Physics
Learning Guide

Years 12 - 13

Student Learning Guide

Sāmoa Physics Curriculum
Years 12 and 13

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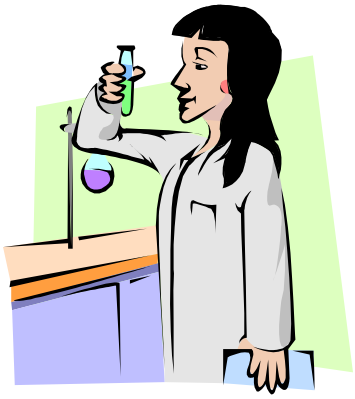
THE SCIENCE OF PHYSICS

What is Physics?

Physics is the most basic of all sciences. A physicist is interested in observing how and why matter and energy behave the way they do. Physicists try to discover and explain the laws that make everything work. When you hear about motion, rockets, electricity, light, sound, forces, radioactivity, nuclear energy, and anything that has to do with the interaction between matter and energy you are hearing about physics.

If Physics is a Science, what is Science?

Science is *a method of explaining and predicting events in the observable (measurable) universe*.



If a person is asked to draw a picture of a scientist they will almost always draw a person using some sort of lab equipment. Try it. Ask someone to draw a picture that is instantly recognisable as a picture of a scientist. Usually they will draw a person using the tools of science such as telescopes, microscopes, beakers, and test tubes. Many pictures will include math equations (especially $E=mc^2$). The picture will almost always show some act of measurement or observation with a clipboard or notebook to record the observations. This intuitive depiction is really a quite accurate definition of what science is.

The reason that people include the tools of science in their pictures is that they know, at least at some basic level of understanding, that scientists are interested in finding out about the things around us that can be measured and put into numbers. That's exactly right. Scientists *do things* and most of what they do involves a measurement or observation of some kind.

The fact that science uses measurement and observation as the basis for its explanations and discoveries is the source of both the strength and weakness of scientific knowledge.

STRENGTH. Findings can be checked by repeating the measurements and observations.

WEAKNESS. Scientists can only study those things that can be measured. That is the definition of physical - that which can be observed and measured.

Because scientists can only do science in the physical universe they cannot use science to answer many important questions about God, culture, human behaviour or art. This does not mean that a scientist cannot be interested in these areas. It only means that it is impossible to deal with them in a scientific way.

Although science is limited to what can be observed and measured it has been very successful. We live in a technological world. We are healthy and comfortable largely because our scientific knowledge and techniques allow us to understand and manipulate the world around us so that it meets our needs. The food we eat, the medicines we take, the cars, ships and planes we ride in and all the things in our homes are possible because we understand how things work. Unfortunately the scientific techniques that enable us to shape our physical environment cannot be applied to problems in our society and culture.

What defines science then is its use of methods of measurement and observation that can be repeated and verified by anyone. Because of this, science is limited to the study of the natural or physical universe.

The important characteristics of science can be summarised as follows.

1. Science explains and predicts.
2. Science uses techniques of measurement and observation.
3. These measurements and observations can be checked (verified).
4. Science concerns itself with the physical universe.

Science is very successful because scientists limit themselves to what can be observed. What can be observed can be observed by all. They don't argue endlessly about their theories and ideas. They do argue, sometimes for a long time, but not endlessly. The basic idea of science is that a scientist can say "Look, if I'm right you'll see this happen when you do this." Because scientists deal only in the observable universe their ideas and conclusions can be tested.

The description of how scientific problems are solved is usually called the **scientific method -** *the sequence of events that leads to scientific discoveries and solutions to scientific problems*. The sequence is:

- observation and data collection
- recognition of a problem or question
- development of an hypothesis
- test of the hypothesis
- analysis of the test

The important items on this list are the collection of data and the test of the hypothesis. Good science and good physics will always seek measurable data and develop hypotheses that can be tested by collecting more data.

STUDYING PHYSICS

Getting Ready

As the last section pointed out, physics is a **problem-solving** discipline. Your physics teacher will stress major themes and principles, and one major goal is that you, the student, will be able to apply these principles to understand and solve problems. You should focus on the fact that in a physics course, **you are expected to solve problems.**

An overview of your course can help you organise your efforts and increase your efficiency. To understand and retain data or formulas, you should see the underlying principles and connecting themes. It is almost certain that you will sometimes forget a formula, and an understanding of the underlying principle can help you generate the formula for yourself.

Take these steps to getting an overview early in the term so that all the following material can be built into your overview:

1. Examine the course outline carefully. Your Teacher will have developed the year's course from the Physics Achievement Objectives set out in the ***Science Curriculum Statement for Sāmoa Secondary Schools.*** These Achievement Objectives are also set out in this Learning Guide with the appropriate page numbers of the textbook.

2. Preview the textbook:
   Year 12: *Physics for You*, Keith Johnson – published by Nelson Thornes.
   Year 13: *Advanced Physics for You* – Keith Johnson, Simmone Hewett, Sue Holt, John Miller – published by Nelson Thornes.
   a. Read the introduction and table of contents.
   b. Read the notes to the student or teacher (p. 3).
   c. Check the course outline to see what chapters or topics are assigned and which ones you do not need to study.

Participating in a Physics Class

It's important that you be well prepared for class. You should do the following:

Before each class:

1. Check the course outline or reading assignment to see what will be covered. Prepare by briefly previewing the sections of the textbook that apply to the Achievement Objectives to be covered. This preview will improve your ability to follow the class. You will have seen the new words or concepts and will recognise signposts that will help integrate the classes into an overall picture.

2. Look at the section headings and subheadings. Try to formulate questions in your mind about the subjects to be covered. This question formulating helps you manipulate and therefore better understand the material.

3. Examine the drawings and pictures. Try to work out what principles they illustrate.

4. Make notes of new words, new units of measure, statements of general laws, and other new concepts.

5. Do not underline or highlight the text, since you do not yet know what will be emphasised by your teacher.

6. Right before the beginning of class, check your notes from the last class. Reading your notes will prepare you to listen to the new physics class as part of an integrated course and will help you to see the broad development of themes.

During each class:

1. Arrive at class on time.

2. Take good notes. It's helpful to draw up a set of abbreviations and use them consistently in taking notes. Keep a list of them for later reference. Leave plenty of space for later comments and for

questions or write on only one side so that you can use the opposite side for comments and questions (see After Class, below).
3. When you copy drawings, completeness is worth more than careful artwork. You should not only copy what is on the board but also record important points that the teacher talks about.
4. If you get behind in your note taking, leave a space in your notes and go on. You can fill in your notes later with the help of a classmate or your textbook.
5. Ask questions. Don't be embarrassed to ask your teacher questions. Many teachers depend on feedback from students to help them set a proper pace for the class. And of course it can happen that the teacher does not explain a step he or she takes, or even makes a mistake when writing something on the board.

After class:
1. As soon as possible after class, review and edit your notes. You need not rewrite them. Rather, you should look for important ideas and relationships among major topics. Summarise these in the margin or on the opposite side if you've taken notes only on one side. At this time you may want to add an outline to your notes. Also, this would be a good time to add notes from your textbook into your class notes; then you will have one set of complete notes to study from.
2. As you review your notes, certain questions may come to mind. Leave space for recording questions, and then either ask the teacher or even better, try to answer these questions for yourself with your friends and with the help of the textbook.

Reading Your Physics Textbook
Reading the text and solving homework problems is a cycle: Questions lead to answers that lead back to more questions. An entire chapter will often be devoted to the consequences of a single basic principle. You should look for these basic principles. These Laws of Nature give order to the physicist view of the universe. Nearly all of the problems that you will be faced with in a physics course can be analysed by means of one or more of these laws. Some suggestions for your physics reading are:

1. Make use of the preview that you did before the class. Again, quickly look at the major points of the chapter. Think back to the points stressed in class and any questions you might have written down.

2. Read the homework problems first. If specific homework problems have not yet been given, select several and look these over. Work out what principles seem to be most significant in the assigned chapter. Based upon your brief review of the class and

your examination of the problems, try to generate questions in your mind that you want the chapter to answer.

3. Read actively with your questions in mind. A passive approach to reading physics wastes your time. Read with a pencil and paper beside the book to jot down questions and notes. If you find that you are not reading actively, once again take a look at the problems and the lecture notes. Read to learn, not to cover material.

4. Stop now and again and recall the material that you have read. It is a good idea to repeat material aloud and especially to add notes from the textbook into the margins of your class notes.

5. During your reading you will notice sections, equations, or ideas that apply directly to problems your teacher may have given you. After you have read such a section, stop and work out how you can use it in your homework problem. The process of reading and problem solving is part of the cycle of:

question → answer → question

It helps you gain insights that are not possible by reading alone, even careful reading alone. Passive reading is simply following the words in the book. Active reading also involves exploring the possibilities of what is being read. By actively combining the questions that come up when problem solving with your reading, you improve both your concentration while reading and your ability to recall and to apply the material.

Problem Solving in Physics

As you read this, you may be a beginner problem solver. The goal of this section is to help you become an expert problem solver. Effective, expert problem solving involves answering seven questions:

- What's the problem about?
- What am I asked to find?
- What information am I to use?
- What principles apply?
- What do I know about similar situations?
- How can I go about applying the information to solve the problem?
- Does my solution make sense?

You, the expert, will decide, 'this is an energy problem,' or, 'this is a Newton's Second Law problem.' A beginner is more likely to decide, 'this is a pulley problem,' or, "this is a car problem." The beginner concentrates on the surface features of the problem while you concentrate on the underlying

principle. You, an expert problem solver, will answer these questions, play around (briefly) with the problem, and make drawings and sketches (either in your mind, or even better, on paper) before writing down formulas and putting in numbers. A beginner problem solver, on the other hand, will try to write down equations and plug in numbers as soon as possible. A beginner will make many more mistakes than you will when you become an expert.

In a physics course it's important to remember a couple of things about physicists and physics teachers:

- A physicist seeks those problems that can be modeled or represented by a picture or diagram. Almost any problem you encounter in a physics course can be described with a drawing. Such a drawing often contains or suggests the solution to the problem.
- A physicist seeks to find unifying principles that can be expressed mathematically and that can be used in a range of physical situations. Your physics textbook contains many specific formulas, but you must understand the broader Laws of Nature in order to understand the general overview of physics. This broad understanding is vital if you are to solve problems that may include several different principles and that may use several different formulas. Virtually all specific formulas in physics are combinations of basic laws.

How to approach a physics problem:

1. Read the problem. Look up the meanings of any words that you do not know. Answer for yourself the question, 'What's this about?' Make sure you understand what is being asked. It is very helpful if you write out the problem in your own words or if you tell a friend what the problem is about.

2. Make a drawing of the problem. Even a poor drawing can be helpful, but for a truly good drawing include the following:

a. Give a title that identifies the quantity you are seeking in the problem or that describes the problem.

b. Label the drawing, including the parameters or variables on which the solution depends and that are given in the problem. Write down the given values of these parameters on the drawing.

c. Label any unknown parameters that must be calculated along the way or obtained from the text in order to find the solution.

d. Always give the units of measure for all quantities in the problem. If the drawing is a graph, be sure to give both the units and the scale of the axes.

e. Include on the drawing information that is assumed and not given in the problem (such as *g*, the value of the acceleration due to gravity), and whether air resistance and friction are neglected.

3. Establish which general principle relates the given parameters to the quantity that you are seeking. Usually your picture will suggest the correct techniques and formulas. At times it may be necessary to obtain further information from your textbook or notes before the proper formulas can be chosen. It often happens that further information is needed when the problem has a solution that must be calculated indirectly from the given information. If further information is needed or if intermediate quantities must be computed, it is here that they are often identified.

4. Draw a second picture that identifies the coordinate system and origin that will be used in relating the data to the equations. In some situations this second picture may be a graph, free body diagram, or vector diagram rather than a picture of a physical situation.

5. Even an expert will often **use the concrete method** of working a problem. In this method you do the calculation using the given values from the start, so that the algebra gives numerical values at each intermediate step on the way to the final solution. The disadvantage of this method is that because of the large number of numerical calculations involved, mistakes are likely, and so you should take special care with significant figures. However this method has the advantage that you can see, at every step of the way, how the problem is progressing. It also is more direct and often makes it easier to locate a mistake if you do make one.

6. As an expert, you will more and more **use the formal method** of working a problem. In this method, you calculate the solution by doing as much as possible without using specific numbers. In other words, do as much of the algebra as you can before substituting the specific given values of the data. In long and complicated problems terms may cancel or expressions simplify. Gain experience in problem solving by substituting the numbers when you start physics, but gradually adopt the formal approach as you become more confident. Many people adopt a compromise approach where

they substitute some values but retain others as symbols (for example, "g" for the acceleration due to gravity).

7. Criticise your solution: Ask yourself, "Does it make sense?" Compare your solution to any available examples or to previous problems you have done. Often you can check yourself by doing an approximate calculation. Many times a calculation error will result in an answer that is obviously wrong. Be sure to check the units of your solution to see that they are appropriate. This examination will develop your physical intuition about the correctness of solutions, and this intuition will be very valuable for later problems and on exams.
An important thing to remember in working physics problems is that by showing all of your work you can much more easily locate and correct mistakes. You will also find it easier to read the problems when you prepare for exams if you show all your work.

8. In the examination, you may have to do problems under a strict time limitation. Therefore, when you are finished with a homework problem, **practise doing it again faster**, in order to build up your speed and your confidence.

When you have completed a problem, you should be able, at some later time, to read the solution and to understand it without referring to the text. You should therefore write up the problem so as to include a description of what is wanted, the principle you have applied, and the steps you have taken. If, when you read your own answer to the problem, you come to a step that you do not understand, then you have either omitted a step that is necessary to the logical development of the solution, or you need to put down more extensive notes in your write-up to remind you of the reasons for each step.

It takes more time to write careful and complete solutions to homework problems. Writing down what you are doing and thinking slows you down, but more important it makes you behave more like an expert. You will be well paid back by the assurance that you are not overlooking essential information. These careful write-ups will provide excellent review material for exam preparation.

EFFECTIVE TEST AND EXAM PREPARATION

If you have followed an active approach to study similar to the one suggested here, your preparation for exams will not be difficult. If you haven't been very active in studying, your preparation will be somewhat harder, but the same principles still apply. Always remember: Physics courses, and therefore physics exams, involve problem solving. Hence, **your approach to studying for exams should stress problem solving.**

Here are some principles:

1. In the week prior to the exam, follow the three steps below. These steps should give you a reasonably good idea of what has been stressed and on what you can expect to be tested.

a. Review your notes and recheck the course outline. Your goal at this point is to make sure you know what has been emphasised.

b. Reread your solutions to the homework problems. Remember that these solutions, if complete, will note underlying principles or laws.

c. Review the assigned chapters. Once again, your purpose in this early stage of exam preparation is to make sure you know what topics or principles have been emphasised.

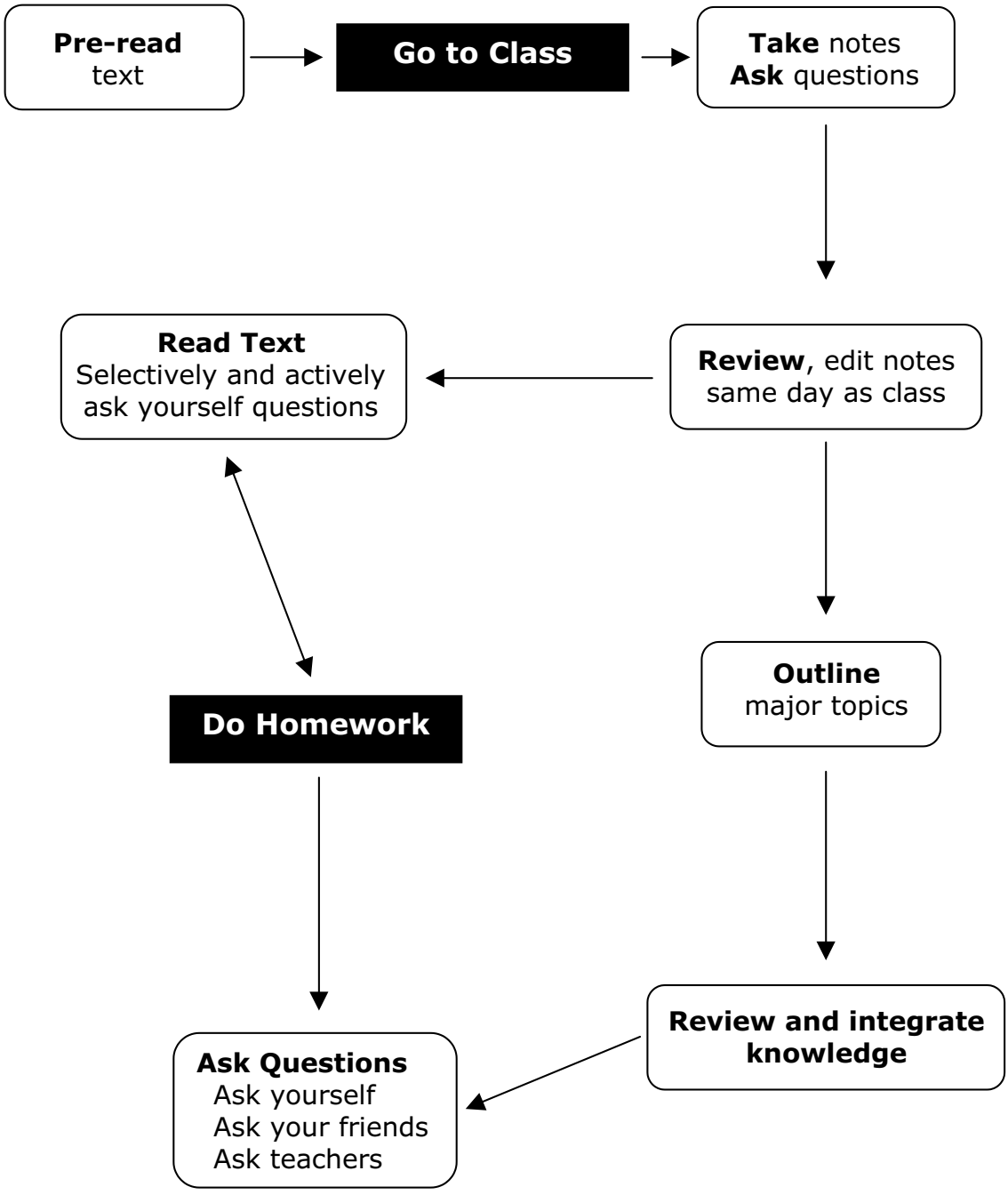
2. From this rapid overview, generate a list of themes, principles, and types of problems that you expect to be covered. If samples of previous exams are available, look them over. But do not assume that only previous types of problems will be included.

3. Review actively. Don't be satisfied with simple recognition of a principle. Aim for actual knowledge that you will be able to recall and to use in a test situation. Try to look at all the possible ways that a principle can be applied.

4. Effective examination preparation involves an interaction among homework problems, the classes, your notes and the text. Review actively. Include self-tests in which you create your own problems that use a combination of principles. You need to be sure that you can work problems without referring to your notes or to the textbook. Practise doing problems using both the concrete and the formal approaches to see which you are more comfortable with.

5. Remember that exams will include a variety of different problems. You want to look back on an exam and say, "I know how to do friction problems so well, that even though they were asked in a weird way, I could recognise them and solve them."

WEEKLY FLOW CHART FOR STUDYING PHYSICS



Sāmoa Physics Curriculum
Achievement Objectives
Years 12 and 13

SAMOA PHYSICS CURRICULUM YEAR 12

ACHIEVEMENT OBJECTIVES

Bold numbers refer to pages in the Year 12 Physics textbook: ***Physics for You***, Keith Johnson: Nelson Thornes (London). 2001 edition.

S T R A N D 1: M E A S U R E M E N T

AIM: From their study of MEASUREMENT students win understand **units for measurement**.

Students win investigate and develop their scientific understanding of:
Mass, length, time and volume when they:

- **Identify and use** the appropriate units for mass, length, time and volume. **7, 83**
- **Carry out investigations** involving the use of appropriate instruments to measure mass, length, time, e.g., *ruler; vernier scale, micrometers, stop-watches.*

SI Units, prefixes and standard form when they:

- **Identify and use** the names and symbols of different SI units. **7**
- **Write and transform** numbers using prefixes and standard form. **7**

AIM: from their study of MEASUREMENT students win understand **quantities**.

Students win investigate and develop their scientific understanding of:
Calculating quantities and finding unknowns when they:

- **Use** raw data to calculate quantities e.g. *density* **82,**
- **Apply** a variety of methods to find unknowns e,g. *formulae, graphical methods.* **390-391**

Scalar and vector quantities when they:

- **Compare and contrast** scalar and vector quantities. e.g., mass, weight, speed, velocity. **96**
- **Use** scalar and vector quantities appropriately in the description of physics concepts. **96**

Aim: From their study of MEASUREMENT students win understand the principles of graphs.

Students win investigate and develop their scientific understanding of:
Graphing, interpolation and extrapolation when they:

- Plot or sketch graphs appropriate to the data and the purpose. e.g., line graphs, appropriate axes, labelling. **130, 390**
- Use interpolation and extrapolation to estimate points on graphs.
- Describe the reliability of information gained from interpolation and extrapolation of graphs.

STRAND 2: MECHANICS

AIM: From their study of MECHANICS students win understand **kinematics**.

Students will investigate and develop their scientific understanding of:
Displacement, velocity and acceleration when they:

- **Carry out** an investigation to measure distance and time using a variety of instruments in simple situations *e.g., people running, cycling* **134**
- **Plot graphs**: displacement vs time, velocity vs time, and acceleration vs time **132-134**
- **Interpret graphs** by relating slope to the variables *e.g., velocity vs time- acceleration, constant acceleration, stopped.* **134**
- **Use formulae and graphical methods** to find unknowns. *e.g. displacement, velocity, acceleration.* **135**
- **Describe** examples of the application of ideas relating to displacement, velocity and acceleration. *e.g. safe stopping distances while driving, speed limits, crash helmets.* **142-143**

AIM: From their study of MECHANICS students will understand **dynamics**.

Students will investigate and develop their scientific understanding of:
Forces when they:

- **Identify** common forces and their effects. *e.g, gravitational, magnetic, electric, frictional.* **73, 92, 93, 122, 247, 292**
- **Carry out** an investigation into the effect of balanced and unbalanced forces on the straight-line motion of an object. **95-96, 99, 136**
- **Use** formulae, graphical methods and force diagrams to calculate the resultant force on objects. **96**
- **Describe** the effects of balanced and unbalanced forces on the motion of an object. *e.g., a plane taking off and in horizontal flight, a rugby ball being kicked, carrying a baby in a basket.* **99**
- **Carry out** an investigation into friction. **92-93**
- **Explain** the application of ideas relating to friction. *e.g., why is it easier to slip on smooth surfaces like Papaseea Sliding Rocks, than on a gravel road?* **92-93**

AIM: From their study of MECHANICS students will understand **parallel forces**.

Students will investigate and develop their scientific understanding of:
Simple machines when they:

- **Carry out** an investigation into the involvement of moments in simple machines. *e.g., levers, beams.* **122- 127**
- **Calculate** the efficiency of simple machines. *e.g., pulley systems, levers, beams.***123-7**
- Explain the principles of simple machines. *e.g., moving a large load with small effort, moving a small load a large distance, applying a force in a difficult place.* **123**
- **Carry out** an investigation into torque. (**26,** Year 13 book)
- **Describe** applications involving movement in couples and torques. (**26-27**, year 13 book)
- **Use** formulae and vector methods to seek solutions to a variety of problems. **96**

AIM: From their study of MECHANICS students will understand **pressure**.

Students will investigate and develop their scientific understanding of:
Pressure and density when they:

- Carry out an investigation into the measurement of pressure and density. *e.g., variation of pressure in a liquid with change in depth.* **85-90**
- Explain applications of Archimedes Principles of Flotation. *e.g., why steel ships float.* **87**

AIM: From their study of MECHANICS students will understand **energy, work and power**.

Students will investigate and develop their scientific understanding of:

Energy when they:

- Carry out an investigation into factors that affect the amount of potential and kinetic energy an object has. **108, 116-117**
- Describe the concepts of potential energy and kinetic energy and how one can be converted into the other. **108**
- Describe and identify examples of energy conservation principles. *e.g., energy cannot be destroyed only changed in form.* **108**
- Apply formulae to find unknowns in a variety of problems. e.g., $E_p = m \times g \times h$,

  $KE = \frac{1}{2} mv^2$ **116-117**

Work and power when they:

- Carry out an investigation into work and power. *e.g., measuring the lifting rate of model cranes.* **118**
- Apply formulae to find unknowns in a variety of problems. W = Fd P = W/t. **118**

STRAND 3: HEAT
From their study of HEAT students will understand **heat** and **temperature**.

Students will investigate and develop their scientific understanding of:

Heat transfer and its importance to people when they:

- **Carry out an investigation** into the transfer of heat through conduction, convection and radiation. **42**
- **Describe** how conductors and insulators influence the rate of heat transfer. **44**
- **Explain** how the transfer of heat by conduction, convection and radiation occurs or is reduced in simple applications *e.g., gas stove, radiator; coil element, refrigerator; chilly bin, Thermos flask.* **42, 51**
- **Interpret information** in cooling and heating curves in terms of latent heat and changes of state. **55-60**
- **Explain** the difference between heat and temperature. **28**

Temperature scales when they:

- **Gather, process and present** information about temperature scales and the construction and use of thermometers. *e.g.,, mercury, alcohol, thermocouples, gas.* **28-29**
- **Explain** the use of the concept of absolute zero and absolute temperature in fixing temperature scales. **29**

Specific heat and its importance to people when they:

- **Carry out an investigation** into the specific heat capacities of different substances using calorimeters or mixtures method *e.g., water; iron, copper; alloy.* **39-40**
- **Explain** applications of differences in specific heat capacity in everyday situations *e.g., land and sea breezes, water cooling of engines, cooking utensils.* **39, 47**

The expansion of materials when they:

- **Carry out an investigation** into the expansion of gases, liquids or solids. **21-32**
- **Describe** the behaviour of particles in the expansion of solids, liquids and gases. **26**
- **Explain** applications of expansion in everyday situations e.g., telephone lines, a bottle of water in the freezer. **21-23**

S T R A N D 4: M A G N E T I S M

From their study of MAGNETISM students will understand **properties of magnets**.

Students will investigate and develop their scientific understanding of:

Magnets and their properties when they:

- **Carry out an investigation** using a freely suspended magnet to investigate the interaction of magnetic fields. **284**
- **Explain** why like poles repel and unlike poles attract. **284**

Magnetic and non-magnetic materials when they:

- **Compare** the properties of magnetic and non-magnetic materials e.g., soft iron, steel, alloys (alnico). **289**
- **Carry out an investigation** into the making of a permanent magnet. **285**
- **Describe** methods of making permanent magnets e.g., single stroke method, divided stroke method, electromagnetic method. **285**
- **Explain** how materials can be magnetised and demagnetised. **285**
- **Identify** precautions to prevent magnets from being de-magnetised.

From their study of MAGNETISM students will understand **magnetic fields** and **field lines**.

Students will investigate and develop their scientific understanding of:

Shape and direction of magnetic fields when they:

- **Draw** diagrams of magnetic fields around a bar magnet, horseshoe magnet and iron ring. **287**
- **Carry out an investigation** on the magnetic fields around two bar magnets placed parallel to each other.
- **Explain** the shapes of interacting magnetic fields in terms of repulsion and attraction. **287**

Geomagnetism when they:

- **Identify** and describe the earth as a magnet and polarity of the equivalent magnet. **287**
- **Explain** how the magnetic field of the earth is not always parallel to the earth's surface. **287**

From their study of MAGNETISM students will understand **electromagnets**.

Students will investigate and develop their scientific understanding of:

Properties and uses of electromagnets when they:

- **Carry out an investigation** into making an electromagnet. **285**
- **Identify** the poles of the electromagnet. **294**
- **Describe** examples of electromagnets and temporary magnets. **290**, **294**

From their study of MAGNETISM students will understand **magnetic induction**.

Students will investigate and develop their scientific understanding of:

Properties of magnetic induction when they

- **Carry out an investigation** on induction using a magnet placed near an iron nail i.e. when it is in contact and not in contact. **288**
- **Explain** the effect of the earth's magnetic field on iron objects e.g., railings, flagpole.

S T R A N D 5: ELECTRICITY

From their study of ELECTRICITY students will understand **electrostatics**.

Students will investigate and develop their scientific understanding of:

Forces between charges when they:

- **Carry out investigations** into the:
  - Transfer of electrons and charging a rod by friction or rubbing. **248**
  - Identification of charged and uncharged bodies or conductors and insulators using the electroscope. **249**
  - Charging materials by conduction and by induction. **249-50**
- **Apply** knowledge of atomic structure and positive and negative charges to explain examples of electrostatics. **248**
- **Explain** the characteristics of charged bodies (attraction and repulsion) and the distribution of a charge on a conductor. **248**
- **Describe** examples and applications of electrostatics *e.g., lightning conductors, atmospheric electric charges, electrostatic screening.* **252**

From their study of ELECTRICITY students will understand **electric fields**.

Students will investigate and develop their scientific understanding of:

The shape and direction of electric fields when they:

- **Carry out an investigation** into the shape and direction of the electric field between two parallel charged plates and around point charges. **250**
- **Explain** how charge is stored in electric capacitors. **251**

From their study of ELECTRICITY students will understand **current electricity**.

Students will investigate and develop their scientific understanding of:

Current electric1ty when they:

- **Investigate** the storage of electrical energy using different types of cells *e.g., dry cell, lead-acid cell.* **266**
- **Carry out an investigation** into potential difference and flow of charge through a conductor. **258**
- **Carry out an investigation** into a factor affecting resistance *e.g., length, temperature.* **260**
- **Define** terms and their units: voltage, current and resistance. **258, 256, 259**
- **Interpret** information on voltage, current and resistance in a circuit. **265**
- **Use** Ohm's Law to calculate voltage (V), current (I) and resistance (R). **259**

From their study of ELECTRICITY students will understand **electrical circuits**.

Students will investigate and develop their scientific understanding of:

Properties of electrical circuits when they:

- **Draw and interpret** circuit diagrams containing a range of components in series and parallel connections. *e.g., power supply, cells, switches, resistors, meters, LEDs.* **254**
- **Carry out an investigation** into parallel and series connections of electrical components in a circuit. **256-7**
- **Apply** formulae of resistance in series and parallel to calculate unknowns in simple examples. $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} ..... \frac{1}{R_n}$, $R_T = R_1 + R_2 ..... R_n$ **262-263**
- **Apply** formulae for power to calculate unknowns in simple examples. P = VI. **272**

From their study of ELECTRICITY students will understand **electromagnetism**.

Students will investigate and develop their scientific understanding of:

The magnetic effect of electric current when they:

- **Carry out an investigation** into the magnetic effect around a conductor *e.g., straight wire, circular coil, solenoid.* **292-3**
- **Draw or describe** the magnetic field lines around a conductor: straight wire, circular coil and a solenoid. **292-3**

- **Explain** the practical application and working principles of examples of electromagnetism *e.g., magnetic relay, electric bell, telephone, microphone, moving iron ammeter.* **294-5**

The motor effect when they:

- **Carry out an investigation** into the effect of a magnetic field on a wire carrying a current. **296**
- **Describe** applications of the motor effect. *e.g., turning force on a rectangular coil kept in a uniform magnetic field, field, moving coil meter; D.C. electric motor, moving coil loud speakers, force between two parallel conductors carrying current.* **298**

Electromagnetic induction when they:

- **Carry out an investigation** into the production of a current through electromagnetic induction *e.g., a magnet moving into a coil, moving a coil towards a magnet.* **303**
- **Describe** how factors affect the amount of current formed in electromagnetic induction. *e.g., speed of movement, strength of magnet, number of turns on a coil.* **303**
- **Explain** the practical application and working principles of examples of electromagnetism *e.g., bicycle dynamo, induction through a primary and secondary coil, ignition coil in a car.* **312-313**
- **Describe** how a transformer works. **308**

From their study of ELECTRICITY students will understand **electrochemistry (chemical effect)**

Students will investigate and develop their scientific understanding of:

Electrolysis when they:

- **Carry out an investigation** into electrolysis *e.g., water, copper sulfate solution.*
- **Describe** the process of electrolysis. **277-9**
- **Outline** the process of electroplating of copper and other metals. **279**

STRAND 6: WAVES

From their study of WAVES students will understand **types of waves**.

Students will investigate and develop their scientific understanding of:

Waves when they:

- **Carry out investigations** into the propagation of longitudinal and transverse waves *e.g., slinky, sea, ripple tank.* **174-5**
- **Describe** waves in terms of frequency (f), wave length (λ), period (T), velocity (v), amplitude (A). **175**
- **Apply** formula to determine speed of waves. **175**
- **Compare** and contrast the nature of light and sound. **177**

From their study of WAVES students will understand **sound**.

Students will investigate and develop their scientific understanding of:

Sound when they:

- **Describe** how the ear acts as a receiver. **232**
- **Describe** the speed of sound in different mediums *e.g., air, water*. **229**
- **Explain** the pitch of sound and its relationship to frequency. *e.g., glasses with different volumes of water.* **234**
- **Investigate** applications of reflection of sound. *e.g., echoes, scanners.* **240**

From their study of WAVES students will understand **light.**

Students will investigate and develop their scientific understanding of:

Propagation of light when they:

- **Interpret** evidence of rectilinear propagation of light. *e.g., shadows, eclipses, pin hole camera.* **179-82**

The reflection of light when they:

- **Carry out an investigation** into reflection of light. **184**
- **Use** ray diagrams to describe images. *e.g., size, position, type* formed in different types of mirrors *e.g., plane, concave, convex.* **186, 189**
- **Explain** the formation of real and virtual images. **190-91**

The refraction of light when they:

- **Carry out an investigation** into refraction of light. **192**
- **Use** ray diagrams to describe images. e.g., *size, position, type* formed in different types of lenses. *e.g., plane, concave, convex.* **202**
- **Explain** the formation of real and virtual images. **203**
- **Investigate** applications of refraction. e.g., microscope, eyes, camera. **206**
- **Investigate** defects of the eyes and their corrections. **208**

Tlie dispersion of light when they:

- **Carry out an investigation** into dispersion of light by prisms. **217**
- **Explain** the dispersion of light to form rainbows. **216**

SAMOA PHYSICS CURRICULUM YEAR 13

ACHIEVEMENT OBJECTIVES

Bold numbers refer to pages in the Year 13 Physics text book: ***Advanced Physics for You***, Keith Johnson, Simmone Hewett, Sue Holt and John Miller: Nelson Thornes (London). 2000 edition.

STRAND 1: MEASUREMENT

From their study of MEASUREMENT students will understand physical quantities.

Students will investigate and develop their scientific understanding of:

Measurement and the metric system when they:

- **Recognise** SI units and their symbols. **6-7**
- **Express** numbers in scientific notation. **401**
- **Recognize** that all measurements have experimental uncertainty. **398-399**
- **Complete** calculations using SI units. **7**
- **Give** calculation results to the appropriate number of significant figures. **400**

From their study of MEASUREMENT students will understand graphical representation.

Students will investigate and develop their scientific understanding of:

Drawing and interpreting graphs when they:

- **Construct** line graphs following standard conventions. **404**
- **Plot** data on a graph grid and draw a best-fit line. **396**
- **Calculate** the slope (gradient) of a straight-line graph. **404**
- **Analyse** straight-line graphs using the equation: $y = mx + c$. **405**
- **Use** the process of interpolation and extrapolation to gain further information.

From their study of MEASUREMENT students will understand the use of mathematics in physics.

Students will investigate and develop their scientific understanding of:

Calculating and problem solving when they:

- **Identify** the accuracy with which a measurement is made. **397 -398**
- **Calculate** a result to the appropriate number of significant figures. **400**
- **Use** the rules of algebra when working with formulae. **407**
- **Show** clear and correct working when solving problems. **407**
- **Use** a scientific calculator effectively. **401**, **407**

STRAND 2: WAVES

From their study of WAVES students will understand the nature of light.

Students will investigate and develop their scientific understanding of:

The propagation of light when they:

- **Explain** the production of shadows in terms of rectilinear propagation.

The reflection of light when they:

- **Construct** ray diagrams which locate images produced by plane and curved mirrors. (**189,** Year 12 book**)**
- **Use** the relationship: $S_iS_o = f^2$ or $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$. to calculate the position of an image. **135**
- **Distinguish** between real and virtual images in concave mirrors. (**190**, Year 12 book)
- **Recognize** and apply the terms lateral inversion, pole, focus, focal length and radius of curvature. (**189 – 190**, Year 12 book)
- **Compare** and contrast the properties of concave and convex mirrors.

The refraction of light when they:

- **State** that a light ray will tend towards the normal as it enters an optically denser material. **127**
- **Plot** a graph of sin θ_i against sin θ_r and interpret the gradient as the relative refractive index for the two materials. **129**
- **Solve** problems that involve using the relationship: $n_1\sin\theta_1 = n_2\sin\theta_2$ **127**
- **Observe** the partial reflection that occurs as light rays are mainly refracted at the boundary between two media of differing optical densities. **130**
- **Observe** the condition of critical angle within an optically denser medium when a ray meets the boundary with an optically less dense medium. **130**
- **Realise** that when θ_1 is the critical angle, then θ_2 is 90^o. **130**
- **Calculate** the critical angle for a given pair of substances and describe total internal reflection. **130**
- **Use** and draw ray diagrams to determine the position of images formed by single converging or diverging lenses. **134-135**
- **Use** one of the lens relationships to determine the position of images:
- $S_iS_o = f^2$ or $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ **135**
- **Distinguish** between real and virtual images formed by converging lenses. **134-135**
- **Compare** and contrast the properties of converging and diverging lenses. **133**
- **Determine** magnification of images from:
- $M=\frac{u}{v}$ or $M=\frac{h_i}{h_o}$ **135**

From their study of WAVES students will understand the nature of waves.

Students will investigate and develop their scientific understanding of:

Wave properties and their propagation when they:

- **Realize** that waves carry energy from one position to another. **116**
- **Understand** and demonstrate the difference between longitudinal and transverse waves. **118**
- **Describe** the ideas of amplitude, wavelength and frequency. **115-116**
- **Establish** and use the relationship $v = f\lambda$. **115**
- **Illustrate** the propagation of waves in water. **113**
- **Realise** that the wave front is perpendicular to the direction of travel. **113**
- **Understand** that the average displacement of vibrating particles involved in wave progress is zero.
- **Associate** differing speeds of sound propagation with qualities of the transporting medium. (**229,** Year 12 book)

From their study of WAVES students will understand Wave Theory.

Students will investigate and develop their scientific understanding of:

Phenomena in terms of Wave Theory when they:

- **Reveal** an understanding of reflection and refraction portrayed by the effect of boundaries on incident wave fronts. **126**
- **Demonstrate** dispersion of different frequencies present in white light. (**216-217**, Year 12 Book)
- **Recall** that refraction is greatest in the higher frequency ranges; blue light bends more than red light. **(217 Year 12 book)**
- **Discuss** the failure of the corpuscular light model. **(370 Year 12 book)**
- **Discuss** the wave light model. **(370 Year 12 book)**
- **Discuss** the photon light model. **166**
- **Understand** the dual nature of light. (**370**, Year 12 book)

The phenomena of Diffraction and Interference when they:

- **Use** the superposition principle to draw the resultant shape when two waves or pulses are wholly or partly superimposed. **140**
- **Predict** situations in which diffraction is likely to occur. **144**
- **Predict** what will happen when two diffraction patterns overlap. **146**
- **Know** the value of interference patterns as support for the wave model. **149**
- **Recognize** double slit arrangements from which wavelengths may be estimated. **151**
- **Use** the relationships:
- $\lambda = \frac{d\Delta x}{L}$ and $\left(n - \frac{1}{2}\right)\lambda = d\sin\theta$. **149**
- **Understand** the term *coherent* as applied to a light source. **149**
- **Understand** the importance of path difference from two sources to a point under consideration in determining the cancellation or reinforcement of light waves (nodal or antinodal quality). **148**

STRAND 3: MECHANICS

From their study of MECHANICS students will understand kinematics.

Students will investigate and develop their scientific understanding of:

Kinematics with graphical representation and equation relationships when they:

- **Understand** the concepts of displacement, velocity and acceleration. **32-33**
- **Draw** and interpret displacement-time and velocity-time graphs. **34-35**
- **Interpret** and determine the gradient of both s – t and v – t graphs. **34**
- **Establish** that the area under a v – t graph represents displacement. **35**
- **Interpret** correctly the meaning of negative values attributed to displacements and velocities. **34**
- **Use** the kinematic equations for solving problems. **36**
- **Determine** an average velocity over a particular time period. **32**
- **Understand** the difference between an *instantaneous velocity* and an *average velocity*. **32**

From their study of MECHANICS students will understand vectors.

Students will investigate and develop their scientific understanding of:

Vector addition, subtraction and resolution when they:

- **Distinguish** between scalar and vector quantities. **10**
- **Understand** the importance of the direction property of a vector. **10**
- **Represent** vectors by scaled lines. **10**
- **Represent** vectors numerically.
- **Add** vectors to get a resultant. **11**
- **Subtract** vectors to get a resultant. **11**
- **Resolve** single vectors into two components at right angles to each other by construction. **12**
- **Resolve** by trigonometry. **14**
- **Interpret** vector diagrams. **10-14**
- **Determine** a change value in a vector during a particular period. **13**

From their study of MECHANICS students will understand dynamics.

Students will investigate and develop their scientific understanding of:

Forces when they:

- **Understand** that force **is not** a general prerequisite for continuing motion. **44**
- **Understand** that the F in the relationship F = ma is a **net** force applied to a body. **46-47**
- **Experimentally** verify F = ma. **47**
- **Calculate** a resultant or unbalanced force. **11**
- **Solve** problems involving F= ma. **47**
- **Calculate** the torque of a force, but only in the perpendicular case. **26**
- **Solve** problems where torques act in opposition, and where equilibrium is established. **27**

- **Interpret** " *m* " as the gradient of a force versus acceleration graph.
- **Define** the newton in terms of the acceleration given to a unit mass. **16**
- **Apply** vector qualities to forces. **11**

From their study of MECHANICS students will understand momentum.

Students will investigate and develop their scientific understanding of:

Moving bodies when they:

- **Calculate** the momentum of an object. **46**
- **Realize** that momentum is a vector quantity and hence calculate the total momentum of two objects.
- **Recognize** that in a collision or explosion momentum is conserved. **54**
- **Calculate** the change in momentum of an object owing to an external force. **54**
- **Solve** problems involving conservation of momentum in two dimensions. **55**
- **Recognize** that it is the velocity which gives the vector quality to momentum. **46**

From their study of MECHANICS students will understand acceleration.

Students will investigate and develop their scientific understanding of:

Acceleration in gravitational fields when they:

- **Recognize** that the acceleration of an object in free vertical fall is constant. **38**
- **Recognize** that all objects dropped in the same gravitational field experience the same acceleration. **38**
- **Recognize** that the force of gravity on an object is proportional to its mass, i.e. F = mg. **16**
- **Understand** that the weight of an object depends upon the gravitational field in which it is situated. **16**

From their study of MECHANICS students will understand projectile motion.

Students will investigate and develop their scientific understanding of:

The kinematics of projectiles when they:

- **Describe** the motion of an object which moves horizontally into a vertical force field. **40**
- **State** that in the above case:
  a. The horizontal component of velocity remains constant. **40**
  b. The vertical component of velocity increases or decreases uniformly with time. **40**
- **Sketch** the path of an object travelling through a gravitational field. **40**
- **Calculate** vertical and horizontal displacement or velocity. **41**
- **Use** the kinematic equations to solve projectile problems. **41**

From their study of MECHANICS students will understand motion in a circular path.

Students will investigate and develop their scientific understanding of:

Circular motion when they:

- **Understand** that an object travelling in a path along the circumference of a circle, is accelerating despite the fact that the speed may be constant **72**
- **Use** the relationship: $a = \frac{v^2}{r}$. and state that this represents a centripetal acceleration, with *v* as the instantaneous velocity perpendicular to the acceleration. **72**
- **State** that the direction of the **net** centripetal force needed to keep an object in uniform circular motion is towards the centre of that motion. **72**
- **Solve** problems involving objects in circular motion. **75**
- **Discuss** the use of the universal law of gravitation, and realize that it is an inverse square law. **78**
- **Understand** that the centripetal force maintaining the circular motion of planets and satellites is a force of gravitational attraction. **69**

From their study of MECHANICS students will understand energy.

Students will investigate and develop their scientific understanding of:

Work done and power when they:

- **Calculate** the work done using: W = Fs. **60**
- **Determine** the component of the force which is in the direction of movement and thus contributing to the work done. **60**
- **Recognise** that the area under a force-displacement graph identifies the work done. **60**
- **Determine** power attributes relating to work activity and machines. **61**

Kinetic energy and potential energy when they:

- **Calculate** kinetic energy using: $E_k = \frac{1}{2}mv^2$. **62**
- **Calculate** gravitational potential energy using: $E_p = mgh$. **62**
- **Draw** a graph of force versus extension in a spring and recognize the gradient to be the spring force constant, *k*, i.e. F = kx. **282**
- **Calculate** spring potential energy. **283**
- **Recognize** that when work is done on a body, energy is transferred to that body. **60**
- **Understand** the term *elastic collision* during which there is a conservation of kinetic energy. **66**

Heat energy when they:

- **Describe** the requirement of energy change, described as *latent heat*, in order to produce a change of state. **300-301**
- **Recognize** that no temperature change is associated with a change of state. **301**
- **Interpret** temperature-time graphs for substances either gaining or losing energy at a steady rate.**300**
- **Use** the relationship $h_L = mL$ and solve problems relating to energy supply and change of state. **301**

- **Use** the relationship $h = mc\Delta L$ and solve problems involving the energy required to change the temperature of a particular substance. **303**
- **Determine** specific heat capacity from information yielded by temperature-time graphs where energy change is at a steady rate. **302**
- **Solve** problems involving the interchange of energy between energy manifestations where the sum is conserved.

From their study of MECHANICS students will understand pressure of gases.

Students will investigate and develop their scientific understanding of:

Pressure and its relationship with the volume and temperature of gases when they:

- **Recognise** and use the Pascal unit. **20**
- **Recognise** that the forces producing the pressure of a contained gas come from the collisions of moving gas molecules. **313**
- **Establish** and know that the pressure of a gas is inversely proportional to its volume, with temperature held constant. **314**
- **Establish** and know that the pressure of a gas varies directly with **absolute** temperature, with volume held constant. **317**
- **Recognise** and use the combined relationship: $PV = nRT$ **318**
- **Convert** Celsius to Kelvin and vice versa. **299**
- **Realise** that temperature is a measure of the average kinetic energy of the particles of a gas. **296**

STRAND 4: ELECTRICITY AND ELECTROMAGNETISM

From their study of ELECTRICITY AND ELECTROMAGNETISM students will understand electrical principles.

Students will investigate and develop their scientific understanding of:

Electrical principals relating to simple DC circuitry when they:

- **Know** that current results from movement of charge, Qt^{-1}, in an electric field. **192**
- **Recognize** electrons as the conveyors (carriers) of charge. **192**
- **Distinguish** between the directions of conventional current and electron flow. **191**
- **Know** the qualities that make materials good or bad conductors. **191**
- **Interpret** resistances as materials opposing charge movement, and receiving energy from passing charge. **196-197**
- **Identify** the influence of temperature on resistance wires. **199**
- **State** that charge flows from higher to lower potentials. **194**
- **Draw** a graph of potential difference across, versus current through, a conductor, and interpret the gradient. **198**
- **Use** Ohm's law $V = IR$ in calculations. **196**
- **Know** that the e.m.f. of a battery is the amount of energy it supplies to each unit of charge, EQ^{-1}. **212**
- **Recognize** that charge and hence current is conserved at all points in a circuit. **206**

- **Calculate** resistance of series and parallel combinations. **208-209**
- **Calculate** potential differences between points in a circuit. **207**

From their study of ELECTRICITY AND ELECTROMAGNETISM students will understand electrical energy transfer.

Students will investigate and develop their scientific understanding of:

Energy transfer in electrical circuits when they:

- **Understand** the concept of power as energy per unit time in an electrical context, $P = \dot{E}t^{-1}$ **200**
- **Interpret** the power ratings given to appliances. **201**
- **Calculate** the power output of a resistance using: $P = I^2R$. **200**
- **Calculate** the amount of energy carried by a current. **195**
- **Calculate** the energy dissipated as heat in a resistor.

From their study of ELECTRICITY AND ELECTROMAGNETISM students will understand the motor effect.

Students will investigate and develop their scientific understanding of:

Charges, conductors and magnetic fields leading to the motor effect when they:

- **Know** that a current-carrying conductor placed in a magnetic field experiences a force. **220**
- **Recall** that the magnetic force is perpendicular to the current and the field, as demonstrated by the right hand rule. **220**
- **Determine** the direction of the force on a current-carrying conductor when it is in a magnetic field. **224-228**
- **Apply** the principles of magnetic force to explain and predict the turning effect on a coil conductor mounted in a magnetic field. **239**
- **Describe** the principle of the electric motor and explain how continuous rotation of the coil is achieved. **239**
- **Describe** the moving coil galvanometer and the way it is adapted to offer a reading related to current size. **233**

From their study of ELECTRICITY AND ELECTROMAGNETISM students will understand magnetic fields.

Students will investigate and develop their scientific understanding of:

Magnetic fields surrounding current-carrying conductors when they:

- **Draw** the magnetic field around a single long current-carrying wire. **220**
- **Recognize** and use the normal symbols that describe the direction of conventional currents and magnetic fields, into or out of the page. **220**
- **Draw** the magnetic field associated with two parallel long wires carrying currents and determine whether the force between the conductors is one of attraction or one of repulsion. **228**
- **Apply** the relationship: $B = \frac{kI}{d}$ appropriately, and recognize *k* as being a constant. **222**
- **Apply** the relationship: $F = \frac{kI_1I_2L}{d}$. in order to determine the force on a length of conductor. **228**

From their study of ELECTRICITY AND ELECTROMAGNETISM students will understand electromagnetic induction.

Students will investigate and develop their scientific understanding of:

Electromagnetic induction when they:

- **State** the conditions that are necessary to induce a voltage in a straight conductor or a coil. **232**
- **Predict** the effect of changing:
- Magnetic field strength. **233**
- Direction of field, **233**
- Rate of cutting through the magnetic field, *b* , **233**
- Direction of moving through the magnetic field, *b.* **233**
- **Understand** that Lenz's law predicts a conservation of energy. **238**
- **Understand** and apply the relationship: V= Blv.
- **Understand** that the induced current arises because of the magnetic force experienced by the electrons in the conductor. **232**
- **Know** that the induced current itself produces a magnetic field. **220**
- **Recognize** that as a conductor is pushed through a magnetic field, an opposing force develops as a result of the induced current. **238**
- **Relate** the induced voltage in the secondary coil to the developing field around the primary coil. **234**
- **Relate** the design of a transformer to induction in the secondary coil. **234, 236**
- **Understand** why commercial transformers cannot operate on dc supply. **246**

From their study of ELECTRICITY AND ELECTROMAGNETISM students will understand electrostatics.

Students will investigate and develop their scientific understanding of:

Characteristics of electrical charge when they:

- **Know** the unit of charge as the coulomb. **192**
- **Represent** diagrammatically the electric field that surrounds a positive and a negative charge. **256**
- **Draw** the electric fields between like charges and between unlike charges. **254**
- **Identify** the role that friction can play in the transfer of charge. **253**
- **Realise** that a charged object holds an imbalance of charge. **252**
- **Describe** the transfer of charge by rubbing. **253**

Behaviour of materials relating to charge when they:

- **Know** that different materials have a natural tendency either to gain or to lose electrons. **252**
- **Determine** whether two charged materials will attract or repel depending upon the charge type held. **252**
- **Know** the behavioural differences between conductors and insulators. **191**
- **Know** that the earth is a conductor of charge. **258**
- **Know** that charged bodies discharge quickly in humid or salty conditions.

Coulomb's Law for charge when they:

- **Apply** Coulomb's law to simple charge situations. **254**
- **Know** that the electric force between two charges is proportional to the product of the charges. **254**
- **Know** that the electric force varies inversely as the square of the distance between the charges. **254**
- **Identify** the similarity between Newton's relationship for gravitation and that of Coulomb for electrical charge. **255**

Characteristics of electrical fields when they:

- **Understand** the concept of an electric field. **256**
- **Draw** the shape of an electric field between two parallel plates. **257**
- **Use** the concept of electric field lines. **257**
- **Know** the convention that establishes the direction of an electric field at a point. **256**
- **Know** that the spacing of field lines is an indication of field strength.
- **Know** that field lines begin or end with charged particles. **256-257**
- **Know** that the strength of an electric field is given by: $E = \frac{F}{Q}$. **256**
- **Realise** that the *e* field is a vector. **256**
- **Use** the relationship: $E = \frac{kQ}{r^2}$ determine the field strength due to a charge. **257**
- **Find** the combined influence of two charges at a point by finding the vector sum at the point. **256**

Energy and potential energy in electrical fields when they:

- **Determine** the work done on a charge in moving it through an electric field
- W = EQd or W = QV. **258**
- **Understand** that as a positive charge is moved against the field direction, it gains potential energy, which is stored in the field. **258**
- **Understand** that there is a property associated with the field described as the electrical potential difference. **258**
- **Use** the relationship: V = Ed determine the potential difference between two points in a field. **257**

STRAND 5: NUCLEAR PHYSICS

From their study of NUCLEAR PHYSICS students will understand the atom and radioactivity.

Students will investigate and develop their scientific understanding of:

Rutherford and the atom when they:

- **Give** a brief description of the Rutherford model of the atom. **329**
- **Describe** the causes of deflection of alpha particles fired at a thin metallic film. **329**
- **Know** that deflection observations confirmed the presence of the dense nucleus. **329**
- **Describe** the atom in terms of the nuclear bound protons and neutrons, and the electrons at varying energy levels in space around the nucleus. **330**

Photoelectric effects and consequences when they:

- **Describe** the photoelectric effect. **165-166**
- **Recognise** the support provided by the photoelectric phenomenon for a particle explanation of light. **166**
- **Use** the term photon. **166**
- **Recognise** that the frequency of a photon determines its associated energy. **167**
- **Use** the relationship: E = hf. **167**
- **Understand** the idea that different materials require different energy amounts to remove electrons away from the surface. **168**
- **Understand** that both emitted photoelectrons and incoming photons possess momentum and that there is overall momentum conservation. **169**

Isotopes and radioactivity when they:

- **Understand** the term isotope, and distinguish between isotopes of an element in terms of its neutrons, with reference to mass number, A, and atomic number, Z, with ${}^{A}_{Z}X$ for element X . **331**
- **Understand** that radioactivity involves the emission of particles or electromagnetic waves. **332**
- **Describe** alpha and beta particles, $\alpha = {}^{4}_{2}He$, $\beta = {}^{0}_{1}e$. **334-335**
- **Describe** the characteristics of gamma rays, g. **334-335**
- **Recognise** and use the symbols for alpha and beta particles, protons, neutrons and electrons. **334-335** and **330-331**
- **Determine** the paths of alpha and beta particles, and neutrons travelling through a magnetic field of given direction. **334**

- **Compare** the penetrating distances of alpha, beta particles and gamma rays. **335**
- **Understand** the concept of half life. **343**
- **Determine** the half life of a substance given its decay curve. **343**
- **Determine** the particle emission during radio-active decay by applying conservation rules. **341-343**

Radioactivity influences when they:

- **Know** that atomic radiation influences the structure of chemicals in living tissue. **336**
- **Describe** the ways in which atomic radiation can be a valuable servant in medicine. **344**
- **Describe** the ways in which radiation can cause serious damage to organisms. **336**
- **Describe** the precautions adopted in nuclear power generation plants and hospitals where radiation equipment is used. **354-356**
- **Understand** the strong arguments for caution in the increased use of atomic energy.
- **Understand** the reasons for the ‘Nuclear Free Pacific” policy and the counter arguments.