Physics

Senior High

Grades 11 and 12

Syllabus

Standards-Based

Department of Education

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Issued free to schools by the Department of Education

Published in 2020 by the Department of Education, Papua New Guinea.

Graphic Design Layout by David Kuki Gerega

ISBN 978-9980-905-74-1

Contents

Acknowledgements

Grades 11 and 12 Physics Syllabus was developed by the Curriculum Development Division of the Department of Education. It was coordinated by Gibson Jack with assistance from the Subject Curriculum Group (SCG) members and the writing team.

Dr. Arnold Kukari, Technical Advisor - Curriculum, is acknowledged for his technical advice on the development of this syllabus. Curriculum Panel (CP), Syllabus Advisory Committee (SAC), and Board of Studies (BoS) Committee members are also acknowledged for their consideration and endorsement of the syllabus.

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
OBC	Outcome-Based Curriculum
OBE	Outcome-Based Education
PNG	Papua New Guinea
SAC	Syllabus Advisory Committee
SBC	Standards-Based Curriculum
SBE	Standards-Based Education
SCG	Subject Curriculum Group
STEAM	Science, Technology, Arts, 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 career, 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. Essential STEAM principles, concepts, processes, and skills have been embedded in the national content standards and grade-level benchmarks to enable all students to learn and use these to solve problems created by both the natural and physical environments by developing creative and innovative solutions.

The realigned Science curriculum is focused on scientific skills and process, utilizing the analytical and inquiry based approaches where students will be encouraged to predict, explore, question, test ideas, formulate questions and challenge their own ideas and overtime become scientifically literate. Scientific literacy is critically important for Papua New Guinea to participate productively in an increasingly competitive knowledge and technologically based societyThe

By the end of grades 11 and 12, all students will acquire the essential Physics proficiencies and develop the ability to be creative, innovative, productive, and competitive in diverse knowledge and technology-based contexts.

Teachers are encouraged to use the syllabus, in conjunction with the teacher guides and other relevant resources, to teach the Physics content and enable all students to progressively learn and master the essential scientific knowledge, skills, values, and attitudes.

I approve and commend this Grades 11 and 12 Physics Syllabus to be used by teachers in all Senior High Schools throughout Papua New Guinea.

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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 science continue to emerge and evolve, and impact on our lives in many different ways.

Papua New Guinea needs to be on par with the rest of the world. The need to understand and use science in everyday life, in schools, and in the workplace has never been greater. Physics knowledge, skills, values, and attitudes are needed in a variety of careers, including STEAM related careers, in the 21st Century. The 21st Century job market is very competitive. Those who do not possess the in-demand proficiencies will find it difficult to get any sort of employment or create and sustain their own career pathways. Thus, it is important that students are encouraged, motivated, and enabled to develop a scientific attitude of the mind to enjoy learning Physics and, simultaneously, achieve high academic standards and attain the required career, higher education, and citizenship proficiencies before leaving school.

In this Century and beyond, those who understand and can-do science will have more opportunities and options to create and sustain a future of their choice. Scientific competence increases career choices and opens doors to productive and rewarding futures. All students should be provided the opportunity and necessary support to learn Physics and achieve the expected Physics standards and proficiencies before leaving school.

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

Time allocation for grades 11 and 12 Physics is 240 minutes per week.

Teacher can use the time allocated to do their time table or program according to their school needs.

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 social, economic, political, cultural, religious, philosophical, environmental, and educational values and beliefs. Curriculum principles are evidence-based and influenced by best practice. The following principles underpin the design, development, and implementation of SBC in PNG.

Relevance

The national curriculum should target the national, community, and personal; social, economical, 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

PNG 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 as 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;

- 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, 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 PNG 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 PNG 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 both girls and boys.

Females are generally a disadvantaged group in PNG. PNG 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, and cultural language, or 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 the 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.

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

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 proficiencies 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 knowledge, skills, values, and attitudes to be taught from prep to post-secondary school level to provide opportunities for all students to attain STEAM related proficiencies before leaving school. 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 pursue STEAM related academic programs in institutions of higher education.

Standards-Based Curriculum Principles

The principles of 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

Physics Rationale, Aim and Goal, and Guiding Principles

Papua New Guinea like any other countries in the world is also making concerted efforts to boost student achievement in literacy, numeracy and Life skills. Science course is no exception since Science is regarded as a key life skill and efforts are aimed at improving science education to develop deep, lasting changes in how students learn this critical yet vital subject.

Across the world, there is an increased demand to pursue careers in science, technology, and engineering that drive the innovation and invention necessary for economic growth and improving the quality of life. To meet this demand, it is increasingly important to prepare significant proportions of students to enter advanced study in these areas.

Their understanding of science should build throughout their schooling so that when, as adults, they are faced with decisions relating to such diverse issues as the treatment of diseases, climate change, and the applications of technology, they are able to act from a sound scientific basis.

Science is organised around four main strands – Science as Inquiry, Physical Science, Life Science, and Earth and Space Science. These strands are comparable with the strands used internationally. Therefore, the learning of key science concepts, ideas, processes and inquiry methods should start at the early stage of a child's education. The scientific method should be re-emphasised at various stages of a child's education until the child masters the methods. This will prepare a student well to take on higher studies in science.

Science has been always the main driver for all creativity, innovation, discoveries, inventions or constructions. Science is also fundamental in life because it has direct application to nearly all aspects of life and society, from sustaining humankind survival through the maintenance and improvement of lifestyles and health to understanding and solving local, regional, and global issues.

Physics Rationale

Physics is one of the most fundamental scientific disciplines, and its main goal is to understand how the universe behaves. The grades 11 and 12 Physics course for the secondary school level in PNG is to provide the students with a broad understanding of the physical principles of the universe, to help them develop critical thinking and quantitative reasoning skills, to empower them to think creatively and critically about scientific problems and experiments, and to provide training for student planning careers in physics and in the physical sciences broadly defined, including those whose interests lie in research, P-12 or college teaching, industrial jobs, or other sectors of our society.

Developing a broad understanding of the physical understanding of the physical principles of the universe requires a detailed knowledge of a wide range of topics, requiring a highly structured program of courses. The contents are designed to develop strong mathematical and analytical skills, good laboratory skills, and effective oral and written communication skills.

Ultimate Aims of Science

The Science Course aims are to:

(i) Guide students in acquiring knowledge with understanding for application in their daily lives such that they;

- are motivated to learn science through contextual and hands-on learning,
- are able to problem-solve and use thinking and inquiry processes,
- can communicate effectively,
- develop safety consciousness and safe practice and
- become confident citizens who are able to cope with the changing and progressive nature of science and technology in the world.

(ii) Enable students to develop 21st Century competencies which would;

- enable them to acquire problem-solving skills and use thinking and inquiry processes,
- enable them to become responsible individuals and productive citizens,
- enable them to acquire life-long learning skills,
- enable them to show care and concern for people and the environment and
- allow them to use information communication technology (ICT) for communications, collaboration and as a tool for data collection and the analysis of results.

(iii) Enable students to be suitably prepared for post-secondary courses, such that they;

- develop abilities and skills which would also be relevant and useful in the work place and
- become aware of the impact of science and technology on society, industry, and business.

Science Goals

Students will be able to;

- cultivate and maintain an attitude to respect life, care for nature, and contribute to the protection of the environment,
- help develop and sustain Papua New Guinea's environment and its physical and human resources, for the benefit of current and future generations,
- become wise guardians of Papua New Guinea's resources and
- 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.

Science Guiding Principles

The science curriculum principles identify, describe and focus attention on the important concerns that must be addressed when developing and implementing science curriculum. There are the underlying guidelines in which both the teacher and the learner should be aware of and be focused on when teaching or learning Science.

The recipients should be able to develop a certain level of sensitivity to the implications of science for individuals and society and understand that science is a human endeavour with consequent limitations. Students should be guided to create an interest and openness to new ideas, to critically analyse situations, generate new theories and ideas, develop intellectual honesty, integrity and respect for evidence based on data and value the outcome of what is explored and gathered. The science at Senior High School founded on the following guiding principles:

- Community and Student-Centred Science Learning.
- Science as inquiry.
- Creating and Promoting a Safe Working Environment.
- Instructional Technology.
- Links to other learning areas (cross-curricular).

Science as Inquiry

Scientists engage in scientific inquiry by following key science practices that enable them to understand the natural world and answer questions about it. Learning science is something that students do, not something that is done to them. Hands-on activities, while essential are not enough. Students must have minds-on experiences in which they become fully engaged in creative scientific thinking.

Students of science must become proficient at these practices to develop an understanding of how the scientific enterprise is conducted. These practices include skills from daily life and school studies that students use in a systematic way to conduct scientific inquiry. These include students asking questions, make observations, make predictions and carry out experiments to test their predictions.

The science practices are fundamental to all science disciplines. When students are engaged, they are:

- Asking questions based on observations.
- Generating evidence.
- Working with data.
- Answering the research question.
- Making an argument from evidence.

Five practices that are fundamental to scientific inquiry are represented in detail in the Grades 11 and 12 Teachers Guides. In this syllabus the Science as Inquiry recommended for Grades 11 and 12 are provided in the table below and are also expanded in the teachers' guides.

Grade 11 recommended working scientifically skills	Grade 12 recommended working scientifically skills
• Perform tests, collect data, analyse relationships, and display data. • Identify and communicate • Identify and examine possible and reasons • Formulate explanations by using logical thinking and evidence. • Solve scientific problems • Examine the usefulness of data presented	• The locations, sequences, or time intervals • Recognise and assess the issues of statistical variability and the need for controlled tests. • Analyse situations and solve problems • Combining and applying concepts from more than one area of science. • Researching the literature, analyse data, and communicating the findings • Determine when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent.

Monitoring and Mastering Science Inquiry skills

The table below shows the expectation for students studying Science to master the Science Inquiry Skills from Preparatory to Grade 12. It shows:

- **Emerging** – when the student starts
- **Progressing** – when the student shows evidence of progressing and working towards mastering the skill
- **Mastering** – When the student has mastered the skill and is able to apply in all life situations.

This practice must be on-going and progressively carried out throughout the child's learning in that particular grade.

Schools are encouraged to use this for each student and should be passed on to the next grade so the students mastery level of each skill is monitored right throughout their learning from Preparatory to grade 12.

Level of skills	Low				Medium					High			
Inquiry Skills by grades	P	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	G 10	G 11	G 12
Observing	*	*	**	***	***	***	***	***	***	***	***	***	***
Classifying		*	*	**	***	***	***	***	***	***	***	***	***
Measuring		*	*	**	**	**	***	***	***	***	***	***	***
Inferring				*	**	**	***	***	***	***	***	***	***
Predicting			*	**	***	***	***	***	***	***	***	***	***
Hypothesizing				*	*	**	***	***	***	***	***	***	***
Experimenting				*	**	**	***	***	***	***	***	***	***
Communicating			*	**	**	**	***	***	***	***	***	***	***
Researching				*	*	*	**	***	***	***	***	***	***
Problem-solving				*	*	**	**	***	***	***	***	***	***
Identifying and controlling variables				*	*	*	**	**	**	***	***	***	***
Use/make models			*	*	**	**	***	***	***	***	***	***	***
Use numbers				*	*	**	**	***	***	***	***	***	***
Collect data				*	*	*	**	**	**	***	***	***	***
Analyse relationships						*	*	**	**	***	***	***	***
Use appropriate tools and techniques to make observations and gather data				*	**	***	***	***	***	***	***	***	***
Assess the reliability of data that was generated in the investigation					*	**	***	***	***	***	***	***	***
Formulating questions that can be answered through scientific investigations				*	*	*	**	**	***	***	***	***	***
Formulate explanations by using logical thinking and evidence							*	*	*	**	**	***	***
Proving scientific theories as facts or fraudulent										*	**	***	***
Identifying and explaining mis-conceptions							*	*	*	**	***	***	***
Looking for patterns and meanings								**	**	***	***	***	***
Read, interpret and examine the credibility and validity of scientific claims in different sources of information							*	*	*	**	**	***	***
Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.							*	**	**	***	***	***	***
Explain and distinguish independent and dependent variables including those that are kept constant and those used as controls.							*	**	**	***	***	***	***
Use mathematical operations to analyse and interpret data and present relationships between variables in appropriate forms.							*	**	**	***	***	***	***

Draw conclusions and present plausible explanations based on research data and assess results based on the design of the investigation								*	*	**	**	***	***
Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.					*	*	*	**	**	***	***	***	***
Science as Inquiry/grades	P	G1 G	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Level of skills	**Low**				**Medium**					**High**			

The number of asterisks denotes the amount of emphasis given to each process skill in each year level.

* Emergent ** Progressive *** Mastery

Enhancing Science Teaching and Learning Using Instructional Technology

The use of current and emerging technologies is essential to the P–12 Sciences instructional program. Specifically, technology must accomplish the following:

- Assist in improving every student's functional literacy. This includes improved communication through reading/information retrieval (the use of telecommunications), writing (word processing), organization and analysis of data (databases, spreadsheets, and graphics programs), presentation of one's ideas (presentation software), and resource management (project management software).
- Be readily available and regularly used as an integral and ongoing part of the delivery and assessment of instruction.
- Include instrumentation oriented toward the instruction and learning of science concepts, skills, and processes. Technology, however, should not be limited to traditional instruments of science, such as microscopes, lab ware, and data-collecting apparatus, but should also include computers, robotics, interactive-optical laser discs, video-microscopes, graphing calculators, CD-ROMs, probe ware, global positioning systems (GPS), online telecommunication, software and appropriate hardware, as well as other emerging technologies.
- Be reflected in the "instructional strategies" generally developed at the local school division level.

In most cases, the application of technology in science should remain "transparent" unless it is the actual focus of the instruction. One must expect students to "do as a scientist does" and not simply hear about science if they are truly expected to explore, explain, and apply scientific concepts, skills, and processes.

As computer/technology skills are essential components of every student's education, it is important that teaching these skills is a shared responsibility of teachers of all disciplines and grade levels.

Creating and Promoting a Safe Working Environment

During Science lessons, teachers must be certain that students know how to follow safety guidelines, demonstrate appropriate laboratory safety techniques, and use equipment safely while working individually and in groups. Safety must be given the highest priority in implementing the instructional program for science. Correct and safe techniques, as well as wise selection of experiments, resources, materials, and field experiences appropriate to age levels, must be carefully considered with regard to the safety precautions for every instructional activity. Safe science classrooms require thorough planning, careful management, and constant monitoring of student activities. Class enrolment should not exceed the designed capacity of the room.

Teachers must be knowledgeable of the properties, use, and proper disposal of all chemicals that may be judged as hazardous prior to their use in an instructional activity. The identified precautions involving the use of goggles, gloves, aprons, and fume hoods must be followed as prescribed.

While no comprehensive list exists to cover all situations, the following should be reviewed to avoid potential safety problems. Appropriate safety procedures should be used in the following situations:

- observing wildlife; handling living and preserved organisms; and coming in contact with natural hazards, such as poison ivy, ticks, mushrooms, insects, spiders, and snakes;
- engaging in field activities in, near, or over bodies of water;
- handling glass tubing and other glassware, sharp objects, and lab ware;
- handling natural gas burners, Bunsen burners, and other sources of flame/ heat;
- working in or with direct sunlight (sunburn and eye damage);
- using extreme temperatures and cryogenic materials;
- handling hazardous chemicals including toxins, carcinogens, and flammable and explosive materials;
- producing acid/base neutralization reactions/dilutions;
- handling power equipment/motors, and;
- working with high voltage/exposed wiring

STEAM Rationale, Aim and Goals, and Guiding Principles

Rationale

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 elementary 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, skill, values, and attitudes to solve real problems and come up with 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.

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 a particular subject, grade, or school level. They embed essential knowledge, skills, values, and attitudes that all students are expected to learn and master in each strand or unit to prepare them for the next grade or 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 proficiency.

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. They 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 Physics.

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 and 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 11.1.1**. and **Benchmark** as **11.1.1.1**

Content Overview

Physics grades 11 and 12 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 is further expanded to units which has a rationale that justifies its inclusion in the science curriculum.

Each unit embeds a particular aspect of Physics and articulates the subject matter to be learnt. What students are expected to learn and demonstrate proficiency on is described in the unit content standard. Each unit 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 Physics strands and units for grades 11 and 12 are as follows:

Table of strands and units

	Strand	Grade 11 Units	Grade 12 Units
PHYSICS	**Science as Inquiry**	• Quantities and Measurement	• Embedded in Grade 12 Physical Science
	Physical Science	• Kinematics (Motion) • Dynamics (Force and Motion) • Work, Energy and Power • Electricity • Electronics	• Fluid Mechanics • Thermal Physics • Waves • Electromagnetism • Atomic and Nuclear Physics

Grades 11 and 12 Strands

Strand 1 : Science as Inquiry

Rationale

Scientists engage in scientific inquiry by following key science practices that enable them to understand the natural world and answer questions about it. Learning science is something that students do, not something that is done to them. Hands-on activities, while essential are not enough. Students must have minds-on experiences in which they become fully engaged in creative scientific thinking. Students of science must become proficient at these practices to develop an understanding of how the scientific enterprise is conducted. These practices include skills from daily life and school studies that students use in a systematic way to conduct scientific inquiry.

Science as inquiry refers to the many ways in which scientists study the natural world. When engaging in inquiry, students make observations by describing objects and events, ask questions, plan their activities, gather information, test ideas and carry out investigations and deducing their own conclusions, communicate their understanding to others and consider alternative explanations

Evidence Outcomes

At the end of grades 11 and 12, all students can:

- Identify and formulate questions that can be answered through scientific investigation.
- Read, interpret, and examine the credibility and validity of scientific claims in different sources of information.
- Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.
- Design and conduct appropriate types of scientific investigations to answer different questions.
- Explain and distinguish independent and dependent variables, including those that are kept constant and those used as controls.
- Use appropriate tools and techniques to make observations and gather data.
- Assess the reliability of the data that was generated in the investigation.
- Use mathematical operations to analyse and interpret data, and present relationships between variables in appropriate forms.
- Draw conclusions and present plausible explanations based on research data, and assess results based on the design of the investigation.
- Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.

Grade 11 and 12

Unit 1: Quantities and Measurement

Senior high school students will be able to use the scientific reasoning and Physics skills they learned at senior high school level to be able to carry out independent scientific investigations and analyse and communicate their findings using various communication tools that are available.

This unit runs from grade 11 to grade 12, however, there is not specific content or actual lessons in grade 12. In grade 12 this unit is embedded within the physical science units. The students will apply the skills, knowledge, skills, attitudes and values learned in grade 11.

Content Standard: 11.1.1 and 12.1.1

Students will be able to explain the nature and the processes of scientific inquiry and use the modes of scientific inquiry and habits of mind to investigate and interpret the world around them.

Grade 11 Benchmarks	Grade 12 Benchmarks
11.1.1.1 Identify appropriate quantities, their units and measurement methods using the metric system.	**12.1.1.1** Use appropriate tools and techniques to make observations and gather data.
11.1.1.2 Design and conduct appropriate types of scientific investigations to answer different questions.	**12.1.1.2** Assess the reliability of the data that was generated in the investigation.
11.1.1.3 Use appropriate tools and techniques to make observations and gather data.	**12.1.1.3** Use mathematical operations to analyse and interpret data, and present relationships between variables in appropriate forms.
11.1.1.4 Use mathematical operations to analyse and interpret data, and present relationships between variables in appropriate forms.	**12.1.1.4** Draw conclusions and present plausible explanations based on research data, and assess results based on the design of the investigation.
11.1.1.5 Apply mathematical operations to solve scalar and vector operations.	**12.1.1.5** Communicate about science in different.

Strand 2: Physical Science

Rationale

Students can develop skills and knowledge of science by studying about the properties of matter in its three states, namely, solids, liquids and gases. Students are also expected to learn about why things move and study about the forces that are responsible for the motion. In this strand, the main focus will be on the physical principles and laws of the universe and how it functions. Therefore, physical science strand in Physics subject mainly focuses on units under force and motion and energy and how they interact.

Evidence Outcomes

Grade 11	Grade 12
At the end of the grade, all students can; • Describe the characteristics of motion by applying the equations of motion and graphs. • Use vectors to explain force and motion. • Explain the characteristics of motion by using graphs. • Apply the laws of motion to determine the effects of forces on the linear motion of objects. • Describe circular motion. • Calculate momentum using the concept of conservation of momentum. • Differentiate between work, energy and power in mechanics. • Predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, capacitors and inductors. • Solve problems involving Ohm's law. • Classify types of resistors using their properties. • Deduce power consumption rate and cost at home. • Describe how atoms interact by transferring or sharing electrons. • Examine the uses of semiconductor materials. • Explain the behavior and functions of diodes and resistors in electronic circuits • Examine and explain the types and functions of logic gates.	At the end of the grade, all students can; • Explain and provide examples of electromagnetic radiation and sound using a wave model. • Calculate the efficiency of energy transfer within biological and physical systems. • Investigate the structure of matter including atoms, protons, neutrons, and electrons. • Examine and explain how atoms interact by transferring or sharing electrons. • Research the nature of solids, liquids, and gases by examining molecular structures. • Research nuclear reactions and how they produce energy. • Examine how atoms bond using valence electrons. • Research and analyse transverse and longitudinal waves and their properties. • Determine that the magnitude of the force on a moving particle (with charge q) in a magnetic field is qvB sin (a), where a is the angle between v and B (v and B are the magnitudes of vectors v and B, respectively), and students use the right-hand rule to find the direction of this force.

Grade 11

Unit 1: Kinematics (Motion)

There are many different types of motion occurring around us all the time. People are walking, cars are being driven along the roads, airplanes are flying in the sky, footballs are being kicked, tapes are rotating on video recorders, and mail is being sorted and so on. Thus movement forms an important part of our everyday life that the students need to master the kinematics contents.

Content Standard: 11.2.1

Students will be able to examine and explain the structure, properties and changes of motion with motion equation.

Benchmarks

11.2.1.1 Derive and use equations of motion.

11.2.1.2 Demonstrate the characteristics of motion by using graphs.

11.2.1.3 Analyse free fall and projectile motion.

Unit 2: Dynamics (Force and Motion)

You make forces all the time. Forces press on you, and you use them to press on objects. Pushing your foot against your bicycle pedal makes a force. The force sets the bike in motion. Every time something starts moving or stops moving, a force is responsible.

You use force to throw a ball in the air. The force of Earth's gravity pulls the ball back down. Every step you take creates a force on your foot and on the ground. Forces and motion are part of everyday life. The Dynamics phenomena are vital and the study of it will enable students to understand and make fair decisions on the dynamic principles in the world.

Content Standard 11.2.2
Students will be able to investigate and derive Newton's Laws of motion and apply it to the physical world.

Benchmarks

11.2.2.1 Analyse the relationship between force, mass and motion of objects, and the major natural forces of gravitational, electric and magnetic.
11.2.2.2 Use vectors to explain force and motion.
11.2.2.3 Apply the laws of motion to determine the effects of forces on the linear motion of objects.
11.2.2.4 Analyse circular motion.
11.2.2.5 Define and apply the laws of conservation of momentum.

Unit 3: Work, Energy and Power

The ability to work or generate an effort results in the production of moment. The study of energy and momentum covers. It is for the best benefit for students to understand the transformation of energy from one form to another and the conservation of energy. To collect data in experimental collisions and calculation of energy, students can make better decisions in understanding the right energy for a moment.

Content Standard 11.2.3

Students will be able to identify and explain work, power and energy within physical and natural phenomenon

Benchmarks

11.2.3.1 Define and explain work within physical systems.

11.2.3.2 Calculate the efficiency of energy transfer within physical systems.

11.2.3.3 Apply the concepts of power to solve problems.

Unit 4: Electricity and Magnetism

Electricity is a powerful force of nature. Electricity is everywhere in the universe. Electrical forces hold water, metals, and all other kinds of matter together. You can walk and run because electric signals go through your nerves from your brain to your muscles. The signals tell your muscles where to move.
Electricity makes many machines work. Electricity makes bulbs light up and runs motors in saws, fans, hairdryers, and other appliances. The computer you are using works because of electricity. To fully understand all the electrical phenomena, the study of it is essential.

Content Standard 11.2.4

Students will be able to investigate and explain the electricity phenomena and processes in the physical and natural world.

Benchmarks

11.2.4.1 Explain charged particles as sources of electric fields and are subject to the forces of the electric fields from other charges.

11.2.4.2 Predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, capacitors and inductors.

11.2.4.3 Solve problems involving Ohm's law.

11.2.4.4 Establish that any resistive element in a DC circuit dissipates energy, which heats the resistor.

11.2.4.5 Calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula.

$$Power = IR \text{ (potential difference)} \times I \text{ (current)} = I^2R.$$

11.2.4.6 Determine the static electric field patterns produced by arrangement of electric charge(s).

Unit 5: Electronics

Electric charge comes from the parts inside atoms. There are two kinds of electric charge called positive charge and negative charge. Positive charge comes from the nucleus of an atom. Negative charge comes from electrons. Atoms do not normally have any overall charge because their positive and negative charges cancel each other out. Charge comes when electrons move away from an atom. Computers are designed based on the logic gates functions. To understand all this concepts and inventions, the study of Semiconducting devices and Electronic systems are of great importance.

Content Standard 11.2.5

Students will be able to examine and explain semiconducting devices and electronic systems.

Benchmarks

11.2.5.1 Explain how atoms interact by transferring or sharing electrons.

11.2.5.2 Investigate the uses of semiconductor materials from which solid state devices, such as the diode and transistor are made.

11.2.5.3 Describe the behaviour and applications of the diode and the transistor.

11.2.5.4 Establish that the physical and electrical properties of transistors and the role of transistors in electric circuits

Grade 12

Unit 1: Fluid Mechanics

A fluid is a substance that offers no permanent resistance to deforming forces. Fluids maybe classified further into liquids and gases. A liquid has a definite size but adapts its shape to the shape of the container in which it is placed. A gas has a neither a definite size nor a definite shape – it always completely fills the containing vessel. The scientific study of fluids at rest is called hydrostatics and fluid dynamics for the study of fluids in motion. In this unit, the students can be able to investigate and analyse the structure and properties of liquid at rest and in motion.

Content Standard 12.2.1

Students will be able to examine and explain the structure properties of fluids at rest and in motion.

Benchmarks

12.2.1.1 Explain density and pressure in solids and liquids

12.2.1.2 Describe static and dynamic fluid principle and applications.

Unit 2: Thermal Physics

When we think of heat we usually think of how heat makes us feel. In our homes we use heat in many different ways. We use it for cooking food and ironing clothes and to provide hot water for washing. Heat is widely used in industry. It is used to cut and weld metals, and to make glass, paper, textiles, and many other products.

Heat is very useful but it can cause problems such as bushfires, and explosions. Heat inside the earth can generate volcanic eruptions. Lava from volcanoes causes much damage to the environment. The study of heat in physics is called thermal physics. The students will investigate all properties and heat transfer phenomenon in this units.

Content Standard 12.2.2

Students will be able to examine and explain the structure properties of fluids at rest and in motion.

Benchmarks

12.2.2.1 Define heat and temperature and calculate the efficiency of energy transfer within physical systems.

12.2.2.2 Research the nature of solids, liquids and gases by examining their molecular structures.

12.2.2.3 Deduce and apply the laws of thermodynamics to solve problems involving thermodynamics.

Unit 3: Waves

Waves on ropes or water are familiar examples of wave. There are many other examples of waves around us. We hear sound because sound waves travel from vibrating source through the air into our ear. The energy released by a large explosion can shatter windows far from its source because a wave of compression moves out from the source in all directions. The ‘shock wave’ of sonic boom from a jet plane can have similar effects. Seismic or earthquake waves travel through the earth following movement of rock layers beneath the earth’s surface. Students are to cover all the required content to meet the content standards and the benchmarks set.

Content Standard 12.2.3

Students will be able to analyse and apply the properties, types and patterns of waves in energy transfer.

Benchmarks

12.2.3.1 Analyse and compare transverse and longitudinal waves and their properties.

12.2.3.2 Research the nature of matter and energy, forms of energy, including waves and energy transformations.

12.2.3.3 Explain and provide examples of electromagnetic radiation and sound using a wave model.

Unit 4: Electromagnetism

The phenomenon of magnetism was known to Chinese as early as 2500 BC. They found that certain minerals could attract pieces of iron. When suspended freely, these materials would always point in a north – south direction. There are many examples of the use of magnets in modern civilization. They are used in dynamos, motors, radios, televisions, refrigerator door locks and in tape recorders. As we go through this unit, the students can deduce the importance of electromagnetism in everyday life.

Content Standard 12.2.4

Students will be able to examine and evaluate electromagnetism properties and concepts and derive equations to find magnetic field strength and voltage induced in AC and DC motors and generators.

Benchmarks

12.2.4.1 Investigate how magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

12.2.4.2 Examine the relationship between magnetic field changes and the production of electric fields, which results in the inducement of currents in nearby conductors.

12.2.4.3 Investigate how voltage is induced by a changing magnetic field in AC and DC motors and generators.

Unit 5: Atomic and Nuclear Physics

Given many forms and properties of matter, Greek philosophers such as Leucippus and Democritus suggested that matter was composed of tiny particles called atoms. The idea of tiny particles was suggested by the fact that matter can be cut into smaller and smaller pieces.

Becquerel suggested that rays with penetrating power were emitted from the uranium salt. These rays were called radioactive rays. The phenomenon of emitting radioactive rays is called radioactivity. The students can excel their notion about Atomic and Nuclear Physics as they learn the contents of this unit.

Content Standard 12.2.5

Students will be able to explain and examine the structure, properties and changes of matter as well as sources, uses, conservations and changes of energy.

Benchmarks

12.2.5.1 Investigate the structure of matter including atoms, protons and neutrons.

12.2.5.2 Examine how atoms interact by transferring or sharing electrons.

12.2.5.3 Research nuclear reactions and how they produce energy.

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 students 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/quizzes/presentations/practical work samples

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
Atom	The smallest portion into which an element can be divided and still retain its properties, made up of a dense, positively charged nucleus surrounded by a system of electrons.
Capacitor	Devices used in electronic circuits to store charge and energy.
Commutator	Reverses the current flow in the coil every half-cycle to ensure the coil continues to rotate in the one direction.
Convection	The transfer of heat by the flow of particles in the heated material.
Electronics	Electronics is concerned with the development of tiny electrical circuits and the devices that are used to make these circuits.
Element	A substance that cannot be broken down into a simpler one by a chemical reaction.
Energy	A supply or source of electrical, mechanical or other forms of power that can generate work.
Experiment	A test, especially a scientific one, carried out in order to discover whether a theory is correct or what the results of a particular course of action would be.
Fluids	A subject whose molecules flow freely. These are substances that offer no permanent resistance to deforming forces.
Frequency	The number of complete vibrations per second
Hypothesis	A statement that predicts the outcome of a problem to be tested or experimented.
Matter	Refers to any materials which occupy space and can be examined by measuring, weighing or by experimental testing.
Mirage	An optical illusion that results from the total internal reflection of light in air.
Motion	The process in change of position of an object or particle at a particular time elapsed.
Period	The time required for one complete vibration or revolution.
Radiation	The flow of heat from one place to another via infrared rays without involving particles of matter.
Radioactivity	The phenomenon of emitting radioactive rays.
Scientific Inquiry Process	The scientific solving problems approach.
Solenoid	A long coil made up of many turns of wire that produces its own magnetic field.
Thermal Physics	The study of heat transfer and heating and cooling of matter.
Torque	The turning effect of a force.
Transistor	Small, three-terminal, semiconductor devices which have revolutionized electronics.
Vector	A physical quantity that can be measured with direction of the motion.
Wave	A disturbance caused in the process to transfer energy.

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