UNIVERSITY OF EDUCATION, WINNEBA

THE CONTENT VALIDITY OF TEACHER-MADE CORE MATHEMATICS TESTS IN SENIOR HIGH SCHOOLS

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DECLARATION

STUDENT'S DECLARATION

I, Homuame Esinam Mariam, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature……………………………………

Date…………………………………………

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this Thesis was supervised in accordance with the guidelines for supervision of Thesis as laid down by the University of Education, Winneba.

Name of Supervisor: Dr. JONES APAWU

Signature………………………………………………………….

Date……………………………………………………………….

DEDICATION

I dedicate this work to the memories of my mum, Edith Nana Saaba Penneigh and aunt Faustina Penneigh.

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ABSTRACT

The purpose of the study was to investigate the content validity of teacher-made Core Mathematics tests in senior high schools in the Eastern region of Ghana. The study purposed to identify the profile dimensions the items in the Core Mathematics tests address. Also, the study sought to find out the test construction skills and practices teachers exhibit in teaching and learning of Core Mathematics. For the purpose of this study, three research questions were formulated to guide the study. A descriptive survey design was used to examine the characteristics of the teacher-made tests. The population of the study was drawn from senior high schools in the Eastern region and sample was drawn from St. Peter's Senior High School, St. Rose's Senior High School, St. Martin's Senior High School and Akim Swedru Senior High School. A sample of 40 teachers who taught Mathematics was drawn by a simple random technique and 509 teacher-made Core Mathematics test items were used. Convenient, purposive and simple random sampling technique was employed in the study. The instruments used were a 19-item Likert scale questionnaire and Core Mathematics test items constructed by teachers of Mathematics to assess year 2 students of the sampled senior high schools. The results of the different data sources; the 19-item Likert scale questionnaire and the expert rated Core Mathematics tests were used to answer the research questions. The main findings from the study are captured as follows, in line with the research questions. The test items tested higher cognition (application of knowledge) more than lower cognition (knowledge and understanding). 78.4% of items tested for application of knowledge whilst 21.6% of the test items tested for knowledge and understanding. The expert ratings recorded the means of 3.35, 3.55 and 3.47 with a grand mean of 3.46 indicating that the content of teacher-made Core Mathematics test is valid. The test practices and skills teachers exhibit are; teachers consider the cognitive abilities of students, teachers put into consideration test planning and techniques for the test and teachers consider the content of the test. It was however recommended that giving teachers training in test construction contribute to teachers constructing content valid tests. Hence, adequate training should be provided very often to enhance test construction skills.

CHAPTER 1

INTRODUCTION

1.0 Overview

This chapter consists of the background to the study, the statement of the problem, purpose of the study, research objectives, research questions, significance of the study, delimitation of the study, limitation of the study and organizational plan of the study.

1.1 Background to the Study

Mathematics education forms an integral part of learning all over the world and its study is very crucial for many developing countries as it is seen as a subject that brings development to most areas of life. The study of Mathematics is based on effective knowledge of science and reasoning, logical thinking, formulating and testing conjectures, making sense of things and forming judgments (Legner, 2013). In Ghana, the Ministry of Education through the Ghana Education Service places much emphasis on the study of Mathematics because of its relevance in our individual academic pursuits. As a result, Mathematics is studied as a core subject in basic and senior high schools. Teaching and learning Mathematics is mainly an activity where the instructors explain mathematical concepts with various illustrative activities and give solutions to various mathematical problems. Hence, the complexity of teaching and learning Mathematics in some situations is minimized by constant activities performed by learners, by way of classroom exercises, assignments and project work put together by teachers. Supervisors of teaching and learning in Ghana, such as the circuit supervisors of the Ghana Education Service rate the success of teaching a concept in Mathematics by the number of tests and exercises given to learners and the learners' ability to provide solutions to the questions.

There have been a lot of effort and strife to make teaching Mathematics and students' achievement in Mathematics improve. One effective way of improving students' Mathematics achievement is by assessing them through tests constructed by teachers. According to Notar et al. (2004), education in recent years has focused much more on accountability, one of the ways of measuring such accountabilities is by the extent to which students' performance in teacher-made tests can predict the performance of students in standardized national examinations such as the West Africa Senior Secondary Certificate Examinations (WASSCE). It is also stated by Quansah et al. (2019) that policymakers, teachers and school managements in the process of taking decisions pertaining to teaching and learning in the course of learning, before learning and mostly after learning, take decisions based on information gathered from students' learning abilities.

The intended use of the outcomes on primary assessment and accountability are to hold schools accountable for the attainment and progress made by students to inform their parents and schools about students' performance to enable benchmarking between schools, as well as monitoring performance locally and nationally (Angeli et al., 2016). The basic point for institutional superiority, educational development and individual goals stated in a school's curricula is the effectiveness of learning goals. This requires teachers to have adequate knowledge in achieving learning goals in a very effective manner. Hence, it is right for teachers to have the knowledge in the science and art of constructing tests (D'Agostino et al., 2007).

Quansah et al. (2019) explained that a test is a key component in an educational setting and that it is an assessment tool for gathering information about the progress of students' learning. Tests are indispensable tools in every educational system. In other words, tests and teaching move hand in hand. In order to test what students know or have learnt, well-crafted test items should be employed. Test construction is an essential part of teachers' responsibility and teachers are therefore supposed to craft well-functioning items in ensuring effective teaching and learning. As stated by Quagrain (1992), tests provide the needed information for evaluation, which provides a link between feedback and knowledge gained. Knowledge of results enhances systematic improvement in learning.

Teacher-made test is regarded as an essential teaching and learning process which is driven by the assumption that if students have knowledge about the progress they make in their regular academic work, then they are bound to learn better due to the feedback they receive. Formative assessments in the form of teacher-made tests give students the opportunity to have firsthand information about their own progress and allow teachers to identify various aspects of the curriculum content which need much more effective instruction and attention (Clark, 2008; Tomlinson, 2008). In a situation where students have to write a summative assessment such as a national examination for entry into the tertiary institution, that is the WASSCE in the case of Ghana, students' performance in the summative examinations largely depend on the effectiveness of the teacher-made formative assessments.

Hathcoat (2013) and Parr and Bauer (2006) suggest that if teacher-made tests will adequately prepare learners for summative tests at the end of the key stage of their study, then the teacher-made tests must be comparable on important attributes such as validity and reliability. A test can be valid if it measures what it is intended to measure.

Hamafyelto et al. (2015) had stated that the competency in test construction is an essential tool needed by every teacher if learning and instructional objectives are to be effectively attained. The importance of tests in the educational system is enormous as tests provide a platform by which any significant educational objectives can be achieved.

Teacher-made tests are generally adapted to outcomes and contents of the classroom. They normally have the flexibility that afford continuous adaptation of measurement to new material and changes in procedure, and well adaptable to various-sized work units, but tend to neglect complex learning outcomes (Linn & Gronlund, 1995).

Suutam et al. (2016) had asserted that although classroom teachers have long used various forms of assessment including tests to monitor their students' mathematical learning and inform their future instruction, increasingly, external assessments are used by policy makers throughout the world to gauge the mathematical knowledge of a country's students. Sometimes Mathematics assessments are mostly used to compare the knowledge of students in Mathematics from other countries.

Wilson and Kenney (2003) posit that in various jurisdictions all over the world, students are assessed in Mathematics using some forms of large-scale tests. This form of assessment could take the form of national, state or provincial. However, these forms of assessments in Mathematics are mostly used to monitor educational systems and used as graduation and grade promotion of students depending on their performance. Teachers are sometimes evaluated based on how well their students perform in such Mathematics test.

It is recognized that the purposes of Mathematics assessment are sometimes not distinct because teachers of Mathematics often use Mathematics summative classroom assessments for formative purposes. The Mathematics summative assessment results are often used to interpret results and also design future instruction accordingly (Parke et al., 2003).

However, Baird et al. (2014) states that traditionally a test as an assessment in Mathematics comes from psychometric and measurement perspective. This is primarily concerned with scores of students rather than examining students' thinking and communication processes. A psychometric perspective is concerned with reliably measuring the outcome of learning, rather than the learning itself.

But Amajuoyi et al. (2013) posit that the results obtained from a test can only be meaningful and relevant if they have the right representation of the level of understanding and attainment of the testee in the task the test items present. These test items are supposed to reflect the entire topics and behavioural objectives expected to be covered in a subject by a student. A test or an examination that bear these characteristics is said to be content valid. Consequently, the findings from the research of Kinyua and Odiemo (2014) indicate various factors that contribute to the validity of a test. These factors include training on tests and analysis, level of expertise of teachers in terms of test construction, use of Bloom's taxonomy in the moderation of tests and length of tests.

According to Abayomi (1999), a table of specification ensures the content validity of a test at the construction stage. Hence to ensure the validity of a test, the teacher should aim at covering the entire subject matter and the objectives stated. Sireci and Faulkner-Bond (2014) explain the concept of content validity as the extent to which a measure represents all facets of a given construct. Thus, the extent to which the items on a test fairly represent the entire domain the test seeks to measure. Content validity requires the use of recognized subject matter experts to evaluate whether test items assess the defined content.

Pellegrino et al. (2016) stated cognition as a component of content validity. Cognition addresses the extent to which an assessment taps important forms of domain. Cognitive validity should be based on what is known about the nature of student cognition and understanding in areas of curriculum. Hence there is the need for careful consideration with regards to the design and validation of assessments intended for classroom use for both formative and summative purposes. Meanwhile, many of such assessments are tied more closely to detailed analysis of the instructional domain.

The Ghana Mathematics curriculum stipulates a profile dimension which was made central to the syllabus. It specifies two profile dimensions for teaching, learning and testing at the senior high school level, which are; knowledge and understanding and application of knowledge. Each of the dimensions has been given a percentage weight that should be employed into teaching, learning and testing (Curriculum Research and Development Division, Mathematics syllabus, 2010).

Oduro-Okyere (2008) posits that the West African Examinations Council (WAEC) at the terminal points of the educational system conducts tests that cannot be said to be entirely standardized since they may not meet all the standard characteristics of standardized achievement tests. Examples of the WAEC conducted tests are the Basic Education Certificate Examination (BECE) and the West African Senior Secondary Certificate Examination (WASSCE).

Linn and Gronlund (1995) spell out the characteristics of a carefully constructed standardized test, and include the following:

1. The test items are of a high technical quality. They have been developed by educational and test specialists, tried out experimentally (pretested) and selected on the basis of difficulty, discriminating power and relationship to a clearly defined and rigid set of specifications.
2. Directions for administering and scoring are so precisely stated that the procedures are standard for different users of the test.
3. Norms based on national samples of students in the grades where the test is intended for use are provided as aids in interpreting the scores.
4. Equivalent and comparable forms of the tests are usually provided as well as information concerning the degree to which the tests are comparable.
5. A test manual and other accessory materials are included as guides for administering and scoring the test, evaluating its technical qualities, and interpreting and using the results.

McDaniel et al. (1994) argues that there exist three steps that make a test move from an ordinary state and gives it a sound basis for evaluating students' achievement. There is an overwhelming mystery in constructing better classroom test most especially when it undergoes such processes as test planning, item analysis and revision. To promote an effective instructional programme in Mathematics in every educational setting , the responsibility lies solely on teachers of Mathematics to put together fair, focused, well-thought through and objective oriented tests in which case, enables teachers to have a very reliable evidence gathered about students' performance and make very meaningful judgments about students' performance, instructional plans and decisions.

The Bloom's taxonomy is a theory that is used by most teachers and educational developers to assess learning outcomes and cognitive abilities. This taxonomy is a list of cognitive skills that is used to determine the level of thinking students have achieved. The taxonomy ranks the cognitive skills on a continuum from lower order thinking to higher order thinking. The objectives of Ghana's Mathematics curriculum on teaching, learning and testing are based on the Bloom's taxonomy of educational objectives. The Bloom's taxonomy is a skeleton that was constructed to categorize the goals of any curriculum in terms of explicit and implicit cognitive skills and abilities. This taxonomy is regarded as one of the crucial models that contribute to the curriculum development in the 21st century. Anderson (2000) states that, nearly all complex learning activities require the use of several different cognitive skills. The Bloom's taxonomy demonstrates that each level of knowledge corresponds to a specific cognitive process in students. Anderson (2000) continues to argue that teachers who keep stock of questions in accordance to the Bloom's taxonomy encourage higher-order thinking in their students than teachers who do not practice such.

Experts in assessment have the responsibility to make use of correct tables of specification also known as test blue print to avoid over emphasis and under-emphasis of topics and cognitive levels (Amajuoyi et al., 2013). Parr and Bauer (2006) suggested that if teacher-made tests are supposed to prepare learners adequately for summative assessments like the WASSCE, the characteristics of teacher-made tests must comply with the demands of their validity and reliability components.

1.2 Statement of the Problem

In Ghana, several researches (Eshun, 2004; Awanta, 2004; Yidana,, 2004) have gone into looking at the causes of the declining performance of students in Mathematics at the senior high school level. According to Brookhart (1999), classroom evaluation plays an important part in determining the quality of input process and output elements of education. In every educational system, once a learner is taken through a programme of study, the learner can never escape the possibility of an exposure to a wide range of educational assessment processes. This is because, assessments are used to gather information about what students have learnt and how far they have understood what have been taught but researchers seldom consider the test items made for assessing students at the senior high schools both by teachers and stakeholders as a factor that can contribute to their performance.

Vital decisions are often made through the information gathered from informal classroom test, hence, it is important for teachers to always adhere to approved standards and principles in the construction of a Mathematics test. There is much zeal to make Mathematics tests more valid reducing the problems students are likely to face when their test results are used for what they are intended to be used for. Teachers are solely in charge of providing results from the assessment of students to help in decision making. Amedahe (1989) pointed out that irrespective of pre-service training, teachers in Ghana construct, administer, score and interpret the results of classroom achievement tests. The Ministry of education through the Ghana Education Service employs the services of professional and non- professional personnel to teach. Every professional teacher in the senior high school supposedly has gone through at least a semester's course on measurement and evaluation during their courses of study. The course is expected to give them enough training and guidance in testing students and scoring them.

Fives and Di Donato-Barnes (2013) stated that there is mostly a mismatch between the content examined in class and the material assessed in class, hence, this may lead to the incredulity of assessment tools on which basis teachers make valid judgments about students' progress. Adusei (2017) also asserts there is a mismatch between scores students obtains in internal assessment and grades from their external examinations in Mathematics which give parents a lot of worry. This is because, there is little correlation in their school examination results and grades in their external examinations. Mostly, stakeholders and parents have worries and concerns about how students learn and prepare for examinations. Parents' concern is mostly based on how students prepare with the various item formats used in writing examinations in Mathematics. They believe the ability of students to write tests in the classroom determine the students' ability to write end of programme examination by the West Africa Examination Council (WAEC).

There is a consideration of various factors that lead to the inconsistencies in test construction. Ebinye (2001) argues that, the test construction role of teachers is said to be a major source of worry for teachers, especially, those with few years of experience. This anxiety according to him stems from inadequate test construction skills of these teachers.

Quansah and Amoako (2018) show by their research that, though teachers have had adequate training in school assessment including test construction, most teachers do not follow the rules governing the construction of tests, leading to the crafting of poor test items. Teachers' attitude towards test construction is negative, particularly towards planning of classroom test and item construction. Meanwhile, Quansah et al. (2019) had stated that teachers have limited skills in the construction of end-of-term examinations. This issue was found with the content representativeness and relevance of the test, reliability and fairness of the test items.

Kinyua and Odiemo (2014) state that in the context where students sit an end of programme examination like the WASSCE for entry into the tertiary institutions, the more effective the internal (formative) assessment becomes the better the performance in the WASSCE. Hence, the effectiveness of a formative assessment can largely affect the outcome of a summative assessment, but assessment on students' achievement on formative assessment has not been positive.

It was observed in Egor Local Government area by Kinyua and Odiemo (2014), that the content validity of Mathematics tests used by teachers is very low. For some tests, the test items were not representative of the objectives of the syllabus and the weighting of items were not balanced. Most of the test items focused on the lower level of cognitive domain of the Bloom's taxonomy of educational objectives. This was attributed to lack of planning in test construction. This was also supported by Marso and Pigge (1992) who noted that the major reason for the poor quality of Mathematics teacher-made tests was because of lack of preparation in the test construction.

While some teachers construct poor test items, others are fond of repeating already existing questions (Onyechere, 2000). It appears that, some teachers do not have much knowledge in testing practices or do not simply adhere to the principles of testing. Teachers' inadequate skills in test construction in senior high schools in Ghana mostly ranges from lifting questions directly from textbooks to testing only recall of facts, ambiguity in questions, unreasonable difficulty levels of questions and improper time allocation among others. In a nutshell, McDaniel et al. (1994) stated that some teachers prefer quick memory level questions which require students to recall facts and knowledge and not to apply knowledge. Such questions are not so difficult to construct but rather give wrong signals to students about the values of education.

A study by Amedahe (1989) to find out whether teachers in the secondary schools in the Central Region of Ghana adhered to the principles of test practices outlined by experts in their classroom achievement test revealed that, to a great extent, teachers did not follow the basic principles of test construction, administration and scoring of classroom tests.

Bosan (2018) posits that teachers are fond of giving students classwork and assignments from past examination questions from WAEC and sometimes, there is little effectiveness in marking these class works or assignments. Interviewing the teachers, it was gathered that the Mathematics teachers believe much more in high-stake examinations and therefore depend on the high-stakes examinations, hence their test practices are mostly influenced by items from these high-stake examinations.

From the researcher's experience and observation as a Mathematics teacher, the practice of constructing items to assess students is not done in any specified order and by any format to ensure the content validity. Teachers normally believe that past questions from WASSCE are enough guide to aid them in constructing tests. Hence, the test items they give students are mostly a collection of already existing items from the WASSCE. The researcher believes it is important to assess whether teachers consider the various important factors in constructing test items and also if the items meet the cognitive levels of the students and represents the profile dimensions stated in the Ghana Mathematics curriculum. The researcher believes that in order to reach a more authentic finding that could either refute or confirm the findings of other researchers, there is the need for an extensive and an in-depth research to be done in order to generalize the study for teachers in Ghana. Also, given the prevalence of classroom achievement tests in Ghanaian schools and the variety of uses to which the results from these tests are put, there is the need to research into what goes into Mathematics test construction and to ascertain their content validity in selected schools in the Eastern Region of Ghana.

1.3 Purpose of the Study

The purpose of the study was to investigate the content validity of teacher-made Core Mathematics tests in Senior High Schools in the Eastern region of Ghana. The study aimed to find out whether Core Mathematics test items constructed at the senior high schools are balanced regarding the profile dimensions stipulated in the Mathematics curriculum. And also, whether the test items designed addressed the objectives stated in the Mathematics curriculum.

1.4 Objectives of the Study

This objectives of the study was to

- determine the profile dimension Core Mathematics test items constructed by teachers for students in the senior high schools represent.
- ascertain if teacher-made Core Mathematics test items address the content objectives they represent.
- investigate the test construction practices and skills teachers exhibit in constructing Mathematics test.

1.5 Research Questions

The study was guided by the following research questions:

1. What profile dimension of the Ghana mathematics curriculum do teacher-made Core Mathematics tests adequately address?

2. To what extent do the teacher-made tests items in the senior high schools' Core Mathematics tests address the content objectives being examined?
3. What practices and skills of testing do teachers exhibit in constructing tests for students in senior high schools?

1.6 Significance of the Study

The relevance of Mathematics teachers assessing students in Mathematics cannot be overemphasized such that, workbooks and examination scripts of students are supervised and inspected to ascertain whether students are adequately assessed based on the content covered and the cognitive levels of students adequately met. This study will place relevance on the consideration of the profile dimensions stipulated in the Mathematics curriculum which aids teachers in constructing test items that prepare students for the end of programme examinations (West Africa Senior Secondary Certificate Examination). This study is expected to help correct the conventional practices of teachers putting together tests for students that lead to the imbalances in students' responses. The facts gathered by the study will help determine the state of affairs with respect to achievement testing in the Ghanaian educational system. The findings are supposed to inform stakeholders in education and help structure training programmes on testing. It will also help to get teachers who received instructions on educational measurement and evaluation to put the knowledge of the course into good practice to improve on their testing skills. It is hoped that the study will serve as a reference source for teachers and students in test development and also add up to the already existing studies in this area.

1.7 Limitation of the Study

The study used a descriptive survey method, however a mixed-method using both qualitative and quantitative means would address more adequately the content of teacher-made Core Mathematics tests and the skills and practices of test construction. The sample size of 4 schools and 40 teachers and the use of the convenience sampling were major limitations to the study since the findings from the study cannot be a generalized for the entire population. Hence, the specific findings in schools with specific characteristics in test construction practices were also limited.

1.8 Delimitation of the Study

This study was limited to senior high schools in the Eastern region Ghana with sample taken from four schools. A sample of 40 teachers of Mathematics were used for the study, teacher-made Core Mathematics tests constructed for SHS students in year 2 was employed because the researcher believed it was suitable for the purpose of the study. The study focused on the Core Mathematics test items for SHS 2 students. The researcher believed that such items were appropriate for the study and will bring more findings to add to literature. The study however employed the Bloom’s taxonomy of educational objectives as a theoretical framework but confines itself to the part of the taxonomy that elicits the hierarchy of the cognitive processes.

1.9 Organization Plan of the Study

This study is organized into five main chapters. Chapter one discussed the background of the study, the statement of the problem, the purpose of the study, the objectives of the study, research questions, significance of the study, limitation and delimitation of the study. Chapter two comprises of a review of relevant literature under specific sub-headings. It included a discussion on assessment in education, the theoretical framework (the cognitive domain of Bloom's taxonomy), the Revised Bloom's Taxonomy, the senior high school mathematics curriculum and profile dimension, theories of validity of a test, concept of content validity of a test, concept of cognitive validity, Mathematics assessment and test items, concept of testing and test development and finally, teacher's test construction skills, practices and attitude. Chapter three consists of the methodology used to carry out the research. This included discussions on research design, population, sample and sampling technique, research instrument, piloting of test items, validity, reliability, selection of experts, data collection procedure and data analysis procedure. Data collected were analyzed and presented in chapter four. The results were used to answer three research questions. Chapter five included the summary of the study and the major finding made from the study followed by the implication of the study and conclusion. Recommendations were also made including areas for further study.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

This research studied the content validity of teacher-made Core Mathematics test items. It employed the use of the Bloom's taxonomy as a theoretical framework. With the various levels of learning objectives in the cognitive domain of the Bloom's taxonomy, the study ascertained the spread of Mathematics questions under the two profile dimensions stipulated by the senior high school Mathematics curriculum. The study examined the relevance of the test items to the subject matter under discussion and also gathered the test practices and skills of Mathematics teachers in senior high schools. This chapter is organized under the following themes.

- Theoretical framework (the cognitive domain of the bloom's taxonomy)
- Assessment in education
- The senior high school Mathematics curriculum and profile dimension
- Theories of validity of a test
- Concept of content validity of a test
- Concept of cognitive validity
- Mathematics assessment and tests items
- Concept of testing and test development
- Teachers' test construction skills, practices and attitude

2.1 Theoretical Framework

This study employed the Bloom's taxonomy as a theoretical framework to ascertain the content validity of teacher-made core mathematics test items. The Bloom's taxonomy is a framework used in categorizing the levels of reasoning skills required in the classroom situation. The taxonomy is a classified order of objectives and skills defined for students by educators and divides educational objectives into three major domains; cognitive, affective and psychomotor. The cognitive domain makes a way for thinking to be classified into six levels, from the basic level to higher levels that are complex (Anderson, 2006). The six hierarchical levels of the cognitive domain is adopted to set a guide for the study of the content validity of mathematics test items in this study.

The affective domain is concerned with feelings or emotions, social and emotional learning and skills. This taxonomy is also arranged from simpler to more complex. That is receiving, responding, valuing, organization and characterization. However, the psychomotor domain has to do with those discreet physical functions, reflex actions and interpretive movements. Again, the psychomotor domain has to do with encoding information with movement and with activities.

2.1.1 The cognitive domain of the Bloom's taxonomy

The Cognitive domain of the Bloom's taxonomy is widely used by educators, instructors and facilitators to write learning objectives that describe the skills and abilities that learners are expected to master and demonstrate. The Bloom's taxonomy differentiates between the various cognitive skills and places emphasis on learning objectives that require higher levels of cognitive skills which lead to deeper learning and transfer of knowledge and skills to greater tasks and contexts. The Bloom's taxonomy serves as a skeletal framework that is constructed to categorize the goals of any curriculum with regards to cognitive skills and abilities. The cognitive domain of the Bloom's taxonomy is regarded as a crucial model that contributes to curriculum development.

Guskey (2010) asserts that the practice of formative assessment has its foundational roots from the Bloom's concept as a mastery instructional learning approach that supports the use of assessment to track students' progress toward mastering a learning goal. Bloom's taxonomy is a classification system used to define and distinguish between different levels of human cognition. The taxonomy has been used by educators to inform and guide the development of assessments, curriculum and instructional methods.

The Bloom's taxonomy was constructed to put the goals of any curriculum into specific categories in terms of explicit and implicit cognitive skills and abilities, it has contributed remarkably to the development of curriculum in the 21st century. The first consideration, given a well-designed course, is the determination and identification of the course objectives. The Bloom's taxonomy is largely used to devise learning outcomes or objectives in respective domains; cognitive mental skills, psychomotor or physical skills and affective or growth in feelings (Soozandehfar &Adeli, 2016).

Adams (2015) had written that the Bloom's taxonomy has several usefulness; firstly, instructors are encouraged to consider the learning objectives in behavioral terms to factor in what the leaner would achieve at the end of the lesson or instruction. The best way of assessing the skills and knowledge of a learner is by writing a learning objective using an action verb. Secondly, the taxonomy aids the instructor to consider the need for including learning objectives that require higher levels of cognitive skills in light of Bloom's taxonomy that lead to deeper learning and transfer of knowledge and skills to a greater variety of tasks and contexts. Meanwhile, the higher-level skills in the taxonomy incorporate many lower-level skills.

2.1.2 The six hierarchical levels of Bloom's cognitive domain

The cognitive domain involves knowledge and development of intellectual skills which includes the recall and recognition of specific facts, procedural patterns and concepts that serve in the development of intellectual abilities and skills. There are six major categories of cognitive skills ranging from lower-order skills that require less cognitive processing to higher-order skills that require deeper learning and a greater degree of cognitive processing that begins from the simplest behaviour to the most complex one. The categories are thought of as degrees of difficulties; the first category must be mastered before the next category can occur (Mahmud et al., 2019). These six categories have verbs that measure their objectives. The following make up the various categories:

Knowledge

This level of cognitive skill deals with remembering or retrieving previously obtained knowledge in answering questions on basic concepts. This includes knowledge of the main ideas taught, knowledge of specific facts and methods to deal with specifics, knowledge of terminologies and facts and knowledge of methodology. Questions asked in this level are solely to test learners about specific information gained from lessons. Verbs that are ascribed to this skill are; find, relate, list, define, recall, tell, list, label and name (Ferris & Azzis, 2005).

Comprehension

This level requires the ability of a learner to grasp or construct meaning from materials and concepts. It also deals with the ability of a learner to translate, interpret and extrapolate or construct ideas. A comprehension level of question requires a learner not to simply recall facts, but understand concepts which enables the learner to interpret concepts. Examples of verbs that relate to this function are; restate, locate, report, recognize, explain, express, identify, discuss, describe, review, illustrate, interpret, draw, represent, differentiate, conclude etc. (Krathwool, 2002).

Application

This is the ability to use learnt material or implement material in new and concrete situations. Application questions require learners to apply or use the knowledge they have learnt. Examples of verbs that relate to this function are; apply, relate, develop, organize, employ, restructure, demonstrate, illustrate, translate, use, operate, practice, calculate, show, complete, solve, examine etc. (Amer, 2006).

Analysis

This level deals with the ability to break down or distinguish the parts of a material into its components so that its organizational structure may be better understood. At this level, students are required to go beyond knowledge and application to see patterns that can analyse a problem. Examples of verbs that relate to this function are; analyze, compare, probe, inquire, examine, contrast, categorize, differentiate, investigate, detect, survey, classify, deduce, experiment, scrutinize, discover, inspect, dissect, discriminate, separate (Ferris & Azzis, 2005).

Synthesis

This level also deals with the ability to put parts together, to form a coherent and unique new whole. Learners are required to use the given facts to create new theories or make predictions by pulling in knowledge from multiple subjects and synthesize information before coming to a conclusion. Examples of verbs that relate to this function are; plan, invent, formulate, collect, set up, generalize, document, combine, relate, propose, develop, arrange, construct, organize, originate, derive, write, propose, compose, produce, design, assemble, create, prepare, predict, modify etc. (Krathwool, 2001).

Evaluation

This is the highest level of the taxonomy. In this level, the learner is expected to exhibit the ability to judge, check and even critique the value of material for a given purpose. Learners are also expected to assess information and come to a conclusion. Examples of verbs that relate to this function are; judge, assess, compare, evaluate, conclude, measure, deduce, argue, decide, choose, rate, (Amer, 2005).

2.1.3 The cognitive domain of the Bloom's taxonomy

The Cognitive domain of the Bloom's taxonomy is widely used by educators, instructors and facilitators to write learning objectives that describe the skills and abilities that learners are expected to master and demonstrate. The Bloom's taxonomy differentiates between the various cognitive skills and places emphasis on learning objectives that require higher levels of cognitive skills which lead to deeper learning and transfer of knowledge and skills to greater tasks and contexts. The Bloom's taxonomy serves as a skeletal framework that is constructed to categorize the goals of any curriculum with regards to cognitive skills and abilities. The cognitive domain of the Bloom's taxonomy is regarded as a crucial model that contributes to curriculum development.

Guskey (2010) asserts that the practice of formative assessment has its foundational roots from the Bloom's concept as a mastery instructional learning approach that supports the use of assessment to track students' progress toward mastering a learning goal. Bloom's taxonomy is a classification system used to define and distinguish between different levels of human cognition. The taxonomy has been used by educators to inform and guide the development of assessments, curriculum and instructional methods.

The Bloom's taxonomy was constructed to put the goals of any curriculum into specific categories in terms of explicit and implicit cognitive skills and abilities, it has contributed remarkably to the development of curriculum in the 21st century. The first consideration, given a well-designed course, is the determination and identification of the course objectives. The Bloom's taxonomy is largely used to devise learning outcomes or objectives in respective domains; cognitive mental skills, psychomotor or physical skills and affective or growth in feelings (Soozandehfar &Adeli, 2016).

Adams (2015) had written that the Bloom's taxonomy has several usefulness; firstly, instructors are encouraged to consider the learning objectives in behavioral terms to factor in what the leaner would achieve at the end of the lesson or instruction. The best way of assessing the skills and knowledge of a learner is by writing a learning objective using an action verb. Secondly, the taxonomy aids the instructor to consider the need for including learning objectives that require higher levels of cognitive skills in light of Bloom's taxonomy that lead to deeper learning and transfer of knowledge and skills to a greater variety of tasks and contexts. Meanwhile, the higher-level skills in the taxonomy incorporate many lower-level skills.

2.1.4 The six hierarchical levels of Bloom's cognitive domain

The cognitive domain involves knowledge and development of intellectual skills which includes the recall and recognition of specific facts, procedural patterns and concepts that serve in the development of intellectual abilities and skills. There are six major categories of cognitive skills ranging from lower-order skills that require less cognitive processing to higher-order skills that require deeper learning and a greater degree of cognitive processing that begins from the simplest behaviour to the most complex one. The categories are thought of as degrees of difficulties; the first category must be mastered before the next category can occur (Mahmud et al., 2019). These six categories have verbs that measure their objectives. The following make up the various categories:

- **Knowledge**

  This level of cognitive skill deals with remembering or retrieving previously obtained knowledge in answering questions on basic concepts. This includes knowledge of the main ideas taught, knowledge of specific facts and methods to deal with specifics, knowledge of terminologies and facts and knowledge of methodology. Questions asked in this level are solely to test learners about specific information gained from lessons. Verbs that are ascribed to this skill are; find, relate, list, define, recall, tell, list, label and name (Ferris & Azzis, 2005).

- **Comprehension**

  This level requires the ability of a learner to grasp or construct meaning from materials and concepts. It also deals with the ability of a learner to translate, interpret and extrapolate or construct ideas. A comprehension level of question requires a learner not to simply recall facts, but understand concepts which enables the learner to interpret concepts. Examples of verbs that relate to this function are; restate, locate, report, recognize, explain, express, identify, discuss, describe, review, infer, illustrate, interpret, draw, represent, differentiate, conclude etc. (Krathwool, 2002).

- **Application**

  This is the ability to use learnt material or implement material in new and concrete situations. Application questions require learners to apply or use the knowledge they have learnt. Examples of verbs that relate to this function are; apply, relate, develop, organize, employ, restructure, interpret, demonstrate, illustrate, translate, use, operate, practice, calculate, show, complete, solve, examine etc. (Amer, 2006).

- **Analysis**

  This level deals with the ability to break down or distinguish the parts of a material into its components so that its organizational structure may be better understood. At this level, students are required to go beyond knowledge and application to see patterns that can analyse a problem. Examples of verbs that relate to this function are; analyze, compare, probe, inquire, examine, contrast, categorize, differentiate, investigate, detect, survey, classify, deduce, experiment, scrutinize, discover, inspect, dissect, discriminate, separate (Ferris & Azzis, 2005).

- **Synthesis**

  This level also deals with the ability to put parts together, to form a coherent and unique new whole. Learners are required to use the given facts to create new theories or make predictions by pulling in knowledge from multiple subjects and synthesize information before coming to a conclusion. Examples of verbs that relate to this function are; plan, invent, formulate, collect, set up, generalize, document, combine, relate, propose, develop, arrange, construct, organize, originate, derive, write, propose, compose, produce, design, assemble, create, prepare, predict, modify etc. (Krathwool, 2001).

- **Evaluation**

  This is the highest level of the taxonomy. In this level, the learner is expected to exhibit the ability to judge, check and even critique the value of material for a given purpose. Learners are also expected to assess information and come to a conclusion. Examples of verbs that relate to this function are; judge, assess, compare, evaluate, conclude, measure, deduce, argue, decide, choose, rate, select, estimate, validate, consider, appraise, value, criticize, infer, select, judge, debate, recommend etc. (Amer, 2005).

2.1.4 Revised Bloom's taxonomy

The Bloom's taxonomy of educational objectives is an important medium that investigates the usefulness of a curriculum. The original taxonomy created the taxonomy of educational objectives which is a tool for identifying and classifying different kinds of thinking. The taxonomy placed much emphasis on cognitive and affective objectives in education. The cognitive and affective domains offered a way to classify thinking skills into six levels, from the most basic to levels that are more complex (Ferris and Aziz, 2005). However, a former student of Bloom's spearheaded a group which met for the purpose of updating the taxonomy with the aim of adding relevance to suit 21st century students and teachers (Anderson and Krathwool, 2001). Hence, the revision of the original Bloom's taxonomy, the revision saw some changes which seemed trivial yet significant.

According to Anderson (2001) there were two major aims of revising the original Bloom's taxonomy. There was the need to redirect the focus of educators from considering the value of the original taxonomy as a historical document to viewing it as a taxonomy that came ahead of it time. Again, the revision came as a need to incorporate new knowledge and thought into the original framework.

The revision includes renaming the six major cognitive hierarchy from noun to verbs because it believed that cognition is connected to thoughts that is, to think and thinking is an active process. Hence, the use of verbs that better describe the action was employed for the new taxonomy. Two hierarchies; comprehension and synthesis were renamed as understanding and creating respectively. The order of hierarchy was also altered, the position of synthesis was interchanged with evaluation because it is believed that creative thinking is a more complex cognitive process than is critical thinking. The new taxonomy is two-dimensional, it identifies both the knowledge to be learnt and the cognitive processes expected from the students (Anderson, 2001).

The revised taxonomy consists of knowledge and cognitive processes. The knowledge dimension is similar to the sub-categories of the original knowledge category and the cognitive processes is similar to the six categories of the original taxonomy with the

Knowledge category named Remember, the Comprehension category named Understand, Synthesis renamed Create and made the top category, and the remaining categories changed to their verb forms: Apply, Analyze, (Krathwohl 2002). The knowledge dimensions are in four categories: factual, conceptual, procedural and metacognitive (Anderson, 2001).

The move from one dimension to two dimensions in the Revised Bloom's Taxonomy has brought about a significant change in the structure of the taxonomy. The introduction of the two-dimensional Taxonomy Table which is the analytical tool for the Revised Bloom's Taxonomy makes it possible for stating learning objectives. It also makes it possible for planning and guiding instruction using a two-dimensional guide for clearly defined assessments and a stronger connection of assessment to both objectives and instruction (Amer, 2006).

According to Amer (2006) the Taxonomy Table is used to analyze and reflect the objectives of a unit or a syllabus, the taxonomy table assists teachers to separate activities from objectives. The table helps teachers to realize the relationship between assessment and teaching and learning activities. The table also helps to examine curriculum alignment. Anderson (2002) also proposes that the Taxonomy Table is a framework for estimating curriculum alignment in all subject matters at every grade. Curriculum alignment is the process of organizing three key elements which are instruction and materials, objectives and standard and test.

Bloom's revised taxonomy was chosen as a categorization tool, the taxonomy was made to analyze and develop standards teaching and assessment. Whereas this revised taxonomy seek to efficiently and effectively advance student learning and also ensure the alignment of classroom instruction and materials to objective standards, this study used the Original Blooms taxonomy as its theoretical framework. The profile dimension of the Ghana Mathematics curriculum elicits its components based on the Original Bloom's taxonomy. However, the elaboration of the components of the two profile dimensions dwell on the revised dimension to give much more meaning to this study. This research sought a one-dimensional study of the requirements of Mathematics test items and did not dwell on the two-dimensional study. The Ghana Mathematics curriculum has been designed in line with the Original Bloom's taxonomy. The Original Bloom's taxonomy is the framework that guides the educational objectives in the syllabus.

Hanna (2007) and Pickard (2007) had used the Revised Bloom's taxonomy as a categorization tool, however, none of the studies evaluated the usefulness of the taxonomy. Hence there is the lack of studies about the Revised Bloom's taxonomy. But, for the purposes of this study, the Revised Bloom's Taxonomy helped in giving much meaning to the six hierarchies of cognitive levels in the original Bloom's taxonomy. The Revised Bloom's Taxonomy had made changes to the six hierarchies of the cognitive levels. These cognitive levels had been written using verbs, hence, it was easy relating to the original for more meaning.

2.2 Assessment in Education

An assessment is the process of gathering data, more specifically, ways instructors gather data about their teaching and students' learning (Hanna & Dettmer, 2004). Assessment forms an integral part of instructional process to identify individual learning difficulties and remediation procedures prescribed to address such difficulties. According to Pellegrino and Hickey (2006), one major tool that has the power of amplifying learning and skill acquisition is assessment. For this reason, there have been the call for educators to use educational assessment systems that are more balanced and results in gathering useful information for varied purposes of education, ranging from how to shape ongoing instructions in the classroom to making decisions of accountability at the policy making levels.

Educational assessment is conducted for various reasons, such that, its nature often reflects the purpose for which the assessment is carried out. Amedahe and Asomaning-Gyimah (2013) mentioned some purposes of assessment which include planning and organization of instructions, instructional management, decision making, motivating students and grading of students.

Though there is the call for the need of thorough assessment on students' learning needs, Shepard (2006) opines that one important purpose that has been dominating assessment is the issue of school accountability, as a result, schools have assessed students periodically in various subjects such as Mathematics. In most instances where students are assessed, the tests are not intended to help identify students' learning needs or to provide relevant information that can be used to restructure instructions instead, the tests serve as accounting or monitoring functions. Meanwhile, it is important that the purpose of assessing learners must include reasons that aid in identifying students' learning achievement and goals.

Assessment must be purposed to collect information that will enhance teaching and learning to benefit the learner. Amoah (2005) stated that assessment may generally be used for summative or formative purposes. The summative type of assessment involves an overall assessment or decision concerning the worth of an educational program. Formative assessment on the other hand, is designed to help the teacher make effective teaching and learning decisions. Clark (2008) posits that formative assessment is a key aspect of teaching and learning process. This is backed by the assertion that if students are regularly informed about their progress of learning, then as a result of this feedback they are bound to learn better. Formative assessment is useful in the sense that students are allowed to assess their own progress as well as teachers are made to identify aspects of the content where effective instruction is required.

Hills (1991) had stated earlier that students' performance in effective assessment reflects in their performance in the national summative assessments which means that the effectiveness of the formative assessment can largely predict the outcome of the summative assessment. Another study by Notar et al. (2004) showed that students' grades in formative classroom assessment are usually not consistent with the students' grades at the end of the standardized test. This assertion is backed by Kingston and Nash (2011) who discovered that formative assessment seems not to have any significant impact on students' achievement due to the fact that teacher-made tests are often flawed. A suggestion from the finding was that if teacher-made tests are going to prepare learners for summative assessment then teacher-made tests must have key characteristics such as validity and reliability.

Pellogrino et al. (2016) postulate that an assessment that performs its role close to classroom teaching and learning promotes academic achievement. However, not much attention has been given to its design. According to Guskey (2010), there are suggestions that rather than assessing students at the end of a unit, assessment must be used by teachers as an integral part of the instructional process to identify individual learning difficulties and prescribe remediation procedures.

Pellogrino et al. (2016) presented types and forms of evidence needed to construct classroom assessment of elementary Mathematics curriculum in a framework that discusses the concept of validity classified in three components; cognitive validity, instructional validity and inferential validity to establish a validity argument for classroom assessment. Yusof (2019) posits that there are two elements involved in an assessment; relevance and representativeness. The relevance of an assessment tool is the extent of appropriateness of its elements for the targeted constructs and functions of the assessment and the representativeness of the assessment tool is the extent to which the element of the assessment is proportional to the facets of the targeted constructs.

In Ghana, the national curriculum which is a formal document authorized by the Ministry of education provides clear guidelines for classroom instructions and assessment. An effective classroom assessment system is an important contribution to improving the quality of education in Ghana. Mills and Mereku (2016) in the Saber Country Report focuses on benchmarking student's assessment policies and systems. It categorizes assessment in Ghana into three main types of activities; classroom assessment, examinations and large-scale system level assessment. The classroom assessment provides real-time information to support ongoing teaching and learning in classroom, the use of variety formats, observation, questioning and paper and pencil tests. On the other hand, examinations provide a basis for selecting or certifying students as they move from one level to the next level.

With regards to Mathematics assessment, the Ghana Mathematics Curriculum (2007) asserts evaluation of classroom instruction draws on the judgement of the instructor to determine the overall outcome based on data gathered from assessment practices which aids in the decision-making where ways to improve the recognized weaknesses, gaps and deficiencies are carved. According to the Ghana Mathematics Curriculum

(2007) evaluative assessments can be in the form of oral questions, quizzes, class assignment, essays and project work or task or assignments that will challenge learners to apply knowledge to problems.

2.2.1 Formative and summative assessment

Formative assessment as a process is intended to yield information about students' learning that help teachers to design their instruction to meet students' needs which will also enhance students' understanding. The purpose of promoting learning by informing instructions, differentiates formative assessment from other kinds of students' assessment such as the summative assessment which is used by teachers to form final judgment about what students have learnt. Erickson (2008) considers assessment done formatively as the continual stock taking that teachers practice by observing students during an ongoing course of instruction which focuses on specific aspect of students' development and understanding which aids in making decisions about the next level in instructions. The teacher needs to use instructional practices that will uncover the mastery level of a concept by students and their level of understanding. Assessment practices need to be well grounded in the instructional process that identifies how instruction should be modified to advance students' understanding. Meanwhile, Heritage (2010) emphasizes the inseparable relation between formative assessment, teaching and learning.

Pellogrino et al. (2001) cautions that though any assessment could be used for formative purposes, using the same type of assessment for different purposes reduces the effectiveness for the purpose of the examinations. Formative assessment reveals students' progress towards specific learning goals. Students' thought processes and any misconceptions are dependent on the instructional situation and the students. Assessment must be tuned to the particular students being assessed, the relevant learning objectives specified in the instructional process (Heritage, 2010; Shepard, 2005). There can be no particular prescription for what a single instance of formative assessment should look like. Any instructional process that bring out the way a student thinks about what is being taught and can be used to promote improvements in learning, serves a formative purpose.

The utilization of formative testing in teaching and learning process involves breaking up subject matter content or course into smaller hierarchical units for instructions specifying objective for each units, designing and administration of validated formative test, offering remediation in areas where students are deficient before moving to another unit and then the administration of summative test on completion of all units (Fakeye, 2016).

Summative assessment on the other hand is an appraisal that occurs at the end of an instructional unit such as end of semester examination and end of year examination. Students' mastery of learning is evaluated and offers information on what students know and what they do not know. It usually consists of evaluation tools designed to measure a certain level of academic achievement. Summative assessment is invaluable, such that educators use data from summative assessment for decision with long term consequences that affect an educational system and students. Summative assessment improves future instructions by providing educators with data on the effectiveness of curriculum and instruction (Moss, 2013).

Summative assessment occurs at the end of the instruction, meanwhile, it is valued as a diagnostic tool which guides teachers in adjusting instructions to suit students' level of understanding. Educators rely on two major forms of summative assessment; teacher constructed and standardized assessment. Teacher-constructed assessment is the most common form of assessment found in classrooms. Both types of summative assessment have a place in an effective education system (States et al., 2018). Teacher-constructed assessment, the most commonly used type of summative assessment is normally put together from the teacher's daily interactions. These assessments depend heavily on a teacher's professional judgment. A teacher-constructed assessment must deliver vital information needed for the teacher to make accurate conclusions about each student's performance in a content area and also ensuring that a teacher-constructed instrument is reliable and valid.

However, it is important to encourage student' responses and feedback in assessment. Brookhart et al., (2010) asserts that in encouraging students' feedback, mentorship can be provided to students to become proficient at asking their own questions and responding with ideas, reasoning and experiences as well giving feedbacks to each other. Feedback has been termed as the link of the components of the formative assessment process.

The issue of feedback is large and complex with a rich history of research. The information about the gap between a student's current understanding and the targeted level of understanding depends on the role feedback plays in assessment. Feedback actually helps students to clarify the goals of learning as well as their progress towards the said goals and what needs to be done to reach such goals (Hattie & Timperley, 2007).

2.3 The Senior High School Mathematics Curriculum and Profile Dimension

A good and comprehensive Mathematics curriculum is very essential for teaching and learning Mathematics. A curriculum document defines the objectives, learning outcomes and content of the subject matter inscribed in it. Devesh (2015) asserts that curriculum as defined by the Oman government is a series of processes, skills and attitudes that transcends the prescribed teaching curricula and it is carried out through classroom activities and out of class activities. A Mathematics curriculum should consist of quality materials that integrate Mathematics content with the students' learning experiences in other disciplines. The basic goal of a Mathematics curriculum is to educate students to be active thinking citizens, being able to interpret the world mathematically and using Mathematics to help form their predictions and decisions about personal priorities (Anderson & Krathwool, 2009). The National Council of Teachers of Mathematics (2000) proposed the need for a well-designed curriculum and the need for preparing teachers for quality Core Mathematics knowledge for the preparation of students for Mathematics.

The main rationale of the senior high school Mathematics curriculum is to tune its attention to achieving one important goal, that is, to enable students in Ghana acquire mathematical skills, insights, attitudes and values that will be required in their chosen career and daily lives. The curriculum was established on one major foundation, that is, every student can learn Mathematics and also all need to study Mathematics. The curriculum is designed to meet the global standards of Mathematics. The senior high school Mathematics curriculum is designed such that, the knowledge and the competencies acquired at junior high school level is developed and built on (Curriculum Research and Development Division, Mathematics syllabus, 2010).

An appropriate Mathematics curriculum is obtained from a series of ideas pertaining to three linked components thus; content, instruction and assessment. The design of the Mathematics curriculum is structured in five main columns; a column indicating unit number, another column showing the specific objectives, the content, the teaching and learning activities and finally evaluation (Curriculum Research and Development Division, Mathematics Syllabus, 2010).

The concept of profile dimension, a collection of psychological units of a particular learning behavior considered as the central aspect of the senior high school Mathematics curriculum expected to guide teaching, learning and assessment. Profile dimension is an action verb that is made up of specific objectives stated in the Mathematics curriculum. Each specific objective contains a verb that describes the behavior the student is expected to exhibit at the end of an instruction. There are six main dimensions that serve as the main goal of teaching and learning in senior high schools. These are knowledge, understanding, application, analysis, synthesis and evaluation which have been contextualized from the cognitive domain of the Bloom's taxonomy.

The senior high school Mathematics curriculum (Curriculum and Research Development Division, Mathematics Curriculum, 2010) has specified two main profile dimensions stated for teaching, learning and testing. And they are:

- **Knowledge and understanding**

  This profile dimension is given a weighted percentage of 30% for teaching, learning and testing. This dimension is made of two learning behavior levels: knowledge and understanding. Knowledge, the ability to remember or recall already learnt materials. Some specific verbs that measure knowledge are; count, read, identify, define, describe, list, name, locate, match and state.

  Understanding is the ability to grasp the meaning of materials be it verbal, pictorial or symbolic. Specific verbs that measure understanding are: explain, distinguish, factorize, calculate, expand, measure, predict, generalize and estimate.

- **Application of knowledge**

  This profile dimension has 70% weight allocation. It deals with the ability to use knowledge or apply knowledge. It has a number of learning or behavior levels. These levels include application, analysis, synthesis, and evaluation. These four levels of behavior have their individual definitions but have been put together into one profile dimension.

2.4 Theories of Validity of a Test

The unitary conceptualization of validity as construct validity is considered as having a great level of imperfection as many views by expert oppose this assertion (Sirecci, 2007). Its complexity for lay audiences' understanding is much pronounced, but the concept of validity and its components goes beyond making a unitary conceptualization, but validity according to Nitko and Brookhart (2007) is the soundness of one's interpretation and the use of students' assessment results. From the definition given by Nitko and Brookhart (2007), the meaningfulness and appropriateness of an assessment results matters in ensuring the suitability of its use. Hence, test items must be valid and in ensuring that, various factors of validity must be adhered to.

In ensuring the validity of a test, Pellegrino et al. (2016) stipulate that for the purposes of classroom assessment contexts, a specific validity framework that considers the various forms of validity that are applicable to large-scale standardized tests must be considered. Validity may not be a property of an instrument but validity is judged according to the intended interpretation of the instrument and scores. However, for a given intended interpretation, multiple aspects of validity can be evaluated. These include face validity, construct validity, content validity and criterion validity.

2.4.1 Face validity of a test

Oluwatayo (2012) defines face validity as the degree to which a measure appears to be related to specific construct in the judgment of non-experts such as test takers. A test has face validity if its content simply looks relevant to the person taking the test. Face validity evaluates the appearance of an instrument in terms of feasibility, readability, consistency of style and formatting. Taherdoost (2016) stipulates that face validity could refer to researcher's subjective assessment of the presentation and relevance of a measuring instrument as to whether the items in the instrument appear to be relevant, reasonable, unambiguous and clear. The face validity of an instrument is a subjective judgment on the operationalization of a construct.

Kinyua and Odiemo (2014) emphasizes that, given the function of face validity as a mere glance at a test instrument, one can judge the validity of the test. Though not scientific and considered as the weakest form of validity, many will suggest that it is not a form of validity in the strictest sense. Face validity ensures that the test content represents the construct being measured just at a glance without necessarily measuring the other factors of validity which may seem to be scientific.

2.4.2 Construct validity of a test

Construct validity as posited by Taherdoost (2016) refers to how well a concept, an idea or behavior is transformed into a functioning or an operating reality. Shadish et al. (2002) posits that construct validity concerns the efficacy of using a test as a measure of what students know and can do and using the representativeness of the intervention as an illustration of curriculum alignment. Students' achievement can be measured in several ways such as using curriculum alignment, but in the case where only one model of curriculum alignment is used construct validity will be weak.

Construct validity seeks to ensure the measurement of certain specific attribute and not extraneous attributes, for instance, the vocabulary used in a test. Construct validity has two components: discriminant and convergent validity. Discriminant validity is the extent to which a variable is distinct from other variables whiles convergent validity is a parameter that is common in sociology and the behavioral sciences is the degree to which two measures of constructs that are supposed to be related theoretically relate (Adusei, 2017).

Shadish et al. (2002) stated three threats to construct validity: inadequate preoperational explication of constructs. This has to do with the failure to adequately define and explain the nature of the construct being investigated. Another threat to construct validity is mono-operation bias which focuses on the nature of the intervention used for carrying out the test. The third threat, mono-method bias refers to limitations based on a single way of measuring variables in a test. In the case when only one method is used in the intervention, inferences are limited to a particular method. In sum, construct validity seeks to ensure that the test is actually measuring the intended attribute and no other extraneous attributes.

2.4.3 Criterion validity

Criterion validity otherwise known as concrete validity is the extent to which a measure relates to an outcome. Criterion validity measures how well one measure predicts the outcome of another measure (Taherdoost, 2016). Amedahe and Asamoah-Gyimah (2013) had indicated that criterion validity deals with the method of studying the relationship between the test scores or other measures and some independent external measures. A test has this type of validity if it is useful for predicting performance or behavior in another situation (past, present, or future). In criterion validity, test scores are used to predict an individual's standing on a measure of interest. This is attained by checking performance of the student on a test against a standard measure which is a direct and independent measure of the specific behavior which the test is designed to predict (Adusei, 2007). This validity is put into two main categories; concurrent validity and predictive validity.

- **Concurrent Validity**

  Concurrent validity refers to the extent to which an individual's current status on a criterion can be predicted from their prior performance on an assessment instrument (Nitko & Brookhart, 2007). Concurrent validity is a type of validity evidence that can be gathered to defend the use of a test for predicting other outcomes. It refers to the extent to which the results of a particular test or measurement, correspond to those of a previously established measurement for the same construct. For instance, if the current performance of an individual is judged by the performance from previously taken test, then the test is valid in this regard for that purpose.

- **Predictive Validity**

  Predictive validity is the ability of one assessment tool to predict future performance either in some activity or on another assessment of the same construct. The best way to directly establish predictive validity is to perform a long-term validity study (Taherdoost, 2016). Predictive Validity Evidence is where the performance of one test is used to predict the potential performance in another test. For example, the performance of a student in the West Africa

Senior School Certificate Examination (WASSCE) used in predicting the Grade Point Average in the University at the first semester.

2.5 Concept of content validity of a test

Straub et al. (2004) defines content validity as the degree to which items in an instrument reflect the content universe to which the instrument is generalized. It basically involves evaluating a new survey instrument in order to ensure that the instrument contains relevant items and eliminates items that are undesirable to a particular domain. Content validity ensures that a test covers broad areas of the syllabus. Items are sampled from various sections which have been covered from the syllabus. This is mostly facilitated by a test panel moderating the test to ensure the test designer does not construct items testing only topics of a particular interest.

Content validity as said by Airasian (2005) can be ensured when test items match with course objectives, instruction and reflect adequate sampling of instructional materials. The items must be a fair representation of the content of the curriculum and what is taught in the classroom. To determine the content validity of test, the items are therefore, compared with the table of test specification. Test experts or judges may also be asked to assess the extent of content validity in a particular test.

According to Popham (2014), validity is a measure of how well an instrument gauges the relevant skills of a subject. Contemporary perspectives call for an interpretive argument that specifies the interpretations and uses of tests and test results by outlining the inferences and assumptions that comes from the observed performances to the conclusions based on the performances. Assessment design processes are essential elements for argumentation and evidence purposes for validity. Different forms of empirical evidence are required to ascertain how well an assessment performs in relation to assertions about what an assessment was designed to do.

The American Educational Research Association (2014) enumerates validity evidence based on the content of a test as one of the five forms of validity based evidence; validity based on test content, validity based on response processes, validity based on internal structure, validity based on relations to other variables and validity based on testing consequences. For the purposes of testing and various forms of assessment of knowledge and skills possessed by testees, validity evidence based on the content of a test is basically a tool for putting up a validity argument to support the use of a test for a particular purpose and determining how well the content of an assessment is congruent to and appropriate for the specific test purposes. Validity evidence based on test content was described as content validity which was also used in psychometric literature.

Several expositions have been given to what validity based on the content of a test means. Yusoff (2019) explains content validity as a vital phenomenon that ensures an overall validity, content validation is performed systemically based on evidence and best practices. There are two major aspects of content validity that is, relevance and representativeness of a test. However, content validity has been frequently measured based on the relevance of the assessment and its establishment is vital to support validity of assessment tools. The America Education Research Association (2014) defines validity based on the content of a test as the degree to which evidence and theory support the interpretation of test scores entailed by proposed uses of tests, this assertion is similar to an earlier definition provided by Lennon (1956) that content validity is "*the extent to which a subject's responses to the items of a test may be* *considered to be a representative sample of his responses to a real or hypothetical situations which together constitute the area of concern to the person interpreting the test*" (1956 p. 125).

Content validity has been related to the response of a test, there have been other interpretations relating content validity to the purposes of a test. Sireci and Faulkner-Bond (2014) describe content validity as the degree to which the content of a test is congruent to the purposes for testing. It is however important that the content of a test represents its intended purpose which is also appropriate for achieving the testing purposes. Content validity includes any validity strategies that address the content of a test by investigating the extent to which a test represents the content of the stated objectives or the specifications of the test that it is originally supposed to measure.

Straub et al. (2004) asserts that content validity is the degree to which items in an instrument reflect the content universe to which the instrument will be generalized. It is highly recommended to apply content validity in the development of an instrument since it essentially involves the evaluation of a new instrument to ensure that the instrument includes all items that are essential and eliminates the undesirable items to a particular construct domain.

With regards to the accurate definition of validity in testing, two schools of thought vie for dominance. One school of thought attributes validity to the inferences of scores from a test and the uses of test scores whiles the other school of thought base their argument on validity based on the instrument under consideration (Sireci & Faulkner-Bond, 2014). In this regard, the reason for validation is affected since there is the question of the kind of evidence that ought to be sought in the process of validating a test. The instrument-based approach is easily accepted in psychological testing because there is a real attribute that is being measured. Both approaches to content validity are applicable but the content validity based on test score interpretation can be used in virtually all contexts of testing but content validity based on instrument is applicable where specific attributes are measured (Kinyua & Adiemo, 2014).

According to Sirecci (1998b), behavioral scientist had argued that assessments used indicators must be content valid. There has been an emphasis on the relevance of the content representation in the process of the construction and evaluation of an instrument but the controversy of the term content validity still persists. Meanwhile, the much controversies and arguments on the use of the term content validity and its importance of demonstrating content representativeness has been undermined. The demonstration of content validity is a fundamental requirement of assessment instrument but measures cannot be validated based on content validity evidence alone.

The America Educational Research Association (1999) posits that a test cannot be judged to be valid or invalid in vague without considering what makes the test valid or invalid. The validity of a test is not the test itself but the use of the test for a particular purpose. In view of this, the first step of test development whiles ensuring test validation is to specify the intended uses and interpretations of test scores. Hence, gathering validity evidence based on test content must focus much more on intended testing purposes.

Sirecci (1998b) described content validity as pertaining to four elements which basically focuses on test development. He provided four elements that ensure test quality. That is, domain definition, domain representation, domain relevance and the appropriateness of the test development processes. These four elements are important for evaluating the use of a test for a particular purpose. Hence, the vital elements for evaluating test content are the four elements of content validity, which are domain definition, domain representation, domain relevance and appropriateness of test construction procedures.

Wynd et al. (2003) asserts there are two interrelated steps in the process of constructing an instrument that is content valid. First, the domain of content related to the phenomena of interest which is preceded by a thorough review of literature must be identified and secondly, designing an instrument that relates to the identified domain of content. There are no agreed criteria for determining the extent to which a measure has attained content validity. This shows the absence of any rigorous and objective measures for achieving content validity. Despite the consensus about the four elements; domain definition, domain representation, domain relevance and appropriateness of the test development processes being important for evaluating the use of a test for a particular purpose, validity theorist claimed the term '*content validity*' is not technically correct to interpret the use of a test and its content but rather refers to the interpretation of the test scores.

2.5.1 Domain definition and representation of a test

In content domain representation, Amedahe and Asamoah-Gyimah (2013) had said the content and universe in assessing the content validity of a particular test must be first defined. Sirecci and Faulkner-Bond (2014) explain domain definition which is a vital part of content validity to be how a test operationally defines the construct it measures. The definition of a domain gives details regarding what the test measures hence, transforming the theoretical construct into a more concrete content domain. Defining the domain of an educational test is attained by stating the detailed descriptions of the content areas and cognitive abilities the test measures, test specification that indicate the specific content or strands coupled with the cognitive levels measured and finally, the specific content standards which is the curricular objectives and abilities that are contained in the various content strands and cognitive levels.

The curriculum serves as a source for the content and cognitive elements of the test specification. In evaluating the definition of a domain, external consensus that ensures that the operational definition of the test is in line with prevailing perspectives held by experts of the field. In achieving this, an independent expert panel is convened to develop and evaluate test specifications. The domain representation which is the extent to which a test adequately measures its construct as defined in the test specifications. In order to evaluate the domain representation, subject matter experts are employed to review and rate all the items on a test. The items are evaluated to determine whether they sufficiently represent the targeted domain and the congruence of the test with the curriculum framework.

Meanwhile, Raymond (2001) indicated that for achievement test conducted in elementary, middle and secondary schools, the content and cognitive elements of the test specification are carved from the curriculum framework that guides instruction.

2.5.2 Determining content validity

Measuring content validity of an instrument is important. Yaghmie (2003) stipulates that content validity of an instrument ensures construct validity and gives confidence about the instrument. However, documenting the content validity of an instrument may seem expensive in terms of time and human resources but its importance warrants greater attention when a valid assessment is to be developed. In content validity, two judgments are necessary; the measurable extent of each item for defining the traits and the set of items that represent all aspects of the traits. Thus, content validity is representative of the content of an instrument and this depends on the adequacy of a specified domain of the content that is sampled.

Content validity measures the comprehensiveness and representativeness of the content of a scale. Taherdoost (2016) suggests that in order to facilitate validation of instruments, researchers are required to be present with experts for the judgmental procedure in establishing the content validity of a test. However, there is not always a possibility of having many experts of a particular research topic at a location and this serves as a major limitation to conduct validity on the content of an instrument.

Bums and Grove (1993) stated that content validity is derived from three main sources, that is, literature, representatives of the relevant populations and experts' judgments. Content validity can also be established in two stages, that is, development and judgment stages. The first step in addressing content validity is the development of the instrument in question, this is to identify the domain of construct that should be measured which can be determined through literature reviews, interviews and focus groups. A qualitative method can be helpful for determining the domain and concepts of constructs that are of interest.

Bums and Grove (1993) continued to state that there is no complete method for determining the content validity of an instrument neither is there a statistical approach. However, content validity in its judgment stage is based on quantitative evidence. Hence, examining content validity in the judgment stage requires the professional subjective judgment to determine the extent of measure of a trait of interest. Three variables that affect the validity of teacher-made tests are the test taker, the environment and the test.

In evaluating the degree to which the content of an assessment conforms to the testing purposes, several methods could be employed. Whiles some methods are based on traditional notions of content validity others are based on newer notions of test and curriculum alignment. The methods differ based on the task presented to the subject matter experts, how data are analyzed, and the size of the content domain under focus and finally how the data are summarized. Meanwhile it is worth noting that all other methods make use of subject matter experts. The knowledge and expertise of the subject matter experts is very essential since the quality of the content validity study depends largely on the subject matter experts (Penfield & Miller, 2004). Gathering validity evidence-based test content require the use of subject matter experts to either

a) match test items to their intended targets or
b) rate the degree to which items adequately represent their intended content and cognitive specifications
c) rate the degree to which items are relevant to the domain tested

A matching task is usually used to measure the congruence between each item and the content domain. It provides enough data that informs about the degree to which the items represent their targeted domains and cognitive levels. The matching task can be used to eliminate or revise particular items or create new items that represent the areas perceived to be less congruent.

2.5.3 Content validity index

In the quest to identify a means of determining content validity, Yusoff (2019) asserts that evidence of content validity can be determined by the content validity index.

According to Yusoff (2019), recent studies had established content validity using the content validity index to support the validity of an assessment tool. In the process of content validation, six steps are outlined. Firstly, preparing a content validation form that ensures that the review panel of experts has clear expectation and understanding of the procedures. Secondly, selection of a review panel of experts with good expertise on the subject matter. The third process is conducting content validation through a face-to-face or non-face-to-face approach. A review of the domain and items domain definition must be clearly provided to the experts. The score on each item of the assessment must be provided and lastly, calculation of the content validity index is done.

The content validity index allows at least two raters to review and evaluate independently the relevance of a sample of items to the domain of content represented in an instrument. The proportion of cases in which raters agree are tallied and the stability of their agreement is determined. A Likert-type ordinal scale with four possible responses is used. The response include a rating of 1, 2, 3 and 4, with 1and 2 indicating a weaker rating as 3 and 4 indicate a stronger rating Items rated 1 and 2 are regarded as content invalid and 3and 4 as content valid, hence, the actual content validity index is the proportion of items that is rated by 3 and 4 by experts. It is always advisable to refute the four ordinal response ranking into two categories that is, content valid and invalid (Lynn, 1986 as cited in Wynd et al., 2003).

For the number of experts who can rate the content of an assessment, Pollit and Beck (2006) prescribed that three to five experts can form a panel to determine the content validity index of an instrument. In calculating the content validity index, there are two forms; the content validity index based on item and content validity index based on scale. Prior to the rating, the relevance rating must be recorded as 1 that is, the relevance scale of 3 or 4 and 0 for the relevance scale of 1 or 2. The content validity based on item is the proportion of content experts giving an item a relevance of 3 or 4 (Yusoff, 2019).

2.6 The Concept of Cognitive Validity

Field (2013) explains cognitive validity as the extent to which the mental processes learners use to perform tasks reflects the processes students use to perform same tasks in real-life situations. Cognitive validity examines the relationship between what an assessment aims to measure and what it actually elicits from test takers (Smith, 2017). Bransford et al. (2000) assert cognitive validity should be based on knowledge of the nature of students' cognition and understanding in specific areas of the curriculum and assessment, such as mathematics and the rate at which cognition develops over time in terms of instructions.

Of a great need is a research into aspects of cognitive validity that throws much insight into whether assessment depict the knowledge, skills and cognitive processes that are being measured (Pellegrino et al., 2001). Horns (2006) have sought empirical evidence about the actual thinking processes students involve in when taking tests in certain subjects and whether the test tap the kind of thinking being measured. Cognitive validity have relied on theoretical analysis by subject matter experts, who have determined what tests items elicit in the hands of students, but these judgments are prone to error and do not have empirical evidence of students' thinking.

Cho and So (2014) in their research interviewed school children to ascertain their test-taking experiences to understand the extent to which a test is cognitively valid for the school children. The school children were expected to provide cognitive validity evidence which was gathered from them. One factor that addresses the extent to which a test requires a candidate to engage in cognitive processes is construct validity which is similar to those factors that could be used in a non-test circumstance.

Cognitive complexity is very important in considering the cognitive validity of an instrument. It is crucial for all the various levels of learning to be tested in a test instrument. A good test reflects the goal of the instruction. Some instructors' main concern is students' memorizing facts; hence, tests are designed to ask for simple recall of facts (Clay, 2001). As part of the activities of testing, there must be enhancement to the test content and also changes in conformity to policies and to ensure that each item of a test measure the intended cognitive skills and in a reason range of difficulty (Dixson & Worrel, 2016).

Cognitive validity is based on the knowledge about the nature of student cognition and understanding in essential areas of the curriculum such as mathematics and science and how it develops over time with instruction to determine what knowledge and skills students are required to use and the knowledge and skills they actually use during assessment (Duschl et al., 2007). Cognitive validity is a concept within a larger domain of a test validation argument and it is considered as an important subject to test even before test scores are put to use. Cognitive validity elicits whether the tests exhibit the mental processes that students employ in real-world conditions.

Pellogrino et al. (2016) presented a framework that explains the concept of validity classified in three components that is cognitive validity, instructional validity and inferential validity. These classifications of components form evidence required to form a validity argument for classroom assessment of mathematics curriculum.

The impact of cognitive validity in educational measurement in recent times has been quite considerable. Cognitive validity has been applied to tests of scientific and logical reasoning and to measuring other forms of higher order thinking and reasoning (Thelk and Hoole, 2006). Cognitive validity has been used to evaluate mapping of concepts and a self-report instrument for assessing mastery of lesson content (Koskey et al., 2010).

In judging the adequacy of the thinking processes used in an assessment demand the use of analyzing tasks such that they reflect the steps to successful performance of the test taker. However, scientific explorations are ongoing for identifying techniques in cognitive requirements of performance tasks and other forms of open-ended assessments. In the United States, traditional centered instructions in other fields of study require students to memorize and recite factual information and this call for students to involve in analytical processes (Scheurman & Reynolds, 2010). However, Notar et al. (2004) advocates for a guard against imbalances and disproportionate item distribution, it is better for test designers to draw a table of specification targeting the cognitive objectives as prescribed by the Bloom's taxonomy before items are prepared.

2.7 Mathematics Assessment and Test Items

An assessment is one of the set of standards for Mathematics curriculum and it is the means by which the objectives planned by a curriculum were achieved. These objectives include, the level reached by students and the outcomes of learning and experience gained (Swan & Burkhardt, 2012). A mathematical assessment can be described as the process of collecting evidence about students' knowledge and ability to use mathematical knowledge and trends (National Council of Teachers of Mathematics, 1995). Mathematics has been stereotyped as a cut and dried subject, hence, teachers and instructors who design assessment assume that designing a quality mathematics task can be simple and straightforward (Newton, 2007). That assumption is not entirely true because Mathematics relies on precise reasoning. Mathematics test enhances students' learning in several ways, each of these ways needs thorough investigation before a judgment is made on the efficacy of the test. Assessment raises both students and teacher's expectations of performance which rather results in greater learning (National Research Council, 2012).

Though each and every student is involved in an assessment process, the tests are not only intended to help students identify their learning need or to provide information that can be used to modify subsequent instructions, instead, the test serves as an accounting or monitoring function such as counting the number of students who meet a particular grade level (Trumbull & Lash, 2013).

Messick (1989) asserts that Mathematics assessment is judged on how well the assessment reflects the learning principle with regards to the goals the testing principles seek to promote. A Mathematics assessment whether it comprises a system of only examinations or single task, the assessment must be evaluated against three educational principles: content, learning and equity. Meanwhile, validity is considered as a major factor in evaluating mathematics educational assessments which has been characterized as an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of the inferences and actions based on test scores or other modes of assessment.

Traditionally, Mathematics tests have been built from test blueprints with a two-dimensional array with topics to be covered on one side and the type of skills and processes required to teach such topics on the other side. Mostly, assessments need to involve more than one mathematical concept to enable students make appropriate connections among mathematical ideas they have learnt. But assessment that are meant to be challenging are opened to multiple approaches, involving varied and multiple processes and these assessments should be designed such that students are encouraged for using alternative solutions (Baird et al., 2014).

Bleiler and Thompson (2012) assert that further explorations are required into learning more about the appropriate use and development of Mathematics education assessment frameworks. Mathematics assessment frameworks show the complex nature of Mathematics rather than frameworks that enhance assessment by providing teachers with better targets for teaching and by clearly communicating what is valued to students, parents and the general public.

An individual assessment may not address all facets of the assessment framework. The collection of assessment needed to evaluate what students are learning needs to be comprehensive. If an assessment represents a significant but a small fraction of important mathematical knowledge and performance, then the same assessment should not be used over and over again. However, repeated use of assessment could narrow the curriculum.

In developing a test, the instructor must have in mind clearly what is intended for students to learn at the end of the course. The general and specific objectives of the course must be written at specific learning levels that is, from the lower to the higher level of difficulty. The Bloom’s taxonomy suggests how to construct these objectives and to develop a hierarchy of learning (Bleiler & Thompson, 2012).

Mathematics education reforms have underpinned the importance of the interconnections among mathematical topics and its connections to other domains and disciplines. Much assessment traditions and practices do not bring out the connections between Mathematics and other domains. New ways of reflecting the various connections in the assessment tasks designed for students must be developed by assessment developers. One way of ensuring these connections is to create task that challenge students to exhibit the various aspects of mathematics (Bodin, 1997).

In a study by Boudett and Steele (2007), the researchers posited that setting of tasks in a real-world context serves as an approach in reflecting important mathematical connections. Tasks put in real-world contexts are likely to capture students' interest and enthusiasm and may also suggest new ways of understanding the world through mathematical models so that assessment becomes part of the learning process. On the other hand, Swan (1993) stated that, difficulties emerge when attempts are made to put Mathematics into realistic settings. Swan (1993) continues to state that the settings may be unfamiliar that students may not see Mathematics in it, the designer of the test may have strained too hard to make Mathematics applicable which may end up with an artificial reality.

It is presumed that students need more active engagement in learning Mathematics and assessment in Mathematics aids students learning such that it engages students with limited mathematical proficiency in solving meaningful Mathematics. In the case of challenging assessments that are far beyond the grasp of students whose knowledge progress slowly behind the goals and reforms of the assessments, such students are not encouraged to demonstrate what they know. The assessment may have negative effects on these students' learning. More often, students' engagement should be judged through various types of evidence which includes teacher reports, student reports and observations (O'Neil, 1992).

Wolf (1991) had written that teachers whose proficiencies are weak in Mathematics have difficulty in making decisions about the Mathematics reflected in students' work. Teachers in such situation are unable to differentiate between correct and incorrect alternatives presented by students with novel ideas about a problem. This brings to light the importance of sustained attention paid to teachers' professional development.

Validity theory can be much of the technical machinery for determining whether the educational principles are met by a Mathematics assessment. A rough correspondence can be created between the content principle and content validity, between the learning principles and consequential or systematic validity, equity principle and criteria of fairness and accessibility (Silver & Lane, 1993). In applying content principle to Mathematics assessment, it requires a judgment to ascertain how well the assessment reflects the Mathematics that students deem important. The judgments are similar to content validity notions that were limited to the representativeness and relevance of test content. The greater concern lies on the quality of Mathematics reflected in the assessment tasks and in the responses to them.

The thinking processes students are expected to use in an assessment are as important as the content of the tasks. Boudette and Steele (2007) espouse that the process dimension of Mathematics has not merited sufficient attention in evaluations of traditional multiple-choice tests. The key issue is whether the assessment tasks actually call for students to use the kind of intellectual processes required to demonstrate mathematical power, reasoning, problem solving, communicating, making connections and so on. This kind of judgment becomes important as interesting tasks are developed that may have the veneer of mathematics but can be completed without students' ever engaging in serious mathematical thinking.

Winke (2011) and Menken (2008) found out that in establishing the test-score validity in a given context, it requires ensuring that tests are at the appropriate level of difficulty for the test takers. This is very important because when test tend to be too difficult for students, they may feel inadequate, humiliated, stressed and they may question their self-worth.

Darling-Hammond and Pecheone (2010) posit that educators are advocating for education assessment systems that are more balanced and retrieve useful information for educational purposes ranging from how to shape ongoing instruction in the classroom to accountability decisions made at the level of the policy making levels.

2.8 Testing and Test Development

Test is a medium of carrying out the process of evaluation. Joshua (2005) defines test as a systematic procedure for measuring a sample of behavior. In general, there are two broad types of test items: objective test and essay test. The West African Examination Council employs the two types in examining students in the standardized examinations. An advantage of the objective type of test is that it makes a fair representation of all the topics in the Mathematics curriculum because it contains numerous questions. Tests including examination can be classified under classroom guidance and administrative functions.

Crocker and Algina (2008) described a test as a standard procedure for obtaining a sample of behaviour from a specified domain. For achievement purposes, a test is normally administered to students after a period of instruction, taking into consideration the vital role information from a test play in making decisions in education for students as well as for management. It is important that test developers and users should ensure the validity of the test items in order to get the true information that sums the individual students' true characteristic which the test seeks to estimate.

Amedahe and Gyimah (2003) classifies the educational uses of tests into instructional management decisions, selection decisions, classification decisions, placement decisions, counselling and guidance decisions and credentialing and certification decisions. The instructional management decisions refer to all the classroom decisions taken by the teacher on the basis of the assessment results of students.

Estey (2004) stated that it is very crucial to vary formats in a single test for the reason that one item format may not be used to exclusively measure all the learning outcomes. Etsey (2004) prescribed the use of a table of specification which matches the course content with instructional objectives. The table of specification helps to prevent overlapping in the construction of the test which helps to determine the weighting of learning outcomes regarding the content areas and considers the inclusion of all aspects of the course or subject thereby helping to ensure content validity of the test. However, Newell (2002) asserts that teacher-made tests usually cover a limited part of a subject content and do not cover a broad range of abilities and these tests rely mostly on memorized facts and procedures.

Zimmaro (2016) gives some guidelines on how effectively a teacher can prepare items whiles in the process of teaching. Zimmaro (2016) suggests test items should be created whiles class lessons are prepared. The teacher should make notes of questions that students frequently ask during classes, notes of common misconceptions students make during class or in homework should be taken and finally, students should be invited to submit items at the end of a class.

Meanwhile, Tamakloe et al. (1996) and Estey (2004) listed eight principles that should be observed before a test is constructed and administered to students. These principles are the following listed:

a) Define the purpose of the test

b) Determine the item format to use

c) Determine what is to be tested

d) Write the individual items

e) Review the items,

f) Prepare the scoring key,

g) Write directions, and

h) Evaluate the test.

Amajuoyi et al. (2013) stipulates that scores from a test can only be meaningful and relevant if it actually represents the level of understanding and attainment of the testee in the task presented by the test items. These items of the test are supposed to reflect the entire topics and behavioural objectives which are expected to be covered in a subject by students. In other words, the items of an achievement test should cover the scope of the topics in the examination syllabus and core curriculum and the behavioural objectives it purports to achieve. This is made possible by the use of table of specifications or test blue print.

To aid the construction of a test, Zimmaro (2016) suggest the use of a test blueprint which is also known as test specification consisting of charts representing the number of questions that have to be included in a test within each topic and level of objective. The test specification identifies the objectives and skills that are to be tested and their relative weight on the test. The test blueprint helps to ensure that the desired coverage of topics and level of objective is obtained.

Cho and So (2014) stated that in revising the design of a test, the test questions and task directions must be simple and clear, task descriptions must be clear and the amount of information to be retained by learners during testing must be limited. Zimmaro (2016) also shared same view as he stated that teachers should be sure each item deals with an important aspect of the content area and also be sure that the questions are clear and unambiguous ensuring that each item is independent of all other items.

McDaniel et al. (1994) asserts that generally, classroom achievement tests are teacher-made tests mostly constructed by teachers to test the amount of learning done by students or their attainment at the end of a course unit. These tests constructed are well adapted to outcomes and content of the classroom. They have the flexibility that enhance continuous adaptation to new materials and changes in procedure and also adaptable to various-sized work units.

2.8.1 Test item types and formats

Different types and formats of tests are applied in the process of testing students, with the aim of determining their achievement and to identify their strengths and weaknesses. In the Ghanaian classroom and the external examination, there are two major types of test formats that are normally used. The format of the test could either be objective items or essay type items. According to Adusei (2017), the objective tests are in two major forms. These are the selection type and the supply type. The selection type items give options for a testee to select the correct answer or the best answer from a number of options presented. The variety of items that fall under the selection type items are the multiple-choice type, true or false type and matching type. One of the selection types of objective test that is most frequently used in the Ghanaian school systems is the multiple-choice format. This type of objective test is reviewed with the essay type because they are the two specific item formats of interest in this study.

2.8.2 Multiple-choice item format

Nitko and Brookhart (2007) and Etsey (2003) posit that a test is objective when the procedure of obtaining the accuracy of responses to items remains the same from one rater to the other. The objective nature of a test basically depends on the scoring of the test. These tests consist of a large number of items and the responses are scored with much objectivity such that the expert observers would agree to the scoring of the test.

As stated in his research, Etsey (2004) stipulates that the most common item formats in classroom achievement testing are the essay type and objective-type items. It is sometimes necessary to use one item format in a single test. The purpose of the test determines the choice of the item format. One item format cannot be used exclusively to measure all learning outcomes. Multiple-choice items are mostly used to assess the achievement of students in large classes; however, it is most likely for instructors to find writing good items that require students to do more than memorize facts and details (Zimmaro, 2016).

Multiple-choice items are widely used to measure knowledge, comprehension and application outcomes. These types of items provide the most useful format for measuring achievement at various levels of learning. Meanwhile, the use of multiple-choice items has several advantages over the essay type items. The learning outcomes of multiple-choice test from simple to complex levels can easily be measured.

Multiple choice items gives a broad sample of achievement that can be measured and scoring is easy objective and reliable (Zimmaro, 2016).

Notwithstanding the merits, multiple-choice test has certain limitations. Constructing good multiple-choice items is time consuming whiles there is also lack of feedback on individual test processes. It is also difficult to determine reasons why individual students selected incorrect responses. It focuses on testing factual information and fails to test higher levels of cognitive thinking (Clay, 2001). In developing a multiple-choice test, there are a number of procedures involved. Clay (2001) lists four steps involved in developing multiple-choice items: setting an assessment framework, constructing items, reviewing items and conducting a try-out.

An outstanding advantage of a multiple-choice test according to Adusei (2017) is the content validity of the test. The multiple-choice test is widely used in achievement tests of all types to assess a variety of learning outcomes. Multiple-choice items do not only measure factual recall, but can also measure the students' ability to reason and to exercise judgements.

Nitko and Brookhart (2007) and Etsey (2003) posit that the objectivity of a test occurs when the procedures by which the accuracy to the responses of the various items determined does not differ from one rater to the other. Thus, the objective nature of a test refers to the scoring of the test. These tests normally consist of a large number of items and the responses are scored without subjectivity, to the extent that expert observers can agree on the correct responses.

2.8.3 Essay-type item format

Reiner et al. (2002) defined essay type test as a test which requires a response designed by the test taker. The responses of essay type tests are usually in the form of one or more sentences such that no single response or pattern can be listed and labeled as correct. Its accuracy and quality can be judged only by one skilled or specialized expert in the subject matter. Testing experts have affirmed that essay-type tests can either have extended or limited response types.

Tamakloe et al. (2005) have described an essay type test as one which gives the student or the test taker the chance to compose their own responses to the items. These items are usually in the form of logically arranged related sentences. No plausible responses are provided for the testee and there is no selection of correct answers made by the testee. Essay type items measure learning outcomes that are complex. Essay type items can also be used in circumstances which may not necessarily require the measurement of complex learning outcomes. But essay type items may be required in certain specific cases such as; when the tester wants to test the ability of the testee.

Essay-type items can be classified as open-ended tasks and can be difficult to construct and administer because, they can misrepresent what students know. Students may give a minimal response that is correct but that fails to show the depth of their mathematical knowledge. They may be confused about what constitutes an adequate answer, or they may simply be reluctant to produce more than a single answer when multiple answers are called for. In an internal assessment constructed by a teacher, the administration and scoring can be adapted to take account of misunderstanding and confusion. In an external assessment, such adjustments are more difficult to make. The contexts in which assessment tasks are administered and the interpretations students are making of them are critical in judging the significance of the content. Jaschik (2011) had written that some tests which incorporate open-ended questions often requires human scoring and grading which is tedious and expensive.

2.9 Teachers' Test Construction Skills, Practices and Attitude

As written by Flanagan et al. (1997), on philosophical bases, the quest for truth and reality is through the act of assessment. Constantly in an educational system, decisions are made about students' achievement and curricula programmes to influence educational policies, hence, it is impossible for anybody to study in an educational system without being taken through a wider range of education and assessment procedures (Oduro-Kyireh, 2008). Oduro-Kyireh (2008) continues to state that testing cannot be separated from teaching, without the knowledge of learners' performance, there cannot be effective teaching and learning.

Test construction is an important part of teacher's responsibilities and duties; it is the responsibility of teachers to craft well-functioning items to ensure effective classroom instructions. Amedahe and Gyimah (2003) had stated that it is important for the classroom teacher to constantly diagnose his/her instructions and effect changes to aspects which are defective and this is done through feedback gathered from students. For a teacher to engage in diagnosis and remediation, the teacher engages in testing to identify students who need special assistance or remedial help.

Faleye and Adefisoye (2016) had also stated that classroom achievement tests do not only serve as the basis for setting students' level of achievement tests in a particular subject area, they also help the teacher in monitoring the likelihood of achieving goals of teaching at that particular level of schooling. When results of teacher-made classroom achievement tests are released, all those involved in the procedures that led to the release of that results are able to evaluate the quantity of their contribution.

States et al. (2018) stipulate an essential question that is to be asked when developing an informal teacher-made assessment. 'Does the assessment consistently assess what the teacher intended to be evaluated based on the material being taught?' The best assessment practices of teachers involve teachers answering questions by incorporating assessment design into the instructional design process. Assessments are best crafted at the same time as lessons are planned.

A study by Kinyua and Odiemo (2014) to find out the factors that influence the validity and reliability of teacher-made test in selected schools in Kenya, discovered that experiences of teachers, training on test construction and analysis, level of tests, use of Bloom's taxonomy affect the validity and reliability of a test.

A study by Onyechere (2000) posited that experienced teachers who had gained training in test construction applied a number of principles in their test construction practices. Moreover, experienced teachers are likely to design tests with higher validity and reliability than teachers who have not had such training in test construction. The study concluded that teacher-made tests are generally valid and reliable and suggested that there should be an enhancement of test construction and analysis in order to raise test validity and reliability.

In Ghana, the various colleges of education and universities that train teachers for senior high school education train teachers in assessment of which test construction is an important aspect. A full course in educational assessment is organized for students. The course content equips students with practical knowledge on test construction and assessment. However, from their anecdotal study in the Cape Coast Metropolis, Anhwere (2009) and Ebinye (2001) assert that even though teachers have had training in school assessment which includes test construction, teachers do not adhere to the principles and rules governing test construction which results in test items poorly constructed. Interaction with teachers indicated that teachers' attitude towards test construction is not good enough. Similarly, a study among teachers in junior high school in the Cape Coast Metropolis indicated that teachers have limited competencies in the management and practices of test construction. An examination of literature indicates that, globally, most teachers in all levels of education across diverse subjects exhibit poor test construction skills.

Hamafyelto et al. (2015) discovered that senior high school teachers in Borno State in Nigeria constructed items which focused on lower cognitive operations. In Ebinye (2001), test construction has been found to be a major source of anxiety among many teachers in Nigerian schools, especially, less experienced teachers. This anxiety stems greatly from lack of skills in test construction among teachers.

In addition to teachers' test construction competencies, an evaluation of test construction skills of professional and non-professional teachers in schools in Nigeria reported that professional teachers tend to construct effective evaluative tests more than the non-professional teachers. Teachers have the potential of employing various principles and techniques which is less likely to happen in the case of non-professional teachers (Ololube, 2008).

Onyechere (2000) asserts the situation of poor test construction among teachers is a great issue as students achievement results are reported to have errors. There is a question of whether teachers are not well trained in test construction or teachers feel reluctant in using their knowledge in test construction despite the training they have had. However, comprehensive report on what teachers know about test construction has not been provided. This is evident in Ebinye (2001) who found that construction of test items appears to be cumbersome for teachers, regardless of the knowledge teachers have acquired.

Adodo (2014) opined that the effectiveness of an educational system of a teacher depends on the effective availability of truly qualified, committed, dedicated and vocationally spirited teachers to achieve the schools' objectives and national goals on education. Learning is maximized when teachers are trained and educated very well in various assessment techniques.

According to Etsey (2004), the foremost task of a teacher is to prepare students in advance for test and it is important that students are made aware of when the test will be given, the conditions under which the test will be given, the content areas, the kinds of items, whether objective-type or essay-type, how the test will be scored and graded and the importance of the test results.

In an earlier research, a major concern shared by Amedahe (1989) is whether teachers are prepared and well equipped to perform the role of constructing good test items. But, irrespective of teachers' pre-service training, teachers in Ghana construct, administer, score and interpret results of classroom achievement tests. By his general observation, Amedahe (1989) asserts the effect of teachers' inadequate test practices ranges from lifting test items from textbooks, test items testing only recall of facts, improper wording of test items resulting in ambiguity, unreasonable difficulty levels of items, unclear directions, unreasonable time limit allotment, subjective and inconsistent scoring, test results that are interpreted wrongly or not interpreted at all.

In some instances, teachers succumb to writing quick memory level items. This came out of a study of 342 teacher-made tests revealed that most teachers use short answer tests measuring knowledge of facts. These tests only require students to remember but not apply knowledge. Such tests are easy to construct but they send the wrong signals to students about the things we value in education (Amedahe, 1989).

Oduro-Okyireh (2008) from his research gathered that pre-service training in educational measurement had positive impact on teachers' skills in testing practices though the impact is not so pronounced. Oduro-Okyireh (2008) recommends that teachers must be given formal training in educational measurement and evaluation since competence skills in assessment is paramount to teacher effectiveness, there was a suggestion for universities in Ghana to streamline actual testing principles in the classroom in their roll-out courses in their educational measurement courses to enable teachers implement the theoretical knowledge they acquire.

McDaniel et al. (1994) had written that there is nothing mysterious in constructing better classroom tests. For a very good instructional programme, the responsibility lies on teachers to take time to create fair and well thought through test. Hence, teachers can have confidence in the evidences they gather and make reasonable assumptions about their students' performance and make effective future instructional decisions. Three steps that elevate a test from its ordinary state and provide a sound basis for evaluating students' achievements are test planning, item analysis and revision.

Kinyua and Odiemo (2014) revealed from the findings of their study that teachers' experiences and training on test construction and analysis, teacher's level of education and knowledge of Bloom's taxonomy and the ability of teachers to moderate test and its length affect the validity of the test. The research found that experienced teachers who had adequate training and applied such knowledge in their test constructions designed tests with higher validity than teachers who had little training in test construction.

The competency of teachers to construct effective tests for students is an important tool needed by every teacher in order to achieve learning and instructional objectives effectively. There is varied importance of test in the educational system.

CHAPTER 3

METHODOLOGY

3.0 Overview

This chapter describes how the study was conducted. It describes the research design, population, sampling and sampling procedure, research instruments, piloting of test items, selection of experts, data collection procedure, and method of data analysis.

3.1 Research Design

A research design describes the procedures for conducting the study, including when, from whom and under what condition the data was obtained (McMillan & Schumacher, 2013). The main aim of this research was to determine the content validity of teacher-made Core Mathematics tests by determining which profile dimension of the senior high school Mathematics curriculum teacher-made test items adequately address. Also by determining how the test items reflect the subject matter being examined by matching test items to their intended objectives and rating the degree to which items are relevant to the content domain. Hence, to address the three research questions, the researcher adopted a descriptive survey. Amedahe (2004) explains a descriptive survey to involve the collection of data in order to answer research questions concerning the current state of the subjects of the study. A descriptive survey research describes the characteristics of a phenomenon that is under study. This included an observational method carried out with a document analysis which involved a matching task proposed by Sirecci and Faulkner-Bond (2014).

3.2 Population

Hayes et al. (2011) defines population as the entire people in which the researcher is interested and to which he or she would like to generalize the results of a study. The population for this research consisted of senior high schools and teachers of Mathematics in the Eastern Region of Ghana. There are 99 second cycle schools of which 91 are senior high schools and 8 are technical institutions. The researcher chose this population because the study was purposed to find out the content validity of teacher-made Core Mathematics test items and also identify the test construction practices of teachers in senior high schools in the Eastern Region.

3.3 Sample and Sampling Technique

Since the research adopted a descriptive survey which sought to study the characteristics of the phenomenon under study, the sample for this study were chosen from the Nsawam municipality, Birim South, Denkyembour and Kwahu East districts. The specific schools included St. Martin's Senior High School, Akim Swedru Senior High School, St. Roses Senior High School and St. Peter's Senior High School. These schools were selected because they are all government schools and adhere to the regulations of the Ghana Education Service and use the senior high school Mathematics curriculum for instructional purposes. The schools also fall under the various groups of categorization of the senior high schools as conducted by the Ghana Education Service based on academic performance. This sample was selected by convenience because of the researcher's nearness and access to these schools. McMillan and Schumacher (2013) had stated that in convenience sampling, a group of subjects is selected on the basis of being accessible or expedient. 40 teachers were selected by simple random from the schools above with ten teachers selected randomly from each of the four schools. A purposive sample was used to choose the

Core Mathematics test items used for the study. Tongco (2007) defines a purposive sampling technique as the deliberate choice on a subject due to the qualities possessed by the subjects.

3.4 Research Instruments

The first instrument employed for the study was teacher-made Core Mathematics tests for the 2018/2019 academic year made for second year students from the sampled senior high schools (SHS 2) students for first and second semesters. These instruments were chosen because of the extent of the content covered by students in SHS two. A total of 310 multiple-choice items consisted in the first section of the tests was examined and a total of 199 essay-type Core Mathematics items were also examined. These test items were constructed based on the content covered as prescribed by the senior high school Mathematics curriculum. Also, a Likert-scale questionnaire contextualized from Amoako and Quansah (2018) was designed to gather information on test construction practices of teachers. A total of 19 items were put together on a four scale of agreement (SD-strongly agree, A-Agree, D-Disagree, SD-Strongly Disagree).

3.5 Piloting of Questionnaire

In testing the instrument (questionnaire) for the study, a pilot test was conducted on 20 teachers from Nsawam Senior High School. These teachers were not involved in the research. Hence, it was easy for the researcher to use their responses to test the instrument. The important factor here was for the researcher to ensure that the items on the questionnaire accurately addressed the research question. The pilot also tested whether the items on the questionnaire was comprehensible, appropriate and well defined, clearly understood and presented in a consistent manner. The researcher realized that the sequencing of the questions was not properly done and the responses to some items suggested the responses to other items. Hence, the researcher had to reframe the items on the questionnaire.

3.6 Validity

Validity as explained by Taherdoost (2016) is how well the data collected covers the actual area of investigation. Field (2013) also defined validity as a measure of what is intended to be measured. In this research, two forms of validity were considered; face validity and content validity. The researcher employed the services of three colleagues who are teachers of Mathematics to ascertain whether or not the items on the questionnaires used for the study were face valid. They gave suggestions and comments in line with what the items on the questionnaire sought to measure which is, the skills and practices of testing teachers exhibit in constructing tests for students in the senior high schools. This involved checking the language and appropriateness of the structure and the items on the questionnaire. The content validity was determined by two heads of Mathematics department from two different schools who rated the items valid or invalid. The researcher's supervisor scrutinized the items under the principles of face validity and content validity.

3.7 Reliability

A total of 509 test items were classified into two profile dimensions thus; knowledge and understanding and application of knowledge. The individual cognitive skills were used as a guide for the classifications. The classification was carried out by the three experts together. Three different classifications were obtained, hence an inter-rater reliability was calculated in order to establish an agreement of concordance between the three classifications. The inter-rater reliability was determined by using the method for calculating inter-rater reliability coefficient for normal data. The inter-reliability coefficient for the classifications among the three experts was 80.4% which showed that the data was reliable for use. This scaled the total number of items down from 509 to 409 which was used for the analysis.

Table 3.1: Percentages of rater agreements of classification of test items by Bloom's taxonomy

Type of Agreement	Frequency	Percent	Cummulative percent
Raters' agreement on classification	409	80.4	80.4
Raters' disagreement on classification	100	19.6	100

Source: Field Data, 2020

3.8 Selection of Experts of Mathematics

For the purposes of determining the content validity of teacher-made tests for senior high schools, the researcher required the assistance of a number of experts in Mathematics tests to rate the items to ascertain whether the sampled tests are content valid or content invalid. The researcher contacted a number of experts in teaching Mathematics who have had several years of experience in teaching and learning Mathematics but only three gave consent to assisting in rating the test items. Hence three experts agreed to assist in rating the test items. The researcher wrote to the three experts seeking their formal consent and assistance. In rating the items, the researcher prepared a validation form that prescribed how the ratings are to be carried out. The validation form which served as a guide together with a classification template for the classification exercise was sent to each of the experts by email. Each of the three experts downloaded these document and used for the classification. There was a brainstorming exercise to decide on the mode of categorization and to brief on the interpretation of the six hierarchies of the cognitive processes for the Bloom's taxonomy.

3.9 Data Collection Procedure

The researcher sought permission and approval from the managements of the various schools involved to collect their end of semester tests and administer questionnaires to Mathematics teachers. In pursuant of effective data collection and ease of getting respondents, the researcher established a cordial relationship with the teachers. A formal request was made through the heads of department of the various schools involved for the teacher-made tests since the Core Mathematics tests had to be sought from the school's archives. A period of one week was given for the respondents to complete the questionnaire.

In gathering the data from the teacher-made test instruments, the researcher classified the test items under the specific cognitive skills to enable easy classification under the two profile dimensions and the various content or topics the items represent. The study used a matching task proposed by Sirecci and Faulkner-Bond (2014), which was designed in a five-column tabulated task. The first column indicated the test item number, the second column indicated the content domain the test item represents, the third column indicated the learning objective the item is aligned to, the fourth indicated the profile dimension and the final column provided a relevance rating scale for content validity index. The profile dimensions of the items were determined by rating the items using the various verbs attached to the cognitive skills by Bloom's taxonomy which is consisted in the profile dimensions. The verbs determined the items rated under a specific cognitive level. For instance, the first profile dimension was knowledge and understanding made up of two cognitive skills; knowledge and comprehension/understanding. For an item rated under knowledge and understanding, implied the item measured knowledge or understanding. Knowledge was measured with verbs such as list, label, find, name etc. whereas comprehension was measured with verbs such as describe, contrast, discuss, predict etc. The second profile dimension is a culmination of four cognitive skills, that is, application, synthesis, analysis and evaluation. Each of these four skills has their unique verbs that measured them. Therefore, for any item that made use of a verb associated to any of these four individual cognitive skills, the item was classified under application of knowledge. The researcher after this, classified the items under their respective profile dimensions.

The three experts who were employed in this research, were engaged in a non-face-to face approach as suggested by Yusoff (2019) which required the experts to do their ratings through an online medium facilitated by the researcher, through which they rated test items for their relevance. A review and validation form was prepared and sent to the experts. The validation form indicated clearly the guidelines for the ratings. A relevance rating was done on a rating scale from 1, 2, 3 and 4. However, Lynn (1986) suggested that ratings 1 and 2 represent a weaker validity and ratings 3 and 4 represented a stronger validity. The various rating from the experts were collated.

3.10 Data Analysis Procedure

The various test taken from the four schools were classified A, B, C and D. The study did a classification of the test items under the topic the item fall under, the specific objective, the profile dimension the test item represent and the relevance rating of the test item (see Appendix C). The test items classified under the two profile dimensions were expressed in frequencies and percentages. The test items which were classified under the various topics they represented were also presented in frequencies and percentages. The relevance ratings of 1, 2, 3 and 4 from the experts were presented in means and grand mean was calculated for the means. A mean above 2.5 for a relevance rating rendered the content of the test valid and a mean below 2.5 rendered rating content invalid. A principal component factor analyses were performed using Varimax to examine the factor structure and to remove problematic items. The exploratory factor analysis made use of Eigen values greater than 1. The analysis indicated that, the variables could be reduced to 5 with the first accounting for 18.60% of the variability in all the 19 items. The cumulative variance of the 5 variables was 66.76%. As recommended by Kasimu, (2017) and Field (2009) a factor loading cut-off point of 0.40 was used as the inclusion criterion for factor interpretation. A reliability analysis (Cronbach's Alpha Coefficient) was checked using guidelines. The factors were further reduced to three based on factor loadings of the questions onto the factors. Based on these factor loadings, questions that load onto the same factors were identified with common themes (Sub-Scales). In all, 3 sub-scales were used: i) Student's cognitive ability ii) Test planning and techniques iii)Test Construction.

Table 3.2: Factor loadings of items

Extracted Construct	Items	Factor Loadings	Reliability Co-efficients
Students' Cognitive Ability	It is important to consider the cognitive abilities of students when constructing a Mathematics test.	.77	.74
	I construct my questions based on the various cognitive abilities of students.	.75	
	I consider the difficulty levels of questions in relation to the various cognitive levels.	.72	
	I normally consider the thinking skills a question measures before examining students.	.71	
Test planning and Techniques	I have ever undergone training in test construction.	.59	.61
	I have sufficient knowledge about the basic principles of test construction.	.66	
	I plan the format of a test/examination before constructing the questions	.57	
	Time allocated to test items is based on the specific content and the number of questions given	.62	
	I consider the total number of students in my class before deciding the number of questions in a Mathematics examinations	.63	
Test content	I use a table of specification/scheme of work in constructing questions for examinations	.86	.84
	I prepare the solutions/marking scheme to the questions constructed before examining students	.81	
	I choose and select my Mathematics questions for end of semester examinations directly from WASSCE past questions	.89	
	I test students on areas they are supposed to know whether they have been taught or not	.84	
	I believe constructing a good Mathematics test requires the consideration of learning objectives of the topics involved	.82	

Source: Field data, 2020

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Overview

This chapter focuses on the results of the analyses of the data and discussion of the major findings. The data were presented using tables, descriptive and inferential statistics. The purpose of this study was to investigate the content validity of teacher-made Core Mathematics tests by

- Finding the profile dimensions the teacher-made Core Mathematics test items in senior high schools represent.
- Determining the extent to which topics and content of the senior high school Mathematics curriculum are well represented in the teacher-made tests and how the test adequately address the objectives being examined.
- Investigating the test practices and skills teachers' exhibit in constructing tests.

The following research questions were used to guide the study:

- What profile dimension of the Ghana Mathematics curriculum do teacher-made Core Mathematics tests adequately address?
- To what extent do the teacher-made tests items in the senior high schools' Core Mathematics tests address the content and objectives being examined?
- What practices and skills of testing do teachers exhibit in constructing tests for students in senior high schools?

The results and discussions in this chapter are presented in three sections according to the research questions.

4.1 The spread of the profile dimensions as presented in the teacher-made tests in the multiple choice tests for the two semesters

Research Question 1: What profile dimension of the Ghana Mathematics curriculum do teacher-made Core Mathematics tests adequately address?

In answering research question 1, the classified teacher-made items by the three experts were analyzed and presented in frequencies and percentages.

Table 4.1: The percentage spread of the profile dimensions of multiple-choice test items

School	Knowledge and understanding		Application of knowledge	
	Frequency	**Percent**	**Frequency**	**Percent**
A	16	29.6	38	70.4
B	13	20.3	51	79.7
C	8	10.7	67	89.3
D	16	29.0	39	71.0

Source: Field data, 2020

Table 4.1 displays the results from the multiple choice items which shows that 29.6% of items tested knowledge and understanding and 70.4% tested application of knowledge from school A. School B recorded 20.3% for knowledge and understanding whiles 79.7% tested for application of knowledge out of a total of 64 items. 10.7% of items from school C tested for knowledge and understanding whilst application of knowledge was tested with 89.3% of items out of 75 items. Knowledge and understanding had 3.5% items as 96.5% of items tested for application of knowledge out of 55 items. This shows that teacher-made Core Mathematics multiple-choice test items test for application of knowledge.

Table 4.2: The percentage spread of the profile dimensions of the teacher-made essay-type test items

School	Knowledge and understanding (%)		Application of knowledge (%)	
	Frequency	**Percent**	**Frequency**	**Percent**
A	8	27.6	21	72.4
B	14	29.2	34	70.8
C	11	19.6	45	80.4
D	1	3.5	27	96.5

Source: Field data, 2020

From Table 4.2 the essay-type questions for schools A, B, C and D shows 27.6%, 29.2%, 19.6%, 3.5% of Mathematics essay type items tested knowledge and understanding respectively whilst application of knowledge was tested with 72.4%, 70.8%, 80.4%, 96.4% for schools A, B, C and D respectively. This indicates that teacher-made Core Mathematics essay-type items address application of knowledge.

Table 4.3: Overall frequency and percentage spread of the profile dimensions of the teacher-made tests of the four schools

School	Knowledge and understanding		Application of knowledge	
	Frequency	**Percent**	**Frequency**	**Percent**
A	24	28.1	59	71.9
B	27	24.2	85	75.8
C	19	14.5	112	85.5
D	17	20.5	66	79.5

Source: Field data, 2020

The results in Table 4.3 shows that from school A, 71.9% of a total of 83 test items tested for application of knowledge and 28.1% tested knowledge and understanding. The results further shows that for school B, 75.8% of the test addressed application of knowledge whilst 24.2% addressed students' knowledge and understanding out of a total of 112 test items. From school C, the results in the table indicates that 85.5% of the tests tested application of knowledge as knowledge and understanding was tested by 14.5% of the test items from a total of 131. Finally, 79.5% of test items tested for students' application of knowledge and 20.5 tested for knowledge and understanding in school D out of a total of 83 items. This indicates that, the teacher-made test items from the four schools tested for application of knowledge. Hence, the tests address higher level cognitive skills. The total spread of the test items is organized in Table 4.4.

Table 4.4: A frequency and percentage spread of the total teacher-made test items

	Total	**Knowledge and understanding**		**Application of knowledge**	
		Frequency	**Percent**	**Frequency**	**Percent**
Total items	409	87	21.6	322	78.4

Source: Field data, 2020

The results in Table 4.4 shows that out of a total 409 test items, 87 test items representing 21.6% and 322 test items representing 78.4% tested application of knowledge. This indicates that a higher number of Core Mathematics test items test for application of knowledge.

4.2 A result of the content of the teacher-made tests for first and second semesters

Research Question 2: To what extent do the teacher-made tests items in the senior high schools' Core Mathematics tests address the content and objectives being examined?

Tables 4.6 below show the spread of topics in the test items as presented in the teacher-made Core Mathematics tests for the four schools in the first and second semester tests.

Table 4.5: Frequency and percentage spread of topics from the first year content of the curriculum as represented in the first semester test for the four schools.

S/No	Topics	School A	School B	School C	School D	Total
1	Sets and operations on sets	2	1	1	2	6(2.2%)
2	Real number system	3	3	4	4	14(5.9%)
3	Algebraic expression	3	1	12	4	20(8.4%)
4	Surds	0	0	7	1	8(3.4%)
5	Number bases	2	0	2	3	7(3%)
6	Plane Geometry 1	7	6	8	12	33(13.9%)
7	Linear equations and inequalities	0	5	5	2	12(5.1%)
8	Bearings and vectors in a plane	0	6	0	0	6(2.2%)

Source: Field data, 2020

The results in the table 4.6 indicate that 8 topics representing 52.6% of topics from the SHS 1 content of the Core Mathematics curriculum were tested. Sets and operations on sets covered 2.2%, Real number system represented 5.9%, Algebraic expressions took 8.4% of the test whilst Surds covered 3.4%, Number bases had 3%, Plane Geometry 1 represented 13.9% of the test, Linear equations and inequalities covered 5.1%, Bearings and vectors in a plane also covered 2.2%.

Table 4.6: Frequency and percentage spread of topics from the second year content of the curriculum as represented in the first semester test for the four schools

S/No	Topics	School A	School B	School C	School D	Total
1	Ratio and rates	0	0	3	1	4(1.7%)
2	Percentages 1	0	0	6	0	6(2.2%)
3	Modular arithmetic	6	6	13	0	25(10.5%)
4	Indices and logarithms	9	14	32	7	62(26.1%)
5	Simultaneous linear equations	2	1	1	1	5(1.8%)
6	Variation	0	0	0	4	4(1.7%)
7	Quadratic functions and equations	1	5	4	0	12(5.1%)

Source: Field data, 2020

The test constructed for SHS 2 students captured 7 out of 10 topics representing 36.8% from the SHS 2 content in the senior high school Core Mathematics curriculum. Ratio and rates forms 1.7% of the test, Percentages 1 took 2.2%, Modular arithmetic and indices and logarithms which are the first two topics of the SHS 2 content of the Core Mathematics curriculum covered 10.5% and 26.1% respectively indicating that much consideration was given to SHS 2 topics, meanwhile, Simultaneous linear equations had 1.8% coverage, Variation took 1.7%, Quadratic functions and equations had 4.2%, Plane geometry II had 1.3% and Trigonometry represented 0.8%. This indicates a fair representation of the topics from the SHS 2 content since the test was constructed for SHS 2 students.

Table 4.7: Frequency and percentage spread of topics from the third year content of the curriculum as represented in the first semester test for the four schools

S/No	Topics	School A	School B	School C	School D	Total
1	Plane Geometry II	0	0	0	3	3(1.3%)
2	Trigonometry I	1	0	0	2	2(0.8%)

Source: Field data, 2020

The test tested 2 topics from the SHS 2 component of the Mathematics curriculum representing 22.2% of the SHS 3 content. The test consisted of items from Plane Geometry II which had 3 items representing 1.3% and Trigonometry I had 2 items which represented 0.8% of the test. This implies that, senior high school teachers do not construct test that limits the content to only the level of the students but from other scope above their level.

Table 4.8: Frequency and percentage spread of topics from the elective mathematics curriculum

S/No	Topics	School A	School B	School C	School D	Total
1	Matrices	0	6	0	0	6(2.2%)
2	Polynomial functions	1	3	0	0	3(1.3%)

Source: Field data, 2020

2 topics that is, Matrices and Polynomial functions representing 10.5% of the content of the test was covered by topics from the Elective Mathematics curriculum. This indicates that, teachers would want to construct tests to suit the model of the West Africa Examinations Council. Since the examination council examines students on such topics from the Elective Mathematics curriculum.

Table 4.9: Frequency and percentage spread of topics in the first year content of the curriculum as represented in the second semester test for the four schools

S/No	Topic	School A	School B	School C	School D	Total
1	Sets and operations on Sets	0	4	8	4	16(5.9%)
2	Real Number System	2	2	2	3	9(3.3%)
3	Algebraic expression	2	5	8	6	21(7.7%)
4	Surds	2	2	1	3	8(2.9%)
5	Number bases	2	1	2	2	7(2.6%)
6	Relations and functions	3	5	4	4	12(5.9%)
7	Plane Geometry I	2	4	3	2	11(4.0%)
8	Linear equations and inequalities	1	2	0	2	5(1.8%)
9	Bearings and vectors in a plane	12	8	1	1	22(8.1%)

Source: Field data, 2020

From Table 4.10, 9 out of 13 topics representing 28.1% of the SHS1 content was represented in the second semester test. The test comprised Sets and operations on sets which covered 5.9%, Real number system covers 3.3%, Algebraic expressions had 7.7% of the test, Surds tested 2.9% of the items in test, Number bases represented 2.6%, Relations and functions had 5.9%, Plane Geometry tested 4%, Linear equations and inequalities had 1.8% of the test items and Bearings and vectors in a plane had 8.1% of the test.

Table 4.10: Frequency and percentage spread of topics in the second year content of the curriculum as represented in the second semester test for the four schools

S/No	Topic	School A	School B	School C	School D	Total
1	Ratio and rates	5	0	3	0	8(2.9%)
2	Percentages I	1	1	5	3	10(3.7%)
3	Modular Arithmetic	2	5	2	1	10(3.7%)
4	Indices and Logarithms	6	5	2	7	8(2.9%)
5	Simultaneous linear equations	2	1	1	0	4(2.6%)
6	Variation	0	6	8	3	17(6.3%)
7	Statistics II	5	9	14	4	11(4.0%)
8	Probability	1	3	0	1	5(1.8%)

Source: Field data, 2020

Table 4.11 indicates 8 out of 10 topics from the Core Mathematics curriculum representing 25% of the content of the Core Mathematics curriculum was presented in the test. The topics are from the SHS 2 content of the curriculum. The topics are Ratio and rates, Percentages I, Modular Arithmetic, Indices and Logarithm, Simultaneous linear equations, Variation, Statistics II and Probability which had 2.9%, 3.7%, 3.7%, 2.9%, 2.6%, 6.3%, 4.0% and 1.8% respectively in the Mathematics test for the second semester.

Table 4.11: Frequency and percentage spread of topics in the third year content of the curriculum as represented in the second semester test for the four schools

S/No	Topic	School A	School B	School C	School D	Total
1	Trigonometry I	8	15	0	0	23(8.5%)
2	Rigid motion II	5	0	0	0	5(1.8%)
3	Quadratic functions and equations	0	3	1	1	5(1.8%)
4	Mensurations	1	1	1	2	5(1.8%)
5	Plane Geometry II	0	3	0	0	3(1.1%)
6	Construction	0	0	8	2	10(3.7%)

Source: Field data, 2020

Table 4.12 displays the SHS 3 topics presented in the test for the second semester. 6 out of 10 topics representing 18.8% of the content of the curriculum. Trigonometry I covered 8.5% of the test, Rigid motion II had 1.8% of items, Quadratic functions and equations also presented 1.8% items. Mensuration covered 1.8% of the items, Plane Geometry II had 11% and Construction covered 3.7% of the test. This also indicates that the semester's test comprises of content from SHS 1, SHS 2 and SHS 3.

Table 4.12: A descriptive statistics of the experts' ratings for test items from the four schools

Experts	Mean	Standard deviation
1	3.35	0.477
2	3.55	0.498
3	3.47	0.500
Grand mean	3.46	

Source: Field data, 2020

The ratings of the three experts on research question two sought to find out the extent to which the content of teacher-made tests of SHS Core Mathematics items addressed the subject matter being examined. The rating was analyzed in terms of their means and standard deviations. Table 4.13 shows the mean score from the three tests experts and their corresponding rating levels. From the table, the mean scores of the three experts were 3.35, 3.55 and 3.47 with standard deviation of 0.477, 0.498 and 0.500 respectively. The mean scores from the three test experts show that the content of the teacher-made Core Mathematics constructed for the four schools for two semesters truly addressed the subject matter being examined as the ratings were all high (3.35 to 3.55). Their grand mean score was 3.46 which also show a very high rating from the three experts.

The results show that the content of the teacher-made Core Mathematics constructed for the four schools for two semesters actually addressed the subject matter being examined as the ratings were all high.

4.3: A presentation on the skills and practices teachers exhibit in test construction

Research question 3: What skills and practices of testing do teachers exhibit in constructing tests for students in senior high schools?

Table 4.13: Teachers' response on skills and practices teachers exhibit in test construction

Variable	Item	Agree N (%)	Neutral N (%)	Disagree N (%)
Students' cognitive ability	It is important to consider the cognitive abilities of students when constructing a Mathematics test.	38 (95.0)	1 (2.5)	1 (2.5)
	I construct my questions based on the various cognitive abilities of students.	34 (85.0)	2 (5.0)	4 (10.0)
	I consider the difficulty levels of questions in relation to the various cognitive levels.	36 (90.0)	3 (7.5)	1 (2.5)
	I normally consider the thinking skills a question measures before examining students.	35 (87.5)	2 (5.0)	3 (7.5)
Test planning and techniques	I have ever undergone training in test construction.	37 (92.5)	1 (2.5)	2 (5.0)
	I have sufficient knowledge about the basic principles of test construction.	36 (90.0)	2 (5.0)	2 (5.0)
	I plan the format of a test/examination before constructing the questions	37 (92.5)	0 (0.0)	3 (7.5)
	Time allocated to test items is based on the specific content and the number of questions given	38 (95.0)	0 (0.0)	2 (5.0)
	I consider the total number of students in my class before deciding the number of questions in a Mathematics examinations	16 (40.0)	4 (10.0)	20 (50.0)

	I use a table of specification/scheme of work in constructing questions for examinations	37 (92.5)	2 (5.0)	1 (2.5)
	I prepare the solutions/marking scheme to the questions constructed before examining students	29 (72.5)	4 (10.0)	7 (17.5)
Test Content	I choose and select my Mathematics questions for end of semester examinations directly from WASSCE	14 (35.0)	4 (10.0)	22 (55.0)
	I test students on areas they are supposed to know whether they have been taught or not	13 (32.5)	2 (5.0)	25 (62.5)
	I believe constructing a good Mathematics test requires the consideration of learning objectives of the topics involved	39 (97.5)	1 (2.5)	0 (0.0)

Source: Field data, 2020

Research question 3 of the study sought to establish the test construction skills and practices teachers' exhibit. From Table 4.15, the examiners responded to four items on students' cognitive ability, five items each on the teachers' test planning and techniques and test contents respectively.

On the students' cognitive ability, out of the 40 teachers who responded to the four items, almost all of them unanimously agreed that it is important to consider the cognitive abilities of students. 38 teachers representing 95% agreed that they construct Mathematics tests based on the various cognitive abilities of students. 36(90%) indicated they consider the difficulty levels of questions in relation to the various cognitive levels of their students. 35 (87.5%) agreed that they normally consider the thinking skills a question measures before examining students as against a total of 8(20%) and 9(22.5%) who were neutral and disagreed to the four items respectively.

Also, the examiners' response to the first four items about test planning and techniques in test planning is indifferent from their previous answers to the students' cognitive ability. They agreed that they have ever undergone training in test construction, they have sufficient knowledge about the basic principles of test construction, they plan the format of a test/examination before constructing the test items and the time they allocate to test items is based on the specific content and the number of items given. Only few were in disagreement and also neutral to such statements. Contrarily, 20 examiners representing 50% disagreed to the last statement on their test planning techniques. They consider the total number of students in their class before deciding the number of questions in a Mathematics examination. 16 representing 40% agreed and 4(10%) were not sure to the statement.

The last sub-scale was the content of the Core Mathematics test. 37 out of the 40 examiners representing 92.5% agreed to the statement that they use a table of specification/scheme of work in constructing questions for examinations, 2(5%) were not sure whilst 1(2.5%) disagreed to the statement. On the issue of whether the Mathematics teachers test their students on areas they are supposed to know when they have been taught or not, only 13 out of the 40 agreed. 25(62.5) disagreed and 2 were not sure. Furthermore, all the examiners 39 out of 40 (97.5%) believe constructing a good Mathematics test requires the consideration of learning objectives of the topics involved. 14 and 22 respectively agreed and disagreed that they select Mathematics questions for end of semester examinations directly from WASSCE past questions as against 4 who select from other sources.

Lastly, 29 of the examiners were in agreement that they prepare solutions/marking scheme to the questions they construct before examining their students. 7 (17.5) totally disagreed whilst only 4 were neutral to the statement. The findings show that a

Mathematics examiner considers their students' cognitive abilities, test construction skills/techniques and contents of the test before they administer questions to their students.

4.4 Discussion of Results

The major purpose of the study was to investigate the content validity of teacher-made Core Mathematics test items. This was carried out by using the Bloom's taxonomy to investigate the profile dimensions teacher-made Core Mathematics test items address. Also, the study sought to determine the extent to which the topics and content of the senior high school Core Mathematics curriculum are well represented in the teacher-made tests and how the test adequately addressed the subject matter being examined. The essence of this was to ascertain from the ratings whether the items that appeared on the test are relevant with respect to the content domain under which they fall. Finally, the study identified the skills and practices teachers exhibit in constructing a test.

Research question 1: What profile dimension of the Ghana Mathematics curriculum do teacher-made Core Mathematics tests adequately address?

21.6% of the total items from the four schools labeled A, B, C and D tested for students' knowledge and understanding whilst 78.4% tested application of knowledge as stated in the six hierarchical level the Bloom's cognitive domain. This indicates that the test items tested higher level cognition of the students' knowledge. Mahmud et al. (2019) elaborates of this finding by stating that, cognitive domain involves knowledge and development of intellectual skills which includes recall and recognition of specific facts and also development of intellectual abilities and skills. There are six major categories of cognitive skills ranging from lower-order skills that require less cognitive processing to higher-order skills that require deeper learning.

The categories are thought of as degrees of difficulties; the first category must be mastered before the next category can occur. However, there is much evidence in the Curriculum and Research Development Division, Mathematics Curriculum (2010) that states two profile dimensions; knowledge and understanding and application of knowledge. The knowledge and understanding profile dimension has a weighted percentage allocation of 30% for teaching, learning and testing. This indicates that for a Mathematics test it is expected that test items that measure lower cognitive and require less cognitive processing should be minimal in a test. The second profile dimension which is application of knowledge recorded 78.4% from the test items. This indicates that 78.4% of the Core Mathematics tests required higher cognition from students. This is in line with Curriculum and Research Development Division, Mathematics Curriculum (2010) that outlines the weight percentage of items that is required in a test is 70%. Meanwhile application of knowledge has a number of cognitive skills embedded in it though these levels have their specific definitions. These levels are; application, analysis, synthesis and evaluation. The results showed that test items from the multiple choice test from schools A, B, C and D recorded 29.6, 20.3, 10.7 and 29.0 respectively for the first profile dimension, knowledge and understanding whilst the second profile dimension recorded 70.4, 79.7, 89.3 and 71.0 for schools A, B, C and D respectively for the four schools. Again it is clear that the multiple choice questions which according to Adusei (2017) is classified as a selection type of test that gives test takers options to select correct answer from multiple options provided and requires students to do higher level of thinking as items that tested application of knowledge fall in the majority. It is evident that the multiple choice items were constructed according to what has stipulated by the Ghana Mathematics Curriculum. Bleiler and Thompson (2012) stated that the Bloom's taxonomy suggests how to construct these test items using objectives at specific levels from the lower to higher levels of the hierarchy which depicts the difficulty levels of the test. Again, Boudette and Steele (2007) assert that process dimension of Mathematics has not called for enough attention as the underlining issue is whether the test items actually require the kind of intellectual processes required to demonstrate mathematical power, reasoning, problem solving communicating and making connections. However, the findings made from the profile dimensions multiple-choice test items address is in agreement with Zimmoro (2016) that posit that multiple-choice items are widely used to measure knowledge, comprehension and application outcomes. The learning outcomes of multiple-choice test from simple to complex levels can easily be measured. However, the finding contradicts the assertion made by Clay (2001) that multiple-choice items focuses on testing factual information and fails to test higher levels of cognitive thinking. Multiple-choice test items focus on testing factual information and fail to test higher levels of cognitive thinking. But Adusei (2017) had stated a disagreeing view from that of Clay (2001). Adusei (2017) states that multiple-choice items do not only measure factual recall, but can also measure the students' ability to reason and to exercise judgements.

From the results, schools A, B, C and D recorded 27.6% , 29.2%,19.6% and 3.5% respectively for knowledge and understanding (comprehension) and application of knowledge recorded 72.4%, 70.8%, 80.4% and 96.5% for schools A, B, C and D respectively. This shows that essay type test items also have majority of its items requiring students to do higher level of thinking. Tamakloe et al. (2005) support the above finding and asserts that an essay type test item gives the test taker the chance to compose their own responses hence measuring complex learning outcomes. The findings from research question one shows the adherence of teacher-made tests to the

Ghana Mathematics curriculum on the percentage weights allocated to the profile dimensions.

Research question 2: Determining the extent to which topics and content of the senior high school Mathematics curriculum are well represented in the teacher-made tests and how the test adequately address the objectives being examined.

The research question two sought to determine the content of the teacher-made Core Mathematics tests in terms of how well the topics in the Mathematics curriculum are represented in the test and also find out whether the specific test items address the specific objectives being examined. The first semester test was constructed based on 17 topics representing 53.1% from the Mathematics curriculum. 8 topics representing 25% from the year 1 content of the Mathematics curriculum. 7 topics representing 21.9% of the year 2 Mathematics content from the curriculum. 2 topics representing 6.2% were from the year 3 content. Meanwhile, 2 topics making 10.5% of the topics in the Elective Mathematics were covered in the test. The second semester tests had 23 topics representing 71.9% of the topics in the curriculum. 28.1% of the topics were picked from the SHS 1 content, 25% topics came from the SHS 2 content and 18.8% of the test covered the SHS 3 content. The two semester teacher-made tests showed that a considerable number of topics were covered. For the first semester test, 52.6% of topics were from SHS1 content, 36.8% of SHS 2 topics and 22.2% from SHS 3 content. The second semester test covered 28.1% of SHS 1 content and 25% of SHS 2 content with 18.8% of SHS 3 topics. The test consisted of topics from SHS 1, SHS 2 and SHS 3 content although the test was meant for SHS 2. This finding was emphasized by Straub et al. (2004) who asserted that content validity of a test ensures a test covers broad areas of the syllabus. Items are sampled topics from various sections which have covered from the syllabus. Also Airasian (2005) supported the assertion by stating that the items on the test must be a fair representation of the content of the curriculum and what is taught in class. Raymond (2001) indicated that for achievement test conducted in elementary, middle and secondary schools, the content and cognitive elements of the test specification are carved from the curriculum framework that guides instruction. Amajuoyi et al. (2013) stipulates that scores from a test can only be meaningful and relevant if it actually represents the level of understanding and attainment of the testee in the task presented by the test items. These items of the test are supposed to reflect the entire topics and behavioural objectives which are expected to be covered in a subject by students. In other words, the items of an achievement test should cover the scope of the topics in the examination syllabus and core curriculum and the behavioural objectives it purports to achieve. However, Newell (2002) asserts that teacher-made tests usually cover a limited part of a subject content and do not cover a broad range of abilities and these tests rely mostly on memorized facts and procedures.

From the expert's ratings, the mean score for the first expert was 3.35 with a standard deviation of 0.477. The mean score for the second expert was 3.55 and a standard deviation of 0.498 and the third expert had a mean of 3.47 and standard deviation of 0.50. This shows a high rating of the test items by the experts indicating that the test items actually tested the objectives and the subject matter being addressed thereby making the content of the test valid. This finding is seen in the American Educational Research Association (2014) that states that validity evidence based on the content of a test is basically a tool for putting up a validity argument to support the use of a test for a particular purpose and determining how well the content of an assessment is congruent to and appropriate for the specific test purposes. Validity evidence based on test content was described as content validity which was also used in psychometric literature. Airasian (2005) buttresses this this by stating that content validity can be ensured when test items match with course objectives, instruction and reflect adequate sampling of instructional materials.

Research question 3: What practices and skills of testing do teachers exhibit in constructing tests for students in senior high schools?

From the results, students' cognitive abilities, test planning and techniques and test content came out as the practices and skills of teachers in Core Mathematics test construction. Under students' cognitive ability, 95% of teachers agreed that it is important to consider the cognitive abilities of students when constructing a Mathematics test. Majority of the teachers that is, 85% asserted that they construct test based on the various cognitive abilities of students. 90% of teachers consider the difficulty levels of test items in relation to the various cognitive levels and 87% of teachers normally consider the thinking skills an item requires before examining students. This is enough evidence that teachers take into consideration the cognition of students in test construction. This similar to a finding from Bransford et al. (2000) who posits that cognitive validation should be based on knowledge of the nature of students' cognition and understanding in specific areas of the curriculum and assessment. Hence, teachers should have enough knowledge of the state of students' understanding of Mathematics concept before examining them.

In test planning and techniques, 92% of the teachers had undergone training in test construction whilst 90% of teachers have sufficient knowledge about the basic principles of test construction. This is in agreement to the findings of Kinyua and Odiemo (2014) on factors that promote the validity and reliability of teacher-made test in Kenya. It was discovered that experiences of teachers, training on test construction and analysis and the use of Bloom's taxonomy. Again, Onyechere (2000) posited that experienced teachers who had gained training in test construction applied a number of principles in their test construction practices. Moreover, experienced teachers are likely to design tests with higher validity and reliability than teachers who have not had such training in test construction. However, Anhwere (2009) and Ebinye (2001) mentioned an opposing view stating that even though teachers have had training in school assessment which includes test construction, teachers do not adhere to the principles and rules governing test construction which results in test items poorly constructed. Indicating that teachers construct good test items when given the requisite training however, there are still lapses even though teachers have been trained. 92.5 % of teachers plan the format of a test before constructing the test items and 95% of the teachers agreed that the time allocated to a test is based on the specific content and the number of items given. 50% consider the total number of students in their class before deciding the number of questions in a Mathematics test and 92.5% use a table of specification/scheme of work in constructing questions for test. Etsey (2004) prescribed the use of a table of specification which matches the course content with instructional objectives. The table of specification helps to prevent overlapping in the construction of the test which helps to determine the weighting of learning outcomes regarding the content areas and considers the inclusion of all aspects of the course or subject thereby helping to ensure content validity of the test. This finding is emphasized in Messick (1989) that Mathematics assessment is judged on how well the assessment reflect the learning principle with regards to the goals the testing principles seek to promote. A Mathematics assessment whether it comprises a system of only examinations or single task, the assessment must be evaluated against three educational principles: content, learning and equity.

However, in Etsey (2004), the foremost task of a teacher is to prepare students in advance for test and it is important that students are made aware of when the test will be given, the conditions under which the test will be given, the content areas, the kinds of items, whether objective-type or essay-type, how the test will be scored and graded and the importance of the test results.

From the result on the test content, majority of the teachers that is 72.5% prepare the solutions/marking scheme to the questions constructed before examining students. This connects with States et al. (2018) that the assessment practices of teachers involve teachers answering questions by incorporating assessment design into the instructional design process. 35% of the teachers choose and select their Mathematics items for end of semester examinations directly from WASSCE past questions whilst 55% of teachers do not practice that. Amedahe (1989) mentioned that the effect of inadequate training on test practices ranges from teachers lifting test items from textbooks. As a result, test items test only recall of facts, improper wording of test items resulting in ambiguity, unreasonable difficulty levels of items, unclear directions, unreasonable time limit allotment, subjective and inconsistent scoring, test results that are interpreted wrongly.

62.5% of teachers disagreed that they test students on content areas they are supposed to know whether they have been taught or not and 32.5 % claimed they test students on areas they are supposed to know whether they have been taught or not. 97.5% of believe constructing a good Mathematics test requires the consideration of learning objectives. From Amajouyi (2013), items of a test are supposed to reflect the entire topics and behavioural objectives which are expected to be covered in a subject by students. In other words, the items of an achievement test should cover the scope of the topics in the examination syllabus and core curriculum and the behavioural objectives it purports to achieve. This is made possible by the use of table of specifications or test blue print. Newell (2002) asserts that teacher-made tests usually cover a limited part of subject content and do not cover a broad range of abilities and these tests rely mostly on memorized facts and procedures

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Overview

This chapter provides the summary and the major findings of the study. It highlights the conclusion of the study and the implication for practice. It further outlines some recommendations and areas for further research.

5.1 Summary of Study

The purpose of the study was to investigate the profile dimensions teacher-made Core Mathematics tests address using the Bloom's taxonomy of cognitive skills as a theoretical framework. The study also aimed at finding out whether the topics and the test items in the selected tests address the content objectives being addressed. The researcher also sought to investigate the test construction practices and skills teachers engage in at the senior high school level. The literature for the study was mainly drawn from the validity theories of a test and various parameters of a test.

The study employed a descriptive survey design to study the characteristics of the Core Mathematics test items for senior high schools. The population and sample of the study were drawn from senior high schools in the Eastern region of Ghana specifically, St Peter's Senor High School, St Roses Senior High School, St Martin's Senior High School and Akim Swedru Senior High School by convenience sampling. 40 teachers were sampled by simple random from the four schools for the study. Data was drawn from two semester's teacher-made Core Mathematics test from the four schools sampled. A 19-item questionnaire was used to draw data from teachers. Results from the data drawn from the test items and the 19-item questionnaires were used to answer the research questions.

5.3 Summary of Major Findings

The major findings of the study are summarized and presented in line with the research questions.

1. The teacher-made Core Mathematics test items addressed the second profile dimension that is, application of knowledge of the Ghana Mathematics curriculum. Up to 78.4% of the test items tested students' ability to apply knowledge.
2. The Core Mathematics teacher-made test items tested less of the lower cognition that is, the first profile dimension; knowledge and understanding. As low as 21.6% items tested how students recall facts and understand facts.
3. Teacher-made Core Mathematics essay type tests tested the second profile dimension that is, application of knowledge. Majority of the items required students to do higher level of thinking.
4. Multiple choice test items from the teacher-made Core Mathematics test require application of knowledge which represents the higher order of thinking.
5. The Core Mathematics teacher-made tests had items on topics outside the scope of the Core Mathematics curriculum. Some test items covered topics in the Elective Mathematics curriculum. For instance, 6 items representing 2.2% of the content of the test were constructed on Matrices whilst 3 items representing 1.3% of the test covered Polynomial functions.

6. The teacher-made Core Mathematics test items tested the objectives and the subject matter the items addressed hence, the content of the teacher-made Core Mathematics tests was valid.
7. Teacher's test construction practices and skills found from the study were; teachers take into consideration the cognitive abilities of students, they practice good test planning and techniques and also they consider the content of the test.
8. Majority of the teachers had undergone training in test construction and have sufficient knowledge about the basic principles of test construction.
9. The number of student in a class influences the content of the teacher-made tests.
10. Some teachers select Core Mathematics items direct from the already existing WASSCE past questions. 35% of teachers confirmed such practice.
11. Teachers confirmed that they test students only on content areas they have covered and do not examine them on content they have not covered.
12. The teachers attested that they use table of specification in constructing tests. 92.5% of the teachers confirmed this.

5.4 Implication of the Study

The study has shown that senior high school teachers of Mathematics construct tests that conform to the profile dimension stated in the Ghana Mathematics Curriculum. That is, 30% for knowledge and understanding and 70% for application of knowledge. However the percentages of test items that should test knowledge fell below what is stipulated in the Mathematics curriculum and also the percentage of test items that should test application of knowledge fell above what is stipulated. This implies that students might have few items that require lower level of cognition and more test items that require higher cognition. Therefore, individual students who are unable to do higher order thinking may be limited to the number of test items they can attempt. But it is likely for the students who have the ability to do higher order of thinking to be able to attempt test items that require both lower level cognition and higher level cognition. Hence there is the need for a range of the percentage weight to be provided to limit teachers to the percentage of items that can fall below what is stipulated.

The study also indicated that the content of teacher-made Core Mathematics tests is valid. The teacher-made tests items address the content and objectives it is meant to address, meaning that teachers in the senior high schools construct test items according to what the content and the objectives in the Core Mathematics Curriculum and not tests items that fall outside what the content require.

The study also evident that although some researchers have stated that Core Mathematics multiple-choice test items require simple level of cognition than essay-type test items, the test constructed by the teachers showed that Core Mathematics tests, whether multiple choice items or essay type items require both lower level of cognition and higher level of thinking from students. The study also revealed that teachers consider students' cognitive abilities, the test planning techniques and the content of the test before putting together items for a Mathematics test. This implies that teachers take into account students' ability to do a test and how the test should be planned and what constitutes the content of the test before examining students.

Although teachers claimed they use test specification and scheme of work to construct a test, the SHS 2 tests consisted of items from SHS 1, SHS 2 and SHS 3 and also items from the Elective Mathematics curriculum. It is however clear that teachers may want to construct questions to meet the style and standard of the West Africa Senior Secondary Certificate Education. From the study, the teachers have undergone training in test construction and so it is expected that they adhere to the principles and practices of test construction.

5.5 Conclusion

Based on the findings made from the study, it can be concluded that the Core Mathematics teacher-made items test the two profile dimensions according to the Ghana Mathematics Curriculum, thus, knowledge and understanding and application of knowledge in their various proportions. Also it is concluded that teacher-made Mathematics test items examine higher level of cognition than it tests lower levels of cognition. This is not surprising as teachers have received training in test construction and so teachers consider carefully the students' cognitive abilities, the test planning and techniques and the content of the Mathematics test before constructing a test. It is clear that the content of the Core Mathematics teacher-made test is valid and test what the content ought to address.

5.6 Recommendations

From the findings of this study, it is recommend that,

- Stakeholders of education at the senior high school level should institute a regulatory body that regulate the content of test in the schools so as to check the constitute of Mathematics tests for a balance in items that require both profile dimensions.
- Teachers should be encouraged to construct Mathematics items from topics and content within the domain of the class they teach and the content domain covered.

- To ensure the content validity of Mathematics tests, teachers should be encouraged to construct test items that address the objectives of the subject matter being addressed.
- Teachers should be made to adhere strictly to the various test construction principles.
- Teachers should be encouraged not to depend solely on the already existing test items from the West Africa Senior Secondary Certificate Examination but also construct entirely new test item that adequately test the appropriate subject matter.
- The Ghana Education Service must hold periodic training workshops for teachers in test constructions to equip them with basic test construction skills and practices.

5.6 Areas for Further Research

The educational implication of the findings of this study calls for further research involving teacher-made Core Mathematics test in Ghana. The following are suggested for further research**:**

- Similar studies should be conducted at the basic school level.
- Similar studies should be conducted among teachers with training in test construction and teachers with little training in test construction.
- A study should be conducted into the cognitive levels students demonstrate in their responses to teacher-made Core Mathematics tests.
- Similar studies should be conducted among specific Core Mathematics topics.
- Similar studies should be conducted at the various levels of the senior high school, that is, year one (SHS 1) and year 3 (SHS 3).

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APPENDICES

APPENDIX A

VALIDATION FORM FOR TEACHER-MADE CORE MATHEMATICS ITEMS

CONTENT VALIDITY STUDY

Dear Experts,

Attached to this are teacher made Core Mathematics test items for four schools. In all, there are 509 test items.

Your expert judgement on the categorization of the test items under the various dimensions is needed.

Your expert judgement on the degree of relevance of each of the test items is required.

The review should be based on the relevant definition of terminologies provided

Please be as objective and constructive as possible.

Degree of relevance of test items

1-Item is not relevant to the domain

2-Item is somehow relevant to the measured domain

3-Item is quite relevant to the measured domain

4-Item is highly relevant to the domain

Profile dimensions

Knowledge and understanding: This dimension is made of two learning behavior levels that is, knowledge and understanding.

Some specific verbs to guide the categorization: count, read, identify, define, describe, list, name, locate, match state explain, distinguish, factorize, calculate, expand, measure, predict, generalize and estimate.

Application of knowledge: It deals with the ability to use knowledge or apply knowledge. It has a number of learning or behavior levels. These levels include application, analysis, synthesis, and evaluation. These four levels of behavior have their individual definitions but have been put together into one profile dimension.

This dimension involves executing, implementing, differentiating, organizing, attributing, checking, critiquing, generate planning. It also involves the ability to produce, solve, plan, demonstrate, discover.

APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF MATHEMATICS EDUCATION

QUESTIONNAIRE FOR TEACHERS

This questionnaire is to investigate the content validity of teacher-made Core Mathematics) tests in Senior High Schools. I would be very grateful if you could provide responses to the following questions. All responses provided shall be used solely for academic purposes and shall be treated with utmost confidentiality.

Please tick [√] on a scale of 1-5.

Strongly Agree-5 Agree-4 Neutral-3 Disagree-2 Strongly Disagree-1

Section A: Background Information

Gender: Male [ ] Female [ ]

Number of years of experience in teaching Mathematics: 1-5years [ ] 6-10years [ ] 11-15years [ ] 16years+ [ ]

How many classes do you teach Mathematics? : 1-3 [ ] 4-6 [ ] 7-9 [ ] 10+ [ ]

STATEMENT	Strongly	Agree	Neutral	Disagree	Strongly Disagree
I have sufficient knowledge about the Bloom's taxonomy of learning objectives.					
I have sufficient knowledge about the order of cognitive skills of the Bloom's taxonomy of learning objectives.					
It is important to consider the cognitive abilities of students when constructing a Mathematics test.					
I have sufficient knowledge about the percentage allocation to the cognitive skills in a Mathematics test as stated by the Mathematics curriculum (syllabus).					
I construct my questions based on the various cognitive abilities of students.					
I normally consider the thinking skills a question measures					

before examining students.					
I consider the difficulty levels of questions in relation to the various cognitive levels.					
I plan the format of a test/examination before constructing the questions.					
I choose and select my Mathematics questions for end of semester examinations directly from WASSCE past questions.					
I believe constructing a good Mathematics test requires the consideration of learning objectives of the topics involved.					
I use a table of specification/scheme of work in constructing questions for examinations.					
I have ever undergone training in test construction.					
I have sufficient knowledge about the basic principles of test construction.					
I test students on areas they are supposed to know whether they have been taught or not.					
I keep stock of questions I construct in the course of teaching.					
It is always possible to construct entirely new Mathematics questions.					
Time allocated to test items is based on the specific content and the number of questions given.					
I consider the total number of students in my class before deciding the number of questions in Mathematics examinations.					
I prepare the solutions/marking scheme to the questions constructed before examining students.					

APPENDIX C

SCHOOL A (First Semester) Expert Agreement Rating

Item No	Content	Objectives The student will be able to	Profile Dimension	Relevance rating			
				1	2	3	4
Q1	Solving equations involving indices	Solve equations involving indices	Knowledge and understanding			✓	
Q2	Polygons	Calculate the sum of interior and exterior angles of polygons	Application of knowledge				✓
Q3	Difference of two squares	Apply difference of two squares to solve problems	Application of knowledge			✓	
Q4	Standard form	Express numbers in standard form	Application of knowledge				✓
Q5	Polygons	Calculate the sum of interior and exterior angles of polygons	Knowledge and understanding			✓	
Q6	Binomial expressions	Multiply two binomial expressions	Application of knowledge				✓
Q7	Gradient of a straight line	Find the gradient of a straight line given the coordinates of two points on the line	Application of knowledge				✓
Q8	Laws of indices	Write in exponent form the repeated factors	Application of knowledge				✓
Q9	Rules of logarithm and their application	Apply the rules of logarithms	Application of knowledge				✓
Q10	Solving equations involving indices	Solve equations involving indices	Application of knowledge				✓
Q11	Factorization	Factorize algebraic expressions	Application of knowledge			✓	
Q12	Calculation of a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge				✓
Q13	Find the antilogarithm of a given number	Find the anti-logarithms of a given number	Knowledge and understanding			✓	
Q14	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application of knowledge				✓
Q15	Laws of indices	Write in exponent form the repeated factors	Knowledge and understanding			✓	
Q16	Parallel lines	State and use the properties of parallel lines	Knowledge and understanding			✓	
Q17	Mapping	Determine the rule for a given mapping	Knowledge and understanding				✓
Q18	Rational and irrational	Perform operations on rational numbers	Knowledge and understanding			✓	
Q19	Properties of set operations	Identify the properties of the operation	Knowledge and understanding				✓
Q20	Properties of set	Identify the properties of the	Knowledge and				✓

	operations	operation	understanding				
Essay-type items							
Q1a	Addition and multiplication tables for a given modulo	Add and multiply numbers in a given modulo	Application of knowledge			✓	
Q1b(i)	Addition and multiplication tables for a given modulo	Add and multiply numbers in a given modulo	Application of knowledge				✓
Q1b(ii)	Addition and multiplication tables for a given modulo	Add and multiply numbers in a given modulo	Application of knowledge				✓
Q2a(i)	Quadrilaterals/Angles/Triangles	State properties of quadrilaterals Calculate the angles at a point Identify various properties of special triangles	Application of knowledge			✓	
Q2a(ii)	Quadrilaterals/Angles/Triangles	State properties of quadrilaterals Calculate the angles at a point Identify various properties of special triangles	Application of knowledge			✓	
Q2b	Operations on numbers involving number bases other than base ten	Perform operations on number bases other than base ten	Application of knowledge			✓	
Q3a	Polygons	Calculate the sum of interior angles and exterior angles of a polygon	Application of knowledge			✓	
Q3b	Standard form	Express very large and very small numbers in standard form	Application of knowledge			✓	
Q4ai	Binary operation/Addition and multiplication tables in a given modulo	Interpret given binary operation and apply them to real numbers Add and multiply numbers in a given modulo	Application of knowledge			✓	
Q4aii(α) and (β)	Binary operation/Addition and multiplication tables in a given modulo	Interpret given binary operation and apply them to real numbers Add and multiply numbers in a given modulo	Application of knowledge			✓	
Q4b	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application of knowledge				✓
Q5a	Special triangles isosceles and equilateral triangles	Use the various properties of triangles to find the length of a side of isosceles triangle	Application of knowledge			✓	
Q5b	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge				✓

Q6a	Find the antilogarithm of a given number	Find the antilogarithm of a given number	Application of knowledge				✓
Q6b	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
Q6c	Sine, cosine and tangent of acute angles	Use the concept of sine, cosine and tangent of acute angles to simplify the given trigonometric expression.	Application of knowledge			✓	

SCHOOL A (Second Semester) Experts Agreement Rating

Item No	Content/Topic	Specific Objectives By the end of the lesson a student will be able to	Profile dimension	Relevance rating(validity)			
				1	2	3	4
Q1	Reverse bearing	Find the bearing of a point A from another point B given the bearing of B from A	Knowledge and understanding			✓	
Q2	Triangle law of vectors	Add two vectors using the triangle law of vector addition	Application			✓	
Q3	Column vectors	Express the component of a vector in column form	Application			✓	
Q4	Addition, subtraction and multiplication of surds	Carry out operation involving surds	Application				✓
Q5	Rules of logarithms and their application	Apply the rules of logarithms	Application				✓
Q6	Calculation of a number for a given modulo	Calculate the value of numbers for a given	Application				✓
Q7	Rates	Explain and use common rates such as km/h, m/s	Knowledge and understanding			✓	
Q8	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application			✓	
Q9	Vectors	Add and subtract vectors	Application			✓	
Q10	Change of subject of a relation	Change the subject of a relation	Application				✓
Q11	Sine, cosine and tangent of acute angles	Compute the Sine, cosine and tangent of an acute angle	Application			✓	
Q12	Sine, cosine and tangent of acute angles	Compute the Sine, cosine and tangent of an acute angle	Application			✓	
Q13	Vectors	Add and subtract vectors	Application			✓	
Q14	Reflection in a line	Identify and explain the reflection of an object in a mirror line	Knowledge and				✓

			understanding				
Q15	Magnitude and direction of a vector	Find the magnitude and direction of a vector	Application			✓	
Q16	Rules of logarithms and their application	Deduce the rules of logarithms and apply them	Application				✓
Q17	Rotation	Find the image of an object under rotation	Application			✓	
Q18	Solving equations involving indices	Solve equations involving indices	Application			✓	
Q19	Bearing of a point from another	Interpret bearing as direction of one point from another	Knowledge and understanding				✓
Q20	Solving equations involving indices	Solve equations involving indices	Application			✓	
Q21	Rational and irrational numbers	Operations on rational numbers	Application				✓
Q22	Operations on numbers involving number bases other than base ten	Perform operations on number bases other than base ten	Application			✓	
Q23	Addition, subtraction and multiplication of surds	Carry out operations involving surds	Application			✓	
Q24	Rates	Explain and use common rates such as km/h, m/s	Analysis			✓	
Q25	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Analysis			✓	
Q26	Gradient of a straight line	Find the gradient of a straight line given the coordinates of two points on the line	Application				✓
Q27	Bearing of a point from another	Interpret bearing as direction of one point from another	Analysis				✓
Q28	Application of trigonometry ratios	Apply the use of trigonometric ratios to calculate distances and heights	Application				✓
Q29	Probability of an event	Calculate the probability of an event	Analysis			✓	
Q30	Discount, commission simple interest	Do money making calculation that apply percentages	Application			✓	
Q31	Polygons	Calculate the sum of interior angles and exterior angles of a polygon	Knowledge and understanding			✓	
Q32	Operations on numbers involving number bases other than base ten	Perform operations on number bases other than base ten	Knowledge and understanding			✓	

Q33	Difference of two squares	Apply difference of two squares to solve problems	Application				✓
Q34	Perimeter of plane figures/Area of quadrilaterals	Calculate the area and perimeter of plane figures	Application			✓	
Q35	Change of subject of a relation	Change the subject of a relation	Application				✓
Q36	Rules of logarithms and their application	Deduce the rules of logarithms and apply them	Application			✓	
Q37	Parallel lines (Properties)	State and use the properties of parallel lines	Knowledge and understanding				✓
Q38	Special triangles/Right-angled triangle	Identify various properties of special triangles	Application			✓	
Q39	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application			✓	
Q40	Binomial expressions	Multiply two binomial expressions	Application			✓	
Essay-type items							
Q1(i)	Distance bearing form	Write bearing of one point from another	Knowledge and understanding				✓
Q1(ii)	Distance bearing form	Write bearing of one point from another	Application				✓
Q1(iii)	Distance bearing form	Write bearing of one point from another	Application				✓
Q2a	Graphs of linear function	Draw and calibrate the axes using the given scales	Knowledge and understanding			✓	
Q2bi	Rigid motion	Draw an object according to a given condition	Knowledge and understanding			✓	
Q2bii	Reflection in a line	Identify and explain the reflection of an object in a mirror line.	Knowledge and understanding			✓	
Q2biii	Translation by a vector	Identify and translate an object or point by a translating vector and describe the image	Knowledge and understanding			✓	
Q2biv	Rotation	Find the image of an object under rotation	Knowledge and understanding			✓	
Q2c	Column vectors	Express the components of a vectors in column form	Application			✓	
3a	The use of calculators to read sine, cosine and tangent of angles between 0^0 and 360^0	Use the calculator to read the values of sine, cosine and tangent of angles up to 360^0	Application			✓	
3b	Graph of trigonometric	Draw the graph of a given trigonometric function	Knowledge and				✓

	functions		understanding				
3ci	Trigonometric equations	Draw graph a trig function and use it to solve trigonometric equations	Application				✓
3cii	Trigonometric equations	Draw graph a trig function and use it to solve trigonometric equations	Application				✓
3d	Trigonometric equations	Draw graph a trig function and use it to solve trigonometric equations	Application				✓
4ai	Ratio	Divide a quantity in a given ratio	Application			✓	
4aii	Ratio	Divide a quantity in a given ratio	Application			✓	
4b	Ratio	Divide a quantity in a given ratio	Application			✓	
4c	Magnitude and direction of a vector	Find the magnitude and direction of a vector	Application				✓
5a	Frequency distribution table	Draw frequency distribution table for ungrouped data	Knowledge and understanding			✓	
5bi	Mode of a distribution	Find the mode of a given data	Application			✓	
5bii	Median of a distribution	Find the median of a given data	Application			✓	
5biii	Mean of a distribution	Calculate the mean using appropriate formula	Application			✓	

SCHOOL B (First Semester) Experts Agreement Rating

Item No	**Content**	**Specific Objective** **By the end of the lesson a student will be able to**	**Profile dimension**	**Relevance rating**			
				1	**2**	**3**	**4**
Q1	Finding the number of subsets in a set with n elements	Determine and write the number of subsets in a set	Knowledge and understanding			✓	
Q2	Rational and irrational numbers	Operations on rational numbers	Application of knowledge				✓
Q3	Standard form	Express numbers in standard form	Knowledge and understanding				✓
Q4	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q5	Rules of logarithms and their application	Apply the rules of logarithms	Application of knowledge			✓	
Q6	Solutions sets of	Find solution sets for linear	Application of			✓	

	linear equations in one variable	equations in one variable	knowledge				
Q7	Addition and subtraction of vectors	Add and subtract vectors	Application of knowledge			✓	
Q8	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application of knowledge			✓	
Q9	Relating indices to logarithms in base ten	Relate indices to logarithm	Application of knowledge				✓
Q10	Linear inequalities in one variable	Solve linear inequalities in one variable	Application of knowledge			✓	
Q11	Change of subject of a relation	Change the subject of a relation	Application of knowledge			✓	
Q12	Solving quadratic equations by factorization	Identify and solve quadratic equations by factorization	Application of knowledge			✓	
Q13	Change of subject of a relation	Change the subject of a relation	Application of knowledge			✓	
Q14	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	

Q15	Special triangles isosceles and equilateral triangles	Identify various properties of special triangles	Knowledge and understanding				✓
Q16	Rules of logarithms and their application	apply the rules/laws of logarithms	Application of knowledge			✓	
Q17	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q18	Solving equations involving indices	Solve equations involving indices	Application of knowledge				✓
Q19	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
Q20	Rules of logarithms and their application	apply the rules/laws of logarithms	Application of knowledge			✓	
Q21	Algebraic expressions	Express statements in mathematical symbols	Knowledge and understanding				✓
Q22	Equal and parallel vectors	State the conditions for two vectors to be equal or parallel	Knowledge and understanding				✓
Q23	Determinant of a 2×2 matrix	Find the determinant of a 2×2 matrix	Application of knowledge			✓	
Q24	Solving quadratic equations by factorization	Identify and solve quadratic equations by factorization	Application of knowledge			✓	
Q25	Solving quadratic equations by completing the square	Solve quadratic equations by method of completing the squares and by formula	Application of knowledge			✓	

Q26	Polygons	Calculate the sum of interior and exterior angles of polygons	Application of knowledge				✓
Q27	Roots of quadratic equation	Use the discriminant to describe the nature of roots of quadratic equation	Application of knowledge				✓
Q28	Finding the logarithm of given numbers	Find the logarithm of a given number	Application of knowledge				✓
Q29	Inverse of a 2×2 matrix	Find the inverse of a 2×2 matrix	Application of knowledge				✓
Q30	Special triangles-isosceles and equilateral triangles	Identify various properties of special triangles	Knowledge and understanding			✓	
Q31	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q32	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
Q33	Rules of logarithms and their application	Apply the rules/laws of logarithms	Application of knowledge				✓
Q34	Binomial expressions	Multiply two binomial expressions	Application of knowledge			✓	
Q35	Addition and subtraction of matrices	Add and subtract matrices	Application of knowledge			✓	
Q36	Multiplying a vector by a scalar	Multiply a vector by a scalar	Application of knowledge				✓
Q37	Solving quadratic equations by factorization	Identify and solve quadratic equations by factorization	Application of knowledge				✓
Q38	Solving quadratic equations by factorization	Identify and solve quadratic equations by factorization	Application of knowledge				✓
Q39	Gradient of a straight line	Find the gradient of a straight line given the coordinates of two points on the line	Application of knowledge				✓
Q40	Magnitude of a line segment	Find the distance between two points	Application of knowledge				✓
Essay-type							
Q1a	Rational and irrational numbers	Operations on rational numbers	Application of knowledge			✓	
Q1b	Completing the square	Solve quadratic equations by method of completing the squares	Application of knowledge			✓	
Q1c	Addition and multiplication tables for a given modulo/Binary operations	Add and multiply numbers in a given modulo Interpret given binary operation and apply them to real numbers	Application of knowledge			✓	
Q1c(i)	Addition and multiplication	Add and multiply numbers in a given modulo	Application of knowledge			✓	

	tables for a given modulo/Binary operations	Interpret given binary operation and apply them to real numbers					
Q1c(ii)	Addition and multiplication tables for a given modulo/Binary operations	Add and multiply numbers in a given modulo Interpret given binary operation and apply them to real numbers	Application of knowledge			✓	
Q2a	Rules of logarithms and their application	Application of the rules/laws of logarithms	Application of knowledge				✓
Q2bαi	Addition and subtraction of vectors	Add and subtract vectors	Application of knowledge			✓	
Q2 bαii	Addition and subtraction of vectors	Add and subtract vectors	Application of knowledge			✓	
Q2β	Equal and parallel vectors	State the conditions for two vectors to be equal or parallel	Knowledge and understanding			✓	
Q2c	Equality of Matrices	Use the concept of equal Matrices in related problems	Application of knowledge			✓	
Q3a	Solving equations involving indices	Solve equations involving indices	Application of knowledge				✓
Q3b	Multiplication of matrices	Multiply a matrix by a scalar and a matrix by a matrix	Application of knowledge			✓	
Q3c	Parallel lines	State and use the properties of parallel lines	Knowledge and understanding				✓
Q4a	Graphs of quadratic functions	Draw graphs for given quadratic functions	Knowledge and understanding			✓	
Q4b	Graphs of Quadratic functions	Draw quadratic graphs for a given function	Application of knowledge			✓	
Q4c	Graphs of functions Quadratic functions	Draw quadratic graphs for a given function	Application of knowledge			✓	
Q4d	Rules of logarithms and their application	Apply rules/laws of logarithms	Application of knowledge				✓

SCHOOL B (Second Semester) Experts Agreement Rating

Item No	Content	Specific objective By the end of the lesson a student will be able to	Profile dimension	Relevance rating			
				1	2	3	4
Q1	Operations on algebraic expressions	Add and subtract algebraic expressions	Application of knowledge			✓	
Q2	Rational and	Perform operations on rational	Application of				✓

	irrational	numbers	knowledge				
Q3	Right- angled triangle	Apply the Pythagoras' theorem	Application of knowledge				✓
Q4	Simplifying surds	Simplify surds	Application of knowledge			✓	
Q5	Change of subject of a relation	Change the subject of a relation	Application of knowledge				✓
Q6	Solving quadratic equations by factorization	Identify and solve quadratic equations by factorization	Application of knowledge				✓
Q7	Polygons	Calculate the sum of interior and exterior angles of polygons	Application of knowledge				✓
Q8	Operations on numbers involving number bases other than base ten	Perform operations on number bases other than base ten	Application of knowledge				✓
Q9	Operation on algebraic expressions with binomial denominators	Perform operations on simple algebraic fractions.	Application of knowledge				✓
Q10	Circle Theorem	State and use the circle theorems	Application of knowledge			✓	
Q11	Magnitude and direction of a vector	Find the magnitude and direction of a vector	Application of knowledge			✓	
Q12	Column vectors	Express the components of a vector in column vectors	Application of knowledge			✓	
Q13	Standard deviation and variance	Interpret standard deviation and variance of ungrouped data	Knowledge and understanding				✓
Q14	Sine, cosine and tangent of acute angles	Define and compute the sine, cosine and tangent of an acute angle in degrees	Application of knowledge				✓
Q15	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q16	Sine, cosine and tangent of acute angles	Define and compute the sine, cosine and tangent of an acute angle in degrees	Application of knowledge			✓	
Q17	Indirect variation (inverse variation)	Solve problems involving indirect variation	Application of knowledge			✓	
Q18	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q19	Probability of an event	Calculate the probability of an event	Application of knowledge				✓
Q20	Standard form	Express numbers in standard form	Application of knowledge			✓	
Q21	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application of knowledge			✓	

Q22	Bearing of a point from another	Interpret bearing as direction of one point from another	Application of knowledge				✓
Q23	Probability of an event	Calculate the probability of an event	Application of knowledge				✓
Q24	Mean of a distribution	Calculate the mean using appropriate formula	Application of knowledge				✓
Q25	Measures of dispersion	Calculate the interquartile range of the given distribution	Application of knowledge				✓
Q26	Change of subject of an equation	Change the subject of the given formula	Application of knowledge			✓	
Q27	Sine, cosine and tangent of acute angles	Define and compute the sine, cosine and tangent of an acute angle in degrees	Application of knowledge			✓	
Q28	Bearing of a point from another	Interpret bearing as direction of one point from another	Application of knowledge			✓	
Q29	Simplifying surds	Simplify surds	Application of knowledge			✓	
Q30	Circle Theorem	State and use the circle theorems	Knowledge and understanding				✓
Q31	Solving problems involving joint variation	Solve problems involving joint variation	Application			✓	
Q32	Calculation of a number for a given modulo	Calculate the value of numbers for a given	Application			✓	
Q33	Application of trigonometric ratios	Apply the use of trigonometric ratios to calculate distances and heights	Application of knowledge				✓
Q34	Application of trigonometric ratios	Apply the use of trigonometric ratios to calculate distances and heights	Application of knowledge				✓
Q35	Mean of a distribution	Calculate the mean using appropriate formula	Application of knowledge				✓
Q36	Bearing of a point from another	Interpret bearing as direction of one point from another	Application			✓	
Q37	Solving problems involving joint variation	Solve problems involving joint variation	Application			✓	
Q38	Reverse bearing	Find the bearing of a point A from another point B, given the bearing of B from A.	Application			✓	
Q39	Solving quadratic inequalities	Solve given quadratic inequalities	Application				✓
Q40	Zero or undefined algebraic fractions	Determine the conditions under which algebraic fraction is zero or undefined	Application			✓	
Q41	Measures of Central Tendencies	Identify central tendencies	Knowledge and understanding			✓	
Q42	Perimeter of plane figures	Identify the perimeter of plane figures	Knowledge and understanding				✓

Q43	Application of trigonometric ratios	Apply the use of trigonometric ratios to calculate distances and heights	Application of knowledge				✓
Q44	Trigonometric equations	Apply the concept of complementary angles to solve trigonometric equations.	Application of knowledge				✓
Q45	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
Q46	Right-angled triangle	Identify the Pythagorean Triples	Knowledge and understanding			✓	
Q47	Properties of set operations	Identify the properties of operations on set	Knowledge and understanding			✓	
Q48	Parallel lines	State and use properties of parallel lines	Knowledge and understanding			✓	
Q49	Equation of a straight line	Find the equation of a straight line	Application of knowledge			✓	
Q50	Algebraic expressions	Express statements in mathematical symbols and solve	Application of knowledge				✓
Essay-type items							
Q1a	The trigonometric ratios of 30^o, 45^o, and 60^o	Use the trigonometric ratios of acute angles to solve the given problem.	Application of knowledge			✓	
Q1b	Operations on algebraic expressions	Add and subtract algebraic expressions	Application of knowledge			✓	
2ai	Change of subject of relations	Change the subject of formula	Application of knowledge			✓	
2aii	Change of subject of relations	Change the subject of formula	Application of knowledge			✓	
2b	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
3a	Three-set problems using Venn diagrams	Find the solution to practical problems involving classifications using Venn diagram	Application of knowledge			✓	
3bi	Three-set problems using Venn diagrams	Find the solution to practical problems involving classifications using Venn diagram	Knowledge and understanding				✓
3bii	Three-set problems using Venn diagrams	Find the solution to practical problems involving classifications using Venn diagram	Knowledge and understanding				✓
3biii	Three-set problems using Venn diagrams	Find the solution to practical problems involving classifications using Venn diagram	Knowledge and understanding				✓
4a	Addition and multiplication tables for a given modulo	Add and multiply numbers in a given modulo	Application			✓	

4bi	Addition and multiplication tables for a given modulo	Add and multiply numbers in a given modulo	Knowledge and understanding			✓	
4biiα	Addition and multiplication tables for a given modulo	Add and multiply numbers in a given modulo	Knowledge and understanding			✓	
4iiβ	Addition and multiplication tables for a given modulo/Identity element	Find the identity element and use it to find the inverse of a given element	Application of knowledge				✓
4c	Equation of a straight line	Use the concept of perpendicular lines to solve given problems	Application of knowledge				✓
5a	Cumulative frequency curves (Ogive)	Draw cumulative frequency curves and interpret them	Knowledge and understanding			✓	
5bi	Cumulative frequency curves (Ogive)	Draw cumulative frequency curves and interpret them	Application of knowledge			✓	
5bii	Cumulative frequency curves (Ogive)	Draw cumulative frequency curves and interpret them	Application of knowledge			✓	
5biii	Cumulative frequency curves (Ogive)	Draw cumulative frequency curves and interpret them	Application of knowledge			✓	
6a	Probability of an event	Calculate probability of an event	Application			✓	
6bi	Partial variations	Solve problems involving partial variations	Application of knowledge				✓
6bii	Partial variations	Solve problems involving partial variations	Knowledge and understanding				✓
7a	The use of calculators to read sine, cosine and tangent of angles up to 360^0	Use the calculator to read the values of sine, cosine and tangent of angles up to 360^0	Knowledge and understanding			✓	
7b	Graph of trigonometric functions	Draw the graph of a given trigonometric function	Knowledge and understanding			✓	
7ci	Graph of trigonometric functions	Identify features of trigonometric graph	Knowledge and understanding			✓	
7cii	Trigonometric equations	Identify features of trigonometric graph	Knowledge and understanding			✓	
7dα	Trigonometric equations	Use the graph of trig function to solve trigonometric equations	Application of knowledge			✓	
7dβ	Trigonometric equations	Use the graph of trig function to solve trigonometric equations	Application of knowledge			✓	

8a	Circle Theorem	State and use the circle theorems	Application of knowledge			✓	
8b	Trigonometric ratios	Apply the use of trigonometric ratios to calculate distances and heights	Application of knowledge			✓	
9ai	Distance and bearing of a point from another	Calculate the distance between two points	Application of knowledge				✓
9aii	Distance and bearing of a point from another	Find the bearing of one point from another	Application of knowledge				✓
9b	Factorization	Factorize algebraic expressions	Application of knowledge			✓	
10a	Depreciation	Determine the depreciation of an item over a specified period	Application of knowledge				✓
10b	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
10c	Column vectors	Express the components of a vector in column vectors	Application of knowledge			✓	

SCHOOL C (First Semester) Experts Agreement Rating

Item No	Content	Specific Objectives By the end of the lesson a student will be able to	Profile Dimension	Relevance rating			
				1	2	3	4
Q1	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
Q2	Standard form	Express numbers in standard form	Application of knowledge			✓	
Q3	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge				✓
Q4	Anti-logarithms of given numbers	Find the anti-logarithm of a given number	Application of knowledge			✓	
Q5	Zero or undefined algebraic fractions	Determine the conditions under which algebraic fraction is zero or undefined	Application of knowledge			✓	
Q6	Operations on algebraic expressions	Add and subtract algebraic expressions	Knowledge and understanding			✓	
Q7	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application of knowledge				✓
Q8	Algebraic expression	Express statements in mathematical symbols	Application of knowledge				✓
Q9	Solution sets of linear equations in one variable	Find solution sets for linear equations in one variable	Application of knowledge			✓	
Q10	Factorization	Factorize algebraic expressions	Application of knowledge			✓	
Q11	Difference of two squares	Apply difference of two squares to solve problems	Application of knowledge				✓
Q12	Simplifying surds	Simplify surds	Application of knowledge			✓	

Q13	Ratio	Divide a quantity in a given ratio	Application of knowledge			✓	
Q14	Discount, Commission and Simple interest	Do money-making calculations that apply percentages	Application of knowledge			✓	
Q15	Difference of two squares	Apply difference of two squares to solve problems	Application of knowledge			✓	
Q16	Solution sets of linear inequalities in one variable	Find solution sets for linear inequalities in one variable	Application of knowledge			✓	
Q17	Polygons	Calculate the sums of interior angles and exterior angles of a polygon	Application of knowledge			✓	
Q18	Solving equations involving indices	Solve equations involving indices	Application of knowledge				✓
Q19	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q20	Ratio	Divide a quantity in a given ratio	Application of knowledge			✓	
Q21	Rational and irrational numbers	Operations on rational numbers	Application of knowledge			✓	
Q22	Rational and irrational numbers	Operations on rational numbers	Application of knowledge			✓	
Q23	Change of subject of a relation	Change the subject of a relation	Application of knowledge				✓
Q24	Binomial expressions	Multiply two binomial expressions	Application of knowledge			✓	
Q25	Operations on algebraic expressions	Add and subtract algebraic expressions	Application of knowledge			✓	
Q26	Algebraic expression	Express statements in mathematical symbols	Knowledge and understanding			✓	
Q27	Polygons	Calculate the sum of interior and exterior angles of polygons	Application of knowledge			✓	
Q28	Parallel lines	State and use the properties of parallel lines	Knowledge and understanding				✓
Q29	Parallel lines	State and use the properties of parallel lines	Knowledge and understanding				✓
Q30	Comparisons by percentages	Compare two amounts or quantities by expressing one as a percentage of the others	Application of knowledge			✓	
Q31	Difference of two squares	Factorize algebraic expressions	Application of knowledge			✓	
Q32	Simplifying surds	Simplify surds	Application of knowledge			✓	
Q33	Rates	Explain and use common rates such as km/h, m/s	Application of knowledge			✓	
Q34	Solution sets of linear equations in one variable	Find solution sets for linear equations in one variable	Application of knowledge			✓	

Q35	Operations on numbers involving number bases other than base ten	Perform operations on number bases other than base ten	Application of knowledge			✓	
Q36	Laws of indices	Write in exponent form the repeated factors of a number	Application of knowledge			✓	
Q37	Polygons	Calculate the sum of interior and exterior angles of polygons	Application of knowledge			✓	
Q38	Relating indices to logarithms in base ten	Relate indices to logarithms in base ten	Application of knowledge				✓
Q39	Operations on numbers involving number bases other than base ten	Perform operations on number bases other than base ten	Application of knowledge			✓	
Q40	Laws of indices	Write in exponent form the repeated factors of a number	Application of knowledge			✓	
Q41	Discount, Commission and simple interest	Do money-making calculation that apply percentages	Application of knowledge				✓
Q42	Polygons	Calculate the sum of interior and exterior angles of polygons	Application of knowledge			✓	
Q43	Operations on algebraic expressions	Add and subtract algebraic expressions	Application of knowledge			✓	
Q44	Hire purchase	Do money-spending calculations that apply hire purchase	Application of knowledge				✓
Q45	Change of subject of a relation	Change the subject of a relation	Application of knowledge				✓
Q46	Zero or undefined algebraic fractions	Determine the conditions under which algebraic fraction is zero or undefined	Application of knowledge			✓	
Q47	Parallel lines	State and use the properties of parallel lines	Application of knowledge			✓	
Q48	Parallel lines	State and use the properties of parallel lines	Application of knowledge			✓	
Q49	Rules of logarithms and their application	Apply the rules of logarithms to solve the given logarithmic equation	Application of knowledge			✓	
Q50	Simplifying surds	Simplify surds	Application of knowledge			✓	

Essay-type items							
Q1a	Standard form	Express numbers in standard form	Application of knowledge			✓	
Q1b	Laws of indices	Write in exponent form the repeated factors of a number	Application of knowledge			✓	
Q2a	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
Q2b	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	
Q2c	Solving equations involving indices	Solve equations involving indices	Application of knowledge			✓	

Q2d	Solving equations involving indices	Solve equations involving indices	Application of knowledge				✓
Q3a	Relating indices to logarithms in base ten	Relate indices to logarithms in base ten	Application of knowledge			✓	
Q3b	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q3c	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q3d	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q4a	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q4b	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q4c	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge				✓
Q5a	Relating indices to logarithms in base ten	Relate indices to logarithms in base ten	Application of knowledge			✓	
Q5b	Relating indices to logarithms in base ten	Relate indices to logarithms in base ten	Application of knowledge			✓	
Q5c	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q5d	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q6a	Anti-logarithms of given numbers	Find the anti-logarithm of a given number	Application of knowledge				✓
Q6b	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge				✓
Q6c	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q6d	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q7i	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge				✓
Q7iia	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Knowledge and understanding			✓	
Q7iib	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Knowledge and understanding			✓	
Q7iiia	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Knowledge and understanding			✓	

Q7iiib	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Knowledge and understanding			✓	
Q7iiic	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Knowledge and understanding			✓	
Q7iiid	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Knowledge and understanding			✓	
Q8a	Graphs of quadratic functions	Draw graphs for given quadratic functions	Application of knowledge				✓
Q8b	Minimum and maximum values and points of quadratic graphs	Find the minimum and maximum values and points from graphs	Application of knowledge			✓	
Q8c	Graphical solution of quadratic equations	Solve quadratic equations by graphical method	Application of knowledge			✓	
Q8d	Equation of line of symmetry	Identify the line of symmetry and write its equation	Application of knowledge			✓	
Q9i	Discount, Commission, simple interest	Do money-making calculations that percentages	Application of knowledge				✓
Q9ii	Simplifying surds	Simplify surds	Application of knowledge			✓	
Q10ia	Simplifying surds	Simplify surds	Application of knowledge			✓	
Q10b	Simplifying surds	Simplify surds	Application of knowledge			✓	
Q10c	Simplifying surds	Simplify surds	Application of knowledge			✓	
Q10ii	Properties of set operations	Identify the properties of operations on sets and use them	Application of knowledge			✓	
Q11ai	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q11aii	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q11bi	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q11bii	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q11biii	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q11c	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge				✓
Q12ai	Solving equations involving indices	Solve equations involving indices	Application of knowledge				✓
12aii	Rules of logarithms and their application	Apply the rules of logarithms to solve the given logarithmic equations	Application of knowledge			✓	
12aiii	Rules of logarithms and their application	Apply the rules of logarithms to solve the given logarithmic equations	Application of knowledge			✓	
12b	Discount, Commission, simple interest	Do money-making calculations that apply	Application of knowledge				✓

		percentages					

Comments

- Questions 28, 29, 47 and 48 are incomplete.
- Diagrams not well labeled.

SCHOOL C (Second Semester) Experts Agreement Rating

Item No	Content	Specific objectives	Profile Dimension	Relevance rating			
				1	2	3	4
Q1	Properties of set operations	Identify the properties of operations on sets.	Knowledge and understanding			✓	
Q2	Rational and irrational numbers	Operations on rational numbers	Application of knowledge			✓	
Q3	Operations on algebraic expressions	Add and subtract algebraic expressions	Application of knowledge			✓	
Q4	Converting base ten numerals to numerals in another base and vice versa	Convert base ten numerals to other bases and vice-versa	Application of knowledge			✓	
Q5	Polygons	Calculate the sums of interior angles and exterior angles	Application			✓	
Q6	Polygons	Calculate the sums of interior angles and exterior angles	Application			✓	
Q7	Algebraic expression	Express statements in mathematical symbols	Application of knowledge			✓	
Q8	Mode of a distribution	Find the mode of the distribution	Application			✓	
Q9	Median of a distribution	Find the median of the distribution	Application			✓	
Q10	Mean of a distribution	Find the mean of the distribution using appropriate formula	Application			✓	
Q11	Cumulative frequency curve	Draw cumulative frequency curves and interpret them	Knowledge and understanding				✓
Q12	Direct variation	Write direct variation in symbols for given proportional	Application of knowledge			✓	
Q13	Direct variation	Write direct variation in symbols for given proportional	Application of knowledge			✓	
Q14	Solving joint variation	Solve problems involving direct variation	Application of knowledge			✓	

Q15	Zero or undefined algebraic fractions	Determine the conditions under which algebraic fraction is zero or undefined	Application			✓	
Q16	Zero or undefined algebraic fractions	Determine the conditions under which algebraic fraction is zero or undefined	Application			✓	
Q17	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application			✓	
Q18	Rates	Explain and use common rates such as km/h, m/s	Application of knowledge				✓
Q19	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application			✓	
Q20	Solving equations involving indices	Solve equations involving indices	Application				✓
Q21	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q22	Simplifying surds	Simplify surds	Application			✓	
Q23	Direct variation	Write direct variation in symbols for given proportional relations	Application of knowledge			✓	
Q24	Solving joint variation	Solve problems involving joint variation	Application of knowledge			✓	
Q25	Discount, Commission and simple interest	Do money-making calculation that apply percentages	Application of knowledge			✓	
Q26	Gradient of a straight line	Find the gradient of a straight line, given the co-ordinates of two points	Application of knowledge			✓	
Q27	Solving quadratic equations by factorization	Identify and solve quadratic equations by factorization	Application			✓	
Q28	Polygons	Calculate the sums of interior angles and exterior angles	Application			✓	
Q29	Change of subject of a relation	Change the subject of a relation	Application			✓	
Q30	Converting base ten numerals to numerals in another base and vice versa	Convert base ten numerals to other bases and vice-versa	Application of knowledge			✓	
Q31	Constructing loci	Construct a particular locus	Application				✓
Q32	Constructing loci	Construct a particular locus	Application				✓
Q33	Inverse variations	Solve problems involving indirect variations	Application			✓	

Q34	Factorization	Factorize algebraic expressions	Application			✓	
Q35	Change of subject of a relation	Change the subject of a relation	Application			✓	
Q36	Gradient of a straight line	Find the gradient of a straight line, given the co-ordinates of two points	Application of knowledge			✓	
Q37	Algebraic expression	Express statements in mathematical symbols	Application of knowledge			✓	
Q38	Standard deviation and variance	Calculate and interpret standard deviation and variance of ungrouped data	Knowledge and understanding				✓
Q39	Graphical representation of data	Represent data on a suitable graph and interpret given graphs	Knowledge and understanding			✓	
Q40	Graphical representation of data	Represent data on a suitable graph and interpret given graphs	Application and knowledge				✓
Essay-type items							
Q1	Perimeter of plane figures	Calculate the perimeter of plane figures	Application of knowledge				✓
Q2	Algebraic expression	Express statements in mathematical symbols	Application of knowledge				✓
Q3	Standard deviation and variance	Calculate and interpret standard deviation and variance of ungrouped data	Application of knowledge			✓	
Q4i	Indirect variation	Solve problems involving indirect variation	Application of knowledge			✓	
Q4ii	Indirect variation	Solve problems involving indirect variation	Application of knowledge			✓	
Q5	Algebraic expression	Express statements in mathematical symbols	Application of knowledge			✓	
Q6a	Solving joint variation	Solve problems involving joint variation	Application of knowledge				✓
Q6b	Mapping	Determine the rule for a given mapping	Application			✓	
Q7a	Cumulative frequency	Construct cumulative frequency table	Knowledge and understanding			✓	
Q7aii	Cumulative frequency	Construct cumulative frequency table	Knowledge and understanding			✓	
Q7b	Cumulative frequency curve	Draw cumulative frequency curves and interpret	Application			✓	
Q8a	Construction of triangles and quadrilaterals	Construct a triangle or quadrilateral under a given condition	Application			✓	
Q8b	Constructing loci	Construct a particular locus	Application			✓	
Q8c	Constructing loci	Construct a particular locus	Application			✓	

Q8d	Constructing loci	Construct a particular locus	Application			✓	
Q8c	Constructing loci	Construct a particular locus	Application			✓	
Q8d	Constructing loci	Construct a particular locus	Application			✓	
Q9a	Ratio	Divide a quantity in a given ratio	Application of knowledge				✓
Q9b	Calculation of a number for a given modulo	Calculate the value of numbers for a given modulo	Application of knowledge			✓	
Q10ai	Discount, Commission and simple interest	Do money-making calculation that apply percentages	Application of knowledge				✓
Q10aii	Discount, Commission and simple interest	Do money-making calculation that apply percentages	Application of knowledge				✓
Q10bi	Depreciation	Determine the depreciation of an item over a specified period	Application of knowledge				✓
Qb10bii	Discount, Commission and simple interest	Do money-making calculation that apply percentages	Application of knowledge				✓
Q11a	Histogram	Draw a histogram for a given data	Application			✓	
Q11b	Histogram	Draw a histogram for a given data	Application of knowledge			✓	
Q11c	Histogram	Draw a histogram for a given data	Application of knowledge			✓	
Q12a	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q12bi	Properties of set operations	Identify the properties of operations on sets and use them	Knowledge and understanding			✓	
Q12bii	Properties of set operations	Identify the properties of operations on sets and use them	Knowledge and understanding			✓	
Q12biii	Properties of set operations	Identify the properties of operations on sets and use them	Knowledge and understanding			✓	
Q13a	Three-set problems using Venn diagrams	Find solution to practical problems involving classification Venn diagrams	Application of knowledge			✓	
Q13bi	Three-set problems using Venn diagrams	Find solution to practical problems involving classification Venn diagrams	Application of knowledge			✓	
Q13bii	Three-set problems using Venn diagrams	Find solution to practical problems involving classification Venn diagrams	Application of knowledge			✓	

Q13biii	Three-set problems using Venn diagrams	Find solution to practical problems involving classification Venn diagrams	Application of knowledge			✓	

Comments

- The diagrams to be used to answer questions 5, 6, 39 and 40 are not well-labeled.

SCHOOL D (First Semester) Experts Agreement Rating

Item No	Content	Specific Objective	Profile Dimension	Relevance rating			
				1	2	3	4
Q1	Properties of set operations	Identify the properties of operations on sets and use them	Knowledge and understanding			✓	
Q2	Properties of set operations	Identify the properties of operations on sets and use them	Knowledge and understanding			✓	
Q3	Standard form	Express numbers in standard form	Knowledge and understanding			✓	
Q4	Simplifying surds	Simplify surds	Application			✓	
Q5	Rational and irrational numbers	Operations on rational numbers	Application of knowledge			✓	
Q6	Factorization	Factorize algebraic expressions	Application			✓	
Q7	Operations on algebraic expressions	Add and subtract algebraic expressions	Application of knowledge			✓	
Q8	Equations involving number bases	Solve simple equations involving number bases	Application				✓
Q9							
Q10	Solving simultaneous equations in two variables	Find solution sets of two given linear equations in two variables	Application			✓	
Q11	Exterior angle theorem	State and use the exterior angle theorem of a triangle	Application of knowledge				✓
Q12	Exterior angle theorem	State and use the exterior angle theorem of a triangle	Application of knowledge				✓
Q13	Angles at a point	Calculate the angles at a point	Application				✓
Q14	Parallel lines	State and use the properties of parallel lines	Application of knowledge			✓	

Q15	Quadrilaterals	State and use the properties of quadrilaterals	Application of knowledge			✓	
Q16	Angles at a point	Calculate the angles at a point	Application of knowledge			✓	
Q17	Indirect variation	Solve problems involving indirect variation	Application of knowledge			✓	
Q18	Solving equations involving indices	Solve equations involving indices	Application				✓
Q19	Laws of indices	Write in exponent form the repeated factors of a number	Application of knowledge			✓	
Q20	Simplifying surds	Simplify surds	Application			✓	
Q21	Ratio	Divide a quantity in a given ratio	Application of knowledge			✓	
Q22	Real numbers on the number line	Represent real numbers on the number line	Knowledge and understanding			✓	
Q23	Direct variation	Write direct variation in symbols for given proportional	Application of knowledge			✓	
Q24	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge			✓	
Q25	Rational and irrational numbers	Operations on rational numbers	Application of knowledge			✓	
Q26	Polygons	Calculate the sums of interior angles and exterior angles	Application			✓	
Q27	Converting base ten numerals to numerals in another base and vice versa	Convert base ten numerals to other bases and vice-versa	Application of knowledge			✓	
Q28	Algebraic expression	Express statements in mathematical symbols	Application of knowledge			✓	
Q29	Polygons	Calculate the sums of interior angles and exterior angles	Application of knowledge			✓	
Q30	Angles at a point	Calculate the angles at a point	Application of knowledge			✓	
Essay-type items							
Q1	Algebraic expression	Express statements in mathematical symbols	Application of knowledge				✓
Q2a	Change of subject of a relation	Change the subject of a relation	Application			✓	

Q2b	Change of subject of a relation	Change the subject of a relation	Application			✓	
Q3a	Relating indices to logarithm in base ten	Relate indices to logarithms in base ten	Application of knowledge			✓	
Q3b	Rules of logarithms and their application	Apply the rules of logarithms to simplify the given logarithmic expression	Application of knowledge				✓
Q4a	Polygons	Calculate the sums of interior angles and exterior angles	Application			✓	
Q4b	Equations involving number bases	Solve simple equations involving number bases	Application			✓	
Q5a	Partial variation	Solve problems involving partial variations	Application			✓	
Q5b	Partial variation	Solve problems involving partial variations	Application of knowledge			✓	
Q6a	Circle Theorem	State and use the circle theorem	Application of knowledge				✓
Q6b	Circle Theorem	State and use the circle theorem	Application of knowledge				✓
Q7a	Solving equations involving indices	Solve equations involving indices	Application				✓
Q7bi	Inverse of trigonometric ratios	Find the inverse of trigonometric ratios	Application of knowledge				✓
Q7bii	Inverse of trigonometric ratios	Find the inverse of trigonometric ratios	Application of knowledge				✓
Q8i	Polygons	Calculate the sums of interior angles and exterior angles	Application			✓	
Q8ii	Parallel lines	State and use the properties of parallel lines	Application of knowledge			✓	

APPENDIX D

SAMPLE OF CORE MATHEMATICS TESTS

ST. ROSE'S SENIOR HIGH SCHOOL, AKWATIA
END OF FIRST SEMESTER EXAMINATION DECEMBER, 2018
SHS 2 CORE MATHEMATICS

DURATION: 2HR

SECTION B

Answer **all** *questions from this part*

Q1. a. Simplify $37\frac{1}{2} \div \frac{5}{9}$ of $\left(\frac{4}{7}+\frac{1}{5}\right) - 80\frac{1}{3}$

b. Using completing squares method, correct to one decimal place, $\frac{2x-2}{x-1} = \frac{5x-3}{3-x}$

c. Draw table for the operation $*$ which is defined in modulo 5 on the set $P = \{1, 2, 3, 4\}$ by $m * n = m + n + 2mn$, where $m, n \in P$. Use your table to evaluate

(i) $(2 * 3) * (3 * 4)$

(ii) $(x + 1) * (x - 1) = (x - 3)$

Q2. a. Evaluate using logarithm tables only $\sqrt[3]{0.246 \times 1.023}$

b. A, B, C and D are four points such that $A(-3, 2)$, $C(6, 3)$, $\overrightarrow{AB} = \begin{pmatrix} 5 \\ 4 \end{pmatrix}$ and $\overrightarrow{CD} = \begin{pmatrix} -5 \\ 1 \end{pmatrix}$

α. Calculate

(i) the coordinates of B and D

(ii) the vectors $\overrightarrow{BC}$ and $\overrightarrow{AD}$

β. What is the relationship between $\overrightarrow{BC}$ and $\overrightarrow{AD}$?

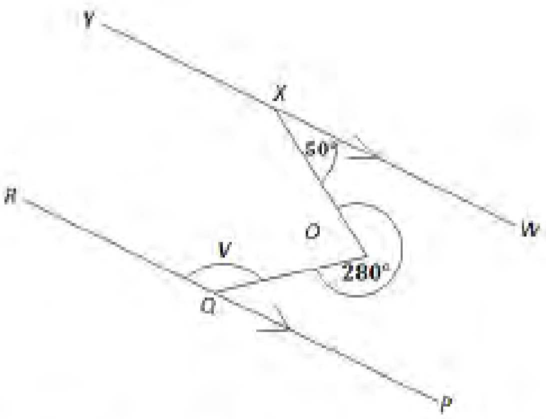
c. Given that $\begin{vmatrix} 3x - 1 & 7 \\ 2x + y & 3 \end{vmatrix} = \begin{bmatrix} 10 & 3x - y \\ 8 & 3 \end{bmatrix}$, find the values of x and y.

Q3. a. Solve the equation $2^{(2x+1)} - 9(2^x) + 4 = 0$

b. Given that $P = \begin{vmatrix} y & 8 \\ 3 & 2 \end{vmatrix}$, $Q = \begin{vmatrix} -3 & -5 \\ 4 & x \end{vmatrix}$, $R = \begin{vmatrix} -59 & -93 \\ z & 27 \end{vmatrix}$ and PQ=R,

find the values of x, y and z.

c.



In the diagram above, WY//PR, <WXO=50°, reflex <XOQ= 280° and <OQR=V.
Find the value of V

Q4. a. Copy and complete the following table of values for the relation $y = (x-4)(x+2)$ for $-3 \le x \le 5$

x	-3	-2	-1	0	1	2	3	4	5
y				-8					

b. Using a scale of 2cm to 1 unit on the x-axis and 2cm to 2 units on the y-axis, draw the graph of $y = (x-4)(x+2)$ for $-3 \le x \le 5$.

c. Using the graph, find the

(i) values of x for which y is decreasing.

(ii) gradient of the curve at $x - 0$.

d. Given that log 2=0.3010 and log7=0.8451, evaluate $\log\sqrt{28}$.

SECTION A

Answer all questions from this section.

1. The set $P = \{1, 2, 3, 4\}$ and $Q = \{2, 3, 4, 5\}$ are subsets of $U = \{1, 2, 3, 4, 5, 6\}$.
   If P' is the complement of P. Find the number of elements in $P' \cup Q$.
   A. 3 B. 4 C. 5 D. 6

2. Evaluate $\frac{49^{2/3} \times 49^{1/6}}{(7)^{-1/6} \times (7)^{1/6}}$
   A. 1 B. 0 C. 49 D. 7

3. Express $(4.2 \times 10^{-7})^3$ in a standard form.
   A. 7.4000×10^{-9} B. 7.4000×10^{-7} C. 7.4000×10^{-10} D. 7.4000×10^{-20}

4. If $3 + 4 + 2 = 4 (mod N)$. Find N
   A. 3 B. 5 C. 7 D. 8

5. $\log_{10} 2 = 0.3010$ and $\log_{10} 2^y = 1.8060$, find the correct to the nearest whole number, the value of y
   A. 7 B. 6 C. 5 D. 4

6. If $\frac{1\frac{1}{2}}{7\frac{1}{2}} = \frac{x}{96}$, find the value of x
   A. 12 B. 15 C. 34 D. 64

7. Given that $p = \binom{3}{4}$, $q = \binom{1}{2}$ and $r = \binom{-2}{1}$, find $2p + 3q - 4r$.
   A. $\binom{-4}{7}$ B. $\binom{1}{10}$ C. $\binom{17}{5}$ D. $\binom{-7}{10}$

8. Given that $2x + y = 7$ and $3x - 2y = 8$, by how much is $7x$ greater than 10.
   A. 1 B. 5 C. 7 D. 17

9. If $\log_2(3x - 1) = 5$, find x.
   A. 2.00 B. 3.67 C. 11.00 D. 8.67

10. Solve the inequality: $\frac{1}{2}(3x - 1) + 1 \leq 7 + 2x$
    A. $x \geq -13$ B. $x \leq -13$ C. $x \leq -14$ D. $x \geq -14$

11. Make m the subject of the relation: $q = \frac{1}{3}(m + n)k$

A. $m = \frac{3q}{k} + n$ B. $m = \frac{3q}{k} - n$ C. $m = 3q + kn$ D. $m = 3q - kn + n$

12. The roots of a quadratic equation are $\frac{4}{3}$ and $\frac{-3}{7}$. Find the equation.

A. $21x^2 - 19x - 12 = 0$ B. $21x^2 + 3x - 12 = 0$

C. $21x^2 - x + 12 = 0$ D. $21x^2 + 7x - 4 = 0$

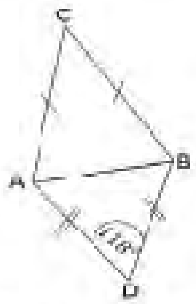
13. If $v = \frac{4}{3}\pi r^3$ and $s = 2\pi r^2$, which of the following statements is true?

A. l $v = 3sr$ B. $3v = sr$ C. $3s = \frac{1}{4}vr$ D. $4v = 3sr$

14. If $3^{-x} = k$, what is 3^x?

A. $-k$ B. 3^k C. k^3 D. $\frac{1}{k}$

15.



In the diagram above, <ADB=118°, <ABC=70°, $\overline{AC} = \overline{BC}$ and $\overline{AD} = \overline{BD}$, find <CAD

A. 31° B. 40° C. 52° D. 101°

16. Simplify $\frac{\log 625}{\log 125}$

A. $\frac{4}{3}$ B. $\frac{5}{3}$ C. 2 D. 5

17. If $6 \otimes 7 = m(mod 8)$, find m.

A. 3 B. 4 C. 2 D. 5

18. $2^n = y$, find $2^{(2+\frac{n}{3})}$

A. $4y^{1/3}$ B. $2y^{1/3}$ C. $4y^{-2}$ D. $4y^{-3}$

19. If $3^{2x-1} = \frac{1}{27}$, find the value of x
A. -2 B. 1 C. -1 D. 2

20. $log2 = m$ and $log3 = n$, find the value of $log24$ in terms of m and n.

A. $4mn$ B. $m + 3n$ C. $3mn$ D. $3m + n$

21. Akua is n years old. Her brother's age is 5years more than half of her age. How old is her brother?
A. $\frac{n}{2} + \frac{5}{2}$ B. $\frac{n}{2} - 5$ C. $5 - \frac{n}{2}$ D. $\frac{n}{2} + 5$

22. Which of the following vectors is parallel to $\begin{pmatrix} 5 \\ 4 \end{pmatrix}$?
A. $\begin{pmatrix} -10 \\ -25 \end{pmatrix}$ B. $\begin{pmatrix} -15 \\ -6 \end{pmatrix}$ C. $\begin{pmatrix} -2 \\ 5 \end{pmatrix}$ D. $\begin{pmatrix} 3 \\ 154 \end{pmatrix}$

23. If the determinant of the matrix $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$ is p, deduce the determinant of the matrix $\begin{bmatrix} ka & kb \\ kc & kd \end{bmatrix}$ in terms of p.
A. kp^2 B. k^2p C. kp D. p

24. If $a + \frac{6}{a} = 5$, find the value of $a^2 + \frac{36}{a^2}$
A. $\frac{2}{9}$ B. $\frac{9}{2}$ C. 6 D. 9

25. What value of m will make the expression $x^2 + \frac{3}{4}x + m$ a perfect square.
A. $\frac{3}{2}$ B. $\frac{9}{16}$ C. $\frac{3}{8}$ D. $\frac{9}{64}$

26. The interior angles of a pentagon are $y°$, $2x°$, $3x°$, $2x°$ and $y°$. If $y = \frac{3x}{2}$, find the value of y
A. 72 B. 81 C. 108 D. 126

27. Given that one of the roots of the equation $2x^2 + (k + 2)x + k = 0$ is 2, find the value of k.
A. -4 B. -2 C. -1 D. $-\frac{1}{4}$

28. If $log5.957 = 0.7750$, find $log\sqrt{0.0005957}$

A. $\bar{4}.1986$ B. $\bar{1}.5197$ C. $\bar{1}.2353$ D. $\bar{2}.9250$

29. Find A^{-1} if $A = \begin{bmatrix} 3 & 5 \\ -2 & -4 \end{bmatrix}$

A $\begin{bmatrix} 2 & 5 \\ -1 & -3 \end{bmatrix}$ B $\begin{bmatrix} -\frac{3}{2} & \frac{5}{2} \\ -2 & -3 \end{bmatrix}$ C $\begin{bmatrix} 4 & 3 \\ -2 & 5 \end{bmatrix}$ D $\begin{bmatrix} 2 & \frac{5}{2} \\ -1 & \frac{-3}{2} \end{bmatrix}$

30. Which of these statements about an acute angled triangle is true?

A. It has three equal angles
B. It has two equal angles
C. It has all its angles less than 90°
D. It has one angle less than 90°

31. Given that $2x + 1 = 4(mod7)$ where x is an integer. Find the least value of x

A. 2 B. 3 C. 4 D. 5

32. What is the value of m if $4 \times 3^m = 324$?

A. 81 B. 3 C. 27 D. 4

33. Given that $\log_{10} y = 1 + 3\log_{10} x$, express y in terms of x

A $y = 10x^3$ B $10x^{-3}$ C $y = x^3$ D $y = x^{-3}$

34. Find the value of k if $a^2 + 5a + k = (a + 3)^2$

A. $\frac{4}{9}$ B. 6 C. $\frac{9}{2}$ D. 9

35. Two matrices M and N are defined by $M = \begin{bmatrix} 2 & 0 \\ 1 & 2 \end{bmatrix}$ and $N = \begin{bmatrix} 2 & 0 \\ 1 & 2 \end{bmatrix}$. Find $M - 2N$

A. $\begin{bmatrix} 2 & 0 \\ 3 & 2 \end{bmatrix}$ B $\begin{bmatrix} 2 & 0 \\ -2 & 0 \end{bmatrix}$ C. $\begin{bmatrix} -2 & 0 \\ 3 & -2 \end{bmatrix}$ D. $\begin{bmatrix} -2 & 0 \\ -1 & -2 \end{bmatrix}$

36. If the vector $\begin{pmatrix} 12 \\ x \end{pmatrix}$ is the perpendicular to $\begin{pmatrix} 8 \\ 6 \end{pmatrix}$, what is the value of x?

A. 8 B. 16 C. 0 D16

37. Solve the equation $8x^2 - 5 = -6x$

A. $x = \frac{1}{2}$ or $1\frac{1}{4}$ B. $x = -\frac{1}{2}$ or $1\frac{1}{4}$ C. $x = \frac{1}{2}$ or $\frac{1}{4}$ D. $x = \frac{1}{2}$ or $-1\frac{1}{4}$

38. Find the coordinates of the maximum point of the relation $y = 3 + 2x - x^2$

A. (0, 3) B. (1, 4) C. (4, 1) D. (−1, 3)

A straight line passes through the points P(1, 2) and Q(5, 8).
Use this information to answer questions 39 and 40.

39. Calculate the gradient of the line PQ.
A. $\frac{3}{5}$ B. $\frac{2}{3}$ C. $\frac{3}{2}$ D. $\frac{5}{3}$

40. Calculate the length of PQ.
A. $4\sqrt{11}$ B. $4\sqrt{10}$ C. $2\sqrt{17}$ D. $2\sqrt{13}$

ST ROSE'S SENIOR HIGH SCHOOL-AKWATIA

SECOND SEMESTER EXAMINATIONS-JULY 2019

SHS 2 MATHEMATICS

DURATION: 1 hour 30mins

1. By how much does $a + 2b - c$ exceed $2b - a - c$?
   A. $2a$ B. $4b$ C. $2a + 2b$ D. $2a + 4b$

2. Simplify $\frac{1\frac{1}{3}\times\frac{2}{3}}{\frac{1}{4}+1\frac{1}{2}}$
   A. 5 B. $5\frac{1}{3}$ C. 6 D. 10

3. An isosceles triangle has base of 10cm. If the other sides are 13cm each, find the height of the triangle.
   A. 5cm B. 8cm C. 12cm D. 13cm

4. Simplify $\frac{\sqrt{50}\times\sqrt{45}}{\sqrt{15}}$
   A. $\sqrt{3}$ B. 5 C. $5\sqrt{6}$ D. $15\sqrt{2}$

5. Make V the subject in the relation $T = K + \frac{1}{2}mV^2$
   A. $V = \frac{2T-2K}{m}$ B. $V = \frac{\sqrt{T-K}}{m}$ C. $V = \sqrt{\frac{2(T-K)}{m}}$ D. $V = \sqrt{\frac{m}{2(T-K)}}$

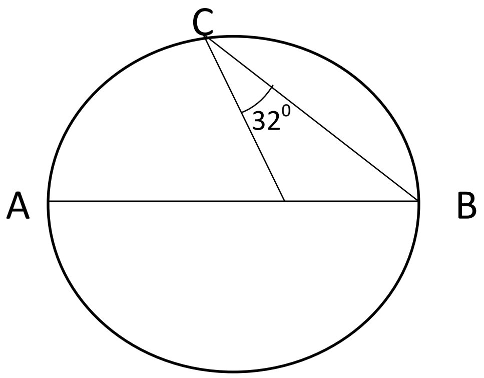
6. Find the solution set of $15x^2 - 8x + 1 = 0$
   A. $\left\{x: x = \frac{1}{2}, \frac{1}{3}\right\}$ B. $\left\{x: x = \frac{1}{5}, \frac{1}{3}\right\}$ C. $\left\{x: x = \frac{1}{2}, \frac{1}{5}\right\}$
   D. $\{x: x = 5,3\}$

7. In a given regular polygon, the ratio of the exterior angle to the interior angle is 1:3. How many sides has the polygon?
   A. 6 B. 8 C. 10 D. 11

8. Calculate for x if $43_x = 23$
   A. 4 B. 7 C. 6 D. 5

9. Simplify $\frac{1}{x+5} - \frac{2(x+2)}{x^2-25}$
   A. $\frac{x+9}{x^2-25}$ B. $\frac{x-9}{x^2-25}$ C. $\frac{-x+9}{x^2-25}$ D. $\frac{-x-9}{x^2-25}$

10. In the diagram below, line AB is a diameter of the circle ABC. If $\angle BKC = 102°$ and $\angle$KCB=32°.



Calculate the value of ∠KAC.

A. 44° B. 50° C. 60° D. 66°

11. If $PQ = \binom{2}{4}$ and $= \binom{2}{-1}$, find $|QR|$.

A. $\sqrt{8}$ B. 5 C. $\sqrt{26}$ D. 6

12. Change $QP = (10km, 065°)$ to a column vector.

A. $\binom{11}{15}$ B. $\binom{10}{5}$ C. $\binom{9.16}{4.25}$ D. $\binom{9.06}{4.23}$

13. Which of the following is not a measure of dispersion?

A. Mean deviation B. Variance C. Range D. Mean

14. If $\sin x = \frac{1}{k}$, find $\tan x$.

A. $\frac{1}{k+1}$ B. $\frac{1}{\sqrt{k^2+1}}$ C. $\sqrt{k^2 - 1}$ D. $\sqrt{k^2 + 2}$

15. Simplify $\frac{(\log 16)(\log 27)}{(\log 9)(\log 64)}$

A. 1 B. 5 C. 10 D. 21

16. If $\sin \theta = \frac{3}{5}$, find the value of $2\sin\theta + 3\cos\theta$.

A. 3 B. $3\frac{1}{3}$ C. $3\frac{3}{5}$ D. $5\frac{1}{3}$

17. Y varies inversely as x. When y=8, x=3. Find the value of x when y=12

A. 2 B. 8 C. 10 D.12

18. Given that $\log_{10} 2 = 0.431$ and $\log_{10} 3 = 0.682$. Find the value of $\log_{10} 1.5$.

A. 0.5 B. 0.176 C. 0.251 D. 0.21

19. The probability that Abu, Demsi and Klaye pass a written test are $\frac{5}{7}, \frac{1}{3}, \frac{4}{5}$ respectively. What is the probability that none of them pass the test?

A. 0.003 B. 0.038 C. 0.112 D. 0.434

20. Express 98000 in standard form.

A. 9.8×10^{-4} B. 9.8×10^{3} C. 9.8×10^{4} D. 9.8×10^{5}

21. Find the solution set of $x + y = 7$ and $x = y + 3$.
A. $\{x = 2, y = 5\}$ B. $\{x = 3, y = 3\}$ C. $\{x = 5, y = 2\}$ D. $\{x = 2, y = 6\}$

22. If $AB = \binom{3}{-5}$ and $CB = \binom{2}{1}$, find the bearing of C from A to the nearest degree.
A. 80° B. 90° C. 161° D. 171°

23. In a class of 40 students, 30 do Biology and 20 do Chemistry. Find the probability that a student chosen at random from the class does Biology only.
A. $\frac{1}{10}$ B. $\frac{1}{4}$ C. $\frac{1}{3}$ D. $\frac{1}{2}$

The frequency table below gives the age distribution of students who offered Core Mathematics in School Z. Use the information to answer question **24** and **25.**

Age(years)	15	16	17	18	19	20
Number of students	3	10	8	5	2	2

24. Calculate the mean age of the students.
A. 16.97 B. 16.21 C. 15.7 D. 17.11

25. Find the interquartile range of the distribution.
A. 3 B. 6 C. 16 D. 2

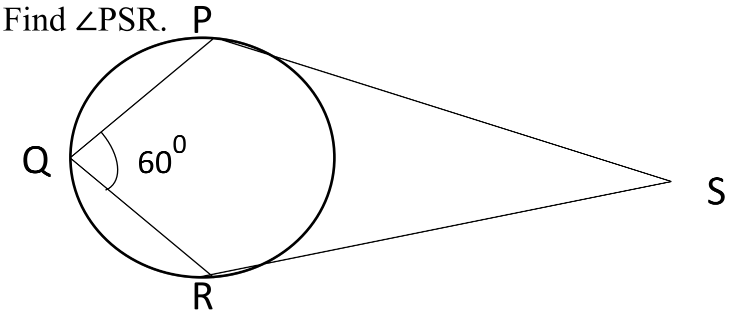
26. If $5p - 2q = 3(p + q)$, find $\frac{p}{q}$
A. $\frac{2}{5}$ B. $\frac{5}{2}$ C. $\frac{3}{2}$ D. $\frac{5}{8}$

27. If $\cos 4x = \sin 30°$, which of the following gives the value of x.
A. 15° B. 30° C. 45° D. 60°

28. A ship at point X sails 5km due west and then 7km due south to point Y. Find correct to the nearest degree, its bearing of Y from X.
A. 055° B. 056° C. 215° D. 216°

29. If $2\sqrt{5} + \sqrt{125} - \sqrt{45} + 4 = a + b\sqrt{c}$, evaluate $(2a - b)$.
A. 8 B. 4 C. 2 D. 0

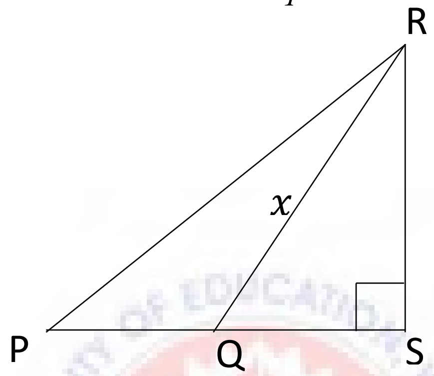
30. In the diagram above, PQR is circle such that PS and RS are tangents and ∠PQR=60°. Find ∠PSR.



A. 30° B. 40° C. 60° D. 120°

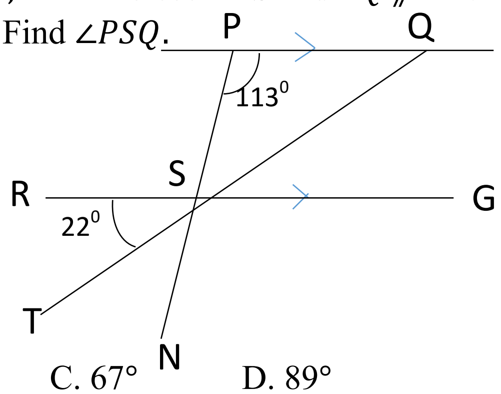
31. A quantity z varies directly as the square root of x and inversely as the cube of s. If $z = 8$ when $x = 4$ and $s = \frac{1}{2}$. Find an expression connecting z, x and s.
    A. $zs^3 = 2\sqrt{x}$ B. $zs^3 = \sqrt{x}$ C. $z\sqrt{x} = 2s^3$ D. $2zs^3 = \sqrt{x}$
32. If $2x = 1$ and mod 3, find the least value of x $5 \leq x \leq 15$.
    A. 8 B. 1 C. 2 D. 7

In the diagram below, $|PS| = 20cm$ $|QR| = xcm$, ∠SPR=90°.
*Use this information to answer questions **33** and **34***



33. Find x
    A. 4 B. 6 C. 10 D. 11.32
34. Calculate $|SR|$
    A. $22.4cm$ B. $19.6cm$ C. $19.1cm$ D. $17.3cm$
35. The mean of seven numbers is 15. When three numbers are added, the mean of ten numbers become 12. What is the mean of the three numbers?
    A. 6 B. 5 C. 4 D. 3
36. Express the true bearing of 230° as compass bearing.
    A. S50°W B. N36°W C. N40°W D. N50°
37. The frequency of vibration , f , of a stretched wire is directly proportional to square root of the length, *l* and inversely proportional to the square root of the tension, T in the wire. Express T in terms of *f*, *l*, where *k* is a constant.
    A. $T = \frac{f^2 l}{k^2}$ B. $T = kf^2 l^3$ C. $T = \frac{k^2}{f^2}$ D. $T = kf^2 l$
38. If $AB = (5km, 300°)$, find BA.
    A. $(5km, 000°)$ B. $(5km, 060°)$ C. $(5km, 300°)$ D. $(5km, 120°)$

39. Find the solution set of the inequality $2x^2 - x - 1 \leq 0$
   A. $\left\{x: -\frac{1}{2} \leq x \leq 1\right\}$ B. $\left\{x: 1 \leq x \leq -\frac{1}{2}\right\}$ C. $\left\{x: \frac{1}{2} \leq x \leq 1\right\}$
   D. $\left\{x: x \geq 1 \; or x \leq -\frac{1}{2}\right\}$
40. For what value of x is the expression $\frac{2x-1}{x-2}$ not defined?
   A. 3 B. 2 C. $\frac{1}{2}$ D. -3
41. Which of the following is a measure of central tendency?
   A. Range B. Variance C. Mode D. Mean
   deviation
42. A sector of a circle is bounded by
   A. a chord and two radii B. a radius and an arc
   C. a minor arc and a chord D. an arc and two radii
43. A ladder, 10cm long, touches a side of a building at a height of 8m. At what height would a ladder with length 12m touch the building, if it makes the same angle with the ground? (Assume that the ladder and the building are on the same horizontal ground).
   A. 10.6m B. 10.4m C. 10.0m 9.6m
44. If $\cos(3x + 28°) = \sin(2x + 48°)$, $0° \leq x \leq 90°$, find the value of x.
   A. 2.8° B. 5° C. 20.0° D. 22.0°
45. If $3^{-x} = k$, what is 3^x?
   A. $-k$ B. k^3 C. $\frac{1}{k}$ D. 3^k
46. Which of the following sets of numbers is the set of the sides of a right-angled triangle?
   A. (2,4,6) B. (3,4,5) C. (3,5,7) D.
   (4,6,7)
47. P, Q and R are subsets of $\{2,3,4,5,6,7,8,9\}$. If $P = \{x: x < 6\}$ $Q = \{y: 3 < y < 8\}$ and $R = \{even\ numbers\}$. Find $P \cap Q \cap R$.
   A. {2,3,4,5,6,7,8} B. {4,5,6,} C. {4,6,} D. {4}
48. In the diagram, PN, QT, RG intersect at S and $PQ \parallel RG$. If $\angle SPQ = 113°$ and $\angle RST = 22°$. Find $\angle PSQ$.



   A. 22° B. 45° C. 67° D. 89°

49. Find the equation of a line which passes through the points $Q(4,0)$ and perpendicular to the line $3y - 2x - 3 = 0$.
    A. $y = -\frac{3}{2}(x - 3)$ B. $y = 2x - \frac{5}{2}$ C. $y = 4x - 6$ D. $y = -\frac{3}{2}(x - 4)$
50. Two consecutive integers are such that greater added to twice the smaller gives 52. Find the numbers.
    A. 19 and 18 B. 18 and 17 C. 17 and 16 D. 16 and 1

PAPER2

DURATION: 2 HOURS

This paper consists of two parts, **PART I** and **PART II**; *answer eight questions in all. ALL questions from* **PART I** *and any four questions from* **PART II.**

Answer all questions from this part. All questions carry equal marks.

1. a). Solve $\frac{2\sin 60° - 3\cos 45°}{1 + \tan 30°}$ leave your answer in surd form where possible.
   b)Find the ratio of a and b if $2(a + b) - 3(5 + 2b) = -9$ and hence, find the value of $\frac{ab}{\frac{1}{a} - \frac{1}{b}}$.

2. a). The positive number, I, n E, R and r are connected by the formular $I = \frac{nE}{nR + r}$

   i). Express n in terms of I, E, R and r.

   ii). If $E = 12V, I = 2A, R = 5\ ohms\ and\ r = 3ohms$, find the number of turns in the coil(n).

   b). Solve $3^{2x+3} = 4^{x-1}$

3. A, B and C are subsets of the universal set U such that U= $\{0,1,2,3, \dots ,12\}$,
   A=$\{x: 0 \leq x \leq 7\}$, where x is an integer, B= $\{4,6,8,10,12\}$ and C=$\{y: 1 < y < 7\}$, where y is a prime number.

   a). Draw a Venn diagram to illustrate the information given above

   b). Find

   i). $(B \cup C)' \cap$

ii). $(A\cap B \cap C)$

iii). $A' \cup (B \cap C)$

3. a). Construct a multiplication $\otimes$ table for modulo 9 on the set T= {2,4,6,8}

   b). Use the table in (a) above to

   i) Solve $(x \otimes 4) \otimes x = 0$

   ii). Find

   α) the truth set of $n \otimes n = n - 6$

   β) the identity element.

   c). The equation $mx + ny + p = 0$ passes through the point (-1,4) and is perpendicular to the line $3y - 2x - 6 = 0$. Find the values of m,n and p.

PART II

4. The following is the frequency distribution table of the marks scored by the candidate in an examination**.**

Marks	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
Frequency	2	7	8	13	24	30	6	5	3	2

a) Make a cumulative frequency distribution table and use it to draw the cumulative frequency curve for the distribution.

b) Use the graph to estimate:

   i) The median

   ii) Interquartile range

   iii) The pass mark, if 40% of the candidate passed

5. a) The probabilities of Abu, Kuraku and Musu passing their post JAMP Examinations are $\frac{3}{7}, \frac{5}{9}, \frac{12}{13}$ respectively. What is the probability that only one of them will pass?

   b). The table below shows the relationship between three variables p, q and r is connected by $r = mp^2 + \frac{n}{q}$

P	-2	6	1
Q	x	10	4
R	4	2	10

i) Find the value of x from the table

ii) Express the variation in words

6. a) Copy and complete the table below of the values for $y = 3\sin 2\theta - \cos\theta$

θ	30°	60°	90°	120°	150°	180°
Y	1.73		0.00			1.00

c) Using a scale of 2cm to 30° on the θ axis and 2cm to 1 unit on the y-axis, draw graph of $y = 3\sin 2\theta - \cos\theta$ for $0° \leq \theta \leq 180°$.

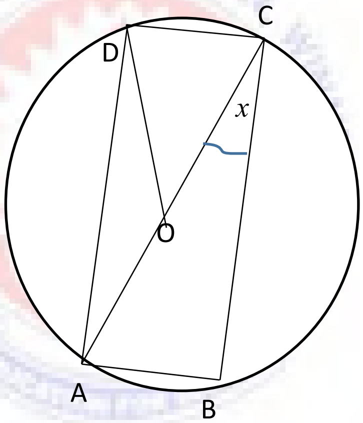
d) Using your graph:

i) Find

ii) α) maximum point correct to one decimal place.

iii) β) values of θ for which the graph is decreasing.

Solve α) $3\sin 2\theta - \cos\theta = 0$ β) $3\sin 2\theta - \cos\theta + 1.5 = 0$



7. a) In the figure above, ABCD is a circle with the centre O such that AC is a straight line. If BC is parallel to AD and $|AB| = |DC|$, find the value of x.

b) the angle of elevation of the top of a tower from a point R on the ground level is 60°. If the height of the tower is 100m, correct to one decimal place, the distance between R and the base of the tower.

8. Three towns P, Qand R are such that the distance between P and Q is 50km and the distance between P and R is 90km. If the bearing of Q from P is 075° and the bearing of R from P is 310°, find the:

i) distance between Q and R.

ii) bearing of R from Q.

b) Reduce to the lowest form $\frac{2x^2+4x-48}{2x^2-32}$

10. a) A dealer bought some electric toasters for GHC720.00. Later, when the price dropped GHC3.00 a piece, he was able to buy 8 more than the original for the same amount of money. What was the original price per toaster?

b) If $2^{2k} = 32$ evaluate 2^{3-2k}

c) In ΔABC, AB= $\binom{-4}{6}$ and AC= $\binom{3}{-8}$. If P is the midpoint of AB, express CP as a column vector.

AKIM SWEDRU SENIOR HIGH SCHOOL

END OF FIRST SEMESTER EXAMINATION

SHS 2 **MATHEMATICS** **DURATION: 2 HRS**

Section A

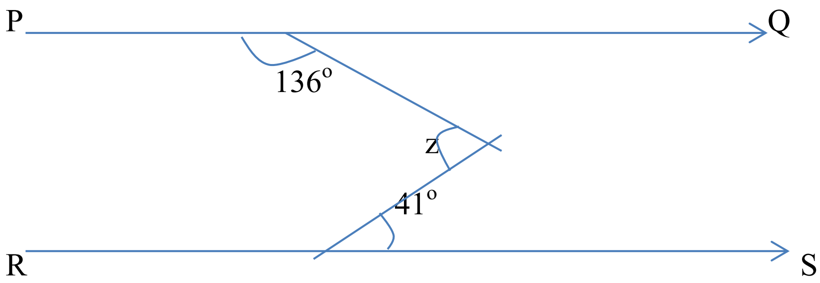
Answer **ALL** the questions in this section

1. If $3^{-X} = k$, what is 3^x ?
   A. $-k$ B. 3^k C. k^3 D. $\frac{1}{k}$
2. The interior angles of a pentagon are y^o, $2x^o$, $3x^o$, $2x^o$ and y^o. If $y = \frac{3x}{2}$, find y.
   A. 72 B. 81 C. 108 D. 126
3. Simplify: $\frac{a-1}{a^2-1}$
   A. $\frac{1}{a}$ B. $\frac{1}{a-1}$ C. $\frac{1}{a+1}$ D. $\frac{1}{a^2}$
4. Express 0.0098 in standard form.
   A. 9.8×10^{-3} B. 9.8×10^{-2} C. 9.8×10^{2} D. 9.8×10^{3}
5. The sum of the interior angles of a regular polygon is 1260^o. Find the number of sides.
   A. 6 B. 7 C. 8 D. 9
6. Expand $(3x - 2y)(3x + 2y)$.
   A. $9x^2 - 4y^2$ B. $9x^2 + 4y^2$ C. $9x^2 - 12xy + 4y^2$ D. $9x^2 + 12xy + 4y^2$
7. Find the gradient of the line joining the points P(3, -2) and Q(-2, 6).
   A. $-\frac{8}{5}$ B. $-\frac{5}{8}$ C. $\frac{1}{4}$ D. $\frac{8}{5}$
8. Simplify: $\left(\frac{1}{16}\right)^{-\frac{1}{2}} + \left(\frac{8}{27}\right)^{\frac{2}{3}}$
   A. $\frac{13}{36}$ B. $\frac{25}{36}$ C. $1\frac{7}{9}$ D. $4\frac{4}{9}$
9. Express $\log 3 + 3\log 2 - 3\log 4$ as a single logarithm.
   A. $\log\frac{3}{8}$ B. $\log\frac{3}{16}$ C. $\log\frac{8}{3}$ D. $\log\frac{3}{2}$
10. If $8^{\left(x-\frac{2}{3}\right)} = 2^{x^2}$, find the value of x.
    A. -2 or -1 B. -2 or 1 C. 2 or -1 D. 2 or 1
11. Factorize completely the expression $(h^2 - k^2) - p(h + k)$.
    A. $(h - k)^2$ B. $(h + k)(h - k)$ C. $h^2 - k^2 - h - kp$ D. $(h + k)(h - k - p)$
12. If 25(mod 7) = x, find x.
    A. 2 B. 3 C. 4 D. 5
13. Find the antilog of $\bar{2}.6021$
    A. 0.0040 B. 0.0400 C. 0.4000 D. 0.7749
14. Given that $2x + 3y = 16$ and $y - 3x = 1$, find the value of $(8x - y)$.
    A. 7 B. 6 C. 5 D. 4

15. Evaluate: $2^0 + 2^{-1} + 2^{-2}$.

A. $\frac{1}{8}$ B. $\frac{3}{4}$ C. $1\frac{1}{8}$ D. $1\frac{3}{4}$

16.



In the diagram above, PQ//RS. Find the value of z.

A. 75° B. 85° C. 95° D. 177°

17. What is the rule for the mapping $x \rightarrow y$ in the table below

x	0	1	2	3	4
↓	↓	↓	↓	↓	↓
y	2	4	6	8	10

A. $x \rightarrow (2x^2) + 2$. B. $x \rightarrow (x + 3)$ C. $x \rightarrow 2x + 2$ D. $x \rightarrow x^2$

18. Janet spends $\frac{17}{35}$ of her pocket money on transport and food. If she spends $\frac{2}{7}$ on transport only, what fraction does she spend on food?

A. $\frac{15}{28}$ B. $\frac{5}{7}$ C. $\frac{1}{5}$ D. $\frac{1}{4}$

P = $\{x: 4 < x \leq 14\}$, Q = $\{x: 4 \leq x < 12\}$ and R = $\{x: x = 3, 9, 12, 15\}$ are subsets of the universal set $\mu = \{x: 2 < x < 18\}$. Use the information to answer questions 19 and 20.

19. Find $P \cap (Q \cup R)^1$

A. {13, 15} B. {13, 14} C. {16, 17} D. {10, 11, 12, 13, 14}

20. Find $P \cap Q \cap R$.

Section B

Answer ANY Five questions from this section. All questions carry equal marks.

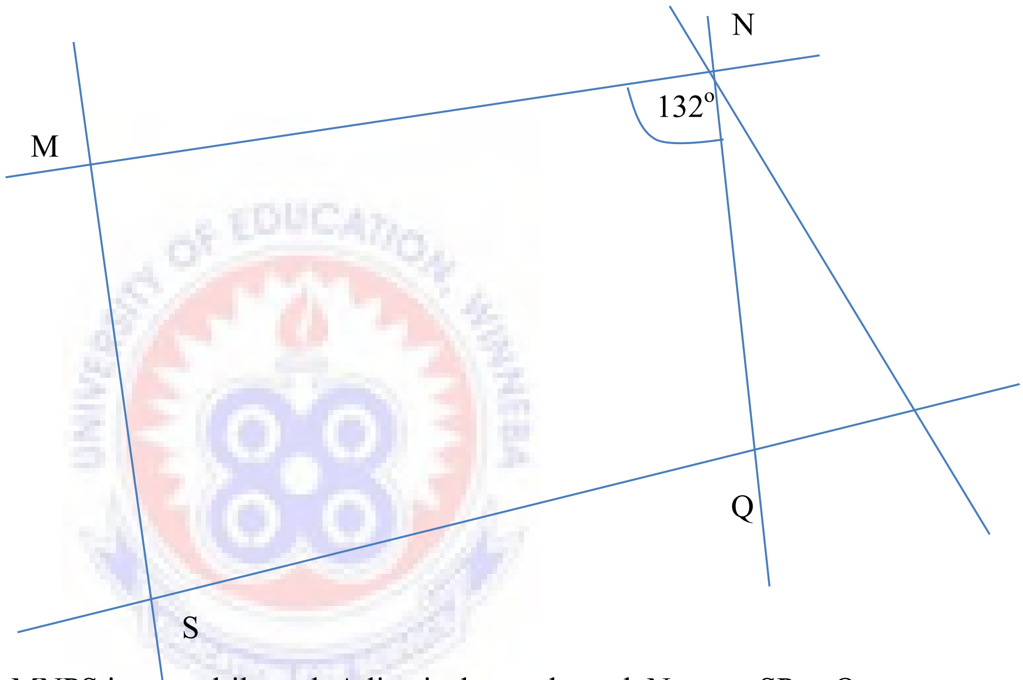
1. (a) Draw the addition ⊕ and multiplication ⊗ tables on the set T = {2, 5, 7, 11} in the arithmetic modulo 12.

   (b) From your tables:

   (i) Evaluate (5⊗ 7) ⊕ (7⊗ 11)

   (ii) Find n if n⊗ (n ⊕ 2) = 11.

2. (a)



In the diagram, MNPS is a quadrilateral. A line is drawn through N to cut SP at Q. Angle MNQ= 132°, angle SMN is twice angle MSQ = 132°, and angle NPQ is twice angle QNP. If NP bisects the acute angle at N, find:

(i) Angle SQN

(ii) Angle MSQ.

(b) A number is written as 14_n . If three times the number is equal to 45_n, find the value of n.

3. (a) The ratio of the interior angle to the exterior angle of a regular polygon is 5:2. Find the number of sides of the polygon.

   (b) Given that a = 4.0 x 10^{-2}, b = 3.0 x 10^{-2} and c = 100. Evaluate, without using tables or calculator, $\sqrt{\frac{a^2+b^2}{c}}$, and leave your answer in standard form.

4. (a) An operation * is defined on the set X= {1, 3, 5, 6 } by m*n = m + n + 2 (mod 7), where m, n ∈ ℝ.
   (i) Draw a table for the operation
   (ii) Using the table, find the truth set of:
   (α) 3 * n = 3
   (β) n * n = 3

   (b) Solve simultaneously, the equations: $5x - 4y = 6$; $3^{3(y-x)} = \frac{1}{27}$

5. (a) The height of an isosceles triangle is 4 cm. Find the length of the base if the other sides are 5 cm long.

   (b) Without using mathematical tables or calculator, simplify:
   $\frac{1}{2}\log_{10}\left(\frac{25}{4}\right) - 2\log_{10}\left(\frac{4}{5}\right) + \log_{10}\left(\frac{320}{125}\right)$

6. (a) Use logarithms to evaluate $\sqrt{(23.56\ x\ 66.45)}$. Leave your answer correct to 2 decimal places.

   (b) If $x^5 = 1024$, find the value of x.

   (c) Evaluate without using a calculator: $3(\cos 30^o)^2 + 2(\sin 30^o)^2$.

END OF PAPER

AKIM SWEDRU SENIOR HIGH SCHOOL

END OF SECOND SEMESTER EXAMINATION, JUNE/JULY 2019

MATHEMATICS (CORE)

SHS 2 **DURATION: $2\frac{1}{2}$ HRS**

SECTION A

Answer ALL the questions in this section

1. The bearing of a point Q from another point P is 040°. Find the bearing of P from Q.
   A. 220° B. 160° C. 130° D. 040°

2. If $\overrightarrow{PQ} = \binom{2}{4}$ and $\overrightarrow{RQ} = \binom{-1}{5}$, find $\overrightarrow{PR}$.
   A. $\binom{3}{9}$ B. $\binom{3}{-1}$ C. $\binom{1}{-1}$ D. $\binom{-1}{1}$

3. Express (100km, 225°) in the form $\binom{a}{b}$.
   A. $\binom{70.71}{70.71}$ B. $\binom{70.71}{-70.71}$ C. $\binom{-70.71}{70.71}$ D. $\binom{-70.7}{-70.71}$

4. Evaluate without using table $\sqrt{147} - \sqrt{75} + \sqrt{27}$.
   A. $15\sqrt{3}$ B. $5\sqrt{3}$ C. $3\sqrt{5}$ D. $\sqrt{3}$

5. If $\log_{10} 3$ = a and $\log_{10} 5$ = b, find, in terms of a and b, the value of $\log_{10} 75$.
   A. a + 2b B. 2a + b C. a + b D. 2a

6. Determine the least value of y for which 5 +y ≡2(mod 7).
   A. 6 B. 5 C. 4 D.3

7. A car travels 245km at a constant speed in $3\frac{1}{2}$ hours. How far does it travel in 90 minutes?
   A. 47km B. 70km C. 105km D. 140km

8. Solve, simultaneously, the equations $3x + 5y = 21$ and $7x - 2y = 8$.
   A. $x = -2, y = -3$ B. $x = -2, y = 3$ C. $x = 2, y = -3$ D. $x = 2, y = 3$

9. Find the vector which translates the point (2, 4) to the point (5, 3).
A. $\binom{3}{-1}$ B. $\binom{-3}{1}$ C. $\binom{2}{-2}$ D. $\binom{7}{7}$

10. Make w the subject of the relation $\frac{1}{y} = \frac{a}{x} + \frac{b}{w}$
A. $\frac{by}{x - ay}$ B. $\frac{by}{x + ay}$ C. $\frac{bxy}{x - ay}$ D. $\frac{bxy}{x + ay}$

11. If $8cosx = 3$, calculate the value of x, correct to the nearest degree.
A. 68° B. 76° C. 83° D. 97°

12. If tan$x = \frac{15}{8}$, and x is acute, find the value of sin$x$.
A. $\frac{8}{13}$ B. $\frac{2}{15}$ C. $\frac{8}{17}$ D. $\frac{15}{17}$

13. If **p** =$\binom{-2}{3}$ and **q** = $\binom{4}{-2}$, find **p -3q.**
A. $\binom{-2}{5}$ B. $\binom{-10}{9}$ C. $\binom{-2}{-11}$ D. $\binom{-10}{-3}$

14. The point P(-3, 4) is reflected in the line $x + 2 = 0$. Find the coordinates of the image of P.
A. (7, 4) B. (-2, 4) C. (-1, 4) D. (-3, -4)

15. What is the direction of the vector $\binom{-6}{9}$?
A. 56° B. 146° C. 236° D. 326°

16. Find the value of x if $x \log_{10} 2 + \log_{10} 5 = 1$.
A. 2. B. 1 C. 0 D. -1

17. Find the image of the point (3, -7) under an anticlockwise rotation through 90° about the origin O.
A. (-3, 7) B. (-7, -3) C. (3, 7) D. (7, 3)

18. Find the value of y if $16^{-y} = 8^{-1}$.
A. $\frac{3}{4}$ B. $\frac{1}{2}$ C. $\frac{-3}{4}$ D. $\frac{-1}{2}$

19. Express the true bearing of 230° as a compass bearing.
A. S50°E B. S50°W C. N50°E D. N50°W

20. If $3^{-x} = y$, find the value of 3^x.
A. $3y$ B. $\frac{1}{y}$ C. $\frac{-1}{y}$ D. $-y$

21. Simplify $3\frac{1}{2} - 1\frac{1}{3} \times 2\frac{5}{8}$.
A. 0 B. $\frac{1}{2}$ C. 1 D. 2

22. Find the sum of 303_5 and 104_5.
A. 412_5 B. 402_5 C. 244_5 D. 144_5

23. If $2\sqrt{5} + \sqrt{125} - \sqrt{45} + 4 \equiv a + b\sqrt{c}$, evaluate $(2a - b)$.
A. 8 B. 4 C. 2 D. 0

24. A petrol tank will take a factory 30 weeks when it uses 150 litres per day. How many weeks will it take the factory if it decides to use 500 litres per day?
A. 30 weeks B. 25 weeks C. 15 weeks D. 9 weeks

25. If $3x - y = 5$ and $2x + y = 15$, evaluate $x^2 + 2y$.
A. 29 B. 30 C. 35 D. 42

26. What is the gradient of the line joining the points (2, 5) and (5, 14)?
A. 5 B. 4 C. 3 D. 2

27. A ship sails 5 km due west and then 7 km due south. Find, correct to the nearest degree, its bearing from the original position.
A. 055° B. 056° C. 215° D. 216°

28. The angle of elevation of a bird in the air from a hunter standing on the ground is 35°. If the hunter is 1.4 m tall and the bird is 81.7 m away along the hunter's line of sight, how high, correct to 1 decimal place, is the bird from the ground?
A. 48.3 m B. 58.8 m C. 68.3 m D. 71.1 m

29. There are 20 men in a public bus. Of these, 15 wear glasses and 10 wear wrist watches. If one man is chosen at random from the bus, what is the probability that he wears both glasses and wrist watch?
A. $\frac{1}{5}$ B. $\frac{1}{4}$ C. $\frac{3}{5}$ D. $\frac{3}{4}$

30. After allowing a discount of 15% on an article, a seller collected $36000.00 in cash. How much was the discount?
A. $6952.94 B. $6502.94 C. $6352.94 D. $6203.94

31. The sum of the interior angles of an n-sided polygon is 1620°. Find n.
A. 9 B. 10 C. 11 D. 12

32. The average of 5 numbers is 40_{six}. Find the sum of the numbers in base six.
A. 200_{six} B. 260_{six} C. 300_{six} D. 320_{six}

33. Simplify: $\frac{m^2 - n^2}{n-m}$
A. $m+n$ B. $-m-n$ C. $-m+n$ D. $m-n$

34. Find the dimensions of a rectangle whose perimeter and area are 46 cm and 112 cm^2, respectively.
A. 16 cm by 7cm B. 17 cm by 6 cm C. 14 cm by 9 cm D. 12 cm by 11 cm

35. Given that $\frac{1}{m} = t - \frac{1}{n}$, make n the subject of the formula.
A. $n = \frac{t-1}{m}$ B. $n = \frac{m}{t-1}$ C. $n = \frac{mt-1}{m}$ D. $n = \frac{m}{mt-1}$

36. If $\log x = \bar{7}.2365$, evaluate $\log \sqrt[5]{x}$.
A. $\bar{1}.0473$ B. $\bar{1}.4473$ C. $\bar{2}.4471$ D. $\bar{2}.6473$

37. The interior angles on the same side of a transversal on two parallel lines are
A. Equal B. Obtuse C. Complementary D. Supplementary

38. The length of a side of an equilateral triangle is 10 cm. Find the height of the triangle.
A. 11.18 cm B. 10.00 cm C. 8.66 cm D. 5.00 cm

39. If $Y \div M = X$ remainder 6, then

A. $Y = X(mod\ 6)$ B. $Y = 6(mod\ M)$ C. $M = 6(mod\ Y)$
D. $M = X(mod\ 6)$

40. Find the product of $(2x + y)$ and $(2x - y)$.
A. $4x^2 + 4xy + y^2$ B. $4x^2 - 4xy - y^2$ C. $4x^2 + y^2$ D. $4x^2 - y^2$

SECTION B

Answer three questions only from this section. All questions carry equal marks.

1. The bearing of Q from P is 150°, and the bearing of P from R is 015°. If Q and R are 24km and 32km respectively from P,
   (i) represent this information on a diagram;
   (ii) calculate the distance between Q and R, correct to two decimal places;
   (iii) find the bearing of R from Q, correct to the nearest degree.

2. (a) Using a scale of 2cm to 2 units on both axes, draw, on a sheet of graph paper, two perpendicular axes Ox and Oy, for the intervals -10 ≤ x ≤ 10 and -12 ≤ y ≤ 12.
   (b) Draw on the same graph sheet, showing clearly the coordinates of all vertices
   (i) the ΔPQR with $P(4, 8)$, $\overrightarrow{QP} = \binom{-2}{2}$ and $\overrightarrow{RQ} = \binom{2}{4}$.
   (ii) The image $\Delta P_1Q_1R_1$ of ΔPQR under a reflection in the line y = -2, where $P \rightarrow P_{1,}\ Q \rightarrow Q_1$ and $R \rightarrow R_{1.}$
   (iii) The image $\Delta P_2Q_2R_2$ of ΔPQR under a translation by the vector $\binom{-8}{2}$, where $P \rightarrow P_{2,}\ Q \rightarrow Q_2$ and $R \rightarrow R_2$
   (iv) The image $\Delta P_3Q_3R_3$ of ΔPQR under a rotation through 180° about the origin where $P \rightarrow P_3, Q \rightarrow Q_3$ and $R \rightarrow R_3$.
   (c) Find $\overrightarrow{QQ_2}$.

3. (a) Copy and complete the following table of values for $y = 9cosx + 5sinx$, to one decimal place:

x	0^o	30^o	60^o	90^o	120^o	150^o
y		10.3			−0.2	

(b) Using a scale of 2cm to 30° on the x −axis and 2cm to 2 units on the y −axis, draw the graph of $y = 9cosx + 5sinx$ for $0^o \leq x \leq 150^o$.

(c) Use your graph to solve the equations:

(i) $9cosx + 5sinx = 0$

(ii) $9cosx + 5sinx = 3.5$

(d) Find, correct to one decimal place, the value of y for which $x = 72^o$.

4. (a) The ratio of boys to girls in a school is 12:25. If there are 120 boys,

(i) How many girls are in the school?

(ii) What is the total number of boys and girls in the school?

(b) If $\frac{p+2q}{p} = \frac{7}{5}$, find the value of $\frac{q}{p}$, where $p \neq 0$.

(c) The vertices of a triangle are A(1, -3), B(7, 5) and C(-3, 5). Show that ΔABC is isosceles.

5. The marks obtained by students in a class test were

4	8	7	6	7
2	1	7	4	7
3	7	6	4	3
7	5	2	7	2
5	4	8	3	2

(a) Construct a frequency distribution table for the data.

(b) Find the:

(i) Mode of the distribution;

(ii) Median mark of the test;

(iii) Mean mark.

END OF PAPER

ST. MARTIN'S SENIOR HIGH SCHOOL
1ST SEMESTER EXAMINATION
DECEMBER, 2018
CORE MATHEMATICS FORM 2

NAME……………………………………………..

INDEX NUMBER……………………………………

SECTION A

Answer all questions in this Section

$P = \{1,2,4,5,7\}$ and Q{3, 4, 7, 8} are subsets of the universal set $U = \{1,2,3,\ldots,9,10\}$. Use this information to answer Question 1 and 2.

1. Find P'
   a. {3, 6, 8} b. {3, 6, 7, 8} c. {3, 6, 8, 9, 10} d. {3, 6, 7, 8, 9, 10}

2. $P' \cap Q'$
   a. {4, 7} b. {1, 2, 3} c. {6, 9, 10} d. {3, 6, 7, 8, 9, 10}

3. Calculate 73×89, leaving your answer in standard form.
   a. 6.4947×10^{-3} b. 6.4947×10^{-2} c. 6.4947×10^{2} d. 6.4947×10^{3}

4. Simplify $\sqrt{45} - \frac{1}{\sqrt{5}}$
   a. $\frac{2}{5}\sqrt{5}$ b. $\frac{44}{5}$ c. $\frac{14}{5}\sqrt{5}$ d. $\frac{44}{5}\sqrt{5}$

5. Evaluate : $\dfrac{3\frac{1}{2} - \left(2\frac{3}{5}\right)}{4\frac{1}{2}}$
   a. $\frac{61}{35}$ b. $\frac{61}{45}$ c. $\frac{61}{75}$ d. $\frac{61}{549}$

6. Factorise $2x^2 - 7x - 15$
   a. $(x-5)(2x+3)$ b. $(x-5)(2x-3)$ c. $(2x-5)(x+3)$ d. $(2x+5)(x-3)$

7. Simplify: $(5a+3b)-(2a-7b)$
   a. $3a-4b$ b. $3a+4b$ c. $3a-10b$ d. $3a+10b$

8. If $133_x = 73_{ten}$, find x.
   a. 6 b. 7 c. 8 d. 9

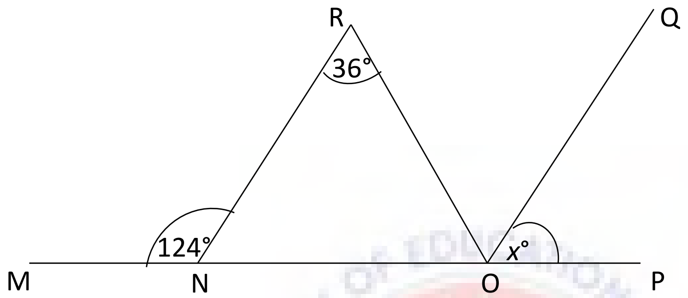
9. Find the value $9x$ in the diagram.

a. 18° b. 36° c. 54° d. 60°

10. Find s and t from the simultaneous equations: $2s+t=5$ and $3s-2t=4$.

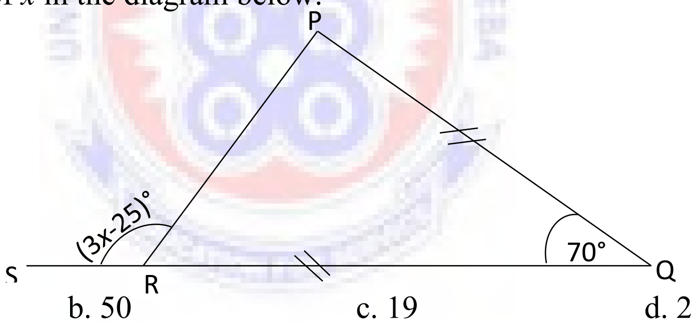
a. $s=-1, t=2$ b. $s=1, t=2$ c. $s=2, t=-1$ d. $s=2, t=1$

11. In the diagram above, < MNR = 124°, < NRO = 36° and OQ bisects < ROP. Find the value of x.



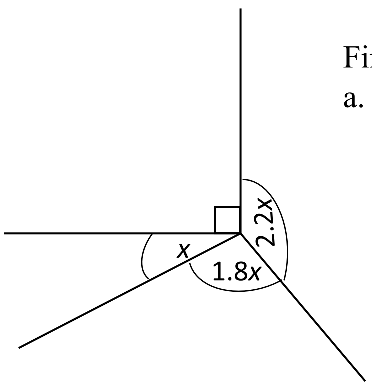
a. 36 b. 41 c. 46 d. 56

12. Find the value of x in the diagram below.



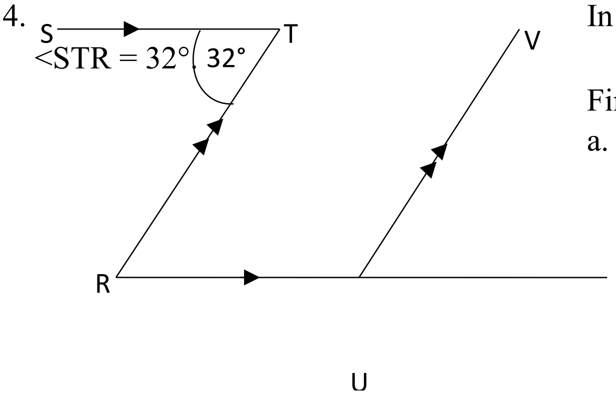
a. 45 b. 50 c. 19 d. 21

13.



Find the value of the largest angle in the diagram.

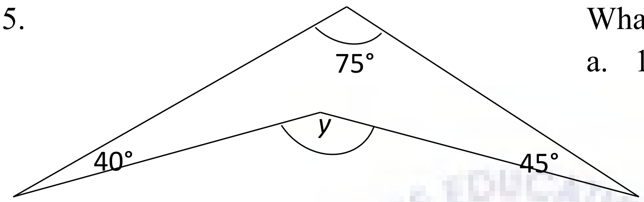
a. 118.8° b. 97.2° c. 90.0° d. 54.0°

14. 

In the diagram, ST//RU, RT//UV and <STR = 32°

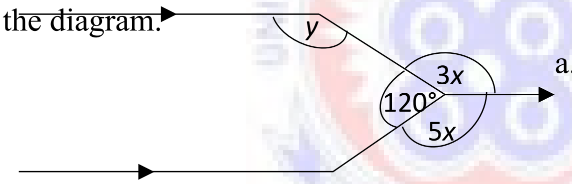
Find <RUV.

a. 32° b. 100° c. 148° d. 160°

15. 

What is the value of y in the diagram.

a. 160° b. 130° c. 120° d. 105°

16. 

Find the value of the angle marked y in the diagram.

a. 120° b. 90° c. 60° d. 30°

17. P varies directly as the square of q and inversely as r. Express P in terms of q, r, and k, where k is a constant.

a. $P = \frac{kr^2}{q}$ b. $P = \frac{kq^2}{r}$ c. $P = \frac{kq}{r^2}$ d. $P = \frac{q^2}{kr}$

18. Given that $25^x = 1$. Find the value of x.

a. 0 b. $\frac{1}{2}$ c. 1 d. 2

19. Evaluate $\left(4^{\frac{1}{2}} + 9^{\frac{1}{2}} + 16^{\frac{1}{2}}\right)^2$

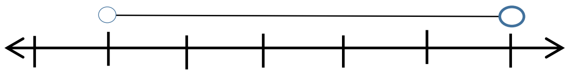
a. 9 b. 16 c. 81 d. 246

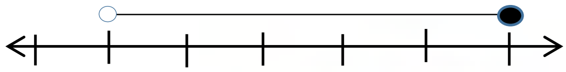
20. Evaluate $4\sqrt{3}\left(\frac{3}{\sqrt{3}} + 3\right)$

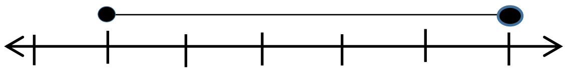
a. $12\sqrt{3}+12$ b. $24\sqrt{3}$ c. 24 d. 16

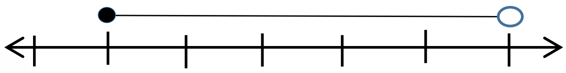
21. Three people share ₵540,000.00 in the ratio 2:3:4. Find the least amount received.
    a. ₵60,000.00 b. ₵120,000.00 c. ₵180,000.00 d. ₵240,000.00

22. Which of the following is an illustration of the inequality $-5 \leq x < 0$ on the number line?

a.


b.


c.


d.


23. Z varies directly as *x* and *y*; $z = 6$ when $x = 2$ and y = 6. Find the value of *z* when $x = 3$ and $y = 8$.
    a. $2\frac{1}{4}$ b. $4\frac{1}{2}$ c. 12 d. 18

24. Express $\log_{10} 2 - 3\log_{10} 3 + 2\log_{10} 5$ as a single logarithm.
    a. $\log_{10}\left(\frac{20}{27}\right)$ b. $\log_{10}\left(\frac{27}{20}\right)$ c. $\log_{10}\left(\frac{27}{50}\right)$ d. $\log_{10}\left(\frac{50}{27}\right)$

25. Express 0.275 as a fraction in its lowest term.
    a. $\frac{11}{80}$ b. $\frac{1}{4}$ c. $\frac{53}{200}$ d. $\frac{11}{40}$

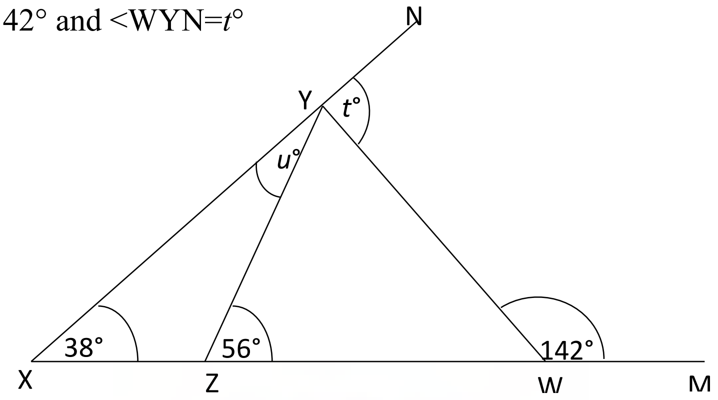
26. Find the interior angle of a 12-sided regular polygon.
    a. 30° b. 60° c. 150° d. 210°

27. Express 236 as a base 8 numeral.
    a. 352_8 b. 354_8 c. 453_8 d. 548_8

28. 132 pencils were packed into boxes. Each box can take 12 pencils. How many boxes were fully packed?
    a. 10 boxes b. 11 boxes c. 12 boxes d. 13 boxes

Use the information below to answer questions 29 and 30.

In the diagram, XYZ and WYZ are triangles. $< YWZ = 38°$, $< XYZ = u°$, $<$ YZW= 56°,
<YWM=142° and <WYN=t°



29. Calculate the value of u.
    a. 18 b. 38 c. 56 d. 76
30. Calculate the value of t.
    a.18 b. 38 c. 56 d. 76

SECTION B

Answer **all** questions in this Section

1. Find three consecutive odd integers such that the sum of the last two is 15 less than 5 times the first.

2. If $t = \sqrt{\frac{p-r}{p+r}}$, find
   a. r in terms of p and t
   b. the value of r when $t = 3$ and $p = 10$.

3. Evaluate :
   a. $2^x = 5$
   b. Given that $\log 7 = 0.8451$ and $\log 3 = 0.4771$, find without using calculator $\log_{10}\left(\frac{9}{7}\right)$.

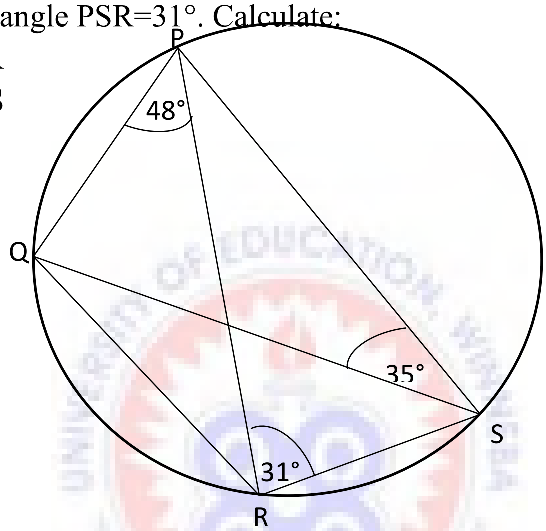
4.
   a. An irregular polygon has its external angles 28°, 40°, 120° 142° and x°. find the value of x.
   b. Find the value of x such that $365_{seven} + 43_x = 217$.

SECTION C

Answer **two** questions only from this section

5. The resistance, R to the motion of a car is partly constant and partly varies as the square of the speed, V. When the car is moving at $30kmh^{-1}$ the resistance is 630N and at $50kmh^{-1}$ the resistance is 950N. Find:
   a. An expression for R in terms of V.
   b. The resistance at $80kmh^{-1}$.

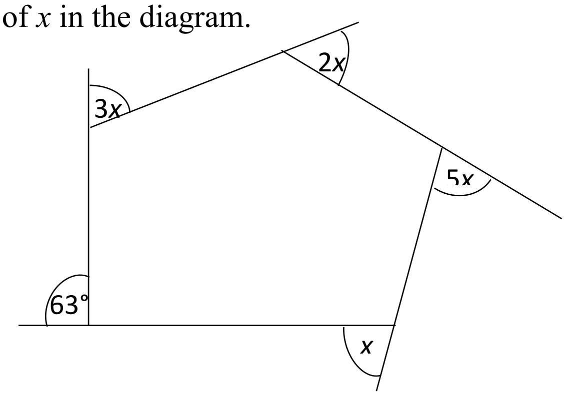
6. In the diagram below, P, Q, R and S are points on the circle. Angle QPR = 48°, < PSQ =35° and angle PSR=31°. Calculate:
   a. Angle PQR
   b. Angle QRS



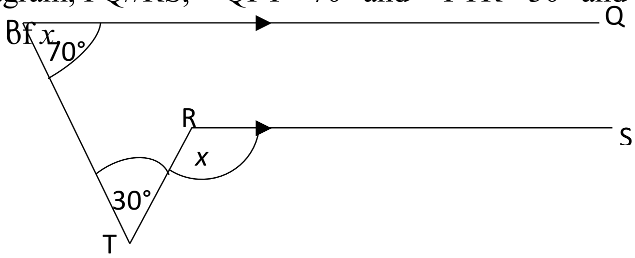
7.
   a. Solve the equation $\frac{64^n \times 2}{16^{1-n}} = 4^{2n}$
   b. i. If $4\tan x = 3$, where $0° \leq x \leq 90°$, find the value of x.

      ii. Evaluate $\frac{1+\cos x}{2-\cos x}$

8.
   i. Find the value of x in the diagram.



ii. In the diagram, PQ//RS, < QPT =70° and < PTR =30° and < TRS = x°. Find the value of x



ST. MARTIN'S SENIOR HIGH SCHOOL

2ND SEMESTER EXAMINATION
DECEMBER, 2018

CORE MATHEMATICS FORM 2

SECTION A

ANSWER ALL QUESTIONS IN THIS SECTION

1. A) Given $n(X) = 26, n(Y) = 25, n(Z) = 22, n(X \cap Y) = 11, n(X \cap Y) = 5,$ $n(X \cap Z) = 8, n(X \cup Y \cup Z) = 52$ and $n(X \cup Y \cup Z)^I = 0.$
   - i. Draw a Venn diagram of the above information within a universal set U.
   - ii. Find $n(X \cap Y \cap Z)$

   B) In a senior secondary school, 156 students passed Geography or History. 75 students passed in both subjects. If 9 more passed Geography than history, find how many were taking each subject.

2. A) solve the following equations
   - i. $2^x = 27$
   - ii. $3^{x-4} = 5^{x-1}$

   B) find the reciprocal of $\frac{5}{b-1} + \frac{3}{b}$

3. A) How long will it take for an investment of $2500.00 to triple if it is invested in an account that earns in a year at 6% interest compounded quarterly.
   B) Find the time in which the interest on $600 at 5% per annum is %90.00.

4. A) Express $\frac{1-\sqrt{2}}{\sqrt{2}}$, in the form $p + q\sqrt{2}$, where p and q are real numbers.
   B) A rectangle has length 20 cm and width W cm. The perimeter is less than 60 cm but greater than 50 cm. how wide is the reactangle?
   C) Twice a certain number added to three times the difference between the number and four is greater than 1. Find the possible range of values of the number.

SMARTS

1. There are 36 students in a class. Each student offers at least one of chemistry and physics. If 30 students offer chemistry and 26 offer physics how many students offer physics only
   A. 6 B. 10 C. 16 D. 20
2. Express 236 as a base 8 numeral
   A. 540_8 B. 453_8 C. 352_8 D. 354_8
3. The locus of a point equidistant from two intersecting lines is ....
   A. A circle touching the two circles
   B. A bisector of the angle between the two lines
   C. A perpendicular bisector of one of the lines
   D. A line parallel to the two lines
4. If $(3n-1)^{\frac{1}{3}} = 2$
   A. 4 B. 3 C. 2 D. 1

The frequency table shows the number of days students in a class were absent from school in a term

Number of days absent	1	2	3	4	5	6	7
Number of students	7	5	8	3	4	1	2

Use the information above to answer questions 5 and 6

5. Find the mode of the distribution
   A. 1 day B. 2 days C. 3 days D. 7 days
6. Calculate the mean of the distribution
   A. 3.0 days B. 3.1 days C. 3.3 days D. 3.4 days
7. Which of the following is not a measure of dispersion?
   A. Mean deviation B. mean C. variance D. range
8. A fair die is tossed twice. What is the probability that the sum of the digits is a perfect square?
   A. $\frac{1}{12}$ B. $\frac{1}{6}$ C. $\frac{7}{36}$ D. $\frac{2}{9}$
9. The volume of a cone of height 9cm is $1848cm^3$. Find the diameter of its base. [take $\pi = \frac{22}{7}$]
   A. 48cm B. 28cm C. 56cm D. 20cm
10. What transformation is represented by the mapping $\binom{x}{y} \to \binom{-y}{x}$?
   A. Reflection in the y axis
   B. Reflection in the x axis

C. 90^0 clockwise rotation about the origin
D. 90^o anticlockwise rotation about the origin

11. Calculate the compound interest on ₵2 000 000.00 for 2years at 3.5% per annum.
A. ₵70000.00 B. ₵142 450.00 C. ₵72 450.00 D. ₵140 000.00
12. Given that p varies inversely as the square of q and p=4 when q=2. Find q when p=$\frac{1}{4}$
A. 16 B. 4 C. 8 D. 2
P, Q and R are points in the Cartesian plane. $\overrightarrow{QP} = \binom{4}{-3}and\overrightarrow{PR} = \binom{4}{9}$
Use the information to answer questions 24 and 25
13. Find the vector $\overrightarrow{QR}$
A. $\binom{7}{-5}$ B. $\binom{6}{-4}$ C. $\binom{8}{6}$ D. $\binom{8}{12}$
14. If $2^{-n} = x, find\ 2^{n+1}$
A. $-2x$ B. $\frac{1}{2x}$ C. $\frac{x}{2}$ D. $\frac{2}{x}$
15. Express $log3 + 3log2 - 3log4$ as a single logarithm
A. $log\frac{3}{8}$ B. $log\frac{8}{3}$ C. $log\frac{3}{16}$ D. $log\frac{3}{2}$
16. If $2\sqrt{5} + \sqrt{125} - \sqrt{45} + 4 \equiv a + b\sqrt{c}$, evaluate (2a-b)
A. 8 B. 0 C. 4 D. 2
17. On the cumulative frequency curve what scale on the percentile scale equals the upper quartile?
A. 25 B. 50 C. 75 D. 100
18. If y varies directly as x^2 and y=4 when x=-1, find y when x=3.
A. 4 B. 9 C. 12 D. 36
19. Express as a simple fraction, $\frac{1}{3(x-y)} - \frac{1}{4(x-y)}$
A. $\frac{1}{12(x-y)}$ B. $\frac{7}{12(x-y)}$ C. $\frac{1}{12}$ D. $\frac{7}{12}$
20. In what modulus is it true that 9+8=5?
A. Mod 13 B. mod 12 C. mod 11 D. mod 10
21. Find the truth set of $2^{9x-3} = 8^{3-x}$
A. (0) B. (1) C. (2) D. $\left(\frac{1}{2}\right)$
22. If $log_{10}9 = 0.9542$, find the value of $\log_{10} 0.009$
A. 3.9542 B. 2.9542 C. $\bar{2}.9542$ D. $\bar{3}.9542$
23. Evaluate $3\sqrt{5}\left(\frac{3}{\sqrt{5}} + \sqrt{5}\right)$.
A. 31 B. 24 C. $12\sqrt{5}$ D. $9\sqrt{5}$
24. Which of the following fractions lies between $\frac{2}{3}\ and\ \frac{3}{4}$?

A. $\frac{3}{5}$ B. $\frac{17}{24}$ C. $\frac{9}{11}$ D. $\frac{5}{8}$

25. Make h the subject of the relation $v = \frac{1}{3}\pi r^2 h$

A. $\frac{3v}{\pi r^2}$ B. $\frac{3\pi v}{r^2}$ C. $\frac{3v}{r^2}$ D. $\frac{v}{3\pi r^2}$

26. Find the gradient of the line passing through the points (5,0) and (0,2)

A. $-\frac{5}{2}$ B. $-\frac{2}{5}$ C. $\frac{2}{5}$ D. $\frac{5}{2}$

27. Kofi's age in the next 10 yrs will be 4 times his age 5 yrs ago. How old is Kofi now?

A. 5 B. 6 C. 10 D. 15

28. Solve for x from the equation $\frac{x}{5} + 3 = \frac{x}{3} + 5$

A. -15 B. -1 C. 1 D. 15

29. The minute hand of a wall clock is 10.5cm long. How far does its tip travel in 24 hours? [take $\pi = \frac{22}{7}$]

A. 1.32m B. 15.84m C. 7.92m D. 0.66m

30. The sum of four consecutive odd numbers is 1112. Find the least of the four numbers

A. 273 B. 275 C. 281 D. 283

31. If y varies directly as x^2 and y=4 when x=-1, find y when x=3.

B. 4 B. 9 C. 12 D. 36

32. At what point does the graph of 3y-2x+6=0 cut the y axis?

A. (-3,0) B. (3,0) C. (0,2) D. (0,-2)

33. Solve the equation $3(2x + 9) = x^2$

A. $X = 3 \text{ or } -9$ B. $x = 9 \text{ or } 3$ C. $x = -3 \text{ or } 9$ D. $x = -9 \text{ or } -3$

34. Find the interior angle of a 12 sided regular polygon

A. 30^o B. 60^o C. 150^o D. 210^o

35. Make U the subject of the relation $E = V + \frac{1}{2}mu^2$

A. $U = \sqrt{\frac{2(E-V)}{m}}$ B. $U = \left(\frac{2(E-V)}{m}\right)^2$ C. $U = \sqrt{\frac{2E-V}{m}}$ D. $U = \sqrt{2\left(\frac{E}{m} - V\right)}$

36. Arrange $10011_2, 111_4, 20_{10}$ in ascending order of magnitude

A. $20_{10}, 111_4, 10011_2$
B. $111_4, 20_{10}, 10011_2$
C. $10011_2, 111_4, 20_{10}$
D. $10011_2, 20_{10}, 111_4$

37. For what value of x is $\frac{x-3}{x^2+5x-6}$ equal to zero?

A. -3 B. 3 C. 1 D. 0

38. Find the value(s) of x for which $\frac{1+x}{4-x^2}$ is undefined.

A. 2, -1 B. 2,-2 C. 0, -2 D. 0, -1

39. Correct 5045.00049 to three significant figures.

A. 5045.00 B. 5050.00 C. 5045.005 D. 5050.005

40. The sum of all the interior and exterior angles of a regular polygon is 1080^o. Find the number of sides.

A. 8 B. 7 C. 6 D. 5

ST PETER'S SENIOR HIGH SCHOOL

END OF FIRST SEMESTER EXAMINATION

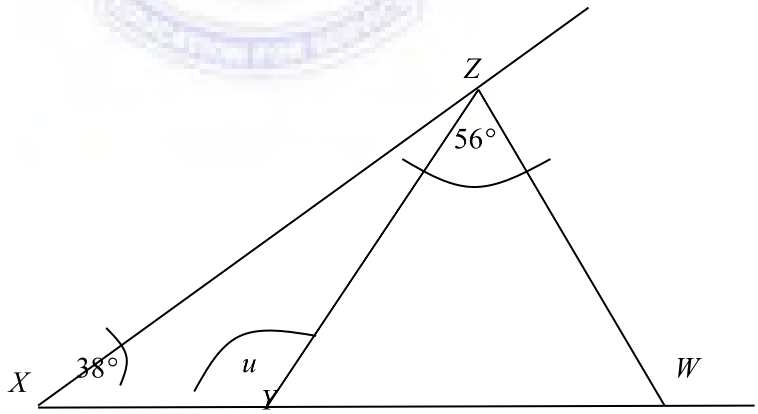
SHS TWO- FIRST SEMESTER **TIME : 1 HOUR 30 MINS**

CORE MATHEMATICS 1

OBJECTIVES

1. What property is shown by $X \cup (Y \cap Z) = (X \cup Y) \cap (X \cup Z)$, where X, Y and Z are sets?
   A. The associative property
   B. The commutative property
   C. The distributive property
   D. The closure property
2. Which of the following fractions lies between $\frac{2}{3}$ and $\frac{3}{4}$?
   B. $\frac{3}{5}$ B. $\frac{17}{24}$ C. $\frac{9}{11}$ D. $\frac{5}{8}$
3. Express as a simple fraction, $\frac{1}{3(x-y)} - \frac{1}{4(x-y)}$
   B. $\frac{1}{12(x-y)}$ B. $\frac{7}{12(x-y)}$ C. $\frac{1}{12}$ D. $\frac{7}{12}$
4. Express 112_{seven} as a base in four
   A. 322 B. 223 C. 321 D. 232

   In the diagram below, XYZ and WYZ are triangles, $< YXZ = 38^o$, $< XYZ = u^o$, $< YZW = 56^o$, $< YWM = 142^\circ$ and $< WYN = t^o$.



   Use the information to answer questions 5 and 6
5. Calculate the value of u
   A. 18 B. 38 C. 56 D. 86
6. Calculate the value of t
   A. 18 B. 38 C. 56 D. 76

7. The sum of four consecutive odd numbers is 1112. Find the least of the four numbers

   B. 273 B. 275 C. 281 D. 283

   The table below shows the distribution of marks obtained by twenty pupils in a test.

Marks	1	2	3	4	5	6	7
Number of students	1	3	5	6	2	1	2

   Use the information to answer questions 8 to 10.

8. What is the modal mark of the distribution?

   A. 5 B. 4 C. 3 D. 2

9. Find the median mark.

   A. 6 B. 5 C. 4 D. 3

10. Find the mean mark of the distribution.

   A. 2.7 B. 2.9 C. 3.8 D. 4.0

11. On the cumulative frequency curve what scale on the percentile scale equals the upper quartile?

   B. 25 B. 50 C. 75 D. 100

12. If y varies directly as x^2 and y=4 when x=-1, find y when x=3.

   C. 4 B. 9 C. 12 D. 36

13. The mass of a uniform sphere is directly proportional to the cube of its radius. If a certain spherical balloon of radius 2 cm has a mass of 64kg, what is th mass of a spherical balloon of radius 4 cm, made from the same material?

   A. 512 kg B. 128 kg C. 96 kg D. 256 kg

14. A quantity Z varies directly as the square root of x and inversely as the cube of s. if Z=8 when x=4 and $s = \frac{1}{2}$, express Z in term of x and s

   A. $Z = \frac{2\sqrt{x}}{s^3}$ B. $Z = \frac{\sqrt{x}}{s^3}$ C. $Z = \frac{2s^3}{\sqrt{x}}$ D. $Z = \frac{\sqrt{x}}{2s^3}$

15. For what value of x is $\frac{x-3}{x^2+5x-6}$ equal to zero?

   B. -3 B. 3 C. 1 D. 0

16. Find the value(s) of x for which $\frac{1+x}{4-x^2}$ is undefined.

   B. 2, -1 B. 2,-2 C. 0, -2 D. 0, -1

17. Find the point where the lines $y + 2x = 3$ *and* $3y - 4x = 4$ intersect.

   A. $x = \frac{1}{2}$ and $y = 2$

   B. $x = 1$ and $y = \frac{1}{2}$

   C. $x = 2$ and $y = 1$

   D. $x = \frac{3}{2}$ and $y = 2$

18. A car travels 120 km/h. find the distance it covers in 15 seconds.

   A. 0.5 m B. 50.0 m C. 500.0 m D. 5.0 m

19. In what modulo is it true that 9+8=5?

   B. Mod 13 B. mod 12 C. mod 11 D. mod 10

20. Find the truth set of $2^{9x-3} = 8^{3-x}$

    B. (0)   B. (1)   C. (2)   D. $\left(\frac{1}{2}\right)$

21. If $log_{10}9 = 0.9542$, find the value of $\log_{10} 0.009$

    B. 3.9542   B. 2.9542   C. $\bar{2}.9542$ D. $\bar{3}.9542$

22. Evaluate $3\sqrt{5}\left(\frac{3}{\sqrt{5}} + \sqrt{5}\right)$.

    B. 31   B. 24   C. $12\sqrt{5}$ D. $9\sqrt{5}$

23. P varies directly as the square of Q. if p=3 when Q=2, find Q when P=27

    A. 4   B. 6   C. $4\frac{1}{2}$ D. $1\frac{1}{3}$

24. Given that $x\alpha \frac{y}{z^2}$, such that x=2 when y=6 and z=3, calculate the constant of proportionality.

    A. 6   B. 4   C. 2   D. 2

25. The simple interest on ₵360,000.00 for 2 years is ₵90,000.00. find the rate pr annum

    A. 2%   B. 12.5%   C. 25%   D. 50%

26. At what point does the graph of 3y-2x+6=0 cut the y axis?

    B. (-3,0)   B. (3,0)   C. (0,2)   D. (0,-2)

27. Solve the equation $3(2x + 9) = x^2$

    B. $X = 3\ or\ -9$ B. $x = 9\ or\ 3$ C. $x = -3\ or\ 9$ D. $x = -9\ or -3$

28. Find the interior angle of a 12 sided regular polygon

    B. 30^o B. 60^o C. 150^o D. 210^o

29. Make U the subject of the relation $E = V + \frac{1}{2}mu^2$

    B. $U = \sqrt{\frac{2(E-V)}{m}}$ B. $U = \left(\frac{2(E-V)}{m}\right)^2$ C. $U = \sqrt{\frac{2E-V}{m}}$ D. $U = \sqrt{2\left(\frac{E}{m} - V\right)}$

30. Arrange $10011_2, 111_4, 20_{10}$ in ascending order of magnitude

    E. $20_{10}, 111_4, 10011_2$
    F. $111_4, 20_{10}, 10011_2$
    G. $10011_2, 111_4, 20_{10}$
    H. $10011_2, 20_{10}, 111_4$

31. Which of the following is the locus of points equidistant from two intersecting lines?

    A. Circle   B. the mediator   C. angle bisector   D. arc of a circle

32. A point P moves in space such that it is always at a constant distance from a fixed point Q. what is the locus of p?

    A. A sphere with centre Q
    B. A circle with centre Q
    C. An arc of a circle

D. Concentric circle with a common centre Q

33. If P is inversely proportional to Q and P=24 when Q=8, find P when Q=12.

A. 16 B. 18 C. 28 D. 32

34. Factorise $x(x-2)-3xy+6y$

A. $(x-2)(x-3y)$ B. $(x-2)(x+y)$ C. $(x-2)(x+3y)$ D. $(x-2)(3x+y)$

35. Make h the subject of the relation $v=\frac{1}{3}\pi r^2 h$

B. $\frac{3v}{\pi r^2}$ B. $\frac{3\pi v}{r^2}$ C. $\frac{3v}{r^2}$ D. $\frac{v}{3\pi r^2}$

36. Find the gradient of the line passing through the points (5,0) and (0,2)

B. $-\frac{5}{2}$ B. $-\frac{2}{5}$ C. $\frac{2}{5}$ D. $\frac{5}{2}$

37. Kofi's age in the next 10 yrs will be 4 times his age 5 yrs ago. How old is Kofi now?

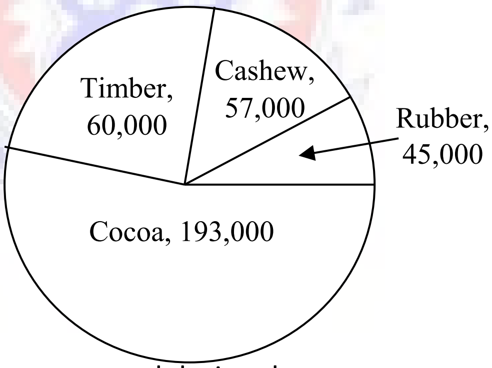
A. 5 B. 6 C. 10 D. 15

38. Which of the following is not a measure of dispersion?

A. Range B. mean C. mean deviation D. variance

The pie chart below shows Ghana's exports in a particular year. The total value of exports amounted to ₵301, 500.00

Use the information to answer questions 39 and 40.



39. Find the value of cocoa exported during the year

A. ₵50, 250, 000.00 B. ₵100, 500,000.00 C. ₵217, 750,000.00 D. ₵201, 000, 000.00

40. What percentage of total exports was timber?

A. 5.56% B. 16.67% C. 11.12% D. 8.33%

ST PETER'S SENIOR HIGH SCHOOL

END OF TERM EXAMINATION

SHS TWO- SECOND SEMESTER **TIME : 2 HOURS 30 MINS**

CORE MATHEMATICS 2

SECTION A

ANSWER *ALL* QUESTIONS FROM THIS SECTION

1. The length of a rectangular field is 7 m more than its width. If the perimeter of the field is 34 m, find the lengths of the diagonals of the field.
2. The mean of 5 numbers is 10. If two numbers, one greater than the other by 10 are added the mean becomes 10. Find the two new numbers added.
3. Find the standard deviation of the following numbers: 12, 15, 19, 22, 25 and 27
4. P varies inversely as the square of (Q+1) and P is 2 when Q is 3.
   i. Write an expression connecting P and Q
   ii. Find the possible values of Q when P=8
5. The value of the fraction $\frac{p}{q}$ in its lowest term is $\frac{2}{3}$. If 3 is subtracted from the numerator and added to the denominator of the fraction $\frac{p}{q}$, its value becomes $\frac{3}{7}$. Find the values of p and q.

SECTION B

ANSWER ANY *FIVE* QUESTIONS FROM THIS SECTION

6. A) The rate of revolution n, of the tyres of a car varies directly as the speed V of the car and inversely as the rim specification r, of its wheels. At a speed of 35 km/h a tyre of a rim 12 model car makes 140 revolutions a minute. A new model of the same basic car is fitted with wheels of rim specification 18. Find the rate of revolution of a tyre of the new model when its travelling at a speed of 48 km/h.
   B) find the rule for the mapping below.

X	3	4	5	6	7
↓	↓	↓	↓	↓	↓
Y	7	5	3	1	-1

7. The table below gives the distribution of the ages (in years) of all persons (to the nearest thousand) in a town who were under the age of 40 years on 18th June, 2016.

Ages (in years)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
No. of persons(in thousands)	4	6	12	30	24	14	8	2

a) Using the table, calculate
   i. The total number of persons under the age of 20
   ii. The total number of persons between 14 and 30 years

b) Prepare a cumulative frequency table and use it to draw a cumulative frequency curve

8. Using a ruler and a pair of compasses only construct,
   a) a quadrilateral ABCD such that $|AB| = 8cm\ cm$, $|BC| = 6.5\ cm$, $|AD| = 5.5\ cm$ and angle $ABC = 60^o\ and\ BAD = 75^o$
   b) locus l_1 of points equidistant from A and B
   c) locus l_2 of points equidistant from B and C
   d) locate a point P where P is the intersection of $l_1\ and\ l_2$
9. A) A man gave out ₵24, 000.00 to his three sons Kofi, Kwame and Kojo to be shared among them. If Kofi takes twice as much as Kwame and Kwame is given one-third of what Kojo takes, how much did each of them receive?
   B) Draw a table in modulo 8 of multiplication ⊗ on the set {2,3,5,7} and use it to find the solution set of $n \otimes n = 1$.
10. A company buys a car for GH₵ 27, 000.00 and sells it to Mr. Ampadu for GH₵ 36, 000.00 after a discount of 10% on the marked price of the car by the company.
    a) Calculate the
       i. Marked price of the car
       ii. Percentage profit made by the company
    b) If Mr. Amapdu sells the car after covering a mileage of 128, 000km, find the
       i. Value of the car if the rate of depreciation is GH₵ 0.03 per km
       ii. Range of values for which Mr. Ampadu could sell the car so he does not lose more than GH₵ 2000.00 or gain more than GH₵ 3, 000.00 on the depreciated value
11. The table below shows the distribution of marks obtained by students in an examination.

Marks	Frequency
11-20	5
21-30	21
31-40	15
41-50	43
51-60	10

61-70	14
71-80	7
81-90	3
91-100	2

a) Draw a histogram to represent the above data

b) Use your histogram to estimate the mode

c) Find the class that contains the median mark

12. A) Without using tables, find the value of x given that

$$2\log\frac{2}{3} = \frac{1}{2}\log x - \log 18 + \log 16$$

B) given that A, B and C are subsets of the universal set U of real numbers such that

$A = \{1,2, \dots .16\}$

$B = \{x: 0 < x < 16\}$

$C = \{p: p < 16\}$, where x is an odd integer and p is a prime number.

i. List all the elements of B

ii. Find $B \cap C$

iii. Find $(A \cap B)'$

13. In a class of 70 students, 6 offer economics only, 18 offer economics but not mathematics, 36 offer economics and Geography, 53 offer economics, 50 offer geography and 34 offer Mathematics and Geography. All the students study at least one subject

a) Illustrate the information in a Venn diagram

b) Determine the number of students who offer

   i. Mathematics

   ii. Mathematics and Geography but not economics

   iii. At least two subjects