Advanced Mathematics

Senior High

Grades 11 and 12

Syllabus

Standards-Based

PAPUA NEW GUINEA

Department of Education

'FREE ISSUE
NOT FOR SALE'

Advanced Mathematics

Senior High

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Issued free to schools by the Department of Education

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Acronyms

AAL	Assessment As Learning
AFL	Assessment For Learning
AOL	Assessment Of Learning
BOS	Board of Studies
CDD	Curriculum Development Division
CP	Curriculum Panel
IHD	Integral Human Development
NDoE	National Department of Education
PNG	Papua New Guinea
SAC	Syllabus Advisory Committee
SBC	Standards-Based Curriculum
SBE	Standards-Based Education
SCG	Subject Curriculum Group
STEAM	Science, Technology, Art, and Mathematics
UNCRC	United Nations Convention on the Rights of the Child

Secretary's Message

The ultimate aim of Standards-Based Education (SBE) in Papua New Guinea (PNG) is to prepare students for careers, higher education, and citizenship. This means that education should focus on developing and equipping students with essential careers, higher education, and citizenship readiness knowledge, skills, values, and attitudes that they can use to work, study, and live in the complex, competitive, technology driven, and knowledge-based economy and society of the 21st Century. Rigorous and comparable learning standards have been set at the national and grade-levels to enable all students to acquire essential career, higher education, and citizenship proficiencies before leaving school at the end of grade 12.

Education must also aim to motivate and prepare students to pursue Science, Technology, Engineering, Arts, and Mathematics (STEAM) courses in higher education and pursue careers in STEAM related fields. STEAM principles and skills have been integrated into the national content standards and grade-level benchmarks from prep-grade 12 to enable students to learn and use these to solve problems and address the challenges posed by the natural and physical environments.

The emphasis in the study of mathematics is for students to develop analytical thought and fluency in calculation, problem-solving, logical reasoning, and statistical thinking and inquiry skills Students will also learn to identify appropriate mathematical processes, transfer skills between contexts, make informed decisions, make connections, and develop mathematical arguments.

By the end of grade 12, all students will be proficient in the essential mathematical knowledge, skills, values, and attitudes, and develop the ability to be creative, innovative, productive, and competitive in diverse and knowledge-based contexts. The fundamental mathematical knowledge, skills, attitudes, and values students acquire will prepare them to effectively meet the demands of the 21st Century.

Teachers are encouraged to use the syllabus, in conjunction with the Teacher Guides and other relevant resources, to generate creative teaching and learning activities to teach the Mathematics content and enable all students to progressively learn and master the essential mathematical knowledge, skills, values, and attitudes.

I approve and commend this Grades 11 and 12 Advanced Mathematics Syllabus to be used by teachers in all Senior High Schools throughout PNG.

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UKE W KOMBRA, PhD
Secretary for Education

Introduction

The 21st Century is a time of rapid change. New knowledge, tools, and ways of doing and communicating mathematics continue to emerge and evolve, and impact on our lives in many different ways.

PNG needs to be on par with the rest of the world. The need to understand and be able to use mathematics in everyday life, in schools, and in the workplace has never been greater. Mathematical knowledge, skills, values, and attitudes are essential for employment and careers, including STEAM related careers, in the 21st Century. The job market is very competitive. Those who do not possess 21st Century knowledge, skills, values, and attitudes will find it difficult to get any sort of employment. Thus, it is important that students are encouraged, motivated, and enabled to develop a mathematical attitude of the mind to enjoy learning mathematics and, simultaneously, achieve high academic standards. And motivated to pursue STEAM academic programs in institutions of higher education and take up STEAM related careers.

In this 21st Century and beyond, those who understand and can do mathematics will have more opportunities and options for determining their futures. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed. Everyone needs to understand mathematics. All students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding.

Grades 11 and 12 Advanced Mathematics learning standards are comparable to regional and global mathematics standards. This syllabus and the teacher guides will provide the bases for all students to progressively learn and master the essential mathematical knowledge, skills, values, and attitudes to effectively prepare them for careers, higher education, and citizenship for the 21st Century and beyond.

Time allocation for Grades 11 and 12 Advanced Mathematics is 400 minutes per week.

Aims and Goals

The ultimate aim of education in PNG is to prepare students for careers, higher education, and citizenship. To achieve this aim, a number of enabling aims and goals were formulated based on evidence. The ultimate aim and the enabling aims and goals are closely linked. The enabling or operational aims and goals are described below.

Aims and Goals of Standards-Based Education and Curriculum

Curriculum aims and goals articulate the outcomes that will be achieved in the long-term and the medium-to-long term. They embed the development and educational aspirations of PNG and its citizens. These have been influenced by evidence from the analysis of context and research on teaching and learning, and on social, economic, political, technological, and cultural developments. There is a close link between the aims and goals of the curriculum. This is important for ensuring that the chain of learning results is clear.

Aim 1: Students will acquire essential and relevant knowledge, skills, values, and attitudes that will prepare them for careers, higher education, and citizenship.

Goals

Students will be able to;

(a) obtain prerequisite knowledge and skills and cultivate and foster important values and attitudes required to effectively function in a higher education and training environment.
(b) achieve high language, mathematics, science, social science, moral, values, and ethical, creative and vocational skills, and citizenship standards that will ensure a smooth transition from secondary school to higher education and training institutions.
(c) acquire and use intellectual, emotional, cultural, physical, creative, vocational, recreational, and spiritual knowledge, skills, values, and attitudes as bases for living fulfilling, purposeful, and productive lives in communities in which they choose to live.

Aim 2: Students will achieve high standards in Language, Mathematics, Science and Technology, Social Science, Civic and Citizenship Education, Character and Social Development, and Skills Education (Creative, Physical, and Vocational skills).

Goals

Students will be able to;

(a) acquire and use intellectual, emotional, cultural, physical, creative, vocational, recreational, and spiritual knowledge, skills, values, and attitudes as a basis for living a fulfilling and a productive life in the communities in which they choose to live.
(b) understand and apply mathematical reasoning, processes, formulas, and concepts to solve mathematical problems.
(c) examine and apply scientific reasoning, processes, and concepts to improve real life situations.
(d) aware of scientific standards and methods and their application across all branches of science.
(e) aware of logical and abstract thinking in the formulation of problems, the importance of mathematics in science reasoning, and recognize the role of science in every aspect of life.
(f) explain the connection between science and technology and recognize the importance of technology in the development of communities, the improvement of peoples' lives, in communication, and industry.
(g) acquire fundamental knowledge and skills to build and market different types of technology.
(h) communicate orally and in writing, use different approaches and modes of communication, identify different purposes of communication, and understand and appreciate PNG's languages and the languages of people from different cultures.
(i) aware of their civic and citizenship responsibilities, the importance of these responsibilities to harmonious living and maintaining social cohesion, and to community and national development and well-being.
(j) acquire knowledge, skills, values and attitudes required for learning and practice of creative arts, and the application of knowledge and skills to express themselves, promote PNG's cultures, and make a living.
(k) recongnise the importance of healthy mind, body, and spirit, the importance of physical exercise and sport, balanced diet, and regular exercise in living a healthy life style.
(l) recognise the importance of healthy mind, body, and spirit, the importance of physical exercise and sport, balanced diet, and regular exercise in living a healthy life style.
(m) attain essential agriculture knowledge, skills, values, and attitudes required for making a living in agriculture related contexts, starting and managing agriculture businesses for personal and family sustainability, and pursing agriculture-oriented livelihoods.

Aim 3: Students will attain both regional and internationally comparable standards in literacy and numeracy

Goals

Students will be able to;

(a) acquire essential reading skills to enable them to learn to read and read to learn throughout their lives.
(b) learn basic skills of writing, comprehending and evaluating information, following instructions, analysing others writing, and communicating with others.
(c) learn and apply basic mathematic skills in real life situations to improve their own personal growth and the advancement of their communities and the nation.

Aim 4: Students will develop their full potential and empowered to be dynamically involved in the process of freeing themselves from oppressive situations, contribute to promoting the common good and welfare of society, and develop a sense of responsibility for oneself and others.

Goals

Students will be able to;

(a) recognize and critically analyse the situations that oppress and marginalize them and others, and take appropriate individual and collective actions to transform these situations in order to improve their wellbeing.
(b) develop a positive attitude towards community service and responsibility for the well-being of the community while being responsible for their personal behaviour and conduct and hold others to account for their behaviour and attitudes in the interest of public good.
(c) develop effective communication and social skills, and think critically and rationally when solving problems and making decisions at different stages of their personal development.
(d) interpret language and cultural expressions attributed to oppressed and marginalized groups by dominant and powerful groups and challenge these in order to improve their situations.

Aim 5: Students will contribute towards the development of knowledge-based economy and society, and the transformation of Papua New Guinea from a developing to a middle income country by continuously learning and applying knowledge, skills, values, and attitudes to improve the prevailing social, economic, political, cultural, scientific, and technological conditions.

Goals

Students will be able to;

(a) value creativity and innovation; the spirit of autonomy and independence; and foster an attitude to knowledge creation and application to improve working and development conditions.
(b) obtain relevant knowledge, skills, values, and attitudes that will enable them to be multi-skilled, lifelong learners, and knowledge-based workers capable of functioning in a changing world and work environment.

Aim 6: Students will continue to learn throughout their lives and apply the outcomes of learning to improve their personal and collective learning, growth and development, and the quality of life for oneself and others.

Goals

Students will be able to;

(a) think sensibly for themselves and to develop as individual members of a community.
(b) develop and foster an attitude towards continuous learning as a basis for improving one's own knowledge, thinking, practice, value and belief system and hence improve life outcomes.
(c) cultivate a positive attitude towards research, reflection, and critical analysis as bases for lifelong learning.

Aim 7: Students will acquire essential knowledge, skills, values, and attitudes necessary for the building of peaceful and safe communities, living together, upholding the principles of a democratic state and society, building social cohesion, promoting equity and social justice, and ensuring economic prosperity for all.

Goals

Students will be able to;

(a) value justice, responsibility, equality between men and women, mutual respect and cooperation, and actively contribute to the building and fostering of peaceful, safe, and inclusive communities.
(b) use effective communication skills and think creatively in a rational manner and develop better problem solving and decision making skills at appropriate levels and ages.

Aim 8: Students will foster an understanding and an appreciation of PNG's many cultures and languages, their influence on the construction and representation of Papua New Guinean's identities, and the value, knowledge, and belief systems that underlie these diverse cultures and languages; while embracing the cultural and linguistic differences, and take actions to sustain the good and eliminate the bad aspects of cultures.

Goals

Students will be able to;

(a) have pride and responsibility towards their cultures and languages, and preserve and promote one's identity through language and culture while at the same time learning, appreciating, and tolerating other cultures and languages, both local and international.
(b) communicate with other people through written and spoken language, through mathematics and through other ways such as art, music and movement.
(c) investigate the underlying knowledge, value, and belief systems of different cultures and languages, and take appropriate individual and collective actions to eliminate aspects of cultures that hinder the building and fostering of healthy relationships and peaceful and safe environments, that are oppressive and detrimental to human development, and detrimental to the promotion of inclusive development and a hindrance to promoting and safeguarding fundamental human rights.

Aim 9: Students will develop their knowledge and an appreciation and respect for the natural environment and physical and human resources, and the need to develop these in ways that are sustainable for the benefit of current and future generations.

Goals

Students will be able to;

(a) cultivate and maintain an attitude to respect life, care for nature, and contribute to the protection of the environment.
(b) help develop and sustain Papua New Guinea's environment and its physical and human resources, for the benefit of current and future generations.
(c) become wise guardians of Papua New Guinea's resources.
(d) act responsibly and within the spirit of environment sustainability in the use of natural resources with the knowledge that local actions on environment have both local and global consequences.

Aim 10: Students will develop healthy self-concepts; contribute to the establishment and sustainability of healthy communities; the eradication of common diseases; and improvement in the health status of all citizens.

Goals

Students will be able to;

(a) demonstrate an understanding of the different stages of child development from conception to childhood, adolescence to adulthood.
(b) show awareness and understanding of the importance of building and promoting healthy life styles and healthy communities as prerequisites for healthy living and life style.
(c) investigate common diseases in PNG and their causes and symptoms, appreciate the consequences and impact they have on the citizens, look at what is being done to eradicate these diseases, and know how they can contribute to eradicating these diseases.

Aim 11: Students will understand that parenthood is a lifelong responsibility however, in exercising this right they should be aware of the impact of uncontrolled population growth and its consequences on families, communities, the environment, available resources, and the nation.

Goals

Students will be able to;

(a) appreciate the importance of having a family unit and show awareness of parental responsibilities, recognize the consequences of the decisions they make regarding the size of their families, recognizing the fact that the quality of life for their students depend on the decisions they make.
(b) aware of the contributing factors to population growth and demonstrate an understanding of the consequences of uncontrolled population growth.

Aim 12: Students will acquire knowledge, skills, values, and attitudes required for social and economic development, for gainful employment and self-employment, and for transforming individual and collective livelihoods and alleviating poverty.

Goals

Students will be able to;

(a) acquire knowledge, skills, values, and attitudes required for active participation in the formal and informal economy as means for making a sustainable living.
(b) explain and apply the concepts and practices of self-reliance and personal viability to create own employment as an alternative to formal employment.
(c) foster an attitude towards work by acquiring relevant values, knowledge, and skills that will prepare them to pursue vocational skills occupations.

Aim 13: Students will develop required values and respect for oneself, others, and the community, and use these as a basis for developing effective national and global citizenships traits.

Goals

Students will be able to;

(a) learn about and show awareness about past and present outstanding and model citizens whose character, moral standing, ethical standards, and contributions have shaped PNG and the world.
(b) demonstrate awareness and understanding of their civic and citizenship roles and responsibilities, the importance of performing these responsibilities in a transparent and accountable way for the greater good of PNG and their communities, and the consequences of neglecting these roles and responsibilities.
(c) develop and foster values, behaviours, attitudes, and communication competencies required to live together and in harmony with peoples of other cultures and linguistic groupings.
(d) show awareness and concern for the welfare and the rights of others, contribute to the promotion of justice for all and the empowerment of the oppressed and marginalized people, promote gender and social inclusion as the basis for protecting and promoting the rights of all.

Overarching Curriculum Principles

Curriculum principles identify, describe and focus attention on the important concerns that must be addressed when developing the curriculum at all levels of schooling. They are based on significant cultural, social and educational values and beliefs.

Relevance

The national curriculum should target the national, community, and personal social, economic, political, cultural, environmental, and spiritual, development needs and aspirations. Curriculum should aim to prepare students for careers, higher education and citizenship. Students should be equipped with essential, in demand knowledge, skills, values, and attitudes to meet the demands and challenges of working, studying, and living in a complex, knowledge-based, and technology driven economy and society of the 21st Century. This can be achieved through the development of rigorous and comparable learning standards, design, development, implementation, and monitoring of a quality SBC, and embedding of values and critical, creative, decision-making, reasoning, problem-solving, high level, 21st Century, and STEAM skills in the curriculum.

The national curriculum will enable teachers to support students' learning by encouraging teaching and learning in real-life contexts, and providing opportunities for students to address the problems posed by the natural and physical environments by developing creative and innovative solutions. This means students will relate and use the knowledge, skills, values and attitudes learnt in different subjects to real life situations.

Multiculturalism

Papua New Guinea is blessed and fortunate to have so many languages and cultures. The diversity of our cultures is the source of our knowledge, skills, attitudes and values. As a multicultural society, we must protect, promote and respect our many cultures and languages. There are many people from our own ethnic groupings and from other countries with their own cultures, living and working together in PNG. This is the most multicultural country in the world. We must ensure that we promote and share our cultures with the rest of the world. We must also critically examine and address the problematic aspects of our cultures.

Ethics, Morals, and Values

Papua New Guinea is striving to create a society in line with democratic liberal traditions. The citizens of PNG should recognise appropriate social relationships based on sound human and religious ethics, morals and values. These are required for interaction with families, villages, and other economic groups and people from other provinces and nations. The process of socialisation requires a belief in the ethics, morals and values of the Melanesian extended family, dialogue with and respect for others and a willingness to conserve and promote those aspects of our traditions, which are consistent with studying, working and living in the 21st Century global society. Socialisation also requires an awareness of the interdependence of individuals, societies and nations in the postmodern world. It requires involvement with family, school, church, community and the world beyond.

Integral Human Development

Integral human development focuses on the holistic development of every person. National curriculum should provide opportunities for all students to receive an education that will enable them to:

- be dynamically involved in the process of freeing themselves from every form of domination and oppression so that they will have the opportunity to develop integrated persons in relationship with others. This means that the national curriculum must integrate and maximise socialisation, participation, liberation and equality;
- be aware of human potential and the willingness to develop and maximize this potential so that each individual can solve his or her own problems, contribute to the common good of society and maintain, promote and improve the learning, working, and living conditions of all, and
- acquire and consistently use Biblical and spiritual values, personal, social and sustainability values, and work, relationship, health, and peace values in their lives.

Papua New Guinea is a rapidly changing society and faces many challenges. To face these effectively, an individual must strive to become an integrated person and to work with others to create a better community.

The process of integral human development calls for a National Curriculum, which helps individuals to:

The process of integral human development calls for a National Curriculum, which helps individuals to:

- identify their basic human needs;
- analyse situations in terms of these needs;
- see these needs in the contexts of spiritual and social values of the community; and
- take responsible action in co-operation with others.

The success of a national curriculum requires the integrated involvement of all the agents of education such as the home, church, school and community.

The Right to Healthy Living

The health status of Papua New Guinea is very low. All citizens have a right to a healthy life such as clean water, a nutritious diet, improved sanitation, appropriate and better local health services. Students need to learn attitudes; skills and knowledge that will help them become productive, healthy and contented citizens of PNG. They need to be given a set of skills that will enable them to improve their own and their community's health in order to improve the health status of PNG. The National Curriculum will ensure that students have the opportunity to learn about healthy living.

Nation Building and National Unity

Our nation is young and there is still a great deal of nation building to be done. Students need to be given the skills to undertake this task and participate in nationally organised events. The national curriculum should enable them to understand how Papua New Guinean societies work and how they can be a useful part of these societies. Students should learn that they have a place in PNG and that Papua New Guinea has a place in the world as a whole.

They will be able to help PNG develop a national identity as one nation if they learn to;

- work together with tolerance,
- respect one another, their traditional ways and resolve problems peacefully,
- respect and act in the spirit of the National Constitution,
- recognise their capabilities and develop their own talents,
- participate in the development of the national community and
- protect and safeguard the national wealth and resources.

Sustainability

The natural environment of Papua New Guinea is as diverse as its cultures. It is often a violent natural and physical environment, which is under threat from rapid population and misuse of resources such as over logging, abuses associated with mining, over fishing, dynamiting reefs and dumping toxic wastes. Our diverse cultures are also under threat from over exploitation and commercialisation of sacred cultural practices. Our cultural traditions are not being handed down from generation to generation. The national curriculum will guide students to further appreciate, respect and value their natural environment, cultures, customs and traditions. It will give them the skills and knowledge to identify problems and issues and to take action to sustain these aspects of life in PNG.

Gender Equity and Social Inclusion

Gender is what it means to be a woman or a man. It refers to those behaviours and attitudes that are culturally accepted as ways of being a woman (femininity) and being a man (masculinity). Addressing gender issues goes well beyond ensuring that females have the same opportunities as males to receive an education. A person's experiences determine the way they understand and make sense of the world. Gender is also culturally determined. In PNG, there is a need for sensitivity to local cultural practices and values, with respect to traditional roles for males and females. The national curriculum will provide students with subjects, resources, activities and experiences that value the needs of girls and boys.

Females are generally a disadvantaged group in PNG. Papua New Guinea does not have in place a good record about gender equity for females. Violence against females is widely acknowledged as a serious problem. A number of health and other indicators of human development show that females have a lower quality of life than males. Females have lower literacy rates and lower income levels than males. Males hold nearly all positions of leadership, authority and decision making.

Men hold most senior positions in government departments and the community. It is a similar situation in the Department of Education, provincial education divisions and schools. The national curriculum will provide students with opportunities to consider these problems and ways of addressing gender issues.

Inclusive Curriculum

The national curriculum is inclusive and designed to meet the needs of all students irrespective of their abilities, gender, geographic locations, cultural and language backgrounds, or their Socio-economic backgrounds. The national curriculum must be implemented by teachers in ways that are inclusive of all students at all levels of schooling. Much more can be achieved if parents, community leaders, churches, and schools co-operate and communicate with each other.

Students learn in different ways. It is best to use a variety of methods to teach them. No one method is best. It is true that students are very different and even the same students learn best from different methods at different times. By using a range of teaching methods, it is more likely that the needs of all students will be met. In order to be inclusive of all students, teachers need to cater for a range of physical, social, cultural, emotional, spiritual, and intellectual needs of their students. This can be achieved through using appropriately and carefully planned learning activities, a range of teaching methods and strategies and thoughtful use of a teacher's language of communication.

To be inclusive, teachers will need to ensure that all girls and boys have the opportunity to participate. Teaching practices, including classroom organisation and management, should ensure that girls and boys are able to participate fully in all learning activities. Participation requires that individuals are motivated to achieve the goal of socialisation fully where they are encouraged to develop a sense of obligation for the opportunity to contribute. Through participation, individual creativity can be recognised and encouraged, without losing sight of the principle of communal sharing. Participation is the key to social interaction and can lead to social mobility. It can also help to conserve and generate knowledge and cultural values for future generations.

Student-Centred Learning

Student-centred learning recognises the fact that no two classes are alike and no two students are the same with respect to their needs. A teacher who uses a student-centred approach will endeavour to create a classroom environment that will motivate students to discover new skills and knowledge. In such an environment, the teacher might focus on teaching students how to learn and help them discover relevant information. It is essential to teach students how to learn while at the same time teaching them important content. A student- centred classroom will usually involve students working together in small groups using activity centres set up in the classroom while the teacher works more closely with one or two students. The national curriculum describes what all students are expected to learn in all subjects. A student-centred approach allows teachers to be more flexible in determining the most effective ways to help all students achieve these learning outcomes.

Lifelong Learning

School is an important part of a student's education but learning continues throughout life. The initial experience that students have with the school curriculum is critical in encouraging them to continue learning throughout their lives. Going to school should be an enjoyable and satisfying experience for the students and should prepare them for life after school. Students know many things when they come to school. They will learn many things outside of school and continue to learn after they leave school. The national curriculum should build on what students already know. Teachers should make use of this knowledge and skills. When students are learning new, unfamiliar things, teachers should relate the new things to what students already understand. This important learning will continue throughout life as students increasingly take responsibility for their own learning. Increasingly, students who leave school will look for opportunities to continue their education and to return to school or some other educational or training institutions in order to improve their qualifications.

Language Development Across the Curriculum

The national curriculum will provide opportunities for language development across the curriculum. Language development across the curriculum should be encouraged because all subject areas provide meaningful contexts for purposeful learning. Specific subjects have different language requirements such as, the vocabulary and language features of science and the written and oral genres to narrate, explain, persuade, report, and discuss the particular content of various subjects. The conventions and differences must be explicitly taught in relevant contexts across the curriculum.

Knowledge, Skills, Values, and Attitudes for Careers, Higher Education, and Citizenship in the 21st Century

PNG shapes and is being shaped by the 21st Century social, economic, political, cultural, religious, and environmental discourses and practices. It is important to provide opportunities for students to learn in-depth and master the 21st Century knowledge, skills, values, and attitudes to prepare them for careers, higher education, and citizenship. There is an increasing demand for knowledge-based workers and workers with qualifications in STEAM globally. This cadre of workers is not available in PNG because education is not geared towards preparing this category of workers. PNG students should be equipped with the necessary 21st Century and STEAM knowledge, skills, values, and attitudes to ensure that they are marketable globally and can contribute meaningfully to the development of PNG.

Science, Technology, Engineering, Arts, and Mathematics

The majority of careers in the 21st Century is STEAM related. However, demand for STEAM graduates and experienced workers far exceed the supply of this cadre of workers. What is more, although a slow paradigm shift is taking place, careers in STEAM fields are dominated by males. Females are beginning to venture into these careers but at a very slow pace. There is an enormous gender parity gap in this area. Thus, it is critical for STEAM education to be introduced and taught from prep to the higher education level to provide opportunities for students to study in-depth and master the STEAM related knowledge, skills, values, and attitudes, and provide equal opportunity to be engaged in real life experiences to learn and have hands-on experience of applying STEAM concepts, processes, ideas, skills, values, and attitudes to solve real problems and come up with creative and innovative solutions. The main aim of this education is to shape students' thinking, motivate, and influence them to develop an interest in careers in the STEAM field, and to pursue undergraduate and postgraduate programs in institutions of higher education.

Standards-Based Curriculum Principles

The principles of the Standards-Based Curriculum (SBC) include the following:

- Setting of high academic standards and a careful and continuous assessment and reporting of students' performance against these standards will motivate students to perform at a much higher level.
- Standards allow every student, every parent, and every teacher to share in common expectations of what students should know, understand, and be able to do.
- Students will learn more when more is expected of them in school and at home.
- The setting of clear, measurable, and attainable standards is the key to attaining high academic standards and hence the attainment of the desired quality of education.
- All students are capable of learning and achieving high academic standards, regardless of their backgrounds.
- Students can learn in their own ways and at their own pace.

Protection of Children's Rights

It is paramount that children's rights stipulated in national legal and policy frameworks, and international conventions such as the United Nations Convention on the Rights of the Child (UNCRC) are recognised, promoted, protected, and safeguarded by everyone and every organisation working and dealing with children's welfare and well-being. A child is defined by UNCRC as a human being below the age of 18 years. However, definitions of a child may differ based on the socio-cultural contexts of different countries. Notwithstanding the differences in definitions, biologically, a child is generally anyone between birth and puberty.

The four core principles of UNCRC underpinning children's rights are;

- non-discrimination,
- devotion to the best interests of the child,
- the right to life, survival and development, and
- respect for the views of the child.

Children's rights are human rights and therefore they should be promoted and safeguarded by the whole of the education system. They should permeate all education plans, policies, programs, and activities, and firmly embedded in the school curriculum, teaching and learning practices, and the overall management of the education system.

Mathematics Rationale, Aim and Goal, and Guiding Principles

Rationale

Papua New Guinea like any other countries in the world, is making a concerted effort to boost student achievement in literacy and numeracy. Mathematics is key to improving students' numeracy levels. It underpins many aspects of everyday life such as making sense of natural patterns and using information in various ways to make sense of reality and make informed decisions. Mathematics in general and statistical thinking in particular is influencing current developments and technological innovations and advancements in Information and Communications Technology, Engineering and Science, and the Social Sciences. It is a catalyst for building and promoting knowledge-based and technology driven economies and societies.

Mathematics curriculum is focused on mathematics skills and fundamental mathematical processes (reasoning, communicating, connecting, and representing), and utilizing problem-solving based approaches to enable students to learn and demonstrate proficiency on essential mathematical knowledge, skills, values and attitudes.

The end goal is for students to enjoy learning mathematics, develop and sustain a mathematical mindset and achieve high mathematical standards, which are comparable globally.

Ultimate Aim of Mathematics

The overall aim of mathematics is to nurture mathematically literate individuals who can identify and understand mathematical phenomena by applying mathematical thinking, problem-solving processes, and methods.

Goal of Mathematics

The goal of mathematics is to ensure that all students attain essential mathematical proficiencies required for careers, high education and citizenship before leaving school at the end of grade 12.

Mathematics Guiding Principles

Mathematics guiding principles describe and focus attention on the important values and beliefs that underpin the Mathematics Curriculum. These principles should be taken into account when designing and developing the mathematics curriculum, and when planning, teaching and assessing it.

A Coherent and Focused Curriculum

In a coherent curriculum, mathematical ideas are linked to and build upon another so that students' understanding and knowledge are deepened and their ability to apply mathematics expands. An effective mathematics curriculum focuses on important mathematics knowledge, skills, values and attitudes that will prepare students for further study, to work in different settings and live in the community. A well-articulated curriculum enables all students to progressive learn and engages them in an in-depth study of mathematics and develop essential competencies in mathematics.

Gender Equity and Social Inclusion

All students, regardless of their gender, ability, and other backgrounds, are expected to achieve high academic standards in mathematics. High expectations and strong support for especially female students and students living with disability will enable all students to be actively involved in the learning of mathematics. All students come to school with expectations to learn mathematics that meets their individual interests and needs. Mathematics standards provide a wide range of opportunities for students to acquire and apply mathematical knowledge, processes, concepts, ideas, skills, values, and attitudes in real life. Every student regardless of race, colour, gender and ability should have the benefit of quality instructional materials, good libraries, and adequate technology to enable them to effectively learn and attain the expected mathematics outcomes.

Evidence-Based Teaching and Learning

Assessment should focus on improving students' learning of mathematics. Students progress towards meeting the expected mathematics standards should be assessed and evaluated. Assessment data should be used to report on students' progress towards meeting grade-level expectations and national content standards, identify and assist students who are yet to meet the expected standards, monitor the progress of weak students, and for lesson planning and instruction. Assessment should inform and guide teachers as they make instructional decisions. The tasks teacher's select for assessment convey a message to the students about what kind of mathematical knowledge, skills, values, and attitudes, and performance are valued. Feedback from assessment task helps students' in setting goals, assuming responsibility for their own learning, and becoming more independent learners.

Teaching and Learning Mathematics Using Technology

Technology is essential in the teaching and learning of mathematics. It influences the way mathematics is taught and contributes to enhancing students' learning of mathematics. Technology can enhance the teaching and learning of mathematics if used appropriately. The use of technological tools such as measuring instruments, base ten blocks, fraction chart and pieces, calculators, and computers can help students learn and master essential mathematical concepts, ideas, and processes. These tools can contribute to a rich learning environment for developing and applying mathematical concepts.

STEAM Rationale, Aim and Goals, and Guiding Principles

Ultimate Aim

The ultimate aim of STEAM education is to develop a STEAM literate society in which all citizens have the expected level of STEAM literacy. STEAM literacy refers to an individual's:

- knowledge, skills, values, and attitudes to identify problems and questions in life situations, explain the natural and design world, and draw evidence-based conclusions about STEAM issues;
- understanding of characteristic features of STEAM disciplines as forms of human knowledge, inquiry, and design;
- awareness of how STEAM disciplines shape our material, intellectual, and cultural environments, and
- willingness to engage in STEAM related issues and with the ideas of STEAM as a constructive, concerned, and reflective citizen.

Goals

The following are the goals of STEAM.

(i) Provide students with STEAM related experiences and opportunities to use STEAM concepts, ideas, and skills to solve problems relating to the natural and physical worlds, and use the evidence to make informed decisions about the interventions.

(ii) Build positive attitudes and embed essential STEAM values in students thereby motivating them to choose STEAM related careers or undertake STEAM related academic programs or courses of study.

(iii) Provide students opportunities to work in collaboration and partnership with people engaged in STEAM related careers or disciplines to learn about how STEAM skills, concepts, processes, and ideas are applied in real life.

(iv) Build a pool of STEAM workers who can contribute to national and global development and progress.

(v) Enable students to achieve high academic standards.

Guiding Principles

Integration and application of knowledge and skills in real life situations

Integration of STEAM knowledge and skills and their application to real-life situations inside and outside of the classroom setting will enable students to explain how STEAM disciplines shape our material, intellectual, cultural, economic, social, and environmental contexts.

Emphasis is on the learning and the application of STEAM knowledge and skills to investigate, explain, and solve problems rather than on content

STEAM education emphasizes the learning and the application of knowledge, and skills to investigate, explain, and solving physical and natural problems rather than on in-depth teaching and learning of STEAM content.

STEAM related knowledge and skills are used to investigate, explain, and solve problems relating to the natural and physical environments

STEAM education focuses on providing the learners real life experiences of how STEAM related skills, concepts, processes, ideas, principles, values, and attitudes are applied and used to identify problems and questions in real life situations, explain the natural and physical world, and draw evidence-based conclusions.

Core Curriculum

A core set of common learning's (knowledge, skills, values, and attitudes) have been integrated into the curriculum to provide all students an opportunity to acquire and master these before they are career, higher education, and citizenship ready.

The core curriculum includes;

- Cognitive skills (critical and creative thinking),
- Reasoning, problem-solving and decision-making skills,
- High level thinking skills (analysis, evaluation and synthesis),
- 21ST Century skills,
- STEAM principles and skills,
- Spiritual values and virtues,
- Reading, writing and communication skills, and
- Essential values and attitudes.

The above knowledge, skills, values and attitudes should be taught and assessed by all teachers from prep to grade 12. These are reinforced at each school grade and school level to enable students to become proficient in their application in different careers, higher education and citizenship contexts.

Essential Knowledge, Skills, Values, and Attitudes

Students' level of proficiency and progression towards the attainment of content standards will depend on their mastery and application of essential knowledge, skills, values and attitudes in real life or related situations.

These knowledge, skills, values and attitudes have been integrated into the content standards and benchmarks. They will also be integrated into the performance standards. Teachers are expected to plan and teach these essential knowledge, skills, values and attitudes in their lessons, and assess students' performance, proficiency and progression towards the attainment of content standards.

Provided here are examples of different types of knowledge, processes, skills, values and attitudes that all students are expected to learn and master as they progress through the grades. These are expanded and deepened in scope and the level of difficulty and complexity are increased to enable students to study in - depth the subject content as they progress from one grade to the next.

Types of Knowledge

There are different types of knowledge. These include:	
• Public and private (privileged) knowledge • Specialised knowledge • Good and bad knowledge • Concepts, processes, ideas, skills, values, attitudes • Theory and practice • Fiction and non-fiction • Traditional, modern, and postmodern knowledge	• Subject and discipline-based knowledge • Lived experiences • Evidence and assumptions • Ethics and Morales • Belief systems • Facts and opinions • Wisdom • Research evidence and findings • Solutions to problems

Types of Processes

There are different types of processes. These include:	
• Problem-solving • Logical reasoning • Decision-making • Reflection	• Cyclic processes • Mapping (*e.g*. concept mapping) • Modelling • Simulating

Types of Skills

There are different types of skills. These include:

1. Cognitive (Thinking) Skills

Thinking skills can be categorized into critical thinking and creative thinking skills.

i. Critical Thinking Skills

A person who thinks critically always evaluates an idea in a systematic manner before accepting or rejecting it. Critical thinking skills include:	
Analysis Skills – Analysis skills involve examining in detail and breaking information into parts by identifying motives or causes, underlying assumptions, hidden messages; making inferences and finding evidence to support generalisations, claims, and conclusions.	Evaluation Skills – Evaluation skills involve justifying and presenting and defending opinions by making judgments about information, validity of ideas or quality of work based on set criteria.
Key words	**Key words**
Analyse, compare, contrast, classify, distinguish, infer, explain, separate, select, categorise, connect, differentiate, discriminate, divide, order, point out, prioritise, sub-divide, survey, advertise, appraise, breakdown, calculate, conclude, correlate, criticize, devise, deduce, arrange, discover, establish, examine, organize, outline, investigate, examine, simplify, see, research, recognize, highlight, in-depth, discuss, list, find, group, divide, focus, question, experiment, test, illustrate, identify, deconstruct, simplify,	Evaluate, criticize, order, appraise, judge, support, compare, decide, discriminate, recommend , summarise, assess, choose, convince, defend, estimate, find errors, grade, measure, predict, rank, score, select, test, argue, conclude, consider, monitor, check, debate, determine, justify, explain, give reasons, interpret, opinion, validate, value,

ii. Creative Thinking Skills

A person who thinks creatively has a high level of imagination, able to generate original and innovative ideas, and able to modify ideas and products. Creative thinking skills include;
Synthesis/Creative Skills – Synthesis skills involve changing or creating something new, compiling information together in a different way by combining elements in a new pattern proposing alternative solutions.
Key words
Categorise, combine, compose, create, devise, design, explain, generate, modify, organize, plan, rearranges, construct, deconstruct, reconstruct, relate, reorganize, revise, rewrite, summarise, tell, write, formulate, invent, hypothesise, develop, compile, prepare, produce, arrange, rearrange, assemble, role-play, anticipate, make, predict, act-out, model, build, convert, discuss, elaborate, solve, propose, visualize, imagine, extend, tabulate, transform, integrate, innovate, maximize, minimize,

2. **Reasoning Skills** - Reason is a skill used in making a logical, just, and rational judgment.
3. **Decision-Making Skills** - Decision-making involves selection of the best solution from various alternatives based on specific criteria and evidence to achieve a specific aim.
4. **Problem Solving Skills** – These skills involve finding solutions to challenges or unfamiliar situations or unanticipated difficulties in a systematic manner.

Types of Values

1. Personal Values (importance, worth, usefulness, etc)

Core values	Sustaining values
• Sanctity of life • Truth • Aesthetics • Honesty • Human • Dignity • Rationality • Creativity • Courage • Liberty • Affectivity • Individuality	• Self-esteem • Self-reflection • Self-discipline • Self-cultivation • Principal morality • Self-determination • Openness • Independence • Simplicity • Integrity • Enterprise • Sensitivity • Modesty • Perseverance

2. Social Values

Core values	Sustaining values
• Equality • Kindness • Benevolence • Love • Freedom • Common good • Mutuality • Justice • Trust • Interdependence • Sustainability • Betterment of human kind • Empowerment	• Plurality • Due process of law • Democracy • Freedom and liberty • Common will • Patriotism • Tolerance • Gender equity and social inclusion • Equal opportunities • Culture and civilisation • Heritage • Human rights and responsibilities • Rationality • Sense of belonging • Solidarity • Peace and harmony • Safe and peaceful communities

3. Types of Attitudes

Attitudes - Ways of thinking and behaving, points of view	
• Optimistic • Participatory • Critical • Creative • Appreciative • Empathetic • Caring and concern • Positive • Confident • Cooperative	• Responsible • Adaptable to change • Open-minded • Diligent • With a desire to learn • With respect for self, life, equality and excellence, evidence, fair play, rule of law, different ways of life, beliefs and opinions, and the environment.

Content Standards, Benchmarks, and Evidence Outcomes

Content standards, benchmarks, and evidence outcomes are all curriculum standards. However, they have specific curriculum purposes. Despite this, these curriculum standards are interconnected and enable the intended learning outcomes to be attained.

Content Standards

Content Standards are broadly stated expectations of what students should know, understand, and be able to do in particular subjects, grade, or school level. They embed essential knowledge, skills, values, and attitudes that all students are expected to acquire and master in each strand or unit to prepare them for next grade and level of schooling.

Benchmarks

Benchmarks are specifications of content standards or more detailed descriptions of a specific level of performance expected of students at particular ages, grades, or levels of development.
Benchmarks focus on the essential knowledge, skills, values and attitudes that all students are expected to learn, master and demonstrate competency.

Evidence Outcomes

Evidence outcomes are indicators that indicate students' progress towards meeting an expectation at the mastery level. They measure students' mastery and application of knowledge, skills, values, and attitudes at each grade, cluster or school level.

Evidence outcomes indicate that a student is meeting an expectation or achieving a benchmark at the mastery level. They enable teachers to know if a student can do what he/she was expected to know, understand, and do in real life or relevant situations. Evidence outcomes are given for each strand in each grade to describe what all students should do at the end of the different strands of mathematics.

Content Standards and Benchmarks Coding

The following is the coding system used to code the content standards and benchmarks to not only make it easier to interpret and understand the relationship between these two learning standards but also to guide lesson planning, instruction, assessment and reporting of students' performance in relation to a benchmark or content standard.

Grade	: Grade is indicated by the first number (*for example,* **11**.1.1.1)
Strand	: Strand is indicated by the second number (*for example*, 11.**1**.1.1)
Content Standard	: Content Standard is indicated by the third number (*for example,* 11.1.**1**.1)
Benchmark	: Benchmark is indicated by the fourth number (*for example,* 11.1.1.**1**)

Thus, the code will read as **Content Standard 1** and **Grade Level Benchmark** as **11.1.1.1**

Content Overview

Grades 11 and 12 Advanced Mathematics Syllabus is organised by strands. Strands are broad content areas that define and describe the subject matter to be taught and learned. They incorporate cross-curriculum learning as well. Each strand has a rationale that justifies its inclusion in the mathematics curriculum.

Each strand embeds a particular aspect of Mathematics and articulates the subject matter to be learnt. What students are expected to learn and demonstrate proficiency on is described in the strand content standard. Each strand has one content standard which is set at the national level. Significant aspects of the content standards (knowledge, skills, values and attitudes) are benchmarked at the grade level.

The Mathematics strands for grades 11 and 12 Advanced Mathematics are as follows:

1. Number, Operation and Computation.
2. Geometry, Measurement and Transformation.
3. Patterns and Algebra.
4. Statistics and Probability.

Grades 11 and 12 Strands

Strand 1: Number, Operation, and Computation

Rationale

The unit on Numbers is the basis of all mathematics. Number is used for order and size in calculations. We calculate by adding, subtracting, multiplying, and dividing numbers, either mentally, written or by using technology. We also build patterns using numbers in written or symbolic forms to represent mathematical ideas. We need numbers to count, compare, and measure. In everyday life, we use numbers for almost everything. Our age, weight and height, time, money, and work are measured using numbers. Numbers have meaning and are represented in many different forms.

This strand covers whole numbers, decimal, fractions, percentages, integers, scientific notation, exponential numbers, and logarithmic numbers under the Real Numbers System. Complex numbers are introduced in the latter part to prepare students for especially higher education.

Evidence Outcomes

Grade 11	Grade 12
At the end of the grade, all students can; • apply arithmetic properties to operate on and simplify expressions that include radicals and other real numbers. • Apply laws of indices and logarithms with different bases. • apply laws of logarithms to solve problems.	At the end of the grade, all students can; • perform arithmetic operations with complex numbers. • represent complex numbers and their operations on the complex plane. • use complex numbers in polynomial identities and equations. • solve real-world problems using complex numbers.

Content Standard 1: Students will be able to represent numbers in various situations and forms, develop fluency in calculations through operations, use base ten as key for extending numbers and operations, and apply numbers in practical situations to develop number sense.

Grade 11 Benchmarks	Grade 12 Benchmarks
11.1.1.1 Apply arithmetic properties to operate on and simplify expressions that include radicals and other real numbers.	**12.1.1.1** Use the complex number system, the notation for complex numbers, and the definition of "*i*" to solve problems in standard form.
11.1.1.2 Apply laws of indices and logarithms with different bases.	**12.1.1.2** Add, subtract, multiply and divide complex numbers and represent a complex number on an Argand diagrams to calculate its modulus and argument.
11.1.1.3 Solve logarithmic equations in various problems.	**12.1.1.3** Express complex numbers in standard and polar form and convert from one form to another.
	12.1.1.4 Multiply and divide complex numbers in polar form and find powers of complex numbers.
	12.1.1.5 Apply quadratic equations to solve real-world situations and complex number problems.

Strand 2: Geometry, Measurement and Transformation

Rationale

Topics of geometry, measurement, and transformation remain important component of the mathematics curriculum at all levels. This body of knowledge helps in making informed decisions on some necessities in life. We think geometrically when we choose shapes, and solids, we want precision so we take measurements seriously, and we like to be creative so we transform what is common to something new. When questioned we justify our choices, for clarity we explain the processes required to arrive at solutions. These knowledge, skills, and techniques are integrated in teaching of these topics.

In PNG context, building a house is almost every family's dream. Shape, measurement and transformation come at a cost. A sound mathematical knowledge will ensure satisfaction at an acceptable cost.

Evidence Outcomes

Grade 11	Grade 12
At the end of grade, all students can; • convert between imperial units and metric measurements. • use analogue and digital devices to identify scale division. • calculate unknown lengths and angles using trigonometric ratios. • apply the concepts of special right-angled triangles. • apply trigonometric ratio to explore values of reciprocal trigonometric ratios. • apply the properties of unit circle and graph trigonometric functions with and without the use of digital technologies. • define and represent vectors notation and calculate position vector. • apply the properties of scalar multiplication to explain and use in parallel vectors. • apply geometrical properties in cyclic quadrilaterals or polygons, prove congruency and similarity and calculate angles. • explain the relationship between pairs of angles to determine unknown angle measures or definition of properties. • perform arithmetic operations on vectors and apply to real life problems including triangular velocities.	At the end of grade, all students can; • covert accurately between radians and degrees. • solve problems in trigonometric function and inverse trigonometric function and solve trigonometric equations including sine rule and cosine rule. • sketch trigonometric functions and finding solutions to trigonometric equations. • use fundamental trigonometric identities, including sum and difference formulas, double-angle formulas and half-angle formulas to solve problems. • verify trigonometric identities. • use the trigonometric functions in the form to determine various properties of the function including domain, range, period, phase shift and amplitude. • identify real-world phenomena that can be represented by the trigonometric function in the form. • explain the relationship between trigonometric functions and their inverse. • explain trigonometric functions in the form form $y = A\sin(Bx + C) + D$ and $y = A\cos(Bx + C) + D$.

Content Standard 2: Students will be able to comprehend the meaning and significant of geometry, measurements and spatial relationship including units and system of measurement and develop and use techniques, tools, and formulas for measuring the properties of objects and relationships among the properties and use transformations and symmetry to analyze mathematical situations.

Grade 11 Benchmarks	Grade 12 Benchmarks
11.2.2.1 Convert metric measurements to imperial or vice versa using length, mass and volume quantities.	**12.2.2.1** Translate between radians and degrees and calculate the arc length and area of sector.
11.2.2.2 Use analogue and digital devices to identify scale division.	**12.2.2.2** Explain the relationship between trigonometric functions and their inverse and sketch trigonometric functions.
11.2.2.3 Use right angle trigonometric ratios to determine an unkown length of a side or the measure of angle.	**12.2.2.3** Find the value of a trigonometric function and inverse trigonometric function and solve trigonometric equations.
11.2.2.4 Apply trigonometric ratios to calculate unknown lengths and angles.	**12.2.2.4** Apply trigonometric identities to find solutions to trigonometric equations.
11.2.2.5 Apply the concepts of special right-angled triangles to real-world situations.	**12.2.2.5** Use fundamental trigonometric identities, including sum and difference formulas, double-angle formulas and half-angle formulas to solve problems.
11.2.2.6 Appy Pythagoras theorem and trignometry to solve 3-Dimensional problems involving right angle triangles.	**12.2.2.6** Verify trigonometric identities.
11.2.2.7 Define plane and calculate angles between a line and plane.	**12.2.2.7** Solve trigonometric equations and inverse trigonometric equations that include all solutions or solutions with restricted domains.
11.2.2.8 Use vector notation to represent vectors and calculate position vector.	**12.2.2.8** Use the trigonometric functions in the form $y = A \sin (Bx + C) + D$ and $y = A \cos (Bx+C) + D$ to determine various properties of the function including domain, range, period, phase shift and amplitude.
11.2.2.9 Apply triangle and parallelgram laws and perform arithmetic operations on vectors.	**12.2.2.9** Identify real-world phenomena that can be represented by the trigonometric function in the form $y = A \sin (Bx + C) + D$.
11.2.2.10 Use properties of vectors to sketch velocity vectors and apply to real life problems including triangular velocities.	
11.2.2.11 Draw similar triangles using scales.	
11.2.2.12 Use the concept of corresponding parts to prove that triangles and other polygons are congruent or similar.	
11.2.2.13 Use protractor and compass to construct geometric angles and shapes.	
11.2.2.14 Use circle properties and angles in cyclic quadrilaterals or polygons.	

Strand 3: Patterns and Algebra

Rationale

Algebra is the language of generalization. If something is done once you probably don't need algebra. But if the process is to be done repeatedly, algebra provides a very simple language for describing what is being done. Algebra is the language through which we describe patterns. Many areas of mathematics integrate algebra specifically for problem solving.

When we add, subtract, multiply, and divide we follow patterns. Algebra develops patterns into equations and formulas that come handy in life. You may want to buy a piece of land and want to know the formula for area, or sew clothes and want to know the amount of fabric needed or perimeter for amount of fencing etc... They all involves applying some formula.

Evidence Outcomes

Grade 11	Grade 12
At the end of the grade, all students can;	At the end of the grade, all students can;
• factorize quadratic and cubic expressions. • solve linear and quadratic inequality and plot on number line or plane. • factorize and simplify algebraic fractions and expressions. • calculate the gradient using intercept form and line through two points and concepts of parallel and perpendicular lines. • calculate the distance of a point from a line, distance between two points and intersection of two straight lines. • derive and sketch graphs of hyperbolic, exponential, logarithm functions and discuss their asymptotes and applications. • define and describe functions using vertical line test. • define and describe a functions using the vertical line test and explain different functions and their features. • solve problems involving linear, quadratic and exponential and inequalities involving absolute values.	• apply the properties of arithmetic and geometric sequences and series to solve problems. • use the binomial theorem and the Pascal's triangle to expand binomial expression. • solve systems of linear equation in two or three variables using determinants. • recognize limits from graphs and tables. • find limits of sums, differences, products, quotients and rational functions. • explain continuity in terms of limits and functions. • calculate the derivatives of functions, including polynomial, rational, trigo- nometric, logarithmic, inverse, composite and exponential functions. • calculate tangents, normal and stationary points on curves. • solve problems on maxima and minima, and practical problems on rate of change. • define theorems and rules of integrations. • calculate the anti-derivatives of functions, including polynomial, rational, trigonometric, inverse, composite and exponential functions. • solve problems on applications of integration.

Content Standard 3: Students will be able to interpret various types of patterns and functional relationships, use symbolic forms to represent, model, and analyze mathematical situations and collect, organize, and represent data to answer questions.

Grade 11 Benchmarks	Grade 12 Benchmarks
11.3.3.1 Factorize quadratic and cubic expressions.	**12.3.3.1** Differentiate between the nth term and sum of n terms of arithmetic and geometric sequences and use sigma notation.
11.3.3.2 Simplify algebraic fractions.	**12.3.3.2** Apply the properties of arithmetic and geometric sequences and series to solve problems.
11.3.3.3 Factorise, solve and sketch quadratic expressions and equations.	**12.3.3.3** Use the binomial theorem and the Pascal's triangle to expand binomial expression.
11.3.3.4 Simplify algebraic fractions to solve simultaneous equations using elimination, substitution and graphical methods.	**12.3.3.4** Solve systems of linear equation in two or three variables using determinants.
11.3.3.5 Solve inequalities and plot on number line or plane.	**12.3.3.5** Recognize limits from graphs and tables.
11.3.3.6 Calculate the gradient of a straight line using intercept form and line through two points.	**12.3.3.6** Find limits of sums, differences, products, quotients and rational functions.
11.3.3.7 Apply the concepts of parallel and perpendicular lines to find gradient and equation.	**12.3.3.7** Define continuity in terms of limits and functions
11.3.3.8 Calculate the distance of a point from a line, distance between two points and intersection of two straight lines.	**12.3.3.8** Calculate the derivatives of functions, including polynomial, rational, trigonometric, logarithmic, inverse, composite and exponential functions.
11.3.3.9 Define and describe functions using vertical line test.	**12.3.3.9** Calculate tangents, normal and stationary points on curves.
11.3.3.10 Recorgnise and explain different functions and their features and calculate their range and domain.	**12.3.3.10** Solve problems on maxima and minima, and practical problems on rate of change.
11.3.3.11 Define absolute value of a number and graph absolute value functions.	**12.3.3.11** Define theorems and rules of integrations.
11.3.3.12 Solve problems involving linear, quadratic and exponential and inequality equations involving absolute values individually or simultaneously using algebraic or graphs.	**12.3.3.12** Calculate the anti-derivatives of functions, including polynomial, rational, trigonometric, inverse, composite and exponential functions.
11.3.3.13 Derive and sketch graphs of hyperbolic, exponential, logarithm functions and discuss their asymptotes and applications.	**12.3.3.13** Solve problems on applications of integration.
11.3.3.14 Derive and sketch graphs of circles.	
11.3.3.15 Convert and write equation of circles in standard form $(x - h)^2 + (y - k)^2 = r^2$	

Strand 4: Statistics and probability

Rationale

In the study of social science, students might encounter data. In a science laboratory experience, students might collect data. In a mathematics classroom, students would be expected to know how to calculate the mean of a set of numbers. Statistics has become more important, its connections with everyday literacy, science, health, and the social sciences suggest statistics must be taught across the curriculum as a topic in mathematics. Probability is required for reading newspapers, being an informed citizen, it helps one to understand and evaluate information in the world around us, and it is a prerequisite knowledge for other fields of study. In the current curriculum design, students may encounter probability topics, by themselves or in connection with descriptive statistics as early as elementary level, or as late as senior high school.

Evidence Outcomes

Grade 11	Grade 12
At the end of the grade, all students can; • construct stem and leaf plots, frequency polygons and histogram, cumulative frequency distribution. • intepret and analyse data by calculating the various measures of central tendency. • calculate percentile,quartile and interquartile ranges and interpret left and right skewed distribution. • calculate mean, variance and standard deviation. • explain sets and elements, define equality of sets, subsets and Venn diagram, and apply universal sets and complement of a set, discussing some algebraic laws, and solve related problems. • interpret data by calculating probabilities of events, from experiamental data and life data tables, compound events of two-dimensational grids and tree. • calculate probabilities for simple events under different relationships such as inclusion, disjoint, complementary, independent and dependent, mutually and non-mutually exclusive, with replacement and without replacement.	At the end of the grade, all students can; • plot scatter diagrams, draw line of best fit and recognise linear and non-linear relationship. • calculate regression and correlation coefficient, *r,* and write equation of the regression line, and interpret regression and correlation coefficients in the context of the problem. • use appropriate technology as a tool for problem solving.

Content Standard 4: Students will be able to investigate how to interpret data using methods of exploratory data analysis, develop and evaluate inferences, predictions and arguments that are based on data and understand and apply basic notions of chance and probability.

Grade 11 Benchmarks	Grade 12 Benchmarks
11.4.4.1 Explore data by constructing stem and leaf plots, frequency polygons and histogram, cumulative frequency distribution.	**12.4.4.1** Plot scatter diagrams, draw line of best fit and recognise linear and non-linear relationship.
11.4.4.2 Explore, intepret and analyse data by calculating the various measures of central tendency.	**12.4.4.2** Calculate regression and correlation coefficient, *r,* and write equation of the regression line, and interpret regression and correlation coefficients in the context of the problem.
11.4.4.3 Calculate Percentile, quartile, inter-quartile ranges and interpret left and right skewed distribution	**12.4.4.3** Use appropriate technology to aid concept development as a tool for problem solving.
11.4.4.4 Calculate mean, variance and standard deviation.	
11.4.4.5 Define sets and elements, equality of sets and subsets, and venn diagram.	
11.4.4.6 Identify and explain various sets and represent sets on venn diagram.	
11.4.4.7 Apply universal sets and complement of a set, discussing some algebraic laws, and solve related problems.	
11.4.4.8 Explore, analyse and interpret data by calculating probabilities of events, from experiamental data and life data tables, compound events of two-dimensational grids and tree.	
11.4.4.9 Explore, analyse and interpret data by calculating probabilities of mutually and non-mutually from the venn diagrams and calculate using the addition and multiplication rules of probability.	

Assessment, Monitoring, and Reporting

The relationship between content standards, benchmarks and performance standards is that they all define students' expected level of proficiency or education quality but at different levels of schooling. Content standards describe the national expectations that all Papua New Guinean students are expected to meet while benchmarks describe the grade-level expectation that all students in a particular grade must meet before proceeding to the next grade. Conversely, performance standards describe students' level of proficiency in a specific knowledge, skill, value or attitude taught in a lesson and measure students' progress towards meeting grade-level expectations and the content standards. Effective instruction and assessment are aligned to performance standards, grade-level expectations, and national content standards.

What is Assessment?

The term "assessment" is generally used to refer to all activities that teachers use to assess students' mastery of what is learned, and to measure and monitor students' progress towards meeting grade-level expectations and the content standards. Assessment is an on-going process of gathering and interpreting information about students' performance and progress towards meeting grade-level expectations as well as the achievement of the content standards described in the subject syllabuses. Data should also be used to help and guide students who are yet to meet grade-level and national expectations to make the required progress towards meeting these expectations.

What is Standards-Based Assessment?

In standards-based curriculum, assessment is used to assess students' level of competency or proficiency of a specific knowledge, skill, value, or attitude taught using a set of performance standards (indicators or descriptors) and measuring, monitoring, evaluating, and reporting their progress towards meeting grade and national-level expectations. Assessment is viewed not only as a measurement activity that is performed after a course or a curriculum topic has been taught (summative), but more importantly, as a continuous process (formative) that provides students' performance data to teachers and students regarding their progress towards achieving the intended standards. Timely and ongoing assessment of student's learning and mastery of what is learned are key to the learning process and the attainment of the desired learning outcomes.
Throughout the year, teachers will be assessing students' performance and progress towards meeting each grade-level benchmark (grade-level expectation) and each content standard (national-level expectation), and using the data to identify areas where a student or a group of students need more attention, and monitor their progress towards meeting the required standards.

Purpose of Assessment

The primary purpose of assessment is to improve students' learning and teachers' teaching. The other purposes of assessment are to;

- improve students' learning, levels of proficiency, and progress towards meeting the expected standards,
- provide data that teachers, schools and Department of Education can use to make informed decisions about how to improve the quality of teaching and learning in the education system,
- inform teachers about the progress of students towards meeting grade-level and national expectations (standards) and enable them to adjust their lesson planning, instruction, and assessment to improve student learning and proficiency levels,
- inform parents and guardians about their students's achievements and status of progress towards meeting national standards; and what needs to be done to close the gaps and enable children to make the progress required to meet these standards, and
- provide information for schools and systems about teaching strategies, resource allocations and curriculum, and other educational institutions, employers and the community about the achievements of students in general or of particular students.

Whatever its purpose, assessment is seen as an integral part of the teaching and learning program rather than a separate process.

Types of Assessment

The following types of assessment have been adopted to assess and monitor students' achievement of the education standards.

- Assessment For Learning
- Assessment Of Learning
- Assessment As Learning

Assessment For and Assessment Of Learning are also known as formative and summative assessments.

Assessment For Learning

Assessment For Learning (AFL), also known as classroom assessment is different. It is an ongoing process that arises out of the interaction between teaching and learning. It is not used to evaluate learning but to help learners learn better. It does so by helping both students and teachers to understand;

- the performance standards, grade-level benchmarks and content standards that students are expected to meet to achieve the desired level of proficiency or quality of education,

- where each learner is in relation to the national curriculum standards,
- where they need to be, and
- what they need to do to make progress towards meeting the expected standards.

Assessment Of Learning

Assessment Of Learning (AOL) is the use of a task or an activity to measure, record, and report on a student's level of achievement in regards to specific learning expectations such as unit tests and end of term or year exams. It is normally referred to as Summative Assessment.

Assessment As Learning

Assessment As Learning (AAL) is the use of an assessment task or an activity by the teacher in his/her everyday teaching. This strategy provides students with opportunities to understand what they have learnt or are having difficulties with. Self and peer assessments allow students to reflect on their own learning and identify areas of strengths and weaknesses. These tasks offer students the chance to set their own personal goals to improve their own learning.

Diagnostic Assessment

Apart from these three main types of assessment, teachers are expected to do the diagnostic test/assessment to identify strengths and weaknesses in students. This can be done before any teaching and learning of a new content and for new entry levels for students.

Diagnostic assessment is a form of pre-assessment that allows a teacher to determine students' individual strengths, weaknesses, knowledge, and skills prior to instruction. It is primarily used to diagnose student difficulties and to guide curriculum and lesson planning.

Assessment Methods

These are some methods that teachers can use to assess students' performance.

- Observing students during the lesson
- Conferencing with students
- Student's Portfolio
- Tests
- Assignments
  - Projects
  - reports
  - practical work sample
- Quizes
- Presentation

Recording and Reporting

Recording

Teachers must keep accurate records of students' performance and achievements. They must report these achievements in fair and accurate ways to parents, guardians, teachers and students. Examples of recording methods include;

- anecdotal notes in a journal or diary,
- checklists,
- portfolios of students' work,
- progressive records, and
- work samples with comments written by the teacher.

Reporting

Reporting is communicating clearly to students, parents, guardians, teachers and others the information gained from assessing students' learning.

Students' reports should be based on assessment information collected from ongoing assessments. Schools will decide on how best the reports will be presented to suit the needs of their communities. Methods will include interviews and written reports. Written reports should include;

- a written record of progress made towards meeting grade-level expectations and the attainment of content standards by each student since the previous report,
- a written record of each student's learning and mastery problems and what needs to be done to make the required progress towards meeting grade-level benchmarks and national content standards, and
- information about students' attitudes, values and general behaviour.

Monitoring and Evaluation

Assessment information should be used to make judgments about students' achievements and monitor their progress towards meeting grade-level expectations and national content standards.

Monitoring

Data from performance assessment should be used to monitor and report on students' performance towards meeting grade-level and national expectations. Performance standards or indicators should be used to report and keep a tab on each students' progress towards meeting the expected level of proficiency or competency. Teachers should develop a clear and measurable set of performance standards or indicators to monitor and report on students' progress and achievements on a regular basis.

Evaluation

Teachers should use assessment data to evaluate the effectiveness of their teaching and their students' learning, and make improvements to their teaching practices in order to improve student learning outcomes. Evaluation tools such as written records, questionnaires, logs and diaries, submissions or records of meetings and discussion with general staff members, teaching staff, parents and other community members should be used to evaluate students and teachers' competency levels, and make informed decisions about how these could be improved.

Glossary

Terms	Definitions
Absolute Value	The magnitude of a number, irrespective of whether it is positive or negative, symbolized by placing the number within vertical bars, thus |8| = |-8| = 8
Algorithm	A recursive procedure where by an infinite sequence of terms can be generated.
Amplitude	The farthest distance that a vibrating or oscillating system such as a pendulum travels from a mean or zero point.
Analogue computer	A computer that uses a variable physical quantity such as voltage to represent data.
Angular velocity	The rate of rotation of a body around an axis. Symbol ω
Arc length	Length of circular arc.
Arithmetic Progression	A sequence of numbers in which a constant figure common difference is added to each term to give the next.
Asymptote	A line that draws increasingly nearer to a curve without ever meeting it.
Binomial	Algebraic expression that consists of exactly two terms separated by + or -, such as x + y or ab – cd.
Bisector	A straight line or plane that divides an angle or another line into two exactly equal parts.
Complex Numbers	any number of the form a + *i*b, where a and b are real numbers and $i = \sqrt{-1}$
Congruent	Objects and figures that have the same size and shape. The shapes can be turned into one another with a flip, rotation or turn.
Continuity	Functions which tangents can be drawn at any point on the curve.
Correlation	The degree to which two or more variables are related and change together.
Correlation Coefficient	A number or function indicating the degree of correlation between two variables. It ranges between 1 for high positive correlation to -1 for high negative correlation, with 0 indicating a purely random relationship.
Determinant	A square array of elements that itself has a numerical value, used in various mathematical processes such as solving simultaneous equations and studying linear transformations.
Domain	The set of possible values specified for a given mathematical function.
Elevation	The height above a specific reference point, especially sea level.
Exponential	Describes a mathematical entity such as a curve, function, equation, or series that contains, is expressed as, or involves numbers or quantities raised to an exponent.
Extrapolate	To estimate a value that falls outside a range of known values, *e.g.* by extending a curve on a graph.
Factorial	The number resulting from multiplying a whole number by every whole number between itself and 1 inclusive. 6 factorial, or 6! is 6 x 5 x 4 x 3 x 2 x 1 = 720. Symbol!
Functions	A variable quantity whose value depends upon the varying values of other quantities.
Geometry	The branch of mathematics that is concerned with the properties and relationships of points, lines, angles, curves, surfaces, and solids.
Imaginary number	any complex number of the form *i*b, where $i = \sqrt{-1}$
Index	A number or variable given as a superscript before a square-root sign showing which root is to be taken.
Inequality	A mathematical equation containing either a greater than, less than or not equal to symbols.
Inferences	The process of reasoning from a premise to a conclusion.

Integration	The mathematical process of finding the solution of a differential equation or a function whose differential equation is known.
Interpolate	To estimate the value of a mathematical function that lies between known values, often by means of a graph.
Interquartile	A measure of the spread of a group of values equal to the difference between the upper limit for the lower quarter and the lower limit for the upper quarter.
Irrational Number	A number that cannot be represented as a decimal or as a fraction. A number like pi is irrational because it contains an infinite number of digits that keep repeating, many square roots are irrational number
Limit	A numerical value approached by a mathematical function as the independent variable of the function approaches infinity or a specific value.
Linear Velocity	Velocity, in physics, rate of linear motion of a body in a particular direction. Velocity is a vector—that is, it has both magnitude and direction.
Logarithm	The power to which a base must be raised to equal a given number. For example, the logarithm of 8 to the base 2 is 3, since $2^3 = 8$.
Matrix	A rectangular array of mathematical elements, e.g. the coefficients of linear equations, whose rows and columns can be combined with those of other arrays to solve problems.
Maxima	The greatest value that a continuous function can attain over a specific interval.
Minima	The smallest value of a continuous function over a particular interval.
Normal	A line or plane that is perpendicular to another line or plane.
Percentile	A value on a scale of one hundred that indicates whether a distribution is above or below it.
Position Vectors	The vector of a point drawn from an origion to the point.
Quartile	Each of the three values that divide a frequency distribution into four parts that each contain a quarter of the sample population.
Radical	Relating to the roots of numbers.
Rational	Able to be expressed exactly as the quotient of two whole numbers or polynomials.
Real numbers	A number that is either, rational or irrational rather than imaginary.
Recurring Decimals	A decimal number in which one or more digits recur indefinitely after the decimal point.
Scalar Product	A number scalar equal to the product of the magnitudes of any two vectors and the cosine of the angle formed between them.
Skewed Distribution	Distribution being in a slanted or unsymmetrical position.
Standard Deviation	A statistical measure of the amount by which a set of values differs from the arithmetical mean, equal to the square root of the mean of the differences' squares.
Stationary point	a point on a curve where the gradient is zero.
Tangent	A geometric line, curve, plane, or curved surface that touches another curve or surface at one point but does not intersect it.
Tessellation	To fit together without leaving any spaces (refers to geometric shapes)
Transformation	A change in the position or direction of the axes of a mathematical coordinate system without changing their relative angles.
Truncated	Describes a geometric figure that has the apex or an end removed and replaced with a plane section, often parallel to the base.

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