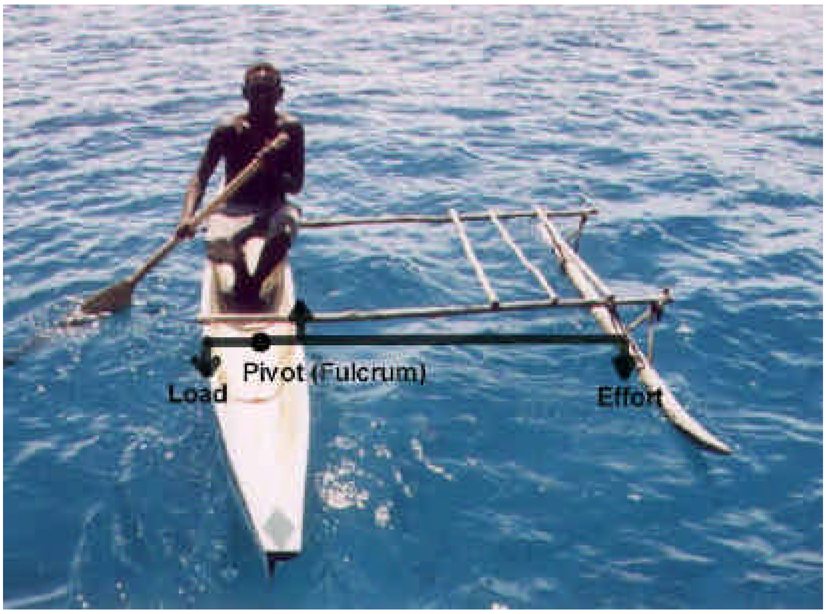
Mathematics Science Strand

Physical Science

Physical Science

Lecturers' Guide



Lecturer Support Material

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Contents

Unit overview

Core and essential learning

Due to changes to the Lower and Upper Primary Syllabuses the content and emphases of some modules have changed from that originally proposed in Program 2000. In developing a College program it is important to take into consideration the changing Primary School Curriculum as well as the knowledge students bring with them to the College. The three **key areas** are Matter and Materials, Force and Motion, and Energy and Waves. **CORE modules are P3, P4 and P5.**

The following modules, content and sequence of topics are based on essential learnings in the Primary Syllabuses. The emphasis in teaching should be based on student needs to teach science in a Primary school and concept development and understanding for teaching. All topics should be relevant to the real world and draw on examples in PNG surroundings and everyday life.

Hours for the modules have been suggested in the table below for both the semester and trimester programs, that is, for a 42 or a 36-hour unit in *Physical Science*. *Physical Concepts and Machines* should be taught before *Energy and Waves*.

Module/s	Semester program (42 hours)	Trimester program (36 hrs)
P1 Matter and materials	3 hours	Review only
P3 Useful Materials and Reactions	12 hours	12 hours
P4 Physical Concepts and Machines	9 hours	9 hours
P2 and P5 Energy and Waves	18 hours	15 hours

Trimester program

In a Trimester program most Colleges should have 12 weeks for contact lectures per Semester. This will provide 3 hours per week of contact lecture time giving a total of 36 hours for the Semester. However any shortening of the length of a Trimester or hours of contact will create difficulties in adequately preparing Primary teachers and teaching the requirements of Program 2000.

There are a number of ways Colleges may choose to overcome the time deficiencies.

- Increase the hours per week of contact lectures to maintain a total of 36 hours for a unit.
- Structure the teaching program so those students have a proportion of independent study as part of the requirements.
- Reduce the material in the modules to essential learnings however there is a risk of doing too little and not preparing students adequately with this approach.

Links to Primary Syllabuses

It is essential that lecturers keep abreast of the changes in the Primary Syllabuses and modify the Unit content, emphases and teaching programs to reflect these changes. It is only through a proactive approach to curriculum development and teaching that Primary teachers will be adequately prepared to teach the new Syllabuses. This table summarises the relationship between the current Program 2000 modules and the draft Primary Syllabuses.

Physical Science		**Lower Primary**			**Upper Primary**		
Code	**Module/topic**	**Yr3**	**Yr4**	**Yr5**	**Yr6**	**Yr7**	**Yr8**
P1	**Matter and materials**						
	• atomic structure						✸
	• change of state	Ö	Ö		✸		✸
	• elements, compounds and mixtures	Ö			Ö	Ö	✸
	• structural materials	Ö	✸	Ö			
P2	**Energy**						
	• forms of energy		✸		✸	Ö	✸
	• energy transformations		Ö	Ö	✸		✸
	• useful energy		Ö	Ö	✸	Ö	✸
	• electricity	Ö	Ö		✸		
P3	**Reactions**						
	• chemical change	Ö	Ö	Ö	✸	✸	✸
	• acids and bases		Ö		✸	✸	
	• oxidation/reduction			Ö			
	• useful materials	Ö	✸	Ö		✸	
P4	**Force and motion**						
	• velocity and acceleration			Ö		Ö	
	• mass, density and gravity	Ö	Ö		Ö		✸
	• force, work and energy	Ö		Ö	Ö	Ö	✸
	• simple machines				✸	Ö	✸
P5	**Waves**						
	• properties of waves	Ö	Ö				✸
	• electromagnetic spectrum				Ö		✸
	• light and sound	Ö	Ö		✸	✸	✸
	• communications	Ö	Ö	Ö			✸

Notes: ✸ Important topic in the syllabus
√ Some of this topic in the Syllabus

Content and sequencing

You may choose to mix and match the modules to suit local conditions and needs.

Depending on student background P1 and P3 may be combined into one module. P1 is not considered essential core and could be omitted as it has little relevance to the current and draft Primary Syllabuses. It is recommended that P1 (Structure of Matter) should be reviewed before teaching P3 (Useful materials and Reactions), Some background knowledge of the structure of matter is needed to understand the applications to useful materials.

Most students should already be familiar with the basic concepts of Energy. P4 (Physical Concepts and machines) should be taught before P2 and P5 (Energy and Waves). P2 (Energy) has been combined with P5 (Waves) as these modules are closely related and should be studied together.

The modules listed are those presented in Program 2000. In view of changes to the College Semesters to Trimester programs, modules may need to be combined and times changed to suit the college program. A suggested sequence is given below.

Module P1 Matter and materials

- substances and mixtures
- physical changes and states of matter
- structure of matter
- elements and molecules
- compounds and formulae
- chemical bonds and ions

Module P3 Useful Materials and Reactions

- useful reactions – acids and bases, oxidation, reduction
- useful substances in industry - alloys, metals, solvents, plastics, concrete, resins, glues, fuels
- useful substances in the house and garden – bleach, cleaners, soap, fertilisers, pesticides.
- environmental implications – phosphates, plastics

Module P4 Physical Concepts and Machines

- Physical Concepts: mass/length/time, velocity/acceleration/gravity, force/work/energy/power, pressure, density/buoyancy, aerodynamics
- Simple Machines
- Metric measurement system

Modules P2 and 5 Energy and Waves

- Useful Energy and Energy Transformations
- Sound
- Light
- Electricity
- Communication

Approaches to teaching and learning

It is very important that the teaching of science is approached from the personal experience of students. These experiences will provide a real life connection to the important science concepts and the application to PNG situations. Students' prior knowledge and misconceptions about important issues must be established before planning the teaching program.

Student interaction and participation is essential to build on fundamental understandings in science. Practical experiences should be incorporated in the student learning experiences wherever possible. Activities which encourage group debate should form an integral part of the teaching strategies particularly for the modules dealing with resource utilisation.

Activities should contribute to student development of skills in comprehension, hypothesising, investigation, analysis, science processes, research, problem solving and cooperative learning.

Local resources should also be utilised for student learning experiences. These resources include the local environments (reef, mangroves, forest), PNG resource materials, NGOs and government bodies.

It also important to ascertain "tambus" in relation to different cultural origins and beliefs before the discussing sensitive issues. Alternative teaching and learning strategies may need to be provided to avoid potential conflict.

Assessment strategies

In keeping with a student-centred approach to teaching and learning it is important that assessment strategies provide opportunity for students to prepare for their professional roles as teachers. Therefore a range of assessment items should be utilised to reflect the teaching approaches and student application to their profession. This unit should be assessed in such a way that students are given the opportunity to demonstrate their knowledge of concepts and be able to explain to children in simple terms the meaning of such concepts demonstrated in the everyday world.

This unit should be assessed in such a way that students are given the opportunity to demonstrate their knowledge of concepts and be able to explain to children in simple terms the forms of chemical and physical energy, and transformations which they can see in the physical world.

Consideration could be given to the making of **posters** or wall charts to help in teaching, construction of demonstrations (e.g., **circuits or models** including bulbs, batteries, motors and switches, homemade torch, construction of demonstration machines or models including levers, pulley wheels and inclined planes), the compilation of an exercise book with diagrams and **explanations of how things work in Tok Pisin** and local area research.

A study could be made of prior knowledge at a village level, or **children's knowledge** of the topics and concepts in schools. Research into the **historical scientific discoveries** that shaped our knowledge and the scientists who made them with a time line could supplement the lectures with human interest. This could be presented in the form of a drama script, illustrated cartoons or resource pages that could be used in teaching. Lastly there is the pen and paper examination comprising multiple choice, short answer and extended answer questions.

A list of suggested items has been included but is not exhaustive by any means. Some assessment items may include a number of strategies as a "package". For example, a student may conduct a survey, research his/her findings and assemble a teaching package tailored to local needs.

Some forms of assessment are:

- Stories and cultural beliefs about science concepts in the world around us;
- Interviews, e.g., Prior understandings of science concepts;
- Concept mapping - linking and sequencing concepts for a specific teaching topic;
- Teaching resources e.g., prepare resource for teaching a science topic;
- Wall charts and posters for teaching science topics;
- Demonstration lesson using sequence developed as a concept map;
- Practical, e.g., Activities, investigations and experiments;
- Models, e.g., Simple machines, alternative energy sources, molecules, food chains;
- Problem-solving, e.g., solution of a novel situation;
- Student presentations of experiments and findings, seminars;
- Portfolio, e.g., Selected tasks completed and submitted by students;
- Reflective journal about science activities and experiments and learning experiences;
- Comparative studies, e.g., Old versus new (wooden or fibreglass canoes);
- Library and media research, e.g., Selected science topics from newspapers; CD – ROMS, library references;
- Group projects, e.g., field project and report – natural products and their uses
- Research and report or presentation, e.g., impact of chemical pollution on habitats of PNG;
- Case studies, e.g., collect and collate latest information on energy use and sources of energy in PNG;
- Pen and paper examination e.g. multiple choice, short answer and extended answers.

Resources

This list provides colleges with recommended resources for the teaching of this unit. College lecturers should continue to keep abreast of changes and the publication of new books and new editions through the relevant booksellers.

The following titles are essential and it is highly recommended that colleges add multiple copies of these to their libraries:

Deutrom, B. (1998). Science for the Pacific: A – Z of Essential Terms. Oxford:PNG. (ISBN: 0-19-554162-6. Price approx AUD13.00 available from the Co-operative Bookshop).

Cross, R. (1996). Teaching Primary Science: Empowering children for their world. Addison Wesley Longman: Melbourne. (ISBN: 0-582-80364-0. Price approx. AUD30.00).

Anderton, J. (Ed). (1999). Fundamental Science for Melanesia: Books 1, 2, 3 and 4. Longman. (ISBN: 0 582 72123 7; Approx price each AUD20.00**. This series of books are textbooks used throughout PNG in secondary schools.**

The following CD ROM set is also very useful for both students and lecturers:

Oxford University Press. (2001). Encyclopaedia Britannica 2001 Deluxe Edn. (CD ROM). Oxford University Press: London. (CDDLX01/01: Cost approx. AUD99.00. Available from any good computer software store such as Harvey Norman or Office Works (Price: Approx. AUD90.00).

Chemistry

Gallagher, R. & Ingram, P. (1998). *Chemistry Made Clear*. Oxford University Press. (ISBN: 0 19 914267 X Price approx. AUD35.00).

Selinger, B. K. (1997). *Chemistry in the Marketplace (*5th edition). Allen & Unwin; (ISBN: 1865082554; Price: Approx: AUD50.00 Paperback.)

Physics

Armitage, et al. (1998). *Physics One*. Heinemann. (ISBN: 858595494; Approx. price AUD29.00)

Kim, H. (1994). *Showy science.* Good Year Books, Glenview IL

Lomas, R. (1999). *The man who invented the twentieth century: Nikola Tesla, forgotten genius of electricity*. Headline Book: London
Websites: http://www.headline.co.uk; http://www.robertlomas.com

Luck, S. (Ed). (1998). *Philip's Nature Encyclopedia*. George Philip: London

Microsoft Corporation. (2000). *Encarta Encyclopaedia deluxe 2000*. U.S.A.

Ministry of Education, Tonga, (1997). *Form Ill Science teachers' guide, Science Skills Book 1*

Pople, Stephen. (1998). *Explaining Physics*. Oxford University Press: London (ISBN: 0 19 914272 6; Approx. price: AUD35.00).

Reader's Digest. (1994), *Reader's Digest Book of Facts*. Reader's Digest (Australia): Surrey Hills NSW.

Sneddon. (1999). *Energy Alternatives*. Heinemann. (ISBN: 431117624 Approx. AUD30.00).

Wilson, M. (1973). *Energy*. Time-Life Books: U.S.A.

Web sites

Curious Questions (Science in everyday life): http://www.last-word.com/

Fuel Cells: http://www.fuelcells.org/

Light and Wavelengths: http://www.cea.berkeley.edu/Education/light/light_tour.html

Optics and Light: http://www.opticalres.com/kidoptx.html

Renewable Energy: http://solstice.crest.org/renewables/re-kiosk/index.shtml

Science Hobbyist Site: Full of great experiments and science facts: http://www.eskimo.com/~billb/

New Scientist readers Additional content for http://www.nsplus.com/ -

http://www.last-word.com/ - The Last Word archive of over 350 intriguing science Q & A

http://www.keysites.com/ - A new expanded top sites and discussion section

http://www.grand-tours.com/ - Our science travel section

Equipment

This list is suggested to enable colleges to purchase the necessary equipment and consumables to conduct the recommended activities contained in the students and lecturers' materials.

- Unless otherwise indicated the items are available from Supply and Distribution Services (Queensland Services Group) in Queensland, Australia. All Colleges should have access to the most recent catalogue from this supplier.
- The suggested equipment and consumables in this list is by no means exhaustive. Colleges should make their own decisions about needs based on current stocks, class numbers and budgetary priorities.
- Colleges need to estimate the quantities needed for their classes (generally assumes that you need enough for one class at a time).

Chemistry

In the case of dangerous and inflammable chemicals, these should be procured locally from Belltek (Brian Bell). It is important to stipulate, when ordering, that you only require the commercial grade. This grade is generally satisfactory for most experiments at a Primary school level. The list describes items as they are in the SDS catalogue. This will make easier for Colleges to order.

- Atomic models, ball and stick, sets
- Basin, evaporating, 75 mm diameter
- Beaker, glass, 100 mL (for heating)
- Beaker, glass, 500 mL (for heating)
- Beaker, polypropylene, opaque, 250ml (unsuitable For Heating)
- Bunsen burners or spirit burner
- Burette, 50 mL, polypropylene with stopcock
- Condenser, Liebig
- Crucible, porcelain with lid
- Cylinder, graduated, 10 mL
- Cylinder, measuring glass, 1 mL grad, 100 mL
- Dish, petri, soda glass, 80mm x 15mm (Pkt/18)
- Distillation flask, about 500 mL
- Dropping bottle, clear, glass dropper with screw cap & plastic teat, 50ml capacity
- Flask, conical (Erlenmeyer), 250 mL
- Flask, round bottom, 500 mL
- Funnel, Filter, Glass, 100 mm
- Funnel, Filter, Poly, 80 mm
- Gauze mats
- Gauze, Wire Mat, 150mm square, non-asbestos centre, folded edges
- Indicator paper, pH 1-14, full range, 30 second development, approx 5M length
- Jars, gas, with lids (for collecting gas)
- Periodic chart, large for display
- pH meter, Digital, range 0.1 to 15.0 pH (Approx. AUD 120.00 from SDS).
- Reagent jar, glass, wide mouth, plastic screw cap, 250ml
- Safety spectacles, chemical and impact resistant, basic style
- Safety spectacles, chemical and impact resistant, basic style
- Spatulas (can use the wooden sticks that are inside ice-creams and popsicles)
- Stand, filter

- Stand, retort
- Stoppers, rubber, assorted sizes to fit flasks
- Syringe, plastic, grad 50 - 60 mL (Box/40)
- Test tube holders, wooden, peg type
- Test Tube, borosilicate, glass with rim, 13mm x 100mm (Box/100)
- Thermometer, maximum/minimum, mercury, -30 to 50 degrees Celsius
- Tile, spotting, porcelain, 110mm x 90mm, 12 depressions
- Tripods
- Trough, glass, pneumatic, round (for gas collection) and glass bee-hive shelves
- Tube, clear polythene, delivery, to fit glass tubing (need to check size of existing glass tubing)
- Tube, glass (to match delivery tube)
- Wash bottle, plastic with spout

Chemicals and consumables needed to teach this unit

- Acetic acid (can always use vinegar – clear type is best, e.g., rice vinegar)
- acetone (see local hardware or ship builder for this – used to repair fibreglass canoes)
- alum (used to purify drinking water – buy or see a Water Board person)
- aluminum wire (old Elcom high voltage power lines)
- ammonia (use cloudy ammonia from stores)
- calcium carbonate, powdered form
- calcium chloride (only needed for drying gases – not essential)
- calcium hydroxide (slaked lime – might be available in hardware stores)
- candles
- carbon electrodes (centre rods out of old batteries, cells, are ideal for this)
- caustic soda (commercial grade used for making soap – sold in many stores).
- copper sulfate
- cotton wool
- ethanol (methylated spirits will do for most experiments)
- filter paper
- hydrochloric acid (Belltek or hardware store)
- iron (II) sulfate
- hydrogen peroxide (see local chemist – used as an antiseptic for wounds)
- litmus paper, books (red and blue)

- magnesium nitrate
- magnesium ribbon
- naphthalene flakes (or moth balls) or iodine crystals
- nitric acid (not essential)
- potassium iodide or sodium iodide
- potassium nitrate (not essential)
- potassium permanganate (Condy's Crystals - also see local chemist)
- sodium bisulfate (hydrogen sulfate) – not essential
- sodium chloride (need to be careful and use refined salt – not sea salt for some experiments)
- steel springs (ones out of biros are ideal for this experiment (P3 - Activity 4)
- steel wool
- Strips of different metals - aluminum (drink cans); copper (electrician); lead (plumber or sinkers), iron (nails or OK), zinc (outer casing of a torch battery but needs to be cleaned in acid))
- sulfate of ammonia (hardware or didiman supplies – fertiliser)
- sulfur (see local chemist)
- sulfuric acid (Belltek, hardware store or garage)
- universal indicator solution
- vinegar
- zinc dust
- zinc sulfate

Physics

- Alligator clips for use with banana plugs, 30mm long
- Ammeter dual range DC 0 - 1A and 0 - 10A
- Ball and ring
- Banana plugs, black, 4mm with piggyback capacity
- Bimetallic strip
- Bulb holder for 2.5 and 6.2 V (Pkt/10)
- Bulb, flashlight, screw type 6.2V, 0.5A (Pkt/10)
- Clips, alligator
- Diffraction apparatus kit, with filters, slits (single & double) & bulb (For use with 12 Volt power supply)
- Digital timer, counts up and down to 1/100th sec with alarm

- Digital timer, counts up and down to 1/100th sec with alarm (~AUD18.00)
- Ear, model (this may also be used for HPE)
- ELFS Kit, Science Electronics Kit
- Eye, model (this may also be used for HPE)
- Hodson light box, ray track apparatus
- IEC Ripple Tank with accessories
- Magnet, permanent bar, pairs
- Magnetic field demonstrator, cube containing glycerine & iron filings
- Mass hanger, brass 50g
- Meter, multimeter, digital (about AUD30.00)
- Mirror, acrylic 100 mm x 100mm
- Motor, electric, plastic base with detachable dual pulley, banana plug attachments
- Plugs, banana, black and red ones for circuits
- Power supply, transformer rectifier, 2-12V, AC/DC Switchable
- Prism, 60x60x60 degrees, 38 mm
- Pulley, double, fixed metal for 6mm rope
- Radio, transistor (any cheap radio that will receive FM/AM)
- Resistors (need a range of standard resistors or find old ones at local TV repair shop)
- Rope, polypropylene, 6 mm diameter, roll (for use with 6 mm pulleys)
- Solenoid, air core 150 mm
- Sound level meter
- Spectroscope, direct vision
- Spring balance, 100N/10kg
- Spring balance, 10N/1kg, cream
- Torch, takes 3 D cells (suitable for light experiments – best to buy local)
- Voltmeter, 0 – 12V, multirange
- Wave demonstrator kit - 2 slinkies + one long spring
- Wire, copper, bare, about 30SWG, roll
- Wire, black, PVC, copper flexible, 24 strand, 100M
- Wire, nichrome 32SWG, bare, 50g, 0.274mm diameter, ~18.4 ohm/M
- Wire, red, PVC, copper flexible, 24 strand, 100M

P 1 Structure of matter

Rationale

P1 is not considered essential core and could be omitted as it has little relevance to the Primary Syllabuses. However some background knowledge of the structure of matter may need to be reviewed based on the prior knowledge of students. It provides students with a background about the structure of matter and enables them to understand the applications to useful materials in the world around us and in use by modern societies. This module provides opportunities for students to investigate and explain the physical and chemical changes occurring in both the natural and manufactured environment.

The teaching and learning strategies should include a range of activities that relate directly to common substances and the utilisation of these substances for human endeavour. Activities should cater for students' prior knowledge and abilities. They should be engaged in such a way that they relate the theory directly to their surroundings.

Objectives

At the end of this module students should be able to

(a) explain the meaning of terms atom, element, molecule and compound;

(b) describe the changes that occur to form ions from atoms;

(c) perform experiments to demonstrate changes of state;

(d) differentiate between pure substances and mixtures;

(e) describe atomic models in terms of protons, neutrons and electrons;

(f) perform experiments safely to investigate the physical and chemical properties of a number of common substances;

Main ideas developed

Matter is something that has mass and takes up space, and exists in three forms, solid, liquid and gas.

Substances can be classified as elements, compounds and mixtures.

Atoms are indivisible by normal physical means. Atoms contain a nucleus of protons and neutrons with outer electrons. Protons are positively charged, neutrons have no charge and electrons are negatively charged.

Elements contain one type of atom and can be classified as metal or non-metal.

The behaviour of matter may be explained through the action of particles - atoms and molecules.

Matter may be changed from one state to the other by adding or removing energy.

Substances may undergo physical changes that are easily reversible because no new substances are formed.

Mixtures are formed when two or more substances are mixed in any proportion.

Compounds are formed when two or more different atoms combine chemically.

Content and sequencing

Substances and mixtures

- Solids, liquids and gases and changes of state
- physical changes and states of matter
- Mixtures – solutions, solutes and solvents

Structure of matter

- Atomic models and subatomic particles
- Elements and molecules
- Structure of some common elements (metals and gases)

Compounds

- Chemical bonds
- Formulae of compounds
- Ions

Suggested teaching strategies

Lecturers should avoid spending a lot of time on atomic theory which is not of great importance in the Primary Syllabus. The behaviour and properties of substances should be used to explain atomic principles. Lecturers should ensure that students do have a background understanding of atomic structure. It is highly recommended that locally available and familiar materials be used to teach the principles of physical and chemical changes.

Some specific strategies that may be used by lecturers when teaching this module include:

- Seeking expert advice before teaching a topic.
- Role play, e.g., students act out model of an atom and properties of subatomic particles.
- Excursion to a local industry where a common substance is manufactured
- Improvisation - use readily available materials to make models of common substances
- Guided discovery - exploring scientific phenomena with guidance

Structure of matter

This topic should be introduced through activities looking at a range of everyday substances, solid, liquid and gas. Students should be challenged to think about their own ideas about the structure of matter based on their own observations.

It is important that the ideas about and the differences between the particles of matter are understood by students. Modelling is essential for this topic. Atoms and particles of atoms cannot be seen!

The particle theory needs to be demonstrated through questioning about events and simple demonstrations. For example: "How does smoke fill a room?" Students will propose many theories even for this simple idea.

Potassium permanganate crystals dropped into water will also demonstrate the particle theory. The water, when left for some time, will eventually become uniform in colour (purple). Why?

Mechanical models are also useful to show how particles move and fill a container in the case of liquids and gases. This could be a simple transparent container filled with beads and shaken. Students should be able to relate the analogy to particle motion.

Simple activities such as pumping up a basketball with a pump will also demonstrate that air has mass and occupies space otherwise how would the ball inflate and become hard (increase in pressure)?

Substances and mixtures

Seawater and rivers are **mixtures** that contain dissolved substances. Examples like these should be used to demonstrate and investigate the properties of mixtures and solutions. The dissolving of sugar, brewing tea and coffee are further examples of solutions (mixtures).

Evaporating a colourless solution (salt and water) to obtain the dissolved salt is a good activity to convince students that **solutions are mixtures**. However it is equally important to show that the original salt, that was dissolved and recovered, has the same properties and it has not changed. This will also demonstrate that solutions are only **physical changes**.

Compounds and chemical changes

All lecturers have a responsibility to trial any chemical reaction before carrying out an experiment in class. They also must read about the reaction to ensure it is safe.

There are many everyday substances that may be used to teach the concepts of compounds, molecules, formula and chemical changes.

Introduce this topic with a number of spectacular reactions. Try not to blow up the laboratory! Here are some ideas:

1. Mix sulfur dust and zinc dust in equal volumes. Ignite with a long taper. ***Why is this reaction so hot?*** *(Very exothermic reaction giving off excess energy that is not needed for the new chemical bonds).* ***What is the white powder formed?*** *(ZnS).*
2. Fill a balloon with hydrogen gas. (You can look up the books to see how to make the hydrogen gas. That way you will also find out the dangers in making hydrogen gas.) Tie the balloon when it is about ¼ full and pin it to a board. Attach a taper or twisted newspaper to a long stick. Light it with a match and put it near the balloon. ***Why is there an explosion? What is combining?*** *(Again there is energy left over after the hydrogen reacts with the oxygen from the air to form water! This excess energy is given off as heat and sound.)* This is also a good time to talk about energy conversions and transformations.
3. Heat potassium permanganate in a test tube. (It will break down into manganese dioxide, oxygen and water***). How can we test for oxygen?*** *(Relight a glowing*

splint). This is a reaction that needs energy to break bonds. Again it should be obvious to students that the original substance cannot be easily regained.

4. Heating sugar will show a chemical decomposition as well. Sugar is easier to get.
5. Set up a series of pretty coloured precipitation reactions. These will also attract student interest. Students will notice that there is no appreciable heat given off. These are simple double replacement reactions.
6. Show students examples of slow reactions such as rusting. Leave some steel wool in a jar overnight with a bit of salt water. Do the same with ordinary tank water. ***Why is there a big difference?*** *(Salty water is a conductor so the rusting process (electrochemical cell) is accelerated)*. **Relate this to anodes on outboard boat motors.** ***Why do the outboard motors have zinc on them?*** *(The zinc reacts in the seawater instead of the iron and aluminium parts on the motor).*

Discuss common reactions that students are familiar with and try to ascertain the type of reactions that are seen.

Galvanised tanks are protected because the zinc corrodes before the iron.

Coral is limestone (calcium carbonate) which contains calcium, carbon and oxygen atoms. When heated calcium carbonate produces calcium oxide and carbon dioxide gas. The calcium oxide is lime (used for betel nut chewing) and it reacts with water to produce slaked lime. (Both are very alkaline and damage human tissue and cause cancer.)

There are also many more examples of chemical reactions around us: rusting, corrosion, batteries and soap to name a few. Students may be able to describe some more.

Suggested student activities

These activities include supplementary and advanced activities that lecturers may choose for students who are ahead in their work.

Structure of matter

1. Build models, using ball and stick, washers, bottle tops and nails, to show the difference between compounds and molecules. Use the models to explain to the group how the properties of the different states of matter (solid, liquid and gas) can be explained by particle motion.
2. Use a balloon tied with a short piece of string as a model of a molecule of oxygen to explain properties of gases.
3. Research the concept of physical change. Give five examples of physical changes that happen in everyday life.
4. Design a demonstration to convince a Middle Primary class that air exists, even though it cannot be seen.
5. Place a rubber stopper at the end of a plastic syringe where the needle usually fits. Try to compress the air in the syringe. Explain this property in terms of the particles in air and the properties of gases.

Substances and mixtures

1. Boil some water in a container with a thermometer placed in the water. Observe (a) small bubbles forming at first, (b) large bubbles coming to the surface when the water boils. (c) Read and record the temperature at regular intervals then, (d) draw a graph of the temperature changes against time. (e) Hold a cold metal or glass container in the steam and observe what happens. Explain all of your observations in terms of energy and the behaviour of water molecules.
2. Place some ice cubes in very cold water in a beaker on a tripod and gauze. Heat with a burner (or on a stove), stirring regularly, and use a thermometer to measure the temperature. Draw a graph of the temperature against time and explain the shape of the graph to the group.
3. Write a story entitled "My Exciting Day" where you imagine you are a water molecule and you describe the changes that take place during various changes of state.
4. Experiment with changes of state using locally available materials and substances. For example, explain the changes that take place when fat/butter/margarine are placed in a pan for cooking some meat.
5. Observe a cold bottle or can of soft drink. Explain (a) why drops of water form on the outside, (b) why bubbles form in the drink when you open it, (c) why the drink sprays out if you shake the container, (d) why the drink is less "fizzy" if it is cold.
6. Explain in terms of water molecules and air movement why you feel cold when you get out of the river/sea after swimming.
7. Mix some salt, sand and iron filings and design an experiment that could separate each again. Carry out your experiment and report to the group what you did, what happened and why.

Compounds

1. Mix some iron filings and sulfur and heat strongly in a test tube. Observe what happens and explain to the group what the reaction products are. Use bottle tops or nuts, etc. to explain the reaction in terms of the different atoms involved.
2. Make a small fire with wood, small enough to be covered by a suitable cover such as a dish, frying pan, etc. Cover the fire for a short time, then take the cover off again. Repeat this process a number of times. Explain your observations to your partner. What is the chemical reaction in a fire? Write formula and an equation for the burning reaction? Where is the energy coming from?
3. Heat some blue copper sulfate crystals in a test tube and observe what happens. Use bottle tops or nuts to explain the reaction in terms of the different atoms or substances involved.
4. Prepare a teaching chart about a substance and its properties for a specific grade.
5. Attach a short candle to a cork floating on water. Light the candle. Place a small glass jar over the candle and observe what happens.

P 3 Useful materials and reactions

Rationale

We use many chemical substances, both natural and manufactured, in our daily lives. There are many useful chemicals and substances around us. Some of these may be used directly while others need to be processed or changed to be useful, e.g., soap is made from fat and caustic soda. Many reactions occur in nature as a day to day process. Some reactions are necessary to sustain life while others are a nuisance, such as rusting of iron and corrosion of outboard motors. In this module you will study a selection of useful substances and some reactions associated with those substances.

The teaching and learning strategies should include a range of activities that relate directly to common substances and the utilisation of these substances for human endeavour, both in a modern and traditional setting. Activities should cater for students' prior knowledge and abilities. Students should be engaged in such a way that they relate the theory directly to their surroundings.

Objectives

At the end of this module students should be able to

(g) Describe why some molecules are essential to life;

(h) list a number of useful metals and describe their uses and chemical properties

(i) explain the processes of corrosion such as rusting;

(j) describe ways to prevent corrosion;

(k) list useful non-metals and describe their importance in everyday life;

(l) list the major types of chemical reactions that affect useful substances;

(m) provide examples of reaction types with reference to the chemical properties of common and everyday substances;

(n) investigate locally available chemical substances;

(o) describe a number of useful organic substances and their properties and uses;

(p) perform experiments safely to investigate the physical and chemical properties of a number of common substance.;

Main ideas developed

- Substances may undergo chemical changes that are relatively difficult to reverse because new substances are formed.
- Reactions may take place between substances involving energy changes and the formation of new substances.
- Acids react with metals, carbonates and bases to form salts
- Acids and bases are useful chemicals in everyday life.
- Oxygen in the atmosphere reacts with many substances in a process called oxidation.

- There are many examples of oxidation reactions in everyday life.
- A range of protection measures needs to be taken to prevent oxidation (corrosion) of important things.
- Many useful chemicals are manufactured by chemical reactions.
- Properties of some substances make them useful as cleaning agents, solvents, etc
- There are many useful organic substances: plastics, epoxy resin, glues, clothing.

Content and sequencing

1. Useful metals and their reactions

- Lead – ores, extraction and uses
- Aluminium – physical and chemical properties; importance and uses
- Copper – ores, extraction and uses
- Iron and steel – production, alloys, properties, tempering of steel
- Reactivity of metals – related to PNG environment
- Corrosion of metals and cells; protection from corrosion
- Toxicity of metals in the environment
- Recycling of metals

2. Useful non-metals

- Acids and bases (common acids and bases used in everyday life)
- Natural acids and bases
- Ammonia – physical and chemical properties
- Cleaning properties of ammonia

3. Useful organic substances

- Fabrics and flammability – types of synthetics, properties and risks
- Plastics – types and uses
- Glues and adhesives – types and uses
- Soap and detergents

4. Cement and Concrete

- Composition of cement
- Making concrete
- Strength of concrete
- Reactions of concrete

Suggested teaching strategies

To effectively teach this module, lecturers may obtain information and reference material from fertilizer and chemical companies, the PNG Mining Council and mining companies operating in PNG.

It is also useful to collect labels and information about the common substances available in the local stores and environment.

In a larger area it might be possible to include an excursion to a local site or factory.

More ideas and strategies are listed under the topics.

Useful metals and their reactions

The lecturer should collect a number of metals used in everyday life.

Get students to discuss in groups the uses of a common alloys and metals, copper, iron, zinc, lead, aluminium, brass, bronze, steel, etc.

Activity 1.

Visit a metal working industry and plumbers to get the scrap pieces you need. Recycle wastes for scrap metal, e.g., aluminium cans.

Discuss the differences in metals and alloys after being left in the weather for some time. Ask questions to get students think about reasons: "Why do some metals resist corrosion?" "Why does steel rust quickly?" What kind of steel resists rusting?" "Why?"

Activity 2

Aluminium strips are easily obtained from soft drink cans. Aluminium wire is used for TIG welding, that is, where aluminium boats are welded. Try a boat repair place or engineering works for the wire. If not try Elcom for a bit of high voltage power cable.

In testing the conductivity, students may need a refresher about circuits especially if this module precedes P5 (Electricity). It might be best for the lecturer to set up a demonstration circuit for students to copy.

Make sure students are aware of safety aspects when heating the Al strips in a bunsen flame. It will melt and could splutter onto someone causing nasty burns.

Students also need to be reminded about acids and the danger to eyes. Make sure some baking soda solution is on hand whenever handing acids. (The baking soda neutralises the acid.)

The same safety warnings should be given about the use of caustic soda solutions. Have vinegar on hand to neutralise the alkali.

Activity 4

A biro spring is ideal for this experiment. Student can lose the temper (not their temper!) first by heating and cooling in air.

Some might like to extend their experiment and temper a knife and pick.

Activity 5

The chemicals used for this experiment do not have to be laboratory grade. The zinc can come from the outer casing of torch batteries but you need to clean in HCl first.

You could have groups try different metal solutions with nails and zinc to see which react faster.

The students should discover that:

- Zinc is more reactive than copper.
- Iron is more reactive than copper.

The copper is seen forming on the metals as a brown-black coating and the solutions change colour. The copper sulfate (blue) loses colour with zinc and turns greenish with the iron (nail).

The equations for the reactions are:

Zinc + copper sulfate ——— zinc sulfate + copper

Zn $CuSO_4$ $ZnSO_4$ Cu

Iron + copper sulfate ——— iron sulfate + copper

Fe $CuSO_4$ $FeSO_4$ Cu

Are we able to deduce that zinc is more reactive than iron? Ask students to propose a further experiment to test this hypothesis. (Activity 6 looks at this).

Do not waste a lot of time with symbol equations. These have no relevance to the Primary Syllabuses!

Activity 6

This is a good practical and real-life example of what happens to metals in the sea.

It is best to assign pairs of different metals to groups. The voltage can be measured with voltmeters or a simple multimeter.

Yes! The different metals do produce a chemical cell in seawater. This is why things corrode so fast in seawater.

Research

Steel and aluminium parts are protected by using a "sacrificial anode". This means that the zinc must be more reactive and corrodes instead of the steel or aluminium on ships and outboard motors.

Aluminium window frames are protected by **anodising** the aluminium. The surface of the aluminium is coated with a fine layer of oxide. This is done evenly and quickly using electrolysis in a factory.

Toxicity

It is important to stress to students that some inferior ceramic cookware may contain cadmium and lead levels above the safe recommendations. The problem happens when lead glazes are used to finish the pots.

Old lead paints may still be around in PNG. Ask the students if they know of any instances of lead poisoning from paint.

Useful non-metals

This topic gives students the opportunity to investigate many common substances, including acids and bases, ammonia compounds and fertilisers.

Research

pH is a mathematical expression for the concentration of hydrogen ions in a solution. In neutral solutions, such as distilled water, the concentrations of hydrogen ions and hydroxide ions are equal. Theoretically water consists of equal numbers of each ion.

Concentration of H^+ = concentration of OH^-

$$[H^+] = [OH^-] = 10^{-7}\ M.$$

It is the negative log of the hydrogen ion concentration. In water, the concentration of H^+ = 10^{-7} Molar.

A 1 Molar solution is one in which there is one gram (molecular or atomic) weight of the ion or substance dissolved per litre of solution. For H^+ the GAW is 1.00. Therefore a 1.0M solution of hydrogen ions would contain 1.0 gram of hydrogen ions. The pH would be –1, very acid!

Household vinegar has a pH of about 3.0. This means that vinegar contains 1/1000 GAW of hydrogen ions in a one lire solution. $[H^+] = 10^{-3}$ M.

Activity 7

Allow students to test the pH of a range of common substances in solution.

Substance	pH
0.1 M HCl	1.0
Gastric juice (stomach)	1.4
Lemon juice	2.3
Vinegar	2.9
Orange juice	3.5
Tomatoes	4.2
Coffee	5.0
Rainwater	6.2
Distilled water	7.0
Blood	7.4
Seawater	8.5
Soap	11.0
Household ammonia	11.5
0.1 M NaOH	13.0

Approximate pH values of some common substances

Discuss some of these substances with students and ask questions to get them thinking about the reasons for the acidity or alkalinity.

Why is our stomach is so acid?

Why does soap burn your eyes?

Why is blood alkaline?

Why are some acids strong and others weak?

Explain briefly that "**strong**" and "**weak**" refer to how much substances dissociate (break apart) in water, that is, produce ions. Organic substances such as vinegar and ammonia do not break apart readily and produce what are called weak acids or alkalis.

Concentrated and **dilute** refers to a totally different concept. It is simply a measure of how much is dissolved in a litre of solution. If more is dissolved it is more concentrated. It is bit like having three teaspoons of sugar in your coffee rather than one!

Obtain some packages that list the contents so that students may discuss the adequacy of warnings.

Ammonia

The lecturers should acquaint themselves with the common candles that contain ammonia. A local didiman or hardware store will be able to help with this. A number of these are listed in the student book.

Table 2.2 Salts forme d by reaction of ammonia with various acids

Formula	Chemical name	Common name	% N	% P	% S
NH_4Cl	Ammonium chloride				
NH_4NO_3	Ammonium nitrate	Nitrate of ammonia	34.0		
$(NH_4)_2SO_4$	Ammonium sulfate	Sulfate of ammonia	21.0		
$NH_4H_2PO_4$	Monoammonium dihydrogen phosphate	MAP	19.0	20.0	
$(NH_4)_2HPO_4$	Diammonium hydrogen phosphate	DAP	13.0	22.0	

It might be worth discussing the use of these as fertilisers with some pertinent remarks. This would tie into community development – agriculture. Some are also sources of other essential elements, e.g., phosphorus (P) and sulfur (S).

They are all sources of nitrogen but a quick look at the formulae should indicate to students which are the best sources. The best source of nitrogen (N) is ammonium nitrate. Students could calculate the % nitrogen using atomic weights**. This would give students some more practice at maths.**

Example: The molecular weight of $(NH_4)_2SO_4$ $= \{14 + (4 \times 1)\} \times 2 + 32 + (4 \times 16)$

$= 132$

% nitrogen $= \dfrac{28 \times 100}{132}\%$ (2 x N atoms)

$= \underline{21.2\ \%}$

You could also calculate the % sulfur for this fertiliser.

Other comments about these fertilisers:

1. Ammonium sulfate and MAP make the ground more acidic so they should not be used on soil that is already acidic.
2. Ammonium chloride makes the ground salty (saline) so it is not a good fertiliser to use long term. It should be avoided on low lying coastal soils or near beach areas.
3. Ammonium nitrate is a good alternative but it is expensive and also an explosive when mixed with diesel.
4. DAP makes soils more alkaline so it is good on acid soils which are very common in forest areas of PNG.

5. MAP and DAP are both good in soils which have been leached (high rainfall) as they contain both nitrogen and phosphorus.

Activity 8

It is not necessary to use every possible metal salt to test amnmonia solution. Just select a couple of the more spectacular ones like copper nitrate and silver nitrate.

At first the copper and ammonium ions produce a powder blue gelatinous precipitate of copper hydroxide. Addition of more ammonia reacts with the precipitate giving a transparent deep blue solution. This is due to the formation a complex with the copper ions.

The ion formed is called copper tetraamine, a complex ion of Cu: $[Cu(NH_3)_4]^{2+}$

The silver ions behave in a similar way producing a complex silver ion: $[Ag(NH_3)_2]^{+}$

Useful organic substances

Start this topic by discussing useful plants of PNG. This could create some interesting discussions. For example: *"For what is the derris leaf (vine) used?"* It is used for stunning fish. *How?*

Maybe some of these plants could be collected before the lectures. (Advance planning is needed!)

Activity 9

It will depend on time whether this activity can be done but it is a good example of how natural plant substances have been used in the past to make dyes and inks. The materials are relatively easy to obtain. The hydrogen peroxide should be available at a chemist or local hospital. **If you have bought hydrogen peroxide make sure it is kept in a refrigerator. It does not last in the heat of the tropics.**

Activity 10

Alum (potassium aluminium sulfate) is needed for this demonstration. It always interests students. It can also be used as an example of a chemical change. *What happens to the alum when it is heated?*

Alum is: $KAl(SO_4)_2.12H_2O$

Activities 11 and 12

Collect a lot of different plastics before the lectures. Broken tail lights are also plastic. There are probably plenty of samples of plastics on the streets of PNG!

Take care burning plastics as some produce very toxic fumes. It is recommended that this activity be done outside a classroom.

Activity 14 Soap

Probably plenty of students have seen soap made at home. Begin this activity by discussing some of the problems with soaps that are not made with the right quantities of chemicals and procedures. (Residual caustic soda is the biggest problem).

You may wish to vary the recipe or even have different groups make different soaps. For example, one group might make palmolive! (Use olive and palm oils for this). Experiment with different oils and fats.

Some extra notes about organic substances for lecturers

INKS

Invisible Writing Activity (Demonstration)

Alum is used to purify drinking water. You might be able to obtain some from the Water Board in your area.

The dry invisible alum letters become visible as dark carbonised areas. The alum dehydrates the cellulose in paper by acting as a proton donor to form H_2O from the OH groups of the cellulose. Alum is representative of substances that are inert at normal temperatures but become active when heated.

Black Ink Activity

The lecturer will need to obtain some hydrogen peroxide from the chemist or store. It is used as a disinfectant.

Reactions

$$2H^+ + Fe\ (s) \rightarrow Fe^{2+} + H_2(g)$$

$$2H^+ + 2Fe^{2+} + H_20_2 \rightarrow 2Fe^{3+} + 2H_2O$$

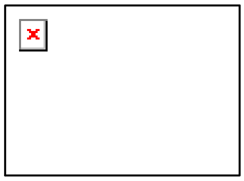
$$Fe^{3+} + \text{tannic acid} \rightarrow \text{ferric tannate}$$

Notes

1. Hydrogen peroxide is available from pharmacies and is used for cleaning wounds. It is a strong oxidising agent and should be handled with care. It is also poisonous if swallowed, so it must be used carefully. Before you add the peroxide to your solution, make sure the solution has cooled to near room temperature. Don't spill the peroxide, because it is a powerful bleach.

2. Ferric tannate may stain, so be careful to avoid contact with your clothing.

GLUES



Methyl methacrylate is polymerised in bulk or suspension methods using free-radical initiators. As a polymer repeating unit, its structure is as shown at right.

The presence of the methyl (CH_3) groups prevents the polymer chains from packing closely in a crystalline fashion and from rotating freely around the carbon-carbon bonds. As a result, PMMA is a transparent and rigid plastic. Because it retains these properties over years of exposure to ultraviolet radiation and weather, PMMA is an ideal substitute for glass. A most successful application is in internally lighted signs for advertising and directions. PMMA is also employed in domed skylights, swimming pool enclosures, aircraft canopies, instrument panels, and luminous ceilings. For these applications the plastic is sold in the form of sheets that are machined or thermoformed, but it is also injection-moulded into headlights and taillights and lighting-fixture covers.

Suggested student activities

Reactions (overview)

1. Research the concept of oxidation. Design and carry out an experiment using steel wool and glass jars with lids or stoppers to find out what are the conditions that lead to rusting (oxidation) of the steel wool. Hint: you might use water and kerosene in your experiment. Report your findings to the whole class.
2. As a group, research and be able to explain to the class the similarities and differences between the terms burning, combustion, corrosion, rusting, respiration and oxidation
3. Conduct a survey of your classroom, the kitchen, the workshop, the college surrounds, etc. Make a list of all the examples of oxidation (e.g., rusting, corrosion, respiration, etc.) you can find. Make a separate list of the different ways in which people have tried to protect materials from rusting.
4. Why are examples of oxidation much easier to find than reduction? (Hint: what is in the atmosphere?). Research and report on reduction of metals in PNG. Why are large quantities of energy required to smelt copper ore to obtain copper metal? How is smelting related to oxidation/reduction.

Useful metals and their reactions

1. Use the Periodic Table to explain (a) the placement of metals and non-metals on the table and (b) the reactivity of different metals to a partner.
2. Most metals oxidise over a period of time. Find examples of oxidation of metals, e.g., green stain on copper, etc. Which metals resist oxidation? (Hint: Why is gold used for jewellery?). Research and find out ways in which different metals are protected from oxidising. Present a report to the class.

Useful non-metals

1. Research the concept of acid. Make a list of the acids and the foods that contain them in the foods you eat. Draw a table of the important acids in a balanced diet. Find a breakfast cereal box (or other food container) and find out what acids are in that food.
2. Research acids in the human body. Explain to a partner why acids are in the body and why some people need to take antacid tablets.
3. Research acids in soil. Explain to a partner why it is important that the pH of a soil is important. Find out what villagers in the local area do to control the pH of their garden soil.
4. Make various types of concrete mixtures and test the properties and strength of your concrete. Use old UHT milk cartons as moulds to make the concrete.
5. Make a list of the places where acid is used in everyday life. (Hint: truck battery is one place). Visit a hardware or garden store and make a list of the acids that are sold and write down the uses for each one. Make a list of the safety precautions that must be taken when using strong (concentrated) acids.

6. Research the concept of indicators. Find out how to make an indicator and experiment with some of the plants in the area to see if you can make an indicator. When you have made and tested an indicator explain to the group what you did and how indicators work.
5. Research the concept of a base. Explain how acids and bases are related. Write a simple equation for a neutralisation reaction and use different coloured bottle-tops or nuts etc. to explain what happens to the atoms in such a reaction.
6. Make a list of the places where bases (alkalis) are used in everyday life. (Hint: Look in the cleaning cupboard). Visit a hardware or garden store and make a list of the bases that are sold and write down the uses for each one. Make a list of the safety precautions that must be taken when wing strong (concentrated) alkalis.
7. Design and carry out an experiment to show how acids and bases react with metals. Explain the reactivity series to a partner. List some uses of such reactions.
8. Make some ammonia gas and investigate the properties.

P 4 Physical concepts and machines

This module is a prerequisite to the combined module P2 and P5, Energy and Waves. The first topic in Energy and Waves may be studied in conjunction with this module. That topic deals with energy changes.

Rationale

Words such as 'power', 'energy' and 'strength' have a confused meaning in everyday speech. Is a strong cup of coffee the same as the strong Trukai Rice man? Is a strong piece of cardboard the same as a strong rubber band? This module gives scientific precision to such terms.

The way that complex concepts can be built up is reflected in their units. Complex units are built on the fundamental concepts of mass, length and time. The module begins with fundamental concepts and the way that complex concepts can be built from them is traced.

Anyone who has taken the cover off a machine, be it VCR or water pump, will have seen gears, drive belts, cams and other moving parts. Complex machines are arrangements of simple machine units such as levers and pulleys. The second topic discusses simple machines but relates them to the useful machines of everyday life.

Finally, the appendix gives a simple but coherent approach to using metric prefixes. Students who master the approach will be able to perform metric conversions mentally and have an appreciation of 'orders of magnitude'.

It is expected that this module will develop preservice teachers who:

- Are able to use terms for scientific concepts accurately
- Are able to identify physical concepts in real life contexts
- Can confidently explain to children these concepts
- Can identify examples of concepts to illustrate lessons from children's daily experience

Objectives

After studying this module students should be able to

Knowledge and Processes

- identify physical science concepts from verbal or visual descriptions
- identify the number of dimensions something has
- name the purposes of various simple machines
- explain the principles underlying common tools
- recall the prefixes, abbreviations and sizes of metric units from pico- to Tera

Skills

- convert units with prefixes to decimals or positive powers of ten
- convert units from within the range of pico- to Tera- using prefixes

- work out whether, after using simple machines, the force is greater or smaller and whether the amount and direction of movement is changed (in a qualitative way)
- estimate sizes for physical science concepts using benchmark examples

Values and attitudes

- Appreciate how complex concepts can be derived from simple concepts and measurement units
- Value precision in terminology and measurement
- Appreciate technological achievements
- Value experimental investigation and discovery

Main ideas developed

Mass is the measure of the amount of matter.

Speed depends on distance travelled in a given time.

Velocity is determined by displacement from an original position in a given time.

Acceleration is a measure of how fast the velocity of an object is changing.

Acceleration of an object depends on its mass and the force applied to it.

Acceleration due to gravity is 9.8 ms^{-2} or approximately 10 ms^{-2}. The weight force is the force on an object due to gravity.

Deceleration occurs when a frictional force acts in the opposite direction to the force.

Force is a push or pull.

Machines can be used to make work easier.

Increasing the force makes work easier.

An increase in force is accompanied by a decrease in working distance and vice versa.

Pulleys can change the direction of a force.

Screws are based on the inclined plane.

The propeller is an air screw.

The SI unit for speed is ms^{-1}, velocity is ms^{-1}, acceleration/deceleration is ms^{-2}, force is Newton (kg-ms^{-2})

The use of metric prefixes conveniently removes the need to use powers of ten or multiple zeros.

Content and Sequence

Physical Concepts

- Space and Dimensions
- Length, Area, Volume and Capacity
- Time and Frequency
- Weight and Mass

- Speed and Velocity
- Density and Buoyancy
- Inertia and Acceleration
- Force and Pressure
- Work, Energy and Power
- Temperature
- Reference: formulas and units

Simple Machines

- Levers
- Inclined Plane
- Gears and Belts
- Cams and Cranks
- Pulleys
- Examples: tools, clock, hydraulic ram pump

SI Metric System

- Place Value and SI prefixes
- Conversions

Suggested teaching strategies

Try as much as possible to use objects and events (bows and arrows and catapults) which are familiar to students and take plenty of time to help them understand these quite difficult concepts.

Use a relatively unfamiliar situation to allow students to apply their understanding of these concepts. An example could be to write an account of sending a rocket into orbit where the students have to use correctly all of the terms applicable to this topic.

Jt is very important that the teaching of science be approached from the personal experience of students. These experiences will provide a real life connection to the important science concepts and the application to PNG situations. Students' prior knowledge and misconceptions about important issues must be established before planning the teaching programme. Such information can be obtained using cooperative learning techniques such as making lists, milling, surveys and interviews. For example, are fish that are swimming below the surface neither sinking nor ascending, "floating"? Do heavy things fall faster than light things?

Student interaction and participation is essential to build on fundamental understandings in science. Practical experiences should be incorporated in the student learning experiences wherever possible. Enact demonstrations wherever possible, such as accelerating, decelerating, pushing, pulling, displacing and moving. Use as many measuring devices as possible - measuring cylinders, thermometers, stopwatches, sphygmomanometers (blood pressure test instrument), pressure gauges, spring balances and handgrips. These are especially useful when measuring human characteristics or capabilities, since the human body has immediate relevance.

It is wise to omit formulas and calculations. Students may be tempted to apply them in a magical recipe fashion without understanding the concepts. This module emphasises concept formation. Practical application and usefulness has been the focus in selecting content, and rigorous mathematical precision is of little use to primary school teachers. It is all too easy for a physical science course to become extremely abstract. This should be assiduously avoided. Formulas are included in this module only for the sake of completeness and for reference.

One approach to primary science lessons is to begin with "Children, did you know that...", followed by some surprising fact. For example, "Children, did you know that an ordinary bullet travels faster than all but the world's fastest fighter aircraft?" Collect curious facts for use in capturing children's interest and imagination from such sources as the Guinness Book of Records.

More specific strategies or approached to each of the topics is given later.

Assessment

This module should be assessed in such a way that students are given the opportunity to demonstrate their knowledge of concepts and be able to explain to children in simple terms the meaning of such concepts demonstrated in the everyday world. Consideration could be given to the making of **posters** or wall charts to help in teaching, construction of demonstration **machines or models** including levers, pulley wheels and inclined planes, the compilation of an exercise book with diagrams and **explanations of how things work in Tok Pisin**, and local area research. A study could be made of prior knowledge at a village level, or **children's knowledge** of the distinction between mass and weight, distance and displacement, velocity and speed in schools. Research into **historical discoveries** and when various machines were invented, and the people who made them with a time line could supplement the lectures with human interest. This could be presented in the form of a drama script, illustrated cartoons or resource pages that could be used in teaching. Lastly there is the pen and paper examination comprising multiple choice, short answer and extended answer questions.

Pretest

1. *If you were comparing a small book with a big book what measurable quantity would you be looking at?*
2. *If a book were too big to fit on a shelf, what measurable quantity would you be considering?*
3. *When jumping on a springboard or rubber trampoline, what concept is it that pushes you into the air?*
4. *What concept determines whether an object floats or sinks when you put it into water?*
5. *Two children are in a race. One gets off to a better start than the other. What measurable concept are we looking at?*
6. *A plane coming in on the Madang runway could not slow up fast enough and it landed in the sea. What concept is "how fast something slows up"?*
7. *What physical concept is being compared if you compare the melting points of different metals?*
8. *What changes if you go from Earth to the Moon or another planet – mass or weight?*
9. *What word means "the distance from Point A to Point B in a straight line"?*

10. *What concept is being compared if you said you were better at blowing up balloons than someone else?*
11. *What are the units for measuring the light output of light bulbs?*
12. *What unit is used for measuring the energy content of foods?*
13. *What unit is used for measuring the water-holding capacity of a dam?*
14. *What concept is it that tells you how much it hurts your foot when you stand on tiptoe?*
15. *It is easy to read big print and hard to read fine print. What concept tells you the size of the letters?*
16. *Some trees have big leaves and some have small ones. What concept is being compared when you compare the sizes of leaves?*
17. *A tonne of gold would fit inside a rubbish bin. What is the concept when you talk about how much stuff there is in a certain space?*
18. *If we all joined hands, how far could we spread out? What is the concept involved in a line of people all holding hands?*
19. *You might write a letter to your friend every month, while someone else writes more often. "Once a month" or "Five times a second" is called by what scientific name?*
20. *What word describes the characteristic of objects that the bigger they are the harder they are to get to move?*
21. *Which is bigger – a megavolt or a kilovolt?*
22. *Which is smaller – a millimetre or a centimetre?*
23. *What concept measures the amount of ink in a pen?*
24. *What concept measures how sharp the point of a needle is?*
25. *What concept is used to compare two differently sized water pumps?*

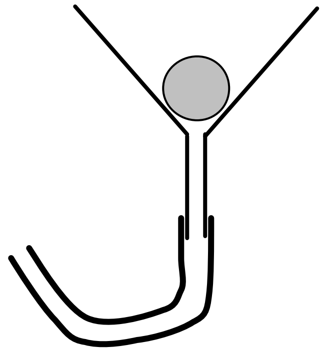
Physical Concepts

The lecturer should gather a collection of suitable demonstrations to introduce the concepts to students. The UNESCO Source Book for Science is a valuable source of good demonstrations to make students wonder why?

The best way to teach physical concepts is to use a range of demonstrations, which challenge students thinking. These strategies include **discrepant events** and **Predict – Observe – Explain (POE):**

Discrepant events

The lecturer outlines a demonstration without saying what will happen. The demonstration is done and students then describe and explain what happened. The main idea with discrepant vents is to select those that will cause a questioning the students' own beliefs (knowledge) about a concept.



Example: Connect a delivery tube to a glass filter funnel and place it wide part up in a stand. Place a ping-pong ball in the funnel and challenge students to blow the ball out. You can even put a monetary prize on this one! No one will be able to blow out the ball thanks to the **Bernoulli principle**. As the air rushes past the ball there is a drop in pressure directly under the ball. The atmospheric pressure forces the ball downwards to try to equalise the pressure. The harder the student blows the more the "suction" downwards on the ball. Here is a good time to clear up any misunderstanding about the concept of vacuum. There is no ideal vacuum in the universe. Most people confuse the effects of lower pressure as a "vacuum".

POE (Predict - Observe – Explain)

This strategy is widely used in science teaching and should form the basis of student knowledge construction. A situation or experiment is presented to students who than try to predict what will happen, observe and record, and finally try to explain what they observed. By providing students with the opportunity to use their own ideas or beliefs we, as lecturers, become more aware of individual differences and focus areas.

Example: Fill a balloon with a colourless gas, actually hydrogen. Pin the balloon to the board. Ask students to predict what will happen if you place a lighted taper near the balloon. After accepting all answers from students, light the balloon. (It will explode with a loud noise, which should startle the students.) Do not tell students what happened at this stage. They are given the opportunity to explain in their own terms. The lecturers will need to utilise questioning skills to lead students through the discussion and reach a consensus. It is important to recognise the contributions of all students even if they appear to be incorrect.

Other suggestions

There are many good demonstrations that can be used to introduce or review concepts in physics.

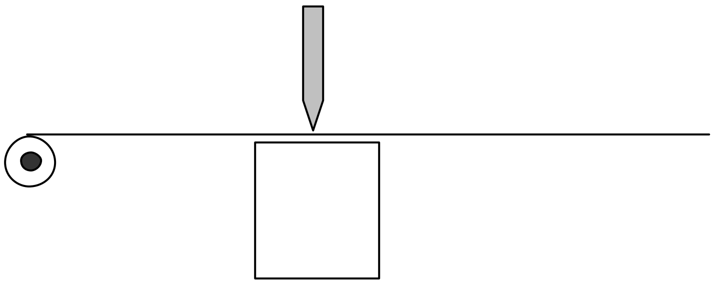
Newton's Third Law: Place a student on a skateboard and have him/her throw a heavy ball to another student. (The board goes backwards and the student loses balance.)

Inertia: Pull a sheet of paper out from under a glass. (if this is done quickly the glass will stay put!)

Density: Mix kerosene and water and allow to stand. (The less dense kerosene "floats" on top of the water.)

Force: Use a spring balance to measure the force needed to "load" a bow, i.e., pull the string back.

Acceleration: Set up a toilet roll on a broomstick. Have one student take off and run with the end while another student using a felt pen to mark every second as the roll is unwound.



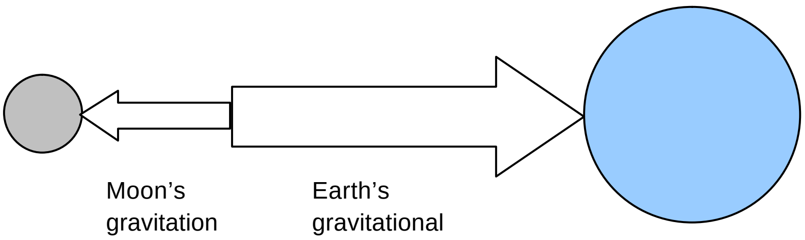
Speed, velocity and acceleration should be related to familiar activities/objects such as running, cars, planes (balus), bows and arrows and slingshots. Effects of braking in a vehicle can be used to explain deceleration, braking distance and inertia.

Mass and weight: make sure students are familiar and understand the difference between these two concepts. Many languages of the Pacific do not have words to describe the difference. In fact the same word/s are used for both in many cases.

Gravity: There is always a lot of confusion among students with this concept. Use demonstrations to show that the acceleration due to gravity is the same for all objects regardless of mass and size! Maybe a student can climb a coconut with two different objects and drop them to prove this one?

It is also worthwhile comparing the gravity on the planets and the moon. ***Why is less force is needed to launch a spacecraft from the moon's surface than the Earth?*** Also relate the effect of distance on the gravitational force.

Force is proportional to $1/\text{distance}^2$.



Answers to Exercise 5. Identify the concepts

1. pressure	2. power	3. power	4. area	5. power
6. displacement	7. area	8. energy	9. work	10. volume
11. displacement	12. area	13. area	14. volume	15. pressure
16. area	17. energy	18. distance	19. displacement	20. energy
21. energy	22. acceleration	23. work	24. pressure	25. mass
26. time	27. speed	28. area	29. volume	30. force
31. work	32. volume	33. work	34. energy	35. pow er
36. time	37. area	38. volume	39. force	40. area
41. displacement	42. distance	43. force	44. energy	45. work
46. energy	47. force	48. mass	49. distance	50. power
51. work	52. area	53. pressure	54. mass	55. mass
56. distance	57. pressure	58. volume	59. energy	60. acceleration
61. energy	62. pressure	63. pressure	64. displacement	65. power
66. area	67. power	68. area	69. acceleration	70. area
71. volume	72. pressure	73. volume	74. energy	75. volume
76. energy	77. power	78. pressure	79. force	80. time
81. distance	82. force	83. force	84. displacement	85. force
86. speed	87. force	88. volume	89. speed	90. work

91. speed	92. area	93. pressure	94. area	95. force
96. area	97. force	98. work	99. pressure	100. displacement
101. energy				

Simple Machines

Obtain several examples of simple machines to demonstrate concepts of energy and work. A bicycle is excellent for demonstrating levers, gears, mechanical advantage, pulleys, etc. A block and tackle as seen in garages and on sailing boats gives good examples of the uses of pulleys for mechanical advantage.

There are many simple machines that students can experience in the classroom. Set up a number of workstations with task cards. Each workstation should have a set of instructions and open-ended questions to allow students to investigate each simple machine. It is important that all students do the investigations. They must experience and observe first-hand.

This is also a good opportunity for students to practice their teaching skills and explain the concepts to their peers. The lecturer will also become more aware of any misconceptions through this approach.

A complimentary set of explanatory cards may also be prepared by the lecturer so that students may check their ideas. However it is again important that students question their ideas and beliefs and seek assistance from the lecturer if they do not understand.

SI Metric System

Answers to Further metric conversion problems

Block A:

1) 0.001 Pascals	2) 0.000 000 000 004 H	3) 3 000 000 Ohms
4) 0.002 Hertz	5) 9 000 000 000 Bytes	6) 0.000 000 000 009 Watts
7) 3 000 000 000 000 W	8) 0.000 000 006 Farads	9) 3 000 000 000 000 Bytes

Block B:

10) 95 000 000 tonnes	11) 0.082 tonnes	12) 82 000 000 Ohms
13) 55 000 Hertz	14) 5 000 000 000 000 Joules	15) 0.000 000 000 093 Hz
16) 0.000 000 000 005 Watts	17) 52 000 000 000 Bytes	18) 93 000 Barns

Block C:

19) 0.000 000 008 7 Farads	20) 0.000 000 005 5 grams	21) 8 400 000 000 000 t
22) 0.004 5 Amps	23) 0.000 000 000 005 Joules	24) 0.000 000 000 002 t
25) 8 600 Watts	26) 0.000 000 008 6 tonnes	27) 4 200 000 000 000 barns

Block D:

28) 25 280 000 000 000 F	29) 0.000 000 000 067 g	30) 0.004 96 Volts
31) 0.000 066 63 grams	32) 19 700 000 000 Pa	33) 55 110 000 000 000 t
34) 0.000 000 000 097 g	35) 0.000 000 000 097 Ohms	36) 0.081 68 Volts

Block E:

37) 2 megafarads	38) 9 terabytes	39) 4 megaAmps
40) 2 kilopascals	41) 4 megavolts	42) 3 picowatts
43) 6 micrometres (microns)	44) 6 megaAmps	45) 1 gigawatt

Block F:

46) 82 picohenries	47) 64 megatolais	48) 70 picojoules
49) 33 millicenturies	50) 79 gigagrams	51) 7 megawatts
52) 39 teraohms	53) 54 megaAmps	54) 36 megapascals

Block G:

55) 9.5 gigametres	56) 3.2 megahertz	57) 6.1 gigaAmps
58) 9.3 picosepiks	59) 1.2 terahenries	60) 9.5 gigavolts
61) 5.3 milliamps	62) 6.8 teragrams	63) 6.6 millipascals

Block H:

64) 45.8 microwatts	65) 99.13 megawagaias	66) 89.81 gigacenturies
67) 89.14 kilojoules	68) 13.29 millibarns	69) 56.73 picojoules
70) 81.16 teravolts	71) 10.60 millitonnes	72) 8.10 picograms

Block I:

73) 0.003 millifarads	74) 0.004 nanoamps	75) 0.008 microns
76) 0.000 002 gigatonnes	77) 0.006 microamps	78) 3 000 kilojoules
79) 1 000 megatonnes	80) 9 000 kilobytes	81) 3 000 000 kilojoules

Block J:

82) 71 000 megawatts	83) 0.037 nanohenries	84) 39 000 000 milliwesterns
85) 33 000 microbarns	86) 44 000 000 kilotonnes	87) 14 000 000 megaAmps
88) 0.048 microhertz	89) 0.045 megahertz	90) 0.065 millimorobes

Block K:

91) 0.000 006 4 microns	92) 4 700 gigagrams	93) 0.000 001 9 microbarns
94) 9 800 000 millicenturies	95) 5 700 000 kilofarads	96) 0.000 007 9 microPascals

97) 9 300 megahertz	98) 1 800 picocenturies	99) 8.2 milliamps

Block L:

100) 0.000 036 85 µA	101) 0.066 8 THz	102) 0.058 27 MV
103) 43 500 000 MB	104) 0.000 029 6 GB	105) 21 600 000 kc
106) 0.093 2 Tohms	107) 27 690 000 kV	108) 16 950 000 000 µJ

Block M:

109) 2 megafarads	110) 9 terabytes	111) 4 megaAmps
112) 2 kilopascals	113) 4 megavolts	114) 3 picowatts
115) 6 microslices	116) 6 megaAmps	117) 1 gigawatt

Block N:

118) 82 picohenries	119) 64 megaloms	120) 70 picojoules
121) 33 milliseconds	122) 79 gigagrams	123) 7 megawatts
124) 39 teraohms	125) 54 megaAmps	126) 36 megapascals

Block O:

127) 9.5 gigametres	128) 3.2 megahertz	129) 6.1 gigaamps
130) 9.3 picoseconds	131) 1.2 terahenries	132) 9.5 gigavolts
133) 5.3 milliamps	134) 6.8 teragrams	135) 6.6 millipascals

Block P:

136) 45.8 microwatts	137) 99.13 megaseconds	138) 89.81 gigacenturies
139) 89.14 kilojoules	140) 13.29 millibarns	141) 56.73 picojoules
142) 81.16 teravolts	143) 10.6 millitonnes	144) 8.1 picograms

Suggested student activities

These suggested activities have been grouped under major concepts. The activities may also be used by the lecturer as an introductory activity to gain student interest, to reinforce the concepts or for further development of a topic by students. If students are having problems with some concepts then some further activities may be selected from the suggestions.

Forces and motion

1. Research the concept of **force**. Write a definition of force in your own words and explain the concept to a friend. Use a ball (cricket ball, football, hockey ball) to explain how different sized forces acting on the ball produce different effects. Use a tool (spade,

hoe) to show different forces produce different results. Use a kitchen utensil (knife, fork) to show different forces in action.

2. Draw a diagram of an Air Niugini plane in flight. Add to the diagram all the forces acting on the plane. Write a short explanation of how each of these forces comes about. Where does the energy to keep the plane flying come from? Explain each of the changes in form of energy involved in keeping the plane flying.
3. Draw a diagram of a person riding a bicycle or sitting in an aeroplane or sitting in a truck. (a) Use arrows to show as many of the forces acting on the vehicle as you can. (b) Describe where the energy is coming from to make the vehicle travel along.
4. Use a bow and arrows to explain the relationship between force, mass and acceleration. (Hint: Make some very thick heavy arrows to show that mass is important).
5. In your group, explain the differences between the terms distance, displacement, speed, velocity and acceleration. Using the actual students in your group, demonstrate each of these terms in a concrete way, that is, direct those students to move in such a way that the different terms are understood by them.
6. Survey your college surrounds and list all the examples of velocity and acceleration that you can find. Remember that when things move there is always an initial acceleration if they were originally at rest (stopped).
7. Use a shanghai/catapult to demonstrate to a partner that different forces (amount the elastic is stretched) cause different amounts of acceleration to the same mass. Use small stones of the same size for equal masses. Research the ways in which catapults were built in ancient times to lay siege to walled cities.

Gravity

1. Try lifting objects of different mass. You are overcoming the force of gravity on them. What is the relationship between the force of gravity and the mass of the objects? Six large rocks are lying on a mat and you try to pull them along with difficulty. Then you decide to use a wheelbarrow to move the rocks. Draw diagrams showing the forces acting in both cases to help you explain to your partner why the wheelbarrow makes it easier to move the rocks.
2. Research the concept of gravity. Use two long pieces of string and on one end of one tie a large rock and to the end of the other, a small rock. Pass the strings over a branch or high railing and gather other members of the class to observe. Let go of both strings at once and observe that the rocks both accelerate down and hit the ground together. Explain to the group why this happens.
3. Research the concept of **mass**. Use apparatus such as the top-loading balance, suspended balance, a balanced piece of wood to demonstrate the idea of objects having equal mass. Would these balances work in space?. Would a shanghai work in space?
4. Place two objects of very different mass (and weight), such as a small stone and a larger stone, one in each hand and move them up and down. You are feeling the effect of

gravity on the masses, their weight. Would you feel a similar effect in space where gravity was not acting and the stones were weightless? Yes, both objects would still have mass and you are trying to accelerate them.

5. Put some sand in a box or try this on the beach. Find two objects about the same size but with very different mass, e.g. a stone and a nut from a tree would do. Drop these objects one at a time from the same height into the sand. What differences do you notice? Explain to a partner why there is a difference. (Hint: mention energy).

Inertia

1. Explain to your partner: (a) why are you pushed back into the seat when a car or plane starts off. (b) Why do you feel a push sideways when a car goes around a corner. (c) Why do you get thrown into the air when a truck on which you are riding goes over a bump.

Centripetal force

1. Take your group outside and tie a rock on the end of a piece of string and (safely!) swing it around your head, then let it go. Observe that the rock travels in a straight line from where you let it go. Explain to the group why this happens.
2. Cut a circle of card to make a model of a cross section through the Earth. Put model people on the edges of your Earth with strings attached to them and passing out through a central hole in the circle (Earth). Pull the strings to show that gravity pulls people in PNG, in France, in South America, everywhere, towards the Earth's centre. Research the size of the force of gravity on different planets. Show this effect on your model.
3. In your group discuss the concept of rockets leaving the Earth to place satellites in orbit. Write down a series of statements in a sequence that would explain to another group what is happening. Use the terms force, energy, gravity and acceleration in your statements.

Measurement and units

1. Research the concept of **work.** Write a definition of work in your own words and explain the concept to a friend. Explain how work is done when simply walking from one village to another. What difference does it make if one village is high on the side of a mountain?
2. Research the **joule**. Explain to your partner what a joule is. Each member of the group must now demonstrate, as closely as each can, a joule of work being done in different ways and explain where the energy is coming from.
3. Research the concept of power. Write your own definition of power.

Density

1. Use a stone and a nut of about the same size but different mass to do this activity. (a) Estimate (or measure if you can) the mass (weight) of each of the objects. (b) Find the volume of the objects. [Hint: Half fill a clear container with water. Mark the water level on the side of the container. Place one of the objects in the water and mark the new

level. Replace this object with the second object and make another mark. If the objects are about the same size, the two marks should be at the same level].

2. Pour a small quantity of oil or kerosene into a clear container (an empty soft drink bottle would be excellent) which is already half filled with water. What do you observe? Explain your observation to a partner. Put the top on the container and shake vigorously. What do you observe? Explain this to your partner. Let the contents settle for a period of time and observe again. Explain to your partner.
3. Place a raw egg (gently) into a container of water and observe what happens. Now place the same egg into a container of salty water (sea water or make your own salty water) and observe. Explain the difference to your partner.
4. Find two pieces of aluminium cooking foil of the same size. Screw one up into a tight ball and make a boat shape with the other. Test whether the two will float in water. Explain your observations to your partner in terms of mass, density and displacement.
5. Drop (gently) a coin and a small piece of wood (about the same size as the coin) into a container of water. What do you observe? Why is there a difference in behaviour? On what property of the objects does this behaviour depend? What determines the density of an object?
6. Make a paper snake and hang it over a burning candle. Observe what happens and explain it to your partner. (Be careful not to set the paper alight).

Machines

1. Find out the scientific definition of a machine. Use some tools or kitchen utensils to explain to a friend the concept of a simple machine. Explain how some different simple machines work.
2. Examine a range of simple machines (tools or kitchen utensils) and choose one to explain the energy changes (transformations) involved when the machine is used.
3. Bring a bicycle into the classroom and use it to explain the difference between velocity and acceleration. Explain what causes acceleration, why the bicycle will slow down if pedalling stops, why the different parts of the bicycle are shaped as they are (e.g., cogs, chain, brakes, etc.) and how each works.
4. Research the definitions of machines and tools. (a) Write a definition of a machine in your own words. (b) List the essential things that must be present in all machines.
5. Carry out a survey of your college and compile a table of the machines used in different parts of the college. Include in your table where each is used, the useful work that each does, and whether they are simple or complex machines, e.g., spade - garden - moves soil - simple machine, or photocopier - office - copies sheets - complex machine.
6. Research and draw up a list of the efficiencies of various machines; e.g., diesel engine, petrol engine, bicycle, etc.

P 2 and P5 Energy and waves

Why study these modules?

What child has not asked a question about the nature of the physical world? (How can you get all the sounds in the world out of a loudspeaker? How do televisions and radios work? What makes lightning and thunder?) Even the children who do not question can be seen fascinated by toy boats carried on a current, or whirlpools in muddy creeks, or aeroplanes taking off and landing. Behind this fascination are the predictable rules which physical things obey.

Every time the density of the boat and its load reaches a certain point, the boat will sink. Every time you spark a battery there will be interference on the radio nearby. Torches always light up when the right amount of current passes through the bulb. Over centuries the rules have been discovered. Knowing them help all of us make sense of the world: it's not arbitrary magic or chaos. It can even help us exercise control over our world: a little knowledge of circuits can help us see why the radio does not work when the batteries are put in the wrong way.

Energy and Waves looks at three main forms of energy: sound, light and electricity. Communication looks at how pictures made of light, music and speech made of sound and other kinds of information can be recreated in distant places. It tries to be as practical as possible and the emphasis is on breadth of understanding and concept development rather than on depth and detail. This is more suitable for primary school teachers; the formulas can be left for the secondary school teacher.

It is expected that this module will develop preservice teachers who…

- Are confident with circuits – bulbs and batteries and how they hook up
- Know the difference between voltage, current, power and energy
- Know safe practices with regard to electricity and the reasons behind them
- Understand the most common devices which change energy from one form to another
- Know a little of how modern technology works so that televisions, radios and computers are not simply 'black boxes'
- Appreciate how the properties of sound and light are perceived in all their richness and variety by the ear and the eye
- Appreciate the role electricity plays in the functioning of the heart, muscles and nerves.

Pre-requisites

The unit *Physical Science* has no pre-requisites. However this Module P5, *Energy* and Waves, presumes knowledge of basic physical concepts covered in the Module P4, *Physical Concepts and Machines*.

Objectives

Knowledge and Processes

After studying this module students should be able to

- identify different forms of energy and state ways they can be inter-converted
- relate properties of sound and light (such as frequency) to auditory and visual effects (such as pitch or hue)
- list the uses of forms of sound which cannot be heard by the ear and forms of light which cannot be seen by the eye

- explain the different ways things such as bells and strings can vibrate to produce different sounds
- explain how common electrical devices function
- warn children of dangers related to electricity
- identify the principles involved in modern communication
- explain the functioning of the ear and eye

Skills

After studying this module students should be able to

- produce standing waves and demonstrate resonance in slinky springs or ropes
- link batteries and bulbs together in circuits and predict the effect on current
- magnetise steel by friction and in a solenoid
- involve children in activities which will help them understand electricity
- use batteries, power supplies and household electricity safely

Values / Attitudes

Students should

- Appreciate the variety in sounds and vision
- Respect electricity
- Appreciate technological achievements
- Value experimental investigation and discovery

Main Ideas Developed

Energy occurs in different forms and may be changed from one form to another.

Energy sources may be classified as renewable or non-renewable.

Energy travels in waves.

The properties of sound and light correspond to the properties of sound and light waves.

Electricity is a useful form of energy.

Different aspects of electricity, light and sound can be measured using various units.

Inaudible frequencies of sound and invisible frequencies of light are useful.

Electricity can travel through some materials better than through others.

Electricity will only flow through a completed circuit under pressure from a battery or generator.

Waves can carry auditory, visual and text information over long distances.

Digital transmission and storage are replacing analogue methods.

Content and sequence

Useful energy and energy transformations

- Mechanical
- Heat
- Electrical
- Chemical
- Radiant
- Potential – elastic, gravitational
- Transformations

Sound

- Frequency ranges for hearing, radios, CD's, voice, piano
- Ultrasound and Subsound
- Ways things vibrate: Bells, Guitar Strings, Closed and open Pipes, Drums
- Pitch, Tone, Quality, Volume
- Shock waves: thunder, clapping, whip cracking
- Ears, hearing and hearing problems (presbycusis, tinnitus, noise damage)

Light

- Eyes, vision and vision problems
- Primary colours for television screens and artists' paint
- Electromagnetic Spectrum: radio and TV waves, microwaves and radar, infrared, ultraviolet, X-rays, gamma radiation (production and usefulness)
- Hue, Saturation and Brightness
- Fireflies, torches, bulbs, fluorescent tubes, cameras, LEDs

Electricity

- Current, Energy, Power and Electrical Pressure
- Batteries and bulbs in series and parallel
- Magnetism: the compass, making magnets and electromagnets, tape recording
- 3-pin plugs
- Safety with household current
- Power transmission, PNG hydro schemes
- Electrical Devices: motors, loudspeaker, television, pacemakers

Communication

- Radio: antenna, tuning through resonance, modulation (AM, FM), microphone, loudspeaker
- Television: camera, picture tube, persistence of vision, parasitic antennas, UHF, VHF
- Facsimile (fax)
- Internet and email
- Satellite relays

Suggested teaching strategies

It is very important that the teaching of science be approached from the personal experience of students. These experiences will provide a real life connection to the important science concepts and the application to PNG situations. Students' prior knowledge and misconceptions about important issues must be established before planning the teaching programme. What do students understand by 'voltage' and 'current', for example? What do they know about the electrical system of the heart? What controls do colour televisions, radios and cassette records have? Who has used a computer? A CD? Such information can be obtained using cooperative learning techniques such as making lists, milling, surveys and interviews.

Student interaction and participation is essential to build on fundamental understandings in science. Practical experiences should be incorporated in the student learning experiences wherever possible. Depending on time constraints, an excursion to a local power station or visit from a technician might be able to be arranged. Where possible demonstrate sound, lighting and electrical effects – show car alternators and spark plugs, look inside the back of a tape recorder and notice the speakers.

It is wise to omit formulas and calculations. Students may be tempted to apply them in a magical recipe fashion without understanding the concepts. This module emphasises concept formation. Practical application and usefulness has been the focus in selecting content, and rigorous mathematical precision is of little use to primary school teachers. It is all too easy for a physical science course to become extremely abstract, dealing as it does with such abstractions as force fields, energy and invisible electrons. This should be assiduously avoided.

One approach to primary science lessons is to begin with "Children, did you know that…", followed by some surprising fact. For example, "Children, did you know that grasshoppers hear with their knees?" The writer of this unit has kept this in mind, and there are curious facts teachers can use to capture children's interest and imagination.

Useful energy and energy transformations

Review students' knowledge about forms of energy and the transformations. Use a few good demonstrations to "trigger" responses from students. Refer to discrepant events. Don't spend to long on this topic. It should be revision.

Sound

Sound takes time to travel. Ask 7 – 8 students to stand about 10 metres apart. Students are told to look at the student in front of them. Another student or the lecturer stands about 10 metres from the first student in line. Use a hammer and strike a piece of steel. Tell the students to put up their hands when they hear the sound. Students relate what they observe and discuss in terms of how sound travels. Reverse the striking end so that all students can see what happens.

The same experiment can be done along a very long steel fence. Two lines of students are used and face with their backs to the source of sound. One line has their ear on the steel pipe or wire of the fence. The others listen in the air. The hammer is hit on the fence and students again raise their hands as they hear the sound.

In both demonstrations students should see a wave move down the line. In the case of the steel fence those with their ears on the fence will almost all put their hands up at the same time.

If students are swimming in the sea or a river the same can be done by having students with one ear in the water. Two stones are banged together. The result will similar.

These experiments should be discussed in terms of the speed sound travels through different media and the nature of sound waves.

Light

Refraction: Stand beside an aquarium or glass bowl full of water and aim torch light (beam) into the top of the water at about 45°. The effect may be improved by sprinkling some chalk dust into the water. This can also be demonstrated with a pool of water, pond, river or sea at night. Discuss students' experiences with torches.

Use an overhead projector to discuss the way the light is used to project the image of writing onto a screen. An overhead projector can also be used to show the path of light when reflected or refracted by passing light through a container of water on top of the projector. (Be careful that you do not spill the water on the OHP!)

Discuss short- and long-sightedness with students. Use old spectacles to show the difference in the lenses.

Use an old car headlight to demonstrate the use of concave mirrors, in this case, a parabolic mirror. Sprinkle chalk dust in front of car headlights at night and the light beam will be obvious.

Communication

Sound energy uses particles to travel. Line students up close to one another. Push the first student in the line and see what happens.

Musical instruments are a good way to introduce the concepts of sound waves, frequency, pitch and loudness. Students should be encouraged to demonstrate different instruments and explain the principles as well as the physical concepts.

Students need to understand the concept of transmission of sound through different media. Discuss the idea of different types of sound waves and transmission through the air. *How far will the sound of the human voice travel? How can we increase the distance?*

Discuss the way messages are transmitted by smoke signals, whistles, garamut, sign language, radio, TV, newspapers, telephone, flags, morse code, etc. *Which are visual, which are sound waves in air, which are transmitted by electromagnetic means?*

Introduce the idea of the string telephone for carrying sound waves a longer distance. *How does this happen?*

Now introduce the concept of radio waves through investigate radio heard as FM and AM. *What do these terms mean? What are the differences between voice waves and these waves?*

Discuss the development of electromagnetic signals from morse code to present day communications. Stress that wires are no longer needed. Telephone, fax and internet uses electromagnetic waves to transmit from one Province to another (microwaves).

Allow students to complete the activities in the student materials to investigate electromagnetic waves as the medium to transmit sound over very long distances.

Students need to see examples of the ways in which information and data is transmitted by different wavelengths of the spectrum. Provide an opportunity for individual research and reporting to the class.

Students may be able to go on an excursion to the local broadcasting station (radio station) in your area. In this way they would see the steps in converting sound to electrical energy, transmitting the electrical signals, receiving the signals and converting back to audible sound.

Suggested student activities

These suggested activities are arranged under the main topics in this module. The activities may be used by the lecturer as an introductory activity to gain student interest, to reinforce the concepts or for further development of a topic by students.

Useful energy and energy transformations

1. Make a list of each of the different forms in which energy occurs and beside each write down what you could do to demonstrate each form to a Grade 6 class.
2. Find out the scientific definition of **energy**. Place a ball at the top of a hill, slope or ramp and let it go. Where does it get the energy to move? Explain the concept of **potential energy** to a partner. Find out five examples of where potential energy is used to do useful work.
3. A truck is being driven along the road. Where does it get the energy to move? Explain the concept of **kinetic energy** to a partner. Find out five examples of where kinetic energy is used to do useful work.
4. Make a table of the sources and uses of energy that you use everyday, e.g., dry cell battery) -in your radio, food for movement, etc. Use pictures/drawings to construct a chart suitable for use in Grade 5 primary classroom that explains the ideas you put in the table of everyday use of energy.
5. Survey a classroom/kitchen/office and list all the forms of energy involved during one 24-hour period in the room. Make a colourful chart that could be used in Grade 5 to explain forms of energy.
6. List the forms of energy that were used in PNG before the coming of white people. State the source of each of these forms and the use to which each was put.
7. Make a list of the energy sources used in PNG. Divide your list into those sources that are produced locally and those that have to be imported. Write a short statement about the cost to PNG of those energy sources that have to be imported. Decide on possible ways of replacing those sources with locally produced energy.
8. Draw up a chart to show all the stages of energy transformation in the formation or making of (a) coal, (b) oil/natural gas (c) a dry cell.
9. A truck is being driven along a road at 30 kph when the driver puts his/her foot on the brake. List all the energy changes that take place in bringing the truck to a stop.

Waves

1. Drop a small stone into a pond of still water and observe the waves produced. Float a stick on the water and try to estimate how many waves pass the stick in a minute (the frequency). Estimate the distance between successive waves (the wavelength). Explain why the floating stick does not move along with the wave, but simply bobs up and down.
2. Experiment with a rope and slinky spring to make waves.
3. Research the concept of refraction of waves. Use a line of students marching side by side and crossing a boundary where the velocity changes to demonstrate refraction of a wave.
4. Research the concept of interference of waves. Carry out a small experiment in a pond or dish of water to demonstrate what happens. Observe what happens at the beach when waves coming from slightly different directions meet.

5. Research the concept of reflection of waves. Use a small pond or dish of water to find out what happens when waves strike, (a) a concave surface, (b) a convex surface, and (c) a straight line) surface.

Sound

1. Research and explain the differences between 'longitudinal' and 'transverse' waves.
2. Role-play the movement of particles as a sound wave passes.
3. Find out how traditional musical instruments are made in your own area.
4. Make a rubber band (or other) guitar, a bamboo flute or a bottle cap xylophone.
5. Measure the speed of sound using a watch and tin can.
6. Make a string and can telephone.
7. Tune a guitar
8. Explain to your partner why, if you see a game such as cricket from a distance, the sound always reaches you after you see the action. If sound is so much slower than light, explain why is it possible to see and hear at the same time, a World Cup soccer match which is taking place 15000 km away.

Light

1. Use a mirror to discover some of the behaviours of light beams.
2. Use a torch to make shadows. Make up a simple shadow play or story and act it out.
3. Use a torch and mirror to demonstrate to a partner the idea of reflection of light. Design and carry out a simple experiment that would allow you to show reflection of sound.
4. Explain to a partner why your reflection in a shiny spoon is not the same as your reflection in a bathroom mirror. Draw diagrams to help your explanation.
5. Find out why a jar of water distorts an object placed behind it.
6. Use a glass prism or a mirror set up at an angle in a shallow dish of water to produce the visible spectrum. Explain to a partner, with the help of diagrams, how this spectrum comes about and how a rainbow is formed.
7. Explain to your partner the term electromagnetic spectrum. Give an example of as many parts of the electromagnetic spectrum being used usefully on Earth as you can.
8. Explain to your partner why some people wear glasses (spectacles). Draw diagrams to help explain how spectacles work. Find out the difference between short-sightedness and long-sightedness.
9. Research the effects of electromagnetic waves on living things. Explain why exposure to too many X - rays can be dangerous and what precautions an X-ray technician must take to limit exposure.
10. Research 'UV-B'. Explain to a partner what it is and what is its significance. Explain how the ozone layer is related to UV-B and what the 'hole in the ozone layer' is.

11. Collect newspaper clippings on the current controversy about the effects of electromagnetic waves on humans. (Some scientists think it is dangerous to live close to power cables and that mobile phones can 'cook' brain cells; other scientists disagree).

Electricity

1. List the different forms of energy that are changed into electricity in PNG. Give an example of the machine/apparatus that brings about the change, e.g., chemical - electrical - dry cell battery).
2. Explain to your partner the differences between a dry cell, a wet cell and a battery.
3. Make a simple electromagnet with a large nail, some insulated copper wire and a source of electricity. Demonstrate your electromagnet to the group and explain how it works. Find as many examples of electromagnets around your college as you can. (Hint: Telephones and radio speakers have electromagnets in them.)
4. Use a simple model or series of diagrams to explain, in simple terms, to your partner how an electrical generator works.
5. Investigate how a light globe/fluorescent tube works.
6. Obtain a copy of an electricity bill (account) and explain to your partner what each of the amounts on the bill represents.
7. Design an experiment to find the efficiency (power out/power in) of an electric jug or kettle used to boil water. Then check your design with your teacher before carrying out the experiment.
8. Survey a number of electrical machines and copy down the details of their voltage, current drawn, power and resistance. (These are often printed on a plate attached to the machine, or are sometimes printed on the base). For each one, calculate the energy used if the machine runs for one hour. Find out the cost of electricity in your area and calculate the cost of running the machine for one hour.
9. Make a table of the many different ways in which electricity can be generated. On the table show the energy source, the device/machine which does the conversion, and an example of a location where it is used.
10. Draw a simple electrical circuit with at least four components. Obtain these components, set up the circuit and use it to demonstrate to your partner the main idea of electricity travelling in a circuit.

Communication

1. Research the concept of sonar. Explain how bats are able to fly so well in dark caves or during the night.
2. Find out how a speaker or microphone works.
3. Look at a TV screen with a hand lens
4. Draw a chart of the electromagnetic spectrum showing its main parts. Because the velocity of all the different waves in the spectrum is constant ('c' velocity of light and

all the other waves), on your chart you should be able to show how frequency and wavelength vary. Explain how each of the main areas of the spectrum is used by humans. For example, X - rays are used to detect broken bones. For each main part of the spectrum name one method by which those rays are detected. For example X-rays are detected with a special film.

5. Find out the numerical value of 'c', the velocity of electromagnetic waves. Use the formula that connects velocity, frequency and wavelength to calculate the wavelengths of the signals from your local radio station and various other radio stations in PNG. (Most stations advertise their broadcasting frequency).
6. Take a radio that is receiving a signal near to an active power cable. What do you notice? Explain to your partner why the power cable interferes with the radio reception.
7. Build an audio tone generator.