BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

PHYSICS
STAGE 6

DRAFT SYLLABUS FOR CONSULTATION

20 JULY – 31 AUGUST 2016

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CONTENTS

THE BOSTES SYLLABUS DEVELOPMENT PROCESS

BOSTES began its syllabus development process for Stage 6 English, Mathematics, Science and History in 2014. This followed state and territory Education Ministers' endorsement of senior secondary Australian curriculum.

The development of the Stage 6 syllabuses involved expert writers and opportunities for consultation with teachers and other interest groups across NSW in order to receive the highest-quality advice across the education community.

A number of key matters at consultations were raised, including the need for the curriculum to cater for the diversity of learners, the broad range of students undertaking Stage 6 study in NSW, development of skills and capabilities for the future, school-based assessment and providing opportunities for assessing and reporting student achievement relevant for post-school pathways.

There was broad support that changes to curriculum and assessment would contribute to the reduction of student stress. BOSTES will continue to use NSW credentialling processes aligned with Stage 6 assessment and HSC examination structures.

A summary of the BOSTES syllabus development process is available at http://www.boardofstudies.nsw.edu.au/syllabuses/syllabus-development.

ASSISTING RESPONDENTS

The following icons are used to assist respondents:

for your information	This icon indicates general information that assists in reading or understanding the information contained in the document. Text introduced by this icon will not appear in the final syllabus.
consult	This icon indicates material on which responses and views are sought through consultation.

CONSULTATION

The *Physics Stage 6 Draft Syllabus* is accompanied by an online consultation survey on the BOSTES website. The purpose of the survey is to obtain detailed comments from individuals and systems/organisations on the syllabus. Please comment on both the strengths and the weaknesses of the draft syllabus. Feedback will be considered when the draft syllabus is revised.

The consultation period is from 20 July to 31 August 2016.

Written responses may be forwarded to:

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INTRODUCTION

STAGE 6 CURRICULUM

Board of Studies, Teaching and Educational Standards NSW (BOSTES) Stage 6 syllabuses have been developed to provide students with opportunities to further develop skills which will assist in the next stage of their lives, whether that is academic study, vocational education or employment.
The purpose of the Higher School Certificate program of study is to:

- provide a curriculum structure which encourages students to complete secondary education
- foster the intellectual, social and moral development of students, in particular developing their:
  - knowledge, skills, understanding, values and attitudes in the fields of study they choose
  - capacity to manage their own learning
  - desire to continue learning in formal or informal settings after school
  - capacity to work together with others
  - respect for the cultural diversity of Australian society
- provide a flexible structure within which students can prepare for:
  - further education and training
  - employment
  - full and active participation as citizens
- provide formal assessment and certification of students' achievements
- provide a context within which schools also have the opportunity to foster students' physical and spiritual development.

The Stage 6 syllabuses reflect the principles of the BOSTES *K–10 Curriculum Framework* and *Statement of Equity Principles*, and the *Melbourne Declaration on Educational Goals for Young Australians* (December 2008). The syllabuses build on the continuum of learning developed in the K–10 syllabuses.

The Stage 6 syllabuses provide a set of broad learning outcomes that summarise the knowledge, understanding, skills, values and attitudes essential for students to succeed in and beyond their schooling. In particular, the literacy and numeracy skills needed for future study, employment and life are provided in Stage 6 syllabuses in alignment with the *Australian Core Skills Framework (ACSF)*.

The syllabuses have considered agreed Australian curriculum content and included content that clarifies the scope and depth of learning in each subject.

Stage 6 syllabuses support a standards-referenced approach to assessment by detailing the essential knowledge, understanding, skills, values and attitudes students will develop and outlining clear standards of what students are expected to know and be able to do. In accordance with the *Statement of Equity Principles*, Stage 6 syllabuses take into account the diverse needs of all students. The syllabuses provide structures and processes by which teachers can provide continuity of study for all students.

DIVERSITY OF LEARNERS

NSW Stage 6 syllabuses are inclusive of the learning needs of all students. Syllabuses accommodate teaching approaches that support student diversity including Students with special education needs, Gifted and talented students and Students learning English as an additional language or dialect (EAL/D).

STUDENTS WITH SPECIAL EDUCATION NEEDS

All students are entitled to participate in and progress through the curriculum. Schools are required to provide additional support or adjustments to teaching, learning and assessment activities for some students. Adjustments are measures or actions taken in relation to teaching, learning and assessment that enable a student to access syllabus outcomes and content and demonstrate achievement of outcomes.

Students with special education needs can access the Stage 6 outcomes and content in a range of ways. Students may engage with:

- syllabus outcomes and content with adjustments to teaching, learning and/or assessment activities
- selected outcomes and content appropriate to their learning needs
- selected Stage 6 Life Skills outcomes and content appropriate to their learning needs.

Decisions regarding adjustments should be made in the context of collaborative curriculum planning with the student, parent/carer and other significant individuals to ensure that syllabus outcomes and content reflect the learning needs and priorities of individual students.

Further information can be found in support materials for:

- Science
- Special education needs
- Life Skills.

GIFTED AND TALENTED STUDENTS

Gifted students have specific learning needs that may require adjustments to the pace, level and content of the curriculum. Differentiated educational opportunities assist in meeting the needs of gifted students.

Generally, gifted students demonstrate the following characteristics:

- the capacity to learn at faster rates
- the capacity to find and solve problems
- the capacity to make connections and manipulate abstract ideas.

There are different kinds and levels of giftedness. Gifted and talented students may also possess learning difficulties and/or disabilities that should be addressed when planning appropriate teaching, learning and assessment activities.

Curriculum strategies for gifted and talented students may include:

- differentiation: modifying the pace, level and content of teaching, learning and assessment activities
- acceleration: promoting a student to a level of study beyond their age group
- curriculum compacting: assessing a student's current level of learning and addressing aspects of the curriculum that have not yet been mastered.

School decisions about appropriate strategies are generally collaborative and involve teachers, parents and students with reference to documents and advice available from BOSTES and the education sectors.

Gifted and talented students may also benefit from individual planning to determine the curriculum options, as well as teaching, learning and assessment strategies, most suited to their needs and abilities.

STUDENTS LEARNING ENGLISH AS AN ADDITIONAL LANGUAGE OR DIALECT (EAL/D)

Many students in Australian schools are learning English as an additional language or dialect (EAL/D). EAL/D students are those whose first language is a language or dialect other than Standard Australian English and who require additional support to assist them to develop English language proficiency.

EAL/D students come from diverse backgrounds and may include:

- overseas and Australian-born students whose first language is a language other than English, including creoles and related varieties
- Aboriginal and Torres Strait Islander students whose first language is Aboriginal English, including Kriol and related varieties.

EAL/D students enter Australian schools at different ages and stages of schooling and at different stages of Australian Standard English language learning. They have diverse talents and capabilities and a range of prior learning experiences and levels of literacy in their first language and in English. EAL/D students represent a significant and growing percentage of learners in NSW schools. For some, school is the only place they use Australian Standard English.

EAL/D students are simultaneously learning a new language and the knowledge, understanding and skills of the Physics Stage 6 syllabus through that new language. They require additional time and support, along with informed teaching that explicitly addresses their language needs, and assessments that take into account their developing language proficiency.

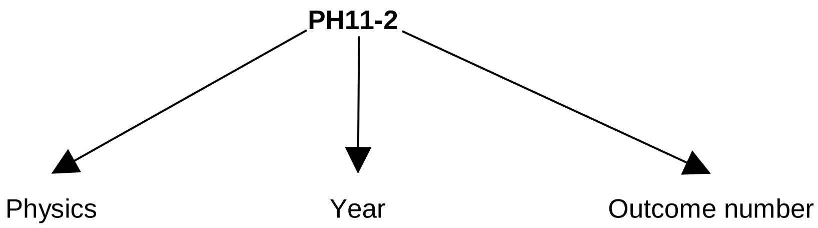
PHYSICS KEY

The following codes and icons are used in the *Physics Stage 6 Draft Syllabus*.

OUTCOME CODING

Syllabus outcomes have been coded in a consistent way. The code identifies the subject, Year and outcome number.

In the *Physics Stage 6 Draft Syllabus*, outcome codes indicate the subject, Year and outcome number, for example:

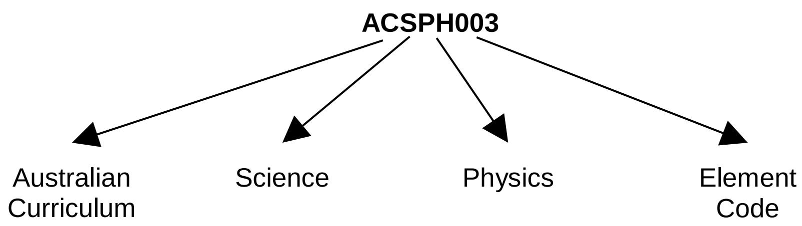


Outcome code	Interpretation
PH11-1	Physics, Year 11 – Outcome number 1
PH12-4	Physics, Year 12 – Outcome number 4

CODING OF AUSTRALIAN CURRICULUM CONTENT

Australian curriculum content descriptions included in the syllabus are identified by an Australian curriculum code which appears in brackets at the end of each content description, for example:

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



Where a number of content descriptions are jointly represented, all description codes are included, eg (ACSPH001, ACSPH002, ACSPH003).

LEARNING ACROSS THE CURRICULUM ICONS

Learning across the curriculum content, including cross-curriculum priorities, general capabilities and other areas identified as important learning for all students, is incorporated and identified by icons in the *Stage 6 Physics Draft Syllabus*.

Cross-curriculum priorities	
	Aboriginal and Torres Strait Islander histories and cultures
	Asia and Australia's engagement with Asia
	Sustainability
General capabilities	
	Critical and creative thinking
	Ethical understanding
	Information and communication technology capability
	Intercultural understanding
	Literacy
	Numeracy
	Personal and social capability
Other learning across the curriculum areas	
	Civics and citizenship
	Difference and diversity
	Work and enterprise

RATIONALE

for your information

The rationale describes the distinctive nature of the subject and outlines its relationship to the contemporary world and current practice. It explains the place and purpose of the subject in the curriculum, including:

- why the subject exists
- the theoretical underpinnings
- what makes the subject distinctive
- why students would study the subject
- how it contributes to the purpose of the Stage 6 curriculum
- how it prepares students for post-school pathways.

consult

The Physics Stage 6 course involves the study of matter and its motion through space and time, along with related concepts such as energy and force. Physics deals with phenomena on scales of space and time from those of nuclear particles and their interactions up to the size and age of the universe, allowing us to better understand the physical world and how it works.

Physics not only incorporates Working Scientifically processes to develop skills, it also focuses on the exploration of models, the understanding of theories and laws and encourages an examination of the connectedness between seemingly dissimilar phenomena.

Students who study Physics are encouraged to use observations to make quantitative models of real-world problems and derive relationships between variables. It requires them to engage in solving equations of these models, make predictions and analyse the interconnectedness of physical entities.

The Physics course builds upon students' knowledge and skills gained in Science Stage 5 and develops a greater understanding of Physics as a foundation for undertaking post-school studies in a wide range of scientific fields. A knowledge and understanding of Physics often provides the unifying link across interdisciplinary studies.

The study of Physics provides the foundation knowledge and skills required to support participation in a range of careers. It is a discipline that encourages innovative and creative thinking which will address new challenges in the fields of the provision of energy, new materials and sustainability.

THE PLACE OF THE PHYSICS STAGE 6 DRAFT SYLLABUS IN THE K–12 CURRICULUM

for your information

NSW syllabuses include a diagram that illustrates how the syllabus relates to the learning pathways in K–12. This section places the Physics Stage 6 syllabus in the K–12 curriculum as a whole.

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Prior-to-school learning

Students bring to school a range of knowledge, understanding and skills developed in home and prior-to-school settings. The movement into Early Stage 1 should be seen as a continuum of learning and planned appropriately.

The *Early Years Learning Framework for Australia* describes a range of opportunities for students to develop a foundation for future success in learning.

Early Stage 1 – Stage 3

Science and Technology K–6

Stage 4 – Stage 5

Science Years 7–10

(including Life Skills Outcomes and Content)

Stage 6

(Years 11–12)

Biology

Chemistry

Earth and Environmental Science

Investigating Science

Physics

Science Life Skills Outcomes and Content

Community, other education and learning and workplace pathways

AIM

for your information

In NSW syllabuses, the aim provides a succinct statement of the overall purpose of the syllabus. It indicates the general educational benefits for students from programs based on the syllabus.

The aim, objectives, outcomes and content of a syllabus are clearly linked and sequentially amplify details of the intention of the syllabus.

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The study of Physics in Stage 6 enables students to develop an appreciation and understanding of the application of the principles of physics, its theories, laws, models and systems and structures. Through applying Working Scientifically processes, the course aims to examine how physics models and practices are used and developed.

OBJECTIVES

for your information

In NSW syllabuses, objectives provide specific statements of the intention of a syllabus. They amplify the aim and provide direction to teachers on the teaching and learning process emerging from the syllabus. They define, in broad terms, the knowledge, understanding, skills, values and attitudes to be developed through study in the subject. They act as organisers for the intended outcomes.

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VALUES AND ATTITUDES

Students:

- develop positive, informed values and attitudes towards Physics
- recognise the importance and relevance of Physics in their lives
- recognise the influence of economic, political and societal impacts on the development of scientific knowledge
- develop an appreciation of the influence of imagination and creativity in scientific research

SKILLS

Students:

- develop skills in applying the processes of Working Scientifically

KNOWLEDGE AND UNDERSTANDING

Students:

- develop knowledge and understanding of fundamental mechanics
- develop knowledge and understanding of energy
- develop knowledge and understanding of advanced mechanics and electromagnetism
- apply an understanding of theories, predictions and evidence in Physics

OUTCOMES

for your information

In NSW syllabuses, outcomes provide detail about what students are expected to achieve at the end of each Year in relation to the objectives. They indicate the knowledge, understanding and skills expected to be gained by most students as a result of effective teaching and learning. They are derived from the objectives of the syllabus.

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TABLE OF OBJECTIVES AND OUTCOMES – CONTINUUM OF LEARNING

SKILLS

Objective Students: ● develop skills in applying the processes of Working Scientifically	
Year 11 course outcomes A student:	**Year 12 course outcomes** A student:
Questioning **PH11-1** poses questions and hypotheses for scientific investigation	**Questioning** **PH12-1** develops and evaluates questions and hypotheses for scientific investigation
Designing investigations **PH11-2** designs and plans appropriate scientific investigations	**Designing investigations** **PH12-2** designs, plans and evaluates primary and secondary-sourced investigations
Conducting investigations **PH11-3** conducts primary or secondary-sourced investigations individually or in a team	**Conducting investigations** **PH12-3** conducts primary and secondary-sourced investigations individually or in a team
Representing **PH11-4** represents qualitative and quantitative data and information using a range of appropriate media	**Representing** **PH12-4** selects and represents key qualitative and quantitative data and information using a range of appropriate media
Analysing **PH11-5** analyses primary and secondary information sources	**Analysing** **PH12-5** analyses primary and secondary information sources

Solving problems **PH11-6** solves scientific problems	**Solving problems** **PH12-6** solves scientific problems using primary and secondary data
Communicating **PH11-7** communicates scientific understanding	**Communicating** **PH12-7** communicates scientific understanding using suitable language and terminology

The Skills outcomes found at the beginning of each module are targeted for emphasis. It is recognised that the other Skills outcomes will also be addressed in each module.

KNOWLEDGE AND UNDERSTANDING

Year 11 course Unit 1	**Year 12 course Unit 3**
Objective Students: ● develop knowledge and understanding of fundamental mechanics	**Objective** Students: ● develop knowledge and understanding of advanced mechanics and electromagnetism
Year 11 course outcomes A student:	**Year 12 course outcomes** A student:
PH11-8 describes and analyses motion in terms of scalar and vector quantities in two dimensions and makes quantitative measurements and calculations for distance, displacement, speed velocity and acceleration	**PH12-8** describes and analyses qualitatively and quantitatively circular motion and motion in a gravitational field, in particular, the projectile motion of particles
PH11-9 describes and explains events in terms of Newton's Laws, the Law of Conservation of Momentum and the Law of Conservation of Energy	**PH12-9** explains and analyses the electric and magnetic interactions due to charged particles and currents and evaluates qualitatively and quantitatively their effect
Year 11 course Unit 2	**Year 12 course Unit 4**
Objective Students: ● develop knowledge and understanding of energy	**Objective** Students: ● apply an understanding of theories, predictions and evidence in Physics
Year 11 course outcomes A student:	**Year 12 course outcomes** A student:
PH11-10 explains and analyses waves and the transfer of energy in sound and light	**PH12-10** describes, evaluates and applies properties of electromagnetic waves and the implications of their study to Physics in a contemporary world
PH11-11 explains and quantitatively analyses electric fields, circuitry and thermodynamic principles	**PH12-11** explains and analyses the nuclear model of the atom, quantitatively analyses electron and photon energies, spectra and the implications of their study in the contemporary world

WORKING SCIENTIFICALLY

Working Scientifically skills are at the core of conducting primary and secondary-sourced investigations in science.

Opportunities for students are to be provided for students to engage with all the Working Scientifically skills for each investigation. In each module, particular outcomes have been identified as those that are most relevant to the intended learning.

Students are challenged to further develop their understanding of Working Scientifically as a group of dynamic and interdependent processes that are applied in each scientific investigation in a way that is appropriate for the task. This dynamism and interrelatedness adds a level of sophistication to students' understanding of the true nature and practice of science. Through regular involvement in these processes, applying them as they arise, in a range of varied primary investigations, students will broaden their interpretation of Working Scientifically beyond the common linear model that suggests Science is a process that simply confirms the way things are.

Students, through a variety of activities, are encouraged to select the most appropriate gateway to the Working Scientifically processes. These gateways become self-evident through the nature of the investigation. An inquiry may be instigated, for example, by direct observation of a phenomenon, or emerge from inconsistencies in results, from quantitative and/or qualitative analysis of data or from secondary research previously conducted by others. Students are challenged to be open to refining or redeveloping their chosen procedures, redefining their questions and/or hypotheses, modifying their methodologies or designs, conducting further secondary research and encouraged to communicate evidence-based conclusions and novel ideas for future research. The processes are informed by the unexpected. Unexpected results are to be used to further inform the pathway towards scientific truth. Knowledge and understanding of science is essential to these processes being performed and, in turn, a deeper knowledge and understanding of scientific concepts emerges from students learning through the practice of science.

Each of the seven Working Scientifically outcomes represents a part of the interdependent dynamic process and its centrality to the study of science and the acquisition of scientific knowledge and skills. This course is structured to provide ongoing opportunities for students to implement these processes, particularly through the depth study provision. The following descriptions of these outcomes provide further information about the skills students are expected to develop throughout the course.

Questioning

Developing, proposing and evaluating inquiry questions and hypotheses challenge students to identify an area that can be investigated scientifically, involving primary and/or secondary-sourced data. Students demonstrate the development of inquiry question(s) that require observations, experimentation and/or research to aid in constructing a reasonable and informed hypothesis. The consideration of variables is to be included in the questioning process.

Designing investigations

In designing investigations, students ensure that all risks are assessed, appropriate materials and technologies are sourced and that all ethical concerns are considered. Variables are to be identified as independent, dependent and controlled to ensure a procedure is developed that will allow for the reliable collection of data. Investigations are to include strategies that ensure that controlled variables are kept constant. Students justify and evaluate the design of investigations.

Conducting investigations

Students are to select appropriate equipment, employ safe work practices and ensure that risk assessments are conducted and followed. Appropriate technologies are to be used and procedures followed when disposing of waste. The selection and criteria for collecting valid and reliable data is to be methodical and, where appropriate, secondary-sourced information is referenced correctly. Reliability is ensured by making modifications to procedure and repeating the investigation or referring to other reliable secondary sources. Accuracy is ensured by using appropriate technologies in a consistent manner.

Representing

In representing data and information, students use the most appropriate and meaningful methods and media to organise and analyse data and information sources, including digital technologies and the use of a variety of visual representations. From these representations students identify trends, patterns and relationships in data and information and recognise error, uncertainty and limitations. Representations are to communicate data and information in order to help solve problems. They make predictions and assist in synthesising data and information to develop evidence-based conclusions and arguments.

Analysing

Students identify trends, patterns and relationships; recognise error, uncertainty and limitations in data; and interpret scientific and media texts. Students evaluate the relevance, accuracy, validity and reliability of the primary or secondary-sourced data in relation to investigations. They evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments. Where appropriate, mathematical models should be constructed and calculations applied to best demonstrate the trends and relationships that occur in data.

Solving problems

Students use critical thinking skills and creativity to demonstrate an understanding of scientific principles underlying the solutions to inquiry questions and problems posed in investigations. Appropriate and varied strategies are employed including using models to quantitatively and qualitatively explain and predict cause and effect relationships. In Working Scientifically, students synthesise and use evidence to construct and justify conclusions. Students interpret scientific and media texts and evaluate processes, claims and conclusions and consider the quality of available evidence to solve problems.

Communicating

Communicating all components of the Working Scientifically processes with clarity and accuracy is essential. Students use qualitative and quantitative information gained from primary and secondary-sourced investigations including digital, visual, written and verbal forms of communication as appropriate. Students apply appropriate scientific notations, nomenclature and scientific language where appropriate and use scientific language suitable for specific audiences and contexts.

INVESTIGATIONS

Primary and secondary-sourced investigations emphasise a range of types of practical activities and may include:

- undertaking laboratory investigations, including fair tests and controlled experiments
- undertaking fieldwork and surveys
- researching by using a variety of print and multimedia, as well as internet and electronic sources of data and information
- using a range of strategies and technologies to collect and record data, including appropriate use of digital technologies
- using and constructing models
- using or reorganising second-hand data, including those in spreadsheets and databases
- extracting and reorganising information in the form of flow charts, tables, graphs, diagrams, prose, keys, spreadsheets and databases
- using digital technologies, eg computer animations and simulations, to capture and analyse data and information
- presenting data and information in multimodal texts.

COURSE STRUCTURE AND REQUIREMENTS

for your information

The following provides an outline of the Year 11 and Year 12 course structure and requirements for the *Physics Stage 6 Draft Syllabus* with indicative hours, arrangement of content, and an overview of course content.

consult

<table>
<tr><td rowspan="6">Year 11 course (120 hours)</td><td rowspan="11">Working Scientifically Skills</td><td>Unit</td><td>Module</td><td>Indicative hours</td></tr>
<tr><td rowspan="2">Unit 1
Fundamental Mechanics</td><td>Module 1
Kinematics</td><td rowspan="2">45–60</td></tr>
<tr><td>Module 2
Dynamics</td></tr>
<tr><td colspan="2">Depth study
Drawn from knowledge outcome(s) in Unit 1 and/or 2</td><td>15</td></tr>
<tr><td rowspan="2">Unit 2
Energy</td><td>Module 3
Waves and thermodynamics</td><td rowspan="2">45–60</td></tr>
<tr><td>Module 4
Electricity and magnetism</td></tr>
<tr><td rowspan="5">Year 12 course (120 hours)</td><td rowspan="2">Unit 3
Beyond the Fundamentals</td><td>Module 5
Advanced mechanics</td><td rowspan="2">45–60</td></tr>
<tr><td>Module 6
Electromagnetism</td></tr>
<tr><td colspan="2">Depth study
Drawn from knowledge outcome(s) in Unit 3 and/or 4</td><td>15</td></tr>
<tr><td rowspan="2">Unit 4
Developing New Ideas in Physics</td><td>Module 7
Waves or particles?</td><td rowspan="2">45–60</td></tr>
<tr><td>Module 8
Models of the atom</td></tr>
</table>

DEPTH STUDY: YEARS 11 AND 12

What are depth studies?
A depth study is any type of investigation/activity that a student completes individually or collaboratively that allows extension of one or more concepts found within or inspired by the syllabus. It may be one investigation/activity or a series of investigations/activities. Depth studies must address at least one knowledge outcome, the Questioning and Communicating skills outcomes and at least two other skills outcomes.

Depth studies allow students the avenue to pursue interests, to acquire a depth of understanding and to take responsibility for their own learning. They promote differentiation, engagement, ongoing feedback and support all forms of assessment.

A depth study may be, but is not limited to:
- a primary investigation or a series of primary investigations
- a secondary-sourced investigation or series of secondary-sourced investigations
- presentations, research assignments or fieldwork reports
- extension of concepts found within the course, either qualitatively and/or quantitatively.

A minimum of 15 hours per year of in-class course time is to be allocated to depth studies. The length of time for any individual study and pedagogies employed are not prescribed. The time for the depth study may be allocated to a single study or spread over the year and incorporate several studies depending on individual school and/or class requirements.

Requirements for depth studies
- A minimum of 15 hours of in-class time is allocated in each of Years 11 and 12.
- At least one depth study must be included in each of Years 11 and 12.
- Depth studies are to form part of the school-based assessment in each of Years 11 and 12.
- Depth studies must contribute a minimum of 20% to a maximum of 40% towards a student's school-based assessment in each of Years 11 and 12.
- The Working Scientifically outcomes of Questioning and Communicating must be addressed in the school-based assessment component in each of Years11 and 12.
- A minimum of two additional Working Scientifically skills outcomes, and at least one knowledge outcome, are to be addressed in depth studies used.

The following outcomes must be addressed in depth studies:

- Questioning and Communicating skills
- A minimum of two additional skills
- At least one Knowledge outcome

POSSIBLE DEPTH STUDIES

Primary investigations

- Design and conduct experiments
- Test a claim
- Test a device.

Secondary-sourced investigations

- Make a documentary or media report
- Conduct a literature review
- Develop an evidence-based argument
- Write a journal article
- Write an essay–historical or theoretical
- Develop an environmental management plan
- Analyse a work of fiction or film for scientific relevance
- Create a visual presentation
- Investigate emerging technologies.

Create

- Design and invent
- Create a working model
- Create a portfolio.

Fieldwork

Fieldwork may be a starting point for a primary investigation or secondary-sourced study and could be initiated by the following stimuli:

- an excursion
- engagement with community experts.

Data analysis

This could be incorporated into a primary investigation or secondary-sourced investigation, for example:

- constructing and analysing graphs/tables
- data analysis from a variety of sources
- analysing research, eg longitudinal data, resource management data.

ASSESSMENT

for your information

The key purpose of assessment is to gather valid and useful information about student learning and achievement. It is an essential component of the teaching and learning cycle. School-based assessment provides opportunities to measure student achievement of outcomes in a more diverse way than the HSC examination.

BOSTES continues to promote a standards-referenced approach to assessing and reporting student achievement. Assessment for, as and of learning are important to guide future teaching and learning opportunities and to give students ongoing feedback. These approaches are used individually or together, formally or informally, to gather evidence of student achievement against standards. Assessment provides teachers with the information needed to make judgements about students' achievement of outcomes.

Ongoing stakeholder feedback, analysis of BOSTES examination data and information gathered about assessment practices in schools has indicated that school-based and external assessment requirements require review and clarification. The HSC Reforms outline changes to school-based and HSC assessment practices to:

- make assessment more manageable for students, teachers and schools
- maintain rigorous standards
- strengthen opportunities for deeper learning
- provide opportunities for students to respond to unseen questions, and apply knowledge, understanding and skills to encourage in-depth analysis
- support teachers to make consistent judgements about student achievement.

Students with special education needs
Some students with special education needs will require adjustments to assessment practices in order to demonstrate what they know and can do in relation to syllabus outcomes and content. The type of adjustments and support will vary according to the particular needs of the student and the requirements of the assessment activity. Schools can make decisions to offer adjustments to coursework and school-based assessment.

Life Skills
Students undertaking Years 11–12 Life Skills courses will study selected outcomes and content. Assessment activities should provide opportunities for students to demonstrate achievement in relation to the outcomes, and to apply their knowledge, understanding and skills to a range of situations or environments.

The following general descriptions have been provided for consistency. Further advice about assessment, including in support materials, will provide greater detail.

Assessment for Learning	• enables teachers to use formal and informal assessment activities to gather evidence of how well students are learning • teachers provide feedback to students to improve their learning • evidence gathered can inform the directions for teaching and learning programs.
Assessment as Learning	• occurs when students use self-assessment, peer-assessment and formal and informal teacher feedback to monitor and reflect on their own learning, consolidate their understanding and work towards learning goals.
Assessment of Learning	• assists teachers to use evidence of student learning to assess student achievement against syllabus outcomes and standards at defined key points within a Year or Stage of learning.
Formal assessment	• tasks which students undertake as part of the internal assessment program, for example a written examination, research task, oral presentation, performance or other practical task • tasks appear in an assessment schedule and students are provided with sufficient written notification • evidence is gathered by teachers to report on student achievement in relation to syllabus outcomes and standards, and may also be used for grading or ranking purposes.
Informal assessment	• activities undertaken and anecdotal evidence gathered by the teacher throughout the learning process in a less prescribed manner, for example class discussion, questioning and observation • used as part of the ongoing teaching and learning process to gather evidence and provide feedback to students • can identify student strengths and areas for improvement.
Written examination	• a task undertaken individually, under formal supervised conditions to gather evidence about student achievement in relation to knowledge, understanding and skills at a point in time, for example a half-yearly, yearly or trial HSC examination • a task which may include one or more unseen questions or items, assessing a range of outcomes and content.

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Physics Draft Assessment Requirements

The draft guidelines for school-based assessment provide specific advice about the number of formal assessment tasks, course components and weightings, and the nature of task types to be administered in Year 11 and Year 12.

The components and weightings for Year 11 and Year 12 are mandatory.

Year 11

- There will be 3 formal assessment tasks
- The maximum weighting for each formal assessment task is 40%
- One task may be a formal written examination
- One task must include an assessment of the depth study and its related knowledge, understanding and skills outcomes with a weighting of 20–40%
- A minimum of 25% weighting must be allocated to practical investigations.

Component	**Weighting %**
Skills in working scientifically	60
Knowledge and understanding of course content	40
	100

Year 12

- There will be no more than 4 formal assessment tasks
- The maximum weighting for each formal assessment task is 40%
- One task may be a formal written examination, eg a trial HSC, with a maximum weighting of 25%
- One task must include an assessment of the depth study and its related knowledge, understanding and skills outcomes with a weighting of 20–40%
- A minimum of 25% weighting must be allocated to practical investigations.

Component	**Weighting %**
Skills in working scientifically	60
Knowledge and understanding of course content	40
	100

Physics Draft Examination Specifications

Sections
Section I Objective response questions *Questions may include stimulus material*
Section II Short response questions which may include multiple sections *Questions may include stimulus material*

HSC examination specifications will be reviewed following finalisation of the syllabuses.

Updated assessment and reporting advice will be provided when syllabuses are released.

The Assessment Certification Examination website will be updated to align with the syllabus implementation timeline.

CONTENT

For Kindergarten to Year 12 courses of study and educational programs are based on the outcomes and content of syllabuses. The content describes in more detail how the outcomes are to be interpreted and used, and the intended learning appropriate for each Year. In considering the intended learning, teachers will make decisions about the emphasis to be given to particular areas of content, and any adjustments required based on the needs, interests and abilities of their students.

The knowledge, understanding and skills described in the outcomes and content provide a sound basis for students to successfully transition to their selected post-school pathway.

LEARNING ACROSS THE CURRICULUM

for your information

NSW syllabuses provide a context within which to develop core skills, knowledge and understanding considered essential for the acquisition of effective, higher-order thinking skills that underpin successful participation in further education, work and everyday life including problem-solving, collaboration, self-management, communication and information technology skills.

BOSTES has described learning across the curriculum areas that are to be included in syllabuses. In the Stage 6 syllabuses, the identified areas will be embedded in the descriptions of content and identified by icons. Learning across the curriculum content, including the cross-curriculum priorities and general capabilities, assists students to achieve the broad learning outcomes defined in the BOSTES *Statement of Equity Principles*, the *Melbourne Declaration on Educational Goals for Young Australians* (December 2008) and in the Australian Government's *Core Skills for Work Developmental Framework* (2013).

Knowledge, understanding, skills, values and attitudes derived from the learning across the curriculum areas will be included in BOSTES syllabuses, while ensuring that subject integrity is maintained.

Cross-curriculum priorities enable students to develop understanding about and address the contemporary issues they face.

The cross-curriculum priorities are:
- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability

General capabilities encompass the knowledge, skills, attitudes and behaviours to assist students to live and work successfully in the 21st century.

The general capabilities are:
- Critical and creative thinking
- Ethical understanding
- Information and communication technology capability
- Intercultural understanding
- Literacy
- Numeracy
- Personal and social capability

BOSTES syllabuses include other areas identified as important learning for all students:

- Civics and citizenship
- Difference and diversity
- Work and enterprise

consult

Aboriginal and Torres Strait Islander histories and cultures

Aboriginal and Torres Strait Islander communities have diverse cultures, social structures and a history of unique, complex knowledge systems. Students are provided with opportunities to learn about how Aboriginal and Torres Strait Islander peoples have developed and refined knowledge about the world through observation, making predictions, testing (trial and error) and responding to environmental factors within specific contexts. Students will investigate examples of Aboriginal and Torres Strait Islander peoples' understanding of the environment and the ways that traditional knowledge and western scientific knowledge can be complementary.

When planning and programming content relating to Aboriginal and Torres Strait Islander histories and cultures teachers are encouraged to consider involving local Aboriginal communities and/or appropriate knowledge holders in determining suitable resources, or to use Aboriginal or Torres Strait Islander authored or endorsed publications.

Asia and Australia's engagement with Asia

Asia and Australia's engagement with Asia provides rich and engaging contexts for developing students' science and technology skills, knowledge and understanding. Students are provided with opportunities to recognise that the Asia region includes diverse environments. Students appreciate how interactions within and between these environments and the impacts of human activity influence the region, including Australia, and have significance for the rest of the world.

The Asia region plays an important role in scientific and technological research and development in areas such as medicine, natural resource management and natural disaster prediction and management.

Sustainability

Sustainability is concerned with the ongoing capacity of the Earth to maintain all life. It provides authentic contexts for exploring, investigating and understanding systems in the natural and made environments. Students are provided with opportunities to investigate relationships between systems and system components, and consider the sustainability of food sources and the natural and human environments. Students will engage with ethical debate and learn to engage with different perspectives in solving ethical problems.

Critical and creative thinking

Critical and creative thinking are integral to activities where students learn to generate and evaluate knowledge, clarify concepts and ideas, seek possibilities, consider alternatives and solve problems. Critical and creative thinking are embedded in the skills and processes of Working Scientifically and Working Technologically. Students are provided with opportunities to develop critical and creative thinking skills through asking and posing questions, making predictions, engaging in primary and secondary-sourced investigations and analysing and evaluating evidence in order to making evidence-based decisions.

Ethical understanding

Students develop the capability to assess ethical values and principles, and understand how reasoning can assist ethical judgement. Students are provided with opportunities for students to form and make ethical judgements in relation to scientific investigations, design, codes of practice, and the use of scientific information and applications. Students explore the importance of reporting honestly based on evidence. They apply ethical guidelines in their investigations, particularly in their implications for others and the environment.

Information and communication technology capability

Information and communication technology (ICT) can be used effectively and appropriately to access, create and communicate information and ideas, solve problems and work collaboratively. Students are provided with opportunities to develop ICT capability when they develop alternative ideas and solutions, research science concepts and applications, investigate scientific phenomena, and communicate their scientific and technological understandings. In particular, they learn to access information, collect, analyse and represent data, model and interpret concepts and relationships, and communicate scientific and technological ideas, processes and information.

Intercultural understanding

Students develop intercultural understanding as they learn to understand themselves in relation to others. This involves students valuing their own cultures and those of others, and engaging with people of diverse cultures in ways that recognise commonalities and differences, create connections and cultivate respect. Students are provided with opportunities for students to appreciate how diverse cultural perspectives have impacted on the development, breadth and diversity of scientific knowledge and applications. Students learn about and engage with issues requiring cultural sensitivity, and that scientists work in culturally diverse teams to address issues and solve problems of national and international importance.

Literacy

Literacy is the ability to use a repertoire of knowledge and skills to communicate and comprehend effectively, using a variety of modes and media. Being 'literate' is more than the acquisition of technical skills – it includes the ability to identify, understand, interpret, create and communicate effectively using written, visual and digital forms of expression and communication for a number of purposes. Students are provided with opportunities to understand that language varies according to the context and engage with different forms of written and spoken language to communicate scientific concepts. Students learn that scientific information can also be presented in the form of diagrams, flowcharts, tables, graphs and models.

Numeracy

Numeracy involves students in recognising and understanding the role of Mathematics in the world. Students become numerate as they develop the confidence, willingness and ability to apply mathematics in their lives in constructive and meaningful ways. Students are provided with opportunities to develop numeracy skills through practical measurement and the collection, representation and interpretation of data from first-hand investigations and secondary sources. Students consider issues of uncertainty and reliability in measurement and learn data-analysis skills, identifying trends and patterns from numerical data and graphs. Students will apply mathematical relationships and concepts in order to solve problems.

Personal and social capability

Students develop personal and social capability as they learn to understand and manage themselves, their relationships and their lives more effectively. This includes establishing positive relationships, making responsible decisions, working effectively individually and in teams and constructively handling challenging situations. Through applying the processes of Working Scientifically students develop skills in collaboration, peer assessment and review. Students learn to plan and conduct a depth study either individually or in a team.

Civics and citizenship

Civics and citizenship content involves knowledge and understanding of how our Australian society operates. Students are provided with opportunities to broaden their understanding of aspects of civics and citizenship in relation to the application of science ideas and technological advances, including ecological sustainability and the development of environmental and sustainable practices at a local, regional and national level.

Difference and diversity

Difference and diversity comprise gender, race and socio-economic circumstances. Students are provided with opportunities for students to understand and appreciate the difference and diversity they experience in their everyday lives. Working Scientifically and Working Technologically provide opportunities for students to work collaboratively, where they can develop an appreciation of the values and ideas of all group members. This also enables them to identify individual rights, challenge stereotypes and engage with opinions different to their own.

Work and enterprise

Students develop work-related skills and an appreciation of the value of working individually and collaboratively when conducting investigations. Students are provided with opportunities to prioritise safe practices and understand the potential risks and hazards present when conducting investigations. They engage with risk assessment whilst working safely in the laboratory or in the field.

ORGANISATION OF CONTENT

for your information

The following provides a diagrammatic representation of the relationships between syllabus content.

consult

The Working Scientifically outcomes and content are to be integrated into each module wherever students undertake an investigation.

PHYSICS YEAR 11 COURSE CONTENT

consult

WORKING SCIENTIFICALLY SKILLS

The following Working Scientifically outcomes and content are to be integrated into each module wherever students undertake an investigation

1. QUESTIONING

OUTCOME

A student:

> poses questions and hypotheses for scientific investigation PH11-1

CONTENT

Students:

- develop and propose inquiry questions and hypotheses to identify an area that can be investigated scientifically, involving primary and/or secondary source data (ACSBL001)

2. DESIGNING INVESTIGATIONS

OUTCOME

A student:

> designs and plans appropriate scientific investigations PH11-2

CONTENT

Students:

- assess risks, consider ethical issues and select appropriate materials and technologies when designing and planning investigations (ACSBL031)
- include the use of variables and experimental controls to ensure that a valid procedure is developed that allows for the reliable collection of data (ACSBL002)

3. CONDUCTING INVESTIGATIONS

OUTCOME

A student:

> conducts primary or secondary-sourced investigations individually or in a team PH11-3

CONTENT

Students:

- employ safe work practices and manage risks (ACSBL031)
- use appropriate technologies to ensure accuracy
- select and extract information from reliable secondary sources, acknowledge them using an accepted referencing style

4. REPRESENTING

OUTCOME

A student:

> represents qualitative and quantitative data and information using a range of appropriate media PH11-4

CONTENT

Students:

- represent qualitative and quantitative data and information using a range of formats, digital technologies and appropriate media (ACSBL004, ACSBL007)

5. ANALYSING

OUTCOME

A student:

> analyses primary and secondary information sources PH11-5

CONTENT

Students:

- determine trends, patterns and relationships; identify error, uncertainty and limitations in data, including primary data and secondary-sourced information (ACSBL004, ACSBL005, ACSBL033)
- evaluate the relevance, accuracy, validity and reliability of primary and secondary-sourced data (ACSBL005)

6. SOLVING PROBLEMS

OUTCOME

A student:

> solves scientific problems PH11-6

CONTENT

Students:

- use modelling (including mathematical examples) to explain phenomena, make predictions and/or solve problems using evidence from primary and/or secondary sources (ACSBL006, ACSBL010)

7. COMMUNICATION

OUTCOME

A student:

> communicates scientific understanding PH11-7

CONTENT

Students:

- use suitable forms of digital, visual, written and verbal forms of communication
- apply appropriate scientific notations, nomenclature and scientific language to communicate in a variety of contexts (ACSBL008, ACSBL036)

UNIT 1 FUNDAMENTAL MECHANICS

MODULE 1 KINEMATICS

OUTCOMES

A student:

- > designs and plans appropriate scientific investigations PH11-2
- > conducts primary or secondary-sourced investigations individually or in a team PH11-3
- > selects and represents key qualitative and quantitative data and information using a range of appropriate media PH11-4
- > analyses primary and secondary information sources PH11-5
- > solves scientific problems PP11-6
- > describes and analyses motion in terms of scalar and vector quantities in two dimensions and makes quantitative measurements and calculations for distance, displacement, speed velocity and acceleration PH11-8

CONTENT FOCUS

Describing, measuring and analysing motion without considering the forces and the masses involved in that motion is the study of kinematics. Uniformly accelerated motion is described in terms of relationships between measurable scalar and vector quantities, including displacement, speed, velocity, acceleration and time.

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

By studying this module, students will understand that scientific knowledge can enable scientists to offer valid explanations and make reliable predictions, particularly in regard to the motion of an object.

Working Scientifically

Opportunities are to be provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on designing and conducting investigations to examine trends in data and to solve problems related to kinematics.

CONTENT

Motion in a straight line

Inquiry question: How do we describe and predict the motion of an object moving in a straight line?

Students:

- describe uniform straight-line (rectilinear) motion and uniformly accelerated motion through:
  - qualitative descriptions
  - the use of scalar and vector quantities (ACSPH060)
- conduct an investigation to gather data to facilitate the analysis of instantaneous and average velocity through:
  - quantitative, first-hand measurements
  - graphical representation and interpretation of data (ACSPH061)
- calculate relative velocity of two objects moving along the same line using vector analysis
- conduct Investigations, selecting from a range of technologies, to record and analyse the motion of objects in a variety of situations in one dimension in order to measure or calculate:
  - time
  - distance
  - displacement
  - speed
  - velocity
  - acceleration
- use mathematical modelling and graphs**,** selecting from a range of technologies, to analyse and derive relationships between time, distance, displacement, speed, velocity and acceleration in rectilinear motion, including:
  - $\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
  - $\vec{v} = \vec{u} + \vec{a}t$
  - $\vec{v}^2 = \vec{u}^2 + 2\vec{a}\vec{s}$ (ACSPH061)

1.1.2 Motion on a plane

Inquiry question: How do we describe motion of an object that changes its direction of movement on a plane?

Students:

- analyse vectors in one and two dimensions to:
  - resolve a two-dimensional vector into two independent, perpendicular components
  - add two perpendicular vector components to obtain a single vector (ACSPH061)
- represent distance and displacement of objects moving on a plane using:
  - vector addition
  - components of vectors (ACSPH060)
- describe ways in which the motion of objects change and describe and analyse these algebraically, graphically and with vector diagrams:
  - velocity
  - displacement
  - velocity and displacement (ACSPH060, ACSPH061)
- describe and analyse the relative positions and motions of one object relative to another on a plane using vector analysis (ACSPH061)
- analyse relative motion of objects in two dimensions for a variety of situations, for example:
  - the motion of a boat on a flowing river
  - the motion of two moving cars
  - the motion of a aeroplane in a cross wind (ACSPH060, ACSPH132)

UNIT 1 FUNDAMENTAL MECHANICS

MODULE 2 DYNAMICS

OUTCOMES

A student:

> designs and plans appropriate scientific investigations PH11-2
> represents qualitative and quantitative data and information using a range of appropriate media PH11-4
> solves scientific problems PH11-6
> describes and explains events in terms of Newton's laws, the law of conservation of momentum and the law of conservation of energy PH11-9

CONTENT FOCUS

This module begins by developing the key concept that forces are always produced in pairs that act on different objects and add to zero. The relationship between the motion of objects and the forces that act upon them is often complex; however, Newton's Laws of Motion can be used to describe the effect of forces on single objects and simple systems.

By applying Newton's Laws directly to simple systems, and where appropriate, the laws of conservation of momentum and mechanical energy, students will examine the effects of forces and the interactions and the relationships that can occur between objects by modelling and representing these using vectors and equations.

In many situations, within and beyond the discipline of Physics, knowing the rate of change of quantities provides deeper insight. In this module, rates of change of displacement, velocity and energy are of particular significance and an understanding of the usefulness and limitations of modelling is developed.

Working Scientifically

Opportunities are to be provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on designing and conducting investigations to interpret trends in data and to solve problems related to dynamics.

CONTENT

Forces

Inquiry question: How are forces produced between objects and what effects do forces produce?

Students:

- using Newton's Laws of Motion and in particular the Third Law, describe static and dynamic interactions between two or more objects and the changes that occur resulting from a:
  - contact force
  - force mediated by fields
- explore the concept of net force and equilibrium in one-dimensional and two-dimensional contexts using: (ACSPH050)
  - algebraic addition
  - vector addition
  - vector addition by resolution into components

- by applying the following relationships, solve problems or make quantitative predictions about resultant and component forces:
  - $F_{AB} = -F_{BA}$
  - $F_x = Fcos(\theta)$, $F_y = Fsin(\theta)$
- conduct an investigation to explain and predict the motion of objects on inclined planes (ACSPH098)

Forces, acceleration and energy

Inquiry question: How can the movement of objects be explained and analysed?

Students:

- apply Newton's first two laws of motion to a variety of everyday situations, including both static and dynamic examples and include the role played by friction (ACSPH063)
- investigate, describe and analyse the acceleration of a single object subjected to a constant net force and relate the motion of the object to Newton's Second Law of Motion through the use of: (ACSPH062, ACSPH063)
  - qualitative descriptions
  - graphs and vectors
  - deriving relationships including $F = ma$ and relationships of uniformly accelerated motion
- apply the law of conservation of mechanical energy to the quantitative analysis of motion involving:
  - work done and change in kinetic energy of an object undergoing acceleration in one dimension ($W = F_{net}s$)
  - changes in gravitational potential energy of an object in a uniform field ($\Delta U = mg\Delta h$)
  - elastic potential energy transferred to an object. ($U_p = \frac{1}{2}kx^2$)
- conduct investigations over a range of mechanical processes to analyse qualitatively and quantitatively the concept of average power $P = \frac{E}{t}$,$P = Fv$, including but not limited to:
  - uniformly accelerated motion
  - objects raised against the force of gravity
  - work done against air resistance, rolling resistance and friction

Momentum, energy and simple systems

Inquiry question: How are the movements of objects in a simple system dependent on the interaction between the objects?

Students:

- conduct an investigation to describe and analyse 1 (collinear) and 2-dimensional interactions of objects in simple closed systems (ACSPH064)
- quantitatively analyse and predict, using the law of conservation of momentum $\Sigma mv_{before} = \Sigma mv_{after}$ and the conservation of kinetic energy $\Sigma\frac{1}{2}mv^2_{before} = \Sigma\frac{1}{2}mv^2_{after}$, the results of interactions in elastic collisions (ACSPH066)
- investigate the relationship and analyse information obtained from graphical representations of Force v time and Force v distance
- the effects of forces involved in collisions and other interactions and analyse the interactions quantitatively using the concept of impulse ($\Delta p = F\Delta t$)
- analyse and compare the kinetic energy of elastic and inelastic collisions (ACSPH066)

Simple harmonic motion

Inquiry question: When the magnitude of the acceleration of an object is not constant, can we still find a way to model its motion?

Students:

- conduct an investigation to examine the motion of a variety of oscillating systems, for example:
  - simple pendulums
  - masses on springs
- investigate oscillations in terms of the variables:
  - amplitude
  - period
  - frequency
  - angular speed.
- perform calculations to demonstrate the relationships between the variables described above:
  - $\omega = 2\pi/T$
- investigate the forces acting on a variety of oscillating systems
- use modelling to demonstrate an oscillating system as simple harmonic motion and relate the acceleration of the system and its displacement from equilibrium using the relationships:
  - $a = -\omega^2 x$
  - $x = x_o \sin(\omega t)$
  - $v = v_o \cos(\omega t)$
- conduct an investigation to analyse Hooke's law:
  - $F = -kx$
- qualitatively and quantitatively investigate the transformations of energy occurring in systems performing simple harmonic motion

UNIT 2 ENERGY

MODULE 3 WAVES AND THERMODYNAMICS

OUTCOMES

A student:

> conducts primary or secondary-sourced investigations individually or in a team PH11-3
> represents qualitative and quantitative data and information using a range of appropriate media PH11-4
> solves scientific problems PH11-6
> communicates scientific understanding PH11-7
> explains and analyses waves and the transfer of energy in sound and light PH11-10

CONTENT FOCUS

In this module students investigate that wave motion involves the transfer of energy without the transfer of matter. By exploring the properties of wave motion and examining the characteristics of wavelength, frequency, period, velocity and amplitude students will come to a better understanding of the properties of waves. This understanding will allow students to demonstrate how waves can be reflected, refracted, diffracted and superposed (interfered). Students will also understand that not all waves require a medium to travel through. They will examine mechanical waves and electromagnetic waves and the differences between their similarities and differences in properties. (ACSPH070, ACSPH112)

Students will also examine an understanding of energy and that it can be transferred in the form of heat from one place to another. Thermodynamics examines the relationship between energy, temperature and matter. An understanding of this relationship provides an appreciation of particle motion within objects. Students will examine how hot objects lose energy in three ways: by conduction and convection – which both involve the motion of particles; and emission of electromagnetic radiation.

Working Scientifically

Opportunities are to be provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on conducting investigations, represent data and information, interpret trends in data and communicate scientific ideas about waves and thermodynamics.

CONTENT

Wave characteristics

Inquiry question: How can wave motion be investigated and characterised?

Students:

- conduct an investigation to create mechanical waves in a variety of situations to explain:
  - the role of the medium in the propagation of mechanical waves
  - the transfer of energy involved in the propagation of mechanical waves (ACSPH067, ACSPH070)
- conduct investigations to explain and analyse the differences between:
  - transverse and longitudinal waves (ACSPH068)

  - mechanical and electromagnetic waves (ACSPH070, ACSPH074)
- construct and/or interpret graphs of displacement v time and displacement v position of transverse and longitudinal wave and relate the features of these graphs to the following wave characteristics:
  - velocity
  - frequency
  - period
  - wavelength
  - displacement and amplitude (ACSPH069)
- solve problems and/or make predictions by modelling, deriving and applying the following relationships to a variety of situations:
  - $v = f\lambda$
  - $f = 1/T$

Wave behaviour

Inquiry question: How do waves behave?

Students:
- explain the behaviour of waves in a variety of situations by investigating the concepts of:
  - reflection
  - refraction
  - diffraction
  - wave superposition (ACSPH071, ACSPH072)
- conduct an investigation to distinguish between progressive and stationary waves (ACSPH072)
- conduct an investigation to explore resonance in mechanical systems and the relationships between:
  - the driving frequency
  - the natural frequency of the oscillating system
  - the amplitude of motion
  - the transfer/transformation of energy within the system (ACSPH073)

Sound waves

Inquiry question: What evidence suggests that sound is a mechanical wave?

Students:
- conduct an investigation to relate the pitch and loudness of a sound to its wave characteristics
- model the behaviour of sound in air as a longitudinal wave
- relate the displacement of air molecules to variations in pressure (ACSPH070)
- conduct an investigation to analyse the relationship between decibels, intensity, power energy and time in a sound wave
- investigate the relationship between distance and intensity of sound
- conduct investigations to analyse the reflection, diffraction and superposition of sound waves (ACSPH071)
- investigate and model the behaviour of standing waves on strings and/or in pipes to quantitatively relate the fundamental and harmonic frequencies of the waves produced to the physical properties (eg length, mass, tension, wave speed) of the medium (ACSPH072)
- analyse qualitatively and quantitatively, the relationships for the the wave nature of sound to explain:
  - beats, ($f_{beat} = [f_2 - f_1]$)
  - the Doppler effect ($f^1 = f(v_{wave} + v_{observer})/(v_{wave} - v_{source})$

The ray model of light

Inquiry question: How does the ray model of light demonstrate the wave nature of light?

Students:

- conduct an investigation to explain the formation of images in mirrors and lenses via reflection and refraction using the ray model of light (ACSPH075)
- conduct investigations to analyse qualitatively and quantitatively the refraction and total internal reflection of light (ACSPH075, ACSPH076)
- quantitatively predict, using Snell's Law and the concept of refractive index, the refraction and total internal reflection of light in a variety of situations
- conduct an investigation to demonstrate and explain the phenomenon of the dispersion of light
- conduct an investigation to demonstrate and relate the inverse square law, the intensity of light and the transfer of energy (ACSPH077)
- apply the following relationships to solve problems or make quantitative predictions in a variety of situations:
  - $n_x = c/v_x$ – for the refractive index of medium *x*, v_x is the speed of light in the medium
  - $n_1 sin\ (i)\ = n_2 sin\ (r)$ – Snell's Law
  - $sin\ (i_c) = 1/n_x$ – for the critical angle i_c of medium *x*
  - $I_1 x_1^2 = I_2 x_2^2$ – to compare the intensity of light at two points, x_1 and x_2

Thermodynamics

Inquiry question: How are temperature, heat, energy and particle motion interrelated?

Students:

- explain the relationship between the temperature of an object and the kinetic energy of the particles within it (ACSPH018)
- explain the concept of thermal equilibrium (ACSPH022)
- analyse the relationship between the change in temperature of an object, its change in heat energy and its specific heat capacity through the equation $\Delta Q = mc\Delta T$ (ACSPH020)
- investigate how energy transfer occurs via:
  - conduction
  - convection
  - radiation (ACSPH016)
- conduct an investigation to analyse, qualitatively and quantitatively, the latent heat involved in a change of state
- quantitatively model and predict energy transfer from hot objects using the concept of thermal conductivity
- apply the following relationships to solve problems or make quantitative predictions in a variety of situations:
  - $\Delta Q = mc\Delta T$ – where c is the specific heat capacity of a substance
  - $Q/t = kA\Delta T/d$ – where k is the thermal conductivity of a material

UNIT 2 ENERGY

MODULE 4 ELECTRICITY AND MAGNETISM

OUTCOMES

A student:

> poses questions and hypotheses for scientific investigation PH11-1
> analyses primary and secondary information sources PH11-5
> communicates scientific terminology understandings and conclusions and engages with peers in reviewing conclusions and presenting associated data and information using appropriate media PH11-7
> explains and quantitatively analyses electric fields, circuitry and thermodynamic principles PH11-11

CONTENT FOCUS

The Atomic Theory and the Laws of Conservation of Energy and electric charge are unifying concepts in understanding the electrical and magnetic properties and behaviour of matter. Interactions resulting from these properties and behaviours can be understood and analysed in terms of fields represented by lines. In this module, such models, along with mathematical models, are used to make predictions about the behaviour of objects. The limitations of the models used in this unit will also be explored.

Students will also examine how the analysis of the behaviour of electrical circuits and the transfer and conversion of energy in electric circuits has led to technological applications.

Working Scientifically

Opportunities are to be provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on developing questions and hypotheses, analysing trends and patterns in data while communicating ideas about electricity and magnetism.

CONTENT

Electrostatics

Inquiry question: How do charged objects interact with other charged objects and with neutral objects?

Students:

- conduct investigations to describe and analyse qualitatively and quantitatively:
  - the processes by which objects become electrically charged (ACSPH002)
  - the forces produced on other objects by charged particles (ACSPH103)
  - the variables which affect electrostatic forces between these particles (ACSPH103)
- using electric field lines model qualitatively to demonstrate the direction and strength of electric fields produced by:
  - simple point charges
  - pairs of charges
  - dipoles
  - parallel charged plates
- apply the field model to account for and quantitatively analyse interaction between charged objects using

  - $E = \frac{F}{q}$ (ACSPH103, ACSPH104)
  - $E = -\frac{V}{d}$
  - $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ (ACSPH102)
- analyse the effects of a moving charge in an electric field to relate potential energy, work and equipotential lines by applying (ACSPH105)
  - $V = \frac{\Delta U}{q}$ where U is Potential Energy and q is the charge

Electric circuits

Inquiry question: How do the processes of transfer and transformation of energy occur in electrical circuits?

Students:

- analyse qualitatively and quantitatively and apply models to investigate the flow of electric current ($I = \frac{q}{t}$) (ACSPH038)
- investigate quantitatively the current–voltage relationships in ohmic and non-ohmic resistors to explore the usefulness and limitations of Ohm's Law using:
  - $V = \frac{W}{q}$
  - $R = \frac{V}{I}$(ACSPH003, ACSPH041, ACSPH043)
- investigate quantitatively to analyse the rate of conversion of electrical energy in components of electric circuits including the production of heat and light, the application of $P = VI$ and other forms of this equation involving Ohm's Law (ACSPH042)
- investigate series and parallel circuits qualitatively and quantitatively to relate the flow of current through, the potential differences across individual components and rate of energy conversion by those components to the laws of conservation of charge and energy by deriving the following relationships: (ACSPH038, ACSPH039, ACSPH044)
  - $\Sigma I = 0\ (Kirchoff's\ current\ law\ -\ conservation\ of\ charge)$
  - $\Sigma V = 0\ (Kirchoff's\ voltage\ law\ -\ conservation\ of\ energy)$
  - $R_{Series} = R_1 + R_2 + \ldots R_n$
  - $\frac{1}{R_{Parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_n}$
- investigate quantitatively the application of the Law of Conservation of Energy to the heating effects of electric currents, including the application of P=IV and variations of this involving Ohm's Law (ACSPH043)

Magnetism

Inquiry question: How do magnetised and magnetic objects interact?

Students:

- investigate and describe qualitatively, the force produced between magnetised and magnetic materials in the context of ferromagnetic materials (ACSPH079)
- investigate and explain the process by which ferromagnetic materials become magnetised (ACSPH083)
- use magnetic field lines to model qualitatively the direction and strength of magnetic fields produced by magnets, current-carrying wires and solenoids and relate these fields to their effect on magnetic materials placed in them (ACSPH083)
- conduct investigations into and describe quantitatively the magnetic fields produced by wires and solenoids, including: (ACSPH106, ACSPH107)

  - $B = \frac{\mu_0 I}{2\pi r}$
  - $B = \frac{\mu_0 NI}{L}$
- apply models to qualitatively represent and quantitatively describe features of magnetic fields

YEAR 11 DEPTH STUDIES

OUTCOMES

Skills

A student:

> poses questions and hypotheses for scientific investigation PH11-1
> designs and plans appropriate scientific investigations PH11-2
> conducts primary or secondary-sourced investigations individually or in a team PH11-3
> represents qualitative and quantitative data and information using a range of appropriate media PH11-4
> analyses primary and secondary information sources PH11-5
> solves scientific problems PH11-6
> communicates scientific understanding PH11-7

Knowledge and understanding

A student:

> describes and analyses motion in terms of scalar and vector quantities in two dimensions and makes quantitative measurements and calculations for distance, displacement, speed velocity and acceleration PH11-8
> describes and explains events in terms of Newton's Laws, the Law of Conservation of Momentum and the Law of Conservation of Energy PH11-9
> explains and analyses waves and the transfer of energy in sound and light PH11-10
> explains and quantitatively analyses electric fields, circuitry and thermodynamic principles PH11-11

CONTENT

Possible depth studies

Unit 1 Fundamental Mechanics

- Examine the mechanics of an inertial reel seat belt
- How are scalar and vector quantities used in space exploration?
- Design a safety feature on a New Age car
- What are the forces involved in playing sport?
- Quantitative modelling of simple harmonic systems
- When does air friction become a problem when computing force and motion?
- Examine how tension and equilibrium of forces operate in bridges and buildings?

Unit 2 Energy

- Quantitatively investigate the behaviour of waves using the equation $y = A\sin\,(\omega t - kx)$ to model and predict wave phenomena such as beats and standing waves
- How is the timbre (quality) of a musical instrument related to the sound waves that it produces?
- Examine traditional ground oven control used by Aboriginal and Torres Strait Islander Peoples
- Explore the physics of traditional tools and instruments, eg didgeridoo
- Investigate the use of ultrasound in nature or in medicine
- How do acoustic engineers improve sound reception in theatres or open-air environments?
- How are lenses and mirrors combined to create optical instruments?
- How are waves used in communications?
- What materials make the best thermal insulators?

PHYSICS YEAR 12 COURSE CONTENT

consult

WORKING SCIENTIFICALLY SKILLS

The following Working Scientifically outcomes and content are to be integrated into each module wherever students undertake an investigation.

1. QUESTIONING

OUTCOMES

A student:

> develops and evaluates questions and hypotheses for scientific investigation PH12-1

CONTENT

Students:

- develop and evaluate inquiry questions and hypotheses to identify an area that can be investigated scientifically, involving primary and/or secondary-sourced data (ACSBL001)

2. DESIGNING INVESTIGATIONS

OUTCOMES

A student:

> designs, plans and evaluates primary and secondary-sourced investigations PH12-2

CONTENT

Students:

- assess risks, consider ethical issues and select appropriate materials and technologies when designing and planning an investigation (ACSBL031)
- justify and evaluate the use of variables and experimental controls to ensure that a valid procedure is developed that allows for the reliable collection of data (ACSBL002)

3. CONDUCTING INVESTIGATIONS

OUTCOMES

A student:

> conducts primary and secondary-sourced investigations individually or in a team PH12-3

CONTENT

Students:

- employ and evaluate safe work practices and manage risks (ACSBL031)
- use appropriate technologies, evaluate accuracy and identify sources of error
- select and extract information from a wide range of reliable secondary sources and acknowledging them using an accepted referencing style

4. REPRESENTING

OUTCOMES

A student:

> selects and represents key qualitative and quantitative data and information using a range of appropriate media PH12-4

CONTENT

Students:

- select and represent qualitative and quantitative data and information and represent them using a range of formats, digital technologies and appropriate media (ACSBL004, ACSBL007)

5. ANALYSING

OUTCOMES

A student:

> analyses primary and secondary information sources PH12-5

CONTENT

Students:

- derive trends, patterns and relationships; consider error, uncertainty and limitations in data; and interpret scientific and media texts (ACSBL004, ACSBL005, ACSBL033)
- evaluate the relevance, accuracy, validity and reliability of primary and secondary-sourced data and suggest improvements to investigations (ACSBL005)

6. SOLVING PROBLEMS

OUTCOMES

A student:

> solves scientific problems using primary and secondary data PH12-6

CONTENT

Students:

- use modelling (including mathematical examples) to explain phenomena, make predictions and solve problems using evidence from primary and secondary sources (ACSBL006, ACSBL010)

7. COMMUNICATION

OUTCOMES

A student:

> communicates scientific understanding using suitable language and terminology PH12-7

CONTENT

Students:

- select and use suitable forms of digital, visual, written and verbal forms of communication
- select and apply appropriate scientific notations, nomenclature and scientific language to communicate in a variety of contexts (ACSBL008, ACSBL036)
- construct evidence based arguments and engage in peer feedback to evaluate an argument and assess its validity (ACSBL034, ACSBL036)

UNIT 3 BEYOND THE FUNDAMENTALS

MODULE 5 ADVANCED MECHANICS

OUTCOMES

A student:

- > selects and represents key qualitative and quantitative data and information using a range of appropriate media PH12-4
- > analyses primary and secondary information sources PH12-5
- > solves scientific problems using primary and secondary data PH12-6
- > communicates scientific understanding using suitable language and terminology PH12-7
- > describes and analyses qualitatively and quantitatively circular motion and motion in a gravitational field, in particular, the projectile motion of particles PH12-8

CONTENT FOCUS

Motion in one dimension at constant velocity or constant acceleration can be explained and analysed relatively simply. However, motion is frequently more complicated: objects move in two or three dimensions: the net force may vary in size or in direction.

In this module students better understand that all forms of complex motion can be understood by analysing the forces acting upon the system, and the energy transformations taking place within and around it. By applying new mathematical techniques, students model and predict the motion of objects within systems. Students will examine two-dimensional motion including projectile motion and uniform circular motion along with the orbital motion of planets and satellites which can be modelled as an approximation to uniform circular motion.

Working Scientifically

Opportunities are to be provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on gathering, representing and analysing data to solve problems and communicate ideas about advanced mechanics.

CONTENT

Projectile motion

Inquiry question: How can projectile motion be modelled and predicted?

Students:

- analyse the motion of projectiles by resolving the motion into two independent horizontal and vertical components, making the following assumptions:
  - a constant vertical acceleration due to gravity
  - zero air resistance
- apply the modelling of projectile motion to quantitatively derive the relationship between the following variables and experimentally investigate the validity of the predictions made:
  - initial velocity
  - launch angle
  - maximum height
  - time of flight
  - final velocity
  - launch height
  - horizontal range of the projectile (ACSPH099)
- solve problems, create models and make quantitative predictions using the relationships:
  - $v_y = -gt + u_y$
  - $y = -1/2gt^2 + u_y t$
  - $v_y^2 = -2gy + u_y^2$
  - $v_x = u_x$
  - $x = u_x t$

  where: 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 = acceleration due to gravity ($9.8ms^{-2}$); t = time into flight (ACSPH099)

Circular motion

Inquiry question: Why do objects move in circles?

Students:

- conduct investigations to explain and evaluate the relationships that exist between:
  - centripetal force
  - mass
  - speed
  - radius for objects executing uniform circular motion
- analyse the forces acting on an object executing uniform circular motion in a variety of situations, for example:
  - cars moving around horizontal circular bends
  - a mass on a string
  - objects on banked tracks
  - vertical circular loops on a roller-coaster (ACSPH100)
- solve problems, model and make quantitative predictions about objects performing uniform circular motion in a variety of situations using the relationships:
  - $a = v^2/r$
  - $\Sigma F = mv^2/r$
  - $\varpi = \frac{\Delta\theta}{t}$

- investigate the relationship between the total energy and work done on an object executing uniform circular motion
- investigate the relationship of the rotation of mechanical systems to the concept of moments for applied torque $\tau = rF_{\perp} = rFsin\theta$

Motion in gravitational fields

Inquiry question: How does the force of gravity determine the motion of planets and satellites?

Students:

- apply Newton's Law of Universal Gravitation qualitatively and quantitatively to:
  - determine the force of gravity between two objects $F = -GMm/r^2$
  - investigate the factors that affect the gravitational field strength g $g = GM/r^2$
  - predict the gravitational field strength at any point in a gravitational field, including at the surface of a planet (ACSPH094, ACSPH095, ACSPH097)
- model the orbital motion of planets and artificial satellites as uniform circular motion to investigate the relationships between the following quantities:
  - gravitational force
  - centripetal force
  - centripetal acceleration
  - mass
  - orbital radius
  - orbital velocity
  - orbital period
- quantitatively predict the orbital properties of planets and satellites in a variety of situations, including near earth and geostationary orbits and relate these to their uses (ASCPH101)
- investigate the relationship of Kepler's Laws of Planetary Motion to the forces acting on, and the total energy of, planets in circular and non-circular orbits utilising: (ASCPH101)
  - $v_o = 2\pi r/T$
  - $r^3/T^2 = GM/4\pi^2$
- derive quantitatively and apply the concepts of gravitational force and gravitational potential energy in radial gravitational fields to a variety of situations, including but not limited to:
  - the concept of escape velocity $v_{esc} = (2GM/r)^{1/2}$
  - the total potential energy of a planet or satellite in its orbit $U = -GMm/r$
  - the total energy of a planet or satellite in its orbit $E = -GMm/2r$
  - the energy changes occurring when satellites move between orbits (ASCPH096)
  - Kepler's Laws of Planetary Motion (ACSPH101)

UNIT 3 BEYOND THE FUNDAMENTALS

MODULE 6 ELECTROMAGNETISM

OUTCOMES

A student:

> develops and evaluates questions and hypotheses for scientific investigation PH12-1
> designs, plans and evaluates primary and secondary-sourced investigations PH12-2
> conducts primary and secondary-sourced investigations individually or in a team PH12-3
> selects and represents key qualitative and quantitative data and information using a range of appropriate media PH12-4
> analyses primary and secondary information sources PH12-5
> explains and analyses the electric and magnetic interactions due to charged particles and currents and evaluates qualitatively and quantitatively their effect PH12-9

CONTENT FOCUS

Discoveries about the interactions that take place between charged particles and electric and magnetic fields not only produced significant advances in physics, but also led to significant technological developments including the generation and distribution of electricity and the invention of numerous devices that convert electrical energy into other forms of energy.

Understanding the similarities and differences in the interactions of single charges in electric and magnetic fields provides a conceptual foundation for this module. Many phenomena, including the force produced on a current-carrying wire in a magnetic field, the force between current-carrying wires, Faraday's Law, the principles of transformers and the workings of motors and generators can all be understood at a fundamental level in terms of the force acting on a charged particle moving in a magnetic field.

The Law of Conservation of Energy underpins all of these interactions and the conversion of energy into forms other than the intended form is a problem that constantly drives engineers to improve designs of electromagnetic devices.

Working Scientifically
Opportunities are to be provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on developing and evaluating questions and hypotheses when designing and conducting investigations to analyse trends, patterns and relationships in data to solve problems about electromagnetism.

CONTENT

Charged particles, conductors and electric and magnetic fields

Inquiry question: What happens to stationary and moving charged particles when they interact with an electric or magnetic field?

Students:

- investigate and quantitatively derive and analyse the interaction between charged particles and uniform electric fields including: (ACSPH083)
  - the electric field between parallel charged plates ($E = \frac{V}{d}$)

  - the acceleration of charged particles by the electric field ($F = ma, F = qE$)
  - the work done on the charge ($W = qV, W = qEd, K = \frac{1}{2}mv^2$)
- qualitatively and quantitatively, model the trajectories of charged particles in electric fields and compare them with the trajectories of projectiles in a gravitational field
- analyse the interaction between charged particles and uniform magnetic fields including: (ACSPH083)
  - the acceleration, perpendicular to the field, of charged particles
  - the work done by the force on the charge ($F = qvBsin(\theta)$)
- compare the interaction of charged particles moving in magnetic fields to:
  - the interaction of charged particles with electric fields
  - other examples of uniform circular motion (ACSPH108)

The Motor Effect

Inquiry question: Under what circumstances is a force produced on a current-carrying conductor in a magnetic field?

Students:

- investigate, qualitatively and quantitatively, the interaction between a current-carrying conductor and a uniform magnetic field ($F = BIlsin(\theta)$) to establish: (ACSPH080, ACSPH081)
  - the conditions under which the force produced is a maximum
  - the relationship between the directions of the vector quantities force, magnetic field strength and current
  - the conditions under which no force is produced on the conductor
- conduct a quantitative investigation to demonstrate the interaction between two parallel current-carrying wires
- analyse the interaction between two parallel current-carrying wires ($\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$) relating this to the SI definition of the ampere and Newton's Third Law of Motion (ACSPH081, ACSPH106)

Electromagnetic induction

Inquiry question: How are electric and magnetic fields related?

Students:

- describe how magnetic flux can change, with reference to the relationship $\Phi = BA$ (ACSPH083, ACSPH107, ACSPH109)
- qualitatively and quantitatively analyse, with reference to energy transfers and transformations, examples of Faraday's Law and Lenz's Law ($emf = -\frac{\Delta\Phi}{\Delta t}$) including but not limited to: (ACSPH081, ACSPH110)
  - the generation of an emf and evidence for Lenz's Law produced by the relative movement between a magnet, straight conductors, metal plates and solenoids
  - the production of an emf in a solenoid by relative movement or changes in current in one solenoid in the vicinity of another
- analyse quantitatively the operation of ideal transformers through the application of (ACSPH110)
  - $\frac{V_P}{V_S} = \frac{N_P}{N_S}$
  - $V_p I_p = V_s I_s$
- qualitatively evaluate the limitations of the ideal transformer model and the strategies used to improve transformer efficiency, including but not limited to:
  - incomplete flux linkage

  - resistive heat production and eddy currents
- analyse applications of step-up and step-down transformers, including but not limited to:
  - the distribution of energy using high-voltage transmission lines
  - an inverter

Applications of the Motor Effect

Inquiry question: How has knowledge about the Motor Effect been applied to technological advances?

Students:

- investigate the operation of a simple DC motor to analyse:
  - the functions of its components
  - the production of a torque ($\tau = nBAcos(\theta)$) and
  - the effects of back emf (ACSPH108)
- analyse the operation of simple DC and AC generators and AC induction motors (ACSPH110)
- relate Lenz's Law to the Law of Conservation of Energy and analyse the application of this law to:
  - DC motors and
  - magnetic braking

UNIT 4 DEVELOPING NEW IDEAS IN PHYSICS

MODULE 7 WAVES OR PARTICLES?

OUTCOMES

A student:

- develops and evaluates questions and hypotheses for scientific investigation PH12-1
- designs, plans and evaluates primary and secondary-sourced investigations PH12-2
- conducts primary and secondary-sourced investigations individually or in a team PH12-3
- selects and represents key qualitative and quantitative data and information using a range of appropriate media PH12-4
- communicates scientific understanding using suitable language and terminology PH12-7
- describes, evaluates and applies properties of electromagnetic waves and the implications of their study to Physics in a contemporary world PH12-10

CONTENT FOCUS

Prior to the twentieth century, physicists, including Newton and Maxwell, developed theories and models about mechanics, electricity and magnetism and the nature of matter, all of which had great explanatory power and produced useful predictions. However, the twentieth century saw major developments in physics as existing theories and models were challenged by observations that could not be explained. These new observations led to the development of Quantum Theory and the Theory of Relativity. Technologies born of these theories have shaped modern civilisation. As an example, the independence of the speed of light on the frame of observation or the motion of the source and observer had significant consequences for the measurement of time and space and conceptions of their nature.

Throughout this module, the evidence supporting these physical theories is explored, along with the power of scientific theories to make useful predictions.

Working Scientifically

Opportunities are to be provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on developing and evaluating questions and hypotheses when designing and conducting investigations to analyse trends, patterns and relationships in data to communicate ideas about the nature of light.

CONTENT

The electromagnetic spectrum

Inquiry question: What is light?

Students:

- investigate Maxwell's contribution to the classical theory of electromagnetism, including:
  - the unification of electricity and magnetism
  - the prediction of electromagnetic waves
  - their propagation velocity (ACSPH113)
- describe the production and propagation of electromagnetic waves and relate these processes qualitatively to the predictions made by Maxwell's electromagnetic theory (ACSPH113, ACSPH112)

- conduct investigations of historical and contemporary methods used to determine the speed of light and its current relationship to the measurement of time and distance (ASCPH082)
- investigate how spectroscopy can be used to provide information about:
  - the identification of elements

Light: the classical wave model

Inquiry question: What evidence supports the wave model of light and what predictions can be made using this model?

Students:

- conduct qualitative investigations to analyse the diffraction of light (ACSPH048, ACSPH076)
- conduct quantitative investigations to analyse the interference of light using double slit apparatus and diffraction gratings ($dsin(\theta) = m\lambda$) (ACSPH116, ACSPH117, ACSPH140)
- analyse the experimental evidence that supported models for light that were proposed by Newton and Huygens (ACSPH050, ACSPH118, ACSPH123)
- conduct quantitative investigations, utilising the relationship of Malus' Law ($I_{max} = I_0 cos^2\theta$) for plane polarisation of light and evaluate the significance of polarisation in conceptualising a model for light (ACSPH050, ACSPH076, ACSPH120)

Light: the Quantum Model

Inquiry question: What evidence supports the particle model of light and what predictions can be made using this model?

Students:

- conduct an investigation into the experimental evidence gathered about black body radiation including Wein's Law $\left(\lambda_{max} = \frac{b}{T}\right)$ to evaluate Planck's contribution to a changed model of light (ACSPH137)
- investigate how temperature, colour, luminosity, age and mass of stars are related
- investigate the life cycle of stars using the Hertzsprung–Russell diagram
- conduct an investigation of the evidence from photoelectric effect investigations that was inconsistent with the wave model for light (ACSPH087, ACSPH123, ACSPH137)
- analyse the photoelectric effect as it occurs in metallic elements by applying the Law of Conservation of Energy $E_k = hf - \Phi$ (ACSPH119)

Light and Special Relativity

Inquiry question: How does the behaviour of light affect conceptions of time, space and matter?

Students:

- analyse the evidence for the two postulates that the speed of light in a vacuum is an absolute constant and that all inertial frames of reference are equivalent, which underpins the theory of special relativity, for example: (ACSPH131)
  - the Michelson–Morley experiment
  - difficulties with the application of Galilean concept of relative motion to electromagnetic radiation
- conduct an investigation of the evidence, from Einstein's thought experiments and from subsequent experimental validation, for time dilation $t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$ and length contraction $l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$ and quantitatively analyse situations in which these are observed, for example:

  - observations of cosmic-origin muons at Earth's surface
  - atomic clocks (Hafele–Keating experiment) and the GPS navigation system
  - evidence from particle accelerators
  - evidence from cosmological studies
- describe consequences and applications of relativistic momentum with reference to:
  - $p_v = \frac{mv}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$
  - the limitation to the maximum velocity of a particle imposed by special relativity (ACSPH133)
- Use Einstein's mass–energy equivalence relationship $E = mc^2$ to calculate the energy released by processes in which mass is converted to energy, for example: (ACSPH134)
  - the production of energy by the sun
  - particle–antiparticle interactions such as positron–electron annihilation
  - burning of conventional fuel

UNIT 4 DEVELOPING NEW IDEAS IN PHYSICS

MODULE 8 MODELS OF THE ATOM

OUTCOMES

A student:

> analyses primary and secondary information sources PH12-5
> solves scientific problems using primary and secondary data PH12-6
> communicates scientific understanding using suitable language and terminology PH12-7
> explains and analyses the nuclear model of the atom, quantitatively analyses electron and photon energies, spectra and the implications of their study in the contemporary world PH12-11

CONTENT FOCUS

Beginning in the late nineteenth and early twentieth centuries, experimental discoveries revolutionised the understanding of the nature of matter on an atomic scale. Observations of the properties of matter and light have inspired the development of better models of matter which, in turn, have been modified or abandoned in the light of further experimental investigations.

By studying the development of the atomic model through the work of Thomson and Rutherford in establishing the nuclear model of the atom: a positive nucleus surrounded by electrons, students come to a better understanding of the limitations of theories and models. The work of Bohr, de Broglie and later Schrödinger demonstrated the quantum mechanical nature of matter as a better way to help understand the structure of the atom. Experimental investigations of the nucleus have led to an understanding of radioactive decay, the ability to extract energy from nuclear fission and fusion, and an even further understanding of the model of the atom.

Particle accelerators have revealed that protons themselves are not fundamental, and have continued to provide evidence in support of the Standard Model of Matter. Students will appreciate that the fundamental particle model is forever being updated and that our understanding of the nature of matter remains incomplete.

Working Scientifically

Opportunities are provided for students to engage with all the Working Scientifically skills for each investigation. In this module students focus on analysing trends, patterns and relationships in data to solve problems and to communicate ideas about the development of the models of the atom.

CONTENT

The structure of the atom

Inquiry question: How do we know that atoms are made up of protons, neutrons and electrons?

Students:

- investigate, assess and model the experimental evidence supporting the existence and properties of the electron, including:
  - early experiments into the nature of cathode rays
  - Thomson’s e/m experiment
  - Millikan's experiment to measure specific charge (ACSPH026)

- investigate, assess and model the experimental evidence supporting the nuclear model of the atom, including:
  - the Geiger Marsden experiment
  - Rutherford's Atomic Model
  - Chadwick's discovery of the neutron (ACSPH026)

The quantum mechanical nature of the atom

Inquiry question: How do we know that classical physics cannot explain the properties of the atom?

Students:

- conduct an investigation to assess the limitations of the Rutherford and Bohr atomic models
- investigate the line emission spectra of elements to demonstrate the Balmer series in hydrogen (ACSPH138)
- qualitatively and quantitatively relate the quantised energy levels of the hydrogen atom and the Law of Conservation of Energy to the line emission spectrum of hydrogen
  - $E = hf$
  - $E = hc/\lambda$
  - $1/\lambda = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$(ACSPH136)
- investigate the de Broglie concept of matter waves, and the experimental evidence using,
  - $\lambda = \frac{h}{mv}$ (ACSPH140)
- analyse the contribution of Schrödinger to the contemporary model of the atom

Properties of the nucleus

Inquiry question: How can the energy of the atomic nucleus be harnessed?

Students:

- investigate the relative strength of the forces acting on particles within the nucleus to explain the stability of atomic nuclei (ACSPH027)
- analyse the spontaneous decay of unstable nuclei, and the properties of the alpha, beta and gamma radiation emitted (ACSPH028, ACSPH030)
- deduce the concept of half-life in radioactive decay and make quantitative predictions about the activity or amount of a radioactive sample using the relationships:
  - $N = N_o e^{-\lambda t}$
  - $\lambda = \frac{ln\,(2)}{t_{1/2}}$ where N = number, N_o = number started with, λ =decay constant, $t_{1/2}$= time for half radioactive amount t_o to decay (ACSPH029)
- investigate to model and explain the process of nuclear fission, including the concepts of controlled and uncontrolled chain reactions, and account for the release of energy in the process (ACSPH033, ACSPH034)
- derive relationships to represent conservation of mass-energy in spontaneous and artificial nuclear transmutations, including alpha decay, beta decay, nuclear fission and nuclear fusion (ACSPH032)
- conduct an investigation to account for the release of energy in the process of nuclear fusion (ACSPH035, ACSPH036)
- quantitatively predict the energy released in nuclear decays or transmutations, including nuclear fission and nuclear fusion by applying: (ACSPH031, ACSPH035, ACSPH036)
  - the Law of Conservation of Energy
  - mass defect
  - binding energy
  - $E = mc^2$

Deep inside the atom

Inquiry question: How do we know that our understanding of matter is still incomplete?

Students:

- analyse the evidence to suggest:
  - that protons and neutrons are not fundamental particles and
  - the existence of subatomic particles other than protons, neutrons and electrons
- investigate the standard model of matter, including:
  - quarks, and the quark composition hadrons
  - leptons
  - fundamental forces (ACSPH141, ACSPH142)
- investigate the operation and the role of particle accelerators in obtaining evidence that tests and/or validates aspects of theories including the Standard Model (ACSPH120, ACSPH121, ACSPH122, ACSPH146)

YEAR 12 DEPTH STUDY

OUTCOMES

Skills
A student:

> develops and evaluates questions and hypotheses for scientific investigation PH12-1
> designs, plans and evaluates primary and secondary-sourced investigations PH12-2
> conducts primary and secondary-sourced investigations individually or in a team PH12-3
> selects and represents key qualitative and quantitative data and information using a range of appropriate media PH12-4
> analyses primary and secondary information sources PH12-5
> solves scientific problems using primary and secondary data PH12-6
> communicates scientific understanding using suitable language and terminology PH12-7

Knowledge and understanding
A student:

> describes and analyses qualitatively and quantitatively circular motion and motion in a gravitational field, in particular, the projectile motion of particles PH12-8
> explains and analyses the electric and magnetic interactions due to charged particles and currents and evaluates qualitatively and quantitatively their effect PH12-9
> describes, evaluates and applies properties of electromagnetic waves and the implications of their study to Physics in a contemporary world PH12-10
> explains and analyses the nuclear model of the atom, quantitatively analyses electron and photon energies, spectra and the implications of their study in the contemporary world PH12-11

CONTENT

Possible Depth Studies

Unit 3 Beyond the Fundamentals

- Examine rotational dynamics: Moment of Inertia
- Modell air resistance in free-fall and projectile motion
- Examine the effect of spin and air-resistance on the movement of a ball
- Examine the physics behind the flight of a boomerang
- Explore applications of satellite technology
- Inquire into interplanetary travel: Hohmann Transfer Orbits and the Interplanetary Transport Network
- Examine the physics of highly elliptical orbits
- Explore the prediction of the existence of and discovery of Neptune, Pluto and ‘Planet X’
- Examine orbital resonance

Unit 4 Developing new ideas in Physics

- Examine applications of spectroscopy to astronomy
- Inquire into statistical modelling of radioactive decay
- Examine applications of radioactivity to medicine
- Examine technological applications of nuclear fission
- Research nuclear fusion and the life-cycle of stars
- Explore the search for controllable nuclear fusion
- Research beyond the standard model of matter

GLOSSARY

for your information

The glossary explains terms that will assist teachers in the interpretation of the subject. The glossary will be based on the NSW Science K–10 glossary and the Australian curriculum senior secondary years Physics glossary.

consult

Glossary term	Definition
account	Account for: State reasons for, report on. Give an account of: narrate a series of event or transactions.
analyse	To consider in detail for the purpose of finding meaning or relationships, and identifying patterns, similarities and differences.
apply	Use, utilise, employ in a particular situation.
assess	Make a judgement of value, quality, outcomes, results or size.
black body	an imaginary object that is a perfect absorber of radiation (and also a perfect emitter) at all wavelengths.
calculate	Ascertain/determine from given facts, figures or information.
charge	The intrinsic electrical nature of a body; may be positive or negative
clarify	Make clear/ plain.
classical physics	Physics as it was understood before the advent of Quantum Physics and Relativity. The term is generally applied to physics that was established before the end of the 19th century
classify	Arrange or include in classes/categories.
collision	An interaction, usually involving contact, between two or more bodies.
collision, elastic	A collision in which the total kinetic energy of the colliding bodies after collision is equal to their total kinetic energy before collision.
collision, inelastic	A collision in which the total kinetic energy of the colliding bodies after collision is less than their total kinetic energy before collision.
Country	An area that is traditionally owned and looked after by an Aboriginal language group or community or certain people within that group. The term may indicate more than simply a geographical area; it is also a concept that can encompass the spiritual meanings and feelings of attachment associated with that area.

Glossary term	Definition
compare	Show how things are similar or different.
conclusion	A judgement based on evidence.
construct	Make, build, put together items or arguments.
contrast	Show similarities or differences.
controlled variable	A variable that is kept constant (or changed in constant ways) during an investigation.
current, alternating	The transfer of electrical energy in a conductor which takes place when the electric charges in the conductor oscillate in response to an alternating potential difference across the conductor.
current, direct	the flow of electric charge in one direction, usually through a conductor (see also current).
current, electric	the flow of electric charge, usually through a conductor or resistor. The term may refer to the flow of charged particles through a vacuum. In the context of current, charge may may be electrons, ions or positive holes (in a semiconductor).
deduce	Draw conclusions.
define	State meaning and identify essential qualities.
demonstrate	Show by example.
dependent variable	A variable that changes in response to changes to the independent variable in an investigation.
design	To plan and evaluate the construction of a product or process, including an investigation.
digital technologies	Tools that handle digital data, including hardware and software, for specific purposes.
dipole	Having opposite electric charge at opposite ends of a molecule or body.
discuss	Identify issues and provide points for and against.
distinguish	Recognise or note/indicate as being distinct or different from; to note differences between.
dynamic	Changing over time eg moving.
elastic	The property of a body which enables it to regain its original shape following the removal of a force that deformed it.
energy	The capacity of a physical system to do work; the capacity of electromagnetic radiation to do work.

Glossary term	Definition
energy potential	The energy that an object has due to its position in a force field or stored in a system by virtue of the configuration and interaction between bodies in that system, eg elastic potential energy.
energy, kinetic	The energy that an object possesses by virtue of its motion.
environment	All the surroundings, both living and nonliving.
equilibrium	A state of balance resulting from the application of two or more forces which produce a zero net force.
equipotential	Points in a field that have the same potential.
evaluate	To examine and judge the merit or significance of something, including processes, events, descriptions, relationships or data.
examine	Inquire into.
explain	Relate cause and effect; make the relationship between things evident/provide why and/or how.
extract	Choose relevant and/or appropriate.
field	A region in which a body experiences a force due to the effects of another body. The effect can be the mass within the bodies, their charges or magnetic properties.
field, electric	A region in which a stationary electric charge experiences a force due to the influence of another charged object.
force	An influence that acts to change the motion of a body or to impose an elastic strain on it.
force, net	The vector sum of the forces acting on a body.
frame of reference, inertial	A reference frame in which a body moves at a constant velocity unless acted on by a net force.
frame of reference	A coordinate system that enables the position of a body to be specified.
hypothesis	A tentative idea or explanation for an observation, which can be tested and either supported or refuted by investigation.
identify	Recognise and name.
independent variable	A variable that is changed in an investigation to see what effect it has on the dependent variable.
inquiry question	A driving question for an investigation.
interpret	Draw meaning from.
investigate	Conduct an investigation.

Glossary term	Definition
investigation	A scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities.
justify	Support an argument or conclusion.
magnet	A magnetic material that has been magnetised i.e. which has a magnetic field.
magnetic material	A material that is capable of being magnetised.
magnetised material	Magnetic material which has magnetic poles.
model	A representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea.
momentum, linear	The product of the mass (m) and the velocity (v) of a body.
outline	Sketch in general terms; indicate the main features.
photoelectric effect	The process in which a photon ejects an electron from an atom so that all the energy of the photon is absorbed in separating the electron and in imparting kinetic energy to it.
Place	Is a space mapped out by physical or intangible boundaries that individuals or groups of Torres Strait Islander peoples occupy and regard as their own. It is a space with varying degrees of spirituality.
plan	Decide on and make arrangements for in advance.
predict	Suggest what might happen based on available information.
primary sources	Information created by a person or persons directly involved in a study or observing an event.
propose	Put forward (for example a point of view, idea, argument, suggestion) for consideration or action.
recall	Present remembered ideas, facts or experiences.
recommend	Provide reasons in favour.
recount	Retell a series of events.
relate	To identify connections or associations between ideas or relationships or between components of systems and structures.
reliability	Data that have been judged to have a high level of reliability; reliability is the degree to which an assessment instrument or protocol consistently and repeatedly measures an attribute achieving similar results for the same population.

Glossary term	Definition
resistance	The ratio of the voltage across a component of a circuit to the current flowing through it; R=V/I; SI unit is ohm (equivalent to a volt/ampere).
resistor	An electrical component or material the properties of which limit the flow of an electric current through it.
secondary-sourced investigation	Information that has been compiled from primary sources by a person or persons not directly involved in the original study or event.
solenoid	A coil made of an electrically conducting material.
static	Not changing over time.
summarise	Express, concisely, the relevant details.
synthesise	Putting together various elements to make a whole.
theory	An explanation of a set of observations that is based on one or more proven hypotheses, which has been accepted through consensus by a group of scientists.
validity	An extent to which tests measure what was intended; an extent to which data, inferences and actions produced from tests and other processes are accurate.
variable	A factor that can be changed, kept the same or measured in an investigation, for example, time, distance, light, temperature.
vector	A quantity having both magnitude and direction.
voltage	A measure of the electrical potential difference between two points; SI unit is the volt (equivalent to joule/coulomb).
work	Work is done by a force when its application results in movement having a component in the direction of the applied force.