1$

Substitute $y = -1$, $x = \frac{1}{2}$, $z = -\frac{1}{2}$ in the eqn (x_0)

$f \propto F^x \cdot l^y \cdot \mu^z$

$f \propto F^{\frac{1}{2}} \cdot l^{-1} \cdot \mu^{-\frac{1}{2}}$

$f \propto \frac{F^{\frac{1}{2}}}{\mu^{\frac{1}{2}} \cdot l}$

∴ The relation is $f \propto \frac{F^{\frac{1}{2}}}{\mu^{\frac{1}{2}} \cdot l}$

2(c)(ii) Given $\rho = \frac{3g}{4\pi RG}$

Required to prove correctness of the relation.

$[\rho] = [ML^{-3}]$

$[g] = [LT^{-2}]$

$[R] = [L]$

$[G] = [M^{-1}L^{3}T^{-2}]$

Input the above dimension in the relation given.

$[\rho] = \frac{[3][g]}{[4][\pi][R][G]}$

$[\rho] = \frac{[g]}{[R][G]}$

$[ML^{-3}] = \frac{[LT^{-2}]}{[L][M^{-1}L^{3}T^{-2}]}$

$= [L^{1-1-3} \cdot M^{0--1} \cdot T^{-2--2}]$

$= [L^{-3} \cdot M \cdot T^{0}]$

$= [ML^{-3}]$

∴ $[ML^{-3}] = [ML^{-3}]$

Since left hand side is equal to right hand side

hence proved

In extract 2.1 the candidate provided clear responses and managed to apply systematically the rules of dimension analysis in deriving the formula relating frequency of a stretched vibrating string, its tension, length and mass per unit length.

The candidates who performed poorly in this question failed to attempt correctly almost all parts of the question. For example, one candidate defined dimensions of a physical quantity as *the fundamental quantities (MLT) to which a physical quantity is measured.* These candidates failed to recognize that, dimensions of a physical quantity are powers to which the fundamental quantities (Mass, Length and Time) must be raised to represent the physical quantity. Apart from that, most of them applied wrong formula and procedures hence ended with incorrect results which indicates that they had inadequate knowledge and skills in solving dimension analysis questions. Extract 2.2 is a sample of an incorrect response taken from the script of one candidate.

Extract 2.2

2. (a) (i) ~~Dimension is the physical quantity which used to measure the distance and length of a substance.~~

2. (a) (ii) The uses of dimension.
(i) used to simplify the equation.
(ii) used to show the unit of the equation.

2. (b) (i) The basic requirement for a physical relation to be correct is dimensional equation have to show the correct basic requirement.

2. (b) (ii) Two quantities whose dimensional is
(i) Force
(ii) Pressure

2. (a) (i) Dimension is the physical quantities which used to show the correct equation by using the blacket sign.

2. (c) From

$$F = Ma$$

but

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

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

$$F = \frac{MV}{T}$$

but $v = \frac{L}{t}$

$$F = \frac{ML \times L}{T}$$

$$F = \frac{ML^2}{T}$$

$$F = ML^2T^{-1}$$

by using dimensional.

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

$$[F] = [ML^2T^{-1}]$$

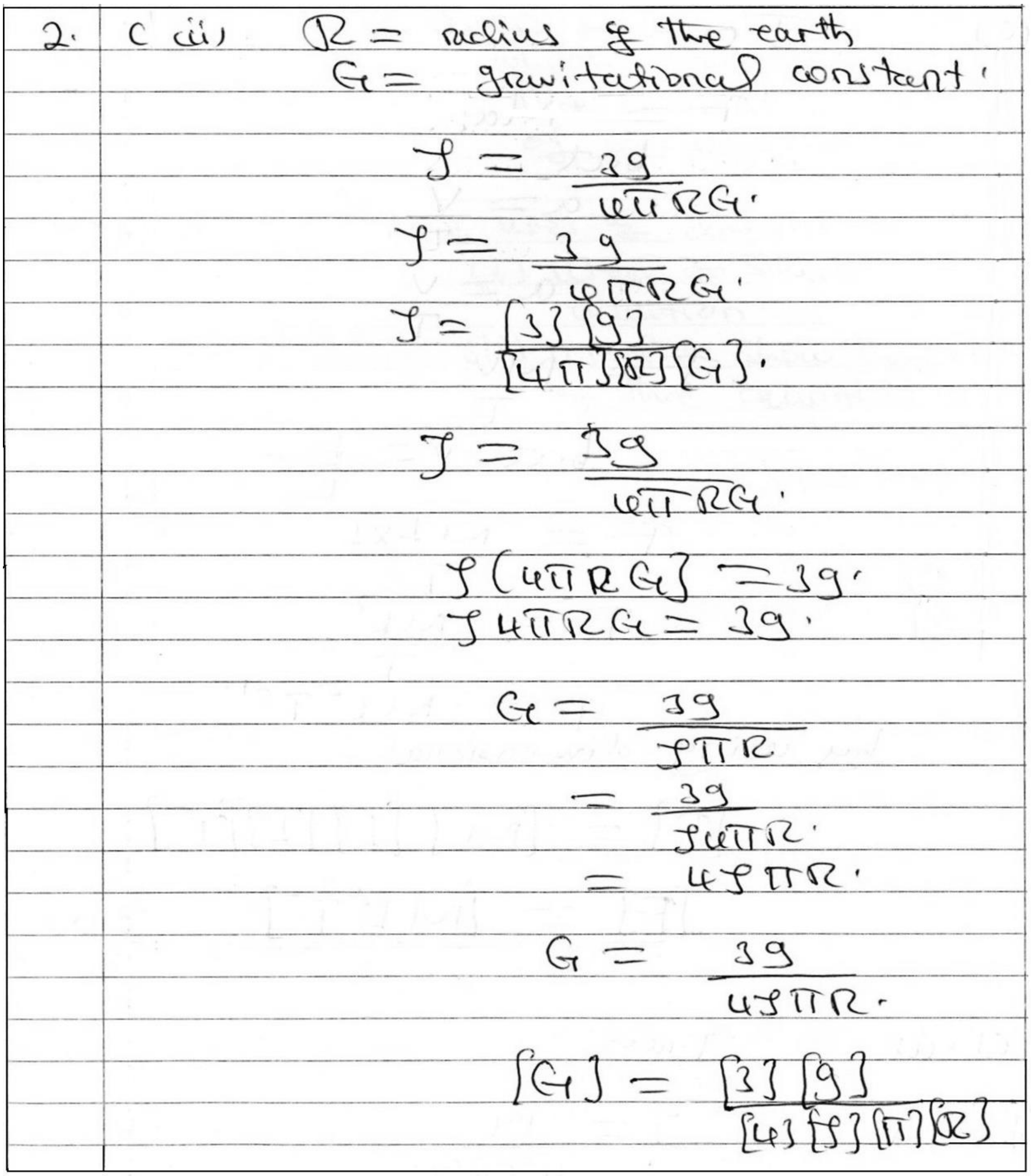
2. (c) (ii) From

$$J = \frac{3g}{4\pi RG}$$

but

J = density

g = accerelation due to gravity



2. c (ii) R = radius of the earth

G = gravitational constant.

$$\rho = \frac{3g}{4\pi RG}$$

$$\rho = \frac{3g}{4\pi RG}$$

$$\rho = \frac{[3][g]}{[4\pi][R][G]}$$

$$\rho = \frac{3g}{4\pi RG}$$

$$\rho(4\pi RG) = 3g$$

$$\rho 4\pi RG = 3g$$

$$G = \frac{3g}{\rho\pi R}$$

$$= \frac{3g}{\rho 4\pi R}$$

$$= 4\rho\pi R$$

$$G = \frac{3g}{4\rho\pi R}$$

$$[G] = \frac{[3][g]}{[4][\rho][\pi][R]}$$

In extract 2.2 the candidate failed to identify the units of the dimension [ML^2T^{-1}] which could enable him/her to obtain the required names of the corresponding physical quantities. Apart from that, in 2 (c) (ii), instead of showing the equation relating the dimension of ρ and $\frac{3G}{4\pi RG}$, he/she showed the equation for $G = \frac{3g}{4\pi\rho G}$ and not its dimension.

2.3 Question 3: Gravitation

This question had two parts, namely (a) and (b). In part (a), the candidates were required to: (i) explain why does the kinetic energy of an earth satellite change in the elliptical orbit, and (ii) give two factors which determine whether a planet has an atmosphere or not. In part (b) the candidates were given a stem which states that; 'a space craft was launched from the earth to the moon. If the mass of the earth was given to be 81 times that of the moon and that the distance from the centre of the earth to that of the moon is about 4.0×10^5 km'. The candidates were then required to: (i) draw a sketch showing how the gravitational force on a spacecraft varies during its journey, and (ii) calculate the distance from the centre of the earth to a point where the resultant gravitational force becomes zero.

A total of 4,354 (23.5%) candidates attempted the question. The candidates who scored below 3.5 marks out of 10 marks were 88.8 percent, out of which 50.2 percent scored 0. Those who scored from 3.5 to 5.5 marks were 9.2 percent and only 2.0 percent of them scored from 6 to 9.5 marks. Generally, the candidates' performance in this question was poor because 88.8 percent scored 3 or below out of 10 marks as shown in Figure 3.

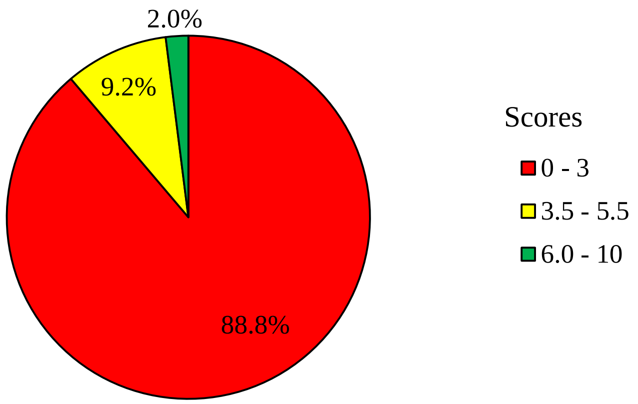
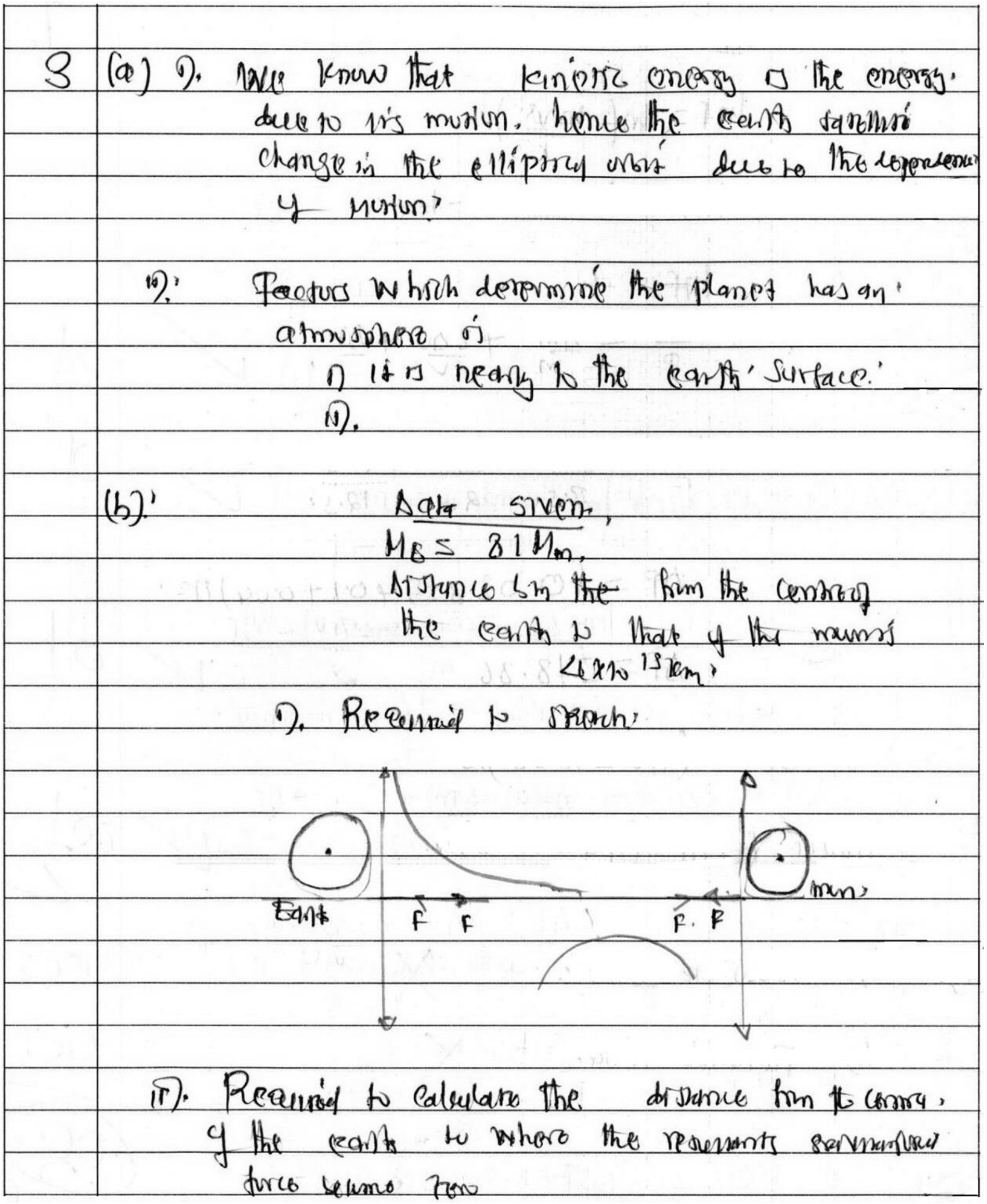


Figure 3: A chart showing candidates' performance in Question 3.

Majority (88.8%) of the candidates who performed poorly had inadequate knowledge about gravitation. Most of them skipped some parts of the question particularly part (b). The few who tried to attempt all parts, failed to provide the correct explanation in part (a). They also sketched poor graphs for variation of gravitational force on a spacecraft against the distance from the moon and the earth. Furthermore, they were not able to use correct formula for calculating the distance from the centre of the earth to a point where the resultant gravitational force becomes zero. Extract 3.1 presents a sample of an incorrect response from one of the candidates.

Extract 3.1



3 (a) i). We know that kinetic energy is the energy due to it's motion, hence the earth satellite change in the elliptical orbit due to the dependence of motion?

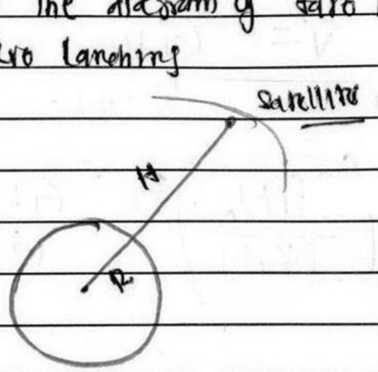
ii). Factors which determine the planet has an atmosphere is
i) It is nearly to the earth' Surface.
ii).

(b). Data given,
$M_E = 81 M_m$,
distance b/n the from the centre of the earth to that of the moons $\angle 6 \times 10^{13}$ km,

i). Required to sketch:

ii). Required to calculate the distance from its centre of the earth to where the resultants gravitational force becomes zero

Consider the diagram of satellite.
Before launching



$$F = \frac{GMM}{R}$$

$$f = \frac{GMm}{(R+h)}$$

But $V = \frac{2Gm}{(R+h)}$

$$f = \frac{mv^2}{r}$$

$$\frac{mv^2}{(R+h)} = \frac{GMm}{(R+h)^2}$$

$$mv^2 = \frac{G M_E M_m}{(R+h)}$$

But
V = Escape velocity of the satellite which is given
$$V = \frac{2GM}{R^2}$$

$$V^2 = \frac{GM_E}{(R+h)}.$$

$$\left(\frac{2GM_m}{(R+h)}\right)^2 = \frac{GM_E}{(R+h)}.$$

$$\frac{4(GM_m)^2}{(R+h)^2} = \frac{GM_E}{(R+h)}$$

$$\frac{4M_m^2}{(R+h)^2} = \frac{M_E}{(R+h)}$$

$$\frac{4M_m^2}{(R+h)} = (M_E)^2.$$

$$\frac{M_E^2}{M_m^2} = \frac{(R+h)}{4}.$$

$$\left(\frac{M_E}{M_m}\right)^2 = \left(\frac{R+h}{4}\right)$$

$$(81)^2 = \frac{R+4\times10^{13}}{4},$$

$$6561 = \frac{R+4\times10^{13}}{4},$$

$$R = 6.561\times10^{12}.$$

In extract 3.1 the candidate provided incorrect responses in all parts except in part (b) where he/she sketched an inaccurate diagram to show the variation of gravitation force on spacecraft and therefore received partial marks.

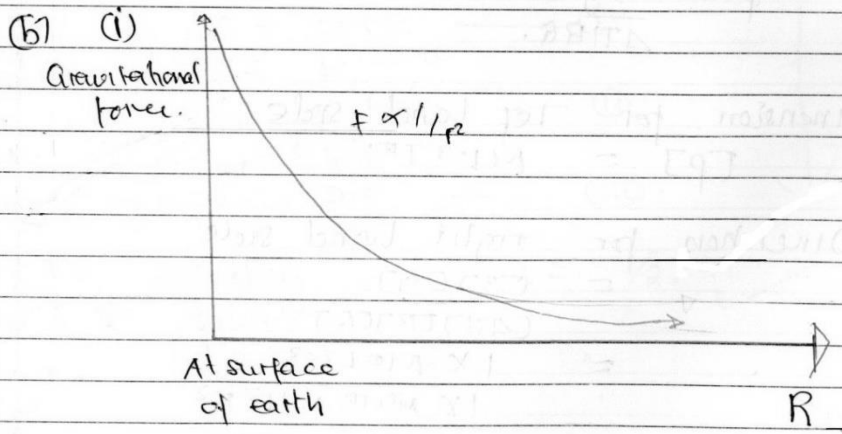
A few candidates (11.2%) that performed well had adequate knowledge on the concept of gravitation. Most of them were able to give clear and correct explanation for the reasons of the change of kinetic energy of an earth satellite in the elliptical orbit as well as the factors which determine whether a planet has an atmosphere or not. They also managed to apply the correct formula in attempting part (b) (ii). Some of them however confused between the sketch of the variation of gravitational force from the earth surfaces to infinity and that of the spacecraft which required them to consider the effect of the moon. Extract 3.2 presents the answer of one of the candidates who scored high marks in the question.

Extract 3.2

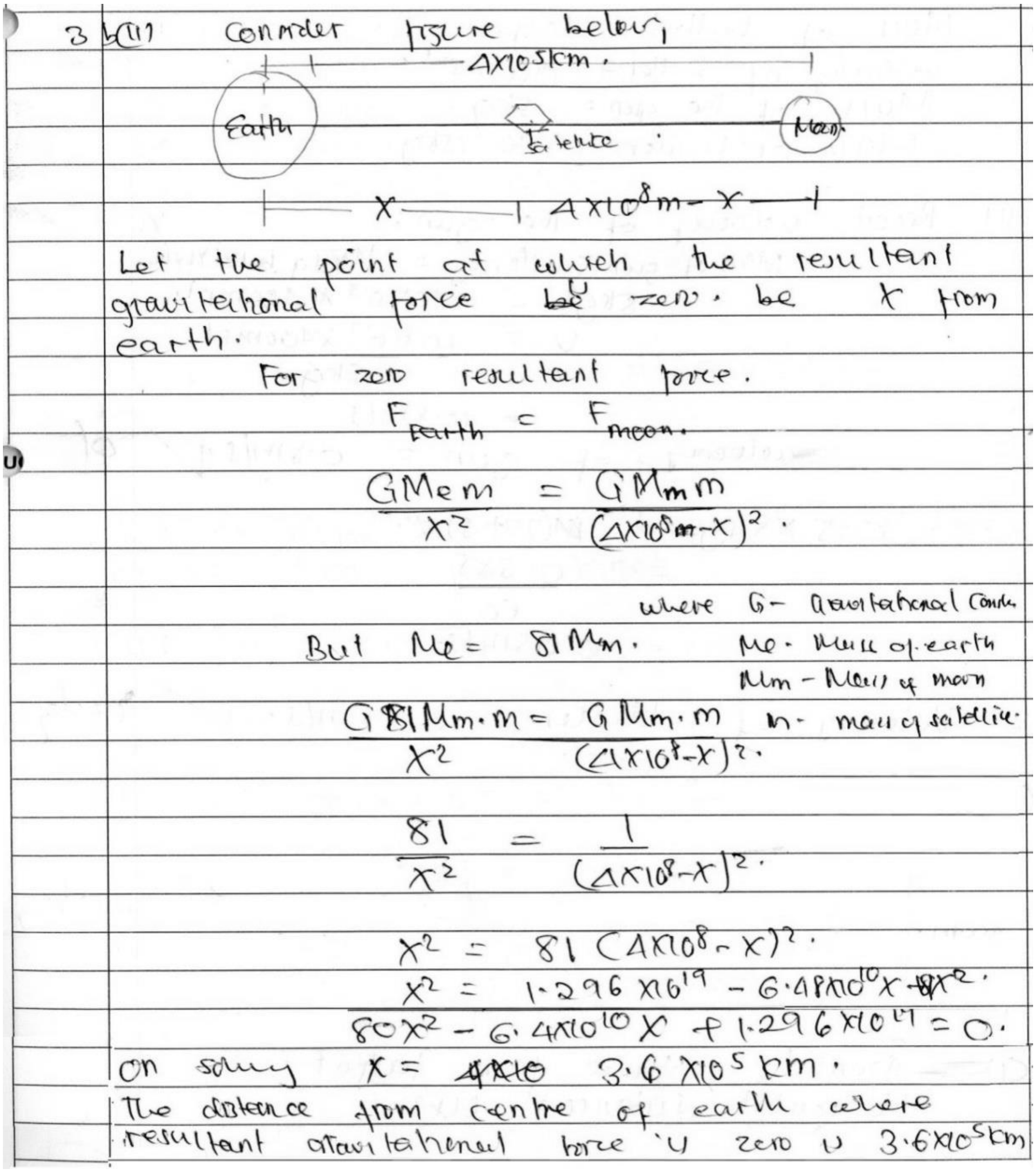
3(a)(i) The kinetic energy of an earth satellite change in an elliptical orbit due to that the velocity of satellite is not constant due to that the gravitational force of attraction has a component to the motion of satellite in an elliptical orbit.

(ii) (i) Value of acceleration due to gravity of the planet
(ii) Surface temperature of the planet.

(b) (i)



where R is distance from earth.



3 b(ii) Consider figure below,

Let the point at which the resultant gravitational force be zero be x from earth.

For zero resultant force.

$F_{earth} = F_{moon}$

$$\frac{GM_e m}{x^2} = \frac{GM_m m}{(4\times10^8 m - x)^2}$$

where G – gravitational constant

But $M_e = 81M_m$. M_e – Mass of earth, M_m – Mass of moon

$$\frac{G\,81M_m \cdot m}{x^2} = \frac{GM_m \cdot m}{(4\times10^8 - x)^2}$$ m – mass of satellite

$$\frac{81}{x^2} = \frac{1}{(4\times10^8 - x)^2}$$

$$x^2 = 81(4\times10^8 - x)^2$$

$$x^2 = 1.296\times10^{19} - 6.48\times10^{10}x + 81x^2$$

$$80x^2 - 6.4\times10^{10}x + 1.296\times10^{19} = 0$$

On solving $x = 3.6\times10^5$ km

The distance from centre of earth where resultant gravitational force is zero is 3.6×10^5 km

In extract 3.2 above the candidate provided correct responses for all parts of the question except part (b) (i) in which he/she sketched the graph for the variation of gravitational force on a spacecraft from the surface of the earth to infinity without considering the effect of the moon on the spacecraft.

2.4 Question 4: Circular Motion

This question consisted of two parts; (a) and (b). In part (a) the candidates were required to: (i) justify the statement that "if no external torque acts on a body its angular velocity will not be conserved", and (ii) find the resultant linear acceleration of a car, given that the car was moving with a speed of 30 ms^{-1} on a circular track of radius 500 m whose speed was increasing at the rate of 2 ms^{-2}. In part (b) the candidates were given a stem which states that; an object of mass 1 kg is attached to the lower end of a string 1m long whose upper end is fixed and made to rotate in a horizontal circle of radius 0.6 m with constant circular speed. In this part they were required to find the: (i) tension in the string and (ii) period of the motion.

About two thirds (67.9%) of the candidates attempted this question out of which 54.7 percent scored below 3.5 and 19.4 percent of these scored 0. The candidates who scored from 3.5 to 5.5 marks were 24.6 percent and those who scored from 6.0 to 10 marks were 20.7 percent. These data shows that the general candidates' performance in this question was average because 45.3% of the candidates scored 3.5 marks or above as illustrated in Figure 4.

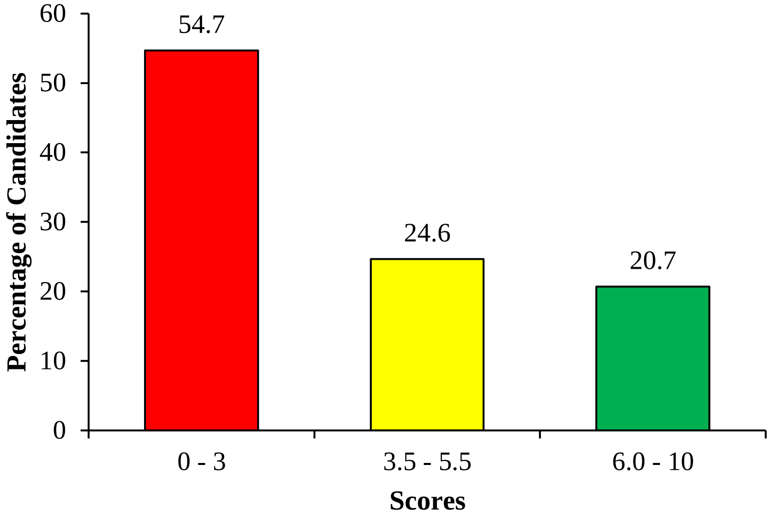


Figure 4: The performance of the candidates in Question 4.

The candidates who received average scores had satisfactory knowledge on the concept of circular motion as they managed to answer correctly some parts of the question. These candidates had good understanding on the condition for conservation of angular momentum as well as the relationship between tangential and centripetal accelerations. Some however failed to resolve the forces acting on a body tied with a rope moving in horizontal circular motion and therefore scored average marks. Extract 4.1 shows the answer of one of the candidates who performed well this question.

Extract 4.1

4 (a) i/ The statement 'If no external torque acts on a body, its angular velocity will not conserved' can be justified by using the principle of conservation of angular momentum, which states that "If no external torque acts on a body, the angular momentum ($I\omega$) before the impact is equal to angular momentum after impact".

i.e

$$I\omega = \text{Constant}$$

This means that the angular momentum is always conserved, but the angular velocity may vary in order to conserve the angular momentum.

ii/ Resultant linear acceleration.

$$a_r = \sqrt{a_c^2 + a_T^2}$$

Centripetal acceleration $(a_c) = \frac{v^2}{r}$

Given; Velocity $(v) = 30 m/s$

Radius of circular track $(r) = 500 m$

$$a_c = \frac{(30)^2}{500}$$

4 (a) ii/ Continues.

$$a_c = \frac{30 \times 30}{500}$$

$$a_c = 1.8 m/s^2$$

Given Tangential acceleration (a_T) = $2 m/s^2$

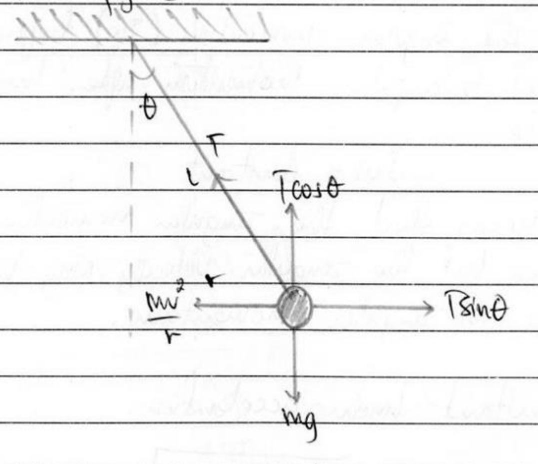
Then.

$$a_r = \sqrt{(1.8)^2 + (2)^2}$$

$$a_r = 2.69 m/s^2$$

∴ The resultant Linear acceleration is $2.69 m/s^2$

4 (b) i/ Consider the figure below



Required: Tension in the string

Given: Mass of object (m) = 1kg
Length of the string (l) = 1m
Radius (r) = 0.6m

at equilibrium;

$$T\cos\theta = mg \quad (1)$$

$$mv^2/r = T\sin\theta$$

4 (b) i/ Continues.

$$\sin\theta = r/L$$

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

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

$$\theta = 36.87^\circ$$

$$T\cos\theta = Mg$$

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

$$= \frac{1 \times 9.8}{\cos 36.87}$$

$$T = 12.25N$$

∴ Tension in the string is 12.25N

ii/ Period of motion.

Period (T) is given by;

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

$$L = 1m$$

$$\cos 36.87 = 0.8$$

$$g = 9.8$$

$$T = 2\pi\sqrt{\frac{1 \times 0.8}{9.8}}$$

$$T = 1.8 \text{ seconds}$$

∴ Period of motion is 1.8 seconds

In extract 4.1 the candidate gave correct responses in every part of the question. For the part which required illustration, the candidate drew a clear diagram that was labelled correctly. Also his/her work is clear and presented systematically.

As for the candidates who had poor performance, some of them failed to interpret the meaning of the word “justify” as used in 4 (a) (i). Most of them tried to state the law of conservation of angular momentum instead of providing the required justification. For example, one candidate responded to this part by writing, '*No its angular velocity will be conserved based on the principle of conservation of angular momentum which states that a body will maintain its state unless an external force acts on it'*. This candidate lacked knowledge about circular motion as he/she failed to distinguish the conceptual ideas of circular motion from linear motion. Others were not able to illustrate correctly the given tasks and apply the correct formula in solving the problems. Extract 4.2 is a sample of a poor responses from one of the candidates.

Extract 4.2

4 as i) if no external torque acts on a body its angular velocity will not conserved in a fact that the external torque balance with the centripetal force, so it put the body in a circular path and with a certain angular velocity.

ii) Given.

$v_1 = 30ms^{-1}$

$r = 500m$.

$\Delta V = 2ms^{-2}$.

from.

$V = r\omega$. divide by t both sides.

$\frac{V}{t} = \frac{r}{t}\omega$, a – linear accel, α – Angular accelar

~~$a = \alpha\omega$~~

and $\omega = \frac{V}{r}$.

So

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

$= 2ms^{-2} \times \frac{30ms^{-1}}{500m}$

~~$= \frac{60m^2s^{-3}}{500m}$~~

$a = 0.12ms^{-2}$

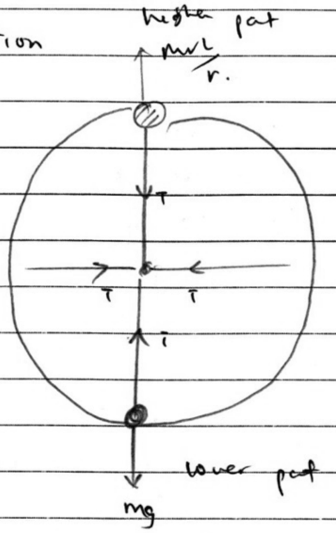
~~∴ The resultant linear acceleration is $0.12ms^{-2}$~~

4 b) solution

M = 1 kg

l = 1 m.

r = 0.6



At upper part

$$\frac{Mv^2}{r} = T + Mg. \quad \text{--- (1)}$$

At lower part

$$\frac{Mv^2}{r} + Mg = T. \quad \text{--- (II)}$$

take eqn (1)

$$\frac{Mv^2}{r} = T + Mg.$$

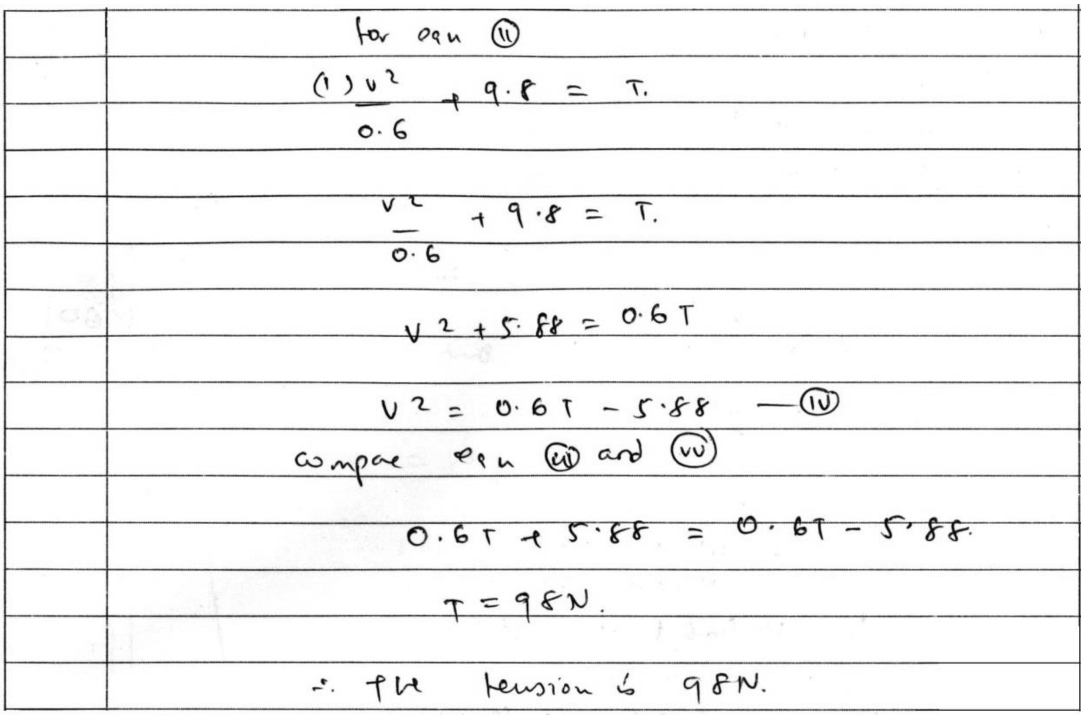
$$T = \frac{Mv^2}{r} - Mg$$

$$\frac{(1)(V)^2}{0.6} = T + 1 \times 9.8$$

$$\frac{V^2}{0.6} = T + 9.8$$

$$v^2 = 0.6T + 5.88$$

$$v^2 = 0.6T + 5.88 \quad \text{--- (II)}$$


for eqn (ii)

$\frac{(1)v^2}{0.6} + 9.8 = T.$

$\frac{v^2}{0.6} + 9.8 = T.$

$v^2 + 5.88 = 0.6T$

$v^2 = 0.6T - 5.88$ — (iv)

compare eqn (iii) and (vv)

$0.6T + 5.88 = 0.6T - 5.88.$

$T = 98N.$

∴ the tension is 98N.

In extract 4.2 the candidate illustrated that the object performs vertical circular motion while the question instructed that the body rotates in horizontal circles. This mistake caused him/her to apply incorrect formula to calculate the tension and the period.

2.5 Question 5: Newton's Laws of Motion and Projectile Motion

This question had two parts (a) and (b). In part (a) the candidates were required to calculate: (i) recoil velocity of the gun, and (ii) velocity acquired by the hunter during firing if a 75 kg hunter fires a bullet of mass 10g with a velocity of 400 ms^{-1} from a gun of mass 5 kg. In part (b) the candidates were given a stem which states that; a jumbo jet travelling horizontally at 50 ms^{-1} at a height of 500 m from sea level drops a luggage of food to a disaster area. The candidates were required to (i) determine at what distance from the target should the luggage be dropped, and (ii) find the velocity of the luggage as it hit the ground.

A total of 13,004 (70.2%) candidates attempted this question: out of these candidates 17.5 percent scored 0; 34.9 percent scored from 0.5 to 3.0 marks; 30.9 percent scored from 3.5 to 5.5 marks; and 16.7 percent scored from 6.0 to 10 marks. These data shows that the performance in this question was average. Figure 5 illustrates the performance of candidates in question 5.

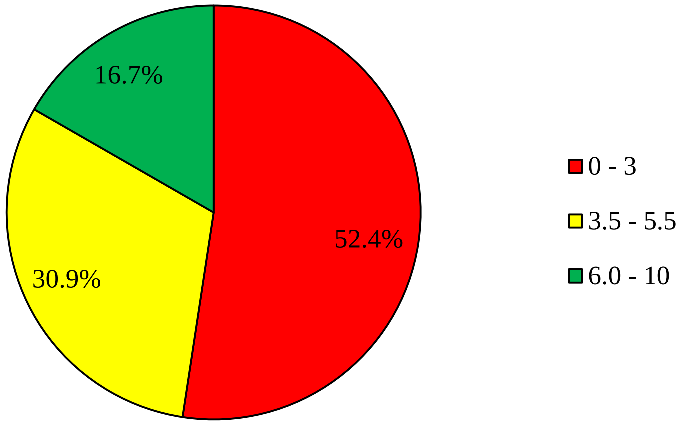


Figure 5: A pie chart representing candidates' average Performance in Question 5

The candidates who attempted this question well had ample knowledge and skills in solving problems relating Newton's laws of motion and projectile motion. These candidates were able to identify the principle governing the motion of the bullet in part (a) and to find the motion of the luggage dropped in air in part (b). Extract 5.1 shows an example of the best response taken from one of the candidates.

Extract 5.1

5(a) Soln. Data given.

Mass of hunter = 75 kg = M_h

Mass of bullet (m_b) = 10g = 10×10^{-3} kg

Velocity of bullet (V_b) = $400 ms^{-1}$

Mass of gun (M_g) = 5 kg

(i) Required to calculate the recoil of the gun from the principle of conservation of linear momentum

"moment before collision = moment after collision"

Since at the begining the moment was zero also the final moment should be equal to zero

That is; moment of gun + moment of bulet = 0

$m_b V_b + M_g V_g = 0$

$10 \times 10^{-3} \times 400 + 5 Vg = 0$

$5 Vg = -4$

$\therefore Vg = -0.8 ms^{-1}$ The negative sign indicates that the gun moves in opposite direction to that of the bullet.

$\therefore$ The gun will recoil with a velocity of $0.8 ms^{-1}$ in the direction opposite to that of the bullet.

5(a) (ii) Required to calculate velocity acquired by the hunter during firing

Let the velocity acquired by the hunter be V'

So the momentum of the hunter will be MV'

But the total momentum is the sum of momentum of the hunter + momentum of the gun + momentum of the bulet = 0

5 (a) ∴ $MV' + M_g V_g + M_b V_b = 0$

here $M = 75kg$, $M_g = 5kg$, $V_g = 0.8 ms^{-1}$, $M_b = 10\times10^{-3} kg$

$V_b = 400 ms^{-1}$

∴ ~~AA~~ $75V' + (5 \times 0.8) + (10\times10^{-3} \times 400) = 0$

$75V' + 4 + 4 = 0$

$75V' + 8 = 0$

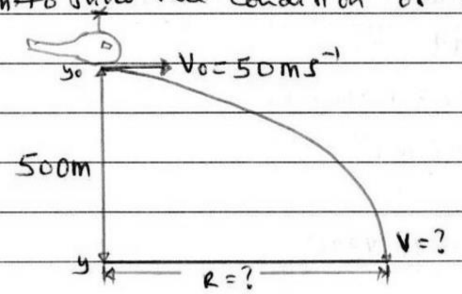
$\frac{75V'}{75} = \frac{-8}{75}$

$V' = -0.107 ms^{-1}$ The negative sign indicate that the direction of the hunter will be opposite to that of the bullet.

∴ Velocity acquired by the hunter during firing is $0.107ms^{-1}$ opposite to that of the bullet.

5 (b) soln.

diagram to show the condition of the problem.



(i) required to find the horizontal distance the luggage to be dropped in order to land at the targeted area

from

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

$-yy^o = V_y t - \frac{1}{2}gt^2$ but V_y initial $= 0$

5(a) (i) $\therefore \quad -500 = -4.9t^2$

$\therefore t = \sqrt{\frac{500}{4.9}}$

$t = 10.102$ sec

Then Range $= V_{ox}\, t$

here $V_{ox} = 50 ms^{-1}$, $t = 10.102$ sec

$\therefore R = 50 \times 10.102$

$R = 505.76$ m

$\therefore$ The luggage should be be dropped 505.76m away from the disaster area.

5(b) (ii) Required to find the velocity of the luggage as it hit the ground.

from

$V_f = \sqrt{V_{ox}^2 + V_{oy}^2}$

but V_{ox} = horizontal velocity $= 50 ms^{-1}$

$V_{oy} = V_o + at$

$V_y = 0 + 9.8 \times 10.102$ sec

$V_y = 98.9996\ ms^{-1}$

$\therefore V_f = \sqrt{50^2 + 98.9996^2}$

$V_f =$ ~~$\sqrt{24\,502\,302}$~~ $\sqrt{12300.92}$

$V_f = 110.91\ ms^{-1}$

$\therefore$ The velocity of the luggage as it hit the ground is $110.91\ ms^{-1}$.

In extract 5.1 the candidate managed to present his/her work well. He/she identified constraints required for calculating each of the asked quantity. The candidate also performed systematically the required calculations and gave correct conclusions.

On the contrary, the candidates who performed poorly failed to identify the principle governing the motion of the bullet based on the concept of Newton's laws of motion. Some attempted to recall the principle of conservation of linear momentum but finally lacked mathematical skills in analysing the given data to get the correct answers. They also faced problems in attempting part (b) which based on the concept of projectile motion. In this part they were supposed to apply the Newton's second equation of motion to solve the problem but instead they applied Newton's first equation which led them to give wrong answers. Extract 5.2 is an example of a poor response to this question.

Extract 5.2

5 (a) (ii)

$M_1U_1 + M_2U_2 = V(M_1 + M_2)$

$\frac{1333.33 \times 10 + 5 \times 400}{10 + 5} = V$

$1022.22 ms^{-1} = V$

Velocity of hunter = $1022.22 ms^{-1}$

(b) Data given

$V_1 = 50 ms^{-1}$

Height = 500 m.

$h_2 = ?$

Soln.

$V = d/t$

$50 = \frac{500}{t}$

$t = \frac{500}{50}$

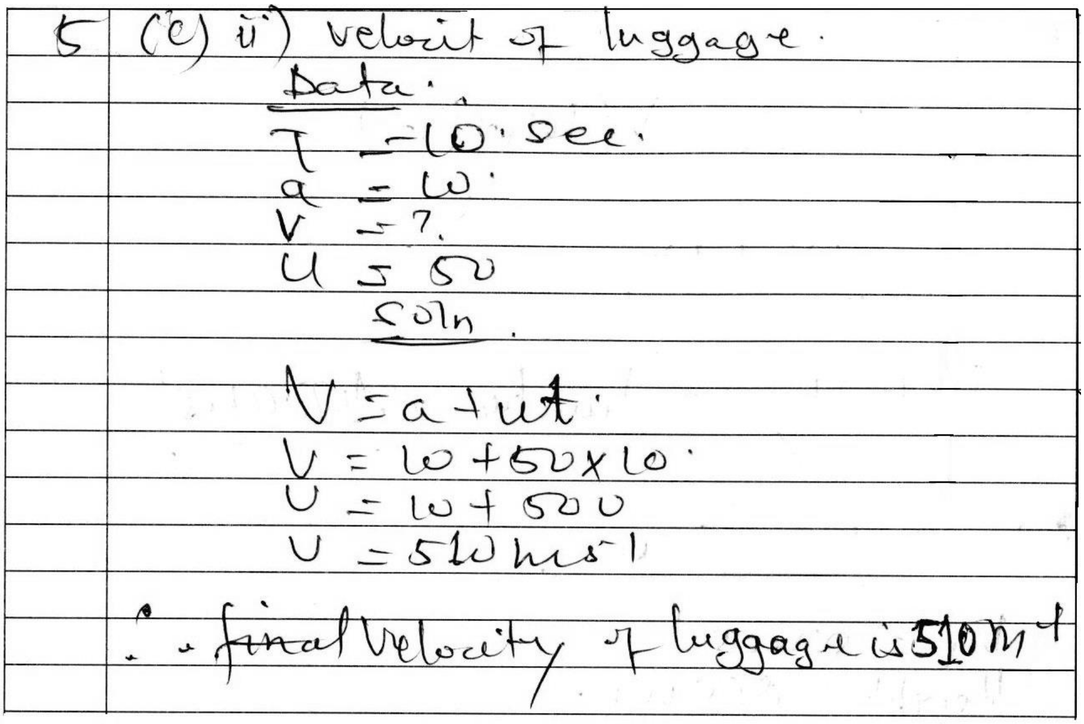
$t = 10$ sec

from.

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

$H = \frac{1}{2} \times 10 \times 10^2$ $\frac{50^2}{20} = 125 m$

∴ The new horizontal distance is 125 m


5 (c) ii) velocit of luggage.
Data.
T = 10 sec.
a = 10.
V = 7.
U = 50
Soln.
V = a + ut.
V = 10 + 50 x 10.
V = 10 + 500
V = 510 ms⁻¹
∴ final Velocity of luggage is 510 m⁻¹

In extract 5.2 the candidate provided incorrect answers in all parts of the question due to the use of wrong formula. The candidate was also not carefull enough as he/she changed the number of the question from 5 (b) (ii) to 5(c) (ii) which is not indicated in the question paper.

2.6 Question 6: Simple Harmonic Motion

The question had two parts; (a) and (b). In part (a) the candidates were given a simple harmonic equation, $x = 6sin10\pi t + 8cos10\pi t$, where x is in centimetre and t in second, then they were required to determine (i) amplitude and (ii) the initial phase of the motion. In part (b) they were required to: (i) show that the total energy of a body executing simple harmonic motion is independent of time, and (ii) find the periodic time of a cubical body of sides 0.2 m and mass 0.004 kg floating in water then pressed and released such that it oscillates vertically.

This question was attempted by 8,283 (44.7%) candidates, out of which 74.5 percent scored below 3.5 marks out of 10 marks allocated to this question. About fifteen percent (15.1%) of the candidates scored 3.5 to 5.5 marks while those who scored 6 to 10 marks were 10.4 percent. These data imply that the general performance in this question was poor. Figure 6 illustrates the performance of candidates in question 6.

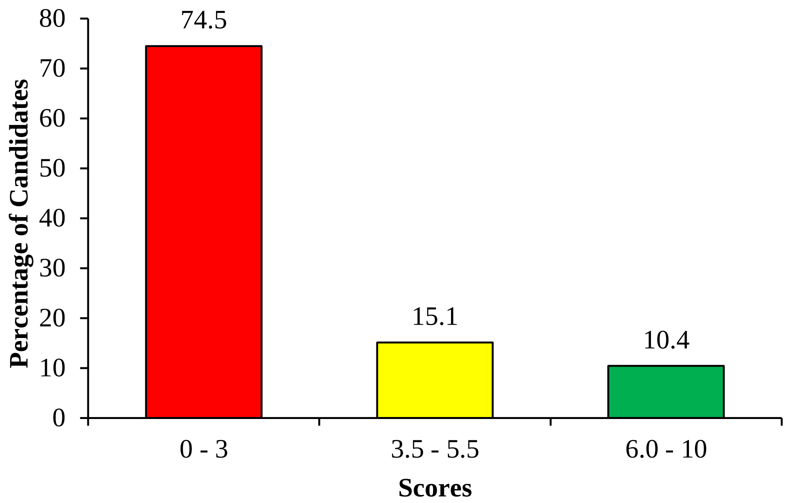
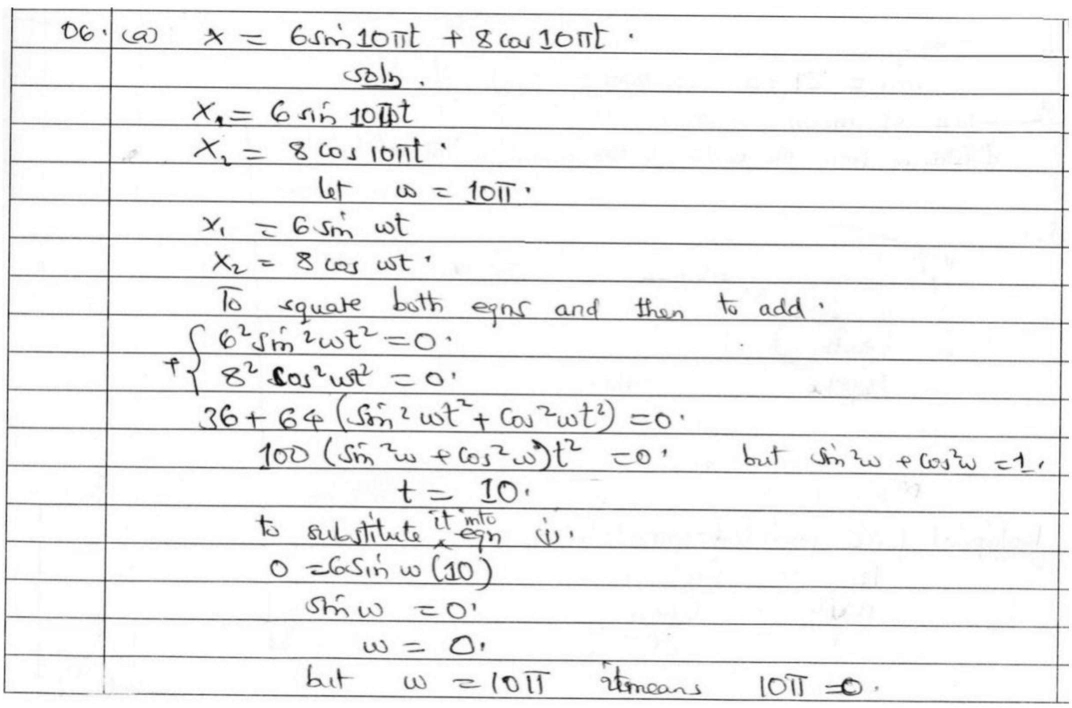
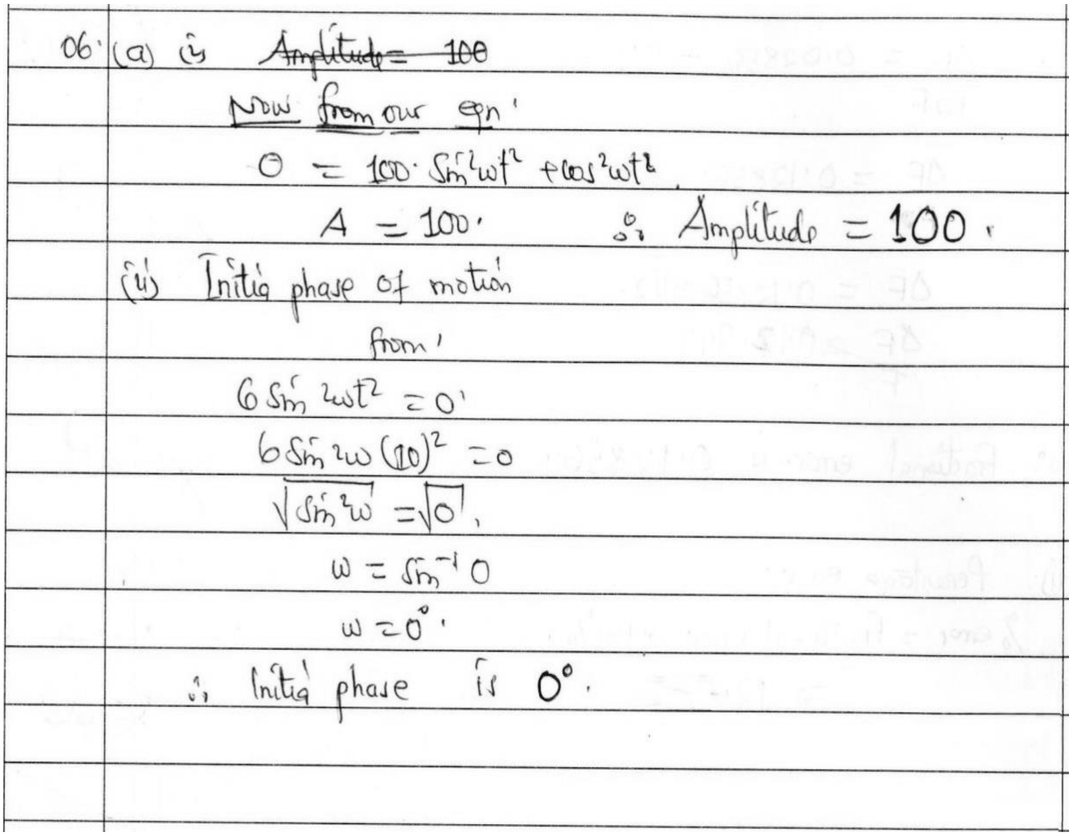


Figure 6: Candidates' Performance in Question 6

The candidates who performed poorly in this question, failed to apply the correct formula in solving the problem. Some of them wrote correct formula but they lacked mathematical skills in manipulating the data to get the correct answer. This is an indication that they lacked knowledge concerning the concept of simple harmonic motion. Extract 6.1 is an example of an incorrect response taken from the script of one of the candidates.

Extract 6.1


06. (a) $x = 6\sin 10\pi t + 8\cos 10\pi t$.
soln.
$x_1 = 6\sin 10\pi t$
$x_2 = 8\cos 10\pi t$.
let $\omega = 10\pi$.
$x_1 = 6\sin \omega t$
$x_2 = 8\cos \omega t$.
To square both eqns and then to add.
$6^2\sin^2\omega t^2 = 0$.
$8^2\cos^2\omega t^2 = 0$.
$36 + 64(\sin^2\omega t^2 + \cos^2\omega t^2) = 0$.
$100(\sin^2\omega + \cos^2\omega)t^2 = 0$. but $\sin^2\omega + \cos^2\omega = 1$.
$t = 10$.
to substitute it into eqn (i).
$0 = 6\sin\omega(10)$
$\sin\omega = 0$.
$\omega = 0$.
but $\omega = 10\pi$ it means $10\pi = 0$.



06. (a) (i) ~~Amplitude = 100~~

Now from our eqn'

$\theta = 100 \cdot \sin^2\omega t^2 + \cos^2\omega t^2$

$A = 100$. ∴ Amplitude $= 100$.

(ii) Initial phase of motion

from'

$6 \sin^2 2\omega t^2 = 0$'

$6 \sin^2 2\omega (10)^2 = 0$

$\sqrt{\sin^2\omega} = \sqrt{0}$,

$\omega = \sin^{-1} 0$

$\omega = 0°$.

∴ Initial phase is $0°$.

In extract 6.1 the candidate attempted wrongly each part of the question. In part (a) he/she obtained false value of time *t* due to poor factorization of *t* from the equations. In part (b) the candidate did not know the meaning of initial phase because he/she associated it with angular velocity.

The candidates who performed well in this question showed a good ability in mastery of the content as they were able to derive the general equation for displacement of a particle executing *s.h.m* and hence compared it with the given equation in order to find the value of amplitude and initial phase of the motion. They also managed to derive the formula for total energy of a body executing *s.h.m* and to link the concepts of s.h.m and the law of floatation in solving part (b) (ii) of the question. Extract 6.2 is an example of a good answer from one of the candidates.

Extract 6.2

6(a)	(i)	soln.
		Data given
		$x = 6\sin 10\pi t + 8\cos 10\pi t$ —(i)
		Amplitude = asked.
		from. $x = a\sin(\omega t + \phi)$
		$x = a\sin\omega t\cos\phi + a\cos\omega t\sin\phi$
		$x = a\cos\phi\sin\omega t + a\sin\phi\cos\omega t$ —(ii)
		Compare the two equation
		$x = 6\sin 10\pi t + 8\cos 10\pi t$
		$x = a\cos\phi\sin\omega t + a\sin\phi\cos\omega t$.
		$6 = a\cos\phi$ —(iii)
		$8 = a\sin\phi$ —(iv)
		square the two eqn. and then
		add them.
		$(6)^2 = a^2\cos^2\phi$
		$(8)^2 = a^2\sin^2\phi$
		$6^2 + 8^2 = a^2\cos^2\phi + a^2\sin^2\phi$
		$6^2 + 8^2 = a^2(\cos^2\phi + \sin^2\phi)$
		but $\sin^2\phi + \cos^2\phi = 1$
		$6^2 + 8^2 = a^2$.
		$a = \sqrt{6^2 + 8^2}$
		$a = 10\text{ cm}$
		$\therefore$ Amplitude = 10 cm
6(a)	(ii)	Initial phase of motion = asked.
		from.
		$6 = a\cos\phi$ —(i)
		$8 = a\sin\alpha$ —(ii)
		take eqn (ii) and divide by (i)

6(a)	(ii)
	$\frac{8}{6} = \frac{a \sin\phi}{a \cos\phi}$
	$\frac{8}{6} = \tan\phi$
	$\phi = \tan^{-1}\left(\frac{8}{6}\right)$
	$\phi = 53.13^\circ$
	$\therefore$ Initial phase of motion $= 53.13^\circ$
6(b)	(i) Soln.
	from.
	$x = a \sin wt$
	$\frac{dx}{dt} = aw\cos wt$
	$v = aw\cos wt \quad -(1)$
	but
	$K.E = \frac{1}{2}mv^2$
	$K.E = \frac{1}{2}m(aw\cos wt)^2$.
	$K.E = \frac{1}{2}m a^2 w^2 \cos^2 wt$
	but $P.E = \frac{1}{2}Kx^2$
	but $k = mw^2$.
	$P.E = \frac{1}{2}mw^2(a \sin wt)^2$.
	$P.E = \frac{1}{2}mw^2(a^2 \sin^2 wt)$
	$P.E = \frac{1}{2}ma^2w^2\sin^2 wt$
	but $E_T = P.E + K.E$
	$E_T = \frac{1}{2}ma^2w^2\sin^2 wt + \frac{1}{2}ma^2w^2\cos^2 wt$

6(b) (i) $E_T = \frac{1}{2} m\omega^2 a^2 (\sin^2\omega t + \cos^2\omega t)$

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

$\therefore E_T = \frac{1}{2} m\omega^2 a^2 \times 1$

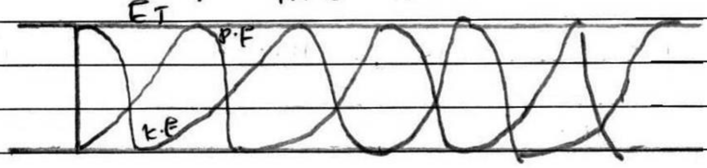
$E_T = \frac{1}{2} m\omega^2 a^2$. hence shown.

Where E_T = Total energy.

a = amplitude

ω = angular frequency

m = mass



6(b) (ii) Soln.

Data Given

Side = Length = 0.2m

mass = 0.004kg.

from.

Area = L . W to

Area = 0.2×0.2 = $0.04 m^2$

but $mg = \rho A h g$

$m = \rho A h$.

$h = \frac{m}{\rho A}$

$h = \frac{0.004}{1000 \times 0.04}$

$h = 1 \times 10^{-4} m$

but $T = 2\pi \sqrt{\frac{h}{g}}$

$T = 2\pi \sqrt{\frac{1 \times 10^{-4}}{9.8}}$

Extract 6.2 illustrates the competence shown by the candidate in performing the calculations. The candidate started by stating the demand of the question in a particular item and then tackled each part of the question carefully to reach the final answer.

2.7 Question 7: First Law of Thermodynamics

This question was divided in two parts; (a) and (b). In part (a) the candidates were required to: (i) give a common example of adiabatic process, and (ii) state what happens to the internal energy of a gas during adiabatic expansion. In part (b) the candidates were given a word problem which stated that; a mass of an ideal gas of volume 400cm^{3}at 288K expands adiabatically where its temperature falls to 273K. The candidates were required to: (i) find the new volume of the gas, and (ii) calculate the final volume of the gas if the gas was finally compressed isothermally until its pressure returns to its original value.

A total of 9,194 (49.6%) candidates attempted this question, out of which 33.9 percent scored 0 marks, 38.3 percent scored 0.5 to 3.0 marks, 20.1 percent scored 3.5 to 5.5 marks, and 7.7 percent scored 6.0 to 10 marks. These scores reveal that the candidates' general performance in this question was poor. The analysed data are illustrated in Figure 7.

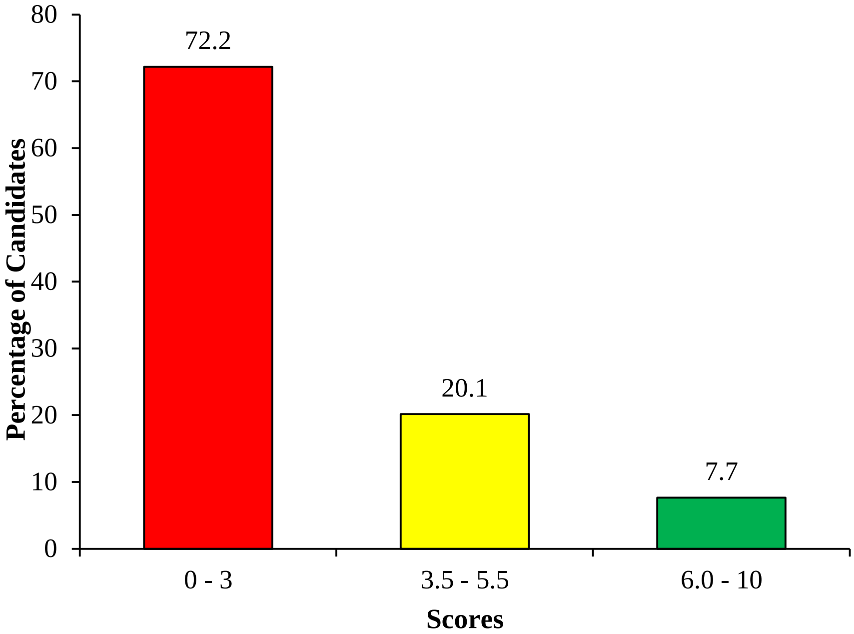


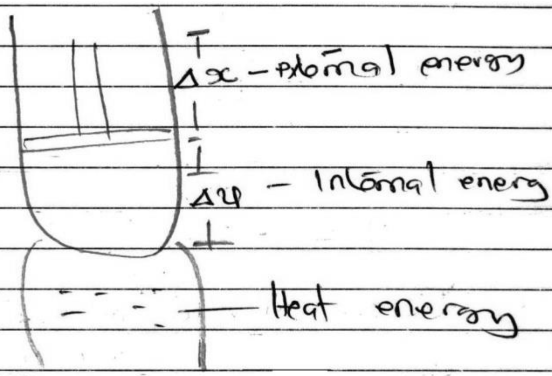
Figure 7: A bar graph showing candidates' performance in question 7.

The candidates who performed poorly in this question, were not able to provide a common example of adiabatic process and to give a proper explanations on the effect faced by the internal energy of a gas during adiabatic expansion. Furthermore, they applied a wrong formula and laws in finding the new and final volumes of a gas under isothermal condition. This shows that most of them lacked knowledge and skills of solving problems related to the concept of first law of thermodynamics. Extract 7.1 shows a sample of an incorrect response given by one of the candidates.

Extract 7.1

7 (a)

(i) – Adding a heat energy to a system adiabatic which involve internal change and external change



$\therefore \Delta Q = \Delta U + P\Delta x$

(ii) – It will expand during heat added to a system

(b) (i) $V = 400\ cm^3$

$T = 288K$

$T_o = 273K$

$V_o = ?$

From charle's

$$\frac{V_o}{T_o} = \frac{V}{T}$$

$$V_o = \frac{T_o V}{T}$$

$$V_o = \frac{273 \times 400}{288}$$

$\therefore V_o = 379.167\ cm^3$

7(b) (ii) at constant pressure = 760 mmHg.

and temperature will be = 293.15K

$V = 400\,cm^3$

$T = 288\,K$

$T_o = 293.15K$ (at constant temperat

$V_o = ?$

$$\frac{V_o}{T_o} = \frac{V}{T}$$

$$V_o = \frac{T_o V}{T}$$

$$V_o = \frac{293.15K \times 400\,cm^3}{288K}$$

$$V = \frac{293.15 \times 400\,cm^3}{288}$$

$V = 407.1527778\,cm^3$

$V = 407.15\,cm^3$

∴ The final volume was $407.15\,cm^3$

In extract 7.1 the candidate provided an illustration in part (a) (i) which did not match with the demand of the question. Also the candidate used Charles' law to calculate volume of the gas under adiabatic process which is not correct.

On the contrary, the candidates who performed well managed to apply the formula and the first law of thermodynamics in analysing the data to get the correct answer. In addition, they provided correct responses on the common example of adiabatic process and gave correct reason for what happens to the internal energy of a gas during adiabatic expansion. This indicates that they had good mastery about the concepts of thermodynamics. Extract 7.2 is a sample of a correct response from one of the candidates who responded correctly to this question.

Extract 7.2

7. (a) (i) Bursting of a tyre.

(a) (ii) From

$$Q = \Delta U + W$$

For Adiabatic process, $Q = 0$

$$0 = \Delta U + W$$

$$\Delta U = -W$$

During expansion the Internal energy decreases as no heat leaves or enters the system, hence internal energy is the one used to do Work.

7 (b) Volume $(V_0) = 400 cm^3$

Temperature $(T_0) = 288k$.

Temperature $(T_1) = 273k$.

(i) New Volume $(V_1) = ?$

From

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

$$T_1 V_1^{\gamma-1} = T_0 V_1^{\gamma-1}.$$

$$\gamma = 1.4.$$

$$V_1^{\gamma-1} = \frac{T_0 V_0^{\gamma-1}}{T_1}$$

$$V_1^{0.4} = \frac{288 \times (400)^{0.4}}{273}$$

$$V_1 = 457.23 cm^3.$$

$\therefore$ The New Volume $= 457.23 cm^3$.

(b) (ii) Initial Volume $(V_1) = 457.23 cm^3$.

Initial Temperature $(T_1) = 273k$.

Final Volume $(V_2) = ?$

Solution

7 (b)(ii) Initial pressure (P_0)

From

$PV = nRT$

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

$P_0 = \frac{8.31 \times 288}{400 \times 10^{-3}}$

$= 5983.2$ Pa.

Final pressure = Initial pressure $= 5983.2$ (P_3)

but

from

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$.

$P_1 = \frac{P_0 V_0 \times T_1}{T_0 \times V_1}$

$= \frac{5983.2 \times 400 \times \sout{288}\ 273}{288 \times 457.23}$

$= 4961.68$ Pa.

Hence

~~$\frac{P_3 V_3}{T_3} = \frac{P_1 V_1}{T_1}$~~

~~$V_3 = \frac{P_1 V_1 \times T_3}{P_3 T_1}$~~

~~$= 4961.68 \times 457.23 \times$~~

From Isothermal Equation

PV = constant

$P_3 V_3 = P_1 V_1$

$V_3 = \frac{P_1 V_1}{P_3}$

$V_3 = \frac{4961.68 \times 457.23}{5983.2}$

$V_3 = 379.17\ cm^3$.

∴ The final volume $= 379.17\ cm^3$.

In extract 7.2 the candidates wrote the correct response for each part of the question. It seemed they had adequate knowledge of adiabatic process therefore they were able to support mathematically the response in 7(a) (ii).

2.8 Question 8: Transfer of Heat and Thermometry

This question consisted of three parts; (a), (b) and (c). In part (a) the candidates were required to state: (i) Prevost's theory, and (ii) Wien's displacement law. In part (b) they were required to explain briefly why, (i) steam pipes are wrapped with insulating material, and (ii) stainless steel cooking pans fitted with extra copper at the bottom are preferred. In part (c) the candidates were required to determine the Celsius temperature defined by the property x that corresponds to a temperature of 50^{o}C on a gas thermometer if the value of the property x of a certain substance was given by $x_{\theta} = x_{o} + 0.5\theta + 2 \times 10^{-4}\theta^{2}$ where θ is the temperature in degree Celsius.

A total of 17,175 (92.7%) candidates attempted the question, out of which 23.7 percent scored 0 to 3.0 marks including 9.1 percent who scored 0. The candidates who scored 3.5 to 5.5 marks were 24.8 percent while those who scored 6.0 to 10 marks were 51.5 percent. Generally, the performance of this question was good. Figure 8 presents performance in question 8.

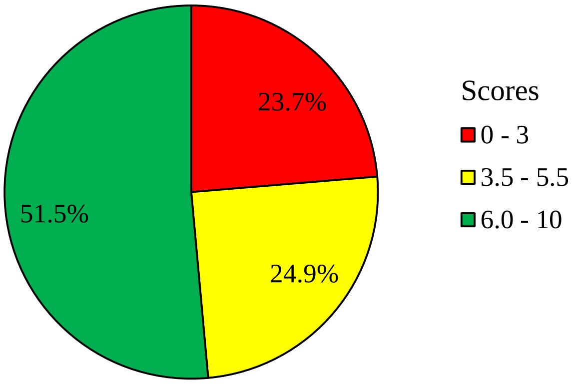


Figure 8: The candidates' performance in question 8.

Majority (76.3%) of the candidates who performed well stated the Prevost's theory of heat exchange as well as Wien's displacement law. They gave correct reasons why steam pipes are wrapped with insulating material and why stainless steel cooking pans fitted with extra copper at the bottom are more preferred in domestic use. In addition, they managed to derive the formula and determine the Celsius temperature with respect to thermometric property of a given substance. Generally these candidates were conversant with the concepts of thermometry. Extract 8.1 illustrates the performance of candidates in question 8.

Extract 8.1

8a(i) Prevost's theory states that, "A body radiates energy at the rate depending on the nature of its surface and its temperature and it absorbs energy at the rate depending on the nature of its surface and the surrounding temperature, and when the temperature of the body is constant, it absorbs radiations at the rate equal to the radiations it emits."

(ii) Wien's displacement law states that, "The wavelength of radiation at which maximum intensity is produced is inversely proportional to the absolute temperature of the body.

b(i) This is normally done so as to reduce heat losses from the steam to the surroundings.

(ii) This is due to the fact that copper is a good conductor of heat and so stainless cooling pans fitted with extra copper at the bottom tend to show good ability as their heat conduction is very good and hence they are preferred

(c) Given: $X_\theta = X_o + 0{\cdot}5\theta + 2\times10^{-4}\theta^2$.

From: $\theta = \left(\frac{X_\theta - X_o}{X_{100} - X_o}\right)100°c.$

$X_{50} = X_o + 0{\cdot}5(50) + (2\times10^{-4})(50)^2.$

$X_{50} = X_o + 25 + 0{\cdot}5$

$\therefore X_{50} = X_o + 25{\cdot}5$

8(c) Also; $X_0 = X_0 + 0.5(0) + 2\times10^{-4}(0)^2$.

$\therefore X_0 = X_0$

Also; $X_{100} = X_0 + 0.5(100) + 2\times10^{-4}(100)^2$.

$X_{100} = X_0 + 50 + 2$

$\therefore X_{100} = X_0 + 52$.

Thus;

$$\theta = \left(\frac{X_{50} - X_0}{X_{100} - X_0}\right)100^\circ c.$$

$$\theta = \left(\frac{(X_0 + 25.5) - X_0}{(X_0 + 52 - X_0}\right)100^\circ c$$

$$\theta = \left(\frac{X_0 + 25.5 - X_0}{X_0 + 52 - X_0}\right)100^\circ c$$

$$\theta = \left(\frac{25.5}{52}\right)100^\circ c$$

$$\theta = 49.03846154^\circ c. \simeq 49.04^\circ c.$$

$\therefore$ The temperature would be $\simeq 49.04^\circ c$.

In extract 8.1 the candidate managed to provide correct responses for each part of the question and he/she presented his/her work systematically and gave precise conclusions.

The candidates who performed poorly failed to comprehend almost all parts of the question. They failed to recognize that steam pipes are wrapped with insulating materials in order to minimize the loss of heat due to radiation. Furthermore copper has greater thermal conductivity than steel as it allows more heat to flow into the pan hence cooking of food becomes easier and faster. Apart from that, most of them had poor mathematical background on thermometry as they failed to relate the given expression of property X in determining its Celsius temperature which corresponds to a temperature of 50^0C on a gas thermometer scale. Extract 8.2 presents a sample response of one of the candidates who performed poorly in this question.

Extract 8.2

8 a/ i/ usethe Provost, theory, is the theory which Shows how temperature depend on environ ment temperature if temperature q environment is low also may lead the temperature In the System to decreace

ii/ Wiens displacement law " State that all radia tion 'which fall on a black body can absorb all energy are reflect non"

b i/ Becouse steam pipe have ability to acquire more energy for short period q time

ii/ Becose are good conductor q head So ~~are~~ when are fitted with extra Copper at the botton helps to reduce the heat becouse Copper Is a bad Conductor q heat

8c/ $X\theta = X_0 + 0.5\theta + 2\times10^{-4}\theta^2$

$50 = X_0 + 0.5\times50 + 2\times10^{-4}\times50^2$

$50 = X_0 + 25 + 0.5$

$50 = X_0 + 25.5$

$50 = X_0 + 25.5$

$X_0 = 50 - 25.5$

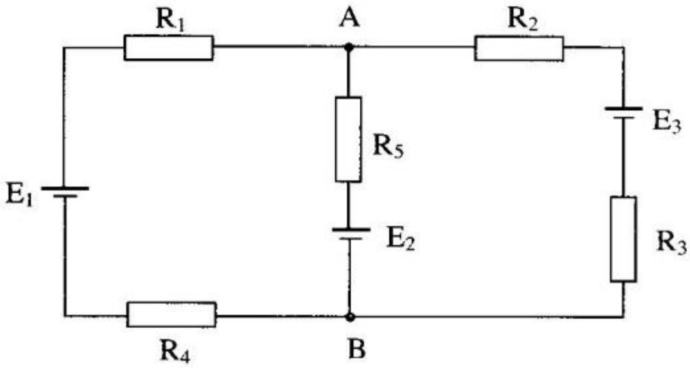
$X_0 = 24.5°$

The degree q Celsius is 24.5 °C

In extract 8.2 the candidate failed to state correctly the Prevost's theory of heat exchange and Wien's displacement law as well as applying the correct formula to find the Celsius temperature corresponding to a temperature of 50^0C on a gas thermometer.

2.9 Question 9: Current Electricity

The question was divided in two parts; (a) and (b). In part (a) the candidates were required to: (i) explain the advantage of using a greater length of potentiometer wire, and (ii) to explain why Wheatstone bridge is not suitable for measuring very high resistance. In part (b) the candidates were given the following circuit diagram then required to calculate the: (i) current flowing through the circuit and (ii) potential difference, V_{ab}.



This question was attempted by 64.1 percent of the candidates; out of which 76.1 percent scored 0 to 3 marks, 18.7 percent scored 3.5 to 5.5 marks while 5.2 percent scored 6 to 10 marks. These analytical data show that the question was poorly done as shown in Figure 9.

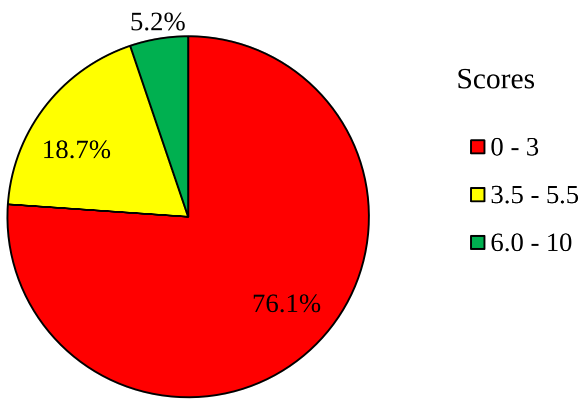


Figure 9: Candidates' Performance in Question 9.

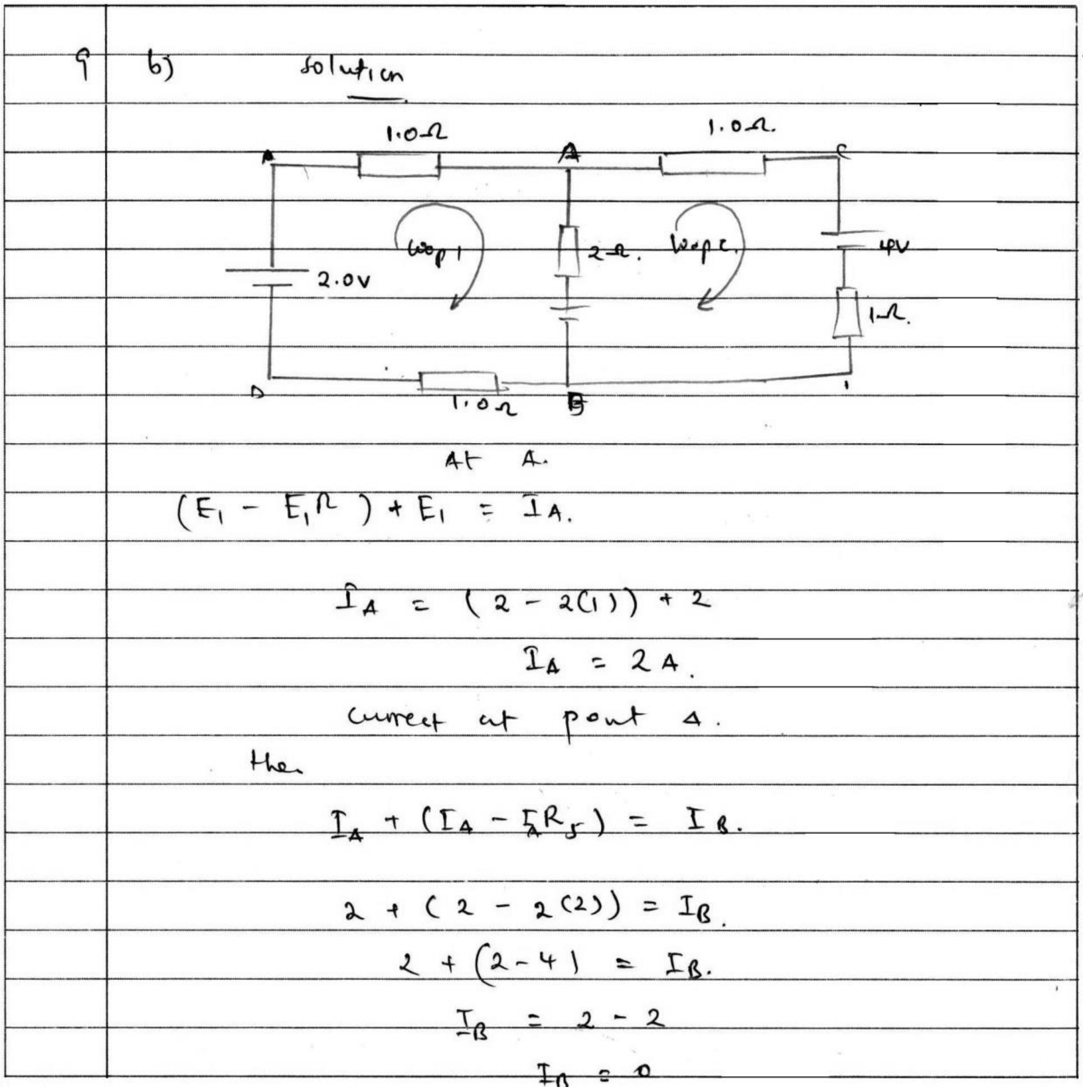
Most of the candidates who responded poorly in part (a) (i) failed to understand that having greater length of potentiometer wire would reduce the potential gradient along the wire and thus increase the wide range and make the measurement taken to be more accurate. One candidate for example wrote *it helps higher amount of electricity to pass* while another candidate wrote *it helps to get* *clearly the resistivity of a particular wire*. In part (a) (ii), the candidates were supposed to show that Wheatstone bridge is not suitable for measuring very high resistance because, for high sensitivity of the bridge, all resistances should have high values to reduce the current passing through it which would damage or make the device insensitive. In part (b) also some of these candidates lacked mathematical skills as they failed to analyse and identify the number of loops in the given figure and hence apply Kirchhoff's laws to calculate the current flowing through the circuit and its corresponding potential difference V_{ab}. Extract 9.1 is a sample taken from the answer of one of the candidates who responded incorrectly to this question.

Extract 9.1

9 a) i) The use of greater length of potentiometer wire is that to reduce the resistinty of a wire, because resistivity of a wire varies inversly proportional to length.

$$\rho \propto 1/L.$$

ii) Wheatstone bridge is not usefull in measurin g very high renstance because it will need a galvanometer with higher renstivity



In extract 9.1 the candidate attempted to explain how the resistivity of the wire could be affected due to greater length instead of the advantage. In part (b), he/she failed to analyse the given circuit diagram and to apply Kirchhoff's laws and hence obtained incorrect answers.

On the contrary, most of the candidates who performed well provided inevitable explanations about the asked terms. They also showed a great ability in analysing the circuit diagram and organizing the data when applying Kirchhoff's laws in finding the correct answers. This is an indication that they had a good understanding about the concept of current electricity. Extract 9.2 shows an example of a good response to this question.

Extract 9.2

9(a)(i) Advantages of greater length potentiometer wire

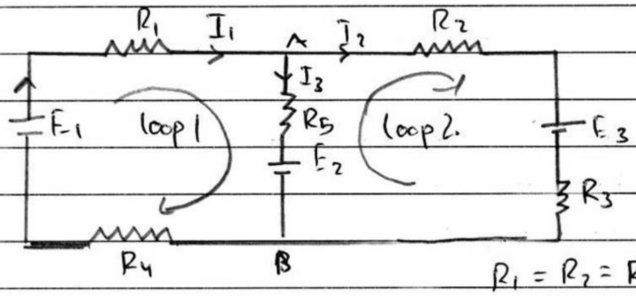
(i) Increases the accuracy to measure the voltage.

(ii) Enable wide range of voltages to be measured.

~~9(a)(ii) High resistance will block bypass the~~

9(a)(ii) High resistance will cause current to by pass the area and take another root which has lower resistance compared to that so there will be no current passing in the region of high resistance.

9(b)(i)



$R_1 = R_2 = R_3 = R_4 = 1.0\Omega$

$R_5 = 2\Omega$

$E_2 = E_3 = 4V$

$E_1 = 2V$

Applying kirchoff law.

Consider loop 1

$$\Sigma Emf = \Sigma pd.$$

$$E_1 - E_2 = I_1R_1 + I_3R_5 + I_1R_4$$

$$2 - 4 = I_1 + 2I_3 + I_1$$

$$-2 = 2I_1 + 2I_3 \text{ ——— (i)}$$

Consider loop 2.

$$\Sigma Emf = \Sigma pd$$

$$E_2 - E_3 = I_2R_2 - I_3R_5 + I_2R_3$$

$$4 - 4 = I_2 - 2I_3 + I_2$$

$$0 = 2I_2 - 2I_3 \text{ ——— (ii)}$$

At Junction A

$$I_1 = I_2 + I_3$$

9(b)(i)	$0 = I_2 + I_3 - I_1$ —— (iii)
	$-2 = 2I_1 + 2I_3$ —— (i)
	$0 = 2I_2 - 2I_3$ —— (ii)
	$0 = I_2 + I_3 - I_1$ —— (iii)
	Solving equation ~~quadra~~ simultaneously
	$I_1 = {}^-0.667A$
	$I_2 = -0.33A$
	$I_3 = -0.33A$
	negative indicates direction
	of flow
	Current in the circuit are
	0.667A through R_1 and R_4
	0.33A through R_5
	0.33A through R_2 and R_3
	but $I_1 = I_3 + I_2 = 0.667A$
	Current through the circuit = 0.667A
9(b)(ii)	$V_{ab} = I_3 R_5 + E_2$
	$= (0.33 \times 2) + 4 = 4.66V$
	$V_{ab} = 4.66V$

Extract 9.2 shows how the candidate was systematic in analysing the circuit diagram and applying Kirchhoff's laws to obtain the correct answers although the responses given in part (a) (i) and (ii) are not so neatly presented.

2.10 Question 10: Current Electricity

This question comprised of three parts; (a), (b) and (c). In Part (a) (i), the candidates were required to list two factors which the resistivity of material depends and in (a) (ii) to determine with reason, the new resistivity of a wire of resistivity ρ if its length was doubled after being stretched. In part (b), the candidates were required to: (i) explain why a high voltage supply should have high internal resistance, and (ii) justify the statement that “it is not possible to verify Ohm’s law by using a filament lamp”. In part (c) the candidates were required to find: (i) resistivity of a wire, and (ii) conductivity of a wire if a potential difference of 4 V is connected to a uniform resistance wire of length 3.0 m and cross sectional area 9×10^{-9} m^2 allowing a current of 0.2 A to flow through it.

A total of 17,320 (93.5%) of the candidates attempted the question, out of which 36.0 percent scored below 3.5 marks including 5.6 percent who scored 0 marks. The candidates who scored 3.5 to 5.5 marks were 57.9 percent while those who scored 6 to 10 marks were 6.1 percent. This shows that the candidates’ general performance to this question was good. The graphical presentation of these data is shown in Figure 10.

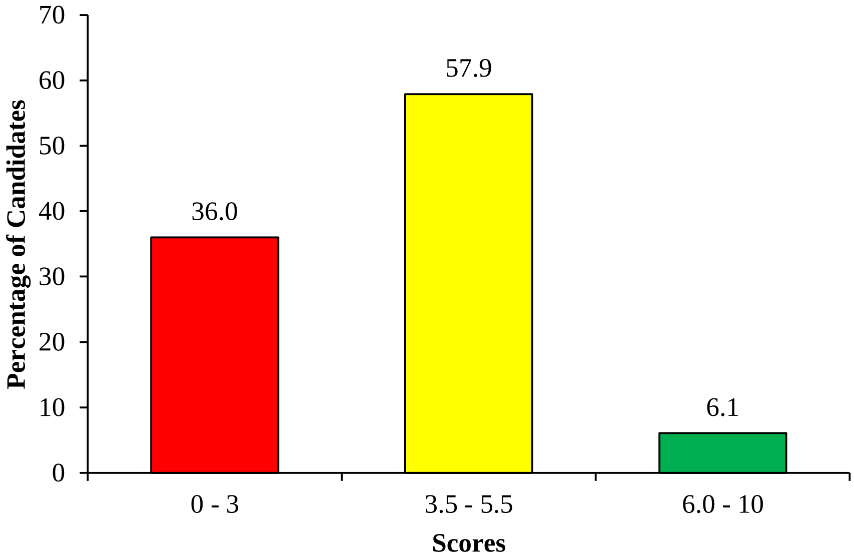


Figure 10: Candidates’ Performance in Question 10.

The candidates with good performance had a good understanding of the subject matter especially on the concept of electric conduction in solids. This enabled them to identify the factors affecting resistivity of a material, the relationship between voltage and internal resistance of a source of e.m.f as well as rationalizing the properties of a filament lamp. In this case, they managed to recognize Ohm’s law and its applications in calculating the resistivity and conductivity of a wire. Extract 10.1 shows a good response from one of the candidates with good performance.

Extract 10.1

10 (a) i/ ~~@~~ ~~Co~~ @ Temperature and ⓑ Nature of materi-l

ii/ Soln

resistivity ρ Initial length, L_i

Final length $L_f = 2L_i$

From

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

$$\rho' = \frac{AR'}{L'} = \frac{AR'}{2L}$$

Note: Resistance depend on length it will also change from R to R'

Since the nature of wire is the same then change in length is outweighted by change in resistance. If A is assumed constant

$$\therefore \frac{L}{R} = \frac{L'}{R'}$$

$$\therefore \frac{\rho}{\rho'} = \frac{RL'}{R'L} \quad \text{since } R' = 2R$$

$$\frac{\rho}{\rho'} = \frac{R2L}{2RL} = 1$$

$$\rho = \rho'$$

∴ Resistivity of the wire will be the same because it is the characteristic of material. It can only be affected by temperature

(b) i/ High voltage supply should have high internal resistance so as to limit the amount of current generated since high current value result into high power loss in form of heat (ie $H = I^2R$).

ii/ It is not possible to verify ohm's law by using filament lamp because it is a non-ohmic conductor and hence does not obey ohm's law.

(c) Soln.

$E = 4V$, $l = 3.0\,m$ $A = 9\times10^{9}$, $I = 0.2A$

i/ Resistivity, ρ

Assumption: The unit of Area to be at SI-unit ie m^2

∴ Resistance of wire, R

$V = IR$

$R = \frac{V}{I} = \frac{4}{0.2} = 20\,\Omega$

Now

$\rho = \frac{AR}{L} = \frac{9\times10^{9}\times 20}{3}\,\Omega m$

∴ Resistivity $\rho = 6\times10^{-8}\,\Omega m$

ii/ Conductivity σ

From

$\sigma = \frac{1}{\rho} = \frac{1}{6\times10^{-8}}\,\Omega^{-1}m^{-1}$

Conductivity, $\sigma = 16.67\times10^{6}\,\Omega^{-1}m^{-1}$

Extract 10.1 indicates the competence shown by the candidate in analyzing the problem. The candidate was precise in organizing the concepts to reach the expected answers.

However, some of the candidates who performed poorly in part (a) wrote two factors as "cross-sectional area" and "length of the wire" as they failed to recognize that resistivity depends only on the nature and temperature of the material so when the wire is stretched to double its length, its new resistivity will remain the same as before. The analysis also shows that instead of comprehending the given statement in part (b), some of the candidates stated Ohm’s law. The candidates did not realize that, filament lamp is non Ohmic material and hence disobeys Ohm’s law. Extract 10.2 illustrates a poor response given by one of the candidates.

Extract 10.2

10.	a)
	i/.
	Resistivity of the material depends on
	- Cross-sectional area of the material
	— The length of the material
	ii/
	If the wire of resistivity, ρ is streched double
	its length there will be decrease is resistivity due to
	resistivity is inversely proportional to length.

10. a)

ii/

$$\rho \propto \frac{1}{L}$$

b). i)

The high voltage supply should have a high internal resistance due to voltage is ~~inversely~~ proportional to current V = IR. The issue of having high internal resistance it will facilitate to have high output power. So as to decrease the e.m.f (E). ie. E = V − Ir

b)

ii/

'It's not possible to verify Ohm's law by using a filament lamp" due to Ohm's law states that:

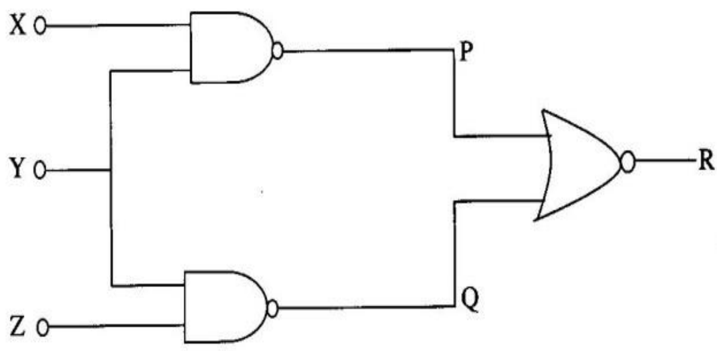
" The current passing through a conductor is directly proportional to p.d across it provided no external force act on it "

, In a filament lamp no flow of current as well as the p.d. to be proportional with.

In extract 10.2 the candidate wrote incorrect factors on which the resistivity of a material depends. In part (b), he/she failed to respond correctly and instead of justifying the given statement, the candidate attempted to state Ohm's law.

2.11 Question 11: Electronics

This question had parts (a), (b) and (c). In part (a) the candidates were required to explain briefly the function of: (i) oscilloscope and (ii) Op-amps. In part (b) they were required to study the given figure and then construct a truth table showing the output P, Q and R.



In part (c), the candidates were required to: (i) list three basic elements of communication system and (ii) explain advantage of using optical fibre systems than coaxial cable system in telecommunication processes.

A total of 11,293 (60.9%) candidates attempted this question, out of which 18.3 percent scored below 3.5 marks, 33.4 percent scored 3.5 to 5.5 marks, and 48.3 percent scored 6.0 to 10 marks. These scores show that the candidates' performance in this question was good. Figure 11 illustrates candidates performance in the question.

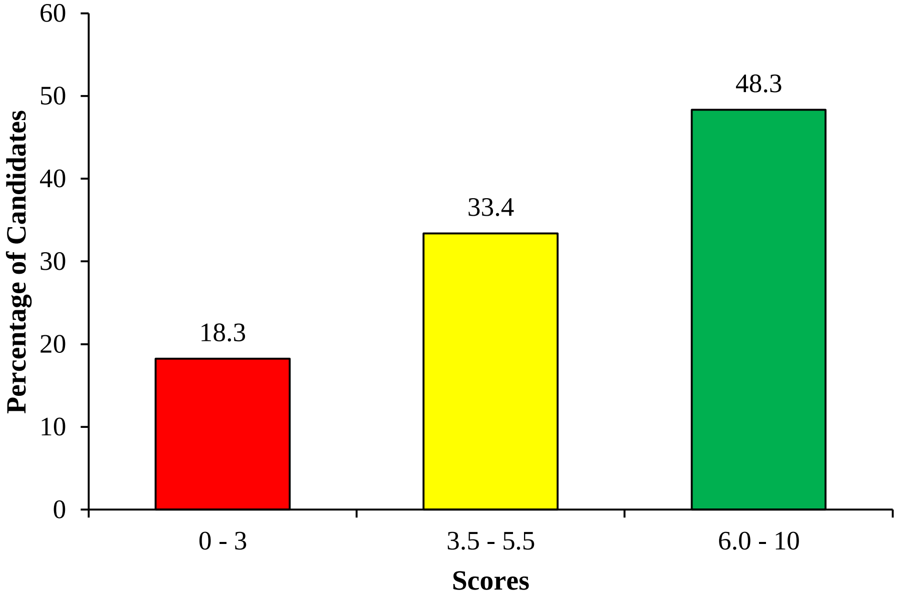


Figure 11: Candidates' Performance in Question 11.

The candidates who performed well were able to explain the function of oscilloscope and Op-amps and they managed to analyse the given figure and drew the correct truth table showing the output P, Q and R. Apart from that, they correctly mentioned the basic elements of communication systems and listed the advantages of using fibre than coaxial cable system in telecommunication processes. Extract 11.1 shows a sample of a good response.

Extract 11.1

11.	a) i) Oscilloscope is a devices which is used to produce rays of light which are useful in different cases such as measuring voltage, clock and other systems
	ii) Op-amps are operational amplifiers which amplifies the difference of its inputs to produce an amplified output and can be used in solving different mathematical operations such as addition, subtraction, differentiation, intergration etcetera.

11 b) Required to construct a truth table showing output P, Q, and R

TRUTH TABLE

Inputs			Outputs		
X	Y	Z	P	Q	R
0	0	0	1	1	0
0	0	1	1	1	0
0	1	0	1	1	0
0	1	1	1	0	0
1	0	0	1	1	0
1	0	1	1	1	0
1	1	0	0	1	0
1	1	1	0	0	1

11 c) i) The basic elements of a communication system are Source, transmitter and receiver.

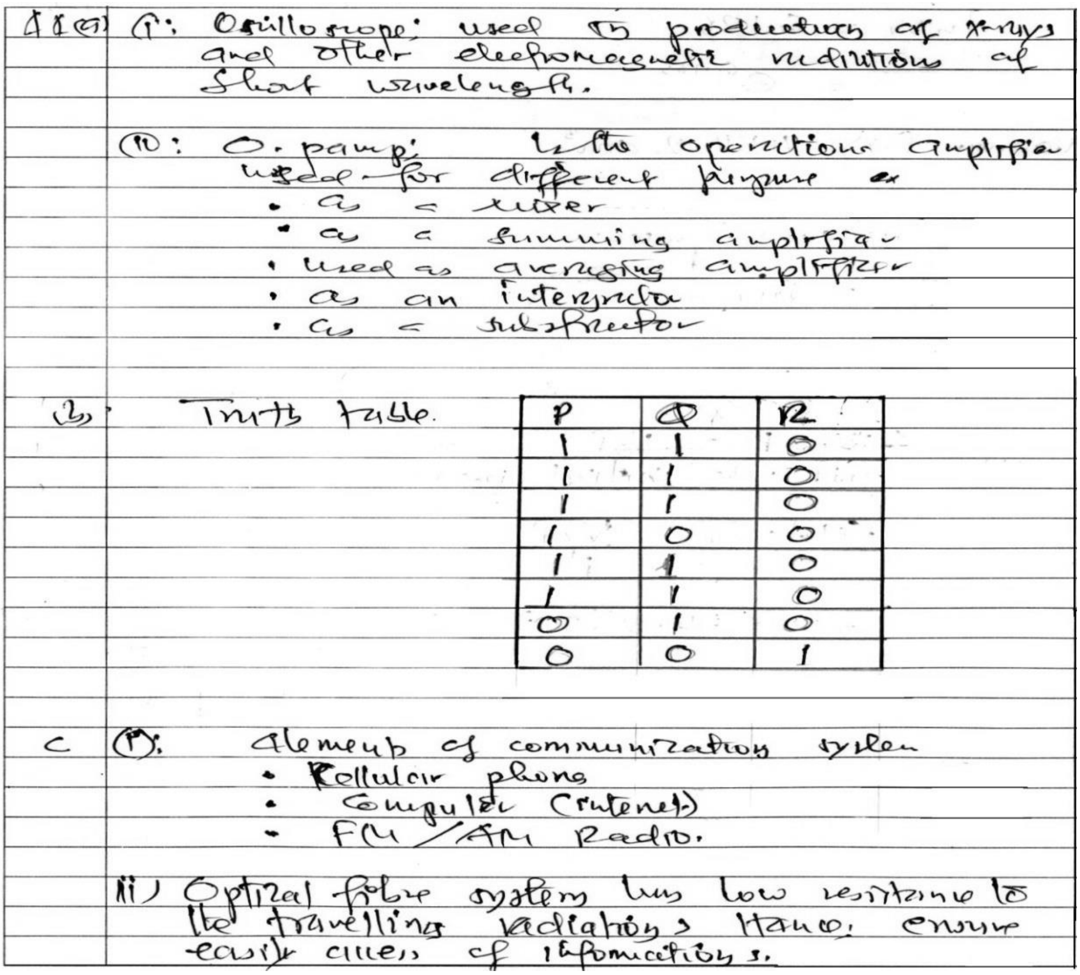
ii) – Optical fibre systems are advantageous than coaxial cable systems since they enable signals to be transmitted over large distances compared to coaxial cable systems

– Also in Optical fibre systems signal strength is maintained when transmitted over large area thus the signal does not lose strength easily while in coaxial cable systems signal strength is loss rapidly compared to optical fibres

Extract 11.1 shows that the candidate managed to provide correct answers to all the parts of the question.

On the contrary, the candidates who performed poorly lacked basic knowledge on amplifiers and the procedure for finding outputs of logic gates. One of these candidates wrote: *Oscilloscope is used for producing x-rays*. This candidate failed to show that oscilloscope is used to display waveforms, measurement of voltage frequency and phase as well as acting as a clock. Besides that, these candidates lacked fundamental concepts regarding telecommunication process as they were not able to even list three basic elements of communication system which are transmitter, communication channel and receiver. Extract 11.2 shows the responses of one of the candidates who performed poorly in this question.

Extract 11.2


1 (a) (i): Oscillosrope: used to production of x-rays and other electromagnetic radiations of short wavelength.

(ii): O. pamp: Is the operation amplifier used for different purpose ex
• as a mixer
• as a summing amplifier
• used as averaging amplifier
• as an integrator
• as a subtractor

(b) Truth table.

P	Q	R
1	1	0
1	1	0
1	1	0
1	0	0
1	1	0
1	1	0
0	1	0
0	0	1

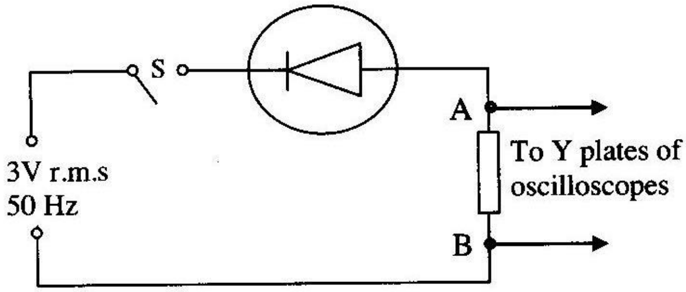
c (i): Element of communication system
• Cellular phone
• Computer (internet)
• FM/AM Radio.

(ii) Optical fibre system has low resistance to the travelling radiations hence ensure easily access of informations.

In extract 11.2 part (a) (i) the candidate stated the function of x-ray machine instead of oscilloscope. He/she mentioned cellular phones, computer and AM/FM Radio as the basic elements of communication system instead of transmitter, communication channel and receiver. He/she lacked understanding on the topic of communication.

2.12 Question 12: Electronics

This question had three parts; (a), (b) and (c). Part (a) required the candidates to: (i) define the term semiconductor and (ii) give three examples of semiconductor materials. In part (b), the candidates were required to: (i) outline two factors on which electrical conductivity of a pure semiconductor depends and (ii) explain how the forbidden energy gap of an intrinsic semiconductor varies with increase in temperature and finally, in part (c), the candidates were given a circuit diagram as shown in the Figure below and were required to calculate: (i) the peak voltage and (ii) the period.



A total of 12,905 (69.6%) candidates attempted the question, out of which 34.5 percent scored 0 to 3 marks including 6.9 percent who scored 0 marks. The candidates who scored 3.5 to 5.5 marks were 27.6 percent and those who scored 6 to 10 marks were 37.9 percent. The analysed data indicates that the general performance in this question was good as illustrated in Figure 12.

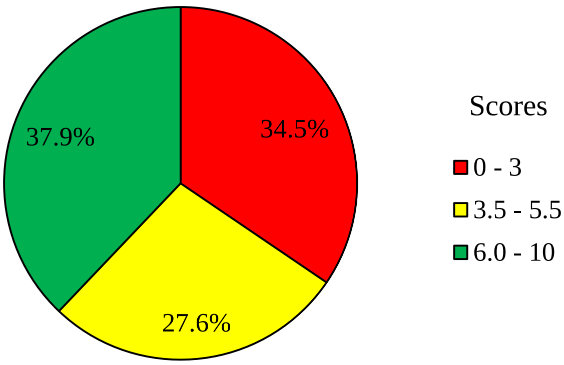


Figure 12: Candidates' performance in Question 12.

The candidates who performed well in this question managed to provide a correct definition and give examples of semiconductor materials, explain two factors on which electrical conductivity of a pure semiconductor depends and they explained precisely the manner in which forbidden energy gap of an intrinsic semiconductor varies with increase in temperature. They were also able to apply the correct formula and the given data to calculate the values of the peak voltage and period of a.c source. These candidates had good understanding about semiconductors and its characteristics. Extract 12.1 presents an example of a good response to the question.

Extract 12.1

12	(a) (i) Semiconductor ÷ Is a substance/materials whose electrical conductivity lies between the conductivity of conductors and insulators
	(ii) – Gallium arsenide
	– Silicon
	– Germanium
	(b) (i) – Temperature
	– Forbidden energy gap
	(ii) – When the temperature increases the formbidden energy gap decreases and vise versa : Therefore the ~~tem~~ change in temperature varies inversely with the forbidden energy gap

12. (c) (i) Data given

$E_{rms} = 3\,V$

Frequency (f) = 50Hz

Now

$E_0 = \sqrt{2}\,E_{rms}$

where

E_0 = Peak voltage

E_{rms} = Root mean square voltage

Then

$E_0 = \sqrt{2} \times 3 = 3\sqrt{2}\,V = 4.242640687\,V$

∴ Peak voltage = 4.243 V

(ii) The periodic time (T)

since $T = \frac{1}{f}$

$T = \frac{1}{50}\,s = 0.02\,s$

where f – Frequency

T – Time period

∴ Periodic time is 0.02 seconds

In extract 12.1 the candidate provided short and clear responses for each part of the question which required explanations as well as precise calculations for the parts which required computation.

The candidates who performed poorly failed to clearly define the term semiconductor and list its examples. One candidate for example wrote: *solid state, liquid state and gaseous state* which are three states of matter instead of *silicon, germanium and gallium arsenide.* Besides that, they were not able to outline two factors on which electrical conductivity of a pure semiconductor depends, or to interpret the given circuit diagram and apply the correct formula to calculate the period and peak voltage. They therefore lacked basic knowledge on semiconductors and its properties. Extract 12.2 is a sample answer from one of the candidates who performed poorly in this question.

Extract 12.2

12. (i) Semi-conductor is the one which is between their conductor and insulator.

examples of semi-conductor materials are
(i) solid state
(ii) Liquid state
(iii) gaseous state.

(b) electrical conductivity of pure semi-conductor depend on:
(i) Amount of temperature.
(ii) The nature of the materials.

(ii) Because their a very few amount of the energy that involved when the temperature increase compared to their intrinsic semi-conductor.

c
(i) The peak voltage:
Data given.
The root means square (r.m.s) = 3V.
frequency 50Hz.
from $I_{r.m.s} = \frac{I_0}{\pi}$.
$I_{rms} = \frac{V_0}{\pi}$.
$I_{r.m.s} = \frac{3}{\pi}$

$I_{r.m.s} = 0.95.$

$I_{r.m.s} = 0.95 A.$

by $V = IR.$

$V = 0.95 \times 1$

(i) $= 0.95 V.$

(ii) The period

12. from; Frequency = 5 Hz.

$T = \frac{1}{2\pi}\sqrt{\ }$

from, $T = \frac{1}{f}\sqrt{\frac{I_0}{\pi}}.$

$T = \frac{1}{5}\sqrt{\frac{0.95}{\pi}}.$

$T = 0.110.$

The five period is 0.11 s

In extract 12.2, part (a) and (b) the candidate failed to comprehend correctly the concepts asked and applied wrong formula in part (c) to find the period and peak voltage.

2.13 Question 13: Electronics

This question comprised of three parts, namely (a), (b) and (c). In part (a) the candidates were required to explain the meaning of: (i) P-type semiconductor and (ii) N-type semiconductor. In part (b) the candidates were required to: (i) list three types of transistor configurations, and (ii) Explain why a collector of a transistor is made wider than emitter and base. In part (c) the candidates were required to calculate: (i) the current amplification factor, β and (ii) current gain, α, given that;

a charge of $100\mu A$ in a base current produces a change of 3mA in the collector current.

Ninety percent (90%) of the candidates attempted this question, out of which 27.3 percent scored below 3.5 marks, 24.5 percent scored from 3.5 to 5.5 marks and 48.2 percent scored 6 to 10 marks. These scores imply that the performance of the question was generally good. These data are shown in Figure 13 below.

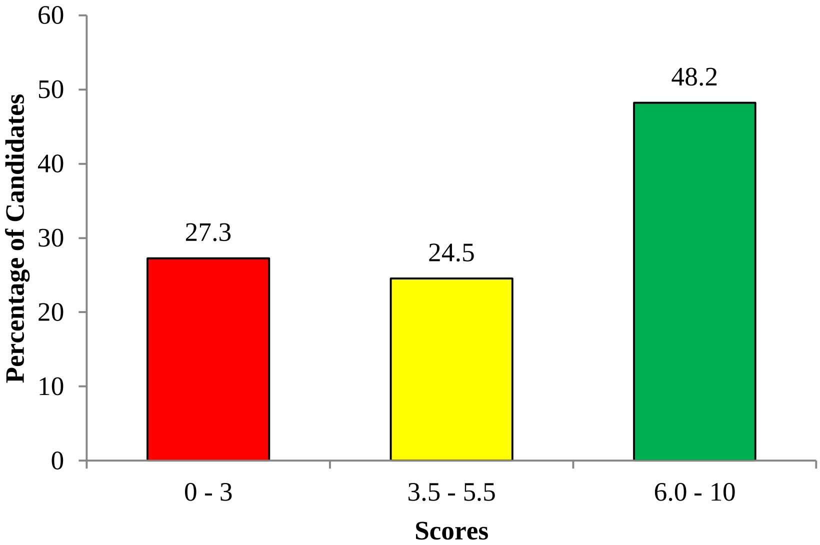


Figure 13: Candidates' performance in Question 13.

Majority (72.7%) of the candidates who performed well were able to explain precisely the meaning of P-type and N-type of semiconductor and to give the correct reason why the collector of transistor is made wider than emitter and base. Some also applied the correct formula in calculating the current amplification, β and current gain, α. This indicates that they had good understanding on transistors and its configurations. Extract 13.1 shows the responses of one of the candidates who performed well in this question.

Extract 13.1

13 (a) (i) P-type semiconductor is the impure semiconductor that is doped using the trivalent elements or trivalent materials such as Boron. The P-type semiconductor is rich in holes than electrons. The majority current carriers are holes.

(ii) N-type semiconductor is the semiconductor that is made after the doping of intrinsic semiconductor using pentavalent elements or materials. They are rich in electrons. The majority current carriers are electrons. Examples of pentavalent materials are Gallium and Antimony (Sb).

(b) (i) Three types of transistor configuration

1. Common-Emitter Configuration
2. Common-Collector
3. Common-Base transistor.

(ii) The collector is made wider than emitter and base, because most of the heat that is produced is dissipated into the collector so it is made wider than emitter and Base.
Emitter is made thin to allow the passage of electrons towards the collector. Also this enables the emitter not to accumulate electrons. Most electrons are passed to collector.

13 (e) (i) Given

$\Delta I_B = 100\mu A$ – base current

$\Delta I_C = 3mA$ – Collector current.

Required

(i) Current Amplification factor β

from $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{3mA}{100\mu A} = 30$.

∴ The Current Amplification factor β is 30

(ii) The current gain. α.

From The relation

$$\beta = \frac{\alpha}{1-\alpha}$$

$$30 = \frac{\alpha}{1-\alpha}$$

$$30 - 30\alpha = \alpha$$

$$30 = 31\alpha$$

$$\alpha = 0.9677.$$

∴ The Current gain = 0.9677

Extract 13.1 shows a candidate with good understanding on the concepts asked as he/she managed to write the correct responses for each part of the question.

The candidates who performed poorly in this question failed to explain the meaning of P-type and N-type of semiconductors which are basic concepts in electronics. Most of them failed to argue why the collector of a transistor is made wider than that of an emitter and base. This implies that they had inadequate knowledge and skills in solving electronics problems. In this case, the candidates showed a good understanding that, during its operation the excess heat is produced at the collector junction. Therefore, the collector is made wider to dissipate heat and so protect it from distortion. Extract 13.2 is a sample response of one of the candidates who performed poorly in this question.

Extract 13.2

13 @ (i) P-type Semiconductor is the type of semiconductor which inter the electricity with the circuit.

13 a (ii) N-type is the type of semiconductor which carry out the electric current flowing in the circuit.

13 (b) (i) Three types of transistor is
(i) BJT transistor
(ii)

13 (b) (ii) Collector of a transistor made wider than emitter and base because emmiter are the source of current and base are out current in the circuit.

13 (c) (i) Data given

Charge = 100 μA
current = 3×10^{-3} A.
current amplification = ?
From

$I_B = \frac{I_C}{I}$

$I_B = \frac{100 \mu A}{3 \times 10^{-3}}$

$I_B = 0.033 A$.

∴ The current amplification is 0.033A

In extract 13.2, the definitions of P-type, N-type semiconductors and the wrong formula written by the candidate show that he/she completely lacked the basic knowledge of transistors and its mode of operation.

2.14 Question 14: Environmental Physics

This question had two parts; (a) and (b). In part (a), the candidates were required to: (i) state three sources of heat energy within the interior of the earth, and; (ii) discuss two advantages of windbreaks to plant environment. In part (b), the candidates were required to explain briefly the major causes of: (i) water pollution and (ii) air pollution.

A total of 14,708 (79.4%) candidates attempted this question, out of which 2.1 percent scored 0 marks, 14.9 percent scored 0.5 to 3 marks, 56.8 percent scored 3.5 to 5.5 marks and 26.2 percent scored 6 to 10 marks. These scores imply that the general candidates' performance in this question was good as illustrated in Figure 14.

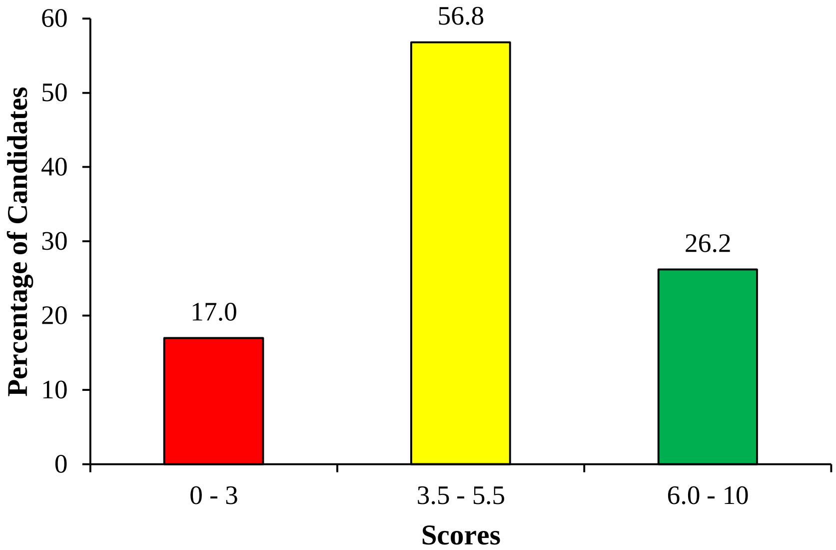


Figure 14: Candidates' performance in question 14.

The candidates who performed well in this question were able to state correctly the three sources of heat energy within the interior of the earth and explained correctly the two advantages of windbreaks to plant environment. They also were able to briefly explain the major causes of water and air pollutions as required, showing that they had knowledge about environmental physics. Extract 14.1 shows the responses of one of the candidates who performed well in this question.

Extract 14.1

14: (a) (i) Sources of heat energy within the interior of the earth are:

(a) Radioactive decay of the isotopes such as Thalium (Th), Uran and Uranium (U)

(b) The gravitational work done by the earth when it rotates on its own axis

(c) Collision of the particles during the earth formation

(ii) Advantages of wind breaks to plant environment are:

(a) It increases the yield,
- Wind breaks helps to increase yields of the crops by preventing the excessive loss of water by plants through transpiration as the wind is prevented.

(b) It improves the crops spraying activities.
- Spraying of the insecticides and pesticides is well when there is wind breaks.

(b)(i) Major causes of water pollution are:
(a) bad fishing method,
- Some of people use chemicals during fishing activities which causes the death of large number of acquatic animals especially fish and thus polluting the environment of water

14: (b) (i)

(b) Chemicals and waste from industries
- The chemicals from industries are directed to the water source, and thus polluting water in the sea, ocean or river.

(c) Agricultural products.
- Agricultural products such as crops residue, fertilizers, and manure, may be directed to water sources by the wind or rainfall.

(ii) Causes of air pollution:

(a) Burning of vegetation.
- Burning of forest introduce the dusts and harmful gases in the atmosphere.

(b) ~~Burning of~~ Harmful gases from industries
- Industries produce the harmful gases such as carbon dioxide and sulphur dioxide in the atmosphere.

(c) Burning of fuels.
- The fuels such as coal, coke and natural gases, when burned introduce the harmful gases in the atmosphere.

In extract 14.1 the candidate provided the correct responses with respect to the demand of question. He/she was precise in explaining the three sources of heat energy in the interior of the earth, two advantages of windbreaks to plant environment and the major causes of water and air pollutions in the environment.

The candidates who performed poorly in this question failed to provide correct responses in most parts of the question. Some of them misinterpreted the question by providing responses which are not relevant. One of the candidates for example listed three sources of heat within the interior of the earth as *energy from the sun, energy from wind and energy from the surrounding*. In actual fact, these are renewable energy which are found outside the earth. Extract 14.2 presents a sample of such incorrect responses.

Extract 14.2

14 (a) (i) Source of heat energy
— energy from the Sun
— energy from wind
— energy from Surrounding

(ii) Advantages of wind breaks to plant
i/ Act as the pollant agent
ii/ influence the enzymes to take place

(b) (i) water pollution is the addition of unwanted materials to the water resources.

(c) Air pollution is the addition of unwanted materials to the air such as harmful gases.

In extract 14.2 part (a) the candidate gave wrong answers but also in part (b) he/she attempted to define water and air pollution instead of stating its causes.

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

3.1 Question 1: Fluid Dynamics

This question had three parts (a), (b) and (c). In part (a), the candidates were required to: (i) state Bernoulli's theorem for the horizontal flow (ii) state the principle on which Bernoulli's theorem is based and (iii) find the rate of flow of water through the pipe which is full of water, given that at a certain point A, it tape from 30 cm diameter to 10 cm diameter at B and the pressure difference between points A and B is 100 cm of water column. In part (b), they were required to (i) define the term terminal velocity and (ii) derive an expression for the terminal velocity of spherical body falling from rest through a viscous fluid. In part (c) the candidates were required to find the pressure difference across the first capillary when two capillaries of the same length and radii rating of 1 : 2 are connected in series and the liquid flows through the system under stream line conditions, given that the pressure across the two extreme ends of the combination is 1 m of water.

The question was attempted by 81.9 percent of the candidates, out of these 38.0 percent scored 0 to 6.5 marks, 34.9 percent scored from 7 to 11.5 marks and 27.1 percent scored from 12 to 20 marks. These scores indicate that the general performance in this question was good as illustrated in Figure 15.

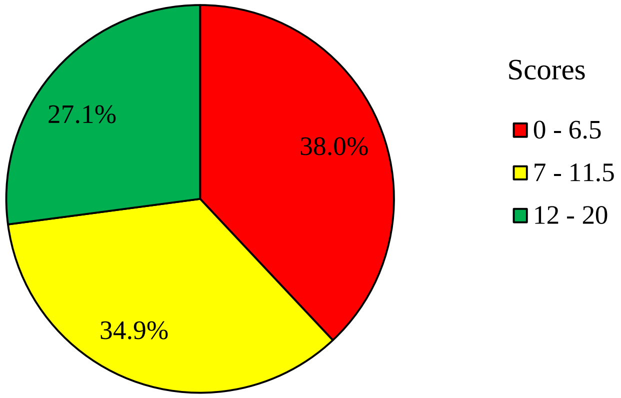
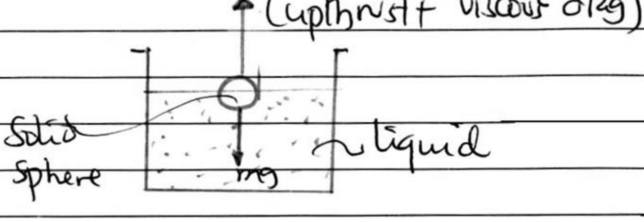


Figure 15: Candidates' Performance in Question 1

The candidates who performed well in this question correctly stated Bernoulli's theorem for the horizontal flow, and mentioned the principle on which Bernoulli's theorem is based. Most of them were able to recall and apply both equations of continuity and Bernoulli's equation to find the rate of flow of water through the pipe. In addition, they managed to define the given terms, to derive the expression and calculate the pressure difference correctly. These candidates had good understanding on the concept of fluid dynamics. Extract 15.1 shows one of the responses from the candidate who answered the question correctly.

Extract 15.1

1.a)	(i) The bernoullis theorem for the horizontal flow states that " for steady motion and non-viscous fluids the sum of the pressure energy and Kinetic energy per unit volume e at every point in the flow is always constant".
	Such that $\left[P + \frac{1}{2} \rho v^2 = \text{constant} \right]$.
	(ii) The bernoullis theorem is based on the principle of conservation of energy which states that energy can neither be created nor destroyed rather it can be transfered from one form to another.
1(b)	(i) Terminal velocity is the maximum velocity that a body acquires when moving through a fluid (Liquid/gas) of infinite extent.
	(ii) Consider an object of density σ_o released on the surface of fluid of coefficient of viscosity η.
	

Balancing forces vertically,

$$ma = mg - (\text{upthrust} + \text{viscous force})$$

Recall; stoke's law.

$$f(\text{drag}) = 6\pi\eta r v.$$

$$ma = mg - (\text{upthrust} + 6\pi\eta r v).$$

But upthrust $= m_L g.$

$$= \rho_L V_o g.$$

$$= \frac{4\pi r^3}{3} \rho_L g$$

$$ma = \sigma V_o g - \left(6\pi\eta r v + \frac{4\pi r^3}{3}\rho_L g\right)$$

But when terminal velocity is reached

$f_{net} = 0$ and $a = 0$

$$\sigma V_0 g = 6\pi\eta r V_T + \frac{4\pi r^3}{3}\rho_L g.$$

$$\frac{4\pi r^3 \sigma g}{3} = 6\pi\eta r V_T + \frac{4\pi r^3}{3}\rho_L g.$$

$$6\pi\eta r V_T = \frac{4\pi r^3 \sigma g}{3} - \frac{4\pi r^3 \rho_L g}{3}$$

$$6\pi\eta r V_T = \frac{4\pi r^3 g}{3}(\sigma - \rho_L)$$

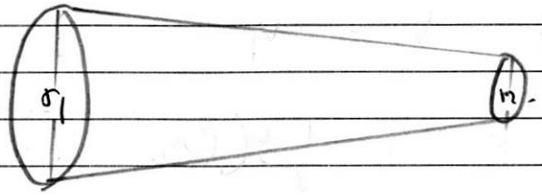
$$3\eta V_T = \frac{2r^2 g(\sigma - \rho_L)}{3}$$

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

$\therefore$ Terminal velocity $V_T = \frac{2r^2 g(\sigma - \rho_L)}{9\eta}$

Where V_T = Terminal velocity
r = Radius of spherical ball
σ = Density of sphere
ρ_L = Density of Liquid
η = Viscosity of Liquid

1 a) (III) Consider:



By using the continuity equation.

$$A_1 v_1 = A_2 v_2$$

$$\pi r_1^2 v_1 = \pi r_2^2 v_2$$

$$v_1 = \left(\frac{r_2}{r_1}\right)^2 v_2$$

$$r_1 = 30cm, \quad r_2 = 10cm.$$

$$v_1 = \left(\frac{10}{30}\right)^2 v_2$$

$$v_2 = 9v_1 \quad \text{—— (1)}$$

for horizontal pipe; Use bernoulli's eqn.

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

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

$$(P_1 - P_2) = \frac{1}{2}\rho(V_2^2 - V_1^2)$$

But $V_2 = 9V_1$

$$(P_1 - P_2) = \frac{1}{2}\rho((9V_1)^2 - V_1^2)$$

$$\frac{2(P_1 - P_2)}{\rho} = 81V_1^2 - V_1^2$$

$$80V_1^2 = \frac{2(P_1 - P_2)}{\rho}$$

But $(P_1 - P_2) = \rho g h$

$$80V_1^2 = \frac{2\rho g h}{\rho}$$

$$V_1^2 = \frac{2gh}{80}$$

$$V_1 = \sqrt{\frac{2gh}{80}}$$

$$V_1 = \sqrt{\frac{2 \times 9.8 \times 1}{80}}$$

$$V_1 = 0.4949 \text{ m/s}$$

Recall: $Q = AV$

$$Q = A_1 V_1$$

$$Q = \pi r_1^2 V_1$$

$$Q = \pi \left(\frac{0.3}{2}\right)^2 \times 0.4949$$

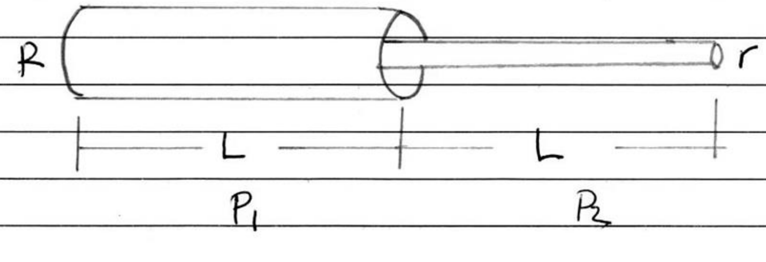
$$Q = \pi (0.15)^2 \times 0.4949$$

$$Q = 0.034987 \ m^3/s.$$

$$Q \approx 0.035 \ m^3/s.$$

∴ The rate of flow of water $= 0.035 m^3/s$.

1 c) Consider the sketch:



By using poiselli's formula.

$$Q_1 = \frac{\pi R_1^4 P_1}{8\eta L}$$

$$Q_2 = \frac{\pi R_2^4 P_2}{8\eta L}$$

for horizontal pipes $Q_1 = Q_2$

$$\frac{\pi P_1 R_1^4}{8\eta L} = \frac{\pi P_2 R_2^4}{8\eta L}$$

$$\underline{P_1 R_1^4} = P_2 R_2^4$$

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

But $R_1 : R_2 = 1 : 2$

$$\left(R_1/R_2\right)^2 = \left(1/2\right)^4 = 1/16$$

$$P_2 = \frac{P_1}{16}$$

Given that $P_1 + P_2 = 1.$

$$P_1 + \frac{P_1}{16} = 1.$$

$$\frac{16P_1 + P_1}{16} = 1.$$

$$P_1 = \frac{16}{17} \text{ m of water.}$$

Therefore, the pressure accross the first capillary is $16/17$ m of water.

In extract 15.1 the candidate answered correctly all parts based on the requirements of the question.

The candidates who performed poorly in this question failed to state Bernoulli's theorem and to apply the equations of continuity and Bernoulli's to find the rate of flow of water through the pipe. Some also confused defining the term 'terminal velocity' with linear velocity. They failed to derive the expression of terminal velocity for a spherical body. One of the candidate for example wrote, *terminal velocity is the velocity possessed by a body in air due to the resistance of gravitational force* showing that he/she lacked knowledge on fluid dynamics. Extract 15.2 shows a sample response from one of the candidates who attempted this question but did not perform well.

Extract 15.2

1 a) (i)

Bernoulli's theorem for the horizontal flow States that For the fluid moving in horizontal flow the sum of kinetic energy and potential energy and pressure is Constant which express the flow of fluid.

$$\frac{1}{2}Mv^2 + Mgh + \frac{MP}{\rho} = \text{Constant}.$$

(ii)

The Bernoulli's theorem is based on the pressure and density of water.

Also it is based kinetic energy of the fluid flowing through.

(iii)

Data given

Diameter of pipe at point A = 30 cm

Diameter of pipe at point B = 10cm

Pressure difference between point A and B = 100cm, Column.

Rate flow of water through the pipe

$$\frac{\text{Rate at A}}{\text{Rate at B}} = \frac{\text{Diameter at A}}{\text{Diameter at B}}.$$

$$\text{Rate of flow} = \frac{100 \times 10}{30} = 33.3$$

∴ Rate flow of water through the pipe is 33.3

1 (b) (i)
Terminal velocity is the distance travelled by a certain fluid per unit time

(ii)
Kinetic Energy (KE) = $\frac{1}{2}mv^2$
Potential Energy (PE) = mgh
Pressure (P) = ρgh.

$P = \rho gh$

$g = \frac{P}{\rho h}$

$PE = \frac{mPh}{\rho h} = \frac{mP}{\rho}$

~~$PE = \frac{mP}{\rho}$~~

$\frac{1}{2}mv^2 + mgh + \frac{mP}{\rho} = C$

~~$\frac{1}{2}Mv^2 + Mgh + MP/\rho$~~ $= C$.

$\frac{1}{2}v^2 + gh + 1\,P/\rho = C$.

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

c) Data
(h_1/h_2) The ratio of the radius = 1:2.
Pressure = 1m of water
P_2 Pressure difference = ?
~~from $\rho gh + P = C$~~

In extract 15.2 the candidate explained the terms found in Bernoulli's equation e.g. kinetic energy, potential energy and pressure instead of stating Bernoulli's theorem and the principle on which it is based.

3.2 Question 2: Vibrations and Waves

This question had three parts (a), (b) and (c). In part (a), it was given that a cyclist and a railway train were approaching each other with a speed of 10 m/s and 20 m/s respectively. The candidates were required to calculate the following terms at the moment the engine driver sounds a warning siren at a frequency of 480 Hz: (i) the frequency of the note heard by the cyclist before the train had passed, and (ii) the frequency of the note heard by the cyclist after the train had passed. Part (b) required the candidate to: (i) deduce whether the wave is travelling in the positive x-direction or in the negative x-direction given that $y = asin(wt - kx)$ represents a plane wave travelling in a medium along the x-direction, y being the displacement at the point, x at time, t, and (ii) determine the speed of the wave, given that, $a = 1.1 \times 10^{-7} m$, $w = 6.5 \times 10^{3} s^{-1}$ and k = 19 m^{-1}. Part (c) required the candidates to: (i) explain briefly why diffraction is common in sound but not in light and (ii) find the length of the wire that should be reduced to bring it again in unison with the same tuning fork, whereby a 40 cm long wire is in unison with a tuning fork of frequency 256 Hz stretched by a load of density 9 gm^{-3} hanging vertically when the load is then immersed in water.

Ninety eight (97.8%) percent of the candidates attempted this question, out of these 0.8 percent scored 0 marks, 36.6 percent scored from 0.5 to 6.5 marks, 33.1 percent scored 7 to 11.5 marks and 29.5 percent scored 12 to 20 marks. These scores indicate that the general performance in this question was good as shown in Figure 16.

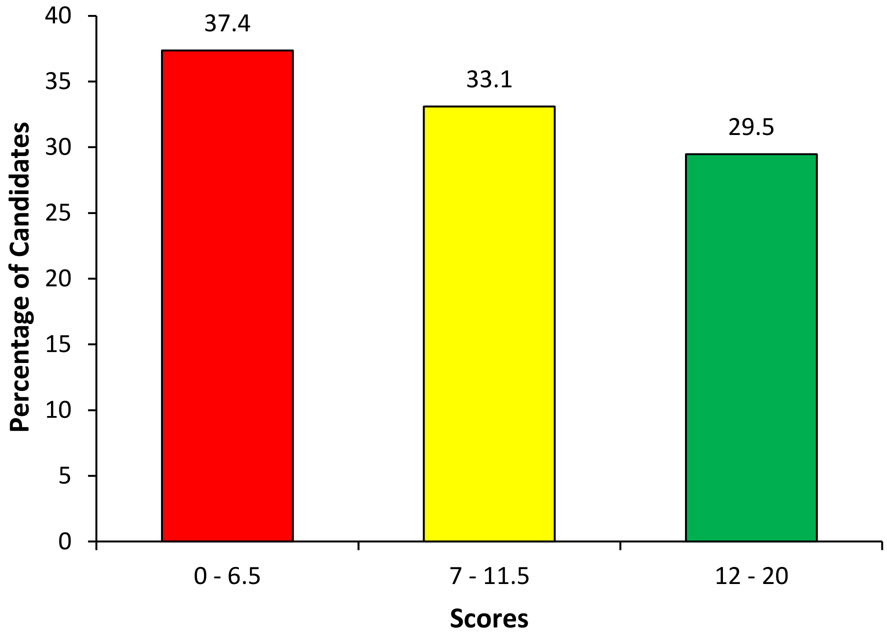


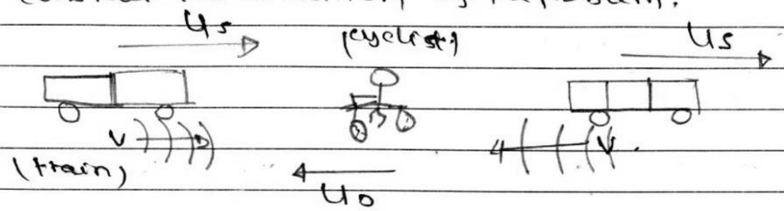
Figure 16: Candidates' Performance in Question 2.

Most of the candidates who performed well in this question were conversant with the concepts of vibrations and waves as they were able to recall and apply the correct formulas in performing calculations by using the given expressions and data to fulfil the demands of the questions. These candidates managed to explain briefly the reasons why diffraction is common in sound but not in light and to show how the length of the wire can be reduced to bring it in unison. The answer of one of the candidates who performed well in all parts of the question is shown in extract 16.1.

Extract 16.1

consider the condition of the problem.

2a i)



First case

Before train has passed

applying doppler principle.

$$f' = \left(\frac{V + U_o}{V - U_s}\right) f$$

$$f' = \left(\frac{340 + 10}{340 - 20}\right) \times 480$$

$f' = 525\,Hz$

Frequency heard by cyclist = 525 Hz

second case.

ii) After the train has passed

$$f' = \left(\frac{V - U_o}{V + U_s}\right) f$$

$$f' = \left(\frac{340 - 10}{340 + 20}\right) \times 480$$

$f' = 440\,Hz$.

frequency heard by cyclist = 440 Hz.

since

2b) $y = a\sin(\omega t - kx)$

Then the wave is travelling in the positive x-direction

2bii) from

$y = a\sin(\omega t - kx)$

but given $\omega = 6.5\times10^{3}\,s^{-1}$

$$2\pi f = 6.5\times10^{3}$$
$$f = \frac{6.5\times10^{3}}{2\pi}$$
$$f = 1034.5\ Hz.$$

also from

$$k = \frac{2\pi}{\lambda}.$$
$$19 = \frac{2\pi}{\lambda}$$
$$\lambda = 2\pi/19$$
$$\lambda = 0.3307\ m.$$

then $v = f\lambda$

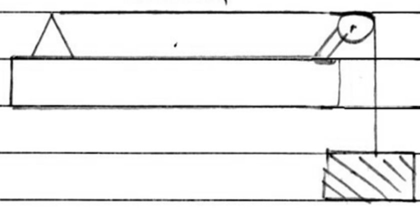
$$v = 1034.5 \times 0.3307$$
$$v = 342.1\ m/s.$$

speed of the wave $= 342.1$ m/s.

2ci) Sound wave have large wavelength compared to light which have small wavelength thus when sound passes through a small opening it is easily to diffracted due to ~~large~~ large wavelength compared to the small opening but light having small waveleng th in most cases its wavelength is small compared to that of small opening so no diffraction is observed under normal circumstances.

2c(ii) consider the condition of the problem.

48cm

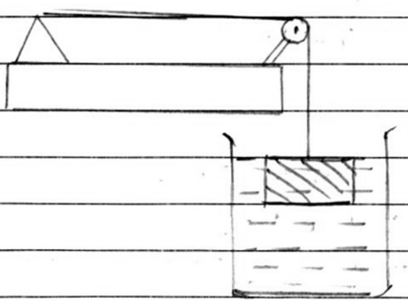


Then

$$f = \frac{1}{2L}\sqrt{T/\mu}$$

$$f = \frac{1}{2L}\sqrt{\frac{\rho V g}{\mu}}. \quad \text{———} \text{ (i)}$$

when the weight was immersed in water.



$$f' = \frac{1}{2L}\sqrt{T/\mu}.$$

but due to upthrust apparent weight of load, $T = (\rho - \rho_L)Vg$.

2c

$$f' = \frac{1}{2L_1}\sqrt{\frac{(\rho - \rho_L)Vg}{\mu}}.$$

but its required that

$$f = f'$$

$$\frac{1}{2L}\times\sqrt{\frac{\rho Vg}{\mu}} = \frac{1}{2L_1}\sqrt{\frac{(\rho - \rho_L)Vg}{\mu}}$$

$$\frac{1}{L}\times\sqrt{\rho} = \frac{1}{L_1}\sqrt{(\rho - \rho_L)}$$

$$\frac{1}{L}\frac{\sqrt{\rho}}{\sqrt{\rho - \rho_L}} = \frac{1}{L_1}$$

$$L_1 = L\sqrt{\frac{(\rho - \rho_L)}{\rho}}$$ but $L = 40\,cm$

$\rho_L = 1000\,kg/m^3$

$$L_1 = L\sqrt{\frac{9\times10^{-3} - 1000}{9\times10^{-3}}}$$ $\rho = 9\,gm^{-3}$

$= 9\times10^{-3}\,kg/m^3$

$$L_1 = 40\times\sqrt{\frac{9\times10^{-3} - 1000}{9\times10^{-3}}}$$

* but the density given is small compared to the density of water so the question cannot be solvent further.

- alternatively if we ass take density given to be $9\,gcm^{-3}$ then density of load $= 9000\,kgm^{-3}$.

then

$$L_1 = 40 \times\sqrt{\frac{9000 - 1000}{9000}}$$

In extract 16.1 the candidate gave the correct responses according to the requirements of the question. He/she was able to recall and apply the formula of finding frequency before the train passed and the frequency after the train passed.

Some of the candidates performed poorly in this question as they failed to recall and apply the correct formulas in performing calculations. Most of them were not able to give reason on why diffraction is common in sound but not in light. One candidate for example wrote; *Diffraction is common in sound and not in light since longitudinal wave have tendency of spreading unlike electromagnetic waves*. This verified to inadequate knowledge on the concepts of vibrations and waves and its propertied. The candidates should understand that, diffraction effect is quite pronounced if the size of the obstacle or opening is of the order of the wavelength of the wave. i.e, since the wavelength of light is very small compared to the objects around us, diffraction of light is not easily seen unlike that of sound waves. Extract 16.2 shows a sample response from one of the candidates who performed poorly in this question.

Extract 16.2

2 a) Data given

Velocity of cyclist = 10 m s⁻¹ - U_o

Velocity of railway train = 20 m/s - U_s

Frequency = 480 Hz

F = ? of note to heard by cyclist = ?

$V = 340\ ms^{-1}$ sound.

Observer → $U_o = 10\ ms^{-1}$ ← source $U_s = 20\ ms^{-1}$

$$f' = \left(\frac{V - U_s}{V + U_o}\right) f$$

$$f' = \left(\frac{340 - 20}{340 + 10}\right) f$$

$$f' = \left(\frac{320}{350}\right) f$$

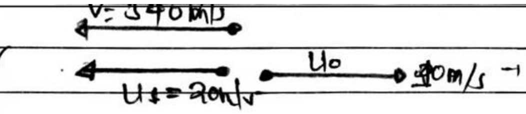
$$f' = \left(\frac{320}{350}\right) 480\ Hz.$$

$$f' = 438.86\ Hz.$$

Before train has pass = 438.86 Hz.

(ii)

$f' =$



$$f' = \left(\frac{V + U_s}{V - U_o}\right) f$$

$$f' = \left(\frac{340 + 20}{340 - 10}\right) f$$

$$f' = \left(\frac{360}{330}\right) f$$

but frequency = 480Hz.

$$f' = (1.091)\, 480$$

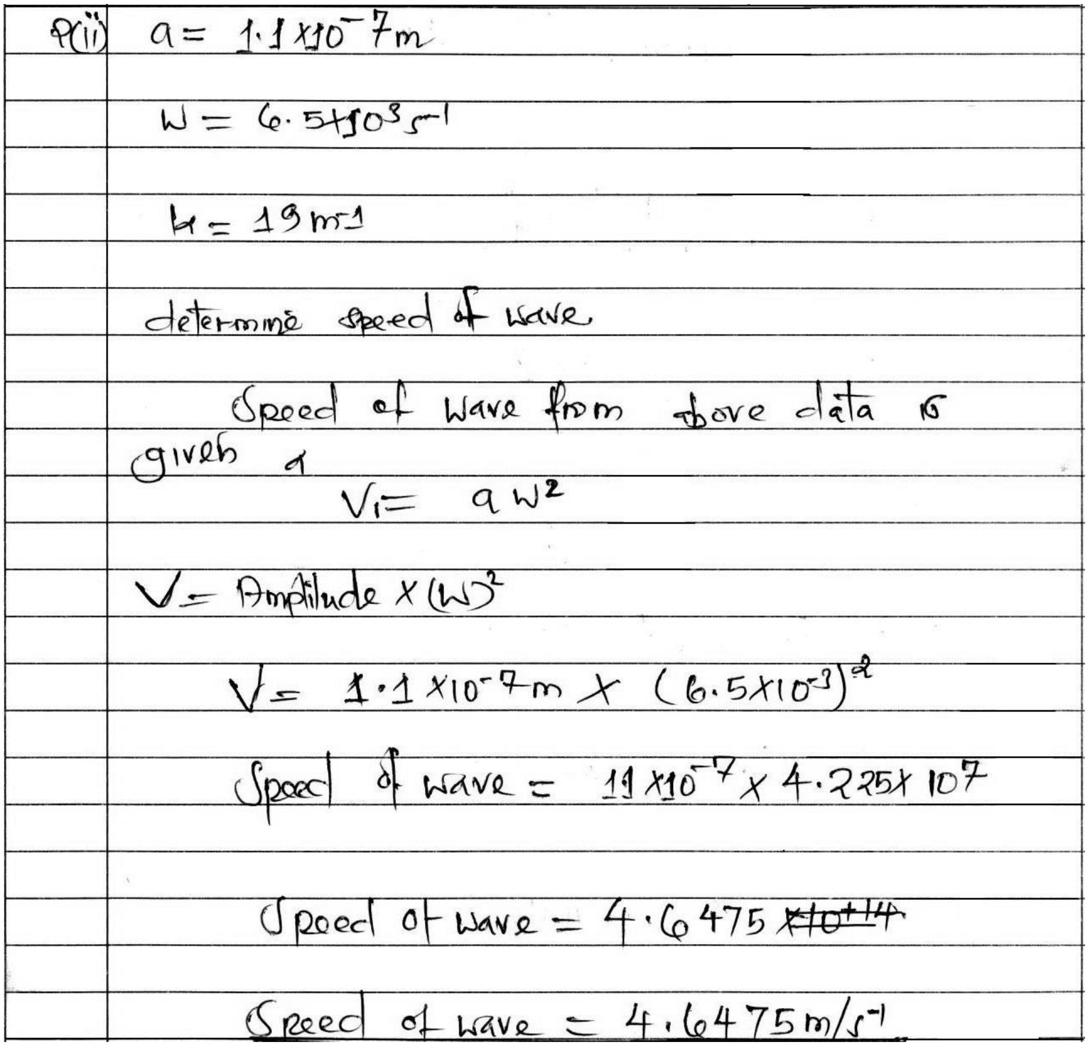
$$f' = 523.64\,Hz.$$

2.(b) From $y = a\sin(\omega t - kx)$

The

$$y = a\sin\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda}\right)$$

The equation is travelling is negative x- direction.



In extract 16.2 the candidate wrote the formula for finding frequency but he/she interchanged the formula of frequency before and after the train had passed.

3.3 Question 3: Vibrations and Waves

This question had three parts; (a), (b) and (c). In part (a) the candidates were required to determine the separation of double slit, given that in Young's double slit experiment a total of 23 bright fringes occupying a total distance of 3.9 mm were visible in a travelling microscope, which was focused on a plane being at a distance of 31 cm from the double slit, and the wavelength of light used was $5.5\text{x}10^{-7}$ m. In part (b) they were required to find wavelength of the light when a grating with 300 lines per millimetres is illuminated normally with parallel beam of monochromatic light and if a second order principal maximum is observed at 18.9^0 straight to the direction. Part (c) required the candidates to find the value of the width "a" that will be the first minimum of light falling at the angle of 30^0 when the wave length of light is 6500 nm.

The question was attempted by 33.3 percent of the candidates whose scores are as follows: 33.3 percent scored from 0 to 6.5, including 5.3 percent who scored 0, 33.6 percent scored from 7.0 to 11.5 marks and 33.1 percent scored from 12 to 20 marks. These scores indicate that the performance in this question was good as shown in Figure 17.

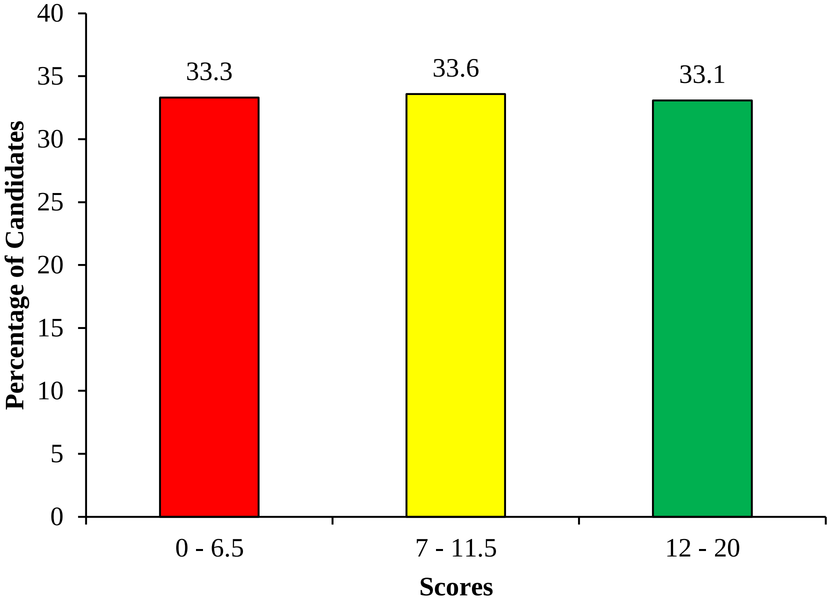


Figure 17: Candidates' Performance in Question 3.

The candidates who performed well in this question were able to use the correct formulas and give proper procedures in finding the separation of the double slit, the wave length of light and the width of the slits 'a'. Extract 17.1 presents a sample of responses from the candidates who performed well in this question.

Extract 17.1

3(a) Data given;

number of fringes ; $n = 23$.

fringe separation ; $x = 3.9mm = 3.9 \times 10^{-3} m$.

Distance between slits and screen; $D = 31cm = 0.31m$.

Wavelength ; $\lambda = 5.5 \times 10^{-7} m$.

Required; Double slits separation; $y = ?$.

From formular.

$$D n \lambda = xy \quad \text{- for single fringes}$$

$$D(n-1)\lambda = xy \quad \text{- for number of fringes.}$$

Formular to use.

$$xy = D(n-1)\lambda.$$

Where by x = fringe separation.

y = slits separation

D = Distance from slits to screen

λ = wavelength

n = number of ~~fringe~~ bright fringes.

$$xy = D(n-1)\lambda.$$

$$y = \frac{D(n-1)\lambda}{x}.$$

$$y = \frac{0.31m(23-1) \times 5.5 \times 10^{-7} m}{3.9 \times 10^{-3} m}$$

$$y = 9.62 \times 10^{-4} m.$$

$\therefore$ Separation of the double slit is $9.62 \times 10^{-4} m$.

3(b) Data given;

grating ; $g = 300$ lines per millimeters.
Order of principle $= 2$.
$\Theta = 18.9^0$

Required; Wavelength of light; $\lambda = ?$

Solution:
But Distance between slits and screen $D = \frac{1}{g} = \frac{1}{300}$ mm.

$D = 3.33 \times 10^{-3}$ mm.
$D = 3.33 \times 10^{-6}$ m.

∴ Distance between slits and screen; $D = 3.33 \times 10^{-6}$ m.

From; Formular;
$D \sin \Theta = n\lambda$.

To make λ the subject.

$$\lambda = \frac{D \sin \Theta}{n}.$$

$$\lambda = \frac{3.33 \times 10^{-6} m \times \sin 18.9^0}{2}$$

$$\lambda = 5.4 \times 10^{-7} m.$$

∴ Wavelength of the light is 5.4×10^{-7} m.

3(c) Data given;

Wavelength ; $\lambda = 6500nm = 6500 \times 10^{-9} m = 6.5 \times$

Wavelength ; $\lambda = 6.5 \times 10^{-6} m$

Angle ; $\theta = 30°$.

Required; The value of "a" for the first minimum light fall.

Solution.

Form

Formular

$d \sin \theta = n\lambda$.

where d = width (a)

n = order of light falls

λ = wavelength,

θ = An angle.

Therefore

$d \sin \theta = n\lambda$

$d = \frac{n\lambda}{\sin \theta}$

$d = \frac{1 \times 6.5 \times 10^{-6} m}{\sin 30°} = 1.3 \times 10^{-5} m$.

∴ The value slit width "a" is $1.3 \times 10^{-5} m$

In extract 17.1 the candidate was systematic in organizing the data, hence ended with correct answers in all parts of the question.

It has been observed from candidates' scripts that most of them wrote correct formulas but they used wrong procedure in determining the correct answers. This shows that they lacked knowledge on the concept of vibrations and waves particularly on how Young's double slit experiment can be carried out to determine the distance of separation of double slit, wavelength and a slit width. Extract 17.2 is a sample taken from the script of one of the candidates who performed poorly in this question.

Extract 17.2

3 a

Soln

$n = 23$

$Y_n = 3.9\,mm = 3.9 \times 10^{-3}\,m$

$D = 31\,cm = 0.31\,m$

$\lambda = 5.5 \times 10^{-7}\,m$

$d = ?$

from

$$\frac{n\lambda}{d} = \frac{Y_n}{D}$$

$$\frac{23 \times 5.5 \times 10^{-7}}{d} = \frac{3.9 \times 10^{-3}}{0.31}$$

$$d = \frac{23 \times 5.5 \times 10^{-7} \times 0.31}{3.9 \times 10^{-3}}$$

$= 1.01 \times 10^{-3}\,m = 1.01\,mm$

$\therefore$ separation of the double slit is $1.01 \times 10^{-3}\,m$

b	soln
	$N = 300\ mm^{-1}$
	$n = 2$
	$\theta = 18.9^{o}$
	$\lambda = ?$
	from
	$= n\lambda \sin\theta = \frac{1}{N}$
	$\lambda = \frac{1}{nN\sin\theta}$
	$= \frac{1}{2 \times 300 \times \sin 18.9^{\circ}}$
	$= 5.15 \times 10^{-3}\ mm$
	$\therefore$ Wavelength of Light $= 5.15 \times 10^{-3}\ mm$

c.	Soln
	$n = 1$
	$\theta = 30^{\circ}$
	$\lambda = 6500nm$
	$N = a = ?$
	from
	$n \lambda \sin \theta = \frac{1}{N}$
	$n \lambda \sin \theta = \frac{1}{a}$
	$a = \frac{1}{n \lambda \sin \theta}$
	$= \frac{1}{1 \times 6500nm \times \sin 30}$
	$\therefore a = 3.08 \times 10^{-4} nm^{-1}$

In extract 17.2 the candidate failed to recognize and apply the correct formula and procedure in finding the separation of double slits, wavelength of light and the width of the slit.

3.4 Question 4: Properties of Matter

This question had three parts; (a), (b), and (c). Part (a) required the candidates to find the tension in the rod when it has cooled to 20^{0}C given that a steel rod of length 0.60 m and cross sectional area $2.5 \times 10^{-5} m^{2}$ at a temperature of 100^{0}C is clamped so that when it cools it was unable to contract. In part (b), the candidates were required to find the length when a load of 500 g is applied on a spring, given that a spring of 60 cm long was stretched by 2 cm by a load of 200 g. In part (c), the candidates were required to calculate the percentage increase in length of a wire of diameter 2.2 mm stretched by a load of 100 kg, if the Young's modulus of wire is $12.5 \times 10^{10} Nm^{-2}$.

A total of 11,346 (61.2%) candidates attempted this question, out of these candidates 25.5 percent scored from 0 to 6.5 marks, 26.6 percent scored from 7.0 to 11.5 marks and 47.9 percent scored from 12 to 20 marks. These scores indicate that the general performance in this question was good. The following pie chart illustrates the information given above.

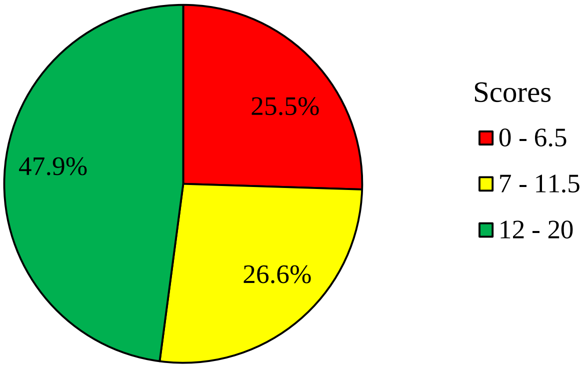


Figure 18: Candidates' Performance in Question 4.

The candidates who attempted this question correctly had good understanding on properties of matter especially the concept of elasticity. Most of them were able to find the tension of the rod, its length and hence calculate the percentage increase in length. Extract 18.1 below shows the response of one of the candidates who performed well in this question.

Extract 18.1

A (a) Given.

$l = 0.60m$

$A = 2.5 \times 10^{-5} m^2$

$\theta_1 = 100°C$

$\theta_2 = 20°C$

$$\alpha = \frac{l - l_0}{\Delta\theta\, l_0}$$

$$l - l_0 = \alpha(\theta_1 - \theta_2) l_0$$

~~1.6×10^{-7}~~ =

$$l - 0.6 = 1.6 \times 10^{-7}(100-20)0.6$$

$$l - 0.6 = 7.68 \times 10^{-6}$$

$$l = 7.68 \times 10^{-6} + 0.6$$

$$l = 0.60$$

$$e = l - l_0$$

$$e = 7.68 \times 10^{-6} m.$$

$$Y = \frac{Fl}{Ae}$$

$$F = \frac{YAe}{l}$$

$$F = \frac{2 \times 10^{11} \times 2.5 \times 10^{-5} \times 7.68 \times 10^{-6}}{0.6}$$

$$F = 64N.$$

∴ The tension in the rod when cooled to 20°C is 64N.

4. (b) Given.

~~$l = 60\times10^{-2}m$~~

$l = 60cm$

$e = 2cm$

$m_1 = 200g$

$m_2 = 500g.$

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

$$Y = \frac{mgl}{Ae}$$

$$Y = \frac{200\times980\times60}{A\times2}$$

$$Y = \frac{500\times980\times60}{A\times e}$$

$$\frac{200\times980\times60}{2A} = \frac{500\times980\times60}{A.e}$$

$$1 = \frac{5}{e}$$

$$e = 5cm$$

after applying 500g

$$l = 60+e$$
$$= 60+5$$
$$= 65cm.$$

∴ The length after applying load of 500g is 65cm.

4. (i) Given.

$d = 2.2mm \times 10^{-3}m$

$m = 100Kg$

$Y = 12.5 \times 10^{10} N/m^2$

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

$$\frac{1}{Y} = \frac{Ae}{FL}$$

$$\frac{F}{YA} = e/L$$

percentage increase in length is given as

$$e/L \times 100\% = F/YA$$

$$= \frac{mg}{YA} = \frac{mg}{Y\pi d^2/4}$$

$$100\% \times e/L = \frac{4mg}{Y\pi d^2}$$

$$= \frac{4 \times 100 \times 9.8}{12.5 \times 10^{10} \times \pi \times (2.2 \times 10^{-3})^2}$$

$$100\% \times e/L = 2.06 \times 10^{-3} \times 100\%$$

$$= 0.206\%.$$

∴ The percentage increase in length of the wire is 0.206%.

In extract 18.1 the candidate managed to recognize and apply the required formula to get the correct answers in all parts of the question.

The candidates who performed poorly were not able to recall the formula of Young’s modulus and apply it in finding the tension, length and the percentage increase in length of a wire. Some lacked mathematical skills as they tried to answer some parts of the question and left other parts, this led them to score low marks. These candidates lacked knowledge and skills for solving questions based on the concept of elasticity. Extract 18.2 presents a sample of a poor responses from the script of one of the candidates.

Extract 18.2

4. a/. SOLN

Data Given

Length of a steel = 0.60m

If cross-sectional area = $2.5 \times 10^{-5} m^2$

Temperature = 100°C

Cooled temperature = 20°c

Required:-

To find the tension in the rod

then

$0.60m \times 2.5 \times 10^{-5} m^2$

temp = 100°c − 20°c

temp = 80°c

$\frac{1.5 \times 10^{-5} m}{80°c}$

= 0.0187

∴ The tension in the rod = 0.0187

b/. SOLN

Data Given

Length of spring = 60cm

Stretched length = 60cm + 2cm = 62cm

Mass of load = 200g

Mass of load = 500g

then.

60cm + 2cm = 62cm → 200g

? → 500g

$\frac{62cm \times 500g}{200g} = \frac{200g \times X}{200g}$

X = 155cm

∴ The length = 155cm

c/. SOLN

Data Given

Diameter of wire = 2.2 mm = 0.22m

Mass of load = 100 kg

Young's modulus of wire = 12.5×10^{10} Nm^{-2}

then

$$\frac{0.22m \times 12.5 \times 10^{10} Nm^{-2}}{100kg}$$

$$\frac{2.75m \times 10^{10} Nm}{100kg}$$

0.0275×10^{10} Nm $\times 100$

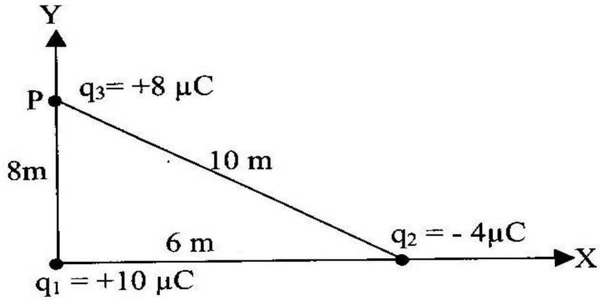
27.5×10^{10} Nm %

∴ The percentage Increase = 27.5×10^{10} Nm %

In extract 18.2 the candidate didn't write any formula when performing calculations. He/she substituted the data in a place where there is no formula and thus ended up with an incorrect answer.

3.5 Question 5: Electrostatics

This question had three parts; (a), (b), and (c). In part (a), the candidates were required to: (i) define the terms capacitance and electric potential and (ii) determine the value of capacitance, C of the capacitor when it is fully charged by 200 V battery, then discharged through a small coil of resistance wire embedded in a thermally insulated block of a specific heat capacity 2.5×10^2 $Jkg^{-1}K^{-1}$ and of mass 0.1 kg, if the temperature of the block rises by 0.4 K. In part (b), the candidates were required to: (i) calculate the capacitance of the capacitor and (ii) the energy stored in the capacitor when a parallel plate capacitor has plates each of area 0.24 m^2 is separated by a small distance 0.50 mm when the capacitor is fully charged by a battery of electromotive force of 24 V. In part (c), the candidates were required to: (i) comment on the assertion that the safest way of protecting yourself from lightning is to be inside a car, and (ii) find the total potential energy of the system of point charges shown in the Figure below.



The question was attempted by 46 percent of the candidates, out of which 36.7 percent scored from 0 to 6.5 marks including 4.5 percent who scored 0 marks, 37.5 percent scored from 7 to 11.5 marks and 25.8 percent scored from 12 to 20 marks. These scores suggest that the general performance in this question was good.

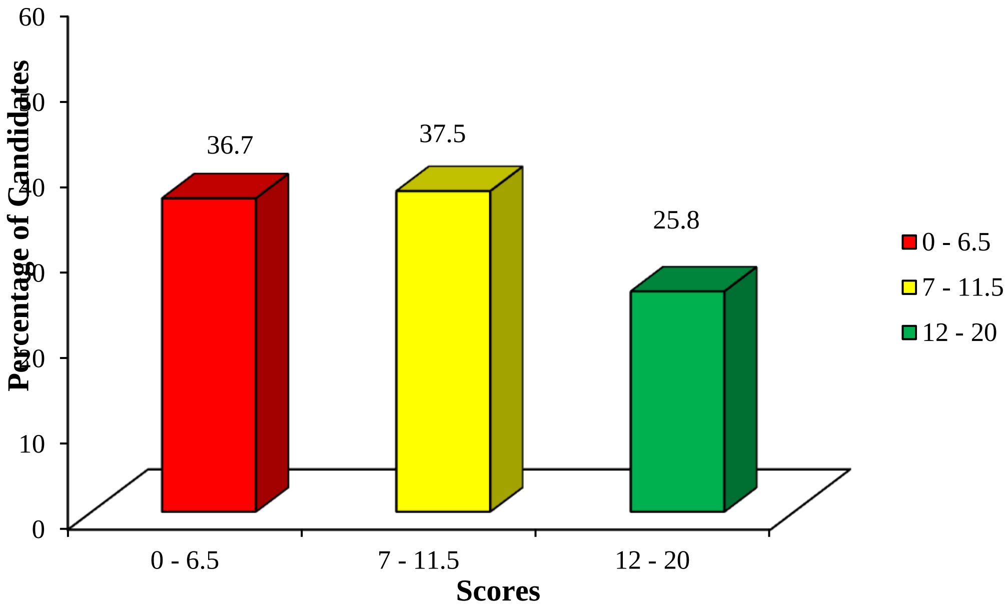


Figure 19: Candidates' Performance in Question 5.

The candidates who performed well in this question were conversant with the concepts of capacitors and electric potential due to point charges as they managed to define the terms and apply the correct formula to find the capacitance, C of a capacitor, the energy stored and the total potential energy of the system of point charges. Most of them were able to give correct comments on the assertion that the safety way that one could protect himself from lightning is to be inside a car. Extract 19.1 presents the answer of a candidate who attempted well.

Extract 19.1

5	
(a)i	Capacitance of a capacitor : Is the ability of a pair
	Capacitor to store electric charges.
	and $c = \varepsilon A/d$
	Electric potential at a point : Is the work done
	in Moving a unit charge from infinity
	to that Point
ii/	Given :
	Capacitance = c
	$V = 200V$
	$C = 2.5 \times 10^2 JKg^{-1}K^{-1}$
	$M = 0.1Kg$
	$\Delta\theta = 0.4K$
	Required value of c

	Energy Lost by Capacitor = energy gained by the block
	~~$\frac{1}{2} MV^2$~~
	$\frac{1}{2} CV^2 = MC\Delta\theta$
	$\frac{CV^2}{V^2} = \frac{2MC\Delta\theta}{V^2}$
	$C = \frac{2MC\Delta\theta}{V^2}$ ——— (1)
	$C = \frac{2 \times 0.1kg \times 2.5\times10^2 Jkg^{-1}K^{-1} \times 0.4K}{(200)^2}$
	$C = 5\times10^{-4}$ F
	∴ Capacitance C is 5×10^{-4} F
5b	Given that
	$A = 0.24M^2$.
	$d = 0.5\times10^{-3}M$
	$V = 24V$
	i/ capacitance of capacitor c
	$C = \frac{\varepsilon_0 A}{d}$
	$C = \frac{8.854\times10^{12} Nm^{-2}kg^{-2} \times (0.24M^2)}{(0.5\times10^{-3})}$
	$C = 4.25\times10^{-9}$ F
	∴ Capacitance of capacitor is 4.25×10^{-9}F

5bii	Considering that
	Energy stored by a capacitor is given by
	$E = \frac{1}{2} cv^2$
	$E = \frac{1}{2} \times 4.25 \times 10^{-9} F \times (24V)^2$
	$E = 1.224 \times 10^{6}$ Joules
	$\therefore$ Energy stored by capacitor $= 1.224 \times 10^{-6} J$
5ci	On the Light of the given statement when one is inside the car, the car is considered to have a gausian Surface at the top, hence inside the car charges are not present [Q=0] hence Lightning strike cannot entre/penetrate into the car an affect the person, hence the person is Safe
CII.	Required
	Potential energy W of the system.
	$P.E = \frac{Kq_1q_2}{r}$
	$PE_T = \frac{Kq_1q_2}{r_1} + \frac{Kq_1q_3}{r_2} + \frac{Kq_3q_2}{r_3}$
	$PE_T = K\left[\frac{q_1q_2}{r_1} + \frac{q_1q_3}{r_2} + \frac{q_3q_2}{r_3}\right]$

$$E = 9\times10^{9}\left[\frac{-10\times10^{-6}\times4\times10^{-6}}{6M} + \frac{10\times10^{-6}\times8\times10^{-6}}{8M} + \frac{-8\times4\times10^{-12}}{10M}\right]$$

$$E = 9\times10^{9}\,(1.333\times10^{-13})\ J$$

$$E = 1.2\times10^{-3}\ \text{Joules.}$$

$\therefore$ Total energy is 1.2×10^{-3} Joules

In extract 19.1 the candidate comprehended correctly to all terms and applied the correct formula and procedures in performing calculations to get the correct answers.

As for the 36.7 percent of the candidates who performed poorly, they failed to respond correctly to many parts of the question. Some of them failed to justify the given statement in part (c) (i). For example, one of the candidates wrote *safety way is to be away from all things which can conduct electric charge during rain like phones, radios and television*. This response does not match with the demand of the question. Moreover, many candidates didn't understand the principle on which the capacitor works i.e charging and discharging process of a capacitor. This shows that they lacked knowledge on the concept of electrostatic as well as poor mathematical skills in performing calculations. Extract 19.2 shows a response from a candidate who performed poorly in this question.

Extract 19.2

5 a) (ii) Data

Charge of a Capacitor = 200 V

Specific heat capacity $2.5\times10^{2}\ J\,Kg^{-1}K^{-1}$

Mass = 0.1 kg

Temperature of the block 0.4 K

from Capacitance = PV.

Capacitance

$C = 2.5\times10^{2}\times200\times0.4$.

$C = 200\times10^{4}$

b)

Data

Area (A_1) = 0.24 m^2

Area (A_2) = 0.24 m^2

Areas between the two areas is 0.5 mm

$= 5\times10^{-4}$ m

Electromotive force EmF

V = 24 V.

(i) the Capacitance of the Capacitor

5 (b) (i)

Capacitance (c)

$= (0.24\psi) \times 2 \times 5 \times 10^{-4} \times 24\psi$

$C = 5.76 \times 10^{-3}$.

(ii) Energy Stored in the capacitor

Energy $= 24\psi \times 5 \times 10^{-4}$

$= 0.012$ J.

c) (i) The safest way of protecting yourself from lightining is not to be inside a car but the safest way is to be away with the all things which can Conduct electric charge during raining for example be away of those things which are using network to work like phones and radios or televisions or be away from the wide area where a man himself is a tallest one than all things around then a man will be safe.

In extract 19.2 the candidate wrote incorrect answers which were irrelevant to the asked concepts.

3.6 Question 6: Properties of Matter

Part (a) of this question required the candidates to: (i) define the terms tensile stress and tensile strain (ii) calculate the work done in stretching copper wire of 100 cm long and 0.03 cm^2 cross sectional area, when a load of 120 N is applied. In part (b) the candidates were required to: (i) mention any two factors on which modulus of elasticity of a material depends and (ii) Find fractional increase in length of the wires due to the weight of the traffic light, given that a 45 kg mass of traffic light is suspended with two steel wires of equal lengths and radii of 0.5cm and the wires make an angle of 15^0 with the horizontal. In part (c) the candidates were required to: (i) define free surface energy in relation to the liquid surface (ii) explain what will happens if two bubbles of unequal radii are joined by a tube without bursting and (iii) calculate the work done in breaking the drop of mercury of radius 5 mm falling on the ground and breaking into 1000 droplets.

A total of 11,618 (62.7%) candidates attempted this question, out of these 53.1 percent scored from 0 to 6.5 marks, 31.6 percent scored from 7.0 to 11.5 marks; and 15.3 percent scored from 12 to 20 marks. These data indicates that this question was averagely performed. The above data are summarized in Figure 20.

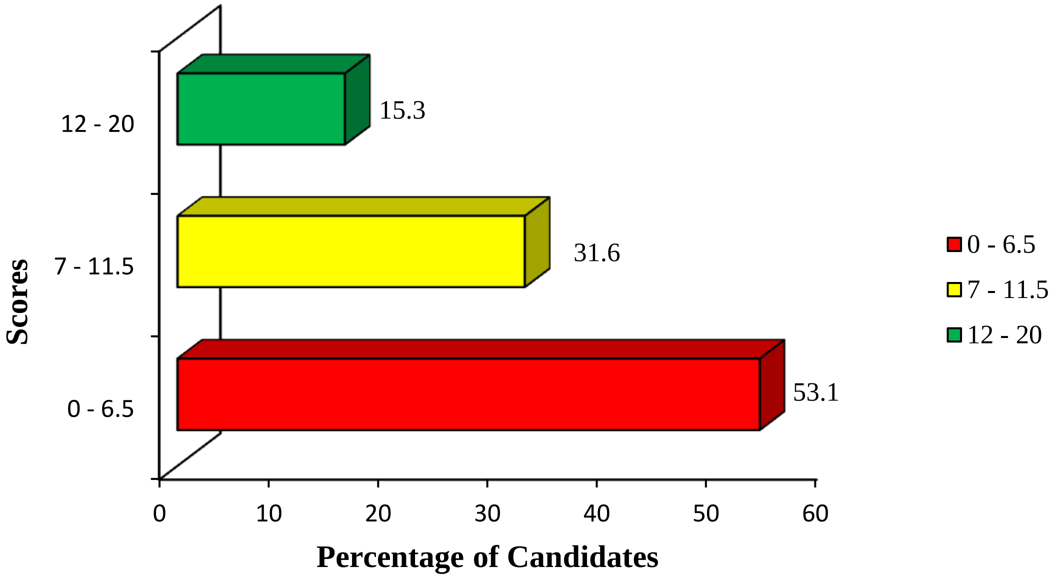


Figure 20: Candidates' Performance in Question 6.

The candidates who performed well in this question were conversant in the concept of properties of matter as they managed to describe surface tension and elasticity in terms of molecular theory. In addition, they were able to analyze surface tension in terms of surface energy. By doing so they managed to find the work done in stretching a copper wire, in breaking a spherical drop of mercury into 1000 droplets and resolving the fractional increase in length due to weight of a traffic light. Extract 20.1 shows the answer of one candidate who performed well in this question.

Extract 20.1

6, (a) (i) Tensile stress is the force acting per unit crossection area. $\left(F/A\right)$.

Tensile strai is the extension produced per unit orginal length.

e/L

6. (ii). Soln.

$w = \frac{1}{2}Fe.$

From Young Modulus.

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

~~e =~~

$e = \frac{FL}{AE}$

$w = \frac{1}{2}F\left(\frac{FL}{AE}\right).$

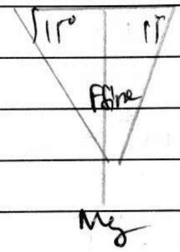
$= \frac{1}{2}\frac{F^2L}{AE}.$

$w = \frac{1}{2} \times \frac{(120)^2 \times 100\times10^{-2}}{0.03 \times10^{-4} \times 1.1\times10^{11}}$

$w = 0.022J.$

∴ The work don is 0.022 J.

6	(b).(i) Factors of which elasticity depend
	→ 1. Cross section area.
	→ 2 Amount of stress applied.
	(ii) Soln.
	$2F\sin\theta = Mg$
	$F = \frac{Mg}{2\sin\theta}$
	$E = \frac{FL}{Ae}$
	$e/L = \frac{F}{AE}$
	$e/L \times 100 = \frac{Mg}{2A\,E\sin\theta}$
	$e/L = \frac{45 \times 9.8}{2 \times (0.5\times10^{-2})^2 \pi \sin 15}$
	$e/L =$
	∴ Fraction increase in length is 5.42×10^{-5}
	(c)(i) Surface energy is the work done on increasing the area und isothermal condition
	(ii) If two buble joining of equal radii by a tube without bursting the pressure in the tube will be equal. then The buble will coellice to form single large drop



6 (iii) (c)

Soln'.

$WDA_1 = 4\pi R^2 \gamma.$

$WDA_2 = n4\pi r^2 \gamma$

$\Delta w = \Delta w_1 - \Delta w_2.$

$\Delta w = (4n\pi r^2 - 4\pi R^2 \gamma$

$\Delta w = \gamma(4$

but $\frac{4}{3}\pi R^3 = \frac{4}{3}\pi r^3 n.$

$\frac{R^3}{r^3} = n.$

$\Delta w = 4\pi\gamma\left[nr^2 - R^2\right]$

$4\pi\gamma\left[\frac{R^3}{r^3} \cdot r^2 - R^2\right]$

$\Delta w = 4\pi\gamma R^2\left[\frac{R}{r} - 1\right].$

$\Delta w = 4\pi\gamma R^2\left[n^{1/3} - 1\right].$

$\Delta w = 4 \times \pi \times 0.472 \times (5 \times 10^{-3})^2 \left[\sqrt[3]{1000} - 1\right]$

$\Delta w = 1335 \times 10^{-3} J.$

∴ The work done is 1.335×10^{-3} J.

Extract 20.1 shows that the candidate attempted well this question by following correct procedures, applying correct formulas and conceptual ideas that met the demands of the question.

However, some of the candidates who performed poorly in this question were not able to recognize and apply the correct formulas and procedures in calculating the work done. They also failed to illustrate the given instructions with a free body diagram identifying an angle of 15^0 that two steel wires made with the horizontal. Moreover, majority failed to comprehend correctly part (c) (ii). This indicates that the candidates had inadequate knowledge especially on the concepts of elasticity and surface tension. One candidate for example wrote; *a bubble with smaller radii* *will increase in size due to higher pressure from a bigger bubble*. The candidates should understand that the smaller bubble will gradually collapse while the larger bubble expands. Extract 20.2 presents an incorrect response from one of the candidates.

Extract 20.2

6 (a) Soln

(b) Soln

Data given

diameter of Copper wire = 100cm

~~diameter~~ (d_2) = 0·03

Area = 0·03 cm^3

a load = 120N

Young modulus of Copper = $1 \cdot 1 \times 10^{11}$ Pa,

Work done = Force x distance

Force = mass x accelera

Work done = $120 \times \left(\frac{0.03}{100}\right)$

= 0·036

∴ Work done in a stretching Copper

= ~~$0.036N \times 1.1 \times 10^{11}$~~

$\left(\frac{120 \times 0.03}{100}\right) 1.1 \times 10^{11}$

$= 3.96 \times 10^9$ N

∴ Work done in a stretching Copper

= 3.96×10^9 N

6. b)

i) Two factors on which modulus of elasticity

i) ~~Free~~ Permattivity of free space

ii) — Permattivity of empty space

ii) Soln

Data given

mass = 45kg

radius = 0.5cm

Angle = 15

Young modulus of steel = 2.0×10^{11} Pa

fractional weight = $\frac{\sin\theta \times \text{mass}}{0.5 \times 2.0 \times 10^{11}}$

$= \frac{\sin 15 \times 45}{0.5 \times 2 \times 10^{11}}$

$= 1.165 \times 10^{-10}$

$= 1.165 \times 10^{-10}$

∴ Fractional increase in the length due to the weight of light = 1.165×10^{-10}

6. c/
i/
Surface
Free Surface energy; is the materials which are Contain Free Surface area which Consist of a Certain energy used in side of it.

ii/ This are the bubbles which when Combicled to the tube, where those two bubble have the same Pressure and temperature in side the tube. which Create the Pressure which are ferezble also where those two bubbles ~~be they not~~ where the tube Can not busting.

6. c/
iii/
Soln
Data given
Radius (r) = 5mm
droplets = 1000
Surface te of mercury γ = 0.472 kgs^{-2}.

Work done = Force x distance
where
W.d = F x d
Force = Mass x accele
F = M.A

Distance = length / time.

In extract 20.2 the candidate wrote incorrect answers to all parts of the question. In part (c) (iii) for example he/she wrote formulas based on the concept of Newton's laws of motion instead of properties of matter as required in this question.

3.6 Question 7: Atomic Physics

This question had four parts (a), (b), (c) and (d). In part (a), the candidates were required to give the meaning of the terms: (i) Atomic mass unit (a.m.u) (ii) Binding energy and (iii) Mass defect. In part (b) they were required to calculate the binding energy per nucleon for phosphorus $^{31}_{15}P$, given that $^{31}_{15}P$ =30.97376 a.m.u and $^{1}_{1}H$ =1.00782 a.m.u. In part (c), the candidates were required to: (i) write down the equation for the disintegration of thorium nucleus $^{226}_{90}Th$ originally at rest decays to form a radium nucleus $^{222}_{88}Ra$, α-particle and γ - rays (ii) determine the energy of ɤ-rays, when an alpha particle is emitted with energy of 2.38MeV, given that the rest mass of $^{226}_{90}Th = 226.0249 a.m.u$, $^{222}_{88}Ra = 222.0154 a.m.u$ and α - particle = 4.0026 a.m.u. In part (d) the candidates were required to calculate the mass of helium nucleus produced when a nucleus of deuterium (hydrogen-2) fuses with nucleus of tritium (hydrogen-3) to helium nucleus and neutron, when 2.88 x 10^{-12}J of energy is released while given the equation for the reaction as $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$.

The question was attempted by 56.1 percent of the candidates, who obtained the following scores: 68.1 percent scored from 0 to 6.5 marks including 13.6 percent scoring 0 marks; 23.5 percent scored from 7.0 to 11.5 marks and 8.4 percent scored from 12 to 19 marks. These data indicate that the performance in this question was generally poor as illustrated in Figure 21.

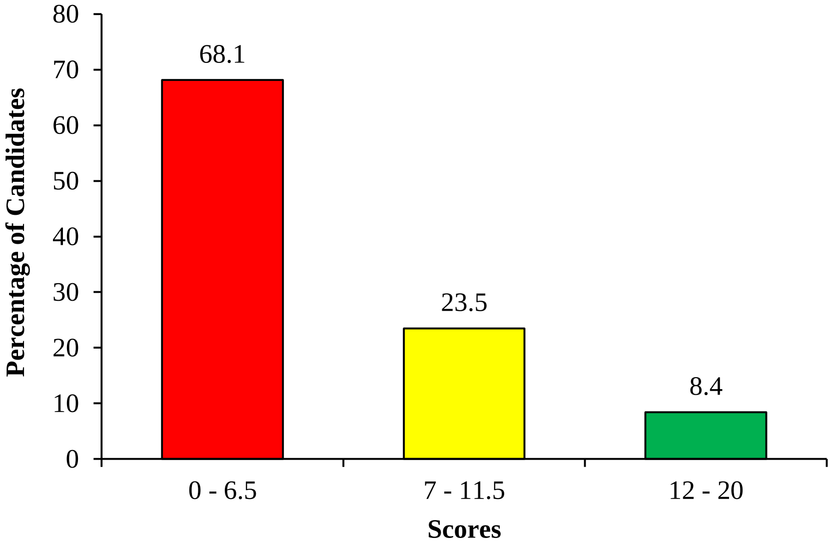


Figure 21: Candidates' Performance in Question 7.

The candidates who attempted this question correctly managed to identify criteria for stable and unstable nucleus and analyse the relation between nuclear mass and binding energy. Most of them defined correctly all the asked terms; atomic mass unit, binding energy and mass defect and applied the correct formula in calculating the energy of gamma ray and the mass of helium nucleus produced. This implies that they were familiar with the concepts of atomic physics specifically nuclear physics. Extract 21.1 shows a sample response from a candidate who performed well this question.

Extract 21.1

~~7(a) (i) Atomic mass unit (a.m.u) is the 1/12 x mass of the carbon -12 atom.~~

(i) Atomic mass unit (a.m.u) is the mass which is given as 1/12 times the mass of carbon – 12.

(ii) Binding energy is the total energy required to separate the nucleus into its constituents nucleons such as protons and neutrons.

(iii) Mass defect is mass difference between the actual mass of the nucleus and the total mass of the nucleons.

(b) soln.

$^{31}_{15}P$

• Total mass of nucleons;

⇒ Total mass of protons = 15 x 1.00782 a.m.u
= 15.1173 a.m.u

⇒ Total mass of neutrons = 16 x 1.00865 a.m.u
= 16.1384 a.m.u

The total mass of neutrons

$= 15.1173\,a.m.u + 16.1384\,a.m.u$

$= 31.2557$ atomic mass unit.

Total mass of nucleons = $31.2557\,a.m.u$

Atomic mass of nucleus = $30.97376\,a.m.u$

Mass defect = Total mass of nucleons − Atomic mass of nucleus

$= 31.2557\,a.m.u - 30.97376\,a.m.u$

$= 0.28194\,a.m.u.$

Binding energy for the phosphorus.

$1\,a.m.u = 931\,MeV$

$0.28194\,a.m.u =$

$\Rightarrow 262.48614\,MeV$

But

Binding energy per nucleon = $\frac{\text{Binding energy}}{\text{Mass number}}$

$= \frac{262.48614\,MeV}{31}$

$= 8.467\,MeV$

∴ The binding energy per nucleon for phosphorus is $8.467\,MeV$.

(C) soln.

(i)

$^{226}_{90}Th \longrightarrow ^{222}_{88}Ra + \alpha\text{-particle} + \gamma\text{-rays}$

$^{226}_{90}Th \longrightarrow ^{222}_{88}Ra + ^{4}_{2}He + \gamma\text{-rays}$

(ii) soln.

The total mass of products

$= 222.0154\ a.m.u + 4.0026\ a.m.u + ^{4}_{2}He$

But Atomic mass of helium is given as

From $1\ a.m.u = 931\ MeV$

$? \quad 2.38\ MeV$

$= \frac{2.38}{931}\ a.m.u$

$= 2.5564 \times 10^{-3}\ a.m.u.$

Now

$= 222.0154\ a.m.u + 4.0026\ a.m.u + 2.5564 \times 10^{-3}\ a.m.u$

$=$

Total mass of products.

$= 222.0154\ a.m.u + 4.0026\ a.m.u$

$= 226.018\ a.m.u.$

Total mass of $^{226}_{90}Th$ = 226.0249 a.m.u

Mass defect = Total mass of $^{226}_{90}Th$ − Total mass of the products

= (226.0249 − 226.018)

= 6.9×10^{-3} a.m.u.

But Energy released in this process Q is given as

1 a.m.u = 931 MeV

6.9×10^{-3} a.m.u = ?

$Q = 931 \times 6.9 \times 10^{-3}$ MeV

Q = 6.4239 MeV

The total energy released in this process

Q = Energy of α-particle + Energy of γ-ray.

6.4239 MeV = 2.38 MeV + Energy of γ-ray

Energy of γ ray = (6.4239 − 2.38) MeV

= 4.0439 MeV

∴ The energy of the γ-ray is 4.0439 MeV.

d) soln.

$^2_1H + ^3_1H \longrightarrow ^4_2He + ^1_0n + Q.$

But mass of ^1_0n = 1.00865 a.m.u given

Total mass of products:

= 1.00865 a.m.u + MHe.

Total mass of reactants

= 1.00782 a.m.u + 1.00782 a.m.u

= 2.01564 a.m.u

Mass defect = (2.01564 − 1.00865) a.m.u + MHe

mass defect = 1.00699 − MHe.

But 1 a.m.u = $931 \times 10^{19} \times 1.6 \times 10^{6}$ J

? 2.88×10^{-12} J

$= \frac{2.88 \times 10^{-12}}{931 \times 10^6 \times 1.6 \times 10^{-19}}$

mass defect = 0.019334 a.m.u.

Mass defect = 1.00699 − mHe.

MHe = 1.00699 − 0.01934 a.m

MHe = 0.9814 a.m.u.

∴ Mass of the helium produced

MHe = 0.9814 a.mu

Extract 21.1 shows how the candidate applied the correct formula and procedure in attempting the question. The candidate managed to get the correct answers to many parts of the question and scored high marks. However he/she failed to get the correct answer for part (d).

The candidates who performed poorly failed to respond correctly to the terms of atomic mass unit, binding energy and mass defect. Some of them were not able to write the radioactive equation correctly as $^{31}_{15}P = 16(^{1}_{0}n) + 15(^{1}_{1}H)$ which could assist them in finding mass defect and finally the binding energy per nucleon. Moreover, they failed to apply Einstein's mass-energy equation to determine the energy of gamma ray. These candidates lacked knowledge about the structure of nucleus and properties of radioactive elements. Extract 21.2 is a sample of an incorrect answer from one of the candidates.

Extract 21.2

7. (a) (i) Is the 1/12 of one atom of Carbon 12 isotope.

(ii) Binding energy - Is the energy required to separate the nucleons of an atom.

(iii) Mass defect - Is the difference/change in mass between the nucleus mass and the nucleons masses.

Or Is the change in mass between the neutrons, electrons and protons of a nucleus and the actual mass of the nucleus.

(b) $^{31}_{15}P + ^{1}_{0}n \longrightarrow 31\,^{1}_{1}H$

Mass of reactants = 30.97376 + 1.00865

= 31.98241

Mass of products = 31(1.007821)

= 31.242451

But ΔM = M reactants − Mass products

Mass defect = 31.98241 − 31.242451
ΔM = 0.739959 a.m.u
But E = ΔM × 931 MeV
E = 0.739959 × 931 MeV
E = 688.90 MeV
∴ Binding energy per Nucleon = 688.90 MeV

7. (c) $^{226}_{90}Th \rightarrow ^{222}_{88}Ra + ^{4}_{2}He + ^{0}_{0}n\ (^{0}_{0}n)$
α-particle γ-ray
Mass of products = 222.0154 + 4.0026 + 1.00865
= 227.02665 a.m.u
Mass defect = 227.02665 a.m.u − 226.0249
ΔM = 1.00175 a.m.u
But E = ΔM × 931 MeV
E = 1.00175 × 931 MeV
E = 932.62925 MeV
But $E_\alpha = E - E_\gamma$.
$E_\gamma = E - E_\alpha$
E_γ = 932.62925 MeV − 2.88
E_γ = 930.24925 MeV
∴ The energy of gammaray (γ) = 930.249 MeV

7. (d) $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$.
Energy = 2.88×10^{-12}
From E = $\Delta M \times 931 \times 10^{6}$ eV
(1.6×10^{-19})
E = ΔM × 931 MeV × 1.6×10^{-19}
E = ΔM × 931 MJ
But Mass of reactants = 1.00782 a.m.u
+ 1.00782
= 1.01564 a.m.u

In extract 21.2 the candidates applied wrong formula and procedure in performing calculations hence ended with incorrect answers.

3.7 Question 8: Electromagnetism

This question consisted of four parts; (a), (b), (c) and (d). Part (a) of this question required the candidates to state the law of force acting on a conductor of length l, carrying an electric current in a magnetic field. In part (b) they were required to: (i) draw the diagram of the solenoid with certain number of turns placed in the magnetic field and indicate any suitable directions of the flow of current in it, and (ii) write down the formulae for the magnetic field induced at the centre of the solenoid. In part (c) the candidates were given that it is desired to design a solenoid that produces a magnetic field of 0.1 T at the centre of the solenoid of radius 5 cm, length of 50 cm carrying a current of 10 A. Then they were required to calculate: (i) the number of turns per unit length of the solenoid and (ii) the total length of the wire. In part (d) the candidates were required to: (i) state Biot–Sarvat law (ii) determine the magnetic flux density produced at the site of the proton in the nucleus when an electron is kept moving around its nucleus with a constant speed of 2.18×10^{6} ms^{-1} in a hydrogen atom, assuming that the orbit is a circle of radius 5.3×10^{-11} m.

This question was attempted by 31.0 percent of the candidates, out of these candidates 78.5 percent scored from 0 to 6.5 marks, 16.5 percent scored from 7.0 to 11.5 marks and 5.0 percent scored from 12 to 20 marks. Only one candidate scored full marks in this question. Figure 22 illustrates candidates' poor performance in this question.

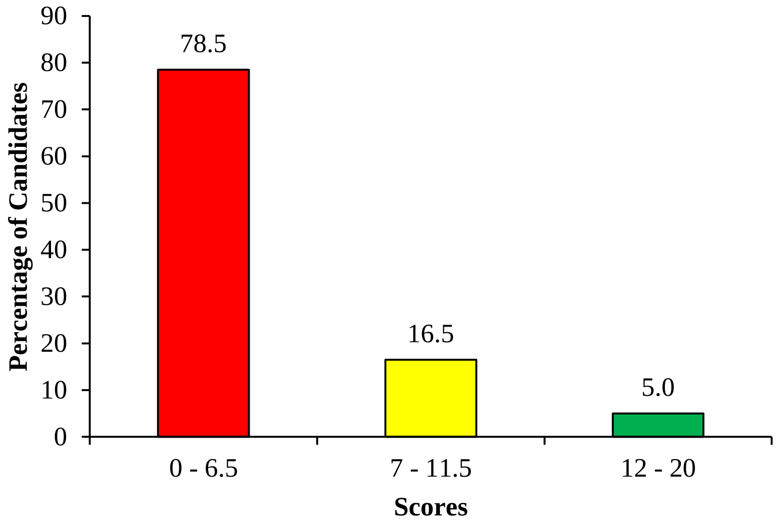


Figure 22: Candidates' Performance in Question 8.

Majority (78.5%) of the candidates who performed poorly in this question failed to investigate the magnetic field density due to a conductor carrying current and to analyse the motion of a charged particle moving in a magnetic field. Instead of drawing a diagram of solenoid with a certain number of turns indicating the direction of flow of current and magnetic field lines, some drew a bar magnet. This shows that the candidates lacked clear understanding on the concept of electromagnetism. Extract 22.1 shows a response of one of the candidates who performed this question poorly.

Extract 22.1

8 a/ The law of force acting on a conductor op a length L is state for a straught conductor op carrying current (I) from a pont distance r with a very short distance dl with a small angle is given by

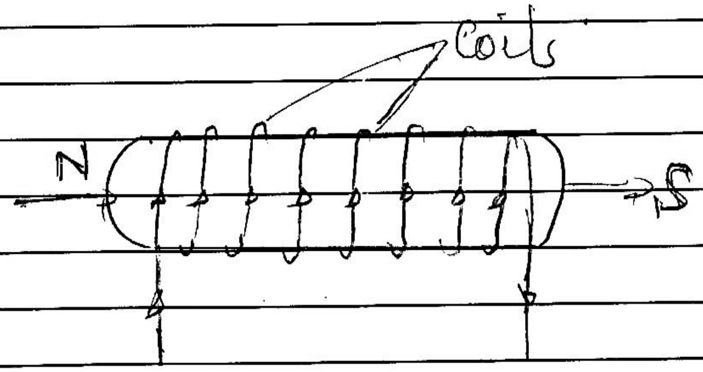
$$\frac{d\theta}{dt} \propto \frac{I dl \sin\theta}{r^2}$$

$$\frac{d\theta}{dt} = \frac{k I dl \sin\theta}{r^2}$$

where $k = \mu_o$

$$\frac{d\theta}{dt} = \frac{\mu_o I dl \sin\theta}{r^2}$$

b/ i/



8b	ii) $B = \frac{NI}{2r}$
	where
	B = magnetic field
	N = number of turns
	I = current
	r = radius.
8c	Data
	Magnetic field B = 0.1T length = 50cm x10⁻²m
	radius of solenoid r = 50cm = 50x10⁻²m
	Current I = 10A
	i) number of turn per unit length, n = N/L
	$B = \frac{NI}{2r} = N/L$
	$N = \frac{2Br}{I}$
	$N = \frac{2 \times 0.1 \times 50 \times 10^{-2}}{10}$
	N = ~~0.01~~ 0.01 turn
	$N/L = \frac{0.01}{50 \times 10^{-2}}$
	N/L = 0.02

In extract 22.1 the candidate provided a wrong response in each part as he/she failed to show the correct directions of current and magnetic field lines and used wrong formulas in performing calculations which led to incorrect answers.

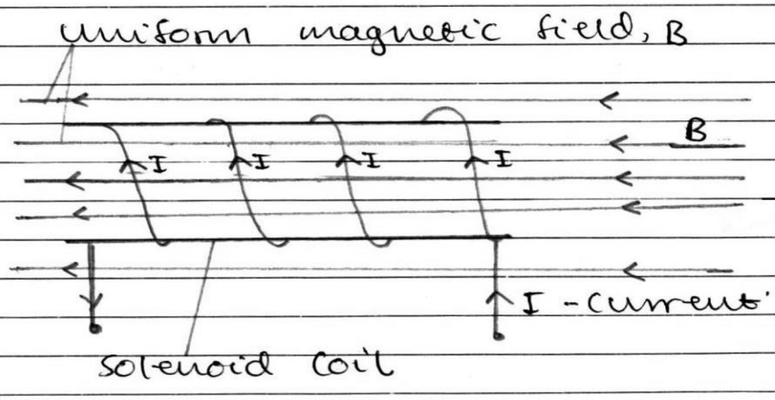
A few candidates (21.5%) that performed well in this question were able to analyse the motion of a charged particle moving in a magnetic field, to state the laws, to draw the diagram of a solenoid indicating the directions of current and magnetic field lines. They also able to calculate the number of turns per unit length of the solenoid as well as the magnetic flux density produced at the centre of the proton in the nucleus. This indicates that these candidates were conversant with the concept of electromagnetism. Extract 22.2 present a response from one of the candidate who answered this question correctly.

Extract 22.2

8. (a) "When a straight current carrying conductor of length L, is placed in a uniform magnetic field, the force produced on it is direct proportional to the magnetic strength of field, B, the length, L of the conductor, the steady current I and the sine of an angle the conductor make with uniform magnetic field."

$F \propto BIL \sin\theta$.

(b)(i)



(ii) $B = \mu_0 n I$

where B – magnetic field strength

μ_0 – permeability of free space.

n – number of turns per unit length

I – steady current flowing.

(c)(i) Given $B = 0.1 T$

$r = 5 cm$

$l = 50 cm$

$I = 10 A$.

From $B = \mu_0 n I$

$$n = \frac{B}{\mu_0 I} = \frac{0.1 T}{4\pi \times 10^{-7} Hm^{-1} \times 10 A}$$

$n = 7962$ turns per metre.

(ii) circumference of one solenoid $= 2\pi r$

$= 2\pi \times 0.05 m$

$= 0.314 m$.

But $\frac{N}{L} = n$.

$N = nL$

$= 7962 \times 0.5$ turns

$= 3981$ turns needed

But 1 turn has $0.314 m$ length

3981 turns will have

length $= 3981 \times 0.314 m$

$= 1250.034 m$.

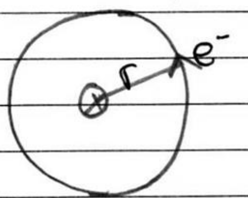
(d)(i) The small change in magnetic field strength, dB at a point around a current carrying conductor is direct proportional to the steady current, I flowing, the small change in length of conductor the sine of angle to which a point makes with the small change in length of a conductor and inversely proportional to the square of the separation distance of a conductor from the point"

$$dB \propto \frac{I\,dl \sin\theta}{r^2}$$

(ii) Given:

$V = 2.18 \times 10^6 ms^{-1}$

$r = 5.3 \times 10^{-11} m$



from $B = \frac{\mu_0 I}{2r}$

But $I = \frac{Q}{t} = e/t$.

But time taken to complete one revolution, $t = \frac{C}{V} = \frac{2\pi r}{V}$

$I = e\left(V/2\pi r\right)$.

$$B = \frac{\mu_0 e}{2r}\left(\frac{V}{2\pi r}\right)$$

$$= \frac{4\pi \times 10^{-7} \times 1.6 \times 10^{-19} \times 2.18 \times 10^6}{2 \times 5.3 \times 10^{-11} \times 2 \times 3.14 \times 5.3 \times 10^{-11}}$$

$B = 12.417\ T$

In extract 22.2 the candidate correctly wrote the formula and determined well the number of turns per unit length of the solenoid.

3.8 Question 9: Atomic Physics

This question was divided into three parts; (a), (b) and (c). In part (a), candidates were required to calculate the shortest wavelength of the Balmer series using the Rydberg constant, $R_H=1.0974x10^7m^{-1}$. Part (b) required them to use the Bohr 's theory for hydrogen atom to determine the: (i) radius of the first orbit of the hydrogen atom in $\overset{0}{A}$ units, and (ii) velocity of the electron in the first orbit. In part (c), the candidates were required to: (i) give the meaning of ionization potential of an atom (ii) show that the ionization potential of hydrogen is 13.6eV and (iii) account for the chemical behaviour of atoms on the basis of the atomic electrons and shells.

A total of 12,336 (66.6%) candidates attempted this question, out of which 61.3 percent scored 0 to 6.5 marks, 26.6 percent scored 7 to 11.5 marks and 12.1 percent scored 12 to 20 marks. These data show that the question was averagely done as illustrated in Figure 23.

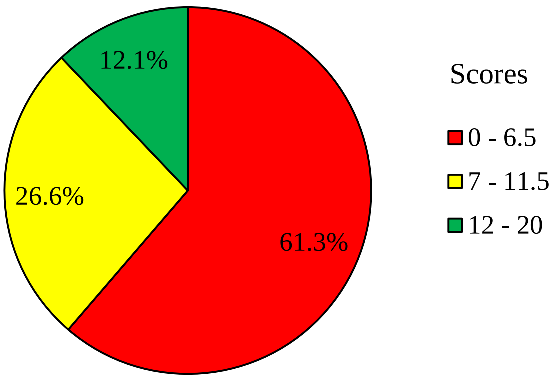


Figure 23: Candidates' Performance in Question 9

The candidates who performed well in this question understood the concept of atomic physics especially the structure of the atom. They were able to describe Bohr's theory of hydrogen atom and use Rydberg constant $R_H=1.0974x10^7m^{-1}$to calculate the shortest wavelength of the Balmer series, the radius of hydrogen atom and velocity of an electron in the first orbit. In addition, they were able to show that the ionization potential of hydrogen is 13.6_eV and explain the chemical behaviour of atoms basing on atomic electrons and shells. Extract 23.1 shows a response from a candidate who provided a correct solution to this question.

Extract 23.1

9. (a) Solution

Given $R_H = 1.0974 \times 10^7 m^{-1}$

required the shortest wavelength (λ) of the Balmer series.

from $\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$n_1 = 2.$

$n_2 = \infty$

Then $\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{\infty^2}\right)$

$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$

$\frac{1}{\lambda} = \frac{R_H}{4}$

$R_H \lambda = 4$

$\lambda = 4/R_H = \frac{4}{1.0974 \times 10^7}$

$\lambda = 3.645 \times 10^{-7} m$

$\lambda = 364.5 nm$

∴ The shortest walength is 364.5 nm.

(b) (i) Solution

from $mvr = \frac{nh}{2\pi}$

Then $mv = \frac{nh}{2\pi r}$

9. (b) (i) $(mv)^2 = \left(\frac{nh}{2\pi r}\right)^2$

$$m^2v^2 = \frac{n^2h^2}{4\pi^2r^2}$$

$$m\left(mv^2\right) = \frac{n^2h^2}{4\pi^2r^2}$$

$$mv^2 = \frac{n^2h^2}{4\pi^2mr^2}$$

$$mv^2 = \frac{n^2h^2}{4\pi^2mr^2} \quad - - - \cdot (i)$$

Also $\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$

$$mv^2 = \frac{e^2}{4\pi\varepsilon_0 r} \quad - - - (ii)$$

Equating the two equations

$$\frac{n^2h^2}{4\pi^2mr^2} = \frac{e^2}{4\pi\varepsilon_0 r}$$

$$\frac{n^2h^2\varepsilon_0}{\pi me^2} = r$$

So

$$r_1 = \frac{1^2 \times (6.63\times10^{-34})^2 \times 8.854\times10^{-12}}{\pi \times 9.1\times10^{-31} \times (1.6\times10^{-19})^2}$$

$$r_1 = 0.53\,A^\circ$$

∴ The radius of the first orbit of the hydrogen atom is $0.53\,\mathring{A}$.

(ii) Velocity of the electron in the first orbit

from $mvr = nh/2\pi$

9. (b) (ii) $mvr = \frac{nh}{2\pi}$

$v = \frac{nh}{2\pi m r}$

$v = \frac{h}{2\pi m r_1}$

but $r_1 = 0.53 Å$

so

$v = \frac{6.63 \times 10^{-34}}{2\pi \times 9.1 \times 10^{-31} \times 0.53 \times 10^{-10}}$

$v = 2.188 \times 10^{6} m/s$

∴ The velocity of the electron in the first orbit is $2.188 \times 10^{6} m/s$.

(c) (i) Ionization potential of an atom is a potential required by the atom to remove completely electron from the outermost shell.

(ii) Solution.

From total energy of any orbit (n)

$E_n = K.E + P.E$

$E_n = \frac{e^2}{8\pi\varepsilon_0 r} + \frac{-e^2}{4\pi\varepsilon_0 r}$

$E_n = \frac{-e^2}{4\pi\varepsilon_0 r}$

9. (c)(ii) but $r_n = \frac{n^2h^2\varepsilon_0}{\pi me^2}$

$$E_n = \frac{-e^2 \pi me^2}{4\pi\varepsilon_0 \cdot n^2h^2\varepsilon_0}$$

$$E_n = \frac{-e^4 m}{4\varepsilon_0^2 h^2}\left(\frac{1}{n^2}\right)$$

$$E_n = \frac{-(1.6\times10^{-19})^4(9.1\times10^{-31})}{4(8.854\times10^{12})^2(6.63\times10^{-34})^2}\left(\frac{1}{n^2}\right)$$

$$E_n = \frac{-2.176\times10^{-18}\,J}{n^2}$$

$$E_n = \frac{-2.176\times10^{-18}/1.6\times10^{-19}}{n^2}$$

$$E_n = \frac{-13.6eV}{n^2}$$

then for ionization of hydrogen

$$\Delta E = E_2 - E_1$$

$$\Delta E = 0 - \left(\frac{-13.6eV}{1^2}\right)$$

$$\Delta E = 0 + 13.6eV = 13.6eV$$

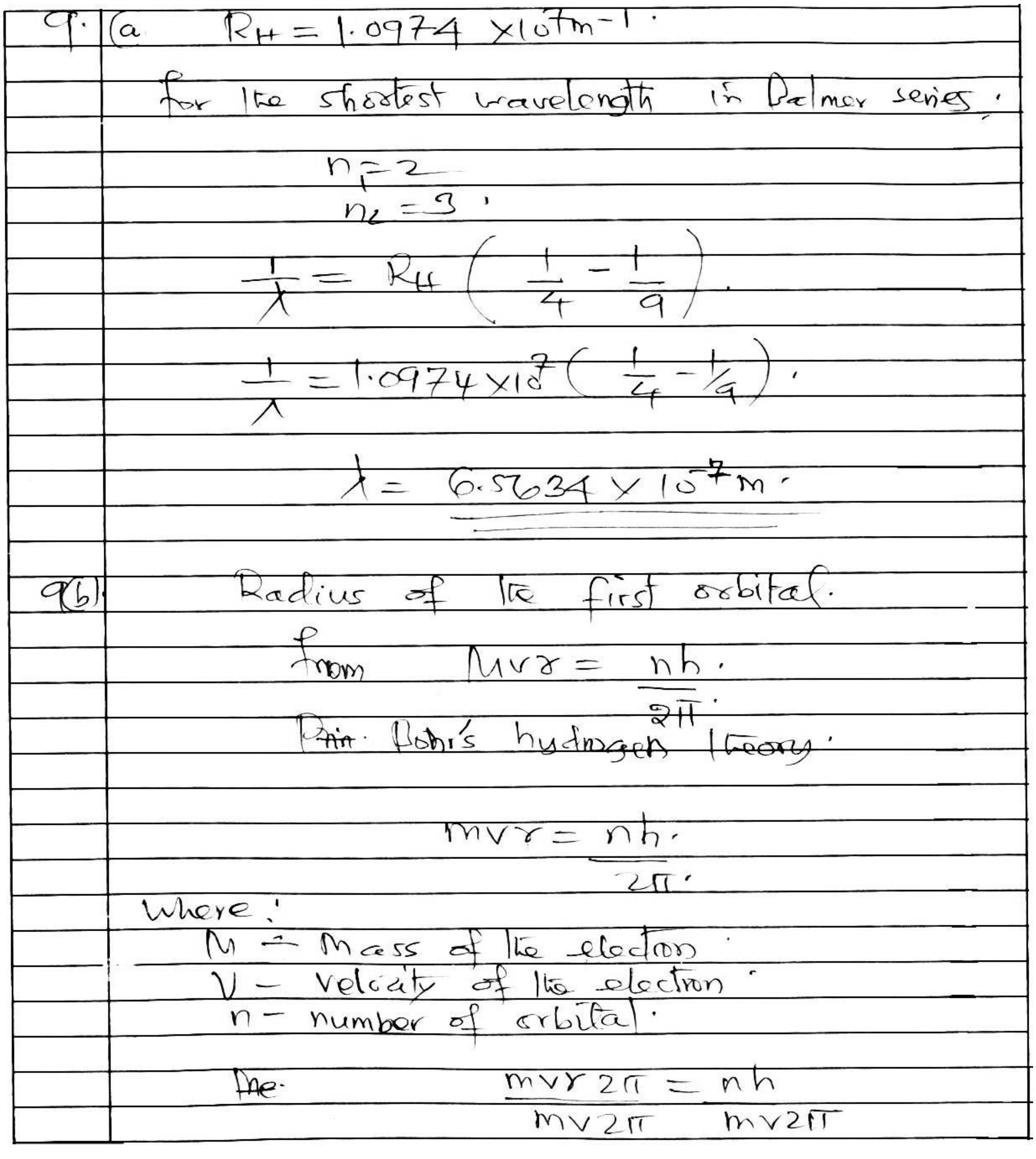
∴ The ionization potential of hydrogen is 13.6eV Hence shown.

(iii) The chemical behaviour of atoms is determined by the number of electrons that are occupied by an atom in the outermost shell. This is due to the fact that they are involved in chemical reactions of an atom.

Extract 23.1 shows that the candidate was able to recall the Rydberg formula and to apply it to determine the shortest wavelength of Balmer series.

The candidates who performed poorly in the question were not able to describe Rutherford and Bohr models of the atom in the process of analysing atomic energy levels. Most of them failed to perceive that, the shortest wavelength of Balmer series is obtained when the quantum numbers $n_1 = 2$ and $n_2 = \infty$, since some wrote $n_1 = 2$ and $n_2 = 3$. Apart from that most of them failed to give the correct meaning of ionization potential and apply Bohr's second postulate to determine the velocity of electron in the first orbit. These candidates lacked knowledge on atomic physics essentially on the structure of an atom. Extract 23.2 shows a sample of an incorrect response from one of the candidates.

Extract 23.2



9. (a $R_H = 1.0974 \times 10^7 m^{-1}$.

for the shortest wavelength in Balmer series:

$n_1 = 2$

$n_2 = 3$.

$\frac{1}{\lambda} = R_H\left(\frac{1}{4} - \frac{1}{9}\right)$.

$\frac{1}{\lambda} = 1.0974 \times 10^7\left(\frac{1}{4} - \frac{1}{9}\right)$.

$\lambda = 6.5634 \times 10^{-7} m$.

9(b) Radius of the first orbital.

from $Mvr = \frac{nh}{2\pi}$.

From Bohr's hydrogen theory.

$mvr = \frac{nh}{2\pi}$.

Where:

M – Mass of the electron.

V – Velocity of the electron.

n – number of orbital.

The $\frac{mvr2\pi}{mv2\pi} = \frac{nh}{mv2\pi}$

$$r = \frac{nh}{2\pi m_e V}$$

$$r = \frac{1 \times 6.626 \times 10^{-34}}{2\pi \times 9.10 \times 10^{-31} \times 3 \times 10^{8}}$$

$$r = 3.8629 \times 10^{-3} Å$$

The Radius of the first orbit is $3.8629 \times 10^{-3} Å$

(b) (ii) from: $E = \frac{+13.6 eV}{n^2}$

$$\frac{1}{2}mv^2 = \frac{+13.6 eV}{1}$$

$$\frac{mv^2}{m} = \frac{2(-13.6)}{m_e}$$

$$v^2 = \frac{2(-13.6)}{m_e}$$

$$V = 4.784 \times 10^{12} m/s$$

The - sign is neglected.

9(c) Ionization potential of an atom: Is the amount of energy required to excite an electron ~~the~~ from the surface of the material.

(c) (ii) 13·6eV

To show that ionization potential is 13·6eV.

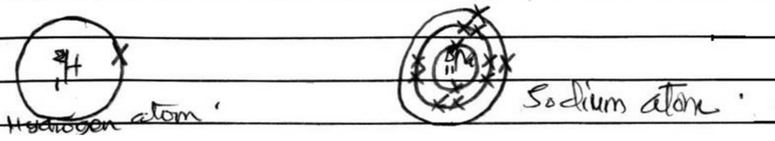
from:

$mvr = \frac{nh}{2\pi}$

But $E = \frac{13.6eV}{n^2}$

If $n = 1$ $E = 13.6eV$.

9(c)(ii) An increase of electrons in the atom is associated with an increase in number of shells.
When the atomic electrons increase in the shells of atom the atom become reactive and because there is a decrease of nuclear force of attraction.
Reactivity increase in an atom.
If the number of shells increases an atom expands
For example Sodium and Hydrogen.



In extract 23.2 the candidate failed to identify that for the shortest wavelength in Balmer series, the quantum numbers $n_1 = 2$ while $n_2 = \infty$ and not 3. He/she also failed to use Bohr's second postulate to calculate the velocity of electron in the first orbit and to explain the chemical behaviour of atoms on the basis of atomic electrons and shells.

4.0 ANALYSIS OF CANDIDATES' PERFORMANCE PER TOPIC

The analysis of the candidates' performance in each topic reveals that, in Physics paper 1, out of six (06) topics which were tested, three (03) topics of *Measurements, Environmental Physics* and *Electronics* had good performance and two (02) topics of *Heat* and *Current Electricity* had average performance. The average performance was due to lack of sufficient knowledge by most of the candidates on the concepts as they skipped some parts of the questions requiring detailed explanations. Some of them also showed poor background in mathematics as they failed to analyse the given data and perform the correct calculations. The topic of *Mechanics* in the same paper had weak performance. The reasons behind weak performance in this topic include; failure of the candidates to distinguish and derive different physical quantities, failure to describe the methods of dimensional analysis and failure to interpret and apply the laws in attempting the given problems.

The analysis also shows that in Physics paper 2, out of six (06) topics which were tested, four (04) topics of *Vibrations and Waves, Electrostatics, Fluid Dynamics* and *Properties of Matter* had good performance while one (01) topic of *Atomic Physics* was averagely performed. The average performance in Atomic Physics was due to failure of the candidates to describe Rutherford and Bohr models of the atom in the process of analysing atomic energy levels.

The analysis further shows that, one (01) out of six (06) topics that were examined in Physics paper 2 had weak performance. This topic was *Electromagnetism*. The reasons for weak performance in this topic include; lack of knowledge on the concept of magnetic field density due to a conductor carrying current and therefore inability to analyse the motion of a charged particle in magnetic field. The summary of candidates' performance in each topic tested in ACSEE 2017 for both paper 1 and 2 and as compared to year, 2016 is shown in the appendices A & B.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The analysis of the candidates' performance per question in physics revealed that, majority of the candidates attempted questions well although some of them faced challenges in responding to the questions. The major challenges which were identified through this analysis are as follows:

(a) Inadequate knowledge which caused some of the candidates to provide incorrect responses in many parts of the questions. This may have been due to ineffective revision of the candidates, poor coverage of some topics by teachers or lack of practice which could enhance candidates' understanding and easy recalling of the acquired knowledge.

(b) Failure to identify the demand of the questions which led some candidates to provide responses which were incorrect. This challenge may have resulted from inadequate exercises which could help to build and improve candidates' experience in responding correctly to the questions.

(c) Few candidates skipped some parts of the questions. This challenge may have been due to either failure of the candidates to manage the given time in attempting questions or lack of knowledge required to answer the asked concepts.

(d) Poor background in mathematical skills which made some candidates to fail to correctly apply formulas in solving analytical problems.

Despite of the explained challenges in attempting questions in ACSEE, 2017 for both Physics paper 1 and 2, it has been observed that, the candidates' performance in 2017 has improved as compared to 2016. This is due to the fact that, a total of seven (07) topics out of twelve (12) had good performance, three (03) topics had average performance while only two (02) topics were poorly done. This indicates that many candidates were conversant with the subject matter which lead them to give appropriate and sufficient responses to the questions asked.

It is expected that the feedback given in this report will enable students, guardians, education stakeholders, teachers and public at large to take the necessary measures to improve the candidates' performance in ACSEE Physics examinations in the future.

5.2 Recommendations

In order to improve performance in future, it is recommended that:

(a) Students have to prepare well, read carefully and understand the demands of the questions when doing examinations;

(b) Students have to concentrate on conceptual understanding of theories and the subject matter of each topic covered under the syllabus and should not rush to solve questions without adequate theoretical knowledge;

(c) Students should work hard in attaining mathematical skills to improve their learning so that they can be able to solve problems with calculations;

(d) Students have to apply theories, laws and principles of Physics to manipulate skills acquired so as to attempt the questions correctly;

(e) Teachers should encourage students to do more practical work during normal learning hours. This will improve the level of understanding of the content and improve students' level of competence on the subject matter; and

(f) Teachers should inculcate a sense and ability for self – study to the students in order to develop their interest in Physics subject.

Appendix A

COMPARISON OF CANDIDATES' PERFORMANCE IN EACH TOPIC BETWEEN 2016 AND 2017

S/n	Topic	2016 EXAMINATION PAPER			2017 EXAMINATION PAPER		
		Number of Questions	% of Candidates Who Scored 35 Percent or Above	Remarks	Number of Questions	% of Candidates Who Scored 35 Percent or Above	Remarks
1	*Measurements*	1	53.6	Average	2	90.1	Good
2	*Environmental Physics*	1	33.4	Weak	1	83.0	Good
3	*Electronics*	3	43.1	Average	3	73.3	Good
4	*Vibrations and Waves*	2	23.9	Weak	2	64.7	Good
5	*Electrostatics*	2	36.2	Average	1	63.3	Good
6	*Fluid Dynamics*	1	35.2	Average	1	62.0	Good
7	*Properties of Matter*	1	11.5	Weak	2	60.7	Good
8	*Heat*	2	43.4	Average	2	52.1	Average
9	*Current Electricity*	2	53.3	Average	2	44.0	Average
10	*Atomic Physics*	2	35.6	Average	2	35.3	Average
11	*Mechanics*	5	39.3	Average	4	32.4	Weak
12	*Electromagnetism*	1	54.2	Average	1	21.5	Weak
13	*Rotation of Rigid Bodies*	1	16.8	Weak			

Appendix B

CANDIDATES' PERFORMANCE IN EACH TOPIC IN THE YEAR 2017