Physics

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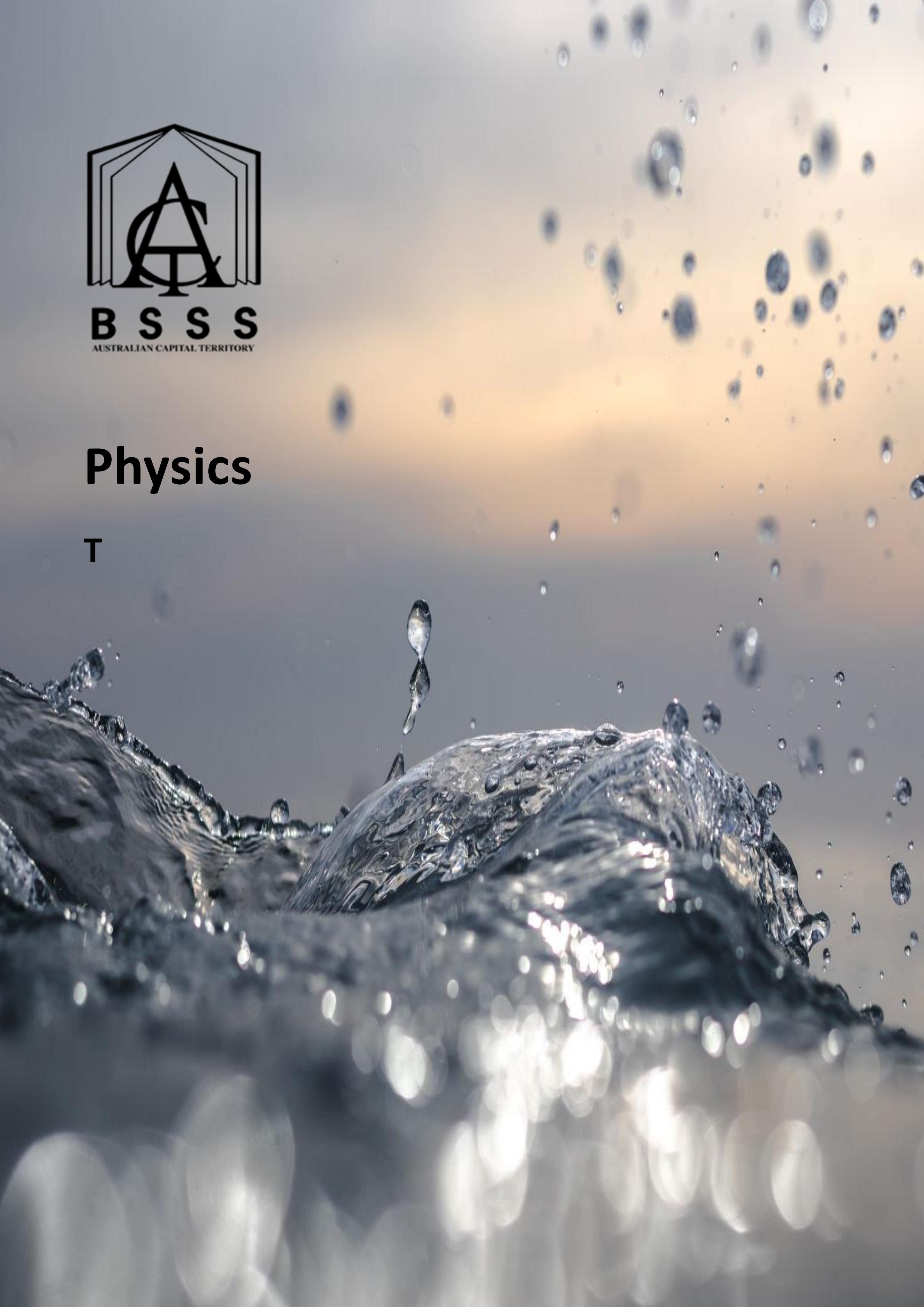

Cover Art provided by Canberra College student Aidan Giddings

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The ACT Senior Secondary System

The ACT senior secondary system recognises a range of university, vocational or life skills pathways.

The system is based on the premise that teachers are experts in their area: they know their students and community and are thus best placed to develop curriculum and assess students according to their needs and interests. Students have ownership of their learning and are respected as young adults who have a voice.

A defining feature of the system is school-based curriculum and continuous assessment. School-based curriculum provides flexibility for teachers to address students' needs and interests. College teachers have an opportunity to develop courses for implementation across ACT schools. Based on the courses that have been accredited by the BSSS, college teachers are responsible for developing programs of learning. A program of learning is developed by individual colleges to implement the courses and units they are delivering.

Teachers must deliver all content descriptions; however, they do have flexibility to emphasise some content descriptions over others. It is at the discretion of the teacher to select the texts or materials to demonstrate the content descriptions. Teachers can choose to deliver course units in any order and teach additional (not listed) content provided it meets the specific unit goals.

School-based continuous assessment means that students are continually assessed throughout years 11 and 12, with both years contributing equally to senior secondary certification. Teachers and students are positioned to have ownership of senior secondary assessment. The system allows teachers to learn from each other and to refine their judgement and develop expertise.

Senior secondary teachers have the flexibility to assess students in a variety of ways. For example: multimedia presentation, inquiry-based project, test, essay, performance and/or practical demonstration may all have their place. College teachers are responsible for developing assessment instruments with task specific rubrics and providing feedback to students.

The integrity of the ACT Senior Secondary Certificate is upheld by a robust, collaborative and rigorous structured consensus-based peer reviewed moderation process. System moderation involves all Year 11 and 12 teachers from public, non-government and international colleges delivering the ACT Senior Secondary Certificate.

Only students who desire a pathway to university are required to sit a general aptitude test, referred to as the ACT Scaling Test (AST), which moderates student course scores across subjects and colleges. Students are required to use critical and creative thinking skills across a range of disciplines to solve problems. They are also required to interpret a stimulus and write an extended response.

Senior secondary curriculum makes provision for student-centred teaching approaches, integrated and project-based learning inquiry, formative assessment and teacher autonomy. ACT Senior Secondary Curriculum makes provision for diverse learners and students with mild to moderate intellectual disabilities, so that all students can achieve an ACT Senior Secondary Certificate.

The ACT Board of Senior Secondary Studies (BSSS) leads senior secondary education. It is responsible for quality assurance in senior secondary curriculum, assessment and certification. The Board consists of representatives from colleges, universities, industry, parent organisations and unions. The Office of the Board of Senior Secondary Studies (OBSSS) consists of professional and administrative staff who support the Board in achieving its objectives and functions.

ACT Senior Secondary Certificate

Courses of study for the ACT Senior Secondary Certificate:

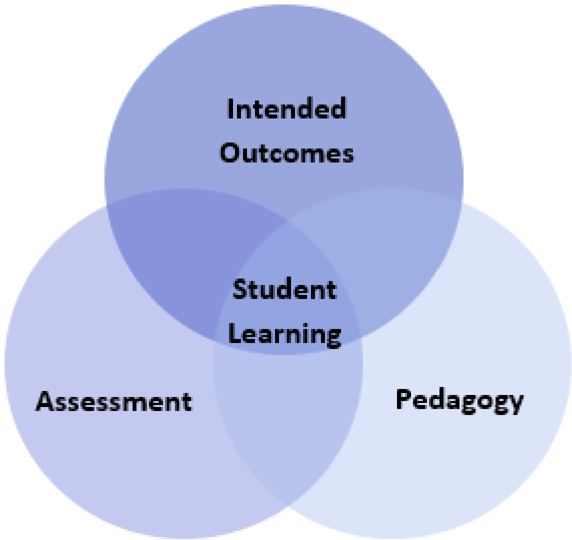
- provide a variety of pathways, to meet different learning needs and encourage students to complete their secondary education
- enable students to develop the essential capabilities for twenty-first century learners
- empower students as active participants in their own learning
- engage students in contemporary issues relevant to their lives
- foster students' intellectual, social and ethical development
- nurture students' wellbeing, and physical and spiritual development
- enable effective and respectful participation in a diverse society.

Each course of study:

- comprises an integrated and interconnected set of knowledge, skills, behaviours and dispositions that students develop and use in their learning across the curriculum
- is based on a model of learning that integrates intended student outcomes, pedagogy and assessment
- outlines teaching strategies which are grounded in learning principles and encompass quality teaching
- promotes intellectual quality, establish a rich learning environment and generate relevant connections between learning and life experiences
- provides formal assessment and certification of students' achievements.

Underpinning beliefs

- All students are able to learn.
- Learning is a partnership between students and teachers.
- Teachers are responsible for advancing student learning.



Learning Principles

1. Learning builds on existing knowledge, understandings and skills.
   (Prior knowledge)
2. When learning is organised around major concepts, principles and significant real-world issues, within and across disciplines, it helps students make connections and build knowledge structures.
   (Deep knowledge and connectedness)
3. Learning is facilitated when students actively monitor their own learning and consciously develop ways of organising and applying knowledge within and across contexts.
   (Metacognition)
4. Learners' sense of self and motivation to learn affects learning.
   (Self-concept)
5. Learning needs to take place in a context of high expectations.
   (High expectations)
6. Learners learn in different ways and at different rates.
   (Individual differences)
7. Different cultural environments, including the use of language, shape learners' understandings and the way they learn.
   (Socio-cultural effects)
8. Learning is a social and collaborative function as well as an individual one.
   (Collaborative learning)
9. Learning is strengthened when learning outcomes and criteria for judging learning are made explicit and when students receive frequent feedback on their progress.
   (Explicit expectations and feedback)

General Capabilities

All courses of study for the ACT Senior Secondary Certificate should enable students to develop essential capabilities for twenty-first century learners. These 'capabilities' comprise an integrated and interconnected set of knowledge, skills, behaviours and dispositions that students develop and use in their learning across the curriculum.

The capabilities include:

- literacy
- numeracy
- information and communication technology (ICT)
- critical and creative thinking
- personal and social
- ethical behaviour
- intercultural understanding

Courses of study for the ACT Senior Secondary Certificate should be both relevant to the lives of students and incorporate the contemporary issues they face. Hence, courses address the following three priorities. These priorities are:

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability

Elaboration of these General Capabilities and priorities is available on the ACARA website at www.australiancurriculum.edu.au.

Literacy

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 evaluate 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

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 Technology (ICT) capability

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

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

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 understanding

Ethical understanding 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, evaluate 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

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.

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.

Aboriginal and Torres Strait Islander Histories and Cultures

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.

Asia and Australia's Engagement with Asia

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.

Sustainability

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.

Physics T

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.

Goals

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.

Student Group

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.

Unit Titles

- Linear Motion and Waves
- Thermal, Nuclear and Electrical Physics
- Gravity and Electromagnetism
- Revolutions in Modern Physics

In Units 1 and 2 *(Linear Motion and Waves* and *Thermal, Nuclear and Electrical Physics*), 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, (*Gravity and Electromagnetism* and *Revolutions in Modern Physics*) 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.

Organisation of Content

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

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.

Assessment

The identification of criteria within the achievement standards and assessment task types and weightings provides a common and agreed basis for the collection of evidence of student achievement.

Assessment Criteria (the dimensions of quality that teachers look for in evaluating student work) provide a common and agreed basis for judgement of performance against unit and course goals, within and across colleges. Over a course, teachers must use all these criteria to assess students' performance but are not required to use all criteria on each task. Assessment criteria are to be used holistically on a given task and in determining the unit grade.

Assessment Tasks elicit responses that demonstrate the degree to which students have achieved the goals of a unit based on the assessment criteria. The Common Curriculum Elements (CCE) is a guide to developing assessment tasks that promote a range of thinking skills (see Appendix C). It is highly desirable that assessment tasks engage students in demonstrating higher order thinking.

Rubrics are constructed for individual tasks, informing the assessment criteria relevant for a particular task and can be used to assess a continuum that indicates levels of student performance against each criterion.

Assessment Criteria

Students will be assessed on the degree to which they demonstrate an understanding of:

- concepts, models and application
- contexts
- inquiry skills.

Assessment Task Types

Suggested tasks

Individual tasks may incorporate one or more of the following:

- models
- commentary
- debate
- portfolio/journal
- field work
- investigation
- document/source analysis
- practical report
- role play
- research report
- test/quiz
- seminar/workshop/lecture
- poster
- response to stimulus
- essay
- multimedia presentation
- creative response
- interview
- discussion forum
- rationale/validation
- practical skills

It is recommended that a student conceived investigation be undertaken at least once during a minor and twice during a major. This investigation may either be theoretical or practical, or a combination of both.

Weightings in A/T/M 1.0 and 0.5 Units:

No task to be weighted more than 45% for a standard 1.0 unit.

Additional Assessment Information

Requirements

- For a standard unit (1.0), students must complete a minimum of three assessment tasks and a maximum of five.
- For a half standard unit (0.5), students must complete a minimum of two and a maximum of three assessment tasks.
- Students must experience a variety of task types and different modes of communication to demonstrate the Achievement Standards in both theoretical and practical tasks.
- All Achievement Standards must be demonstrated in standard (1.0) or half-standard (0.5) units.
- Task types need to be selected to address all Achievement Standards within the Concepts, Models & Applications, Contexts and Inquiry Skills strands across a standard (1.0) or half-standard (0.5) unit.
- For tasks completed in unsupervised conditions, schools need to have mechanisms to uphold academic integrity, for example: student declaration, plagiarism software, oral defence, interview, or other validation tasks.

Achievement Standards

Years 11 and 12 achievement standards are written for A/T courses. A single achievement standard is written for M courses.

A Year 12 student in any unit is assessed using the Year 12 achievement standards. A Year 11 student in any unit is assessed using the Year 11 achievement standards. Year 12 achievement standards reflect higher expectations of student achievement compared to the Year 11 achievement standards. Years 11 and 12 achievement standards are differentiated by cognitive demand, the number of dimensions and the depth of inquiry.

An achievement standard cannot be used as a rubric for an individual assessment task. Assessment is the responsibility of the college. Student tasks may be assessed using rubrics or marking schemes devised by the college. A teacher may use the achievement standards to inform development of rubrics. The verbs used in achievement standards may be reflected in the rubric. In the context of combined Years 11 and 12 classes, it is best practice to have a distinct rubric for Years 11 and 12. These rubrics should be available for students prior to completion of an assessment task so that success criteria are clear.

BSSS Achievement Standards for Science T Course – Year 11

	A student who achieves an **A** grade typically	A student who achieves a **B** grade typically	A student who achieves a **C** grade typically	A student who achieves a **D** grade typically	A student who achieves an **E** grade typically
Concepts, Models & Applications	• evaluates the fundamental properties and functions of system components, processes and interactions, and the effects of factors across a range of scales	• analyses the fundamental properties and functions of system components, processes and interactions, and the effects of factors across a range of scales	• explains the fundamental properties and functions of system components, processes and interactions and the effects of factors across a range of scales	• describes the fundamental properties and functions, and with some description of system components, processes and interactions, and the effects of factors across a range of scales	• identifies the fundamental properties and functions of system and identifies components, processes and interactions, and the effects of factors across a range of scales
	• evaluates the nature, functions, limitations and applications of theories and models using evidence, in unfamiliar contexts	• analyses the nature, functions, limitations and applications of theories and models using evidence, in familiar contexts	• explains the nature, functions, limitations and applications of theories and models using evidence, in familiar contexts	• describes the nature, functions, limitations and applications of theories and models with supporting evidence	• identifies the nature, functions, applications, and some possible limitations of theories and models, with some evidence
	• analyses evidence with reference to models and/or theories, and develops evidence-based conclusions and evaluates limitations	• assesses evidence with reference to models and/or theories, and develops evidence-based conclusions and discusses limitations	• explains evidence with reference to models and/or theories, and develops evidence-based conclusions and identifies limitations	• describes evidence, and develops conclusions with some reference to models and/or theories	• identifies evidence, and asserts conclusions with little or no reference to models and/or theories
Contexts	• evaluates epistemology, role of peer review, collaboration and technology in developing knowledge	• analyses epistemology, role of peer review and technology in developing knowledge	• explain epistemology, role of peer review and technology in developing knowledge	• describes the role of peer review in developing knowledge	• identifies that scientific knowledge has changed over time
	• evaluates the influence of social, economic, ethical and cultural factors on Science	• analyses the influence of social, economic, ethical and cultural factors on Science	• explains the influence of social, economic, ethical and cultural factors on Science	• describes the influence of social, economic, ethical and cultural factors on Science	• identifies the influence of social, economic, ethical and cultural factors on Science
Inquiry Skills	• designs, conducts and improves safe, ethical and original inquiries individually and collaboratively, that collect valid, reliable data in response to a complex question	• designs, conducts and improves safe, ethical inquiries individually and collaboratively, that collect valid, reliable data in response to a question	• plans and conducts safe, ethical inquiries individually and collaboratively, that collect valid data in response to a familiar question	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data in response to a simple question with varying success	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data with little or no connection to a question
	• analyses causal and correlational relationships, anomalies, reliability and validity of data and representations, and analyses errors	• analyses causal and correlational relationships, anomalies, reliability and validity of data and representations, and discusses errors	• explains causal and correlational relationships, anomalies, reliability and validity of data and representations, and cites common errors	• describes trends, relationships and anomalies in data, identifies anomalies, and some possible sources of error	• identifies trends and relationships in data, with little or no reference to sources of error
	• analyses processes and claims, and provides a critique based on evidence, and analyses alternatives	• assesses processes and claims, and provides a critique with reference to evidence, and analyses alternatives	• explains processes and claims, and identifies alternatives with reference to reliable evidence	• describes processes and claims, and identifies the need for improvements with some reference to evidence	• identifies processes and the need for some improvements, with little or no reference to evidence
	• reflects with insight on own thinking and that of others, and evaluates planning, time management, and use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking and analyses planning, time management, use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking and explains planning, time management, use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking, with reference to planning and the use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking with little or no reference to planning, time management, and use of work strategies to work independently and collaboratively
	• communicates concisely, effectively and accurately, demonstrating scientific literacy in a range of modes, styles, representations, and genres for specific audiences and purposes, with appropriate evidence and accurate referencing	• communicates clearly and accurately, demonstrating scientific literacy in a range of modes, styles, representations and genres for specific audiences and purposes, with appropriate evidence and accurate referencing	• communicates accurately demonstrating scientific literacy, in a range of modes, styles, representations, and genres for specific purposes, with appropriate evidence and mostly consistent referencing	• communicates demonstrating some scientific literacy, in a range of modes, representations, and genres with some evidence and inconsistent referencing	• communicates demonstrating limited scientific literacy, in a range of modes and representations, with inconsistent and inaccurate referencing

BSSS Achievement Standards for Science T Course – Year 12

	A student who achieves an **A** grade typically	A student who achieves a **B** grade typically	A student who achieves a **C** grade typically	A student who achieves a **D** grade typically	A student who achieves an **E** grade typically
Concepts, Models & Applications	• evaluates the properties and functions of system components, processes and interactions, and the interplay and effects of factors across a range of scales	• analyses the properties and functions of system components, processes and interactions, and the interplay and effects of factors across a range of scales	• explains the fundamental properties and functions of system components, processes and interactions, and the effects of factors across a range of scales	• describes the fundamental properties and functions of system components, processes and interactions, and the effects of one or more factors	• identifies the fundamental properties and functions of system components, processes and interactions, and some affective factors
	• evaluates applications, limitations, and predictions of theories and models to explain systems and create solutions, with evidence, in unfamiliar contexts	• analyses applications, limitations, and predictions of theories and models to explain systems and create plausible solutions, with evidence in familiar contexts	• explains applications, limitations, and predictions of theories and models to explain systems and create plausible solutions in familiar contexts	• describes the nature, functions, limitations and applications of theories and models to create solutions to problems with supporting evidence	• identifies the nature, functions, limitations and applications of theories and models, and suggest solutions to problems with supporting evidence
	• evaluates evidence with reference to analysis of models and/or theories, and develops evidence-based conclusions and evaluates limitations	• analyses evidence with reference to models and/or theories, and develops evidence-based conclusions and discusses limitations	• explains evidence with reference to models and/or theories, and develops evidence-based conclusions and identifies limitations	• describes evidence, and develops conclusions with some reference to models and/or theories	• identifies evidence, and asserts conclusions with little or no reference to models and/or theories
Contexts	• evaluates epistemology, role of peer review, collaboration, and technology in developing knowledge	• analyses epistemology, role of peer review and technology in developing knowledge	• explains epistemology, role of peer review and technology in developing knowledge	• describes role of peer review and technology in developing knowledge	• identifies that scientific knowledge has changed over time
	• evaluates the influence of social, economic, ethical and cultural factors on Science	• analyses the influence of social, economic, ethical and cultural factors on Science	• explains the influence of social, economic, ethical and cultural factors on Science	• describes the influence of social, economic, ethical and cultural factors on Science	• identifies the influence of social, economic, ethical and cultural factors on Science
Inquiry Skills	• designs, conducts and improves safe, ethical and original inquiries individually and collaboratively, that collect valid, reliable data in response to a complex question	• designs, conducts and improves safe, ethical inquiries individually and collaboratively, that collect valid, reliable data in response to a question	• plans and conducts safe, ethical inquiries individually and collaboratively, that collect valid data in response to a familiar question	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data in response to a simple question with varying success	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data with little or no connection to a question
	• evaluates cause and correlation, anomalies, reliability and validity of data and representations, and evaluates errors	• analyses cause and correlation, anomalies, reliability and validity of data and representations, and analyses errors	• explains causal and correlational relationships, anomalies, reliability and validity of data and representations, and discusses common errors	• describes trends, relationships and anomalies in data, identifies anomalies, and cites sources of error	• identifies trends and relationships in data with reference to sources of error
	• evaluates processes and claims, and provides a critique based on evidence, and evaluates alternatives	• analyses processes and claims, and provides a critique with reference to evidence, and analyses alternatives	• explains processes and claims, and identifies alternatives with reference to reliable evidence	• describes processes and claims, and identifies the need for improvements with some reference to evidence	• identifies processes and the need for some improvements, with little or no reference to evidence
	• reflects with insight on own thinking and that of others, evaluates planning, time management, and use of appropriate independent and collaborative work strategies	• reflects on their own thinking and analyses planning, time management, and use of appropriate independent and collaborative work strategies	• reflects on their own thinking and explains planning, time management, and use of appropriate independent and collaborative work strategies	• reflects on their own thinking, with reference to planning and the use of appropriate independent and collaborative work strategies	• reflects on their own thinking with little or no reference to planning, time management, and use of appropriate independent and collaborative work strategies
	• communicates concisely, effectively and accurately, with scientific literacy in a range of modes, representations, and genres for specific audiences and purposes, and accurate referencing	• communicates clearly and accurately, with scientific literacy in a range of modes, representations and genres for specific audiences and purposes, and accurate referencing	• communicates accurately demonstrating scientific literacy, in a range of modes, representations, and genres for specific purposes, and mostly consistent referencing	• communicates demonstrating some scientific literacy, in a range of modes, representations, and genres with some evidence and inconsistent referencing	• communicates demonstrating limited scientific literacy, in a range of modes and representations, with inconsistent and inaccurate referencing

Linear Motion and Waves Value 1.0

Linear Motion and Waves a **Value: 0.5**

Linear Motion and Waves b **Value: 0.5**

Specific Unit Goals

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

Science as a Human Endeavour

- Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility
- Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines
- Advances in science understanding in one field can influence other areas of science, technology and engineering
- The use of scientific knowledge is influenced by social, economic, cultural and ethical considerations
- The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences
- Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions
- Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability

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
- Representations, including graphs and vectors, and/or equations of motion, can be used qualitatively and quantitatively to describe and predict linear motion
- Vertical motion is analysed by assuming the acceleration due to gravity is constant near Earth's surface
- 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
- 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
- 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
- Collisions may be elastic and inelastic; kinetic energy is conserved in elastic collisions

Mathematical representations and relationships

Linear motion and force

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

  s = displacement, t = time interval, u = initial velocity, v = final velocity, a = acceleration

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

  a = acceleration, F = force, m = mass

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

  W = work, F = force, s = displacement, ΔE = change in energy

- $p = mv, \Delta p = F\Delta t$

  p = momentum, v = velocity, m = mass, F = force, Δp = change in momentum, Δt = time interval over which force F acts

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

  E_k = kinetic energy, m = mass, v = speed

- $\Delta E_p = mg\Delta h$

  ΔE_p = change in potential energy, m = mass, g = acceleration due to gravity, Δh = change in vertical distance

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

  Σmv_{before} = vector sum of the momenta of all particles before the collision, Σmv_{after} = vector sum of the momenta of all particles after the collision

- For elastic collisions: $\Sigma \frac{1}{2} mv_{before}^2 = \Sigma \frac{1}{2} mv_{after}^2$

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

Waves

- $v = f\lambda$

  v = speed, f = frequency, λ = 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, λ = 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, $\lambda_2 =$ wavelength in medium 2

- Waves are periodic oscillations that transfer energy from one point to another
- Longitudinal and transverse waves are distinguished by the relationship between the direction of oscillation relative to the direction of the wave velocity
- 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
- Mechanical waves transfer energy through a medium; mechanical waves may oscillate the medium or oscillate the pressure within the medium
- The mechanical wave model can be used to explain phenomena related to reflection and refraction (for example, echoes, seismic phenomena)
- 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
- 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
- Light exhibits many wave properties; however, it cannot be modelled as a mechanical wave because it can travel through a vacuum
- A ray model of light may be used to describe reflection, refraction and image formation from lenses and mirrors
- 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
- 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.

A guide to reading and implementing content descriptions

Content descriptions specify the knowledge, understanding and skills that students are expected to learn and that teachers are expected to teach. Teachers are required to develop a program of learning that allows students to demonstrate all the content descriptions. The lens which the teacher uses to demonstrate the content descriptions may be either guided through provision of electives within each unit or determined by the teacher when developing their program of learning.

A program of learning is what a college provides to implement the course for a subject. It is at the discretion of the teacher to emphasis some content descriptions over others. The teacher may teach additional (not listed) content provided it meets the specific unit goals. This will be informed by the student needs and interests.

Assessment

Refer to pages 12-14.

Thermal, Nuclear and Electrical — Value 1.0

Thermal, Nuclear and Electrical a — **Value: 0.5**
Thermal, Nuclear and Electrical b — **Value: 0.5**

Specific Unit Goals

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
- 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
- conduct investigations, including using temperature, current and potential difference measuring devices, safely, competently and methodically for the collection of valid and reliable data
- 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
- 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

- 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
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

- science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility
- development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines
- advances in science understanding in one field can influence other areas of science, technology and engineering
- the use of scientific knowledge is influenced by social, economic, cultural and ethical considerations
- the use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences
- scientific knowledge can enable scientists to offer valid explanations and make reliable predictions
- scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability

Science Understanding

Heating processes

- heat transfer occurs between and within systems by conduction, convection and/or radiation
- the kinetic particle model describes matter as consisting of particles in constant motion, except at absolute zero
- all systems have thermal energy due to the motion of particles in the system
- temperature is a measure of the average kinetic energy of particles in a system
- 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
- 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
- two systems in contact transfer energy between particles so that eventually the systems reach the same temperature; that is, they are in thermal equilibrium
- 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
- 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
- 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

Mathematical representations and relationships

Heating processes

- $Q = mc\Delta T$

  Q = heat transferred to or from the object, m = mass of object, c = specific heat capacity of the object, ΔT = temperature change

- $Q = mL$

  Q = heat transferred to or from the object, L = latent heat capacity of the material, m = mass of object

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

  η = 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
- 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
- some nuclides are unstable and spontaneously decay, emitting alpha, beta and/or gamma radiation over time until they become stable nuclides
- each species of radionuclide has a specific half-life
- alpha, beta and gamma radiation have sufficient energy to ionise atoms
- 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
- alpha and beta decay are examples of spontaneous transmutation reactions, while artificial transmutation is a managed process that changes one nuclide into another
- 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
- a fission chain reaction is a self-sustaining process that may be controlled to produce thermal energy, or uncontrolled to release energy explosively
- nuclear fusion is a reaction in which light nuclides combine to form a heavier nuclide, with the release of energy
- more energy is released per nucleon in nuclear fusion than in nuclear fission because a greater percentage of the mass is transformed into energy.

Mathematical representations and relationships

Ionising radiation and nuclear reactions

- $N = N_o \left(\frac{1}{2}\right)^n$ (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

- $\Delta E = \Delta mc^2$

  ΔE = energy change, Δm = mass change, c = speed of light (3×10^8 m s^{-1})

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
- electric current is carried by discrete charge carriers; charge is conserved at all points in an electrical circuit
- energy is conserved in the energy transfers and transformations that occur in an electrical circuit
- 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
- 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
- power is the rate at which energy is transformed by a circuit component; power enables quantitative analysis of energy transformations in the circuit
- resistance for ohmic and non-ohmic components is defined as the ratio of potential difference across the component to the current in the component
- 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.

Mathematical representations and relationships

Electrical circuits

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

  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.

A guide to reading and implementing content descriptions

Content descriptions specify the knowledge, understanding and skills that students are expected to learn and that teachers are expected to teach. Teachers are required to develop a program of learning that allows students to demonstrate all the content descriptions. The lens which the teacher uses to demonstrate the content descriptions may be either guided through provision of electives within each unit or determined by the teacher when developing their program of learning.

A program of learning is what a college provides to implement the course for a subject. It is at the discretion of the teacher to emphasis some content descriptions over others. The teacher may teach additional (not listed) content provided it meets the specific unit goals. This will be informed by the student needs and interests.

Assessment

Refer to pages 12-14.

Gravity and Electromagnetism Value 1.0

Gravity and Electromagnetism a **Value: 0.5**

Gravity and Electromagnetism b **Value: 0.5**

Specific Unit Goals

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
- 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
- conduct investigations, including the manipulation of force measurers and electromagnetic devices, safely, competently and methodically for the collection of valid and reliable data
- 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
- 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

- 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
- 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
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

- ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of datasets with which scientists work
- 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
- the acceptance of science understanding can be influenced by the social, economic and cultural context in which it is considered
- people can use scientific knowledge to inform the monitoring, assessment and evaluation of risk
- 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
- international collaboration is often required when investing in large-scale science projects or addressing issues for the Asia-Pacific region
- scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability

Science Understanding

Gravity and motion

- the movement of free-falling bodies in earth’s gravitational field is predictable
- 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
- 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
- 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
- gravitational field strength is defined as the net force per unit mass at a particular point in the field
- 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
- projectile motion can be analysed quantitatively by treating the horizontal and vertical components of the motion independently
- 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
- 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

Mathematical representations and relationships

Gravity and motion

- $w = mg$

  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 $(6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}})$, 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

- $v_y = gt + u_y$, $y = \frac{1}{2} gt^2 + u_y t$, $v_y{}^2 = 2gy + u_y{}^2$, $v_x = u_x$ 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 $(6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}})$

Electromagnetism

- electrostatically charged objects exert a force upon one another; the magnitude of this force can be calculated using Coulomb's Law
- 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
- 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
- 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
- current-carrying wires are surrounded by magnetic fields; these fields are utilised in solenoids and electromagnets

- the strength of the magnetic field produced by a current is called the magnetic flux density
- magnets, magnetic materials, moving charges and current-carrying wires experience a force in a magnetic field; this force is utilised in DC electric motors
- magnetic flux is defined in terms of magnetic flux density and area
- 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
- conservation of energy, expressed as Lenz's law of electromagnetic induction, is used to determine the direction of induced current
- electromagnetic waves are transverse waves made up of mutually perpendicular, oscillating electric and magnetic fields
- oscillating charges produce electromagnetic waves of the same frequency as the oscillation; electromagnetic waves cause charges to oscillate at the frequency of the wave

Electromagnetism

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

  F = force, $\frac{1}{4\pi\varepsilon_0}$ = Coulomb constant (9×10^9 N m^2 C^{-2}), 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, $\frac{1}{4\pi\varepsilon_0}$ = Coulomb constant (9×10^9 N m^2 C^{-2})

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

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

- $B = \frac{\mu_0 I}{2\pi r}$

  B = magnetic flux density, I = current in wire, r = distance from the centre of the wire, $\frac{\mu_0}{2\pi}$ = magnetic constant (2×10^{-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

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

  emf = induced potential difference, $\Delta\phi$ = 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.

A guide to reading and implementing content descriptions

Content descriptions specify the knowledge, understanding and skills that students are expected to learn and that teachers are expected to teach. Teachers are required to develop a program of learning that allows students to demonstrate all the content descriptions. The lens which the teacher uses to demonstrate the content descriptions may be either guided through provision of electives within each unit or determined by the teacher when developing their program of learning.

A program of learning is what a college provides to implement the course for a subject. It is at the discretion of the teacher to emphasis some content descriptions over others. The teacher may teach additional (not listed) content provided it meets the specific unit goals. This will be informed by the student needs and interests.

Assessment

Refer to pages 12-14.

Revolutions in Modern Physics Value 1.0

Revolutions in Modern Physics a **Value: 0.5**

Revolutions in Modern Physics b **Value: 0.5**

Specific Unit Goals

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
- 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
- conduct investigations, including use of simulations and manipulation of spectral devices, safely, competently and methodically for the collection of valid and reliable data
- 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
- 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
- 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

- 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
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

- ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of datasets with which scientists work
- 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
- the acceptance of science understanding can be influenced by the social, economic and cultural context in which it is considered
- people can use scientific knowledge to inform the monitoring, assessment and evaluation of risk
- 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
- international collaboration is often required when investing in large-scale science projects or addressing issues for the Asia-Pacific region
- scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability

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)
- Einstein's special theory of relativity predicts significantly different results to those of Newtonian physics for velocities approaching the speed of light
- 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
- motion can only be measured relative to an observer; length and time are relative quantities that depend on the observer's frame of reference
- relativistic momentum increases at high relative speed and prevents an object from reaching the speed of light
- the concept of mass-energy equivalence emerged from the special theory of relativity and explains the source of the energy produced in nuclear reactions

Mathematical representations and relationships

Special relativity

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

  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 $(3 \times 10^8 \text{ m s}^{-1})$

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

  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 ($3 \times 10^8\ m\ s^{-1}$)

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

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

- $\Delta E = \Delta mc^2$

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

Quantum theory

- atomic phenomena and the interaction of light with matter indicate that states of matter and energy are quantised into discrete values
- 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)
- a wide range of phenomena, including black body radiation and the photoelectric effect, are explained using the concept of light quanta
- atoms of an element emit and absorb specific wavelengths of light that are unique to that element; this is the basis of spectral analysis
- 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
- 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).

Mathematical representations and relationships

Quantum theory

- $E = hf$

  E = energy of photon, f = frequency, h = Planck's constant (6.626×10^{-34} J s)

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

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

- $E_k = hf - W$

  E_k = kinetic energy of photoelectron, hf = energy of incident photon, W = work function of the material

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

  λ = wavelength associated with particle, p = momentum of particle, h = Planck's constant (6.626×10^{-34} J s)

- $n\lambda = 2\pi r$

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

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

  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 (6.626×10^{-34} J s)

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

  λ = wavelength of spectral line, n_i = principal quantum number of initial electron state, n_f = principal quantum number of final electron state, R = Rydberg's constant (1.097×10^{7} 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 nuclear force, leptons do not
- the standard model explains three of the four fundamental forces in terms of an exchange of force-carrying particles called gauge bosons; each force is mediated by a different type of gauge boson
- interactions between particles, including nuclei and nuclear components, can be represented by simple reaction diagrams
- lepton number and baryon number are conserved in all reactions between particles; these conservation laws can be used to support or invalidate proposed reactions
- new reactions between particles can be predicted by applying time-reversal symmetry or charge-reversal symmetry to all the particles that participate in a reaction, or by applying crossing symmetry to an individual particle in a reaction (for example, applying symmetry to beta-minus decay enables reactions in which a proton is converted into a neutron to be predicted)

- high-energy particle accelerators are used to test theories of particle physics including the standard model
- the standard model is used to describe and explain the evolution of the four fundamental forces and the creation of matter in the Big Bang theory.

A guide to reading and implementing content descriptions

Content descriptions specify the knowledge, understanding and skills that students are expected to learn and that teachers are expected to teach. Teachers are required to develop a program of learning that allows students to demonstrate all the content descriptions. The lens which the teacher uses to demonstrate the content descriptions may be either guided through provision of electives within each unit or determined by the teacher when developing their program of learning.

A program of learning is what a college provides to implement the course for a subject. It is at the discretion of the teacher to emphasis some content descriptions over others. The teacher may teach additional (not listed) content provided it meets the specific unit goals. This will be informed by the student needs and interests.

Assessment

Refer to pages 12-14.

Appendix A – Implementation Guidelines

Available course patterns

A standard 1.0 value unit is delivered over at least 55 hours. To be awarded a course, students must complete at least the minimum units over the whole minor, major, major/minor or double major course.

Course	Number of standard units to meet course requirements
Minor	Minimum of 2 units
Major	Minimum of 3.5 units

Units in this course can be delivered in any order.

Prerequisites for the course or units within the course

Nil.

Arrangements for students continuing study in this course

Students who studied the previous course may undertake any units in this course provided there is no duplication of content.

Duplication of Content Rules

Students cannot be given credit towards the requirements for a Senior Secondary Certificate for a unit that significantly duplicates content in a unit studied in another course. The responsibility for preventing undesirable overlap of content studied by a student, rests with the principal and the teacher delivering the course. Students will only be given credit for covering the content once.

Guidelines for Delivery

Program of Learning

A program of learning is what a school provides to implement the course for a subject. This meets the requirements for context, scope and sequence set out in the Board endorsed course. Students follow programs of learning in a college as part of their senior secondary studies. The detail, design and layout of a program of learning are a college decision.

The program of learning must be documented to show the planned learning activities and experiences that meet the needs of particular groups of students, taking into account their interests, prior knowledge, abilities and backgrounds. The program of learning is a record of the learning experiences that enable students to achieve the knowledge, understanding and skills of the content descriptions. There is no requirement to submit a program of learning to the OBSSS for approval. The Principal will need to sign off at the end of Year 12 that courses have been delivered as accredited.

Content Descriptions

Are all content descriptions of equal importance? No. It depends on the focus of study. Teachers can customise their program of learning to meet their own students' needs, adding additional content descriptions if desired or emphasising some over others. A teacher must balance student needs with their responsibility to teach all content descriptions. It is mandatory that teachers address all content descriptions and that students engage with all content descriptions.

Half standard 0.5 units

Half standard units appear on the course adoption form but are not explicitly documented in courses. It is at the discretion of the college principal to split a standard 1.0 unit into two half standard 0.5 units. Colleges are required to adopt the half standard 0.5 units. However, colleges are not required to submit explicit documentation outlining their half standard 0.5 units to the BSSS. Colleges must assess students using the half standard 0.5 assessment task weightings outlined in the framework. It is the responsibility of the college principal to ensure that all content is delivered in units approved by the Board.

Moderation

Moderation is a system designed and implemented to:

- provide comparability in the system of school-based assessment
- form the basis for valid and reliable assessment in senior secondary schools
- involve the ACT Board of Senior Secondary Studies and colleges in cooperation and partnership
- maintain the quality of school-based assessment and the credibility, validity, and acceptability of Board certificates.

Moderation commences within individual colleges. Teachers develop assessment programs and instruments, apply assessment criteria, and allocate Unit Grades, according to the relevant Framework. Teachers within course teaching groups conduct consensus discussions to moderate marking or grading of individual assessment instruments and Unit Grade decisions.

The Moderation Model

Moderation within the ACT encompasses structured, consensus-based peer review of Unit Grades for all accredited courses over two Moderation Days. In addition to Moderation Days, there is statistical moderation of course scores, including small group procedures, for T courses.

Moderation by Structured, Consensus-based Peer Review

Consensus-based peer review involves the review of student work against system wide criteria and standards and the validation of Unit Grades. This is done by matching student performance with the criteria and standards outlined in the Achievement Standards, as stated in the Framework. Advice is then given to colleges to assist teachers with, or confirm, their judgments. In addition, feedback is given on the construction of assessment instruments.

Preparation for Structured, Consensus-based Peer Review

Each year, teachers of Year 11 are asked to retain originals or copies of student work completed in Semester 2. Similarly, teachers of a Year 12 class should retain originals or copies of student work completed in Semester 1. Assessment and other documentation required by the Office of the Board of Senior Secondary Studies should also be kept. Year 11 work from Semester 2 of the previous year is presented for review at Moderation Day 1 in March, and Year 12 work from Semester 1 is presented for review at Moderation Day 2 in August.

In the lead up to Moderation Day, a College Course Presentation (comprised of a document folder and a set of student portfolios) is prepared for each A, T and M course/units offered by the school and is sent into the Office of the Board of Senior Secondary Studies.

The College Course Presentation

The package of materials (College Course Presentation) presented by a college for review on Moderation Days in each course area will comprise the following:

- a folder containing supporting documentation as requested by the Office of the Board through memoranda to colleges, including marking schemes and rubrics for each assessment item
- a set of student portfolios containing marked and/or graded written and non-written assessment responses and completed criteria and standards feedback forms. Evidence of all assessment responses on which the Unit Grade decision has been made is to be included in the student review portfolios.

Specific requirements for subject areas and types of evidence to be presented for each Moderation Day will be outlined by the Board Secretariat through the *Requirements for Moderation Memoranda* and Information Papers.

Visual evidence for judgements made about practical performances

(also refer to BSSS Website Guidelines)

It is a requirement that schools' judgements of standards to practical performances (A/T/M) be supported by visual evidence (still photos or video).

The photographic evidence submitted must be drawn from practical skills performed as part of the assessment process.

Teachers should consult the BSSS website for current information regarding all moderation requirements including subject specific and photographic evidence.

Appendix B – Course Developers

Name	College
Marion Gilmour-Temu	Canberra Girls Grammar School
Lynn Bean	Dickson College
Alan Lyall	University of Canberra Senior Secondary College, Lake Ginninderra

Appendix C – Common Curriculum Elements

Common curriculum elements assist in the development of high-quality assessment tasks by encouraging breadth and depth and discrimination in levels of achievement.

Organisers	Elements	Examples
create, compose and apply	apply	ideas and procedures in unfamiliar situations, content and processes in non-routine settings
	compose	oral, written and multimodal texts, music, visual images, responses to complex topics, new outcomes
	represent	images, symbols or signs
	create	creative thinking to identify areas for change, growth and innovation, recognise opportunities, experiment to achieve innovative solutions, construct objects, imagine alternatives
	manipulate	images, text, data, points of view
analyse, synthesise and evaluate	justify	arguments, points of view, phenomena, choices
	hypothesise	statement/theory that can be tested by data
	extrapolate	trends, cause/effect, impact of a decision
	predict	data, trends, inferences
	evaluate	text, images, points of view, solutions, phenomenon, graphics
	test	validity of assumptions, ideas, procedures, strategies
	argue	trends, cause/effect, strengths and weaknesses
	reflect	on strengths and weaknesses
	synthesise	data and knowledge, points of view from several sources
	analyse	text, images, graphs, data, points of view
	examine	data, visual images, arguments, points of view
	investigate	issues, problems
organise, sequence and explain	sequence	text, data, relationships, arguments, patterns
	visualise	trends, futures, patterns, cause and effect
	compare/contrast	data, visual images, arguments, points of view
	discuss	issues, data, relationships, choices/options
	interpret	symbols, text, images, graphs
	explain	explicit/implicit assumptions, bias, themes/arguments, cause/effect, strengths/weaknesses
	translate	data, visual images, arguments, points of view
	assess	probabilities, choices/options
	select	main points, words, ideas in text
identify, summarise and plan	reproduce	information, data, words, images, graphics
	respond	data, visual images, arguments, points of view
	relate	events, processes, situations
	demonstrate	probabilities, choices/options
	describe	data, visual images, arguments, points of view
	plan	strategies, ideas in text, arguments
	classify	information, data, words, images
	identify	spatial relationships, patterns, interrelationships
	summarise	main points, words, ideas in text, review, draft and edit

Appendix D – Glossary of Verbs

Verbs	Definition
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
Argue	Give reasons for or against something
Assess	Make a Judgement about the value of
Classify	Arrange into named categories in order to sort, group or identify
Compare	Estimate, measure or note how things are similar or dissimilar
Compose	The activity that occurs when students produce written, spoken, or visual texts
Contrast	Compare in such a way as to emphasise differences
Create	Bring into existence, to originate
Critically analyse	Analysis that engages with criticism and existing debate on the issue
Demonstrate	Give a practical exhibition an explanation
Describe	Give an account of characteristics or features
Discuss	Talk or write about a topic, taking into account different issues or ideas
Evaluate	Examine and judge the merit or significance of something
Examine	Determine the nature or condition of
Explain	Provide additional information that demonstrates understanding of reasoning and /or application
Extrapolate	Infer from what is known
Hypothesise	Put forward a supposition or conjecture to account for certain facts and used as a basis for further investigation by which it may be proved or disproved
Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Planning, inquiry into and drawing conclusions about
Justify	Show how argument or conclusion is right or reasonable
Manipulate	Adapt or change
Plan	Strategize, develop a series of steps, processes
Predict	Suggest what might happen in the future or as a consequence of something
Reflect	The thought process by which students develop an understanding and appreciation of their own learning. This process draws on both cognitive and affective experience
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
Respond	React to a person or text
Select	Choose in preference to another or others
Sequence	Arrange in order
Summarise	Give a brief statement of the main points
Synthesise	Combine elements (information/ideas/components) into a coherent whole
Test	Examine qualities or abilities
Translate	Express in another language or form, or in simpler terms
Visualise	The ability to decode, interpret, create, question, challenge and evaluate texts that communicate with visual images as well as, or rather than, words

Appendix E – Glossary for ACT Senior Secondary Curriculum

Courses will detail what teachers are expected to teach and students are expected to learn for year 11 and 12. They will describe the knowledge, understanding and skills that students will be expected to develop for each learning area across the years of schooling.

Learning areas are broad areas of the curriculum, including English, mathematics, science, the arts, languages, health and physical education.

A **subject** is a discrete area of study that is part of a learning area. There may be one or more subjects in a single learning area.

Frameworks are system documents for Years 11 and 12 which provide the basis for the development and accreditation of any course within a designated learning area. In addition, frameworks provide a common basis for assessment, moderation and reporting of student outcomes in courses based on the framework.

The **course** sets out the requirements for the implementation of a subject. Key elements of a course include the rationale, goals, content descriptions, assessment, and achievement standards as designated by the framework.

BSSS courses will be organised into units. A unit is a distinct focus of study within a course. A standard 1.0 unit is delivered for a minimum of 55 hours generally over one semester.

Core units are foundational units that provide students with the breadth of the subject.

Additional units are avenues of learning that cannot be provided for within the four core 1.0 standard units by an adjustment to the program of learning.

An **Independent Study unit** is a pedagogical approach that empowers students to make decisions about their own learning. Independent Study units can be proposed by a student and negotiated with their teacher but must meet the specific unit goals and content descriptions as they appear in the course.

An **elective** is a lens for demonstrating the content descriptions within a standard 1.0 or half standard 0.5 unit.

A **lens** is a particular focus or viewpoint within a broader study.

Content descriptions refer to the subject-based knowledge, understanding and skills to be taught and learned.

A **program of learning** is what a college develops to implement the course for a subject and to ensure that the content descriptions are taught and learned.

Achievement standards provide an indication of typical performance at five different levels (corresponding to grades A to E) following completion of study of senior secondary course content for units in a subject.

ACT senior secondary system **curriculum** comprises all BSSS approved courses of study.

Appendix F – Course Adoption

Conditions of Adoption

The course and units of this course are consistent with the philosophy and goals of the college and the adopting college has the human and physical resources to implement the course.

Adoption Process

Course adoption must be initiated electronically by an email from the principal or their nominated delegate to bssscertification@ed.act.edu.au. A nominated delegate must CC the principal.

The email will include the **Conditions of Adoption** statement above, and the table below adding the **College** name, and circling the **Classification/s** required.

College:	
Course Title:	Physics
Classification/s:	T
Accredited from:	2014
Framework:	Science