The Australian
Curriculum

Subjects	Physics
Units	Unit 1, Unit 2, Unit 3 and Unit 4
Curriculum version	Version 8.3
Dated	Friday, 16 December 2016

AUSTRALIAN CURRICULUM, ASSESSMENT AND REPORTING AUTHORITY

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The Australian Curriculum
Physics

Rationale and Aims

Rationale

Physics is a fundamental science that endeavours to explain all the natural phenomena that occur in the universe. Its power lies in the use of a comparatively small number of assumptions, models, laws and theories to explain a wide range of phenomena, from the incredibly small to the incredibly large. Physics has helped to unlock the mysteries of the universe and provides the foundation of understanding upon which modern technologies and all other sciences are based.

Physics uses qualitative and quantitative models and theories based on physical laws to visualise, explain and predict physical phenomena. Models, laws and theories are developed from, and their predictions are tested by making, observations and quantitative measurements. In this subject, students gather, analyse and interpret primary and secondary data to investigate a range of phenomena and technologies using some of the most important models, laws and theories of physics, including the kinetic particle model, the atomic model, electromagnetic theory, and the laws of classical mechanics.

Students investigate how the unifying concept of energy explains diverse phenomena and provides a powerful tool for analysing how systems interact throughout the universe on multiple scales. Students learn how more sophisticated theories, including quantum theory, the theory of relativity and the Standard Model, are needed to explain more complex phenomena, and how new observations can lead to models and theories being refined and developed.

Students learn how an understanding of physics is central to the identification of, and solutions to, some of the key issues facing an increasingly globalised society. They consider how physics contributes to diverse areas in contemporary life, such as engineering, renewable energy generation, communication, development of new materials, transport and vehicle safety, medical science, an understanding of climate change, and the exploration of the universe.

Studying senior secondary Science provides students with a suite of skills and understandings that are valuable to a wide range of further study pathways and careers. Studying physics will enable students to become citizens who are better informed about the world around them and who have the critical skills to evaluate and make evidence-based decisions about current scientific issues. The subject will also provide a foundation in physics knowledge, understanding and skills for those students who wish to pursue tertiary study in science, engineering, medicine and technology.

Aims

Physics aims to develop students':

- appreciation of the wonder of physics and the significant contribution physics has made to contemporary society
- understanding that diverse natural phenomena may be explained, analysed and predicted using concepts, models and theories that provide a reliable basis for action
- understanding of the ways in which matter and energy interact in physical systems across a range of scales
- understanding of the ways in which models and theories are refined and new models and theories are developed in physics; and how physics knowledge is used in a wide range of contexts and informs personal, local and global issues
- investigative skills, including the design and conduct of investigations to explore phenomena and solve problems, the collection and analysis of qualitative and quantitative data, and the interpretation of evidence
- ability to use accurate and precise measurement, valid and reliable evidence, and scepticism and intellectual rigour to evaluate claims
- ability to communicate physics understanding, findings, arguments and conclusions using appropriate representations, modes and genres.

Organisation

Overview of the senior secondary Australian Curriculum

ACARA has developed senior secondary Australian Curriculum for English, Mathematics, Science and History according to a set of design specifications. The ACARA Board approved these specifications following consultation with state and territory curriculum, assessment and certification authorities.

The senior secondary Australian Curriculum specifies content and achievement standards for each senior secondary subject. Content refers to the knowledge, understanding and skills to be taught and learned within a given subject. Achievement standards refer to descriptions of the quality of learning (the depth of understanding, extent of knowledge and sophistication of skill) expected of students who have studied the content for the subject.

The senior secondary Australian Curriculum for each subject has been organised into four units. The last two units are cognitively more challenging than the first two units. Each unit is designed to be taught in about half a 'school year' of senior secondary studies (approximately 50–60 hours duration including assessment and examinations). However, the senior secondary units have also been designed so that they may be studied singly, in pairs (that is, year-long), or as four units over two years.

State and territory curriculum, assessment and certification authorities are responsible for the structure and organisation of their senior secondary courses and will determine how they will integrate the Australian Curriculum content and achievement standards into their courses. They will continue to be responsible for implementation of the senior secondary curriculum, including assessment, certification and the attendant quality assurance mechanisms. Each of these authorities acts in accordance with its respective legislation and the policy framework of its state government and Board. They will determine the assessment and certification specifications for their local courses that integrate the Australian Curriculum content and achievement standards and any additional information, guidelines and rules to satisfy local requirements including advice on entry and exit points and credit for completed study.

The senior secondary Australian Curriculum for each subject should not, therefore, be read as a course of study. Rather, it is presented as content and achievement standards for integration into state and territory courses.

Senior secondary Science subjects

The Australian Curriculum senior secondary Science subjects build on student learning in the Foundation to Year 10 Science curriculum and include:

- Biology
- Chemistry
- Earth and Environmental Science
- Physics.

Structure of Physics

Units

In Physics, students develop their understanding of the core concepts, models and theories that describe, explain and predict physical phenomena. There are four units:

- Unit 1: Thermal, nuclear and electrical physics
- Unit 2: Linear motion and waves
- Unit 3: Gravity and electromagnetism
- Unit 4: Revolutions in modern physics.

In Units 1 and 2, students further investigate energy, motion and forces, building on the ideas introduced in the F–10 Australian Curriculum: Science. In Unit 1, students investigate energy production by considering heating processes, radioactivity and nuclear reactions, and investigate energy transfer and transformation in electrical circuits. In Unit 2, students describe, explain and predict linear motion, and investigate the application of wave models to light and sound phenomena.

In Units 3 and 4, students are introduced to more complex models that enable them to describe, explain and predict a wider range of phenomena, including, in Unit 4, very high speed motion and very small scale objects. In Unit 3, students investigate models of motion in gravitational, electric and magnetic fields to explain how forces act at a distance, and use the theory of electromagnetism to explain the production and propagation of electromagnetic waves. In Unit 4, students investigate how shortcomings in existing theories led to the development of the Special Theory of Relativity, the quantum theory of light and matter, and the Standard Model of particle physics.

Each unit includes:

- Unit descriptions – short descriptions of the purpose of and rationale for each unit
- Learning outcomes – six to eight statements describing the learning expected as a result of studying the unit
- Content descriptions – descriptions of the core content to be taught and learned, organised into three strands:
  - *Science Inquiry Skills*
  - *Science as a Human Endeavour*
  - *Science Understanding (organised in sub-units).*

Organisation of content

Science strand descriptions

The Australian Curriculum: Science has three interrelated strands: *Science Inquiry Skills, Science as a Human Endeavour* and *Science Understanding*. These strands are used to organise the Science learning area from Foundation to Year 12. In the Senior Secondary Science subjects, the three strands build on students' learning in the F-10 Australian Curriculum: Science.

In the practice of science, the three strands are closely integrated: the work of scientists reflects the nature and development of science, is built around scientific inquiry, and seeks to respond to and influence society. Students' experiences of school science should mirror this multifaceted view of science. To achieve this, the three strands of the Australian Curriculum: Science should be taught in an integrated way. The content descriptions for *Science Inquiry Skills*, *Science as a Human Endeavour* and *Science Understanding* have been written so that this integration is possible in each unit.

Science Inquiry Skills

Science inquiry involves identifying and posing questions; planning, conducting and reflecting on investigations; processing, analysing and interpreting data; and communicating findings. This strand is concerned with evaluating claims, investigating ideas, solving problems, reasoning, drawing valid conclusions, and developing evidence-based arguments.

Science investigations are activities in which ideas, predictions or hypotheses are tested and conclusions are drawn in response to a question or problem. Investigations can involve a range of activities, including experimental testing, field work, locating and using information sources, conducting surveys, and using modelling and simulations. The investigation design will depend on the context and subject of the investigation.

In science investigations, the collection and analysis of data to provide evidence plays a major role. This can involve collecting or extracting information and reorganising data in the form of tables, graphs, flow charts, diagrams, prose, keys, spreadsheets and databases. The analysis of data to identify and select evidence, and the communication of findings, involve the selection, construction and use of specific representations, including mathematical relationships, symbols and diagrams.

Through the senior secondary Science subjects, students will continue to develop generic science inquiry skills, building on the skills acquired in the F-10 Australian Curriculum: Science. These generic skills are described below and will be explicitly taught and assessed in each unit. In addition, each unit provides more specific skills to be taught within the generic science inquiry skills; these specific skills align with the *Science Understanding* and *Science as a Human Endeavour* content of the unit.

The generic science inquiry skills are:

- Identifying, researching and constructing questions for investigation; proposing hypotheses; and predicting possible outcomes
- Designing investigations, including the procedure/s to be followed, the materials required and the type and amount of primary and/or secondary data to be collected; conducting risk assessments; and considering ethical research
- Conducting investigations, including using equipment and techniques safely, competently and methodically for the collection of valid and reliable data
- Representing data in meaningful and useful ways; organising and analysing data to identify trends, patterns and relationships; recognising error, uncertainty and limitations in data; and selecting, synthesising and using evidence to construct and justify conclusions
- Interpreting scientific and media texts and evaluating processes, claims and conclusions by considering the quality of available evidence; and using reasoning to construct scientific arguments
- Selecting, constructing and using appropriate representations to communicate understanding, solve problems and make predictions
- Communicating to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes.

The Senior secondary science subjects have been designed to accommodate, if appropriate, an extended scientific investigation within each pair of units. States and territories will determine whether there are any requirements related to an extended scientific investigation as part of their course materials.

Science as a Human Endeavour

Through science, we seek to improve our understanding and explanations of the natural world. The *Science as a Human Endeavour* strand highlights the development of science as a unique way of knowing and doing, and explores the use and influence of science in society.

As science involves the construction of explanations based on evidence, the development of science concepts, models and theories is dynamic and involves critique and uncertainty. Science concepts, models and theories are reviewed as their predictions and explanations are continually re-assessed through new evidence, often through the application of new technologies. This review process involves a diverse range of scientists working within an increasingly global community of practice and can involve the use of international conventions and activities such as peer review.

The use and influence of science are shaped by interactions between science and a wide range of social, economic, ethical and cultural factors. The application of science may provide great benefits to individuals, the community and the environment, but may also pose risks and have unintended consequences. As a result, decision making about socio-scientific issues often involves consideration of multiple lines of evidence and a range of stakeholder needs and values. As an ever-evolving body of knowledge, science frequently informs public debate, but is not always able to provide definitive answers.

Across the senior secondary Science subjects, the same set of *Science as a Human Endeavour* content descriptions is used for Units 1 and 2 of the subjects; and another set for Units 3 and 4. This consistent approach enables students to develop a rich appreciation of the complex ways in which science interacts with society, through the exploration of *Science as a Human Endeavour* concepts across the subjects and in multiple contexts.

'Examples in context' will be developed to illustrate possible contexts related to *Science Understanding* content, in which students could explore *Science as a Human Endeavour* concepts. These will be made available to complement the final online curriculum. Each *Example in context* will be aligned to the relevant sub-unit in *Science Understanding* and will include links to the relevant *Science as a Human Endeavour* content descriptions.

Science Understanding

Science understanding is evident when a person selects and integrates appropriate science concepts, models and theories to explain and predict phenomena, and applies those concepts, models and theories to new situations. Models in science can include diagrams, physical replicas, mathematical representations, word-based analogies (including laws and principles) and computer simulations. Development of models involves selection of the aspects of the system/s to be included in the model, and thus models have inherent approximations, assumptions and limitations.

The *Science Understanding* content in each unit develops students' understanding of the key concepts, models and theories that underpin the subject, and of the strengths and limitations of different models and theories for explaining and predicting complex phenomena.

Science understanding can be developed through the selection of contexts that have relevance to and are engaging for students. The Australian Curriculum: Science has been designed to provide jurisdictions, schools and teachers with the flexibility to select contexts that meet the social, geographic and learning needs of their students.

Organisation of achievement standards

The Physics achievement standards are organised by two dimensions: 'Physics Concepts, Models and Applications', and 'Physics Inquiry Skills'. They describe five levels of student achievement.

'Physics Concepts, Models and Applications' describes the knowledge and understanding students demonstrate with reference to the content of the *Science Understanding* and *Science as a Human Endeavour* strands of the curriculum. 'Physics Inquiry Skills' describes the skills students demonstrate when investigating the content developed through the strands of *Science Understanding* and *Science as a Human Endeavour*.

Senior secondary achievement standards have been written for each Australian Curriculum senior secondary subject. The achievement standards provide an indication of typical performance at five different levels (corresponding to grades A to E) following the completion of study of senior secondary Australian Curriculum content for a pair of units. They are broad statements of understanding and skills that are best read and understood in conjunction with the relevant unit content. They are structured to reflect key dimensions of the content of the relevant learning area. They will be eventually accompanied by illustrative and annotated samples of student work/ performance/ responses.

The achievement standards will be refined empirically through an analysis of samples of student work and responses to assessment tasks: they cannot be maintained *a priori* without reference to actual student performance. Inferences can be drawn about the quality of student learning on the basis of observable differences in the extent, complexity, sophistication and generality of the understanding and skills typically demonstrated by students in response to well-designed assessment activities and tasks.

In the short term, achievement standards will inform assessment processes used by curriculum, assessment and certifying authorities for course offerings based on senior secondary Australian Curriculum content.

ACARA has made reference to a common syntax (as a guide, not a rule) in constructing the achievement standards across the learning areas. The common syntax that has guided development is as follows:

- Given a specified context (as described in the curriculum content)
- With a defined level of consistency/accuracy (the assumption that each level describes what the student does well, competently, independently, consistently)
- Students perform a specified action (described through a verb)
- In relation to what is valued in the curriculum (specified as the object or subject)
- With a defined degree of sophistication, difficulty, complexity (described as an indication of quality)

Terms such as 'analyse' and 'describe' have been used to specify particular action but these can have everyday meanings that are quite general. ACARA has therefore associated these terms with specific meanings that are defined in the senior secondary achievement standards glossary and used precisely and consistently across subject areas.

Links to Foundation to Year 10

Progression from the F-10 Australian Curriculum: Science

The Physics curriculum continues to develop student understanding and skills from across the three strands of the F-10 Australian Curriculum: Science. In the *Science Understanding* strand, the Physics curriculum draws on knowledge and understanding from across the four sub-strands of Biological, Physical, Chemical and Earth and Space Sciences.

In particular, the Physics curriculum continues to develop the key concepts introduced in the Physical Sciences sub-strand, that is, that forces affect the behaviour of objects, and that energy can be transferred and transformed from one form to another.

Mathematical skills expected of students studying Physics

The Physics curriculum requires students to use the mathematical skills they have developed through the F-10 Australian Curriculum: Mathematics, in addition to the numeracy skills they have developed through the *Science Inquiry Skills* strand of the Australian Curriculum: Science.

Within the *Science Inquiry Skills* strand, students are required to gather, represent and analyse numerical data to identify the evidence that forms the basis of their scientific arguments, claims or conclusions. In gathering and recording numerical data, students are required to make measurements with an appropriate degree of accuracy and to represent measurements using appropriate units.

Students may need to be taught inverse and inverse square relationships as they are important in physics, but are not part of the Year 10 Australian Curriculum: Mathematics.

Students may need to be taught to recognise when it is appropriate to join points on a graph and when it is appropriate to use a line of best fit. They may need to be taught how to construct a straight line that will serve as the line of best fit for a set of data presented graphically.

It is assumed that students will be able to competently:

- perform calculations involving addition, subtraction, multiplication and division of quantities
- perform approximate evaluations of numerical expressions
- express fractions as percentages, and percentages as fractions
- calculate percentages
- recognise and use ratios
- transform decimal notation to power of ten notation
- change the subject of a simple equation

- substitute physical quantities into an equation using consistent units so as to calculate one quantity and check the dimensional consistency of such calculations
- solve simple algebraic equations
- comprehend and use the symbols/notations <, >, Δ, $\approx$, $\sqrt{}$, $\leq$, $\geq$, $\sum$
- translate information between graphical, numerical and algebraic forms
- distinguish between discrete and continuous data and then select appropriate forms, variables and scales for constructing graphs
- construct and interpret frequency tables and diagrams, pie charts and histograms
- describe and compare data sets using mean, median and inter-quartile range
- interpret the slope of a linear graph
- calculate areas of right-angled and isosceles triangles, circumference and area of circles, areas and volumes of rectangular blocks, cylinders and spheres
- use Pythagoras' theorem, similarity of triangles and the angle sum of a triangle.

Representation of General capabilities

Literacy is important in students' development of *Science Inquiry Skills* and their understanding of content presented through the *Science Understanding* and *Science as a Human Endeavour* strands. Students gather, interpret, synthesise and critically analyse information presented in a wide range of genres, modes and representations (including text, flow diagrams, symbols, graphs and tables). They evaluate information sources and compare and contrast ideas, information and opinions presented within and between texts. They communicate processes and ideas logically and fluently and structure evidence-based arguments, selecting genres and employing appropriate structures and features to communicate for specific purposes and audiences.

Numeracy is key to students' ability to apply a wide range of *Science Inquiry Skills*, including making and recording observations; ordering, representing and analysing data; and interpreting trends and relationships. They employ numeracy skills to interpret complex spatial and graphic representations, and to appreciate the ways in which physical systems are structured, interact and change across spatial scales. They engage in analysis of data, including issues relating to reliability and probability, and they interpret and manipulate mathematical relationships to calculate and predict values.

*Information and Communication Technolog*y *(ICT) capability* is a key part of *Science Inquiry Skills*. Students use a range of strategies to locate, access and evaluate information from multiple digital sources; to collect, analyse and represent data; to model and interpret concepts and relationships; and to communicate and share science ideas, processes and information. Through exploration of *Science as a Human Endeavour* concepts, students assess the impact of ICT on the development of science and the application of science in society, particularly with regard to collating, storing, managing and analysing large data sets.

Critical and creative thinking is particularly important in the science inquiry process. Science inquiry requires the ability to construct, review and revise questions and hypotheses about increasingly complex and abstract scenarios and to design related investigation methods. Students interpret and evaluate data; interrogate, select and cross-reference evidence; and analyse processes, interpretations, conclusions and claims for validity and reliability, including reflecting on their own processes and conclusions. Science is a creative endeavour and students devise innovative solutions to problems, predict possibilities, envisage consequences and speculate on possible outcomes as they develop *Science Understanding* and *Science Inquiry Skills.* They also appreciate the role of critical and creative individuals and the central importance of critique and review in the development and innovative application of science.

Personal and social capability is integral to a wide range of activities in Physics, as students develop and practise skills of communication, teamwork, decision-making, initiative-taking and self-discipline with increasing confidence and sophistication. In particular, students develop skills in both independent and collaborative investigation; they employ self-management skills to plan effectively, follow procedures efficiently and work safely; and they use collaboration skills to conduct investigations, share research and discuss ideas. In considering aspects of *Science as a Human Endeavour,* students also recognise the role of their own beliefs and attitudes in their response to science issues and applications, consider the perspectives of others, and gauge how science can affect people's lives.

Ethical behaviour is a vital part of science inquiry. Students evaluate the ethics of experimental science, codes of practice, and the use of scientific information and science applications. They explore what integrity means in science, and they understand, critically analyse and apply ethical guidelines in their investigations. They consider the implications of their investigations on others, the environment and living organisms. They use scientific information to evaluate the claims and actions of others and to inform ethical decisions about a range of social, environmental and personal issues and applications of science.

Intercultural understanding is fundamental to understanding aspects of *Science as a Human Endeavour*, as students appreciate the contributions of diverse cultures to developing science understanding and the challenges of working in culturally diverse collaborations. They develop awareness that raising some debates within culturally diverse groups requires cultural sensitivity, and they demonstrate open-mindedness to the positions of others. Students also develop an understanding that cultural factors affect the ways in which science influences and is influenced by society.

Representation of Cross-curriculum priorities

While the significance of the cross-curriculum priorities for Physics varies, there are opportunities for teachers to select contexts that incorporate the key concepts from each priority.

Through an investigation of contexts that draw on *Aboriginal and Torres Strait Islander histories and cultures* students can appreciate Aboriginal and Torres Strait Islander Peoples' understanding of physical phenomena, including of the motion of objects, and of astronomical phenomena.

Contexts that draw on Asian scientific research and development and collaborative endeavours in the Asia Pacific region provide an opportunity for students to investigate *Asia and Australia's engagement with Asia*. Students could examine the important role played by people of the Asia region in such areas as medicine, communication technologies, transportation, sports science and energy security. They could consider collaborative projects between Australian and Asian scientists and the contribution these make to scientific knowledge.

The cross-curriculum priority of *Sustainability* provides authentic contexts for exploring, investigating and understanding the function and interactions of physical systems. Physics explores a wide range of physical systems that operate at different temporal and spatial scales. By investigating the relationships between systems and system components and how systems respond to change, students develop an appreciation for the ways in which matter and energy interactions shape the Earth system. In exploring applications of physics knowledge, students appreciate that science provides the basis for decision making in many areas of society and that these decisions can impact the Earth system. They understand the importance of using physical science knowledge to predict possible effects of human and other activity, and to develop management plans or alternative technologies that minimise these effects and provide for a more sustainable future.

Safety

Science learning experiences may involve the use of potentially hazardous substances and/or hazardous equipment. It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students and that school practices meet the requirements of the *Work Health and Safety Act 2011,* in addition to relevant state or territory health and safety guidelines.

When state and territory curriculum authorities integrate the Australian Curriculum into local courses, they will include more specific advice on safety.

For further information about relevant guidelines, contact your state or territory curriculum authority.

Animal ethics

Through a consideration of research ethics as part of *Science Inquiry Skills*, students will examine their own ethical position, draw on ethical perspectives when designing investigation methods, and ensure that any activities that impact on living organisms comply with the *Australian code of practice for the care and use of animals for scientific purposes 7th edition* (2004) (http://www.nhmrc.gov.au/guidelines/publications/ea16) .

Any teaching activities that involve the care and use of, or interaction with, animals must comply with the *Australian code of practice for the care and use of animals for scientific purposes 7th edition*, in addition to relevant state or territory guidelines.

When state and territory curriculum authorities integrate the Australian Curriculum into local courses, they will include more specific advice on the care and use of, or interaction with, animals.

For further information about relevant guidelines or to access your local Animal Ethics Committee, contact your state or territory curriculum authority.

Unit 1: Thermal, nuclear and electrical physics

Unit Description

An understanding of heating processes, nuclear reactions and electricity is essential to appreciate how global energy needs are met. In this unit, students explore the ways physics is used to describe, explain and predict the energy transfers and transformations that are pivotal to modern industrial societies. Students investigate heating processes, apply the nuclear model of the atom to investigate radioactivity, and learn how nuclear reactions convert mass into energy. They examine the movement of electrical charge in circuits and use this to analyse, explain and predict electrical phenomena.

Contexts that could be investigated in this unit include technologies related to nuclear, thermal, or geothermal energy, electrical energy production, large-scale power systems, radiopharmaceuticals and electricity in the home; and related areas of science such as nuclear fusion in stars and the Big Bang theory.

Through the investigation of appropriate contexts, students understand how applying scientific knowledge to the challenge of meeting world energy needs requires the international cooperation of multidisciplinary teams and relies on advances in ICT and other technologies. They explore how science knowledge is used to offer valid explanations and reliable predictions, and the ways in which it interacts with social, economic, cultural and ethical factors.

Students develop skills in interpreting, constructing and using a range of mathematical and symbolic representations to describe, explain and predict energy transfers and transformations in heating processes, nuclear reactions and electrical circuits. They develop their inquiry skills through primary and secondary investigations, including analysing heat transfer, heat capacity, radioactive decay and a range of simple electrical circuits.

Learning Outcomes

By the end of this unit, students:

- understand how the kinetic particle model and thermodynamics concepts describe and explain heating processes
- understand how the nuclear model of the atom explains radioactivity, fission, fusion and the properties of radioactive nuclides
- understand how charge is involved in the transfer and transformation of energy in electrical circuits
- understand how scientific models and theories have developed and are applied to improve existing, and develop new, technologies
- use science inquiry skills to design, conduct and analyse safe and effective investigations into heating processes, nuclear physics and electrical circuits, and to communicate methods and findings
- use algebraic and graphical representations to calculate, analyse and predict measurable quantities associated with heating processes, nuclear reactions and electrical circuits
- evaluate, with reference to empirical evidence, claims about heating processes, nuclear reactions and electrical technologies
- communicate physics understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills

Identify, research, construct and refine questions for investigation; propose hypotheses; and predict possible outcomes (ACSPH001)

Design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSPH002)

Conduct investigations, including using temperature, current and potential difference measuring devices, safely, competently and methodically for the collection of valid and reliable data (ACSPH003)

Represent data in meaningful and useful ways, including using appropriate Système Internationale (SI) units and symbols; organise and analyse data to identify trends, patterns and relationships; identify sources of random and systematic error and estimate their effect on measurement results; identify anomalous data and calculate the measurement discrepancy between experimental results and a currently accepted value, expressed as a percentage; and select, synthesise and use evidence to make and justify conclusions (ACSPH004)

Interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments (ACSPH005)

Select, construct and use appropriate representations, including text and graphic representations of empirical and theoretical relationships, flow diagrams, nuclear equations and circuit diagrams, to communicate conceptual understanding, solve problems and make predictions (ACSPH006)

Select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions (ACSPH007)

Communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports (ACSPH008)

Science as a Human Endeavour (Units 1 & 2)

Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility (ACSPH009)

Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines (ACSPH010)

Advances in science understanding in one field can influence other areas of science, technology and engineering (ACSPH011)

The use of scientific knowledge is influenced by social, economic, cultural and ethical considerations (ACSPH012)

The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences (ACSPH013)

Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions (ACSPH014)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSPH015)

Science Understanding

Heating processes

Heat transfer occurs between and within systems by conduction, convection and/or radiation (ACSPH016)

The kinetic particle model describes matter as consisting of particles in constant motion, except at absolute zero (ACSPH017)

All systems have thermal energy due to the motion of particles in the system (ACSPH018)

Temperature is a measure of the average kinetic energy of particles in a system (ACSPH019)

Provided a substance does not change state, its temperature change is proportional to the amount of energy added to or removed from the substance; the constant of proportionality describes the heat capacity of the substance (ACSPH020)

Change of state involves internal energy changes to form or break bonds between atoms or molecules; latent heat is the energy required to be added to or removed from a system to change the state of the system (ACSPH021)

Two systems in contact transfer energy between particles so that eventually the systems reach the same temperature; that is, they are in thermal equilibrium (ACSPH022)

A system with thermal energy has the capacity to do mechanical work (that is, to apply a force over a distance); when work is done, the internal energy of the system changes (ACSPH023)

Because energy is conserved, the change in internal energy of a system is equal to the energy added or removed by heating plus the work done on or by the system (ACSPH024)

Energy transfers and transformations in mechanical systems (for example, internal and external combustion engines, electric motors) always result in some heat loss to the environment, so that the usable energy is reduced and the system cannot be 100 percent efficient (ACSPH025)

Mathematical representations and relationships

$\mathrm{Q = mc\Delta T}$

$\mathrm{Q} =$ heat transferred to or from the object, $\mathrm{m} =$ mass of object, $\mathrm{c} =$ specific heat capacity of the object, $\Delta \mathrm{T} =$ temperature change

$\mathrm{Q = mL}$

$\mathrm{Q} =$ heat transferred to or from the object, L = latent heat capacity of the material, $\mathrm{m} =$ mass of object

$$\eta = \frac{\text{energy output}}{\text{energy input}} \times \frac{100}{1}\,\%$$

$\eta =$ efficiency

Ionising radiation and nuclear reactions

The nuclear model of the atom describes the atom as consisting of an extremely small nucleus, which contains most of the atom's mass and is made up of positively charged protons and uncharged neutrons surrounded by negatively charged electrons (ACSPH026)

Nuclear stability is the result of the strong nuclear force, which operates between nucleons over a very short distance and opposes the electrostatic repulsion between protons in the nucleus (ACSPH027)

Some nuclides are unstable and spontaneously decay, emitting alpha, beta and/or gamma radiation over time until they become stable nuclides (ACSPH028)

Each species of radionuclide has a specific half-life (ACSPH029)

Alpha, beta and gamma radiation have sufficient energy to ionise atoms (ACSPH030)

Einstein's mass/energy relationship, which applies to all energy changes, enables the energy released in nuclear reactions to be determined from the mass change in the reaction (ACSPH031)

Alpha and beta decay are examples of spontaneous transmutation reactions, while artificial transmutation is a managed process that changes one nuclide into another (ACSPH032)

Neutron-induced nuclear fission is a reaction in which a heavy nuclide captures a neutron and then splits into two smaller radioactive nuclides, with the release of neutrons and energy (ACSPH033)

A fission chain reaction is a self-sustaining process that may be controlled to produce thermal energy, or uncontrolled to release energy explosively (ACSPH034)

Nuclear fusion is a reaction in which light nuclides combine to form a heavier nuclide, with the release of energy (ACSPH035)

More energy is released per nucleon in nuclear fusion than in nuclear fission because a greater percentage of the mass is transformed into energy (ACSPH036)

Mathematical representations and relationships

$N = N_o \left(\frac{1}{2}\right)^n$ (for whole numbers of half-lives only)

$N =$ number of nuclides remaining in a sample, n = number of whole half-lives, $N_o =$ original number of nuclides in the sample

$\Delta E = \Delta mc^2$

$E =$ energy change, $\Delta m =$ mass change, $c =$ speed of light $\left(3 \times 10^8 \text{ m s}^{-1}\right)$

Electrical circuits

Electrical circuits enable electrical energy to be transferred efficiently over large distances and transformed into a range of other useful forms of energy including thermal and kinetic energy, and light. (ACSPH037)

Electric current is carried by discrete charge carriers; charge is conserved at all points in an electrical circuit (ACSPH038)

Energy is conserved in the energy transfers and transformations that occur in an electrical circuit (ACSPH039)

The energy available to charges moving in an electrical circuit is measured using electric potential difference, which is defined as the change in potential energy per unit charge between two defined points in the circuit (ACSPH040)

Energy is required to separate positive and negative charge carriers; charge separation produces an electrical potential difference that can be used to drive current in circuits (ACSPH041)

Power is the rate at which energy is transformed by a circuit component; power enables quantitative analysis of energy transformations in the circuit (ACSPH042)

Resistance for ohmic and non-ohmic components is defined as the ratio of potential difference across the component to the current in the component (ACSPH043)

Circuit analysis and design involve calculation of the potential difference across, the current in, and the power supplied to, components in series, parallel and series/parallel circuits (ACSPH044)

Mathematical representations and relationships

$I = \frac{q}{t}$

$I =$ current, $q =$ the amount of charge that passes a point in the circuit, $t =$ time interval

$V = \frac{W}{q}$

$V =$ potential difference, $W =$ work, $q =$ charge

$R = \frac{V}{I}$

R = resistance, V = potential difference, $I =$ current

For ohmic resistors, resistance, R, is a constant

$P = \frac{W}{t} = VI$

$P =$ power, W = work = energy transformed, t = time interval, V= potential difference, $I =$ current

Equivalent resistance for series components, $I =$ constant

$$V_t = V_1 + V_2 + .. V_n$$
$$R_t = R_1 + R_2 + .. R_n$$

$I =$ current, $V_t =$ total potential difference, V_n = the potential difference across each component, $R_t =$ equivalent resistance, R_n = resistance of each component

Equivalent resistance for parallel components, $V =$ constant

$$I_t = I_1 + I_2 + .. I_n$$

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + .. \frac{1}{R_n}$$

$V =$ potential difference, $I_t =$ total current, I_n = current in each of the components, $\frac{1}{R_t} =$ the reciprocal of the equivalent resistance, $\frac{1}{R_n} =$ the reciprocal of the resistance of each component

Physics

Unit 2: Linear Motion and Waves

Unit Description

In this unit, students develop an appreciation of how an understanding of motion and waves can be used to describe, explain and predict a wide range of phenomena. Students describe linear motion in terms of position and time data, and examine the relationships between force, momentum and energy for interactions in one dimension.

Students investigate common wave phenomena, including waves on springs, and water, sound and earthquake waves, and compare the behaviour of these waves with the behaviour of light. This leads to an explanation of light phenomena, including polarisation, interference and diffraction, in terms of a wave model.

Contexts that could be investigated in this unit include technologies such as accelerometers, motion-detectors, photo radar, GPS, energy conversion buoys, music, hearing aids, echo locators, fibre optics, DVDs and lasers, and related areas of science and engineering such as sports science, car and road safety, acoustic design, noise pollution, seismology, bridge and building design.

Through the investigation of appropriate contexts, students explore how international collaboration, evidence from a range of disciplines and many individuals, and the development of ICT and other technologies have contributed to developing understanding of motion and waves and associated technologies. They investigate how scientific knowledge is used to offer valid explanations and reliable predictions, and the ways in which it interacts with social, economic, cultural and ethical factors.

Students develop their understanding of motion and wave phenomena through laboratory investigations. They develop skills in relating graphical representations of data to quantitative relationships between variables, and they continue to develop skills in planning, conducting and interpreting the results of primary and secondary investigations.

Learning Outcomes

By the end of this unit, students:

- understand that Newton’s Laws of Motion describe the relationship between the forces acting on an object and its motion
- understand that waves transfer energy and that a wave model can be used to explain the behaviour of sound and light
- understand how scientific models and theories have developed and are applied to improve existing, and develop new, technologies
- use science inquiry skills to design, conduct and analyse safe and effective investigations into linear motion and wave phenomena, and to communicate methods and findings
- use algebraic and graphical representations to calculate, analyse and predict measurable quantities associated with linear and wave motion
- evaluate, with reference to evidence, claims about motion, sound and light-related phenomena and associated technologies
- communicate physics understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills

Identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes (ACSPH045)

Design investigations, including the procedure to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSPH046)

Conduct investigations, including the manipulation of devices to measure motion and the direction of light rays, safely, competently and methodically for the collection of valid and reliable data (ACSPH047)

Represent data in meaningful and useful ways, including using appropriate SI units and symbols; organise and analyse data to identify trends, patterns and relationships; identify sources of random and systematic error and estimate their effect on measurement results; identify anomalous data and calculate the measurement discrepancy between the experimental results and a currently accepted value, expressed as a percentage; and select, synthesise and use evidence to make and justify conclusions (ACSPH048)

Interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments (ACSPH049)

Select, construct and use appropriate representations, including text and graphic representations of empirical and theoretical relationships, vector diagrams, free body/force diagrams, wave diagrams and ray diagrams, to communicate conceptual understanding, solve problems and make predictions (ACSPH050)

Select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions (ACSPH051)

Communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports (ACSPH052)

Science as a Human Endeavour (Units 1 & 2)

Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility (ACSPH053)

Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines (ACSPH054)

Advances in science understanding in one field can influence other areas of science, technology and engineering (ACSPH055)

The use of scientific knowledge is influenced by social, economic, cultural and ethical considerations (ACSPH056)

The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences (ACSPH057)

Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions (ACSPH058)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSPH059)

Science Understanding

Linear motion and force

Uniformly accelerated motion is described in terms of relationships between measurable scalar and vector quantities, including displacement, speed, velocity and acceleration (ACSPH060)

Representations, including graphs and vectors, and/or equations of motion, can be used qualitatively and quantitatively to describe and predict linear motion (ACSPH061)

Vertical motion is analysed by assuming the acceleration due to gravity is constant near Earth's surface (ACSPH062)

Newton's Three Laws of Motion describe the relationship between the force or forces acting on an object, modelled as a point mass, and the motion of the object due to the application of the force or forces (ACSPH063)

Momentum is a property of moving objects; it is conserved in a closed system and may be transferred from one object to another when a force acts over a time interval (ACSPH064)

Energy is conserved in isolated systems and is transferred from one object to another when a force is applied over a distance; this causes work to be done and changes to kinetic and/or potential energy of objects (ACSPH065)

Collisions may be elastic and inelastic; kinetic energy is conserved in elastic collisions (ACSPH066)

Mathematical representations and relationships

$\mathrm{v = u + at}$, $\mathrm{s = ut + \frac{1}{2}at^2}$, $\mathrm{v^2 = u^2 + 2as}$

$\mathrm{s} =$ displacement, t = time interval, $\mathrm{u} =$ initial velocity, $\mathrm{v} =$ final velocity, $\mathrm{a} =$ acceleration

$\mathrm{a = \frac{F}{m}}$

$\mathrm{a} =$ acceleration, $\mathrm{F} =$ force, m = mass

$\mathrm{W = \Delta E}$; where the applied force is in the same direction as the displacement, $\mathrm{W = Fs}$,

W = work, $\mathrm{F} =$ force, $\mathrm{s} =$ displacement, $\Delta\mathrm{E} =$ change in energy

$\mathrm{p = mv}$, $\Delta\mathrm{p = F}\Delta\mathrm{t}$

p = momentum, $\mathrm{v} =$ velocity, m = mass, F = force, p =change in momentum,

$\Delta\mathrm{t}$ = time interval over which force F acts

$\mathrm{E_k = \frac{1}{2}mv^2}$

$\mathrm{E_k}$ = kinetic energy, m = mass, $\mathrm{v} =$ speed

$\Delta\mathrm{E_p = mg}\Delta\mathrm{h}$

$\Delta\mathrm{E_p} =$ change in potential energy, $\mathrm{m} =$ mass, $\mathrm{g} =$ acceleration due to gravity, h = change in vertical distance

$\Sigma\mathrm{mv_{before}} = \Sigma\mathrm{mv_{after}}$

$\Sigma\mathrm{mv_{before}} =$ vector sum of the momenta of all particles before the collision, $\Sigma\mathrm{mv_{after}}$ = vector sum of the momenta of all particles after the collision

For elastic collisions: $\Sigma\,\mathrm{\frac{1}{2}mv^2_{before}} = \Sigma\,\mathrm{\frac{1}{2}mv^2_{after}}$

$\Sigma\,\mathrm{\frac{1}{2}mv^2_{before}}$ = sum of the kinetic energies before the collision, $\Sigma\,\mathrm{\frac{1}{2}mv^2_{after}}$ = sum of the kinetic energies after the collision

Waves

Waves are periodic oscillations that transfer energy from one point to another (ACSPH067)

Longitudinal and transverse waves are distinguished by the relationship between the direction of oscillation relative to the direction of the wave velocity (ACSPH068)

Waves may be represented by time and displacement wave diagrams and described in terms of relationships between measurable quantities, including period, amplitude, wavelength, frequency and velocity (ACSPH069)

Mechanical waves transfer energy through a medium; mechanical waves may oscillate the medium or oscillate the pressure within the medium (ACSPH070)

The mechanical wave model can be used to explain phenomena related to reflection and refraction (for example, echoes, seismic phenomena) (ACSPH071)

The superposition of waves in a medium may lead to the formation of standing waves and interference phenomena, including standing waves in pipes and on stretched strings (ACSPH072)

A mechanical system resonates when it is driven at one of its natural frequencies of oscillation; energy is transferred efficiently into systems under these conditions (ACSPH073)

Light exhibits many wave properties; however, it cannot be modelled as a mechanical wave because it can travel through a vacuum (ACSPH074)

A ray model of light may be used to describe reflection, refraction and image formation from lenses and mirrors (ACSPH075)

A wave model explains a wide range of light-related phenomena including reflection, refraction, total internal reflection, dispersion, diffraction and interference; a transverse wave model is required to explain polarisation (ACSPH076)

The speed of light is finite and many orders of magnitude greater than the speed of mechanical waves (for example, sound and water waves); its intensity decreases in an inverse square relationship with distance from a point source (ACSPH077)

Mathematical representations and relationships

$v = f\lambda$

$v =$ speed, $f =$ frequency, $\lambda =$ wavelength

angle of incidence = angle of reflection

$l = n\frac{\lambda}{2}$ for strings attached at both ends and for pipes open at both ends

$l = (2n - 1)\frac{\lambda}{4}$ for pipes closed at one end

$n =$ whole numbers 1, 2, 3… relating to the harmonic, $l =$ length of string or pipe, $\lambda =$ wavelength of sound wave

$I \propto \frac{1}{r^2}$

$I =$ intensity, $r =$ distance from the source

$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$i =$ incident angle (relative to the normal), $r =$ angle of refraction (relative to the normal), $v_1 =$ velocity in medium 1, $v_2 =$ velocity in medium 2, $\lambda_1 =$ wavelength in medium 1, λ_2 = wavelength in medium 2

Units 1 and 2 Achievement Standards

Physics concepts, models and applications

A	B	C	D	E
For the physical systems studied, the student:	*For the physical systems studied, the student:*	*For the physical systems studied, the student:*	*For the physical systems studied, the*	*For the physical systems studied,*

Physics concepts, models and applications

• analyses physical phenomena in complex scenarios qualitatively and quantitatively • analyses the relationships between components and properties of physical systems qualitatively and quantitatively • explains the theories and model/s used to explain the system and the aspects of the system they include • applies theories and models of systems and processes to explain phenomena, interpret complex problems, and make reasoned, plausible predictions in unfamiliar contexts *For the physical science contexts studied, the student:* • analyses the roles of collaboration, debate and review, and technologies, in the development of physical science theories and models • evaluates how physical science has been used in concert with other sciences to meet diverse needs and to inform decision making, and how these applications are influenced by interacting social, economic and ethical factors	• explains physical phenomena qualitatively and quantitatively • explains the relationships between components and properties of physical systems qualitatively and quantitatively • describes the theories and model/s used to explain the system • applies theories and models of systems and processes to explain phenomena, interpret problems, and make plausible predictions in unfamiliar contexts *For the physical science contexts studied, the student:* • explains the roles of collaboration, debate and review, and technologies, in the development of physical science theories and models • explains how physical science has been used to meet diverse needs and to inform decision making, and how these applications are influenced by social, economic and ethical factors	• describes physical phenomena in simple scenarios qualitatively and quantitatively • describes the relationships between components and properties of physical systems qualitatively • describes a theory or model used to explain the system • applies theories or models of systems and processes to explain phenomena, interpret problems, and make plausible predictions in familiar contexts *For the physical science contexts studied, the student:* • describes the roles of collaboration, review, and technologies, in the development of physical science theories or models • discusses how physical science has been used to meet needs and to inform decision making, and discusses some social, economic or ethical implications of these applications	*student:* • describes physical phenomena in simple scenarios qualitatively • describes how components of physical systems are related • identifies aspects of a theory or model related to the system • describes phenomena, interprets simple problems, and makes simple predictions in familiar contexts *For the physical science contexts studied, the student:* • describes the roles of communication and new evidence in developing physical science knowledge • describes ways in which physical science has been used in society to meet needs, and identifies some implications of these applications	*the student:* • Identifies properties of physical phenomena • identifies components of physical systems • identifies aspects of a theory or model related to parts of the system • describes phenomena and makes simple predictions in familiar, simple contexts *For the physical science contexts studied, the student:* • identifies that physical science knowledge has changed over time • identifies ways in which physical science has been used in society to meet needs

Physics inquiry skills

A	B	C	D	E
For the physical science contexts studied, the student:	*For the physical science contexts studied, the*	*For the physical science contexts studied, the*	*For the physical science contexts*	*For the physical science contexts*

Physics inquiry skills

	student:	*student:*	*studied, the student:*	*studied, the student:*

Physics inquiry skills

Physics inquiry skills

• designs, conducts				

Physics inquiry skills

designs, conducts and improves safe, ethical investigations that efficiently collect valid, reliable data in response to a complex question or problem • analyses data sets to explain causal and correlational relationships, the reliability of the data and sources of error • justifies their selection of data as evidence, analyses evidence with reference to models and/or theories, and develops evidence-based conclusions that identify limitations • evaluates processes and claims, and provides an evidence-based critique and discussion of improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve complex and unfamiliar problems • communicates effectively and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs, conducts and improves safe, ethical investigations that collect valid, reliable data in response to a question or problem • analyses data sets to identify causal and correlational relationships, anomalies, and sources of error • selects appropriate data as evidence, interprets evidence with reference to models and/or theories, and provides evidence for conclusions • evaluates processes and claims, provides a critique with reference to evidence, and identifies possible improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve unfamiliar problems • communicates clearly and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs and conducts safe, ethical investigations that collect valid data in response to a question or problem • analyses data to identify relationships, anomalies, and sources of error • selects data to demonstrate relationships linked to physical science knowledge, and provides conclusions based on data • evaluates processes and claims, and suggests improvements or alternatives • selects, constructs and uses appropriate representations to describe relationships and solve problems • communicates clearly in a range of modes, styles and genres for specific purposes	• plans and conducts safe, ethical investigations to collect data in response to a question or problem • analyses data to identify trends and anomalies • selects data to demonstrate trends, and presents simple conclusions based on data • considers processes and claims from a personal perspective • constructs and uses simple representations to describe relationships and solve simple problems • communicates in a range of modes and genres	• follows a procedure to conduct safe, ethical investigations to collect data • identifies trends in data • selects data to demonstrate trends • considers claims from a personal perspective • constructs and uses simple representations to describe phenomena • communicates in a range of modes

Unit 3: Gravity and electromagnetism

Unit Description

Field theories have enabled physicists to explain a vast array of natural phenomena and have contributed to the development of technologies that have changed the world, including electrical power generation and distribution systems, artificial satellites and modern communication systems. In this unit, students develop a deeper understanding of motion and its causes by using Newton's Laws of Motion and the gravitational field model to analyse motion on inclined planes, the motion of projectiles, and satellite motion. They investigate electromagnetic interactions and apply this knowledge to understand the operation of direct current (DC) and alternating current (AC) motors and generators, transformers, and AC electricity distribution systems. Students also investigate the production of electromagnetic waves.

Contexts that could be investigated in this unit include technologies such as artificial satellites, navigation devices, large-scale electrical power generation and distribution, motors and generators, electric cars, synchrotron science, medical imaging and astronomical telescopes such as the Square Kilometre Array, and related areas of science and engineering such as sports science, amusement parks, ballistics, forensics, black holes and dark matter.

Through the investigation of appropriate contexts, students explore the ways in which models and theories related to gravity and electromagnetism, and associated technologies, have developed over time and through interactions with social, economic, cultural and ethical considerations. They investigate the ways in which science contributes to contemporary debate about local, regional and international issues, including evaluation of risk and action for sustainability, and recognise the limitations of science to provide definitive answers in different contexts.

Students develop their understanding of field theories of gravity and electromagnetism through investigations of motion and electromagnetic phenomena. Through these investigations they develop skills in relating graphical representations of data to quantitative relationships between variables, using lines of force to represent vector fields, and interpreting interactions in two and three dimensions. They continue to develop skills in planning, conducting and interpreting the results of primary and secondary investigations and in evaluating the validity of primary and secondary data.

Learning Outcomes

By the end of this unit, students:

- understand that motion in gravitational, electric and magnetic fields can be explained using Newton's Laws of Motion
- understand how the electromagnetic wave model explains the production and propagation of electromagnetic waves across the electromagnetic spectrum
- understand transformations and transfer of energy in electromagnetic devices, as well as transformations and transfer of energy associated with motion in electric, magnetic and gravitational fields
- understand how models and theories have developed over time, and the ways in which physical science knowledge and associated technologies interact with social, economic, cultural and ethical considerations
- use science inquiry skills to design, conduct, analyse and evaluate investigations into uniform circular motion, projectile motion, satellite motion and gravitational and electromagnetic phenomena, and to communicate methods and findings
- use algebraic and graphical representations to calculate, analyse and predict measurable quantities related to motion, gravitational effects and electromagnetic phenomena
- evaluate, with reference to evidence, claims about motion, gravity and electromagnetic phenomena and associated technologies, and justify evaluations
- communicate physics understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills

Identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes (ACSPH078)

Design investigations, including the procedure to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSPH079)

Conduct investigations, including the manipulation of force measurers and electromagnetic devices, safely, competently and methodically for the collection of valid and reliable data (ACSPH080)

Represent data in meaningful and useful ways, including using appropriate SI units, symbols and significant figures; organise and analyse data to identify trends, patterns and relationships; identify sources of uncertainty and techniques to minimise these uncertainties; utilise uncertainty and percentage uncertainty to determine the uncertainty in the result of calculations, and evaluate the impact of measurement uncertainty on experimental results; and select, synthesise and use evidence to make and justify conclusions (ACSPH081)

Interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the accuracy and precision of available evidence; and use reasoning to construct scientific arguments (ACSPH082)

Select, construct and use appropriate representations, including text and graphic representations of empirical and theoretical relationships, vector diagrams, free body/force diagrams, field diagrams and circuit diagrams, to communicate conceptual understanding, solve problems and make predictions (ACSPH083)

Select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions (ACSPH084)

Communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports (ACSPH085)

Science as a Human Endeavour (Units 3 & 4)

ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of datasets with which scientists work (ACSPH086)

Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power (ACSPH087)

The acceptance of science understanding can be influenced by the social, economic and cultural context in which it is considered (ACSPH088)

People can use scientific knowledge to inform the monitoring, assessment and evaluation of risk (ACSPH089)

Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question (ACSPH090)

International collaboration is often required when investing in large-scale science projects or addressing issues for the Asia-Pacific region (ACSPH091)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSPH092)

Science Understanding

Gravity and motion

The movement of free-falling bodies in Earth's gravitational field is predictable (ACSPH093)

All objects with mass attract one another with a gravitational force; the magnitude of this force can be calculated using Newton's Law of Universal Gravitation (ACSPH094)

Objects with mass produce a gravitational field in the space that surrounds them; field theory attributes the gravitational force on an object to the presence of a gravitational field (ACSPH095)

When a mass moves or is moved from one point to another in a gravitational field and its potential energy changes, work is done on or by the field (ACSPH096)

Gravitational field strength is defined as the net force per unit mass at a particular point in the field (ACSPH097)

The vector nature of the gravitational force can be used to analyse motion on inclined planes by considering the components of the gravitational force (that is, weight) parallel and perpendicular to the plane (ACSPH098)

Projectile motion can be analysed quantitatively by treating the horizontal and vertical components of the motion independently (ACSPH099)

When an object experiences a net force of constant magnitude perpendicular to its velocity, it will undergo uniform circular motion, including circular motion on a horizontal plane and around a banked track (ACSPH100)

Newton's Law of Universal Gravitation is used to explain Kepler's laws of planetary motion and to describe the motion of planets and other satellites, modelled as uniform circular motion (ACSPH101)

Mathematical representations and relationships

$w = mg$

$w =$ weight force, $m =$ mass, $g =$ acceleration due to gravity (gravitational field strength)

$F = \frac{GMm}{r^2}$ and $g = \frac{F}{m} = \frac{GM}{r^2}$

$F =$ gravitational force, $G =$ universal constant of gravitation $\left(6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}\right)$, $M =$ mass of first body, $m =$ mass of second body, $r =$ separation between the centres of mass of the two bodies, g = acceleration due to gravity

$v_y = gt + u_y$, $y = ½\,gt^2 + u_y t$, $v_y{}^2 = 2gy + u_y{}^2$, $v_x = u_x$ and $x = u_x t$

y = vertical displacement, x = horizontal displacement, $u_y =$ initial vertical velocity, $v_y =$ vertical velocity at time t, $u_x =$ initial horizontal velocity, v_x = horizontal velocity at time t, g = speed of light acceleration due to gravity, $t =$ time into flight

$v = \frac{2\pi r}{T}$

$v =$ tangential velocity, T = period

$a_c = \frac{v^2}{r}$

a_c = centripetal acceleration, v = tangential velocity, r = radius of the circle

$F_{net} = \frac{mv^2}{r}$

$F_{net} =$ net force, m = mass of body undergoing uniform circular motion, $v =$ tangential velocity, r = radius of the circle

$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$

T = period of satellite, M = mass of the central body, r = orbital radius, $G =$ universal constant of gravitation $\left(6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}\right)$

Electromagnetism

Electrostatically charged objects exert a force upon one another; the magnitude of this force can be calculated using Coulomb's Law (ACSPH102)

Point charges and charged objects produce an electric field in the space that surrounds them; field theory attributes the electrostatic force on a point charge or charged body to the presence of an electric field (ACSPH103)

A positively charged body placed in an electric field will experience a force in the direction of the field; the strength of the electric field is defined as the force per unit charge (ACSPH104)

When a charged body moves or is moved from one point to another in an electric field and its potential energy changes, work is done on or by the field (ACSPH105)

Current-carrying wires are surrounded by magnetic fields; these fields are utilised in solenoids and electromagnets

(ACSPH106)

The strength of the magnetic field produced by a current is called the magnetic flux density (ACSPH107)

Magnets, magnetic materials, moving charges and current-carrying wires experience a force in a magnetic field; this force is utilised in DC electric motors (ACSPH108)

Magnetic flux is defined in terms of magnetic flux density and area (ACSPH109)

A changing magnetic flux induces a potential difference; this process of electromagnetic induction is used in step-up and step-down transformers, DC and AC generators, and AC induction motors (ACSPH110)

Conservation of energy, expressed as Lenz's Law of electromagnetic induction, is used to determine the direction of induced current (ACSPH111)

Electromagnetic waves are transverse waves made up of mutually perpendicular, oscillating electric and magnetic fields (ACSPH112)

Oscillating charges produce electromagnetic waves of the same frequency as the oscillation; electromagnetic waves cause charges to oscillate at the frequency of the wave (ACSPH113)

Mathematical representations and relationships

$F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$

F = force, $\frac{1}{4\pi\varepsilon_o}$ = Coulomb constant $\left(9 \times 10^9\ N\,m^2\,C^{-2}\right)$, q = charge on the first object, Q = charge on the second object, r = separation between the charges

$E = \frac{F}{q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

E = electric field strength, F = force, q = charge, r = distance from the charge, $\frac{1}{4\pi\varepsilon_o}$ = Coulomb constant $\left(9 \times 10^9\ N\,m^2\,C^{-2}\right)$

$V = \frac{\Delta U}{q}$

V = electrical potential difference, ΔU = change in potential energy, q = charge

$B = \frac{\mu_o I}{2\pi r}$

B = magnetic flux density, I = current in wire, r = distance from the centre of the wire, $\frac{\mu_o}{2\pi}$ = magnetic constant $(2 \times 10^{-7} T\,A^{-1} m)$

For a straight, current carrying wire perpendicular to a magnetic field $F = BIl$

B = magnetic flux density, F = force on the wire, l =length of wire in the magnetic field, I = current in the wire

For a charge moving perpendicular to a magnetic field $F = qvB$

F = force on a charge moving in an applied magnetic field, q = charge, v = velocity of the charge, B = magnetic flux density

$\phi = BA_\perp$

ϕ = magnetic flux, $A_\perp$ = area of current loop perpendicular to the applied magnetic field, B = magnetic flux density

$emf = -\frac{n\triangle\left(BA_\perp\right)}{\Delta t} = -n\frac{\Delta\phi}{\Delta t}$

emf = induced potential difference, ϕ = change in magnetic flux, n = number of windings in the loop, $A_\perp$ = area of current loop perpendicular to the applied magnetic field, Δt = time interval over which the magnetic flux change occurs, B = magnetic flux density

$\frac{V_p}{V_s} = \frac{n_p}{n_s}$

V_p = potential difference across the primary coil, V_s = potential difference across the secondary coil, n_p = number of turns on primary coil, n_s = number of turns on secondary coil

$I_p V_p = I_s V_s$

I_p = current in primary coil, V_p = potential difference across primary coil, I_s = current in secondary coil, V_s = potential difference across secondary coil

Physics

Unit 4: Revolutions in modern physics

Unit Description

The development of quantum theory and the theory of relativity fundamentally changed our understanding of how nature operates and led to the development of a wide range of new technologies, including technologies that revolutionised the storage, processing and communication of information. In this unit, students examine observations of relative motion, light and matter that could not be explained by existing theories, and investigate how the shortcomings of existing theories led to the development of the special theory of relativity and the quantum theory of light and matter. Students evaluate the contribution of the quantum theory of light to the development of the quantum theory of the atom, and examine the Standard Model of particle physics and the Big Bang theory.

Contexts that could be investigated in this unit include technologies such as GPS navigation, lasers, modern electric lighting, medical imaging, nanotechnology, semiconductors, quantum computers and particle accelerators; and related areas of science such as space travel, the digital revolution and the greenhouse effect.

Through the investigation of appropriate contexts, students explore the ways in which these models and theories, and associated technologies, have developed over time and through interactions with social, economic, cultural and ethical considerations. They investigate the ways in which science contributes to contemporary debate about local, regional and international issues, including evaluation of risk and action for sustainability, and recognise the limitations of science to provide definitive answers in different contexts.

Through investigation, students apply their understanding of relativity, black body radiation, wave/particle duality, and the quantum theory of the atom, to make and/or explain observations of a range of phenomena such as atomic emission and absorption spectra, the photoelectric effect, lasers, and Earth's energy balance. They continue to develop skills in planning, conducting and interpreting the results of investigations, in synthesising evidence to support conclusions, and in recognising and defining the realm of validity of physical theories and models.

Learning Outcomes

By the end of this unit, students:

- understand the consequences for space and time of the equivalence principle for inertial frames of reference
- understand how the quantum theory of light and matter explains blackbody radiation, the photoelectric effect, and atomic emission and absorption spectra
- understand how the Standard Model explains the nature of and interaction between the fundamental particles that form the building blocks of matter
- understand how models and theories have developed over time, and the ways in which physical science knowledge and associated technologies interact with social, economic, cultural and ethical considerations
- use science inquiry skills to design, conduct, analyse and evaluate investigations into frames of reference, diffraction, black body and atomic emission spectra, the photoelectric effect, and photonic devices, and to communicate methods and findings
- use algebraic and graphical models to solve problems and make predictions related to the theory and applications of special relativity, quantum theory and the Standard Model
- evaluate the experimental evidence that supports the theory of relativity, wave-particle duality, the Bohr model of the atom, the Standard Model, and the Big Bang theory
- communicate physics understanding using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Science Inquiry Skills

Identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes (ACSPH114)

Design investigations, including the procedure to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSPH115)

Conduct investigations, including use of simulations and manipulation of spectral devices, safely, competently and methodically for the collection of valid and reliable data (ACSPH116)

Represent data in meaningful and useful ways, including using appropriate SI units, symbols and significant figures; organise and analyse data to identify trends, patterns and relationships; identify sources of uncertainty and techniques to minimise these uncertainties; utilise uncertainty and percentage uncertainty to determine the cumulative uncertainty resulting from calculations, and evaluate the impact of measurement uncertainty on experimental results; and select, synthesise and use evidence to make and justify conclusions (ACSPH117)

Interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments (ACSPH118)

Select, construct and use appropriate representations, including text and graphic representations of empirical and theoretical relationships, simulations, simple reaction diagrams and atomic energy level diagrams, to communicate conceptual understanding, solve problems and make predictions (ACSPH119)

Select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions (ACSPH120)

Communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports (ACSPH121)

Science as a Human Endeavour (Units 3 & 4)

ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of datasets with which scientists work (ACSPH122)

Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power (ACSPH123)

The acceptance of science understanding can be influenced by the social, economic and cultural context in which it is considered (ACSPH124)

People can use scientific knowledge to inform the monitoring, assessment and evaluation of risk (ACSPH125)

Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question (ACSPH126)

International collaboration is often required when investing in large-scale science projects or addressing issues for the Asia-Pacific region (ACSPH127)

Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability (ACSPH128)

Science Understanding

Special relativity

Observations of objects travelling at very high speeds cannot be explained by Newtonian physics (for example, the dilated half-life of high-speed muons created in the upper atmosphere, and the momentum of high speed particles in particle accelerators) (ACSPH129)

Einstein's special theory of relativity predicts significantly different results to those of Newtonian physics for velocities approaching the speed of light (ACSPH130)

The special theory of relativity is based on two postulates: that the speed of light in a vacuum is an absolute constant, and that all inertial reference frames are equivalent (ACSPH131)

Motion can only be measured relative to an observer; length and time are relative quantities that depend on the observer's frame of reference (ACSPH132)

Relativistic momentum increases at high relative speed and prevents an object from reaching the speed of light (ACSPH133)

The concept of mass-energy equivalence emerged from the special theory of relativity and explains the source of the energy produced in nuclear reactions (ACSPH134)

Mathematical representations and relationships

$$t = \frac{t_o}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

t = time interval in the moving frame as measured by the observer in the proper frame, t_o = proper time interval (time interval for a clock at rest in the observer's frame), v = relative speed of the two inertial frames, c = speed of light in a vacuum $\left(3 \times 10^8 \text{ m s}^{-1}\right)$

$$l = l_o \sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

l = length interval in the frame moving at velocity (v) with respect to the observer, l_o = proper length (length in a frame at rest with respect to the observer), c = speed of light $\left(3 \times 10^8 \text{ m s}^{-1}\right)$

$$p_v = \frac{mv}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

p_v = relativistic momentum for an object moving with velocity, v, with respect to the observer, m = mass, c = speed of light $\left(3 \times 10^8 \text{ m s}^{-1}\right)$

$$\Delta E = \Delta m c^2$$

ΔE = change in energy, Δm = change in mass, c = speed of light $\left(3 \times 10^8 \text{ m s}^{-1}\right)$

Quantum theory

Atomic phenomena and the interaction of light with matter indicate that states of matter and energy are quantised into discrete values (ACSPH135)

On the atomic level, electromagnetic radiation is emitted or absorbed in discrete packets called photons; the energy of a photon is proportional to its frequency; and the constant of proportionality, Planck's constant, can be determined experimentally (for example, from the photoelectric effect or the threshold voltage of coloured LEDs) (ACSPH136)

A wide range of phenomena, including black body radiation and the photoelectric effect, are explained using the concept of light quanta (ACSPH137)

Atoms of an element emit and absorb specific wavelengths of light that are unique to that element; this is the basis of spectral analysis (ACSPH138)

The Bohr model of the hydrogen atom integrates light quanta and atomic energy states to explain the specific wavelengths in the hydrogen spectrum and in the spectra of other simple atoms; the Bohr model enables line spectra to be correlated with atomic energy-level diagrams (ACSPH139)

On the atomic level, energy and matter exhibit the characteristics of both waves and particles (for example, Young's double slit experiment is explained with a wave model but produces the same interference pattern when one photon at a time is passed through the slits) (ACSPH140)

Mathematical representations and relationships

$\mathrm{E = hf}$

E = energy of photon, f = frequency, h = Planck's constant $\left(6.626 \times 10^{-34}\ \mathrm{J\ s}\right)$

$\lambda_{\mathrm{max}} = \frac{\mathrm{b}}{\mathrm{T}}$

λ_{max} = peak wavelength , T = absolute temperature, b = Wien's displacement constant $(2.898 \times 10^{-3}\ \mathrm{m\ K})$

$\mathrm{E_k = hf - W}$

$\mathrm{E_k}$ = kinetic energy of photoelectron, hf = energy of incident photon, W = work function of the material

$\lambda = \frac{\mathrm{h}}{\mathrm{p}}$

λ = wavelength associated with particle, p = momentum of particle, h = Planck's constant $\left(6.626 \times 10^{-34}\ \mathrm{J\ s}\right)$

$\mathrm{n}\lambda = 2\pi \mathrm{r}$

n = an integer 1, 2, 3, 4... , λ = wavelength of electron, r = orbital radius of electron

$\mathrm{mvr} = \frac{\mathrm{nh}}{2\pi}$

m = mass of electron, v = velocity of electron, r = orbital radius of electron, n = an integer 1, 2, 3, 4, etc., h = Planck's constant $\left(6.626 \times 10^{-34}\ \mathrm{J\ s}\right)$

$\frac{1}{\lambda} = \mathrm{R}\left(\frac{1}{\mathrm{n_f^2}} - \frac{1}{\mathrm{n_i^2}}\right)$

λ = wavelength of spectral line, $\mathrm{n_i}$ = principal quantum number of initial electron state, $\mathrm{n_f}$ = principal quantum number of final electron state, R = Rydberg's constant $(1.097 \times 10^{7}\ \mathrm{m^{-1}})$

The Standard Model

The Standard Model is based on the premise that all matter in the universe is made up from elementary matter particles called quarks and leptons; quarks experience the strong force, leptons do not (ACSPH141)

The Standard Model explains three of the four fundamental forces (strong, weak and electromagnetic forces) in terms of an exchange of force-carrying particles called gauge bosons; each force is mediated by a different type of gauge boson (ACSPH142)

Reactions between particles can be represented by simple reaction diagrams (ACSPH143)

Lepton number and baryon number are examples of quantities that are conserved in all reactions between particles; conservation laws can be used to support or invalidate proposed reactions (ACSPH144)

Variations of reactions can be found by applying symmetry operations to known reactions. These include reversing the direction of the reaction diagram (time reversal symmetry) and replacing all particles with their antiparticles and vice versa (charge reversal symmetry). Energy and momentum must also be conserved for such a reaction to be possible. (ACSPH145)

High-energy particle accelerators are used to test theories of particle physics including the Standard Model (ACSPH146)

The Standard Model is used to describe the evolution of forces and the creation of matter in the Big Bang theory (ACSPH147)

Units 3 and 4 Achievement Standards

Physics concepts, models and applications

A	B	C	D	E
For the physical systems studied, the student:	*For the physical systems studied, the student:*	*For the physical systems studied, the student:*	*For the physical systems studied, the*	*For the physical systems studied,*

Physics concepts, models and applications

			student:	*the student:*

Physics concepts, models and applications

• analyses physical phenomena in complex scenarios at a range of scales qualitatively and quantitatively • analyses the relationships between mass, energy and properties of physical systems qualitatively and quantitatively • explains the theories and model/s used to explain the system, the supporting evidence, and their limitations and assumptions • applies theories and models of systems and processes to explain phenomena, critically analyse complex problems, and make reasoned, plausible predictions in unfamiliar contexts *For the physical science contexts studied, the student:*	• explains physical phenomena at a range of scales qualitatively and quantitatively • explains the relationships between mass, energy and properties of physical systems qualitatively and quantitatively • describes the theories and model/s used to explain the system, some supporting evidence, and their limitations • applies theories and models of systems and processes to explain phenomena, analyse problems, and make plausible	• explains physical phenomena qualitatively and quantitatively • explains the relationships between mass, energy and properties of physical systems qualitatively • describes key aspects of a theory or model used to explain system processes, and the phenomena to which they can be applied • applies theories or models of systems and processes to explain phenomena, interpret problems, and	• describes physical phenomena qualitatively • describes how components and properties of physical systems are related • describes key aspects of a theory or model used to explain a system process • describes phenomena, interprets simple problems, and makes predictions in familiar contexts *For the physical science contexts studied, the student:*	• describes properties of physical phenomena • describes components of physical systems • identifies aspects of a theory or model related to a system process • describes phenomena and makes simple predictions in familiar contexts *For the physical science contexts studied, the student:* • identifies that physical

Physics concepts, models and applications

• analyses the roles of collaboration, debate and review, and technologies, in the development of physical science theories and models • evaluates how physical science has been used in concert with other sciences to meet diverse needs and to inform decision making; and how these applications are influenced by interacting social, economic and ethical factors	predictions in unfamiliar contexts *For the physical science contexts studied, the student:* • explains the roles of collaboration, debate and review, and technologies, in the development of physical science theories and models • explains how physical science has been used to meet diverse needs and to inform decision making; and how these applications are influenced by social, economic and ethical factors	make plausible predictions in some unfamiliar contexts *For the physical science contexts studied, the student:* • describes the roles of collaboration and review, and technologies, in the development of physical science theories or models • discusses how physical science has been used to meet needs and to inform decision making, and some social, economic or ethical implications of these applications	• describes the roles of communication and new evidence in developing physical science knowledge • describes ways in which physical science has been used in society to meet needs, and identifies some implications of these applications	science knowledge has changed over time • identifies ways in which physical science has been used in society to meet needs

Physics inquiry skills

A	B	C	D	E
For the physical science contexts studied, the student:	*For the physical science contexts studied, the*	*For the physical science contexts studied, the*	*For the physical science contexts*	*For the physical science contexts*

Physics inquiry skills

	student:	student:	studied, the student:	studied, the student:

Physics inquiry skills

Physics inquiry skills

• designs, conducts				

Physics inquiry skills

• designs, conducts and improves safe, ethical investigations that efficiently collect valid, reliable data in response to a complex question or problem • analyses data sets to explain causal and correlational relationships, the reliability of the data, and sources of error • justifies their selection of data as evidence, analyses evidence with reference to models and/or theories, and develops evidence-based conclusions that identify limitations • evaluates processes and claims, and provides an evidence-based critique and discussion of improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve complex and unfamiliar problems • communicates effectively and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs, conducts and improves safe, ethical investigations that collect valid, reliable data in response to a question or problem • analyses data sets to identify causal and correlational relationships, anomalies, and sources of error • selects appropriate data as evidence, interprets evidence with reference to models and/or theories, and provides evidence for conclusions • evaluates processes and claims, provides a critique with reference to evidence, and identifies possible improvements or alternatives • selects, constructs and uses appropriate representations to describe complex relationships and solve unfamiliar problems • communicates clearly and accurately in a range of modes, styles and genres for specific audiences and purposes	• designs and conducts safe, ethical investigations that collect valid data in response to a question or problem • analyses data to identify relationships, anomalies, and sources of error • selects data to demonstrate relationships linked to physical science knowledge, and provides conclusions based on data • evaluates processes and claims, and suggests improvements or alternatives • selects, constructs and uses appropriate representations to describe relationships and solve problems • communicates clearly in a range of modes, styles and genres for specific purposes	• plans and conducts safe, ethical investigations to collect data in response to a question or problem • analyses data to identify trends and anomalies • selects data to demonstrate trends, and presents simple conclusions based on data • considers processes and claims from a personal perspective • constructs and uses simple representations to describe relationships and solve simple problems • communicates in a range of modes and genres	• follows a procedure to conduct safe, ethical investigations to collect data • identifies trends in data • selects data to demonstrate trends • considers claims from a personal perspective • constructs and uses simple representations to describe phenomena • communicates in a range of modes

Physics Glossary

Absolute uncertainty
Estimate of the dispersion of the measurement result; the range of values around the measurement result that is most likely to include the true value.

Accuracy
The extent to which a measurement result represents the quantity it purports to measure; an accurate measurement result includes an estimate of the true value and an estimate of the uncertainty.

Algebraic representation
A set of symbols linked by mathematical operations; the set of symbols summarise relationships between variables.

Animal ethics
Animal ethics involves consideration of respectful, fair and just treatment of animals. The use of animals in science involves consideration of replacement (substitution of insentient materials for conscious living animals), reduction (using only the minimum number of animals to satisfy research statistical requirements) and refinement (decrease in the incidence or severity of 'inhumane' procedures applied to those animals that still have to be used).

Anomalous data
Data that does not fit a pattern; outlier.

Data
The plural of datum; the measurement of an attribute, for example, the volume of gas or the type of rubber. This does not necessarily mean a single measurement: it may be the result of averaging several repeated measurements. Data may be quantitative or qualitative and be from primary or secondary sources.

Evidence
In science, evidence is data that is considered reliable and valid and which can be used to support a particular idea, conclusion or decision. Evidence gives weight or value to data by considering its credibility, acceptance, bias, status, appropriateness and reasonableness.

Fundamental forces
Four fundamental forces have been identified. They are, in order from strongest to weakest, the strong, electromagnetic, weak and gravity forces.

Genre
The categories into which texts are grouped; genre distinguishes texts on the basis of their subject matter, form and structure (for example, scientific reports, field guides, explanations, procedures, biographies, media articles, persuasive texts, narratives).

Hypothesis
A tentative explanation for an observed phenomenon, expressed as a precise and unambiguous statement that can be supported or refuted by experiment.

Investigation

A scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities. Investigations can include observation, research, field work, laboratory experimentation and manipulation of simulations.

Law

A statement describing invariable relationships between phenomena in specified conditions, frequently expressed mathematically.

Measurement discrepancy

The difference between the measurement result and a currently accepted or standard value of a quantity.

Media texts

Spoken, print, graphic or electronic communications with a public audience. Media texts can be found in newspapers, magazines and on television, film, radio, computer software and the internet.

Mode

The various processes of communication – listening, speaking, reading/viewing and writing/creating.

Model

A representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea.

Primary data

Data collected directly by a person or group.

Primary source

Report of data created by the person or persons directly involved in observations of one or more events, experiments, investigations or projects.

Random error

Uncontrollable effects of the measurement equipment, procedure and environment on a measurement result; the magnitude of random error for a measurement result can be estimated by finding the spread of values around the average of independent, repeated measurements of the quantity.

Reliability

The degree to which an assessment instrument or protocol consistently and repeatedly measures an attribute achieving similar results for the same population.

Reliable data

Data that have been judged to have a high level of reliability; reliability is the degree to which an assessment instrument or protocol consistently and repeatedly measures an attribute achieving similar results for the same population.

Representation

A verbal, visual, physical or mathematical demonstration of understanding of a science concept or concepts. A concept can be represented in a range of ways and using multiple modes.

Research

To locate, gather, record, attribute and analyse information in order to develop understanding.

Research ethics

Norms of conduct that determine ethical research behaviour; research ethics are governed by principles such as honesty, objectivity, integrity, openness and respect for intellectual property and include consideration of animal ethics.

Risk assessment

Evaluations performed to identify, assess and control hazards in a systematic way that is consistent, relevant and applicable to all school activities. Requirements for risk assessments related to particular activities will be determined by jurisdictions, schools or teachers as appropriate.

Secondary data

Data collected by a person or group other than the person or group using the data.

Secondary source

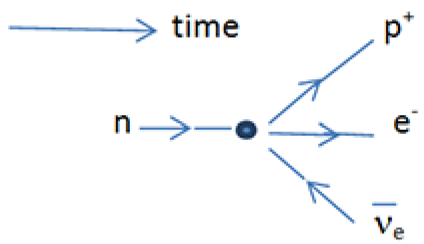
Information that has been compiled from records of primary sources by a person or persons not directly involved in the primary event.

Significant figures

The use of place value to represent a measurement result accurately and precisely.

Simple reaction diagrams

A visual representation of reactions between subatomic particles. In the diagram, time runs from left to right. The lines represent particles and the circle represents the reaction process. Antiparticles have the time arrow reversed.



Simulation

A representation of a process, event or system which imitates a real or idealised situation.

System

A group of interacting objects, materials or processes that form an integrated whole. Systems can be open or closed.

Systematic error

The contribution to the uncertainty in a measurement result that is identifiable and quantifiable, for example, imperfect calibration of measurement instruments.

Theory

A set of concepts, claims and/or laws that can be used to explain and predict a wide range of related observed or observable phenomena. Theories are typically founded on clearly identified assumptions, are testable, produce reproducible results and have explanatory power.

Uncertainty

Range of values for a measurement result, taking account of the likely values that could be attributed to the measurement result given the measurement equipment, procedure and environment.

Validity

The extent to which tests measure what was intended; the extent to which data, inferences and actions produced from tests and other processes are accurate.

Glossary

Abstract

Abstract scenario: a scenario for which there is no concrete referent provided.

Account

Account for: provide reasons for (something).

Give an account of: report or describe an event or experience.

Taking into account: considering other information or aspects.

Analyse

Consider in detail for the purpose of finding meaning or relationships, and identifying patterns, similarities and differences.

Apply

Use, utilise or employ in a particular situation.

Assess

Determine the value, significance or extent of (something).

Coherent

Orderly, logical, and internally consistent relation of parts.

Communicates

Conveys knowledge and/or understandings to others.

Compare

Estimate, measure or note how things are similar or dissimilar.

Complex

Consisting of multiple interconnected parts or factors.

Considered

Formed after careful thought.

Critically analyse

Examine the component parts of an issue or information, for example the premise of an argument and its plausibility, illogical reasoning or faulty conclusions

Critically evaluate

Evaluation of an issue or information that includes considering important factors and available evidence in making critical judgement that can be justified.

Deduce

Arrive at a conclusion by reasoning.

Demonstrate
Give a practical exhibition as an explanation.

Describe
Give an account of characteristics or features.

Design
Plan and evaluate the construction of a product or process.

Develop
In history: to construct, elaborate or expand.

In English: begin to build an opinion or idea.

Discuss
Talk or write about a topic, taking into account different issues and ideas.

Distinguish
Recognise point/s of difference.

Evaluate
Provide a detailed examination and substantiated judgement concerning the merit, significance or value of something.

In mathematics: calculate the value of a function at a particular value of its independent variables.

Explain
Provide additional information that demonstrates understanding of reasoning and/or application.

Familiar
Previously encountered in prior learning activities.

Identify
Establish or indicate who or what someone or something is.

Integrate
Combine elements.

Investigate
Plan, collect and interpret data/information and draw conclusions about.

Justify
Show how an argument or conclusion is right or reasonable.

Locate
Identify where something is found.

Manipulate
Adapt or change.

Non-routine

Non-routine problems: Problems solved using procedures not previously encountered in prior learning activities.

Reasonableness

Reasonableness of conclusions or judgements: the extent to which a conclusion or judgement is sound and makes sense

Reasoned

Reasoned argument/conclusion: one that is sound, well-grounded, considered and thought out.

Recognise

Be aware of or acknowledge.

Relate

Tell or report about happenings, events or circumstances.

Represent

Use words, images, symbols or signs to convey meaning.

Reproduce

Copy or make close imitation.

Responding

In English: When students listen to, read or view texts they interact with those texts to make meaning. Responding involves students identifying, selecting, describing, comprehending, imagining, interpreting, analysing and evaluating.

Routine problems

Routine problems: Problems solved using procedures encountered in prior learning activities.

Select

Choose in preference to another or others.

Sequence

Arrange in order.

Solve

Work out a correct solution to a problem.

Structured

Arranged in a given organised sequence.

In Mathematics: When students provide a structured solution, the solution follows an organised sequence provided by a third party.

Substantiate

Establish proof using evidence.

Succinct

Written briefly and clearly expressed.

Sustained

Consistency maintained throughout.

Synthesise

Combine elements (information/ideas/components) into a coherent whole.

Understand

Perceive what is meant, grasp an idea, and to be thoroughly familiar with.

Unfamiliar

Not previously encountered in prior learning activities.