Physics

Upper Secondary Syllabus

Papua New Guinea
Department of Education

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Contents

Secretary’s message

This Physics syllabus is to be used by Physics teachers to teach Upper Secondary students (Grades 11 and 12) throughout Papua New Guinea. This syllabus builds upon concepts, skills and attitudes learnt in Lower Secondary and provides a sound foundation for further learning.

The Upper Secondary Physics Syllabus contributes to integral human development as it is based on the students’ physical environments, societies and cultures. It links to the National Education Plan’s vision, which is that secondary education enables students to achieve their individual potential to lead productive lives as members of the local, national and international community, as they undertake a broad range of subjects and work-related activities.

The study of Physics gives students a means of enhancing their understanding of the physical world and the natural laws that govern it. Working scientifically and making scientific inquiries, investigations and experiments immerses students in both practical and conceptual aspects of the subject.

Physics teachers are challenged to teach the fundamental concepts of the subject and also to promote, provide and practise lifelong skills such as investigating, collecting information, solving problems and communication. Physics prepares students to further develop these skills as they move on to higher learning institutions. Grounding in Physics improves students’ further education and training as well as helping them to make informed judgements on scientific or technical issues affecting their communities and societies in Papua New Guinea and abroad.

I recommend and approve this syllabus as the official curriculum for Physics to be used in all schools with Grades 11 and 12 students throughout Papua New Guinea.

DR JOSEPH PAGELIO

Secretary for Education

Introduction

This syllabus is based on the curriculum principles from the National Curriculum Statement. It has been designed using learning outcomes that identify the knowledge, skills, attitudes and values that all students achieve or demonstrate by the end of Grade 12. It is linked to the national curriculum learning area of Science and builds on the knowledge and skills students have learnt since elementary grades. This Physics syllabus offers a number of pathways to post-secondary study and the workforce. It has specialised and general applications in both areas.

Lower Secondary Science Strands	Lower Secondary Science Units	Upper Secondary Physics Units
The Nature of Science Matter and Energy Earth and Space Life and Living	Working Scientifically Atoms and the Periodic Table Electricity Working Scientifically through Projects and investigations Light Communication	Measurement Motion (Kinematics) Force and Motion (Dynamics) Work, Power and Energy Electricity Principles Electronics Fluids Temperature and Heat Waves Electromagnetism Radioactivity and Nuclear Energy

Physics is a subject that requires a high level of English and Mathematics competency. Students need to be fluent in reading, writing and speaking English for research, report writing and oral and written presentations. Students also need to be competent in Mathematics to understand and solve numerical problems in Physics.

Assessment is an important component of teaching for learning and is integrated into the learning and teaching activities of Physics. Continuous assessment in Physics provides feedback to students and the teacher on students' progress towards achievement of the learning outcomes. It helps students improve their standards of achievement by knowing what they need to do well and where they need to improve. In Physics, teachers will gather evidence from students' work during the course of the term and use those continuous assessments to improve their teaching and students' learning.

The syllabus is developed by Papua New Guineans for Papua New Guinea, to encourage young Papua New Guineans to be creative, innovative and rational thinkers, and to enable students to understand the basic concepts about the world in which they live.

Physics is the study of matter and energy and the natural laws that govern their behaviour. Students develop and apply skills as they cover the units outlined in the syllabus. Physics builds on learning from Lower Secondary where the focus is on the nature of sciences, matter and energy and earth and space.

This syllabus outlines the strands and units for all students in Grade 11 and Grade 12. The learning in Physics is more meaningful and interesting when students are actively involved in carrying out investigations as they cover the units in this syllabus.

Students engage in all units through practical tasks and theory assessments, which will enable them to build the basic physics principles, concepts and skills needed for higher education or a life of self-employment.

Physics is to be timetabled for 240–250 minutes per week in Grade 11 and Grade 12.

Rationale

Many natural phenomena occur on our planet. For us to be able to deal with their effects, we must understand the rules of nature and be able to predict their behaviour. Physics deals with observations regarding the behaviour and structure of matter and the laws governing nature. It provides the basis for understanding the behaviour of matter and why it behaves as it does.

An understanding of physics is necessary in order to establish some measure of control over the world we live in. A background in physics allows us to make informed judgement on technical and scientific issues. Our technological society depends heavily upon understanding the fundamentals of physics to safely exploit resources found in the lithosphere, hydrosphere and atmosphere.

Physics contributes to scientific literacy, which helps to enhance public policy decision making. As future leaders, students must act upon the best available information to provide government and decision makers with the best-informed advice for the good of the country.

Physics is one of the scientific bases for technologies that have had, and will continue to have, a profound influence on all aspects of our contemporary and progressive life. Some of these physics-based developments and technologies have had a gigantic impact in transforming the infrastructure of our society. They include electricity, information technology, data storage, telecommunications, energy technology, transportation, agriculture, buildings, medical technology, entertainment devices and many more. The contributions of physics in these and many other fields justify the importance and the relevance of physics in any modern society today. A Physics education will enable Papua New Guineans to realise and benefit from the contributions physics has and will make to the world.

It must be emphasised to students that Physics as part of the school curriculum is not taught as a general subject on its own. Students study Physics because of its relevance and importance to the present and future technology-driven lifestyle in this country and therefore the study of Physics must be taken seriously.

In all units, students engage in practical tasks and theory that will enable them to build the basic physics principles, concepts and skills needed for higher education or self-employment.

Aims

Physics aims to enable students to:

- understand and acknowledge the interrelationship between science, society and the environment, which will contribute to active debates and responsible decision making on issues related to technological development, environmental management, lifestyle choices, economics, human health, and social and human development
- critically evaluate the impacts of scientific and technological achievements that affect all aspects of our lives and ensure a better standard of living
- understand and appreciate the principles of physics in everyday life and use the principles to solve problems.

Learning outcomes

The Physics learning outcomes identify the knowledge, skills, attitudes and values all students achieve or demonstrate at the end of Grade 12. The learning outcomes for Physics are listed below.

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions
6. relate relevant traditional knowledge, beliefs, and skills to principles and concepts of physics

Note: While all ideas and concepts in Physics are linked, the table below indicates the connections that should be highlighted most.

Learning outcomes mapped against units

Learning outcomes	Units										
	11.1	11.2	11.3	11.4	11.5	11.6	12.1	12.2	12.3	12.4	12.5
1. Demonstrate understanding of fundamental physics principles and models	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Apply scientific inquiry and reasoning skills to find solutions to problems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3. Communicate scientific data and information from investigations and laboratory work in different ways	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4. Analyse and interpret data and information	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5. Analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
6. Relate relevant traditional knowledge, beliefs, and skills to principles and concepts of physics	✓			✓				✓	✓		

Unit sequence and content

Grade 11 units	Grade 12 units
11.1 Measurement *3–4 weeks* • Quantities and units • Measuring instruments • Dimensional analysis • Error analysis • Graphs **11.2 Motion (Kinematics)** *6–7 weeks* • Characteristics of motion • Graphs of motion • Equations of motion • Projectile and freefall motion • Circular motion **11.3 Force and Motion (Dynamics)** *6–7 weeks* • Force • Friction • Newton's first law of motion • Newton's second law of motion • Newton's third law of motion • Momentum and impulse • Applications of Newton's laws **11.4 Work, Power and Energy** *5–6 weeks* • Work • Power • Energy • Simple machines **11.5 Electricity Principles** *8–9 weeks* • Electrostatics • Current electricity • Wheatstone bridge and potentiometer • Alternating current (AC) circuits **11.6 Electronics** *5–6 weeks* • Solid state electronics • Digital electronics	**12.1 Fluids** *5–6 weeks* • Fluid statics • Fluid dynamics **12.2 Temperature and Heat** *6–7 weeks* • Temperature • Thermal expansion • Specific and latent heat • Heat transfer **12.3 Waves** *6–7 weeks* • Properties and types of waves • Superposition and interference of waves • Propagation of waves • Applications **12.4 Electromagnetism** *7–8 weeks* • Magnetic field and force due to current • Electromagnetic induction • Transformers and power losses in transmission lines **12.5 Radioactivity and Nuclear Energy** *5–6 weeks* • Radiation • Radioactivity • Nuclear energy

Grade 11 units

11.1 Measurement

3–4 weeks

This unit provides students with an understanding of the parameters of measurement including quantities, units and errors.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions
6. relate relevant traditional knowledge, beliefs, and skills to principles and concepts of physics.

To achieve these outcomes, students:

- demonstrate the use of basic scientific instruments and analyse the readings to a reasonable degree of accuracy
- estimate the order of magnitude of very, very small and very, very large quantities in suitable and appropriate units
- analyse, deal with and minimise the expected errors involved in various measurements and calculations
- carry out simple experiments using measuring instruments
- draw and interpret experimental data
- use and convert internationally accepted units of measurement
- identify examples of traditional quantities, their units and measurement methods.

Warning

Be careful when handling fragile instruments and equipment like thermometers and measuring cylinders

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Quantities and units

- definition and explanation of measurement
- specify traditional quantities such as (but not limited to) time and length, their units and measurement methods

- definition and classification of physical quantities as scalar and vector
- International System of Units (SI)
- write the magnitude of quantities with their respective units
- conversions and identification of significant figures in a given number
- normal and scientific notation—expressions and conversions
- use of prefixes

Measuring instruments

- use of various laboratory apparatus
  - timer, thermometer, measuring cylinder, balance
  - vernier callipers and micrometer screw gauge
- measure physical quantities and read scales correctly
- write the magnitude of quantities with their respective units

Dimensional analysis

- fundamental units
- relationship of formula to units
  - dimensional analysis to obtain derived units

Error analysis

- definition of error
- types of errors
  - random and systematic error
  - parallax and zero error
  - reaction time error
- uncertainties in measurement
- minimising errors
  - group method
  - averaging readings
- estimation, rough measurement and calculations
  - mentally checking measurement and order of magnitude
- analysing errors by performing calculations
  - % error, relative and absolute error, multiple error occurrence; for example, $(5 \pm 0.2) \times (3 \pm 0.3) = 15 \pm \Delta E$

Graphs

- dependent and independent variables
- line of best fit and error bar
- extrapolation

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being precise and accurate
- being sceptical and questioning

Process skills

- collecting, observing and analysing data
- measuring
- using equipment
- estimating, predicting and interpreting data
- communicating scientific data

General skills

- decision making
- thinking logically and critically
- cooperating and collaborating

11.2 Motion (Kinematics)

6–7 weeks

In this unit students are introduced to motion without considering the force that caused it (kinematics). There are fundamental principles governing motion and they can be used to explain the motion of an object.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information.

Warning

Make sure that ticker timers are correctly connected before using

To achieve these outcomes, students:

- demonstrate an understanding of the characteristics of motion
- draw and explain graphs of motion
- derive and use equations of motion
- describe and analyse free fall and projectile motion
- describe and analyse circular motion.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Characteristics of motion

- distance, displacement, speed, velocity and acceleration
- instantaneous velocity, average speed, average velocity, acceleration, initial velocity, final velocity, and elapsed time
- experiment using rulers and timers to generate data or obtain data from other sources
- vector operations

Graphs of motion

- distance–time, speed–time, velocity–time, displacement–time and acceleration–time graphs
- interpreting kind of motion from graphs
  - conduct ticker timer experiments for uniform and accelerated motions and plot the relevant graphs
  - describe the motion of an object from a ticker tape record and from graphs

- determine displacement from a velocity–time graph
- solve worded problems with the aid of diagrams

Equations of motion

- equations of uniform linear motion
- equations of uniformly accelerated motions
- equations of speed, velocity, average velocity, acceleration, average speed
- equation of vertical motion under gravity (free fall)
- word problems applying equations for
  - uniformly accelerated motion to find s, u, v, a, or t

$v_{av} = \frac{s}{t}$,

a = $\frac{(v-u)}{t}$,

$v_{av} = \frac{u+v}{2}$

$v^2 = u^2 + 2as$ and

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

Projectile motion

- graphs of motion in two dimensions from given experimental data
- motion of a projectile and its equations
- worked examples on projectile motion

Circular motion

- circular motion, its quantities (angular displacement, velocity and acceleration) and their units (δθ, radians per second, ω, radians, degrees)
- equations of circular motion and the relationships between linear and angular quantities
- worked examples on circular motion

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being sceptical and questioning

Process skills

- collecting, observing and analysing data
- communicating in scientific terms

General skills

- thinking critically
- cooperating and collaborating

11.3 Force and Motion (Dynamics)

6–7 weeks

In this unit motion is combined with force. First, force is treated on its own, and then Newton's three laws of motion are introduced. Next, collisions which involve the concepts of momentum and impulse, including the relationship to Newton's laws are dealt with. The unit is concluded with applications of Newton's laws to a variety of situations.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions.

To achieve these learning outcomes, students:

- define and classify types of forces
- state and discuss Newton's laws of motion
- investigate and describe friction
- conduct experiments on forces
- demonstrate an understanding of momentum and impulse.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Force

- definition of force and its units
- types of forces
- calculation of net force
- resolving of force into its vertical and horizontal components

Friction

- friction due to solid surfaces in contact—static and kinetic friction
- coefficient of friction

Newton's first law of motion

- Newton's first law of motion
  - worked examples on the first law

Newton's second law of motion

- Newton's second law of motion
  - worked examples of the second law

Newton's third law of motion

- Newton's third law of motion
  - worked examples of the third law

Momentum and impulse

- definition of momentum and impulse
- derivation of momentum and impulse from Newton's second law of motion
- force–time graphs associated with impulse
- law of conservation of momentum
- applying laws of conservation of momentum and energy to collision problems
- experiments showing that in an inelastic collision some energy is transferred as heat and sound

Applications of Newton's laws

- weight and apparent weightlessness
- body moving on an inclined plane
- coupled bodies

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being sceptical and questioning

Process skills

- collecting, observing and analysing data
- solving problems
- manipulating equipment
- measuring
- communicating in scientific terms

General skills

- thinking critically
- cooperating and collaborating

11.4 Work, Power and Energy

5–6 weeks

In this unit students learn the fundamentals of mechanical energy, work, power and simple machines. Energy conversion is fundamental for understanding what we know, observe and experience in our day-to-day living in harnessing energy to improve our living. The study of simple machines enables students to learn principles of these machines in moving loads.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions
6. relate relevant traditional knowledge, beliefs, and skills to principles and concepts of physics.

To achieve these learning outcomes, students:

- name and describe different forms of energy
- state and apply the Law of Conservation of Energy in terms of the energy transformation to practical situations
- explain how force, energy and work are related and perform a practical exercise
- perform calculations relating work done by an object and the changes involved in kinetic energy and potential energy
- research and discuss energy application situations in the school, in Papua New Guinea and in the world in terms of natural resources; list potential sources of energy
- identify and discuss traditional simple machines.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Work

- define work done (W) by a force (F) in moving a distance (s): W = Fs
- units of work

- calculations and analysis of work done by a net force under different situations such as (but not limited to):
  - a horizontal force pulling a body on a horizontal surface for a certain distance
  - a force at an angle θ to a displacement, s
  - a body dragged along a level floor by (the tension in) a rope at an angle θ to the horizontal
  - the work done by gravity on a body sliding down a smooth inclined plane of height, h

Power

- definition of power as the rate of work done
- units of power
- problems and calculations on power

Energy

- definition of energy
- units of energy
- forms of energy such as
  - kinetic
  - gravitational potential
  - heat
  - electromagnetic
  - sound
  - chemical and so on
- law of conservation of energy
- examples of energy converters
- energy transformations such as
  - pendulum
  - free fall
  - car motion up and downhill
- problem solving on mechanical energy (KE and PE)

Simple machines

- definition of simple machines as devices for transmission and modification of forces (or devices designed to reduce the force needed) to lift a heavy load
- examples of simple machines
  - levers
  - pulleys
  - gears
  - wheel and axle
- mechanical advantage of a machine:

$$\text{mechanical advantage} = \frac{load}{effort}$$

- velocity ratio of a machine:
- velocity ratio = $\frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load}$
- relationship between mechanical advantage, velocity ratio and efficiency
- calculations of mechanical advantage, velocity ratios and efficiency using data determined experimentally from one of the following simple machines:
  - a lever, pulleys and the wheel and axle

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being sceptical and questioning
- self-organising, open minded, appreciative

Process skills

- collecting, observing and analysing, communicating

General skills

- thinking critically
- cooperating and collaborating

11.5 Electricity Principles

8–9 weeks

Students have some learning experiences in electricity in Grade 9 through the sub-strand Electricity, which covers areas including types of electricity, series and parallel circuits, uses of electricity, household electricity, and practical exercises on setting up circuits and measuring current and voltage in the circuits with ammeters and voltmeters respectively.

This unit is an expansion of the Grade 9 Electricity unit, with more emphasis on types of electricity, circuits and resistance. This unit also contains new concepts, including electromotive force, potentiometer, Wheatstone bridge and alternating current circuits.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions.

To achieve these outcomes, students:

- apply the concepts of electrostatics to simple point and continuous charge distributions
- demonstrate an understanding of electromotive force, internal resistance and terminal voltage of cells or batteries
- investigate, analyse and explain that resistance of a conductor is a function of its physical dimensions, material type and temperature
- describe and explain resistance, current, voltage, energy and power, and the relationships between these quantities
- describe different types of electric circuits including series, parallel and network circuits
- demonstrate an understanding of Kirchhoff’s circuit laws and apply these laws to network circuits
- discuss the principles of alternating current (AC) circuits
- discuss the replacement of traditional sources of energy with electricity when doing things such as (but not limited to) cooking, lighting, laundry or moving loads

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Warning

Be careful when dealing with mains electricity

Electrostatics

Charging principles

- how a body acquires electric charge by friction, contact and induction methods of charging

Electrostatic force, field and potential

- coulomb's law of force $\left(F = k\frac{Q_1Q_2}{r^2}\right)$ between point charges, electric field $\left(E = \frac{F}{q} = k\frac{Q}{r^2}\right)$ and potential $\left(V = k\frac{Q}{r}\right)$ due to point charges
- electrostatic force and field are vector quantities and the potential is a scalar quantity
- direction of electric field around a point charge (positive or negative) and between a pair of like and unlike charges
- equations of electrostatic force, field and potential to problems involving multiple charges

Current electricity

Definitions and units and symbols of circuit parameters

- the volt, the ohm and the ampere
- electromotive force (emf), resistance, potential difference and current symbols in circuits

Electromotive force, internal resistance and terminal voltage

- electromotive force (emf), internal resistance of emf sources (cells or batteries) , terminal voltage and potential drop across a resistor in a simple circuit
- combining of cells in series (aiding and opposing) and parallel
- emf sources (cells) are connected in series (aiding and parallel) to obtain higher terminal voltage and circuit current respectively
- simple circuits and measuring emf, internal resistance of the emf source and the terminal voltage of the emf source
- why the voltage across the terminals of a battery is less than its rated value

Series and parallel circuits

- simple series and parallel circuits
- experiments that investigate the characteristics of series and parallel circuits including the following features:
  - current is constant at all points in series circuits, but divides in parallel circuits

  - potential difference is added in series circuits but is the same across parallel circuits
- advantages and disadvantages of series and parallel circuits
- voltmeters and ammeters in a circuit

Resistance

- experiments showing current flowing through a resistor
- resistance of a resistor, plot a V versus I characteristic for a hot filament bulb
- resistance (R) of a wire is proportional to its length (l) and resistivity (ρ) but inversely proportional to its cross-sectional area (A)

  $$\left(i.e.\ \ R = \rho \frac{l}{A} \right)$$

- conduct experiment to show that the resistance of a wire is proportional to its length, and depends on the thickness and material
- resistance of a wire also varies with temperature, T, as

  $$R = Ro\left(1 + \alpha T + \beta T^{2}\right)$$

Electrical energy and power

- electrical energy, $E = VIt = I^2Rt = \frac{V^2}{R}t$ and power $P = VI = I^2R = \frac{V^2}{R}$
- resistance network circuits and Kirchhoff's circuit laws
  - resistance networks
  - Kirchhoff's junction (current) and loop (voltage) laws
  - apply Kirchhoff's circuit laws to simple resistance network circuits

Wheatstone bridge and potentiometer

Wheatstone bridge

- Wheatstone bridge circuit
- operation principle of a Wheatstone bridge
  - resistance networks to determine ratio of resistances as well as the resistance of an unknown resistance
- experiment using Wheatstone bridge to measure unknown resistances

Potentiometer

- potentiometer circuit
- operation principle of potentiometer, determination of an unknown emf
- experiment using potentiometer to measure an unknown emf

Alternating current (AC) circuits

The alternating current and voltage

- the reasons that electricity is supplied by power stations to our homes, factories and laboratories is alternating voltage, as opposed to the direct current from storage batteries

- the output voltage V and the current I from a generator vary with time according to the equations

  $V = V_o \sin \omega t$ and $I = I_o \sin \omega t$
- parameters in the above equations for V and I
- alternating voltage as a function of time and indicating the peak voltage and the period
- in one half cycle, an alternating voltage is positive, and negative in the next half cycle

Effective values of voltage and current

- explain that the actual voltage (and current) measurement at any time gives effective value (also known as the root-mean-square value), and the effective voltage V_{eff} is defined by the equation:

  $V_{rms} = V_{eff}$

  $= \sqrt{mean\ of\ the\ squares\ of\ the\ voltages\ over\ one\ cycle}$
- show that $V_{rms} = V_{eff} = \frac{V_o}{\sqrt{2}}$ and $I_{rms} = I_{eff} = \frac{I_o}{\sqrt{2}}$
- applying Ohm's Law to determine peak current and potential drop in resistive AC circuits
- calculate V_{rms}, I_{rms} and Power in resistive AC circuits

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being self-organising, open-minded, appreciative, sceptical and questioning

Process skills

- observing, classifying, measuring, estimating, experimenting and investigating, predicting, using and manipulating equipment

General skills

- communicating, thinking critically, problem solving, making decisions, cooperating and collaborating, organising and interpreting data, graphing

11.6 Electronics

5–6 weeks

This unit introduces briefly a class of material known as semiconductor materials, from which many modern electronic devices, including the transistor and the diode, are made. These are called 'solid state devices' because they are made of solid semiconductor materials. Accordingly, the branch of electronics based on these devices is described as 'solid state electronics'. The operation, principles and some examples of uses of the transistor and the diode are described.

Digital electronics, having logic gates as functional blocks, and their operational principles is another branch of electronics also covered.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions.

To achieve these outcomes, students:

- demonstrate an understanding of semiconductor materials from which solid state devices, such as the diode and the transistor, are made
- describe and explain behaviour and applications of the diode and the transistor
- explain that diodes and transistors in large numbers are incorporated into integrated circuit chips of very small size to perform different functions
- investigate, describe and explain logic gates as examples of digital electronics
- discuss the use of electronics in modern Papua New Guinea society in areas such as information communication technology, transport, and entertainment.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Solid state electronics

The intrinsic and extrinsic semiconductors

- intrinsic (pure) and doped semiconductors
- how the n-type and p-type semiconductors are produced

Solid state devices: Diode and transistor

- how the diode and the transistor are made from semiconductor materials
- electronic circuit symbols for diode and transistor (NPN and PNP)
- operation principles of the diode and the transistor including I-V characteristics and biasing methods
- use of diode as a switch and as a rectifier
- experiment using a diode as a switch
- use of transistor as a switch and as an amplifier (common-emitter, common-base and common collector configurations)
- experiment using a transistor as a switch and/or amplifier

Digital electronics

Digital signal levels

- signal levels employed in digital electronics or circuits are ‘high’ (for example, +5 volts) and ‘low’ (for example, 0 volts), and sometimes the ‘high’ and ‘low’ states are referred to as ‘1’ and ‘0’ respectively

Logic gates

- electronic symbols of the logic gates AND, OR, NOT, NOR, NAND, XOR
- logic gates (AND, OR, NOT, NOR, NAND, XOR, combinations) and their truth tables for 2, 3 and 4 inputs
- the behaviour of a 2 inputs AND gate and a 2 inputs OR gate with simple circuit using 2 switches, a lamp and batteries
- the output of each of AND, OR, NOT, NOR, NAND, XOR
- exercises on determining outputs of simple circuits made from logic gates

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being self-organising, appreciative, questioning

Process skills

- observing, classifying, experimenting, organising and interpreting data

General skills

- communicating, thinking critically, cooperating and collaborating

Grade 12 units

12.1 Fluids

5–6 weeks

The study of fluids in this unit has two parts, statics and dynamics. Fluids statics concentrates on fluids at rest requiring the concepts of Newton's first and third laws while fluid dynamics focuses on properties related to the motion of fluids based on Newton's laws and conservation of energy

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions.

To achieve these outcomes, students:

- explain density and pressure in solids and liquids
- explain static and dynamic fluid principles and applications.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Fluid statics

- density in solids and liquids and specific gravity
- pressure in solids and liquids
- Pascal's Law
  - principles of hydraulic lift using Pascal's Law
- buoyancy and Archimedes Principle
- surface tension and capillarity

Fluid dynamics

- flow rate and equation of continuity
- Bernoulli's equation

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- appreciating, sceptical and questioning

Process skills

- investigating and experimenting
- problem solving and analysing

General skills

- communication, thinking critically
- cooperating and collaborating
- organising
- making decisions
- interpreting data

12.2 Temperature and Heat

6–7 weeks

This unit deals with temperature and heat. Students learn that temperature dependent properties of different substances can be used to measure temperature. Solids, liquids and gases expand and contract when temperature increases and decreases respectively. Heat is classified as a form of energy and is fundamental in calorimetry calculations, change of state phenomena and the modes in which heat can be transferred.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions
6. relate relevant traditional knowledge, beliefs, and skills to principles and concepts of physics.

To achieve these learning outcomes, students:

- explain temperature, its units and measurement
- describe different thermal expansions and heat transfer methods
- explain heat, its units and heat required to change temperature and state of a substance
- solve problems on temperature, thermal expansion, heat and heat transfer
- perform experiments on heat and explain the results.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Warning

Be careful of heated objects

Temperature

- definition of temperature and its units
- mechanical, electrical and radiation types of temperature-measuring instruments (for example, mechanical: liquid in glass; electrical: thermocouple; radiation: pyrometer; and so on)
- conversion of one temperature scale to another (Fahrenheit, Kelvin and Celsius)

Thermal expansion
- linear, superficial and volume expansions
- problems and calculations involving these expansions

Heat
- definition of heat and its units
- specific and latent heat
- heat capacity and specific heat capacity
- experiments on heat

Heat transfer
- heat transfer by means of conduction, convection and radiation
- thermal conductors and insulators

Application
- fire dancing, mumu, air conditioning, refrigerators

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values
- sceptical and questioning, self-organising, appreciative

Process skills
- communicating, collecting, analysing
- experimenting and investigating

General skills
- thinking critically, problem solving, making decisions, cooperating and collaborating

12.3 Waves

6–7 weeks

This unit deals with waves including properties and types, superposition and interference, propagation. The unit concludes with several applications of the concepts of waves.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions
6. relate relevant traditional knowledge, beliefs, and skills to principles and concepts of physics.

To achieve these learning outcomes, students:

- demonstrate an understanding of types, properties, propagation, superposition and interference of waves
- apply mathematical formulas in determining wave parameters
- describe and explain the application of wave principles
- perform experiments on waves and explain their results.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Properties and types of waves

Transverse and longitudinal waves

- generating waves using ropes and springs
- difference between transverse and longitudinal waves in terms of particle movement and direction of propagation (direction of energy transfer)
- waves can be either mechanical or electromagnetic; that is, mechanical waves require a medium of transmission and electromagnetic waves can travel through a vacuum
- examples of transverse and longitudinal waves
- wave properties include amplitude, wavelength, period and frequency

- the relationship between frequency and period: $T = \frac{1}{f}$
- draw wave diagrams from given parameters

Superposition and interference of waves

- waves that are 'in phase' or 'out of phase' with respect to a reference wave
- constructive and destructive interference
- using the ripple tank to demonstrate constructive and destructive interference

Propagation of waves

- using the equation v = fλ to calculate unknown quantities of a given wave
- Snell's Law, $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$ where n_1 *and* n_2 are the absolute refractive indexes of medium 1 and medium 2 respectively and angles *i* and *r* are the angles of incidence and refraction

Applications

- practical applications of total internal reflection in periscopes, prisms, optical fibres, endoscopes and so on
- effect of refraction; determining the real depth and apparent depth of objects under water
- research and recognise that sound energy can be transmitted by waves through solids, liquids and gases; for example, sonar through liquids and earthquakes through the earth and that in each case sound can exhibit the properties of reflection and refraction

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being self-organising, open-minded, appreciative, sceptical and questioning

Process skills

- observing, measuring, estimating, experimenting and investigating, communicating, interpreting data

General skills

- thinking critically, problem solving, making decisions, cooperating and collaborating

12.4 Electromagnetism

7–8 weeks

The generation, transmission, distribution and use of electric power are crucial to modern life. This unit provides the fundamental concepts of electromagnetism in generation and transmission of electricity. The scope includes principles of magnetic fields and forces, electromagnetic induction and transformers.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions.

Warning

Be careful when dealing with mains electricity

To achieve these learning outcomes, students:

- show experimentally that current generates a magnetic field in a conductor
- describe the forces acting on a current-carrying conductor when placed inside an external magnetic field
- demonstrate and explain, using models, the principle of operation in electric motors
- explain how a current is induced in a conductor when moved inside an external magnetic field or when placed inside a constantly changing magnetic field
- explain the principle of operation in AC and DC generators and identify their basic structure
- describe transformer operations and perform transformer calculations
- state the role of transformers in power transmission and distribution
- discuss how electromagnetic-based electric machines (models, generators and transformers) make a positive impact on Papua New Guinean society.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Magnetic field and force due to current

Magnetic field

- current-carrying wire generates magnetic field, B= $\frac{\mu I}{2\pi r}$
- experiment with a compass held close to a current-carrying wire and/or coil to show that increasing the current or number of turns in the coil will increase magnetic field strength, which will be indicated by an increase in the deflection of needle in the compass
- experimentally show the direction of magnetic field created using a compass and Fleming's right-hand grip rule

Force experienced by current carrying conductor

- why a current carrying conductor experiences a force when placed inside an external magnetic field, and show the direction of the force using Fleming's left-hand rule
- how force experienced by a current carrying wire is affected by:
  - the length of the wire in a magnetic field
  - the magnitude of the current
  - the strength of the magnetic field and the angle between the conductor and the magnetic field
- use formula: $F = B\,Il\,\sin\theta$, to calculate the magnitude of the force experienced by the conductor
- the formula $F = n\,B\,I\,l\,\sin\theta$, where n represents the number of turns, and l is the length (circumference) of a single turn

Force between two parallel conductors

- the behaviour of two parallel wires when placed a finite distance apart with current flowing through

DC electric motors and AC electric motors

- parts of a simple electric motor
- the principle of operation of an electric motor
- the qualitative effect of torque on the rotor at different points of rotation in an electric motor

Electromagnetic induction

Generation of current

- current is induced in a straight wire when moved through a magnetic field
- a current is induced in a stationary coil by a changing magnetic field

Factors determining magnitude of current

- qualitative discussion of Faraday's Law on the polarity of the induced emf
- experiments that indicate that the size of an induced current on a straight wire moved inside an external magnetic field depends upon:
  - the length of the wire
  - the strength of the field

- the speed of the wire

- experiments that indicate that the size of the current in a stationary coil depends on:
  - the number of turns of coil (increased length of wire)
  - the strength of the field
  - the speed of the magnet
- Lenz's Law
- Flemings' right-hand rule and the right-hand grip rule to determine direction of magnetic current induced

AC and DC generators

- basic structure of AC and DC generators

Transformers and power losses in transmission lines

Transformers

- mutual inductance in two stationary coils of wires
- the operating principle of a transformer
- for an ideal transformer:
  - $\frac{\text{voltage across secondary coil}}{\text{voltage across primary coil}} = \frac{\text{number of turns on secondary}}{\text{number of turns on primary}}$
  - power output = power input, $V_{out} \times I_{out} = V_{in} \times I_{in}$
  - calculations involving step-up and step-down transformers

Power transmission

- advantage of AC generators over DC generators in power transmission
- why power is transmitted over large distances at very high voltages
- importance of transformers in power transmission
- problems on power losses and voltage drop across transmission lines using:

  $P = I^2 R$ and $V_{drop} = V_{station} - V_{town}$ where $V = I R$
  thus verifying that increasing the voltage before transmission reduces the current along transmission lines leading to minimum power loss thus leading to minimum energy loss

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- being self-organising, open-minded, appreciative, questioning

Process skills

- investigating, experimenting, problem solving

General skills

- communicating, thinking critically, making decisions, cooperating and collaborating, analysing

12.5 Radioactivity and Nuclear Energy

5–6 weeks

In this unit the students study radiation particles, radioactivity, nuclear reaction processes and nuclear energy.

Learning outcomes

Students can:

1. demonstrate understanding of fundamental physics principles and models
2. apply scientific inquiry and reasoning skills to find solutions to problems
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information
5. analyse and evaluate developments in physics from the past and present and its impacts on people and the environment; and use the information to support and make informed decisions.

To achieve these learning outcomes, students:

- demonstrate an understanding of radiation particles, radioactivity decay, nuclear reaction processes and nuclear energy
- describe and explain behaviour of radiation particles
- describe and explain radioisotope applications and radiation protection measures.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Radiation

Radiation particles

- atomic structure and properties of radioisotopes
- main radiation types [alpha(α), beta(β), gamma(γ) and neutron(n)]
- compare properties (mass, charge, range and penetration power) of the radiation particles
- the range and penetrating power of the particles in different materials
- tracks caused by α and β particles in a cloud chamber

Radioactivity

- radioactivity units: the curie and the becquerel
  - convert curie to becquerel and vice versa

- graphs showing exponential decay of a radioactive substance from experimental data
- half-life of a radioactive substance from its decay curve
- equations for radioactive decay
- uses of radioisotopes including, but not limited to, the following tracers: radiography, thickness gauging, radiotherapy and radiocarbon dating
- safety precautions necessary to protect radiation workers and environment

Nuclear energy

- processes of nuclear fission and fusion
- relationship between mass and energy ($E = mc^2$)
- applying the equation $E = mc^2$ to calculate the energy released in a fission or fusion process
- simple nuclear reactor
- use of nuclear reactors in generating electricity
- development of nuclear energy for peaceful and non-peaceful purposes
- articles on radioactivity and nuclear energy in popular science journals such as *New Scientist*

Skills

Specific skills and attitudes practised and gained through this unit include:

Attitudes and values

- sceptical and questioning

Process skills

- observing, classifying, investigating, researching, problem solving

General skills

- communicating, reading scientific articles, cooperating and collaborating, organising and interpreting data

Assessment components, weighting and tasks

The internal assessment mark for Physics is to be based on the Upper Secondary syllabus only. Final assessment should be based on a range and balance of assessment instruments. Components, weighting and tasks for Grades 11 and 12 are detailed below.

Components, weightings and tasks for Grade 11

Component	Weighting	Tasks
Written tests	50%	May include multiple-choice items, short answers, extended responses, statistical interpretation, graphical skills, calculations. These can utilise contemporary or hypothetical situations
Practical work	20%	Testing ability of students using laboratory skills and techniques, such as setting up logic circuits and checking behaviour, measuring diameter of a cylinder using vernier calipers and so on
Problem-solving assignments Project work	30%	Tasks include analytical skills in solving applied problems requiring understanding, recognition, analysis of data and use of appropriate concepts and equations, and calculations for given situations Project work Laboratory investigation and a report or research project and seminar presentation
Marks	**300**	

Components, weightings and tasks for Grade 12

Component	Weighting	Tasks
Written tests	50%	May include multiple-choice items, short answers, extended responses, statistical interpretation, graphical skills, calculations. These can utilise contemporary or hypothetical situations
Practical work	20%	Testing ability of students using laboratory skills and techniques, such as setting up logic circuits and checking behaviour, measuring diameter of a cylinder using vernier calipers and so on
Problem-solving assignments Project work	30%	Tasks include analytical skills in solving applied problems requiring understanding, recognition, analysis and use of appropriate concepts, equations, calculations for given situations. Practical work competency and some ratings given on presentation and communication to be accommodated in projects that include laboratory investigation or research project and seminar
Marks	**300**	

Assessment, examinations and certification

Assessment and reporting practices described here are detailed further in the *National Assessment and Reporting Policy for Papua New Guinea* (2003) and in other support materials produced by the Department of Education.

Assessment

The main purpose of assessment is to improve student learning.

Assessment needs to be *for* learning as well as *of* learning. It is used to evaluate and improve learning and teaching, report achievement and provide feedback to students on their progress.

Assessment measures students' achievement of learning outcomes as described in the syllabus. It is the ongoing process of identifying, gathering and interpreting information about students' achievement of the learning outcomes.

Teaching and learning using an outcomes approach requires teachers to plan their teaching and assess learner performance in relation to outcomes, using criteria derived from those outcomes. Assessment involves focusing less on whether a learner has 'passed' or 'failed' and more on what outcomes a learner has achieved and in which areas further support is required.

Assessment in Physics

A student's achievement in Physics at the end of Grade 12 will be assessed against the learning outcomes. Assessment of student progress towards achieving these learning outcomes is cumulative throughout Grade 11 and Grade 12.

It is important that teachers plan the learning and teaching sequence so that there is a balanced spread of assessment during the year. Some tasks, such as investigations or case studies, can be designed so that they are completed over a period of time rather than at the end of the unit. Other tasks can be done immediately the relevant section of the unit or topic has been covered.

Assessment for certification

A student's overall achievement in Physics will be both internally and externally assessed. The mark awarded to each student will be a combination of the internal assessment mark provided by the school and the examination mark.

Internal assessment

Internal assessment provides a measure of a student's achievement based on a wider range of syllabus content and outcomes than may be covered by the external examination alone.

For Physics the internal assessment marks will provide a summation of each student's achievements in Grades 11 and 12. The assessment tasks are set by the teacher and used to determine the internal assessment mark. These tasks must comply with the components, weightings and types of tasks specified in the tables on page 36. A variety of tasks gives students the opportunity to demonstrate all the learning outcomes in different ways to improve the validity and reliability of the assessment.

All schools must meet the requirements for internal assessment as specified in the Grade 12 *Assessment, Examination and Certification Handbook.*

External examination

The external examination provides a measure of student achievement of those aspects of the learning outcomes that can be reliably measured in an examination setting. Questions for the external examination in Physics will be developed using the outcomes, knowledge and skills in the syllabus.

Recording

All schools must meet the requirements for maintaining and submitting student records as specified in the Grade 12 *Assessment, Examination and Certification Handbook.*

Certification

Candidates will be awarded the national certificate only if they meet all requirements for internal and external assessment. Eligibility rules for the award of certificates are specified in the Grade 12 *Assessment, Examination and Certification Handbook.*