Government of **Western Australia**
School Curriculum and Standards Authority

Physics

ATAR course

Year 12 syllabus for teaching from 2027

Acknowledgement of Country

Kaya. The School Curriculum and Standards Authority (the Authority) acknowledges that our offices are on Whadjuk Noongar boodjar and that we deliver our services on the country of many traditional custodians and language groups throughout Western Australia. The Authority acknowledges the traditional custodians throughout Western Australia and their continuing connection to land, waters and community. We offer our respect to Elders past and present.

Important information

As part of the Western Australian Certificate of Education (WACE) Refreshment, the School Curriculum and Standards Authority (the Authority) has revised the course rationale and aims, and updated the General Capabilities to create clearer connections with the syllabus content.

This syllabus is effective from 1 January 2027.

Users of this syllabus are responsible for checking its currency.

Syllabuses are formally reviewed by the Authority on a cyclical basis, typically every five years.

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Contents

Rationale

The Physics ATAR course helps to develop an understanding of the mysteries of the universe, from the sub-atomic scale to the evolution of the universe. Physics is a fundamental science that endeavours to explain all the natural phenomena that occur in the universe. Its power lies in the use of a comparatively small number of assumptions, models, laws and theories to explain a wide range of phenomena, from the incredibly small to the incredibly large. It provides the foundation of understanding upon which modern technologies and all other sciences are based.

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

The Physics ATAR course uses qualitative and quantitative models and theories based on physical laws to visualise, explain and predict physical phenomena. Models, laws and theories are developed from, and their predictions are tested by, making observations and quantitative measurements. Students gather, analyse and interpret primary and secondary data to investigate a range of phenomena and technologies using some of the most important models, laws and theories of Physics, including the theory of special relativity, the electromagnetic theory and quantum theory.

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

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

Aims

The Physics ATAR course aims to develop students':

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

Organisation

This course is organised into a Year 11 syllabus and a Year 12 syllabus. The cognitive complexity of the syllabus content increases from Year 11 to Year 12.

Structure of the syllabus

The Year 12 syllabus is divided into two units which are delivered as a pair. The notional time for the pair of units is 110 class contact hours.

Unit 3 – Gravity and relativity

Students investigate models of motion in a gravitational field to explain how forces act at a distance. They examine the theory of special relativity and the consequences of general relativity.

Unit 4 – Electromagnetism and modern physics

Students use the theory of electromagnetism to explain the production and propagation of electromagnetic waves and investigate how shortcomings in existing theories led to the development of the quantum theory of light and matter.

Each unit includes:

- a unit description – a short description of the focus of the unit
- unit content – the content to be taught and learned.

Organisation of content

Science strand descriptions

The Physics ATAR course is organised into three interrelated strands: Science Inquiry Skills, Science as a Human Endeavour and Science Understanding, which build on students' learning in the Years 7–10 Science curriculum. The three strands of the Physics ATAR course should be taught in an integrated way. The content descriptions for each strand have been written so that this integration is possible in each unit.

Science Inquiry Skills

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

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

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

Science as a Human Endeavour

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

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

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

Science Understanding

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

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

Safety

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

Animal ethics

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

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

Mathematical skills expected of students studying the Physics ATAR course

The Physics ATAR course requires students to use the mathematical skills they have developed through the Years 7–10 Mathematics curriculum, in addition to the numeracy skills they have developed through the Science Inquiry Skills strand of the Years 7–10 Science curriculum.

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

Students may need to be taught inverse and inverse square relationships as they are important in Physics but are not part of the Year 10 Mathematics curriculum.

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

It is assumed that students will be able to:

- perform calculations involving addition, subtraction, multiplication and division of quantities
- perform approximate evaluations of numerical expressions
- express fractions as percentages, and percentages as fractions
- calculate percentages
- recognise and use ratios
- transform decimal notation to power of ten notation
- change the subject of a simple equation
- substitute physical quantities into an equation using consistent units so as to calculate one quantity and check the dimensional consistency of such calculations
- solve simple algebraic equations
- comprehend and use the symbols/notations <, >, Δ, ≈, √, ≤, ≥, ∑
- translate information between graphical, numerical and algebraic forms
- distinguish between discrete and continuous data and then select appropriate forms, variables and scales for constructing graphs
- interpret frequency tables and diagrams, pie charts and histograms
- describe and compare data sets using range, mean and median
- interpret the slope of a linear graph
- use Pythagoras' theorem, similarity of triangles and the angle sum of a triangle
- solve simple sine, cosine and tangent relationships in a right-angle triangle
- recognise the graphical representation of a sine and cosine curve.

Representation of the General Capabilities

The General Capabilities encompass the knowledge, skills, behaviours and dispositions that will support students to live and work successfully now and into the future. They are not assessed unless identified within the specified unit content. Teachers should find opportunities to incorporate the following General Capabilities into the teaching and learning program for the Physics ATAR course.

Critical and creative thinking

Students' critical and creative thinking capability is developed in this course through the science inquiry process. Science inquiry requires the ability to construct, review and revise questions and hypotheses about increasingly complex and abstract scenarios, and to design related investigation methods. Students interpret and evaluate data; interrogate, select and cross-reference evidence; and analyse processes, interpretations, conclusions and claims for validity and reliability, including reflecting on their processes and conclusions.

Digital literacy

Digital literacy capability is a key part of Science Inquiry Skills developed in this course. Students use a range of strategies to locate, access and evaluate information from multiple digital sources; collect, analyse and represent data; model and interpret concepts and relationships; and communicate and share science ideas, processes and information.

Ethical understanding

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

Literacy

Students develop literacy through the course as they gather, interpret, synthesise and critically analyse information presented in a wide range of genres, modes and representations, including text, flow diagrams, symbols, graphs and tables. They evaluate information sources and compare and contrast ideas, information and opinions presented within and between texts. Students communicate processes and ideas logically and fluently and structure evidence-based arguments, selecting genres and employing appropriate structures and features to communicate for specific purposes and audiences.

Numeracy

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

Addressing the other General Capabilities

Although the following General Capabilities have not been identified as a focus in the Physics ATAR Year 12 syllabus, teachers may find opportunities to incorporate them into the teaching and learning program.

- Intercultural understanding
- Personal and social capability

Such opportunities may occur through the application of different contexts, pedagogical practices and/or assessment strategies that relate to the syllabus as part of the teaching and learning program.

Summary representation of the General Capabilities in the Physics ATAR course

The unit content and assessment types for this course provide students with the opportunity to develop the General Capabilities summarised in the table below.

Year	Course	Course type	General Capabilities						
			CCT	DL	EU	IU	L	N	PSC
Year 11	Physics (AEPHY)	ATAR	✓	✓	✓		✓	✓	
Year 12	Physics (ATPHY)	ATAR	✓	✓	✓		✓	✓	

Key
CCT: Critical and creative thinking, DL: Digital literacy, EU: Ethical understanding, IU: Intercultural understanding, L: Literacy, N: Numeracy, PSC: Personal and social capability

Representation of the Cross-curriculum Priorities

The Cross-curriculum Priorities address contemporary issues that students face in a globalised world. Teachers may find opportunities to incorporate them into the teaching and learning program for the Physics ATAR course. The Cross-curriculum Priorities are not assessed unless they are identified within the specified unit content.

Aboriginal and Torres Strait Islander histories and cultures

Contexts that draw on Aboriginal and Torres Strait Islander histories and cultures provide an opportunity for students to appreciate Aboriginal and Torres Strait Islander Peoples' understanding of physical phenomena, including the motion of objects, and astronomical phenomena, including Aboriginal constellations, their meanings and their relationship with Creation/Dreaming stories.

Asia and Australia's engagement with Asia

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

Sustainability

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

Unit 3 – Gravity and relativity

Unit description

Field theories have enabled physicists to explain a vast array of natural phenomena and have contributed to the development of technologies that have changed the world, including electrical power generation and distribution systems, artificial satellites and modern communication systems. In this unit, students develop a deeper understanding of motion and its causes by using Newton's laws of motion and the gravitational field model to analyse circular motion, including on banked curves, and satellite motion.

Contexts that can be investigate in this unit include technologies, such as artificial satellites and navigation devices, and related areas of science and engineering, such as sports science and amusement parks.

Through the investigation of appropriate contexts, students explore the ways in which models and theories related to gravity and relativity, and associated technologies, have developed over time.

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

Unit content

An understanding of the Year 11 content is assumed knowledge for students in Year 12. It is recommended that students studying Unit 3 and Unit 4 have completed Unit 1 and Unit 2.

This unit includes the knowledge, understandings and skills described below. This is the examinable content.

Science Inquiry Skills

- identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes
- design investigations, including the procedure to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
- conduct practical work, including the manipulation of devices, safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate *Système International* (SI) units and symbols, and significant figures
- organise and analyse data to identify trends, patterns and relationships
- identify sources of random and systematic uncertainty and estimate their effect on measurement results
- state absolute uncertainties in values and calculate percentage uncertainty where appropriate

- combine uncertainties in calculations to determine the overall uncertainty in a measurement (addition, subtraction, multiplication and division)
- identify anomalous data and calculate the percentage difference between the experimental results and a currently accepted value
- select, synthesise and use evidence to make and justify conclusions
- interpret a range of scientific texts and evaluate processes and conclusions by considering the available evidence, and use reasoning to construct scientific arguments
- select, construct and use appropriate representations, including text and graphical representations of empirical and theoretical relationships, to communicate conceptual understanding, solve problems and make predictions
- select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions
- relate gradients and axis intercepts of linear graphs to physical quantities
- apply dimensional analysis to determine the appropriate units for calculated quantities, e.g. a gradient in a graph
- use uncertainty bars to represent the uncertainty in a value on a graph and take into account when sketching a line of best fit
- communicate to specific audiences and for specific purposes using appropriate language and nomenclature

Science as a Human Endeavour

Gravity and motion

- artificial satellites are used for communication, navigation, remote-sensing and research. Their orbits and uses are classified by altitude (low, medium or high Earth orbits) and by inclination (equatorial, polar and sun-synchronous orbits)
- experimental observations of high-speed muons created in the upper atmosphere provide evidence for Einstein’s theory of special relativity
- Einstein’s theory of general relativity explains phenomena including time dilation in atomic clocks on global positioning system (GPS) satellites, the existence of black holes, gravitational waves and gravitational lensing

Science Understanding

Static equilibrium and centre of mass

- the stability of an object depends on the location of its centre of mass
- when an object experiences a net force at a distance from a pivot and at an angle to the lever arm, it will experience a torque or moment about that point, including applying the relationship
  $\tau = rF\sin\theta$ where $\theta =$ angle between the force F and the lever arm
- for a rigid body to be in equilibrium, the sum of the forces and the sum of the moments must be zero, including applying the relationships
  $\Sigma F = 0$ $\tau = rF\sin\theta$ $\Sigma\tau = 0$
- static equilibrium contexts may include
  - objects leaning against a frictionless wall, e.g. a ladder
  - objects pivoting about one point, e.g. a seesaw
  - bridges and cantilevers
  - suspension of objects by cables, e.g. signs

Circular motion in horizontal and vertical plane

- when an object experiences a net force perpendicular to its velocity, it will undergo circular motion, including:
  - uniform circular motion on a horizontal plane
  - circular motion involving 'banking', e.g. objects moving around a banked track, aeroplanes and birds turning in flight
  - vertical circular motion, both uniform and non-uniform
  - apparent weight of objects undergoing circular motion
    This includes applying the relationships
    $v = \frac{2\pi r}{T}$ $a_c = \frac{v^2}{r}$ resultant $F_c = ma_c = \frac{mv^2}{r}$
- the law of conservation of energy applies to circular motion, including applying the relationships:
  $E_p = mg\Delta h$ $W = \Delta E$ $E_k = \frac{1}{2}mv^2$

Gravity

- all objects with mass attract one another with a gravitational force and the magnitude of this force can be calculated using Newton's law of universal gravitation, including applying the relationship
  $F_g = G\frac{m_1 m_2}{r^2}$
- objects with mass produce a gravitational field in the space that surrounds them
- a gravitational force on an object is due to the presence of a gravitational field, including applying the relationship
  $F_{weight} = mg$
- work is done when a mass moves from one point to another in a gravitational field and its potential energy changes, including applying the relationships
  $E_p = mg\Delta h$ $W = Fs$ $W = \Delta E$ $E_k = \frac{1}{2}mv^2$

- gravitational field strength is defined as the net force per unit mass at a particular point in the field, including applying the relationships
  $$g = \frac{F_g}{m} = G\frac{M}{r^2}$$
- the vector nature of the gravitational force can be used to analyse motion on inclined planes by considering the components of the gravitational force (that is, weight) parallel and perpendicular to the plane
- projectile motion can be analysed quantitatively by treating the horizontal and vertical components of the motion independently, including applying the relationships
  $$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} \qquad v_f = v_i + a\Delta t \qquad s = v_i\Delta t + \frac{1}{2}a\Delta t^2 \qquad {v_f}^2 = {v_i}^2 + 2as \qquad E_k = \frac{1}{2}mv^2$$
- Newton's law of universal gravitation is used to explain Kepler's third law of planetary motion and to describe the motion of planets and other satellites, which is modelled as uniform circular motion, including deriving and applying the relationship
  $$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

Relativity

- Einstein's theory of special relativity is based on two postulates: that the speed of light in a vacuum is an absolute constant, and that the laws of physics are the same in all inertial reference frames
- observations of objects travelling at very high speeds cannot be explained by Newtonian physics
- events that are simultaneous in one inertial frame of reference may not be simultaneous in another
- motion can only be measured relative to an observer. Length and time are relative quantities that depend on the observer's frame of reference, including applying the relationships
  $$\ell' = \ell\sqrt{\left(1 - \frac{v^2}{c^2}\right)} \qquad \Delta t' = \frac{\Delta t}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}} \qquad u = \frac{u' + v}{1 + \frac{u'v}{c^2}} \qquad u' = \frac{u - v}{1 - \frac{uv}{c^2}}$$

Unit 4 – Electromagnetism and modern physics

Unit description

The development of quantum theory fundamentally changed our understanding of how nature operates and led to the development of a wide range of new technologies, including technologies that revolutionised the storage, processing and communication of information. In this unit, students investigate electromagnetic interactions and apply this knowledge to understand the operation of direct current motors, direct current (DC) and alternating current (AC) generators, transformers, and AC power distribution systems. They also investigate the production of electromagnetic waves.

Students examine observations of light and matter that could not be explained by existing theories and investigate how the shortcomings of existing theories led to the development of the quantum theory of light and matter. They evaluate the contribution of the quantum theory of light to the development of the quantum theory of the atom and examine the Big Bang theory.

Through investigation, students apply their understanding of black body radiation, wave/particle duality and the quantum theory of the atom to make and/or explain observations of a range of phenomena, such as atomic emission and absorption spectra, the photoelectric effect and lasers.

Unit content

This unit builds on the content covered in Unit 3.

This unit includes the knowledge, understandings and skills described below. This is the examinable content.

Science Inquiry Skills

- identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes
- design investigations, including the procedure to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
- conduct practical work, including the manipulation of devices, safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate *Système International* (SI) units and symbols, and significant figures
- organise and analyse data to identify trends, patterns and relationships
- identify sources of random and systematic uncertainty and estimate their effect on measurement results
- state absolute uncertainties in values and calculate percentage uncertainty where appropriate
- combine uncertainties in calculations to determine the overall uncertainty in a measurement (addition, subtraction, multiplication and division)
- identify anomalous data and calculate the percentage difference between the experimental results and a currently accepted value
- select, synthesise and use evidence to make and justify conclusions
- interpret a range of scientific texts and evaluate processes and conclusions by considering the available evidence, and use reasoning to construct scientific arguments

- select, construct and use appropriate representations, including text and graphical representations of empirical and theoretical relationships, to communicate conceptual understanding, solve problems and make predictions
- select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions
- relate gradients and axis intercepts of linear graphs to physical quantities
- apply dimensional analysis to determine the appropriate units for calculated quantities, e.g. a gradient in a graph
- use uncertainty bars to represent the uncertainty in a value on a graph and take into account when sketching a line of best fit
- communicate to specific audiences and for specific purposes using appropriate language and nomenclature

Science as a Human Endeavour

- electromagnetism is utilised in a variety of applications in society, including:
  - motors, generators and transformers in common household appliances, entertainment systems and industrial settings
  - generation and transmission of electrical energy
  - transport, e.g. electric and hybrid vehicles, magnetic levitation trains
  - communication systems
  - medical settings, e.g. magnetic resonance imaging
  - linear particle accelerator (linac), cyclotron, synchrotron, mass spectrometer, velocity selector

Science Understanding

Electromagnetism

- electrostatically charged objects exert a force upon one another; the magnitude of this force can be calculated using Coulomb's law, including applying the relationship
  $$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$
- point charges and charged objects produce an electric field in the space that surrounds them; field theory attributes the electrostatic force on a point charge or charged body to the presence of an electric field
- a positively-charged body placed in an electric field will experience a force in the direction of the field; the strength of the electric field is defined as the force per unit charge, including applying the relationship
  $$E = \frac{F}{q}$$
- when a charged body moves, or is moved, from one point to another in an electric field and its potential energy changes, work is done on the charge by the field, including applying the relationship
  $$\Delta V = \frac{W}{q}$$

- between charged, parallel plates separated by distance *d*, the electric field is uniform, including applying the relationship
  $$E = \frac{\Delta V}{d}$$
- the direction of conventional current is that in which the flow of positive charges takes place, while the electron flow is in the opposite direction
- current-carrying wires are surrounded by magnetic fields; these fields are utilised in solenoids and electromagnets
- magnetic field diagrams are used to show the direction and strength of the magnetic field surrounding objects, including permanent magnets, current-carrying conductors and the Earth
- the strength of the magnetic field produced by a current is a measure of the magnetic flux density, including applying the relationship
  $$B = \frac{\mu_0}{2\pi}\frac{I}{r}$$
- magnets, magnetic materials, moving charges and current-carrying wires experience a force in a magnetic field when they cut flux lines; this force is utilised in DC electric motors and particle accelerators, including applying the relationships
  $F = qvB\sin\theta$ where $\theta =$ angle between the field B and the velocity v
  and
  $F = I\ell B\sin\theta$ where $\theta =$ angle between the field B and the conductor length ℓ
- the force due to a current in a magnetic field in a DC electric motor produces a torque on the coil in the motor, including applying the relationship
  $\tau = rF\sin\theta$ where $\theta =$ angle between the force F and the lever arm
- an induced emf is produced by the relative motion of a straight conductor in a magnetic field when the conductor cuts flux lines, including applying the relationship
  induced emf: $\varepsilon = \ell vB\sin\theta$
- magnetic flux is defined in terms of magnetic flux density and area, including applying the relationship
  $\Phi = BA_{\perp}$ where $A_{\perp} =$ area perpendicular to the field B
- a changing magnetic flux induces a potential difference; this process of electromagnetic induction is used in DC and AC generators, including applying the relationships
  induced emf: $\varepsilon = -N\frac{\Delta\Phi}{\Delta t} = -N\frac{\Delta BA_{\perp}}{\Delta t}$ where $A_{\perp} =$ area perpendicular to the field B
  AC generator emf$_{max}$: $\varepsilon_{max} = 2N\ell vB = 2\pi NBAf$ $\varepsilon_{rms} = \frac{\varepsilon_{max}}{\sqrt{2}}$
- step-up and step-down transformers are used in large scale AC power distribution systems including applying the relationships
  $$\frac{V_p}{V_s} = \frac{N_p}{N_s} \qquad P = VI = I^2R = \frac{V^2}{R}$$
- conservation of energy, expressed as Lenz's law of electromagnetic induction, is used to determine the direction of induced current
- electromagnetism is utilised in a range of technological applications, including:
  - the back emf produced in a motor
  - regenerative braking
  - induction hotplates

Particle accelerators

- electric and magnetic fields are used in high-energy particle accelerators to control the motion of charged particles, including applying the relationships
  $E = \frac{F}{q} = \frac{\Delta V}{d}$ $\Delta V = \frac{W}{q}$ $\frac{m\,v^2}{r} = qvB$
  $a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$ $v_f = v_i + a\Delta t$ $s = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ${v_f}^2 = {v_i}^2 + 2as$ $p = mv$
- relativistic momentum increases at high speed and prevents an object from reaching the speed of light, including applying the relationship
  $p = \frac{mv}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$
- the concept of mass–energy equivalence emerged from the theory of special relativity and explains the source of the energy produced in nuclear reactions. The mass of an object is constant and independent of its motion, including applying the relationship for total energy *E*
  $E = \frac{mc^2}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$
- the total energy *E* of a moving object is the sum of the energy due to its mass and kinetic energy, including applying the relationships
  $E = E_{rest} + E_k$ $E_{rest} = mc^2$
- the total energy *E* of an object can be expressed in terms of its mass and momentum, including applying the relationship
  $E^2 = p^2c^2 + m^2c^4$

Science as a Human Endeavour

Wave particle duality and the quantum theory

- fluorescence, phosphorescence and X-rays are utilised in a variety of applications in society, including:
  - medical and forensic sciences
  - astronomy, e.g. space telescopes
  - industry, e.g. food irradiation, airport scanners, X-ray fluorescence, fluorescent labelling and dyes, biological markers
  - domestic and industrial lighting
  - pharmaceutical and cosmetic industries
- devices developed from the application of quantum physics include the laser, photovoltaic cells and light-emitting diodes (LEDs)

Science Understanding

Wave particle duality and the quantum theory

- a wave model is required to explain light-related phenomena of diffraction and interference, including Young's double-slit experiment
- light exhibits many wave properties, but it cannot be modelled as a mechanical wave because it can travel through a vacuum
- a transverse wave model is required to explain polarisation
- electromagnetic waves are transverse waves made up of mutually perpendicular, oscillating electric and magnetic fields
- oscillating charges produce electromagnetic waves of the same frequency as the oscillation; electromagnetic waves cause charges to oscillate at the frequency of the wave
- atomic phenomena and the interaction of light with matter indicate that states of matter and energy are quantised into discrete values
- the observed spectrum of thermal radiation emitted by a black body radiator is not able to be explained by the classical wave model. A particle model is needed to explain the shape and dependence of the spectra on temperature
- on the atomic level, electromagnetic radiation is emitted or absorbed in discrete packets called photons. The energy of a photon E is proportional to its frequency f and momentum p, including applying the relationships

  $c = f\lambda \qquad E = hf = \frac{hc}{\lambda} \qquad E = pc$
- the constant of proportionality, Planck's constant, can be determined experimentally using the photoelectric effect, including applying the relationship

  $E_k = hf - \phi$ where $\phi =$ the work function of the surface
- atoms of an element emit and absorb specific wavelengths of light that are unique to that element; this is the basis of spectral analysis, including applying the relationships

  $\Delta E = hf \qquad E_2 - E_1 = hf$
- the Bohr model of the hydrogen atom integrates light quanta and atomic energy states to explain the specific wavelengths in the hydrogen spectrum and in the spectra of other simple atoms; this model enables line spectra to be correlated with atomic energy-level diagrams and explains the phenomena of fluorescence and phosphorescence, and X-ray production
- on the atomic level, energy and matter exhibit the characteristics of both waves and particles. Young's double-slit experiment is explained with a wave model but produces the same interference and diffraction patterns when one photon at a time or one electron at a time are passed through the slits, including applying the relationships

  $\lambda = \frac{h}{p} \qquad E = pc$

Cosmology

- units of measurement for astronomical distances include the astronomical unit (AU), light year and parsec
- the Big Bang theory describes the early development of the universe
- there is a variety of evidence that supports the Big Bang theory, including cosmic background radiation, expansion of space, the abundance of light elements and the red shift of light from galaxies that obey Hubble's law, including applying the relationship

  $v = H_0 d$

Assessment

Assessment is an integral part of teaching and learning that in the senior secondary years:

- provides evidence of student achievement
- identifies opportunities for further learning
- connects to the standards described for the course
- contributes to the recognition of student achievement.

Assessment for learning (formative) and assessment of learning (summative) enable teachers to gather evidence to support students and make judgements about student achievement. These are not necessarily discrete approaches and may be used individually or together, and formally or informally.

Formative assessment involves a range of informal and formal assessment procedures used by teachers during the learning process to improve student achievement and to guide teaching and learning activities. It often involves qualitative feedback (rather than scores) for both students and teachers, which focuses on the details of specific knowledge and skills that are being learnt.

Summative assessment involves assessment procedures that aim to determine students' learning at a particular time, for example when reporting against the standards or after completion of a unit or units. These assessments should be limited in number and made clear to students through the assessment outline.

Appropriate assessment of student work in this course is underpinned by reference to a set of pre-determined course standards. These standards describe the level of achievement required to achieve each grade from A to E. Teachers use these standards to determine how well a student has demonstrated their learning.

Where relevant, higher order cognitive skills (e.g. application, analysis, evaluation and synthesis) and the General Capabilities should be included in the assessment of student achievement in this course. All assessment should be consistent with the requirements identified in the course assessment table.

Assessment should not generate workload and/or stress that, under fair and reasonable circumstances, would unduly diminish the performance of students.

School-based assessment

The *Western Australian Certificate of Education (WACE) Manual* contains essential information on principles, policies and procedures for school-based assessment that must be read in conjunction with this syllabus.

School-based assessment involves teachers gathering, describing and quantifying information about student achievement.

Teachers design school-based assessment tasks to meet the needs of students. As outlined in the *WACE Manual*, school-based assessment of student achievement in this course must be based on the Principles of Assessment:

- Assessment is an integral part of teaching and learning
- Assessment should be educative
- Assessment should be fair
- Assessment should be designed to meet its specific purpose/s
- Assessment should lead to informative reporting
- Assessment should lead to school-wide evaluation processes
- Assessment should provide significant data for improvement of teaching practices.

The table below provides details of the assessment types and their weighting for the Physics ATAR Year 12 syllabus.

Summative assessments in this course must:

- be limited in number to no more than eight tasks
- allow for the assessment of each assessment type at least once over the year/pair of units
- have a minimum value of five per cent of the total school assessment mark
- provide a representative sampling of the syllabus content.

Assessment tasks not administered under test or controlled conditions require appropriate authentication processes.

Assessment table – Year 12

<table>
<tr><th>Type of assessment</th><th>Weighting</th></tr>
<tr><td>Science inquiry portfolio
The purpose of the portfolio is to gather a body of experimental work that students have completed over the wide variety of practical opportunities that occur within the course, to assess the Science Inquiry Skills of students.

Teachers should design experiences that cover a comprehensive range of Science Inquiry Skills to allow students to practise and develop their understanding in a variety of experimental contexts and with provision of feedback.

These feedback opportunities may include:
• communication of experimental data
• demonstration of practical skills
• analysis of data including linearisation, identifying relationships between gradients, axis intercepts and physical properties, and recognition and analysis of uncertainties
• application of scientific reasoning
• evaluation of data and experimental design.

A small selection of items (three to five) in the portfolio must be used to authenticate the portfolio.</td><td>10%</td></tr>
<tr><td>Test
Tests typically consist of questions requiring short answers, extended answers and problem solving.

This assessment type is conducted in supervised classroom settings.</td><td>40%</td></tr>
<tr><td>Examination
Examinations require students to demonstrate use of terminology, understanding and application of concepts and knowledge of information. It is expected that questions would allow students to respond at their highest level of understanding.

Examinations are typically conducted at the end of each semester and/or unit and reflect the examination design brief for this syllabus. This assessment type is conducted in supervised classroom settings.</td><td>50%</td></tr>
</table>

Teachers are required to use the assessment table to develop an assessment outline for the pair of units.

The assessment outline must:

- include a set of assessment tasks
- include a general description of each task
- indicate the unit content to be assessed
- indicate a weighting for each task and each assessment type
- include the approximate timing of each task; for example, the week the task is conducted, or the issue and submission dates for an extended task.

Reporting

Schools report student achievement, underpinned by a set of pre-determined standards, using the following grades:

Grade	Interpretation
A	Excellent achievement
B	High achievement
C	Satisfactory achievement
D	Limited achievement
E	Very low achievement

The grade descriptions for the Physics ATAR Year 12 syllabus are provided in Appendix 1. They are used to support the allocation of a grade. They can also be accessed, together with annotated work samples, on the course page of the Authority's website (www.scsa.wa.edu.au).

To be assigned a grade, a student must have had the opportunity to complete the education program, including the assessment program (unless the school accepts that there are exceptional and justifiable circumstances).

Refer to the *WACE Manual* for further information about the use of a ranked list in the process of assigning grades.

The grade is determined by reference to the standard, not allocated on the basis of a pre-determined range of marks (cut-offs).

ATAR course examination

All students enrolled in the Physics ATAR Year 12 course are required to sit the ATAR course examination. The examination is based on a representative sampling of the content for Unit 3 and Unit 4. Details of the ATAR course examination are prescribed in the examination design brief below.

Refer to the WACE Manual for further information.

Examination design brief – Year 12

Time allowed

Reading time before commencing work: ten minutes
Working time for paper: three hours

Permissible items

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: drawing templates, drawing compass, protractor, and up to three calculators which do not have the capacity to create or store programmes or text

Provided by the supervisor

A Formulae and Data booklet

Additional information

Instructions to the candidate state:

When calculating numerical answers, show your working or reasoning clearly. Unless otherwise instructed, give final answers to three significant figures and include appropriate units where applicable.

Section	Supporting information
Section One **Short response** 30% of the total examination 10–15 questions Suggested working time: 50 minutes	Questions are generally simple calculations. Responses can include diagrams, tables, calculations, explanations and/or predictions.
Section Two **Problem-solving** 50% of the total examination Six to eight questions Suggested working time: 90 minutes	Questions can be scaffolded and require the candidate to respond to stimulus material. Stimulus material can include scenarios, current events information, extracts from scientific journals and/or any other data. Responses can include diagrams, tables, simple and/or complex calculations, explanations and/or predictions.
Section Three **Comprehension and data analysis** 20% of the total examination Two questions Suggested working time: 40 minutes	Candidates are to apply concepts, principles and strategies to solve problems. Stimulus material can include scenarios, current events information, extracts from scientific journals and/or any other data. The questions can have sequential parts. Responses can include diagrams, tables, simple and/or complex calculations, explanations and/or predictions. One question is comprehension and may come from an unfamiliar context. One question is data analysis and requires analysis of experimental data.

Appendix 1 – Grade descriptions Year 12

Note: grade descriptions are to be refined using validated evidence from assessment samples and feedback from teachers. These descriptions will be reviewed at the end of the second year of implementation of this syllabus.

A	**Understanding and applying concepts** Applies models and scientific principles to comprehensively explain and link complex systems and processes. Supports responses with a range of appropriate examples and accurate diagrams. Consistently applies scientific knowledge to accurately explain, in detail, unfamiliar contexts or examples. Selects and accurately evaluates scientific information from a variety of sources to present logical, well-developed arguments, which are supported by relevant, detailed evidence. Describes complex relationships between concepts using appropriate terminology and conventions. Provides responses that are comprehensive and contain detailed information. Consistently selects and manipulates equations to solve complex problems. Provides logically sequenced working and expresses answers using correct units and significant figures.
	Science inquiry skills Formulates a testable hypothesis that describes a quantifiable relationship between the dependent and independent variables. Plans and conducts investigations, identifying appropriate variables and explaining how they are controlled. Describes experimental method in detail and accurately collects valid and reliable data. Consistently organises and processes data accurately, including uncertainty of measurement. Presents data logically in a range of forms, including graphs, tables and diagrams. Comprehensively explains trends using quantitative data, where appropriate, as evidence to draw conclusions that relate to the hypothesis. Evaluates the experimental method and provides specific and relevant suggestions to improve the reliability of the data collected. Communicates detailed information and concepts logically and coherently. Consistently uses appropriate terminology and conventions.

B	**Understanding and applying concepts** Applies models and scientific principles to accurately explain and link simple, and some complex, phenomena. Supports responses with appropriate examples and accurate diagrams. Often applies scientific knowledge to accurately explain unfamiliar contexts or examples, sometimes lacking detail. Selects and evaluates scientific information from a variety of sources to present logical arguments, which are supported by relevant evidence. Describes relationships between concepts using appropriate terminology and conventions. Provides responses that are detailed and contain relevant information. Selects and manipulates equations to solve simple multiple-step problems. Provides adequate working and generally expresses answers using correct units and significant figures.
	Science inquiry skills Formulates a testable hypothesis that describes a relationship between the dependent and independent variables. Plans and conducts investigations, identifying and controlling appropriate variables. Describes the experimental method and accurately collects appropriate data. Often organises and processes data accurately. Presents data logically in a range of forms, including graphs, tables and diagrams. Explains trends using some quantitative data, where appropriate, and uses evidence to draw conclusions that relate to the hypothesis. Evaluates the experimental method and provides relevant suggestions to improve the reliability of the data collected. Communicates information and concepts logically. Often uses appropriate terminology and conventions.

Grade	Descriptor
C	**Understanding and applying concepts** Applies models and scientific principles to describe simple systems and processes. Provides examples in some responses. Draws simple diagrams that lack detail. Sometimes applies scientific knowledge to unfamiliar contexts and provides generic responses. Selects some scientific information to provide generalised arguments or statements, which are supported by some evidence. Describes simple relationships between concepts using appropriate terminology and conventions. Provides responses that lack detail and may include irrelevant information. Selects and manipulates equations and data to solve simple problems. Provides adequate working that may contain errors and expresses answers with some errors in units and significant figures.
	Science inquiry skills Formulates a testable hypothesis that includes the dependent and independent variables. Plans and conducts investigations identifying and controlling some variables. Briefly outlines the experimental method and collects data. Organises and processes data with minor errors or omissions. Presents data in basic graphs, tables and diagrams. Describes trends in data and draws simple conclusions that may not link to the hypothesis. Provides general suggestions to improve the reliability of the data collected. Communicates information and concepts simply. Sometimes uses appropriate terminology and conventions.
D	**Understanding and applying concepts** Incorrectly applies scientific models and principles to describe systems and processes. Presents diagrams which are incomplete or incorrect. Inconsistently applies scientific knowledge to unfamiliar contexts. Presents statements of ideas with limited development of an argument, without providing sufficient supporting evidence. Incorrectly describes the relationships between concepts using everyday language. Provides responses that contain errors, inconsistencies and misconceptions. Performs simple problems with errors and omissions. Provides working out that is unclear and consistently expresses answers without appropriate units and significant figures.
	Science inquiry skills Identifies one or more relevant variables. Plans investigations without controlling variables. Describes an experimental method that lacks detail. Organises and processes data with significant errors or omissions. Presents data that is unclear, insufficient and lacks appropriate processing. Identifies trends in data incorrectly or overlooks trends and draws simple conclusions that are not always supported by the data or are not related to the hypothesis. Provides suggestions to improve the reliability of the data collected that may not be feasible. Communicates information ineffectively. Rarely uses appropriate terminology and conventions.
E	Does not meet the requirements of a D grade and/or has completed insufficient assessment tasks to be assigned a higher grade.

Appendix 2 – Glossary

This glossary is provided to enable a common understanding of key terms.

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

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

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

Amplitude
The displacement of a point on an oscillating object from the centre of oscillation.

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

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

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

Characteristic
Distinguishing aspect (including features and behaviours) of an object, material, living thing or event.

Classify
Arrange into named categories to sort, group or identify.

Collaborate
Work with others to perform a specific task.

Conclusion
A judgement based on evidence.

Contemporary science
New and emerging science research and issues of current relevance and interest.

Data

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

Design

Plan and evaluate the construction of a product or process, including an investigation.

Discrete data

Quantitative data consisting of a number of separate values where intermediate values are not permissible.

Energy

The potential to move or bring about changes; the higher the energy content, the greater the impact when it is transformed or transferred.

Environment

All the surroundings, both living and non-living.

Evaluate

Examine and judge the merit or significance of something, including processes, events, descriptions, relationships or data.

Evidence

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

Experimental (investigation)

An investigation that involves carrying out a practical activity.

Field

A position in space where susceptible objects experience (are affected by) a force or acquire potential energy as they are 'worked' into that position. Gravitational fields affect the mass of an object; electric fields affect charged objects; magnetic fields affect ferromagnetic objects; electromagnetic fields affect charge carriers in matter.

Field work

Observational research undertaken in the normal environment of the subject of the study.

Force

A push or pull between objects which may cause one or both objects to change speed and/or the direction of their motion (e.g. accelerate) or change their shape. Scientists identify four fundamental forces: the gravitational, the electromagnetic (involving both electrostatic and magnetic forces), the weak nuclear forces and the strong nuclear forces. All interactions between matter can be explained as the action of one, or a combination, of the four fundamental forces.

Fundamental forces

Four fundamental forces have been identified that interact with all matter in the universe. They are, in order from strongest to weakest, the strong nuclear, the electromagnetic, the weak nuclear and the gravitational.

Genre

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

Hypothesis

A scientific statement based on the available information that can be tested by experimentation. When appropriate, the statement expresses an expected relationship between the independent and dependent variables for observed phenomena.

Intensity

The average rate of flow of energy per unit area.

Investigation

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

Law

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

Linear motion

Straight-line motion or an idealisation of approximately straight line motion when an object moves from one place to another.

Longitudinal

As in longitudinal waves, where the direction of oscillation of particles is parallel to the direction of energy transfer.

Material

A substance with particular qualities or used for specific purposes.

Matter

A physical substance; anything that has mass and occupies space.

Measurement discrepancy

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

Media texts

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

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

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

Nuclide
The range of atomic nuclei associated with a particular atom which is defined by its atomic number and the various isotopes of that atom as identified by the mass number.

Oscillate
To-and-fro motion about an equilibrium position; characterised by the period of its motion or velocity and acceleration at different positions as it moves.

Primary data
Data collected directly by a person or group.

Primary source
Information created by the person or persons directly involved in a study, investigation or experiment or observing an event.

Property
Attribute of an object or material, normally used to describe attributes common to a group.

Qualitative data
Information that is not numerical in nature.

Quantitative data
Numerical information.

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

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

Reliable data
Data that has 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.

Report
A written account of an investigation.

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

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

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

Resonance
The effect achieved when a system has a natural predisposition to accept energy impacting it; characterised by a particular frequency or frequencies.

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

Scientific language
Terminology that has specific meaning in a scientific context.

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

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

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

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

Sustainable
Supports the needs of the present without compromising the ability of future generations to support their needs.

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

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

Technology
The development of products, services, systems and environments, using various types of knowledge, to meet human needs and wants.

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

Thermodynamics
The study of heating processes and their relationships with various forms of energy and work; concerned with characteristics of energy, such as temperature, entropy and pressure, and their inter-relationships.

Thought experiments
A process whereby the consequences of a principle, postulate or theory are examined without necessarily undertaking the experiment.

Transverse
As in transverse waves, where the direction of oscillation of particles is perpendicular to the direction of energy transfer.

Trend
General direction in which something is changing.

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

Universal law
The applicability of the relationships expressed in the law extends from Earth to the known universe.

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

Work
A concept that relates force to energy; defined as the product of a force and the displacement of an object on which it acts.