CONCEPTIONS OF ALGEBRA HELD BY SENIOR SECONDARY SCHOOL STUDENTS IN KWARA STATE, NIGERIA

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By

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00/25OC047

DEDICATION

This research work is dedicated to Almighty Allah; my beloved husband, Alhaji Abdullah Musa; my late father, Alhaji Akeeb Omoloye.

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ABSTRACT

Algebra in Mathematics deals with the use of letters and signs to represent numbers and values. It also involves equations, which can be solved using graphical method. Students do perform poorly in solving problems involving quadratic equations by graphical method as contained in the chief examiners report. This could be attributed to factors such as lack of understanding and inadequate interpretation as conceived. This study, therefore, investigated the conceptions of quadratic graph held by Senior Secondary School students in Kwara State, Nigeria. The objectives of this study were to: (i) find out the conceptions of quadratic graph held by Senior Secondary School students; (ii) determine the proportion of Senior Secondary School students with correct conceptions, alternative conceptions and misconceptions of quadratic graph; (iii) determine the influence of gender on students' conceptions of quadratic graph in algebra; (iv) determine the influence of score level on students' conceptions of quadratic graph in algebra; and, (v) examine the influence of subject combination on students' conceptions of quadratic graph in algebra.

The study adopted a descriptive research method of the survey type. The population was all Senior School students offering Mathematics in Kwara State, while the target population was all SS 2 students offering Mathematics in the State. The sample for the study was 1,200 SS II students. The Algebra Conceptions Test (ACT) was used as the instrument. The Pearson Product Moment Correlation coefficient was used to determine the reliability of the instrument, giving a value of 0.76. The research questions were answered using the percentage, while the hypotheses were tested using Chi-square, at 0.05 level of significance.

The findings of the study were that:

(i) correct conceptions, alternative conceptions and misconceptions of quadratic graphs existed among Senior Secondary School students in Kwara State, Nigeria;

(ii) the proportion of students with correct conceptions, alternative conceptions and misconceptions of quadratic graph in algebra were 25.7%, 30.3% and 44.0%, respectively;

(iii) there was a significant difference in the conceptions of quadratic graph held by male and female Senior Secondary School students: ($\chi^2_{(2)}$ = 6.386; $p<0.05$), in favour of the male students;

(iv) there was a significant difference in the conceptions of quadratic graph in algebra held by Senior Secondary School students based on score levels: ($\chi^2_{(4)}$ = l68.210; $p<0.05$), in favour of the high scoring students; and

(v) there was a significant difference in the Senior Secondary School students' conceptions of quadratic graph in algebra based on subject combination ($\chi^2_{(4)}$ = 95.788; $p<0.05$), in favour of the science students.

The study, therefore, concluded that a low percentage (25.7%) of the Senior Secondary School students held correct conceptions of quadratic graph; gender, score level of students and subject combination influenced students' conceptions of quadratic graph in algebra. The implication of this result is that a high proportion of Senior Secondary School students (44.0%) held misconception of quadratic graph in algebra. It was, thus, recommended that teachers should employ innovative teaching strategies that facilitate students' correct conceptions, and remediate their alternative conceptions and misconceptions.

CHAPTER ONE

INTRODUCTION

Background to the Problem

Mathematics can be described as the backbone of other branches of Science, such as Pure, Applied and Social Sciences, Engineering, Agriculture, Medicine, and others. Mathematics is the study of topics such as quantities (numbers), structure, space, and change in quantities. Azuka (2013) viewed mathematics as not only the language of science but an essential nutrient for thought and logical reasoning. It is the spine for all scientific and technological investigations and all activities of human development (Olaleye & Aliyu, 2013).

Adeleke (2013) opined that mathematics is an instrument for problem-solving which plays a major role in understanding and applying concepts in science and technology useful to mankind. Mathematics is the heart of many successful careers and successful lives (National Council of Teachers of Mathematics, 2000). It has been described as a model of thinking, which encourages the learner to observe, reflect and reason logically about a problem and in communicating ideas, making it occupy a central intellectual discipline; it plays a vital role in science, commerce, and technology (Iji, 2008). In the same vein, Salman (2005) conceived Mathematics as a precursor of scientific development and inventions.

Mathematics as a subject deals with measurements, numbers, and quantities. Its knowledge and skills are the bedrock of all societal transformation and transfer of ideas into reality (Abubakar, Wokoma &Afebwame, 2012). Mathematics is a subject required in all fields of life for human survival. Animashaun (2002) reported that the effective and meaningful teaching of the content of Mathematics would provide students with the right mathematical knowledge necessary for successful schooling and its knowledge is also inevitable for human survival in everyday life.

The study of Mathematics occupies a unique position in Nigeria education system. According to Bassey (2010), Mathematics is central to the national curriculum and its roles toward technological and industrial development made it a one of the core subjects at the primary school level, likewise in secondary schools in Nigeria. The Federal Government of Nigeria (FRN, 2013) stated that Mathematics education should equip students with the skills and knowledge that would make them functional members of the society.

Despite the importance of Mathematics in technological advancement of a nation, the persistent high rate of students' poor performance in public Mathematics examinations is of great concern to stakeholders. As Nigeria desires scientific and technological advancement, there is the need for good achievement in Mathematics by students at all levels of education, with specific focus on secondary school from where future leaders are prepared for tertiary education (Aliyu, lawal & Garba, 2013).

Literature reviewed have shown that students' performance in Mathematics at both internal and external examinations are still poor (Agwadah, 2001; Amazigo, 2008). Salman (l998) posited that the outcomes of previous researchers and complaints by examiners of mathematics in the senior secondary school certificate examinations (SSCE) have confirmed that students lack adequate understanding of the concepts involved in Mathematics.

Also, in the research carried out by Salman, Mohammed, Ogunlade and Ayinla (2012) on causes of mass failure in senior school certificate Mathematics examinations, they identified teachers', students' and parents' factors as major causes of students' poor performance in Mathematics. The research findings indicated that 98% of teachers and 76% of students identified laziness on the part of students as a factor responsible for mass failure in senior school certificate mathematics examinations while 97% of teachers and 79% of students indicated students' lack of frequent practice of mathematics questions as another factor responsible for mass failure in Mathematics problems, among others.

Amazigo (2008) and Ige (2001) observed that teachers' failure in engaging learners to develop conceptual understanding of the subject matter content and enhancing problem-solving ability may lead to the continual problem of students' poor performance. In addition, the inappropriate method of teaching by teachers, unavailability of teaching equipment and materials, lack of interest, readiness and problem solving abilities, self-concept and achievement motivation on the part of the learners also lead to poor performance in the subject (Akinsola, l999; Yilgi & Tongjura, 2000; Salman, 2003).

Furthermore, WAEC Chief Examiners' Reports (WAEC, 2013, 2014 & 2015) identified students' weaknesses in algebra as a contributing factor to poor performance of students in mathematics. Algebra is generalised arithmetic that involves the use of letters and symbols to represent quantities. Barton (2013) explained algebra as the use of method of calculation according to a set of established rules to simplify the expression and find a solution to the equation. The algebraic process is one of the themes of senior secondary education curriculum in Nigeria. It is identified with the theory of equations; the Greek Mathematician Diophantus has traditionally been known as the father of algebra. Algebra is the study of mathematical symbols and the rates for manipulating these symbols. It is the unifying trait of almost all forms of mathematics (Kieran, 2007).

Elementary algebra is generally considered to be essential in the study of mathematics, Science or engineering, as well as its applications in medicine and economics. The abstract algebra is a major area in Advanced Mathematics that is studied by professional mathematicians. Elementary algebra differs from arithmetic in terms of abstraction such as using letters to stand for numbers that are either unknown or allowed to take on many values. For example, $x + 2 = 5$, the letter x is unknown but the application of the law of inverse can be explored to find the value of x which is 3. Also, $E = MC^2$, where the letter, E and M are variables and the letter C is a constant. Algebra gives methods for solving the equation and expressing formulas that are much easier than the older method of writing everything out in words. Algebra denotes a specific mathematics structure; the usual structure has an addition, multiplication, subtraction, division and a scalar multiplication.

Algebra and its expression are considered as mathematical language; and are used to describe the relationship between people, thought, elements and structures. Algebra expressions play an important role in mathematics curriculum and mathematics in general; it serves as a way of understanding and making deduction about facts. It helps in the calculation of incomes, loans and bank interest. Also, companies use it for their annual budget calculation including their expenditures. Algebra can also be used to predict the demand of a product and then place order.

Despite the important place of algebra in mathematics and human daily activities, the reports of WAEC Chief Examiners from the period of 2005 to 2016 indicated that weaknesses of candidates were noticed in algebra due to the inability to understand the instructions needed to solve and interpret algebraic word problems and the inability to analyse the rule of BODMAS and its application (WAEC, 2014). Candidates' weakness was traceable to lack of or shallow knowledge of the basic concept, principles and appropriate application of laws, theories and formulae in solving mathematical problem (Cealadina & Yushau, 2007).

In the year 2010, the Chief Examiners' report indicated majority of the candidates attempted the quadratic graph question while those who attempted it were reported to have completed the table of values and drew the graph correctly. However, reading and drawing inferences from the graph posed some problems to candidates. While only a few candidates were reported not to have plotted the points correctly, majority of them were reported not to have determined the required range of values correctly. Finding the roots of the equation $\frac{1}{2}x(x - 6) = 5$ also posed some problems to these candidates.

The question on quadratic graph in the Nov/Dec 20l0 General Certificate in Education was attempted by candidates, majority of them were able to get the values of the given table correctly while the candidates who attempted the question drew the graph correctly. However, the report further stated that candidates' responses indicated that they needed to do more work at interpreting graphs correctly. Determining a point on the graph and using the given scale was poorly handled.

In 2011, the WAEC Chief Examiners' report indicated that majority of the candidates who attempted the quadratic question were able to find the missing values in the given table and correctly plot the graph, but some of them didn't draw the tangent of the curve as required by the question. Hence, they were unable to determine the gradient of the curve. In year 2012, the Chief Examiners reported that the quadratic graph question was reported to be quite popular among the candidates because those who attempted it completed the table of values and drew the required graph. However, reading and answering questions from the graph were poorly handled by majority of the candidates.

In year 2013, The Chief Examiners stated that this question on quadratic graph was also very popular among the candidates. According to the report, majority of the candidates completed the given table and correctly drew the graph, but they found it difficult to read from the graph, as most of the candidates
Could not calculate the required gradient by drawing the appropriate tangent to the curve. In 20l5, The Chief Examiners reported that this question on quadratic graph was popular among the candidates and they performed very well in it. Majority of them were reported to have completed the table of values and plotted the points

correctly. However, some of them did not apply the correct scale and some others could not read from the graph correctly.

The weaknesses observed by the Chief Examiners' Reports may be due to students' misconception of the wording of the questions. Balogun (2010); Abdulraheem (2012); Charles-organ (2014), emphasised on the importance of studies on the conception of students in mathematics and science. Idehen and Omoifo (2016) studied students' misconceptions in algebra. The study showed that students had high rate of right conceptions in the concept of addition, subtraction, and division of a whole. The study identified four significant misconceptions in algebra which are the concept of subtraction operation, zero as a multiplicand, a division of the whole number by fraction, and addition of fraction.

Mangwabnan (2013) assessed the translation of misconceptions inside the classroom. The research is comprised of three parts, which was developed in an 11-page fillip incised questionnaire, analysis of mathematics thinking process of the respondents and identification of the alternative conception or error of the students in translating word problems which lead to incorrect or misconceived answer. The researcher grouped the assimilation error mode by students as a result of Algebraic Translation Error (ALE), Language-Based Errors (LBE) and Relational Symbol Errors (RSE).

Teaching and learning of mathematics require the ability to think and reason. Ausubel (1968) revealed that subsumptive model of learning prior knowledge is used for interpreting the new information to be learned by the learner. The author stated further that meaningful learning takes place as a result of general subsuming concept available in learners' cognitive structure. Also, Ausubel's description of 'advance organiser' placed a great emphasis on concept learning as the central learning task. Piaget and Inheder (1969) that many students view the concept of mathematics, science, and technology as complex. It is true that if students are taught abstract concepts without concrete materials and explanations, there will be no understanding (Foster, 2007). If students understand the mathematical concept, they will be able to solve the problem themselves. According to Hornby (20l0); in Oxford Advanced Learner's Dictionary, conception is the process of forming an idea or a plan. Balogun (20l0) defined conceptions as the viewpoint of an individual in explaining certain events. Conceptions generally refer to individual views or idea about a particular phenomenon in a subject matter.

Novak (2003) and Hewson (2007) opined that the previous idea which students held before attending the classroom could be a factor responsible for their various conceptions. The idea could either be correct conceptions, misconceptions, or alternative conceptions. Correct conception is an idea held by an individual that agree with acceptable scientific ideas or knowledge. Misconceptions are an idea held by an individual that disagrees with acceptable scientific ideas or knowledge. An alternative conception is a term used for describing the idiosyncratic knowledge of the learners. It is not necessarily in conflict with accepted scientific knowledge but has its value, and is therefore not necessarily wrong (Hewson, l981; Hewson, 2007). According to Abimbola (1984), an alternative conception can be used to explain learner's autonomous conceptions of natural phenomena.

Misconception refers to erroneous understanding which occurs with relatively high frequency. Misconception could arise from other factors such as the failure to realise the importance of examining the subject prior concept and the resistance to such conception to be modified by conventional teaching. Also, misconception occurs when input is filler through schemas that are oversimplified, distorted or incorrect. Its effect on students learning showed that misconceived prior knowledge can lead to misconception. Therefore, in view of the above reason; the researcher is interested in the conceptions held by students in algebra.

Researchers are still investigating the relationship between gender and students' academic performance. Research has shown that there is a difference in the academic performance of male and female while other findings showed that sex as a factor had no impact on students' achievement. Also, Salman (2005), Adeniyi (2012) and Akanmu (2013) asserted that gender did not have any significant influence on students' achievement. Also, Halpen (2000) and Keller

(2002) reported that students' achievement in mathematics is in favour of males. Other researchers reported little or no gender difference in students' achievement in mathematics (Voyer, Voyer & Bryden, 1995).

Similarly, students' score level has been considered to influence students' achievement in mathematics. In a study carried out by Yusuf (2004) and Balogun (20l0), it was discovered that students' score level has no influence on students' performance. Olasehinde (2003), in a similar study discovered that students who develop conceptual understanding early perform better on procedural knowledge and are able to perform successfully on near transfer tasks and to develop procedure and skills they had not been taught. The researcher found that students with low level of conceptual understanding need more practice in order to acquire procedural knowledge. Sam-Kayode (2015) also investigated the conceptions of geometry held by senior secondary school mathematics students in Ogun State, Nigeria. 757 senior school II students were involved as sample in the study. Geometry Conception Test (GCT) was used as the instrument for data collection which was analysed using Chi-square. The results of the study showed that the subject combination had no significant difference in the number of students holding various conceptions. Hence, the study examined the conceptions of Algebra held by Senior Secondary School students based on gender, score level and subject combination.

Statement of the Problem

Students’ poor performance in public Mathematics examinations has always been confirmed and reported by West African Examinations Council Chief Examiners’ Reports. This is as evident in the example, the West African Senior Secondary School Certificate Examinations of (2011, 2012, 2013, 2014, 2015 & 2016) Observation reports indicated that candidates usually avoid the questions in algebra or attempts it incorrectly due to inability to understand and interpret the basic concepts in algebra. This misconception was found to be as a result of previous incorrect ideas held by students. Misconception and alternative conceptions were the opinion students held prior to their classroom experience (Abimbola, 1984; Blosser, 1987; Hewson, 1986; Hewson, 2007; Novak, 1987; Novak, 2003).

Egodawatte (2011) conducted a research on the errors committed and students’ misconceptions in algebra. The study was conducted in Toronto and the findings showed that students committed a number of errors in algebra. Some of the errors committed emanated from the misconception’s students held. The main difficulty one was in the area of word problems which was due to lack of proper interpretation of natural language to algebraic language; this led the students to resolve to the use of guessing or trial and error method in solving word problems involving algebra.

Ebendele and Adetunji (2013) carried out a study on symbolic notation and senior secondary school students' achievements in algebra in Ojo Local Education District, Lagos. The study revealed that students showed interest in algebra but still the usefulness of algebra notations are not known to them. The findings of the research indicated that significant difference exist between students with a symbolic notation which occur as a result of inadequate teaching strategies explored by the teachers. Idehen and Omoifo (2016) carried out a study on students' misconception in algebra. The study was conducted in Edo State in Nigeria. The researchers identified students' correct conceptions and misconceptions of six basic algebraic concepts in Mathematics. The study showed that students had correct conceptions of addition, subtraction, and division of whole numbers while significant misconceptions were identified in algebras

Sam-Kayode (2015) carried out a study on the conception of geometry held by senior secondary school students in Ogun State, Nigeria. The study revealed that correct conceptions, misconceptions, and alternative conceptions exist among students and gender influenced students' conceptions. Also, the study showed that there was a significant difference in the number of students who held correct conceptions, misconceptions, and alternative conceptions in geometry based on students' scoring levels and subject combination.

Abdulwali, and Fahad (2012) carried out research on the secondary school students' alternative conceptions about genetics. The aim of the study was to explore secondary school students' alternative conceptions of concepts related to genetics and heredity. The results indicated that students hold many alternative conceptions about concepts related to genetics and heredity, which are; direct and indirect cell division, reduction division, sexual and asexual reproduction, and the process of genetic information transfer.

The results indicated also that there is an overlap in students' understanding of the mechanisms of transferring genetics and heredity characteristics in reproduction and cell division. These types of alternative conceptions have weakened students' ability to express themselves; as a result, such misconception may hinder students' understanding of most biological concepts.

Macson and Chigozirim (2015) researched into students' conceptions and misconceptions in chemical kinetics in Port Harcourt metropolis of Nigeria. The study sample was made up of 107 SS 3 students. Two main instruments were used to collect data for the study; they are the chemical kinetic calculation problem and alternative conceptions test in chemical kinetics. Overall results of the study showed that students' performance in basic chemical kinetics calculation was generally poor with the mean scores less than one point. Item-by-item analyses on the conception test revealed that about 10% of the students identified the correct answers while about 90% could not identify the correct answers.

However, the findings from the cited studies indicated that more studies still need to be carried out on the effect of students' conceptions as related to academic performance. Hence, the present study focused on identifying senior secondary school students' conceptions of algebra with reference to quadratic graph in mathematics. The study explored the influence of gender, score levels and subject combination on senior secondary school students' conceptions of Algebra in Kwara State.

Purpose of the Study

This study identified the conceptions of quadratic graph in algebra held by senior secondary school students in Kwara State, Nigeria. Specifically, the study sought out:

1. the conceptions of senior secondary school students on quadratic graph in algebra;
2. the proportion of senior school students holding correct conceptions, alternative conception and misconceptions of quadratic graph in algebra;
3. if there would be any significant difference between male and female senior secondary school students' conceptions of quadratic graph in algebra;

4. if there would be any significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on score level;
5. if there would be any significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on subject combination.

Research Questions

Answers were sought to the following research questions

1. What are the conceptions of senior secondary school students on quadratic graph in algebra?
2. What proportion of senior school students hold correct conceptions, alternative conceptions and misconceptions of quadratic graph in algebra?
3. Is there is any significant difference between male and female senior secondary school students' conceptions of quadratic graph in algebra?
4. Is there any significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on score levels?
5. Is there any significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on subject combination?

Research Hypotheses

The following research hypotheses were formulated and tested at 0.05 level of Significance

Ho_1: There is no significant difference between male and female senior secondary school students' conceptions of quadratic graph in algebra.

Ho_2: There is no significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on score levels.

Ho_3: There is no significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on subject combination.

Scope of the Study

The scope of the study was restricted to Kwara State, Nigeria. Only the senior secondary school two students II were involved in the study, because they had more time to participate fully in the study without any distraction as they were not be preparing for any external examination. Also, the study focused on the correct, alternative conception and misconceptions held by senior secondary school students in quadratic graph in Mathematics. The study identified the correct conception, alternative conception and misconceptions of quadratic graph in algebra based on students' gender, score levels and subject combination.

The selection of algebra for this study is based on the fact that it is made up of four major mathematical themes being taught in senior secondary school. Similarly, the topics are taught at all levels of education in Nigeria; from the basic level to the tertiary institutions level. Moreover, this is coupled with the fact that the West Africa Examinations Council Chief Examiners' report had identified algebra (especially quadratic graph) as one of the areas where students do perform poorly in external examinations due to misunderstanding and misinterpretations of the question set.

Significance of the Study

It is assumed that the findings of this study would be of benefits to students, teachers, curriculum planners and developers, textbook writers, examination bodies, and educational researchers in the following ways.

The findings of this study would help secondary school students identify their correct conception, alternative conceptions and misconceptions held with respect to algebra. This would help them to identify and realise the wrong ideas they might have acquired from previous lessons.

The results of this study would help mathematics teachers to have in-depth knowledge of misconceptions which students hold about algebra. This would help mathematics teachers to employ more effective teaching methods such as linking the previous acquired knowledge with the new knowledge to be acquired.

The findings of this study would also encourage teachers to adopt new innovative teaching strategies and appropriate measures that will make the concept of algebra and mathematics in general easy for students to understand.

In a similar vein, curriculum planners and developers should also be guided through the findings of this study to identify students' misconceptions in algebra, taking cognizance of the necessary corrections.

Findings from this study shall also be beneficial to examination and educational regulatory bodies such as the West African Examinations Council (WAEC), the National Examinations Council (NECO), the National Business and Technical Examinations Board (NABTEB), and the Joint Admissions and Matriculation Board (JAMB) so as to guide them against ambiguity which may lead to misconceptions in their prepared questions.

The result of this study shall also be helpful to professional educational bodies such as the Science Teachers' Association of Nigeria (STAN) and Mathematical Association of Nigeria (MAN); that will organize trainings/workshops for teachers; to update the teachers' knowledge by exposing them to correct conception and misconceptions of algebra held by students.

Educational Researchers would also find the results of the study as a source of relevant literature in the field of mathematics education.it would also encourage researcher to replicate the study with other variable based on conceptions

Clarification of Major Terms and Variables

For the purpose of this study, the following major terms and variables are operationally defined as follows:

Concept: the meaning that is assigned to a given symbol, which could be a word or group of words

Correct Conception: students' correct idea about quadratic graphs in algebra

Misconception: wrong idea about quadratic graphs in algebra

Alternative Conceptions: Students' ideas about quadratic graphs in algebra which are not completely wrong but not strictly following the accepted standard working patterns.

Algebra: a branch of Mathematics in which letters and other general symbols are used to represent numbers and quantities in formulae and equations.

Score level: the scoring range of students' terminal mathematics examinations results obtained from the selected schools for the study

High Score level: these are score from 60% and above in their terminal examinations

Medium Score level: these are score between 40% and 59% in their terminal examinations

Low Score level: these are score between 39% and below in their terminal examinations

Gender: male and female students who participated in this study.

Subject combination: these are the senior school subjects that is used to stratify students into Science, Commercial, and Art.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter discusses the related literature reviewed under the following subheadings:

Theoretical Framework for the Study

Objectives and Content of the Senior School Mathematics Curriculum

Concept of Algebra in Mathematics

Empirical Studies on Conceptions of Algebra in Mathematics

Empirical Studies on Gender and Students' Conceptions

Studies on Influence of Score Level and Students' Conceptions

Studies on Influence of Subject Combination and Students' Conception

Appraisal of the Reviewed Literature

Theoretical Framework for the Study

The theoretical framework of a study is the structure that holds and supports the theory of a research work. It serves as the lens that a researcher uses to examine a particular aspect of his or her subject field. In other words, it elucidates the rationale, justification or basis for the study (Khan, n.d.). The nature and function of a theoretical framework can be seen as an attempt to answer two basic questions of: (l) what is the problem that the researcher set out to investigate and answer? (2) What is the specific approach or a realistic or feasible solution to the problem?

The answers to these questions normally stem from the use of a number of sources which are outlined or discussed in a literature review and form a critical part of one's research proposal or study and theoretical framework (Ziedler, 2007).

Cognitive Science and the Philosophy of Science theories of human behavior in teaching and learning are the theories used in this study. Cognitive scientists within science education have variously acknowledged the submissions of Jean Piaget, Van Hiele, David Ausubel and Robert Gagne, among others. The researchers submitted that meaningful learning can only take place when there is a synergy between the prior experience and the new knowledge to be acquired (Novak, 1987)

Gagne (1965) Concepts of Learning could be divided into two main categories as concrete and abstract concepts. The Concrete concepts are learnt starting from the beginning of life of an individual, while abstract concepts are taught by others. The author identified the appropriate sequence of instructions that promote successful learning to include the manipulation of events such as gaining attention, informing learners of objectives and providing guidance. When these events are coupled with the appropriate external conditions of learning, they stimulate the presumed internal process in short-term and long-term memory and cause learning to occur. It is based on the fact that meaningfulness of instructions can be gotten through hierarchical processes of learning from concrete to abstract that entails teaching from simple concepts to complex ones. The present study is, therefore, re based on Robert Gagne’s theory because if there exists misconception of ideas in the mind of students, it will be difficult for a meaningful learning to take place.

The idea of David Ausubel on the role of previous knowledge in learning was considered suitable for this study. According to Ausubel (1968), meaningful learning involves the acquisition of new knowledge whereby the previous experience is relevant to the new one such that a general subsuming concept is already available in the learner’s cognitive structure.

Constructivist model is of the view that, learners are most likely to change their misconceptions and alternative conceptions when there is a conceptual change in the learners minds (Glasersfeld, 1989). Blosser (1987) explained that the conception of students on a particular concept is very much affected by their prior knowledge and experiences. Novak (1987) and Novak (2003) viewed conception as a stage where a learner reaches to obtain meaningful learning. This involves the understanding of the concepts or ideas of that particular field of study based the learner’s experience in previous knowledge.

Conception refers to a broad view or outlook one has about something. Hornby (2010) define conception as the process of forming an idea or a plan. Furthermore, Balogun(2010) described conception as a body of beliefs held by an individual in explaining certain events. This is the formation of a general idea representing the common elements or attributes of a group or class. However, prior ideas brought into the classroom can either be said to be correct conceptions, misconceptions or alternative conceptions. Correct conceptions are ideas held by individuals that agree with accepted scientific ideas or knowledge (Abimbola, 1984). An alternative conception is a term used for describing the idiosyncratic knowledge of the learners. It is not necessarily in conflict with accepted scientific knowledge but has its value and is therefore not necessarily wrong (Hewson, 1981; Hewson, 2007). According to Abimbola (1984), an alternative conception is used to describe learner's autonomous conceptions of natural phenomena. In a study by Abimbola (1986) on the alternative conceptions of human respiration held by selected form four students in Osogbo. The study involved 27 (twenty-seven) students between the ages of l5 and 2l years and, interview method was used before and after instruction to find out their conceptions about respiration. The findings revealed many alternative conceptions before and after the instruction.

Considering the role of conceptions in learning, teachers need to help students to overcome their misconceptions and alternative conceptions in learning. Okebukola (2002) stated that students need to confront their previous ideas whether they are misconceptions or alternative conceptions, along their associated paradoxes and limitations. For students to understand the scientific knowledge and models presented to them, it is necessary for them to restructure their minds to learn meaningfully. Olenick (2008) outlined some steps that teachers must take in managing misconceptions and alternative conceptions in learning. These are:

l. Recognize that misconceptions and alternative conceptions exist;

2. Providing methods of identifying students' misconceptions and alternative

conceptions on a topic through demonstrations, questions and relevant examples;

3. Helping students to reconstruct and internalize their knowledge based on scientific models thereby fostering the correction of the misconceptions and alternative conceptions with new correct conceptions; and

4. Re-evaluating students' understandings by posting conceptual Questions relevant to their level.

Several theories, models and ideas have been propounded on the conceptions of learning. Meanwhile, prominent among the theories is social constructivism. Social constructivism has its roots in constructivism. Constructivism refers to individuals actively engaged in building their own knowledge (Goldin, l990). The process of knowledge building involves making meaning from experiences in terms of existing knowledge (Cobb, Wood, &Yackel, l990). In particular; students individually construct their patterns of reasoning which lead to the actions they take. So, in learning Mathematics, learners relate known patterns to new ones and also build knowledge on it (Hiebert& Carpenter, 1992). Social constructivism recognises that individuals do not exist in isolation but learn within a social setting in which understanding is co-constructed with others (Franke, Kazemi, & Battey, 2007). Each individual's present knowledge is a potential springboard to move to higher rungs of knowledge acquisition and with assistance, this is achievable (Vygotsky, 1978).

Also, it is in the process of communicating and interacting using mathematical terms and words that mathematical concepts are learnt in order to make learning occurs (Campbell, Adams, & Davis, 2007; Lim & Presmeg, 2011; Setati, Chitera, &Essien, 2009). Therefore, in a constructivist classroom, a Mathematics teacher does not focus primarily on the correctness of an answer but on the processes followed by each learner before arriving at it (Beswick, 2007; Hensberry & Jacobbe, 2012).

Newman's (1983a, & b) notion of performance strategies also rests on this belief, such as because the solution to a problem involves a series of stages, forming a pattern that each student builds on as they decide on a pathway to follow in solving problems. Sociocultural theory emphasizes that individuals do not exist in isolation but must interact within communities. As individuals grow up within a community of practice, they are introduced to established ways or patterns of working, and to the communal language of the discipline (Cobb, 1994). Social theorists draw on Leont'ev's and Vygotsky's works and believe that an individual develops his reasoning in line with the patterns of the society (Cobb, 2007).

Students receive social assistance (van Oers, 2000) as complex ideas and solutions to the problems are constructed on the social plane of the classroom and are made available for each individual to internalize and construct knowledge. This highlights the importance of collaboration in the learning of Mathematics. Mathematics is also described as a cultural activity because it uses its own language as a cultural tool for communication (Cobb, 2000). The language has its own vocabulary, representations and symbols. Pape and Tchoshanov (2001) asserted that representation is inherently a social activity. Students come to understand both the process of representation and its products through social activity. Therefore, thinking occurs both internally by the individual, and externally in a verbal form.

Students' engagement in Mathematics learning in the classroom creates opportunities for knowledge building and initiation into cultural practices of the mathematical community (Cobb, 1994). Campbell, Adams and Davis (2007) model in Figure 2.1 illustrates the relationships and interactions that occur in the Mathematics classroom. It seeks coordination between the world of the student learning Mathematics and that of the teacher teaching Mathematics. Both parties bring to the class perceptions of each other, the classroom environment, language and culture, Mathematics, their experiences and knowledge (Shirley, 200l).

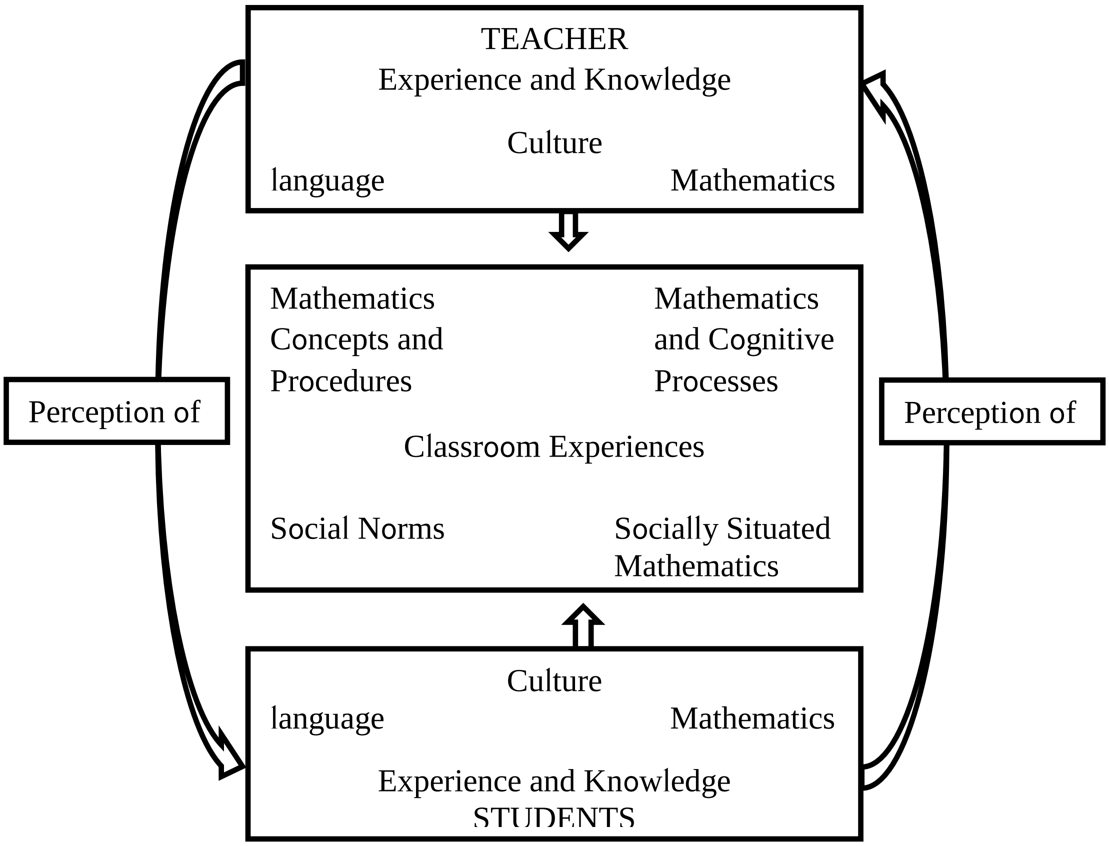


Figure l: Mathematics Classroom Interaction. (Campbell et al., 2007).

These two theories formed the framework on which this research took place. Learning algebra involves many cognitive activities so as to successfully learn and solve problems. These activities can be grouped as: generalised which involves patterns; procedural which involves expressions; relational which uses varying quantities, and structural which uses structural objects (Usiskin, 1999). Kieran (1981and 2007) classified this into three stages: the generational, transformational and the global/meta stages.

The generational stage represents an understanding of algebra as arithmetic that is generalised, in that it uses mathematical language and variables with expressions and functions. The transformation stage consists of understanding algebra as involving representations, identities, equivalence, axioms and properties. The global/meta stage applies the understanding of algebra as a tool to solve real life situations which may not be directly mathematical. These processes in algebra are all important as algebraic reasoning develops.

This study employs Kieran's classifications, focusing mostly on the generational stage but with some references to the transformational stage since the study involves algebra. Algebra is taught in schools as generalised arithmetic and involves a move from the realm of specifics in numbers to the realm of the unknown in letters. The trend in International Mathematics and Science Study Report for the 2011 survey identified that algebra generally presented the most difficult content for Grade 8 students and that they only demonstrated a 37% facility in this area (TIMSS, 2012). Studies showed that this transition is difficult because of the need to use variables, most often seen as letters, in arithmetical operations (Goldin, 2008; Herscovics&linchevski, 1994; linchevski&Herscovics, 1996).

In using both letters and numbers in a given question, a student has to process cognitively at different levels. First, the student must move from the representational format of the question to another format that is generated by the individual for use in solving the problem. A student must be able to interpret, construct and operate effectively use the two representational formats (Pape &Tchoshanov, 200l). This is followed by the need for the use of computations and arithmetic skills on the generated format so as to arrive at a solution (Davis & Maher, 1990and Reed, 1999). The question form and type of solution needed, which might be in words, tables, graphs, symbols or diagrams, determines how representational shifts would be involved.

Schoenfeld (2008) defined the process of algebraic thinking as a particular form of mathematical sense making related to symbolisation while Kieran (1992) described the situation students' encounter as follows: thus, the cognitive demands placed on algebra students include, on the one hand, treating symbolic representations which have little or no semantic content, as mathematical objects and operating upon these objects with processes that do not yield numerical solutions, and, on the other hand, modifying their former interpretations of certain symbols and beginning to represent the relationships of word–problem situations with operations that are often the inverses of those that they used almost automatically for solving similar problems in arithmetic.

The likely thinking patterns of students when trying to solve algebraic problems need to be understood by their teachers. Students may select visible data in the question and perform mathematical operations on them without recourse to the problem context (Palm, 2008). It is important that as cognitive processing goes on, the student should have a proper understanding of the concepts involved.

Word problems written in sentences, also known as verbal problems, serve as an introduction to algebra. Verschaffel, Greer and De Corte (2000) defined word problem as the verbal descriptions of problem situations where in one or more questions are raised, the answer to which can be obtained by the application of mathematical operations to numerical data available in the problem statement. They are important for developing and understanding of algebra, even though students often find algebra word problems difficult (Kieran, 2007; Reed, l999).

Solving word problems requires the abilities to read, interpret and transform the stated words within their context into a symbolic form, before embarking on a search for manipulative or computational strategies (Newman, 1983a; Oviedo, 2005; Pimm, l991). The change of representational form requires the knowledge of the language text; mathematical language and mathematical knowledge (Adetula, 1989; Ormond, 2000; Oviedo, 2005). Word problems are valuable for investigating both language difficulty and conceptual understanding (Newman, l983a; Reed, l999). The level of proficiency in the text language and the language of communication may also affect students' performance in word problems, especially in the case of bilingual and multilingual students (Adetula, l990;

Clarkson, 1991a; Ni Riordai& O'Donoghue, 2009). This is of particular importance to the Nigerian context. In the Mathematics classroom, many bilinguals and multilinguals may experience difficulty in understanding the lesson when the language of instruction is not their first language and the students are not proficient in it (Setati, Chitera & Essien, 2009).

Several teaching strategies have been suggested by researchers. These include explicit instruction about the differences in the everyday and mathematical meaning of the same word, a limit on the number of new words in a lesson, student collaboration, encourage students' use of new words mathematically within real-life contexts, and the use of multiple representation (Kersaint et al., 2009; oviedo, 2005). Language-based approaches provide prompts to facilitate students' development of literacy in Mathematics and subsequently increase their word problem-solving ability. Krebs (2005) stated that much is learnt by and about students from an incomplete or incorrect solution. Booth (1984) reported that in on mathematical tasks given to over 3,500 students aged 13 to 15 years in U.K. on a task that requested students to 'add 4 on to 3n', only 45% of the sampled students and 22% of those aged 13 years obtained the correct answer of 3n + 4. Others gave answers like 3n4, 7n and 12, which indicate a transfer of arithmetic operations with numbers into algebra that uses both numbers and letters. In another study, on the question “add 5 to 3n”, only 38% of students aged 12 years correctly answered 3n + 5 and 17% wrote 8n (Ryan & Williams, 2007).

It is also argued that word problems framed using real-life contexts and situations enabled students to first focus on understanding the question (Chapman, 2006; Palm, 2008; Verschaffel, Greer & De Corte, 2000). However, class observations have evidenced a prevalent practice that word problems are all about algorithms and that teaching is mainly about the mathematical structures in the questions, irrespective of the context of the question (Chapman, 2006; Depaepe, De Corte, &Verschaffel, 2010; Rosales et al., (2012). Algebraic reasoning depends on the understanding of a number of key ideas, of which equivalence and variable are, arguably, two of the most fundamental (Knuth, Alibali, McNeil, Weinberg, & Stephens, 2005).

For students to forge ahead there has to be a connection between what they already know and the correct ways in which these patterns are used. Limited knowledge of arithmetic operations impacts negatively on students’ facility with algebra even beyond the middle school grade levels. When students are unable to correctly conceive new concepts, it might lead to misconceptions and mistakes in algebra problem-solving (Russell, o'Dwyer, & Miranda, 2009; Welder, 2012).

Objectives and Content of the Senior Secondary School Mathematics Curriculum

Mathematics is a logical development which is made up of undefined terms, principles of logic, hypotheses, and logical conclusions that follow from the Hypotheses (Fajemidagba & Adegoke, 2008). Salman (2005) viewed Mathematics as an indispensable tool in the study of sciences, humanities and technology that man uses directly or indirectly in his everyday life. It is used in such areas like measurement of clothing materials, parts of the body, determining speed, distance and time, cutting planks, calculating angles and sides and so on.

Curriculum has been defined as a written statement of educational experience which the school proposes to provide or create for children (Lucas & Chisman, 1973). The aims, materials, procedures of such experiences, and students' activities are outlined in the school curriculum, subject-by-subject, and they are often incorporated into instructional strategies (Benedict, 1993). Curriculum is a key factor in the teaching and learning of Mathematics. It has to do with what is to be learnt, who is to learn and when or at what level it is to be learnt.

According to Alade (2011), curriculum is the medium through which educational institutions seek to translate societal values into concrete reality. The school curriculum is a dynamic and an open document that is constantly changing with the needs and aspirations of the society. The school curriculum of any nation is drawn to achieve a fulfillment of the philosophy of education of the nation and directly linked with the needs of the country. However, the quantity of the education system of a country depends significantly on the quality of its curriculum. According to Rowntree (1974); Curriculum is an academic endeavour that needs continuous revision which involves looking at the objectives to ensure that they are relevant to the needs of the learners and the society at large. The contents of the Curriculum are organised in a spiral form, that is, sections of the curriculum occur every year in order to aid learning and also, give ample opportunity for laboratory activities and discussions are stipulated in the curriculum (Daramola & Omosewo, 2012).

Mathematics curriculum, therefore represents the total learning experiences which learners must acquire. These are: topics, performance objectives, contents, activities of teachers and learners, teaching and learning resources and evaluation guide. The prescriptions represent the content to be taught in the schools in order to achieve the objectives of the Basic Education Programme (NERDC, 2009).

In the current 9-3-4 system of education, Mathematics is compulsory for every learner at the primary and secondary school levels. It is greatly emphasized in the curriculum as one of the core subjects.

The core subjects are the group of subjects which every pupil must take in addition to his or her “specialties”. According to the Federal Republic of Nigeria (FRN, 2013), the core subjects are basic subjects which would enable students to offer arts or science in higher educational institutions. The importance of Mathematics is stressed in the National Policy on Education (FRN, 2013) as one of the core subjects aimed at broadening learners’ horizon and outlook. Hence, there is a need for the use of effective strategies in the delivery of Mathematics curriculum to bring about the following:

i. thorough understanding and proper mastery of mathematical concepts;
ii. bring out a significant increase in retentive ability; and
iii. facilitate and enhance the achievement of curriculum objectives (FRN, 2004).

To enable students to cope confidently with Mathematics need in their future studies, work place or daily life in a technologically changing society, the Curriculum Committee of Wholeben (1984), highlighted that the Mathematics curriculum should aim at helping the learners in their:

a. ability to conceptualise, inquire, reason and communicate mathematically, and use Mathematics to formulate and solve problems in daily life as well as in mathematical contexts;
b. ability to manipulate numbers, symbols and other mathematical objects;

c. number sense, symbols sense, spatial sense and a sense of measurement as well as the capability in appreciating structure and patterns; and

d. positive attitude towards Mathematics and the capability in appreciating the aesthetic nature and cultural aspect of Mathematics.

The secondary school Mathematics curriculum focuses on three areas of learning, namely: knowledge, skill and attitude (McCarthy, 1988). The three areas as collaborated by the Curriculum Development Committee (Woleben, 1984); are given below:

A. Knowledge Area: This induces children to understand and grasp the knowledge of the following:

i. the directed numbers and the real number system;

ii. the algebraic symbols to describe relations among quantities and number patterns;

iii. equations, inequalities, identities, formulas and functions;

iv. measures for simple 2-D and 3-D figures;

v. The intuitive, deductive and analytic approach to the study of geometric figures;

vi. the trigonometric ratios and functions;

vii. the statistical methods and statistical measures;

viii. the simple ideas of probability and laws of probability;

B. Skill Area: The skill area develops the following skills and capabilities of learners in:

i. basic computers, in real numbers and symbols, and ability to judge results reasonably;

ii. using the mathematical language to communicate ideas;

iii. reasoning mathematically, i.e. they should conjecture test and build arguments about the validity of a proposition;

iv. applying mathematical knowledge to solve a variety of problems;

v. handling data and generating information;

vi. number sense and spatial sense;

vii. using modern technology appropriately to learn and work Mathematics;

viii. learning Mathematics independently and collaboratively for the whole life;

C. Attitude Area: Attitude area develops the attitude of learners to:

i. be interested in learning Mathematics;

ii. be confident in their abilities to work Mathematics;

iii. willingly apply mathematical knowledge;

iv. appreciate that Mathematics is a dynamic field with its roots in many cultures;

v. appreciate the precise and aesthetic aspects of Mathematics;

vi. appreciate the role of Mathematics in human affairs;

vii. be willing to persist in solving problems;

viii. be willing to work cooperatively with people and to value the contribution of others.

The goal of Mathematics teaching and learning at the secondary school level in Nigeria as submitted by the Mathematical Association of Nigeria at a conference held in Benin between January 6th and 7th, 1977 are as follows:

i. to generate interest in Mathematics;

ii. to provide a solid foundation for everyday living;

iii. to develop computational skill;

iv. to foster the desire and ability to a degree relevant to the problem at hand;

v. to develop the ability to recognize problems and to solve them with related Mathematical knowledge;

vi. to develop precise, logical and abstract thinking; and

vii. to encourage creativity

Looking at the content of the secondary school Mathematics curriculum and the emphasis placed on its importance in the National Policy on Education (FRN 2013), there is the need for any focused and serious minded community that wants to attain speedy growth and development to source for the best strategy of passing across mathematical knowledge to the community members especially the younger ones. This is because without Mathematics, there is no science; without science, there is no technological development; and without technology, there is no modern society (Okebukola, 2002).

In the curriculum in use, the use of computer to solve simple mathematical calculations are introduced as this will enhance the competency of students both at the junior and senior school levels and in various vocations they will pursue at tertiary levels (NERDC, 2009). It is hoped that the topics will give the students the opportunity to cultivate, understand and apply Mathematics skills and concepts necessary to thrive in the ever changing technological world. It will also make students become prepared for further studies in Mathematics and other related fields.

Some of the aims and objectives of teaching Mathematics at the secondary school level during this period are:

a. to encourage the application of the knowledge of Mathematics to solve life problems;
b. to inculcate the habit of logical thinking in students;
c. that learners should be able to relate the subject to other fields of study;
d. to lay the foundation for further work in Mathematics; and

e. to reveal Mathematics as a basis for culture and learning.

The new senior secondary school Mathematics curriculum, i.e. the post basic education Mathematics was prepared in July, 2007 at the writing workshop for the revision of senior secondary school curricula organised by the Nigerian Educational Research and Development Council (NERDC).The new curriculum took into consideration the United Nations Millennium Development Goals (MDGs). The new curriculum is thematic in approach like the old curriculum. It has seven columns consisting of topics, performance objectives, contents, teaching and learning activities, learning materials as well as evaluation.

The contents of the old curriculum (1985) was infused with elements of the capital market studies, which carefully structured, resulted in the removal of obsolete topics and addition of modern topics that are relevant to the global world. The team that prepared the new curriculum made efforts to ensure that topics that will improve the mathematical competency of Nigerian children as well as prepare them for further and tertiary education are included. In view of the fact that development of entrepreneurial skills is being promoted in Nigeria, the new curriculum emphasized investment, stocks, shares and other mathematical topics that will enhance capital market skills.

The computerized nature of the global world has led to the intensification of the use of computer in teaching many of the topics in Mathematics. Hence, a lot of computer assisted instructional materials including scientific calculators are recommended for the teaching of various topics. The new curriculum also added few introductory topics in logic, matrices, modular arithmetic and simple calculus which are hitherto restricted to Further Mathematics; but which will enhance the competency of students in various vocations they will purse at tertiary levels. This curriculum also accommodates the need of students in the commercial and technical subject areas.

The themes have changed from the six-pronged approach to a five-pronged approach as follows:

1. Number and Numeration: New topics added are modular arithmetic, determinants and arithmetic of commerce, matrices, rates, value added tax etc,
2. Algebraic Processes: New topic added is logical reasoning
3. Geometry which is now an embodiment of plane geometry, co-ordinate geometry, menstruation and trigonometry: new topic added is coordinate geometry
4. Statistics

5. Introductory Calculus which focuses mainly on differentiation and integration of algebraic expressions. It is hoped that these topics will pave way for the exposure of the students to calculus in future studies.

Considering the spiral nature of the curriculum, it is strongly recommended that the treatment of the theme should be preceded by a review of the contents of the same theme at the lower class levels. For instance, to treat the content of Number and Numeration in SS 2, the teacher is advised to lead the students to review the content of number and numeration in SS l. The curriculum is further broke down into four major themes for SS I to SS III as follows:

Table l:

Senior Secondary School Mathematics Curriculum Breakdown

Year	**Theme**	**Topic**
SS I	1. Number and Numeration	Indices and Logarithms, Set
	2. Algebraic Process	Quadratic Equations
		Graphical Representation of Quadratic Equation
	3. Geometry	Plane Geometry
		Mensuration
		Trigonometry
	4. Statistics	Data presentation: Tallying
		Graphical presentation of data
SS II	1. Number and Numeration	Indices and Logarithm

			Number Approximation Error Estimation Progression and Regression
	2.	Algebraic Process	Quadratic Equations Inequalities
	3.	Geometry	Plane Geometry Trigonometry
	4.	Statistics	Group Data Presentation Measures of Central Tendency and Dispersion for Ungrouped and Grouped Data Probability
SS III	1.	Number and Numeration	Laws of Logarithm and Application, Matrices, Number Bases other than lo, Modular Arithmetic, Variation, Surds
	2.	Algebraic Process	Linear Equations Quadratic Equation and Application Algebraic Fractions
	3.	Geometry	Menstruation: Multiple Dimensional Objects Trigonometry Coordinate Geometry
	4.	Introductory Calculators	Differentiation of Polynomial Integration of Polynomial

The breakdown of Mathematics curriculum into themes shows that algebraic process is a major concept of Mathematics that students need to learn at senior secondary school level of education in Nigeria.

Concepts of Algebra in Mathematics

Algebra is one of the broad branches of Mathematics including number theory, geometry and analysis. In its most general form, Algebra is the study of mathematical symbols and the rules for manipulating the symbols; it is a unifying thread of almost all aspects of Mathematics. It includes everything from elementary equation solving to the study of abstractions such as groups, rings, and fields.

Historically, and in current teaching, the study of algebra started with the solving of equations such as the quadratic equation especially linear equation. Then, more general questions, such as "does an equation have a solution?", "how many solutions does an equation have?", "what can be said about the nature of the solutions?" are considered. These questions led to ideas of form, structure and symmetry. This development permitted algebra to be extended to consider non-numerical objects, such as vectors, matrices, and polynomials. The structural properties of these non-numerical objects are then abstracted to define algebraic structures such as groups, rings, and fields.

Algebra is an important domain in Mathematics and it is fundamental for mathematical proficiency. Algebra is defined as the domain consisting of operating on and with the letters, transformation of expressions with letters, formal and generalised understanding of rules and properties of operations, and using the letter for representing, proving and generalising (Banerjee & Subramaniam, 2012). Previously, Algebra involved the use of alphabets known as letters or literal symbols to mainly represent the unknown, but mathematical developments have led to its use to represent the known, allowing for generalizations of both the known and unknown (Kieran,1992). For example, if one need to find the value of

5h, and h = 2, then 5h = 10, but if h = 0.4, then 5h = 2; so h is a variable that can take on any value assigned to it. Similarly if z = 4 + p, then it follows that as the value of p changes, the value of z will also change. This notion of algebra moves away from just a representation of the unknown to generalizations of patterns and is defined by Kieran (1992) to be the branch of Mathematics that deals with symbolizing general numerical relationships and mathematical structures and with operating on these structures. Algebra has been described as the gateway to higher Mathematics (Kaput, 1999; Stacey, 2004); so, the failure to understand algebra affects its application, which is needed in other areas of Mathematics (Goos, Stillman& Vale, 2007).

The use of principles and generalisations in Mathematics makes the knowledge of algebra fundamental for success. As a result of its various uses; various definitions exist. However, for this study, which is situated in algebra, which is on the introductory and early aspects of algebra taught in the first few years of the senior secondary school, it will be viewed mainly as generalised arithmetic (Kieran, 1992). Students are introduced to the use of the algebraic letter to solve questions given in symbolic form and word problems which are, mathematical questions written in literal form, in other words, mathematical sentences (Stacey & MacGregor, 1997).

In Nigeria, Algebra is taught under the theme of algebraic processes and is offered at both the junior and senior secondary school level. In Algebra, concepts of the variable, expressions, equality, graphs and functions are necessary but the literature has established that students often have misconceptions about them (Kieran, 1981; Küchemann, 1981; MacGregor& Stacey, 1993b; Perso, 1993; Sfard, 1991). These misconceptions have been linked to the difficulties that students experience as they transit from arithmetic to algebra. While Herscovics and linchevski (1994) described the ensuing state as a cognitive gap, Goldin (2008) called it a cognitive obstacle existing in the transition process. These difficulties translate into students committing various errors, identifiable through error analysis protocols. Newman (1983) identified five performance strategies that have been found to be useful when solving mathematical questions. These steps are: reading recognition, comprehension, transformation, process skills and encoding.

White (2005) reported the use of these steps in a professional development workshop for primary school teachers in Brunei. The Newman strategies allowed the teachers to identify students' processing errors which in turn would help teachers provide proper remediation. Difficulties in Algebra may arise from the generalisations involved and the use of letters which, in algebra, differ from the everyday use that students know. For example, in Stacey and MacGregor's (1997) study, tasks were given to over 2,000 Australian students aged 11 to 15 years. In one of the tasks, the students were told that David is l0cm taller than Con and Con is h cm tall. Students were asked what they could write as David's height.

Answers given included: l8 (taking h as the eighth letter and computing 10 + 8), 10h, h10, h = h + 10 and 11. Their study reported misconceptions by students such as, using letters as labels for objects, using sums as products and giving solutions that did not reflect an understanding of the use of equality. With these tendencies, it is no wonder that students experience difficulties in algebra and Mathematics in general. As a result, students' general interest and attitude to the subject is poor.

However, teachers also have a role to play in reducing the occurrences of algebraic misconceptions. Teachers' methods of teaching and beliefs affect students' learning. Mathematics and the Sciences are closely linked, and Science teaching in Nigeria is largely teacher-centred and traditional in approach (Benjamin, 2004). It has been noted that the quality of teaching and learning science is compromised by students' poor background knowledge of Mathematics (ogunmade, 2005).

Empirical Studies on Students' Conceptions of Algebra in Mathematics

Algebra consists of the important and fundamental mathematical concepts of variables, expressions, equality, functions and graphs (Goos et al., 2007; Knuth et al., 2005; Nathan &Koellner, 2007; Schoenfeld&Arcavi, 1999; Sfard, 1991). The first three of these are the initial concepts introduced to students.

On misconceptions about the variables; studies have shown that students have misconceptions about variables. A variable is a quantity that can have varying values and is represented with an alphabetical letter (Goos et al., 2007). The letter can take on different roles depending on the context of the problem at hand (Ely & Adams, 2012; Usiskin, 1999). The different uses of a letter as a variable implies that the quantity it represents may or may not vary. It may be a single letter; a combination of letters and operations, or an abstract number of things (linchevski & Herscovics, 1996; Philipp &Schappelle, 1999; Usiskin, 1999).

The letter can represent a unique unknown value like $x + 8 = 19$; have a varying quantity (ies) in an observed general expression like $2m + 3$ or the final answer of an operation like $3x + 5y$; represent varying quantities that vary and used to show relationships of two sides like $2f + 4 = 7d$. Ely and Adams (2012) asserted that two important practices required for the developed idea of variables are (a) the use of a letter to stand for any set of indeterminate quantities, not just a single unknown; and (b) the representation and quantification of the way one quantity changes with respect to another. This implies that students have to go beyond ‘seeing’ the letter as an unknown value to its use as a placeholder and its ability to take on varying values.

Ryan and Williams (2007) noted that these various meanings and uses of the algebraic letters are a source of difficulty for many who are beginning to learn algebra and that they may bring about misconceptions based on students' misinterpretation. These misconceptions are identified below:

i. a letter is an object/label (Booth, 1984; Küchemann, l98l; MacGregor& Stacey, 1993b; Wagner, 1999);

ii. a letter is a word so it cannot be used/ ignored (Küchemann, 1981; Perso, 1993);

iii. a letter has a fixed value from its alphabetical position (MacGregor& Stacey, 1993b; Watson, 1980);

iv. a stand/alone letter has a fixed value of l (Perso, 1993; Stacey & MacGregor, 1997);

v. a letter has a fixed/ specific known number (Knuth et al., 2005; Küchemann, 1981);

vi. letters have place values (Booth, 1984); and

vii. different letters cannot have the same value (Booth,1984; MacGregor& Stacey, 1993b; Perso, 1993).

Understanding the concept of equality is challenging to many students. Students enter the secondary school with the belief that the equal sign means they should write the final answer after completing necessary operations (Kieran, 1992), or the belief that it is a link to the next operation (Stacey & MacGregor, 1997). An equation is “any algebraic expression of equality containing a letter (or letters)” (Herscovics & Kieran, 1999). Students write the letter in the equation as the subject (stand-alone) or engage in guess work using specific values (Egodawatte, 2011; Kieran, 1992).

Many students seem to have more of an operational view of the equal sign rather than a relational view (Knuth et al., 2005). 56% of Grade 7 students’ definitions of the equal sign were variations of the sign asking them to perform an operation, in contrast to the 36% who saw the sign as some form of equivalence. However, students’ relational view of the equal sign improved from Grades 6 to Grade 8. This relational view is essential to understand that the transformations performed in the process of solving an equation preserve the equivalence relation – an idea many students find difficult, and that is not an explicit focus of typical instruction. The misinterpretation of the equal sign continues beyond the middle grades for some students (Egodawatte, 2011). Since word problems are literal, translations are sometimes done directly from the left to the right, leading to the formation of wrong symbolic notations and errors including situations involving inverse operations (Kieran, 1992; Reed, 1999).

Clement (1982) gave 150 first year engineering students some questions to write in algebraic notation. Write an equation using the variables S and P to represent the following statement: There are six times as many students as professors in this university. Use S for the number of students and P for the number of professors.

Only 63% of the students wrote the answer correctly while the rest answered incorrectly with 6S = P. The students had read and translated into numbers and letters literally without regard to the reversal in-built in the question (Clement, 1982). One of the reasons why the students made this error was that in their minds, they rightly ‘saw’ the quantities of the two objects but were unable to establish their equivalence, S=6P. This is known as ‘static comparison’ (Clement, 1982).

High proportions of students using the letter as a label or having reversal errors on the same question have since then been identified. The use of mathematical terms and language may bring about misconceptions of operations that need to be performed. In the course of translation, sum and product are often misinterpreted, which may lead to also reversal errors (Reed, 1999). MacGregor and Stacey (1993) found that only 35% of the 28l Year 9 students sampled could use symbols to represent the sentence “ the number y is eight times the number z” with many writing it as z = 8y instead of y = 8z. Also, less than 30% could correctly write “s t” as many wrote t = s + 8 instead of s = t + 8. There was also an association of y with the number 8 while z and t became the subjects of the equation. Some students may wrongly generate expressions or inequalities as answers to word problems which rightly require construction of equations. These errors were named as “lack of equation” and “inequation” (MacGregor, 1991). Writing algebra involves using or interpreting the letter within a particular context without any extra meanings being read into it (Ormond, 2000).

Idehen and Omoifo (20l6) carried out a research study on students’ misconceptions in algebra in Edo State, Nigeria. The study was designed to identify students’ correct conception and misconceptions of six basic Algebraic concepts in Mathematics. The survey design was used to select 4332 students from 114 senior secondary school s in Edo State. Frequency counts and simple percentages were used to analyze data and answer the three research Questions raised. Results showed that students had high correct conception in the concepts of addition, subtraction and division of whole numbers.

Furthermore , four significant misconceptions were identified in Algebra ((i) Using number line to perform the operation of subtraction of two whole numbers connotes addition; (ii) “3 ÷ ¼ = ¾”, means dividing the whole number by the denominator of the fraction when the numerator of the divisor is 1; (iii) ½ + ¼ = 2/6, means ½ + ¼ = 1 + ½ + 4 (when adding fractions, add numerator to numerator and denominator to denominator); and (iv) 0 x 10 = 0, means there are lo zeros (10 “nothing” equals “nothing”). That is, the number 0 has no value.). Conceptual change instructional strategies were recommended as measures that would help teachers and text writers to identify and correct students' misconceptions in Algebra.

In another study, Dejene (2014) examined students' misconceptions of the limit concept in a first calculus course. Misconceptions of the limit concept were examined in 130 pre-engineering students in Dilla Universities. Questionnaire and interview were deigned to explore students understanding of the idea of a limit of a function and to explore the cognitive schemes for the limit concept. The study employed a quantitative-descriptive or survey design. The empirical investigation was done in two phases. A questionnaire on the idea of a limit was given to 130 students during the first phase. During the second phase 14 interviews were conducted.

The results indicated that students in the study saw a limit as unreachable, an approximation, a boundary, a dynamic process and not as a static object, and are under the impression that a function will always have a limit at a point. Regarding the relationship between a continuous function and a limit were: Students think that a function has to be defined at a point to have a limit at that point. A function that is undefined at a certain point does not have a limit; students think that when a function has a limit, then, it has to be continuous at that point.

Other misconceptions were: the limit is equal to the function value at a point, i.e. a limit can be found by a method of substitution, when one divides zero by zero, the answer is zero, Most of the students know that any other number divided by zero is undefined. The study concluded that many students' knowledge and understanding rest largely on isolated facts, routine calculation, memorising algorithm, procedures and that their conceptual understanding of limits, continuity and infinity is deficient. The outstanding observation was that students see a limit as unreachable. This could be due to the language used in many books to describe limits for example 'tends to' and 'approaches'. Another view of a limit that the students have is that a limit is a boundary point. This could be because of their experience with speed limits, although that could be always exceeded.

Gunawardena (2011) conducted a research work on the secondary school students' misconceptions in Algebra in United States of America. The study investigated secondary school students' errors and misconceptions in Algebra with a view to exposing the nature and origin of those errors and to make suggestions for classroom teaching. The study used a mixed method research design. An algebra test which was pilot-tested for its validity and reliability was given to a sample of Grade 11 students in an urban secondary school in Ontario Canada. The test contained questions from four main areas of Algebra: variables, algebraic expressions, equations, and word problems. A rubric containing the observed errors was prepared for each conceptual area.

The results indicated that some errors emanated from misconceptions. Under variables, the main reason for misconceptions was the lack of understanding of the basic concept of the variable in different contexts. The abstract structure of algebraic expressions posed many problems to students such as understanding or manipulating them according to accepted rules, procedures, or algorithms. Inadequate understanding of the use of the equal sign and its properties when it is used in an equation was a major problem that hindered solving equations correctly.

The main difficulty in word problems was translating them from natural language to algebraic language. Students used guessing or trial and error methods extensively in solving word problems. Some other difficulties for students which are non-algebraic in nature were also found in the study. Some of them features were: unstable conceptual models, haphazard reasoning, lack of arithmetic skills, lack or non-use of metacognitive skills, and test anxiety. The researcher suggested that having the correct conceptual (why), procedural (how), declarative (what), and conditional knowledge (when) based on the stage of the problem solving process will allow students to avoid many errors and misconceptions. Conducting individual interviews in classroom situations is important not only to identify errors and misconceptions but also to recognise individual differences.

Amirali (2010) also researched into students' conceptions of the nature of Mathematics and attitudes towards Mathematics learning in Karachi, Pakistan by analyzing data obtained from 82 students studying in grade eight in a private school context. The survey was conducted using a five-point Likert scale ranging from 'Strongly Agree' through 'Neutral' to 'Strongly Disagree'. The survey findings illustrated that students consider Mathematics as a useful subject which is used in daily life routines and facilitates problem-solving skills, development and to strengthen future career of learners.

However, the findings also highlighted students' confusion and contradictions in terms of the nature of mathematical knowledge i.e., they show their level of agreement to both 'absolutist' and 'fallibilist' view of Mathematics. With respect to mathematics attitude, the results showed that female students hold a more positive attitude towards Mathematics and lesser mathematical anxiety than their male counterparts.

Ebiendele and Adetunji (2013) carried out a study on symbolic notations and its impact on students' achievement in Algebra. The main reason for this study rested on the researchers' personal observation and professional experiences on students' increasing hatred for Algebra. One hundred and fifty (150) senior secondary school students (SSS) from Ojo local Education District, Ojo, Lagos, Nigeria formed the sample population for the study. Three research instruments were used for the study, questionnaires were constructed for both students' and teachers to measure students' perceptions about symbolic notations like symbols, letters and signs in Algebra and how it affect their learning of Algebra, while the teacher's instruments measured the mode/strategies of teaching notation symbols in Algebra at the classroom levels. The t-test and Chi-square ($\chi2$) at 0.05 level of significance were used to test the stated Hypotheses .

Results from the hypotheses showed that students' do not have interest in Algebra and the usefulness of Algebraic notations are not known to them because they were not introduced to Algebraic topics with notations symbols early enough in schools. Also, inadequate modes/strategies in handling notation symbols the teacher's at the classrooms also resulted in significant differences between the performance of students' in the achievement test with symbolic notations and without symbolic notations. It was recommended among others that the schools should have mathematics laboratories where different mathematics teaching materials could easily be at the reach of the teacher.

Misconceptions arising both from the use of a letter as an object, label or word, and about the meaning of the equal sign make it difficult for many students to transit from arithmetic to introductory algebra, where letters are substituted and patterns emerge. Inability to translate, perform inverse operations and develop suitable algebraic forms from word problems inhibits proper processing of questions and leads to errors before the computation and processing stages are reached (Clement, 1982; White, 2005).

Empirical Studies on Gender and Students' Conceptions

Conceptions have been defined by Thompson (1992) as conscious or subconscious beliefs, concepts, meanings, rules, mental images, and preferences. Conception is defined here as an abstract or general idea that may have both affective and cognitive dimensions, inferred or derived from specific instances. Hence, students' conceptions consist of their belief systems, values and attitudes reflecting their experiences. Beliefs are part of conceptions. Sumpter (2008) defined beliefs as an individual's understandings that shape the ways that individual conceptualises and engages in mathematical behavior generating and appearing as thoughts in mind. A belief could be central and strongly held, or peripheral and likely to change. This dimension doesn't exist in a knowledge system (Furinghetti & Pehkonen, 2002). If you know something, you are not likely to accept any contradiction to it. Beliefs are held in clusters. These clusters may not necessarily have any relationship with each other and thus could be kept isolated. The reason for seeing beliefs as a part of a system is that beliefs are not isolated and they are context/ situation bound. They function in operational terms as a part of a model of cognition.

Gender in this study refers to the categorisation of people based on their sex as either male or female and at different times and places; it has been observed that several stereotypical and biased assumptions have been made when using gender for categorizations. For example, males are considered to be more logical than females (Sumpter, 2008). Mathematics is considered a male dominated course. It is in this context that boys and girls develop their gender identities by facing, often contradictory, images and negotiate them to a personal identity (Volman & Ten Dam, 1998). As stated earlier, many students in the senior secondary school perceive Mathematics as a male domain (Brandell&Staberg, 2008), which means that the structure, the symbols and the identity are all more likely to be pro-male. Such an environment could be connected to a potential underperformance by women since they are under a stereotype threat (Cadinu et al., 2005). It is therefore necessary to find out if gender actually influences secondary school students' conceptions about Mathematics.

Sam-Kayode (2015) researched on the conceptions of geometry held by senior secondary school Mathematics students in Ogun State, Nigeria. The study was a descriptive survey type using 350 male and 407 female students from some selected schools in Ogun State. The findings of the study showed a significant difference in the number of male and female students' conceptions of geometry (X^2-value = 8.95, p-value = 0.01 which was less than 0.05 level of significance).

The study further revealed that 56.29% of male and 63.14% female held correct conceptions of geometry; 23.71% male and 27.76% female held misconceptions of geometry while 35.14% of male and 25.06% of female students held alternative conception of algebra respectively.

Adedoyin (2016) also researched into the conceptions of the nature of science held by undergraduate pre-service science teachers in South-West, Nigeria. The study was a descriptive research of the survey method. 149 male and 127 female undergraduate pre-service teachers were sampled for the study. The findings of the study revealed that there is no statistically significant difference in the number of male and female undergraduate pre-service teachers that held correct conceptions and misconceptions about the nature of science.

Bello (2018) also analysed the misconceptions and alternative conceptions of difficult topics in on line senior secondary school Biology Resources. The study was a survey type of descriptive research using multistage sampling procedure in selecting 90 on line Biology resources which were grouped into three categories based on ownerships i.e educational institutional, corporate organisation, and blogger websites. Three research instruments (namely: Misconceptions in online Biology Resources Content Analysis Template (MOBRCAT), Alternative conceptions in online Biology Resources Contents Analysis Template (ACOBRCAT); and a Questionnaire on Students' Frequently visited Biology

Websites (SFVBW) were used for data collection. The findings of the study revealed that no significant difference in the misconceptions and alternative conceptions male and female undergraduate pre-service teachers on the difficult topics in on line senior secondary school Biology resources.

Studies on Influence of Score Level and Students' Conceptions

Balogun (2010) carried out a study on conceptions of thermodynamics held by chemistry students in Kwara State Colleges of Education. A 10-item Thermodynamic Conception Test (TCT) was administered to 191 final year students from the three state-owned colleges of education. The findings showed that low ability students had the greatest percentage of misconceptions followed by medium ability ones, while those with high ability levels had the least percentage of misconceptions. Hence, ability level had effect on students' misconception.

Abdulraheem (2012) studied the conceptions of electromagnetism held by colleges of education Physics students in North Central states, Nigeria. A total of 1, 200 final year students from 14 colleges of education participated in the study. The instrument used for the study was a 20-items Electromagnetic Conception Test (ECT). The study employed the use of frequency count and the percentage to identify correct conceptions, misconceptions and alternative conceptions held by the students. The findings of the study showed a significant difference in the number of conceptions held by the physics students about electromagnetism.

Sam-Kayode (2015) also investigated conceptions of geometry held by senior secondary school Mathematics students in Ogun State, Nigeria. The study involved 757 senior school II students comprising 350 male and 407 female students. The instrument for the study was a 26-item Geometry Conceptions Test (GCT).The Chi-square statistics tool was used to determine the differences in the number of students with any conception based on gender, scoring levels and subject combinations. The findings from the study revealed that there was a significant difference in the number of students who are of different scoring levels holding Correct conceptions, misconception and alternative conceptions of geometry (X^2-value = 4.39, p-value = 0.35 which was greater than 0.05 level of significance) percentages of high, medium and low score level with; Correct conceptions were 70.66%, 60.85% and 48.87%; misconceptions were 35.93%, 22.98% and 22.56%; and alternative conceptions were 46.ll%, 36.54% and 33.83% respectively.

Studies on Influence of Subject Combination and Students' Conceptions

Classification of studies into various subject combinations at the senior secondary schools has to do with grouping students based on their subject discipline. These subject combination s are mainly in three major groups which are; Arts, Commercial and the Sciences. The arts class comprises of students offering main subjects like History, Literature in English, Government, Geography plus English Language, Mathematics, Biology and one Nigerian language, one vocational subject and a religious studies. In some cases, the art students do offer some elective subjects such as Economics, French language, Music and fine art. The Commercial class subjects are the social sciences subjects which include Economics, Commerce, Accounts, Business Studies, Type Writing, Shorthand, Office Practice

On the influence of subject combination on students' conceptions Sam-Kayode (2015) investigated the conceptions of geometry held by senior secondary school Mathematics students in Ogun State, Nigeria. The study involved 757 senior school II students. The instrument used for the collection of data was a 26-item Geometry Conception Test (GCT). The Chi-square statistics was used to determine the differences in the number of students with any conception based on gender, scoring levels and subject combinations. The findings from the study revealed that there was no significant difference in the number of students holding correct conceptions. Misconception and alternative conceptions of geometry (X^2-value=6.36; p-value=0.35 which was greater than 0.05 level of significance). Further analysis showed that the percentages of art, commercial and science students with correct conceptions were 58.l0%, 58.62% and 6l.90%; misconceptions were 21.43%, 27.16% and 28.25%, while alternative conceptions were 28.57%, 36.2l% and 46.98% respectively.

Adedoyin (20l6) carried out a study on the conceptions of the nature of science held by undergraduate pre-service science teachers in South-West, Nigeria. The study was a descriptive research of the survey method.149 male and 127 female undergraduate pre-service teachers were sampled for the study. The findings of the study revealed that there are differences in the number of correct conceptions and misconceptions about the nature of science held by undergraduate pre-service teachers based on the area of specialization.

Appraisal of the Literature Reviewed

The issue of senior secondary students' mass failure in external Mathematics examinations in the recent years is of great concerns to all the stakeholders in education sector in Nigeria (Amazigo, 2001; Agwadah, 2001, Salman, 1998). The literature reviewed indicated that ineffective engagement of learners' interest in developing conceptual understanding of the subject matter and enhancing problem-solving ability (Amazigo, 2001; Ige, 2001; Salman, 2003) especially in algebra.

The WAEC Chief Examiners' Report indicated that weaknesses of candidates were observed in algebra due to the inability of students to understand the instructions needed to solve and interpret algebraic word problems and inability to analyze the rule of bracket, off, division, multiplication, addition and subtraction and its application (WAEC, 2011, 2012, 2014, & 2015; Caelaina & Yushau, 2007)

Studies on students' misconceptions of algebra in Mathematics were reviewed; these included Mangwabnam (2013); Ebiendeleand Adetunji (2013); Charles-organ (2014), Idehen and Omoifo (2016). Based on the reviewed studies, misconceptions of algebra in Mathematics have been found to exist among students at different levels of education. Students' conceptions have contributed negatively to their performance in various examinations due to some reasonable factors. These factors include but not limited to; the effects of teachers' methods of instructions, students' negative attitudes towards the subjects, teachers' qualifications, school types or school location, curriculum/syllabus structure, class size, textbooks, prior knowledge and instructional materials used for teaching (Abimbola, 1986; Ausubel, 1968; Hewson, 2007; Novak, 2003; Salman et al. 2012).

Studies carried out in relation to conceptions of algebra in Mathematics include Clement (1982), Macgregor and Stacey (1993) , Idehen and omoifo (2016), Dejene (2014), Gweunawarden, Ebiendele and Adetunji (2013) . Some of these studies were carried out in Nigeria, while all of the reviewed studies were carried out outside Kwara State, Nigeria. With the important placed on algebra in Mathematics curriculum for all levels of education and the increasing students' poor performance in the content of algebra, this present study sought to investigate the conceptions of algebra held by senior secondary school students in Kwara State, Nigeria.

CHAPTER THREE

RESEARCH METHOD

This chapter focused on the methodology used in carrying out this study. It was discussed under the following subheadings: Research Type; Population, Sample and Sampling Techniques; Research Instrument; Validation of Research Instrument; Procedure for Data Collection; and Data Analysis Techniques.

Research Type

This study was a descriptive research of the survey type. Since this study is examining the conception of larger population from a small population, the use of survey method is considered appropriate.

Population, Sample and Sampling Techniques

The population for the study was all senior secondary school students in Kwara State, Nigeria; but the targeted population for this study was all Students in Senior Secondary School II in Kwara State, Nigeria. The sample selection for the study was done using proportionate, stratified and random sampling techniques. The sampled schools were selected across the three senatorial districts of Kwara State (Kwara North, Central and South) using proportional sampling techniques, while 50 students were sampled from each of the selected schools for the study. This is to ensure proportional representations of all the variables.

A sample of one thousand two hundred (l200) senior secondary school II students was selected from the three senatorial districts of Kwara State for the study. The samples were drawn from twenty-four (24) secondary schools out of 346 public senior secondary schools in the State. Eight (8) senior secondary schools were selected from each of the three senatorial districts of Kwara State (Kwara North (81), Central (101) and South (164)).

Research Instrument

The research instrument for this study was a researcher-designed test titled: Algebra Conception Test (ACT). It consisted of two parts: Part 1 contained the demographic data of the respondents which included: name of the school, student's gender, subject combination (Arts, Commercial or Science). Part 2 contained 4 essay tests on quadratic graph algebra.

The result collection format was given to the Mathematics teachers in each of the participating schools to fill in the terminal results of the participating students as a supporting instrument. Information collected on the results was to enable the researcher to classify the respondents into high, medium and low score levels.

Validation of Research Instrument

The research instrument was given to three Mathematics educators in the Department of Science Education, University of Ilorin and two Mathematics teachers to ascertain both the face and content validity of the instrument. The validators were required to scrutinize whether the instrument would measure what it is supposed to measure in terms of content such as clarity of instruction, relevance and adequacy of items. Suggestions made on the validation of the content of the instrument, as well as the marking scheme and all other corrections were effected and submitted to the supervisor for further scrutiny and approval.

The reliability of the instrument was carried out through a trial testing by involving 20 Senior School Two students (SS2) drawn from Ilorin East Local Government Area of Kwara State who did not participate in the main study. Test-retest method was used to administer the instrument to the selected students with in two weeks interval. The instruments yielded reliability values of 0.76 using Pearson Product Moment Correlation Coefficients

Procedure for Data Collection

A letter of introduction was obtained by the researcher from the Head of Department of Science Education, University of Ilorin to the Principals of the selected schools. The consent and co-operation of the parents of the students that were involved in the study were also sought. The researcher with the help of two research assistants visited the selected secondary schools to administered the instrument personally to enhance their prompt responses.

The respondents were allowed to participate voluntarily in the study. Informed consent forms were made available to the school authorities, Mathematics teachers and the respondents in order to get their consent to be involved in the study. In a school where the Mathematics teacher declined to act as research assistant, the researcher took charge of the class.

The names of the participating schools, Research Assistants and the respondents was not to be revealed in the study, while all related data were handled with confidentiality and used for the purpose of the research only. The respondents were also not exposed to any risk during the research. To ensure originality of the study, the write-up of the study was subjected to plagiarism test and all the necessary corrections were made in order to make the study free of plagiarism. The outcome of this study was beneficial to both the students and the Mathematics teachers.

Data Analysis Techniques

The data collected were subjected to both qualitative and quantitative analyses. Qualitatively, the responses were analysed to identify the nature of conceptions held by the students. The data collected were subjected to descriptive and inferential statistical analysis using Statistical Package for Social Sciences (SPSS) version 22.0 to obtain the results. Percentages were used to answer the research questions while chi-square was used to test the hypotheses formulated for the study. All hypotheses were tested at 0.05 level of significance using chi-square analysis.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

This chapter deals with the analyses and results of the data collected for this study. The data collected were analysed using percentages to describe the demographic data of the respondents and also to answer research questions without corresponding hypotheses. All hypotheses were tested using chi-square at 0.05 level of significance.

Demographic Data of the Respondents

Table l reveals the demographic characteristics of the students on the basis of gender, subject combination and score levels. Out of the 1200 (l00.0%) students sampled for this study, 614 (51.2%) of them were males and 586 (48.8%) were females. Also, 406 (33.8%) of the participants were from Art class; 411 (34.2%) were from Commercial class while the remaining 383 (32.0%) of the participants were from the Science class. In addition, 209 (17.4%) of the participants were of low score level; 704 (58.7) were of medium score level while 287 (23.9%) of the respondents were of high score level.

Table 2

Demographic Characteristics of the Participants (N=1200)

Variable		**Frequency**	**Percentage**
Gender	Male	614	51.2%
	Female	586	48.8%
Score levels	Low	209	17.4%
	Medium	704	58.7%
	High	287	23.9%
Subject Combination	Arts	406	33.8%
	Commercial	411	34.2%
	Science Students	383	32.0%

Data Analysis

Answering of Research Questions

Research Question One: What are the conceptions of senior secondary school students' on quadratic graphs in algebra?

Participants' conceptions of quadratic graph in algebra were subjected to item by item analysis. Thus, item which the majority of students got correctly, alternatively and wrongly were marked as correct conceptions, alternative conceptions and misconceptions, respectively. The statistics of the students' conceptions of each item of quadratic graph in algebra were presented in Table 2.

As revealed in Table 2, out of the 1200 (100.0%) students that took part in this study, 606 (50.5%) of the students held correct conceptions, 392 (32.7%) held alternative conceptions while l45 (12.1%) of the students held misconceptions.57 (4.8%) of the students provided no response to item la at all.Similarly, 340 (28.3%)

of the students held correct conceptions, 287 (23.9%) held alternative conceptions, 468 (39.0%) of the students held misconceptions, while 105 (8.8%) of students gave no response to item lb. Also, 310 (25.8%) of the students held correct conceptions, 599 (49.9%) of the students held alternative conceptions,207 (17.3%) of the students held misconceptions while 84 (7.0%) of the students offered no response to item 1c.Futhermore, 448 (37.3%) of the students held correct conceptions,6l4 (51.2%) held misconceptions, 6l4 (51.2%) of the students held misconceptions while there was no response to item 1d from l38 (11.5%) student respondents. Thus, majority of the sampled students held correct conceptions to item la; alternative conceptions to item 1c and 1d and misconceptions to item lb.

Also, 308 (25.7%) and 582 (48.5%) of the students held correct and alternative conceptions to item 2ai, respectively; 227 (18.9%) held misconceptions, while 83 (6.9%) of the students provided no response to item 2ai.In addition 349 (29.1%) of the students held correct conceptions,6l3 (51.1%) held alternative conceptions, l33 (11.1%) of the students held misconceptions while l05 (8.7%) of the students gave no response to item 2aii.Futhermore, 462 (38.5%) of the students held correct conceptions, 322 (26.8%) held alternative conceptions, 254 (21.2%) of the students held misconceptions, while 162 (13.5%) provided no response to item 2aiii. Moreover 304 (25.3%) of the students held correct conceptions, 262 (21.8%)

held alternative conceptions, 495 (41.3%) of the students held misconceptions, while l39 (11.6%) of the students gave no response item 2b.Similarly, 511 (42.6%) of the students held correct conceptions, 229 (19.1%) held alternative conceptions, and 317 (26.4%) of the students held misconceptions, while 143 (11.9%) of the students gave no response to item 2c. Therefore, majority of the sampled students held correct conception to item 2c alternative conceptions to item 2ai and 2aii, but misconceptions to item 2b respectively.

More so, 502 (41.8%) and 312 (26.0%) of the students held correct conceptions and alternative conceptions respectively to item 3a; 242 (20.2%) held misconceptions, while 144 (12.0%) of the students offered no response to item 3a. Item 3bi was held correctly by 304 (25.3%) of the students; held alternatively by 256 (21.3%) and 472 (39.3%) students held misconceptions, while 168 (14.0%) of the students provided no response to item 3bi. Item 3bii was held correctly by 609 (50.8%) of the students, held alternatively by 201 (16.8%) and 272 (22.7%) students held misconceptions while 118 (14.0%) of the students provided no response to item 3bii. Item 3ci was held correctly by 362 (30.2%) of the students; held alternatively by 511 (42.6%) and 221 (18.4%) held misconceptions with l06 (8.8%) of the students providing no response to item 3ci. Item 3cii was held correctly by 289 (24.1%) of the students; held alternatively by 314 (26.2%) and 498 (41.5%) held misconceptions, while 99 (8.3%) of the students provided no response to item 3cii. Thus, majority of the sampled students held correct conceptions of items 3a and 3bii; alternative conceptions of item 3ci and misconceptions of items 3bi and 3cii respectively.

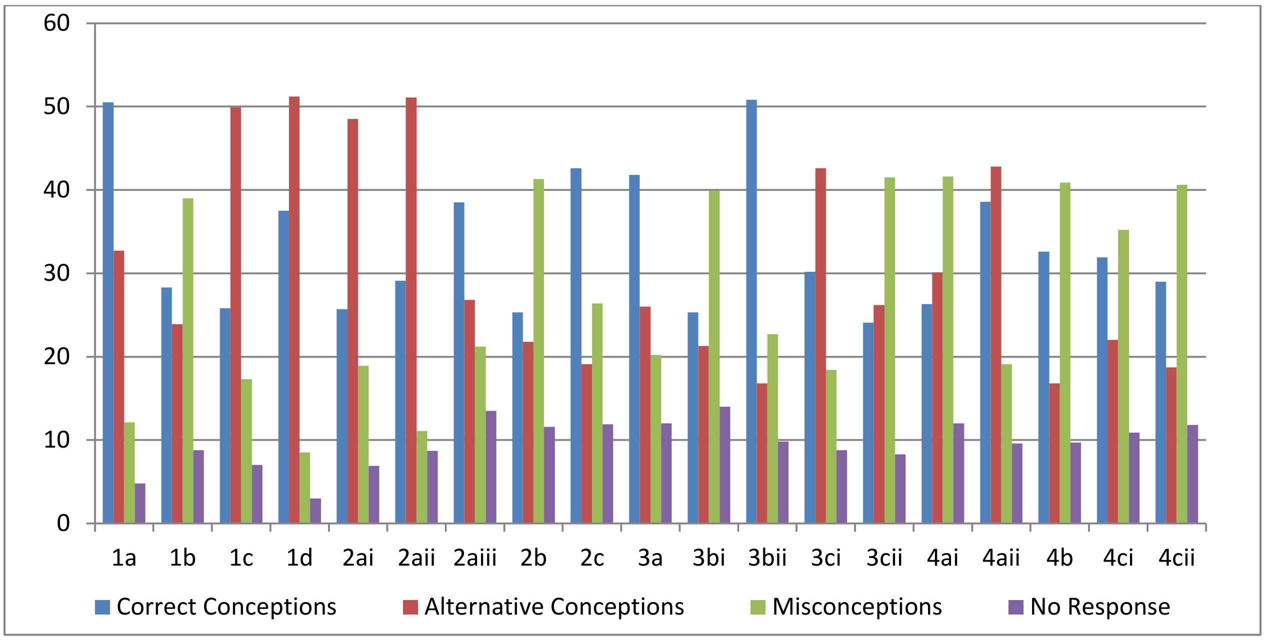
Furthermore, 3l6 (26.3%) and 241 (20.1%) of the students held correct conceptions and alternative conceptions respectively of item 4ai and 499 (36.7%) held misconceptions while 144 (12.0%) gave no response to item 4ai. Item 4aii was held correctly by 343 (28.6%) of the students; held alternatively by 513 (42.8%) and 229 (19.1%) held misconceptions, while 115 (9.6%) of the students provided no response to item 4aii. Item 4b was held correctly by 391 (32.6%) of the students; held alternatively by 202 (16.8%) and 49l (40.9%) held misconceptions while 116 (9.7%) of the students offered no response to item 4b. Item 4ci was held correctly by 383 (31.9%) of the students, held alternatively by 264 (22.0%) and 422 (35.2%) held misconceptions, while 131 (10.9%) of the students provided no response to item 4ci. In the same vein, Item 4cii was held correctly by 348 (29.0%) of the students; held alternatively by 224 (18.7%) and 487 (40.6%) held misconceptions, while 141 (11.8%) of the students provided no response to item 4cii. Therefore, majority of the sampled students held alternative conception of item 4aii and misconceptions of items 4ai, 4b, 4ci and 4cii, respectively.

Table 3

Conceptions of Senior Secondary School Students of Quadratic Graph in Algebra

Quadratic Graph in Algebra	Conceptions: Correct Conception	Conceptions: Alternative Conception	Conceptions: Misconception	Conceptions: No Response	Total	Remark
Itemla	606 (50.5%)	392 (32.7%)	145 (12.1%)	57 (4.8%)	1200 (100.0%)	Correct Conception
Itemlb	340 (28.3%)	287 (23.9%)	468 (39.0%)	105 (8.8%)	l200 (100.0%)	Misconception
Itemlc	310 (25.8%)	599 (49.9%)	207 (17.3%)	84 (7.0%)	1200 (100.0%)	Alternative Conception
Itemld	448 (37.3%)	614 (51.2%)	102 (8.5%)	36 (3.0%)	l200(100.0%)	Alternative Conception
Item2ai	308 (25.7%)	582 (48.5%)	227 (l8.9%)	83 (6.9%)	l200 (100.0%)	Alternative Conception
Item2aii	349 (29.1%)	613 (51.1%)	l33 (11.1%)	105 (8.7%)	1200 (100.0%)	Alternative Conception
Item2aiii	462 (38.5%)	322 (26.8%)	254 (21.2%)	162 (13.5%)	1200 (100.0%)	Correct Conception
Item2b	304 (25.3%)	262 (21.8%)	495 (41.3%)	139 (11.6%)	l200 (100.0%)	Misconception
Item2c	511 (42.6%)	229 (19.1%)	317 (26.4%)	l43 (11.9%)	l200 (100.0%)	Correct Conception
Item3a	502 (41.8%)	312 (26.0%)	242 (20.2%)	144 (12.0%)	l200 (100.0%)	Correct Conception
Item3bi	304 (25.3%)	256 (21.3%)	472 (39.3%)	168 (14.0%)	1200 (100.0%)	Misconception
Item3bii	609 (50.8%)	201 (16.8%)	272 (22.7%)	118 (9.8%)	l200 (100.0%)	Correct Conception
Item3ci	362 (30.2%)	511 (42.6%)	221 (l8.4%)	106 (8.8%)	1200 (100.0%)	Alternative Conception
Item 3cii	289 (24.1%)	314 (26.2%)	498 (41.5%)	99 (8.3%)	1200 (100.0%)	Misconception
Item4ai	316 (26.3%)	241 (20.1%)	499 (41.6%)	144 (l2.0%)	l200 (100.0%)	Misconception
Item4aii	343 (28.6%)	513 (42.8%)	229 (l9.1%)	115 (9.6%)	1200 (l00.0%)	Alternative Conception
Item4b	391 (32.6%)	202 (16.8%)	491 (40.9%)	116 (9.7%)	l200 (100.0%)	Misconception
Item4ci	383 (3l.9%)	264 (22.0%)	422 (35.2%)	l31(l0.9%)	l200 (100.0%)	Misconception
Item4cii	348 (29.0%)	224 (l8.7%)	487 (40.6%)	l41 (11.8%)	1200 (100.0%)	Misconception

As shown in Figure 2, majority of senior secondary school students held correct conception of items 1a, 2aiii, 2c, 3a, and 3bii of the quadratic graph in algebra; items 1c, 1d, 2ai, 2aii, 3ci, and 4aii were held alternatively by the majority of the senior secondary school students, while majority of the students held misconceptions of 1b, 2b, 3bi, 3cii, 4ai, 4b, 4ci and 4cii, respectively.



Research Question Two: What proportion of senior secondary school students' hold correct conception, alternative conception and misconceptions of quadratic graph in algebra?

Students' scores on quadratic graph in algebra were subjected to percentage analysis, given that students held correct conceptions, alternative conceptions and misconceptions of some questions. Thus, the proportion of students' correct conception, alternative conception and misconceptions of quadratic graph in algebra is presented in Table3.

As revealed in Table 3, out of the1200 (100.0%) students sampled for this study, 309 (25.7%) held correct conception of quadratic graph in algebra; 363 (30.3%) held alternative conception, while 528 (44.0%) of the students held misconception of quadratic graph in algebra.

Table 4

Proportion of Senior Secondary School Students Holding Correct Conceptions, Alternative Conceptions and Misconceptions of Quadratic Graph in Algebra

Conceptions of Quadratic Graph in Algebra	**Frequency**	**Percentage**
Correct Conception	309	25.7%
Alternative Conception	363	30.3%
Misconception	528	44.0%
Total	1200	100.0%

As shown in Figure 2, a large proportion (44%) of the senior secondary school students sampled held misconception of quadratic graph in algebra, 30% of the students held alternative conceptions of quadratic graph, 26% of the sampled students held correct conception of quadratic graph in algebra.

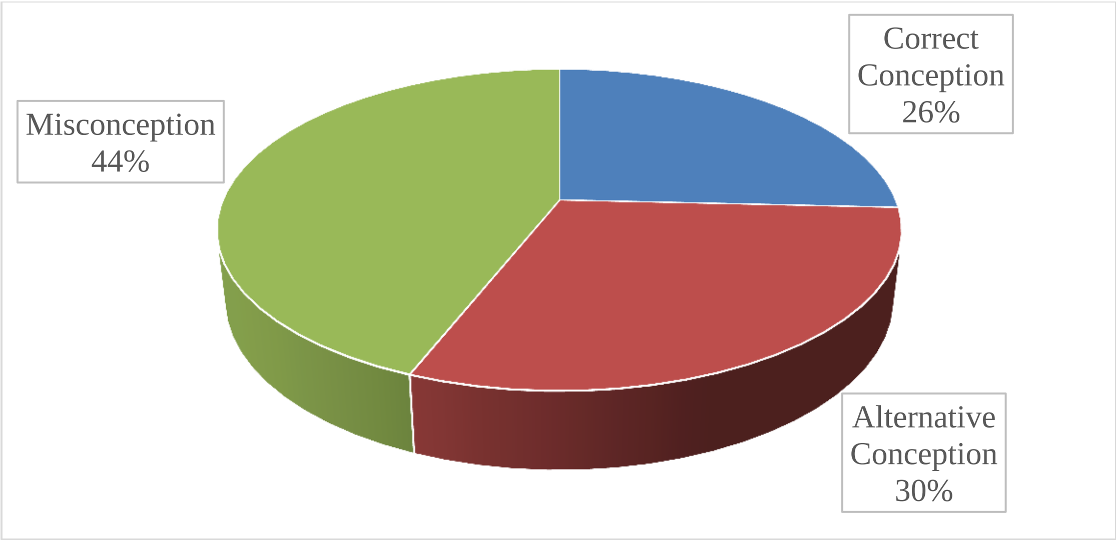


Figure 3:Proportion of Students' Holding Correct Conception, Alternative Conception and Misconceptions of Quadratic Graph in Algebra

Hypotheses Testing

All the formulated hypotheses were tested using chi-square analysis at 0.05 level of Significance

Hypothesis One: There is no significant difference between male and female senior secondary school students' conceptions of quadratic graph in algebra.

Table 4 shows that the χ^2-value 6.386 was obtained with a p-value 0.04l when obtained at 0.05 level of significance. Since the p-value 0.04l is less than 0.05 level of significance , the null hypothesis one was rejected. This implies that there is a statistically significant difference between male and female senior secondary school students' conceptions of quadratic graph in algebra ($\chi^2_{(2)} = 6.386$; $p<0.05$).

Table 5

Chi-Square Statistics Showing the Difference between Male and Female Senior Secondary School Students' Conceptions of Quadratic Graph in Algebra

Gender		**Students' Conceptions of Quadratic Graph in Algebra**							
		Misconception	**Alternative Conception**	**Correct Conception**	**Total**	**df**	**χ^2–cal**	**Sig**	**Remark**
Male	Count	253	l85	l76	6l4				
	Expected	270.2	l85.7	l58.l	6l4.0				
						2	6.386[a]	0.04l	**Ho_l Rejected**
Female	Count	275	l78	l33	586				
	Expected	257.8	l77.3	l50.9	586.0				
Total		**528**	**363**	**309**	**l200**				

**Insignificance at $p<0.05$*

Figure 3 reveals that out of 614 male students sampled for this study, 253 (41.2%) held misconceptions, 185 (30.1%) held alternative conceptions, while 177 (28.7%) of the male students held correct conceptions of quadratic graph in algebra. Also, out of 586 female students sampled for this study, 275 (46.9%) of them held misconceptions of quadratic graph in algebra; 178 (30.4%) held alternative conceptions while l33 (22.7%) held correct conceptions of quadratic graph in algebra. Thus, more female senior secondary school students (46.9%) held misconceptions of quadratic graph in algebra than their male counterpart (41.2%) conversely, more male students held correct conceptions (28.7%) of quadratic graph in algebra than female students (22.7%). However, almost the same proportion of male students (30.1%) and female students (30.4%) held alternative conception of quadratic graph in algebra.

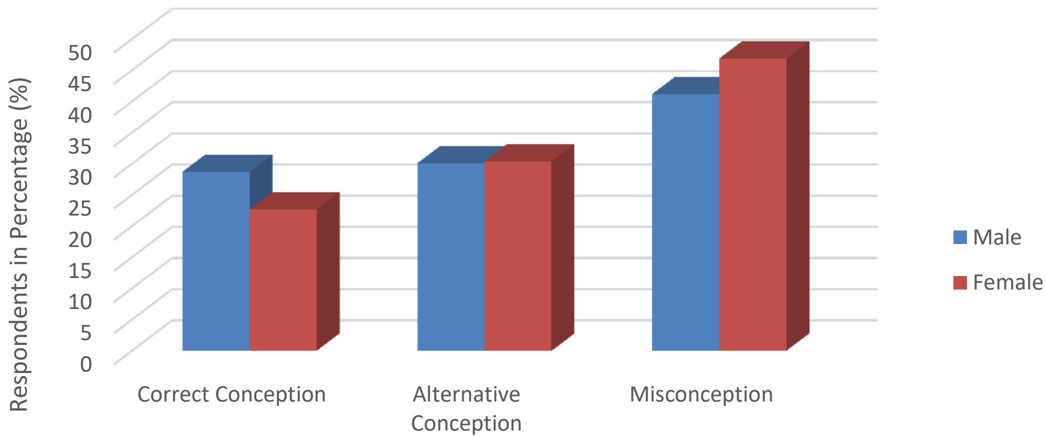


Figure 4: Male and Female Senior Secondary School Students' Conceptions of Quadratic Graph in Algebra

Hypothesis Two: There is no significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on score levels.

As shown in Table 6, the χ^2-value l68.2l0 was obtained with a p-value 0.000 when computed at 0.05 level of significance. Since the p-value 0.000 is less than 0.05 level of significance, the null hypothesis two was rejected. This implies that there was a statistically significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on score levels ($\chi^2_{(4)}$ = l68.2l0; $p<0.05$).

Table 6

Chi-Square Statistics Showing the Difference in Senior Secondary School Students' Conception of Quadratic Graph in Algebra Based on Score Levels

Score levels		Students' Conceptions of Quadratic Graph in Algebra: Misconception	Alternative Conception	Correct Conception	Total	Df	χ^2-cal	Sig	Remark
Low	Count	114	68	27	209				
	Expected	92.0	63.2	53.8	209.0				
						4	l68.2l0[a]	0.000	**Ho_2 Rejected**
Medium	Count	357	219	128	704				
	Expected	309.8	213.0	181.3	704.0				
High	Count	57	76	154	287				
	Expected	126.3	86.8	73.9	287.0				
Total		**528**	**363**	**309**	**l200**				

**Insignificance at <0.05*

Figure 4 revealed that out of the 209 students with low score level, 114 (54.6%) of them held misconceptions of quadratic graph in algebra, 68 (32.5%) held alternative conceptions, while 27 (12.9%) held correct conception s. Also, out of the 704 students with medium score level, 357 (50.7%) of them held misconceptions of quadratic graph in algebra, 2l9 (31.1%) held alternative conceptions, while 128 (18.2%) held correct conceptions. More so, out of the 287 students with high score level, 57 (19.8%) of them held misconceptions of quadratic graph in algebra; 76 (26.5%) held alternative conceptions, while 154 (53.7%) held correct conceptions.

Thus, more students of low score level (54.6%) held misconceptions of quadratic graph in algebra compared to by students of medium score level (50.7%) and students with high score level (19.8%). More students with low score level

(32.5%) held alternative conceptions in quadratic graph, followed by students of medium (31.1%) and high score (26.5%) levels students respectively, while more students with high score level (53.7%) held correct conceptions of quadratic graph in algebra, followed by medium score level (18.2%) and low score levels (12.9%) students, respectively.

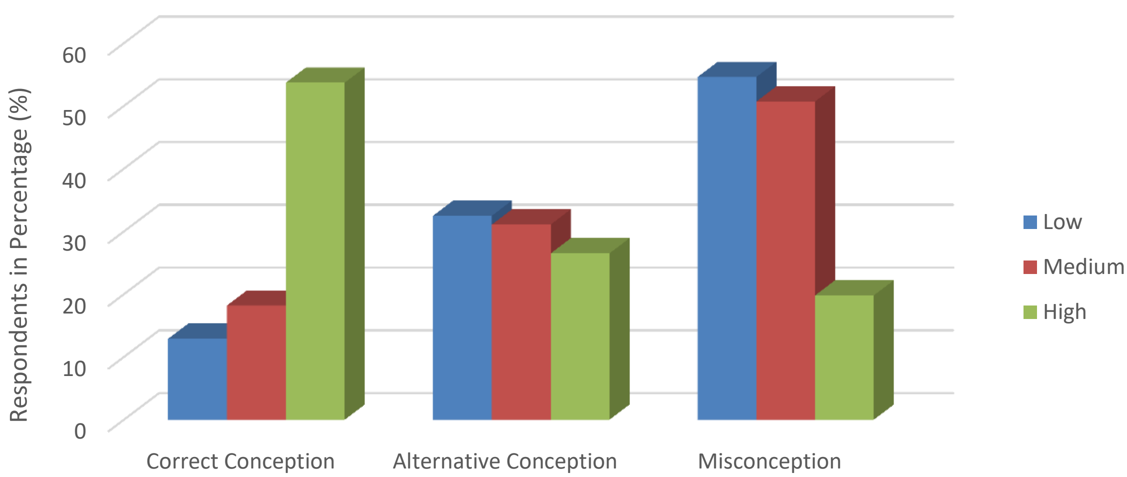


Figure 5: Students' Conceptions of Quadratic Graph in Algebra by Score Levels

Hypothesis Three: there is no significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on subject combinations.

Table 7 reveals that the χ^2-value of 95.788 was obtained with a p-value 0.000 when computed at 0.05 level of significance. Since the p-value 0.000 is less than 0.05 level of significance, the null hypothesis three was rejected. This implies that there is a statistically significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on subject combination s ($\chi^2_{(4)}$ = 95.788; p<0.05).

Table 7

Chi-Square Statistics Showing the Difference in Senior Secondary School Students' Conception of Quadratic Graph in Algebra Based on Subject combination

Subject combination		**Students' Conceptions of Quadratic Graph in Algebra**							
		Misc	**Alter Con**	**Correct Con**	**Total**	**df**	**χ^2-cal**	**Sig**	**Remark**
Arts	Count	243	101	62	406				
	Expected	178.6	122.8	104.5	406.0				
Commercial	Count	l82	128	101	411	4	95.788	0.000	**Ho_3 Rejected**
	Expected	180.2	124.3	105.8	411.0				
Science	Count	103	134	l46	383				
	Expected	168.5	115.9	98.6	383.0				
Total		**528**	**363**	**309**	**l200**				

**Insignificance at p<0.05*

Figure 5 shows that out of the 406 students sampled from the Art class, 243 (59.9%) of them held misconceptions of quadratic graph in algebra; 101 (24.9%) held alternative conceptions, while 62 (15.2%) held correct conceptions of quadratic graph in algebra. Also ,out of the 411 students sampled from the commercial class, l82 (44.3%) of them held misconceptions of quadratic graph in algebra, 128 (31.1%) held alternative conceptions while 101 (24.6%) held correct conceptions of quadratic graph in algebra. More so, out 383 students sampled from the Science class, 103 (26.9%)of them held misconceptions of quadratic graph in algebra; 134 (35.0%) held alternative conceptions while l49 (38.1%) held Correct conceptions.

Thus, more students in Arts class (59.9%) held misconceptions of quadratic graph in algebra, followed by Commercial class students (44.3%) and Science class students (26.9%). More students in Science class (35.0%) held alternative conceptions in quadratic graph, followed by Commercial class students (31.1%) and Arts students (24.9%), respectively. Conversely, more students from the science class (38.1%) held correct conceptions of quadratic graph in algebra, followed by students from the Commercial class (24.6%) and Arts class (15.2%), respectively.

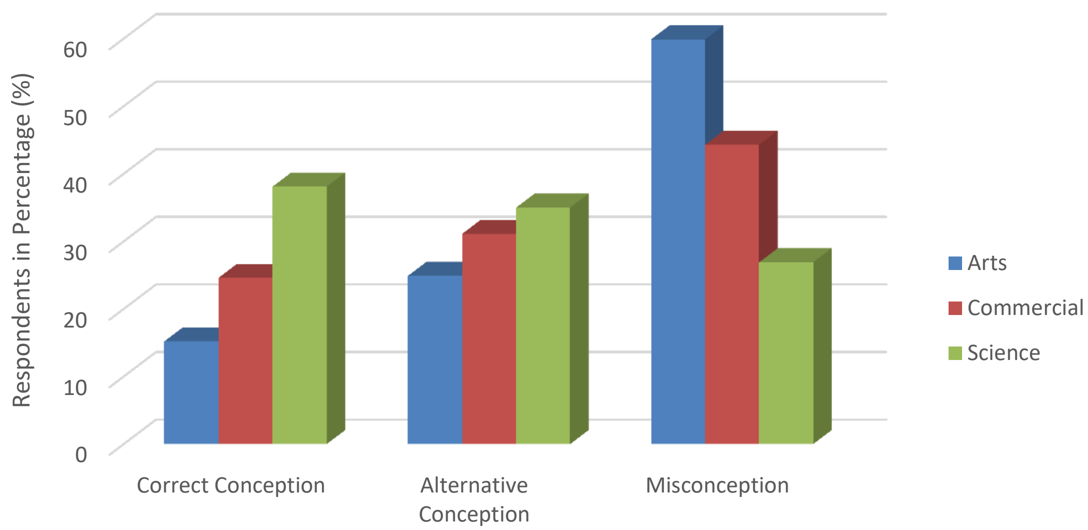


Figure 6: Students' Conceptions of Quadratic Graph in Algebra by Subject Combination

Summary of the Finding

Findings obtained from this study were summarized as follows :

1. Majority of senior secondary school students held correct conception in items 1a, 2c, 3a, and 3bii of the quadratic graph in algebra; alternative conceptions of items 1c, 1d, 2ai, 2aii, 3ci, and 4aii and misconceptions in items 1b, 2b, 3bi, 3cii, 4ai, 4b, 4ci, and 4cii respectively
2. Majority of the senior secondary school students held misconception of quadratic graph in algebra.
3. There was a statistically significant difference between male and female senior secondary school students' conceptions of quadratic graph in algebra ($\chi^2_{(2)}$ = 6.386[a]; $p<0.05$). Thus, male students were observed to hold correct conceptions of quadratic graph in algebra compared to female students
4. There was a statistically significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on score levels ($\chi^2_{(4)}$ = l67.420; $p<0.05$). Thus, more students with high score levels (53.7%) held correct conceptions of quadratic graph in algebra, followed by medium score level (l7.5%) and low score level students (l5.3%).
5. There was a statistically significant difference in senior secondary school students' conceptions of quadratic graph in algebra based on subject combinations ($\chi^2_{(4)}$ = 95.788; $p<0.05$). More students from the science class (38.l%) were observed to hold correct conceptions of quadratic graph in

algebra, followed by students from the Commercial class (24.6%) and Arts class (l5.2%).

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This study investigated the conceptions of senior secondary school students in algebra. This chapter presents the discussion of the research findings and recommendations based on the findings of the study.

Discussion

The findings of the study indicated that students held the correct conceptions, alternative conceptions and misconceptions of quadratic graph in algebra in Mathematics. The result revealed that majority of the senior school students held correct conceptions in items 1a, 2c, 3a, and 3bii of the quadratic graph in algebra; alternative conceptions of items 1c, 1d, 2ai, 2aii, 3ci, and 4aii and misconceptions in items 1b, 2b, 3bi, 3cii, 4ai, 4b, 4ci, and 4cii respectively. This implies that some students held correct conceptions about algebra while some of them held alternative conceptions and misconceptions about it which could be as a result of inadequate knowledge about quadratic graph in algebra. This finding corresponds with the findings of Ryan and Williams (2007), Egodawatte (2011), Clement (1982), MacGregor and Stacey (1993), Sam-Kayode (2015), Idehen and Omoifo (2016) that researched on the conceptions of students in selected topics in mathematics and found out that student held correct conceptions, alternative conceptions and misconceptions of different topics in mathematics.

Findings from this study also revealed that majority of the students do not attempt some of the quadratic graph questions set. This implies that majority of the students possessed poor existing knowledge which may be incomplete or misunderstood about quadratic graph in Algebra. This finding is in line with the submission of the WAEC Chief Examiners' Reports (WAEC, 2013, 2014 & 2015) which stated that students do not perform well in algebraic question especially quadratic graph. The reports further stated that students do not attempt the questions on quadratic graph while those who attempted the questions did not have correct interpretation of the graph; this factor contributed to students' poor performance in Mathematics.

Also, findings from this study revealed that very low number of senior school students held correct conceptions of quadratic graph in algebra. This is in support of the findings of Clement (1982), MacGregor and Stacey (1993) and Egodawatte (2011), who stated in their various research reports that little percentage of the respondents held correct conceptions of algebra in Mathematics.

The findings on students' conception indicated that majority of senior school students' held misconceptions about quadratic graph in algebra. This is in line with the submissions of Clement (1982); MacGregor and Stacey (1993) Egodawatte (2011); Dejene (2014);and Idehen and Omoifo (2016) who showed in their various findings that students held misconceptions of algebra and calculus in mathematics respectively.

The result of the study revealed that male students held more correct and alternative conceptions of quadratic graph compared to their female counterpart. Out of the 614 male students sampled for this study, 176 (28.7%) of male students held correct conceptions while 185 (30.1%) held alternative conceptions. Also, out of the 586 female students sampled for this study, 133 (22.7%) of them held correct conceptions of quadratic graph in algebra while 178 (30.4%) held alternative conceptions. In a nutshell, female students held more misconceptions of quadratic graph compared to their male counterpart; 275(46.9%) of female students held misconceptions of quadratic graph while 253(41.2%) of the male students held misconceptions of quadratic graph.

Thus, more female senior secondary school students held misconceptions and alternative conceptions of quadratic graph in algebra (46.9%, 30.4%) compared to their male counterpart (41.2%, 30.1%), while more male students held correct conceptions (28.7%) of quadratic graph in algebra compared to the female students (22.7). The findings were in agreement with the findings of Sam-Kayode (2015) who stated that gender had influence on senior school students' conceptions of geometry in Mathematics.

The study revealed that all the three categories of score levels students held correct conceptions, alternative conceptions and misconceptions of quadratic graph in Algebra. Out of the 209 students with low score level, 114 (54.6%) of them held misconceptions of quadratic graph in algebra; 68 (32.5%) held alternative conceptions while 27 (12.9%) held correct conceptions. Also, out of the 704 students with medium score level, 357 (50.7%) of them held misconceptions of quadratic graph in algebra; 219 (31.1%) held alternative conceptions while 128 (18.2%) held correct conceptions. More so, out of the 287 students with high score level, 57 (19.8%) held of them misconceptions of quadratic graph in algebra, 76 (26.5%) held alternative conceptions while 154 (53.7%) held correct conceptions.

Thus, more students with low score levels (54.6%) held misconceptions of quadratic graph in algebra. This is followed by the medium score levels (50.7%) and high score levels (19.8%) students. More students with low score levels (32.5%) held alternative conceptions in quadratic graph. This is followed by medium score (31.1%) and low score (26.5%) levels students respectively. Nevertheless, more students with high score levels (53.7%) held correct conceptions of quadratic graph in algebra, followed by medium score level (18.2%) and low score levels (12.9%) students respectively. The results show that there is a significant difference in the number of students holding the correct conceptions, alternative conceptions and misconceptions based on score levels.

This contradicts the findings of Sam-Kayode (2015) who stated that students score levels had no influence on their conceptions of geometry in mathematics.

Findings of the study indicated that all the three categories of subject combinations held correct conceptions, alternative conceptions and misconceptions of quadratic graph in algebra. Out of the 406 students sampled from the Art class, 243(42.4%) of them held misconceptions of quadratic graph in algebra, 101 (24.9%) held alternative conceptions, while 62 (15.2%) held correct conceptions of quadratic graph in algebra. Also, out of the 411 students sampled from the Commercial class, 182 (44.3%) of them held misconceptions of quadratic graph in algebra; 128 (31.1%) held alternative conceptions, while 101 (24.6%) held correct conceptions of quadratic graph in algebra. More so, out the 383 students sampled from the Science class, 103 (26. 9%) of them held misconceptions of quadratic graph in algebra, 134(35.0%) held alternative conception, while 146 (38.1%) held corrects conceptions.

Futhermore, more students in art class (59.9%) held misconceptions of quadratic graph in algebra. This is followed by commercial class students (44.3%) and science students (26.9%) students. More students in science class (35.0%) held alternative conceptions in quadratic graph, followed by commercial students (31.1%) and art students (24.9%) respectively. Conversely, more students in science class (38.1%) held correct conceptions of quadratic graph in algebra, followed by commercial class students (24.6%) and art students (19.7%) students' respectively. This contradicts the findings of Sam-Kayode (2015) who concluded that there was no significant difference in the conceptions of arts, commercial and science class students held in geometry aspect of mathematics.

Conclusion

This study can be concluded that very low percentage of the students held correct conceptions of quadratic graph, while majority of the students held misconceptions of quadratic graph and some of the students sampled did not attempt the quadratic graph questions set for the study. It showed that majority of senior secondary school students do avoid questions on quadratic graph due to lack of understanding of the concept.

The findings from this study revealed that gender affected the correct conceptions, alternative conceptions and misconceptions held by students on quadratic graph. Male and female students in the study displayed different in depth knowledge of quadratic graph questions as there was significant difference in the conceptions of quadratic graph held by male and female students. It was also revealed that high score level students held highest percentage of correct conceptions, followed by the medium score level students while the low scoring students held the least percentage of correct conceptions of quadratic graph. It showed that students score levels influenced his or her conceptions of quadratic graph in algebra.

Furthermore, the findings of this study revealed that students' subject combinations influenced their conceptions of quadratic graph in algebra. This implies that Art class students held highest percentage of misconceptions followed the Commercial class students while the science students held highest percentage of correct conceptions of quadratic graph.

Recommendations

Based on the findings of this study, the following recommendations were considered appropriate:

1. Mathematics teachers must identify students' conceptions of quadratic graph in algebra in a similar way, employ appropriate teaching strategies that can facilitate correct conceptions and remediate their alternative conceptions and misconceptions.
2. Some of the senior school students do not attempt the quadratic graph; therefore the students should be committed to solve problems of quadratic graph in algebra through constant practice.
3. Mathematics teacher should make use of mathematical graph board in teaching quadratic graph in order to arouse better understanding of the students.

4. Mathematics teachers' should consider gender difference and give recognition to both sexes in the classroom. This will geared both male and female students' better understanding of a quadratic graph in Algebra.
5. It is observed that score levels and subjects combination determined students' conceptions of quadratic graph in algebra. Therefore, teachers' emphasis should shift from teacher-centered approach of teaching to a more activities-based learning strategies that will close the gap among the three categorized score levels and subject combination s
6. The professional bodies like National Teacher's Institute (NTI), Mathematical Association of Nigeria (MAN), Teacher Registration Council of Nigeria (TRCN) and National Mathematical Centre (NMC) should organize seminars/workshops for teachers on students' conceptions of quadratic graph in algebra and how teachers could effective tackle the problem with innovative teaching methodologies.
7. The Ministries of Education at both State and Federal levels should organize special workshops for in-service teachers on how to tackle the problem of students' misconceptions of algebra especially quadratic graph.

Suggestions for Further Studies

The following areas have been identified for further research studies:

1. This study was carried out in selected public secondary schools in Kwara State. This type of study should be replicated with both public and private schools in other States of the Federation.
2. The conceptions of students in some difficulty topics in selected subject such as English language, Economics, Geography, and the Sciences could be carried out as well.
3. A study of this nature could be undertaken in some other concepts in mathematics in order to determine the conceptions of students across Mathematics contents.

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APPENDIX I

TEST INSTRUMENT

ALGEBRA CONCEPTIONS TEST (ACT)

Dear Student,

The purpose of this questionnaire is to identify your correct conception s, misconceptions and alternative conceptions of algebra. It would be appreciated if you could answer the questions as understood by you. Your performance in this assessment will have no bearing on your grades or evaluations. The assessment is designed to help you with algebra by helping your teacher understand the mistakes you make, as well as why you make them.

Instructions:

1. answer all the questions
2. use algebraic methods to solve all the problems

Section A: Personal Data

Gender: Male ( ) Female ( )

Subject combination : Arts ( ) Science ( ) Commercial ( )

Section B: Algebra Conception Test (ACT)

Kindly answer the Questions below:

l (a) Copy and complete the following table for the relation y = $\frac{5}{2} + x - 4x^2$

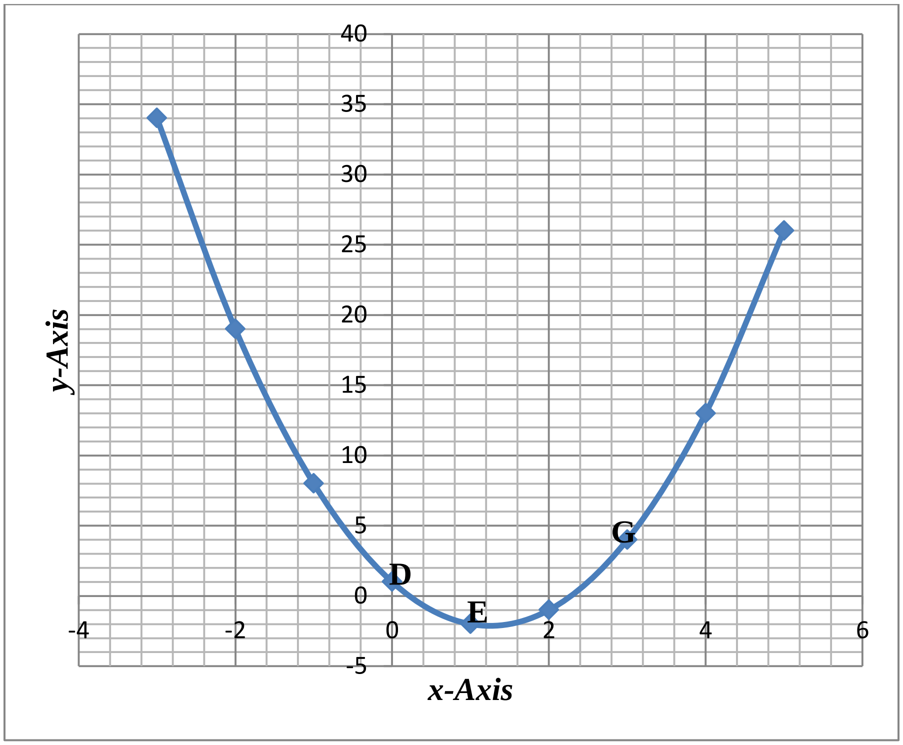
X	-2.0	-l.5	-l.0	-0.5	0	0.5	l	l.5	2
Y	-l5.5			l	2.5				

(b) using a scale of 2cm to l unit on the axis and 2cm to 5 units on the y axis, draw the graph of the relation for -2.0 $\leq x \leq$ 2.0

(c) what is the maximum value of y?

(d) from your graph obtain the roots of the equation $8x^2 - 2x - 5 = 0$

2



Above is the graph of the quadratic function $y = ax^2 + bx + c$ where a, b and c are constants. Using the graph; find:

a(i) the scales on both axes

(ii) the equation of the line of symmetry of the curve

(iii) the roots of the quadratic equation $ax^2 + bc + c = 0$

(b) Use the coordinates of points D, E and G to find the values of the constants a, b and c and hence write down the quadratic function illustrated in the graph

(c) find the greatest value of y within the range $-3 \leq x \leq 5$

3 (a) copy and complete the table of values for the relation y = 5 – 7x – 6x^2 for -3 ≤x≤ 2

x	-3	-2	-l	-0.5	0	l	2
y	-28		6		5		

(b) using a scale of 2cm to l unit on the x –axis and 2cm to 5 units on the y-axis, draw the (i) graph of y = 5 – 7x – 6x^2 (ii) line y = 3 on the same axis

(c) use your graph to find the (i) roots of the equation 2 – 7x – 6x^2 = 0 (ii) maximum value of y = 5 – 7x – 6x^2

4 The table is for the relation y = px^2 – 5x + q

x	-3	-2	-l	0	l	2	3	4	5
y	2l	6		-l2				0	l3

(a) (i) use the table to find the values of p and q

(ii) copy and complete the table

(b) Using scales of 2cm to l unit on the x-axis and 2cm to 5 units on the y-axis, draw the graph of the relation for -3 ≤x≤ 5

(c) Use the graph to find:

(i) y when x = 1.8 (ii) x when y = -8

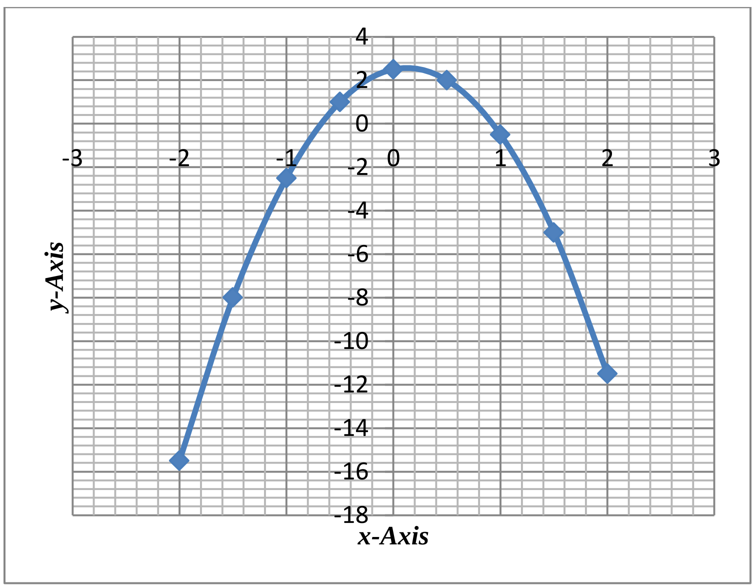
APPENDIX II

ANSWER TO THE ALGEBRA CONCEPTIONS TEST

l (a) Table of value of y = $^5/_2 + x - 4x^2$ from -2.o ≤x≤ 2.o

x	-2.0	-l.5	-l.0	-0.5	0	0.5	1	l.5	2
y	-l5.5	-8.0	-2.5	l	2.5	2.0	-0.5	-5.0	-11.5

(b)



(c) The maximum value of y = 2.5

(d) obtaining the root of $8x^2 - 2x - 5 =$

Divide both sides by -2, i.e $-4x^2 + x + \frac{5}{2} = 0$

∴ Roots are $x = -0.7$ and $x = -0.8$

2) (a) (i) Scale: x-axis: 2cm = l unit

y-axis: 2cm = 5 units

(ii) Equation of line of symmetry is x = l.25

(iii) roots of the equation $ax^2 + bx + c = 0$ are $x = 0.25$; $x = 2.25$

(b) Coordinates are D(0, l); E(l, -2); G(3, 4)

Substituting from $y = ax^2 + bx + c$ for D, E, and G

$l = c$ ……….(i)

$-2 = A + B + 1$ ………..(ii)

$4 = 9a + 3b + 1$ …………..(iii)

(ii) $\Rightarrow a + b = -3$

(iii) $\Rightarrow 9a + 3a = 3$

(ii) $x^3 = 3a + 3b = -9$ ………………(iv)

(iv) – (iii) $= -6a = -12 \Rightarrow a = 2$

Substitute for a in (ii) $= 2 + b = -3 \Rightarrow b = -5$

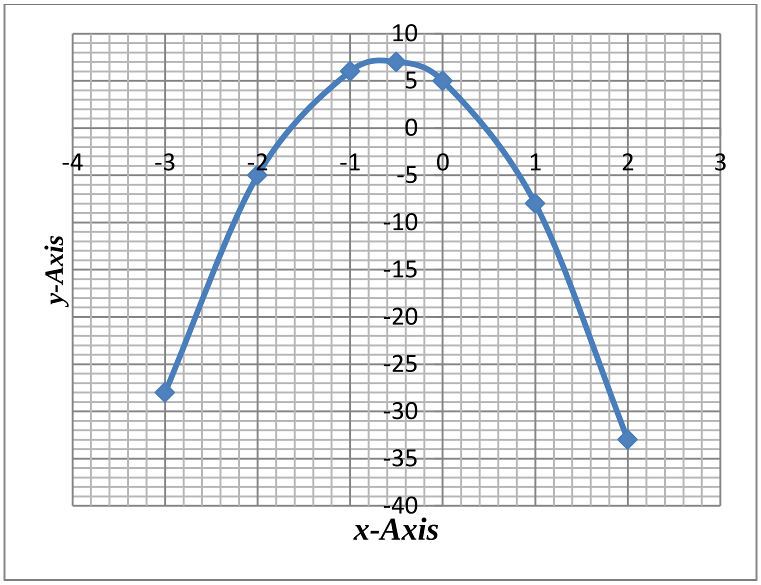
$\therefore$ The equation $= 2x^2 - 5x + l$

(c) greatest value of y = 33.5

3 (a) Table of value $y = 5 - 7x - 6x^2$ $(-3 \leq x \leq 2)$

X	-3	-2	-l	-0.5	0	l	2
Y	-28	-5	6	7	5	-8	-33

(b) (i) Graph of $y = 5 - 7x - 6x^2$



(ii) from the graph y = 3

(c) (i) $2 - 7x - 6x^2 = 0$

$2 + 3 - 7x - 6x^2 = 3$

$5 - 7x - 6x^2 = 3$

∴roots of y = 3 are x = -l.4 and 0.2

(ii) Maximum value of $y = 5 - 7x - 6x^2$ is y = 7

4) $y= px^2 - 5x + q$

(a) i. from the table

y = -12 when $x = 0$,

i.e, $-12 = p(0)^2 - 5(0) + q$

⇒ q = 12 ………. (l)

Y = 0 when $x = 4$, i.e.

$0 = p(4)^2 - 5(4) + q$

0 = l6p – 20 + q

⇒ l6p + q = 20 …………….. (2)

Substitute -l2 for q in (2)

l6p + (-l2) = 20

l6p - l2 = 20

l6p = 20 + l2

l6p = 32

$\Rightarrow$ p = $\frac{32}{l6}$ = 2

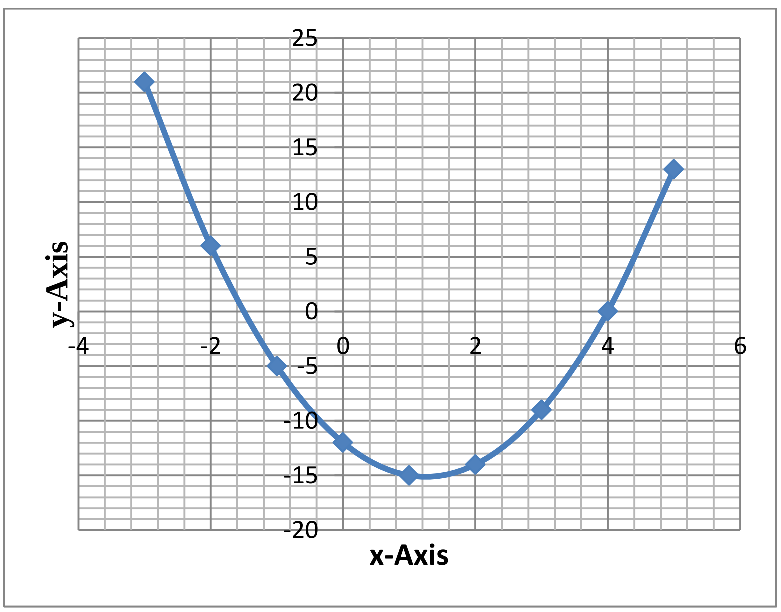
$\therefore$p = 2, q = l2

$\therefore$ y = px^2 – 5x – l2 = y = 2x^2 – 5x – l2

Use it equation to complete the given table

x	-3	-2	-1	0	1	2	3	4	5
y	2l	6	-5	-12	-15	-14	-9	o	13

(b) graph



From the graph:

c) (i) when x = l.8, y = -l4.5

(ii) when y = -8, x = -o.65 or 3.l5 or 3.2

SECTION B

1.

X	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
Y	-15.5	-10.5	-5.5	1	2.5	4.0	5.5	7.0	8.5

9

82/50

ⓐ X	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
Y	-15.5	-15.0	-14.5	1	2.5	2.0	1.5	1.0	2

ⓑ Using a Scale of 2cm + 1 unit On the axis and 2cm to 5 Units On the Y axis draw the graph of the relation for 2.0 ~~xxx~~ 2.0

Solution

$$\frac{2cm}{2cm} = \frac{2.0}{2.0}$$

$$\frac{2cm + 2.0}{2.0 + 2cm}$$

$X = 4$

The unit on the axis and 2cm to 5 units

$$\frac{1}{5}\ \frac{4}{4} = 4$$

$= 4.2$

$$\frac{2cm}{1} = \frac{\cancel{8}2cm}{\cancel{2c}5}$$

$$= \frac{2}{0.4}$$

$= 5$

ⓒ What is the maximum Value of ~~X~~ the maximum of X is ~~5~~ 2.564

ⓓ From your graph obtain the ro of ~~the~~ equation $8x^2 - 2x - 5 = 0$ Solution

$8x^2 - 2x - 5 = 0$

$8x^2 [x^2 - 2x] - 5 = 0$

$6x^2 + -5 = -0.8$

~~= 1.3~~ ~~0 - 9.0 =~~ ~~0.7~~

1 = 0

2 = 0

(2) Above is the graph of the quadratic function $y = ax^2 + bx + c$ where a, b and c are Constants. Using the graph find:-

$ax^2 + bx + c$

$$\frac{ax^2 + bx}{c} = ax^2 \times b \times c$$

$$= \frac{y_2 - y}{ax^2 - \cancel{b}x}$$

$$y = \frac{y_2 - y}{ax^2 - x_1}$$

$$\frac{\text{increase in } y = y_x - y_1}{\text{increase in } ax_2 - x_1}$$

$$= \frac{-2 - 2}{3 - (2)}$$

$$= \frac{-4}{5}$$

$$= 1/\!/$$

(3)

x	-3	-2	-1	-0.5	0	1	2
5	5	5	5	5	5	5	5
7x	-3	-2	-1	-0.5	0	-1	+2
bx^2	-9	-4	-1	-0.25	0	-1	-4
Y	-28	-5	6	7	5	-8	-3

(i) 1.65, 0 − 55

(ii) 7.0

x	-3	-2	-1	0	1	2	3	4	5
Px^2	Px	Px	Px	Px	Px	Px	Px	Px	Px
-5x	15	10	5	0	-5	-10	-15	-20	-25
9x	-13	-12	-1	0	1	2	5	4	5
y	21	6	7	-4	-4	21	-28	-28	-3

Q1

X	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
Y	-15.5	M0 20	M0 -12	1	2.5	12 M0	22 M0	12 M0	44 M0

① $y = \frac{5}{2} \cancel{+x} - 4x^2$

$y = 2x + 20x^2$

$= y = \frac{\cancel{2x} + 20x^2}{\cancel{x}} = 22x$

$\frac{22x}{-2.0} = \frac{40}{2} = 20$

② $\frac{22x}{-1.5} = \frac{110}{5} = 12$

④ $\times 4 = 16$

③ $\frac{22x}{0.5} =$

(b)

③

x	-3	-2	-1	-0.5	0	1	2
y	-28	-0	-1	15	0	3	6

$y = 5 - 7x - 6x^2$ for -

$y = \frac{\cancel{2x} - 6x^2}{\cancel{x}} = \frac{2}{6} = 3.$

$\frac{3}{-3} = 0$

$\frac{3}{-2} = = \frac{+3 \times +2}{+} = \frac{3}{2} = 1$

$= 0.5 = +0.5 = 5 = 15$

Name Baki OLADARIDE Baki
Class SS 2 DART
Gender Male

X	-2.5	-1.5	-1.0	-0.5	0	1	1.5	2
y	-15.5			1	2.5			1

Solution

x	-2.0	-1.5	-0.5	1	1.5	2	
5/2	5/2	5/2	5/2	5/2	5/2	5/2	
x	-2.0	-1.5	0	1	1.5	2	
$4x^2$	-16	-9	-0	1	4		
y							

X	-2.0	-1.5	-0.5	0	1	1.5	2
5/2	5/2	5/2	5/2	5/2	5/2	5/2	5/2
x	-2.0	-1.5	0	0.5	0.5	1.5	2
$4x^2$	-16	-9	0	1	4	4	9
y	-1.55	-8	-2.5	1.25	4.5	13	20.5

2 2 2 1

(i) Maximum Value of y = 2.5 2
(ii) $8x^2 - 2x - 5 = 0$ 2

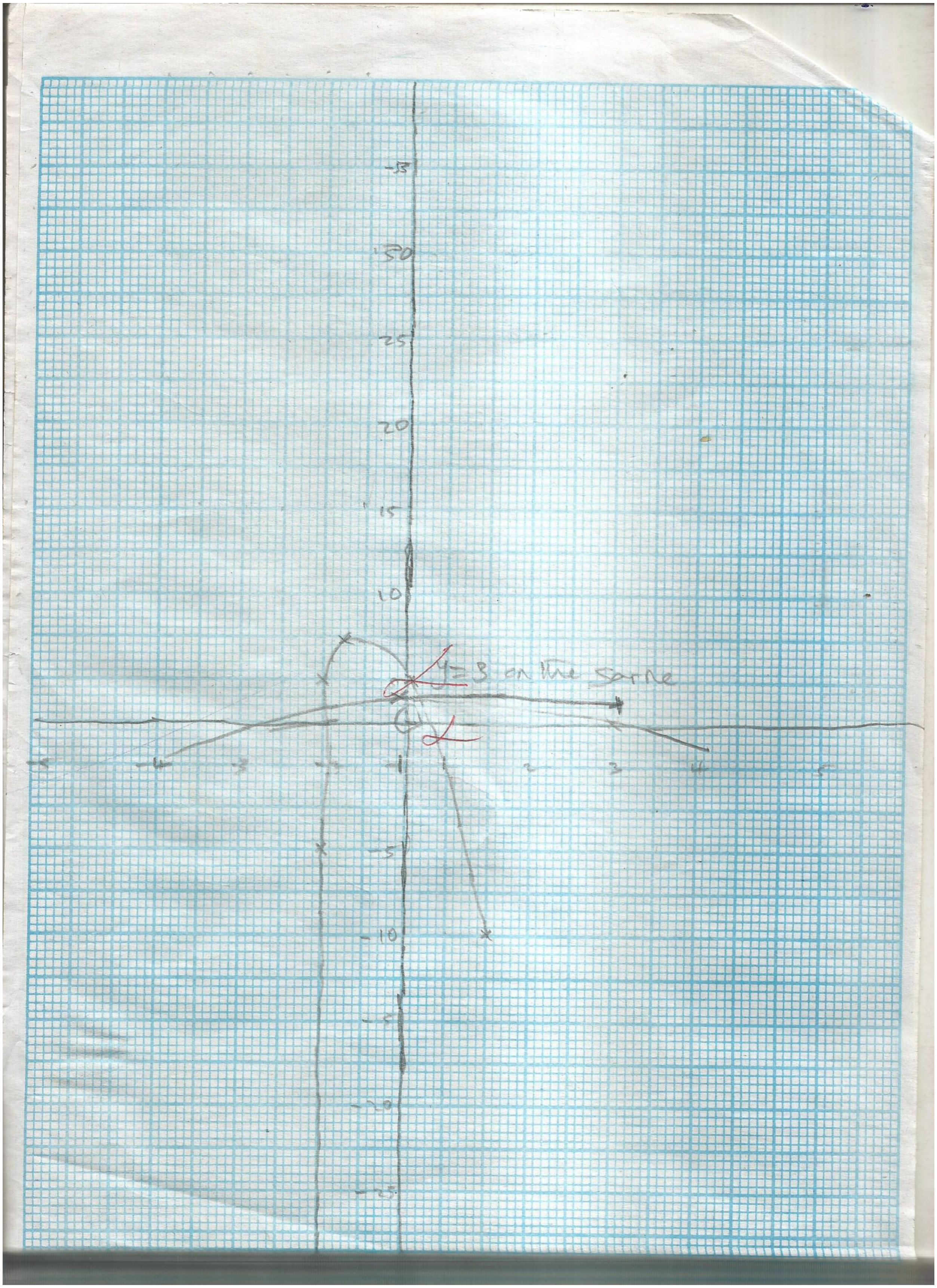
3

(2) 2cm represent 2 unit on x. axis
1cm represent 5 unit on y axis 1

ii
iii $x = 0.5$ and $x = 2.5$ 2
(b) D = 0.3 = 9, E 2.3 G = 4 2

3

C


y=3 on the same

No 22

(1a) x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
Y	-15.5	10	9.5	1	2.5	2	-0.5	13	-11.5

2

(1b) $-0.7, 0.85$ 2

$1\frac{1}{2}$

(1c) 2.7 2

$+4 = 9\frac{1}{2}$

(2a)

Q2

(2i) $y = 2x^2 - 5n - 12$

2iii $0.1, 2.3$ 1

(2b) $O(x = 0\ y = 0.2)$

$0.2 = a(0)^2 + b(0) + b$

$0.2 = c$

$E(x = 1.0\ y = -2)$

$y = 2x^2 + bx + c$

$-2 = a(1-0)^2 + b(1-0) + 0.2$

$-2 = a + b + 0 - 2 = \text{ --- } (1)$

$G = (y = 4.0\ x = 3.0)$

$y = 2x^2 + bx + c$

$4.0 = a(3.0)^2 + b(1.0) + 0.2$

$4.0 = a9 + 3b\ 0.2 \text{ --- } (2)$

$-2 - 0.2 = a + b \text{ --- } (1)$

$4.0 - 0.2 = a9 + 3b \text{ ---- } (2)$

$-2.2 = a + b \times 3$

$3.8 = 9a + 3b \times 1$

$-6.6 = 3a + 3b \times 1$

1

$\frac{3.8}{-10.4} = \frac{9a + 3b}{12a} = \frac{10.4}{12} = \frac{13}{15} = 0.8667$

$-2.2 = 0.8667 + b$

$b = -2.2 + 0.8667$

$b = 1.73$

2

(c) the greatest value of y is 34 ✓ 2

(3a)

x	-3	-2	-1	0.5	0	$1\frac{1}{2}$	2
5	5	5	5	5	5	5	5
-7	21	14	7	3.5	0	-7	-14
$6x^2$	-54	-24	-6	-1.5	0	-6	-24
y	-28	-5	6	7	5	-8	-33

2

(c) 1.65, 0.55 ✓

(ii) 7.0 ✓ 2

+4 = 10

(4)(i)

x	-3	-2	-1	0	1	2	3	4	5
Px^2	Px	Px	Px	Px	Px	Px	Px	Px	Px
$-5x$	-15	10	5	0	-5	-10	-15	-20	-25
	-13	-2	-1	0	1	2	3	4	5
y	21	6	7	0	-7	-4	-21	-28	-30

(ii) $6 = P(-2)^2 - 5(-2) + q$

$6 = 4P + 10 + q$

$-4 = 4P + q$ ——(1)

$0 = P(4)^2 - 5(4) + q$

$0 = 16P - 20 + q$

$20 = 16P + q$ ——(ii)

using simultaneous equation

$-20 = 16P + q$

$\underline{-4 = 4P + q}$

$24 = 12P \quad = \frac{24}{12} = 2$

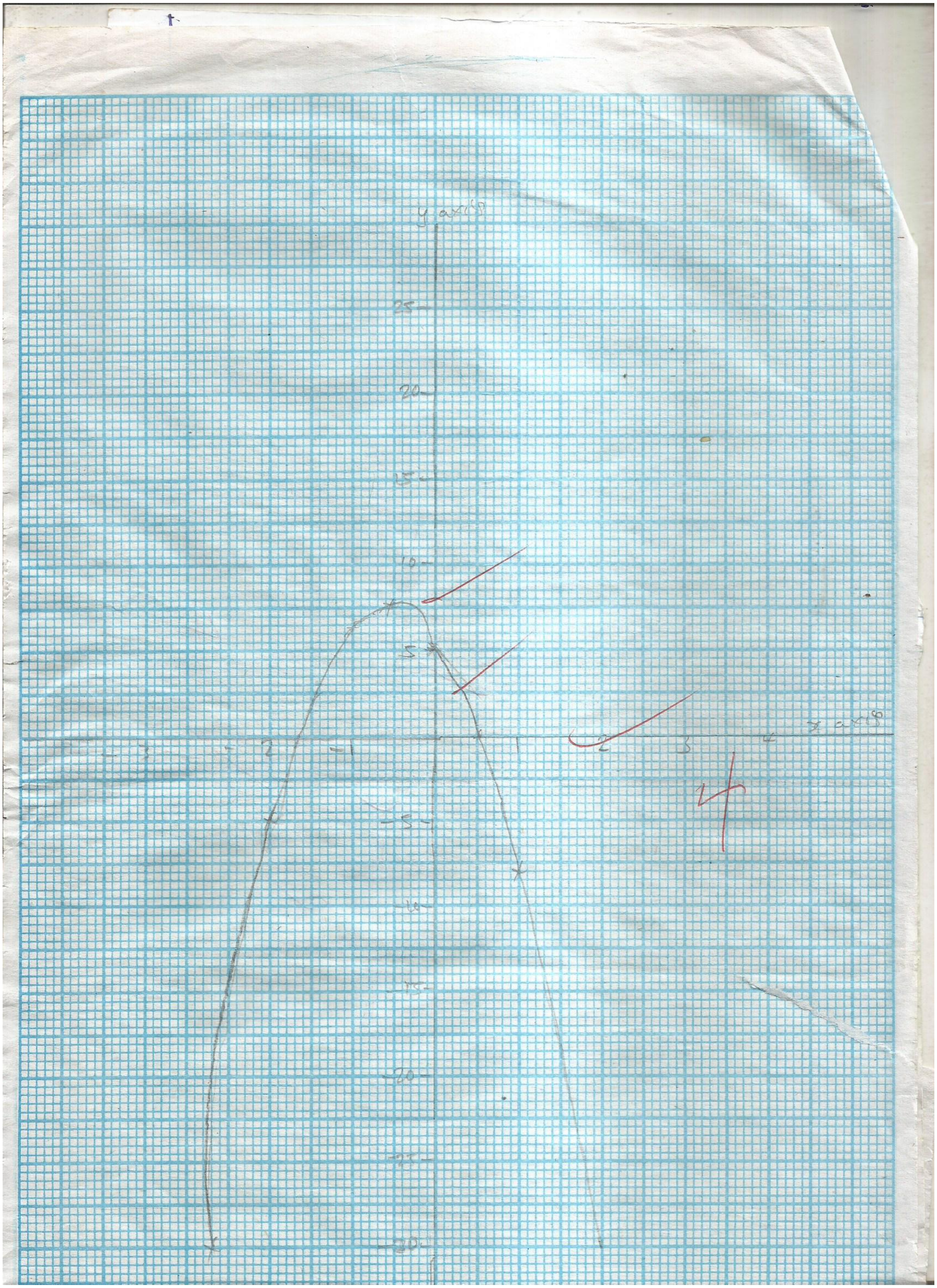
$P = 2$

~~$-4(4)$~~ $-4 = 4(4) + q$

$q = -4 - 8 = -12$

$q = \underline{\underline{-12}}$.

4 + 2 = 6


y axis
25
20
15
10
5
-3
-2
-1
1
2
3
4
x axis
-5
-10
-15
-20
-25
-30
4

(2a) i. 1cm to 5unit on y axis and 1cm to 2units. 2

ii. the equation of line of symmetry of Curves

$x = -0.5$

(iii) There is no roots ly the equation (i.e is imaginar))

(2b) The quadratic function of D, E and (a)

is $y = x2 + x + 4$

2

Q1c Maximum Value of $y = 2.5$ ✓ 2

1d The roots of the equation $8x^2 - 2x - 5 = 0$ is $= 0.7$ ✓ 1

+4

07

Q2

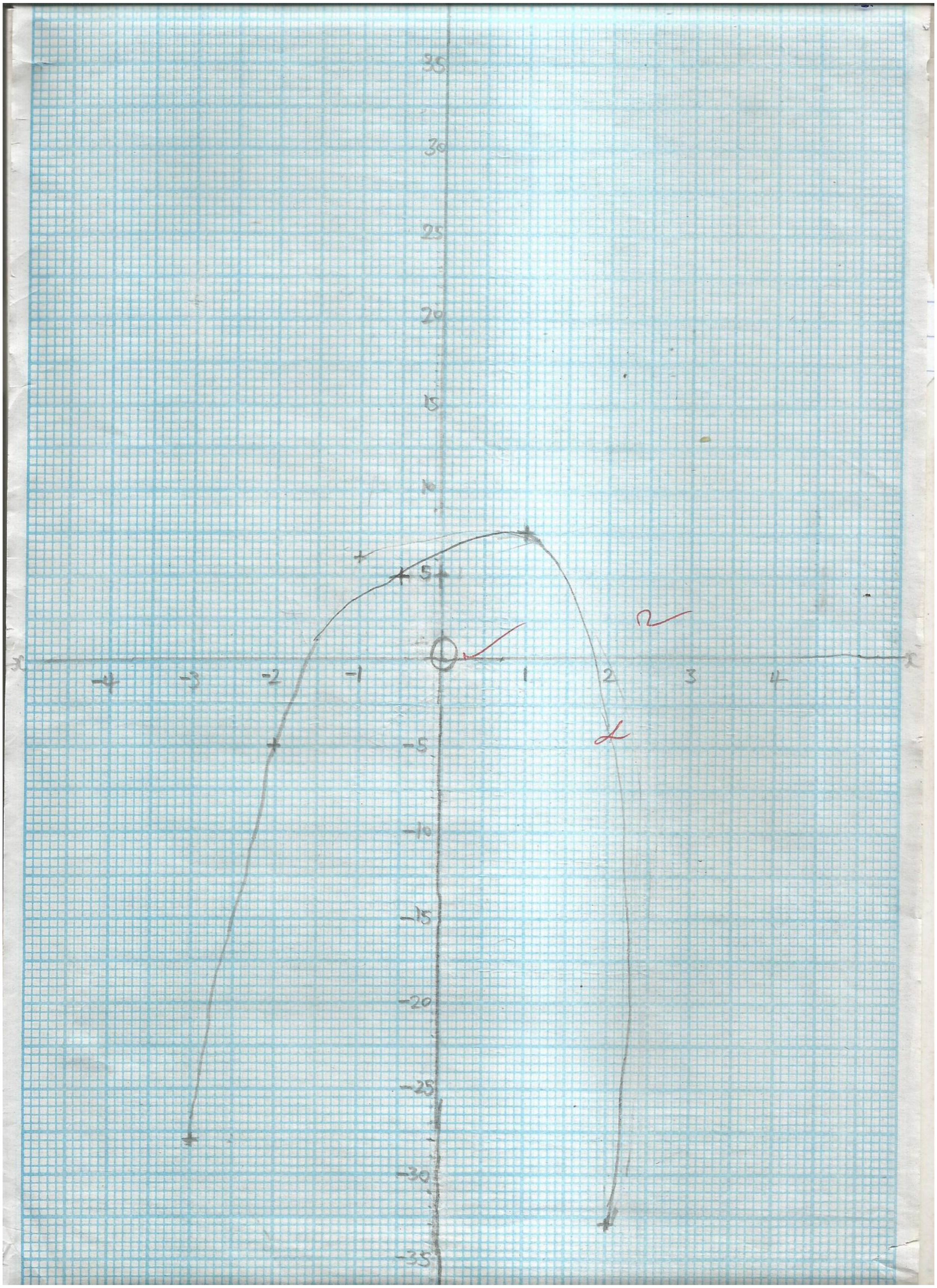
Q2a i 1cm of 5units on y-axis and 1cm to 2units x-axis ✓ 2

ii The equation of line of Symetry of Curve is $x = -0.5$ ✗

iii There is no roots in the equation line of imagnary ✗

Q2b The quadratic function of D, E and G is $y = x^2 + x + 4$ ✗

02



35
30
25
20
15
10
5
-5
-10
-15
-20
-25
-30
-35
-4
-3
-2
-1
1
2
3
4
x
x

Q1c the maximum value of $y = 2.5$ ✓ 2

ed the roots of the equation $8x^2 - 2x - 5 = 0$ is $= 0.7$ ✓ 1

+2

5

Q2a 1cm to 5 units on y-axis and 1cm to 2 units ✓ 1

ii the equation of line of Symmetry of Curve is $x = +0.5$ ✗

iii there is no roots in the equation (ie is imaginary) ✗

Q2b the quadratic function of D, E and G is $y = x^2 \cancel{A} x + 4$ ✗

1

[redacted] JOSHUA

SS 2^A Science class.

-8

$\boxed{0.5}$

(1a)

X	-2.0	-1.5	-1.0	-0.5	0	~~1~~	1	1.5	2
Y	-15.5	-8	-2.5	1	2.5	2	-0.5	-5	-11.5

Solution.

$y = \frac{5}{2} + x - 4x^2$

$y = \frac{5}{2} + (-1.5) - 4(-1.5)^2$

~~[illegible]~~ $y = -8$

~~[illegible]~~

(ii) $y = \frac{5}{2} + x - 4x^2$

$y = \frac{5}{2} + (-1.0) - 4(-1.0)^2$

$y = -2.5$

(iii) $y = \frac{5}{2} + x - 4x^2$

$y = 2.5 + 0.5 - 4(0.5)^2$

$y = 2$

(iv) $y = \frac{5}{2} + x - 4x^2$

$y = 2.5 + 1 - 4(1)^2$

$y = 3.5 - 4$

$y = -0.5$

(v) $y = \frac{5}{2} + x - 4x^2$

$y = \frac{5}{2} + 1.5 - 4(1.5)^2$

$y = 2.5 + 1.5 - 4(2.25)$

$y = -5$

(vi) $y = \frac{5}{2} + x - 4x^2$

$y = 2.5 + 2 - 4(2)^2$

$y = 4.5 - 16$

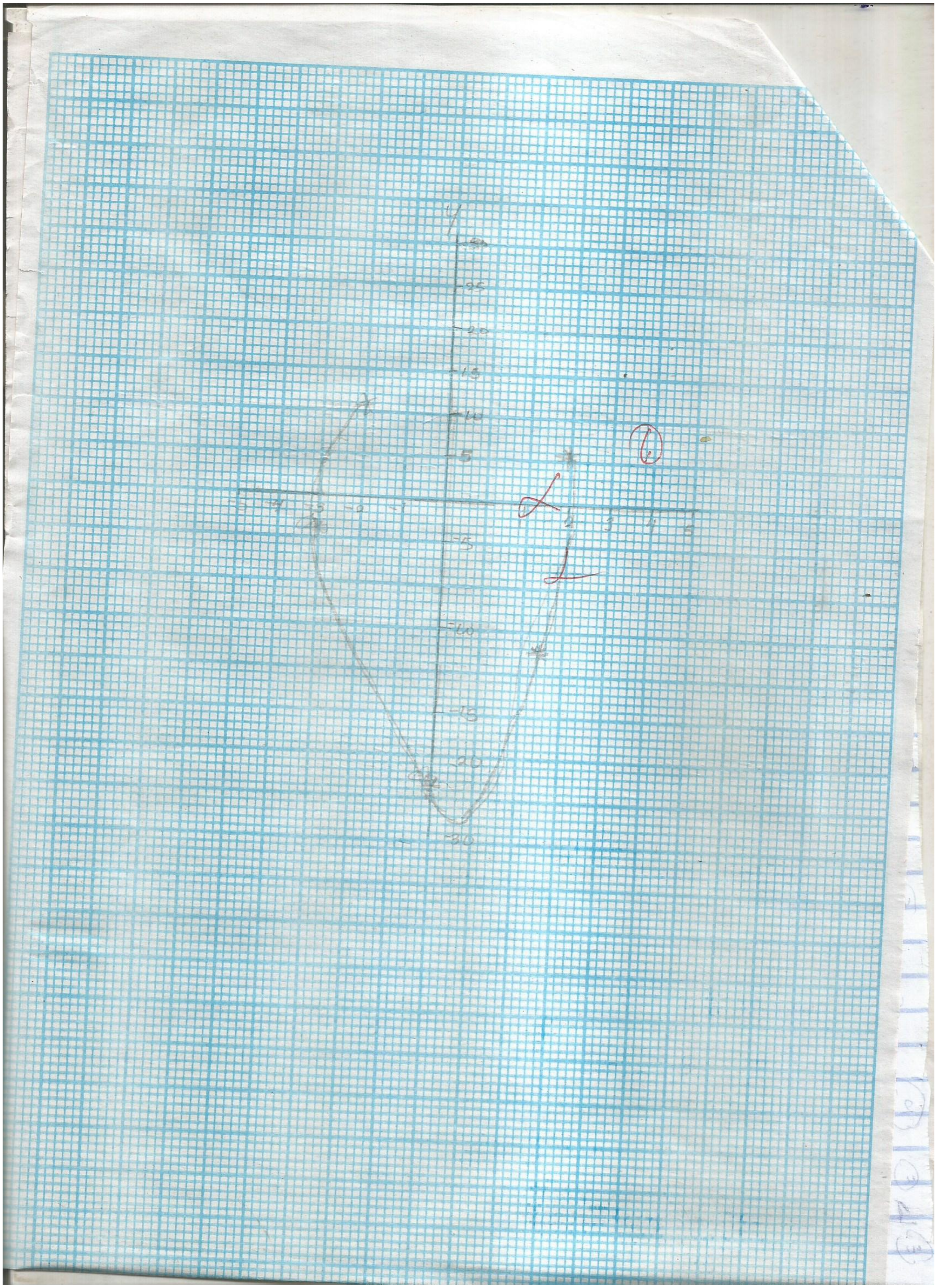
$y = -11.5$

Q2

(2)(a)i

(ii) The equation Of the line of symmetry Of the Curve is 1.

(iii) $ax^2 + bx + c = 0$



$y = \frac{5}{2} + x - 4x^2$

(1)

x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
y	-15.5			1	2.5				

x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$
x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
$-4x^2$	-16	-9	-4	-1	0	-1	-4	-9	-16
y	-15.5	-8	-2.5	1	2.5	2	-0.5	-5	-11.5

3

(i) The maximum value at y is 2.5

12

+4

09

(Q2)

(2)

(i) 0.4cm represent 1 unit of x axis and 5cm represent 1 unit.

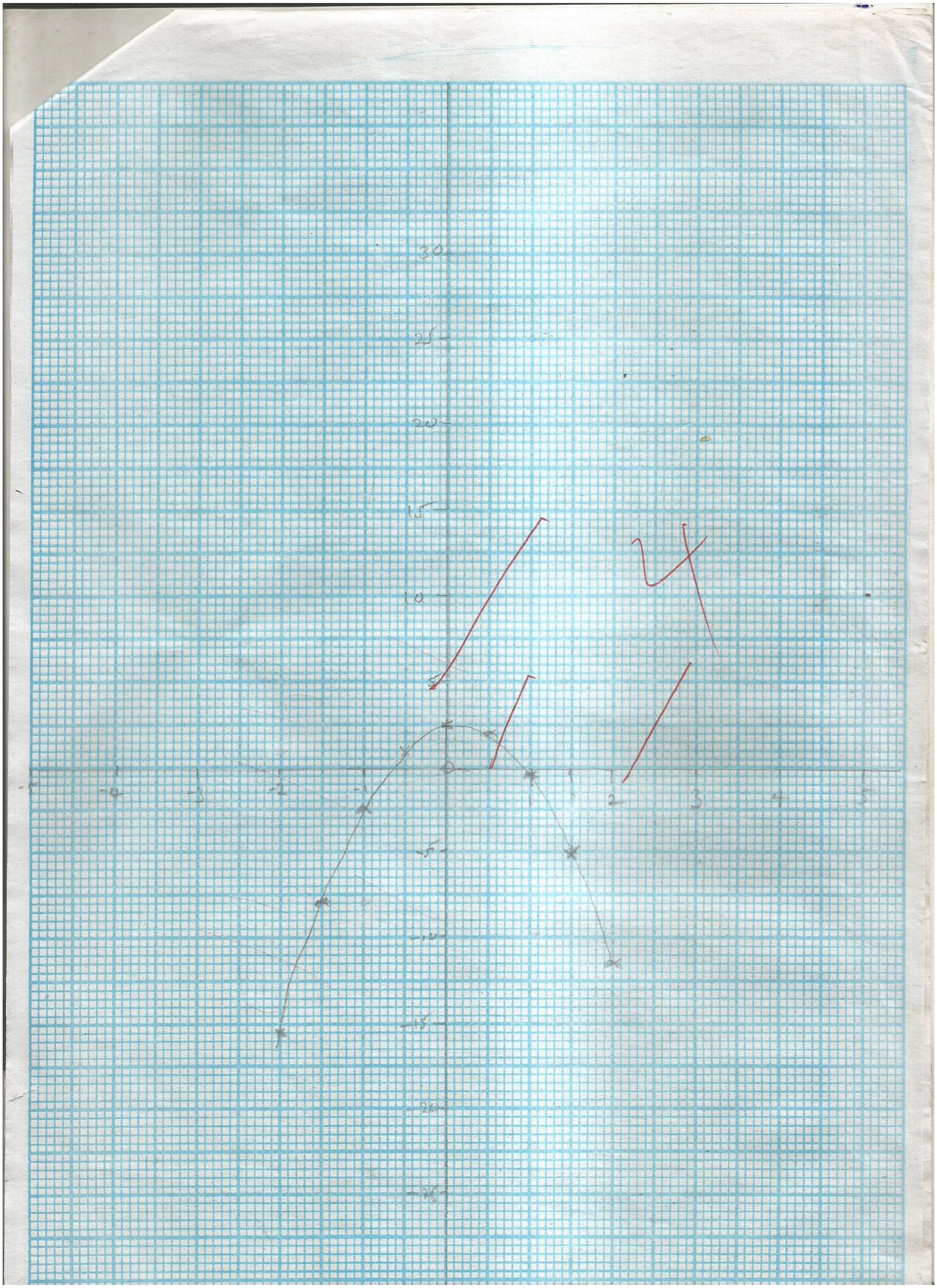
(ii) The ,

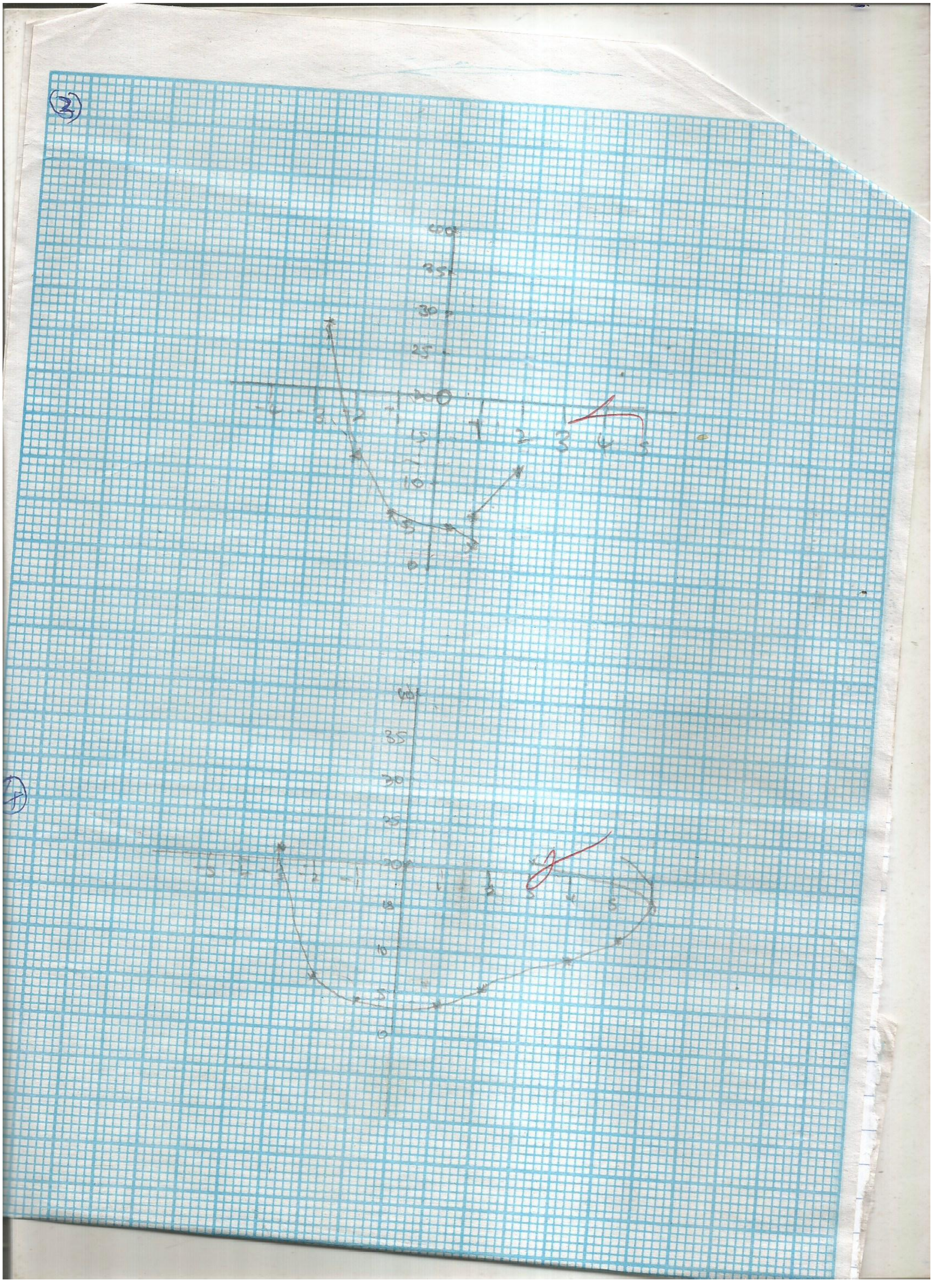
(iii) The roots of the quadratic equation

(3)

x	-3	-2	-1	-0.5	0	1	2
5	5	5	5	5	5	5	5
$-7x$	21	~~28~~ 14	07	3.5	0	-7	-14
$-6x^2$	-54	-24	-6	-1.5	0	-6	-24
Y	-28	-5	6	7	5	-8	-33

2 +4 = 06 +2


30
25
20
15
10
-4
-3
-2
-1
0
1
2
3
4
5
-5
-10
-15
24



1a

x	-2.0	-1.5	-0.5	0	1	1.5	2
$5/2$	$5/2$ 2.5	$5/2$ 2.5	$5/2$ 2.5	$5/2$ 2.5	$5/2$ 2.5	$5/2$ 2.5	$5/2$ 2.5
$+x$	-2.0	-1.5	-0.5	0	1	1.5	2
$-4x^2$	-16	-9	-1	0	-4	-9	-16
y	-15.5	-8	1	2.5	-0.5	-5	-11.5

-1.0
2.5
-1.0
-4
-2.5

$2\frac{1}{2}$

(b)

$+4$

(c) Maximum value of $y = 2.5$

$8\frac{1}{2}$

(2)

(i) 2cm to 5 units on y axis and 1cm to 5 ~~units on x axis~~ 1

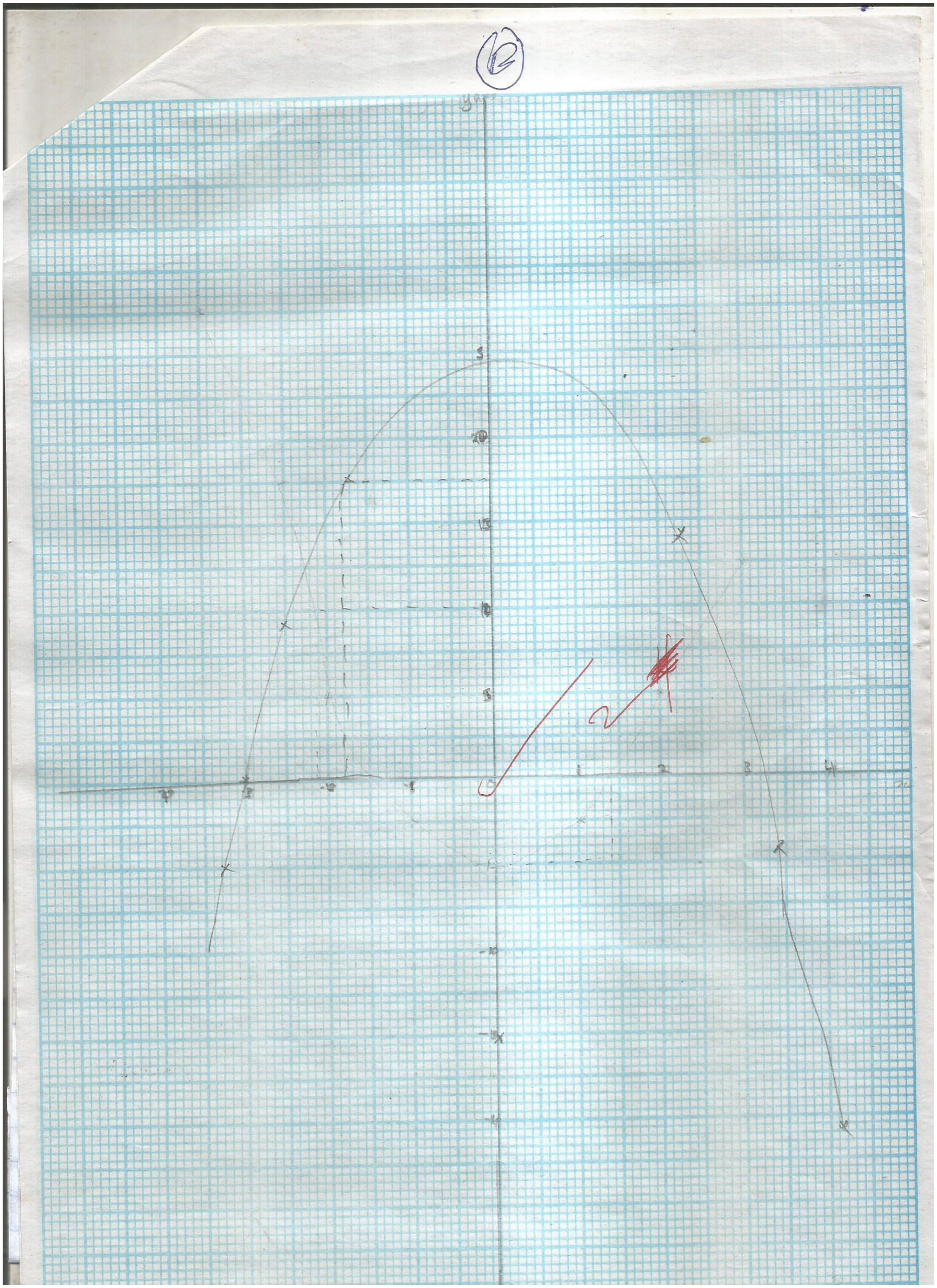
4

(ii)

(3a)

x	-3	-2	-1	-0.5	0	1	2
5	5	5	5	5	5	5	5
$-7x$	21	14	7	-3.5	0	-7	-14
$-6x^2$	-54	-24	-6	-1.5	0	-6	-24
y	-28	-5	6	0	5	-8	-33

$2 + 2 = 4$



01/30

x	-2.0	-1.5	1.0	-0.5	1	1.5	2
y	-15.5	-2.5	2.5	1	7.5	13	20.5

$ay = -3.1$

½

(c) $8x^2 - 2x - 5 = 0$

$8x$

$40x^2$

$(8x^2 - 8x)(+5x - 5)$

$8x(x-1) + 5(x-1)$

$(8x+5) = 0$ OR $x - 1 = 0$

$\frac{8x}{5} = \frac{-5}{5}$ OR $x = 1$

$x = -5/8$ OR $x = 1$

(3)

x	-3	-2	-1	0	1	2	3	4	5
y	21	6	4	12	12			0	13

(2)

x	-3	-2	-1	0.5		0	1	2
y	-28					5		

x 3 -2 -1 -0.5 0 1 2

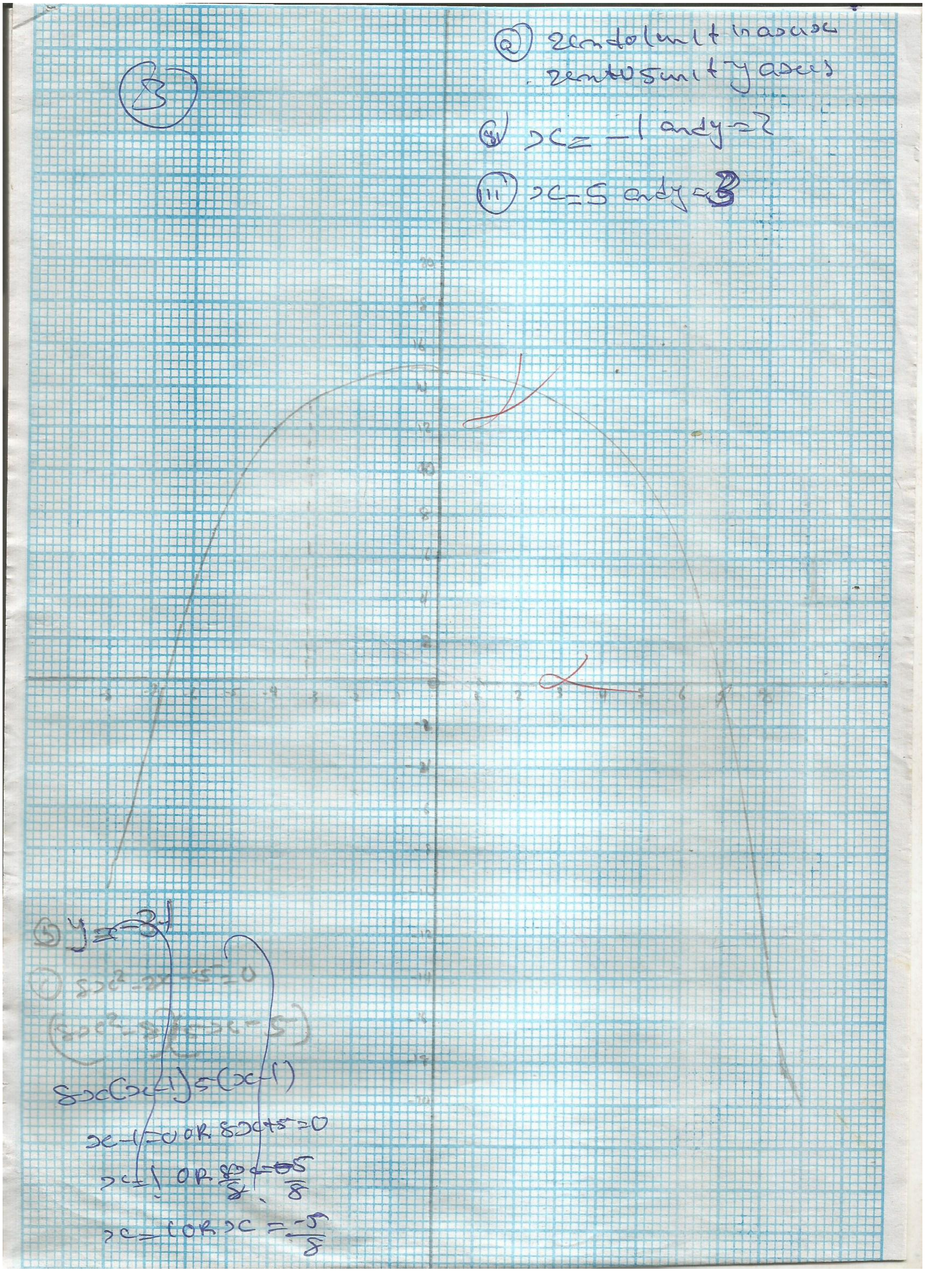
y -28

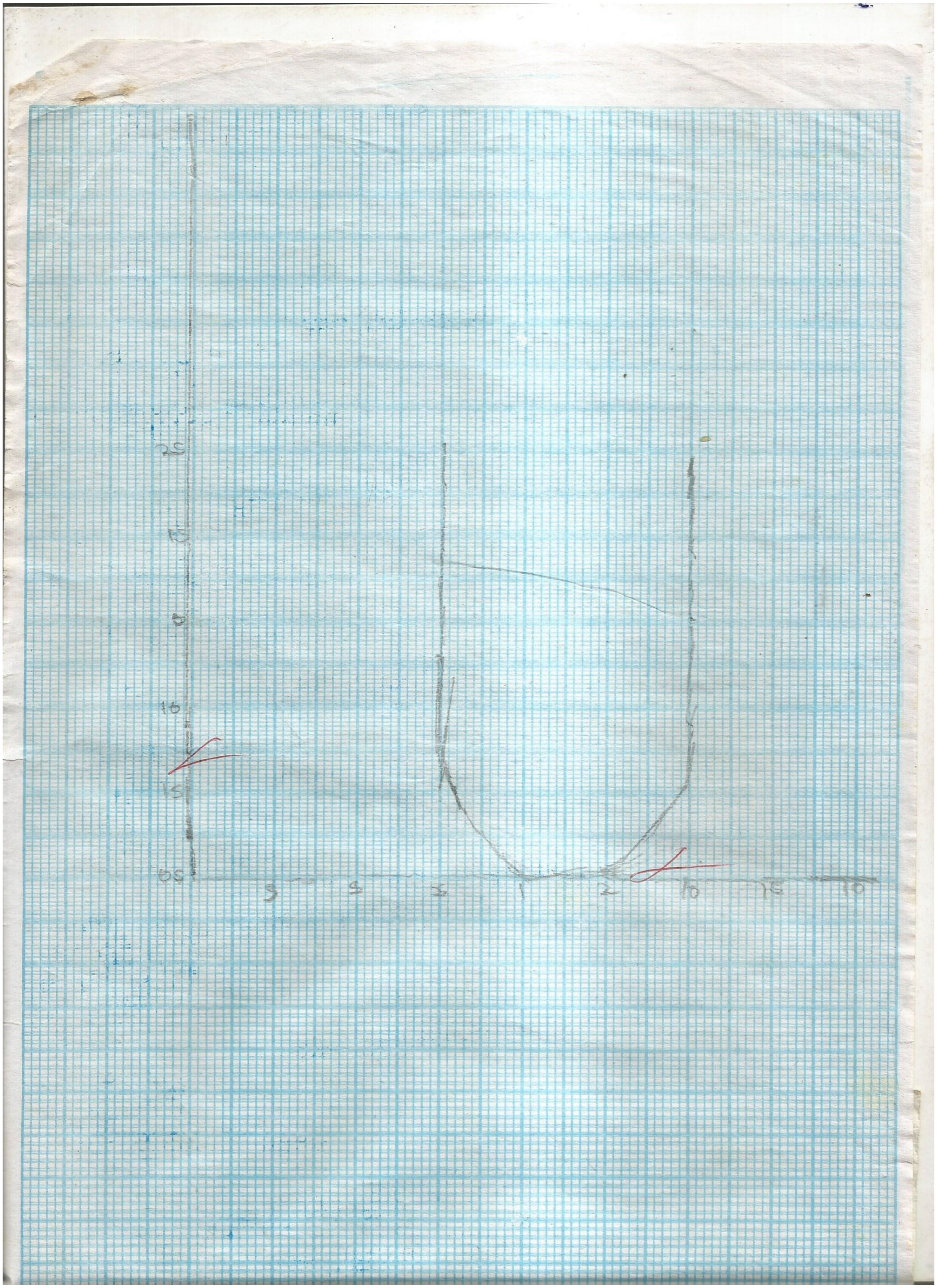
1 = ½

2 = –

3 = –

4 = –


8
(a) 2cm to 1 unit in x axis
2cm to 5 unit y axes
(b)(i) x = -1 and y = 2
(ii) x = 5 and y = 3
(c) y = -3
8x² - 3x - 5 = 0
8x(x-1) 5(x-1)
x-1 = 0 or 8x+5 = 0
x = 1 or x = -5/8



18

x	-2.0	-1.5	1.0	0.5	0	0.5	1	1.5	2
5	5	5	5	5	5	5	5	5	5
x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
$-4x$	-4	-2.25	-1	0.25	0	0.25	-	2.25	-4
y	450			11	2.5				

c the maxiom value of $y = 20.56$

d $8x^2 - 2x - 5 = 0$

$8x^2 - 2x = 0 + 5$

$\frac{6x}{6} = 5$

$= 0.8x$

$\frac{05}{50}$

2

the Scale on both axis ~~are~~ on x are 2cm to represent 5 units and on the x axis 20cm to represent 1 units

(iii) $ax^2 + bx + c = 0$

2b 0 ($x = 0$ $y = 0.2$)

$0.2 = a(0)^2 + b(0) + 6$

$0.2 = 0$

2 ($x = 1.0$, $y = -2$)

$-2 = a(1-0) + b(1-0) + 0.2$

$-2 = a + b + 0 - 2$ ---- (1)

$c = (y = 4.0$ $x = 3(0)$

$y = ax^2 + bx + 6$

$4.0 = a(3.0)^2 + b(1.00 + 0.2$

$4.0 = 9a + 3b$ 0.2 ---- (2)

$-2 - 0 - 2 = a + b$ (1)

1 = 02
2 = 02
3 = 01
4 = —
05

$\frac{0}{32}$

b)

X	
Y	

c) The maximum value of $y = 4.5$

1a

x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
$\frac{5}{2}$	-5	-2.5	$\cancel{1.25}$ -2.5	-1.25	0	1.25	2.5	0.15	5
x	$-2.0x$	$-1.5x$	$-1.0x$	$-0.5x$	$0x$	$0.5x$	$1x$	$1.5x$	$2x$
$-4x^2$									
y	-15.5			1	2.5				

$x+$

0

3a

$y = 8.7x - 6x^2 \quad x = -2$

$y = 5 - 7(-2) - 6(-2)^2$

$y = -1.7$

$y = 5 - 7(-018) - 6(-0.5)^2$

$= 7$

$y = 5 - 7(1) - 6(1)^2$

$y = 8$

$y = 8 - 7(2) - 6(2)^2$

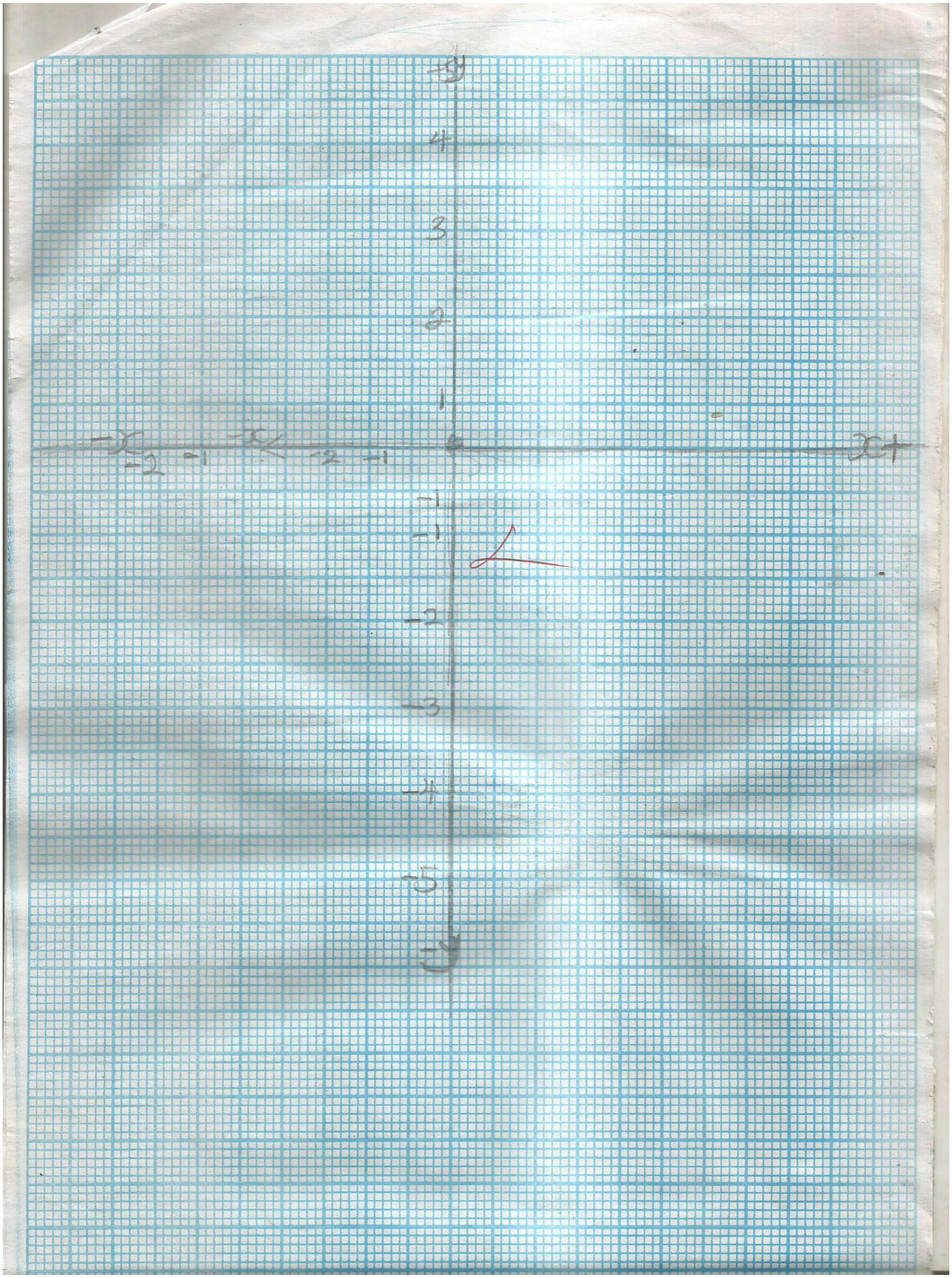
$y = \cancel{35}\ 35$

1 = 0
2 = –
3 = 0
4 = –
0

0

b

x	5	4	3	2	1	0	-2	-4	8
$-6y$	3	3	3	3	3		3	3	3
y	2	1	0	-1	2	3	5	7	9


+y
4
3
2
1
0
x+
-1
-2
-3
-4
-5
-y

x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
$4x^2$	mistake.								
$\frac{5}{2}$									

1a

x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
x	-2.0	-1.5	-1.0	-0.5	0	0.5	1	1.5	2
$-4x^2$	-16	-9	-4	-1	0	-1	-4	-9	-16
2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Y	-15.5	-8	-2.5	1	2.5	2	0.5	-2	-11.5

2½

Arranging of 5/2 to decimal fraction 5/2 = 2.5

c) The maximum value of y 2.5 2

D) The root of equation = 0.7 or 0.9 1 + 1 = 6½

2a i 1cm to represent 2 unit on x-axis and 1cm to 5 unit on y axis

ii $x^2 - 2x$

iii $x = 0$ and $x = 2$

b $a = 1, b = -2$ $c = 0$

The equation $y = x^2 - 2x$

C 15

x	-3	-2	-1	-0.5	0	1	2
$-7x$	21	14	7	3.5	0	-7	-14
$-6x^2$	-54	-24	-6	-1.5	0	-6	-24
5	5	5	5	5	5	5	5
Y	-28	-5	6	17	5	-8	-33

2

as been show ... graph
c $x = -1.6$ or $x = 1.4$ in th group
d 7/1

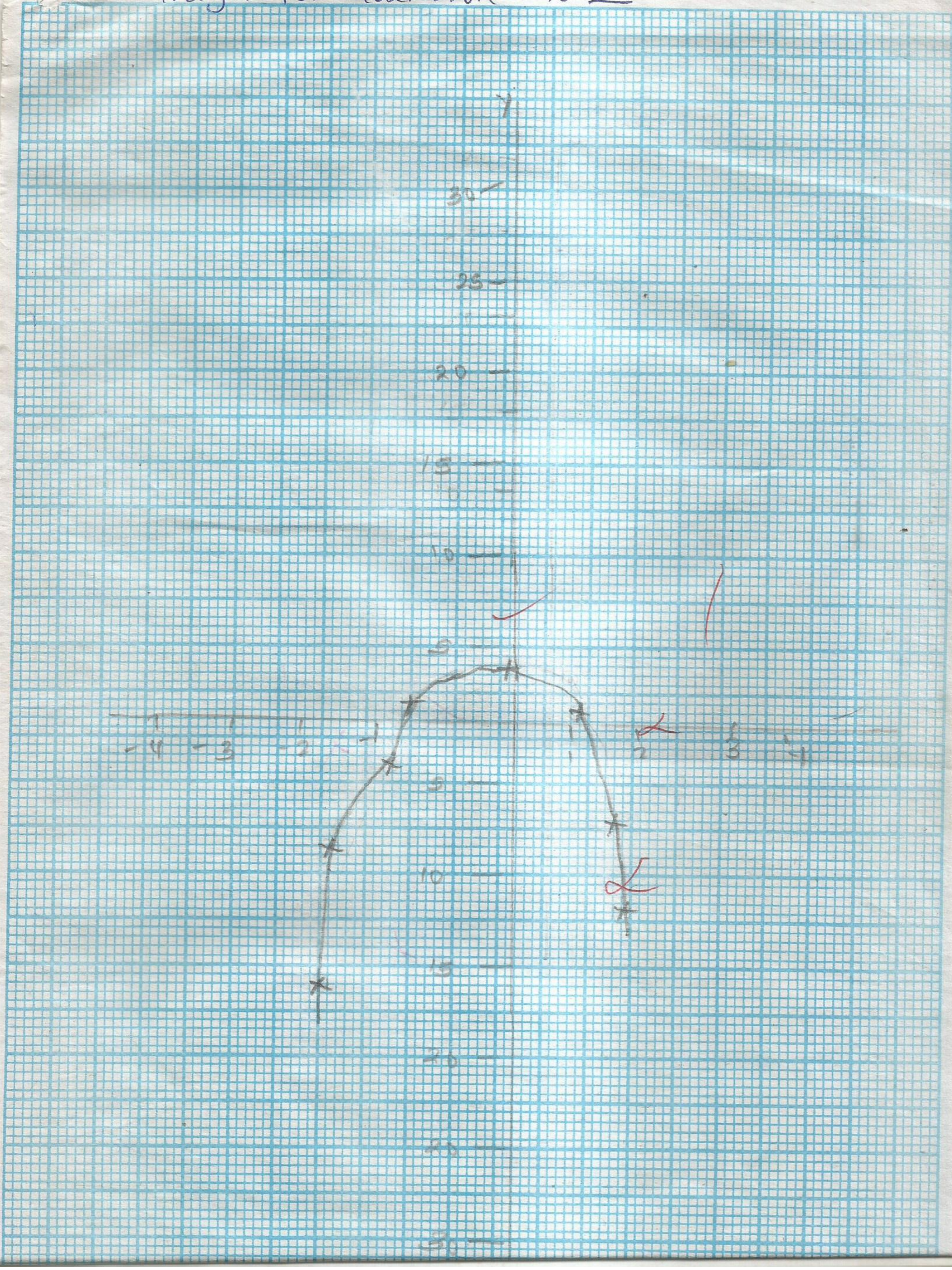
4. The table is for relation $y = px^2 - 5x + q$

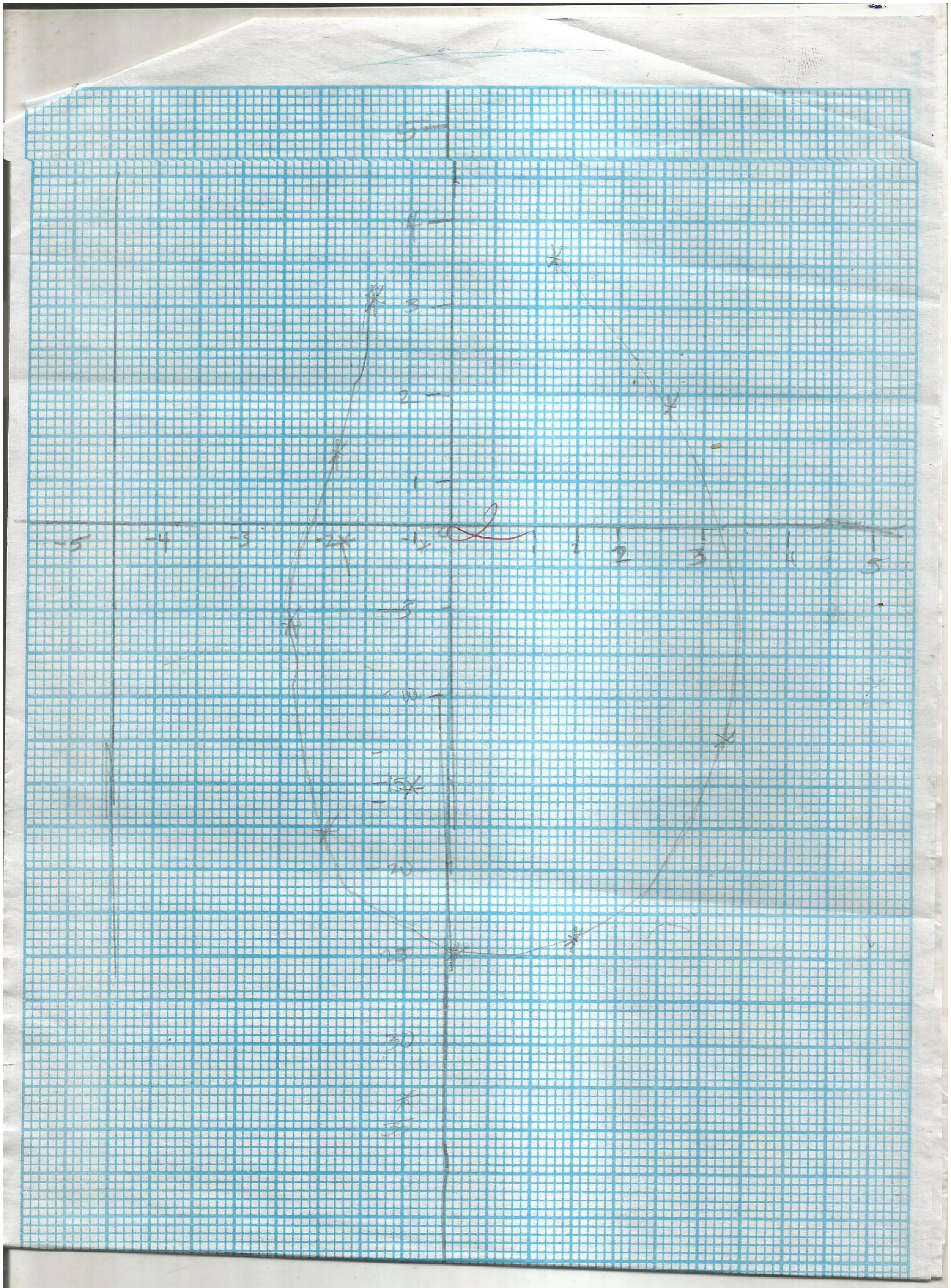
x	-3	-2	-1	0	1	2	3	4	5
y	21	6		-12				0	13

$y = px^2 - 5x + q$
when your $x = -3$ $y = 21$
$y = px^2 - 5x + 3$
$21 = p(-3)^2 - 5(-3) + q$
$21 = p(9) - 5(3) + q$
$21 = p9 + 15 + q$
$21 - 15 = p9 + q$
$6 = p9 + q$
$p9 + 3 = 6$ ---- (1)
when our $x = -2$ $y = 6$
$y = px^2 - 5x + q$
$6 = p(-2)^2 - 5(-2) + q$
$6 = p(4) + 10 + q$
$6 = p4 + 10 + q$
$6 - 10 = p4 + q$
$-4 = p4 + q$
$p4 + q = -4$ --- (2)
so using simutaneous equa
on elimination method
omparing the equation
$9 + q = 6$
$4 + q = 4$
$p9 + q = 6) \times 4$

2

Gragh for quensiton .No 11




-5
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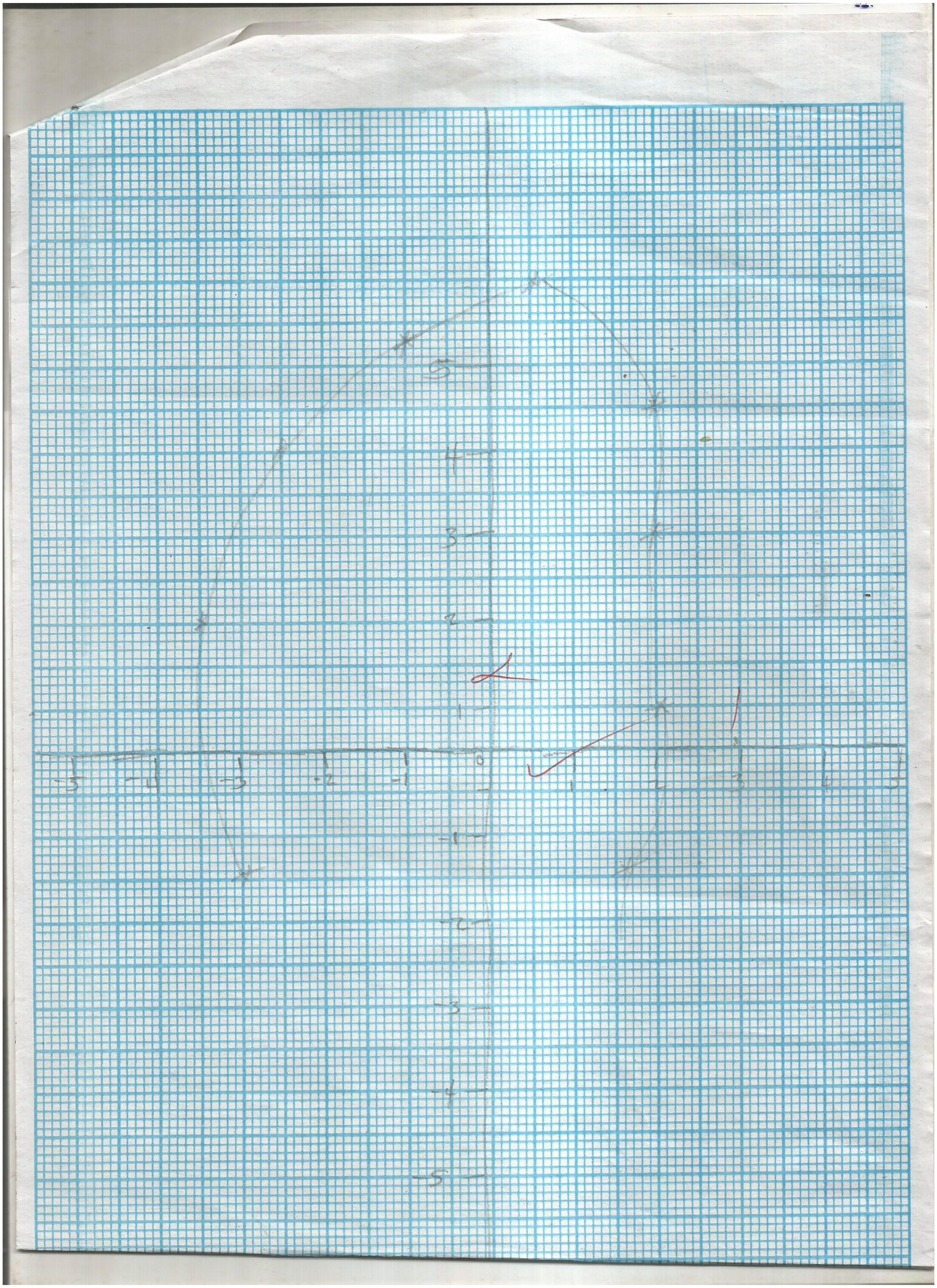

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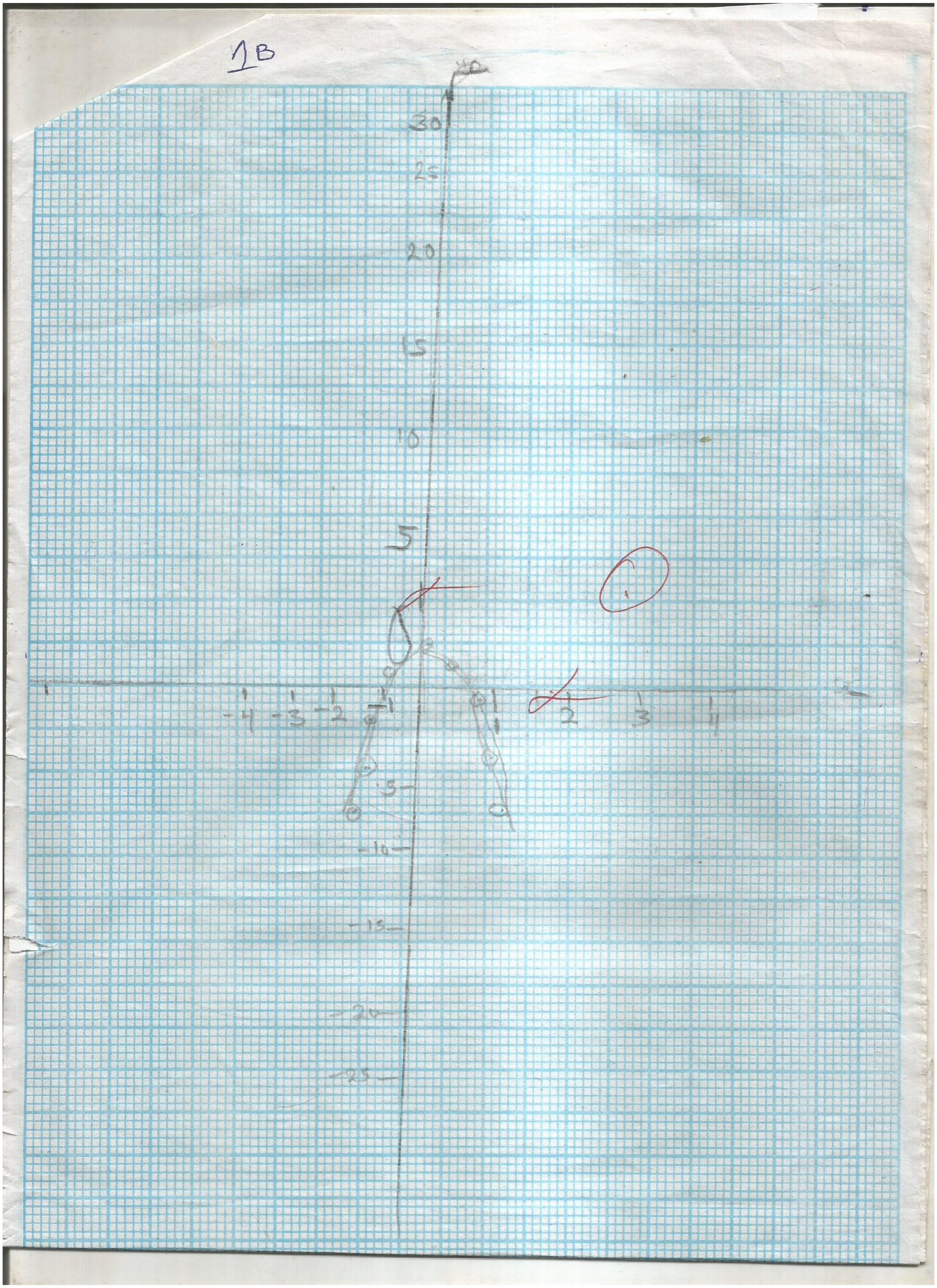
1B
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-20
-25

13=p(3 | 2) - 5 (5+q

13=25p | 25+q

38=25p | - q

25p+ | - 38

4p+q | = -4

21p | = 42

| p=2

[redacted]

SS. 2c Commercial

0/50

x	-2.0	-1.5	-1.0	0.5	0	0.5	1	1.5	2
y	-15.5	-10.5	-5.5	1	2.5	3	2	7	8

solution

when $x = 1$

$x = 1/5\ (x-0)$

$x\ 1/5\ x-0\ 1.5$

$45 + x - 1.5$

$x\ 1.5 = 34$

when $y = 0$

$y = 10 - x = 0$

$y = 5x = 0$

$y = 34 \times 6$

$y\ 6 + 1 = x$

$34 = x - y$

$76 = 9x$

$5x = 110$

(1) $y = 34 - 2$

$y = 20\ (x-2) = 4$

$y = 54 + 8$

$y\ 8.9\ 1/2$

$y = 9$

$y = 1/2 + (-2.0$

$y\ 5/2\ (2.0) + (-2.0$

$y = 0 - 5 - 4.0$

(2)

$a^2 + b^c = 0$

$a + b^c + c = 0$

$a^2 + x - b = 0$

$a^2 + c\,x = a^2$

$a^2 x\, bc = b$

$a^2 c + b = c$

$a^2 c + x = a$

$ax = 1$

x	2.0	-1.5	-1.0	0.5	0.5	1	1.5	2	
y	15.5	12	1.5	1	2.5	14.5	23	31.5	

y when $y = 0$

$y = 5 - 7x = 6$

$y = 7 + (x - 7)$

$y' =$

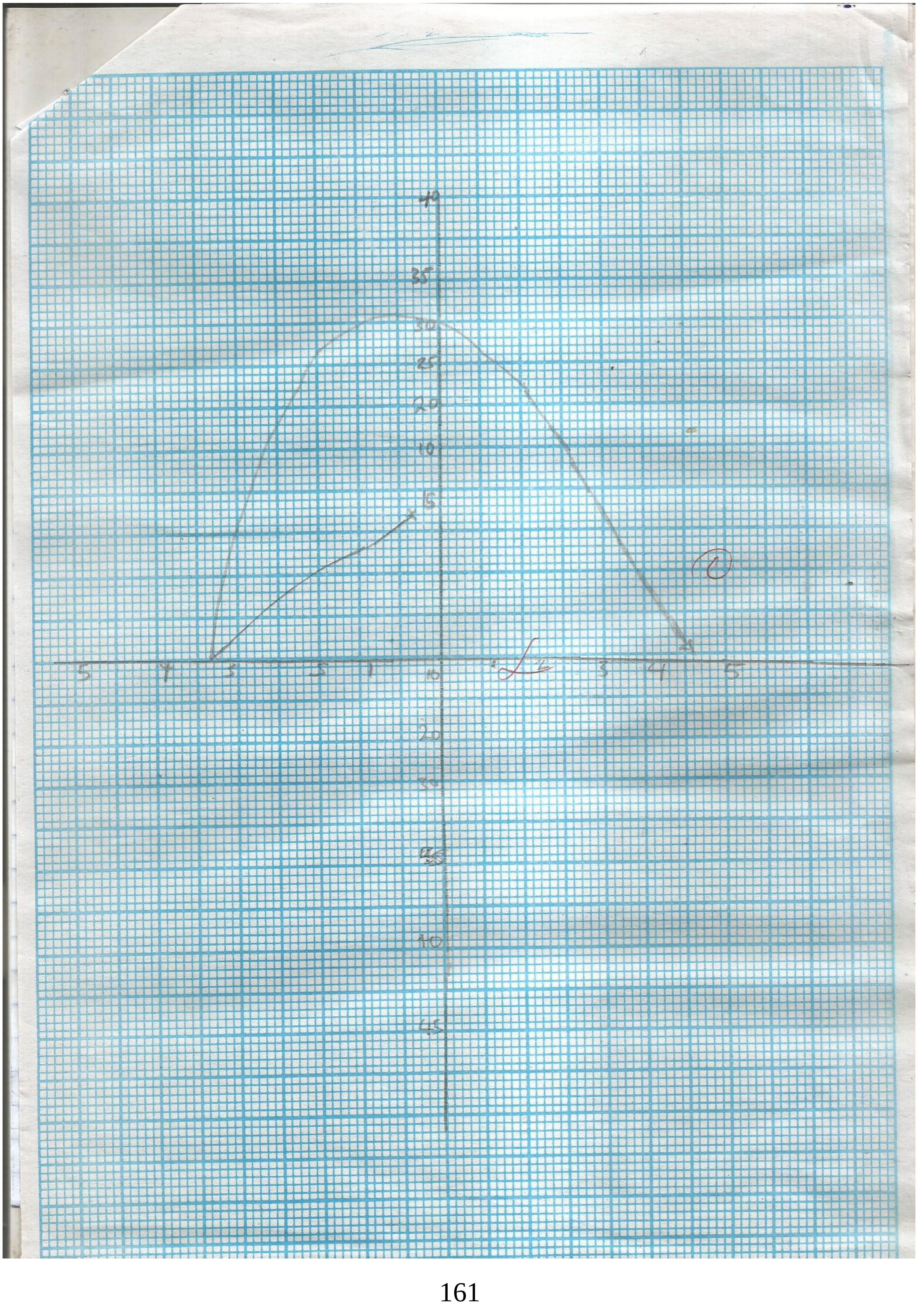
0

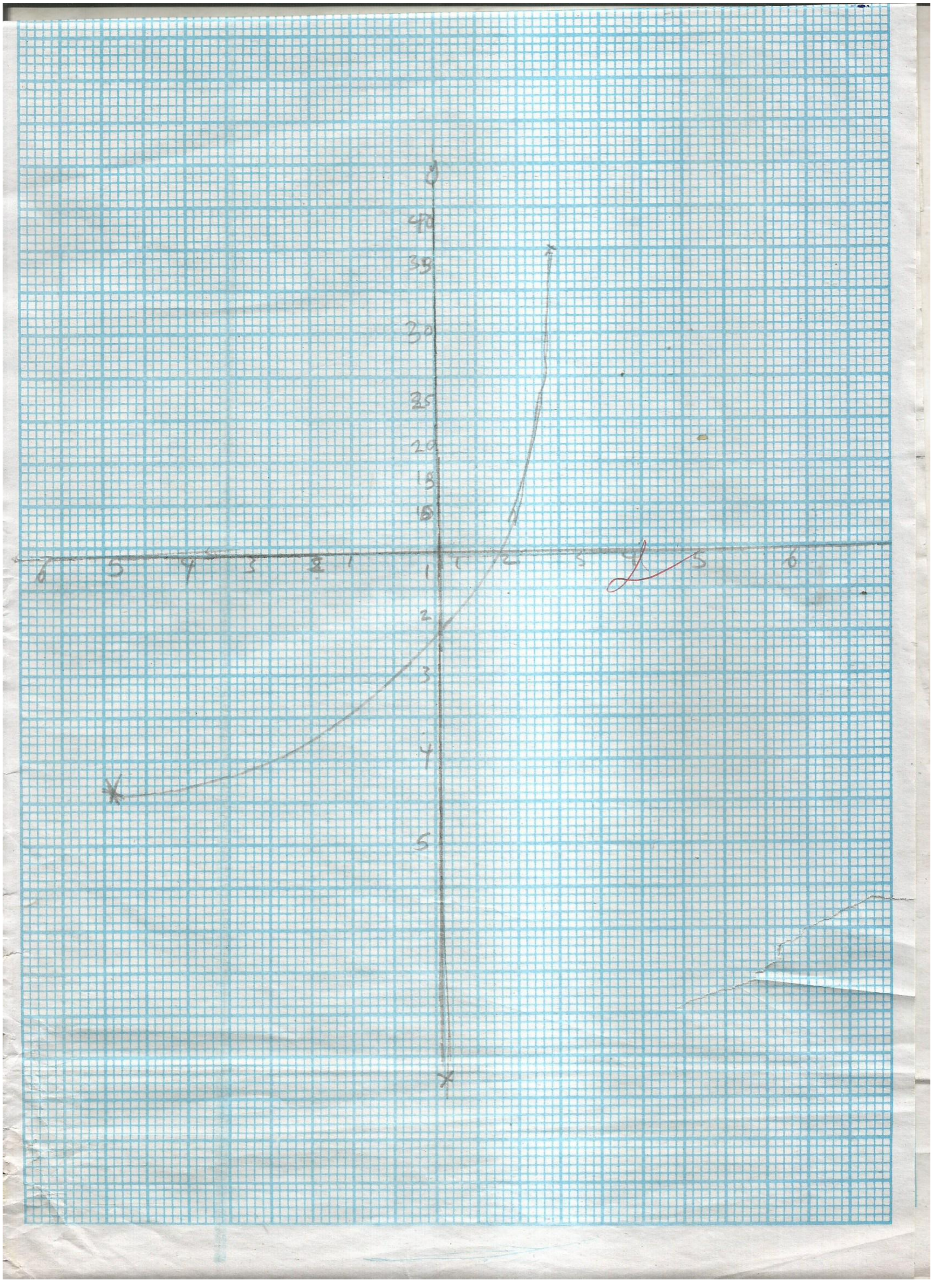
1 = 0

2 = —

3 = 0

4 = —





$y = \frac{5}{2} + x - 4x^2$ $\quad$ $y \cdot \frac{5}{2} = x - 4x^2 + y$

1) $\frac{5}{2} = -1.5 - 4(-1.5)^2$ $\quad$ $\frac{5}{2} = x - 2x^2 + y$

$y = -1.5 - 4(2.25)$ $\quad$ $5 = x - 2x^2 + y$

$y = -1.5 -$ $\quad$ $5 = 2^2 + y$

$y = -10.5$ $\quad$ $y = 4 + 5$

$y = 9$

2) $y = \frac{5}{2} + x - 4x^2$

$y = \frac{5}{2} + (-1.0) - 4(-1.0)^2$

$y = \frac{5}{2} + (-1.0) - 4(1)$

$y = \frac{5}{2} + (1.0) - 4$

$y = 5 + (1.0) - 2$

$y = 0.5$

$y = p(3)^2 + 5(3) + 9$

$y = p(9) + 15 9$

$y \; p9 + 159$

3) $y = \frac{5}{2} + x - 4x^2$

$y = \frac{5}{2} + (0.5) - 4(0.5)^2$

$y = \frac{5}{2} + (0.5 - 4(0.25)$

$y = 2$

4) $y = \frac{5}{2} + x - 4x^2$

$y = \frac{5}{2} + 1 - 4(1)^2$

$Q_1 = 1\frac{1}{2}$

$2 = NR$

$3 = NR$

$4 = NR$

$\frac{02}{50}$

Number (2) $y = px^2 - 5x + 9$

1) $y = p(-1)^2 - 5(-1) + 9$

$y = p(1) - 5 + 9$

$y = p - 5 + 9$

$y = 4$

2) $y = px^2 - 5x + 9$

$y = p(1) - 5(1) + 9$

$y = p = 5(1) + 9$

$y = p - 5 + 9$

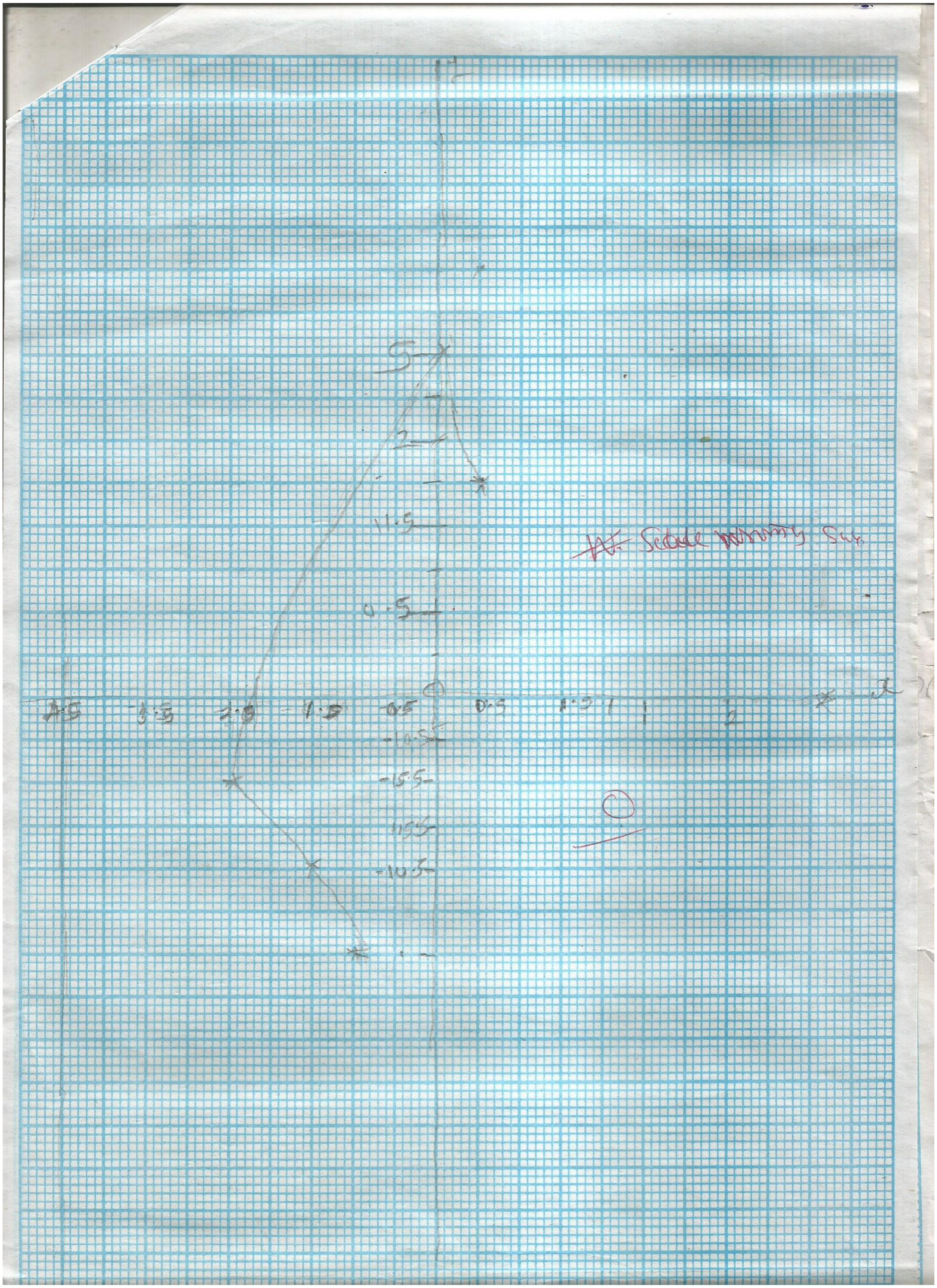
$y = 5$

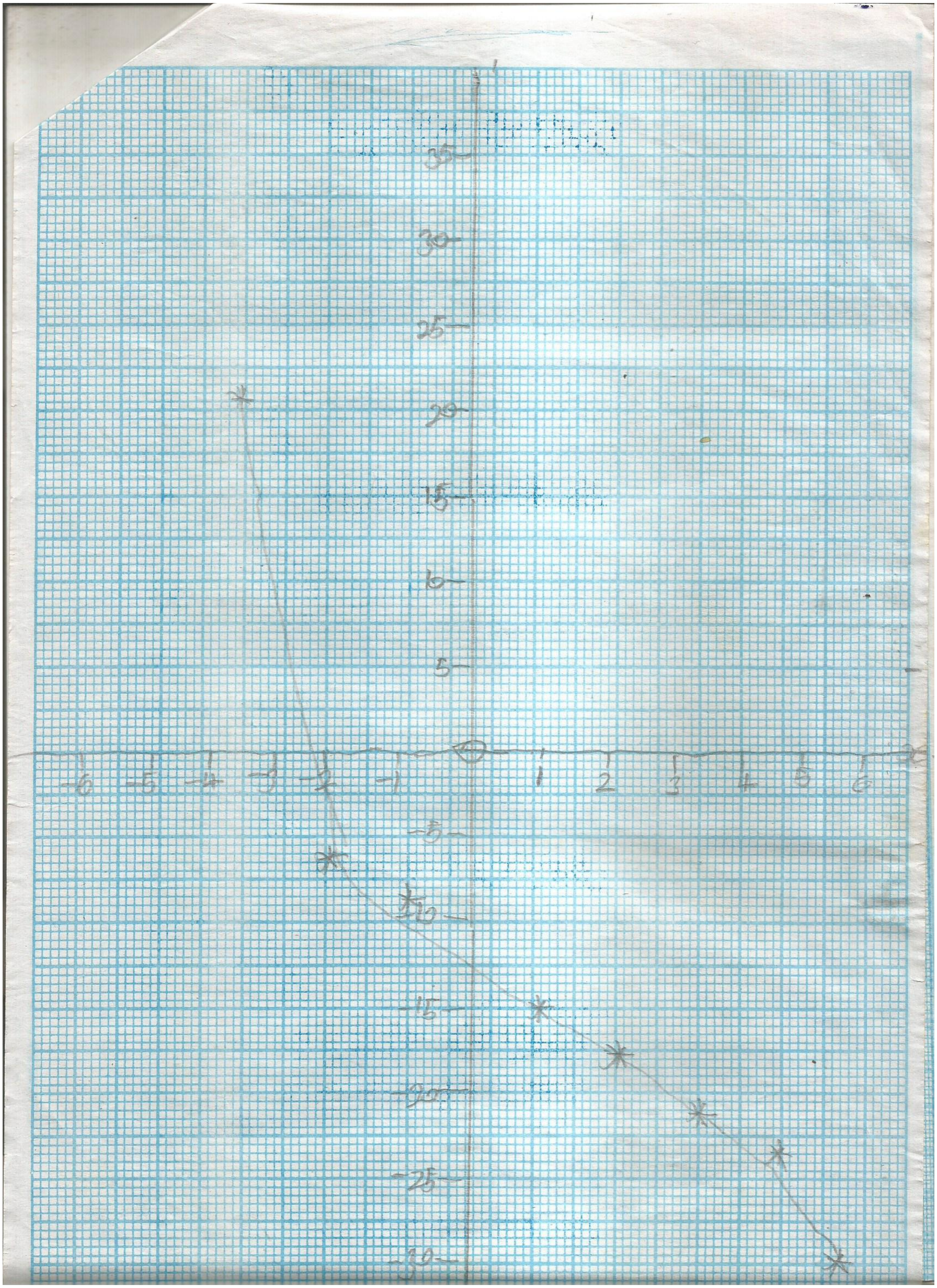
3) $y = p(2)^2 + 5(2) + 9$

$y = p(4) + 10 + 9$

$y = p4 + 10 \; 9$

$= p4 + 10 + 9$





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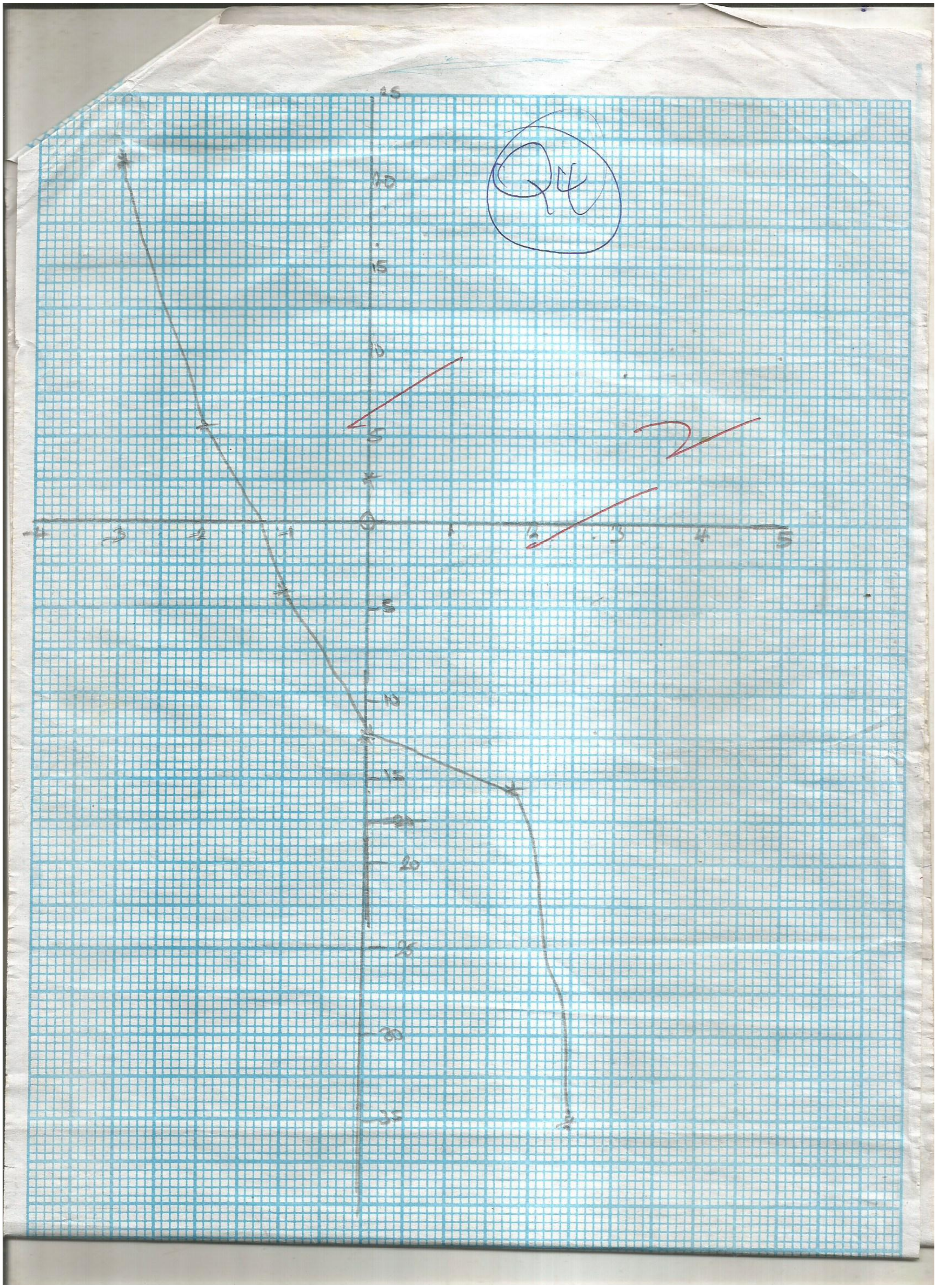
Q4

APPENDIX III

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

DEPARTMENT OF SCIENCE EDUCATION

LETTER TO SCHOOL PRINCIPALS

Dear ______________________________,

I am a Ph. D. student in Mathematics Education, Department of Science Education, University of Ilorin. My thesis supervisor is Prof. Medinat F. Salman. I am also a Mathematics Teacher at Ilorin South Senior Secondary, OkeAdini, Ilorin. I am conducting a Ph.D. research study which examines senior secondary school II students' conceptions about quadratic graph in algebra. I have selected your school as one of the schools to collect data for this study.

The purpose of this study is to identify student difficulties in solving algebraic problems and to suggest some remedial measures to overcome these difficulties. In order to examine student errors and misconception s, I wish to administer a test instrument to SS II students.

I would like to request the participation of your school in this study by allowing me to conduct the test in your school. You will be given an opportunity to receive a summary of the findings at the end of the exercise. I will not use students' names or anything else that might identify them in the written work, oral presentations, or publications. The information remains confidential. They are free to change their minds at any time and to withdraw even after they have consented to participate. They may decline to answer any specific Questions. There are no known risks to you for assisting in this study.

This study has been reviewed by University of Ilorin Ethical Review Committee. If you would like more information, please contact me by phone at o8l334o8433 or by e-mail at bamjum2ol4@gmail.com. Please contact me at your earliest convenience to discuss the work or to provide your consent to participate.

Thank you for your consideration.

Yours sincerely,

MUSA, Rafiat Adejumoke

APPENDIX IV

UNIVERSITY OF ILORIN, ILORIN, NIGERIA
DEPARTMENT OF SCIENCE EDUCATION

PARENT/GUARDIAN CONSENT LETTER

Dear Parent or Guardian,

I am a Ph. D. student in Mathematics Education, Department of Science Education, University of Ilorin. My thesis supervisor is Prof. Medinat F. Salman. I am also a Mathematics Teacher at Ilorin South Senior Secondary, Oke-Adini, Ilorin. I am conducting a Ph.D. research study which examines senior secondary school II students' conceptions about quadratic graph in algebra. I have selected your child's school as one of the schools to collect data for this study.

The purpose of this study is to identify student difficulties in solving algebraic problems and to suggest some remedial measures to overcome these difficulties. In order to examine student errors and misconception s, I wish to administer test SS II students in mathematics. Your child will be asked to participate in a written test during the second term of 2017/2018 academic session. Based on the results, your child may be asked to participate in an interview to identify his or her difficulties in algebraic problem solving.

I would like to request the participation of your child in this study. Participation in this study is voluntary and will not affect your child's attendance in class or his/her evaluation by the school. All information collected will be anonymous. In a way, the results of this study may help the school as well to identify students' difficulties in algebra and propose remedial work.

Please indicate on the attached form whether you permit your child to take part in this study. Your cooperation will be very much appreciated. If you have any Questions or would like more information, please contact me by phone at 08l33408433 or by e-mail at bamjum2ol4@gmail.com and if you have any Questions about your child's rights as a participant in this study, please contact My Supervisor at 08035725654 or by email at salman_mf2005@yahoo.com

Thank you for your consideration.

Yours sincerely,

MUSA, Rafiat Adejumoke (Mrs.)

PARENT/GUARDIAN CONSENT FORM

I agree to allow my child; ______________________________________to participate

In the test ☐

In the interview ☐

Parent's/Guardian's signature: _________________ Date:_____________

APPENDIX V

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

DEPARTMENT OF SCIENCE EDUCATION

INFORMED CONSENT FORM

Dear Student;

Please be informed that you are selected to participate in a research study. Your consent is hereby required to take part in the study. Detail information about the research is provided below. Kindly endorse this consent form if you volunteer to participate in the study after reading about the research.

Purpose of the Research: The purpose of the research is to investigate the misconceptions of algebra held by senior school students, as parts of efforts to promote meaningful learning in Mathematics.

Procedure: Student participants will be required to write a test entitled Algebra Conceptions Test (ACT). The results of the test will be used to identify students' misconception s, correct conception and alternative conceptions about algebra held by senior secondary school students. The test will be marked immediately and you will be given your script in order for you to be aware of the type of conceptions held about algebra in mathematics.

Confidentiality: All information provided by you will be treated with utmost confidentiality and used for the purpose of the research only.

Risks: The test will take place during classroom hours; hence, no risk is envisaged to your person throughout the research period

Benefit: The likely benefits you may derive from the research study include:

i. awareness of the type of conceptions held about algebra in Mathematics, and

ii. You stand to obtain a good grade in mathematics in the senior School Certificate examinations conducted by WAEC and NEC0 and other public examinations required for admission into University

Rights of Volunteers (Student Participants): Your participation in this research is voluntary; hence, if you decide not to take part or stop your participation in the research at any time, you will not lose anything. If you have any Question about the research, you may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria or call the researcher on cellphone number 08133408433 or email: bamjum2014@gmail.com

Student Response Agreement: I hereby voluntarily consent to participate in the research. I know that I may refuse to participate or stop my participation in the research at any time. Also, I understand that if I have any question about the research or my right as a student participant, I may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cellphone number 08133408433 or email: bamjum2ol4@gmail.com

………………………….	…………………	…………….
Student Participant	Signature	Date
………………………….	…………………	……………..
Parent/ Guardian	Signature	Date
………………………….	…………………	...…………..
Researcher	Signature	Date

APPENDIX VI

Result Format of Students' Terminal Mathematics Examinations score Record

The Mathematics Teachers/Examinations' officers are requested to complete the table below

S/No.	Student Identity No.	Exams score	Exams officer's Signature and Date
l			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
l2			
l3			

l4			
l5			
l6			
l7			
l8			
l9			
20			

APPENDIX VII

List of Number of Government Approved Senior secondary school s in Kwara State

Senatorial District	local Government	Public School	Private School	Total	Total Per Senatorial District
Kwara North	Baruten	17	12	29	126
	Edu	21	9	30	
	Kaiama	9	6	15	
	Moro	19	12	31	
	Patigi	15	6	21	
North Central	Asa	22	9	31	191
	Ilorin East	30	19	49	
	Ilorin South	21	42	63	
	Ilorin West	28	20	48	
Kwara South	Ekiti	15	6	21	219
	Irepodun	40	13	53	
	Isin	17	1	18	
	Offa	14	16	30	
	OkeEro	14	2	16	
	Oyun	20	2	22	
	Ifelodun	44	l5	59	

Source: Kwara State Ministry of Education, 2017

APPENDIX VIII

BUDGET PROPOSAL

DESCRIPTION OF ITEM	EXPECTED FROM			TOTAL
	SPONSOR	STUDENT	OTHERS	
1.0 Personnel Costs/Allowances				
1.1 Researcher Assistant (6)		Student		180, 000:00
1.2 Researcher Informants				Nil
1.3 Technical Assistants (3)		Student		30, 000:00
Sub Total (not>20% of budget)				**210, 000:00**
2.0 Equipment (list & Specify)				
2.1 Toshiba laptop		Student		150, 000:00
2.2 HP laserjet Printers (l Colour and 2 black and white)		Student		85, 000:00
2.3 Flash/Modem		Student		l5, 000:00
2.4 Generator (Alternative Power Supply)		Student		45, 000:00
SubTotal (not>20% of budget)				**295, 000:00**
3.0 Supplies Consumables				
3.1 Papers/Toners		Student		120, 000:00
3.2 Purchase of Textbooks and Pen		Student		15, 000:00
3.3 Monthly Subscription of modem at N2500 per month x 30		Student		75, 000:00
Sub Total				**210, 000:00**
4.0 Data Collection & Analysis				
4.1 Analysis		Student		20, 000:00
4.2 Cost of administering the tests and the questionnaire		Student		50, 000:00
Sub Total				**70, 000:00**
5.0 Travels				
5.1Researcher		Student		120, 000:00
Sub Total				**120, 000:00**
6.0 Dissemination				
6.1 Seminar 1 (Proposal)		Student		30, 000:00
6.2 Seminar 2 (Small Panel)		Student		25, 000:00
6.3 Seminar 3 (Mock Defence)		Student		20, 000:00
6.4 Seminar 4 (Oral Defence)		Student		260, 000:00
Sub Total				**335, 000:00**
7.0 others/Miscellaneous				
7.1Accommodation on Research trip		Student		130, 000:00
7.2 Miscellaneous		Student		120, 000:00
Sub Total				**250, 000:00**
GRAND TOTAl				**l, 490, 000:00**