

**Physics**

**Upper Secondary  
Teacher Guide**



Papua New Guinea  
Department of Education

Issued free to schools by the Department of Education

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## **Acknowledgements**

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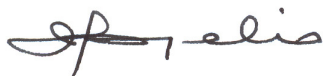
## Secretary's message

This teacher guide is to be used by teachers when implementing the Upper Secondary Physics Syllabus (Grades 11 and 12) throughout Papua New Guinea. The Physics syllabus identifies the learning outcomes and content of the subject as well as assessment requirements. The teacher guide gives practical ideas about ways of implementing the syllabus: suggestions about what to teach, strategies for facilitating learning and teaching, how to assess and suggested assessment tasks.

A variety of suggested learning and teaching activities provides teachers with ideas to motivate students to learn, and make learning relevant, interesting and enjoyable. Teachers should relate learning in Physics to real issues and the local environment. Teaching using meaningful contexts and making sure that students participate in appropriate practical activities assists students to gain knowledge and understanding, and demonstrate skills in Physics.

Teachers are encouraged to integrate Physics activities with other subjects, where appropriate, so that students can see the interrelationships between subjects and that the course they are studying provides a holistic education and a pathway for the future.

I commend and approve the Upper Secondary Physics Teacher Guide for use in all schools with Grades 11 and 12 students throughout Papua New Guinea.



**DR JOSEPH PAGELIO**

Secretary for Education

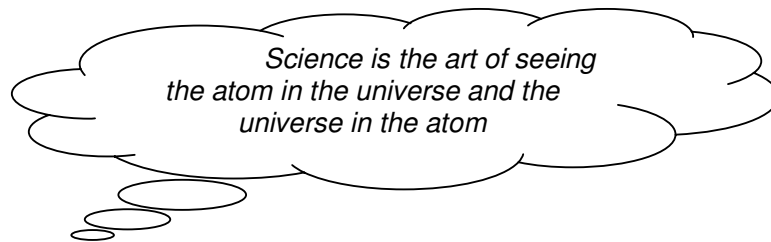
## Introduction

The purpose of this teacher guide is to help you to implement the Physics syllabus. It is designed to stimulate you to create meaningful teaching programs and lessons by enabling you to choose relevant and purposeful activities and teaching activities. It will encourage you to research and look for new and challenging ways of facilitating students' learning in Physics.

The teacher guide supports the syllabus. The syllabus states the learning outcomes for the subject and units, and outlines the content and skills that students will learn, and the assessment requirements.

The teacher guide provides direction for you in using the outcomes approach in your classroom. The outcomes approach requires you to consider assessment early in your planning. This is reflected in the teacher guide.

This teacher guide provides examples of learning and teaching strategies. It also provides detailed information on criterion-referenced assessment, and the resources needed to teach Physics. The section on recording and reporting shows you how to record students' marks and how to report against the learning outcomes.



## The outcomes approach

In Papua New Guinea, the Lower Secondary and Upper Secondary syllabuses use an outcomes approach. The major change in the curriculum is the shift to what students know and can do at the end of a learning period, rather than a focus on what the teacher intends to teach.

An outcomes approach identifies the knowledge, skills, attitudes and values that all students should achieve or demonstrate at a particular grade in a particular subject (the learning outcomes). The teacher is responsible for identifying, selecting and using the most appropriate teaching methods and resources to achieve these learning outcomes.

Imagine the student is on a learning journey, heading to a destination. The destination is the learning outcome described in the syllabus document. The learning experiences leading to the learning outcome are to be determined by the teacher. The teacher uses curriculum materials, such as syllabus documents and teacher guides, as well as textbooks or electronic media and assessment guidelines, to plan activities that will assist students achieve the learning outcomes. The outcomes approach has two purposes. They are:

- to equip all students with knowledge, understandings, skills, attitudes and values needed for future success
- to implement programs and opportunities that maximise learning.

Three assumptions of outcomes-based education are:

- all students can learn and succeed (but not on the same day or in the same way)
- success breeds further success
- schools can make a difference.

The four principles of the Papua New Guinean outcomes approach are:

*1 Clarity of focus through learning outcomes*

This means that everything teachers do must be clearly focused on what they want students to be able to do successfully. For this to happen, the learning outcomes should be clearly expressed. If students are expected to learn something, teachers must tell them what it is, and create appropriate opportunities for them to learn it and to demonstrate their learning.

*2 High expectations of all students*

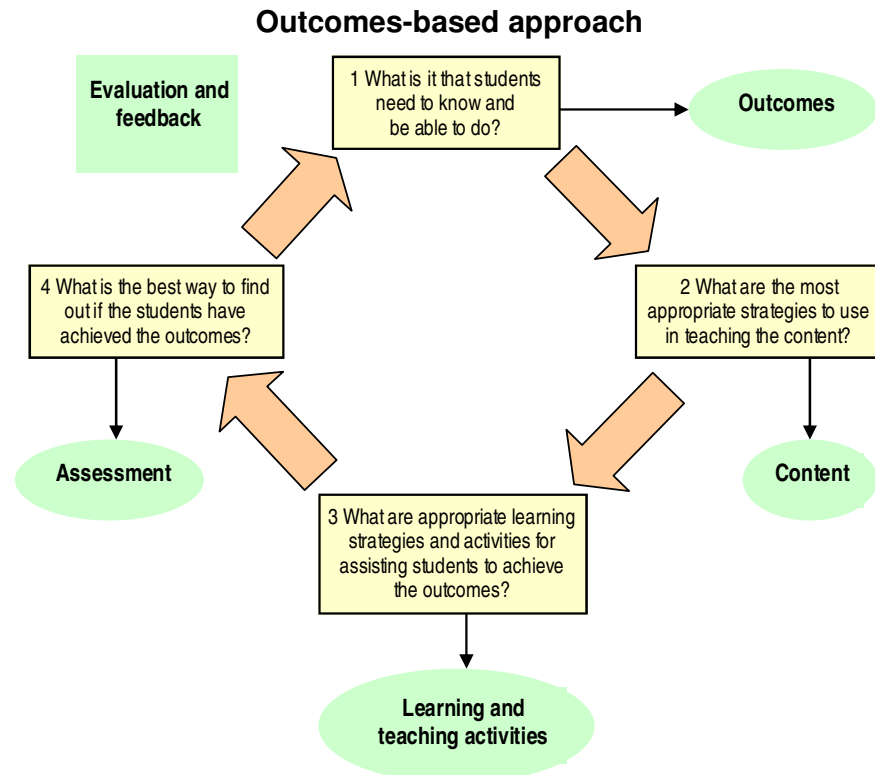
This means that teachers reject comparative forms of assessment and embrace criterion-referenced approaches. The 'principle of high expectations' is about insisting that work be at a very high standard before it is accepted as completed, while giving students the time and support they need to reach this standard. At the same time, students begin to realise that they are capable of far more than before and this challenges them to aim even higher.

*3 Expanded opportunities to learn*

This is based on the idea that not all students can learn the same thing in the same way in the same time. Some achieve the learning outcomes sooner and others later. However, most students can achieve high standards if they are given appropriate opportunities. Traditional ways of organising schools do not make it easy for teachers to provide expanded opportunities for all students.

#### 4 *Planning and programming by 'designing down'*

This means that the starting point for planning, programming and assessing must be the learning outcomes—the desired end results. All decisions on inputs and outputs are then traced back from the learning outcomes. The achievement of the outcome is demonstrated by the skills, knowledge and attitudes gained by the student. The syllabuses and/or teacher guides describe some ways in which students can demonstrate the achievement of learning outcomes.



Learning outcomes provide teachers with a much clearer focus on what students should learn. They also give teachers greater flexibility to decide what is the most appropriate way of achieving the learning outcomes and meeting the needs of their students by developing programs to suit local content and involve the community.

The outcomes approach promotes greater accountability in terms of student achievement because the learning outcomes for each grade are public knowledge—available to teachers, students, parents and the community. It is not the hours of instruction, buildings, equipment or support services that are the most important aspect of the education process but rather, what students know and can do, as they progress through each grade. The outcomes approach means that learning

- has a clearer purpose
- is more interactive—between teacher and students, between students
- has a greater local context than before
- is more closely monitored and acted upon by the teacher
- uses the teacher as a facilitator of learning as well as an imparter of knowledge.

## Learning outcomes

The syllabus learning outcomes describe what students know and can do at the end of Grade 12. The level of achievement of the learning outcome should improve during the two years of Upper Secondary study, and it is at the end of the study that students are given a summative assessment on the level of achievement of the learning outcome.

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



## Learning and teaching

You, as a teacher, must teach the knowledge that is included in the syllabus documents. Not only do you have to be able to teach what students should know, you must also be able to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support learning and teaching. You also need to give students some opportunities to apply their knowledge, to be creative and to solve problems.

## Learning and teaching strategies

Students who participate in guided instruction learn more than students who are left to construct their own knowledge (Mayer 2004). You need to employ a variety of learning and teaching approaches because all students do not learn in the same way. The 'auditory learner' prefers to use listening as the main way of learning new material whereas a 'visual learner' prefers to see things written down. Students should be actively involved in their learning and therefore you need to design appropriate practical activities or experiments, using resources that can be found in your location.

In Grades 11 and 12, students will already have had a wide variety of experiences. You need to make use of your students' experiences when designing and conducting learning in class; learning that is connected to your students' world. There are many learning and teaching strategies described in the Lower Secondary teacher guides.

The following are some important learning and teaching strategies that can be used in implementing the Physics syllabus:

- investigations and problem solving
- inquiry
- laboratory experiments
- field work
- research
- predict–observe–explain
- use of analogies, metaphors and examples
- group work
- cooperative learning
- tinkering table
- use of charts
- mind maps or concept maps
- models

The most efficient and long-lasting learning occurs when teachers encourage the development of higher-order thinking and critical analysis skills, which include applying, analysing, evaluation and creating. Attention should also be paid to developing students' affective and psychomotor skills. To make sure that this takes place, you should encourage deep or rich—rather than shallow—coverage of knowledge and understandings.

## Developing Physics skills

Physics teachers must strive to provide opportunities for students to develop life skills. Student activities are designed to address the content knowledge that general science strands usually ignore.

The broad areas covered in this strand include knowledge, skills, attitudes and values. The knowledge obtained must be relevant, to bring about positive changes in attitudes and values that will have impact on society. The opportunities provided through activities such as laboratory experiments, field work and research will lead to students acquiring applicable knowledge and skills. Such knowledge and skills should enable individuals to participate effectively in this contemporary society.

### What do students do in Physics?

What follows is some elaboration of the skills that students should develop through particular activities.

#### **Fieldwork, laboratory experiments and research**

Fieldwork, laboratory experiments and research are essential parts of the study of Physics. They are scientific tools that facilitate the understanding of scientific processes and inquiry. These can enhance learning opportunities for a wide range of students because they cater for a variety of learning and teaching styles.

##### *Fieldwork*

Fieldwork enables students to:

- acquire knowledge about environments by hypothesising, observing, experimenting, measuring and recording phenomena in the real world in a variety of places, including the school
- explore the scientific processes that form and transform lifestyles
- use different kinds of scientific tools and approaches, including information and communication technology (ICT), to assist in the interpretation of, and decision-making about, scientific phenomena
- locate, select, organise and communicate scientific information
- explore different perspectives on scientific issues.

##### *Laboratory experiments*

Laboratory experiments enable students to:

- identify problems, predict, test hypotheses by conducting experiments, observing, recording and analysing data
- draw conclusions, recognising errors and make recommendations for improvement
- communicate findings based on evidence
- improve manipulative skills.

##### *Research*

Research enables students to:

- explore various media and sources of obtaining information
- select relevant information and issues and make informed choices
- improve research writing skills
- design and develop models or experiments.

### **What do teachers of Physics do?**

The Physics teacher:

- is interested in and concerned about events and movements in the local, national and global community
- actively seeks to keep informed while maintaining a critical stance towards sources of information
- takes a principled stand, and supports others who do so, against injustices and inequalities relating to race, gender, class, physical or mental attributes
- informs him or herself about environmental issues as they impact upon his or her community and on communities and ecological systems globally
- values democratic processes as the best means of bringing about positive change
- engages in some form of social action to support her or his beliefs.

As a teacher, she or he will:

- model democratic values of fairness, justice and equal respect
- use a range of teaching styles that foster both individual development and group cooperation and enable learners to make the best use of their differing learning styles
- encourage her or his learners to adopt a reflecting and questioning position in relation to geological knowledge
- teach the prescribed curriculum well with an emphasis on infusing issues dealing with human rights, relationships, self-esteem and respect for diversity
- be a critical and thoughtful teacher.

### **Developing a program**

A teaching program outlines the nature and sequence of learning and teaching necessary for students to demonstrate the achievement of the learning outcomes. The content of the syllabus describes the learning context and the knowledge required for the demonstration of each outcome. The relevant learning outcomes for each unit or topic are stated at the beginning of the unit and the requirements of the outcomes are elaborated.

Teachers must develop programs that include appropriate learning activities to enable students to develop the knowledge and skills identified in the outcome statements.

The content prescribed in the units indicates the breadth and depth with which topics should be treated. The sequence of teaching is prescribed by the sequence of content. The learning outcomes and assessment, however, must be central to the planning of the teaching program.

## Planning and programming units

The main purpose of planning and programming is to help you to arrange the presentation of the unit in an organised manner. This will help you to know what to teach and when to teach it. It is strongly recommended that you make plans with the other teachers who teach the same subject. By planning together, you will *all* have better lessons and make better use of your limited resources.

### Points to consider when programming

- Which outcomes are students working towards?
- What is the purpose of this unit or topic or learning experience?
- Which learning experiences will assist students to develop their knowledge and understandings, skills, values and attitudes in Physics?
- What are the indicators of student learning that you would expect to observe?
- How can the learning experiences be sequenced?
- How do the learning experiences in the unit relate to students' existing knowledge and skills?
- How are individual learning needs to be catered for?
- What are the literacy demands of this unit or learning experience?
- What authentic links can be made with the content of other subjects?
- How can school events and practices be incorporated into the program?
- Do the assessment methods address the outcomes and enhance the learning?
- How can the assessment be part of the learning and teaching program?

### The planning process

In this teacher guide, ideas for programming and organising have been provided. These have been arranged in steps to help you teach the unit. The steps follow the thinking processes involved in the outcomes approach.

#### Step 1: Interpreting the learning outcomes

The first step is to read the description in the syllabus. Then study the learning outcomes and what students do to achieve the learning outcomes, in order to determine what students will know and be able to do by the end of the unit.

You need to look at the action verb, concept and context of each learning outcome. This will help you to see what skills and knowledge are embedded in the outcome.

#### Step 2: Planning for assessment

It is necessary to plan for assessment early to ensure that you teach the content and skills students need to achieve the learning outcomes.

You will have to decide when to schedule assessment tasks to allow yourself time to teach the required content and time for students to develop the necessary skills. You will also need time to mark the task and provide feedback. Practical tasks may, for example, be broken into a series of stages that are marked over several weeks as students progress with making their product. It is not appropriate to leave all assessment until the end of the unit.

This teacher guide provides performance standards and examples of a marking guide. You should develop marking guides when you are marking tasks to ensure consistency in your assessment. You must also develop clear and detailed instructions for completing the task and make sure all students know exactly what they have to do.

### **Step 3: Programming a learning sequence**

This step requires you to develop a program outlining a sequence of topics and the amount of time spent on each topic. If the unit involves a project, for example, you may plan to teach some theory at appropriate stages during the project, rather than teaching all the theory before the students start the project.

To develop your program you need to study the topics listed in the syllabus and to think about which learning activities will best provide students with the opportunity to learn the content and practise the appropriate skills, and how long the activities will take. You will have to think about some major activities that last several weeks and smaller activities that may be completed in a single lesson.

### **Step 4: Elaboration of activities and content**

Once you have mapped out your program for the term, you must then develop more detailed plans for each topic in the unit. All units require students to be actively engaged in learning, not just copying from the board. Make sure you develop a range of activities that suit all learning needs—some reading and writing, some speaking and listening, some observing and doing.

Browse through the textbooks and teaching resources you have access to and list the chapters, pages or items that you will use for each topic in your program. The textbooks should also provide you with ideas for activities related to the topic. You may have to collect or develop some resources for yourself.

Once you have sorted out your ideas and information, you can then develop your more detailed weekly program and daily lesson plans.

This teacher guide gives some suggested learning and teaching activities for each unit and some suggested assessment tasks that you might like to use to ensure active learning. It also gives background information on some of the content.

## **Using the internet for classroom activities**

### *Planning*

- Where appropriate, incorporate computer sessions as part of planned learning experiences.
- Be aware that computers can be time-consuming and may require extra teacher support at unexpected times.
- Consider methods of troubleshooting, such as having students with computer expertise designated as computer assistants.
- Design activities that provide the opportunity for students to access, compare and evaluate information from different sources.
- Check protocols, procedures and policies of your school and system regarding the use of the internet.

### *Managing*

- Ensure that all students have the opportunity to explore and familiarise themselves with the technologies, navigation tools, e-mail facilities and texts on the internet. It is likely that students will have varying degrees of expertise in searching for information and navigating the internet. Students will also have varying experiences of, and be more or less familiar with, the way texts are presented on the World Wide Web.
- Ensure that all students understand how to access the internet and perform basic functions such as searching, sending and receiving e-mail.
- Students with more experience in using the internet may have information that will benefit the whole class. Provide opportunities for students to share their experiences, interests, information and understandings. As well as planning lessons to instruct students in these skills, pairing students and peer tutoring on the computer can enable more experienced students to assist other students.
- Ensure that students critically analyse physics information gathered on the internet, just as they would for any other text. They should be aware that material posted on the Web is not necessarily subject to the conventional editorial checks and processes generally applied to print-based publications. When evaluating information, students might consider:
  - the intended audience of the site
  - bias in the presentation of information, or in the information itself, including commercial or political motives
  - accuracy of information
  - balanced points of view
  - currency of information, including publishing dates
  - authority of source or author (institution, private individual)
  - ownership of the website (such as corporate, small business, government authority, academic)
  - cultural or gender stereotyping.
- Ensure that software and hardware (computer, modem) are maintained in good working order.
- Ensure that all students are given equal opportunities to use the computer.

### *Assessing student work containing material from the internet*

- Students can download large quantities of information from the internet. In itself, such information provides very little evidence of student effort or student achievement. Students must make judgements about the validity and safety of information when working from the Web. They must consider the purpose of the text, identify bias, and consider the validity of arguments presented and the nature and quality of the evidence provided.
- When assessing student work that includes material drawn from the internet, it is therefore important to recognise how students have accessed the information, what value they place on it and how they have used it for the topic being studied in class. It is useful to look for evidence of critical evaluation, and the development of students' capacities to access, manipulate, create, restore and retrieve information.

## Physics requirements

There are six units in Grade 11 and five units in Grade 12, which all students must complete.

### Physics requirements

Grade	Weeks	Term	Unit	Essential resources for activities and assessment
11	3–4	1	11.1 Measurement	Graduated cylinders, thermometers, balances, metre rules, stopwatches, force meters, vernier calipers, micrometer gauges, regular-shaped objects
11	6–7	1–2	11.2 Motion (Kinematics)	Metre rules, stopwatches, ticker timers and tapes, trolleys, linear air tracks, semicircular tracks, ball bearings, carbon papers, tape measures, pendulums
11	6–7	2	11.3 Force and Motion (Dynamics)	Metre rules, stop watches, tape measures, balances, pulleys, mass, mass carriers, trolleys, wooden blocks, ropes
11	5–6	3	11.4 Work, Power and Energy	Metre rules, balances, force meters, pulleys, mass, levers, pendulum, ropes, model energy converters, wheel and axle
11	8–9	3–4	11.5 Electricity Principles	Electroscopes, Perspex rulers, electroscopes and ebonite and glass rods, silk and fur materials, pieces of paper, ammeters, voltmeters, galvanometers, ohmmeters, dry cells, light bulbs, resistors, dry cell holders, press key switches, resistance boxes, Wheatstone bridges (slide wire form or resistor form), potentiometers (slide wire type), resistance wires (nichrome) of different diameters and lengths, metre rules, copper wire leads
11	5–6	4	11.6 Electronics	Breadboards, 2-inputs and 4-inputs logic gates (AND, OR, NOT, NAND, XOR) and their specifications including pin layout diagrams, 5–10 V power supply sources or dry cell batteries, dry cell battery holders, single strand wires (2 mm diameter) for connections on the breadboards, light-emitting diodes (LEDs), NPN and PNP transistors (common-emitter, common-base, common collector) diodes, cathode ray oscilloscopes
12	5–6	1	12.1 Fluids	Solid objects (regular and irregular shapes), liquids (oil, water, alcohol), graduated cylinders, balances, hydraulic jack, hose, thin light ring of 1 centimetre diameter, spring balances, cotton threads
12	6–7	1–2	12.2 Temperature and Heat	Thermometers, calorimeters, heaters, beakers, blocks of ice; solid metals of regular shapes
12	6–7	2	12.3 Waves	Ripple tanks, ropes, springs, glass and Perspex prisms, ray box kits
12	7–8	3	12.4 Electromagnetism	Permanent magnets, copper wires, iron filings, compasses, power supplies, soft iron core
12	5–6	3–4	12.5 Radioactivity and Nuclear Energy	Radioactive decay data, electroscopes and ebonite and glass rods, silk and fur materials, alpha radioactive source, paper, metal foil, radioactive source (lead) container

## Assessing Physics

Assessment is an important part of learning and teaching. It is used to:

- evaluate and improve learning and teaching
- report achievement
- provide feedback to students on their progress
- provide feedback to stakeholders.

### Criterion-referenced assessment

Assessment in Physics is criterion-referenced and measures students' achievement of the learning outcomes described in the syllabus. In criterion-referenced assessment, particular knowledge, skills or abilities are specified as criteria that must be achieved. The extent to which they are achieved is assessed and facilitated by the teacher.

Criterion-referenced assessment often takes on a problem-centred orientation, rather than a knowledge-based orientation. To achieve an outcome means having to demonstrate the attainment of skills and attitudes, not just write about them. Assessment then becomes more than just a means of judging knowledge and performance—it becomes an integral part of the learning process itself.

Criterion-referenced assessment is:

- standards or criterion-referenced; that is, outcomes are judged against pre-defined standards (see following table)
- direct and authentic, related directly to the learning situation. This has the potential for motivating learning, since students can see a direct relevance between what is learnt and what is assessed.

### Norm-referenced assessment

'Norm-referenced assessment' makes judgements on how well the student did in relation to others who took the test. It is often used in conjunction with a curve of 'normal distribution', which assumes that a few will do exceptionally well and a few will do badly and the majority will peak in the middle, normally judged as average.

### Example of a criterion-referenced test

The driving test is the classic example of a criterion-referenced test. The examiner has a list of criteria, each of which must be satisfactorily demonstrated in order to pass; for example, completing a three-point turn without hitting either kerb. The important thing is that failure in one criterion cannot be compensated for by above-average performance in others; nor can a student fail in spite of meeting every criterion (as they can in norm-referenced assessment) simply because everybody else that day surpassed the criteria and was better than him or her. Criterion-referenced assessment has the following characteristics:

- a syllabus that describes what students are expected to learn in terms of aims, outcomes and content



- a syllabus that provides a clear sense of the syllabus standards through its aims, outcomes and content
- tasks designed to produce an image of what students have achieved at that point in the learning and teaching process relative to the outcomes
- standards of performance at different levels: the 'performance standards'
- a report that gives marks referenced to predetermined standards
- assessment tasks that refer to syllabus outcomes, content, assessment components and component weightings
- assessment that is better-integrated with learning and teaching
- external exams that are based on syllabus outcomes and content. External markers use standards-referenced marking guidelines developed by the Science Examination Committee.

### Criterion or standards-referenced assessment

<b>Learning outcomes performance standards</b>					
<b>Learning Outcomes</b>	<b>Very high achievement</b>	<b>High achievement</b>	<b>Satisfactory achievement</b>	<b>Low achievement</b>	<b>Below minimum standard</b>
1. Demonstrate understanding of fundamental physics principles and models	Demonstrates extensive knowledge and understands a wide range of physics principles and models	Demonstrates sound knowledge and understanding of physics principles and models	Adequate demonstration of knowledge of physics principles and models	Demonstrates limited knowledge of physics principles and models	Has failed to demonstrate understanding of fundamental physics principles and models
2. Apply scientific inquiry and reasoning skills to find solutions to problems	Highly creative and innovative in conducting investigations using scientific methodologies to find solutions to problems	Sound inquiry and reasoning skills in conducting investigations using scientific methodologies in finding solutions to problems	Adequate inquiry and reasoning skills with fair idea of using scientific methodologies in finding solutions to problems	Demonstrates limited inquiry and reasoning skills in problem solving using scientific methodologies	Has failed to demonstrate scientific inquiry and reasoning skills in solving problems using scientific methodologies
3. Communicate scientific data and information from investigations and laboratory work in different ways	Highly efficient and innovative in communicating information and scientific data from investigations and laboratory work	Very good in communicating scientific data and information from investigations and laboratory work	Adequate competency in communicating information and scientific data from investigations and laboratory work	Limited competency in communicating information and scientific data from investigations and laboratory work	Has failed to achieve competency in communicating information and scientific data from investigations and laboratory work
4. Analyse and interpret data and information	Excellent analysis and interpretation of data and information	Very good in analysing and interpreting data and information	Adequate analysis and interpretation of data and information	Demonstrates limited ability in analysing and interpreting data and information	Has failed to demonstrate ability to analyse and interpret data and information

Learning outcomes performance standards					
Learning Outcomes	Very high achievement	High achievement	Satisfactory achievement	Low achievement	Below minimum standard
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	Makes informed decisions based on excellent analysis and evaluation of developments in physics and their impact on society	Makes informed decisions based on sound analysis and evaluation of developments in physics and their impact on society	Makes decisions based on adequate analysis and evaluation of developments in physics and their impact on society	Makes decisions based on limited analysis and evaluation of developments in physics and their impact on society	Makes decisions based on poor analysis and evaluation of developments in physics and their impact on society
6. Relate relevant traditional knowledge, beliefs, and skills to principles and concepts of physics	Displays excellent ability to perceive and effectively correlate traditional knowledge, belief and skills to principles and concepts of physics	Can effectively perceive and correlate traditional knowledge, belief and skills to principles and concepts of physics	Can adequately perceive and correlate traditional knowledge, belief and skills to principles and concepts of physics	Shows limited ability in perceiving and correlating traditional knowledge, belief and skills to principles and concepts of physics	Is not able to perceive and correlate traditional knowledge, belief and skills to principles and concepts of physics

### Assessment for learning

Assessment *for* learning is often called ‘formative assessment’. It is assessment that gathers data and evidence about student learning during the learning process. It enables you to see where students are having problems and to give immediate feedback, which will help your students learn better. It also helps you plan your program to make student learning, and your teaching, more effective. Often it is informal—students can mark their own work or their friend’s. An example is a quick class quiz to see if students remember the important points of the previous lesson.

### Assessment of learning

Assessment *of* learning is often called ‘summative assessment’. Summative assessment is used to obtain evidence and data that shows how much learning has occurred, usually at the end of the term or unit. End-of-year examinations are examples of summative assessment. It is usually done for formal recording and reporting purposes.

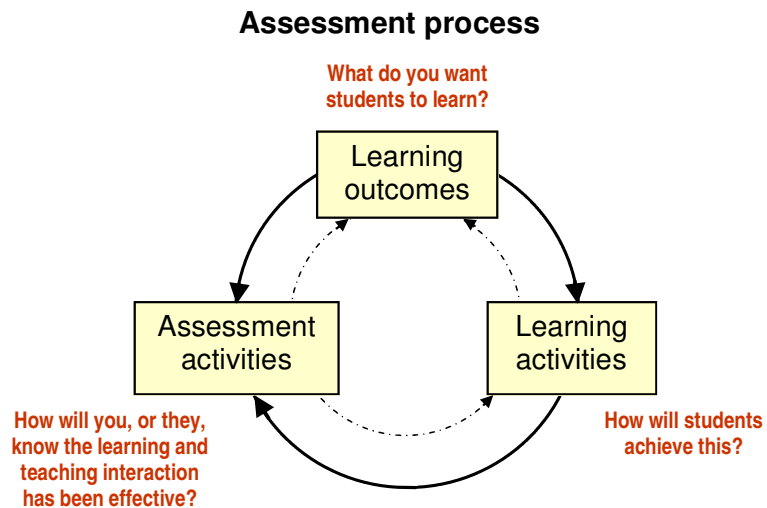
### Assessing Physics units

In Physics the learning outcomes are assessed using the range of assessment methods specified in the syllabus (in the table of components, weightings and tasks).

In deciding what to assess, the starting point is ‘what do you want students to do and/or learn?’ and following from this ‘how will the students engage

with the material?' which in turn leads to the design and development of learning tasks and activities. It is crucial that at this point the assessment tasks clearly link back to the learning outcomes and are appropriate for the learning activities.

The assessment can be used for formative and summative purposes. Assessment can be represented as follows:



Once it is clear what needs to be assessed and why, then the form the assessment will take needs to be determined. There are many types of assessment tasks that can be implemented; the factors that will determine choices include:

- the students—how many are there, what is expected of them, how long will the assessment task take?
- the learning outcomes of the subject and how they might be best achieved.

During the year you must set assessment tasks that ensure that all the learning outcomes of the subject have been assessed internally. Each task you set must include assessment criteria that provide clear guidelines to students as to how, and to what extent, the achievement of the learning outcomes may be demonstrated.

Marking guides and assessment criteria help you with the marking process and ensure that your assessment is consistent across classes. It is important that marking guides and assessment criteria are collectively developed.

Students must complete the assessment tasks set. Each task must provide clear guidelines to students for how the task will be completed and how the criteria will be applied. When you set a task, make sure that:

- the requirements of the task are made as clear as possible to the student
- the assessment criteria and performance standards or marking guides are provided to students so that they know what it is that they have to do
- any sources or stimulus material used are clear and appropriate to the task
- instructions are clear and concise
- the language level is appropriate for the grade
- it does not contain gender, cultural or any other bias

- materials and equipment needed are available to students
- adequate time is allowed for completion of the task.

## Assessment methods

Although assessment components and weightings are stipulated in the syllabus, you decide which assessment method to use when assessing the learning outcomes. You should use a variety of assessment methods to suit the purpose of the assessment. Assessment can be classified into four categories:

- tests
- product or project assessments
- performance assessments
- process skills assessments

Because each has limitations, maintaining a balance of assessment methods is very important.

### Tests

A 'test' is a formal and structured assessment of student achievement and progress, which the teacher administers to the class. Tests are an important aspect of the learning and teaching process if they are integrated into the regular class routine and not treated merely as a summative strategy. Tests allow students to monitor their progress and provide valuable information for you in planning further learning and teaching activities.

Tests will assist student learning if they are clearly linked to the outcomes. Evidence has shown that several short tests are more effective for student progress than one long test. It is extremely important that tests are marked and that students are given feedback on their performance.

There are many different types of tests. Tests should be designed to find out what students know, and also to find out about development of their thinking processes and skills. Open questions provide more detailed information about achievement than a question to which there is only one answer.

#### *Principles of designing classroom tests*

Tests allow a wide variety of ways for students to demonstrate what they know and can do. Therefore:

- students need to understand the purpose and value of the test
- the test must assess intended outcomes
- clear directions must be given for each section of the test
- the questions should vary from simple to complex
- marks should be awarded for each section
- the question types (true or false, fill-in-the-blank, multiple-choice, extended response, short answer, matching) should be varied.

Tests should:

- be easy to read (with space between questions to make reading and writing easier)
- reflect an appropriate reading level

- involve a variety of tasks
- make allowance for students with special needs
- give students some choice in the questions they select
- vary the levels of questions to include gathering, processing and applying information
- provide enough time for all students to finish.

### **Product or project assessments**

A 'project' can be an assessment task given to an individual student or a group of students on a topic related to the subject. The project results in a 'product' that is assessed. The project may involve both in-class and out-of-class research and development. The project should be primarily a learning experience, not solely an assessment task. Because a great deal of time and effort goes into producing a quality product from a project assignment task, you should allow class time to work on the project. A product or project:

- allows the students to formulate their own questions and then try to find answers to them
- provides students with opportunities to use their multiple intelligences to create a product
- allows teachers to assign projects at different levels of difficulty to account for individual learning styles and ability levels
- can be motivating to students
- provides an opportunity for positive interaction and collaboration among peers
- provides an alternative for students with problems reading and writing
- increases the self-esteem of students who would not get recognition on tests or traditional writing assignments
- allows for students to share their learning and accomplishments with other students, classes, parents, or community members
- can achieve essential learning outcomes through application and transfer.

### **Assignments**

'Assignments' are unsupervised pieces of work that often combine formative and summative assessment tasks. They form a major component of continuous assessment in which more than one assessment item is completed within the term. Any of the methods of assessment can be set as assignments, although restrictions in format, such as word limits and due dates, are often put on the assessment task to make them more practical.

### **Investigations**

An 'investigation' involves students in a study of an issue or a problem. Teachers may guide students through their study of the issue; or individual students, or groups of students, may choose and develop an issue in consultation with the teacher. This assessment component emphasises the student's investigation of the issue in its context, by collecting, analysing, and commenting on secondary data and information.

Students should be encouraged to consider and explore a variety of perspectives as they develop and state their position on the issue. Students may present the investigation for assessment in a variety of forms, including one or a combination of the following: a written report, an oral presentation, a website, linked documents, multimedia, a video or audio recording.

#### *Criteria for judging performance*

The student's performance in the investigation will be judged by the extent to which the student:

- identifies and describes the issue or problem
- describes and explains the causes and effects
- critically analyses information and outlines possible steps leading to a solution or recommendation.

### **Portfolios**

Portfolios provide evidence for judgements of student achievement in a range of contexts. Portfolios contain a specific collection of student work or evidence. This collection of work should provide a fair, valid and informative picture of the student's accomplishments.

### **Computer-based tasks**

Using computers to administer student assessment can provide flexibility in the time, location or even the questions being asked of students. The most common type of computer-based assessment is based on multiple-choice questions, which can assist teachers to manage large volumes of marking and feedback.

### **Presentation assessments**

'Presentations' provide opportunities for students to develop skills and confidence when presenting to an audience. When presentations are used for assessment purposes, how the students present is as important as what they present.

Presentations can be formal or informal. Class or group presentations must be timed and the purpose clearly defined. Group presentations can be shared among members to allow all members a turn at talking or presenting. Group and individual oral presentations can be very time-consuming, both in their use of valuable lesson time and in marking. The best approach is to allocate or allow students to choose from a variety of topics, to develop clear criteria for presentations, and to require the rest of the class (audience) to take notes, identify key points or write an evaluation to enhance their learning.

'Spotlighting' uses individual student checklists. This method can be used to focus on a few selected aspects of student presentation or outcomes. It is best to focus on five to six students at a time, systematically working through the class over time.

'Focused questioning' is a technique often used in conjunction with spotlighting. With focused questioning, teachers can gain a deeper awareness as to whether or not students understand the concepts or skills being taught.

### Process skills assessments

This method of assessment involves assessing students' understanding of concepts based on the practical skills that can be used, the evaluation of work done and/or the reporting of information. These skills include, for example:

- interpretation skills
- evaluation skills
- reflection skills
- communication skills (such as writing, speaking, and listening).

### Types of assessment tasks

Using different assessment tasks is the way to make sure that students are able to demonstrate the range of their abilities in different contexts. Each category has advantages in assessing different learning outcomes. For example, a selected-response assessment task, such as a series of multiple-choice questions, is able to assess all areas of mastery of knowledge, but only some kinds of reasoning.

### Assessment ideas for individual students or groups

Tests	Products or projects	Performances	Process skills
Multiple-choice	Case studies	Cooperative learning group activities	Classifying
Matching	Displays	Demonstrations	Estimating
Short answer	Graphs, charts, diagrams	Field trips	Experimenting
True or false	Lab reports	Laboratory experiences	Investigating
Practical	Models	Presentations	Measuring
Extended response	Product descriptions		Observing
	Projects		Predicting
	Research papers		Using and manipulating equipment
			Communicating
			Cooperating and collaborating
			Graphing
			Organising and interpreting data
			Problem solving
			Making decisions
			Researching

### Feedback

When you assess the task, remember that feedback will help the student understand why he or she received the result and how to do better next time. Feedback should be:

- *constructive*, so students feel encouraged and motivated to improve
- *timely*, so students can use it for subsequent learning

- *prompt*, so students can remember what they did and thought at the time
- *focused on achievement*, not effort. The work, not the student, should be assessed
- *specific to the unit learning outcomes*, so that assessment is clearly linked to learning.

### **Types of feedback**

Feedback can be:

- *informal or indirect*—such as verbal feedback in the classroom to the whole class, or person to person
- *formal or direct*—in writing, such as checklists or written commentary to individual students, in either written or verbal form
- *formative*—given during the topic with the purpose of helping the students know how to improve
- *summative*—given at the end of the topic with the purpose of letting the students know what they have achieved.

## **Who assesses?**

### **Teacher assessment**

Assessment is a continuous process. You should:

- always ask questions that are relevant to the outcomes and content
- use frequent formative tests or quizzes
- check understanding of the previous lesson at the beginning of the next lesson, through questions or a short quiz
- constantly mark or check the students' written exercises, class tests, homework activities and so on
- use appropriate assessment methods to assess the tasks.

### *Frequency of assessment*

You should schedule the specified assessment tasks to fit in with the teaching of the content of the unit that is being assessed. Some assessment tasks might be programmed to be undertaken early in the unit, others at the end of the unit. You should take care not to overload classes with assessment tasks at the end of the term.

### *Judging student performance*

Student achievement is recorded and reported against standards. You must use performance standards or marking guides, examples of which are provided in this teacher guide, when making a decision about the achievement of your students in relation to the learning outcomes. The performance standards describe the level at which the student has to be working to achieve a particular standard or mark.

Students should always have access to a copy of the assessment criteria and the performance standards, so that they know what it is they have to know and be able to do to get a good mark in a particular task. The performance standards will help you in your marking and will help your students improve their performance in the future. They are useful when



providing feedback to students, as they explain what it is the student needs to do to improve.

#### *Moderation*

To make sure that you are interpreting the performance standards correctly when assessing your students, it is important to undertake Physics moderation of student work within your school and with teachers of nearby schools.

To moderate student work, a common assessment task must be used and a marking scheme developed so that all students complete the same task under the same conditions, and all teachers use the same marking scheme. Teachers can then compare (moderate) the students' work and come to a common understanding of the performance standards and the requirements for a particular mark or level of achievement.

Moderation enables you to be sure that your understanding of the required standards for levels of achievement is similar to the understanding of other teachers and that you are assessing students at the appropriate level.

#### **Self-assessment and peer assessment**

Self-assessment and peer assessment help students to understand more about how to learn. Students should be provided with opportunities to assess their own learning (self-assessment) and the learning of others (peer assessment) according to set criteria. Self-assessment and peer assessment:

- continue the learning cycle by making assessment part of learning
- show students their strengths and areas where they need to improve
- engage students actively in the assessment process
- enable students to be responsible for the learning
- help to build self-esteem through a realistic view of their abilities
- help students understand the assessment criteria and performance standards.

### **Managing assessment tasks for Physics**

Usually, the marking of assessment tasks is done by the teacher. To reduce the amount of work it is necessary to develop a strategic approach to assessment and develop efficiencies in marking.

In Physics there are some assessment tasks that may be new to teachers and students. Below are suggestions on how to manage some of these tasks to minimise marking or presentation time.

#### **Develop efficiency in marking**

##### *Clarify assessment criteria*

Plan the assessment task carefully, and make sure that all students are informed of the criteria before they begin. Discuss the task and its criteria in class, giving examples of what is required. Distribute a written copy of the instructions and the criteria, or put them on the board. Making the assessment criteria explicit speeds marking and simplifies feedback.

*Supply guidelines on what is required for the task*

Supplying guidelines reduces the amount of time wasted evaluating student work that is irrelevant.

*Use attachment sheets such as marking guides*

An assignment attachment sheet, which is returned with the assessed work, rates aspects of the task with a brief comment. Such a system enables each student's work to be marked systematically and quickly. This strategy can be applied to posters, presentations and performances.

*Assess in class*

Use class time to carry out and to assess tasks. Presentations or projects that are marked by you or the students enable instant developmental evaluation and feedback. Brief assessments of projects, stages of the design process, or practical work take less time to mark and are useful because they give immediate feedback to students on their progress and allow you to mark the project in stages with minimum effort.

*Feed back to the whole class*

Giving feedback to the whole class can cut down on the amount of individual feedback required. On returning assessed work, emphasise the criteria for judging the work, discuss the characteristics of good and bad answers, and highlight common strengths and weaknesses.

*Set group-work alternatives*

Assess one performance per group. The student's mark is the group mark, but may include a component based on the contribution of the individual. A strategy for allocating an individual mark includes each member of the group using criteria to evaluate the relative contributions of individuals, with the marks averaged for the individual.

*Set clear deadlines*

Set aside a time for marking. Be careful about extending this period (by allowing students to hand in work late).

**Shift the responsibility**

*Introduce self-assessment and peer assessment*

Develop in students the skills to evaluate their own work and that of their peers. With the students, use the assessment criteria against which work is judged, highlighting strengths and weaknesses. Self-assessment increases the amount of feedback students get. It can supplement or replace teacher assessment.

**Treat each task differently**

Every piece of work need not be evaluated to the same degree; a mark need not be the outcome in every case; and every piece of student work need not contribute to the final grade. Assessment is designed to enhance the learning and teaching experience for the teacher and the learner, not just to give marks.

## Sample assessment tasks

All assessment tasks must test whether or not the student has achieved the outcome or outcomes. Each task must have clear and detailed instructions. Students must know exactly what they have to do. You should develop marking guides when you are marking tasks to ensure consistency of your assessment.

### Grade 11

The following is an example of an assessment task and marking guide for unit 11.1 Measurement. The sample task and assessment criteria can be used to assess the outcomes of this unit. Teachers can use the sample to develop other assessment tasks, criteria and performance standards.

#### **Sample task: Calculating density of an irregular object**

Students will set up an experiment to find the density of an irregular shaped object.

#### **Learning outcomes**

Students can:

1. demonstrate understanding of fundamental physics principles and models
3. communicate scientific data and information from investigations and laboratory work in different ways
4. analyse and interpret data and information.

#### **Assessment criteria**

Students will be assessed on the extent to which they:

- |   |     |
|---|-----|
| • carry out lab with minimum supervision        | 10% |
| • use selected devices or instruments correctly | 20% |
| • measure and calculate accurately              | 40% |
| • present results                               | 30% |

#### **Task specifications**

1. Measure the mass of the object using a balance and record the reading.
2. Fill a measuring cylinder with 100ml of water.
3. Place the irregular-shaped object in the measuring cylinder and record the change in the water level. The change in the water level would give the volume of the object.
4. Use the mass and volume reading recorded to calculate the density of the object.
5. Present a laboratory report on the investigation.

## Sample marking guide

Marking guides, like the one below, should be used to assess the tasks you set.

### Sample marking guide for calculating density of an irregular object

<b>11.1 Practical skills and laboratory report</b>		<b>100% score</b>
<b>Criteria</b>		<b>Marks</b>
Carry out lab with minimum supervision Use selected devices or instrument correctly	<ul style="list-style-type: none"><li>• Understand task given and carry out lab independently without supervision (10%)</li><li>• Understand how an instrument or device is used and be able to use with confidence (20%)</li></ul>	
Measure and calculate accurately	<ul style="list-style-type: none"><li>• Take correct measurements and perform calculations to obtain accurate result (40%)</li></ul>	
Presentation of results	<ul style="list-style-type: none"><li>• Present outcome of investigation in a clear and comprehensive manner through oral and written report or through a demonstration (30%)</li></ul>	

## Grade 12

The following is an example of an assessment task and marking guide for unit 12.4 Electromagnetism. The sample task and assessment criteria can be used to assess the outcomes of this unit. Teachers can use the sample to develop other assessment tasks, criteria and performance standards.

### Sample task: Project

Students build a cheap-O motor.

### 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.

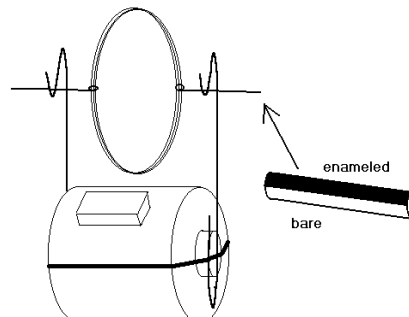
### Assessment criteria

Students will be assessed on the extent to which they:

- carry out the project with minimum supervision 15%
- correctly assemble the motor using required or alternative materials as instructed 30%
- their assembled motor functions efficiently 25%
- present results 30%

### Task specifications: Assembly

1. Wind 12 or so turns of enamelled copper wire (see diagram). It is important to wind the coil as circular a possible, to distribute the mass of the wire evenly all the way around. Winding the coil around a D cell is a great way to keep the coil circular.
2. Use a razor blade or fine sandpaper to remove the enamel completely from one of the tails. With the coil in a vertical position, remove the enamel from the top half only of the other tail.



3. Centre the tails and straighten them to form a shaft for the coil.
4. To form supports for the coil, open 2 jumbo paper clips and bend a hook in the large end as shown.
5. Use a sturdy rubber band to attach one support to each end of a “D” cell. Set a magnet on the cell as shown. You may have to tape the paperclips to the cell terminals tightly with masking tape to achieve excellent connections.
6. To operate the motor, set the coil in the supports. You might have to give the coil a gentle spin to get it started.
7. Wind a second coil with 24 turns or so. See how this compares to the coil with 12 turns.

### Example of a marking guide

Marking guides, like the one below, should be used to assess the tasks you set.

#### Sample marking guide for building an electric motor

12.4 Students build an electric motor		20 marks
Criteria		Marks
Carry out the project with minimum supervision	<ul style="list-style-type: none"> <li>• Follows instructions (1 mark)</li> <li>• Completes project on time (1 mark)</li> <li>• Minimum teacher supervision (1 mark)</li> </ul>	
Correctly assemble the motor using required or alternative materials as instructed	<ul style="list-style-type: none"> <li>• Motor is assembled correctly (6 marks)</li> </ul>	
Their assembled motor functions efficiently Presentation of results	<ul style="list-style-type: none"> <li>• Creativity in design (1 mark)</li> <li>• Model operates efficiently (5 marks)</li> <li>• a written report on the project (3 marks)</li> <li>• Oral presentation explaining operating principle of the motor (2 marks)</li> </ul>	

## Learning activities and assessment tasks

Examples of learning activities and assessment tasks for each of the Physics units are provided in the following sections. Some examples are explained in detail.

### Grade 11 units

#### 11.1 Measurement

##### Suggested activities

###### Quantities and units

Discuss and define measurement.

###### Key questions

- Why is qualitative evaluation of a phenomenon by human senses undesirable? Give an example that stresses the need for measurement
- What is measurement of a quantity?
- What is a quantity? Give an example of a quantity and its measurement method
  - Let students specify examples of their own traditional quantities, their units and the methods of measuring them. The measurement method(s) should not include modern techniques. In this exercise, parents of students or community may be invited to participate and contribute, either in class or by way of contributing towards a homework exercise given to their children.
  - Discuss International System of Units (SI).
  - Describe and classify quantities as basic or fundamental and derived quantities. Name the fundamental quantities, their units and symbols. These class of quantities include mass (kilograms [kg { $m$ ]}), length (metre [m] { $l$ }), time (second [s] { $t$ }), electric current (ampere [A] { $I$ }), temperature (Kelvin [K] { $T$ }), luminous intensity (candela [cd]), and amount of substance (mole [mol { $n$ ]}). Give some examples of derived quantities and their units.
  - Define scalar and vector quantities and give examples of each type together with their respective units and symbols.
  - Describe significant figures in a number and express the number into normal and scientific notation forms. Give examples and exercises involving description and writing of significant figures, numbers in normal and scientific notation forms.
  - Describe prefixes, their symbols, meaning, value expressed in normal and the factor  $10^x$  forms. For example, the prefix *Milli* has the symbol  $m$ , meaning *one thousandth* and the value  $0.001$  and  $10^{-3}$  in normal and  $10^x$  forms respectively.

**Measuring instruments**

- Demonstrate with confidence the use of basic measuring instruments and analyse the readings to a reasonable degree of accuracy
  - timer, thermometer, measuring cylinder, balance, ruler, vernier calipers, micrometer screw gauge and so on

**Dimensional analysis**

- Emphasise that the three commonly used fundamental units applied in dimensional analysis are kilogram (kg), metre (m) and second (s) whose dimensions are [mass, M], [length, L] and [time, T] respectively.
- Express correct symbol of indicating dimension of a quantity; for example: Velocity, V has the unit of m/s. The dimension of velocity is therefore:  $[V] = [L]/[T]$  or  $[V] = [L][T]^{-1}$ . Give examples of quantities and their dimensions.
- Perform dimensional analysis to examine the validity of an expression as well as to determine the dimension of a variable in a function. Give exercises on dimensional analysis of expressions or functions defining a quantity or variable.

**Error analysis**

- Define error in measurement.
- Discuss the following types of errors in measurement
  - random and systematic error
  - parallax and zero error
  - reaction time error
- Discuss uncertainties in measurement.
- Discuss how errors can be minimised: group method; averaging readings
- Perform analysis and calculations of percentage error, relative and absolute error, and errors associated with combining (that is, multiplication, division, addition and subtraction) measured quantities.

**Graphs**

- Draw graphs from experimental data and plot lines of best-fit and error bars on the graph. Specify independent and dependent variables. Explain extrapolation of graphs.
- Perform investigations by collecting data, presenting data in graphical form and drawing conclusions about the investigation; for example, cooling rate of boiling water, extension of spring in response to a load.

**Suggested assessment tasks**

- Assignment and test involving description and writing of significant figures, numbers in normal and scientific notation forms, prefixes and dimensional analysis.
- Laboratory exercise involving measurement of length, width, thickness, radius and mass of regular shaped objects using rulers, vernier caliper, micrometer gauges and balance. Record readings including uncertainties and then calculate area, volume and density of the objects and the errors in these results.



- Laboratory exercise on calculating density of an irregular object.
- Assignment and test on errors in measurement and error analysis (calculations and graphs) from experimental data.

### Resources

- graduated cylinder, objects, thermometer, bench, triple beam balance, teaspoon, pen, metre rule, timer, vernier calliper, ammeter and voltmeter

## 11.2 Motion (Kinematics)

### Suggested activities

#### Characteristics of motion

- Describe characteristic of linear motion including distance, displacement, speed, velocity, acceleration, instantaneous and average speed, velocity and acceleration, and calculate these quantities from a given set of experimental data. Emphasise the correct units of these quantities.
- Perform vector analysis on displacement, velocity and acceleration.

#### Graphs of motion

- Draw and interpret distance–time, speed–time, velocity–time, displacement–time and acceleration–time graphs.
- Conduct ticker timer experiments for uniform and accelerated motions and plot the relevant graphs.
- Describe the motion of an object (uniform and non-uniform) from a ticker tape record and from graphs.
- Determine unknown parameters from graphs of motion; for example, area under displacement–time graph represents average velocity of the moving object.
- Solve worded problems with the aid of diagrams.

#### Equations of motion

- Derive and explain the following equations of linear motion using graphs where necessary. Apply the equations to calculate parameters such as distance, displacement, speed, velocity, acceleration and time.

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

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

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

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

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

- Translate the above equations of linear motion to one-dimensional (vertical) motion of an object under the influence of gravity, as the motion of this object is an example of a linear motion.
- Apply equations of motion to one-dimensional freefall motion (vertical) and solve problems associated with this motion.

### **Projectile motion**

- Draw graphs of motion in two dimensions from a given set of experimental data and worked examples on a two-dimension projectile motion.
- Describe the projectile motion in two separate directions, vertical and horizontal directions, and emphasise the essential facts about the motion along each direction. Derive the relevant equations of motion along each direction.
- Solve word problems on projectile motion.

### **Circular motion**

- Describe quantities of circular motion and their units including angular displacement ( $\theta$ ), velocity ( $\omega$ ) and acceleration ( $\alpha$ ).
- Write the equations of circular motion analogous to the equations of linear motion.
- Explain the relationships between linear and angular quantities.
- Solve worked examples on circular motion.

### **Suggested assessment tasks**

- Assignment and test on vector analysis involving displacement, velocity and acceleration.
- Assignment and test on drawing of graphs of motion in one and two dimensional projectile motion from a given set of experimental data.
- Assignment and test on application of the linear, circular and projectile motion.
- Conduct experiments on uniform linear motions, circular and projectile motions and plot the relevant graphs.

### **Resources**

- Metre rulers, stopwatches, ticker tape timers, centisecond timers or digital timers, laboratory carts or trolleys, linear air tracks, suitable graph paper for plotting graphs

## 11.3 Force and Motion (Dynamics)

### Suggested activities

#### Force

- Define force and identify, name and describe different types of forces such as magnetic, elastic, friction, gravitational, action-reaction, surface tension, upthrust.
- Classify forces as field (non-contact) or contact forces.
- Add forces (calculating net or resultant force) that are acting:
  - in the same direction; in opposite directions; at different angles (use scale drawings or trigonometry).
- Resolve forces into their horizontal and vertical components.

#### Friction

- Explain friction between solid surfaces in contact.
- Differentiate between static and kinetic (dynamic) friction in solids.
- Solve problems on finding friction, static and kinetic friction coefficients.

#### Newton's First Law of Motion

- State and discuss Newton's First Law of Motion.
- Use air track, if available, to demonstrate Newton's First Law of Motion.
- Look at worked examples of the first law.

#### Newton's Second Law of Motion

- State and discuss Newton's Second Law of Motion
- Perform experiments using trolleys, ticker timers and friction compensated runway or air track to show that force is proportional to acceleration (mass is constant) and acceleration is inversely proportional to mass

$$(F \propto a \text{ and } a \propto \frac{1}{m}) \text{ for constant force}$$

- Solve word problems using Newton's Second Law of Motion

#### Newton's Third Law of Motion

- Explain Newton's Third Law of Motion.
- Relate Newton's Third Law of Motion to situations.
- Solve problems related to Third Law of Motion.

#### Momentum and impulse

- Define and calculate momentum and impulse.
- Derive momentum and impulse from Newton's Second Law of Motion.
- Analyse and explain force–time graph associated with impulse.
- Explain how momentum, impulse, force and time are related.
- Solve momentum and impulse problems.

- Conduct experiments to demonstrate momentum and energy in collisions.
- Distinguish between elastic and inelastic collisions.
- Apply laws of conservation of momentum and energy to collision problems.

#### **Applications of Newton's laws**

- Apply concepts of Newton's laws of motion and explain weight and apparent weightlessness, a body moving on an inclined plane, coupled bodies and surface tension of a liquid.
- Conduct an experiment on any one of the following situations to demonstrate the concepts of Newton's laws of motion; weight and apparent weightlessness, a body moving on an inclined plane, coupled bodies and surface tension of a liquid.

#### **Suggested assessment tasks**

- Assignment and test involving solving of problems on Newton's laws of motion.
- Assignment and test on application of laws of conservation of momentum and energy to collision problems.
- Conduct an experiment to measure unbalanced force.
- Conduct an experiment to investigate weight and apparent weightlessness, a body moving on an inclined plane, coupled bodies, and surface tension, using an air track and photo-electric timers.

*Sample project on force and motion: A balloon-propelled car*

#### **Materials (per group of students)**

- 2 drinking straws, 1 large index card, 4 plastic juice bottle caps with small hole drilled in centre of each, 1 plastic "pick-up stick" or wooden skewer, tape, scissors

#### **Assembly**

Instruct each group of students to use the above materials to construct a self-propelled vehicle. Students can have as much tape as they need, and they can modify the straws, card, and skewer as much as they like (you might want to have extras on hand, and then again, you might want to tell each group that if they destroy one of their items, it's gone...). Students will catch on very quickly that the balloon will supply energy to make the car move forward, but it takes a while for them to learn that the drinking straw is required as a nozzle to direct air in the opposite direction of the car's forward motion. You can structure the balloon car challenge in several different ways. For example, you can award a prize or points to the first team to make a car that moves 2 metres, then ask for the fastest car. Encourage all teams to come up with a car that works. Even the team that has a lot of difficulty getting a car to move in a straight line can get points for the best "trick" car. This project makes an excellent take-home assignment as well as a hands-on in-class project. Newton's third law is highlighted really nicely, and students can find applications of all three laws of motion.

#### **Resources**

- magnets, air track, trolleys, ticker timer, ticker tapes, power packs, copper wires

## 11.4 Work, Power and Energy

### Suggested activities

#### Work

- Define work and derive its unit,  $W = F.s$ .
- Analyse and calculate work done by a net force acting:
  - in the same direction as the displacement
  - in the opposite direction to the displacement
  - at an angle to the displacement,  $W = F.s \cos \theta$
- Calculate work from a force-time graph.

#### Power

- Define power and derive its unit,  $P = W/t$ .
- Solve problems on power.

#### Energy

- Define energy and state its units, that is, joule, calorie, kilowatt-hour.
- State and describe different forms of energy.
- State the law of conservation of energy.
- Identify energy converters and types of energy conversions taking place in them.
- Calculate gravitational potential energy and kinetic energy, and relate these energies to work done on a body in motion.
- Describe mechanical energy (KE and PE) transformation and conservation taking place in freefall motion, uphill and downhill motion and pendulum motion.

#### Simple machines

- Explain the definition of simple machines.
- Describe examples of simple machines such as levers, pulleys, gears, ramps, wheel and axle.
- Explain mechanical advantage and velocity ratio of a machine, and the relationship between mechanical advantage, velocity ratio and efficiency of a machine.
- Solve problems on mechanical advantage, velocity ratio and efficiency of machines.
- Perform an experiment using one of the simple machines (such as a lever, pulleys, ramps and the wheel and axle) and use data from this experiment to calculate mechanical advantage, velocity ratio and efficiency of the machine.

### Suggested assessment tasks

- Assignment and test on solving problems on work, power, energy and simple machines.

- Experiment on simple machines.

*Project*

- Project on simple machines.

**Resources**

- pendulum, solar cells, generator models, levers, pulleys, gears, wheel and axle

## 11.5 Electricity Principles

### Suggested activities

#### **Electrostatics**

- State the mass, charge and polarity of protons and electrons.
- Explain that like charges repel and unlike charges attract.
- Perform an experiment: rub Perspex with a cloth and pick up shredded papers to demonstrate electrostatic force.
- Explain Coulomb's law of force between point charges, and emphasise the law with examples of calculating force between a system of charges. Note that force is a vector quantity, hence its magnitude and direction must be specified.
- Explain electric field intensity around a point charge, and do examples of calculating electric field at a point due to a system of charges. Note that the electric field is a vector quantity, hence its magnitude and direction must be specified.
- Explain electric potential due to a point charge, and use examples of calculating the potential due to a system of charges. Note that the potential is a scalar quantity, hence only its magnitude is specified.

#### **Current electricity**

- State the units of voltage, current and resistance.
- State the alphabetical letters used to represent source of electromotive force (emf) such as a battery, potential difference or voltage drop, resistance and current.
- Draw electrical symbols of an emf source and a resistor in a simple circuit.
- Explain a single electromotive force (emf) source such as a battery, its internal resistance and terminal voltage.
- Explain combining of sources of emfs in series (opposing and aiding) and parallel.
- Explain combining of resistors in series and parallel.
- Explain Ohm's Law and apply it to calculate resistance, current and voltage drops across resistors in a circuit.
- Perform experiments to:

- measure the emf, internal resistance and terminal voltage of a source of emf
- construct circuits with sources of emfs combined in series and parallel across a resistor and measure the current and voltage drop across the resistor.
- Conduct experiments with resistances connected in series and parallel across a source of emf and then use ammeters and voltmeters to measure current and voltage drops at different points in the circuits. Use the results of measurement to investigate the characteristics of the series and parallel circuits.
- Explain that the resistance of a conductor (wire) is a function of its length, cross-sectional area and temperature. Give the relevant equations and apply them to calculate resistance of wires that depend on length, thickness and temperature.
- Perform an experiment to examine the validity of Ohm's Law in a circuit consisting of a standard resistor and another circuit with a bulb (hot filament). Measure current and voltage across the resistor and bulb and plot the voltage vs current graphs for each circuit.
- Explain electrical energy and power equations and use them to do calculations of the appropriate energy and power problems.
- Explain Kirchhoff's circuit laws and apply them to find unknown resistances, currents and voltages in simple circuits.

#### **Wheatstone bridge and potentiometer**

- Describe the basic Wheatstone bridge circuit and its operation principle and application of the circuit in determining unknown resistances.
- Describe the simple potentiometer circuit and its operation principle; apply the concepts of the circuit to determine unknown emf.
- Perform experiments to construct a Wheatstone bridge and a potentiometer to measure unknown resistances and emfs.

#### **Alternating current (AC) circuits**

- Explain the merits of employing alternating current for electricity supply to homes and industries.
- State the output voltage and current equations from an AC generator, and explain the parameters (variables) in these functions.
- Explain the effective (root-mean square) values of voltage and current.
- Apply the generator output voltage and current equations, the root-mean square values of current and voltage to determine or calculate peak and root-mean square values of voltage and current.
- Apply Ohm's Law to determine peak values and current and voltage drop in resistive AC circuits.

#### **Suggested assessment tasks**

- Assignment and test on problems in electrostatics, current electricity, Wheatstone and potentiometer circuits, and alternating current circuits.
- Experiments to:

- measure the emf, internal resistance and terminal voltage of a source of emf
- construct circuits with sources of emfs combined in series and parallel across a resistor and measure the current and voltage drop across the resistor.
- An experiment to examine the validity of Ohm’s Law in a circuit consisting of a standard resistor and another circuit with a bulb (hot filament). Measure current and voltage across the resistor and bulb and plot the voltage vs current graphs for each circuit.
- Experiments to construct a Wheatstone bridge and a potentiometer to measure unknown resistances and emfs.

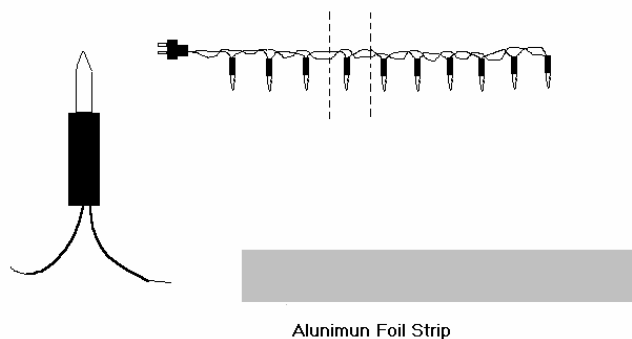
*Sample project on electricity principles: Electric circuits*

**Materials**

- String of miniature holiday lights, wire cutter or stripper, aluminium foil, Scotch tape, scissors, D cell

**Assembly**

1. Make a collection of individual bulbs for your circuit: Cut apart a section of a string of lights so that each bulb has about 5 cm of a wire pair still attached. The number of bulbs you use in your circuits is up to you. Strip about a half inch of insulation from each “tail” of wire.
2. Make a collection of aluminium foil wire: Tear off a piece of aluminium foil, about 30 cm long. Cut this piece lengthwise into long rectangles that measure 30 cm long and about 7.5 cm wide. Place a strip of cellophane tape lengthwise across each rectangle. Fold the aluminium foil rectangles into long strips by using the tape as a guide and as reinforcement. Make as much aluminium foil wire as you need.
3. Wire up your circuits, using a D cell, aluminium foil wire, and miniature bulbs. Have fun – make an interesting pattern or design. You can even poke the bulbs through some cardboard so the wiring is hidden in the back. You can admire the pattern made by the miniature lights on one side, and then turn the project over to see the wiring.
4. Use common household items such as paperclips, washers, rubber band, etc. to design a simple switch that you can operate to turn your circuit on and off.
5. Wire two different circuits; one parallel, one series. Compare the brightness of the bulbs. What happens in each case when you remove a bulb from the circuit?



**Resources**

- ammeters, voltmeters, galvanometers, ohmmeters, dry cells, light bulbs, resistors, dry cell holders, press key switches, resistance boxes, Wheatstone bridges (slide wire form), potentiometers (slide wire form), copper wire leads, resistance wire (nichrome) of different diameter and lengths



## 11.6 Electronics

### Suggested activities

#### Solid state electronics

- Describe intrinsic and doped semiconductors and how the n-type and p-type are produced.
- Describe how semiconductor devices such as the diode and the transistor are made from semiconductor materials.
- Specify electronic symbols for diode and transistor (NPN and PNP).
- Explain operation principles of the diode and the transistor including I-V characteristics and biasing methods.
- Explain application of diode as a switch and as a rectifier.
- Explain application of transistor as a switch and an amplifier.
- Perform an experiment using a diode as a switch in a simple circuit.
- Perform an experiment to use transistor as a switch or as an amplifier (common-emitter, common-base and common collector configurations) use of transistor as a switch and as an amplifier (common-emitter, common-base and common collector configurations).

#### Digital electronics

- Describe 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 binary '1' and '0' respectively.
- Draw electronic symbols for the logic gates AND, OR, NOT, NOR, NAND, XOR.
- Explain the possible number of input combinations for n inputs gates.
- Explain binary numbers and addition of 2 and 3 bits binary numbers.
- Derive the different input combinations for a 2 and 3 inputs gate.
- Describe logic gates (AND, OR, NOT, NOR, NAND, XOR), their output functions (that is, Boolean algebra) and their truth tables for 2 or 3 inputs only.
- Explain and demonstrate the behaviour of a 2 inputs AND gate and a 2 inputs OR gate with simple wired circuit using 2 switches, a lamp and batteries.
- Design simple logic circuits consisting of combination of the gates and determine their output functions and the truth-tables. Restrict the maximum number of inputs to 2 or 3.

### Suggested assessment tasks

- Assignment and test on semiconductors and logic gates.
- Laboratory experiment using
  - a diode as a switch in a simple circuit
  - transistor as a switch or as an amplifier (common-emitter, common-base and common collector configurations).

- Laboratory experiment to investigate operation of 2 or 3 inputs AND, OR, NOT and NAND and XOR gates.

#### *Project*

- Project involving designing and constructing logic circuits for an application. One example is the control of a quiz buzzer in which a light is turned ON by the player who hits his or her buzzer first. The light remains ON and is switched OFF by the judicator when desired. A logic circuit employing logic gates turn ON and OFF the light.

#### **Resources**

- breadboards, 2-inputs and 4-inputs logic gates (AND, OR, NOT, NAND, XOR) and their specifications including pin layout diagrams, 5 volts power supply source or dry cell batteries, dry cell battery holders, single strand wires (2mm diameter) for connections on the breadboards, light emitting diodes (LEDs), NPN and PNP transistors (common-emitter, common-base, common collector), diodes, cathode ray oscilloscope

## **Grade 12 units**

### **12.1 Fluids**

#### **Suggested activities**

##### **Fluid statics**

- Explain density (in solids and liquids) and specific gravity and specify their units.
- Explain pressure in solids and liquids, and emphasise that pressure in solids is a function of the applied force and the area of surface to which the force is applied. Based on this concept, the pressure at a depth in a liquid is a function of the depth. State the equations of pressure in solids and liquids and its unit.
- Explain Pascal's law and the application of this law to the operation principle of hydraulic lift or jack.
- Explain buoyancy and the Archimedes principle. With the aid of diagrams explain the concepts of buoyancy, floating bodies and the conditions of equilibrium for floating bodies. Demonstrate the Archimedes principle using a regular shaped object.
- Explain surface tension in liquids and capillarity.
- Solve examples and problems on density, specific gravity, pressure in solids and liquids, buoyancy and Archimedes principle.

##### **Fluid dynamics**

- Explain flow rate, equation of continuity and Bernoulli's equation.
- Describe applications of flow rate, equation of continuity and Bernoulli's equation, and also solve examples and problems on these concepts.

## Suggested assessment tasks

- Assignment and test on the work covered on fluid statics and fluid dynamics areas covered above.
- Laboratory experiments on:
  - density of regular shaped objects using both the calculated value of the volume of the object and the volume obtained from Archimedes principle
  - flow rate, Bernoulli's and Continuity equations.

### *Project*

- Study the application of fluid statics and explain the design and operation of hydraulic jack.

### Resources

- solid objects (regular and irregular); liquids—oil, water, alcohol (no less than 100 mls); graduated cylinder; triple beam balance

## 12.2 Temperature and Heat

### Suggested activities

#### Temperature

- Explain the definition of temperature and specify its units.
- Name different temperature-measuring instruments and discuss the properties of materials that respond to temperature change in these instruments.
- Explain conversion of one temperature scale to another (Fahrenheit, Kelvin and Celsius).
- Solve examples and problems in converting one temperature scale to another.

#### Thermal expansion

- Define linear, superficial and volume expansions.
- Perform calculations on linear, superficial and volume expansions  
 $\Delta L = L_i \alpha \Delta T$  and  $\Delta V = \beta V_i \Delta T$

#### Heat

- Explain definition of heat and specify its units.
- Explain specific heat and latent heat and specify their units, and also distinguish latent heat of fusion and latent heat of vaporisation.
- Solve examples and problems on the amount of heat required to change temperature and phase of a substance.
- Distinguish between heat capacity and specific heat capacity.

- Calculate heat capacity and specific heat capacity for different objects when a constant heat supply is maintained.
- Perform an experiment to change the phase of a block of solid ice (at temperature less than  $0^{\circ}\text{C}$ ) to steam (at temperature near  $110^{\circ}\text{C}$ ). Record temperature at regular time intervals (every 2 minutes). Calculate the total amount of heat for the ice to change from solid to vapour using the equations for the amount of heat to change temperature ( $Q=mc\Delta T$ ) and phase ( $Q=mL$ ). Plot temperature vs time and temperature vs heat graphs and interpret the results.

### Heat Transfer

- Explain conduction, convection and radiation methods of heat transfer including the equations for the conduction and radiation methods.
- Discuss examples of materials that behave as thermal conductors and insulators, and give uses of these in households in Papua New Guinea.
- Solve examples and problems on these heat transfer methods.

### Application

- Investigate and describe operating principles of refrigerators and heat pumps (air conditioners and heaters).
- Heat exchange in traditional ovens (mumu).

## Suggested assessment tasks

- Assignment and test on the areas covered under 'Temperature', 'Heat' and 'Heat transfer'.
- Laboratory experiments:
  - read temperature from mercury in glass thermometer and convert to other units
  - to change the phase of a block of solid ice (at temperature less than  $0^{\circ}\text{C}$ ) to steam (at temperature near  $110^{\circ}\text{C}$ ). Record temperature at regular time intervals (every 2 minutes). Calculate the total amount of heat for the ice to change from solid to vapour using the equations for the amount of heat to change temperature ( $Q=mc\Delta T$ ) and phase ( $Q=mL$ ). Plot temperature vs time and temperature vs heat graphs and interpret the results

### *Sample project*

- Research on a method of measuring thermal conductivity of a metal rod

### Resources

- Liquid in glass thermometer, thermocouple, pyrometer, Bunsen burner

## 12.3 Waves

### Suggested activities

#### Properties and types of waves

- Define and differentiate longitudinal and transverse waves, and list examples of each wave type.
- Demonstrate generation of transverse and longitudinal waves using a rope and a slinky spring.
- Explain mechanical and electromagnetic waves.
- With the aid of wave diagrams explain wave properties including the amplitude, wavelength, period and frequency, and the relationship between frequency and period.
- Draw wave diagrams from given data on amplitude, wavelength, period and frequency.

#### Superposition and interference of waves

- With the aid of two or more wave diagrams describe superposition of waves at a point and explain how waves can be completely “in phase” and “out of phase”. Use the wave diagrams to describe constructive and destructive interference between the waves.
- Use a ripple tank with two wave sources to demonstrate both generation of waves by one or both sources and interference of waves generated by the two sources.
- Do examples and problems with wave diagrams and draw resultant wave showing constructive and destructive interference.

#### Propagation of waves

- Explain the relationship between speed ( $v$ ), frequency ( $f$ ) and wavelength ( $\lambda$ ) [i.e.  $v = f\lambda$ ], and solve examples and problems on the use of this equation.
- Use a diagram with two mediums and show that the incident wave (light for example) can be reflected and refracted. Also show in the diagram angle of incident wave ( $i$ ), angle of reflected wave ( $r_1$ ) and the angle of the refracted wave ( $r$ ).

- Explain Snell's law of refraction: 
$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

- where  $n_1$  and  $n_2$  are the absolute refractive index of medium 1 to medium 2 respectively.
- Explain that for light passing from one medium 2 to medium 1, of smaller refractive index, the angle of refracted ray will be  $90^\circ$  at certain critical angle ( $C$ ) of incident ray. For angle of incidence beyond the critical angle, the light will be totally reflected within medium 2 and no refracted ray will occur in medium 1. Hence show that:

$$\frac{\sin C}{\sin 90} = \frac{n_2}{n_1}$$

$$\text{Or } \sin C = \frac{n_2}{n_1}$$

- Solve examples and problems using the Snell's law equation.

### Applications

- Describe some applications of total internal reflection in optical fibres, periscopes, and endoscopes.
- Describe effect of refraction in determining real and apparent depth of objects in water.

### Suggested assessment tasks

- Assignment and test on problems from the sections on properties and types of waves, superposition of waves, propagation of waves, and applications.
- Laboratory experiments on
  - generation of a wave and interference of waves in a ripple tank
  - refraction of light using glass, Perspex prisms and ray box kits.

#### *Sample project: Simple optical system*

##### **Materials**

- beaker, water and a pencil

##### **Procedure**

1. Observe the beaker with the water and pencil in
2. Look at the beaker from many different vantage points
3. What strange or interesting things can you see involving the image of the pencil?

##### **Observations**

- The pencil is bent
- There are two pencils
- There are three pencils
- The pencil is magnified
- When you look straight down into the beaker, the pencil doesn't seem bent

The students must explain the reasons for each of the five results observed.

*The explanations given below are information for the teacher only:*

##### **The pencil seems bent by the water when looking through the side of the glass**

The light coming off the pencil is being refracted by the water and the glass of the beaker, but primarily from the water. With the beaker being cylindrical in shape the amount of refraction depends on how much water you look through, so when you see the pencil from different angles there is a different amount of water acting on the image of the pencil and it will seem to change shape, look distorted and move around.

##### **There are two pencils**

Light is bouncing off the pencil in all directions. Some light that comes out of the top of the beaker gets refracted to your eye, and some from the side gets refracted to your eye. We can't really tell just by looking at the beaker what angles the light came off of the pencil, or the angles the light gets refracted when it leaves the beaker. What we do know is that it is

getting to our eye because we can see it. Much in the same way that you may be able to take two totally different routes home from work, the final destination is the same.

#### There are three pencils

In addition to the two pencil case, some observant people may also notice the reflection of the pencil off the bottom of the beaker. This would imply that both refraction and reflection are happening at the same time, which is true. Light is leaving the pencil and travelling in all directions, including down. Some of this light is leaving the beaker and being refracted as it does so. If you can see the pencil from below, then you know this is happening. However, not all of the light is being refracted by the beaker, some is being reflected. We know this because we can see the pencil. If light wasn't getting to our eye, we wouldn't see the pencil, but we do, so light is getting to us.

#### The pencil seems magnified

This is due to the shape of the beaker. The beaker is acting like a convex lens, the same as you would find in a magnifying glass. What we see is the spread out light that forms an image that is larger than the pencil itself.

#### When you look straight down the pencil doesn't seem bent

When the light from the pencil leaves the water perpendicular to the surface of the water its direction is not altered by refraction. It is only when light from the pencil leaves the surface of the water at some angle other than  $90^\circ$  that the image of the pencil would appear bent.

## Resources

- 10m rope, spring, ripple tank, ray boxes, glass blocks

## 12.4 Electromagnetism

### Suggested activities

#### Magnetic field and force due to current

- Explain magnetic field (that is, magnetic flux density),  $B$ , due to a current in a wire and specify its unit, magnitude and direction. Describe right-hand grip rule for determining the direction such that the thumb points in the direction of the current and the fingers encircling the wire point in the direction of the field. Emphasise that  $B$  is a vector quantity and its magnitude is a function of the current and distance from the wire.
- Perform experiment using compass to
  - determine direction of magnetic field around a current-carrying wire and a coil (solenoid)
  - verify that magnitude of  $B$  increases with increase in current and it decreases with increase in distance from the wire or coil. The increase and decrease in the deflection of the compass needle indicate an increase and decrease of magnetic field strength respectively.
- Solve examples and problems using the magnetic flux density equation.
- Explain that the force,  $F$ , experienced by a current-carrying conductor or wire in an external magnetic field  $B$  is given by the equation:  $F = B I l \sin\theta$ . The magnitude of the force  $F$  is therefore a function of the current  $I$ ,  $B$ , the length of the wire  $l$  inside the magnetic field and the angle  $\theta$  between  $B$  and the conductor.

- State that for a coil (solenoid) of  $n$  turns in an external magnetic field, the force,  $F$ , experienced by the coil is:
- $F = n B I l \sin\theta$  where  $n$  is the number of turns and  $l$  is the length (circumference) of a single turn,  $\theta$  is the angle between the plane of the coil and the magnetic field.
- Explain Fleming's right-hand rule for determination of the direction of the force on the current-carrying wire and the coil.
- Solve examples and problems on the force experienced by a current-carrying conductor and coil inside an external magnetic field.
- Use the above concepts of magnetic field due to a current in a wire and the force experience by a wire inside an external magnetic field to describe the force on each of two straight current-carrying conductors lying parallel to each other. The force on each conductor is:
  - $F_1 = B_2 I_1 l = \frac{\mu I_2}{2\pi r} I_1 l, \quad F_2 = B_1 I_2 l = \frac{\mu I_1}{2\pi r} I_2 l$
  - where  $F_1$  and  $F_2$  are the forces on conductors 1 and 2 respectively (Newton [N])
  - $I_1$  and  $I_2$  are the currents in conductor 1 and 2 respectively (Amps [A])
  - $B_1$  and  $B_2$  are the magnetic flux densities due to the currents  $I_1$  and  $I_2$  respectively (Tesla [T])
  - $l$  is the length of one conductor inside the magnetic field due to the current in the other conductor (m)
  - $r$  is the distance between the two conductors (m).
  - Use the right-hand rules to determine direction of magnetic fields due to the currents in each conductor as well as the direction of force on each conductor.
- Conduct an experiment to investigate the nature of forces (repulsion or attraction) between a pair of current-carrying conductors
- Solve examples and problems on force experienced by each of two conductors lying parallel to one another.
- With the aid of diagrams show the essential components (brushes, commutator, coil, shaft) of an electric motor and describe its operation principle in terms of the torque experienced by the coil. (Only qualitative explanation of the torque is required.)

### Electromagnetic induction

- Define electromagnetic induction and explain how an emf or current can be induced in a coil.
- Use either or both of Faraday's Induction Law and Lenz's Law to explain the direction of the induced current in a coil.
- Perform experiment to investigate different ways of inducing current in a coil using an ammeter, a bar magnet and a coil.
- Describe essential components of AC and DC generators and explain their operation principle.

### Transformers and power losses in transmission lines

- Draw the electrical symbol of a transformer.



- Explain mutual inductance in transformers.
- Describe essential parts of a transformer and its principle of operation.
- Distinguish between step-up and step-down transformers.
- Describe transformer equation.
- Solve examples and problems using transformer equation.
- Explain advantages of AC power generators over DC generators.
- Explain roles of transformers in power transmission over long distances.
- Explain equations for power losses and voltage drops in transmission lines.
- Perform power loss and voltage drop calculations on transmission lines.

### Suggested assessment tasks

- Assignment and Test on the sections covered above including Magnetic field and force due to current, Electromagnetic Induction, Transformers and Power losses in transmission lines
- Laboratory experiment: using a compass to:
  - determine direction of magnetic field around a current carrying wire and a coil (solenoid)
  - verify that magnitude of B increases with increase in current and it decreases with increase in distance from the wire or coil. The increase and decrease in the deflection of the compass needle indicates an increase and decrease of magnetic field strength respectively.
  - investigate the nature of forces (repulsion or attraction) between a pair of current-carrying conductors
  - to investigate different ways of inducing current in a coil using an ammeter, a bar magnet and a coil.

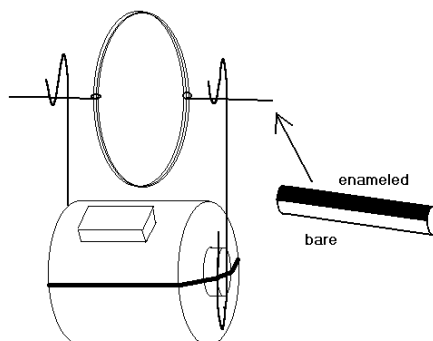
*Sample project: Build a cheap-O motor*

#### Materials

- D cell, about 3-4 meters of enamelled copper wire, 2 large paperclips, 1 magnet (donut magnet), 1 strong, heavy rubber band (not too large), razor blade (sandpaper will work also)

#### Assembly

1. Wind 12 or so turns of enamelled copper wire (see diagram). It is important to wind the coil as circularly a possible, to distribute the mass of the wire evenly all the way around. Winding the coil around a D cell is a great way to keep the coil circular.
2. Use a razor blade or fine sandpaper to remove the enamel completely from one of the tails. With the coil in a vertical position, remove the enamel from the top half only of the other tail.



3. Centre the tails and straighten them to form a shaft for the coil.
4. To form supports for the coil, open 2 jumbo paper clips and bend a hook in the large end as shown.
5. Use a sturdy rubber band to attach one support to each end of a "D" cell. Set a magnet on the cell as shown. You may have to tape the paperclips to the cell terminals tightly with masking tape to achieve excellent connections.
6. To operate the motor, set the coil in the supports. You might have to give the coil a gentle spin to get it started.
7. Wind a second coil with 24 turns or so. See how this compares to the coil with 12 turns.

**Troubleshooting:**

This project is extremely satisfying once you are able to get the motor to run. The main problem spots to watch out for: an unbalanced coil, poor connections, dead battery, or improperly sanded or scraped armature tails.

## Resources

- permanent magnets, copper wires, iron filings, compasses, power supplies, soft iron core, ammeters, voltmeters

## 12.5 Radioactivity and Nuclear Energy

### Suggested activities

#### Radiation

- Write and draw atomic structure and properties of radioisotopes
  - main radiation types [ $\alpha$ ], [ $\beta$ ], [ $\gamma$ ] and [ $n$ ]
- Compare properties (mass, charge, range and penetration power) of the radiation particles.
- Study and read about experiments showing the range and penetrating power of the particles in different materials.
- Draw tracks caused by  $\alpha$  and  $\beta$  particles in a cloud chamber.

#### Radioactivity

- Define and convert radioactivity units: the curie and the becquerel and vice-versa.

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

### **Nuclear energy**

- Differentiate between nuclear fission and fusion processes.
- Use relationship between mass and energy ( $E = mc^2$ ) to calculate the energy released in a fission or fusion process.
- Label parts of a simple nuclear reactor.
- Explain how heat energy produced from nuclear fission reactors in generating electricity.
- Research on development of nuclear energy for peaceful and non-peaceful purposes.
- Read and collect articles on radioactivity and nuclear energy in popular science journals such as *New Scientist*.

### **Suggested assessment tasks**

- Write and draw atomic structure and properties of radioisotopes.
- Write decay equations.
- Calculate the half-life of a radioactive substance from its decay curve and equations for radioactive decay.

### **Resources**

- cloud chamber, Geiger counter or GM tube

## Recording and reporting

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

### Recording and reporting student achievement

When recording and reporting student achievement you must record the achievement of the students in each unit and then, at the end of the year, make a final judgement about the overall achievement, or progress towards achievement, of the learning outcomes. To help you do this, descriptions of the levels of achievement of the learning outcomes are provided in the 'Learning outcome performance standards' table.

When reporting to parents, the school will determine the method of recording and reporting. In an outcomes-based system, student results should be reported as levels of achievement rather than marks.

*Remember that the final school-based mark will be statistically moderated using the external exam results. The students' overall level of achievement may change.*

### Levels of achievement

The level of achievement of the learning outcomes is determined by the students' performance in the assessment tasks. Marks are given for each assessment task, with a total of 100 marks for each 10-week unit, or 50 marks for each 5-week unit. The marks show the students' level of achievement in the unit, and hence their progress towards achievement of the learning outcomes. There are five levels of achievement:

- Very high achievement
- High achievement
- Satisfactory achievement
- Low achievement
- Below minimum standard

A **very high achievement** means overall that the student has an extensive knowledge and understanding of the content and can readily apply this knowledge. In addition, the student has achieved a very high level of competence in the processes and skills and can apply these skills to new situations.

A **high achievement** means overall that the student has a thorough knowledge and understanding of the content and a high level of competence in the processes and skills. In addition, the student is able to apply this knowledge and these skills to most situations.

A **satisfactory achievement** means overall that the student has a sound knowledge and understanding of the main areas of content and has achieved an adequate level of competence in the processes and skills.

**A low achievement** means overall that the student has a basic knowledge and some understanding of the content and has achieved a limited or very limited level of competence in the processes and skills.

**Below the minimum standard** means that the student has provided insufficient evidence to demonstrate achievement of the learning outcomes.

Achievement level					
Total marks	Very high achievement	High achievement	Satisfactory achievement	Low achievement	Below minimum standard
600	540–600	420–539	300–419	120–299	0–119
500	450–500	350–449	250–349	100–249	0–99
400	360–400	280–359	200–279	80–199	0–79
300	270–300	210–269	150–209	60–149	0–59
200	180–200	140–179	100–139	40–99	0–39
100	90–100	70–89	50–69	20–49	0–19
60	54–60	42–53	30–41	12–29	0–11
50	45–50	35–44	25–34	10–24	0–9
40	36–40	28–35	20–27	8–19	0–7

### Sample format for recording Physics assessment task results over two years

Student name: Lucy Mondo

Grade 11 assessment task results			
Unit	Assessment task	Mark	Student mark
11.1	Test involving description and writing of significant figures, numbers in normal and scientific notation forms, prefixes and dimensional analysis	15	
	Laboratory exercise on calculating density of an irregular object	15	
	Assignment on errors in measurement and error analysis (calculations and graphs) from experimental data	20	
11.2	Test on vector analysis involving displacement, velocity and acceleration	20	
	Assignment on drawing of graphs of motion in one and two dimensional projectile motion from a given set of experimental data	15	
	Practical investigation: Conduct experiment on uniform linear motions	15	
11.3	Test involving solving of problems on Newton's laws of motion	20	
	Assignment on application of laws of conservation of momentum and energy to collision problems	15	
	Project on Force and Motion	15	
11.4	Test on solving problems on work, power, energy and simple machines	25	
	Practical investigation -Experiments on simple machines	10	
	Project on simple machines	15	

11.5	Test on problems on Electrostatics, Current Electricity, Wheatstone and Potentiometer circuits, and Alternating Current circuits	20	
	Experiment to examine validity of Ohm's Law in a circuit consisting of a standard resistor and another circuit with a bulb (hot filament). Measure current and voltage across the resistor and bulb and plot the voltage vs current graphs for each circuit	20	
	Project on Electricity Principles	10	
11.6	Test on semiconductors and logic gates	20	
	Laboratory experiment to investigate operation of 2 or 3 inputs AND, OR, NOT and NAND and XOR gates	15	
	Project: designing and constructing logic circuits for an application	15	
	<b>Total marks Grade 11</b>	<b>300</b>	

**Student name: Lucy Mondo**

<b>Grade 12 assessment task results</b>			
<b>Unit</b>	<b>Assessment task</b>	<b>Mark</b>	<b>Student mark</b>
12.1	Test on the work covered on fluid statics	25	
	Laboratory experiment on density of regular-shaped objects using both the calculated value of the volume of the object and the volume obtained from Archimedes principle	10	
	Project: Study the application of fluid statics and explain the design and operation of hydraulic jack	15	
12.2	Test on the areas covered under Temperature, Heat and Heat transfer	20	
	Laboratory experiment on Heat	30	
	Sample project: Research work on a method of measuring the thermal conductivity of a metal rod	20	
12.3	Test on problems from the sections on properties and types of waves, superposition of waves, propagation of waves, and applications	20	
	Laboratory experiment on generation of a wave and interference of waves in a ripple tank	20	
	Sample project on Simple Optical System	20	
12.4	Test on the sections covered including Magnetic field and force due to current, Electromagnetic induction, Transformers and power losses in transmission lines	20	
	Laboratory experiment	20	
	Project: Building a cheap-O motor	20	
12.5	Assignment: Write and draw atomic structure and properties of radioisotopes	20	
	Test on decay equations	20	
	Assignment: Calculate the half-life of a radioactive substance from its decay curve and equations for radioactive decay	20	
	<b>Total marks Grade 11</b>	<b>300</b>	
	<b>Total marks Grades 11 and 12</b>	<b>600</b>	

## Learning outcomes and levels of achievement

Levels of achievement in Grade 11 and Grade 12 are recorded and reported against the learning outcomes. The performance standards for the levels of achievement are described in the table on pages 13 and 14.

## Steps for awarding final student level of achievement

1. Assess unit tasks using unit performance standards and assessment criteria.
2. Record results for each task in each unit.
3. Add marks to achieve a unit result and term result.
4. Add term marks to get a year result.
5. Determine the overall achievement using the achievement level grid.
6. Report results using the learning and teaching learning outcome performance standards.

The following is an example of reporting using the learning outcomes performance standards descriptors.

### Using the learning outcomes performance standards descriptors

Student	<b>Lucy Mondo</b>
Subject	<b>Physics</b>
School-based assessment	<b>High achievement</b>
<b>This means Lucy:</b>	
Demonstrates sound knowledge and understanding of physics principles and models	
Sound inquiry and reasoning skills in conducting investigations using scientific methodologies in finding solutions to problems	
Very good in communicating scientific data and information from investigations and laboratory work	
Very good in analysing and interpreting data and information	
Makes informed decisions based on sound analysis and evaluation of developments in physics and their impact on society	
Can effectively perceive and correlate traditional knowledge, beliefs and skills to principles and concepts of physics	

## Resources

Physics becomes more interesting and meaningful when you use a variety of resources and local materials in your teaching.

You should be always trying to adapt, improvise, make, find or write material that will be useful for lessons. Physics can be taught without expensive equipment by making use of what is around you, though there are some equipment and materials that are essential to teach the Physics syllabus.

### Types of Physics resources

#### Equipment

- Geiger-Müller tube, cloud chamber, vernier calipers, bulbs, ripple tank, permanent magnets, iron fillings, compasses, soft iron core, 10m rope, spring, ripple tank, ray boxes, glass blocks, liquid in glass thermometer, thermocouple, pyrometer, Bunsen burner, solid objects (regular and irregular), graduated cylinder, triple beam balance, breadboards, 2-inputs and 4-inputs logic gates (AND, OR, NOT, NAND, XOR) and their specifications including pin layout diagrams, 5 volts power supply source, single strand wires (2mm diameter) for connections on the breadboards, light-emitting diodes (LEDs), NPN and PNP transistors (common-emitter, common-base, common collector), diodes, cathode ray oscilloscope, ammeters, voltmeters, galvanometers, ohmmeters, dry cells, light bulbs, resistors, dry cell holders, press key switches, resistance boxes, Wheatstone bridges (slide wire form), potentiometers (slide wire type), copper wire leads, resistance wire (nichrome) of different diameter and lengths, pendulum, solar cells, generator models, levers, pulleys, magnets, air track, ticker tapes, copper wires, meter rulers, stopwatches, ticker tape timers, centisecond timers or digital timers, laboratory carts or trolleys, linear air tracks

#### Materials

- textbooks, reference books
- magazines
- diagrams, charts, posters
- worksheets, information sheets
- television and radio broadcasts
- video, film, film strips
- computer software
- pictures, photographs
- models
- newspapers



## General guidelines for selecting and using resources

How effective a resource is depends on whether it is suitable for the knowledge or skill to be learned and the attitude of the students. Classroom organisation is the key to using resources successfully. You need to:

- prepare thoroughly. Make sure that you are familiar with the resource so that you use it with confidence and assurance. If equipment is involved, check that it is in working order, make sure that you know how to operate it and that it is available when you need it
- use the resource at the right place and time—it should fit in with the flow and sequence of the lesson and serve a definite teaching purpose
- (if the resource is radio, film, video or television), introduce the program by outlining the content. You might also set some questions to guide listening or viewing. Follow up after using the resource, by discussing and drawing appropriate conclusions.

## References

- Champion, N 2008, *Nelson Physics VCE Units 1 and 2*, Cengage Learning, South Yarra.
- Duncan, T and Kenneth, H 2001, *GCSE Physics*, 4th edn, London, John Murray.
- Duncan, T and Murray, J 1986, *GCSE Physics*, London, John Murray.
- England, N 2004, *Physics Matters*, 2nd edn, London, Hodder and Stoughton.
- Facilitating and Monitoring Unit 2002, *The State of Education in Papua New Guinea*, National Department of Education Papua New Guinea, Waigani.
- Matane, P 1986, *A Philosophy of Education for Papua New Guinea*, Ministerial Committee Report, NDOE, Waigani.
- Mayer, R 2004, 'Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction', *American Psychologist*, vol 59, no. 1, pp. 14–19.
- National Department of Education Papua New Guinea 2002, National Assessment and Reporting Policy, NDOE, Waigani.
- National Department of Education Papua New Guinea 2002, National Curriculum Statement, NDOE, Waigani.
- National Department of Education Papua New Guinea 2006, *National Education Plan 2005–14*, NDOE, Waigani.
- Nonie, SE and Baimba, AA 2003, *Concise College Physics: Mechanics, Properties of Matter, Fluids, Heat and Thermodynamics*, vol. 1, New Delhi, CBS.
- Nonie, SE and Baimba, AA 2005, *Concise College Physics: Waves, Optics, Electricity, Electromagnetism and Electronics*, vol. 2, New Delhi, CBS.
- Pople, S 1982, *Explaining Physics*, Oxford, Oxford University Press.
- Pople, S 1999, *Complete Physics*, Oxford, Oxford University Press.
- Pople, S 2001, *New Coordinated Science*, 3rd edn, Physics for Higher Tier, Oxford, Oxford University Press.
- Walding, R, Rapkins, G and Rossiter, G 2004, *New Century Senior Physics: Concepts in Context*, 2nd edn, South Melbourne, Oxford University Press.
- Wiecek, C et al 2004, *Physics in Context: The Forces of Life, HSC*, 2nd edn, South Melbourne, Oxford University Press.
- Wiecek, C et al 2004, *Physics in Context: The Forces of Life, Preliminary*, 2nd edn, South Melbourne, Oxford University Press.

## Glossary for Physics

<b>Absolute error</b>	The difference between the measured or inferred value of a quantity and its actual value
<b>Acceleration</b>	The rate of increase of speed or velocity
<b>Apparent</b>	Directly observed or measured but not taking into account factors or effects that should be allowed for, such as distortion caused by the measuring instruments themselves
<b>Buoyancy</b>	The upward thrust on a body immersed in a fluid. This force is equal to the weight of the fluid displaced
<b>Displacement</b>	<ul style="list-style-type: none"> <li>• In Newtonian mechanics, specifies the position of a point in reference to an origin or to a previous position. In simple terms, it's the difference between the initial position and the final position of an object</li> <li>• the amount of movement of an object measured in a particular direction</li> <li>• the amount of fluid such as water that is forced to move by an object floating on or submerged in it, often used as a measure of a ship's size</li> </ul>
<b>Distance</b>	A scalar quantity that describes the length of space separating two people, places, or things
<b>Elastic</b>	Describes an object or substance that can return quickly to its original shape and size after being bent, stretched, or squashed
<b>Energy</b>	The ability of an object to do work. Energy is measured in joules (J) and mega joules (MJ)
<b>Extrapolation</b>	To estimate a value that falls outside a range of known values; for example by extending a curve on a graph
<b>Friction</b>	Force that opposes the motion of an object when the object is in contact with another object or surface. Friction results from two surfaces rubbing against each other or moving relative to one another. It can hinder the motion of an object or prevent an object from moving at all. The strength of frictional force depends on the nature of the surfaces that are in contact and the force pushing them together. This force is usually related to the weight of the object or objects. In cases involving fluid friction, the force depends upon the shape and speed of an object as it moves through air, water, or other fluid
<b>Fundamental</b>	Relating to or affecting the underlying principles or structure of something
<b>Gauge</b>	Special devices used for making accurate measurements
<b>Gear</b>	A component within a transmission device that transmits rotational force to another gear or device. A gear is different from a pulley in that a gear is a round wheel which has linkages ("teeth" or "cogs") that mesh with other gear teeth, allowing force to be fully transferred without slippage. Depending on their construction and arrangement, geared devices can transmit forces at different speeds, torques, or in a different direction, from the power source
<b>Gravity</b>	The force of attraction between all objects that tends to pull them toward one another. It is a universal force in physics, affecting the largest and smallest objects, all forms of matter, and energy. Gravitation governs the motion of astronomical bodies. It keeps the Moon in orbit around Earth and keeps Earth and the other planets of the solar system in orbit around the Sun. On a larger scale, it governs the motion of stars and affects the outward expansion of the entire universe because of the attraction of galaxies to other galaxies. Typically the term gravitation refers to the force in general, and the term gravity refers to Earth's gravitational pull
<b>Heat capacity</b>	The quantity of heat required to raise the temperature of one mole or gram of a substance by one degree Celsius (symbol C)
<b>Hydraulic</b>	Relating to or operated by a device in which pressure applied to a piston is transmitted by a fluid to a larger piston, so as to give rise to a larger force
<b>Impulse</b>	A measure of momentum arrived at by multiplying the average force acting on a body by the length of time it acts
<b>Inelastic</b>	Unable to return quickly to its original shape and size after being bent, stretched, or squashed
<b>Kinetic</b>	Relating to, caused by, or producing motion
<b>Latent heat</b>	The amount of heat absorbed or released by a substance sufficient to produce a change of phase

<b>Lever</b>	A simple machine consisting of a rigid bar that rotates about a fixed point, called a fulcrum. Levers affect the effort, or force, needed to do a certain amount of work, and are used to lift heavy objects. To move an object with a lever, force is applied to one end of the lever, and the object to be moved (referred to as the resistance or load) is usually located at the other end of the lever, with the fulcrum somewhere between the two. By varying the distances between the force and the fulcrum and between the load and the fulcrum, the amount of effort needed to move the load can be decreased, making the job easier
<b>Linear</b>	Relating to a straight line or capable of being represented by a straight line
<b>Machine</b>	A simple device that affects the force, or effort, needed to do a certain amount of work. Machines can make a tough job seem easier by enabling a person to apply less force or to apply force in a direction that is easier to manipulate. Machines lessen the force needed to perform work by lengthening the distance over which the force is applied. Although less force is subsequently used, the amount of work that results remains the same. Machines can also increase the speed at which work makes an object travel, but increasing speed requires the application of more effort
<b>Measurement</b>	The process of estimating the magnitude of some attribute of an object, such as its length, weight, or depth relative to some standard (unit of measurement), such as a metre or a kilogram. The term is also used to indicate the number that results from that process
<b>Mechanical</b>	Relating to or concerned with machinery or tools
<b>Momentum</b>	A quantity characterizing the motion of an object. It is the product of the mass of a moving particle multiplied by its linear velocity. Momentum is a vector quantity, which means that it has both magnitude and direction. The total momentum of a system made up of a collection of objects is the vector sum of all the individual objects' momenta
<b>Net</b>	General or overall, after positive and negative features have been weighed against each other
<b>Pendulum</b>	A device consisting of an object suspended from a fixed point that swings back and forth under the influence of gravity
<b>Projectile</b>	A projectile is any object propelled through space by the exertion of a force, which ceases after launch
<b>Pulley</b>	A simple machine used to lift objects. A pulley consists of a grooved wheel or disk within a housing, and a rope or cable threaded around the disk. The disk of the pulley rotates as the rope or cable moves over it. Pulleys are used for lifting by attaching one end of the rope to the object, threading the rope through the pulley (or system of pulleys), and pulling on the other end of the rope
<b>Quantity</b>	The measurable property of something
<b>Ratio</b>	An expression which compares quantities relative to each other. The most common examples involve two quantities, but in theory any number of quantities can be compared. Mathematically they are represented by separating each quantity with a colon, for example the ratio 2:3, which is read as the ratio "two to three"
<b>Resistance</b>	Property of any object or substance to resist or oppose the flow of an electrical current. The quantity of resistance in an electric circuit determines the amount of current flowing in the circuit for any given voltage applied to the circuit, according to Ohm's Law. The unit of resistance is the ohm, the amount of resistance that limits the passage of current to one ampere when a voltage of one volt is applied to it. The standard abbreviation for electric resistance is R and the symbol for ohms in electric circuits is the Greek letter omega, $\Omega$ . For certain electrical calculations it is convenient to employ the reciprocal of resistance, $1/R$ , which is termed conductance, G. The unit of conductance is the mho, or ohm spelled backward, and the symbol is an inverted omega, $\oslash$
<b>Scalar</b>	A quantity that has magnitude but no direction; for example, mass or time
<b>Specific heat</b>	Amount of heat, as measured in number of calories, that is required to raise the temperature of one gram of a substance one degree Celsius. Specific heat is sometimes expressed as the number of British thermal units necessary to raise the temperature of one pound of a substance one degree Fahrenheit. The specific heat of water is one calorie per degree; that is, one calorie of heat must be supplied to a gram of water to raise the temperature one degree Celsius
<b>Specific heat capacity</b>	The measure of the heat energy required to increase the temperature of a unit quantity of a substance by a certain temperature interval
<b>Speed</b>	Rate of movement irrespective of direction. It is equal either to distance travelled divided by travel time, or to rate of change of distance with respect to time

<b>Static</b>	Motionless: not moving or changing, or fixed in position
<b>Tension</b>	A force related to the stretching of an object (the opposite of compression)
<b>Transformation</b>	Change in atomic nucleus: the change of one type of atom to another, resulting from a nuclear reaction
<b>Uniform</b>	Unchanging: always the same in quality, degree, character, or manner
<b>Variable</b>	An attribute of a physical or an abstract system which may change its value while it is under observation. Examples include the height of a child, the temperature across a state, or the input to a function. This concept is relevant to and applied to almost all areas of mathematics, science and engineering
<b>Vector</b>	A quantity that has both direction and magnitude, such as force or velocity, usually represented by an arrow
<b>Velocity</b>	The rate of change in the position of an object as it moves in a particular direction
<b>Vertical</b>	A position that is upright or at a right angle to the horizon
<b>Watt</b>	The rate at which energy use is measured. A watt is defined as the number of joules per second, that is, $1 \text{ W} = 1 \text{ J/s}$
<b>Watt-hours, kilowatt-hours</b>	Electricity consumption is measured in units of watt-hours (Wh) or, more typically, kilowatt-hours (kwh) and megawatt-hours (mwh), where $1 \text{ mwh} = 1000\text{kwh}$ . 1 kwh means 1 kw of power being used for 1 hour
<b>Wheel and axle</b>	Consisting of a circular object—the wheel—with a shaft—the axle—running through and attached to the centre of the wheel. A round doorknob and a round water faucet are both examples of wheels and axles. The much larger handle turns a much smaller axle to move a door latch, in the case of a doorknob, or open a water valve, in the case of a faucet. The wheel and axle is used to make doing a given amount of work easier. Work is the result of a physical force, such as the effort of pushing or pulling that moves an object over a distance. A wheel and axle makes work easier by changing the amount and direction of the force applied to move (or in this case, turn) an object. The object to be moved is a resistance, or load, located at the axle. A force applied at the outer edge of the wheel moves or turns the load located at the axle. The wheel enables a user to apply the force over a greater distance than would be possible if the force were applied directly to the axle. In this way, a wheel and axle reduces the effort needed to move a load
<b>Work</b>	The transfer of energy, measured as the product of the force applied to a body and the distance moved by that body in the direction of the force (symbol $W$ )

## Glossary for assessment

Syllabus outcomes, criteria and performance standards, and examination questions all have key words that state what students are expected to be able to do. A glossary of key words has been developed to help provide a common language and consistent meaning in the syllabus and teacher guide documents.

Using the glossary will help teachers and students understand what is expected in response to examinations and assessment tasks.

### Glossary of key words for assessment

<b>Account</b>	Account for: state reasons for, report on. Give an account of: narrate a series of events or transactions
<b>Analyse</b>	Identify components and the relationship between them; draw out and relate implications
<b>Apply</b>	Use, utilise, employ in a particular situation
<b>Appreciate</b>	Make a judgement about the value of
<b>Assess</b>	Make a judgement of value, quality, outcomes, results or size
<b>Calculate</b>	Ascertain or determine from given facts, figures or information
<b>Clarify</b>	Make clear or plain
<b>Classify</b>	Arrange or include in classes or categories
<b>Compare</b>	Show how things are similar or different
<b>Construct</b>	Make; build; put together (items or arguments)
<b>Contrast</b>	Show how things are different or opposite
<b>Critically (analyse, evaluate)</b>	Add a degree or level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to (analysis or evaluation)
<b>Deduce</b>	Draw conclusions
<b>Define</b>	State meaning and identify essential qualities
<b>Demonstrate</b>	Show by example
<b>Describe</b>	Provide characteristics and features
<b>Discuss</b>	Identify issues and provide points for and/or against
<b>Distinguish</b>	Recognise or note or indicate as being distinct or different from; to note differences between
<b>Evaluate</b>	Make a judgement based on criteria; determine the value of
<b>Examine</b>	Inquire into
<b>Explain</b>	Relate cause and effect; make the relationships between things evident; provide why and/or how
<b>Extract</b>	Choose relevant and/or appropriate details
<b>Extrapolate</b>	Infer from what is known
<b>Identify</b>	Recognise and name
<b>Interpret</b>	Draw meaning from
<b>Investigate</b>	Plan, inquire into and draw conclusions about
<b>Justify</b>	Support an argument or conclusion

<b>Outline</b>	Sketch in general terms; indicate the main features of
<b>Predict</b>	Suggest what may happen based on available information
<b>Propose</b>	Put forward (for example, a point of view, idea, argument, suggestion) for consideration or action
<b>Recall</b>	Present remembered ideas, facts or experiences
<b>Recommend</b>	Provide reasons in favour
<b>Recount</b>	Retell a series of events
<b>Summarise</b>	Express, concisely, the relevant details
<b>Synthesise</b>	Putting together various elements to make a whole