NSW Education Standards Authority

Physics 11–12 (2025)

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NESA acknowledges Traditional Owners and Custodians of Country throughout NSW, and pays respect to Elders past and present. NESA recognises Aboriginal Peoples' continuing Cultures and Connections to lands, waters, skies and Community.

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Physics 11–12 (2025)

Implementation from 2027

The new Physics 11–12 Syllabus (2025) is to be implemented from 2027 and will replace the **Physics Stage 6 Syllabus (2017)**.

2026

- Plan and prepare to teach the new syllabus

2027, Term 1

- Start teaching the new syllabus for Year 11
- Start implementing new Year 11 school-based assessment requirements
- Continue to teach the **Physics Stage 6 Syllabus (2017)** for Year 12

2027, Term 4

- Start teaching the new syllabus for Year 12
- Start implementing new Year 12 school-based assessment requirements

2028

- First HSC examination for the new syllabus

Overview

Syllabus overview

The *Physics 11–12 Syllabus* aligns with the *Physical World Science Life Skills 11–12 Syllabus* to provide opportunities for integrated delivery.

Through collaborative curriculum planning, it may be decided that Life Skills outcomes and content are the most appropriate option for some students with intellectual disability.

Organisation of Physics 11–12

The organisation of the syllabus illustrates the important role of Working scientifically across all areas of Physics 11–12 and its connection to scientific knowledge and concepts. Depth studies provide students with opportunities to apply their knowledge through scientific investigations.

Figure 1 shows the organisation of Physics 11–12.

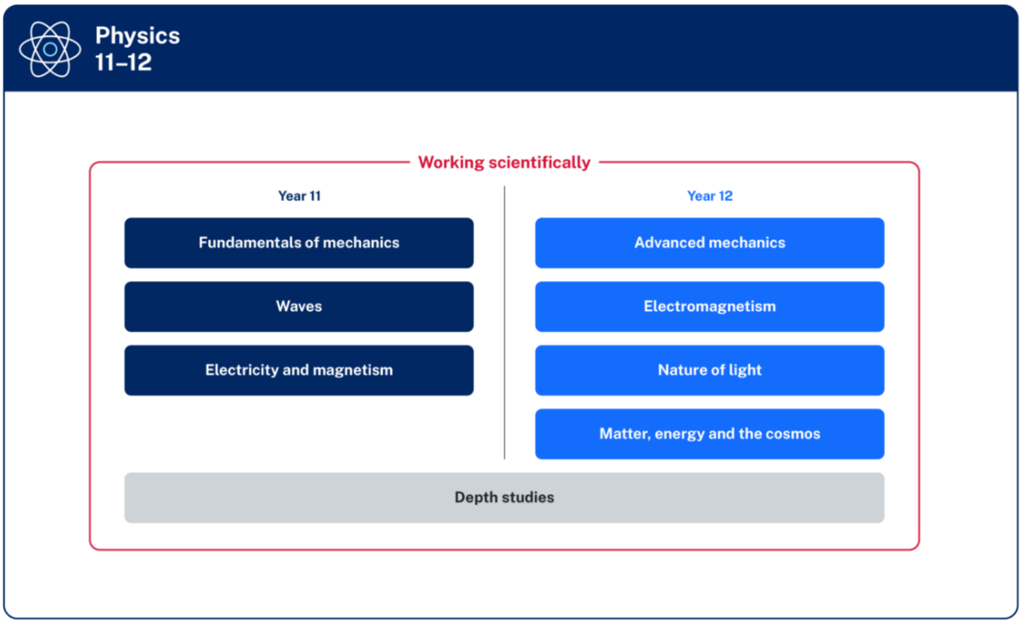

Figure 1: The organisation of Physics 11–12

Image long description: The focus areas are listed in 2 columns under the headings Year 11 and Year 12. The 3 focus areas for Year 11 are Fundamentals of mechanics, Waves, and Electricity and magnetism. The 4 focus areas for Year 12 are Advanced mechanics, Electromagnetism, Nature of light, and Matter, energy and the cosmos. Extending across the bottom of both columns is a rectangular box labelled 'Depth studies'. A line labelled 'Working scientifically' encircles all elements listed.

Protocols for collaborating with Aboriginal and Torres Strait Islander Communities

NESA is committed to working in partnership with Aboriginal Communities and supporting teachers, schools and schooling sectors to improve educational outcomes for young people.

It is important to respect appropriate ways of interacting with Aboriginal Communities and Cultural material when teachers plan, program and implement learning experiences that focus on Aboriginal and Torres Strait Islander Priorities.

Indigenous Cultural and Intellectual Property (ICIP) protocols need to be followed. Aboriginal and Torres Strait Islander Peoples' ICIP protocols include Cultural Knowledges, Cultural Expression and Cultural Property and documentation of Aboriginal and Torres Strait Islander Peoples' identities and lived experiences. It is important to recognise the diversity and complexity of different Cultural groups in NSW, as protocols may differ between local Aboriginal Communities.

Teachers should work in partnership with Elders, parents, Community members, Cultural Knowledge Holders, or a local, regional or state Aboriginal Education Consultative Group. It is important to respect Elders and the roles of men and women. Local Aboriginal Peoples should be invited to share their Cultural Knowledges with students and staff when engaging with Aboriginal histories and Cultural Practices.

Course description

The *Physics 11–12 Syllabus* provides students with the opportunity to analyse, study and enjoy an understanding of the physical world around us. Students build on their learning from the *Science 7–10 Syllabus* (2023) as they investigate phenomena, make predictions and solve problems related to emerging technologies, energy systems and scientific innovation. Students generate and analyse data and evaluate results to make ethical, evidence-based decisions as informed, reflective and scientifically literate citizens.

What students learn

Through the study of Physics 11–12, students:

- develop knowledge and understanding of the complexity of the physical world and the Universe and how they work
- explore how Aboriginal and Torres Strait Islander Peoples' ways of Knowing, Being and Doing enhance and provide social and Cultural context to the study of physics
- apply their knowledge of physics to address real-world problems and explore the impact of physics on society
- develop critical thinking, ethical decision-making and problem-solving skills.

Course structure and requirements

Year 11 course structure and requirements

The Year 11 Physics course comprises a study of:

- 120 indicative hours across 3 focus areas, including 10 hours of depth studies
- integrated Working scientifically outcomes and content.

Students are required to study all components of the course.

Year 11 focus areas	Indicative hours
Fundamentals of mechanics	50
Waves	35
Electricity and magnetism	35

Year 12 course structure and requirements

The Year 12 Physics course comprises a study of:

- 120 indicative hours across 4 focus areas, including 10 hours of depth studies
- integrated Working scientifically outcomes and content.

Students are required to study all components of the course.

Year 12 focus areas	Indicative hours
Advanced mechanics	30
Electromagnetism	30
Nature of light	30
Matter, energy and the cosmos	30

Working scientifically

The Working scientifically outcomes and content are integral to the study of Physics 11–12. The Working scientifically outcomes address:

- questioning and predicting
- planning scientific investigations
- conducting scientific investigations
- processing data and information
- analysing data and information
- problem-solving
- communicating.

Teachers must integrate relevant Working scientifically outcomes and content with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Scientific investigations

Each focus area in the *Physics 11–12 Syllabus* includes content points that contain scientific investigations. These content points include practical investigations and secondary-source investigations and are conducted individually and collaboratively.

Practical investigations include:

- laboratory experiments
- computer simulations; modelling, processing and analysing primary data, and using appropriate digital technologies
- fieldwork.

Secondary-source investigations include:

- extracting, analysing and using data and information from secondary sources
- reorganising and communicating secondary-source data and information in the form of flow charts, tables, graphs, diagrams, written documents, keys, spreadsheets or databases
- using existing models to inform understanding.

Some students with disability may require adjustments to conduct scientific investigations.

Depth studies

Depth studies are targeted scientific investigations in which students deepen their understanding of course content through the application of Working scientifically knowledge. They provide opportunities for students to pursue their interests and deepen their scientific understanding of one or more focus areas.

- 10 hours of depth studies are undertaken as part of course requirements.
- At least ONE depth study must be completed in both Year 11 and Year 12.
- The depth study must include Working scientifically content from Questioning and predicting in addition to content from at least ONE other focus area.
- Depth studies may be completed individually or collaboratively.

Some students with disability may require adjustments in order to engage with the depth studies.

Safety and risk management

Schools are required to ensure they follow safety and risk management in delivering the *Physics 11–12 Syllabus*.

Course enrolment details

Physics Year 11

- Course number: 11310
- Course hours: 120
- Course units: 2
- Enrolment type: Elective
- Endorsement type: Board developed

Exclusions

- Physical World Science Life Skills (Year 11, 2 units): 16667

Prerequisites

- Nil

Corequisites

- Nil

Physics Year 12

- Course number: 15330
- Course hours: 120
- Course units: 2
- Enrolment type: Elective
- Endorsement type: Board developed

Exclusions

- Physical World Science Life Skills (Year 12, 2 units): 16667

Prerequisites

- Physics (Year 11, 2 units): 11310

Corequisites

- Nil

HSC information

Information about curriculum requirements for the HSC are available on Assessment Certification Examination (ACE).

Rationale

Physics is the study of matter, motion and energy across space and time. It includes fields of inquiry that range from nuclear physics, which explores the interactions of nuclear particles, to cosmology, which explores the nature of the Universe.

Physics provides students with opportunities to use observations to develop quantitative models of real-world problems and identify relationships between variables. Students make predictions based on observations, models and interconnected theories. They explore how Aboriginal and Torres Strait Islander Knowledges and Cultures complement Western scientific processes, providing social and cultural context to the study of Physics.

The course enables students to develop knowledge to understand the physical world and the Universe and how they work, and to appreciate their complexity. They develop a deeper understanding of qualitative and quantitative data by formulating explanations and solving problems. Physics develops students' knowledge and understanding of abstract concepts, allowing them to comprehend a range of physical phenomena, including new discoveries that may constitute emerging and future technologies.

Knowledge of physics is applied through the development of essential skills in Working scientifically, such as critical thinking, problem-solving, data analysis and scientific investigation. Students solve equations, make predictions and analyse interconnected theories. Knowledge of the physical world supports students to recognise valid and reliable scientific information and apply it to new challenges and complex problems. Through this knowledge, they make sense of diverse physical phenomena in current and future scientific contexts.

Physics creates opportunities for a wide range of post-school pathways, including careers requiring skills in engineering, research, technology development and data science. Physics provides a foundation for interdisciplinary studies which allows students to make connections between various fields of science and technology. It also plays a crucial role in developing future technologies and helping solve global challenges to support the continued advancement of science and society.

Aim

Physics 11–12 aims to develop students' understanding and appreciation of a wide range of phenomena, from the minute to the immense, in terms of matter, motion and energy. It enables students to apply Working scientifically and the scientific method to their understanding of principles, theories, laws and models and the development of scientific knowledge.

Table of outcomes

Year 11	Year 12
PY-11WS-01 Working scientifically Questioning and predicting develops and evaluates questions and hypotheses for scientific investigations	**PY-12WS-01 Working scientifically Questioning and predicting** develops and evaluates questions and hypotheses for scientific investigations
PY-11WS-02 Working scientifically Planning scientific investigations designs and evaluates scientific investigations	**PY-12WS-02 Working scientifically Planning scientific investigations** designs and evaluates scientific investigations
PY-11WS-03 Working scientifically Conducting scientific investigations conducts scientific investigations to collect data and information	**PY-12WS-03 Working scientifically Conducting scientific investigations** conducts scientific investigations to collect data and information
PY-11WS-04 Working scientifically Processing data and information selects and processes qualitative and quantitative data and information	**PY-12WS-04 Working scientifically Processing data and information** selects and processes qualitative and quantitative data and information
PY-11WS-05 Working scientifically Analysing data and information analyses and evaluates primary and secondary data and information	**PY-12WS-05 Working scientifically Analysing data and information** analyses and evaluates primary and secondary data and information
PY-11WS-06 Working scientifically Problem-solving uses scientific processes to solve scientific problems	**PY-12WS-06 Working scientifically Problem-solving** uses scientific processes to solve scientific problems
PY-11WS-07 Working scientifically Communicating communicates scientific arguments using evidence, scientific language and terminology for a specific audience	**PY-12WS-07 Working scientifically Communicating** communicates scientific arguments using evidence, scientific language and terminology for a specific audience
PY-11-01 analyses motion and events using scientific laws and models	**N/A**
PY-11-02 explains the properties and behaviours of waves	**N/A**
PY-11-03 explains electric and magnetic field interactions	**N/A**
N/A	**PY-12-01** analyses circular and projectile motion in

Year 11	Year 12
	gravitational fields
N/A	**PY-12-02** analyses the effect of the interactions between electric and magnetic fields
N/A	**PY-12-03** analyses the properties of light using models and theories
N/A	**PY-12-04** analyses matter, its relationship with energy, and the roles of matter and energy in astronomical events

Outcomes and content for Year 11

Working scientifically

Outcomes

A student:

- develops and evaluates questions and hypotheses for scientific investigations **PY-11WS-01**
- designs and evaluates scientific investigations **PY-11WS-02**
- conducts scientific investigations to collect data and information **PY-11WS-03**
- selects and processes qualitative and quantitative data and information **PY-11WS-04**
- analyses and evaluates primary and secondary data and information **PY-11WS-05**
- uses scientific processes to solve scientific problems **PY-11WS-06**
- communicates scientific arguments using evidence, scientific language and terminology for a specific audience **PY-11WS-07**

Related Life Skills outcomes: PW-LSWS-01, PW-LSWS-02, PW-LSWS-03, PW-LSWS-04, PW-LSWS-05, PW-LSWS-06, PW-LSWS-07

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Questioning and predicting

- Use observations and scientific knowledge and understanding to propose questions and hypotheses for scientific investigations involving primary and secondary data
- Evaluate questions and hypotheses based on scientific knowledge
- Modify questions and hypotheses to reflect new evidence

Planning scientific investigations

- Justify the use of independent, dependent and controlled variables, and experimental controls in a valid scientific investigation
- Explain how reliable primary data is obtained
- Assess the reliability of secondary data and information when planning
- Assess potential hazards and their associated risks to develop a risk assessment
- Select appropriate materials and technologies to design a scientific investigation
- Discuss ethical issues in the development and use of scientific knowledge

Conducting scientific investigations

- Apply safe work practices and manage risks while conducting a scientific investigation
- Construct and manipulate identified materials and technologies to perform scientific investigations
- Use equipment appropriately and systematically to collect and record data, information, evidence and findings
- Gather data and information from a range of secondary sources

Processing data and information

- Select qualitative and quantitative information from texts, diagrams, flow charts, tables, databases, graphs and multimedia resources
- Apply quantitative processes to data, including unit conversions

- Select and use a range of representations to organise data and information, including graphs, keys, models, diagrams, tables and spreadsheets
- Extract data and information from a wide range of sources and acknowledge these sources using an accepted referencing style
- Describe the Cultural Knowledges and observations of Aboriginal and Torres Strait Islander Peoples and examine how these contribute to the development of scientific knowledge

Analysing data and information

- Describe qualitative and quantitative relationships between variables
- Explain patterns and trends, including inconsistencies in data and information
- Assess error, uncertainty and limitations in data and include calculations of percentage error, range, mean and standard deviation
- Assess the validity, reliability, accuracy and precision of data and information
- Interpret data and information to identify outliers, make predictions, explain results and draw conclusions
- Evaluate data and information to suggest improvements or further investigations
- Use appropriate significant figures to express quantitative solutions
- Use appropriate scale prefixes for powers of 10: femto (f) = 10^{-15}, pico (p) = 10^{-12}, nano (n) = 10^{-9}, micro (μ) = 10^{-6}, milli (m) = 10^{-3}, kilo (k) = 10^{3}, mega (M) = 10^{6}, giga (G) = 10^{9}, tera (T) = 10^{12} and peta (P) = 10^{15}

Problem-solving

- Apply scientific principles to address real-world applications and problems
- Use modelling and cause-and-effect relationships, including mathematical examples, to make predictions, explain phenomena, and solve problems
- Evaluate and modify a scientific investigation in response to new evidence
- Explain why current scientific knowledge is both contestable and testable by further inquiry

Communicating

- Construct evidence-based arguments and recognise the role of peer review in the evaluation of scientific practices, solutions or conclusions
- Select and use appropriate digital, visual, written and oral media to convey scientific arguments
- Apply appropriate scientific notations, language and nomenclature
- Use evidence and correct scientific language and terminology to address a specific audience and purpose in a variety of contexts

Fundamentals of mechanics

Outcomes

A student:

- analyses motion and events using scientific laws and models **PY-11-01**

Related Life Skills outcomes: PW-LS-01, PW-LS-02, PW-LS-03, PW-LS-04, PW-LS-05

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Related: Working scientifically

Quantities of motion

- Classify distance, displacement, time, speed, velocity and acceleration as either scalar or vector quantities
- Use vector diagrams to represent the displacement, velocity and acceleration of an object
- Add and subtract vectors in 2 dimensions
- Resolve vectors into components
- Solve total distance and displacement problems
- Explain how instantaneous speed, average speed, instantaneous velocity and average velocity are measured and calculated
- Solve problems using $\vec{v}_{av} = \frac{\Delta\vec{s}}{\Delta t}$
- Solve problems involving the calculation of velocity in 2 dimensions
- Solve problems to determine speed, velocity, distance, displacement and time
- Solve problems in one and 2 dimensions using $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$

Motion relationships

- Use data to construct displacement–time graphs, velocity–time graphs and acceleration–time graphs
- Use data to analyse motion graphs to describe the displacement, velocity and acceleration of an object
- Analyse motion graphs to determine the relationships between displacement, initial velocity, final velocity, acceleration and time
- Solve problems involving uniformly accelerated motion in one dimension using $\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$, $\vec{v} = \vec{u} + \vec{a}t$ and $\vec{v}^2 = \vec{u}^2 + 2\vec{a}\vec{s}$
- Conduct a laboratory experiment to compare 2 methods of graphically determining a value for acceleration due to gravity and assess the accuracy and reliability of the experimental results
- Analyse problems of relative velocity involving motion in two dimensions using $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$

Forces and motion

- Resolve vectors into perpendicular components using $F_x = F\cos\theta$ and $F_y = F\sin\theta$ where θ is the angle with the x-axis
- Use free-body diagrams and vector analysis to determine the net force acting on an object
- Apply Newton's first law of motion to stationary objects and objects moving with a constant velocity
- Analyse the forces acting on an object moving with constant velocity

- Conduct a scientific investigation to illustrate the relationship between force, mass and acceleration
- Analyse the forces acting on an accelerating object
- Solve problems involving Newton's second law of motion using $\vec{F}_{\text{net}} = m\vec{a}$
- Use examples to describe the effects of Newton's third law of motion
- Analyse the forces acting on connected bodies in physical contact and linked by ropes using vector diagrams and Newton's laws of motion
- Compare static and kinetic friction
- Solve problems using $f_{\text{friction}} = \mu F_N$
- Solve a variety of problems in static and dynamic real-world situations by applying Newton's laws of motion

Motion on inclined planes

- Determine the normal force on objects on inclined planes
- Construct free-body diagrams to show the gravitational, normal, frictional and net force acting on an object on an inclined plane
- Resolve the weight force into perpendicular and parallel components on inclined planes using $F_{\perp} = mg\cos\theta$ and $F_{\parallel} = mg\sin\theta$
- Derive $a = g\sin\theta - \mu g\cos\theta$ to describe the acceleration on an object on an inclined plane with friction using Newton's second law parallel to the plane
- Solve problems involving objects with constant velocity and objects accelerating on inclined planes
- Explain why Aboriginal and/or Torres Strait Islander Peoples used inclined planes to move heavy objects
- Conduct a laboratory experiment to analyse the relationship between the angle of an inclined plane and the acceleration of an object

Momentum and energy

- Compare conservative forces and non-conservative forces
- State the conditions under which total mechanical energy is conserved
- Relate the work done on an object to the change in its kinetic energy during accelerated rectilinear motion using $W = F_{\parallel}s = Fs\cos\theta$
- Solve problems involving changes in gravitational potential energy in a uniform gravitational field using $\Delta U = mg\Delta h$
- Solve problems involving kinetic energy using $KE = \frac{1}{2}mv^2$
- Apply the law of conservation of mechanical energy and use $W = \Delta KE = \frac{1}{2}mv^2$ and $W = \Delta U$ to solve problems
- Analyse energy transformations and calculate the work done when an object moves within a uniform gravitational field, including changes in gravitational potential energy due to height and identifying the forces responsible for doing work
- State the conditions under which momentum is conserved
- Explain why momentum is conserved during collisions
- Classify collisions as elastic or inelastic by calculating and comparing the total kinetic energy before and after the collision
- Solve problems involving momentum using $\vec{p} = m\vec{v}$ and $\Delta\vec{p} = \vec{F}_{\text{net}}\Delta t$
- Solve problems involving the conservation of momentum using $\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$ and, where appropriate, conservation of kinetic energy

- Solve problems involving the conservation of momentum in elastic collisions using
$$\sum \tfrac{1}{2} m v_{\text{before}}^2 = \sum \tfrac{1}{2} m v_{\text{after}}^2$$
- Conduct a practical investigation to analyse the conservation of momentum in collisions

Waves

Outcomes

A student:

- explains the properties and behaviours of waves **PY-11-02**

Related Life Skills outcomes: PW-LS-06, PW-LS-07, PW-LS-12, PW-LS-13

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Related: Working scientifically

Wave properties

- Conduct a practical investigation to model the oscillation of particles in transverse waves and longitudinal waves and relate to the direction of energy transfer
- Describe the wavelength, frequency, period, crest, trough and amplitude of transverse waves
- Describe the wavelength, frequency, period, compression, rarefaction and amplitude of longitudinal waves
- Solve problems using $f = \frac{1}{T}$ and $v = f\lambda$
- Analyse displacement–time graphs for longitudinal and transverse waves
- Analyse displacement–distance graphs for longitudinal and transverse waves
- Describe how Aboriginal Peoples use the wave velocity and wavelength of water waves to approximate water depth

> **Example(s):**
>
> Throwing stones into a still body of water.

Light and sound

- Identify that mechanical waves require a medium for propagation
- Explain how sound waves transfer energy through a medium
- Conduct a practical investigation, to relate wavelength to frequency, frequency to pitch, and amplitude to loudness
- Conduct a practical investigation to demonstrate how frequency and amplitude relate to the energy of a sound wave
- Identify light as an electromagnetic wave that does not require a medium for propagation and travels at c, the speed of light, in a vacuum
- Describe the production and transfer of energy of electromagnetic wave
- Interpret diagrams of the electromagnetic spectrum to quantitatively demonstrate the relationship between frequency, wavelength and energy $E = hf$ and $c = f\lambda$
- Describe practical applications for regions of the electromagnetic spectrum, linking properties to uses
- Solve problems involving the inverse square law using $I \propto \frac{1}{r^2}$ and $I_1 r_1^2 = I_2 r_2^2$ to compare the intensity of light at points r_1 and r_2
- Explain the relationship between distance and radiation intensity from a point source

- Conduct a laboratory experiment to analyse the relationship between light intensity and distance from a light source

Wave behaviours

- Describe examples of the law of reflection

Example(s):

The Gundungurra People reflect a beam of sunlight annually from the Southern Highlands to the Blue Mountains as a contemporary way of connecting to Country and their Peoples.

- Use linear wavefront diagrams and ray diagrams to analyse the motion of a wave
- Conduct a scientific investigation to demonstrate refraction between 2 media
- Relate the velocity of light to the refractive index of a medium
- Solve refractive index problems using $n_x = \frac{c}{v_x}$, where n_x is the refractive index of the medium and v_x is the speed of light in the medium
- Solve problems by applying the law of refraction of light using $n_1 \sin\theta_1 = n_2 \sin\theta_2$
- Solve total internal reflection and critical angle problems using $\sin\theta_c = \frac{n_2}{n_1}$
- Relate the change in velocity of a light wave crossing an interface to differences between refractive indices
- Construct ray diagrams to show reflection from plane mirrors and refraction at a boundary
- Conduct a laboratory experiment to determine the refractive index of a material and assess the accuracy of the measurement
- Conduct a scientific investigation to discuss how spectacles assist people with vision impairment
- Conduct a practical investigation to model how waves diffract through openings and around obstacles of different sizes
- Model the principle of superposition
- Use the principle of superposition to explain the constructive interference and destructive interference of waves
- Explain how the superposition of waves produces interference patterns with observable maxima and minima
- Demonstrate the formation of a standing wave
- Explain the production of nodes and antinodes in a standing wave
- Analyse the frequency and wavelength of standing waves in strings fixed at both ends using
$$v = f\lambda$$
- Explain the frequency shift phenomenon for sound waves and light waves (blueshift and redshift), as a source moves towards and away from an observer
- Solve frequency shift phenomenon problems for sound using $f' = f\frac{(v_{\text{wave}}+v_{\text{observer}})}{(v_{\text{wave}}-v_{\text{source}})}$

Electricity and magnetism

Outcomes

A student:

- explains electric and magnetic field interactions **PY-11-03**

Related Life Skills outcomes: PW-LS-08, PW-LS-09, PW-LS-10, PW-LS-11

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Related: Working scientifically

Electrostatics

- Explain the role of the movement of electrons in charging particles and objects
- Explain how friction, induction and conduction can cause objects to become electrically charged
- Outline characteristics of an electric field surrounding a point charge
- Explain the role of static electricity in producing a lightning strike
- Use the equation $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ to demonstrate that the electric field strength around a point charge follows the inverse square law
- Use field line diagrams to describe the electric field around point charges and between charged particles
- Solve problems involving charges in electric fields using $\vec{F} = q\vec{E}$
- Analyse the factors that affect the force between 2 charged particles using the electrostatic force law and $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$
- Use field line diagrams to describe the electric field between 2 charged parallel plates
- Analyse the factors that affect the strength of the electric field between 2 charged parallel plates using $E = \frac{V}{d}$
- Solve problems relating to the charged particles in electric fields using $\vec{F} = q\vec{E}$, $E = \frac{V}{d}$, $\vec{F}_{\text{net}} = m\vec{a}$ and $W = \Delta KE$
- Explain how the electric potential energy of a charged particle changes due to its position in an electric field
- Solve problems involving changes in electric potential energy in a uniform electric field using $W = qV = qEd$ and $W = \Delta KE$
- Account for the energy transformations that occur when a charge moves in a uniform electric field
- Solve problems involving the work done when moving a charge in an electric field using the relationships between W, ΔU and ΔKE
- Analyse the relationships between voltage, potential energy difference and work when changing the position of a charge in a uniform electric field using $V = \frac{\Delta U}{q}$
- Solve problems relating to changes in position of charges in electric fields using $W = qV$

Electric circuits

- Calculate electric current using $I = \frac{q}{t}$

- Relate the flow of charge to the direction of conventional current
- Explain why electrons flow through a metallic conductor when connected to an external voltage
- Compare direct current (DC) and alternating current (AC)
- Relate voltage to electron flow in a circuit of constant resistance
- Explain why the resistance of a conductor can be affected by its material, length, cross-sectional area and temperature
- Analyse the relationships between voltage, current and resistance using $V = IR$ for electric circuits having constant and variable resistance
- Conduct a laboratory experiment to examine the relationships between voltage and current for ohmic conductors and non-ohmic conductors
- Relate power to energy transformations
- Solve problems using $P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$
- Describe the relationship between power and voltage using $P = VI$
- Solve problems relating to energy loss in circuits using $P = I^2R$ and the law of conservation of energy
- Compare the connection of components in series circuits with that in parallel circuits
- Construct and analyse diagrams of series circuits and parallel circuits
- Explain why ammeters are connected in series, and voltmeters are connected in parallel to components, in electric circuits
- Account for the magnitude of current at any point in a series circuit
- Account for the total voltage of a series circuit being the sum of the voltages of its components using conservation of energy and $V_{\text{series}} = V_1 + V_2 + \cdots + V_n$
- Account for the total resistance of a series circuit being the sum of the resistances of its components using $R_{\text{series}} = R_1 + R_2 + \cdots + R_n$
- Use the relationship between the total resistance and resistance in each branch of a parallel circuit, $\frac{1}{R_{\text{parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$ to calculate resistances
- Explain the relationship between the total current of a parallel circuit and the current passing through each component using $I_{\text{parallel}} = I_1 + I_2 + \cdots + I_n$
- Solve problems involving voltage, current and resistance, in series, parallel and combination circuits
- Conduct a laboratory experiment to measure the voltage differences across components and current at different points in a combination circuit of fixed resistance, and account for variation from the calculated values

Magnetism

- Identify that magnetic field lines are continuous and used to represent the strength and direction of magnetic fields
- Use field line diagrams to analyse the magnetic field around a bar magnet, current-carrying wire and current-carrying loop
- Calculate the strength of the magnetic field produced by a current-carrying wire using $B = \frac{\mu_0 I}{2\pi r}$
- Describe the structure of a simple solenoid
- Account for the shape and direction of the magnetic field produced by a direct current passing through a solenoid
- Calculate the strength of the uniform magnetic field inside a solenoid using $B = \frac{\mu_0 NI}{L}$
- Conduct a secondary-source investigation to assess the choice of materials used in the core of electromagnets
- Conduct a practical investigation to examine the factors affecting the strength of an electromagnet

Outcomes and content for Year 12

Working scientifically

Outcomes

A student:

- develops and evaluates questions and hypotheses for scientific investigations **PY-12WS-01**
- designs and evaluates scientific investigations **PY-12WS-02**
- conducts scientific investigations to collect data and information **PY-12WS-03**
- selects and processes qualitative and quantitative data and information **PY-12WS-04**
- analyses and evaluates primary and secondary data and information **PY-12WS-05**
- uses scientific processes to solve scientific problems **PY-12WS-06**
- communicates scientific arguments using evidence, scientific language and terminology for a specific audience **PY-12WS-07**

Related Life Skills outcomes: PW-LSWS-01, PW-LSWS-02, PW-LSWS-03, PW-LSWS-04, PW-LSWS-05, PW-LSWS-06, PW-LSWS-07

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Questioning and predicting

- Use observations and scientific knowledge and understanding to propose questions and hypotheses for scientific investigations involving primary and secondary data
- Evaluate questions and hypotheses based on scientific knowledge
- Modify questions and hypotheses to reflect new evidence

Planning scientific investigations

- Justify the use of independent, dependent and controlled variables, and experimental controls in a valid scientific investigation
- Explain how reliable primary data is obtained
- Assess the reliability of secondary data and information when planning
- Assess potential hazards and their associated risks to develop a risk assessment
- Select appropriate materials and technologies to design a scientific investigation
- Discuss ethical issues in the development and use of scientific knowledge

Conducting scientific investigations

- Apply safe work practices and manage risks while conducting a scientific investigation
- Construct and manipulate identified materials and technologies to perform scientific investigations
- Use equipment appropriately and systematically to collect and record data, information, evidence and findings
- Gather data and information from a range of secondary sources

Processing data and information

- Select qualitative and quantitative information from texts, diagrams, flow charts, tables, databases, graphs and multimedia resources
- Apply quantitative processes to data, including unit conversions

- Select and use a range of representations to organise data and information, including graphs, keys, models, diagrams, tables and spreadsheets
- Extract data and information from a wide range of sources and acknowledge these sources using an accepted referencing style
- Describe the Cultural Knowledges and observations of Aboriginal and Torres Strait Islander Peoples and examine how these contribute to the development of scientific knowledge

Analysing data and information

- Describe qualitative and quantitative relationships between variables
- Explain patterns and trends, including inconsistencies in data and information
- Assess error, uncertainty and limitations in data and include calculations of percentage error, range, mean and standard deviation
- Assess the validity, reliability, accuracy and precision of data and information
- Interpret data and information to identify outliers, make predictions, explain results and draw conclusions
- Evaluate data and information to suggest improvements or further investigations
- Use appropriate significant figures to express quantitative solutions
- Use appropriate scale prefixes for powers of 10: femto (f) = 10^{-15}, pico (p) = 10^{-12}, nano (n) = 10^{-9}, micro (μ) = 10^{-6}, milli (m) = 10^{-3}, kilo (k) = 10^{3}, mega (M) = 10^{6}, giga (G) = 10^{9}, tera (T) = 10^{12} and peta (P) = 10^{15}

Problem-solving

- Apply scientific principles to address real-world applications and problems
- Use modelling and cause-and-effect relationships, including mathematical examples, to make predications, explain phenomena, and solve problems
- Evaluate and modify a scientific investigation in response to new evidence
- Explain why current scientific knowledge is both contestable and testable by further inquiry

Communicating

- Construct evidence-based arguments and recognise the role of peer review in the evaluation of scientific practices, solutions or conclusions
- Select and use appropriate digital, visual, written and oral media to convey scientific arguments
- Apply appropriate scientific notations, language and nomenclature
- Use evidence and correct scientific language and terminology to address a specific audience and purpose in a variety of contexts

Advanced mechanics

Outcomes

A student:

- analyses circular and projectile motion in gravitational fields **PY-12-01**

Related Life Skills outcomes: PW-LS-01, PW-LS-03, PW-LS-04, PW-LS-05

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Related: Working scientifically

Projectile motion

- Explain why projectiles in a uniform gravitational field experience constant vertical acceleration and zero horizontal acceleration when gravity is the only force acting
- Resolve the instantaneous velocity of a projectile into horizontal and vertical components
- Calculate the time of flight, maximum height, range and final velocity of a projectile using $\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$, $\vec{v} = \vec{u} + \vec{a}t$ and $\vec{v}^2 = \vec{u}^2 + 2\vec{a}\vec{s}$
- Solve problems involving projectiles to analyse the relationships between launch angle, initial velocity, launch height, maximum height, time of flight, final velocity and horizontal range
- Analyse the motion of projectiles used by Aboriginal and/or Torres Strait Islander Peoples
- Conduct a practical investigation to analyse the motion of a projectile

Circular motion

- Account for forces that cause an object to move in uniform circular motion
- Explain why a constant net force acting perpendicular to a body's velocity causes uniform circular motion
- Use vector diagrams to show the relationships between instantaneous velocity, change in velocity, force and centripetal acceleration for an object moving in uniform circular motion
- Analyse the relationship between period and frequency for an object moving in uniform circular motion
- Explain why the speed of an object in circular motion is $v = \frac{2\pi r}{T}$
- Describe the motion of an object that was in uniform circular motion after the forces providing the centripetal acceleration are removed
- Analyse the relationships between speed, period, radius, centripetal force and acceleration in uniform circular motion using $v = \frac{2\pi r}{T}$, $a_c = \frac{v^2}{r}$ and $F_c = \frac{mv^2}{r}$
- Analyse the forces acting on a vehicle moving at constant speed around a horizontal uniform circular bend
- Analyse the forces acting on a mass suspended by a string moving in horizontal uniform circular motion
- Conduct a laboratory experiment of an object in uniform circular motion to analyse the relationships between mass, radius, instantaneous velocity and centripetal force
- Solve quantitative problems involving uniform circular motion
- Analyse the factors that affect the gravitational potential energy of an object above a planet's surface using $U = -\frac{GMm}{r}$

- Analyse graphs of the changes in gravitational potential energy, kinetic energy and work done for an object launched vertically to escape a planet's gravitational field
- Derive the formula for escape velocity $v_{esc} = \sqrt{\frac{2GM}{r}}$ using the law of conservation of mechanical energy
- Solve problems involving gravitational potential energy and escape velocity
- Analyse the relationships between gravitational potential energy, kinetic energy and total energy for a satellite in orbit using $U + K = -\frac{GMm}{2r}$
- Solve problems involving the energy of satellites in orbit
- Analyse how moving to a different circular orbit affects a satellite's gravitational potential energy, kinetic energy and total mechanical energy

Motion in gravitational fields

- Analyse the factors that affect the force of gravity with reference to Newton's law of universal gravitation and $F = \frac{GMm}{r^2}$ and $\vec{F}_w = m\vec{g}$
- Analyse the factors that affect a planet's gravitational field strength with reference to $g = \frac{GM}{r^2}$
- Solve problems involving Newton's law of universal gravitation and gravitational field strength at any point in a gravitational field
- Explain why a planet's radial gravitational field approximates a uniform field close to its surface
- Account for the use of circular motion as an approximation for the orbital motion of satellites and planets
- Derive the orbital velocity of a satellite $v_{orb} = \sqrt{\frac{GM}{r}}$ by applying the law of universal gravitation
- Apply the law of ellipses and the law of equal areas to explain the motion of orbiting bodies
- Derive the law of periods $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$ using Newton's law of universal gravitation
- Compare the motion of 2 satellites orbiting the same central mass using the law of orbital periods and $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$
- Analyse the relationships between acceleration, radius, mass, orbital velocity and period of an orbiting body using $a_c = \frac{v^2}{r}$, $v = \frac{2\pi r}{T}$, $v_{orb} = \sqrt{\frac{GM}{r}}$ and $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$
- Conduct a secondary-source investigation to describe the uses of low Earth orbit satellites and geostationary satellites and relate these to their orbital features
- Discuss the convention of assigning zero gravitational potential energy to masses at an infinite distance from a planet
- Explain why the convention of assigning zero gravitational potential energy to masses at an infinite distance from a planet results in negative gravitational potential energy for a mass in a radial field around the planet

Electromagnetism

Outcomes

A student:

- analyses the effect of the interactions between electric and magnetic fields **PY-12-02**

Related Life Skills outcomes: PW-LS-09, PW-LS-10, PW-LS-11

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Related: Working scientifically

Charged particles in electric and magnetic fields

- Apply conventions to determine the direction of electrostatic forces on charges in an electric field
- Analyse the motion of a charged particle in a uniform electric field using $E = \frac{V}{d}$, $\vec{F} = q\vec{E}$, $W = qV = \Delta KE$, and equations for uniformly accelerated motion
- Analyse the energy changes of a charged particle in a uniform electric field using W, ΔU and ΔKE
- Solve problems involving the trajectories of charged particles projected into uniform electric fields
- Identify factors affecting the magnitude of the magnetic field produced by a moving charge
- Account for the force experienced by a charged particle moving in a magnetic field
- Predict the direction of the force acting on a charged particle moving in a magnetic field
- Analyse the force on a charged particle in a uniform magnetic field by applying $$F = qv_{\perp}B = qvB\sin\theta$$
- Derive the relationship $r = \frac{mv}{qB}$ by equating the centripetal force and the magnetic force
- Solve problems involving the uniform circular motion of charged particles in uniform magnetic fields
- Account for the similarities and differences between the paths of masses in uniform gravitational fields, satellites in orbit, charged particles in electric fields, and moving charged particles in magnetic fields
- Outline the functions and effects of electric fields and magnetic fields in mass spectrometers and electron guns

The motor effect and electric motors

- Use magnetic field interactions to explain why a current-carrying conductor experiences a force in a magnetic field
- Determine the direction of a force acting on a current-carrying conductor in a uniform magnetic field
- Analyse how the magnitude of a force acting on a current-carrying conductor varies by changing the conductor length, current, magnetic field strength, and angle between the current-carrying conductor and magnetic field
- Conduct a laboratory experiment to demonstrate the motor effect
- Solve problems involving the motor effect using $F = Il_{\perp}$ and $B = IlB\sin\theta$
- Analyse factors that affect the magnitude of torque using $\tau = rF\sin\theta$, where θ is the angle between the radius and the direction of the applied force

- Analyse the factors that affect the magnitude of torque on a current-carrying loop using
$$\tau = nIA_{\perp}B = nIAB\sin\theta$$
- Solve problems involving torque on a conducting loop in a magnetic field
- Analyse the structure and function of the components of simple direct current (DC) motors and simple alternating current (AC) motors, including rotor coils, field magnets, brushes, and split-ring commutators and slip rings
- Analyse factors that can increase torque in a brushed electric motor

Electromagnetic induction

- Describe magnetic flux as the measure of the total magnetic field passing through a given area
- Analyse the relationships between magnetic flux, magnetic field strength, and the angle between the magnetic field and the plane of a loop, using $\Phi = BA\cos\theta$, where θ is the angle between the magnetic field and the area vector (normal) of the loop
- Analyse the relationship between generated electromotive force (emf) and the change in magnetic flux per unit time, using the law of electromagnetic induction and $|\varepsilon| = N\left|\frac{\Delta\phi}{\Delta t}\right|$
- Analyse how the size of generated emf is affected by factors, including the number of turns in a coil of wire, and the change in magnetic flux over time
- Explain how $|\varepsilon| = N\left|\frac{\Delta\phi}{\Delta t}\right|$ and the direction of an induced current are consistent with the law of conservation of energy
- Solve problems involving emf by applying the law of conservation of energy and using
$$|\varepsilon| = N\left|\frac{\Delta\phi}{\Delta t}\right|$$
- Account for the production of eddy currents in conductive materials
- Explain the effects of electromagnetic induction in straight conductors, metal plates and solenoids experiencing a change in magnetic flux
- Conduct a scientific investigation to examine the factors affecting electromagnetic induction in a solenoid

Applications of electromagnetic induction

- Relate the structure of simple step-up transformers and step-down transformers to their functions
- Explain why a primary coil requires an AC input to induce an AC output in the secondary coil of a transformer
- Analyse the relationships between the primary and secondary voltages and number of turns in the primary and secondary coils of step-up and step-down transformers using $\frac{V_p}{V_s} = \frac{N_p}{N_s}$
- Solve problems involving ideal transformers using $P = VI$, the law of conservation of energy, and $V_p I_p = V_s I_s$
- Explain the differences in power output between ideal and real transformers in terms of incomplete flux linkage, eddy currents and resistive heating
- Explain how the components of an AC induction motor are designed to support its function and operation
- Explain how electromagnetic induction causes a torque on the armature of a brushless DC motor
- Explain how a force opposing motion is generated during electromagnetic braking
- Outline the differences between a motor and a generator in terms of energy transformation
- Explain the production of back emf in simple DC motors
- Explain the effects of back emf on the current flowing through and speed of a simple DC motor

- Outline the structure and function of components in a simple AC generator and a simple DC generator, including rotor coils, stator magnets, brushes, and slip rings and split-ring commutators
- Explain the variations in current produced by AC generators and DC generators

Nature of light

Outcomes

A student:

- analyses the properties of light using models and theories **PY-12-03**

Related Life Skills outcomes: PW-LS-12, PW-LS-13

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Related: Working scientifically

Electromagnetic waves

- Identify that all forms of electromagnetic radiation have constant speed, c, in a vacuum
- Explain how electromagnetic waves are produced and propagated
- Discuss how the historical prediction of the speed of light was made by relating the electric permittivity and magnetic permeability of free space, using $c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$
- Conduct a secondary source investigation to explain how a spark-gap oscillator and a loop antenna verified the predicted speed of electromagnetic waves (Hertz experiment)
- Conduct a laboratory experiment to measure the speed of electromagnetic waves and assess the accuracy of the measured value

The wave model of light

- Account for the diffraction and interference effects produced when monochromatic light is shone through a double slit
- Explain why small slit gaps are used in diffraction of light experiments
- Interpret the theoretical pattern and intensity graph produced by visible light passing through a double slit
- Explain observations of the double-slit experiment in terms of constructive interference and destructive interference
- Analyse the factors involved in the production of an interference pattern from a double slit and a diffraction grating using $d\sin\theta = m\lambda = \frac{dy}{L}$
- Conduct a laboratory experiment to produce and analyse interference patterns
- Solve problems involving interference patterns from a double slit and a diffraction grating
- Compare linearly polarised and unpolarised light in terms of the plane of the electric field
- Explain how light becomes polarised when passing through a filter
- Solve problems involving polarised light using $I = I_{\text{max}} \cos^2 \theta$
- Evaluate the evidence supporting the wave model of light, including diffraction, interference and polarisation

The quantum model of light

- Explain the particle model of light in terms of photons with discrete energy and frequency
- Analyse the relationships between photon energy, frequency, speed of light and wavelength, using $E = hf$ and $c = f\lambda$
- Describe the relationship between the temperature of an object and the distribution of kinetic energies among particles within the object
- Explain why black bodies emit electromagnetic radiation as a function of their temperature

- Use models to explain why theoretical black bodies are perfect absorbers and emitters of energy
- Analyse the black-body curves of objects of different temperatures
- Solve problems involving black bodies using $\lambda_{\max} = \frac{b}{T}$
- Compare black-body radiation curves with classical curve predictions to highlight the importance of a theory being supported by experimental observations
- Explain how the proposal of quantised energy given by $E = hf$ resolves the difference between classical predictions and experimental evidence for black-body radiators
- Solve problems using $E = hf$
- Use quantum theory to analyse the relationships between frequency of light, intensity of light, energy of photons and number of photons
- Account for the photoelectric effect in metals
- Relate the law of conservation of energy to the maximum kinetic energy of photoelectrons and $$K_{\max} = hf - \phi$$
- Analyse data from photoelectric effect and thermionic emission experiments to explain relationships using $K_{\max} = hf - \phi$ and $K_{\max} = qV_0$
- Solve problems involving the photoelectric effect and thermionic emission using $K_{\max} = hf - \phi$ and $K_{\max} = qV_0$
- Analyse graphs of photoelectric experiments involving different metals
- Conduct a secondary-source investigation to explain how the photelectric effect is used in photovoltaics (solar cells) and one other real-world application
- Explain how observations of the photoelectric effect and data can validate predictions about the quantum nature of light

Light and special relativity

- Compare inertial and non-inertial frames of reference
- Outline Einstein's first and second postulates of special relativity
- Apply Einstein's first and second postulates of special relativity to a simultaneity thought experiment involving 2 events occurring at opposite ends of a vehicle moving at relativistic speed when viewed from different frames of reference
- Apply Einstein's first and second postulates of special relativity to a time dilation thought experiment involving light pulses reflecting inside a vehicle moving at relativistic speed when viewed from different frames of reference
- Account for the relativistic effects of time dilation, length contraction and relativistic momentum from an external frame of reference
- Solve quantitative problems involving $t = \frac{t_0}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$, $l_v = l_0\sqrt{\left(1-\frac{v^2}{c^2}\right)}$ and $p_v = \frac{m_0 v}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$
- Explain why an object with mass cannot travel at the speed of light
- Analyse the evidence supporting the theory of relativity, including the muon lifetime and atomic clocks moving at different velocities

Matter, energy and the cosmos

Outcomes

A student:

- analyses matter, its relationship with energy, and the roles of matter and energy in astronomical events **PY-12-04**

Related Life Skills outcomes: PW-LS-14

Content

Relevant Working scientifically outcomes and content must be integrated with each focus area. All the Working scientifically outcomes and content must be addressed by the end of Year 12.

Related: Working scientifically

Modelling the atom

- Account for the origin of cathode rays in a cathode-ray tube
- Describe the observations made inside a low-pressure tube when a cathode ray interacts with a Maltese cross, a paddle wheel, electric fields, and magnetic fields
- Analyse how observations of cathode rays provide evidence that cathode rays consist of particles with mass and charge
- Explain how the charge-to-mass ratio of the electron was first determined
- Derive the charge-to-mass ratio $\frac{q}{m} = \frac{E}{rB^2}$ for an electron in a cathode ray tube with perpendicular electric and magnetic fields
- Evaluate the evidence supporting the plum pudding model of the atom
- Explain how the observations of the gold foil experiment led to the proposal of a nuclear model of the atom
- Explain how limitations of the nuclear model led to the development of the stationary energy level model of the atom
- Explain how the stationary energy level model of the atom uses a mixture of classical physics and quantum physics to address the limitations of the nuclear model of the atom
- Explain why the difference between the predicted mass and measured mass of a nucleus was a limitation of early models of the atom, and led to the prediction of neutrons
- Analyse how the law of the conservation of energy and the law of the conservation of momentum were applied in experiments to determine the existence and properties of the neutron
- Explain why unique line emission spectra and absorption spectra are produced by an element
- Identify the limitations of the stationary energy level model of the atom
- Interpret energy level diagrams showing the transition of electrons between energy levels involving both absorption and emission of energy
- Explain how the law of conservation of energy applies to electrons transitioning between energy levels
- Solve problems involving the transition of electrons using $E = hf$, $c = f\lambda$ and $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$
- Explain how standing waves can be used to represent electrons in stationary energy levels using qualitative data
- Use $\lambda = \frac{h}{mv}$ to relate wave and particle properties of matter
- Explain why the production of electron diffraction patterns provides evidence for electrons behaving as waves

- Explain how the proposal of electrons as waves in atoms addresses a limitation of the stationary energy level model
- Describe baryons in terms of quark combinations and the role of the strong force
- Describe atomic structure in terms of quarks and leptons
- Explain how particle accelerators and collision experiments are used to discover and study quarks, leptons and force-carrying bosons
- Analyse how experimental evidence can lead to refinements in scientific models

Example(s):

Goppeart Mayer Nuclear shell model, Schrödinger quantum mechanical model.

Radioactivity

- Relate the isotopic mass number of an element to its subatomic components
- Describe the range and effect of the strong nuclear force on nucleons
- Explain how the balance between the strong nuclear force and the electrostatic repulsion force impacts the stability of the nucleus
- Describe the process of alpha decay, beta decay and gamma decay
- Compare the composition, charge, mass, ionising ability, and penetration of alpha radiation, beta radiation and gamma radiation
- Use nuclear decay equations to describe reactions, including radioactive decay and transmutation
- Apply conservation of mass, energy and charge to nuclear reactions, transmutation and radioactive decay
- Describe the role of the weak force in beta-minus decay and beta-plus transformation
- Describe the concept of half-life as it relates to a radioisotope
- Interpret graphs of radioactive decay to determine the changing amounts of radioisotopes over time
- Relate the decay constant λ to the half-life of radioisotopes
- Solve problems involving radioactive decay using $\lambda = \frac{\ln(2)}{T_{1/2}}$
- Conduct a practical investigation to model the process of the radioactive decay of an isotope and analyse its half-life
- Outline the contribution of selected scientists to radio-medicine

Example(s):

Curie.

- Explain how the properties of radioisotopes determine their suitability for use in medical scans and industry

Nuclear energy

- Identify that the special theory of relativity demonstrates the mass–energy equivalence relationship $E = mc^2$
- Account for the law of conservation of mass and the law of conservation of energy being replaced by the law of conservation of mass–energy
- Explain the relationship between mass defect and the energy released in a nuclear reaction using $E = mc^2$

- Explain the process of nuclear fission
- Compare the processes of controlled chain reactions and uncontrolled chain reactions
- Explain the structure and function of the components of a fission reactor, including fuel, control rods, moderator and coolant
- Explain the process of nuclear fusion
- Outline the contribution of selected scientists to the discovery of nuclear fission

  Example(s):

  Meitner, Frisch.

- Use nuclear equations to describe fusion of small nuclei and fission of large nuclei
- Explain why fusion requires high temperatures and pressures
- Compare the energy release of nuclear reactions with the energy release of fossil fuels and conventional explosives
- Explain nuclear binding energy
- Solve problems involving mass defect and nuclear binding energy using $\Delta m = m_i - m_f$ and $E = mc^2$
- Distinguish between the proton-neutron ratio and binding energy in the context of nuclear stability
- Analyse graphical representations of nuclear binding energy per nucleon as atomic number increases, and apply this to the iron limit
- Account for net release of energy in fission reactions and fusion reactions
- Describe the properties of a positron
- Discuss the process of positron–electron annihilation
- Explain how the law of conservation of mass–energy applies to particle–antiparticle annihilation
- Explain how positron emission tomography (PET) uses positron–electron annihilation to produce a medical scan
- Solve problems using mass defect and $E = mc^2$ for nuclear decay, nuclear fission, nuclear fusion, and positron–electron annihilation

Astrophysics

- Analyse how the spectra of astronomical objects can be used to draw conclusions about their translational velocity, chemical composition and surface temperature
- Describe Payne Gaposchkin's spectral analysis technique for determining the chemical composition of stars
- Explain how measured spectra of galaxies provides evidence that the universe is expanding
- Analyse H-R diagrams to classify stars and determine their surface temperature, colour, luminosity and size
- Explain the role of gravity and nuclear fusion in the formation of a main sequence star
- Explain how the mass of a main sequence star determines its position on an H-R diagram and the amount of time that it remains on the main sequence
- Analyse the nucleosynthesis reactions that occur in main sequence stars by interpreting representations of the proton–proton chain and the carbon–nitrogen–oxygen (CNO) cycle
- Relate Aboriginal Peoples' Knowledge of different star colours to the type of nucleosynthesis reactions occurring in main sequence stars
- Describe, using a H-R diagram, the evolutionary path of a star of one solar mass and a star of greater than 3 solar masses, once they have completed hydrogen fusion

- Explain how changing forces of gravity and the outwards pressure created by nuclear fusion allows for the synthesis of successively heavier elements
- Explain, in terms of binding energy, why iron is the heaviest element that can be synthesised in a red supergiant
- Explain how elements up to, and including iron, are synthesised by stars, and how atoms larger than iron are synthesised

Assessment

Course standards

Course standards are comprised of syllabus standards and performance standards. Syllabus outcomes and content form the syllabus standards that describe what students are expected to know, understand and do. Performance standards, including the Common Grade Scale for Preliminary courses, HSC Performance Band Descriptions and Achievement Level Descriptions (for HSC courses with grades only) describe how well students have achieved in relation to syllabus standards. Performance standards are used to report student achievement on NESA credentials.

Common Grade Scale for Preliminary courses

Stage 6 – Year 11

The Common Grade Scale for Preliminary courses provides generic, holistic descriptions for performance at each of the 5 grade levels. It is used to report student achievement in Year 11 courses in all NSW schools.

Performance Band Descriptions for Physics

Stage 6 – Year 12

HSC performance band descriptions summarise the knowledge, understanding and skills typically demonstrated by students at each band level in a particular course. NESA uses these holistic descriptions to report a student's overall level of achievement in an HSC course.

Band 6

A student who performs at this level typically:

- demonstrates extensive knowledge and understanding of scientific concepts in Physics
- applies knowledge and understanding to unfamiliar situations to explain and propose solutions to complex scientific scenarios
- designs and plans investigations to obtain accurate, reliable, valid and relevant primary and secondary data and information, evaluates and mitigates risks, and makes effective modifications in response to new evidence
- selects, processes, interprets and represents data using a range of scientific formats to show patterns and relationships, derive trends, explain phenomena and make predictions
- designs solutions to complex problems, questions or hypotheses using data and by applying scientific processes, modelling and formats
- communicates scientific understanding succinctly, logically and consistently using accurate scientific terms in a variety of formats and contexts.

Band 5

A student who performs at this level typically:

- demonstrates thorough knowledge and understanding of scientific concepts in Physics
- applies knowledge and understanding to unfamiliar situations to explain scientific scenarios
- designs and plans investigations to obtain accurate, reliable, valid and relevant primary and secondary data and information, evaluates and mitigates risks, and makes some modifications in response to new evidence
- selects, processes, interprets and represents data using a range of scientific formats to show patterns and relationships, derive trends, describe phenomena and make predictions

- design solutions to problems, questions or hypotheses using data and by applying scientific processes, modelling and formats
- communicates scientific understanding succinctly and logically using accurate scientific terms in a variety of formats and contexts.

Band 4

A student who performs at this level typically:

- demonstrates sound knowledge and understanding of scientific concepts in Physics
- applies knowledge and information relevant to scientific issues and scenarios
- designs and plans investigations to obtain primary and secondary data and evaluates risks
- processes, interprets and represents data using a range of scientific formats
- uses scientific processes to address problems, questions or hypotheses
- communicates scientific understanding effectively using scientific terms.

Band 3

A student who performs at this level typically:

- demonstrates basic knowledge and understanding of scientific concepts in Physics
- recalls scientific knowledge and information
- implements scientific processes to obtain primary and secondary data and identifies risks
- processes and represents data using scientific formats
- responds to scientific problems, questions or hypotheses
- communicates basic scientific understanding.

Band 2

A student who performs at this level typically:

- demonstrates limited knowledge and understanding of scientific concepts in Physics
- recalls limited scientific knowledge and information in Physics
- outlines investigations to obtain data and information
- provides simple descriptions of scientific problems
- communicates limited scientific understanding.

Band 1

Performance reported as Band 1 indicates that the minimum standard expected was not demonstrated.

School-based assessment

Schools are required to develop an assessment program for each Year 11 and Year 12 course. NESA provides information about the responsibilities of schools in developing assessment programs in course-specific assessment requirements and in the Assessment Certification Examination (ACE) rules and requirements.

Year 11 Physics school-based assessment

Stage 6 – Year 11

Schools are required to submit to NESA a grade for each student based on their achievement at the end of the course.

Teachers use professional, on-balance judgement to allocate grades based on the Common Grade Scale for Preliminary courses.

Teachers consider all available assessment information, including formal and informal assessment, to determine the grade that best matches each student's achievement at the end of the course.

See Assessment Certification Examination (ACE) rules and requirements for further information.

Assessment programs must reflect course components and weightings

The course components and component weightings for Year 11 are mandatory.

Course component	Weighting %
Skills in Working scientifically	60
Knowledge and understanding of course content	40

Schools may determine specific elements of their assessment program

Schools have authority to determine the number, type of task and the weighting allocated to an assessment task. Schools may also follow the sample assessment programs provided by NESA.

Sample assessment program

NESA's sample Year 11 formal school-based assessment program for Physics is:

- 3 assessment tasks, including:
  - one depth study or aspect of a depth study
  - a formal written examination
  - a weighting for any individual task of 20% to 40%.

Some students with disability may require adjustments in order to access assessment opportunities and demonstrate achievement of outcomes.

Year 12 Physics school-based assessment

Stage 6 – Year 12

NESA requires schools to submit a school-based assessment mark for each Year 12 student who completes this course. Formal school-based assessment tasks should reflect the syllabus outcomes and content. The mark submitted by the school provides a summation of each student's achievement measured at several points throughout the course.

A school's program of school-based assessment includes both mandatory and non-mandatory elements.

See Assessment Certification Examination (ACE) rules and requirements for further information.

Assessment programs must reflect course components and weightings

The course components and component weightings for Year 12 are mandatory.

Course component	Weighting %
Skills in Working scientifically	60
Knowledge and understanding of course content	40

Schools may determine specific elements of their assessment program

Schools have authority to determine the number, type of task and the weighting allocated to an assessment task. Schools may also follow the sample assessment programs provided by NESA.

Sample assessment program

NESA's sample Year 12 formal school-based assessment program for Physics is:

- 4 assessment tasks, including:
  - one depth study or aspect of a depth study
  - a formal written examination
  - a weighting for any individual task of 10% to 40%.

Some students with disability may require adjustments in order to access assessment opportunities and demonstrate achievement of outcomes.

Sample assessment schedules

Stage 6

Sample assessment schedules and tasks are being updated to align with new ACE Rules. More information: New limit on take-home assessment tasks from Term 4 2026.

Further information

Stage 6 – Year 12

- Assessment in Stage 6
- Principles of effective assessment
- Assessment in practice
- School-based assessment requirements
- Adjustments to assessment for students with disability
- Life Skills
- Assessment Certification Examination (ACE)

HSC examinations

The external HSC examination measures student achievement in a range of syllabus outcomes.

The external examination and its marking relate to the syllabus by:

- providing clear links to syllabus outcomes
- enabling students to demonstrate the levels of achievement outlined in the Performance Band Descriptions
- applying marking guidelines based on criteria that relate to the quality of the response
- aligning performance in the examination each year to the standards established for the course.

Examination questions may require students to integrate knowledge, understanding and skills developed through studying the course.

The Year 11 course is assumed knowledge for the Year 12 course.

Some students with disability may be eligible for HSC exam provisions when completing the HSC examination.

Physics HSC examination specifications

Stage 6 – Year 12

The examination will consist of a written paper worth 100 marks.

Time allowed: 3 hours plus 10 minutes reading time.

The paper will include a data sheet, formulae sheet and Periodic table.

NESA-approved calculators, a pair of compasses and a protractor may be used.

The paper will consist of two sections.

Questions assessing Working scientifically outcomes will be integrated throughout the examination.

Questions may refer to stimulus material.

Section I (20 marks)

- There will be objective-response questions to the value of 20 marks.

Section II (80 marks)

- Questions may contain parts.
- There will be 20 to 25 items.
- At least two items will be worth 7 to 9 marks.

HSC Physics – Sample examination materials

Stage 6 – Year 12

- HSC Physics – annotated sample examination materials
- HSC Physics – data sheet, formulae sheet and Periodic Table
- Sample HSC examinations: A4 guide for teachers

Further information

Stage 6 – Year 12

- Assessment in Stage 6
- Principles of effective assessment
- Assessment in practice
- School-based assessment requirements
- Adjustments to assessment for students with disability
- Life Skills
- Assessment Certification Examination (ACE)